FRESNO STATE

California Water Institute

Groundwater Recharge to Benefit Disadvantage Communities in Fresno County Feasibility Study

January 2024

Acknowledgment

The California Water Institute thanks and acknowledges the following individuals and organizations. None of this work would have been possible without their time, resources, and knowledge.

A special thank you to the funder of this report for providing our center with the resources necessary to make this report possible.

Pacific Western Bank

A special thank you to our advisory committee for contributing time, industry knowledge, and expertise.

Glen Low - Earth Genome
Austin Ewell - Ewell Group
Ian Buck-Macleod - Friant Water Authority
Daniel Mountjoy - Sustainable Conservation
Eddie Ocampo, Sue Ruiz - Self-Help Enterprises

A special thank you to the following water agencies for contributing time and resources to meet with staff and providing information to make this report possible.

Consolidated Irrigation District
Laguna Irrigation District
Fresno Irrigation District
McMullin Area Groundwater Sustainability Agency

A special thank you to California State University, Fresno **Professor Henry Liang, PE**, and Civil Engineering 180A students for working on portions of this report during the Spring 2023 semester.

Alejandra Gonzalez
Cameron Gonzales
Christopher Gonzalez
Jacqueline Rodriguez-Armas
Eduardo Vega
Adrian Lujan
Carson Hatmaker
Kayla Mata
Rustin Shaw

A special thank you to California State University, Fresno **Faculty Member Xiaoming Yang Ph.D.** for completing the geospatial analysis for this project.

Groundwater Recharge that could benefit Disadvantaged Communities (DAC's) in Fresno County

Feasibility Study

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January 2024

Executive Summary

Since the introduction of groundwater pumping in the San Joaquin Valley Region of California, groundwater has been historically overdrafted. To date, many communities within the region are experiencing the negative ramifications of the historic overdraft of groundwater. The communities that are most widely impacted by these negative effects, such as depleting quality and quantity of groundwater, are disadvantaged communities (DACs) reliant on domestic wells for potable water use. The purpose of this Feasibility Study is to evaluate the feasibility of groundwater recharge, in an effort to improve water quantity, at pre-identified locations in Fresno County within DACs in need of improved groundwater conditions. Feasibility will be predominately based on technical and financial analysis.

In early 2023, the California Water Institute (CWI) conducted a geospatial analysis to identify potential sites for groundwater recharge within DACs in the Fresno County Region currently experiencing groundwater quantity issues. CWI Staff started with developing the site selection consideration factors to evaluate specific criteria identified and weighted by the advisory committee. Publicly available data and information collected was placed in a geospatial software to perform the analysis utilizing the following criteria: disadvantaged communities, number of individuals served in these DACs, number of wells, risk of dewatering, soil texture and infiltration rate, depth of groundwater, land cover/land use, and groundwater quality.

The analysis identified four potential locations that met the project's consideration factors for the design and construction of recharge basins near or in the cities of Kerman, Raisin City, Caruthers, and Laton.

For each site, existing conditions were evaluated to aid in preliminary engineering design and determination of feasibility. The notable existing conditions evaluated for each site included the existing groundwater quality of the nearby community, soil conditions, land use, availability of surface water supply, and demographics. The most important existing conditions of constraint evaluated for each site include the soil type and availability of surface water for recharge.

With the existing conditions determined for each site a conceptual design was completed to define any required project improvements needed. The basis of design used for each of the recharge basins was the Caltrans Infiltration Basin Design Guidance Handbook. Following the production of the preliminary design and cost estimates, a feasibility selection matrix was developed to numerically score each of the project sites. The selection matrix considers potential water availability, proximity to surface water, current land use, recharge potential, construction costs, ease of maintenance and operation, and community benefit. Scores of one (1) through ten (10) were assigned for each criterion, resulting in a maximum score of 70, Table ES-1 displays the scoring for each site.

Criteria	Representative Project Location			
	Scoring (Numerical): 1-10			
	Kerman	Raisin City	Caruthers	Laton
Potential Water Availability	5	1	5	6
Proximity to Surface Water	7	1	4	8
Current Land Use	10	2	2	2
Recharge Potential	7	8	8	5
Construction Costs	7	2	5	5
Ease of Maintenance and Operation	8	3	5	4
Community Benefit	9	6	7	5
Totals	**54**	**23**	**36**	**34**

Table ES-1: Feasibility Selection Matrix

The major factors contributing to the Kerman Site's outscoring is the Site's current proximity to surface water, current land use, construction costs, and ease of maintenance and operation when compared to the other sites. For these reasons, the Kerman Site was determined to be the most feasible location should any of the sites included in the study be considered for further investigation or design. The study produced a cost estimate for improvement of probable capital cost of $6,015,000 for a 44-acre size recharge basin.

Raisin City scored the lowest based on the lack of proximity to infrastructure to access surface water. Conversations with the local groundwater sustainability agency identified plans for future infrastructure making this area more feasible in years to come.

This Study was successful in determining the high-level feasibility of project locations identified for groundwater recharge. Should the recommended location from this report be further investigated and eventually successfully constructed, the positive implications of this Study will be immense for DACs facing a reduction in groundwater level. It is important, however, to discuss next steps and recommendations for any site that is considered for further design or construction. Next steps and recommendations include:

- Obtain groundwater quality samples.
- Obtain a Geotechnical Analysis and Report to confirm in-situ infiltration and percolation rates.
- Further collaboration with water supplying authorities to solidify the capacity of existing water conveyance systems and alternative site recommendations based on local expertise.

- Detailed groundwater investigation to determine historical groundwater depth and current groundwater depth and quality.
- Perform hydraulic modeling.
- Perform a topographic site and pipe alignment survey.
- Prepare preliminary construction design documents to confirm cost estimate.

Groundwater recharge basins is just one of multiple groundwater recharge methods that are taking place and will increase in the coming years near groundwater dependent communities. This study specifically focused on the technical and financial feasibility of recharge basins but sites like these would also work great for flooding during the wet season or for subsurface recharge.

Education of what groundwater recharge is, what are its advantages and disadvantages, as well as how it will affect these communities is something that needs to be done in those communities. As a preliminary effort, CWI and Self-Help Enterprise developed an education campaign that included flyers in English and Spanish to the four evaluated communities as part of this project.

This feasibility study has undertaken an examination of the groundwater overdraft issues in DACs within Fresno County and a potential solution. The success of this study in providing a feasibility analysis underscores groundwater recharge as potential positive implications for these communities facing reductions in groundwater quantity. The results of this work mark a pivotal step towards sustainable groundwater management in the San Joaquin Valley.

Groundwater Recharge in Fresno County
Feasibility Study

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List of Abbreviations

AF - acre-feet
BLM - Bureau of Land Management
CFS - cubic feet per second
CID - Consolidated Irrigation District
CWI - California Water Institute
DAC - Disadvantaged Communities
DWR – California Department of Water Resources
FEMA- Federal Emergency Management Agency
FID - Fresno Irrigation District
GLO - General Land Office
LID - Laguna Irrigation District
MAGSA - McMullin Area Groundwater Sustainability Agency
MCL - Maximum Contaminant Level
NRCS- Natural Resources Conservation Service
SJV - San Joaquin Valley
SAGBI - Soil Agriculture Groundwater Banking Index
SWRCB – State Water Resources Control Board
USDA - United States Department of Agriculture
WSS – Web Soil Survey

1. Introduction

In September 2012, Assembly Bill 685 was passed which legislatively recognized the human right to water in which "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes". As of 2023, multiple areas within Fresno County are still encountering water quality and quantity issues impacting their right to water, namely, disadvantaged communities (DACs) reliant on onsite domestic wells or small public water systems.

All the 4.2 million residents that call the San Joaquin Valley home rely on groundwater for some portion of their total annual water use. Within Fresno County's Study Area proposed for the Project, in 2020, the Water Board reported that there were 1,285 public drinking water systems, and 1,137 systems (~88%) serve less than 1,000 persons, and 590 systems (~46%) serve less than 100 persons. Of the 1,285 public drinking water systems, 146 systems have active enforcement actions pending due to violation of safe drinking water standards. The most prevalent drinking water violations are for 1, 2, 3 – Trichloropropane (TCP) (84 systems), Arsenic (60 systems), and Nitrate (46 systems) – many systems have been cited for multiple drinking water standard violations. These system counts do not include residents in the San Joaquin Valley that rely on onsite individual domestic wells for potable water service, which the Water Board does not currently regulate.

Recognizing the need for sustainable groundwater for domestic wells for potable water use in the San Joaquin Valley, the California Water Institute (CWI) at Fresno State with assistance and consultation from the Earth Genome, Friant Water Authority, Self-Help Enterprises, and Sustainable Conservation conducted this feasibility study. The study's goal was to identify Fresno County DACs experiencing or having a high probability of experiencing a lack of reliable domestic groundwater due to declining groundwater levels. Following the identification of communities meeting the criteria, CWI examined areas that could be suitable locations for groundwater recharge basins to aid in the communities' access to domestic water. These selected communities and groundwater recharge locations were initially evaluated in a geospatial analysis and include sites in or near the communities of Kerman, Raisin City, Caruthers, and Laton.

Of the locations included in the screening study, the four areas were selected based on the best-scoring initial selection criteria. The criteria evaluated via geospatial analysis for selection of the four area locations was as follows:

- Is the proposed groundwater recharge site upgradient or within proximity to benefit the DAC(s)?
- Number of persons served in the target DAC(s).
- Number of wells in the target DAC(s).
- Soil texture and infiltration rate.

- Groundwater level change.
- Depth to groundwater.
- Groundwater quality.
- Current land use.
- Availability of surface water infrastructure to supply water for recharge.

With groundwater recharge basins gaining momentum as a land repurposing option, it is becoming crucial to ensure that those communities reliant on well water for their residential needs are well-informed and engaged. In an effort to do this, Fresno State and Self-Help Enterprises (SHE) developed and executed an Outreach and Implementation Plan tailored to the selected communities. The team developed a groundwater recharge flyer in English and Spanish that included information about the benefits and potential challenges of groundwater recharge, as well as contact information for community members seeking further details.

Groundwater recharge can be done in multiple ways, such as flooding during the winter months or via subsurface technology, for educational purposes, this study focused on the technical and financial feasibility of recharge basins.

This report considers the feasibility of constructing groundwater recharge basin(s) at sites located in or near Kerman, Raisin City, Caruthers, and Laton. In order to determine the feasibility of constructing groundwater recharge basin(s) at each of these areas, this report presents and analyzes the site selection criteria, existing conditions, and project conditions.

2. Problem Statement

The Department of Water Resources (DWR) records have indicated that groundwater levels in Fresno County (County) have declined by approximately 100 feet since groundwater pumping began in 1930. Groundwater elevation decline can be primarily attributed to increased use of groundwater within the County due to several factors including a decline in surface water availability. In some cases, the decline in groundwater elevation has adversely affected the ability of Fresno County communities to access safe and reliable groundwater in both quantity and quality. The enactment of Assembly Bill 685 requires that measures must be taken in an effort to increase the groundwater quality and quantity for communities that are experiencing these groundwater elevation declines. Fresno County DACs are predominately reliant on shallow domestic groundwater wells and are, therefore, disproportionately faced with the negative consequences of declining groundwater elevations.

Currently, one of the more effective and feasible solutions to increasing groundwater quantity is through groundwater recharge, groundwater recharge basins being one of several available managed aquifer recharge options. Although it may take years to adequately improve groundwater quantity, groundwater recharge is considered a historically successful long-term solution. As a result, CWI is exploring the feasibility of constructing groundwater recharge basins within or near the four DACs identified by the initial selection analysis.

3. Phase 1: Geospatial Analysis

The California Water Institute enlisted the help of several organizations to determine consideration factors crucial in identifying desirable groundwater recharge areas and representative sites within those areas with a primary purpose of replenishing groundwater levels near disadvantaged communities affected by drought and groundwater overdraft. These organizations formed an advisory committee that helped serve as a sounding board for all things groundwater recharge and San Joaquin Valley communities. This group met during the initial development of the consideration factors to determine what was most important and why such factors needed to be incorporated into a project of this nature, highlighting potential impacts and undesirable results.

Advisory Committee

Earth Genome
Friant Water Authority
Sustainable Conservation
Ewell Group
Self-Help Enterprises

First, the advisory committee helped identify consideration factors to be incorporated in the geospatial analysis used to identify areas where groundwater recharge could benefit DACs. Consideration factors ranged from populations of persons to land cover and groundwater quality; a more thorough list can be found below. Each of these consideration factors were then scored and analyzed in a 2-stage geospatial analysis.

3.1 Consideration Factors Used to Identify Areas of Benefit

First and foremost, this project focused on DACs with the highest number of persons and highest number of wells within a 1–2-mile radius in Fresno County. Secondly, we incorporated site specific data like soil type and infiltration rate, land slope, groundwater depth, groundwater quality, land use, and groundwater level changes to help identify specific parcels of land suitable for a recharge basin. A complete list and attributes of each of the criterium is as follows.

3.1.1 Disadvantaged Communities

Disadvantaged communities (DACs) and severely disadvantaged communities (SDACs) respectively, were the focus of this study. The acronym DAC (Disadvantaged Community) is used by federal/state/local governments and nonprofits in California to identify and target populations for funding and support. There are two prominent definitions of DACs used, however for the sake of this study, we are basing it on the Median Household Income (MHI) relative to the state median (DWR, 2022). As defined by the California Department of Water Resources (DWR), DACs are Census geographies with an annual MHI that is less than 80% of the Statewide annual MHI. SDACs are Census geographies having less than 60% of the Statewide annual MHI (DWSRF Disadvantaged Community Definitions: A Reference for States, 2022).

2021 Statewide MHI: $84,097

2021 DAC (80% of Statewide): $67,278

2021 SDAC (60% of Statewide): $50,458

The definitions listed above were used to define geographies in our geospatial analysis. Both DACs and SDACs were considered high priority.

3.1.2 Number of individuals served in DACs

The number of individuals served in a DAC was obtained from the United States Census Bureau (2020 Census Data). Census blocks with the highest number of individuals residing in rural areas determined to be a DAC or SDAC was the target of this criterium. Census blocks with a total population of 100 persons or more were the highest priority, 50 to 99 persons were medium priority, and less than 50 persons were low priority.

3.1.3 Number of wells

The number of domestic wells data was obtained from the DWR Well Completion dataset (Well Completion Reports). The highest number of reported wells within any given 1-2-mile radius was the highest priority. Even though the depth of the wells is important to understand the reliability of supply or the risk of dewatering, well depth was not examined in this study. Due to the studies focus, no low or high priority ranking were used for this criterion and only those geographies that met the high priority were used.

3.1.4 Soil Texture/Infiltration Rate

Soil texture and infiltration rates data was obtained from the Soil Agriculture Groundwater Banking Index (SAGBI) (UC Davis). SAGBI was used as a proxy to understand the subsoil recharge characteristics as additional information was not available at the time. This database utilizes factors like deep percolation, root zone residence time, chemical limitations, topographic limitations, and surface conditions to create a SAGBI rating soil suitability to accommodate groundwater recharge. Ratings range from 0-100, with 100 being the most suitable areas for groundwater recharge on agricultural land. SAGBI ratings from 85-100 were high priority, 69-85 were medium priority, and 49-69 were low priority.

The Department of Water Resources is currently developing Airborne Electromagnetic (AEM) Data which could be more appropriately utilized in future studies.

3.1.5 Groundwater Level Change

Groundwater level change data was obtained from the DWR Sustainable Groundwater Management Act (SGMA) Data Viewer (Sustainable Groundwater Management Act (SGMA) Data Viewer). Seasonal reports for Spring from the year 2018 to 2022, in the form of depth points or monitoring points, were obtained to build a trend of groundwater changes. Monitoring points where water levels have decreased by more than 10 feet were high priority, decreased 2.5 to 10 feet were medium priority, changes +/- 2.5 feet were low priority.

3.1.6 Depth of Groundwater

Groundwater depth data was obtained from the DWR SGMA Data Viewer (Sustainable Groundwater Management Act (SGMA) Data Viewer). Groundwater depth seasonal points from Spring 2022 were utilized to gauge current groundwater levels. Depth is represented in feet below the ground surface. Ascending values indicate increasing depth to groundwater (or deeper/lower water levels). All values over 100 feet were considered high priority and were the only ones evaluated. Medium and low priority were not considered for this criterium.

This criterium was used to identify areas where groundwater storage could benefit from recharge and where storage had been depleted.

3.1.7 Land cover, Land use

Land use data was obtained from the DWR 2019 Crop Mapping dataset (Statewide Crop Mapping). Crop classifications were used to identify idle lands (I), unclassified lands (x), rice (R), pasture (P), grain (G), truck crops (T), field crops (F), citrus and subtropical (C), deciduous fruits and nuts (D), vineyard (V), young perennial (YP), urban unspecified (U), and urban landscape (UL). All crops classified as I, X, R, P, G, T, and F were considered High priority. All crops classified C, D, V, YP, U and UL were not considered since these lands either have restrictions in terms of land use or are classified as high value or permanent crops.

In subsequent phases of the study, we learned that the data was a good starting point but was not current as some of the identified areas currently have permanent crops on them.

3.1.8 Groundwater Quality

Groundwater quality data was obtained from the Safe and Affordable Funding for Equity and Resilience (SAFER) Groundwater quality risk assessment provided by the California State Water Resources Control Board (SAFER Dashboard: Water Boards). The nearest monitoring system point were utilized to identify the following: constituents of emerging concern, history of E. coil presence, increasing presence of water quality trends toward MCL, and percentage of sources exceeding an MCL.

Additional research is needed in the effects of groundwater recharge on water quality. In this case water quality risk categories that were low to no risk were high priority, medium risk were medium priority, and high risk areas were low priority as further intervention would be needed in order to mitigate groundwater quality risks. As more research is done and site-specific information is collected, we will know if the priority should have been different.

Although recharge basins are an ideal technique to recharge the groundwater aquifer, additional studies are being conducted to determine their effect on groundwater quality. Any areas utilizing groundwater recharge near groundwater dependent communities should highly consider implementing monitoring wells and develop a plan to analyze water quality changes and mitigation strategies to avoid negative impacts. Additional information on water quality can be found in section 5.2.

3.1.9 Additional Criterium to be Considered

Additional criterium not used at this stage in this study but should be considered in future studies are:

- Predetermined Project Sites (GSPs)
- Proximity to Groundwater Dependent Schools that could benefits from raising groundwater levels
- Ecosystem Restoration Ability/Capacity
- Land use between GW Recharge site and DACs
- Legacy Nutrient Loading of Site (Land use History)
- Williamson Act Parcels

3.2 Representative Sites and the Most Feasible Region for Locating a Recharge Basin

Once the regions of benefit were identified, representative recharge sites were identified within each region. The feasibility of developing a recharge basin within each of the representative sites was investigated. That investigation is discussed in the following sections. It is emphasized that a representative site is defined as a site that could be a recharge basin site within a region and is used in this report to represent that region. The representative site is only used to quantify the typical aspects of a recharge basin within a region. There is no intent to specifically identify any representative site used in this report as the ideal or best location for a recharge basin within a region. Each representative site is discussed in detail in the remainder of this report. The most feasible representative site is determined in this report, which is meant to be a way to identify the region where a future recharge basin is most feasible.

After the consideration factors were selected, each one of the corresponding datasets was in imported into ArcGIS as a layer. Data was analyzed in a 2-stage process, where first we utilized Census Block data to determine where SDACs and DACs were located within Fresno County. Census Blocks that met our criterium listed in section 3.1 under disadvantaged communities, were examined along with the number of persons or population by Census Block and well density displayed in figure 3-2. All Census blocks that did not meet our criterium were excluded from the stage 1 analysis.

Figure 3-1 describes the relationship between population density and well density displayed on the map. Areas where population and well density were highest continued on to stage 2.

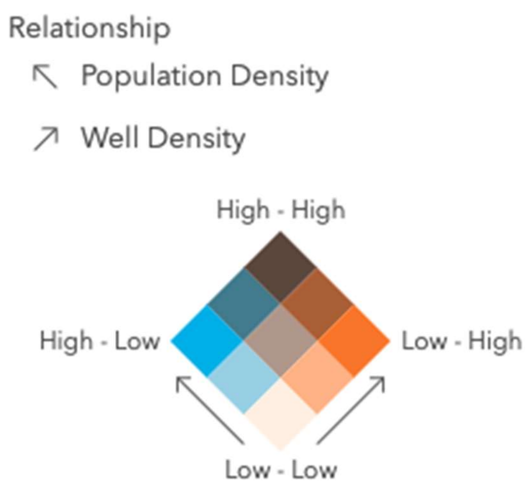


Figure 3-1: Phase 1 Population and Well Density Relationship Graph

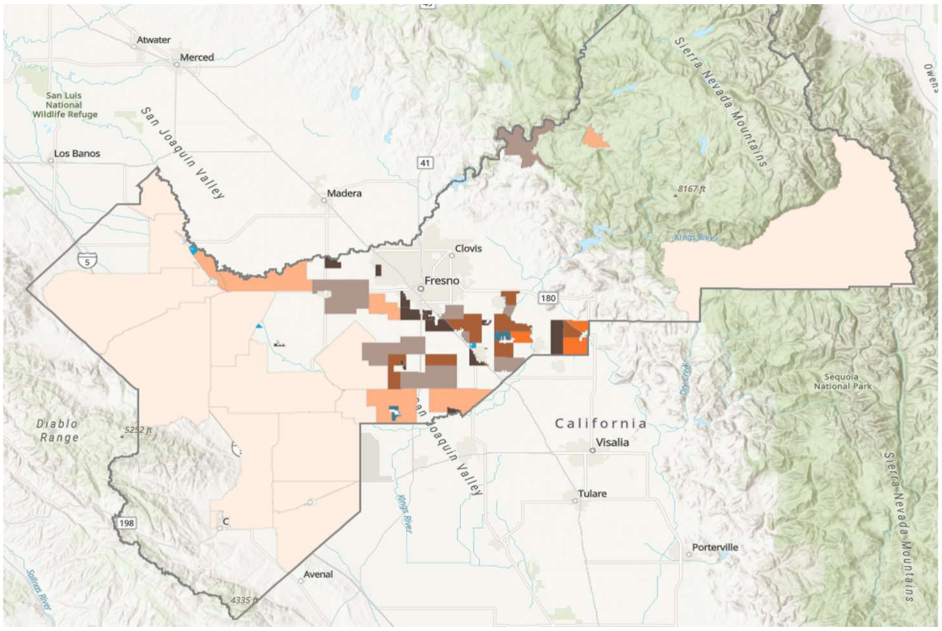


Figure 3-2: Phase 1 - Stage 1 Analysis Results

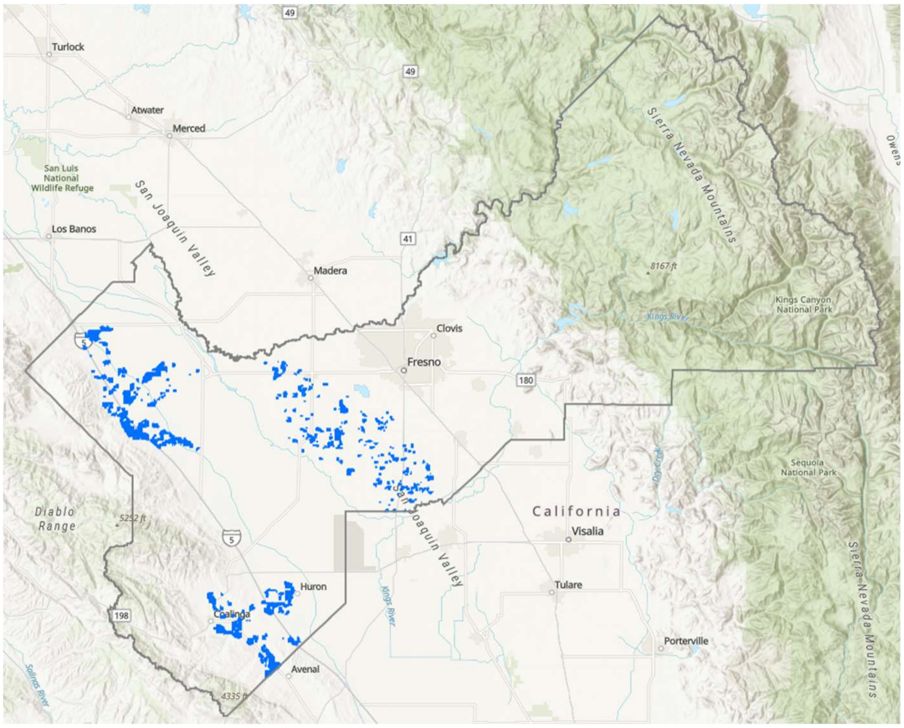


Figure 3-3: Phase 1 – Stage 2 Analysis Results

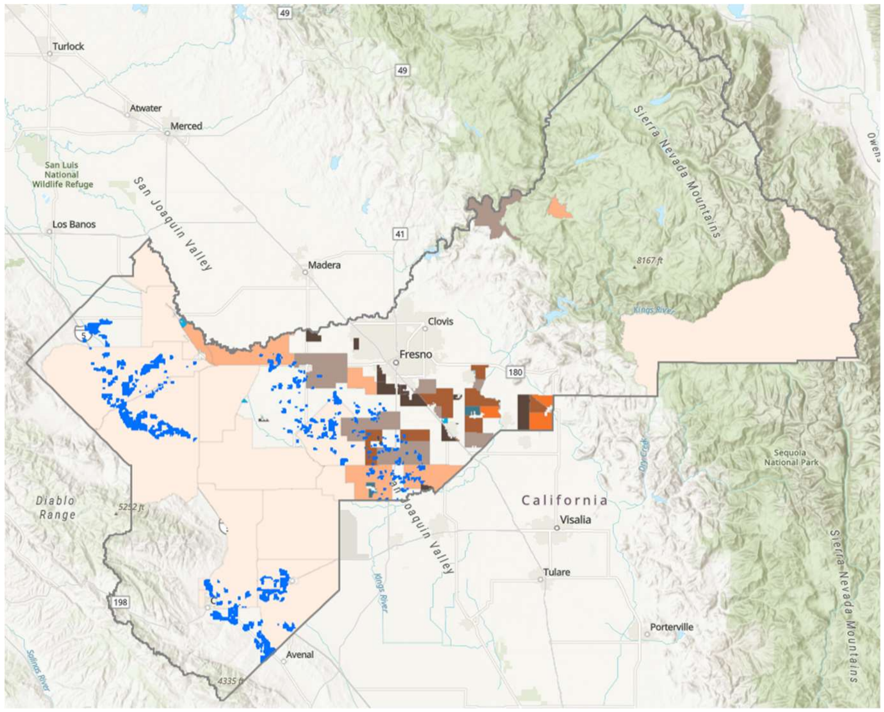


Figure 3-4: Combined Phase 1 stage 1 and 2 Analysis Results

4. Phase 2: Representative Site Selection

Stage 1 - Phase 1 resulted in six geographies that met all the criterium determined by the Advisory board. In Phase 2, we analyzed the six geographies and compared any overlapping areas with the SAFER Dashboard utilizing the nearest monitoring station to understand groundwater quality concerns.

In coordination with water agencies and available geospatial data the closest available conveyance infrastructure, nearby land use, as well as alternative water sources and supplies were identified and used.

After reviewing all results, the following communities were identified as being desirable locations for groundwater recharge, Kerman, Raisin City, Caruthers, and Laton.

5. Phase 3: Representative Site and Project Conditions Analysis

The third phase of this report is to perform a study comparing a representative site from each of the four regions to determine which is most feasible to plot a recharge basin. A necessary aspect of this feasibility study is to determine the benefits and costs of locating a recharge basin at each of the representative sites using existing and developed conditions. Section 5.1 describes each site's existing condition.

Section 5.2 describes the improvements needed at each representative site to create an operational recharge basin at that site. These characterizations provide the information needed to determine the availability of surface recharge water, site soil recharge capabilities, costs for improvements, and conditions for development and permitting. This allows for an objective comparison of the sites to determine the most feasible region in which to locate a recharge basin.

5.1 Existing Conditions

A preliminary investigation to determine the existing conditions and suitability for the construction of a groundwater recharge facility within the selected areas was conducted. The investigation identified and assessed the following conditions and considerations for each representative site:

- Site location
- Groundwater quality
- Soil conditions
- Vegetation
- Roads
- Wet utilities
- Dry utilities
- Site Plans
- Jurisdictional oversight
- Williamson Act registration
- Stakeholders
- Demographics

Additional parameters that may impact the overall cost and design of the project were analyzed as necessary.

5.1.1 Location

Figures 5-1 through 5-5 indicate the representative sites of a proposed groundwater recharge basin within the City of Kerman, Raisin City, the Community of Caruthers, and the Community of Laton area. The Kerman location is the only proposed site that is within city limits. The remaining sites (Raisin City, Caruthers, and Laton) all reside in unincorporated areas within Fresno County but will continue to be referred to by the nearest DAC the recharge basins would serve.

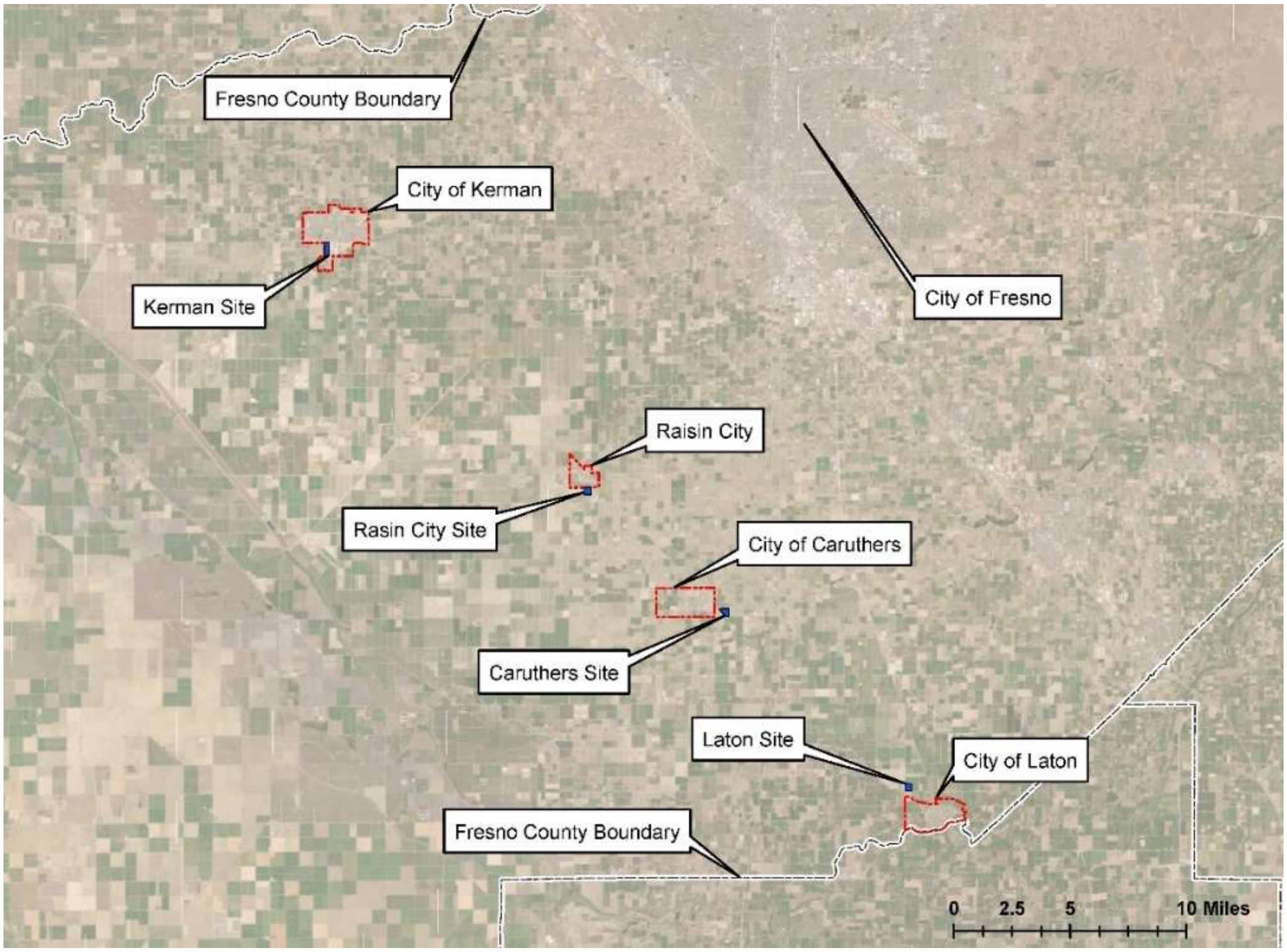


Figure 5-1: Representative Recharge Site Location Area

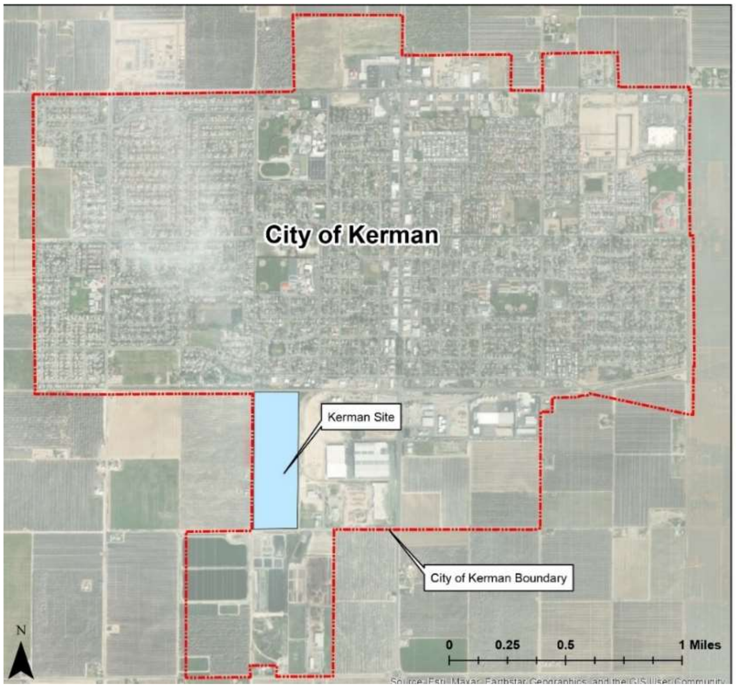


Figure 5-2: Representative Recharge Site for the Kerman Area

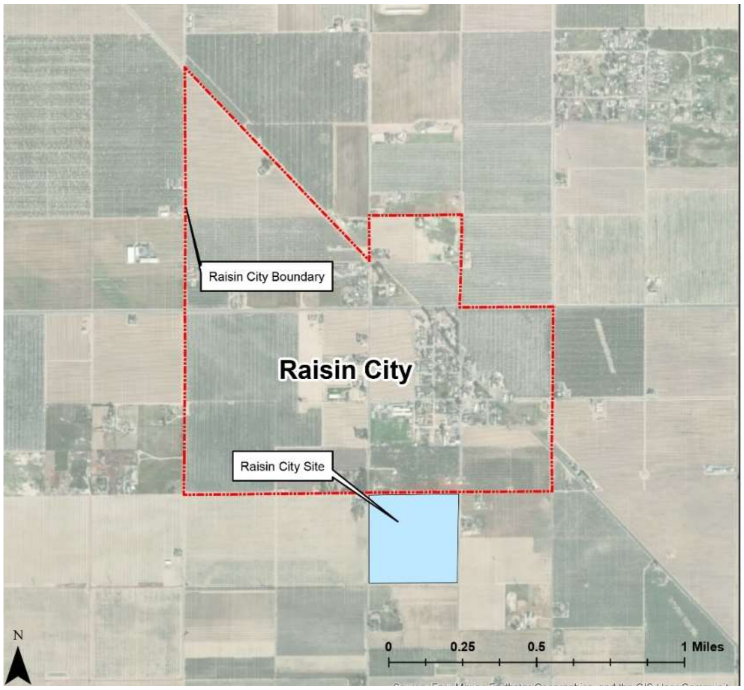


Figure 5-3: Representative Recharge Site for the Raisin City Area

*Disclaimer: These sites depicted in this figure is a representative site. It is only used for educational purposes to evaluate the economic and technical feasibility of a recharge basin development within the identified region.

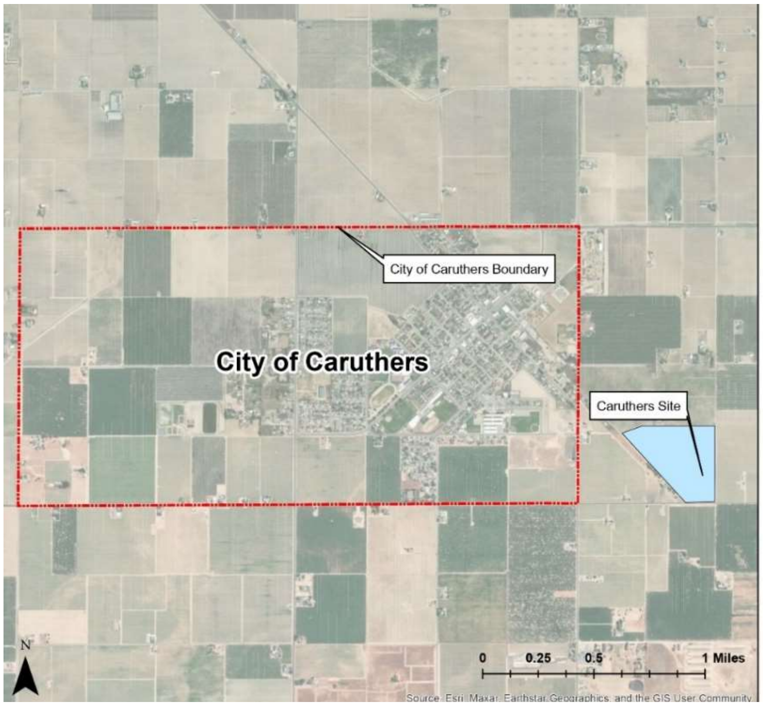


Figure 5-4: Representative Recharge Site for the Caruthers Area

Figure 5-5: Representative Recharge Site for the Laton Area

*Disclaimer: These sites depicted in this figure is a representative site. It is only used for educational purposes to evaluate the economic and technical feasibility of a recharge basin development within the identified region.

5.1.2 Existing Groundwater Quality

Although site-specific shallow groundwater quality is not available at the time of this report, it was estimated that the source water quality of the respective adjacent city for each site would be a suitable surrogate for site-screening purposes. An annual assessment is conducted and published by the State Water Resources Control Board (SWRCB) to determine the water quality provided by a public water system. The results of each condition category and subcategory analyzed in the SWRCB 2023 Drinking Water Needs Assessment are assigned a risk level within the range of no risk, low risk, medium risk, or high risk. For the purposes of this section, the water quality category was reviewed. A summary of the subcategories included in the water quality category is presented in table 5-1, below, as well as each category's applicability to the Study.

Subcategory	Description	Application to Study
History of E. Coli Presence	The history of E. Coli's presence over the previous three years.	Low
Increasing Presence of Water Quality Trends Towards MCL[1]	Increasing levels 80 percent and above that of the MCL for one or more contaminants within the past nine years.	High
Treatment Technique Violations	Violation of an enforceable procedure or technological function during water treatment.	Medium
Past Presence on Failing List	Reflects the presence on the failing list within the past three years.	High
Percentage of Sources Exceeding MCL	Percentage of contaminants exceeding MCL levels within the past three years.	High
Constituents of Emerging Concern	The presence of unregulated chemicals that may impose adverse health effects on humans.	High

Table 5-1: SWRCB Water Quality Risk Categories

[1] The MCL is the maximum level allowed of a contaminant in water which is delivered to any user of a public water system (EPA 2022).

Of the subcategories described in Table 5-1, only four are substantially applicable for consideration in screening potential groundwater recharge sites. A summary of the SWRCB 2023 Drinking Water Needs Assessment findings for the respective areas of the four sites described in this report are presented in Table 5-2, below.

Subcategory	Site Location			
	Kerman	Raisin City	Caruthers	Laton
Increasing Presence of Water Quality Trends Towards MCL	Medium Risk	No Risk	Medium Risk	Medium Risk
Treatment Technique Violations	No Risk	No Risk	No Risk	No Risk
Past Presence on Failing List	Medium Risk	No Risk	Medium Risk	No Risk
Percentage of Sources Exceeding MCL	High Risk	No Risk	High Risk	No Risk
Constituents of Emerging Concern	High Risk	No Risk	No Risk	No Risk
Water Quality Risk Level	**High Risk**	**No Risk**	**High Risk**	**Low Risk**

Table 5-2: Water Quality Risk Level Assessment (California Water Boards 2023)

Safe drinking water is defined by the US Environmental Protection Agency's Safe Drinking Water Standards and Title 22 of the California Code of Regulations. These standards set Maximum Contamination Levels (MCLs) for contaminants in drinking water. While the old saying that dilution is the solution to pollution is true in some cases, the ability to dilute severely contaminated groundwater with recharge water is limited due to the amount of recharge water required to dilute the contaminated water to concentrations less than the MCLs and the time it takes to thoroughly dilute contaminated groundwater. Therefore, placing a recharge basin in a region of highly contaminated groundwater was deemed a lower priority than areas with medium to low contamination. The ability to use dilution to reduce contaminant concentrations to below the MCLs has a much higher probability of success in medium and low contaminated groundwater than in the highly contaminated regions.

In some cases, groundwater recharge might push legacy contaminants down to the water level, this is dependent on several factors and additional studies are needed in this area.

5.1.3 Existing Soil Conditions

In phase 1 of the project, the Soil Agricultural Groundwater Banking Index (SGBI) was used as a preliminary analysis to rank sites. In this phase of the project soil data including soil types and saturated hydraulic conductivity was obtained through the Natural Resources Conservation Service (NRCS) Web Soil Survey (WSS) for each of the potential groundwater recharge sites. Following the collection of WSS data, a site visit and soil sampling was conducted to confirm the findings of the WSS. Samples were collected from each site using a shallow soil auger and soils were analyzed using the United States Department of Agriculture (USDA) Guide to Texture by Feel (Thein, 1979). The USDA flow chart for soil classification is depicted in Appendix A of this report. Understanding the soil characteristics of each project site is critical to evaluating the feasibility of constructing a recharge basin as the soils' characteristic is the determining factor in whether the site will allow for adequate recharge through infiltration and percolation. Soils with large particle diameters are favorable for recharge basin locations as they provide the fastest rate of infiltration and percolation, and because soil characteristics vary over geographic space, analysis of the soils at each project site is essential.

The most accurate way to determine infiltration rates is through conducting geotechnical investigations to better understand a soils' hydraulic characteristics and properly estimate the expected in-situ infiltration rates. Shallow soil samples were taken as a preliminary indicator but additional samples of at least thirty (30) feet are recommended in addition to the Geotechnical investigation. Geotechnical investigations have not been conducted for the purposes of this feasibility study and therefore, saturated hydraulic conductivity is used as a parameter to estimate infiltration. Theoretically, using saturated hydraulic conductivity would yield a conservative estimate of infiltration rates at each project site as saturated hydraulic conductivity is representative of the infiltration rate once the soil has reached its equilibrium infiltration rate, which is lower than a soils' initial infiltration rate.

It is important to note that, without a thorough geotechnical investigation at each future site, there is uncertainty involved as to whether the locations will truly be able to recharge at the rates estimated in this report. Given that there are soil stratifications in the soil profile, it is possible that there are constricting soil layers beneath the topsoil layer investigated as part of the WSS. A constrictive layer would potentially reduce the estimated infiltration rates, and to account for this, a reduction factor of one-third will be applied to the calculated saturated hydraulic conductivity rates calculated from the WSS data.

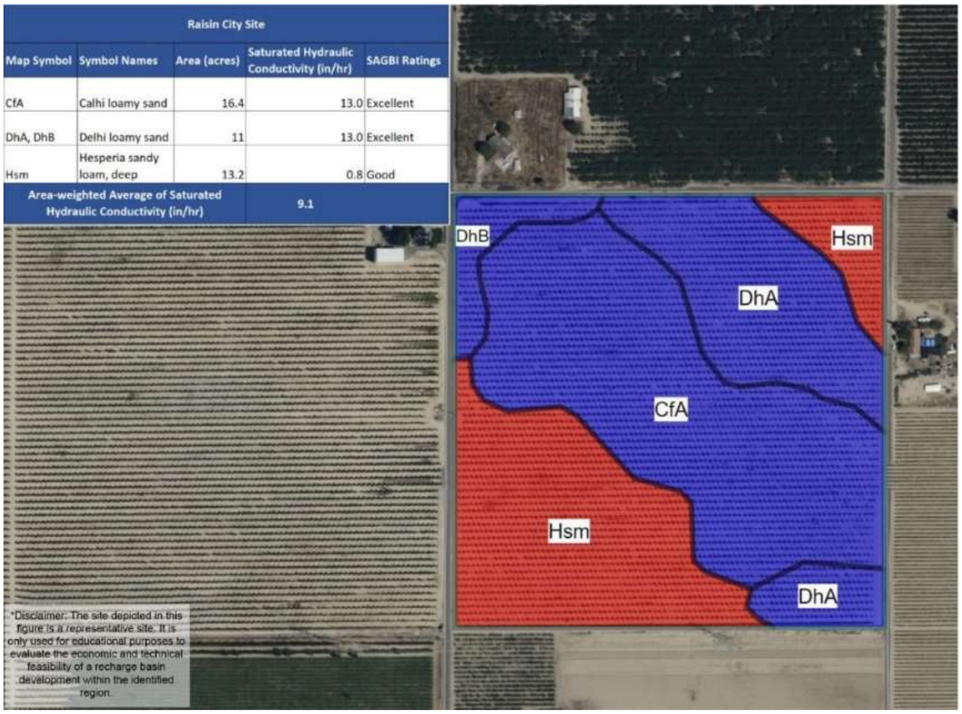
In addition to the analysis of WSS data and in-field soil texture testing, the Soil Agricultural Groundwater Banking Index (SAGBI) was analyzed to determine the soil suitability for recharge at all the representative site locations. SAGBI is a suitability index produced by the University of

California, Davis. The index is based on five major factors: deep percolation, root zone residence time, topography, chemical limitation, and soil surface condition (SAGBI, 2015).

Following the three analyses completed to determine in-situ soil conditions at each proposed site, it is seen that there is relative uniformity between each analysis for all the representative sites. Given the uniformity between analyses and reduction factor applied to the saturated hydraulic conductivity, the calculated infiltration rates are the best estimate of in-situ infiltration rates without completing a geotechnical analysis. The results from all three analyses are summarized in Figures 5-6 through 5-9.

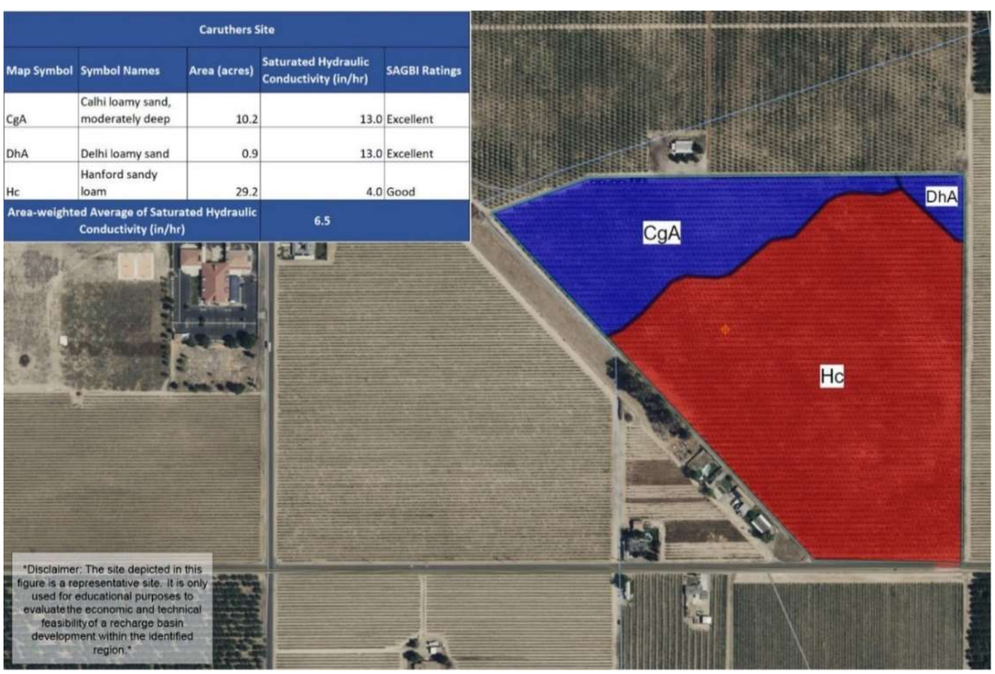
Kerman Site				
Map Symbol	Symbol Names	Area (acres)	Saturated Hydraulic Conductivity (in/hr)	SAGBI Ratings
Hsm	Hesperia sandy loam, deep	20.2	0.8	Good
Ts	Traver sandy loam, moderately deep	9.5	0.2	Moderately Poor
TzbA	Tujunga loamy sand	15.7	13.0	Excellent
Area-weighted Average of Saturated Hydraulic Conductivity (in/hr)			4.9	

Figure 5-6: Representative Kerman Site - Existing Soil Conditions



Raisin City Site				
Map Symbol	Symbol Names	Area (acres)	Saturated Hydraulic Conductivity (in/hr)	SAGBI Ratings
CfA	Calhi loamy sand	16.4	13.0	Excellent
DhA, DhB	Delhi loamy sand	11	13.0	Excellent
Hsm	Hesperia sandy loam, deep	13.2	0.8	Good
Area-weighted Average of Saturated Hydraulic Conductivity (in/hr)			9.1	

Figure 5-7: Representative Raisin City Site - Existing Soil Conditions



Caruthers Site				
Map Symbol	Symbol Names	Area (acres)	Saturated Hydraulic Conductivity (in/hr)	SAGBI Ratings
CgA	Calhi loamy sand, moderately deep	10.2	13.0	Excellent
DhA	Delhi loamy sand	0.9	13.0	Excellent
Hc	Hanford sandy loam	29.2	4.0	Good
Area-weighted Average of Saturated Hydraulic Conductivity (in/hr)			6.5	

Figure 5-8: Representative Caruthers Site - Existing Soil Conditions

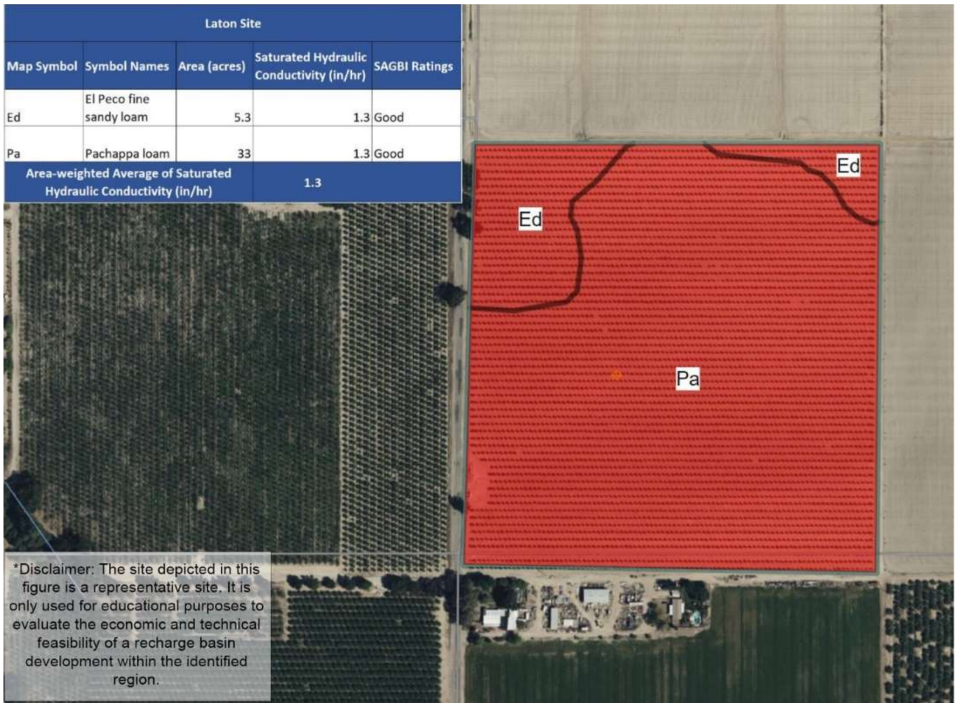


Figure 5-9: Representative Laton Site - Existing Soil Conditions

5.1.4 Existing Vegetation

Geospatial data from DWR used was from 2019 to initially identify sites that were classified as idle or annual crops. As of March 29, 2023, three of the four representative project sites were being actively farmed with existing almond orchards. All vegetation would need to be removed from any site selected as a recharge basin or an alternative site would need to be located. This is a disadvantage for these types of sites for the construction of groundwater recharge basin(s) as the project costs must include (1) the current value of the existing trees, and (2) the value of the lost crop for the remainder of the crop's service life. These costs can be assumed to be included in the cost of the land.

Representative Kerman Site:

The representative Kerman site is currently covered in grass varieties that are roughly 2 feet tall. No other vegetation was present on this site. Vegetation at the Kerman site is shown in Figures 5-10 and 5-11.

Figure 5-10: Southeast corner of representative Kerman site facing North

Figure 5-11: Southern corner of representative Kerman site facing West

Representative Raisin City Site:

An almond orchard, approximately 2- to 5-years old, is in operation on the representative Raisin City site. Vegetation at the Raisin City site is shown in Figure 5-12.

Figure 5-12: Southwest corner of representative Raisin City site facing North

Representative Caruthers Site:

An almond orchard, approximately 5- to 10-years old, is in operation on the representative Caruthers site. Vegetation at the Caruthers site is shown in Figures 5-13 and 5-14.

Figure 5-13: Southwest corner of representative Caruthers Site facing East

Figure 5-14: Southwest corner of representative Caruthers site facing North

Representative Laton Site:

An almond orchard, approximately 2- to 5-years old, is in operation on the representative Laton site. Vegetation at the Laton site is shown in Figure 5-15.

Figure 5-15: Representative Laton site facing West

5.1.5 Existing Roads

Visual assessments of the existing road conditions were conducted at each of the representative sites to determine if any road improvements would be needed for a recharge basin. Observations were made on the traffic volume experienced during a 15-minute interval and the apparent pavement condition. Using aerial images from Google Earth, estimated measurements of the road were made. This information was used to create typical cross sections of the roads to compare with applicable city or county standards.

Representative Kerman Site:

The representative Kerman site is bounded by two streets: Ave A and Ave B. Both roads are classified as collector roads. Ave. A is a 12-foot-wide road and Ave B is roughly 42-feet-wide. Neither road has a curb, gutter, or sidewalk. The traffic volume was observed to be low (less than 5 vehicles per minute) on both roads.

Both Ave A and Ave B are in poor condition. The existing asphalt is old, worn, and patched. Additionally, both roads lack adequate storm drainage. Power lines on Ave A may pose a conflict to equipment entering and exiting the site. Photographs of Ave A and Ave B are included as Figures 5-16 and 5-17, respectively.

Figure 5-16: Ave A facing West

Figure 5-17: Ave B facing Northeast

Representative Raisin City Site:

The representative Raisin City site is bounded by three streets: Ave A, Ave B, and Ave C. All three of the roads are classified as local roads. Ave A and Ave C are roughly 12-feet-wide, and Ave A is roughly 20-feet-wide. None of the roads have a curb, gutter, or sidewalk. The traffic volume was observed to be low (less than 5 vehicles per minute) on all roads.

Ave B is in good condition and appears as though it was recently rehabilitated. Both Ave A and Ave C are in poor condition. The existing asphalt is old and worn. Additionally, all roads lack adequate storm drainage. Photographs of Ave A, Ave B, and Ave C are included as Figures 5-18 and 5-19, respectively.

Figure 5-18: Ave B facing South

Figure 5-19: Ave B facing North

Representative Caruthers Site:

The representative Caruthers site is adjacent to one street, Ave A. Ave A is a local collector road and is roughly 20-feet-wide. The road does not have a curb, gutter, or sidewalk. The traffic volume was observed to be low (less than 5 vehicles per minute) on the road as well.

Ave A is in good condition and appears as though it was recently rehabilitated. A photograph of Ave A is included in Figure 5-20, below. Although Ave A is in good condition, the road lacks adequate storm drainage.

Figure 5-20: Ave A facing East

Representative Laton Site:

The representative Laton site is bounded by two streets: Ave A and Ave B. Both roads are classified as local roads. Ave A is a 20-foot-wide road and Ave B is roughly 12-feet-wide. Neither road has a curb, gutter, or sidewalk. The traffic volume was observed to be low (less than 5 vehicles per minute) on both roads.

Both Ave A and Ave B are in poor condition. The existing asphalt is old, worn, and patched. Additionally, both roads lack adequate storm drainage. A photograph of Ave A and is included as Figure 5-21.

Figure 5-21: Ave A facing South

5.1.6 Existing Wet Utilities

The information provided below is used to understand the existing utilities that may be encountered while working with a site typical to this.

Representative Kerman Site:

Existing Utilities

The representative Kerman site is located within the City of Kerman for water and sewer service. Based on a review of available existing utility data, sewer, water, and storm pipelines exist adjacent to the representative Kerman site.

Potential Recharge Water Sources

Approximately 3,000 feet to the west of the representative Kerman site, Fresno Irrigation District (FID) operates the Lateral Number 1 (Lateral-1) along Ave C. Lateral-1 ranges from 27- to 36-inches in diameter. A potential connection point was identified along Ave A to obtain water from lateral-1 for conveyance to the proposed recharge basin(s). The pipeline has a diameter of 27 inches at the proposed point of connection.

Based on conversations with a FID engineer, Lateral-1 can convey up to 18 cubic feet per second (CFS). FID's engineer anticipates that on a normal water year, Lateral-1 can provide 3 CFS for up to 10 days per month. Water availability is highly dependent on weather conditions; on average it is expected that water deliveries may range from 1 month in a dry year to 6 months in a wet year. It is also important to note that Lateral-1 has been under maintenance for the past few years, with portions being replaced.

Figure 5-22, prepared by FID personnel indicates the representative Kerman site and Lateral-1 in the context of the FID system.

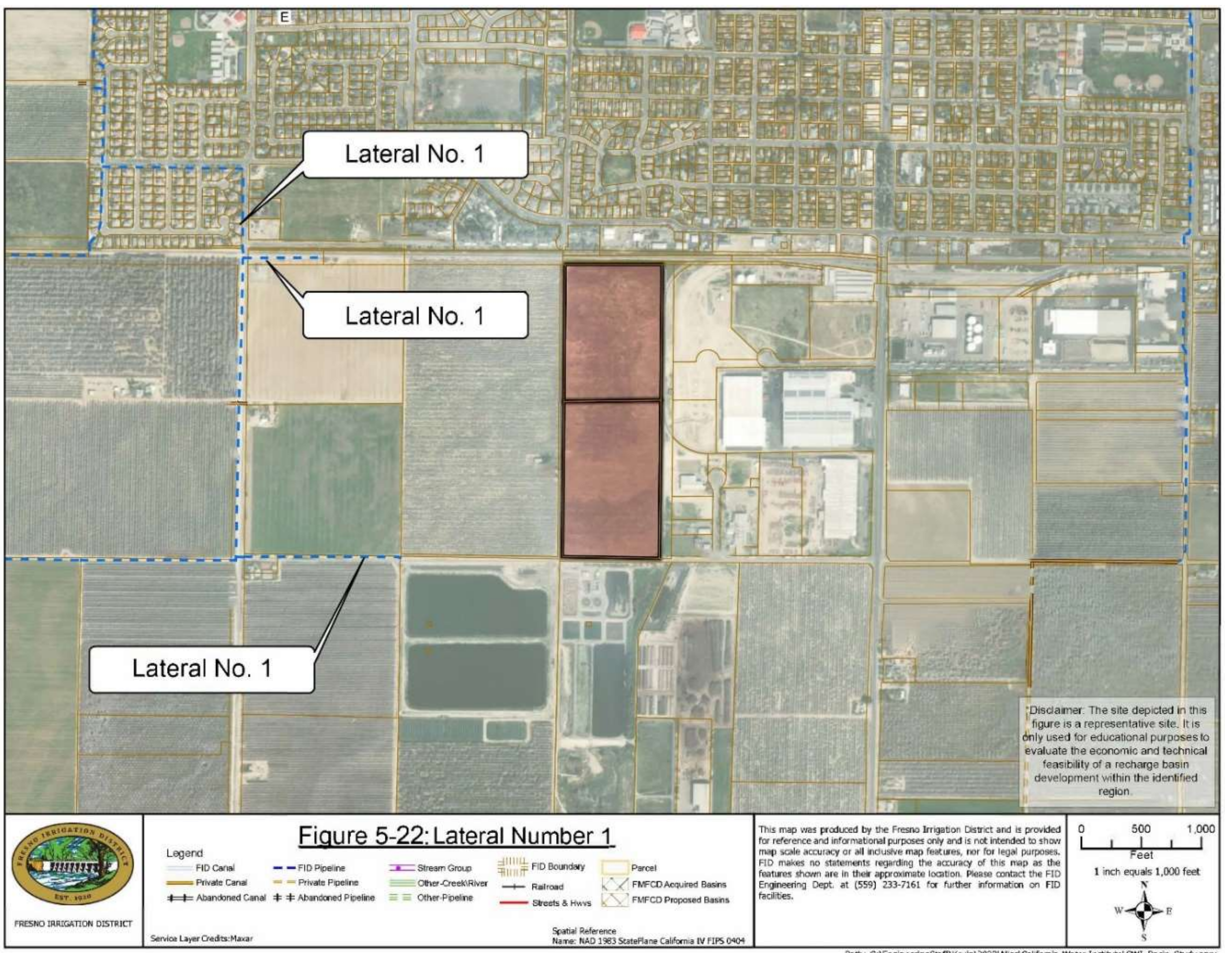


Figure 5-22: Lateral Number 1

Representative Raisin City Site:

Existing Utilities

Based on a review of available aerial imagery, there are no sewer or water pipelines that exist adjacent to the representative Raisin City site. Additional inspections are recommended or working with the local water provider to verify existing utilities, the Raisin City Water District is the nearest provider for water and sewer service to the site.

Potential Recharge Water Sources

Approximately two miles to the south of the representative Raisin City site, McMullin Area Groundwater Sustainability Agency (MAGSA) has proposed construction of the Eastside Canal. A potential turnout point was identified at Ave B and Ave D for conveyance to the proposed recharge basin(s). The proposed Eastside Canal is expected to divert 500 CFS of water from the James Bypass. An accurate estimate of the diversion capacity of the canal to the project site was not available at this time. For the purposes of this Study, it will be assumed that the canal can deliver up to 20 CFS to the representative Raisin City site. However, that cannot be guaranteed, and the resulting uncertainty will be reflected when analyzing the feasibility of this location. The canal is only intended to redirect storm and flood water, so flows would be highly weather-dependent. Additionally, a significant layer of uncertainty to the groundwater recharge project is added given that the canal has not yet been constructed.

Figure 5-23 below illustrates the representative Raisin City site and the proposed Eastside Canal.

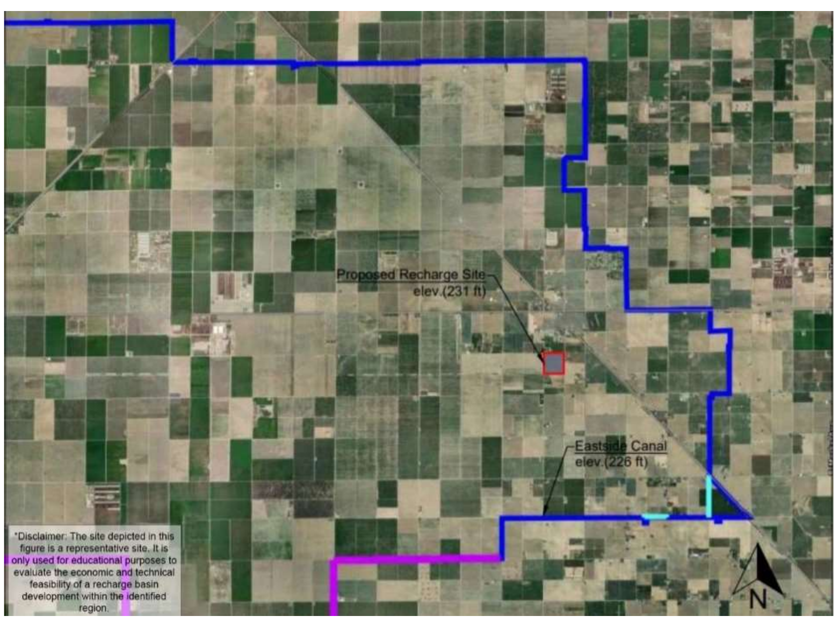


Figure 5-23: Proposed MAGSA Eastside Canal (Provost & Pritchard Consulting Group, 2022)

Representative Caruthers Site:

Existing Utilities

Upon researching local utilities, it does not appear that there are any existing wet utilities in close proximity to the representative Caruthers site. Additional inspections are recommended or working with the local water provider to verify existing utilities, the Caruthers Community Services District is the nearest provider for water and sewer service to the site.

Potential Recharge Water Sources

Approximately 3,850 feet to the north of the representative Caruthers site, Consolidated Irrigation District (CID) operates an existing water conveyance canal, the Harlen Stevens Ditch. The Harlen Stevens Ditch is a canal that flows from east to west split from the Fowler Switch Canal, which diverts water off the Kings River. A potential connection point was identified at Ave B and Ave C or conveyance to the proposed recharge basin(s). The canal could deliver up to 20 CFS to the representative Caruthers site when irrigation demand is low and/or zero. CID is also currently constructing a 100-acre recharge basin upstream of the proposed site in Caruthers, which could have an adverse effect on this site's ability to receive water.

Figure 5-24 below indicates the canal's proximity to the Caruthers site.

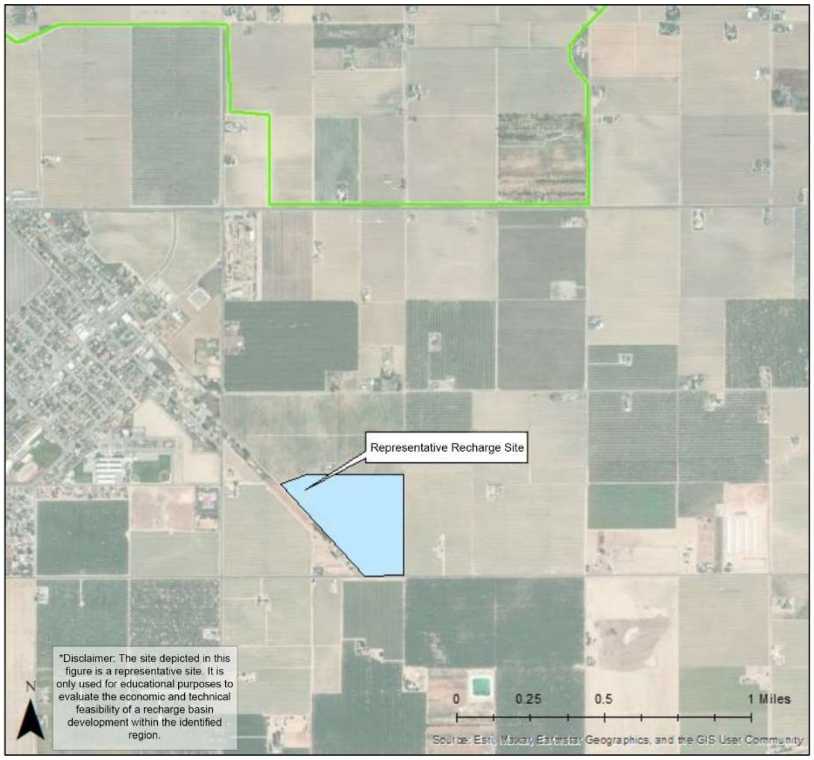


Figure 5-24: Harlen Stevens Ditch

Representative Laton Site:

Existing Utilities

Upon researching local utilities, it does not appear that there are any existing wet utilities in close proximity to the representative Laton site. However, a drip irrigation filtration system is present at the site and would need to be demolished during construction of recharge basin(s) (Figure 5-25).

Figure 5-25: Laton Drip Irrigation System

Potential Recharge Water Sources

Although there are several canals near the representative Laton site, the closest is the Murphy Slough Canal operated by the Laguna Irrigation District (LID). The existing canal diverts water from the Cole Slough and conveys water from east to west through the City of Laton. A potential connection point was identified at the intersection of Ave A and the Murphy Slough for conveyance to the proposed recharge basin(s). Based on discussion with LID staff, the Murphy Slough Canal could deliver between 18 and 20 CFS to the Laton site based on water availability.

Figure 5-26 below indicates the representative Laton site and the Murphy Slough Canal.

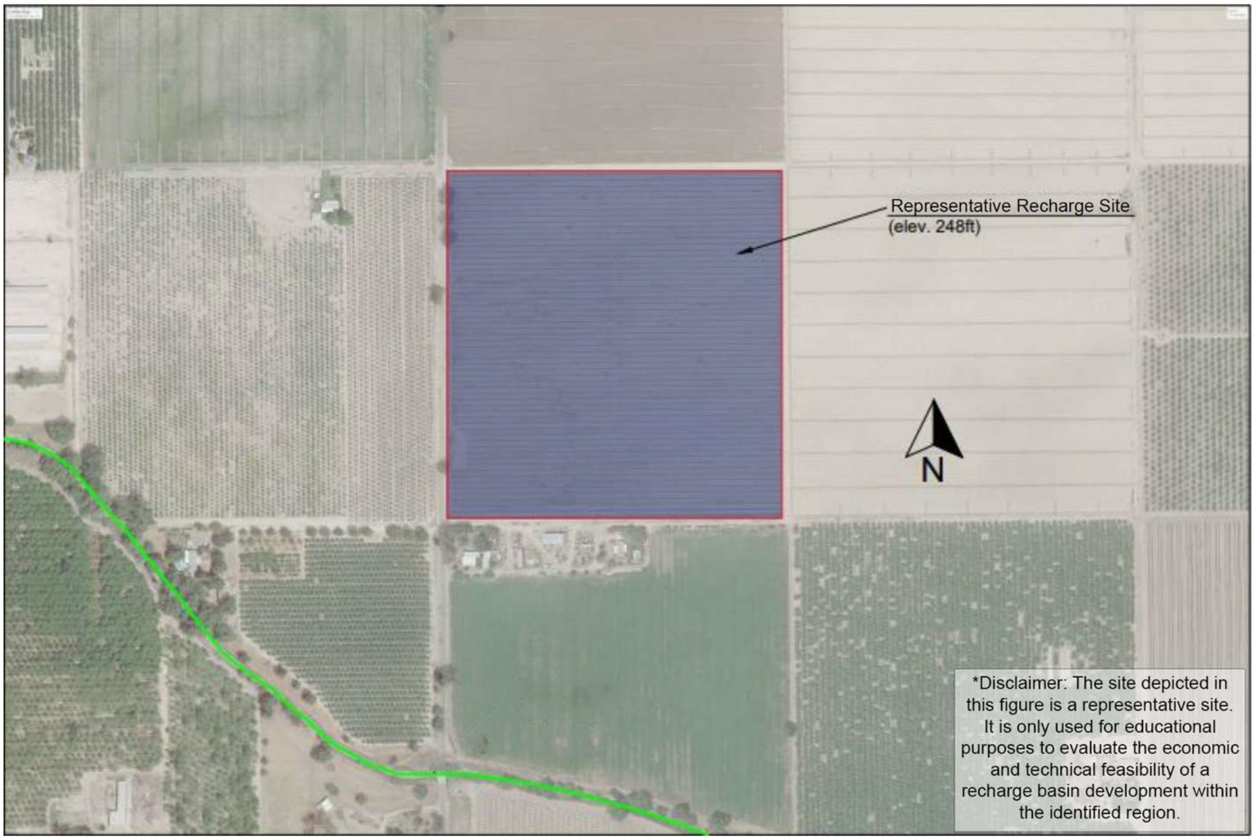


Figure 5-26: Murphy Slough Canal

5.1.7 Existing Dry Utilities

Representative Kerman Site:

Based on a preliminary records search and site visit, the representative Kerman site has overhead power lines that border the entirety of the east and south property lines. There are no known gas pipelines, hazardous liquid pipelines, or telecommunication facilities near the Site.

Representative Raisin City Site:

Based on a preliminary records search and site visit, the representative Raisin City site has overhead power lines that border the west, north, and south property lines. There are no known gas pipelines, hazardous liquid pipelines, or telecommunication facilities near the Site.

Representative Caruthers Site:

Based on a preliminary records search and site visit, the representative Caruthers site has overhead power lines that border the south site property line. There are no known gas pipelines, hazardous liquid pipelines, or telecommunication facilities near the Site.

Representative Laton Site:

Based on a preliminary records search and site visit, the representative Laton site has overhead power lines that border the south of the property line as well as a portion of the west property line. There are no known gas pipelines, hazardous liquid pipelines, or telecommunication facilities near the Site.

5.1.8 Existing Condition Site Plans

Site plans for each of the four representative sites were prepared to document the existing conditions. The existing conditions site plans aim to present a comprehensive view of the conditions previously discussed in this section. Please see the existing conditions site plans included as Figures 5-27 through 5-30.

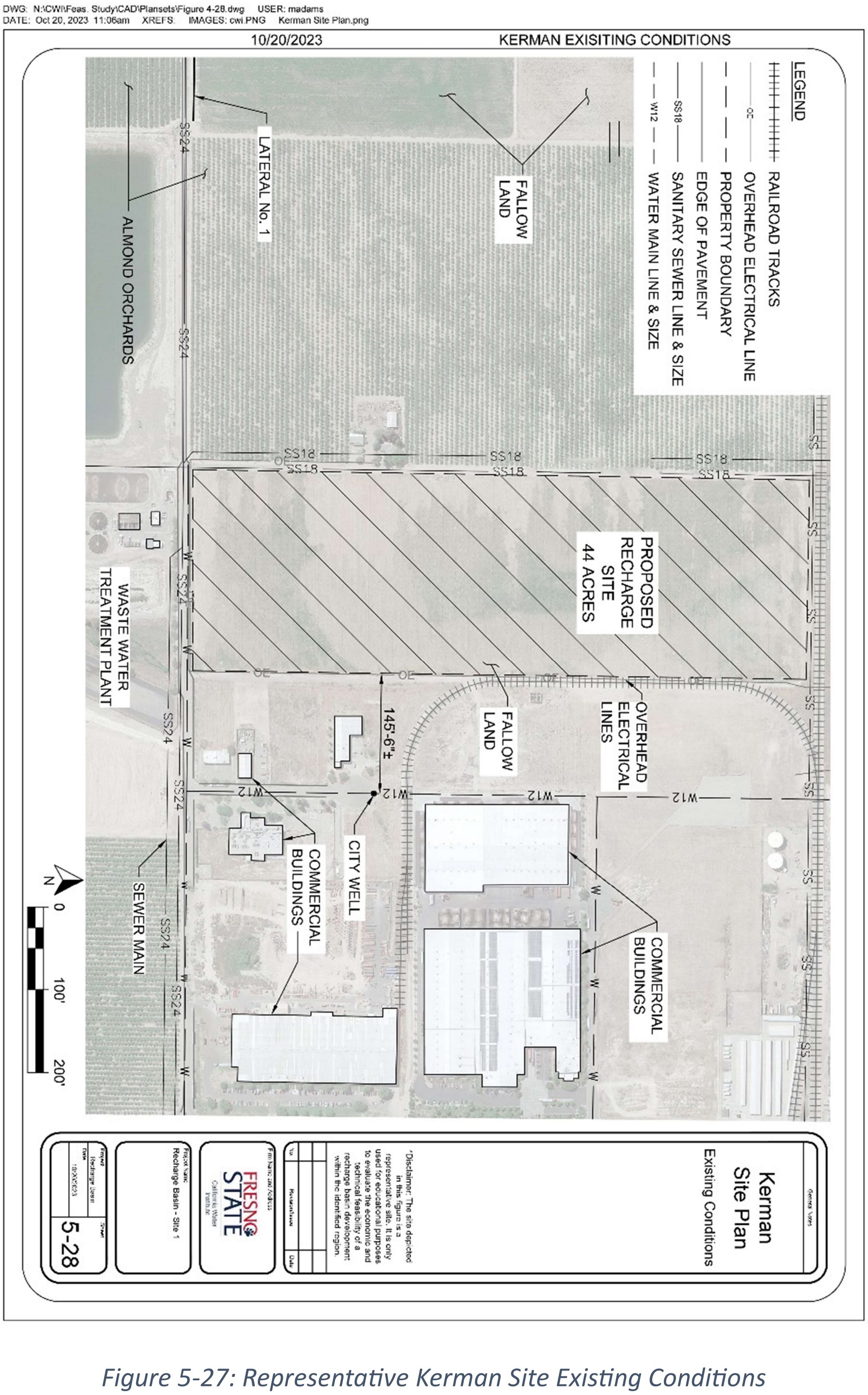


Figure 5-27: Representative Kerman Site Existing Conditions

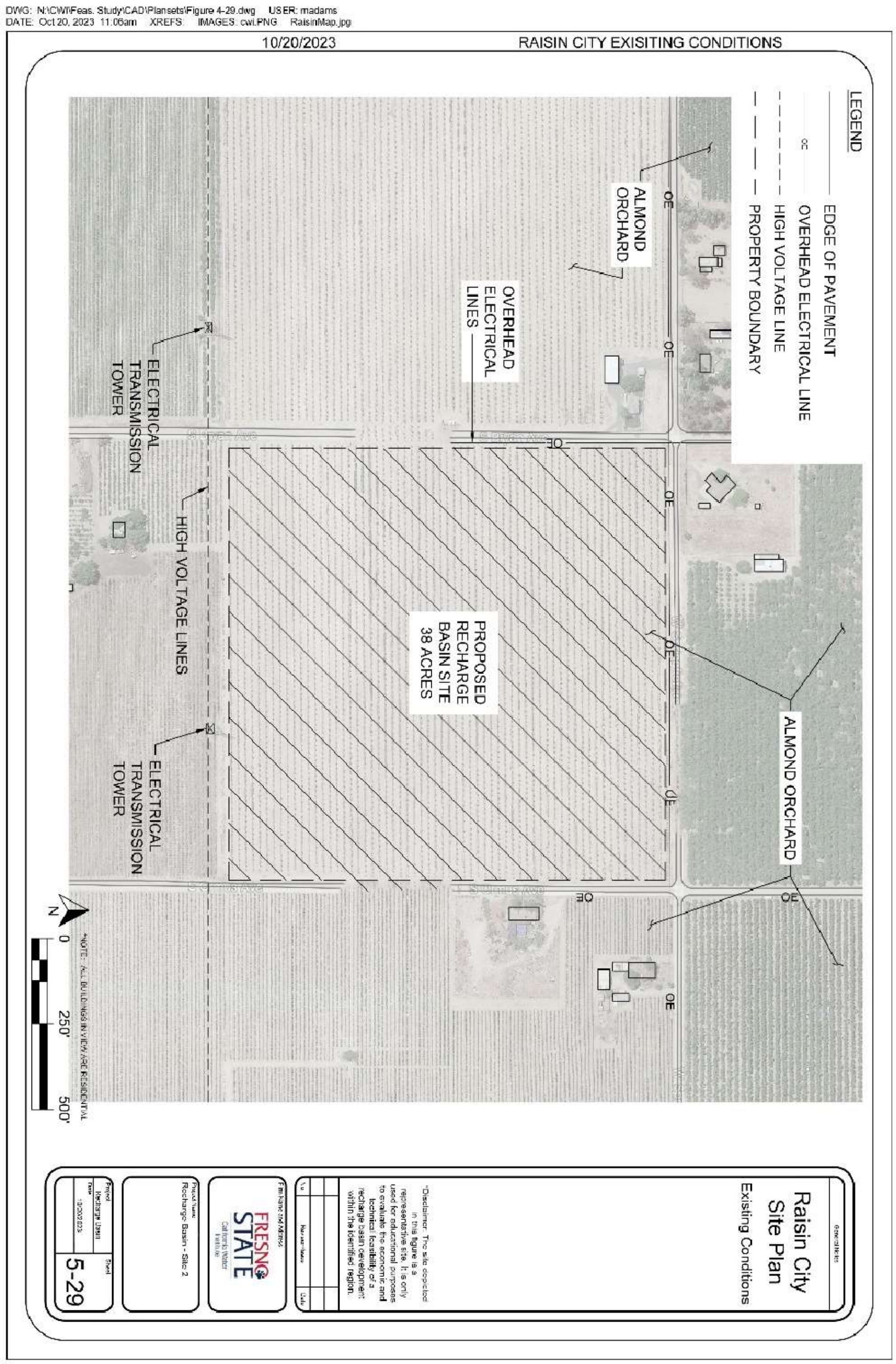


Figure 5-28: Representative Raisin City Site Existing Conditions

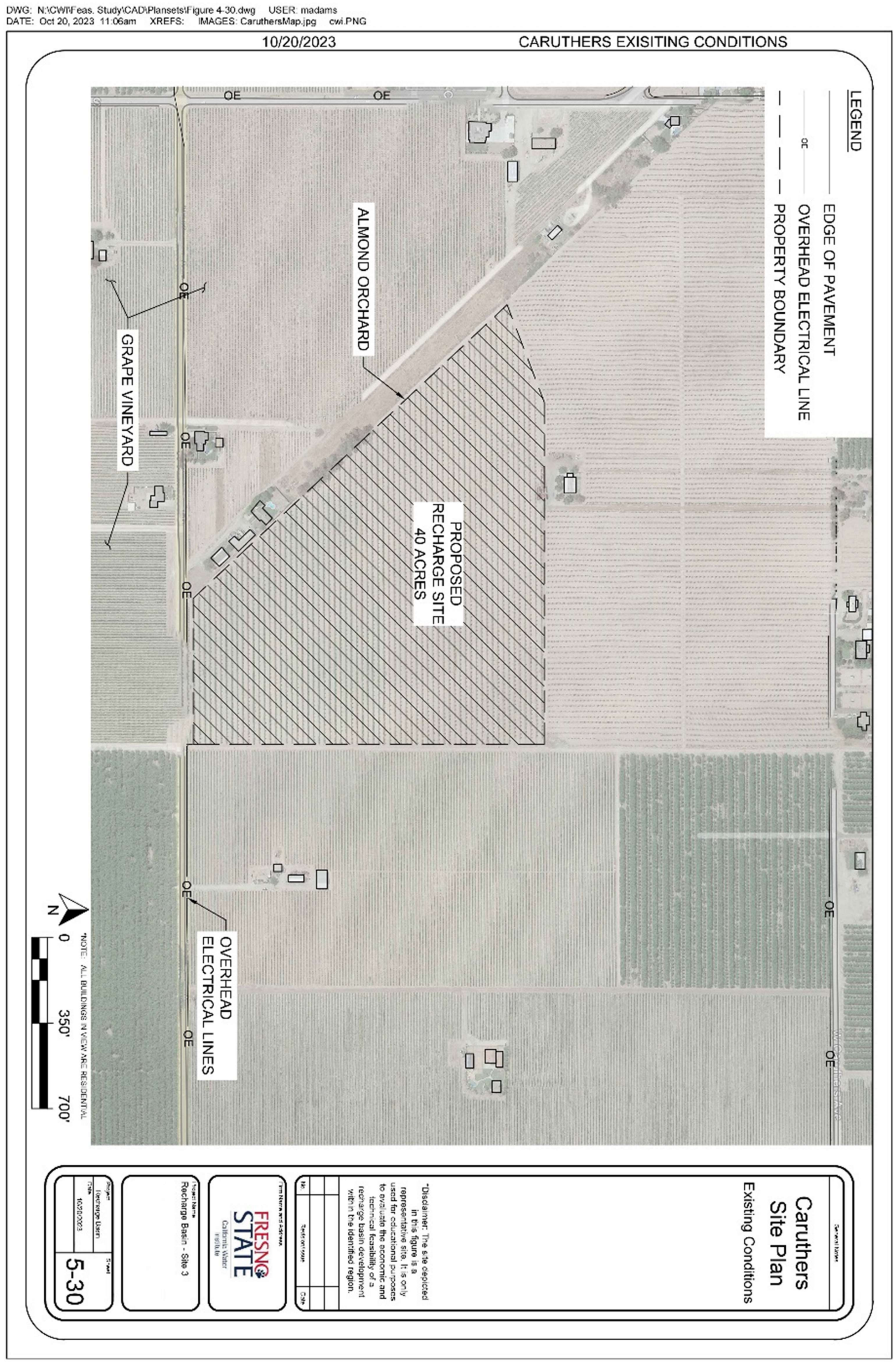


Figure 5-29: Representative Caruthers Site Existing Conditions

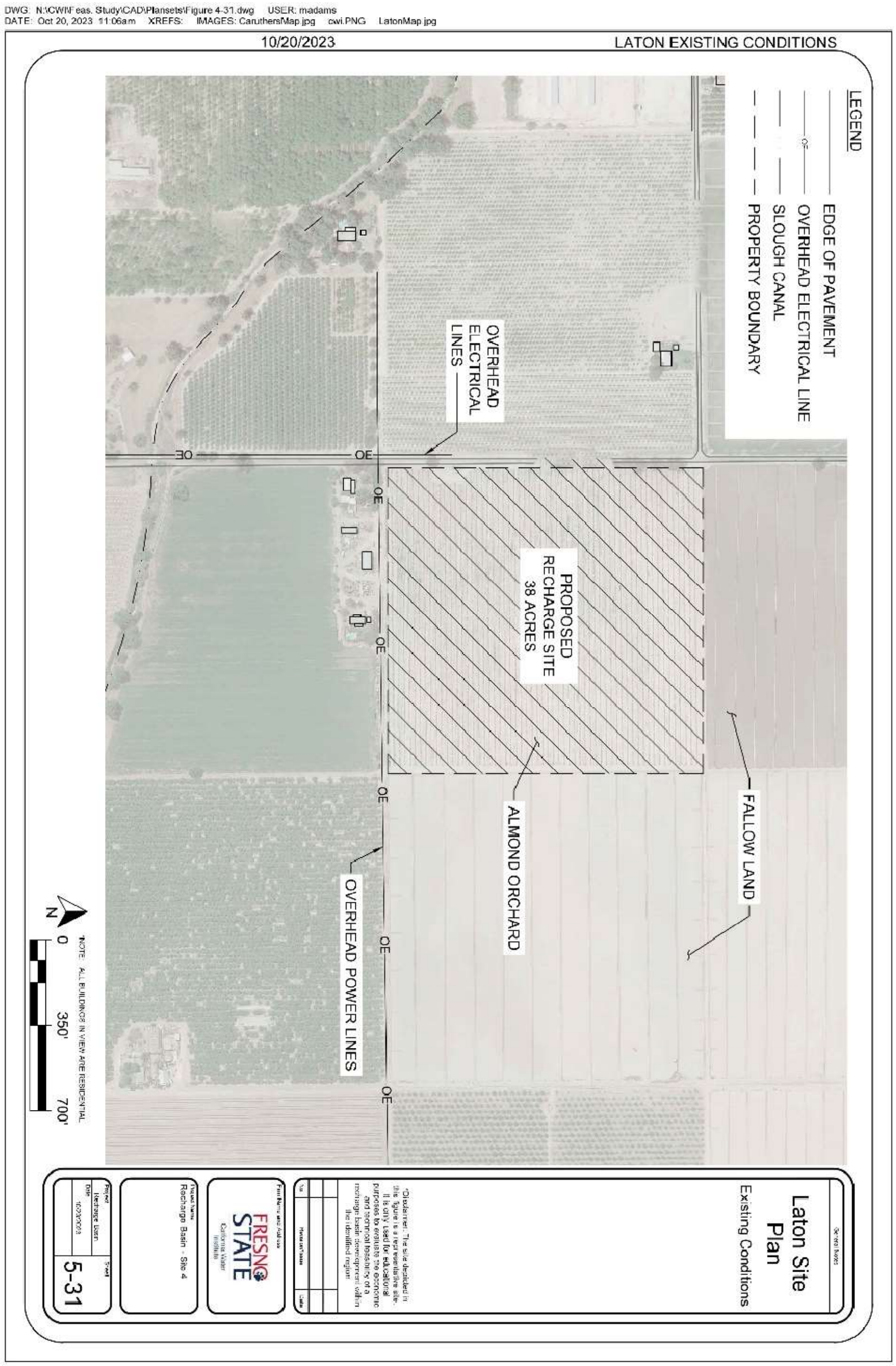


Figure 5-30: Representative Laton Site Existing Conditions

5.1.9 Existing Jurisdiction – Entitlement and Permit Processes

As discussed in Section 5.1, three of the four representative sites for this project are under the jurisdiction of Fresno County. Thus, Fresno County has the authority to approve the proposed projects and issue any required entitlements and permits. The representative Kerman site is within the jurisdiction of the City of Kerman, and as such, the City of Kerman would issue entitlements and permits.

Each representative location would be owned and operated by the respective water authority, farmer, community, or other local entity. That is, all water delivery logistics and fees post-construction would be the responsibility of the respective entity.

Typically, for the Fresno County proposed locations, the permits required for construction of groundwater recharge basins and associated conveyance are a grading and City/County encroachment permit. The grading permit is necessary due to the volume and depth of grading to be completed for construction. The encroachment permit is necessary to install the conveyance pipeline along the roadways between the water source and recharge basin.

For the representative City of Kerman location, the permits required for construction of groundwater recharge basins and associated conveyance are an encroachment and conditional use permit. The conditional use permit is necessary because the two parcels are currently zoned as M-2, Heavy Manufacturing, and the land use is considered Industrial. The conditional use permit will allow for the construction of recharge facilities which would not ordinarily fall under the current zoning requirements. It is anticipated that obtaining a conditional use permit will take roughly 12 weeks. However, the time to obtain the permit could extend past 12 weeks as the permit needs discretionary approval from the Planning Division. The encroachment permit is necessary to install the conveyance pipeline along the roadways between the water source and recharge basin. It should be noted that the City of Kerman did not have any documentation to indicate that a grading permit would be required. The anticipated permits for the development of the proposed sites are summarized in Table 5-3 below.

Site Location	Jurisdiction	Required Permits	Anticipated Time to Acquire Permits
Kerman	City of Kerman	Encroachment, Conditional Use	8 - 12 Weeks
Raisin City	Fresno County	Road Encroachment, Grading	8 - 12 Weeks
Caruthers	Fresno County	Road Encroachment, Grading	8 - 12 Weeks
Laton	Fresno County	Road Encroachment, Grading	8 - 12 Weeks

Table 5-3: Anticipated Permitting Requirements

5.1.10 Williamson Act

When reviewing the most current parcel maps, the representative Raisin City and Caruthers sites were found to be agricultural preserves under the Williamson Act. The Williamson Act was passed to preserve agricultural land and combat urban sprawl of cities. The act allows landowners to voluntarily enter into a contract with their county or city to use the land exclusively for agricultural purposes. In return, property assessments are lower for these parcels as they are not assessed at free market value. This restriction of land use may prevent a project from acquiring the proper permits to construct a recharge basin on sites with Williamson Act contracts (California Department of Conservation, 2023). It will be up to the interpretation of the local City Council or planning department to determine if the Williamson Act will allow for the construction of a recharge basin.

Enrollment of the representative Raisin City and Caruthers sites was verified by reviewing the latest Williamson Act enrollment data listed by the California Department of Conservation, as indicated in Figures 5-31 and 5-32. In the referenced figures, green indicates prime agriculture land, brown indicates nonprime agriculture land, and orange indicates that the parcel will no longer be under the Williamson Act in the following year.

Figure 5-31: Representative Raisin City Site- Williamson Act (California Department of Conservation, 2022)

Figure 5-32: Representative Caruthers Site – Williamson Act (California Department of Conservation, 2022)

Based on the maps provided by the California Department of Conservation, the representative Raisin City site is nonprime land while the site at representative Caruthers is prime agricultural land. Both sites are enrolled under standard contracts with an initial minimum term of 10 years.

While this project does not encourage taking farmland out of production for groundwater recharge purposes, these lands may be ideal sites for FloodMAR or On-Farm Recharge if surface water is available.

5.1.11 Existing Stakeholders

Several stakeholders will be involved in the planning, permitting, and implementation of the proposed project. A summary of the stakeholders involved in the project for each representative site is included in the tables below. Table 5-4 shows the analysis of stakeholders for the representative Kerman Site. Due to all stakeholders being equal with the exception of water authorities at the remaining sites, the analysis of stakeholders for the representative Raisin City, representative Caruthers, and representative Laton Sites are respectively summarized in Table 5-5.

Kerman Site Stakeholder Analysis				
Stakeholder	**Interest in Project**	**Assessment of Power**	**Assessment of Resources**	**Potential Management Level**
Landowner	Right to the property/economic benefit	Potential to reject project/hold land	Land resources	Medium
City of Kerman	Project Site within City Limits	Permit Approval	Public City Resources	High
Fresno Irrigation District	Potential Customer/ Improvement in groundwater levels	Water use approval	Water Resources	High
Neighboring Residents	Project acceptability/benefit to the community	Potential to resist project	City officials	Low
State of California	Compliance with AB 685	Minimal	Public State resources	Low

Table 5-4: Kerman Site Stakeholder Analysis

Raisin City, Caruthers, and Laton Site Stakeholder Analysis				
Stakeholder	**Interest in Project**	**Assessment of Power**	**Assessment of Resources**	**Potential Management Level**
Landowner	Right to the property/economic benefit	Potential to reject project/hold land	Land resources	Medium
Fresno County	Project Site within County Limits	Permit Approval	Public County Resources	High
MAGSA, CID, LID	Potential Customer/ Improvement in groundwater levels	Water use approval	Water Resources	High
Neighboring Residents	Project acceptability/benefit to the community	Potential to resist project	City officials	Low
State of California	Compliance with AB 685	Minimal	Public State resources	Low

Table 5-5: Raisin City, Caruthers, and Laton Stakeholder Analysis

5.1.12 Existing Demographics

Based on an independent analysis performed by the California Water Boards, the residents within the area where the representative sites are located are recognized as members of disadvantaged communities or severely disadvantaged communities by the State of California (California Water Boards, 2023). Additionally, these communities are predominately reliant on groundwater, making them susceptible to the negative impacts of depleting groundwater levels in the San Joaquin Valley.

Kerman Area:

The City of Kerman is the largest community in this study, with a population of approximately 16,000 residents (U.S. Census). The median household income of $61,051 (California Water Boards, 2023) which categorizes the community as a disadvantaged community.

Raisin City Area:

The community with the lowest population in this study is Raisin City. According to recent data, the population is approximately 182 people (U.S. Census). The median household income is $32,142, which categorizes the city as a severely disadvantaged community (California Water Boards, 2023).

Caruthers Area:

The city of Caruthers has a population of approximately 2,503 residents (U.S. Census). This is another severely disadvantaged community, with the median household income being $48,653 (California Water Boards, 2023).

Laton Area:

The City of Laton has a population of 1,551 (U.S. Census). The median household income is $37,813 and is categorized as a severely disadvantaged community (California Water Boards, 2023).

5.2 Project Conditions

This section will outline the necessary conditions for the conceptual design of the recharge basins at each representative site. This includes the criteria and philosophy for design of the basins as well as the water conveyance facilities, basin, and water conveyance design, on and off-site improvements, conceptual design plans, and cost estimates. In each section, assumptions, and further work to verify said assumptions will be clearly outlined.

5.2.1 Design Criteria and Philosophy

The conceptual recharge basin design will follow the details specified by Caltrans Infiltration Basin Design Guidance handbook (Caltrans handbook). This section will discuss the design parameters set by the handbook as well as the parameters and assumptions for recharge basin and water conveyance design. New research and practices are showing that a slight slant in the bed of the basin might be beneficial for wildlife in the area.

5.2.2 Basin Design Criteria

The recharge basin design is predominantly controlled by two variables: infiltration/percolation rates and water delivery capacity. To size the total bottom area[2] of basins at each site, a mass balance is performed to ensure that the basins can maintain steady state conditions as designed (i.e., the total required bottom area of a basin can infiltrate/percolate the delivered water and the delivered water is sufficient to maintain the infiltration/percolation rate). Once the total required bottom area is calculated for each site, that total bottom area is divided into multiple basins to improve the operations and maintenance capabilities of each site. The size and quantity of basins will vary from site to site based on total calculated required bottom area and site logistics.

Infiltration/percolation rates were calculated in CFS for each representative site based on the total required bottom area of each representative site using the area weighted NRCS saturated hydraulic conductivity design values shown in Table 5-6 below. It should be noted that the design of any recharge basin must be based on a geotechnical investigation report to verify the calculated NRCS values for infiltration, as this is one of the most important parameters surrounding the design of the basins. Recommended tests before proceeding with further design include but are not limited to soil classification, double ring infiltrometer tests at various depths below the bottom of the basins, and saturated hydraulic conductivity per ASTM standards for representative soils to depths of 50 to 100 feet, depending on the depth to groundwater. During this testing, depth to groundwater, historical groundwater depth, and groundwater quality should also be investigated by means of analyzing nearby wells or conducting further geotechnical analyses.

[2] Bottom area is defined as the area of the basin floor that is not part of the embankment walls.

Infiltration Rates		
Proposed Site	**Area Weighted NRCS Value (in/hr)**	**Design Value (in/hr)**
Kerman	4.9	1.63
Raisin City	9.1	3.03
Caruthers	6.5	2.17
Laton	1.3	0.43

Table 5-6: Project Site Infiltration Rates

Based on the Caltrans handbook, which recommends minimum infiltration rates of 0.5 in/hr, all of the representative sites fit the minimum recommended infiltration rates for the consideration of an infiltration basin before the design reduction factor of one third is applied to the values. However, after the reduction factor is applied, the representative Laton site no longer fits this criterion, which again emphasizes the need for further geotechnical investigation.

Water delivery rates to each representative site were assumed to be the maximum flowrate provided by each respective water authority. This assumption is grounded in the fact that these basins are anticipated to be fully utilized when there is excess surface water available for recharge, and in which case, delivery of recharge water would not be affecting other customers of the water authority. Before proceeding with the design or a recharge basin, additional correspondence with water authority personnel must be initiated in order to glean a more accurate understanding of the true water delivery capacities.

Evaporation and rainfall were also investigated for each of the regions to determine whether to account for them in the mass balance for the basin sizing. Based on the investigation, the change in basin water levels resulting from evaporation and rainfall were found to be negligible in comparison to infiltration and water delivery flowrates for recharge basins within these regions. As a result, the effects on recharge basin water level from evaporation and rainfall will be accounted for by the conveyance system operator to ensure the basins remain in steady state conditions.

After the mass balance is completed to determine the footprint of the basins at each representative site, the remainder of the geometric properties of the basins were determined based on the Caltrans Infiltration Basin Design Guidance handbook. The design parameters used are summarized in Table 5-7 below.

Infiltration Basin Design Criteria		
Parameter	Minimum Value	Maximum Value
Runoff Volume	For water quality treatment, WQV, or portion thereof	None as long as other site conditions and requirements are met
Freeboard	1 ft minimum	1 ft minimum
Design Overflow Event	Use the HDM Design Storm or local regulations	Use the HDM Design Storm or local regulations
Invert Slope	0% (preferred)	3%
Interior Side Slopes	No steeper than and up to 4H:1V	3H:1V (only with approval by District Maintenance)
Drawdown Time	96 hours max	96 hours max
In-situ Infiltration Rate	0.5 in/hr	2.5 in/hr

Table 5-7: Infiltration Basin Design Criteria (Caltrans 2020)

Using the guidance from the table above, the basins at each site will be designed to have the properties shown in Table 5-8.

Recharge Basin Design Criteria	
Interior Side Slopes	4H:1V
Exterior Side Slopes	3H:1V
Floor Invert Slopes	0%
Water Depth	4 feet
Freeboard	1 foot
Total Depth	5 feet
Embankment widths	12 feet minimum

Table 5-8: Recharge Basin Design Criteria

The water depth of four feet was chosen to limit aquatic growth as well as the earthwork required to construct the basins. For the purposes of conceptual design, it will be assumed that the existing ground surface is cut down to a depth of three feet and the cut material will be used to construct a two-foot-tall embankment of engineered fill to reach the total design depth of two feet. The assumed depths are subject to change upon further geotechnical investigation revealing site-specific geology, as well as the earthwork balancing to minimize the amount of soil needing transportation to reduce cost.

5.2.3 Water Conveyance Infrastructure Design Criteria

The wet utility improvements and design for each project site were based on the following criteria presented in Table 5-9 below.

Wet Utility Design Criteria	
Pipeline Velocity	< 5 ft/s
Pipeline Material	PIP (SDR 41) or C900 (DR 31)
Maximum Operating Pressure	60 psi
Air Release Valves	Air valves to be located at all local high points and ¼ mile minimum spacing.
Blowoff Stations	Blow-off stations to be located at all local low points.
Isolation Valve Type/Material/Spacing	Cast Iron Gate Valves at 1000 foot minimum spacing along water conveyance alignment.
Horizontal and Vertical Clearance	A minimum of 10-foot horizontal clearance between pressure water and sewer pipelines, and a minimum 1-foot vertical clearance shall be provided at perpendicular water and sewer crossings.
Pipe Cover	3 foot minimum or as recommended by geotechnical report in future design.
Thrust Restraint	Concrete thrust blocks at all pipe bends greater than 5 degrees, at tees, at valves, at dead ends, and at other locations there is the potential for thrust.
Pump Requirements	Predicted based on pressure loss calculations.

Table 5-9: Wet Utility Design Criteria

The pipeline sizes needed to convey recharge water from the water agency infrastructure to the representative sites were determined by using the design flowrates to ensure the velocity constraints are met for the selected size. After pipeline sizes were determined, the pressure loss was calculated by summing the total energy losses and change between the water agency infrastructure and the representative site served by the infrastructure. An understanding of energy loss and elevation differences between the representative sites and the water agency infrastructure allows for an accurate prediction on whether a pump station will be necessary at the turnout location to convey the design flows at adequate pressure to the representative sites. It is assumed that pump station design would be completed in subsequent design phases upon selection of an actual recharge basin site.

At the entrance of each representative site, an isolation valve is provided to control the flow of recharge water into the site. Directly downstream, an appropriately sized magnetic flowmeter is provided to measure the quantity of water delivered to the site.

At the basin inlets of each representative site, control structures are provided to manage the flows into each basin. Control structures consist of a manifold with gate valves and piping corresponding to the calculated pipeline size and number of basins on the representative site.

5.2.4 Basin Design

Using the methods explained in Section 5.2.2, total basin bottom areas were calculated for each representative site and divided into multiple basins for the purpose of operations and maintenance. Based on the infiltration rate calculated from the basin bottom area, the total volume of water recharged per year was also calculated in acre-feet assuming the basins have water available for an average of three months out of the year during non-irrigation season. Table 5-10 below summarizes the basin design results.

Representative Project Site	Kerman	Raisin City	Caruthers	Laton
Basin Floor Area (acres)	2.75	3.25	4.5	6.5
Number of Basins	4	2	2	4
Total Basin Recharge Area (acres)	11	6.5	9	26
Infiltration Rate (in/hr)	1.63	3.03	2.17	0.43
Infiltration Rate (cfs)	18.1	19.9	19.7	11.3
Water Delivery Flow (cfs)	18.0	20.0	20.0	20.0
Potential Volume of Water Recharged per Year Recharge Water is Available (AF)	3230	3545	3515	2015

Table 5-10: Basin Sizing and Recharge Potential

For construction of the basins, each of the project sites will need the following on-site improvements:

- Tree/vegetation removal
- Excavation and grading of basins
- Embankment construction and compaction
- Perimeter fencing

5.2.5 Water Conveyance Infrastructure Design

This section includes a description of the anticipated improvements necessary to convey water from the respective source location to the recharge sites. Each of the conceptual designs presented in this section are based on the design criteria presented in Section 5.2.3.

Representative Kerman Site:

The representative Kerman site includes a pipeline to convey approximately 18 CFS from FID's Lateral-1 to the representative site. A 27-inch PIP pipeline would be connected to Lateral-1 in accordance with FID Standard Detail 4-01 followed by a series of duty and standby vertical turbine pumps in a wetwell or "can" structure at Ave A, approximately 0.25-miles west of the representative site. The pipeline is approximately 2,300 linear feet (LF) long, extending from the connection point east to the mid-point of the representative site and north to a basin inlet structure. A flow meter and site isolation valve are provided at the entrance to the representative site. Screening or filtration at the representative site entrance should be considered based on incoming water quality as well. The basin inlet structure consists of a manifold with 14-inch control valves and 15-inch PIP inlet piping to each basin. The design of an actual recharge basin requires coordination with city officials will be necessary to ensure the pipeline construction does not interfere with the existing water, sewer, and storm pipelines adjacent to the project site.

The available pressure at the connection point to Lateral-1 is unknown, and the site is approximately 4-feet higher in elevation. It is anticipated that a pump station may be necessary at the FID connection point to produce adequate pressure to convey the design flows to the project site. As stated above, the pump station would include a series of duty and standby vertical turbine pumps as well as electrical improvements, controls facilities, and appropriate easements or property acquisition. A pressure loss of 20.1-feet (8.7-psi) is estimated between the connection and discharge points. It was assumed that the connection point at Lateral-1 is operated at a pressure well above 8.7 psi.

During a subsequent or preliminary design study, pipe sizes, valve sizes, and pump station requirements should be reevaluated following a geotechnical study and an evaluation of available flows from FID. Further, the existing available pressure in Siskiyou-146 at the connection point should be determined to confirm the necessity of including a pump station.

Representative Raisin City Site:

The representative Raisin City site includes a pipeline to convey approximately 20 CFS from MAGSA's proposed Eastside Canal to the recharge site. A 30-inch C900 pipeline would be connected to the Eastside canal via a turnout at the intersection of Ave D and Ave E, approximately 2.5-miles south and west of the project site. The pipeline is approximately

10,500 LF, extending from the connection point east to Ave B, north to the mid-point of the project site, and east to a representative site's inlet structure. A flow meter and site isolation valve are provided at the entrance to the representative site. Screening or filtration at the site entrance should be considered based on incoming water quality as well. The basin inlet structure consists of a manifold with 14-inch control valves and 14-inch C900 inlet piping to each basin.

The approximate elevation at the connection point to the Eastside Canal is about 8-feet lower in elevation than the representative site. It is anticipated that a pump station would be necessary at the Eastside Canal turnout to produce adequate pressure to convey the design flows to the project site. The pump station would include a series of duty and standby vertical turbine pumps in a wet well or "can" structure, electrical improvements, controls facilities, and appropriate easements or property acquisition. A pressure loss of 32.6-feet (14.1-psi) is estimated between the connection and discharge points.

The completion of a preliminary design study for any recharge basin must include a check on the pipe sizes, valve sizes, and pump station requirements should be reevaluated following a geotechnical study and an evaluation of available flows from MAGSA.

Representative Caruthers Site:

The Caruthers alternative includes a pipeline to convey approximately 20 CFS from CID's Harlen Stevens Ditch to the representative site. A 30-inch C900 pipeline would be connected to the Harlen Stevens Ditch via a turnout at the intersection of Ave B and Ave C, approximately 0.75-miles north of the project site. The pipeline would be approximately 4,300 LF, extending from the connection point south to the mid-point of the project site and west to a representative site's inlet structure. A flow meter and site isolation valve are provided at the entrance to the representative site. Screening or filtration at the site entrance should be considered based on incoming water quality as well. The basin inlet structure consists of a manifold with 20-inch control valves and 20-inch C900 inlet piping to each basin.

The elevation at the connection point to the Harlen Stevens Ditch is approximately equivalent in elevation to the representative site. It is anticipated that a pump station would be necessary at the Harlen Stevens Ditch turnout to produce adequate pressure to convey the design flows to the project site. The pump station would include a series of duty and standby vertical turbine pumps in a wet well or "can" structure, electrical improvements, controls facilities, and appropriate easements or property acquisition. A pressure loss of 16.9-feet (7.3-psi) is estimated between the connection and discharge points.

The completion of a preliminary design study for any recharge basin must include a check on the pipe sizes, valve sizes, and pump station requirements should be reevaluated following a geotechnical study and an evaluation of available flows from CID.

Representative Laton Site:

The representative Laton site includes a pipeline to convey approximately 20 CFS from LID's Murphy Slough Canal to the recharge site. A 30-inch C900 pipeline would be connected to the Murphy Slough Canal via a turnout at the intersection of Ave A and the canal, approximately 0.20-miles south of the project site. The pipeline would be approximately 1,200 LF, extending from the connection point north to the mid-point of the representative site and east to a representative site's inlet structure. A flow meter and site isolation valve are provided at the entrance to the representative site. Screening or filtration at the site entrance should be considered based on incoming water quality as well. The representative site's inlet structure would consist of a manifold with 14-inch control valves and 14-inch C900 inlet piping to each basin.

The elevation at the connection point to the Murphy Slough Canal is approximately equivalent in elevation to the representative site. It is anticipated that a pump station would be necessary at the Murphy Slough Canal turnout to produce adequate pressure to convey the design flows to the project site. The pump station would include a series of duty and standby vertical turbine pumps in a wet well or "can" structure, electrical improvements, controls facilities, and appropriate easements or property acquisition. A pressure loss of 13-feet (5.6-psi) is estimated between the connection and discharge points.

The completion of a preliminary design study for any recharge basin must include a check on the pipe sizes, valve sizes, and pump station requirements should be reevaluated following a geotechnical study and an evaluation of available flows from LID.

5.2.6 Dry Utility Improvements

The only dry utility improvement necessary at all the representative sites is adding new power services to the sites. The electrical improvements for the Raisin City, Caruthers, and Laton sites will be similar. The improvements include electrical improvements and instrumentation for operation of the pump station, flowmeter, and any automatic isolation or control valve.

The representative Kerman site will only need electrical improvements and instrumentation for the operation of the flowmeter and any automatic isolation or gate valves as there is no pump station needed at the representative Kerman site.

All the above-mentioned improvements will require additional planning and design in subsequent phases. Additionally, given that all sites have power lines that run adjacent to the project area, contractors shall follow appropriate codes, standards, and safety procedures when operating equipment near these power lines.

5.2.7 Road Improvements

The majority of the roads adjacent to all representative sites in the Study are in poor condition and fail to meet the current City of Kerman and Fresno County standards in respect to both road width and storm drainage. Given the nature of the proposed representative sites and their minimal traffic impacts, it is not anticipated that any roads will need to be improved as part of the project entitlements. However, if general road conditions, road width, or stormwater drainage improvements are required as a condition of approval, the design and implementation of such improvements will occur in future design of an actual recharge basin.

Within each representative site, maintenance and access roads will be necessary for operations and maintenance of the basins. The maintenance roads will span the entire perimeter of each project site and be 25-feet in width. The access roads will be constructed atop all embankments at each project site and will be a width of 12-feet. Access ramps to reach the embankment access roads will also need to be constructed. However, the design of the access ramps will occur during the design of an actual recharge basin.

5.2.8 Conceptual Design

This section will consist of site improvement plans and pipeline alignment figures for each of the representative sites included in the Study. All figures are reflective of the representative site designs as discussed above. Figures 5-33 through 5-40 show the site improvement plan and pipeline alignment for the representative Kerman site, representative Raisin City site, representative Caruthers site, and representative Laton site, respectively.

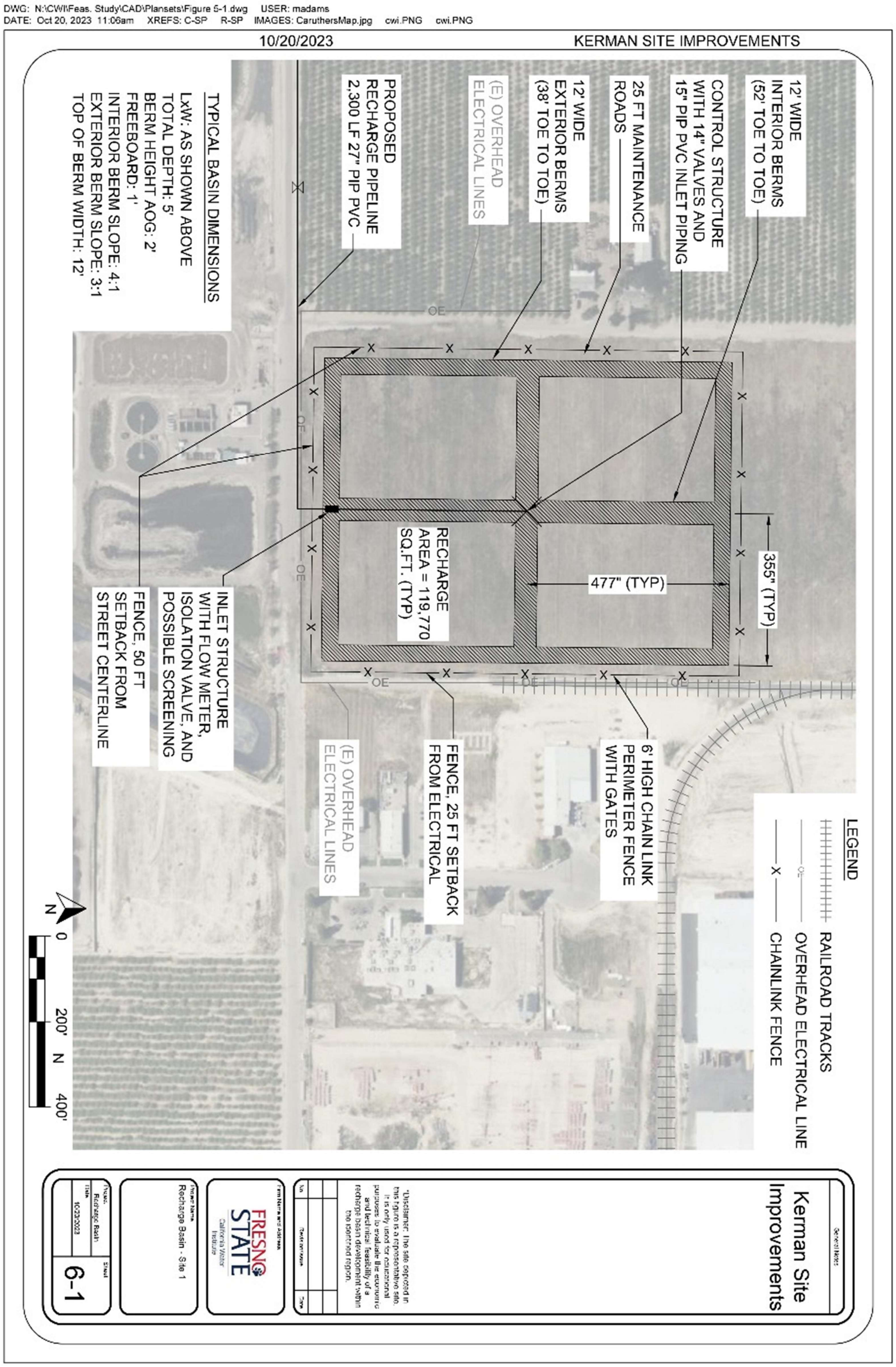


Figure 5-33: Representative Kerman Site Improvements

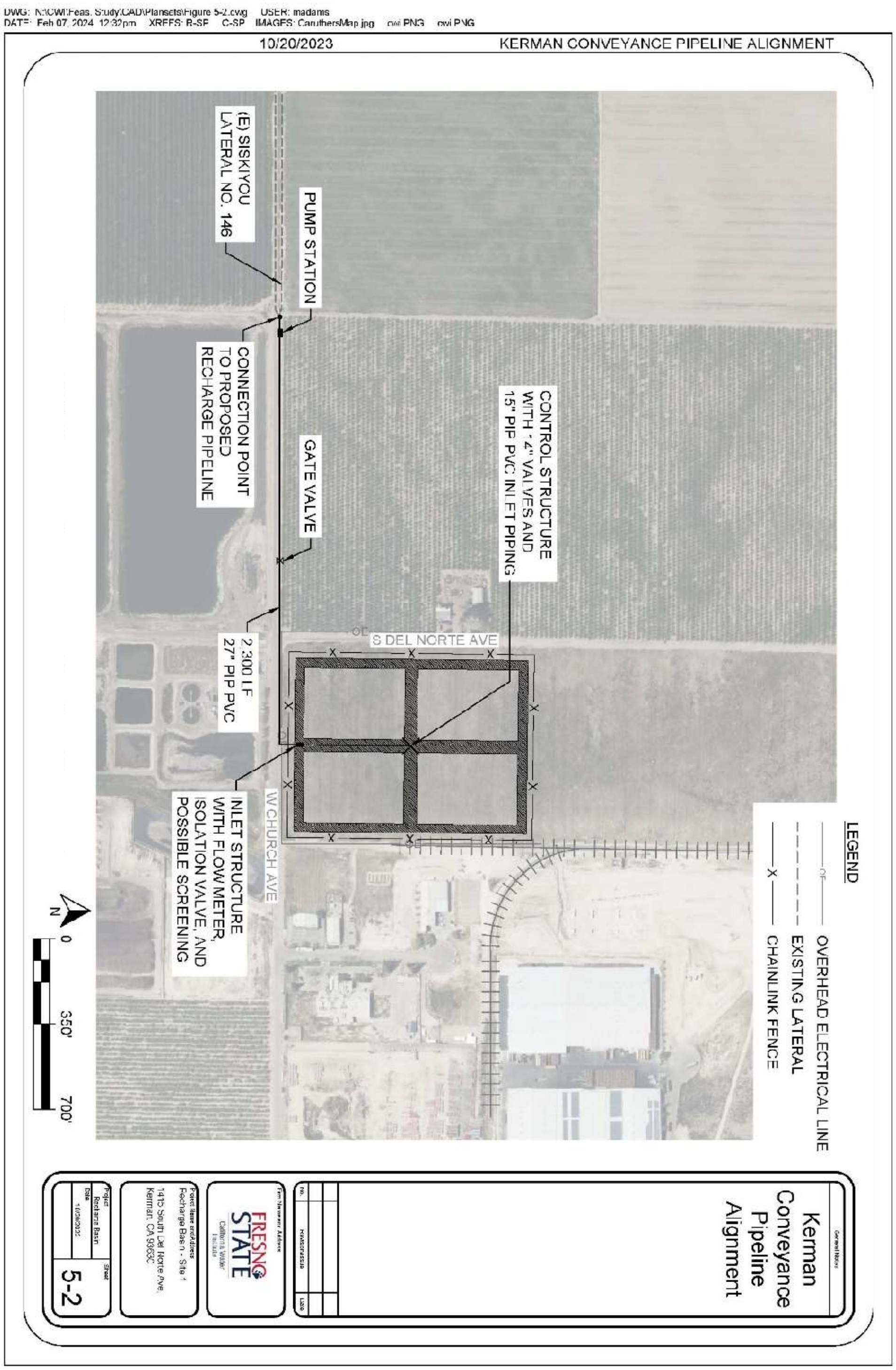


Figure 5-34: Representative Kerman Site Pipe Alignment

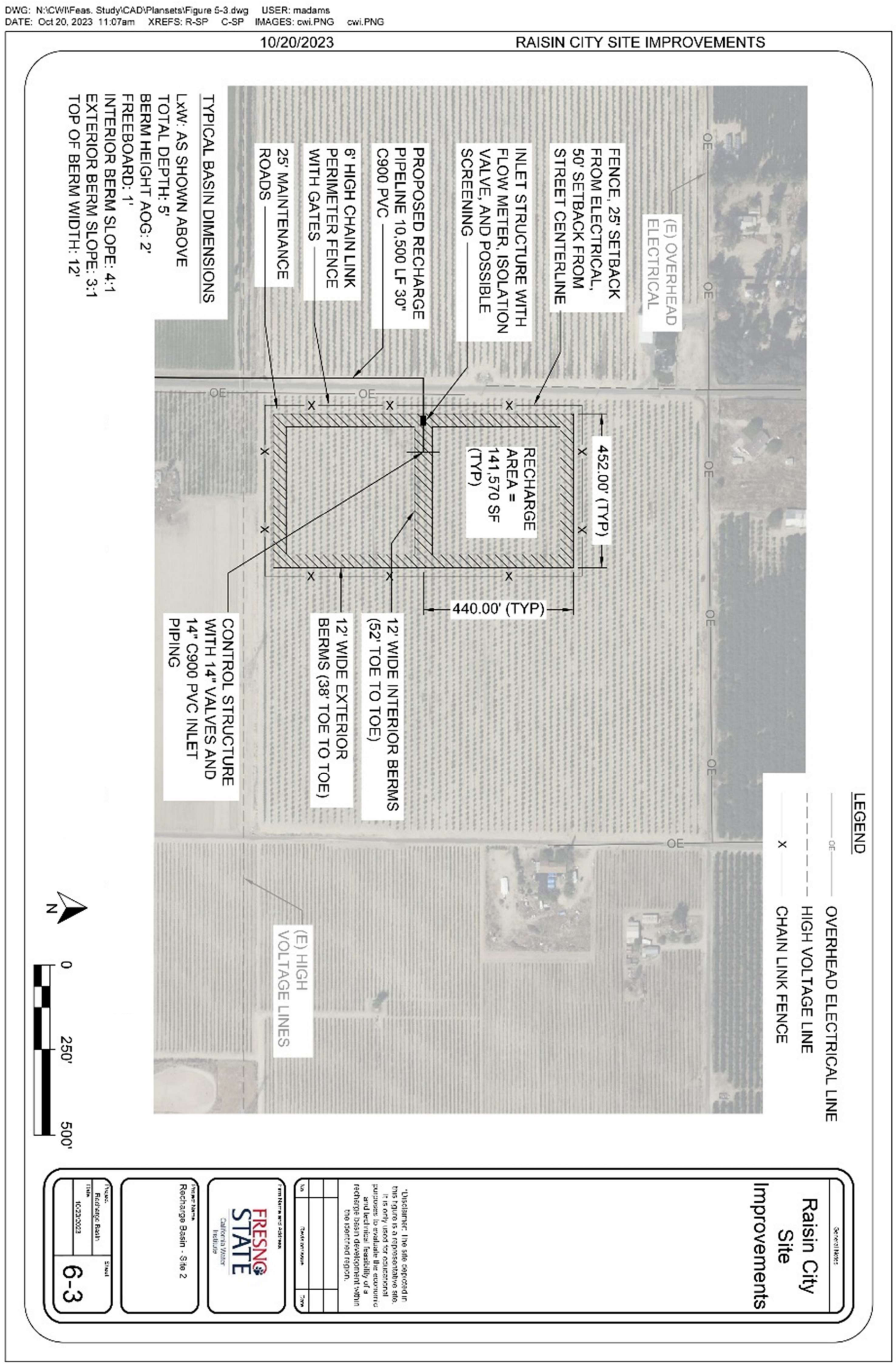


Figure 5-35: Representative Raisin City Site Improvements

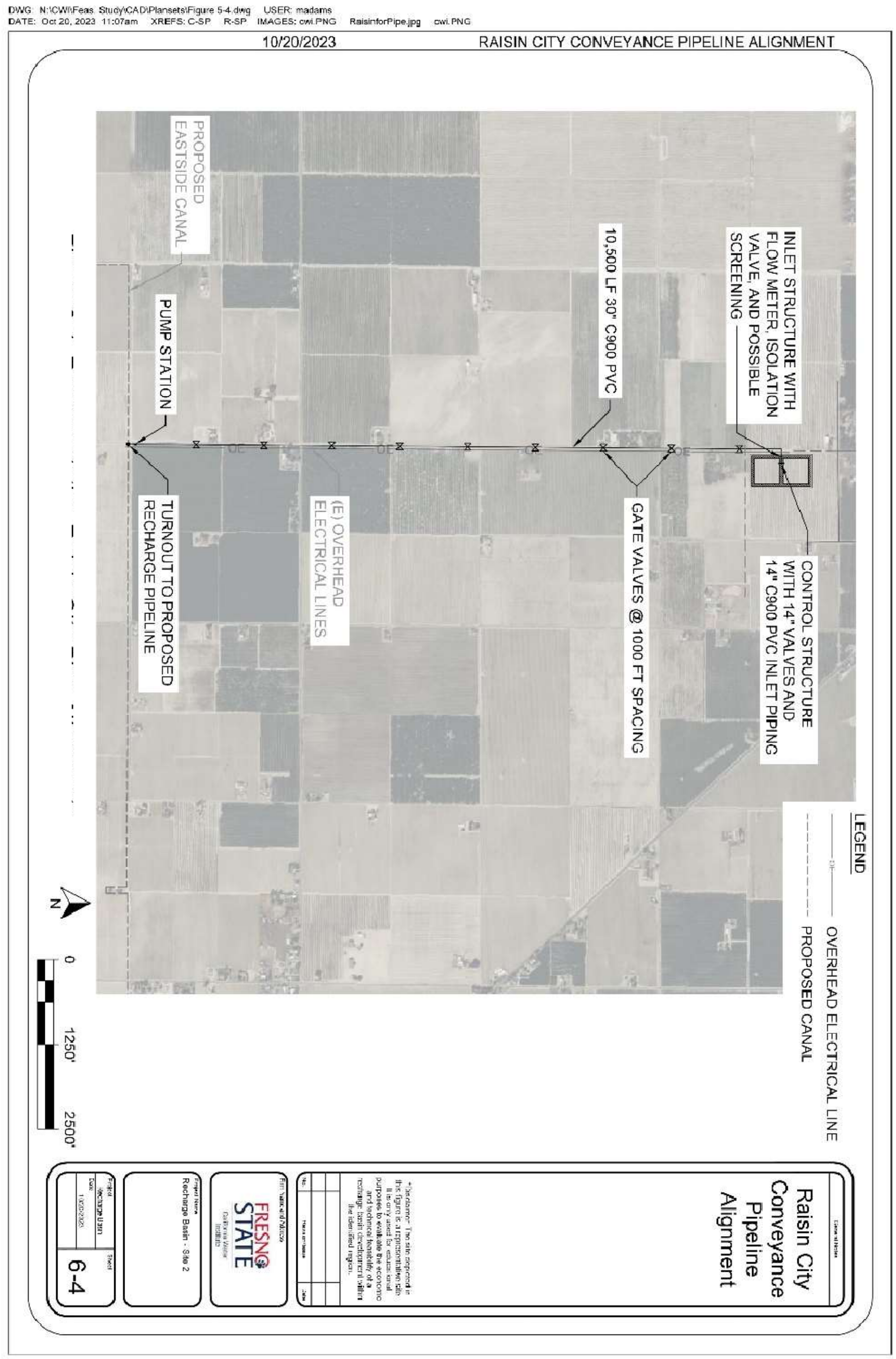


Figure 5-36: Representative Raisin City Site Pipe Alignment

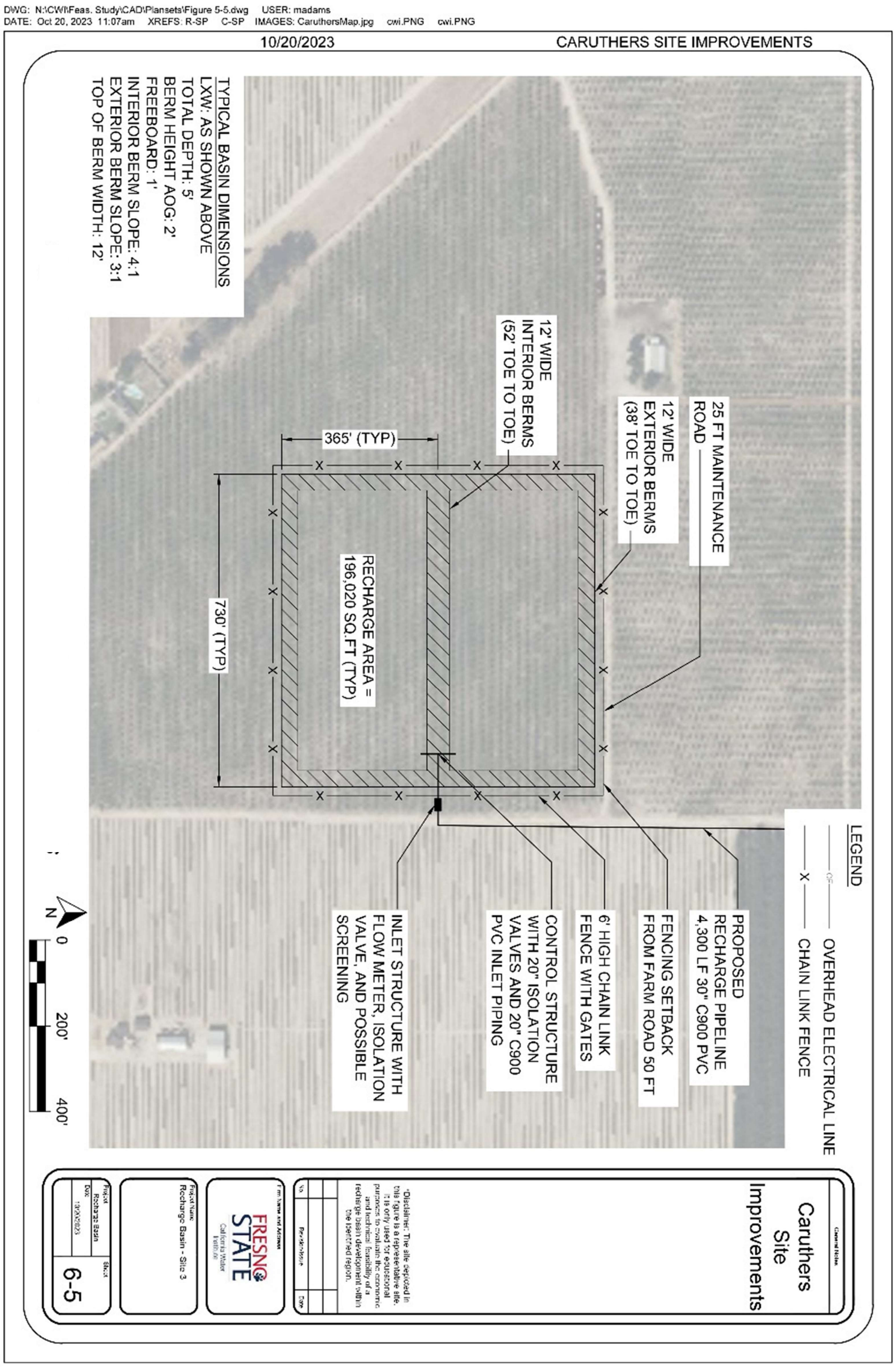


Figure 5-37: Representative Caruthers Site Improvements

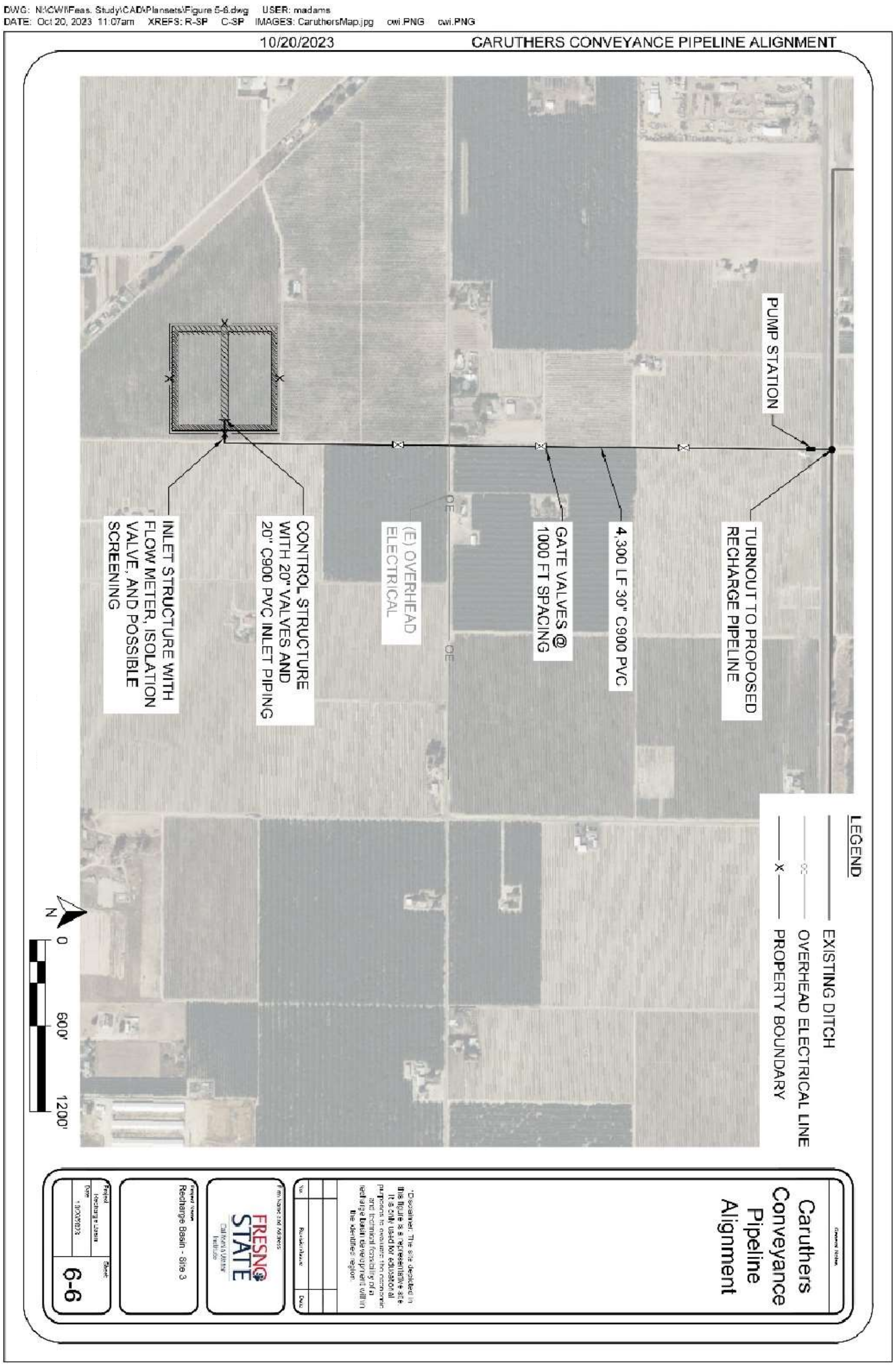


Figure 5-38: Representative Caruthers Site Pipe Alignment

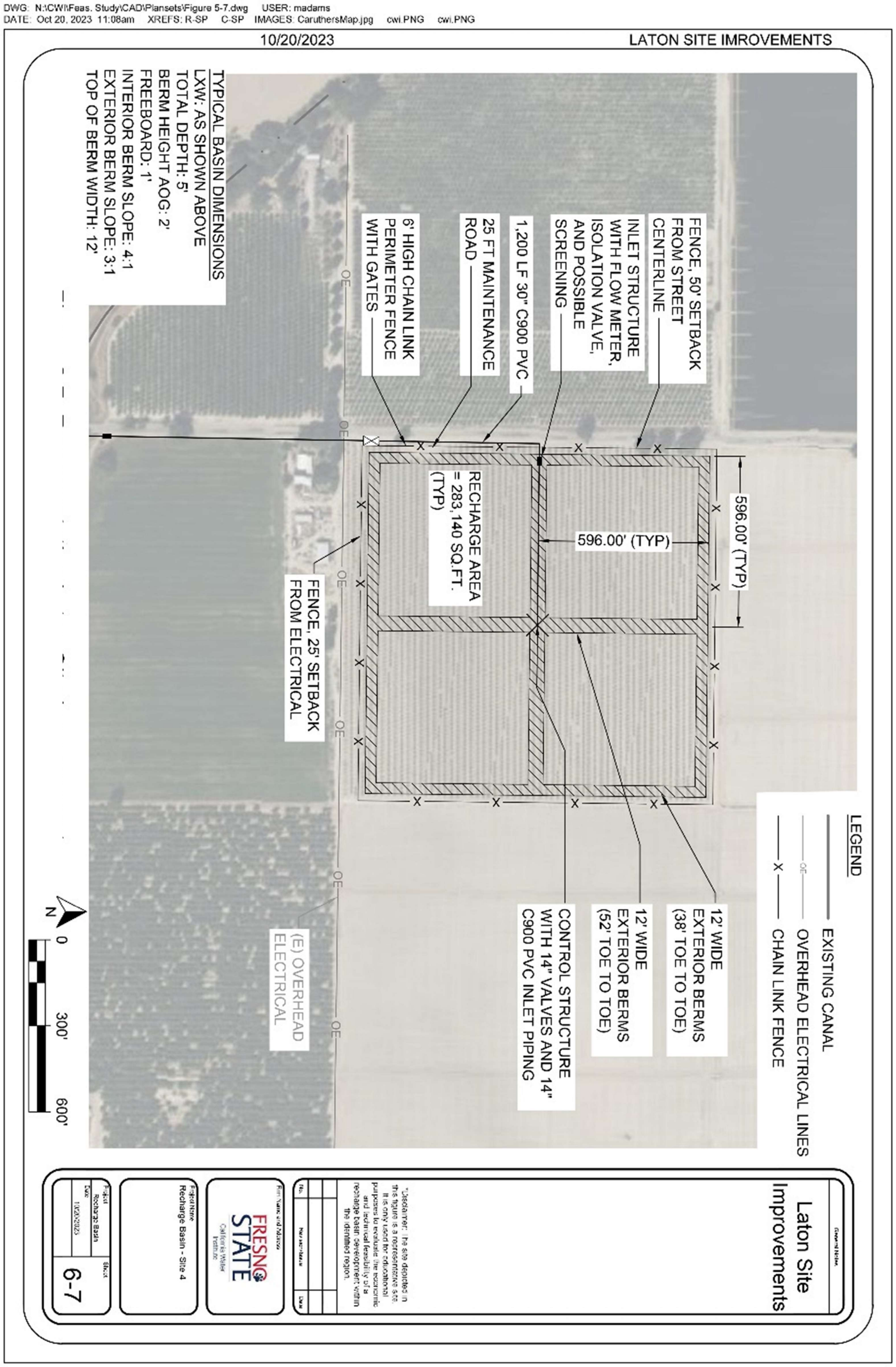


Figure 5-39: Representative Laton Site Improvements

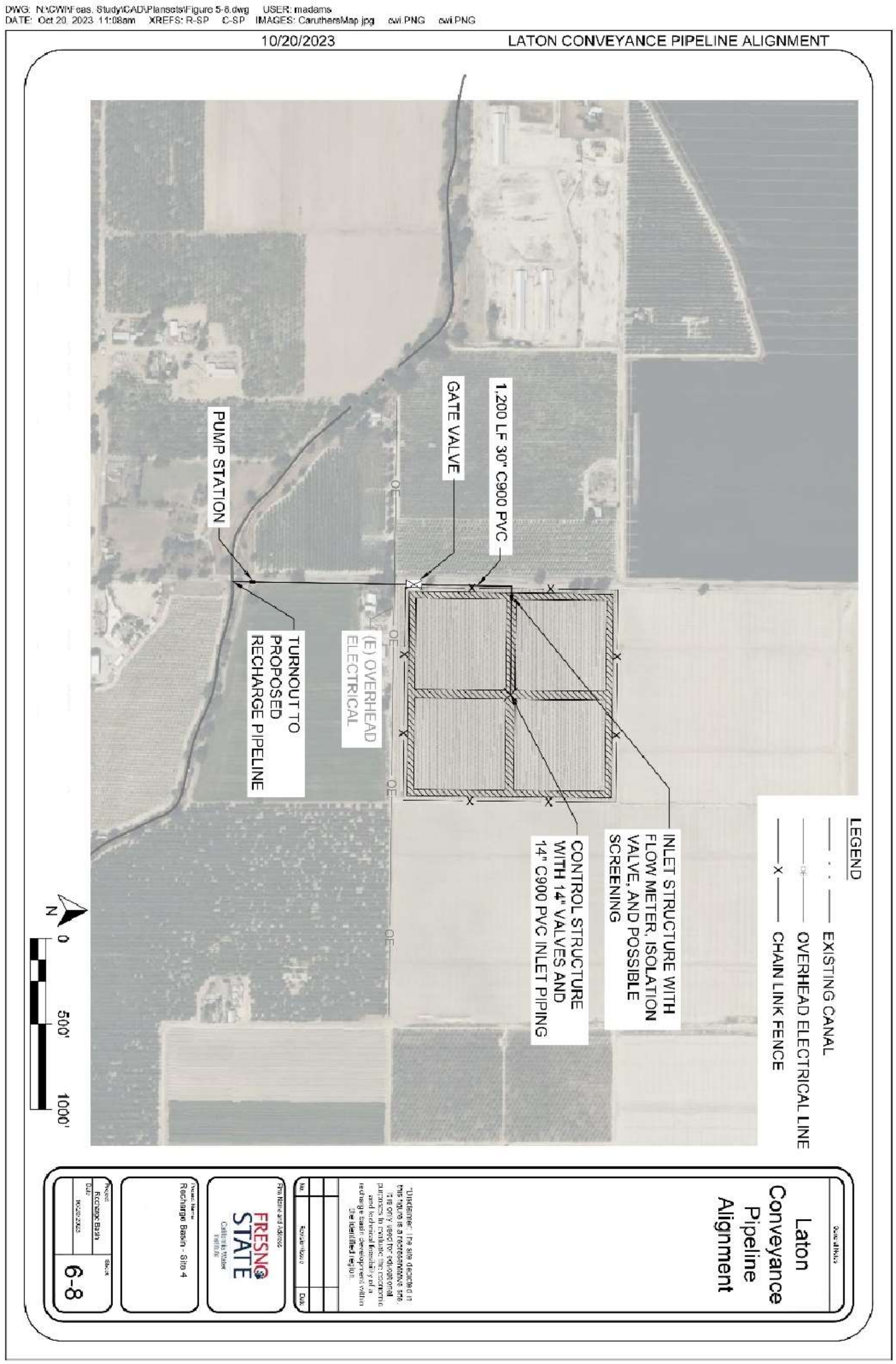


Figure 5-40: Representative Laton Site Pipe Alignment

5.2.9 Cost Estimate

This section includes a preliminary engineering cost estimate based on all materials, required construction, quantity take-offs, and current market pricing for all representative sites and does not consider the economic potential created over the lifetime of the basin depending on water availability. The following assumptions below were made to produce the cost estimates. Assumptions are denoted by superscript within the cost estimate tables.

1. Native soil is sufficient for pipe zone and trench zone backfill. No imported soil required.
2. Includes all electrical work not covered in previous line items and new PG&E service.

Cost estimates can be found in Tables 5-11 through 5-14 below for the representative Kerman site, representative Raisin City site, representative Caruthers site, and representative Laton site, respectively.

Kerman Site Improvements Opinion of Probable Capital Cost					
Item No.	Estimated Quantity	Unit of Measure	Item	Unit Price (in figures)	Extension Price (in figures)
Phase 1 Items					
1	1	LS	Mobilization & Demobilization (5%)	$219,000	$219,000
2	1	LS	Pipeline Connection to FID	$40,000	$40,000
3	1	LS	Basin Inlet Structure	$200,000	$200,000
4	2,300	LF	27-in PIP Pipe	$167	$384,560
5	100	LF	15-in PIP Pipe	$70	$7,040
6	2,300	LF	Trenching/Backfill 1)	$150	$345,000
7	1,750	LF	Pavement Replacement	$40	$70,000
8	2	Days	Traffic Control	$2,000	$4,000
9	1	EA	Magnetic Flow Meter	$25,000	$25,000
10	2	EA	27-in Gate Valve	$20,000	$40,000
11	4	EA	14-in Gate Valve	$12,000	$48,000
12	1	LS	Screening Facility	$141,000	$141,000
13	1	LS	Vertical Turbine BPS	$692,000	$692,000
14	1	LS	Electrical and Instrumentation 2)	$274,000	$274,000
15	15.5	Ac	Grading	$32,000	$496,000
16	3,600	LF	Chain-Link Fencing	$35	$126,000
17	44	Ac	Property Acquisition	$34,000	$1,496,000
			Sub Total Items 1 Through 16		$4,607,600
Engineering, Administration, and Permitting Coordination (15%)					$691,000
Construction Management (10%)					$461,000
Contingency (30%)					$1,382,000
Capital Cost Estimate					$7,141,600

Table 5-11: Representative Kerman Site Cost Estimate

Raisin City Site Improvements Opinion of Probable Capital Cost					
Item No.	Estimated Quantity	Unit of Measure	Item	Unit Price (in figures)	Extension Price (in figures)
Phase 1 Items					
1	1	LS	Mobilization & Demobilization 5%)	$404,000	$404,000
2	1	LS	Concrete Canal Turnout	$100,000	$100,000
3	1	LS	Basin Inlet Structure	$200,000	$200,000
4	10,500	LF	30-in C900 Pipe	$174	$1,824,900
5	100	LF	14-in C900 Pipe	$70	$7,040
6	10,500	LF	Trenching/Backfill 1)	$150	$1,575,000
7	9,800	LF	Pavement Replacement	$40	$392,000
8	10	Days	Traffic Control	$2,000	$20,000
9	1	EA	Magnetic Flow Meter	$10,000	$10,000
10	11	EA	30-in Gate Valve	$21,000	$231,000
11	4	EA	14-in Gate Valve	$12,000	$48,000
12	1	LS	Screening Facility	$141,000	$141,000
13	1	LS	Vertical Turbine BPS	$737,000	$737,000
14	1	LS	Electrical and Instrumentation 2)	$1,000,000	$1,000,000
15	9	Ac	Grading	$32,000	$288,000
16	2,900	LF	Chain-Link Fencing	$35	$101,500
17	1	LS	Easement Acquisition	$50,000	$50,000
18	40	Ac	Property Acquisition	$34,000	$1,360,000
			Sub Total Items 1 Through 18		**$8,489,440**
Engineering, Administration, and Permitting Coordination (15%)					$1,273,000
Construction Management (10%)					$849,000
Contingency (30%)					$2,547,000
Capital Cost Estimate					**$13,158,440**

Table 5-12: Representative Raisin City Site Cost Estimate

Caruthers Site Improvements Opinion of Probable Capital Cost					
Item No.	Estimated Quantity	Unit of Measure	Item	Unit Price (in figures)	Extension Price (in figures)
Phase 1 Items					
1	1	LS	Mobilization & Demobilization (5%)	$292,000	$292,000
2	1	LS	Concrete Canal Turnout	$100,000	$100,000
3	1	LS	Basin Inlet Structure	$200,000	$200,000
4	4,300	LF	30-in C900 Pipe	$174	$747,340
5	100	LF	20-in C900 Pipe	$114	$11,440
6	4,300	LF	Trenching/Backfill 1)	$150	$645,000
7	4,000	LF	Pavement Replacement	$40	$160,000
8	4	Days	Traffic Control	$2,000	$8,000
9	1	EA	Magnetic Flow Meter	$10,000	$10,000
10	4	EA	30-in Gate Valve	$21,000	$84,000
11	2	EA	20-in Gate Valve	$15,000	$30,000
12	1	LS	Screening Facility	$141,000	$141,000
13	1	LS	Vertical Turbine BPS	$737,000	$737,000
14	1	LS	Electrical and Instrumentation 2)	$1,000,000	$1,000,000
15	12	Ac	Grading	$32,000	$384,000
16	3,200	LF	Chain-Link Fencing	$35	$112,000
17	1	LS	Easement Acquisition	$50,000	$50,000
18	42	Ac	Property Acquisition	$34,000	$1,428,000
Sub Total Items 1 Through 18					$6,139,780
Engineering, Administration, and Permitting Coordination (15%)					$921,000
Construction Management (10%)					$614,000
Contingency (30%)					$1,842,000
Capital Cost Estimate					$9,516,780

Table 5-13: Representative Caruthers Site Cost Estimate

Laton Site Improvements Opinion of Probable Capital Cost					
Item No.	Estimated Quantity	Unit of Measure	Item	Unit Price (in figures)	Extension Price (in figures)
Phase 1 Items					
1	1	LS	Mobilization & Demobilization (5%)	$266,000	$266,000
2	1	LS	Concrete Canal Turnout	$100,000	$100,000
3	1	LS	Basin Inlet Structure	$200,000	$200,000
4	1,200	LF	30-in C900 Pipe	$174	$208,560
5	100	LF	14-in C900 Pipe	$70	$7,040
6	1,200	LF	Trenching/Backfill 1)	$150	$180,000
7	900	LF	Pavement Replacement	$40	$36,000
8	1	Days	Traffic Control	$2,000	$2,000
9	1	EA	Magnetic Flow Meter	$10,000	$10,000
10	2	EA	30-in Gate Valve	$21,000	$42,000
11	2	EA	14-in Gate Valve	$12,000	$24,000
12	1	LS	Screening Facility	$141,000	$141,000
13	1	LS	Vertical Turbine BPS	$737,000	$737,000
14	1	LS	Electrical and Instrumentation 2)	$1,000,000	$1,000,000
15	32.5	Ac	Grading	$32,000	$1,040,000
16	5,000	LF	Chain-Link Fencing	$35	$175,000
17	1	LS	Easement Acquisition	$50,000	$50,000
18	40	Ac	Property Acquisition	$34,000	$1,360,000
Sub Total Items 1 Through 18					$5,578,600
Engineering, Administration, and Permitting Coordination (15%)					$837,000
Construction Management (10%)					$558,000
Contingency (30%)					$1,674,000
Capital Cost Estimate					$8,647,600

Table 5-14: Representative Laton Site Cost Estimate

6. Feasibility

This section includes a detailed breakdown of the approach to determine the feasibility of all representative sites within the Study. Each representative site was scored based on feasibility criteria and ranked based upon the sum of their scores. The preferred (i.e., most feasible) representative site is identified and explained.

6.1 Ranking Criteria and Matrix

To determine the feasibility of each representative site's potential for construction of a groundwater recharge basin, the following criteria was analyzed for each representative site.

Potential Water Availability

This criterion was scored based on the representative site's ability to receive water, and the quantity of water available for delivery during years when flood water is in excess.

Proximity to Surface Water

This criterion was scored based on the representative site's distance from the neared water source that can adequately convey surface water to the site.

Current Land Use

This criterion was scored based on the impact the current representative site's land use will have on the cost of the land and site preparation efforts for construction.

Recharge Potential

This criterion was scored based on the representative site's NRCS infiltration rates and potential water available.

Construction Costs

This criterion was scored based on the representative site's total construction cost estimate.

Ease of Maintenance and Operation

This criterion was scored based on the level of effort required to maintain and operate each representative site due to factors such as pipeline distance, infrastructure differences, and total basin footprint.

Community Benefit

This criterion was scored based on the representative site's benefit to the nearest DAC. The benefit of each site was determined by the site's proximity to the nearest DAC, and the population of the nearest DAC.

Based on the analysis, the sites were given a numeric score of 1 through 10 (10 being the best).

Criteria	Representative Project Location			
	Scoring (Numerical): 1-10			
	Kerman	Raisin City	Caruthers	Laton
Potential Water Availability	5	1	5	6
Proximity to Surface Water	7	1	4	8
Current Land Use	10	2	2	2
Recharge Potential	7	8	8	5
Construction Costs	7	2	4	5
Ease of Maintenance and Operation	8	3	5	4
Community Benefit	9	6	7	5
Totals	**54**	**23**	**35**	**34**

Table 6-1: Feasibility Selection Matrix

6.2 Scoring Evaluation

As seen in Table 6.1, the representative Kerman site outscores the representative Raisin City, representative Caruthers, and representative Laton sites. A breakdown of the rational for scoring all sites as well as why the representative Kerman site outscored the other three sites is below.

Representative Kerman Site:

Potential Water Availability

Although the capacity of FID's surface water pipeline is limited in comparison to the other sites, FID has confirmed that water deliveries can be made at rates between 3 CFS and 18 CFS depending on the water year, which is adequate for groundwater recharge at the site.

Proximity to Surface Water

FID's Lateral-1 pipeline is approximately 2,300 feet from the proposed recharge basin locations. This is closer proximity than both the representative Raisin City and representative Caruthers sites.

Current Land Use

The representative Kerman site is currently zoned as M-2, Heavy Manufacturing, and is currently barren. This makes the site vastly more attractive than the other sites for this criterion as the other sites are all currently occupied by almond orchards.

Recharge Potential

Based on the total recharge area and calculated NRCS infiltration design rates, the site has the potential to recharge 3,227 AF of water per year. This is comparable to the recharge potential of representative Raisin City and representative Caruthers sites and around 60 percent more than representative Laton's recharge potential.

Construction Costs

The preliminary cost estimate for the representative site was the lowest of all four representative sites and more than 2.5 million dollars less than the nearest representative site in cost. This lower cost is namely due to the existing land use and water conveyance infrastructure, basin size, and pipeline distance.

Ease of Maintenance and Operation

The Kerman representative site received the highest score for this criterion due to the size of the basins relative to the other sites, the pipeline distance between the recharge basins and existing water conveyance infrastructure, and proximity to the operating entity (FID).

Community Benefit

The representative site received the highest score for this criterion because it lies within the City of Kerman as well as serves the DAC with the highest population within the study.

Representative Raisin City Site:

Potential Water Availability

The potential water source for the representative site is the unconstructed Eastside Canal with limited information as to when the canal will be constructed, and the water delivery capacity once constructed.

Proximity to Surface Water

The Eastside Canal is proposed to be constructed approximately 2.5 miles south of the representative site, making it the furthest conveyance facility when compared to the other representative sites.

Current Land Use

The representative site is currently occupied by a young almond orchard, resulting in a low score for this criterion.

Recharge Potential

Based on the total recharge area and calculated NRCS infiltration design rates, the representative site has the potential to recharge 3,545 AF of water per year. This is comparable to the recharge potential of representative Kerman and representative Caruthers sites and approximately 75 percent more than representative Laton site's recharge potential.

Construction Costs

The preliminary cost estimate for the representative site was the highest of all four sites and 3.7 million dollars more than the nearest representative site in cost. This higher cost is namely due to the pipeline distance, water conveyance infrastructure, and existing land use.

Ease of Maintenance and Operation

The representative site received the lowest score for this criterion due to the pipeline distance between the recharge basins and existing conveyance facility.

Community Benefit

This representative site received a mid-range score for this criterion because Raisin City has the lowest population of approximately 200 people but is in close proximity to the nearest DAC.

Representative Caruthers Site:

Potential Water Availability

The Harlen Stevens Ditch is capable of delivering up to 20 cfs to the site, similar to the representative Kerman and Laton sites.

Proximity to Surface Water

The Harlen Stevens Ditch is approximately 4,300 feet north of the representative site. This is further than the representative Laton and Kerman sites.

Current Land Use

The representative site is currently occupied by a young almond orchard, resulting in a low score for this criterion.

Recharge Potential

Based on the total recharge area and calculated NRCS infiltration design rates, the representative site has the potential to recharge 3,515 AF of water per year. This is comparable to the recharge potential of representative Kerman and Raisin City sites and roughly 75 percent more than the representative Laton site's recharge potential.

Construction Costs

The preliminary cost estimate for the representative site was the second highest of all four sites and approximately one million dollars more than the nearest representative site in cost. This higher cost is namely due to the pipeline distance, water conveyance infrastructure, and existing land use.

Ease of Maintenance and Operation

The representative site received the second highest score for this criterion due to the size of the basins relative to the other representative sites, existing water conveyance infrastructure, and proximity to the operating entity (CID).

Community Benefit

This representative site received the second highest score because Caruthers has a population of approximately 2,500 people and is in close proximity to the nearest DAC.

Representative Laton Site:

Potential Water Availability

The Murphy Slough Canal is capable of delivering up to 20 CFS to the representative site, similar to the Kerman and Caruthers sites.

Proximity to Surface Water

The Murphy Slough Canal is approximately 1,000 feet south of the site, making it the closest conveyance facility out of all representative sites.

Current Land Use

The representative site is currently occupied by a young almond orchard, resulting in a low score for this criterion.

Recharge Potential

This representative site has the poorest recharge potential of all the sites, and as such, the site has the largest basin recharge area to maximize the recharge potential of 2012 AF of water per year. The site still is only capable of recharging approximately 60 percent of the water recharged by the other representative sites.

Construction Costs

The preliminary cost estimate for the representative site was the second lowest of all four sites and approximately one million dollars less than the other nearest representative site in cost. This lower cost is namely due to the pipeline distance and water conveyance infrastructure.

Ease of Maintenance and Operation

The representative site received the second lowest score for this criterion mainly due to the larger size of the basins relative to the other representative sites.

Community Benefit

This site received a mid-range score because Laton has the second lowest population of about 1,500 people but is close to the nearest DAC.

7. Outreach & Education

Fresno State with the help of Self-Help Enterprises (SHE) executed an outreach effort of the groundwater recharge feasibility study intended to preliminarily educate the selected communities (City of Kerman, Raisin City, Caruthers, and Laton) regarding potential groundwater recharge projects.

SHE led the development of an Outreach and Implementation Plan that described the intent and target audience for groundwater recharge education. The outreach's intent was to ensure community residents are informed about groundwater recharge locally and regionally, emphasizing the significance of community engagement during the beginning stages of implementation and monitoring. Furthermore, outreach and engagement efforts will allow the four selected communities to create a space to discuss the impact of a project like this. The community engagement plan is provided in Appendix B of this report.

The outreach plan SHE developed included potential implementation methods by exploring several different options based on different considerations for each community, determined by SHE's experience with that community, as each community has specific needs.

SHE narrowed the implementation options as:

1) develop flyers

2) distribute flyers door to door to allow 1-on-1 dialogue and build trust within the community

3) mailings via Public Water System bills or direct mail

4) meet with residents through local community events or meetings.

SHE then identified a contact within the local public water system agency for each community. Utilizing the information provided by SHE, CWI identified, prioritized, and ranked which options were the most feasible and appropriate for the selected communities.

Working together, the team developed a groundwater recharge flyer in English and Spanish, that included information about groundwater recharge: what it is, its goal, its advantages and disadvantages, and possible concerns. The flyer also included contact information community members can use to obtain more information. The groundwater recharge flyer is provided in Appendix C and D of this report.

Based on the Outreach and Implementation Plan, SHE distributed the groundwater recharge flyers via water billings to all residents who reside in the listed communities. SHE hand-delivered a total of 5,150 flyers: 600 flyers to Caruthers Community Service District, 300 flyers Raisin City Post Office, 450 to Laton Community Service District, and 3,800 flyers to the City of Kerman Finance Department within the months of June and July. SHE followed up with each organization in August to ensure all flyers were mailed in the water billings and asked if any of the Public Water System Agencies had any questions, comments, or concerns from residents about this project. None were reported.

At the request of Laton, SHE also delivered flyers on a door-to-door basis to twenty (20) domestic well users located on the outskirts of the community. These are homes that lie outside the water system distribution boundaries, mostly because they are across a canal or river, or too far away from the infrastructure.

Groundwater recharge is a growing land repurposing option we will see more of. With that, there will come a bigger need to educate those that might be affected by it, such as communities that are dependent on wells for their residential water use. Even though targeted towards each community, it was only a small part of what a truly educational campaign should be. If any of the recommended sites are pursued for construction, an effort should be made to conduct in-person groundwater recharge education events with each of the communities. A more in-depth review of these topics can raise community awareness and better equip community members to advocate for themselves during this process.

8. Conclusions and Recommendations

The purpose of this report was to identify representative sites for groundwater recharge near DACs based on geospatial analysis and determine the feasibility of their construction. This Study was done in an effort to provide solution to the quantity of the groundwater for the groundwater dependent users within the nearest DAC to each identified representative site pursuant to AB 685.

Groundwater recharge basins are just one method for groundwater recharge. Other methods include subsurface recharge technology or flooding the field during a high wet season. For purposes of this study, only recharge basis were used to determine feasibility, but the sites also show high potential for the other two methods of recharge.

Although this study was successful in determining the initial feasibility for construction of recharge basins and selecting representative locations, there are multiple sites within each selected region which should be investigated should any of the representative sites contained in this report be proposed for further design.

A list of recommendations following the completion of this Study at a selected site include:

1) Performing a geotechnical analysis per ATSM Standards
2) Collaborate with water authorities to:
    a) Identify alternative project sites that may be a better fit from a water district standpoint and local needs.
    b) Solidify the capacity of existing surface water conveyance infrastructure to serve the sites.
    c) Solidify the capacity of existing surface water conveyance infrastructure to serve the sites.
3) Develop a monitoring and mitigation plan (If needed) for prospective recharge basins.
4) Conduct additional and more detailed groundwater investigation to identify:
    a) Current groundwater depth and historical depth
    b) Current groundwater quality and associated impacts
    c) Groundwater gradient
5) Perform hydraulic analyses to accurately determine pump requirements.
6) Conduct a topography survey of the recharge site and pipeline alignment.
7) Refine and update geospatial data.
8) Examine previously identified consideration factors to determine additional needs.
9) Examine additional recharge design models and types.
10) Evaluate process for site selection to maximize efficiency.

The outreach efforts taken by Fresno State and Self-Help Enterprises as part of this groundwater recharge feasibility study were instrumental in fostering education in the selected communities. The development and distribution of groundwater recharge flyers in English and Spanish demonstrated a community-oriented approach and ensured that the information was accessible and inclusive. This initial step marks the beginning of a phased approach that should involve more in-depth in-person meetings with community members who can then be empowered to advocate for themselves and contribute to well-informed and resilient communities.

Water districts are the most knowledgeable entities regarding groundwater conditions and project needs in their area. We would encourage all interested parties in this project to reach out to local water districts to learn more about potential projects.

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Appendices

Appendix A - USDA Guide by Texture to Feel Soil Texture Flow Chart

Appendix B – Community Engagement Plan

Appendix C – Groundwater Recharge Flyer – English

Appendix D – Groundwater Recharge Flyer - Spanish

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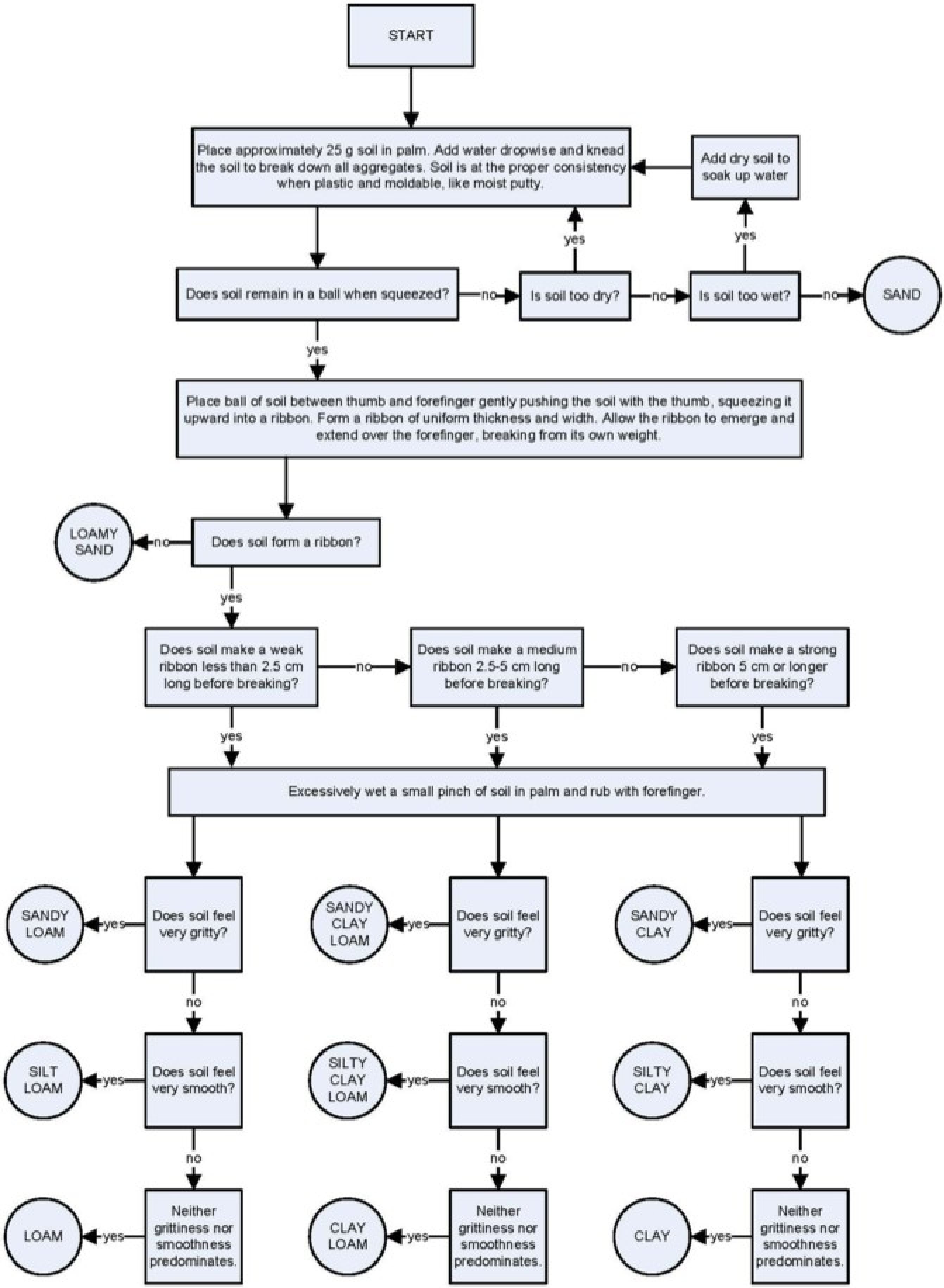
START
Place approximately 25 g soil in palm. Add water dropwise and knead the soil to break down all aggregates. Soil is at the proper consistency when plastic and moldable, like moist putty.
Add dry soil to soak up water
yes
yes
Does soil remain in a ball when squeezed?
no
Is soil too dry?
no
Is soil too wet?
no
SAND
yes
Place ball of soil between thumb and forefinger gently pushing the soil with the thumb, squeezing it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over the forefinger, breaking from its own weight.
LOAMY SAND
no
Does soil form a ribbon?
yes
Does soil make a weak ribbon less than 2.5 cm long before breaking?
no
Does soil make a medium ribbon 2.5-5 cm long before breaking?
no
Does soil make a strong ribbon 5 cm or longer before breaking?
yes
yes
yes
Excessively wet a small pinch of soil in palm and rub with forefinger.
SANDY LOAM
yes
Does soil feel very gritty?
SANDY CLAY LOAM
yes
Does soil feel very gritty?
SANDY CLAY
yes
Does soil feel very gritty?
no
no
no
SILT LOAM
yes
Does soil feel very smooth?
SILTY CLAY LOAM
yes
Does soil feel very smooth?
SILTY CLAY
yes
Does soil feel very smooth?
no
no
no
LOAM
yes
Neither grittiness nor smoothness predominates.
CLAY LOAM
yes
Neither grittiness nor smoothness predominates.
CLAY
yes
Neither grittiness nor smoothness predominates.

CWI Recharge Community Engagement Plan Development

This will describe the process, procedures, and methods to engage with the selected communities, the City of **Kerman,** and **Caruthers, Laton, and Raisin City**. The goal of outreach to these communities is to educate residents on the "features, benefits, advantages, and disadvantages of implementing groundwater recharge" which could potentially be developed near each of the identified communities.

Message of Outreach:

The message to each community will inform residents on two aspects of groundwater recharge: 1) a general discussion of what recharge is, its benefits, advantages, and disadvantages on a regional basis and 2) the same topics specific to the identified community. The community specific message will also identify potential agencies that could develop a recharge basin near the community.

Intent of Outreach:

The intent of outreach to communities is to inform as many community residents as feasible about the concept of groundwater recharge regionally and locally, its potential benefits to increase groundwater levels and quality, its potential disadvantages to groundwater quality, what efforts are being made to increase recharge opportunities regionally and locally, and how important it is for community representatives to be engaged from the conceptual to the implementation and monitoring phases to ensure communities are benefited and not unintentionally harmed. Awareness and understanding of potential recharge projects should inform a community plan for a recharge basin if such plans were to be developed.

Outreach Audience:

The target audience are residents living within the boundaries of the four selected communities. Public agencies and other water management agencies are tasked with "outreach and engagement" of rural communities who may be impacted by recharge basin development near their community. Providing information to community members in the discussion and exploration stages of regional recharge projects will prepare residents to become more effectively engaged during the development, planning and implementation stages. Outreach and education support acquisition of project public funds when communities are informed and prepared to engage. But most importantly, it creates a voice for those most impacted by projects such as this.

Residents will be outreached to via one or more of the following outreach strategies as described in Implementation Options.

Implementation Options:

SHE will work with the local public water system agency, community groups such as churches, schools, service clubs, and local businesses in the small communities to use the combination of outreach strategies that best fits each of the four selected communities.

- Develop flyers to do one or more of the following:
    - Provide basic information about recharge on a regional scale
    - Conceptually describe recharge projects that are currently being developed or implemented, or have been considered or discussed as potential projects near a specific community
    - Provide link to short informative videos
    - Publicize a local community meeting or event
    - Provide contact information to obtain additional information about recharge
- Distribute flyers by one or more of the following options
    - Door to door distribution of flyers, which allows for some one-on-one dialogue and builds trust with community residents
    - Mailings via Public Water System bills or direct mail
    - Via community groups, community library, businesses, and resource centers
- Meet with residents through one or more of the following options
    - Local community events, service clubs, and/or school activities
    - Organized and promoted meetings

Summary:

In summary, outreach to each community will vary dependent on size and governance of the community and/or water system. Similarly, education efforts will vary by community. The message, intent, and the targeted audience will be consistent throughout the four communities. What will vary are the implementation strategies used for outreach and educating communities about groundwater recharge. In all cases, the goal is to ensure local voices are heard and inform local recharge projects when they develop.

CWI Recharge Community Engagement Implementation

Kerman (City)

Implementation Options:

- Develop a flyer specific to Kerman (Priority 1.1)
- Mailings via Public Utility District bills (Priority 2.1)
- Direct mail to community residents (Priority 2.2)
- Distribution of flyers via community groups, community library, businesses, and resource centers (Priority 3)

Considerations:

- Kerman is too large for door-to- door distribution
- Utilizing the Public Utility District bills or direct mail will allow the outreach most efficiently, since the Public Utility District has an existing mailing list
- Targeting businesses, local libraires, and resources centers will allow outreach and education to be conducted at a local level

Caruthers and Laton

Implementation Options:

- Develop a flyer specific to each community (Priority 1)
- Mailing via Public Water System bills (Priority 2.1)
- Direct mail to community residents (Priority 2.2)
- Distribution of flyers via community groups, community library, businesses, and resource centers (Priority 3)
- Door to door distribution of flyers, which allows for some one-on-one dialogue and builds trust with community residents (might be difficult in Caruthers due to size of community) (Priority 5)
- Meet with community residents through local community events, service clubs, and/or school activities (Priority 4)
- Organize one community meeting (Priority 6)

Considerations:

- Caruthers and Laton are both small communities
- Both communities' local governments and public water systems are conducive to supporting outreach through water system bill mailings
- Door to door distribution is feasible and efficient
    - More accessibility to community residents to establish relationships

- Community can provide local meeting location

Raisin City (County Water System)

Implementation Options:

- Develop flyer specific to community (Priority 1)
- Mailing via Public Water System bills (County Service Area) (Priority 2.1)
- Direct mail to community residents (Resident mail picked up at local post office) (??) (Priority 2.2)
- Distribution of flyers via community groups, community library, businesses, and resource centers (Priority 3)
- Door to door distribution of flyers, which allows for some one-on-one dialogue and builds trust with community residents (Priority 5)
- Meet with community residents through local community events, service clubs, and/or school activities (Priority 4)
- Organize one community meeting (Priority 6)

Considerations:

- Raisin City is a small community
- The community is served by a Fresno County Service Area (CSA) Water System
    - The CSA is informed by a Community Advisory Group/Council
- Door to door distribution is feasible and efficient
    - More accessibility to community residents to establish relationships
- Community can provide local meeting location

Groundwater Recharge

What should you know...

What is groundwater recharge?

Groundwater recharge is the process of moving water downward from surface water to groundwater.

Over pumping groundwater for many decades has caused groundwater to decline or go deeper below the surface. One potential solution is to raise the groundwater table with recharge basins.

What is the goal of groundwater recharge?

More groundwater recharge will happen in the coming years because State legislation requires everyone to replenish groundwater and increase resiliency to weather extremes like droughts and floods. Recharge basins help with both by adding water underground to help prevent sinking of the ground (subsidence) and domestic wells and other wells from going dry in the future. Recharge basins also provide a place for flood water to go during wet years.

Why should I know about groundwater recharge?

Groundwater recharge sites are carefully selected based on the soil conditions, historical land use, location, and availability of infrastructure to move water to the location. Since rural areas have experienced decline in water levels and meet a lot of the ideal conditions, you might see groundwater recharge basins being constructed near you and should know what they are.

Should I be concerned about living near a groundwater recharge basin?

Groundwater recharge basins bring many positive results but can also create concerns. One concern could be an increase in contamination of the groundwater. This concern depends on many factors and may take years to happen. Studies are underway to determine if and how groundwater recharge might impact drinking water. In the meantime, if a recharge basin is constructed near you, we encourage you to take regular sample tests of your drinking water to see if there are any changes.

More information or questions, please contact:

California Water Institute at Fresno State

559-278-7001

www.californiawater.org

FRESNO STATE
California Water Institute

Recarga de Aguas Subterráneas

Qué debes saber...

¿Qué es la recarga de aguas subterráneas?

La recarga de agua subterránea es el proceso de mover el agua superficial hasta el agua subterránea.

El bombeo excesivo de agua subterránea durante muchas décadas ha causado que el agua subterránea disminuya o vaya más profundo debajo de la superficie. Una posible solución es elevar el nivel con cuencas de recarga.

¿Cuál es el objetivo de la recarga de aguas subterráneas?

Más recarga de agua subterránea ocurrirá en los próximos años porque la legislación estatal requiere que todos repongan el agua subterránea y aumenten la resistencia a los fenómenos meteorológicos extremos como sequías e inundaciones. Las cuencas de recarga ayudan con ambos al agregar agua subterránea para ayudar a evitar el hundimiento del suelo, los pozos domésticos y otros pozos se sequen en el futuro. Las cuencas de recarga también proporcionan un lugar para que el agua de la inundación vaya durante los años húmedos.

¿Por qué debería saber sobre la recarga de aguas subterráneas?

Los sitios de recarga de aguas subterráneas se seleccionan cuidadosamente en función de las condiciones del suelo, el uso histórico de la tierra, la ubicación y la disponibilidad de infraestructura para mover el agua a la ubicación. Dado que las áreas rurales han tenido una disminución en los niveles de agua y cumplen con muchas de las condiciones ideales, es posible que vea cuencas de recarga de agua subterránea que se están construyendo cerca de usted y debe saber cuáles son.

¿Debería preocuparme por vivir cerca de una cuenca de recarga de agua subterránea?

Las cuencas de recarga de aguas subterráneas traen muchos resultados positivos, pero también pueden crear preocupaciones. Una preocupación podría ser un aumento en la contaminación de las aguas subterráneas. Esta preocupación depende de muchos factores y puede tardar años en suceder. Se están realizando estudios para determinar si y cómo la recarga de agua subterránea podría afectar el agua potable. Mientras tanto, si se construye una cuenca de recarga cerca de usted, le recomendamos que realice pruebas de muestra regulares de su agua potable para ver si hay algún cambio.

Para más información o preguntas, póngase en contacto con:

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www.californiawater.org

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