Butte County
•CALIFORNIA•

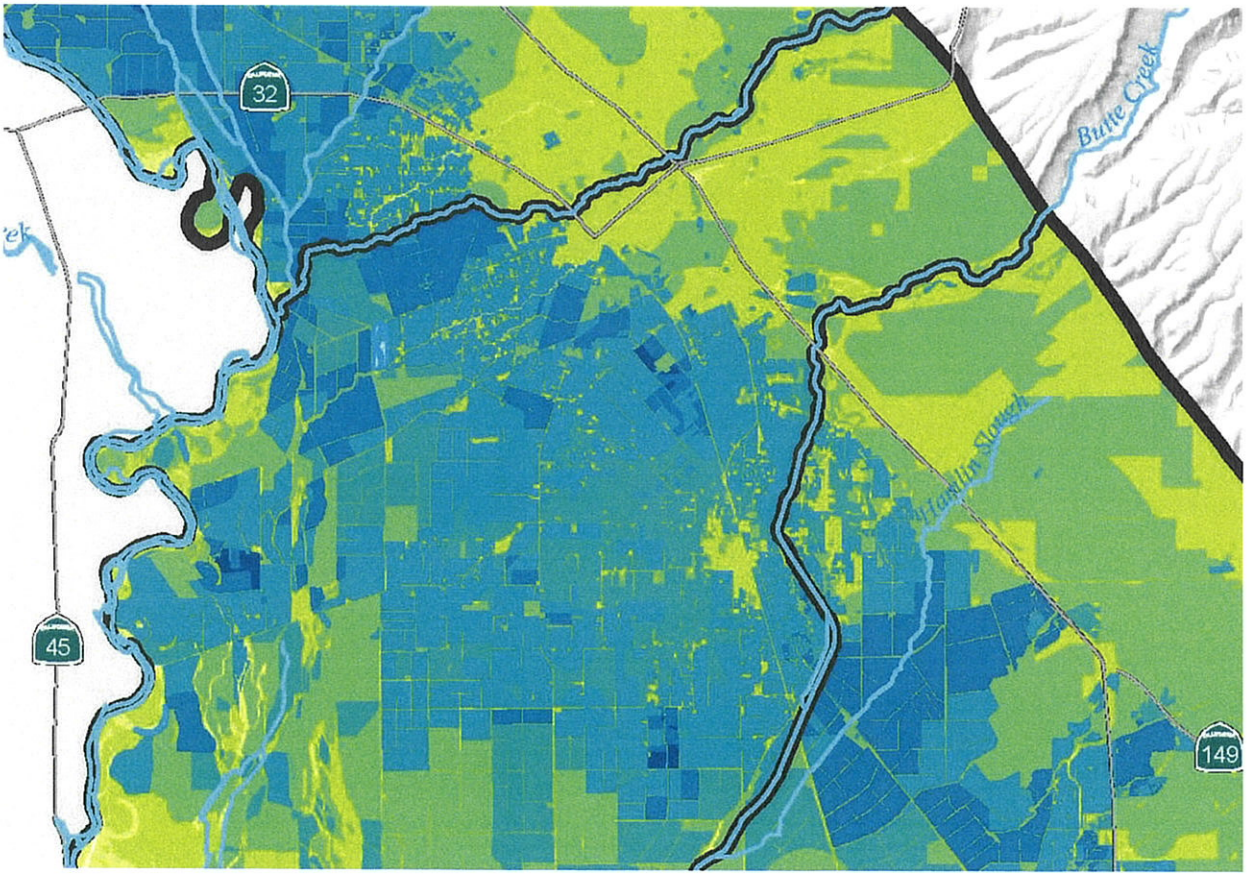
GEI Consultants

Consulting
Engineers and
Scientists

Butte County

Evaluation of Restoration and Recharge Within the Butte County Groundwater Basins

January 2018



Prepared by
GEI Consultants, Inc.

In association with
Davids Engineering, Inc.
ERA Economics
Land IQ

1. EXECUTIVE SUMMARY

The California Department of Water Resources awarded Butte County with a Counties with Stressed Basins Grant under the Sustainable Groundwater Planning Grant Program pursuant to the Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1[1]).

The primary goal of this project is to identify and create tools to help the County of Butte achieve groundwater sustainability as required by the Sustainable Groundwater Management Act (SGMA). This project focuses on the identification and feasibility of both direct and in-lieu recharge of the groundwater basins within Butte County (Vina, West Butte, East Butte and Wyandotte Creek[2]). The Butte County Department of Water and Resource Conservation is the lead agency responsible for this project and serves as contract administrator.

SGMA requires groundwater sustainability agencies (GSAs) to develop groundwater sustainability plans (GSPs). For the County to be successful under SGMA, a complete assessment of the basins is needed to determine optimal places for groundwater recharge and to evaluate the availability of surface water supplies that could be used to provide recharge.

The project is focused on lands within Butte County, but is also regional in nature because all four subbasins within Butte County extend into neighboring counties. This assessment will assist land use planners and water resource managers in decision-making under SGMA. It will further the planning process by providing options for the design and implementation of future direct and in-lieu recharge projects that may become part of Groundwater Sustainability Plans.

A recharge constraints analysis was conducted to identify superior recharge areas by weighting an array of relevant physical characteristics (e.g., soil type, depth to water, geology) and anthropogenic (human-influenced) conditions that affect where recharge could be conducted.

From the analysis conducted on factors affecting site suitability, four main considerations were identified: Land Use; Aquifer Properties; Location; and Environmental Constraints. Factors related to these were used to evaluate various methods of groundwater recharge. There are two general approaches to artificial groundwater recharge: direct recharge and indirect recharge. Direct recharge involves physically delivering water to the aquifer system, whereas indirect (or in-lieu) recharge increases groundwater storage by offsetting the use of groundwater with

[1] Water Code Section 79700 et seq.
[2] The Wyandotte Creek Groundwater Subbasin was subdivided from the North Yuba Groundwater Subbasin in 2016

another water supply source (e.g., surface water). There are advantages to each approach, and local conditions may suggest which methods are more appropriate for a particular location.

A series of constraints maps were developed using a Geographic Information Systems analysis of the various factors that favor or constrain the various method. In general, the best opportunities would provide surface water to lands currently using groundwater in lieu of their present groundwater pumping. Groundwater recharge by creating dedicated recharge ponds would allow capture of available stormflows and may be viable in many areas. Flooding fields is a variant of the recharge ponding method that would be restricted to the non-irrigation season. Injection wells are restricted by regulation to recharge only highly treated potable water, and are not a near-term solution due to the lack of water treatment plants.

Potential sources of water for direct and in-lieu recharge projects in Butte County fall into the following categories:

- Contracted water – primarily State Water Project Table A water contracted to Butte County and stored in Oroville Reservoir
- Natural flow in local waterways
- Surface water diversions distributed through irrigation facilities
- Sacramento River water (use of this source would likely require an exchange of Table A water for water extracted from the river)

The clearest opportunities for promoting groundwater recharge in Butte County lie with planning and support of recharge programs designed to improve the use of water supplies now available within the County. Although, major projects designed to make use of Table A water are attractive long-term options, implementation of any of these alternatives will require a heavy commitment of resources, negotiation of contracts with in-County water purveyors and, in the case of projects that would draw water from the Sacramento River, negotiations with the Bureau of Reclamation.

Given the high cost and long horizon for implementation of any of these alternatives, the best short- and medium-term options make use of water now available within the County. These alternatives tend to be programs to encourage agricultural water users to install dual-source irrigation systems, policies to incentivize urban developers and property owners to install semipermeable pavements, and efforts to identify and advance local *in-lieu* recharge projects that would provide areas, such as Rancho Esquon, now partially reliant on groundwater access to surface water supplies from willing local partners.

To further evaluate the potential to utilize dual-source irrigation systems to make additional use of surface water currently available in the County, an economic and agronomic evaluation of dual-source systems was conducted. Typical components of these systems, which allow growers to make use of either groundwater or surface water for irrigation, were characterized, along with upfront (capital) and ongoing (operations and maintenance) costs relative to systems utilizing groundwater only. Additionally, agronomic factors affecting whether growers choose to utilize groundwater, surface water, or both sources when available were evaluated. Finally, a preliminary economic analysis of local and regional benefits and costs of utilizing dual source systems to address potential groundwater overdraft conditions in Butte County was prepared.

Typical system components required for a dual source system are a surface water irrigation "turnout" or point of delivery to the field, a pipeline or ditch to convey water from the turnout to a pump station, a pump or pumps for pressurization, and filtration. Although the layout and specific components for dual source systems will vary from field to field, these four components generally account for the additional equipment needed for dual source systems as compared to groundwater only or "single source" systems. Accordingly, the additional capital and maintenance costs associated with these components represent an additional upfront investment required to utilize dual source systems, as compared to systems relying solely on groundwater for irrigation; the use of surface water results in a reduction in lift requirements and associated energy requirements compared to the use of groundwater. In some cases, the reduced energy requirements and cost savings may be greater than the capital and maintenance costs of the dual system components, resulting in a net cost savings over time to growers using dual source systems.

Several factors may be considered by growers when deciding to utilize available surface water supplies for irrigation. A primary consideration is cost, and the use of a dual source system may or may not result in a net cost savings over time depending on several factors. Another primary reason growers prefer groundwater is the reliability of an on-demand water source. This advantage of groundwater diminishes if surface water is available on-demand during the growing season. Reliability of water supply is important not just seasonally or annually, but also within a given year when water might be needed on specific days (e.g. for frost protection), or to supply water during particularly dry winter and early spring months. Another primary factor for fruit and nut trees is disease risk. Root and crown rot (Phytophthora) is transmitted through surface water in Butte County and can result in permanent crop damage and yield reduction. Thus, a benefit of using groundwater for orchard irrigation as compared to surface water is reduced risk of root and crown rot; however, there are several management options to prevent contact between wood and water, reducing this risk. Other factors that may result in advantages or disadvantages of using surface water include chemical constituents, such as mineral content and

nitrates in groundwater and total dissolved solids and related considerations such as infiltration and salinity.

In areas where surface water is currently available or could be made available in the future, lack of grower familiarity with dual source systems is a potentially significant barrier to the use of surface water, particularly for pressurized irrigation systems. Growers should consider the added complexity and initial costs of dual source systems, as well as factors related to flexibility, disease risk, and water quality. The Sustainable Groundwater Management Act introduces the long-term sustainability of the groundwater basin as another consideration.

Preliminary evaluation of local and regional benefits and costs associated with dual source systems, although reliant on several key assumptions at the initial stage of investigation, suggest that benefits may significantly exceed the costs and additional investigation of potential projects could be warranted. Economic benefits quantified in the analysis include the value of stable groundwater levels reflected in the avoided cost of groundwater pumping by all groundwater users within the County; the benefit of increased future water supply reliability, reflected in reduced water supply risk to growers; and avoided costs of fallowing (or other programs) to manage groundwater overdraft. Costs quantified in the analysis include the net cost of constructing, operating, and maintaining dual source systems, considering potential cost savings to participating growers through reduced lift requirements. In subsequent stages of analysis, cost estimates would be refined, along with other key assumptions, to include additional costs for planning, design, permitting, legal costs, etc.

The results of this project provide useful information to guide further evaluation to maintain or achieve sustainable groundwater management in Butte County during GSP development for the subbasins subject to SGMA in Butte County. Proactive efforts to identify solutions to potential sustainability challenges offer the opportunity to minimize the risk of actions that could adversely impact the local and regional economy.

5. IDENTIFIED RECHARGE PROJECTS

5.1. Approach

The importance of groundwater recharge has long been recognized in Butte County. However, the recent drought and passage of the Sustainable Groundwater Management Act (SGMA) have accentuated local recognition of groundwater's value as a resource. Candidate recharge projects were identified through review of an array of planning documents and through discussions with local interests. Many of the projects described in this report have long histories that demonstrate the level of consideration that has been given to groundwater recharge either as a single objective effort or as a component of multi-benefit projects and an action item in the Butte County 2030 General Plan.

5.2. Water Sources for Recharge

Potential sources of water for direct and in-lieu recharge projects in Butte County fall into the following categories:

- Contracted water – primarily SWP Table A water contracted to Butte County and stored in Oroville Reservoir
- Natural flow in local waterways
- Surface water diversions distributed through irrigation facilities
- Sacramento River water (use of this source would likely require an exchange of Table A water for water extracted from the river).

5.2.1. Contracted Water

Butte County holds a long-term water supply contract with DWR for 27,500 af/y of State Water Project (SWP) Table A water stored in Lake Oroville. Of this supply 24,000 af/y are now leased to south of Delta entities for municipal and industrial supply with these leases up for renewal in 2031. Historically, use of Table A water within Butte County has ranged from 300 af/y to 3,500 af/y with unused supply being made available to the south of Delta lessees.

Local use of Butte County's Table A supply has long been considered as a water management objective and is noted as a priority in the county's 2005 Integrated Water Resources Program.[21] Beginning in 2008, the County was required to pay for its full Table A allocation regardless of whether the allocation was used, and in 2010 the Butte County Supervisors requested that a fiscally sustainable plan for use of SWP Table A supply be identified.[22] Butte County continues to seek "in-County" purveyors for its SWP Table A water. Unlike most other surface water sources, water stored in Oroville Reservoir under agreements such as the Table A provisions, has the potential to be delivered following a schedule that matches the operating requirements of the user. For example, deliveries of Table A water could be scheduled to meet the operating requirements of water treatment plants or to take best advantage of *in-lieu* or direct recharge opportunities.

Alternatives for use of contracted water for recharge range from the ambitious multiple benefit projects described in DWR's *Oro-Chico Conduit Conceptual Plan*[23] to more modest concepts such as those presented in the *Surface Water Supply Feasibility Study*.[21]

5.2.2. Natural Flow in Local Waterways

Management of water flowing in local waterways is an option for augmenting recharge in areas where streams flow across principal groundwater recharge locations. In these instances, enhanced recharge from waterways would replenish the underlying aquifer and contribute to stream baseflow during low flow periods. This alternative, presented as Option 21 in the Butte County Integrated Water Resources Plan, is intended to support environmental restoration of local streams, contribute to stream baseflow during periods of low flow and to augment groundwater recharge. Other candidate waterways include:

- Dry Creek
- Big Chico Creek
- Little Chico Creek, and
- Pine Creek.

The results of the *Lower Tuscan Aquifer Monitoring, Recharge, and Data Management Project*[24] indicate that the individual stream channels flowing across the Tuscan Formation outcrop to the east of the valley floor are not major sources of recharge to the Lower Tuscan Aquifer. However, this study suggests that shallow alluvial aquifers overlying the Tuscan

[21] CDM, 2005. Integrated Water Resources Program, May 2005 for Butte County Department of Water and Resource Conservation
[22] West Yost Associates, 2015. Surface Water Supply Feasibility Study for Cal Water Chico District
[23] DWR, 1997
[24] Brown and Caldwell, 2013

Formation near the foothills act as a recharge source by absorbing water from precipitation and from the streams as they enter the valley with a portion of this water then percolating from the shallow aquifers to the Lower Tuscan Aquifer. This finding suggests that while the pathway between the creeks and production aquifers may not be direct, a portion of the water recharged from streams does become available to groundwater users. To test this hypothesis, the Brown and Caldwell report recommends that a localized study of recharge potential be conducted.

5.2.3. Water Distributed through Irrigation Facilities

An important source of recharge in Butte County has been delivery of surface water to irrigated lands and percolation of infiltrated irrigation water to aquifers.

Much of the irrigated acreage in Butte County is devoted to rice production because of the suitability of local soils, climate and water supply to this crop. While the practice of flooding rice fields generates deep percolation, the volume of percolation is constrained by the low infiltration rates of soils that can be ponded, a necessary characteristic for rice production. Flooding of rice fields is expected to continue to be a stable source of direct recharge that is unlikely to be greatly affected by changes in cropping or cultural practices. However, the potential for expanded use of rice ground for direct recharge is limited because of the low infiltration rates that make these lands suitable for rice cultivation in the first place. Therefore, the greatest opportunity for increased recharge on rice lands may lie through *in-lieu* recharge to reduce reliance on groundwater for rice irrigation.

Land devoted to other crops presents different challenges and opportunities as some growers are shifting from use of surface water delivered through district-owned facilities to pumping of groundwater from grower-owned wells to provide a more flexible source of irrigation supply. From the standpoint of groundwater management, this shift represents an instance of "reverse *in-lieu*" recharge where groundwater is replacing surface water as the primary source of supply. While the low-volume irrigation techniques used to apply groundwater minimize the volume of water needed to satisfy crop demands, this shift in water source results in a net depletion of groundwater rather than the net recharge observed from application of surface water. Practices such as dual-source irrigation systems represent opportunities to preserve the agronomic advantages of groundwater use while mitigating increased reliance on groundwater. Section 6 of this report – *Economic Evaluation of In-lieu Groundwater Recharge* – includes an extensive analysis of the potential of dual-source irrigation systems as a tool for groundwater recharge.

5.2.4. Pumping from the Sacramento River

The Sacramento River is a potential source of water for recharge. However, as Butte County lacks entitlements to divert water from the river, agreements would be required to allow water from sources such as Butte County's Table A contract to be made available to the Bureau of Reclamation in exchange for an entitlement to divert from the river.

5.3. Project Alternatives

This section describes a variety of project and program alternatives that have been formulated to increase groundwater recharge in Butte County. These concepts range from major construction efforts to small-scale local programs. These project alternatives are mapped on Figure 5-1 at the end of this section.

5.3.1. Alternative 1: Bi-directional Conveyance from Oroville

Variants of this project are presented in DWR's *Oro-Chico Conduit Conceptual Plan* and in the county's *Integrated Water Resources Plan* with the most complete description included in the DWR study. This alternative would convey water via a canal or pipeline from a pumping station in or near Thermalito Forebay to Chico with some configurations extending as far north as Robber's Gulch. Each project alternative would relieve drought conditions in the Cherokee Strip and enhance supplies for portions of the Western Canal and Esquon areas.

Water conveyed to Chico could be delivered either to a water treatment plant or for recharge of the shallow aquifer with recharged water eventually migrating to the Lower Tuscan Formation. Water delivered to the Cherokee Strip, Western Canal and Esquon areas could be used for irrigation in the summer, rice decomposition in the fall and for the creation of habitat, allowing for both direct and *in-lieu* recharge. A possible location for the pumping plant that would draw water for conveyance to Chico is along the Outlet Channel between Lake Oroville and the Thermalito complex, a location that would minimize interference with the Powerhouse and Dam.

A limitation of this and other alternatives reliant on use of surface water as a source for *in-lieu* recharge is that many growers are concerned about application of surface water to orchard crops. Surface water in nearly all creeks, streams, and rivers in Butte County is known to carry spores of *Phytophthora* fungus, a water mold that requires specific conditions, such as wet, saturated soils, standing water around tree trunks, or trunks wetted frequently, to become a disease that infects trees and other plants. *Phytophthora* is known to damage the roots of orchard trees, mainly almonds and walnuts. The risk of use of surface water for irrigation may be controlled by

maintaining adequate surface and subsurface drainage in irrigated fields to discourage transmission of *Phytophthora* by maintaining aeration of the soils.

5.3.1.1. Alternative 1A: Bi-directional Canal - Oroville to Robber's Gulch

This alternative features a bi-directional canal with a variable-height, constant-elevation levee forming its west side. The design concept presented in the *Oro-Chico Conduit Conceptual Plan* features a canal having a uniform invert elevation of 215 ft MSL, a capacity of 300 cfs when flowing from south to north, and a capacity of 1,000 cfs when conveying water intercepted by the canal alignment southward to the Thermalito complex. There would be no embankment on the canal's east side allowing the western embankment to impound runoff reaching the canal alignment to form a chain of lakes. Water stored in these lakes could either be released at locations along the canal to supplement water pumped from the Thermalito complex to support groundwater recharge and irrigation supply or could be transported south to the Forebay where the water could be used to meet required fishery releases in the Feather River or be pumped back for storage in Oroville Reservoir.

This alternative would provide recharge water to the numerous small tributary streams between Oroville and Chico and could supply surface water to the Durham Mutual Water Company, Adams and Gorrill ranches and the Esquon Ranch to reduce groundwater pumping and contribute to *in-lieu* recharge. The capital cost for this alternative presented in the 1997 *Oro-Chico Conduit Conceptual Plan* is $74M. This is equivalent to a 2017 cost of $137M after adjustment using RSMeans' historical cost indices (1997: 54.1 - 2017: 100)

5.3.1.2. Alternative 1B: Bi-directional Canal - Oroville to Hamlin Slough

This alternative resembles 1A in alignment and capacity but is shorter ending at Hamlin Slough. Avoiding a long cut section through an elevated terrace between Nance Canyon and Crouch Ravine substantially lowers the alternative's cost by reducing the required earthwork. The alternative could provide agricultural water to about half of the lands of the Durham Mutual Water Company and supply both the Adams and Gorrill ranches.

The total capital cost for alternative 1B presented in the *Oro-Chico Conduit Conceptual Plan* is $61M which is equivalent to an adjusted 2017 capital cost of $112M.

Benefits cited in the *Oro-Chico Conduit Conceptual Plan* for alternatives 1A and 1B include:

- Increased groundwater recharge in the Butte Basin
- Storage of flood runoff from local creeks in Oroville Reservoir
- Control of sediment from the Cherokee Mine

- Reduction of Cherokee Canal flood flows
- Delivery of surface water by gravity to the Cherokee Strip, to a portion of Western Canal Water District upslope of their main canal and to Rancho Esquon
- Increase Butte County's options for use of their SWP Table A contract.

The economic justification for groundwater recharge framed in the *Oro-Chico Conduit Conceptual Plan* presumes that much of the recharge generated by the project would be sold to water deficit urban areas outside of the Butte Basin. This economic justification reflects the time, 20 years past, when the plan was developed and may not be representative of priorities today.

5.3.2. Alternative 2: South to North Conveyance from Oroville

5.3.2.1. Alternative 2A: South to North Canal

Alternative 2A is a sloped (single-direction) canal capable of carrying 300 cfs from Thermalito Forebay to Hamlin Slough. With no chain of lakes, sediment storage or capability to divert flood flows to the Oroville Project, this configuration is less ambitious and less costly than the bi-directional canals presented in Alternative 1. However, Alternative 2A does perform the central function of Alternative 1 by conveying water diverted from Oroville Reservoir during periods when these diversions could be successfully applied for direct or *in-lieu* recharge.

The total capital cost of this alternative presented in the *Oro-Chico Conduit Conceptual Plan* was $33M which is equivalent to a 2017 capital cost of $61M.

5.3.2.2. Alternative 2B: South to North Pipeline

This alternative is similar in scale to Alternative 2A. However, as the alternative's goal is to convey water from the Thermalito Forebay to Chico, a pipeline is preferred for protection of public health and safety. The *Surface Water Supply Feasibility Study* which presents this alternative favors an alignment following the right-of-way of the abandoned Sacramento Northern Railway, a route that runs largely through rice fields and orchards.

The total capital cost range of this alternative presented in the 2015 *Surface Water Supply Feasibility Study* was from $71M to $108M.

5.3.3. Alternative 3: Construction of Recharge Basins

This alternative focuses on siting recharge basins along the eastern portion of the valley on recharge areas for the Lower Tuscan formation such as an area east of Highway 99 south of Chico. Recharge basins would capture local runoff and excess flows for percolation and could be expanded to capture Table A water conveyed from Lake Oroville using the conveyance alternatives described above. Recharge basins could also be constructed in areas such as lands owned by the M&T Ranch to recharge water diverted from the Sacramento River.

One option for construction of recharge basins is to explore opportunities to use existing gravel quarries for recharge. For example, the *Oro-Chico Conduit Conceptual Plan* notes the possibility of diverting flood flows from Butte and Little Chico creeks into gravel extraction pits neighboring these waterways with seepage from these pits recharging the alluvial fan in the Chico area. Diversions could be made from either Durham Mutual Dam or from the Little Chico to Butte Creek flood overflow channel with diverted water being conveyed to the extraction pits through existing irrigation ditches and pipelines.

5.3.4. Alternative 4: Sacramento River Diversions

The *Surface Water Supply Feasibility Study* evaluated two configurations for conveyance of water from the Sacramento River to Chico. Implementation of either of these options would require an agreement between the Bureau of Reclamation, the State Water Project and Butte County allowing water pumped from the river to be exchanged with a portion of the county's allocation of Table A water.

5.3.4.1. Alternative 4A: Radial Collector Wells

This alternative entails the construction of two radial collector wells in the Sacramento River and of a pipeline on private lands adjacent to the alignment of Highway 32. Use of new radial collector wells would avoid the on-going maintenance at the M&T diversion described below, and water extracted from the collector wells would require less treatment than surface water diversions.

5.3.4.2. Alternative 4B: Use of Existing M&T Ranch Diversion Facilities

In 1997, the M&T Ranch diversion was relocated from Big Chico Creek to the east bank of the Sacramento River downstream of the confluence with Big Chico Creek to correct a condition where pumping caused the creek to run backward. Subsequently, an upstream gravel bar has

encroached on the diversion facility threatening operation of the pumping plant and proper functioning of the 150-cfs fixed cylindrical fish screen.

Although use of the existing diversion structure would have lower construction costs than the radial collector wells proposed in Alternative 4A, reliance on the existing structure may not be practical unless a solution is reached for stabilizing the river channel to control accumulation of gravel on the east bank and bank erosion on the west.

Capital costs for Alternative 4 presented in the 2015 *Surface Water Supply Feasibility Study* ranged from $20M to 32M.

5.3.5. Alternative 5: Cherokee Canal Alternatives

5.3.5.1. Background

The Cherokee Canal refers to the channelized, leveed, downstream section of Dry Creek, which connects further downstream to Butte Creek before discharging to the Butte Basin. The canal collects all drainage water from the 61,000-acre watershed of Dry Creek, Gold Run, and Cottonwood Creek and conveys this water through a predominantly agricultural landscape. The canal originally was designed to provide flood protection to the towns of Biggs, Nelson, and Richvale. Currently, the canal also protects 35,000 acres of agricultural land (Cherokee Watershed Alliance and Butte County, 2005).

5.3.5.2. Alternative 5A: Cherokee Canal Flood Management

Alternatives to improve the flood protection provided by the Cherokee Canal feature the following program elements:

- Construction of a settling basin to capture suspended coarse sediment (fine sand and larger) and to retain sediment at a location where excavation and stockpiling of this material can be performed with minimal disruption to the environment.
- Construction of a flood water attenuation basin to reduce flood peaks so that flows do not exceed the conveyance capacity of the canal.
- Treatment of the watershed of Dry Creek and Cottonwood Creek to improve habitat quality, stabilize exposed sources of sediment and retard runoff to reduce both the quantity of sediment and the flood peaks that enter the Cherokee Canal system.
- Modification of the Cherokee Canal to configure the area within the levees so that it includes both high quality, contiguous habitat and a channel capable of transporting sediment-laden flood water that is accessible for periodic maintenance.

Although none of these improvements was conceived to promote recharge, the proposed program would increase recharge in the watershed, the settling basin, the flood attenuation basin and the prism of the canal. These flood management elements illustrate how recharge opportunities may arise from implementation of projects formulated for other purposes or from linkage of project concepts. For example, the *Oro-Chico Conduit Conceptual Plan* (Alternatives 1A and 1B, above) notes reduction of flood flows and sediment entering the Cherokee Canal among the project's benefits.

5.3.6. Alternative 6: Other Project and Program Options

5.3.6.1. Alternative 6A: Creation of Groundwater Replenishment District

An alternative proposed in the *Integrated Water Resources Program*[25] prepared for the Butte County Department of Water and Resource Conservation would establish groundwater replenishment districts to increase the groundwater supply for future water demands and protect groundwater sources from contamination. These districts could cover any recharge area in the County and would work cooperatively with State and Federal agencies to perform the following:

- Buy, sell and exchange water
- Distribute water to persons in exchange for ceasing or reducing groundwater pumping
- Spread, sink and inject water into the ground
- Store, transport, recapture, recycle, purify, treat or otherwise manage and control water for the beneficial use of persons or property within the district
- Build the necessary works to achieve groundwater replenishment
- Acquire water rights within or outside the District, and
- Exercise the right of eminent domain to take any property necessary to supply the district with replenishment water

The districts would be able to fix rates for sale or exchange of water and would also have the power to levy a tax if the revenues from water charges were insufficient to pay for operating expenses.

Although the *Integrated Water Resources Program* is over ten years old, the concepts in this alternative align well with the emphasis on local groundwater management expressed in the Sustainable Groundwater Management Act and may offer avenues for SGMA implementation

[25] CDM, 2005. Integrated Water Resources Program, for Butte County Department of Water and Resource Conservation, May 2005

through Groundwater Sustainability Agencies (GSAs) and for organizing private pumpers to participate in sustainable groundwater management.

5.3.6.2. Alternative 6B: Protection of Recharge Area Water Quality

This alternative, also presented in the *Integrated Water Resources Program,* includes zoning of lands overlying and immediately upgradient of defined recharge areas to minimize potential impacts to groundwater. Zoning would minimize the potential for water quality degradation by prohibiting new industrial and commercial activities with a significant potential for anthropogenic impact to groundwater. New housing in these areas would require sanitary sewers to minimize nitrate pollution from septic systems and encourage implementation of practices such as use of semi-pervious paving materials where suitable.

5.3.6.3. Alternative 6C: Incentivize Use of Dual System Irrigation

As described previously, one of the challenges to increasing recharge in Butte County is the shift from surface irrigation of tree crops to irrigation of these crops using groundwater applied through low-volume irrigation systems. In addition to reversing a practice where a portion of the applied surface water percolates to groundwater to one where irrigation is supplied by groundwater extraction, the shift from irrigation using surface water to use of groundwater reduces revenue to districts that purvey surface water. One response is the introduction of dual source systems as described in detail in Section 6.

5.3.6.4. Alternative 6D: Partnerships

Many of the alternatives described above require partnerships as a prerequisite to implementation. These partnerships generally entail the following two types of agreements:

- Exchange agreements such as the one that would be needed between the Bureau of Reclamation, the State Water Project and the County to enable the County to pump water from the Sacramento River in exchange for Table A water stored in Oroville.
- Agreements between the County and water purveyors such as Cal Water, Rancho Esquon, Durham Mutual WD and others for the purchase of long-term usage of a portion of the County's Table A entitlement. For example, the *Surface Water Supply Feasibility Study* assumes that up to 20,000 af/y of Table A water would be available for delivery to Cal Water's Chico-Hamilton City District and that this supply would be used for treatment at a new water treatment plant or for recharge to the groundwater basin.

5.3.7. DeSabla-Centerville Project

The PG&E-owned DeSabla-Centerville Project is in the Butte Creek and West Branch Feather River drainage basins. The project consists of the 18.5 MW DeSabla Powerhouse, the 1.5 MW Toadtown Powerhouse and the 6.4 MW Centerville Powerhouse and includes two storage reservoirs in the upper watershed.

PG&E is soliciting proposals from parties interested in acquiring the project either through license transfer, filing of a new license, or other means. Although there has been some anticipation that if PG&E is successful in selling the project, more water may become available for other purposes, FERC's ruling of March 2, 2017 disallowing PG&E's Notice of Withdrawal of its Application for a new license, suggests it is premature to consider reoperation of this project as a potential source of water for recharge.

5.4. Recommendations

Based on the preceding analysis of groundwater recharge project categories, the following recommendations are presented.

5.4.1. Oro-Chico Conduit Alternatives

This group of alternatives is characterized by their ambitious scale, high cost and wide range of benefits. A central feature of these alternatives is that their success depends on operation of the proposed engineered facilities and, more fundamentally, on active operation of the groundwater basins to be recharged. Basin operation is essential because project benefits are predicated on the ability to generate revenue through exercising the basins to produce project yield. Thus, in addition to permitting and other steps needed to bring these projects to completion, detailed studies are necessary to 1) determine how groundwater basins might be operated to generate project yield, and 2) gain local understanding and acceptance of active management of groundwater basins and of the fluctuations in groundwater elevations that would result from active management. Finally, for the project to achieve the central objective of transferring the use of Table A allocation from south-of-Delta lessees to in-County users without placing an unacceptable financial burden on local tax payers, the County would have to identify local entities able to contract for project yield at a worthwhile price. In the past, programs to "exercise the basin" have not been attractive and may not be desirable now. However, there may be aspects of this historical project that are worth considering or can be combined with other ideas.

5.4.2. Oro-Chico Pipeline Alternative

This alternative would convey Table A water from Lake Oroville to a Cal Water treatment plant near Chico or for groundwater recharge. Construction of a pipeline to convey water from Lake Oroville to the facilities of Cal Water's Chico – Hamilton City District appears to be technically feasible and would accomplish the purpose of using Butte County's Table A water to serve purposes within the county. Therefore, the viability of this project appears to turn on the financial terms that could be reached between the County and Cal Water, or agricultural users, for use of Table A water.

5.4.3. Construction of Recharge Basins

Construction of recharge basins is a necessary component of any direct recharge project receiving water from local streams, from Lake Oroville or from the Sacramento River. Hydrogeologic analyses cited in this report indicate that some portion of water recharged at facilities located on the east side of the groundwater basin is likely to migrate to aquifers that are sources of domestic, municipal and agricultural supply. However, as pathways that convey water from the ground surface to production aquifers may be tortuous, field investigations are required before siting these facilities and to estimate the volume of water likely **to be recharged.**

5.4.4. Diversions from the Sacramento River

The evaluation presented in the *Surface Water Supply Feasibility Study* recommends Alternative 4A (construction of two radial collector wells) as the preferred option for diversion of water from the Sacramento River as this option avoids the ongoing maintenance requirements that has been experienced up to this point at the M&T diversion. Because of the proximity of the proposed point of diversion to Cal Water's place of use in Chico, the $28M capital cost of diversion and conveyance to the place of use is substantially less than the estimated $73M capital cost presented in the *Surface Water Supply Feasibility Study* for construction of a pumping plant and pipeline for conveyance of water from the Thermalito Outlet Channel to Chico.

Any alternative for diversion from the Sacramento River is likely to require an agreement with the Bureau of Reclamation to exchange a portion of the County's Table A supply for diverted water. Therefore, as with other alternatives involving Table A water, an important factor in determining the viability of this project is a comparison between the value to the County of continuing to lease Table A water to south-of-Delta interests versus foregoing the leasing agreement in favor of increasing the volume of water available within the County and capturing revenue received by sale of Table A water to in-County interests.

5.4.5. Opportunistic Projects

Each of the alternatives described above entail increasing use of Butte County's Table A supply within the County, an approach that would provide a reliable source of water for both direct and in-lieu recharge but would require the County to forgo at least a portion of the revenue generated through the existing leases of Table A water to south-of-Delta purveyors.

Projects such as Alternative 5A – Cherokee Canal Flood Management are opportunistic efforts. Alternative 5A was not developed as a groundwater recharge project and lies in an area of the County where the advantages of direct recharge are not as great as at other locations. Nevertheless, if this project were to advance as a flood management measure, the project should be recognized for its potential to contribute to groundwater recharge. Similarly, routing of flood flows from streams to nearby gravel pits is a low-cost recharge option that should be exploited when such opportunities are identified.

5.4.6. Recharge Programs

The clearest opportunities for promoting groundwater recharge in Butte County lie with planning and support of recharge programs designed to improve the use of water supplies now available within the County. Although, major projects designed to make use of Table A water are attractive long-term options, implementation of any of these alternatives will require a heavy commitment of resources, negotiation of contracts with in-County water purveyors and, in the case of projects that would draw water from the Sacramento River, negotiations with the Bureau of Reclamation.

Given the high cost and long horizon for implementation of any of these alternatives, the best short- and medium-term options make use of water now available within the County. These alternatives tend to be programs to encourage agricultural water users to install dual-source irrigation systems, policies to incentivize urban developers and property owners to install semipermeable pavements, and efforts to identify and advance local *in-lieu* recharge projects that would provide areas, such as Rancho Esquon, now partially reliant on groundwater access to surface water supplies from willing local partners.

Figure 5-1 Potential Projects