

**ARROYO LAS POSAS  
AND  
ARROYO SIMI  
ARUNDO REMOVAL FEASIBILITY  
AND  
WATER SAVINGS STUDY**

January 2015

Prepared For:

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## EXECUTIVE SUMMARY

The purpose of this Arundo Removal Feasibility Study (Project) is to provide information to help guide the Ventura Water and Sanitation Department (VCWSD) in identifying and prioritizing arundo removal project locations, determining costs associated with removal, and creating an estimate of potential water savings by removing arundo and replacing with native riparian vegetation.

*Arundo donax* (arundo) is a non-native invasive plant that colonizes riparian areas and creates a significant disruption in natural riparian process such as sediment transport, nutrient cycling, reduction of habitat diversity, and loss of water from the local hydrologic cycle. Arundo is designated as a B-rated noxious weed by the state of California, and is not to be produced or sold as nursery stock. The Agricultural Commissioner has authority to reject and destroy noxious weeds, including Arundo, within the jurisdictional boundary of the Ventura County.

The removal of arundo has been well-studied, and known benefits such as increasing biodiversity, reduction of flood damage, and decrease in wildfire spread. Recent studies in southern California and Texas suggest that removal of arundo and replacement with native vegetation can result in significant water savings (Cal-IPC 2011; Watts and Moore 2011).

Arundo distribution was mapped for both the Arroyo Las Posas and Arroyo Simi reaches of Calleguas Creek using a combination of aerial, satellite, and high resolution oblique imagery from multiple angles. A total of 8 miles were surveyed and classified for the project, to the edge of riparian vegetation within the 100-year flood plain. Data were gathered by visual interpretation of aerial photographs for 540 acres. Representative samples of arundo were collected to verify traits and help determine water loss calculations.

In order to assess the presence of arundo within the watershed accurately, four discrete percent cover classes of arundo were created. The project examines two unmodified reaches of the Calleguas Creek, the Arroyo Simi and Arroyo Las Posas. Mapping efforts were focused within the 100-year floodplain for these two reaches and approximately 540 acres of riparian habitat were surveyed.

In an effort to estimate water loss from stands in the two Arroyos, Wildscape referred to the *Arundo Distribution and Impacts* (2011) report published by Cal-IPC. Water loss in the report was estimated in millimeters per day per meter squared (mm/day/m<sup>2</sup>). Reported values for water loss in Calleguas Creek for one acre of arundo were estimated at 24 to 48 acre feet per year (afy). However, 24 afy was assumed to be the maximum.

Water use by arundo for the Arroyo Las Posas ranged from 1,374 to 3,927 afy. Water use by arundo for the Arroyo Simi ranged from 818 to 3,216 afy. Replacing arundo with native riparian vegetation could significantly decrease water use. Water savings by replacing arundo with native vegetation ranged from 681 to 2,680 afy in Arroyo Las Posas to 1,145 to 3,277 afy in Arroyo Simi.

The average cost per acre for arundo control on a watershed level was estimated at \$25,000, which included \$5,000 for management and \$20,000 for implementation. Maintenance costs are estimated to be \$25,000 over a five-year period. Costs are expected to decrease over time assuming that reinfestation is not occurring. For example, the estimated costs may be Year 1 -

\$8,000, Year 2 - \$7,000, Year 3 - \$ 5,000, Year 4 - \$3,000, and Year 5 - \$2,000. Were arundo to be removed for all areas within the Arroyo Simi and Arroyo Las Posas, the total cost to save one-acre foot of water would be \$837.

Although costs of arundo removal may appear prohibitive, there is a potential to save approximately 6,000-acre feet of water per year between the two project reaches. With the cost of state imported drinking water nearing \$1400 per acre foot and projected to rise 5-6% per year over the next 10 years, Arundo removal is a viable option for conserving local water resources.

The findings of this project will help guide VCWSD in a cost-benefit analysis of arundo removal and water savings for the Calleguas Creek watershed.

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## 1 Introduction

The purpose of this Arundo Removal Feasibility and Water Savings Study (Project) is to provide information to help guide the Ventura Water and Sanitation Department (VCWSD) in identifying and prioritizing arundo (*Arundo donax*) removal project locations, determining costs associated with removal, and creating an estimate of potential water savings by removing arundo and replacing with native riparian vegetation. Arundo is designated as a B-rated noxious weed by the state of California, and is not to be produced or sold as nursery stock. The Agricultural Commissioner has authority to reject and destroy noxious weeds, including Arundo, within the jurisdictional boundary of the Ventura County.

There have been numerous studies on the impacts and control of arundo. The Calleguas Creek Arundo Removal Plan (CCARP) and the associated Environmental Impact Report (EIR) provide extensive details on project planning, including vegetation maps, potential removal methods for arundo infestations, potential impacts, and regulatory compliance specific to the Calleguas Creek watershed.

Arundo is a non-native invasive plant that colonizes riparian areas and creates a significant disruption in natural riparian process such as sediment transport, nutrient cycling, reduction of habitat diversity, and loss of water from the local hydrologic cycle. The removal of arundo has well-studied, and known benefits such as increasing biodiversity, reducing flood damage, and decreasing wildfire spread. Recent studies in southern California and Texas suggest that removal of arundo and replacement with native vegetation can result in significant water savings (Cal-IPC 2011; Watts and Moore 2011).

In order to assess the presence and distribution of arundo within the watershed accurately, four discrete percent cover classes of arundo were created. The project examines two unmodified reaches of the Calleguas Creek, the Arroyo Simi and Arroyo Las Posas. Arundo locations and estimated percent cover were mapped via aerial imagery and field observations. Mapping efforts were focused within the 100-year floodplain for the two project reaches and approximately 540 acres of riparian habitat were surveyed.

The findings of this project will help guide VCWSD in a cost-benefit analysis of arundo removal and water savings for the Calleguas Creek watershed.

## 2 Project Location

The Calleguas Creek watershed is the second largest in Ventura County. It is approximately 41 miles long and drains approximately 220,180 acres (Figure 1). Approximately 99 percent of the watershed is located in Ventura County. From its headwaters in the Simi Hills and Santa Susana Mountains, this watershed flows west and south to its estuary in the Mugu Lagoon. The watershed is located in the eastern portion of the County and has an east-west flow direction from Simi Valley towards Camarillo.

Calleguas Creek is divided into three distinct reaches, Arroyo Simi, Arroyo Las Posas, and Calleguas. The Arroyo Simi reach extends from the headwaters east of Simi Valley to Hitch Road in Moorpark, approximately 19 miles. The Arroyo Las Posas reach is 10 miles in length



and extends from Hitch Road to Upland Road in Camarillo. The Calleguas reach continues from Upland Road to the terminus at Mugu Lagoon, approximately 12 miles in length.

For the purpose of this study, Arroyo Simi refers to the reach of the Calleguas Creek from the Simi Valley Wastewater Treatment Plant to an area west of Highway 23 where a railroad track crosses the creek (Figure 2). The reach referred to as Arroyo Las Posas extends from Hitch Boulevard to a private bridge east of Lewis Road in Somis, California (Figure 3). This study focused on the Arroyo Simi and Arroyo Las Posas reaches.

### 3 Impacts of Arundo Infestation

The California Invasive Plant Council (Cal-IPC) defines non-native invasive plant species as those that are introduced to an ecosystem as a direct or indirect result of human activity; and those that cause or are likely to cause environmental harm by displacing native species, hybridizing with native species, altering biological communities, or altering ecosystem processes. Monocultures of non-native invasive plants alter ecosystem processes such as nutrient cycles, fire regimes, and hydrology (Brossard *et al.* 2000).

Arundo is native to the Mediterranean region. It was introduced to North America by Spanish colonists. It was abundant in the Los Angeles River by the 1820s, and is now common throughout the watersheds of southern California. This tall, woody, perennial grass can attain heights of up to 30 feet, is tolerant of drought, flooding, and fire, and can survive extended periods of salinity exposure (Bell 1997). Arundo propagates vegetatively from rhizomes (underground stems) and stem segments. Therefore, it disperses readily during flood events, allowing it to spread rapidly and form extensive monocultures that out-compete native riparian vegetation. This plant thrives in warm environments and is often invasive in coastal riparian areas where it can form dense monocultures (Bell 1997).

One substantial impact of arundo monocultures is its aggressive use of water. A 2011 study by Cal-IPC detailed the distribution and impacts of arundo throughout several southern California coastal watersheds. The study found that one acre of 100percent cover of arundo can result in a maximum loss of somewhere between 24 and 48 acre-feet per year (afy) of water (Cal-IPC 2011). In contrast, native riparian woodland vegetation uses approximately 4 afy of water, although seemingly high, it is significantly less than arundo and other non-native invasive species. Water use by native riparian vegetation varies widely between plant types and species. Willow (*Salix* spp.) species water use is between 1-3 afy, cottonwoods (*Populus* spp.) use 3-6 afy, mulefat uses between 3-5 afy, and cattails (*Typha* spp.) use 3-16 afy (Johns 1989). A “typical” riparian vegetation mix is comprised of 25% trees, 25% shrubs, 25% herbs and 25% open/unvegetated (Cal-IPC 2011). Previous mapping efforts by various organizations show a significant infestation of arundo within the Calleguas Creek watershed. Within the two Arroyos, approximately 540 acres of riparian habitat contain some infestation of arundo.

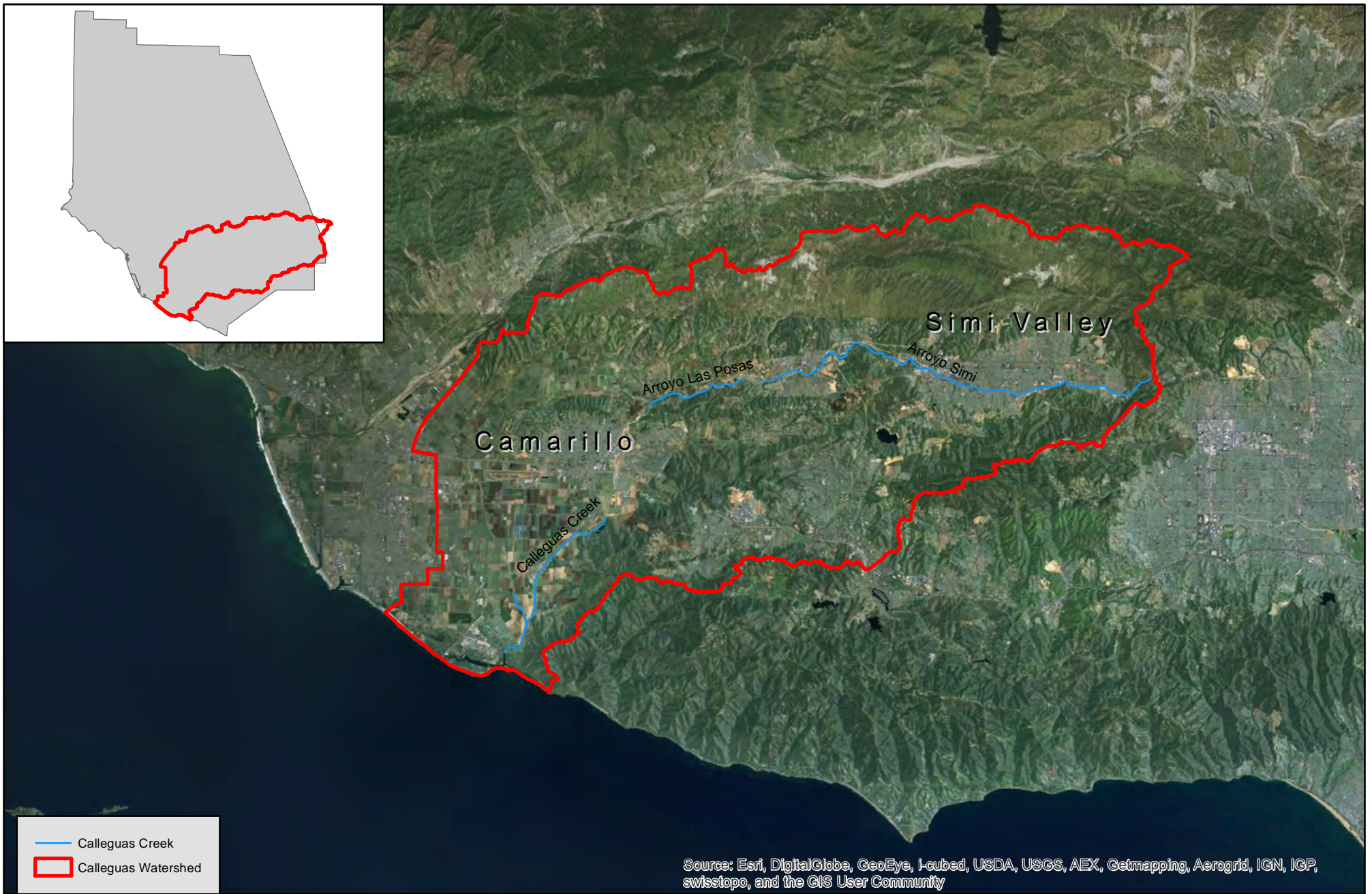
## 4 Initial Removal and Maintenance Methods

### 4.1 Initial Removal Methods

Initial removal methods vary depending on many factors including site access, staging, project size, arundo density or percent cover and presence of native vegetation. One major factor

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guiding the cost estimates and removal methods with each percent cover class is the presence of native vegetation. As previously mentioned, this study assumes that all potential projects will occur in areas with native, riparian vegetation with arundo intermixed. At times arundo will form large, dense monocultures and the appropriate removal methods for those occurrences are discussed below. However, many times, arundo occurs in high-priority areas such as those with incipient populations of arundo, areas within the active floodplain, and areas with high quality, diverse, native habitat. These areas require more precise removal methods, which increase the labor and time to locate and remove arundo. The various initial removal methods are discussed below.



## Regional Project Location

Ventura County Water and Sanitation Department - Arundo Removal Study

Ventura County, California

0 2.25 4.5 9 13.5 18 Miles



Figure 1

Imagery - Microsoft 2010  
Prepared by Wildscape September 2014

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## Arroyo Simi Local Vicinity

Ventura County Water and Sanitation Department - Arundo Removal Study

Ventura County, California

0 0.2 0.4 0.8 1.2 1.6 Miles



Figure 2

Imagery - Microsoft 2010  
Prepared by Wildscape September 2014

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## Arroyo Simi Local Vicinity

Ventura County Water and Sanitation Department - Arundo Removal Study

Ventura County, California

0 0.2 0.4 0.8 1.2 1.6 Miles



Figure 2

Imagery - Microsoft 2010  
Prepared by Wildscape September 2014

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## 4.2 Maintenance Methods

Maintenance methods are similar for all percent cover classes and include foliar herbicide application utilizing a backpack sprayer or large area applications via a spray rig. Variables such as relocating previously treated arundo stands, rental or purchasing of spray equipment, and avoidance of newly emergent native vegetation ultimately affect costs. Total maintenance costs associated with each percent cover class are approximately the same for five years, however, the costs arise from different maintenance methods such as locating small stands within dense riparian vegetation (increased labor-hours) to using specialized equipment such as boom-mounted spray rigs (increased equipment costs).

## 5 Arundo Mapping Results

### 5.1 Mapping Methodology

Arundo distribution was mapped for both the Arroyo Las Posas and Arroyo Simi reaches of Calleguas Creek using a combination of aerial, satellite, and high resolution oblique imagery from multiple angles provided by ESRI and the Ventura County Watershed Protection District (VCWPD), and Google Earth. Aerial imagery was flown in December 2013 by VCWPD and had a resolution of approximately 1 foot per pixel. Satellite imagery from ESRI's ArcGIS program contained imagery from a variety of sources dated to 2010 and has a resolution of approximately 3 feet per pixel. The high-resolution imagery from VCWPD allowed for the identification of smaller isolated stands of arundo in sparse vegetation, while the ESRI imagery allowed for the identification of large, dense monocultures.

A total of 8 miles were surveyed and classified for the project, to the edge of riparian vegetation within the 100-year flood plain. Data were gathered by visual interpretation of aerial photographs for 540 acres. Using aerial and satellite imagery, arundo populations were captured using the digitizing method in ESRI GIS desktop application (ArcGIS v 10.2.2). Distinct arundo stands were delineated by creating polygons at the interface of arundo and the surrounding vegetation. A minimum mapping unit of 0.25-acre was used to ensure smaller, isolated stands of arundo were identified. Existing vegetation layers from previous mapping efforts were incorporated into this study in an effort to identify low-density areas, and arundo populations under the canopy of larger riparian trees. These existing polygons were updated to reflect the information obtained from current imagery as needed.

Following the creation of each polygon, an approximate value of percent cover of arundo was assigned in the attributes table as well as the area of the polygon in acres. After verification of percent cover estimates, the polygons were assigned to one of four discrete percent cover classes: less than 1%, 1% to 49%, 50% to 75%, and greater than 75%. Example photos are shown in Figure 4.

### 5.2 Field Verification

Field verification of arundo locations and percent cover class occurred on September 5 and September 8. Wildscape utilized hard copy maps of each Arroyo, which displayed color-coded

polygons based on the four percent cover classes to verify in the field. The crew verified each percent cover class in several locations along the two Arroyos. Verification was completed by physically walking the polygon, when possible or by visual estimation from an elevated vantage point nearby. Discrepancies in percent cover were noted in field books, annotated on physical maps, and edited in ArcGIS later.

During the field verification visits, Wildscape also collected a representative sample of arundo from each of the percent cover classes in each Arroyo. Sampling was performed to verify that structural traits of arundo canes used in water loss calculations (leaf area, cane density per m<sup>2</sup>, cane length, and age) were similar to that of the Cal-IPC 2011 study.

### 5.3 Arroyo Simi

The Arroyo Simi reach has approximately 300 acres of riparian habitat within the 100-year floodplain. Table 1 below details the approximate acreages of arundo infestation for each percent cover class. Approximately 35 acres had less than 1 percent cover of arundo. These areas, though still in the floodplain, were at relatively higher elevations and thus away from adequate groundwater resources. The majority of the area (175 acres) fell into the 1 to 49 percent cover class, which was distributed evenly throughout the project site. Approximately 45 acres were classified as 50 to 75 percent cover and 44 acres had more than 75 percent cover. Both classes were also evenly distributed across the project (Figure 5).

**Table 1: Percent Cover of Arundo by Acreage in Arroyo Simi**

Percent Cover	Area (acres)
Less than 1%	35
1% - 49%	175
50% - 75%	45
Greater than 75%	44

### 5.4 Arroyo Las Posas

The Arroyo Las Posas reach was found to have approximately 240 acres of riparian habitat within the 100-year floodplain. Table 2, below, details the approximate acreage of arundo infestation for each density class. Approximately 10 acres were classified as having less than 1 percent cover of arundo. Like the Arroyo Simi, the majority of the area (184 acres) fell in to the 1 to 49 percent cover class. Approximately 9 acres were classified as 50 to 75 percent cover, and 36 acres were classified as having more than 75 percent cover (Figure 6).

**Table 2: Percent Cover of Arundo by Acreage in Arroyo Las Posas**

Percent Cover	Area (acres)
Less than 1%	10
1% - 49%	184
50% - 75%	9
Greater than 75%	37

**Figure 4: Representative Site Photos**



1. View southeast at Long Canyon in Arroyo Las Posas of a typical 1 - 49% cover class. September 5, 2014.



2. View southwest at Mejico Creek in Arroyo Las Posas of typical 50% - 75% cover class. September 5, 2014



3. View looking west from Hitch Blvd. at a typical greater than 75% cover class. September 5, 2014.



4. View looking east from weir in Arroyo Simi. 100% cover in immediate riparian corridor. September 8, 2014.



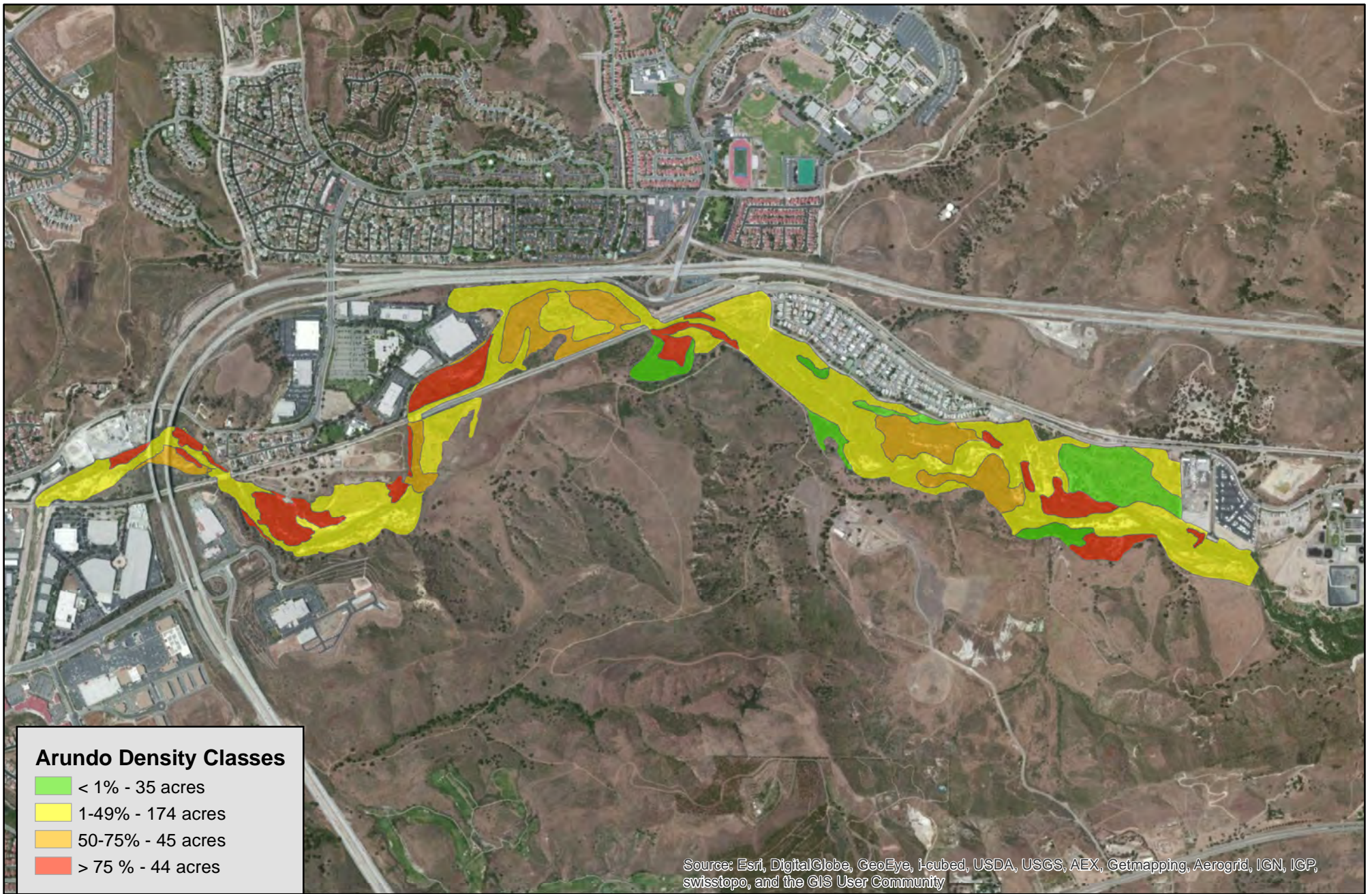
5. Arroyo Simi, old mature stands intermixed with native riparian vegetation. 1% - 49% cover. September 8, 2014



6. Arroyo Simi, new stand intermixed with riparian vegetation. Less than 1% cover. September 9, 2014

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Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, ICP, swisstopo, and the GIS User Community

**Arundo Density Classes**

- < 1% - 35 acres
- 1-49% - 174 acres
- 50-75% - 45 acres
- > 75% - 44 acres

## Arundo Density by Acre - Arroyo Simi

Ventura County Water and Sanitation Department

Ventura County, California

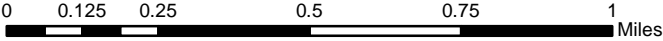
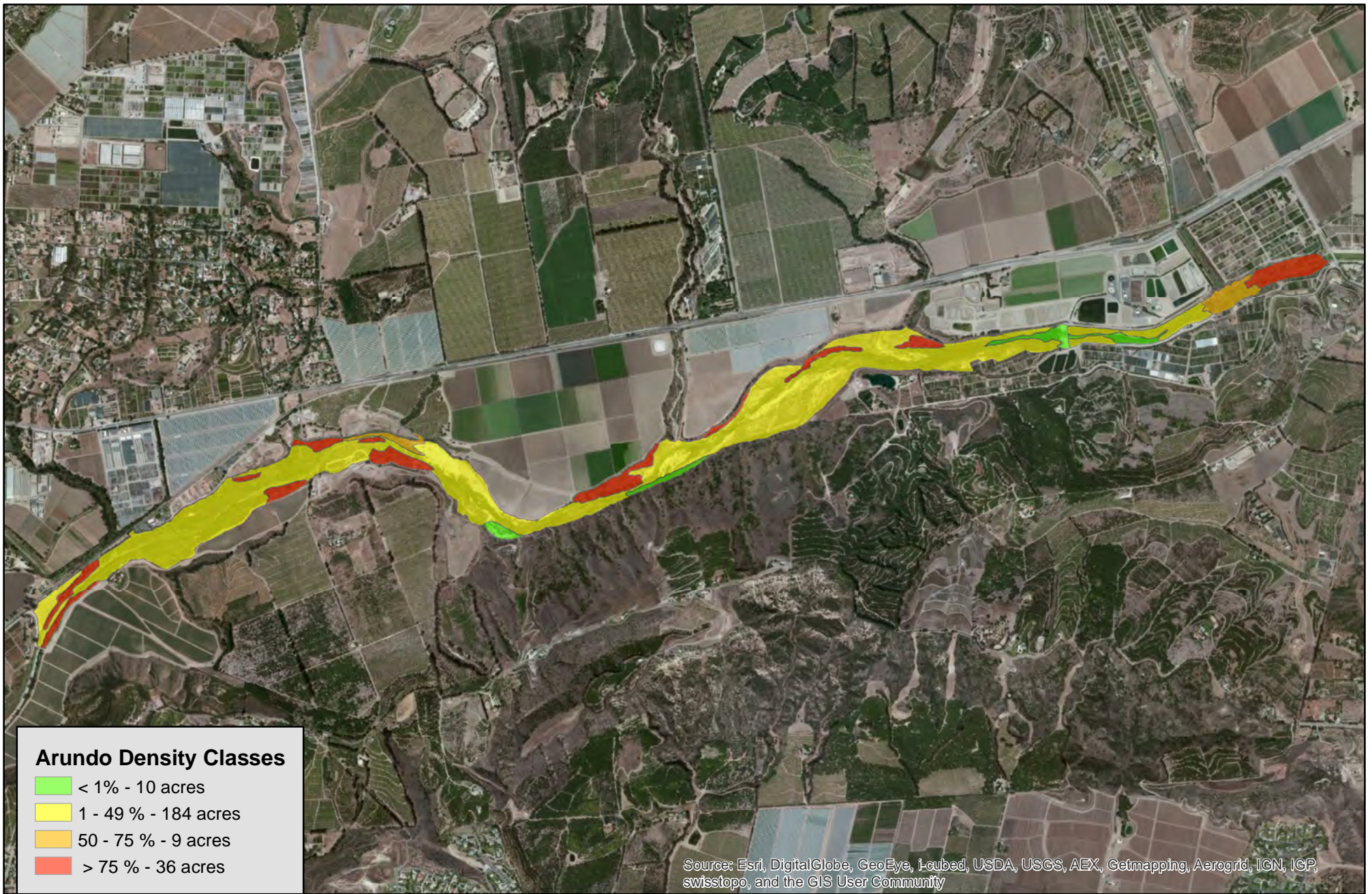


Figure 5

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## Arundo Density by Acre - Arroyo Las Posas

Ventura County Water and Sanitation Department

Ventura County, California

0 0.15 0.3 0.6 0.9 1.2 Miles



Figure 6

Imagery - Microsoft 2010  
Prepared by Wildscape September 2014

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## 6 Water Quantity Savings from Arundo Removal

### 6.1 Calculation Methodology

In an effort to estimate water loss from stands in the two Arroyos, Wildscape referred to the *Arundo Distribution and Impacts* (2011) report published by Cal-IPC. The report estimated water loss from arundo by utilizing a leaf area index (LAI), which is defined as leaf area per unit ground area. Water loss in the report was estimated in millimeters per day per meter squared (mm/day/m<sup>2</sup>). Samples collected in the field were brought back to the office, a number of leaves were randomly selected, and the leaf area measured. The samples were compared to reported values in the Cal-IPC report. The primary factor for determining water loss in arundo is based off the LAI. Our calculated LAI, 1.99, was comparable to the Calleguas Creek LAI from Cal-IPC, 1.9. Therefore, the Cal-IPC water loss values per acre of arundo were used to determine water loss for Calleguas Creek in this report.

Reported values for water loss in Calleguas Creek for one acre of arundo were estimated at 24 to 48 acre feet per year (afy), however, 24 afy was suggested to be the maximum, therefore, 24 afy was used (Cal-IPC 2011). This value is derived from the estimated water use of 20 mm/day per m<sup>2</sup> ground area. To determine water loss for entire stands, the water loss per m<sup>2</sup> ground area was scaled up to an acre and was then multiplied by the number of acres in a stand. Because the estimated water loss values are derived from monoculture stands i.e., 100 percent arundo, a range of water loss values was given for each percent cover class. The limits of the ranges were determined by multiplying the total arundo acreage by 24 afy and then by the lower and upper percent values of each class. For example, to determine the lower range of water use for the 50 to 75 percent cover class for 10 acres, one would multiply 10 by 24 by 0.50. The equations used in this report are shown below.

$$\begin{aligned} & \text{Arundo acreage of Percent Class} \times 24 \text{ afy} \times \text{Percent Class (Lower Value)} \\ & = \text{Low estimate of water use} \end{aligned}$$

$$\begin{aligned} & \text{Arundo acreage of Percent Class} \times 24 \text{ afy} \times \text{Percent Class (Upper Value)} \\ & = \text{High estimate of water use} \end{aligned}$$

One assumption of arundo removal is that it will be replaced with native riparian vegetation. Native riparian vegetation water usage is approximately 3.3 mm/day/m<sup>2</sup> ground area, which is approximately 4 afy per acre (Cal-IPC 2011). Net water savings for arundo removal were calculated by using 16.7 mm/day/m<sup>2</sup> (20 afy/acre). Ranges for water savings were given for each percent cover class using the methods described above. The formula to determine the ranges of water savings is shown below.

$$\begin{aligned} & \text{Arundo acreage of Percent Class} \times 20 \text{ afy} \times \text{Percent Class (Lower Value)} \\ & = \text{Low estimate of net water savings} \end{aligned}$$

$$\begin{aligned} & \text{Arundo acreage of Percent Class} \times 20 \text{ afy} \times \text{Percent Class (Upper Value)} \\ & = \text{High estimate of net water savings} \end{aligned}$$

### 6.2 Estimated Water Use by Arundo in Arroyo Simi

Water use by arundo within the Arroyo Simi project site is listed below in Table 3. Water use values are presented in a range for each percent cover class. The greatest water savings for

arundo removal would likely come from removing the 175 acres of arundo from the 1 to 49 percent class. Approximately 2,053 afy could be saved by removing arundo from this percent cover class.

Accounting for the replacement of arundo with native vegetation results in slightly less water savings than with arundo control alone, but are still substantial. Table 3, below, details the net water savings by replacing arundo with native vegetation.

**Table 3: Estimated Water Use by Percent Cover Class for Arroyo Simi**

Percent Cover Class of Arundo	Arundo Area (acres)	Water Use Low Range (afy)	Water Use High Range (afy)
Less than 1%	35	0	8
1% - 49%	175	42	2,053
50% - 75%	45	540	810
Greater than 75%	44	792	1056
<b>Total</b>	<b>299</b>	<b>1,374</b>	<b>3,927</b>

**Table 4: Net Water Savings with Arundo Removal and Native Revegetation for Arroyo Simi**

Percent Cover Class of Arundo	Arundo Area (acres)	Net Water Savings Low Range (afy)	Net Water Savings High Range (afy)
Less than 1%	35	0	7
1% - 49%	175	35	1,715
50% - 75%	45	450	675
Greater than 75%	44	660	880
<b>Total</b>	<b>299</b>	<b>1,145</b>	<b>3,277</b>

### 6.3 Estimated Water Use by Arundo in Arroyo Las Posas

Water use by arundo within the Arroyo Las Posas project site is listed below in Table 3. Water use values are presented in a range for each percent cover class. The greatest water savings for arundo removal would likely come from removing the 1 to 49 percent cover class. This class is substantially larger than all three other classes combined and could result in a maximum water savings of 2164 afy.

Accounting for the replacement of arundo with native vegetation results in slightly less water savings than with arundo control alone, but are still substantial. Table 4, below, details the net water savings by replacing arundo with native vegetation.

**Table 5: Estimated Water Use by Percent Cover Class for Arroyo Las Posas**

Percent Cover Class of Arundo	Arundo Area (acres)	Water Use Low Range (afy)	Water Use High Range (afy)
Less than 1%	10	0	2
1% - 49%	184	44	2,164
50% - 75%	9	108	162
Greater than 75%	37	666	888
<b>Total</b>	<b>240</b>	<b>818</b>	<b>3,216</b>

**Table 6: Net Water Savings with Arundo Removal and Native Revegetation for Arroyo Las Posas**

Percent Cover Class of Arundo	Arundo Area (acres)	Net Water Savings Low Range (afy)	Net Water Savings High Range (afy)
Less than 1%	10	0	2
1% - 49%	184	37	1,803
50% - 75%	9	90	135
Greater than 75%	37	555	740
<b>Total</b>	<b>240</b>	<b>681</b>	<b>2,680</b>

## 7 Sample Project Implementation Costs

### 7.1 Sample Project Site Selection and Project Implementation Assumptions

Three sample project locations were selected to represent the potential tasks, costs and associated water savings with arundo removal in each of the percent cover classes (1% to 49%, 50% to 75%, and greater than 75%). Potential project sites were chosen by selecting a representative polygon (delineated arundo percent cover class) for each percent cover class in either Arroyo.

A general scope of work for implementation and five years of maintenance, possible native revegetation was developed to guide the cost estimates. In order to provide an accurate cost estimate, a comprehensive implementation plan would need to be completed, which would evaluate the appropriate method of removal, access, staging, biomass disposal, biological surveys, regulatory restrictions, special status species restrictions, and owners' restrictions. Cost estimates in this study do not include the aforementioned variables as the costs associated with each vary greatly between projects and change with time. Other factors such as economy of scale, schedule to complete the work, and prevailing wage may also significantly affect the total cost.

Cost estimates for initial removal and maintenance in this report assume that the arundo to be removed is intermixed with native, riparian vegetation, typical of Calleguas Creek. Arundo distribution was mapped and classified into four classes of arundo density to simplify removal methodology. To determine the total initial cost for a project, the estimated cost per acre was multiplied by the total estimated acreage per density class. The same method was used for estimating maintenance costs. Costs associated with maintenance in this study decrease over time, but the total cost for five years of maintenance is provided in Table 7.

The *Arundo donax* Distribution and Impact Report prepared by Cal-IPC provides relevant data on the costs of arundo control and a cost-benefit analysis. The average cost per acre for arundo control on a watershed level was estimated at \$25,000, which included \$5,000 for management and \$20,000 for implementation. However, costs were much greater in the local Ventura River Watershed.

**Table 7: Approximate Initial Removal and Maintenance Costs for Arundo Removal Projects by Percent Cover Class**

Arundo Percent Cover Category	Methodology	Cost per Acre for Initial Removal	Total Cost for 5 Years of Maintenance <sup>1</sup>	Total Cost for 5 Years per acre
Less than 1%	Hand Removal	\$25,000	\$25,000	\$50,000
1% - 49%	Hand Removal	\$25,000	\$25,000	\$50,000
50% - 74%	Hand Removal and Mechanical Removal	\$12,500	\$25,000	\$37,500
Greater than 75%	Mechanical Removal	\$8,500	\$25,000	\$33,500

Cost of maintenance decreases each year, but the total cost is approximately \$25,000 per acre.

## 7.2 Potential Arundo Removal Project Site Costs

Four potential project sites were chosen between the two project reaches, one at each percent cover class. Appendix A details the total costs by percent cover class for the entire two Arroyos. Table 8 summarizes the costs of removal and maintenance for each project site. Potential project sites are shown below in Figures 7 through 10. Tables 9 through 12 detail the total costs, water savings, and cost to save an acre-foot of water for a five-year project. The cost associated with saving an acre-foot of water is given in a range because the amount of water saved is based on the percent cover of arundo for an acre i.e., 50 to 75 percent.

**Table 8: Summary of Potential Project Site Costs for Initial Removal and Maintenance**

Arundo Percent Cover	Removal Method	Arundo Acreage	Cost per Acre for Initial Removal	Subtotal for Initial Removal	Cost for 5 Years of Maintenance	Subtotal for 5 Years of Maintenance	Total for 5-Year Project
<b>Potential Project Site Number 1: Less than 1% cover</b>							
Less than 1%	Hand Removal	5.49	\$25,000	\$137,250	\$25,000	\$137,250	\$274,500
<b>Potential Project Site Number 2: 1% - 49% cover</b>							
1% -49%	Hand Removal	5.94	\$25,000	\$148,500	\$25,000	\$148,500	\$297,000
<b>Potential Project Site Number 3: 50% - 75% cover</b>							
50% - 75%	Hand and Mechanical Removal	9.37	\$12,500	\$117,125	\$25,000	\$234,250	\$351,375
<b>Potential Project Site Number 4: Greater than 75% cover</b>							
Greater than 75%	Mechanical Removal	6.43	\$8,500	\$54,655	\$25,000	\$160,750	\$215,405





## Potential Project Site -Less than 1% Cover - Arroyo Simi

Ventura County Water and Sanitation Department - Arundo Removal Study

Ventura County, California

0 262.5 525 1,050 1,575 2,100 Feet



Figure 7

Imagery - Microsoft 2010  
Prepared by Wildscape September 2014

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## Potential Project Site - 1-49% Cover - Arroyo Las Posas

Ventura County Water and Sanitation Department - Arundo Removal Study

Ventura County, California

0 180 360 720 1,080 1,440 Feet



Figure 8

Imagery - Microsoft 2010  
Prepared by Wildscape September 2014

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## Potential Project Site - 50-75% Cover - Arroyo Las Posas

Ventura County Water and Sanitation Department - Arundo Removal Study

Ventura County, California

0 180 360 720 1,080 1,440 Feet



Figure 9

Imagery - Microsoft 2010  
Prepared by Wildscape September 2014

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## Potential Project Site - Greater than 75% Cover - Arroyo Simi

Ventura County Water and Sanitation Department - Arundo Removal Study

Ventura County, California

0 180 360 720 1,080 1,440 Feet



Figure 10

Imagery - Microsoft 2010  
Prepared by Wildscape September 2014

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## 7.2.1 Potential Project Site 1: Less Than 1% Cover

### 7.2.1.1 Initial Removal Methods for Less Than 1% Cover

Initial removal methods for areas with less than 1 percent cover rely solely on hand removal techniques including chainsaws and loppers. A dense riparian area with less than 1 percent cover would require crews working in and among native riparian vegetation. Crews will travel through the site on foot to areas with arundo. Small footpaths may be cut through understory brush but access roads for trucks and small tractors may be infeasible due to native trees. Typically, native trees with a diameter at breast height (DBH) of 3-inches or greater are not allowed to be removed without replacement. Arundo canes are bundled and transported by foot to the staging area for chipping or disposal. After removal of arundo, herbicide is applied to the cut stalks via a paint dauber or roller.

The primary factors affecting cost in this class are labor-hours required to traverse the site on foot to locate and remove stands, and transport the cut arundo back out of the site.

The first potential project site for arundo removal is located just south of Collins Drive in Simi Valley (Figure 7). The total acreage for the first project site is approximately 5.49-acres. The site contains sparse, isolated stands of arundo intermixed with native riparian vegetation. Total costs for initial removal of arundo from this site are approximately \$137,250. Maintenance costs for five years are approximately \$137,250. The total cost for removal and maintenance for five years is \$274,500.

Water savings for the first potential project site are approximately 0-1.10 afy, and 0-6 afy over a five-year project. The total cost to save each acre-foot of water over a five-year period is approximately \$47,750.

**Table 9: Potential Project Site: Less than 1% Cover Cost and Water Savings**

Percent Cover of Arundo	Acreage	Total Cost for 5-Year Project	Water Savings (afy)	Total Water Savings over 5-year period (Acre-Feet)	Cost/Acre-Feet Water Saved (5 years)
Less than 1%	5.49	\$274,500	1.10	6	\$45,750

## 7.2.2 Potential Project Site 2: 1% - 49% Cover

### 7.2.2.1 Initial Removal Methods for 1% - 49% Cover

Initial removal methods in the 1 to 49 percent cover class are similar to those of the less than 1 percent class. Crews will enter the site on foot and remove arundo by hand via loppers, chainsaws, machetes, or similar tools. Crews will transport bundled and cut arundo to the staging area for chipping or disposal. However, as larger areas are cleared, equipment such as bobcats, or skip loaders may be able to enter the site and assist with transporting arundo.

Primary factors affecting cost for the initial removal in the 1 to 49 percent cover class are labor-hours required to operate chainsaws and transport arundo, equipment rental and operation costs.

The second potential project site for arundo removal is located south of Highway 118 and approximately one half mile downstream of Hitch Boulevard (Figure 8). The total acreage for the project site is approximately 5.94-acres. The site contains sparse, isolated stands of arundo intermixed with riparian vegetation. Some larger stands of arundo are present near the channel of Arroyo Las Posas. Total costs for initial removal of arundo from this site are approximately \$148,500. Maintenance costs for five years are approximately \$148,500. The total cost for removal and maintenance for five years is \$297,000.

Water savings for the second potential project site vary. The range is based on the estimated percent cover of the project site. Water savings are approximately 1.18 to 58.21 afy, and between 5.9 and 291.06 acre-feet over a five-year project. The total cost to save each acre-foot of water over a five year period ranges from approximately \$1,020 to \$50,338.

**Table 10: Potential Project Site: 1% - 49% Cover Cost and Water Savings**

Percent Cover Class	Acreage	Total Cost for 5-Year Project	Water Savings (afy)	Total Water Savings over 5-year period (Acre-Feet)	Cost/Acre-Foot Water Saved (5 years)
1% - 49%	5.94	\$297,000	1.18 – 58.21	5.9 -291.06	\$1,020 – \$50,338

### 7.2.3 Potential Project Site 3: 50% - 75% Cover

#### 7.2.3.1 Initial Removal Methods for 50% - 75% Cover

Initial removal for areas containing 50 to 75 percent arundo can be both mechanical and hand removal depending on the density of arundo. Typically, areas within this percent cover class have large monoculture stands with no native riparian vegetation allowing for the use of mechanical removal such as a mowers and brush grinders. Some areas may still require a “hunt and peck” method and therefore more labor-hours.

Primary costs associated with removal efforts of the 50 to 75 percent class are associated with purchasing or renting specialized brush removal equipment.

The third potential project site for arundo removal is located south of Highway 118 and approximately one-quarter mile downstream of Hitch Boulevard (Figure 8). The total acreage for the project site is approximately 9.37-acres. The site contains areas of dense monoculture stands with tall willow (*Salix* sp.) and cottonwood (*Populus fremontii*) intermixed. Total costs for initial removal of arundo from this site are approximately \$117,125. Maintenance costs for five years are approximately \$234,250. The total cost for removal and maintenance for five years is \$351,375.

Water savings for the third potential project site vary. The range is based on the estimated percent cover of the project site. Water savings are approximately 93.70 to 140.55 afy, and

between 468.50 and 702.75 acre-feet over a five-year project. The total cost to save each acre-foot of water over a five year period ranges from approximately \$500 to \$750.

**Table 11: Potential Project Site 50% - 75% Cover Cost and Water Savings**

Percent Cover Class	Acreage	Total Cost for 5-Year Project	Water Savings (afy)	Total Water Savings over 5-year period (Acre-Feet)	Cost/Acre-Foot Water Saved (5 years)
50% - 75%	9.37	\$ 477,870	93.7 – 141.5	468 – 702	\$680 - 1021

## 7.2.4 Potential Project Site 4: Greater Than 75% Cover

### 7.2.4.1 Initial Removal Methods for Greater Than 75% Cover

Initial removal for areas containing more than 75 percent cover of arundo is almost exclusively mechanical. Removal would consist of using machinery-mounted brush clearing devices such as brush grinders, masticators, and flail mowers. Areas within this percent cover class have little to no native riparian vegetation. The use of mechanical removal means less labor on the ground and lower initial removal costs.

As with the 50 to 75 percent cover class, the primary costs associated with initial removal efforts in the greater than 75 percent cover class result from purchasing or renting specialized equipment.

The fourth potential project site for arundo removal is located south of the Virginia Colony and Avandia Colonia, east of Highway 23 (Figure 9). The total acreage for the project site is approximately 6.43-acres. The site is primarily dominated by arundo with several extensive, dense monocultures. Some areas contain native riparian and scrub species such as mule fat (*Baccharis salicifolia*), sandbar willow (*Salix exigua*), and poison oak (*Toxicodendron diversilobum*). Total costs for initial removal of arundo from this site are approximately \$54,655. Maintenance costs for five years are approximately \$160,750. The total cost for removal and maintenance for five years is \$215,405.

Water savings for the fourth potential project site vary. The range is based on the estimated percent cover of the project site. Water savings are approximately 96.45 to 128.60 afy, and between 482.25 and 643.00 afy over a five-year project. The total cost to save each acre-foot of water over a five year period ranges from approximately \$335.00 to \$446.67.

**Table 12: Potential Project Site Greater than 75% Cover Cost and Water Savings**

Percent Cover Class	Acreage	Total Cost for 5-Year Project	Water Savings (afy)	Total Water Savings over 5-year period (Acre-Feet)	Cost/Acre-Foot Water Saved (5 years)
Greater than 75%	6.43	\$215,405	96.5-128.6	482.3-643.0	\$335 - 447

## 8 Discussion

The non-native invasive plant, arundo occurs throughout Arroyo Simi and Arroyo Las Posas and through the entire Calleguas Creek watershed. Previous studies have shown that stands of arundo can use anywhere between 8 to 40 mm/day (24 to 48 afy/acre) (Watts and Moore 2011; Cal-IPC 2011). Approximately 539 acres of riparian habitat between the two arroyos contain some infestation of arundo. The majority of riparian habitat (359 acres) can be classified as having between 1 and 49 percent cover of arundo (4 to 176 acres of arundo). Approximately 81 acres between the two arroyos contain more than 75 percent arundo (at least 60 acres of arundo). Transpiration from arundo may result in substantial water loss from the local hydrologic cycle in Arroyo Simi and Arroyo Las Posas.

Water losses for the entire Arroyo Simi project area due to arundo infestations range from 1,374 afy to 3,932 afy. Replacement of arundo with native riparian vegetation results in substantial water savings. Approximate water savings for the entire Arroyo Simi by controlling arundo and replacing with native riparian vegetation range from 1,145 afy to 3,277 afy. Water losses and savings for Arroyo Las Posas are less than Arroyo Simi but still substantial.

Water losses for the entire Arroyo Las Posas project area due to arundo infestations range from 818 afy to 3,216 afy. Approximate water savings for the entire Arroyo Las Posas by controlling arundo and replacing with native riparian vegetation range from 681 afy to 2,680 afy.

Cost of removal of arundo from Arroyo Simi and Arroyo Las Posas primarily varies with the percent cover of arundo as that dictates the means of removal and equipment used. A critical assumption made during the development of potential cost was that the percent cover of native vegetation was complementary to arundo percent cover. This assumption implies that there are no vast expanses of open channel. As previously discussed, cost estimates are highly influenced by several other factors such as access, staging, biomass disposal, biological surveys, regulatory restrictions, special status species restrictions, and owners' restrictions. Additional factors such as economy of scale, schedule to complete the work, and prevailing wage may also significantly affect the total cost.

Estimated costs for initial removal of an area with less than 1 percent cover are approximately \$25,000 per acre. The cost for initial removal of areas 1 to 49 percent cover of arundo is approximately \$25,000 per acre. The cost of removal decreases as percent cover of arundo increases as the use of more specialized equipment is allowed and less labor is required. Project sites containing between 50 and 74 percent cover cost approximately \$12,500 per acre for initial removal. Project sites containing greater than 75 percent cover have an approximate initial removal cost of \$8,500 per acre.

Maintenance costs are estimated to be \$25,000 over a five-year period. Costs are expected to decrease over time assuming that reinfestation is not occurring. For example, the estimated costs may be Year 1 - \$8,000, Year 2 - \$7,000, Year 3 - \$5,000, Year 4 - \$3,000, and Year 5 - \$2,000.

Removal of all arundo from both Arroyos plus five years of maintenance would cost approximately \$24,938,500. Table 13 below shows total estimated costs for the both Arroyos.



**Table 13 Approximate Arundo Removal Costs For Arroyo Simi and Arroyo Las Posas By Percent Cover Class**

Arundo Percent Cover Category	Method	Arundo Acreage	Cost per Acre for Initial Removal	Subtotal for Initial Removal	Cost for 5 Years of Maintenance /acre	Subtotal for 5 Years of Maintenance	Total for 5-Year Project
Less than 1%	Hand Removal	45	\$25,000	\$1,125,000	\$25,000	\$1,125,000	\$2,250,000
1% - 49%	Hand Removal	359	\$25,000	\$8,975,000	\$25,000	\$8,975,000	\$17,950,000
50% - 74%	Hand Removal and Mechanical Removal	54	\$12,500	\$675,000	\$25,000	\$1,350,000	\$2,025,000
Greater than 75%	Mechanical Removal	81	\$8,500	\$688,500	\$25,000	\$2,025,000	\$2,713,500
<b>Grand Total</b>		<b>539</b>	<b>-</b>	<b>\$11,463,500</b>	<b>-</b>	<b>\$13,475,000</b>	<b>\$24,938,500</b>

Table 14 below details the costs and water savings associated with removal of arundo and maintenance for five years.

**Table 14: Costs and Water Savings Associated with Removal and Maintenance of Arundo**

Arundo Percent Cover Category	Total Cost for 5-Year Project	Arroyo Simi Water Savings (afy) (max)	Arroyo Las Posas Water Savings (afy) (max)	Total Water Savings for both Reaches (afy)	Total Water Savings over 5-year period (Acre-Feet)	Cost/Acre-Feet Water Saved (5 years)
Less than 1%	\$2,250,000	7	2	9	45	\$50,000.00
1% - 49%	\$17,950,000	1,715	1,803	3,518	17,590	\$1,020.00
50% - 75%	\$2,025,000	675	135	810	4,050	\$500.00
Greater than 75%	\$2,713,500	880	740	1,620	8,100	\$335.00
<b>Total for all</b>	<b>\$24,938,500</b>	<b>3,277</b>	<b>2,680</b>	<b>5,957</b>	<b>29,785</b>	<b>\$837.00</b>
Total for 1% - 100%	\$22,688,500	3,270	2,678	5,941	29,740	\$763.00
Total for 50% - 100%	\$4,705,000	1,555	875	2,430	12,150	\$390.00

## 9 Conclusion

Arundo infestations in the Calleguas Creek watershed remove substantial amounts of water from the local hydrologic cycle through transpiration. Recent studies have found that the water losses from arundo infestations can range from 24 to 48 afy per acre of arundo. This project looked at two unmodified reaches of the Calleguas Creek, Arroyo Simi and Arroyo Las Posas. With aerial imagery, previously collected arundo distribution data and field verification, accurate estimates of arundo distribution and percent cover for Arroyo Simi and Arroyo Las

Posas were created. These estimates of arundo distribution and percent cover were used in calculations to estimate water loss.

After verifying arundo attribute samples from the field with previously reported arundo attributes important in water loss calculations, water loss estimates for one square meter of ground were calculated. These water loss values were scaled up to the stand level and adjusted for percent cover. In addition to determining water loss by arundo, the costs of removing arundo for each percent cover class were also calculated.

The cost of removing arundo was determined by in-house data and experience as well as consulting the 2011 Cal-IPC report. Costs for arundo removal varied with the percent cover of arundo within a potential project site.

As seen in Table 13, the cost of arundo removal for initial removal and maintenance is less expensive per acre when using mechanical removal methods in areas with higher percent cover of arundo. As the cost of removal of an acre of arundo decreases so does the cost of saving water. Table 14 shows that over the course of 5 years the cost to save one-acre foot of water is \$335 for areas of greater than 75% arundo cover, compared to \$50,000/af for difficult removal in areas containing less than 1% arundo cover. Were arundo to be removed for all areas within the Arroyo Simi and Arroyo Las Posas, the total cost to save one-acre foot of water would be \$837.

As discussed in Section 8, the large variances in cost are primarily associated with site access, locating isolated stands of arundo, special status species protections, permits, etc. Although costs of arundo removal may appear prohibitive, there is a potential to save approximately 6,000-acre feet of water per year between the two project reaches. With the cost of state imported drinking water nearing \$1400 per acre foot and projected to rise 5-6% per year over the next 10 years, Arundo removal is a viable option for conserving local water resources.

## 10 References

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