Acton-Agua Dulce Drought Resiliency

An Evaluation of Regional Water Supply to Develop Multi-benefit, Nature-based Groundwater Replenishment Strategies

March 2026

Prepared by: TreePeople
For: California Department of Water Resources

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Acknowledgment

Authors and Contributors

Igor Bronz

Dustin Herrmann, PhD

Hannah Searles

Amanda Begley

Graphic and Design Support

Cez Cruz

Lorna Xu

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Executive Summary

As part of the Rural Water Supply Reliability program funded through the Urban and Multibenefit Drought Relief Grant Program administered through the California Department of Water Resources, TreePeople was engaged to assist private well owners in the Acton and Agua Dulce communities experiencing dry or underperforming wells, providing both short-term relief and long-term strategies for water supply reliability. Short-term needs were identified and addressed by providing water tanks, well assessments and other forms of immediate assistance.

The conceptualization of a long-term solution for water supply reliability required a comprehensive understanding of the complex environmental, social and regulatory context of the Acton-Agua Dulce area. Design considerations were informed by feedback from the local communities via WaterTalks, flood control feasibility analyses by Stantec in their 2024 report, LA County Public Works planning documents, and a deep analysis of the latest available geologic, groundwater, climate, utility, and population scale data to frame a potential solution in ways not previously attempted. Water supply issues appeared to stem from human intervention of a naturally dynamic landscape despite generally good stewardship on behalf of the residents. Solutions would require active management of water resources, not merely limiting disruption.

During this process, a major monitoring data gap was identified, resolvable through increased investment into groundwater monitoring of the Action Valley Groundwater Basin and East Acton GSA. A possible pathway may be through an adjustment to SGMA basin categorization criteria for small basins where current methods can result in undercounting withdrawals due to significant proportions of the local population living just outside the basin boundary, and high inter-year variances from small water purveyors resulting in inaccurate per-capita water usage rates.

Drought and flooding often have the same root cause - improper management of the water cycle. The team's investigation suggested that a feasible, long-term solution for water supply reliability consists of constructing numerous swale-like systems here called Native Dryland Bioswales within strategic portions of the region, whose primary function is to capture and percolate stormwater from routine storm events, while also reducing erosion and sedimentation rates by stabilizing soil using native plants. Native Dryland Bioswales are designed to be cost-effective, easy to maintain, scalable, constructed using local resources, aesthetically cohesive with the rural character of the area, and provide a host of other important co-benefits.

Similar strategies have been successfully deployed in China, India, Mexico, Arizona and other parts of the world within comparable landscapes, and often at much larger scales. Each of these projects were implemented across several decades, requiring patience and sustained commitment from both the local communities & relevant authorities. Drought resiliency strategies for the Acton-Agua Dulce Area will require similar commitment, but our preliminary understanding suggests that this approach will neither be financially or socially risky. Systems can be constructed, studied, refined, and scaled at a pace that is amenable to and managed by the local community.

The comprehensive analysis of regional water supply is presented to support informed decision-making about the feasibility of drought resiliency strategies and identify data gaps. We hope that this insight will lead to expanded groundwater monitoring efforts and further development of distributed nature-based solutions throughout Acton, Agua Dulce, and other regions of California dealing with similar concerns. The team recommends pilot testing several nature-based stormwater capture approaches, such as the ones described in this report, in strategic locations within the Acton and Agua Dulce watersheds to more accurately understand the function, maintenance needs, and overall feasibility of these systems prior to scaling efforts.

1.0 Introduction

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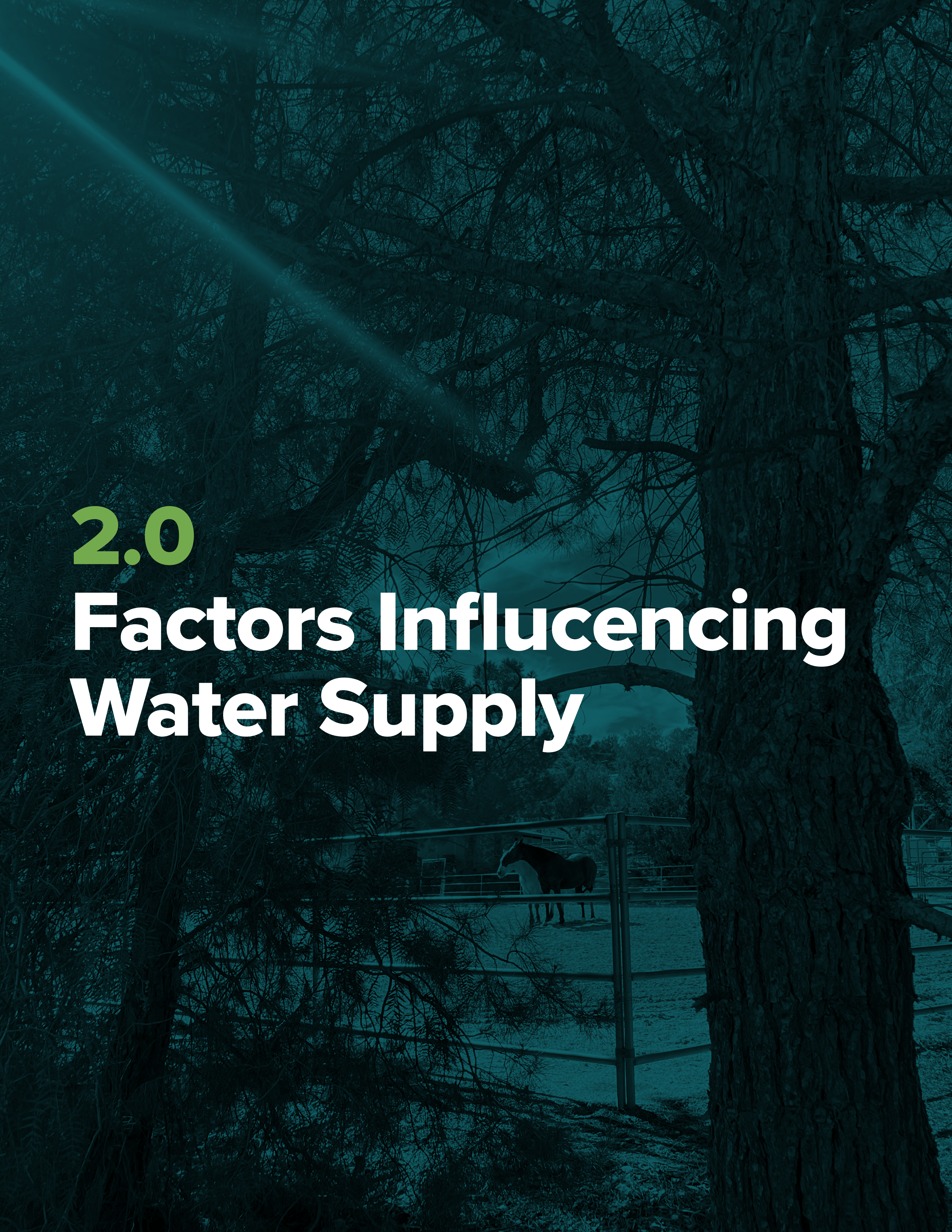
The Acton–Agua Dulce Area (AADA) is a 62.2 sq. mi. rural region in northeastern Los Angeles County characterized by low population density, large parcel sizes, and heavy reliance on local groundwater. Approximately half of residents depend on private domestic wells, many of which draw from unreliable hydrologic units outside of current groundwater basin boundaries. Reports of declining well performance and dry wells in recent years have raised concerns regarding long-term water supply reliability across the area.

This report consists of two main components:

1. An accounting of local hydrology, groundwater budgets, and water supply infrastructure for the AADA to understand regional trends and identify gaps in data and monitoring if present.
2. Developing effective, feasible conceptual solutions and strategies for long-term water supply reliability within the social and environmental contexts of the AADA.

A comprehensive analysis of water resources is necessary to establish a set of recommendations within this report. This report is intended to assist in informed regional decision-making, serving as an introduction to specific actions that may be taken to improve the overall resilience of the environment and needs of the local residents.



2.0 Factors Influcencing Water Supply

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2.1 Population

Understanding population growth trends is critical to identifying patterns in groundwater demand over time. The Acton-Agua Dulce Area (AADA) is a 62.2 sq. mi., largely rural geographical area comprising Acton, CA and Agua Dulce, CA in the northeastern portion of Los Angeles County. The exact geographical boundary of the AADA consists of the combination of the Acton Census Designated Place (CDP) and Agua Dulce CDP boundaries from the US Census Bureau.

Census data for the Acton CDP is available each decade starting from 1990, however the boundaries of the CDP have changed significantly between 2000 and 2010, growing from 4.6 sq. mi. to its current extent of 39.3 sq. mi. The population has not changed much between 2010 to 2020, decreasing from 7,596 residents across 2,814 housing units, to 7,431 residents across 2,821 housing units. Due to lack of comparable geographic reference data for the 2000 population estimate, the population was estimated by using overlapping data from 2000s census tracts and the current 2010 CDP boundary data of Acton. The 2019 US Census Bureau TIGER/Line Shapefiles were used to aggregate Acton census blocks from 2000, 2010, and 2020. To ensure accuracy of this approach, the 2010 and 2020 population numbers were crossreferenced with the 2010 and 2020 US Census data. We are presenting the population that would have existed in Acton in 2000 using the same 39.3 sq. mi. footprint as it is today.

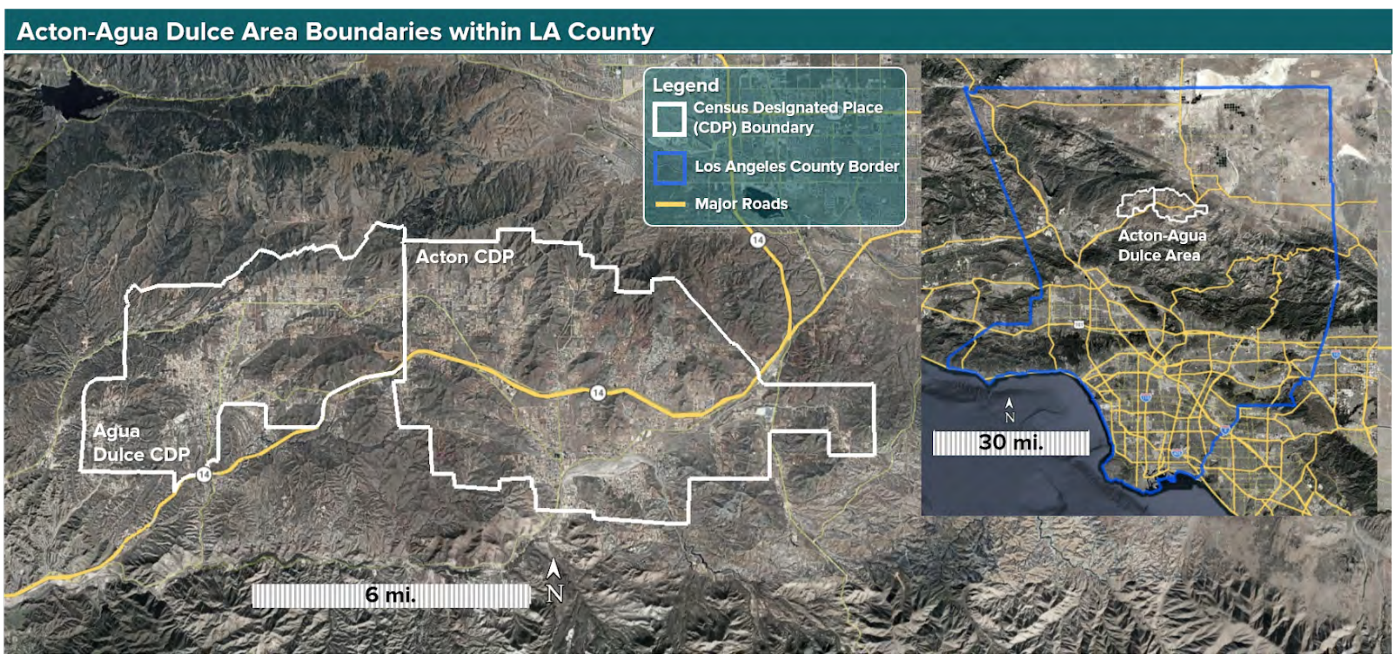


Figure 1: Acton-Agua Dulce Area with inset showing relative location within Los Angeles County. The northern half of Los Angeles County has considerably less population density.

This methodology was also used to accurately reflect the population of two other nearby cities: Santa Clarita and Palmdale. Population for those cities aligns with US Census Data, with the exception of the 2000 Santa Clarita population, for which there was a redefined place boundary that explains discrepancies between our population data and that of the US census.

Census data for the Agua Dulce CDP is available for 2010 and 2020. The population has slightly increased between 2010 and 2020, growing from 3,342 residents and 1,194 housing units to 3,451 residents and 1,303 housing units. Population data for 2000 was reconstructed for Agua Dulce using the same methodology as with Acton by overlapping 2019 CDP boundaries and 2000s census blocks. Individual population trends within Acton and Agua Dulce were comparable.

Table 1: Population for the Acton-Agua Dulce Area from 2000 - 2020

Year	Population	Data Source
2000	9,555	Reconstructed using 2010 place boundaries from existing census blocks
2010	10,938	2010 Census
2020	10,882	2020 Census

The population of the AADA increased by 12.6% from 2000 to 2010, and then stabilized (Table. 1). This modest growth is less than surrounding cities Santa Clarita and Palmdale during the same time period, but consistent with other suburban and exurban areas across the US (9.1%). It is unlikely that population growth alone is responsible for groundwater supply issues within the AADA.

2.2 Climate

Climate considerations, particularly within the AADA, are central for both understanding water resources, and tailoring solutions to any set of environmental problems.

The AADA experiences warm and dry summers, with average monthly temperatures rarely exceeding 71.6° F, though summer daytime temperatures often average above 88° F. This area is classified as warm-summer Mediterranean under the Köppen Climate Classification index. Precipitation can be highly seasonal and annually variable, often falling between 7 and 14 inches with annual averages of 8.43 in. at Acton Fire Station, 9.78 in. at Acton Camp, 10.32 in. at Acton-Escondido, and 12.62 in. at Agua Dulce mostly falling from November - March.

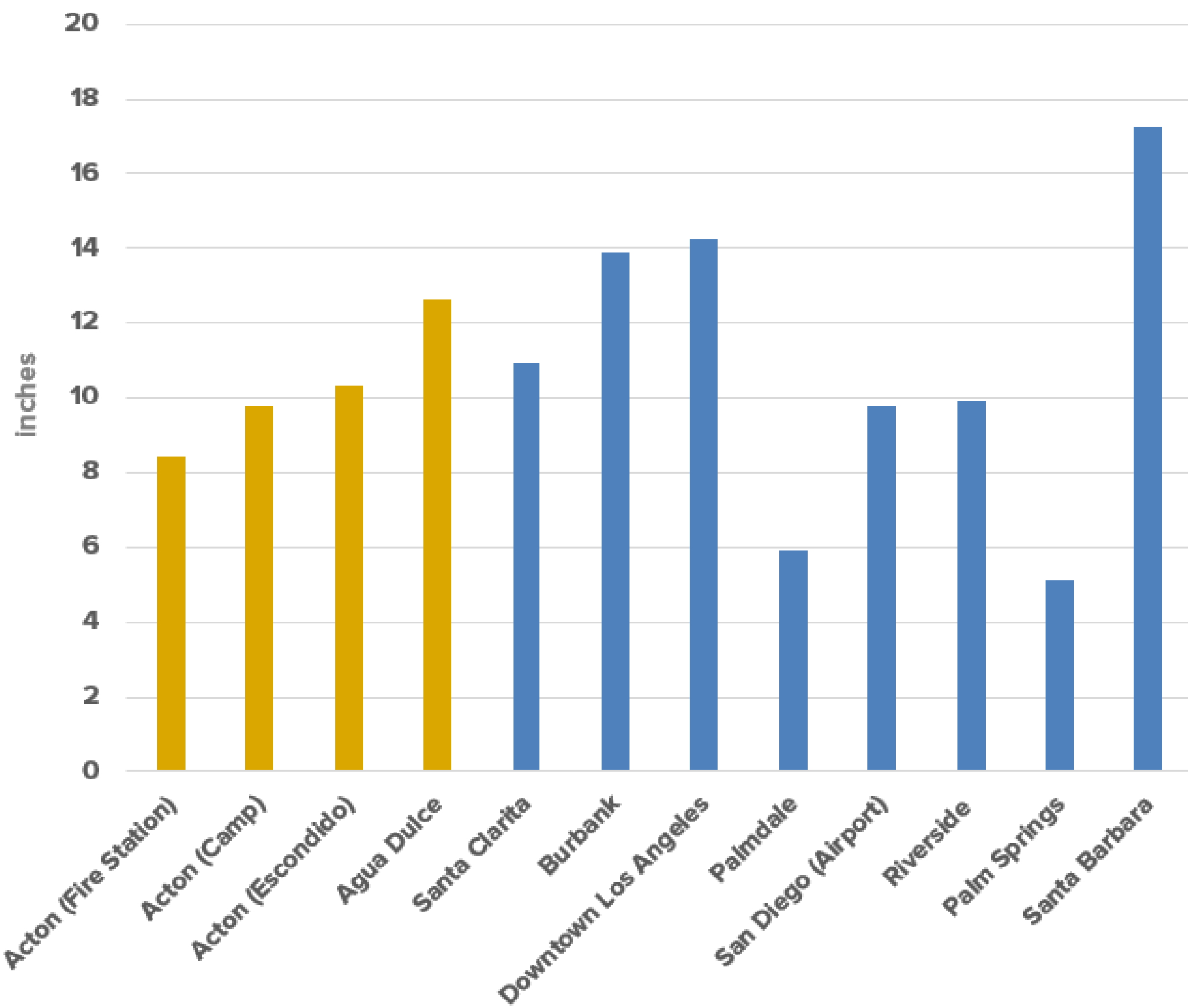


Figure 2: Precipitation season normals for rain gauges in Acton and Agua Dulce compared with select southern California cities

The annual variability can be observed by counting the number of rainy days experienced within the AADA. Between 2020 and 2025, the AADA experienced precipitation above 0.01” for 16-53 days per year. Much of the annual rainfall volume is accumulated through moderate rainstorms depositing 0.2 - 0.9” within a 24-hour period, though more powerful storms exceeding 1” of precipitation are not uncommon, which can cause nuisance flash flooding along certain roads and stream channels during more intense intervals at confluences lower in the watershed. 24-hour storms with a 1-year recurrence interval (statistically likely to occur once a year) deposit 1.6”, and 2-year recurrence intervals deposit 2.22” in Acton. A particularly powerful and unusual storm on August 20th, 2023 deposited 4.94” over 24 hours, coinciding with a 25-year event (statistically likely to occur only once every 25 years), and can cause severe, widespread flooding that is dangerous to life and property. While measuring the precipitation depth of 24-hour events is the hydrological standard for flood management, it is also important to note that storm events tend to cluster within the AADA, with significant daily volumes of precipitation falling for 2-6 days in a row as storm systems work through the region.

The AADA generally experiences less precipitation than coastal areas of Los Angeles County, but more precipitation than further inland areas such as Palmdale and Riverside.

> **The volume of rainfall within the AADA is comparable to many other cities in southern California (Fig. 2). However, the region’s steep topography causes water to move quickly across the watershed. Consequently, aquifer recharge from precipitation is constrained due to the short period of time during which rainwater sits on the soil versus emptying into the Santa Clara River channel.**

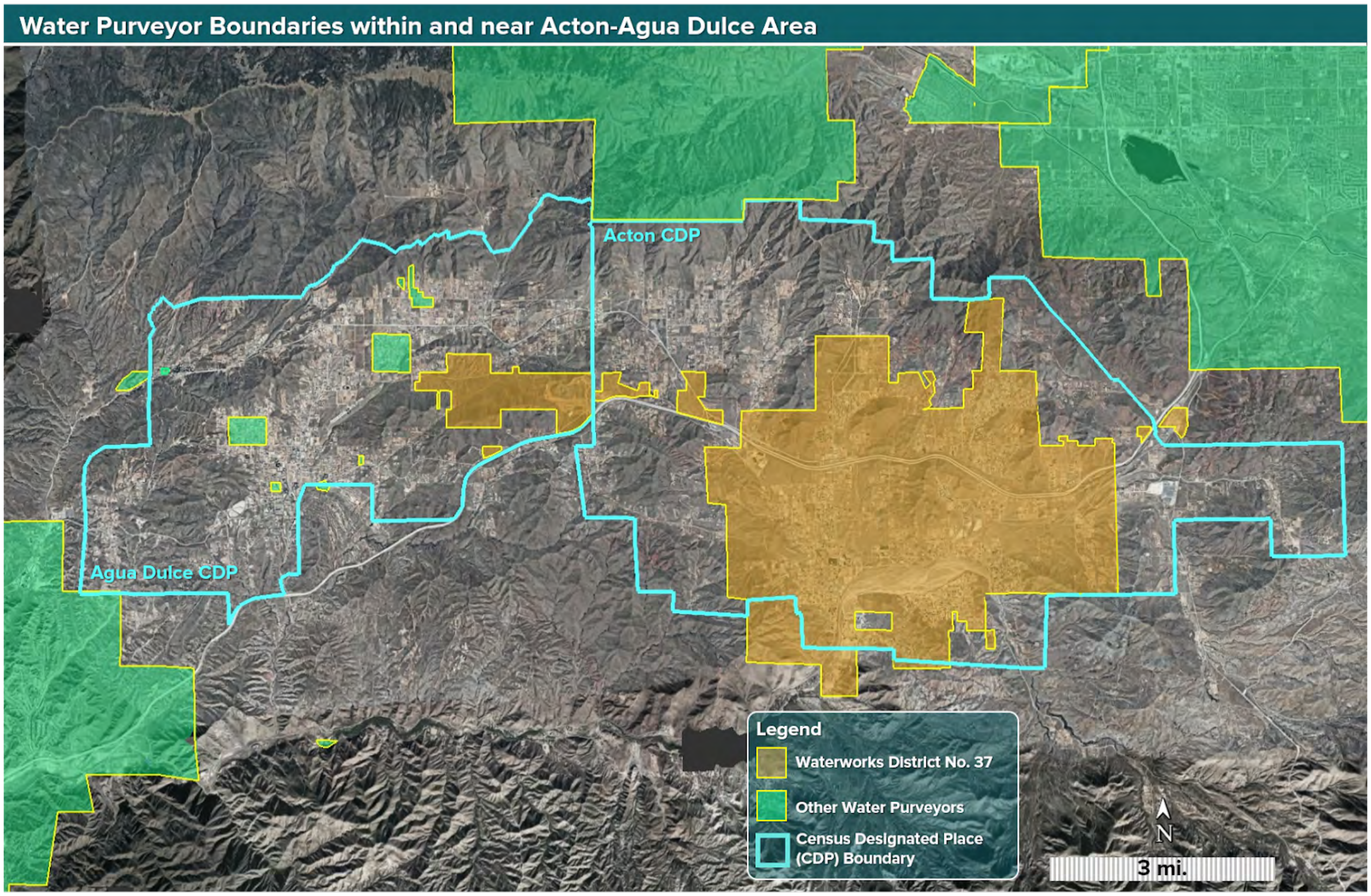


Figure 3: Water purveyor system boundaries within the AADA. Waterworks District No. 37 in orange, while other purveyors outlined in green. Population centers outside water purveyor boundaries rely on private domestic supply wells or hauled water.

2.3 Water Usage

Water usage patterns by source are necessary for understanding which populations or sub-sections of a given geographic area are affected by water supply problems, and defining the shape of potential solutions.

Within the AADA, residential water is supplied as groundwater via municipal supply wells and private domestic supply wells. For Waterworks District No. 37 customers, water is also supplemented through the State Water Project (via the Sacramento River/ San Joaquin Delta).

Municipal supply wells in Acton are located along the Santa Clara River and are managed by District 37, serving customers throughout its service area. Agua Dulce has a number of smaller water purveyors and a proportionally greater reliance on private domestic supply wells compared to the more centralized water supply structure of Acton (Fig. 3). Within the AADA, residents on private domestic wells experiencing water supply issues obtain water from a number of local water haulers.

Within the AADA, it is estimated that 5,300 residents across 1,642 connections receive water through a metered connection, or approximately 48.7% of the population. The remainder (51.3%) are homes outside of water utility boundaries which utilize private domestic wells or purchase hauled water from a private water supplier. Based on well completion reports submitted to the California Department of Water Resources, 94.9% of existing private domestic supply wells have been constructed between 1980 and 2010, largely coinciding with periods of population growth within the area. It is estimated based on local water hauler customer data that between 6 - 10% of private domestic well owners regularly purchase hauled water, indicating potential water supply issues at these properties.

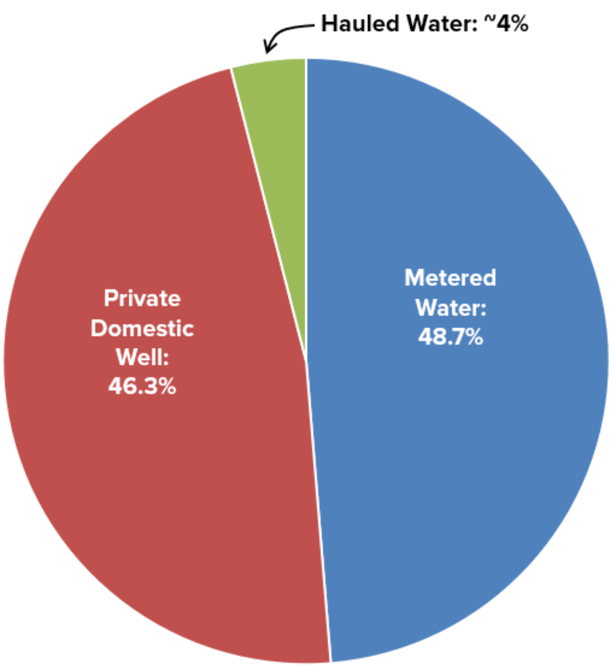


Figure 4: Proportion of residents within the Acton-Agua Dulce Area receiving water by source. Hauled water recipients are estimated at 3-5% of total residents based on provider data.

According to the 2019 Antelope Valley Integrated Water Management Plan, District 37 is capable of meeting the needs of 17,000 consumers from three municipal supply wells along the Santa Clara River producing up to 3.17 million gallons per day of capacity, and an additional 4 million gallons per day of capacity from Antelope Valley-East Kern agency via the State Water Project (water brought in using canals from the Sacramento River/San Joaquin Delta). The exact partitioning of local groundwater and State Water Project water varies based on local factors, such as: water quality constraints, well maintenance cycles, and operational decisions. While the total population of the AADA is smaller than the supply capacity of District 37, significant planning, social and financial challenges exist with expanding District 37's service area.

Though there are varying degrees of water system centralization creating significant distinctions between the Acton and Agua Dulce portions of the AADA with regard to water supply reliability, the majority of the AADA can be categorized as highly vulnerable to disruptions with groundwater resources. Only District 37 customers have access to sources of water besides local groundwater. Hauled water recipients with underperforming wells are still relying on local groundwater, just from more productive wells in the deep alluvium deposits adjacent to the Santa Clara River.

2.4 Geology and Hydrology

With slightly over half of the population within the AADA relying on (or previously relied on) a private domestic well and recent reports of reduced well yields having been anecdotally observed, understanding the local geology and hydrology is necessary to identify the potential causes of groundwater supply issues.

The geological and hydrological setting of the AADA is complex, and can be principally described as recent unconsolidated surface sediment (alluvium) filling the valley floors, achieving a maximum depth of 220 ft near the Santa Clara River and thinning outwards, underlain by diverse, non-carbonate sedimentary strata (conglomerates, sandstones and claystones) of the Vasquez, Mint Canyon and Tick Canyon formations, and highly fractured crystalline bedrock underlying both.

The AADA is geologically heterogeneous. The eastern portion under Acton features a thicker alluvium layer due to its closer proximity and more direct access to the Santa Clara river into which the watershed empties. Sedimentary formations are less prominent, shallower, and the alluvium is directly deposited upon crystalline bedrock in many places. The western portion under Agua Dulce features considerably deeper and more prominent sedimentary strata, with crystalline bedrock primarily exposed near the northern section of Agua Dulce at the Sierra Pelona mountains.

Municipal supply wells and water purveyor wells are frequently drilled into the alluvium surface sediment due to its high porosity and rapid, precipitation-fed recharge, providing a consistent and reliable supply of groundwater. Greater distances from the Santa Clara River require wells to be increasingly drilled into less productive, highly variable non-carbonate sedimentary rocks or fractured, crystalline bedrock units where water accumulates within the faults, cracks and joints of the rock. Based on well completion reports, wells frequently exceed the maximum thickness of the unconsolidated alluvium material, with some as deep as 700 ft. Relative to the alluvium that principally comprises the two groundwater basins within the AADA, other rocks are considered a lower quality aquifer material due to slower overall recharge rates and highly variable compositions, requiring wells to be drilled (and often re-drilled) to much greater depths in order to access water. The heterogeneity of this material can also cause highly variable well yields even across short distances (such as two neighbors having vastly different well performance).

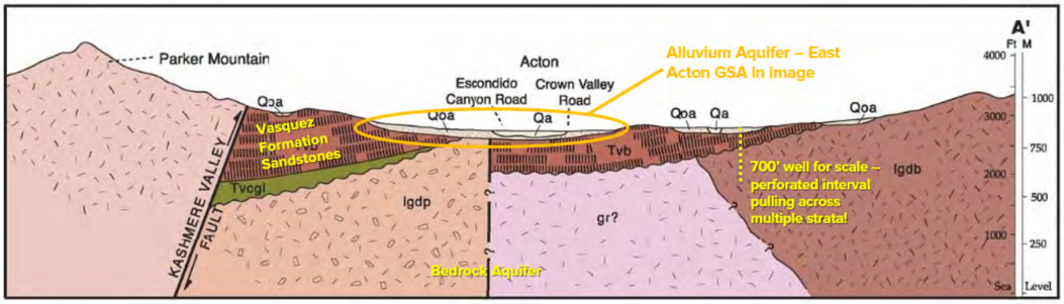


Figure 5: Geologic cross-section featuring a north-east trending transect cutting through downtown Acton, with annotations in yellow and orange (Dibble Geological Foundation, 1996)

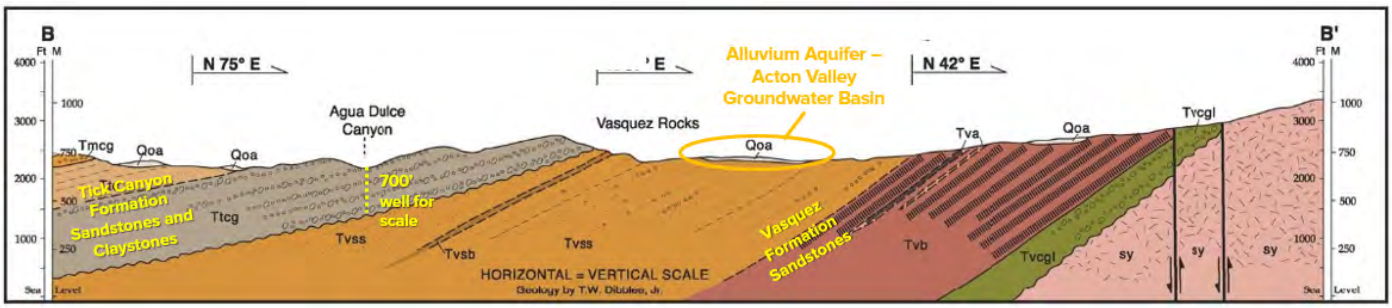


Figure 6 (bottom): Geologic cross-section featuring a north-east trending transect cutting through the Vasquez Rocks area just south of Agua Dulce population centers. The image is annotated in yellow and orange. Note that the transect does not run directly through valley floor, so the Acton Valley Groundwater Basin alluvium material is likely deeper in population centers north of the transect. (Dibble Geological Foundation, 1996)

It is important to note that the AADA is tectonically active, ranging from 8 - 20 miles from the San Andreas fault zone, and encompassing the mapped Soledad Canyon fault. Major earthquakes (such as the 1994 Northridge earthquake) can shear or bend well casings, break threaded joints or welds, and offset the screened interval. Minor earthquakes may not damage the well directly, but can alter the size and location of the cracks and fractures within a bedrock aquifer which store water, sharply changing a well's yield characteristics over a short period of time. Wells placed within unconsolidated alluvium, such as many of the municipal supply wells, are less vulnerable to tectonic activity because their yield is reliant on the fairly uniform primary porosity of the alluvium material, and not inconsistent primary porosity in the sedimentary rocks, or the secondary porosity created by cracks and fractures within the crystalline bedrock, an otherwise non-porous material.

Water purveyors such as District 37, SPV Water Company, North Trails Mutual Water Company, Lunde Water Company, and others whose business it is to supply water drill their wells in optimal unconsolidated alluvium material within the valley floors and banks of the Santa Clara River, however residents using private domestic wells are confined to whatever geology happens to be under their property, which is demonstrated to be highly heterogeneous of the AADA. This creates highly variable water supply conditions which can be even increasingly vulnerable to regional trends of decreasing groundwater supply.

2.5 Groundwater Basin Classification

A groundwater basin is defined as an alluvial aquifer or a stacked series of alluvial aquifers with reasonably well-defined boundaries in a lateral direction and a definable bottom. It is important to note that groundwater basins are not the only sources of groundwater, as described in section 2.4.

The primary groundwater basins within the AADA are the Acton Valley Groundwater Basin (under Agua Dulce), and the East Acton Groundwater Sustainability Area (under Acton), which is part of the Antelope Valley Groundwater Basin.

Though the Acton Valley Groundwater Basin has several vulnerabilities such as high rates of population growth and a relatively high withdrawal rate, it is considered Very Low Priority within the SGMA Basin Prioritization framework due to its small size. Consequently, there is no statutory requirement to prepare a Groundwater Sustainability Plan or engage in more intensive aquifer monitoring efforts.

Similarly, the Antelope Valley Groundwater Basin is also ranked as Very Low Priority despite having a number of vulnerabilities, due to its status as being managed under a court-appointed adjudication via AV Watermaster.

As a result, there is relatively little technical data available for both the Acton Valley Groundwater Basin and the East Acton GSA sub-basin of the Antelope Valley Groundwater Basin, and no plans for groundwater monitoring at the time of this report. This lack of technical and monitoring data limits the resolution of the analysis that can be performed.

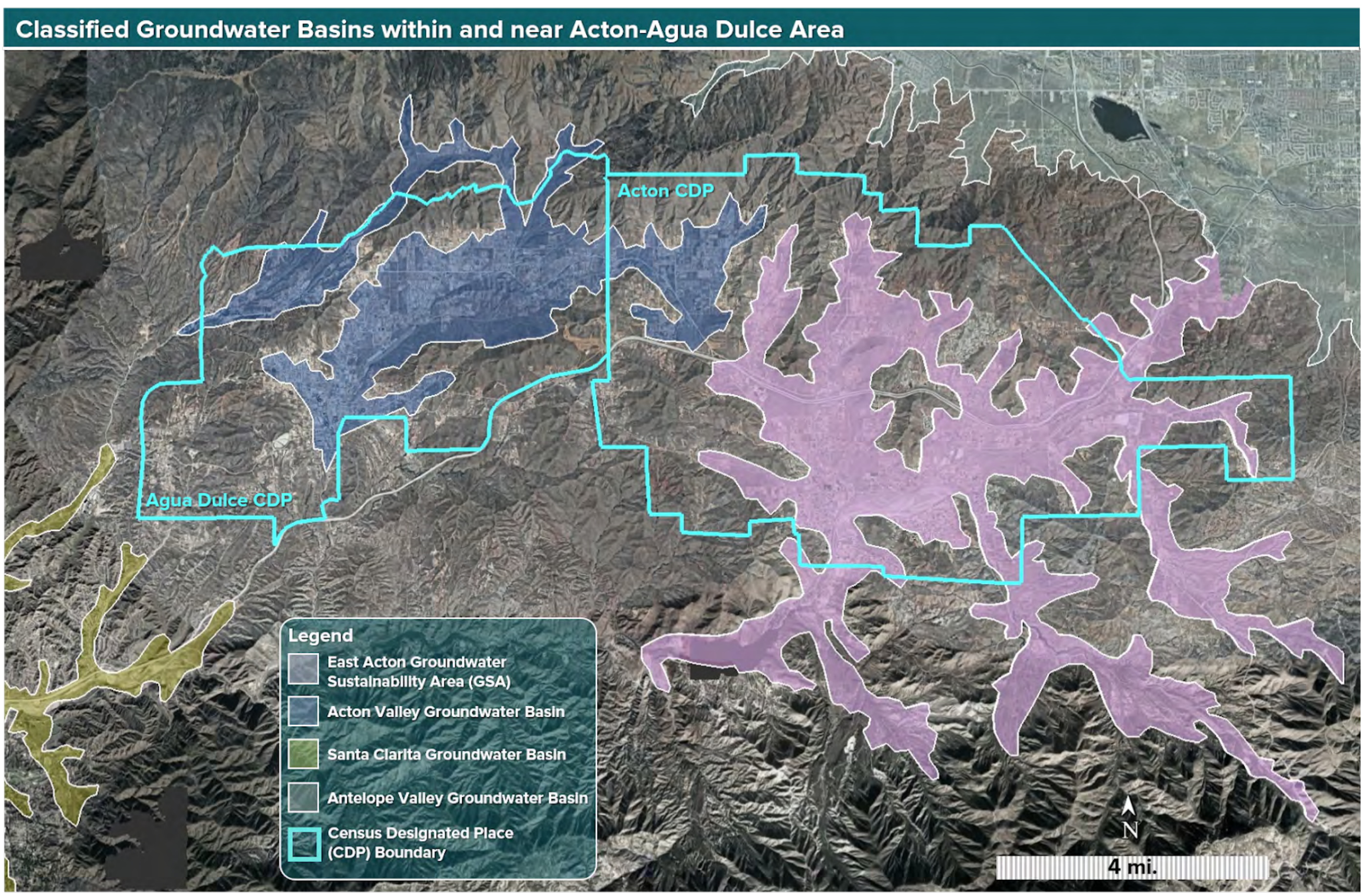


Figure 7: Locations of local groundwater basins in relation to AADA boundaries. Areas outside of these boundaries are reliant on private wells or hauled water. Certain population centers, especially in Agua Dulce CDP, fall outside of groundwater basin boundaries.

3.0 Groundwater Budgets

3.0 Groundwater Budgets

A groundwater budget is an accounting of the inflows, outflows, and changes in water storage within a specific area, crucial for managing groundwater resources effectively. Constructing groundwater budgets, a critical step in understanding regional groundwater use and opportunities for drought resilience, was challenging due to a lack of monitoring data. Within this context, we applied several strategies to better understand groundwater use trends. We use historical descriptions published by the California Department of Water Resources, SGMA GIS mapping tools, utility-provided datasets, reports describing water deliveries, and other resources.

3.1 Acton Valley Groundwater Basin

The Acton Valley Groundwater Basin has a surface area of 12.9 sq. mi. and is primarily located under Agua Dulce, with the eastern portion of the basin present under northwest Acton. Pre-1990 estimates put groundwater storage at 40,000 acre-ft (DWR 1975). Natural recharge rates range from 650 acre-ft/yr (DWR 1975) to 11,100 acre-ft/yr (Geraghty & Miller, Inc in Slade 1990), with 5,600 - 7,200 acre-ft/yr also being a commonly accepted figure (Slade 1990). Subsurface outflow ranges from 1,200 - 2,800 acre-ft/yr; higher end of the range being proportional with higher rainfall.

Several methodologies were utilized to obtain estimates of groundwater use from the Acton Valley Groundwater Basin. The groundwater use estimates are summarized in the table below:

Table 2: Estimates of annual groundwater withdrawal from the Action Valley Groundwater Basin based on source or methodology employed

Estimated Annual Withdrawal from Acton Valley Groundwater Basin (acre-ft/year)	Year of Estimate	Methodology
1,540	1989	Published in Slade 1990; *residential, commercial and agricultural*
1,812	2002-2003	1,641 gal/day/dwelling unit estimate for 986 dwelling units in 2004 Acton-Agua Dulce Conceptual Master Plan for Water Facilities; *residential, commercial and agricultural estimate**
1,360	2013	Per-capita use rate of 363 gallons/day derived from SPV Water Company reporting for 2013 across 2010 population of 3,342 in Agua Dulce; *residential estimate only**
585	2013	Per-capita use rate of 156 gallons/day derived from North Trails Mutual Water Company reporting for 2013 across 2010 population of 3,342 in Agua Dulce; *residential estimate only**
1,696	2014	Per-capita use rate of 453 gallons/day derived from District 37 Water reporting for 2014 across 2010 population of 3,342 in Agua Dulce; *residential estimate only**
544	2014	SGMA 2019 Process & Results

**: Given that industrial, commercial and agricultural usage within the District 37 boundaries of Acton is often approximately 18% of total usage, residential only estimates are likely considerably lower than combined usage estimates.*

It was surprising that the SGMA Basin Prioritization Dashboard estimated 2014 groundwater use for the Acton Valley Groundwater Basin at 544 acre-ft, which is considerably less than previous estimates. Given the further population growth of the area after 2004 and continued drilling of new wells during this time period, the methodology employed in the SGMA estimate required further investigation.

The SGMA methodology for determining groundwater use within a particular groundwater basin is detailed in Component 6: The degree to which persons overlying the basin or subbasin rely on groundwater as their primary source of water (pgs. 16-22) of the Sustainable Groundwater Management Act 2019 Basin Prioritization: Process and Results manual. The methodology consists of calculating both agricultural and urban water use, and the degree of groundwater reliance for 2014. Step 1 of Component 6 Part B involves determining the 2014 population within the boundary of the groundwater basin. Steps 3-6 involve estimating per-capita groundwater use by analyzing average per-capita use from water purveyors, and step 8b involves using water purveyor per-capita information to estimate usage rate by the self-supplied population.

This results in two possible interconnected explanations for the discrepancy between SGMA estimates and other groundwater use estimation techniques:

1. By only measuring populations directly above the groundwater basin, the SGMA methodology may underestimate the total effective population using groundwater from the basin in question via outflows to other water-bearing units.
2. By using water purveyor data as the basis for estimating per-capita use for self-supplied (private domestic well) populations, per-capita water use rates can be significantly underestimated.

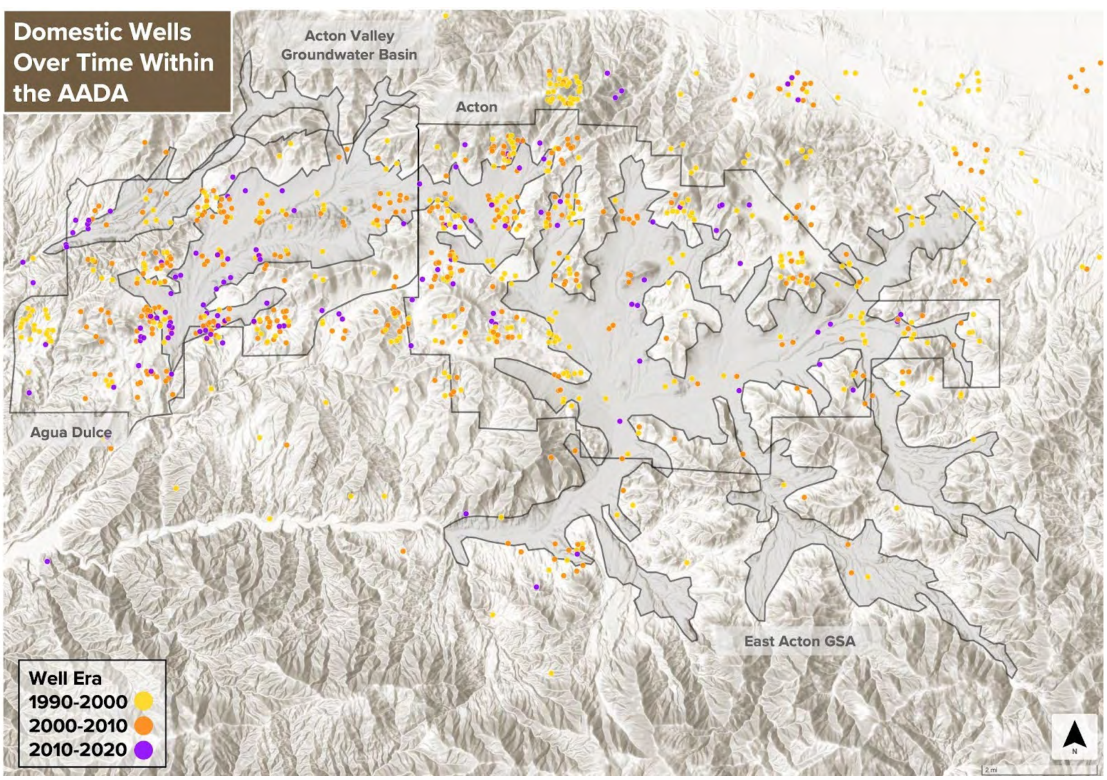


Figure 8: Well completion reports based on decade completed within the AADA (outlined in black) and surrounding areas. Points on map may not align with exact location of each well as the Well Completion Report database maps reports to 1 sq. mi. grid centroids. Stacked points within centroids were algorithmically unstacked.

3.1.1 SGMA Methodology Analysis - Acton Valley Groundwater Basin

Addressing Explanation 1:
Most (71.5%) of the Acton Valley Groundwater Basin (5,917 acres) is located inside the Agua Dulce CDP boundary, 18% (1,496 acres) is located within the Acton CDP boundary, and the remaining 10.5% (857 acres) is located in low population, mountainous areas outside of either place boundary. The total area of the Agua Dulce CDP is 14,629 acres. Agua Dulce is 98% reliant on groundwater, and is served by no other groundwater basins. 7% (1,024 acres) of the Agua Dulce area is served by District 37, however much of that overlap is a sparsely populated mountain area that contains only a handful of apparent properties based on a satellite analysis.

In short, the Acton Valley Groundwater Basin only covers 43.5% of the Agua Dulce CDP, and excludes some of its most populous sections. Several small water purveyors exist in the area. Excluding schools and parks which do not serve residents full-time, water purveyors supply 444 residents out of a total population of 3,451 (2020), or only 12.9%. The residents in Agua Dulce who are not living within the boundary of the Acton Valley Groundwater Basin, and not receiving water from purveyors (exclusively having wells within the Acton Valley Groundwater Basin), are relying on private domestic wells that are drilled either into non-carbonate sedimentary rocks such as conglomerates, sandstones or claystones or bedrock aquifers with highly-variable hydraulic properties, uncharacterized as groundwater basins within the SGMA Basin Prioritization Dashboard.

Indeed, the 2010 population indicated within the SGMA Basin Prioritization Dashboard residing above the Acton Valley Groundwater Basin is 2,280, which is 31.8% less than the census-derived 2010 population of Agua Dulce (3,342) despite the Acton Valley Groundwater Basin extending into a populated section at the northwest of Acton, accounting for some of the discrepancy.

The Acton Valley Groundwater Basin is described in Slade 1990 as a combination of Holocene age alluvium consisting of unconsolidated, poorly bedded, poorly sorted to sorted sand, gravel, silt, and clay with some cobbles and boulders, and Pleistocene age terrace deposits consisting of crudely stratified, poorly consolidated, only locally cemented, angular to subangular detritus of local origin with a maximum thickness of 225 ft. near Acton for the alluvium and 210 ft. north of Acton for the terrace deposits. Wells within the Agua Dulce area are considerably deeper than the maximum depths described in the Acton Valley Groundwater Basin, with some as deep as 700 ft., indicating that they are withdrawing groundwater from hydrologic units other than the Acton Valley Groundwater Basin.

Geologic descriptions of the Acton Valley Groundwater Basin (Slade 1990) mention that there are no confining units separating this basin from the underlying and surrounding rock, estimating subsurface outflow rates are between 1,200 - 2,800 acre-ft/year into surrounding rock units and channels of the Santa Clara river. This outflow rate would be an order of magnitude higher than the estimated 2014 withdrawal rate of 544 acre-ft. There is not sufficient monitoring in this area to determine outflow characteristics in more detail.

> **The Agua Dulce CDP is almost entirely reliant on local groundwater yet the Acton Valley Groundwater Basin covers less than half of it, meaning that the remaining residents must be extracting groundwater from unclassified hydrologic units that interact with the Acton Valley Groundwater Basin. With existing estimates for basin outflow rates being considerably higher than modeled withdrawal, it is highly likely that the SGMA is underestimating basin withdrawal by utilizing a population that is smaller than Agua Dulce, and not considering groundwater use via outflow.**

Addressing Concerns with Explanation 2:
Local water purveyor data can be highly variable, with residential per-capita estimates ranging from 156 gallons/day from North Trails Mutual Water Company in 2010, to 453 gallons/day from Waterworks District No. 37. These estimates can also be quite variable year-over-year, with SPV Water Company's 2016 water deliveries being nearly 40% lower than their 2013 deliveries. In absolute terms, this difference is only 11 million gallons, or about what it would take to irrigate an 18-hole golf course for 2 weeks in Southern California. Small water purveyors are sensitive to individual customer demands (especially larger commercial or industrial customers), drought years, and other factors that can greatly skew their annual output. It also seems implausible that District 37 customers are using water at nearly 3 times the rate of North Trails Mutual Water Company customers, given similarities in property sizes, land uses, and other area demographics.

> **In this particular case, it is unlikely that the average per-capita water delivery by water purveyors is representative of the overall AADA, given their high degree of inter-purveyor variability, high degree of year-over-year variability, small size, and low coverage relative to the overall population.**

3.2 East Acton Groundwater Sustainability Area

The East Acton Groundwater Sustainability Area (East Acton GSA) is a 28 sq. mi., hydrologically distinct portion of the 1,578 sq. mi. Antelope Valley Groundwater Basin. The community of Acton principally sits on top of the East Acton GSA.

Though the sub-basin underlying Acton was designated as a Groundwater Sustainability Area in 2017 following the passage of the 2014 Sustainable Groundwater Management Act (SGMA), this action can be performed for precautionary or administrative purposes. Due to the basin's Very Low Priority classification within the basin prioritization framework, there is no statutory requirement to prepare a Groundwater Sustainability Plan or develop and track groundwater budgets at the sub-basin or GSA level. As a result, the East Acton GSA has not developed independent technical analyses, monitoring programs, or groundwater budgets separate from the Antelope Valley Groundwater Basin information and there are currently no plans to do so. In the absence of groundwater tracking, we will attempt to reconstruct elements of a groundwater budget based on usage data.

The water distribution system for the East Acton GSA is considerably more centralized, with most of Acton (and a small portion of Agua Dulce) being within the Waterworks District No. 37 service area. Waterworks District No. 37 operates three municipal supply wells near the confluence of the Santa Clara River, capable of withdrawing approximately 3,551 acre-ft per year for residential and commercial use, at a maximum rate of 3.17 million gallons/day. As of 2023, District 37 had 4,805 customers across 1,446 service connections.

A 2004 feasibility report modeling a potential expansion of District 37 boundaries indicated that water was supplied to 1,225 dwelling units, with an estimated 2,252 acre-ft annual demand (modeled as 1,641 gallons/day/dwelling unit for the purposes of the report, which likely includes commercial and industrial connections factored into the average). The same report anticipated a maximum possible build out of 2,411 dwelling units within District 37 boundaries if all unimproved lots were improved and settled. 2020 census data indicates that there are 2,816 dwelling units in Acton overall (including District 37 boundaries), which is below the maximum possible number of units 4,329 under modeled in the report.

District 37 also imports supplemental water from the Antelope Valley - East Kern Water Agency (AVEK), originating from Sacramento River/San Joaquin delta, conveyed via the State Water Project and is treated at the Acton Water Treatment Plant starting from 1989. The maximum capacity of this plant is 4 million gallons/day. This excess capacity is mainly used as a backstop to fill gaps in peak water demand, which is typically calculated as double average daily demand (if daily demand is 2.37 million gallons and groundwater wells can supply 3.17 million gallons, you need an additional 1.57 mgd capacity from elsewhere to meet peak summer demand). The plant's overall capacity is sufficient to supply the needs of 17,000 consumers, according to the 2019 Antelope Valley Integrated Regional Water Management Plan.

In volumetric terms, maximum supply capacity could be estimated at 8,032 acre-ft/year (combining maximum output from wells and AVEK). Using 2020 residential per-capita use of 391 gallons/day and a 2020 population of 7,431, this equates to an annual domestic use of 3,252 acre-ft, or 3,415 acre-ft if commercial and industrial uses are also factored in. In either case, this would be less than half of the system's capacity, which makes expanding monitoring efforts into the East Acton GSA a challenging prospect.

The vast majority of the populated areas of the East Acton GSA overlap with Waterworks District No. 37 boundaries with access to metered connections. Population centers outside of the District 37 service area include valleys in the far northern and far eastern portions of the East Acton GSA.

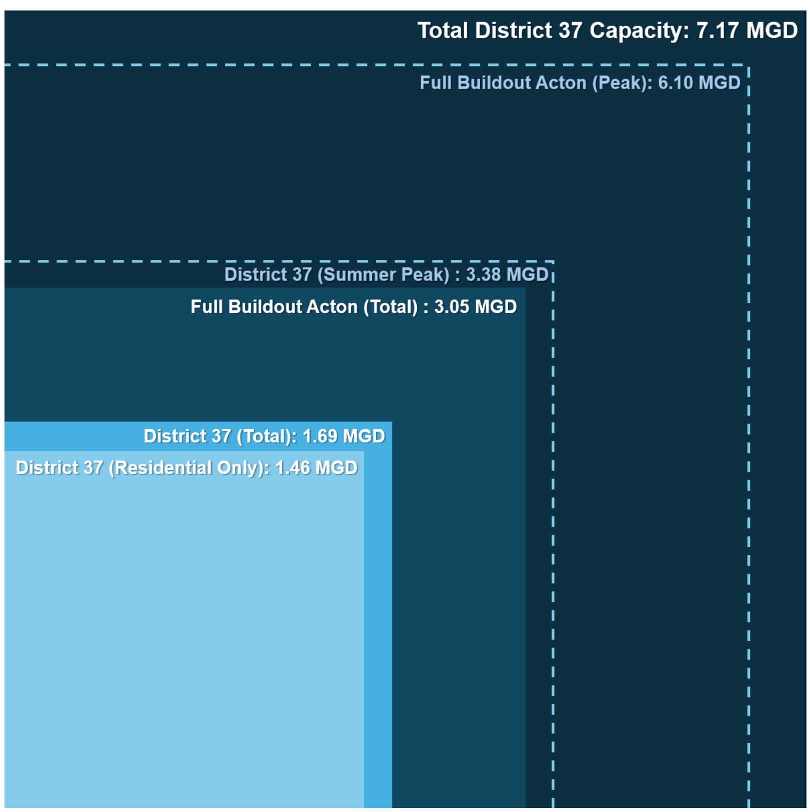


Figure 9: Volumetric representation of water demand by existing District 37 customers and Acton's entire population using 2020 residential and total demand rates compared to District 37's delivery capacity

3.3 Basin Prioritization Considerations

Both the Acton Valley Groundwater Basin and Antelope Valley Groundwater Basin are considered Very Low Priority within the SGMA Basin Prioritization framework for separate reasons. For a groundwater basin to qualify for additional monitoring action under SGMA, the basin at the minimum must not meet any of the following disqualifying conditions:

1. Less than or equal to 2,000 acre-ft. of groundwater use for water year 2014
2. Greater than 2,000 and less than or equal to 9,500 acre-ft. of groundwater use for water year 2014 with no documented impacts
3. For basins with adjudications, basin's non-adjudicated portion extracts less than or equal to 9,500 acre-ft. of groundwater for water year 2014

3.3.1 Acton Valley Groundwater Basin SGMA Classification

The Acton Valley Groundwater Basin is described as having less than 2,000 acre-ft. of groundwater withdrawal for water year 2014 and has No Documented Impacts.

It is not outside the realm of possibility for communities relying on the Acton Valley Groundwater Basin to indeed be withdrawing more than 2,000 acre-ft of groundwater per year under a methodology that takes into consideration both direct basin withdrawals and unclassified hydrologic unit withdrawals fed indirectly by Acton Valley Groundwater Basin outflow, as well as a more rigorous measurement of per-capita usage. This methodology would be most applicable to relatively low population areas with small groundwater basins and mostly self-supplying populations, such as Agua Dulce. The actual point total within the SGMA framework across all components is 17 points, which merits a Medium designation providing that documented impacts are also found. If a Medium Priority designation were adopted, it would likely result in the creation of a Groundwater Sustainability Area (GSA), the preparation of a Groundwater Sustainability Plan, and additional monitoring.

Documented impacts can comprise the following categories: overdraft/groundwater decline, subsidence (permanent sinking of the land due to groundwater extraction), saline intrusion (oceanic salt water entering and occupying the groundwater basin as a result of reduced hydrostatic pressure from groundwater extraction), and documented water quality degradation.

The SGMA Basin Prioritization Dashboard currently assigns 1 point for water quality degradation, and zero points for the three other categories, indicating their absence. Due to geographical and geological considerations, it is unlikely that the AADA will undergo significant subsidence or saline intrusion. Due to the relatively rural and non-industrial character of the AADA, there are few anthropogenic sources that may have the potential to degrade water quality.

Overdraft/groundwater decline is likely the only documented impact category that the Acton Valley Groundwater Basin may qualify for. While the SGMA Basin Prioritization Dashboard does not currently indicate evidence of groundwater levels declining or the aquifer being in significant overdraft, there are currently **zero** monitoring wells operated by either the California Department of Water Resources (DWR) or the U.S. Geological Survey (USGS) for the Acton Valley Groundwater Basin. The closest monitoring well is located at 34.47584, -118.39117 along the Sierra Hwy, and indicates a ~30 ft. drop since 2017.

> **The lack of monitoring wells in the area (at least those publicly accessible) makes it difficult to determine if overdraft is occurring. If a documented impact related to overdraft can be identified, coupled with a methodology adjustment that shows withdrawals exceeding 2,000 acre-ft/year, a basin reclassification from Very Low to Medium is possible.**

3.3.2 East Acton Groundwater Sustainability Area SGMA Classification

The Antelope Valley Groundwater Basin is an adjudicated basin already managed through AV Watermaster with non-adjudicated withdrawals comprising less than 9,500 acre-ft. Only the East Acton GSA portion of the much larger Antelope Valley Groundwater Basin is within the AADA, though the East Acton GSA appears to be hydrologically distinct due to its separation from the Antelope Valley Groundwater Basin by the San Andreas fault complex. The East Acton GSA is also relatively small, only representing 1.7% of the Antelope Valley Groundwater Basin's surface area.

While the SGMA point total of the Antelope Valley Groundwater Basin is 19, which would also merit a medium classification, it is not known whether the East Acton GSA is representative of the rest of the Antelope Valley Groundwater Basin.

For the purposes of water supply to private well owners, given that the areas of the East Acton GSA outside of District 37 boundaries are around the northern and eastern periphery which exhibits strong topographic relief - often over 600 ft higher in elevation than the location of District 37's productive public supply wells - it would probably be more feasible to simply connect remaining private well owners to District 37 plumbing rather than attempting to resolve systemic issues within the groundwater basin which would require significant geologic and hydrologic studies to better understand.

4.0 Drought Resilience Solutions

4.0 Drought Resilience Solutions

4.1 Scope and Purpose

A report published by Stantec titled Acton Flooding Multi-Benefit Solution: Report on Preliminary Approaches in 2024 (hereinafter referred to as 'Stantec 2024') examined the feasibility and efficacy of several modeled stormwater detention basins, as well as a stream diversion channel to control flooding in downtown Acton, concluding that these features would not be effective due to the large scale of flooding that would occur during a 50-year, 24-hour storm at the confluence of several streams where downtown Acton is located, and would be costly and difficult to maintain due to the high quantity of sediment transport present in the area. The report *"recommends the development of an Acton Integrated Watershed Management Plan to select specific and interdependent projects and programs that can be implemented over time to achieve community priorities", defined as "an integrated approach that includes private land management practices, improvements to drainage infrastructure, and the use of nature-based solutions for mitigating small storm events is likely an effective strategy that can align with the three community priorities."*

Similarly, previous reports such as the 2007 Acton Feasibility Report, and 1995 Acton Master Drainage Plan, explored solutions to flooding such as detention basins, debris basins, channel systems and underground storm drains, concluding that many of these solutions were unfeasible due to one or more of the following: permitting challenges, necessary land acquisitions, high costs, incompatibility with community preferences, as well as technical and maintenance limitations with regard to handling large volumes of water and sediment.

One of the goals of this report is to develop a set of solutions that would assist in replenishing groundwater levels within the AADA. While the AADA concerns a larger, 62.2 sq. mi. section that also includes the 20.4 sq. mi. area (composing the Acton Town Boundary) studied in Stantec 2024, due to geographic and demographic similarities, many of the technical and community needs considerations referenced in this and previous reports are also applicable in defining this solution. We are in general agreement with Stantec 2024's findings, paraphrased as: 1) flooding solutions that were modeled may not be feasible or effective for significantly reducing flooding in vulnerable areas such as downtown Acton due to factors mentioned in the previous paragraph, and 2) an integrated approach involving private land management changes and nature-based solutions is needed. The approach in this report will focus on groundwater replenishment as the primary objective, with flooding reduction being recognized as a co-benefit of the proposed solutions.

A potential framework for drought resiliency is here defined as solutions that increase the supply of available groundwater such that this water may be used for potable and irrigation purposes. Higher preference was given to solutions that also carry considerable co-benefits, such as: restoring native plants and improving biodiversity, providing passive irrigation to soil for wildfire risk reduction, reducing flooding by capturing and retaining stormwater, improving soil health through higher and more regular water input, and decreasing sedimentation load by stabilizing soil via vegetation.

Two potential drought resiliency solutions were advanced and evaluated for feasibility.

1. **Household water use reduction**
2. **Installation and scaling of Native Dryland Bioswales across the AADA**

The methodologies employed in assessing these drought resiliency solutions include feasibility assessments based on best available data, engineering and hydrological calculations, the utilization of previously conducted hydraulic modeling data from reports such as Stantec 2024 where applicable, and a review of relevant case studies where similar approaches were successfully implemented.

4.2 Household Water Use Reduction

When there are reports of underperforming wells and other potential indications of decreasing groundwater levels, one of the first steps is to examine population and water usage rates, which was done earlier in this report. Though slightly over half of the AADA population relies on a private domestic well, the remainder that purchases water from a public utility still relies largely on pumped and treated local groundwater from municipal wells operated by water purveyors.

Due to numerous water conservation policies at the state and municipal levels, as well as water-efficient fixtures and technologies, urban per capita water use for California has decreased from 186 gallons/day in 2004 to 128 gallons/day in 2020 - a 31.2% decrease. Reporting data from Waterworks District No. 37 to the California Department of Water Resources (DWR) in 2004 indicates 1,789 acre-ft delivered to 1,249 residential connections (single-family and multi-family), for a per-capita water use of 462 gallons/day. The per-capita water usage for District 37 residential customers from 2022-2024 ranges from 321 - 361 gallons/day, or 22-31% lower than the 2004 estimate, proportionally consistent with water use reduction elsewhere in California, though still nearly triple the urban resident rate in absolute terms. Similar water usage data over time is not available from other water purveyors in the AADA.

Higher usage rates in Acton-Agua Dulce are attributed to the high prevalence of water intensive practices such as maintaining livestock and agriculture, as well as considerably larger property sizes and proportionally greater irrigation needs.

Table 3: Water use over time comparing District 37 residents with average California urban residents, demonstrating proportional water usage declines despite different overall rates

Year	Waterworks District No. 37 Per Capita Daily Water Usage (gallons; residential only)	California Per-Capita Daily Urban Water Usage (gallons)
2004	462	186
2005	426	184
2022	342	130
2023	320	128
Change from 2004-2023	**-30.7%**	**-31.2%**

Important note: The 2004 Acton-Agua Dulce Conceptual Master Plan for Water Facilities published by Waterworks District No. 37 models the average consumer water use at 1,641 gallons/day/dwelling unit for the AADA, or a per capita usage of 592 gallons/day, though this is an average of all accounts, which includes higher-draw commercial and industrial accounts. Residential-only water usage in 2004 was 462 gallons/day.

While we believe that broadly speaking, water conservation could help restore groundwater levels, there is insufficient high-resolution monitoring of groundwater levels within the AADA to determine if a signal for decreased per-capita water use over the last two decades can be observed (potentially rendered as rising or unchanging groundwater levels despite population growth, or groundwater levels decreasing slower than expected given the population growth).

As a result, it is extremely difficult to estimate to which degree water usage would need to be decreased in order to equal groundwater replenishment levels. It is also unlikely that water usage rates would decrease past a certain point as the ability to maintain livestock, agriculture and irrigation on large properties is a significant lifestyle incentive for residents within the AADA.

> **Water conservation efforts are already a significant focus of multiple government agencies at the state and municipal levels, therefore the focus on drought resiliency solutions for the purposes of this report will be placed on improving stormwater capture rather than conservation efforts via decreasing withdrawal rates.**

4.3 Native Dryland Bioswales

In the present condition within the AADA where groundwater reserves are almost entirely reliant on precipitation, and where the combination of topography and rainfall patterns can result in intense, flashy, rapidly moving stormwater that does not have a chance to percolate into the groundwater basins, the primary objective is to construct structures that can each intercept and detain a small portion of the stormwater input in a widely distributed manner across the watershed. Given that stormwater will quickly overwhelm infrastructure at confluences, potential solutions will be modeled as easily scalable, replicable, and individually inexpensive, containing design features that can be rapidly adapted at the point of construction to accommodate a diverse set of land parcels without individually requiring custom design review.

One of the drought resiliency concepts advanced in this report is the use of Native Dryland Bioswales (NDB), here defined as trench-like excavated structures constructed near frequently flooding areas that are filled with engineered soil possessing a high hydraulic conductivity, considerable resistance to compaction, low organic content, and is vegetated with native plants.

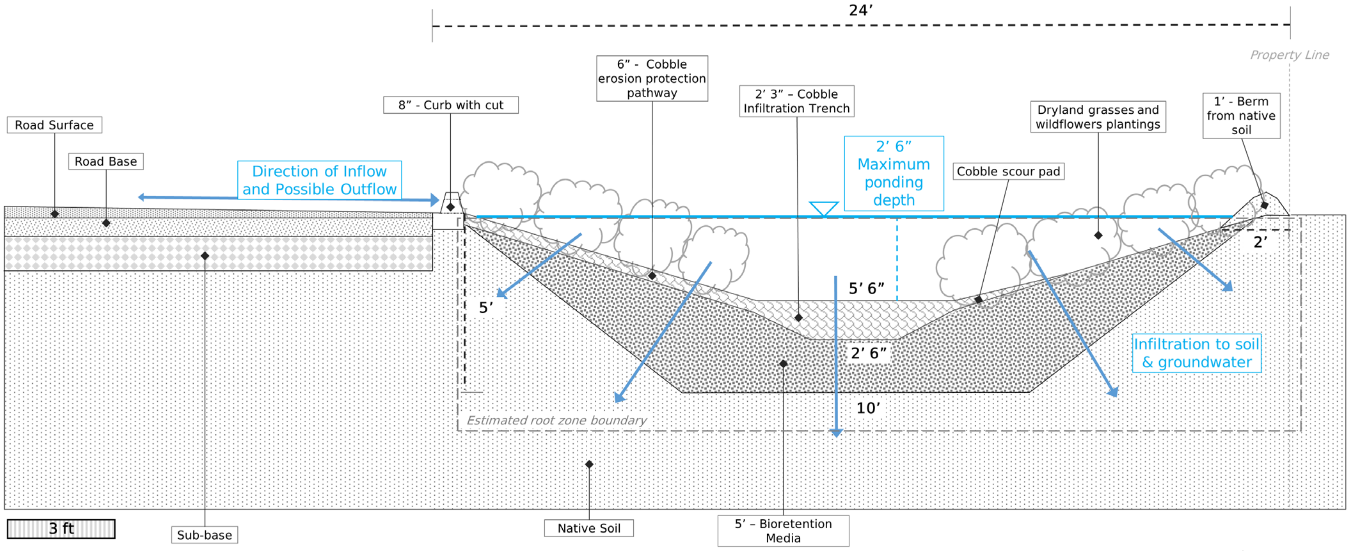
To protect from erosionary forces, the inlets are lined with cobbles across most configurations. The bottom of the trench includes a cobble dry creek bed that would additionally assist in infiltration. A newly constructed system will feature biodegradable fabric coverings to protect from erosion while native plants establish themselves. Unlike most bioretention systems, this system does not include an underdrain or overflow structure. The AADA does not have an underground sewage system that would connect to an overflow structure, and plumbing would significantly add to the cost and complexity of these systems. Instead, the system is designed to simply overflow from the inlets, permitting through-flow back into the surrounding landscape when at capacity or during flash floods.

NDBs are designed to be simple and therefore inexpensive to construct, maintain and adapt to a multitude of site geometries. It was demonstrated in Stantec 2024 that especially powerful storm events will quickly overwhelm highly-engineered basins and conveyance structures with huge volumes of stormwater and sediment. The design approach described here is intended to make NDBs replicable and scalable across the AADA, so that they can be rapidly constructed in areas of low or intermediate flooding in order to intercept and infiltrate stormwater before it reaches a point of confluence.

Native Dryland Bioswale
Arterial Configuration
Detail Profile View

Arterial swales are 20-30' wide and of undefined length, placed along major arterial roads such as Escondido Canyon Rd. These systems are designed for through-flow with wide gravel trench channels as they will be subjected to the highest flow rates during flooding events. Much of the storage capacity of Native Dryland Bioswales is conferred by the ability to capture and pond water. Cobble provides armoring at inlets and within the center of the channel where flow rates, and by extension, erosion are highest.

Drawing is intended to show relative scales, proportions and functions of various components. General measurements are provided where appropriate. Actual measurements vary by site. This is designed as a living system that evolves and improves over time.



Design by Igor Bronz

Figure 10: Native Dryland Bioswale Arterial Configuration Detail Profile View

Native Dryland Bioswale
Arterial Configuration
Artistic Profile View

California native grasses, shrubs and wildflowers are essential to the function of a Native Dryland Bioswale. Their deep roots stabilize soil, greatly reducing erosion from fast-flowing water, and reducing the overall sediment transport rate of the watershed when restored at scale. At the system scale, this dense root architecture sculpts the soil, ensuring high infiltration rates and resistance to clogging despite high sediment inputs traveling with the stormwater. Bioretention media provides the ideal substrate, while cobble armoring and erosion control fabric protect the plants during the crucial establishment period.

Rendering by Lorna Xu

Figure 11: Native Dryland Bioswale Arterial Configuration Artistic Profile View

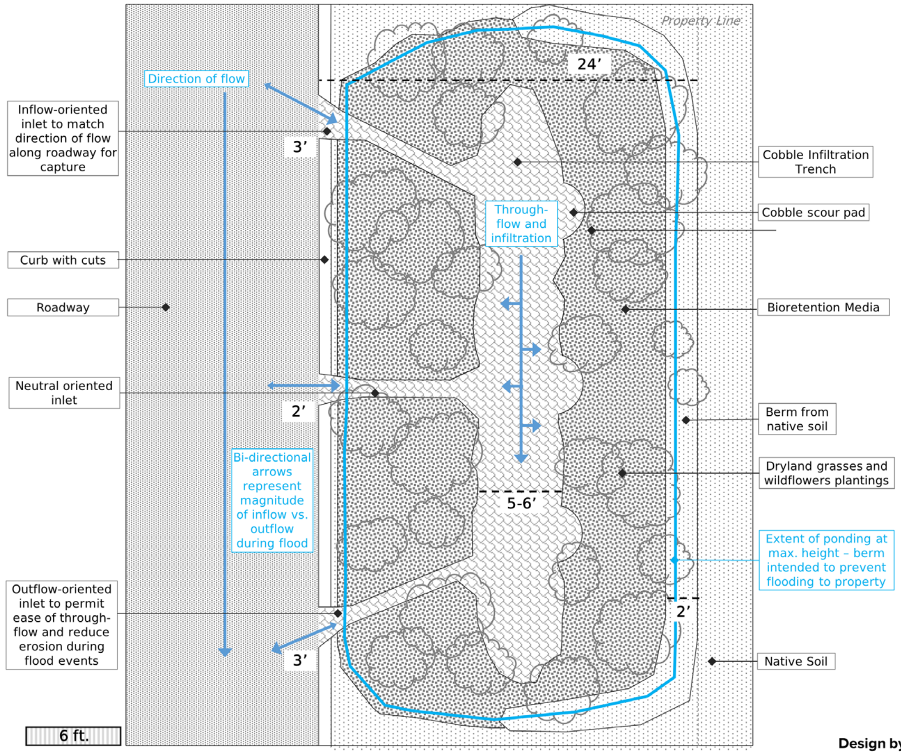
Native Dryland Bioswale

Arterial Configuration
Detail Aerial View

Arterial swales are 20-30’ wide and of undefined length placed along major arterial roads such as Escondido Canyon Rd. These systems are designed for through-flow with wide gravel trench channels as they will be subjected to the highest flow rates during storm events.

Upslope inlets along flow path are tilted to accept stormwater more easily, while downslope inlets are tilted to reduce inflow pressure and promote through-flow once system is at capacity. Neutral inlets are placed along length. The rationale behind this design is to allow the system to flush fine sediment out more easily by decreasing turbulent eddies that may reduce flowrates near inlets.

Drawing is intended to show relative scales, proportions and functions of various components. General measurements are provided where appropriate. Actual measurements vary by site. This is designed as a living system that evolves and improves over time.



Design by Igor Bronz

Figure 12: Native Dryland Bioswale Arterial Configuration Detail Aerial View

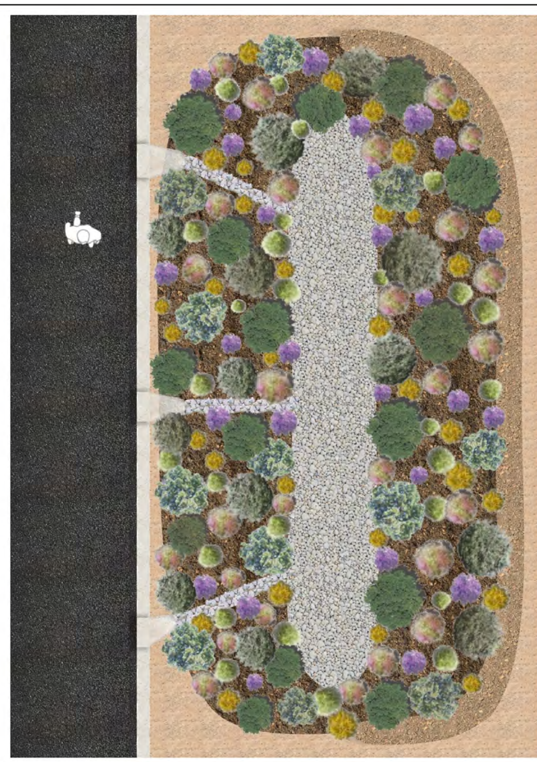
Native Dryland Bioswale

Arterial Configuration
Artistic Aerial View

The graphic represents a fairly short system for the purposes of detailed display, however arterial-configuration Native Dryland Bioswales can be built to virtually any length provided that the grade of the adjacent road is not overly steep (max. ponding depth would prevent more than 2’ of elevation change between start and end of system unless internal check dams are utilized; not pictured here).

More than 60% of the footprint of an arterial-configuration Native Dryland Bioswale is covered by dense, California native grasses, shrubs and wildflowers. These systems add a considerable amount of biodiversity to the landscape, providing a refuge for pollinators, and help entrain air particulates emitted by vehicle exhaust due to their proximity to the road.

Native Dryland Bioswales are designed to be low-maintenance, mainly requiring periodic weeding during the establishment period.



Rendering by Lorna Xu

Figure 13: Native Dryland Bioswale Arterial Configuration Artistic Aerial View

4.3.1 Co-benefits - Native Dryland Bioswales

The primary function of Native Dryland Bioswales (NDBs) is promoting groundwater recharge during storm events. However, like most nature-based solutions, NDBs provide a host of other co-benefits that make them particularly appealing as a drought-resiliency option for the AADA.

Flooding Reduction

The static waterholding capacity of an NDB system is calculated by examining a rectangular cross section of the structure and considering the void spaces of the four primary waterholding components: bioretention media, cobbles, compacted native soil, and topographical relief offered by the ponding depth. A 5' deep, 24' wide and 1' long unit section of an arterial configuration NDB (120 cu. ft.; necessary to measure average capacity per sq. ft. of footprint) contains approximately 36 cu. ft. of bioretention media with a .40 void ratio by volume, 10 cu. ft. of cobbles with a .45 void ratio by volume, 35 cu. ft. of compacted native soil with a .25 void ratio by volume, and 39 cu. ft. of ponding volume. A 120 cu. ft. NDB system section contains 67 cu. ft. of water storage between void space and ponding depth. In this case, crediting the stormwater capture capacity differential of native soils in areas prior to the construction of an NDB is unnecessary due to a lack of ponding mechanism, since the transient infiltration rate of the sandy loam soil common to the AADA during a flood would not capture a significant volume across the duration of a flash flood.

In other words, the average static capacity of a NDB system is 2.8 cu. ft. of stormwater for every sq. ft. of NDB footprint. This can be thought of as approximately 2.8 acre-ft of stormwater detainment for every 1 acre of NDB constructed.

NDB systems empty themselves in three ways: deep percolation into the groundwater, evapotranspiration through plants, and direct evaporation of ponding water. In order to calculate how quickly the system will empty itself and be ready to capture another flood, we use the following design parameters: 9.6 in./day infiltration rate for sandy loam soil below the bioretention media (NRCS Web Soil Survey), 0.07 in./day of evaporation from Nov-March in Reference Evaporation Zone 14 (CIMIS), and 0.04 in./day of evapotranspiration for native shrubs and grasses for this same time interval. A 2.8 ft. (33.6") water depth would take approximately 83 hours to fully exit the system, with almost all of the water going towards groundwater recharge (combined plant usage and atmospheric evaporation only reduce this time by 1 hour).

Native Biodiversity

Native Dryland Bioswales (NDBs) contribute to biodiversity by utilizing California native plants. The mixture of deep-rooting shrubs and grasses planted inside each NDB system will have a two very important practical functions for the performance of the system itself: 1) The rooting architecture of the plants will help facilitate both rapid, shallow infiltration and deep, long-term infiltration into the system, and 2) the roots stabilize soil and protect the NDB from erosion. These two factors both protect individual systems, and at scale, reduce sedimentation across the AADA, which was identified as a major issue within Stantec 2024.

One of the key priorities identified by the communities within the AADA is preserving the rural character of the area. California native plants bridge the gap between aesthetics and function by improving soil characteristics, promoting pollinators, and making the landscape more resilient through faster recovery from flooding, fire and drought.

Figure 14: Swale with similar visual appearance to a Native Dryland Bioswale demonstrating use of California Native Plants (Credit: Madrone Landscapes)

Fire Resilience

The Acton-Agua Dulce Area (AADA) is designated as a Severe High Fire Risk zone by LA County, and Very High under CAL FIRE's Fire Hazard Severity Zones map due to a combination of climate, topography and vegetation.

Native Dryland Bioswales (NDBs) can confer fire protection to properties by helping the landscape retain more water after storm events (decreasing the prevalence of dry, combustible fuel). The gravel trench at the center of these systems can also function as a passive barrier for fire spread. In active fire management scenarios, NDBs can serve as a "moat" during a wildfire, where the system can be filled with water from the nearest property to quickly hydrate soil and reduce the ability of the wildfire to spread to the nearby property.

While NDBs themselves contain dense vegetation, the large property sizes within Acton mean that NDBs can be placed within Zone 3 (more than 60 ft. from the property), which is the lowest risk category of the US Forest Service's Wildfire Defensible Buffer Zones categorization.

Further pilot testing is needed to determine the degree to which NDBs can reduce fire risk, but fire insurance rebates are being considered as a potential mechanism for funding the construction of NDBs.

Sedimentation Reduction

Stantec 2024 notes that the Acton watershed alone produces approximately 56,500 cu. yds. of sediment per year - one of the highest sediment loads of any environment. This places significant challenges on any type of stormwater infrastructure, with stormwater capture and conveyance systems at the location of confluences requiring frequent excavation as part of their regular maintenance.

Fast-flowing stormwater down hillsides has considerable erosive capacity, carrying large quantities of sand, silt and clay, and when this material is captured within a system, the reduced rate of flow causes this sediment to settle into the system. Though NDBs are not envisioned as being immune to sedimentation, there are a number of ways that the sediment issue would be managed.

1. The target location for initial NDB buildouts would be higher in the watershed, not at points of confluence. Confluences, such as in downtown Acton as an example, are places where sediment loads would be highest. Their location and smaller size would reduce sediment loads in both absolute and proportionate terms. Contour swale NDB configurations would be placed directly on stable hillsides to slow water and reduce sediment transport to areas lower in the watershed.
2. NDBs are designed to reduce erosion across the watershed through the use of native plants. Native plants stabilize soil through their deep and extensive roots, and the increased organic matter of the soil within NDBs reduces the soil erodibility factor (K) (susceptibility of soil to erosion) by producing compounds that bind soil particles together - particularly important for the principally sandy loam soils found within the AADA.
3. Arterial NDB configurations are designed to be 'self-flushing'. In the initial stages of a flash flood when rate of flow is fastest and sediment loads are highest, NDBs are designed to tolerate a significant degree of through-flow due to the large gravel trench channel, reducing the amount of sediment settling out of the floodwater. Pilot testing is needed to determine the optimal system specifications for maximizing stormwater capture and minimizing sedimentation across a wide variety of flooding characteristics.

The NDB concept is centered around scale - hundreds or thousands of NDBs of various sizes and configurations are required to increase groundwater replenishment rates across the AADA. Maintenance considerations, especially around sedimentation, were at the forefront of the design process. NDBs are designed to require as little maintenance as possible, but pending pilot testing, it is not yet known what sort of maintenance protocol would be required for this unique landscape.

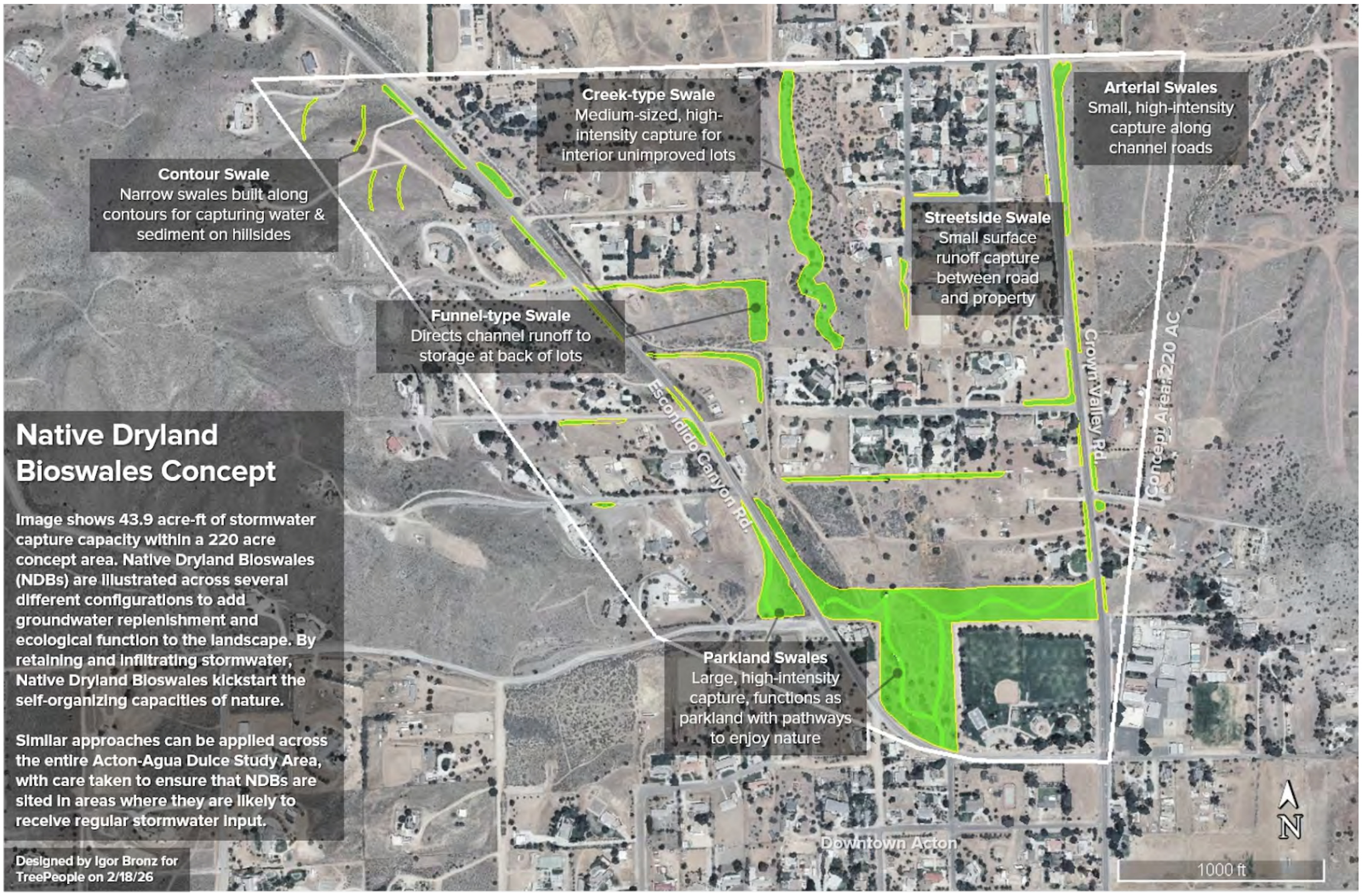


Figure 15: A conceptual drawing of potential locations for various configurations of Native Dryland Bioswales within a 220-acre concept area just north of downtown Acton

4.3.2 Concept Scale and Configurations

Due to their operational simplicity, Native Dryland Bioswales (NDBs) can be adapted to a wide variety of property types, which is also necessary to sufficiently scale this concept across the AADA. For the concept above, the area north of downtown Acton was selected as the study area due to hydrologic modeling already existing from Stantec 2004. During a 50-year, 24-hour storm, maximum water depths in this area are approximately 12 - 18 inches. The NDB configurations described in the concept drawing above are:

Arterial Swales
20-30’ wide swales of undefined length placed along major arterial roads such as Crown Valley Rd. and Escondido Canyon Rd. These systems are designed for through-flow with wide gravel trench channels as they will be subjected to the highest flow rates during flooding events.

Contour Swales
Narrow, shallow swales placed exactly along contour lines on stable hillsides below <15% slope and paired with downslope berms to capture overland flow and sediment in areas with high topographic relief. The primary function of these swales is to stabilize soil and reduce erosion on steep slopes where erosion forces are greatest, as well as hydrate soil to reduce fire risk. Contour swale horizontal spacing would vary based on slope of hillside and proximity to properties.

Creek-type Swales
Large, sprawling, strategically-placed swales within interior, undeveloped lots along topographic depressions. These swales are designed to capture slow moving, shallower overland flow, providing both significant groundwater replenishment capacity, and dense natural space undisturbed by proximity to roadways. Compared to arterial swales, they are less aggressively modified, with excavation occurring mainly to sculpt the natural topography for optimal water holding capacity. They feature thinner bioretention layers and less use of cobble trenches due to slower, less erosive flow regimes. A critical feature of creek-type swales is the use of check dams to retain water inside topographic depressions.

Funnel-type Swales
For residents on down-sloping properties, funnel-type swales can siphon large volumes of stormwater from arterial roads in addition to collecting overland flow. These systems help spread stormwater evenly throughout the landscape and increase capture capacity. Funding structures to incentivize NDBs on private property can be feasible in the form of tax abatements or fire insurance cost reductions.

Streetside Swale
Narrow (4-10') swale systems designed to be placed in denser subdivisions between the street and property line to capture runoff from paved surfaces. These systems are intended for intermediate flow rates and can have narrower gravel channels compared to arterial swales.

Parkland Swales
Very large, complex, park-like NDBs sprawling across multiple acres which provide considerable ecological value along with recreational space for residents and tourists alike. These are envisioned as engineered systems with inlets designed for handling large flow rates and separating sediment, with trails and curated plantings representing the native ecology and history of the area. Due to maintenance requirements, the parkland swales in the concept drawing are envisioned as an extension of Acton Park.

The 220-acre concept area features 679,847 sq. ft. (15.6 acres) of added NDBs, which at an average capture capacity of 2.8 cu. Ft. of stormwater per sq. ft. of added swale, can capture up to 43.7 acre-ft of water during a major storm event. The total AADA study area is 62.2 sq. mi.s. If NDBs were constructed at an equivalent density across only ¼ of the study area (9,942 acres; very conservative estimate excluding overly steep or unsuitable terrain), there would be the potential to capture and replenish 1,974 acre-ft of water per capacity storm event.

As mentioned in Section 2.2, between 2020 and 2025, the AADA experienced precipitation above 0.01" from 16-53 days per year. Much of the annual rainfall volume is accumulated through moderate rainstorms depositing 0.2 - 0.9" within a 24-hour period, which may only periodically cause nuisance flooding in intense 15-30 minute bursts. NDBs are designed to capture rainfall from these types of events. Stronger rainstorms will likely cause them to flood, which is acceptable and a design feature.

For NDBs to maximize groundwater replenishment potential (fill frequently), they should be preferentially placed within close proximity to paved surfaces such as roads or parking lots to capture immediate runoff, and alongside frequently flooding channels and confluences, such as streams and major arterial roadways. Random placement of NDBs across the landscape would not be the best utilization of this approach, as they may not fill with water frequently enough outside of major storm events.

Geospatial analysis for placement of NDBs should size the system relative to its subcatchment, so a 2,400 sq. ft. NDB with an average capture depth of 2.8 ft can capture 6,720 cu. ft. of stormwater. If it takes 83 hours to fully empty the system via a combination of infiltration and evapotranspiration and storm events tend to cluster across a few days within the AADA, we will use a 2-year recurrence, 96-hour design storm of 3.30" for Acton to estimate that this system can manage a paved area up to 24,436 sq. ft. Smaller rain events will only partially fill this system and more intense storm events will overtop it.

It is important to remember that while NDBs help with flooding, they are not a flooding solution but a groundwater replenishment solution. Our target is not to manage the 50-year, 24-hour design storm as is required by the Los Angeles County Stormwater Management Standards, but rather, harvesting as much as possible from ordinary storm events that occur multiple times each year without overdesigning systems for scenarios that are neither likely to cause NDBs to fail, nor contribute meaningfully to groundwater replenishment on an annual basis.

4.3.3 Cost Analysis

In order to see significant benefits from NDBs, you would need to scale these systems throughout a significant portion of the AADA. Due to a relatively low population density, there are limited funds available for costly solutions at the scale needed to resolve problems such as groundwater replenishment and flood reduction, therefore solutions have to be cost-effective and rely on local resources to the greatest extent possible.

The table below models potential construction costs for an arterial-configuration Native Dryland Bioswale that is 24’ wide, 6’ deep, and 100’ long (2,400 sq. ft.).

Table 4: Cost estimates and descriptions for various components of an arterial-configuration Native Dryland Bioswale, here used as an example. Other bioswale systems use slightly different components, volumes of material, and excavation intensity

Item	Low Est.	High Est.	Description
Excavation	$1,890	$4,725	315 CY of soil removed priced from $6 - 15/CY including labor and equipment
Haul Off	$2,520	$7,875	315 CY at $8 - 25/CY, though estimate range varies greatly based on local stockpiling capacity
High Infiltration, Low Nutrient Bioretention Media	$4,690	$8,710	134 CY of bioretention mix delivered to site (at $35 - 65/CY). Cost can be decreased through local mixing. Bioretention media specified as a sandy, low-nutrient mix formulated for California native species and resistant to invasive plants.
2-4” River Rock	$1,495	$3,034	37 CY of 2-4” river rock delivered to site
Erosion Protection Fabric	$500	$1,500	3000 sq. ft. of biodegradable erosion fabric (coconut fiber) at $0.10 - $0.30/sq. Ft. delivered
Curb	$3,000	$4,500	100’ of standard 8” curb with stormwater inlets, at $30 - 45/linear foot
Plantings (Dryland grasses and Wildflowers)	$5,520	$9,200	For 1,700 sq. ft. (excluding cobble trench and channels) at $3.25 - 5.40/sq. ft. Price includes seeds, plugs, 1-gal perennials, grading, amendments, and labor on a weed-free site. Does not include an irrigation system.
Misc. Labor	$2,500	$4,000	Includes labor not covered under excavation, haul off, planting, or curb construction
Construction Subtotals	**$22,115**	**$43,544**	Does not include costs associated with permits, inspections, design and other fees

The above are cost ranges that one could expect for a one-off NDB system. A fair early initial average construction estimate for a Native Dryland Bioswale for a 2,400 sq. ft. system would be approximately $30,000 installed, or $12.50/sq. ft., excluding permits, design and other relevant fees, with costs likely dropping significantly at scale.

The replicable template-style specifications of NDBs are intended to make them cost-effective and scaleable. Costs can be substantially reduced from the numbers quoted above by vertically integrating the operation, as follows:

- Using a shallower layer of bioretention media (though it would negatively impact system capture capacity. The cost-benefit balance for bioretention media depth would require pilot testing to optimize.
- Creating a public soil stockpile in the AADA that receives and repurposes excavated soil material in close proximity to sites in order to reduce haul-off costs.
- Local production of bioretention media, by screening, amending and repurposing excavated soil

While starting a public soil stockpile and bioretention media mixing facility would necessitate their own expenses, they may reduce the overall cost of a scaled buildout of NDBs within the AADA. Financial modeling to that degree was not conducted for the purposes of this report.

In contrast, bioretention systems typically cost $25 - $100/sq. ft. in urban areas depending on system complexity. Major cost drivers are underdrains, storm drain tie-ins, custom designs, and working around complex utilities, which are not factors within the AADA or with this solution. The conceptual designs featured in this report are intended to represent general design specifications for an arterial system configuration and a common site typology (such as the area between the road and property line), rather than matched to a particular site. As such, these costs could be greater or lesser depending on site and system configuration.

In order to achieve the same 374 acre-ft of static storage capacity modeled by the installation of a large detention basin at Vazquez High School in Stantec 2024, you would need to construct approximately 133.5 acres of NDBs, which would cost $72.7 million if modeled at the same cost as the 2,400 sq. ft. system above.

However, many NDBs would be considerably larger than 2,400 sq. ft., and be individually less costly on a per-sq.-foot basis. At that scale, it is also likely that there would be local investment into vertical integration of the operation, as noted above, which would decrease overall costs to a fraction of the $72.7 million price tag.

While costs for detention basins can be highly variable, similar-sized basins can easily exceed $75 million and sometimes multiples of that for more complex structures. Where NDBs excel is that they contribute to groundwater replenishment, biodiversity, and resilience considerably more than detention basins, which are primarily used for flood protection.

Routine maintenance requirements for NDBs can consist of weeding (especially during the establishment phase), sediment removal, and periodic system inspection after flash flooding events.

4.3.4 Case Studies

There are numerous successful US-based and global examples of using swale-based and other techniques to capture water and re-vegetate semi-arid landscapes with rugged terrain and very high sediment transport rates. Lessons from these successful case studies can be readily applied within the AADA to accomplish similar goals.

China - Loess Plateau Rehabilitation

The Loess Plateau, a semi-arid, intensively-farmed 245,000 sq. mi. region located in north-central China was the site of one of the most ambitious reforestation projects ever enacted. Though the environment of the Loess Plateau is quite varied, many portions of it resemble the rugged terrain of the AADA both in topography and rainfall patterns, particularly the north portion. Techniques such as the creation of small infiltration basins (swales), contour swales on hillsides, check dams in gullies, and re-vegetation in close proximity to water capture features were used to restore over 5,790 sq. mi. of forest from 1975 to 2020, as well as significantly decreasing sediment flow into the Yellow River. Other successful techniques employed included terracing steep hillsides, though this is more intended to reduce the impact of agriculture on soil erosion within the Loess Plateau and not as applicable to the AADA.

Figure 16: Images of the Loess Plateau before and after ambitious reforestation projects. Pictures sourced from Click Petróleo e Gás

Figure 17: Images of Rajasthan before and after water conservation efforts. The top left photo displays the drought-ridden landscape, the top right and bottom left photos display two different water capture tactics, and the bottom right photo displays Bhojdari, a village with improved drought-resiliency methods. Pictures sourced from The Earth and I and Watershed Organisation Trust (WOTR).

India - Rajasthan Watershed Revival

Following a severe drought in semi-arid, mountainous, and agriculturally significant portions of Rajasthan, India, volunteers were brought in to assist with water conservation practices. It was found that the construction of johads (traditional, locally-managed percolation ponds) was abandoned in favor of bore wells, coupled with general deforestation, agriculture and other industrial activities degrading the infiltration capacity of the landscape, which consequently resulted in a critical overdraft of the groundwater table.

Led by Rajendra Singh, volunteers and local villagers constructed over 8,600 johads, swales, and check dams to retain and infiltrate water from the monsoon season. This resulted in the groundwater table rising several meters, previously dry wells regaining function, forest regeneration, and the restoration of 5 major rivers across an 1,800 sq. mi. region.

Arizona - Tucson Bioswales

In 2013, Tucson adopted a green streets policy that requires new and reconstructed roadways to capture and infiltrate the first 0.5” of rain on-site through the use of nature-based solutions such as bioswales and rain gardens. Tucson’s FY 23-24 Storm to Shade Report details the construction of over 225,000 sq. ft. of green stormwater infrastructure (mostly bioswales) with an average cost of $9.36 per sq. foot. Separately, a cost-benefit analysis determined returns valued at $48.35 per sq. foot for each $23 per sq. foot invested into nature-based solutions.

While Tucson is considerably more urban than the AADA, it has a similarly seasonal rainfall pattern, and annual totals of 10-12 inches.

Figure 18: Images of Passive System Galleries in Tucson. The photo on the left displays a system reinforced with rocks and a direct overflow feed, the top right photo displays a system with a direct downspout to feed bioswales, and the bottom right photo displays a system with minimal rocks and a direct feed. Pictures from the City of Tucson.

Mexico - Valle de Bravo Watershed Restoration
Located in the semi-arid, rugged highlands approximately 100 mi. south of Mexico City, Valle de Bravo supplies 12% of the water used by Mexico City's 22 million inhabitants. However land use changes and deforestation for development have decreased infiltration rates and increased sediment transport, threatening the integrity of strategically important local reservoirs. Bioswales, contour swales, check dams and soil-stabilizing traditional milpas agricultural practices were utilized as part of a strategy to decrease erosion rates and increase stormwater capture on steep hillsides. Procuenca, a not-for-profit organization that has been leading the restoration of the Valle de Bravo - Amanalco Basin since 2000, claims to have restored over 1,900 hectares of soils and forests using these strategies.

Figure 19: Images of Valle de Bravo (and specifically the Amanalco Basin) before and after revitalization efforts. The top photos display the impacts of development on the shorelines, the bottom left photo displays efforts to restore the land by Procuenca, and the bottom right photo displays the Amanalco Basin as the shoreline improves. Pictures from AP News and Procuenca's Facebook Page.

While the four case studies listed above are located in regions that are economically and socially distinct from the AADA, baseline conditions such as arid climate, seasonal rainfall, rugged topography, and high sedimentation rates are common among them, and similar solutions across all of these case studies are utilized to slow, spread and capture stormwater. We see a consistent use of bioswales, contour swales and check dams incorporated into these landscapes to assist in stabilizing and restoring soil health and groundwater levels.

It's important to remember that these are not newly discovered approaches. While technology and hydrologic modeling capacities have evolved, allowing us to make design decisions with much greater precision, the traditional use of rainwater harvesting techniques of various forms, especially in rugged landscapes, has existed within various cultures for thousands of years. A reciprocal relationship with the local hydrological cycles is often what made these regions inhabitable in the first place. These approaches were always community-led and managed, and worked with nature, not against it. A key feature is that these were not carefully engineered mega projects, but instead small, cost-effective, resilient systems that are replicated across thousands of examples at scale. That's what is being proposed here.

5.0 Conclusions and Recommendations

5.0 Conclusions and Recommendations

Drought resiliency initiatives within the Acton-Agua Dulce Area (AADA) are complicated by a landscape characterized by seasonal flooding risks, wildfire hazards, some of the highest sediment transport rates in the US, and a complex, tectonically-active geology that much of the population happens to be reliant on for their water. Yet, where nature presents challenges, it can also provide solutions.

Previous initiatives to address water supply concerns within the AADA were detailed in the 2004 Acton-Agua Dulce Conceptual Master Plan for Water Facilities, which modeled the costs and considerations surrounding expanding the service area of Waterworks District No. 37 throughout a geography that greatly overlaps with the AADA in order to reduce reliance on private domestic wells and incorporate a water supply backstop with water sourced from the State Water Project. This concept was ultimately not built out.

Flooding mitigation within the Acton portion of the AADA was similarly explored within Stantec's 2024 Acton Flooding Multi Benefit Solution: Report on Preliminary Approaches, the 2007 Acton Feasibility Report, and various Drainage Plans and updates over the decades, which found considerable feasibility challenges with traditional flooding solutions. The community repeatedly expressed interest in the use of nature-based solutions to manage flooding and preserve the rural character of the region.

This report examined the feasibility of achieving key regional goals at a conceptual level by confronting the problem through the lens of groundwater replenishment, rather than flood protection. Bioretention nature-based solutions called Native Dryland Bioswales (NDBs) cost-effectively capture and percolate water from seasonal rain events, restoring groundwater levels while also providing numerous co-benefits such as flooding reduction, sediment stabilization, fire resilience and increase biodiversity in the process. Similar approaches have been used in places such as China, India, Mexico and Arizona to revegetate arid landscapes and regenerate depleted soils with overwhelming, transformative success at both small and massive scales. This approach would effectively replenish groundwater supplies despite the region's geologic complexities.

The process of slowing, capturing and retaining water on the landscape has been understood for millennia by various cultures as integral for protecting soil and groundwater supplies. When initially applied to a landscape, this process kickstarts the self-organizing properties of nature and produces value that is outsized relative to the investment.

The implementation of Native Dryland Bioswales within the Acton-Agua Dulce Area should be viewed as a multi-decadal endeavor - not a quick fix. Hundreds or thousands (depending on size) of individual NDBs will be required to significantly replenish groundwater and create meaningful landscape-scale change. However, this also presents opportunities to develop and continuously refine a concept over a long period such that it may become a distinctly local creation and a source of pride, rather than a risky, costly attempt at a large conventional project that may not succeed at its stated goals or become a burden with maintenance requirements.

We recommend pilot testing and monitoring several configurations of the NDB concept to gain a better understanding of the unique considerations required to design nature-based solutions within the highly dynamic environment of the AADA. While there is still considerable additional theoretical modeling and in-depth case study review that can be performed for the NDB approach, there are also limitations to what can be accomplished absent direct observation of real-life examples of systems.

Furthermore, we recommend modifications to the Sustainable Groundwater Management Act process for basin evaluation with regard to small groundwater basins where boundary differences in populations and usage rates between small water purveyors can result in considerable inaccuracies surrounding groundwater withdrawal rates.

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Appendix

Well Assessments

Well assessments were successfully performed on seven properties within the AADA in November 2025. The assessor completed a form with categories pertaining to the technical specifications of the well, pump, storage tank, age and condition of the well system components thereof, and other homeowner-specific information related to water use and well system performance issues.
The assessor took photographs and created a map of the property with well system components labeled. The assessor sampled water from each well, which was analyzed by FGL Analytical Chemists for various chemical constituents in accordance with methods: EPA 200.7, EPA 200.8, EPA 300.0, SM 4500-H+B, SM 4500-NO3 F.

Participant Profiles

Four of the 7 participants are located in the northern portion of Acton. Three of the 7 participants are located in Agua Dulce. Study participants were selected from a group of private well owners whose well has either run dry or is underperforming. Six of the 7 properties (4 in Acton, 2 in Agua Dulce) are located in areas that are between 1.2 - 3.8 mi.s away (and hundreds of ft. higher in elevation) from the nearest municipal supply well (visible within GAMA), used here as an approximator of good groundwater basin quality. Their proximity to mountain ridges suggests that the hydraulically productive alluvium material is likely thin or entirely absent on their properties. Their well depths range from 300 - 700 ft. While a formal geologic assessment was not performed, it is almost certain that the perforated interval of their wells sits within the hard rock aquifer. Given this information, it is not surprising that their wells are underperforming. One of the 7 participants is located within 0.2 mi.s of a small municipal supply well serving 24 individuals across 17 service connections as of 2020, suggesting that either this participant's water supply issues may be the result of a malfunction within the well system, or their well's perforated interval is within the cone of depression from the nearby municipal well. 4 of 7 participants use water for livestock, and 2 of 7 participants use water for irrigation.

Water Quality

Well water was evaluated for a number of metals and inorganic minerals, as well as fecal coliform. 1 out of 7 samples had detectable levels of fecal coliform. 4 out of 7 participants had samples with levels of iron in excess of the federal MCL. Iron concentrations ranged from 400 µg/L to 3300 µg/L (federal MCL is 300 µg/L). The participants with excessive iron also exclusively had one of the following: excessive arsenic (21 µg/L vs. 10 µg/L MCL), excessive nitrate (309 mg/L vs. 45 mg/L MCL) and nitrate as nitrogen (69.7 mg/L vs. 10 mg/L MCL), excessive manganese (480 µg/L vs. 50 µg/L MCL), and excessive fluoride (9.5 mg/L vs. 2 mg/L MCL). 3 of the 7 participants had samples that did not exceed the federal MCL for any of the constituents that were tested. The anonymized results can be summarized in the table below:

Participant 1	Iron Exceeding MCL Fluoride Exceeding MCL Fecal Coliform Detectable (likely from livestock)
Participant 2	Iron Exceeding MCL Nitrate Exceeding MCL (likely from livestock)
Participant 3	Iron Exceeding MCL Arsenic Exceeding MCL
Participant 4	Iron Exceeding MCL Manganese Exceeding MCL
Participant 5	No constituents exceeding MCL
Participant 6	No constituents exceeding MCL
Participant 7	No constituents exceeding MCL

Excessive iron and manganese can cause the water to have an off taste, but are generally not considered harmful to human health at these levels. However, excessive nitrate, arsenic and fluoride can be harmful to human health, especially in children. Though coliform bacteria alone are typically harmless to humans, their presence can indicate contamination of water with human or animal feces, which can carry other pathogens such as E. coli.

Water hardness, the measure of magnesium, calcium and carbonate minerals in the water, was distributed as follows: soft (1 sample: 19.1 mg/L), moderately hard (1 sample: 91 mg/L), hard (3 samples: 188 mg/L, 214 mg/L and 216 mg/L, and very hard (2 samples: 437 mg/L and 751 mg/L).

Given the relatively small number of samples and iron being the only shared constituent exceeding federal MCLs between them, it is difficult to statistically determine any correlation between the samples, let alone causality. The Groundwater Ambient Monitoring and Assessment (GAMA) monitors groundwater quality across California and was utilized for this analysis.

Nitrate and nitrate as nitrogen are closely monitored across numerous wells in Acton and Agua Dulce with levels rarely exceeding the 10 mg/L MCL for the latter across 23 separate wells, and significantly lower than the 69.7 mg/L measurement at the participant site, suggesting a site-specific issue possibly related to excessive dog urine seepage due to the participant maintaining over 30 dogs on the property (unlikely to be manure or septic tank failure due to lack of fecal coliform and unlikely to be nitrogen fertilizer due to lack of agriculture). Dog urine has been shown within scientific literature to increase nitrogen levels in soil and groundwater.

However, consistent monitoring across most chemical constituents is spotty in this region. As a result, It is challenging to reliably compare quantities of iron, manganese, fluoride and arsenic from participant samples to existing water quality monitoring in the immediate region, though scattered measurements taken from nearby monitoring wells within the last 4 years also show levels occasionally exceeding MCLs for these respective constituents. The participant results are not significantly higher than the measurements found in these monitoring wells. This indicates that high mineral content in water is not regionally uncommon, and may be a result of the highly heterogeneous composition of the hard rock aquifers where this water originates from.

12601 Mulholland Drive,
Los Angeles, CA 90210

treepeople.org