TECHNICAL MEMORANDUM

LAND SUITABILITY AND YIELD ASSESSMENT FOR MULTIBENEFIT LAND REPURPOSING IN EAST TURLOCK SUBBASIN GSA

PREPARED FOR: East Turlock Subbasin Groundwater Sustainability Agency

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Current estimates indicate that net groundwater demand must be reduced by approximately 95,700 acre-feet per year (AFY) to achieve Sustainable Groundwater Yield within the East Turlock Subbasin Groundwater Sustainability Agency (ETSGSA). ETSGSA's strategy to achieve the required net groundwater demand reduction is implementing a Groundwater Overdraft Reduction Framework focused on direct recharge and in-lieu recharge projects and demand management actions that include a multibenefit land repurposing program (MLRP), a land purchase program, a pumping regulation intervention program. The Groundwater Overdraft Reduction Framework is in development, with implementation of some components already in progress and expansion of the program anticipated to occur over the next several years. The MLRP is currently in development under an $8.89 million grant from the California Department of Conservation (DOC). The MLRP is a voluntary demand reduction program with a goal to repurpose 21,000 acres by incentivizing landowners to repurpose portions of their irrigated acreage to new high-value, non-irrigated uses that provide other benefits such as recharge, habitat, flood control and community benefits. Implementation of the MLRP program is anticipated to begin in 2025.

This technical memorandum provides an overview of the spatial analysis process to identify land suitable for implementing MLRP practices within ETSGSA boundaries, and the approach used to calculate the net groundwater demand reduction benefits of the program. The land repurposing practices evaluated include (1) restoration of pre-development hydrology and floodplain reconnection, (2) flood flow dispersal and Flood-Managed Aquifer Recharge (Flood-MAR), (3) orchard swale rewilding, on-farm retention basins, (4) school buffer zones, and (5) delayed orchard replanting (rotational fallowing). The potential water-budget benefits related to demand reduction and the yield from in-lieu and direct recharge for each of these repurposing practices, if applicable, were also estimated. (We note that other repurposing practices are anticipated to be implemented and will provide additional water budget benefits. These will be evaluated in a future analysis.) The geospatial and recharge data from this analysis will be incorporated into the regional California Central Valley Groundwater-Surface Water Simulation Model for the Turlock and Modesto Subbasins (C2VSimTM) to facilitate the evaluation of the effects of implementing MLRP land repurposing practices on the basin's Sustainable Yield. The C2VSimTM model is being updated to evaluate the impact of new and further developed projects and management actions supporting the Turlock Subbasin Groundwater GSP revision. The information presented in this technical memorandum includes:

- A description of the spatial analysis methods and data sources evaluated to identify suitable areas to implement six multibenefit land repurposing practices;
- A summary of the spatial analysis results, including a description of spatial layer outputs and estimated areas for each repurposing practice;
- A summary of the water budget benefit calculation approach, and estimates of the demand reduction, in-lieu recharge and direct recharge benefits of each practice; and
- A generalized timeline for implementation.

1 IDENTIFICATION OF AREAS SUITABLE FOR MLRP PRACTICE IMPLEMENTATION

As described previously, the suitable areas for implementation of six repurposing practices (restoration of pre-development hydrology and floodplain reconnection, orchard swale rewilding, on-farm retention basins, school buffer zones, rotational fallowing, and flood flow dispersal and Flood-MAR) within ETSGSA were identified using a geospatial data analysis process. To identify suitable area, we first determined suitable landscape characteristics necessary to implement each repurposing practice, including complimentary landscape features (e.g., slope < 0.1 degree) and logistical considerations (e.g., how the process can integrate into a working orchard landscape). Next, representative geospatial datasets were selected to identify each landscape characteristic. The spatial datasets were uploaded and overlayed using a sequential, iterative process to refine suitable areas. These areas were then “ground-truthed” using aerial imagery for selected areas to confirm that the process was correctly identifying areas suitable MLRP practice implementation. The potential water budget benefits related to demand reduction, in-lieu recharge and direct recharge were estimated for each repurposing acre. The general assessment protocol is shown in Figure 1.

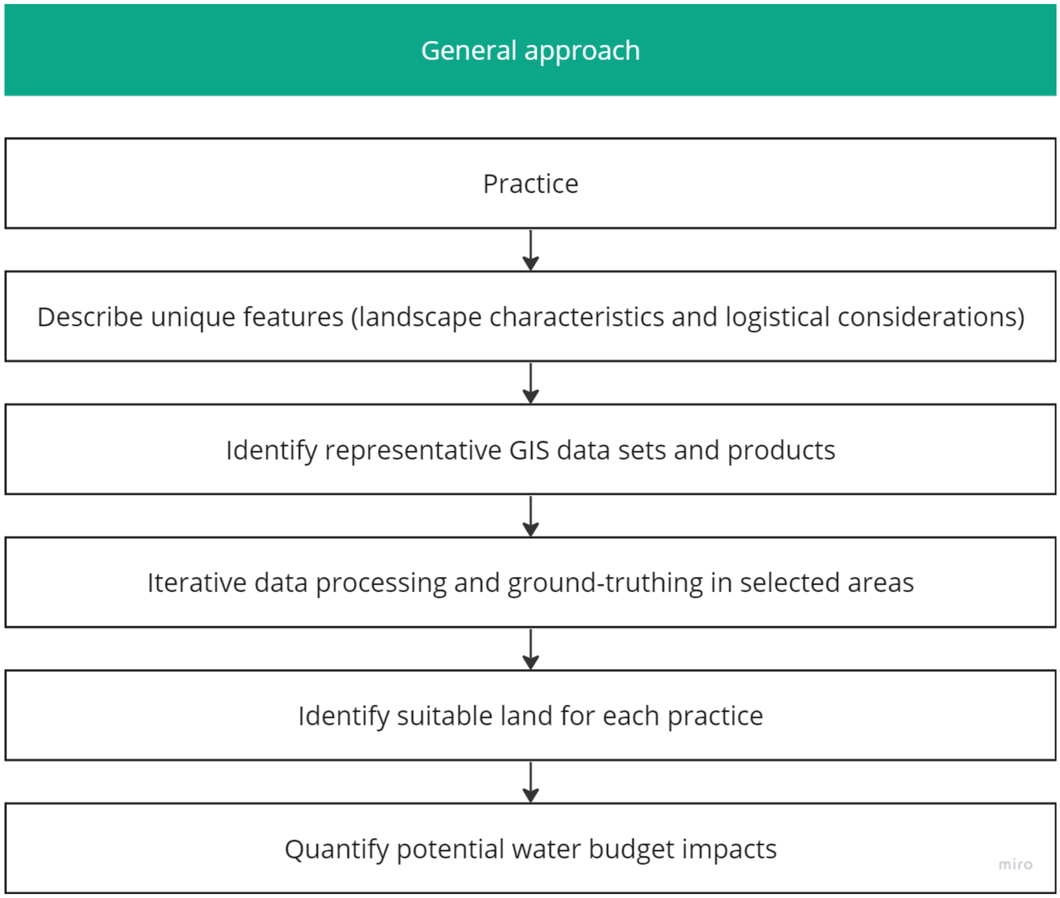

FIGURE 1: GENERAL ASSESSMENT PROTOCOL.

1.1 RESTORATION OF PRE-DEVELOPMENT HYDROLOGY AND FLOODPLAIN RECONNECTION

The MLRP practice of restoration of pre-development hydrology and floodplain reconnection focuses on low-lying, relatively flat areas adjacent to streams, primarily on Mustang Creek and Dry Creek and areas of the Merced River. These areas likely flooded and provided recharge, flood attenuation and habitat benefits during periods of high discharge stage prior to agricultural development. This MLRP practice will employ construction best management practices (BMPs) (e.g., beaver dam analogs, check dams, diversion berms, levee setbacks, seasonal ponds/recharge basins, etc.) that will help slow streamflow, increase the stream wetted perimeter and spread flow across the reconnected floodplain. The practice also includes construction of flow dispersal structures, diversion infrastructure, and off-stream recharge and storage ponds.

The landscape characteristic suitable for floodplain restoration was defined as all land within 200 meters of an identified stream with a land slope of 0.1 degree or less using the process illustrated in Figure 2. The National Hydrography Dataset (NHD; USGS 2023) was used to identify all perennial and intermittent streams within ETSGSA. Land slope for areas within 200 meters of an NHD flowline were then calculated using the 10-meter digital elevation model from National elevation dataset (USGS 2013) that allowed calculation of total acreage available for the MLRP practice. Total irrigated acreage and total almond orchard acreage suitable for restoration of pre-development hydrology and floodplain restoration were calculated by overlaying California Department of Water Resources (DWR) 2020 Crop Layer (CADWR, 2020 Crop Map, released on March 27, 2023).

This process identified a total land area of 5,712 acres and 2,364 acres of irrigated land[1] within ETSGSA that are suitable for restoration of pre-development hydrology and floodplain reconnection and are shown in Figure 2. The practice assumes that irrigated crops will be removed from the identified areas and BMPs will be constructed to allow restoration of the natural hydrology and reconnection of the stream to the floodplain. Additionally, it is assumed that the fields within the identified areas will eventually transition to approximately 75 percent non-irrigated native vegetation and 25 percent riparian vegetation. The removal of irrigated crops from these areas will result in an overall reduction in groundwater demand. Additionally, storage of some runoff in the floodplain areas will be available for either early season irrigation (in-lieu recharge) or direct recharge based on underlying soil and geologic conditions. A description of the estimated demand reduction and recharge related to implementation of the repurposing practice is provided in Section 2.

[1] Irrigated acres were identified by intersecting the total suitable acres with DWR's 2020 Land Use Dataset.

Restoration of pre-development hydrology/floodplain reconnection

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Streams with adjacent low-lying areas where the stream discharge can be slowed and flood discharge reconnected to the adjacent floodplain, with particular focus on Mustang and Dry Creeks

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NHDFlowlines from USGS
DEM (10m)
DWR Crop Layer 2022

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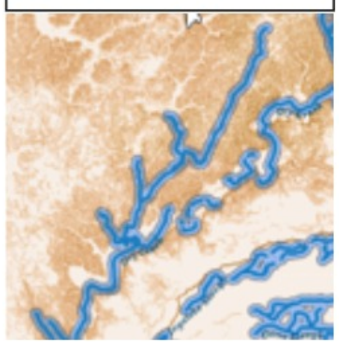
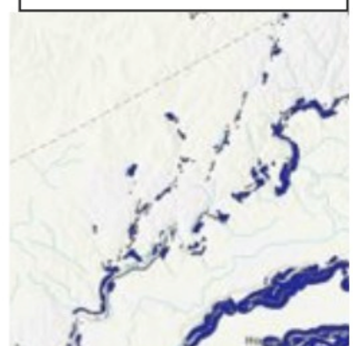
1. Filter NDHFlowlines to Stream/River Hydrographic Category = perennial, intermittent → 2. Expand Flowlines to 200m buffer and calculate slope using DEM → 3. Identify all area within 200m of an NHD Flowline with a 0.1 degree slope or less





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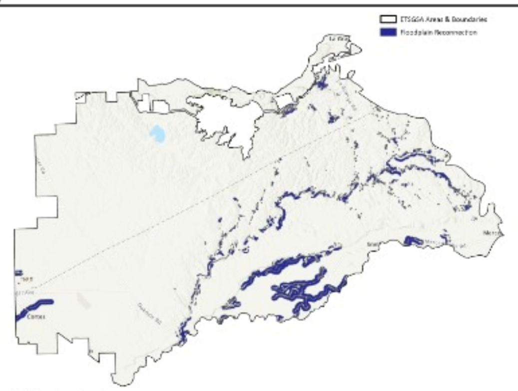
Total acres: 5,712
Irrigated acres: 2,364
Almond orchard acres: 794

Dry Creek acres: 1,439
Mustang Creek acres: 324
Sand Creek acres: 46



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Quantify water budget benefits

FIGURE 2: ASSESSMENT PROTOCOL TO IDENTIFY SUITABLE AREAS FOR RESTORATION OF PRE-DEVELOPMENT HYDROLOGY AND FLOODPLAIN RECONNECTION.

1.2 FLOOD FLOW DISPERSAL AND FLOOD-MAR

The process for identifying areas suitable for floodplain reconnection described above did not result in the identification of any significant area within the Sand Creek watershed, which is managed by the Sand Creek Flood Control District (SCFCD) for flood control protection. Most flow within this watershed moves through constructed ditches and canals and the NHD dataset does not identify perennial or intermittent streams throughout most of this watershed. The MLRP practice of flood flow dispersal and Flood-MAR will focus on the construction of flood attenuation projects with the coupled benefit of direct recharge in the Sand Creek Watershed. This MLRP practice will incorporate BMPs (e.g., retention and flow dispersal structures, Flood MAR, and recharge and storage basins) to convey high flows from canals, ditches, and streams into off-stream recharge and storage basins and areas suitable for Flood-MAR.

The topography within much of SCFCD is relatively flat. Areas suitable for flood flow dispersal and Flood-MAR are defined as being within the SCFCD boundary and the Sand Creek watershed, and adjacent to a canal, ditch, or stream using the process illustrated in Figure 3. To identify suitable areas for flood flow dispersal and Flood-MAR, the Sand Creek watershed boundary was overlain on top of aerial imagery and canals, ditches and streams in the NHD dataset, and an approximately 2,000-foot wide buffer area was delineated around the visible channels. The process identified approximately 4,479 acres that would be suitable for implementing this repurposing practice. For planning purposes, it was assumed that only 25-percent of the identified area would be repurposed using this practice, with equals approximately 1,120 acres repurposed for flood flow dispersal and Flood-MAR. Areas within the SCFCD suitable for flood flow dispersal and Flood-MAR are shown in Figure 3.

It is assumed that all irrigated crops will be removed from the identified areas to allow construction of flood attenuation projects, with adjacent land being allowed to revert to non-irrigated pasture. Removing crops from these areas will result in an overall reduction in groundwater demand. In addition, recharge and Flood-MAR projects will result in direct recharge benefits. A more detailed description of the estimated demand reduction and recharge related to this repurposing practice is discussed in more detail in Section 2.

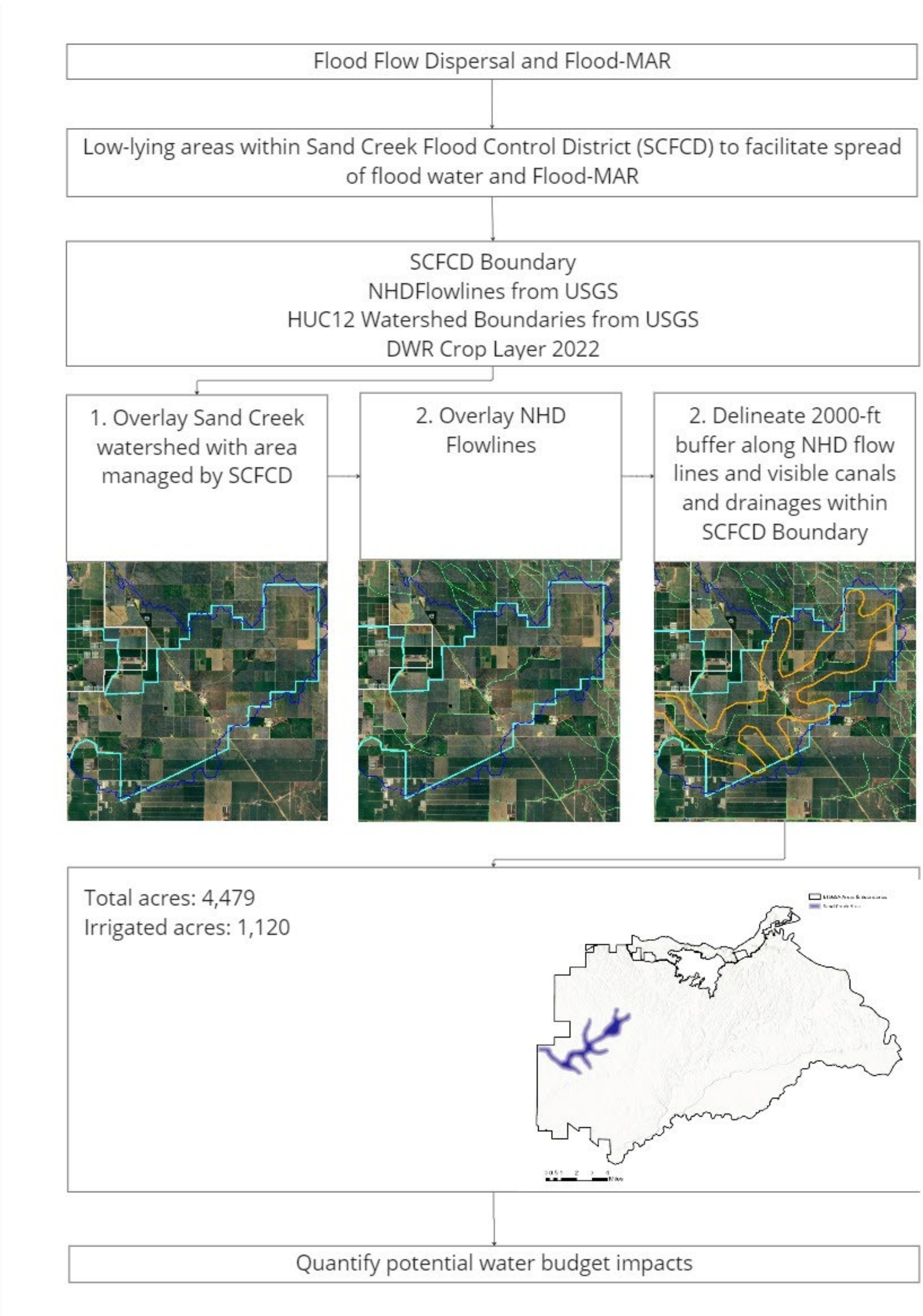

FIGURE 3: ASSESSMENT PROTOCOL TO IDENTIFY SUITABLE AREAS FOR FLOOD FLOW DISPERSAL AND FLOOD-MAR.

1.3 ORCHARD SWALE REWILDING

The MLRP practice of orchard swale rewilding focused on low lying orchard areas that have a high likelihood of runoff accumulation and soil moisture retention. Typically, soil in these areas may be waterlogged at times during the winter, resulting in lower almond production due to stunted and sparse tree growth. This MLRP practice will include crop removal in identified swale areas with BMPs employed to establish non-irrigated pasture or native vegetation. The practice may also include the BMPs of establishing seasonal wetlands, pollinator habitat, and hedgerows.

The landscape characteristics suitable for orchard swale rewilding were defined as ephemeral stream areas with a high likelihood of water accumulation using the process identified in Figure 4. The NHD (USGS 2023) was used to identify all ephemeral streams within ETSGSA. The Topographic Wetness Index (TWI; Beven and Kirkby 1979) spatial dataset was then intersected with the NHD flowlines. A 5-meter buffer was delineated on either side for the NHD flowlines to extract the distribution of TWI values within the 5-meter buffer zone. Assuming these TWI values are representative of ‘typical’ swales in the region, the TWI dataset was then filtered to values within one standard deviation of the mean TWI value from the 5-meter buffer. This new layer was then intersected with the NHD flowlines and a 50-meter buffer along the flowlines to identify areas suitable for orchard swale rewilding.

This process identified a total of 6,807 acres and 4,166 acres of irrigated land within ETSGSA suitable for orchard swale rewilding (Figure 4). The process assumes that all irrigated crops within the identified areas will be removed and be allowed to revert to non-irrigated pastureland. Additional BMPs may be employed that provide habitat, establish water retention features, create pollinator habitat, and establish hedgerows. The removal of irrigated crops from the identified orchard swale areas will result in groundwater demand reduction. Additionally, retaining water within the swales may result in recharge; however, these water budget impacts were not considered as part of this analysis. A more detailed description of the estimated demand reduction associated with implementation of this repurposing practice is provided in Section 2.

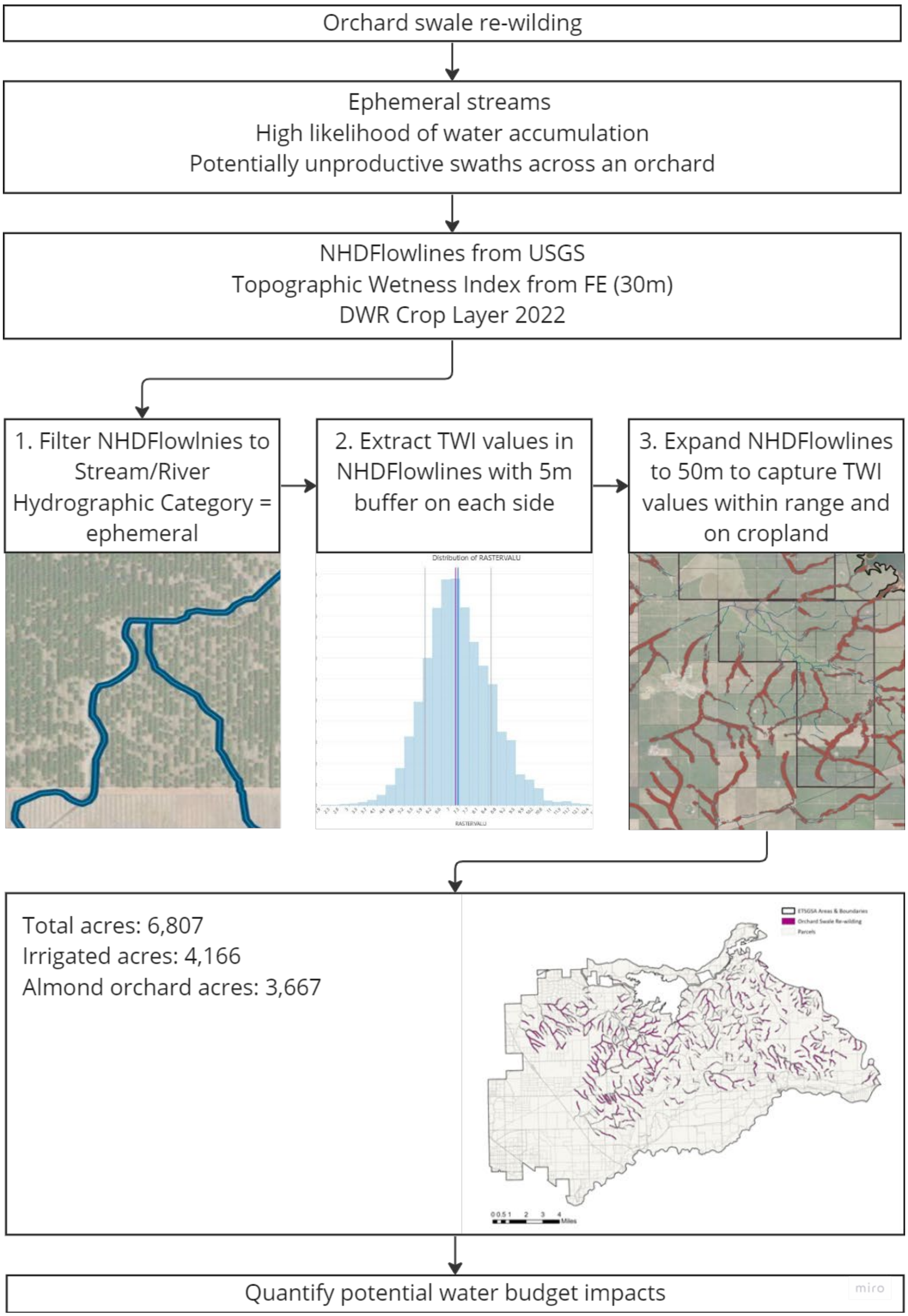

FIGURE 4: ASSESSMENT PROTOCOL TO IDENTIFY SUITABLE AREAS FOR ORCHARD SWALE REWILDING.

1.4 ON-FARM RETENTION BASINS

The MLRP practice of construction of on-farm retention basins looks at natural low points near the edge of a parcel that are along a drainage network and at least 5 acres in area if dams that are 5 feet high are constructed. The process for identifying landscape characteristics for potential on-farm retention basin areas is shown in Figure 5. The Stanislaus County and Merced County assessor parcel boundaries were intersected with the DEM (NED 10 meter; USGS 2013) to identify the highest and lowest points within each parcel boundary. A 20-acre circular buffer was then delineated around each parcel corner. The parcel boundaries were then used to assign portions of each 20-acre buffer to a corresponding parcel. The buffers were then filtered to only include those that intersected with the lowest elevation amongst adjoining parcels. The final selection process included only selecting pond areas that were at least 5-acres in area and connected to an NHD flowline.

A total of 2,304 acres were identified as being suitable for development of on-farm retention basins with 1,708 acres of this area being irrigated. The identified pond areas are shown in Figure 5. It is assumed that all irrigated crops within the identified pond areas will be removed. Ponds will then be constructed by building earthen berms across the drainage flowline. Removal of the crops within the pond area will result in a reduction in groundwater demand. Additionally, runoff water collected within the ponds will also be available for either early season irrigation (in-lieu recharge) or for direct recharge based on the underlying soil characteristics and geology. A more detailed description of the water budget impacts related to the development of on-farm retention basins is provided in Section 2.

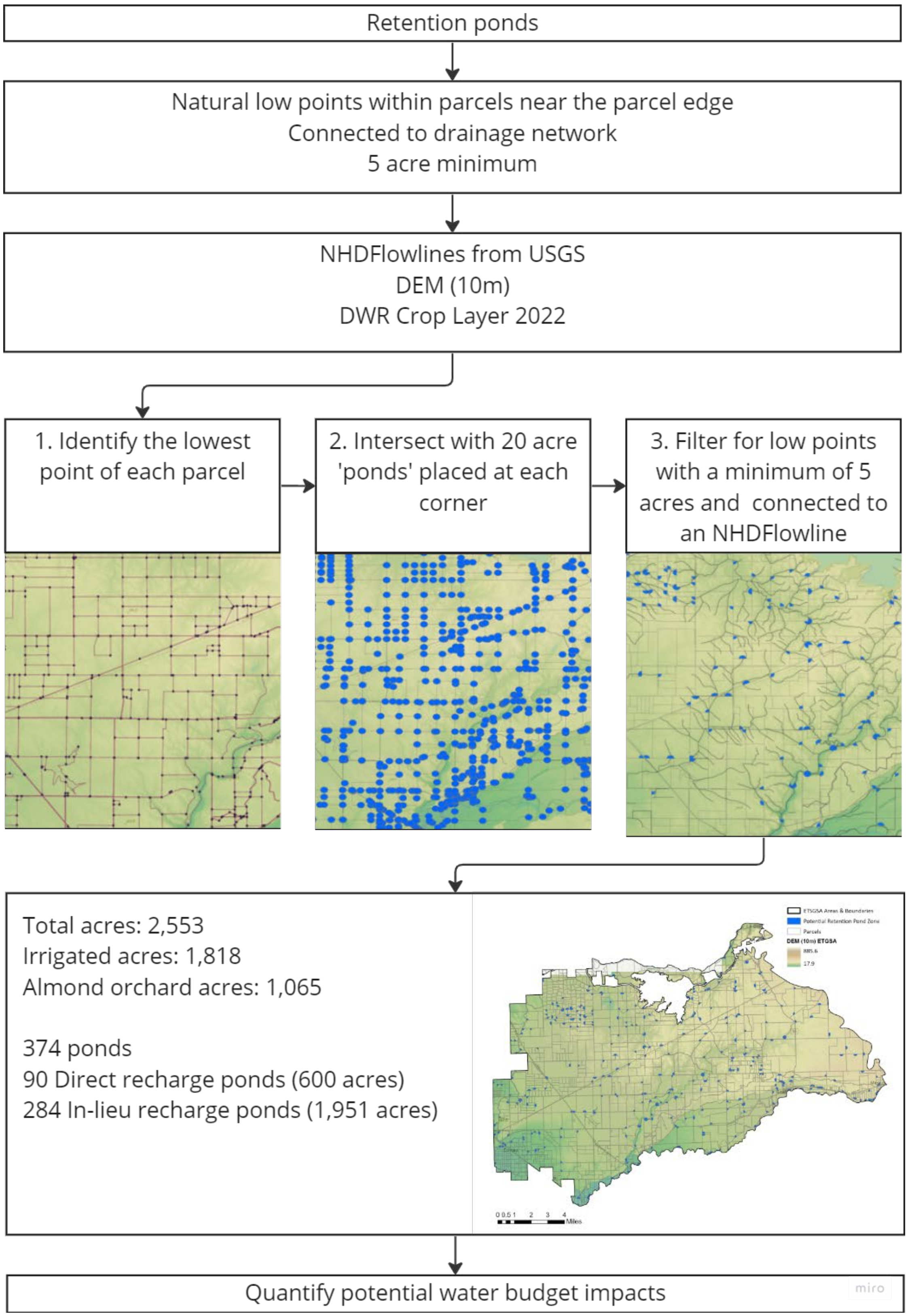

FIGURE 5: ASSESSMENT PROTOCOL TO IDENTIFY SUITABLE AREAS FOR ON-FARM RETENTION BASINS.

1.5 AGRICULTURAL BUFFER ZONES

The MLRP practice of creating agricultural buffer zones around sensitive receptors focused on areas around schools but could be applied to disadvantaged communities (DACs), residential areas, and parks and recreation areas. The landscape characteristics suitable for implementation of this MLRP practice are agricultural areas near a sensitive receptor. It is estimated that a buffer of at least 400 meters surrounding the property with the sensitive receptor is necessary for the buffer to have meaningful impacts (Fernandez-Bou, et al. 2023). To identify suitable acreage for implementation of buffer zones, the California School layer (California Governor’s Office of Emergency Services, 2019) was overlain on the 2020 DWR Crop Layer (CADWR, 2020 Crop Map, released on March 27, 2023) using the process illustrated in Figure 6. Any agricultural land use area within 400 meters of a school area was selected. These identified areas were then expanded to include the entire parcel areas that had any portion of land which intersected the buffer zone.

This process identified a total of 2,727 acres that are suitable to create agricultural buffer zones, 1,647 acres of which are irrigated. Areas identified as being suitable for creation of agricultural buffer zones are shown in Figure 6. This practice assumes that all irrigated crops will be removed from the buffer zones and the areas will be converted to non-irrigated pastureland. Additional benefits can be realized through this practice by planting non-irrigated native vegetation, pollinator habitat, hedgerows, and establishing habitat areas. The removal of irrigated crops and transition to non-irrigated pasture from these buffer zones will result in groundwater demand reduction. A description of estimated demand reduction and impacts to water balance is discussed in Section 2.

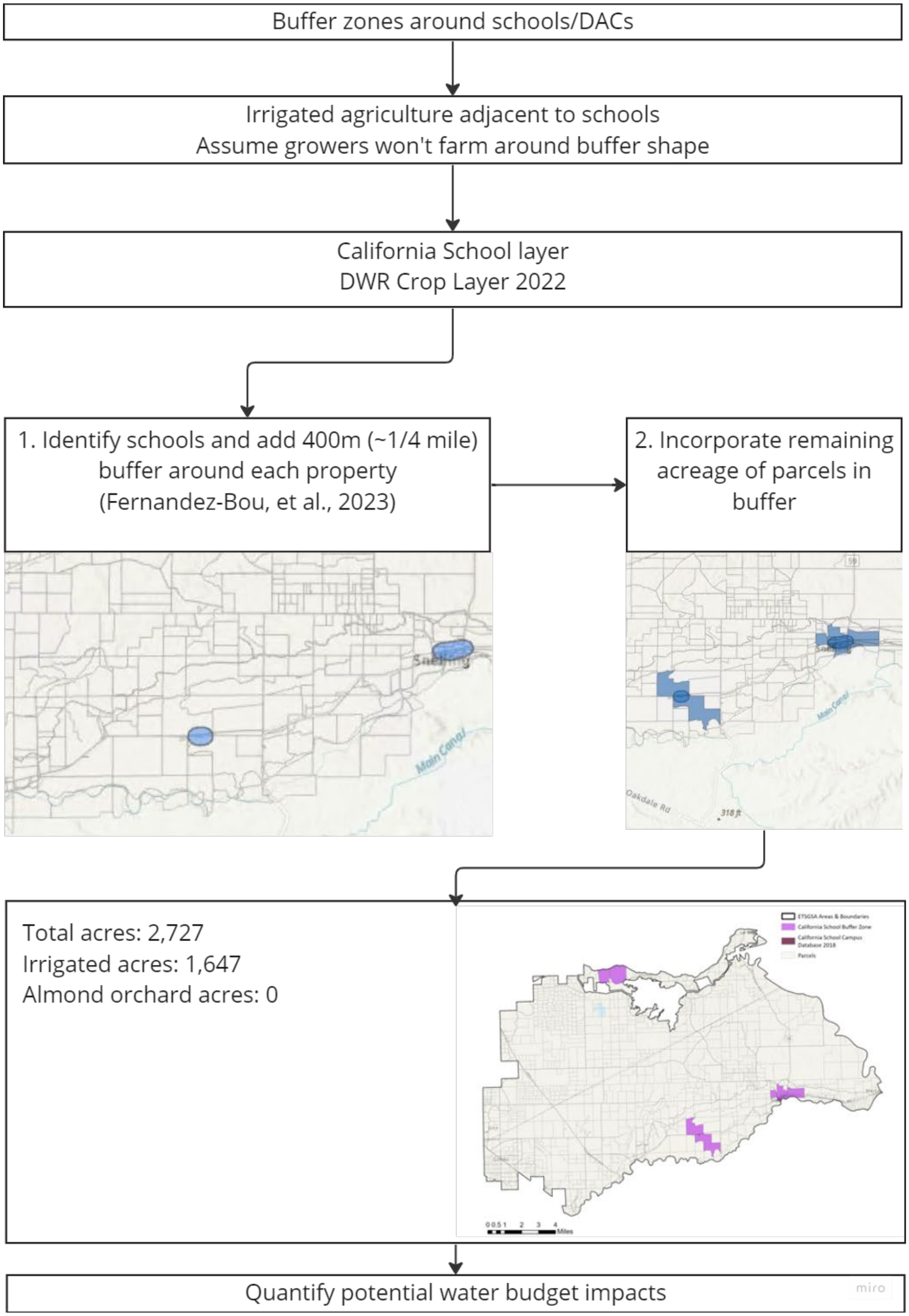

FIGURE 6: ASSESSMENT PROTOCOL TO IDENTIFY SUITABLE AREAS FOR BUFFER ZONES.

1.6 ROTATIONAL FALLOWING

Another groundwater demand reduction process under development is rotational fallowing of almond orchard acreage. The California Almond Board estimates that an almond orchard is productive for approximately 25 years (Marvinney and Kendall 2021). As an almond orchard reaches its end-of-life productivity, it is removed and replanted. ETSGSA will develop a program to incentivize growers to fallow land or use it to grow dryland crops after an orchard is removed for a period of three years prior to replanting almonds. The orchard areas are not irrigated during the fallowing period and can be used to grow winter wheat, non-irrigated crops, or non-irrigated pasture during the three-year rotational period.

There are approximately 57,000 acres of irrigated almonds within ETSGSA as shown on Figure 7. For this analysis, it is assumed that a given acre of almond orchard is fallowed for 3 of every 28 years (25-year orchard life with 3-year fallowing period). This results in an annual reduction in irrigated almond acreage by approximately 6,107 acres. This reduction in irrigated almond acreage results in a reduction in groundwater demand. A description of the demand reduction related to implementation of this repurposing practice is discussed in greater detail in Section 2.

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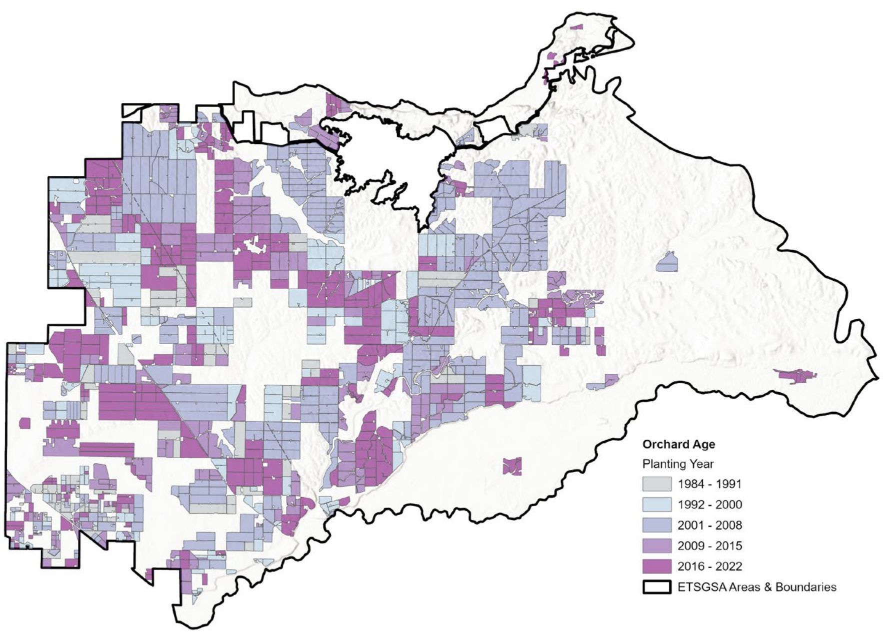

FIGURE 7: IDENTIFIED ALMOND ACREAGE WITHIN ETSGSA.

2 ESTIMATED WATER BUDGET BENEFITS

The analysis identified approximately 17,112 acres of irrigated land that is available for conversion to non-irrigated uses through the MLRP practices as summarized in Table 1. For each repurposing practice identified, the groundwater demand reduction resulting from the corresponding land use change was estimated. Additionally, the local overland runoff and flood water available for either in-lieu or direct recharge was also estimated as described below. Table 1 also includes estimates of groundwater demand reduction and in-lieu and direct recharge benefits, if applicable, for each MLRP practice. The methodology describing how demand reduction and recharge benefits were calculated is described below.

MLRP Practice	Total Acres	Irrigated Acres[1]	Estimated Demand Reduction (Acft)	Estimated In-Lieu Recharge (Acft)	Estimated Direct Recharge Ponds (Acft)
Restoration of Pre-Development Hydrology and Floodplain Reconnection	5,712	2,364	6,363	(Included in Direct Recharge Estimate)	19,281
Flood Flow Dispersal and Flood-MAR	4,479	1,120	3,024	--	4,668
Orchard Swale Re-wilding	6,807	4,166	11,446	--	--
On-Farm Retention Basins	2,304	1,708	4,146	7,602	3,362
Agricultural Buffer Zones	2,727	1,647	3,340	--	--
Rotational Fallowing	6,107	6,107	16,489	--	--
TOTAL	**28,136**	**17,112**	**44,808**	**7,602**	**27,311**

1. Irrigated acres based on intersecting total suitable acres with DWR's 2020 land Use Dataset. Intersection with DWR's 2014 Land Use Dataset may yield slightly different results (estimated up to about 4 percent).

TABLE 1: SUMMARY OF IDENTIFIED MLRP PRACTICE AREAS WITHIN ETSGSA.

2.1 GROUNDWATER DEMAND REDUCTION ESTIMATES

The demand reduction was calculated from the long-term evapotranspiration (ET) dataset and utilized as a proxy for groundwater extraction by pumping. Two datasets from CalETa and LandIQ ET were utilized to calculate the irrigation season ET for each MLRP practice implementation area. CalETa dataset is available from 2003 whereas LandIQ dataset was recently obtained for the 2023 irrigation season. The Almond ET for irrigation season was calculated to be 2.7 feet, which closely aligns with the long- term average ET. Given that 70 percent of the acreage within ETSGSA is almonds the average value is representative of the ETSGSA cropping system. The irrigated acreage was computed for each MLRP practice by intersecting the layer with the 2020-DWR crop layer. The ET demand reduction (Table 1) for the categories 'rotational fallowing' and 'flood-MAR' was determined by multiplying the irrigated area under each of those categories by the average ET demand of 2.7 feet. For all other MLRP practice categories, long-term ET from 2012-2021 was extracted, and the average irrigation season ET is reported as the estimated demand reduction (Table 1).

2.2 ESTIMATION OF DIRECT RECHARGE BENEFITS FROM RESTORATION OF PRE-DEVELOPMENT HYDROLOGY FLOOD-MAR, AND FLOOD ATTENUATION

Provost & Pritchard Consulting Group (P&P) estimated the potential surface water available for recharge projects by evaluating the potential frequency, magnitude, and timing of flood water discharges within the Dry Creek, Sand Creek, and Mustang Creek watersheds, and estimating the volume of water that may be available for recharge projects during periods of wetter hydrology (P&P 2023a and 2023b). Gaged streamflow data was only available for upper Dry Creek (USGS Gauge 11271320; Figure 8) for the period of 1998 through 2023. Available streamflow data was used to extrapolate flows for the larger Dry Creek watershed and the Mustang Creek and Sand Creek watersheds using ratio of watershed areas and ratio of average precipitation methods. Information for Mustang Creek was validated using approximate historical flow data at the Mustang Creek Flood Retention basin provided by Turlock Irrigation District. Potential recharge yields were calculated based on the assumption that diversions would be limited to periods of wetter hydrology, as defined by Bulletin 120 San Joaquin River 60-20-20 Water Supply Index, as “Below Normal”, “Above Normal” and “Wet” years. Diversion volumes were calculated based on total cumulative diversion capacity assumed to be achievable along the creeks under MLRP repurposing projects.

The hydrologic evaluation found that the three watersheds are relatively flashy and characterized as ephemeral. The SCFCD has modified the Sand Creek watershed to transmit flood flows while Mustang and Dry Creeks generally have a more natural hydrology. On average, significant streamflow occurs 15 days per year with water available for diversion over 90 percent of years; however, only periods of wetter hydrology were considered. In general, the evaluation found that the physical diversion capacity was the primary limiting factor rather than the timing, duration, or magnitude of flow within the creeks.

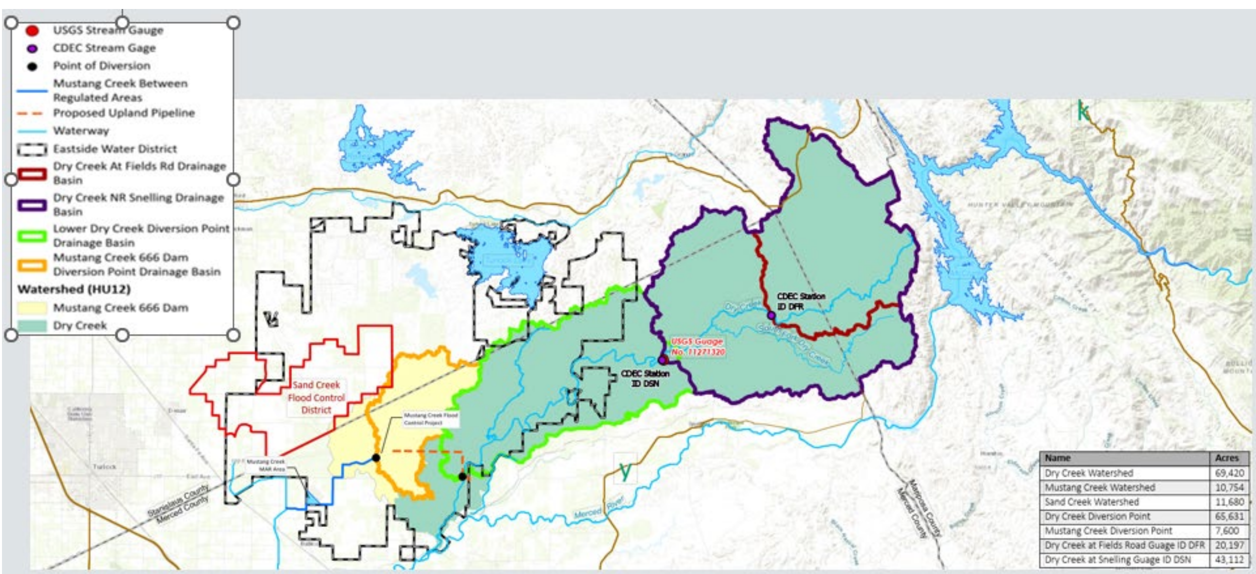

FIGURE 8: DRY CREEK, SAND CREEK, AND MUSTANG CREEK WATERSHED MAP WITH STREAMFLOW GAGE STATION LOCATIONS.

For the analysis of potential recharge benefits, we assumed an average annual flow yield diversion capacity limitation of 250 cubic feet per second (cfs) for Dry Creek and a 100 cfs discharge capacity limitation for Sand and Mustang Creeks, each, as summarized in Table 2. These are cumulative diversion rates along the entire MLRP practice implementation area, and are the midpoint diversion rates analyzed by Provost & Pritchard. The calculated recharge volumes account for BMPs such as Beaver Dam Analogs, check dams, and levee setbacks will be constructed in the Dry Creek and Mustang Creek watersheds to reconnect the floodplain with the stream channel, and ditches, gates, berms and pump stations to divert flows. These BMPs will slow flows and increase the wetted perimeter of the watershed, and will increase the frequency and extent of floodplain inundation and the area available for recharge. Additionally, gravity flow and pumped diversion will be utilized to transmit available water to seasonal recharge/storage basins along the repurposed floodplain and to nearby fields designated for Flood MAR.

The Sand Creek watershed is currently managed by SCFCD to mitigate flood risks and ETSGSA's MLRP practices will align with SCFCD's flood mitigation goals. The practice will focus on development of flood mitigation projects that disperse flood flows to adjacent repurposed agricultural lands, storage basins, and Flood-MAR facilities that store floodwater and promote recharge.

Creek	December (acre-ft)	January (acre-ft)	February (acre-ft)	March (acre-ft)	Total (acre-ft)
Mustang Creek[1]	1,777	968	1,258	770	**4,180**
Sand Creek[1]	1,847	1,0364	1,450	922	**4,668**
Dry Creek[2]	5,092	3,404	4,815	3,487	**15,101**

1. Assumes diversion/recharge capacity of 100 cfs.
2. Assumes diversion/recharge capacity of 250 cfs.

TABLE 2: FLOWS AVAILABLE FOR RECHARGE ALONG DRY CREEK, MUSTANG CREEK, AND SAND CREEK.

2.3 ESTIMATION OF IN-LIEU AND DIRECT RECHARGE BENEFITS FROM ON-FARM RETENTION BASINS

Runoff estimates within ETSGSA were generated using the Central Valley Soil and Water Assessment Tool (CV-SWAT) and used to estimate the water volumes that could potentially be captured by retention basins. Pond water evaporation rates were also estimated, and soil hydraulic conductivities were used to estimate seepage losses and estimate pond water volumes available for irrigation and groundwater recharge. Estimates are based upon CV-SWAT simulations utilizing the 2020 DWR crop map (CADWR, 2020 Crop Map), Natural Resource Conservation Service (NRCS) PEDON soil data (a custom product from the NRCS integrating National Cooperative Soil Survey [NCSS][2] and Soil Survey Geographical Database [SSURGO][3] products), and climatic data from the California Irrigation Management Information System (CIMIS)[4] from 1990-2019, and a 30-meter DEM from the National Aeronautics and Space Administration (NASA; Farr et al. 2007). Runoff amounts are calculated for the entire year, including the irrigation season,

[2] NCSS data is available from https://ncsslabdatamart.sc.egov.usda.gov/
[3] SSURGO data is available from https://www.nrcs.usda.gov/resources/data-and-reports/ssurgo-portal
[4] CIMIS data is available from https://cimis.water.ca.gov/

though efficient irrigation practices are modeled that generate negligible runoff. Retention basins were delineated into areas where they would provide direct recharge and in-lieu recharge based on the extent of the Mehrten Formation and the Recharge Suitability Index developed by Todd Groundwater for the Turlock Subbasin Groundwater Recharge Assessment Tool, with direct recharge is assumed east of the Mehrten Formation and in-lieu recharged assumed west of the Mehrten Formation (Figure 9). The estimated annual runoff within ETSGSA is summarized in Table 3. Open water evaporation from the ponds was estimated using the values shown in table 4.

	Acre-feet					
Area within ETSGSA	**Minimum**	**25th percentile**	**50th percentile**	**Mean**	**75th percentile**	**Maximum**
In-Lieu Recharge	980	4,900	11,000	15,000	20,000	57,000
Direct Recharge	300	1,700	4,000	5,000	7,000	15,000

TABLE 3: SUMMARY STATISTICS FOR ESTIMATED ACRE-FEET OF RUNOFF WITHIN THE ETAGSA BOUNDARY, SUMMARIZED BY THE TYPE OF RECHARGE (EAST = IN-LIEU RECHARGE, WEST = DIRECT RECHARGE).

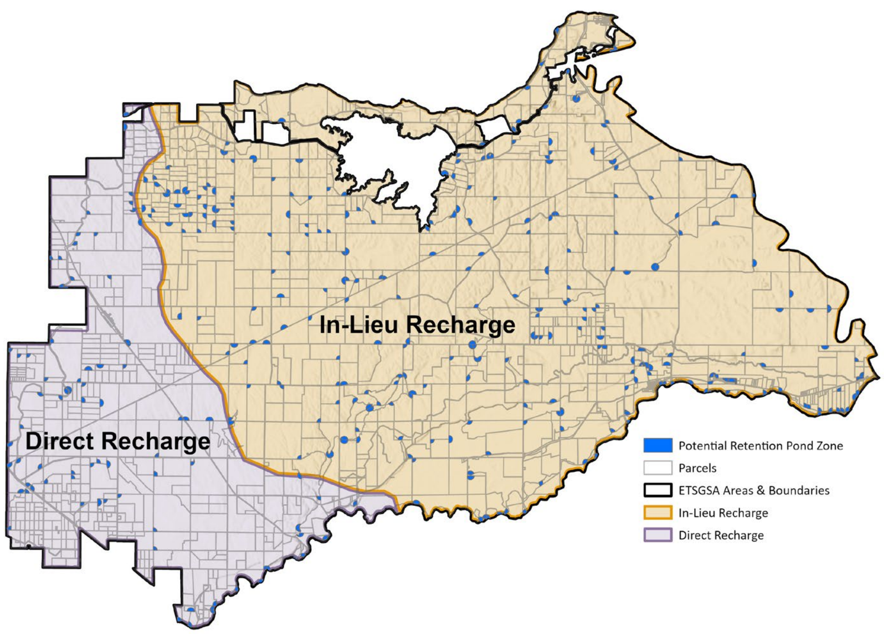

FIGURE 9. AREAS FOR DIRECT AND IN-LIEU RECHARGE WERE CONSERVATIVELY DELINEATED BASED ON THE EXTENT OF THE MEHRTEN FORMATION AND THE RECHARGE SUITABILITY INDEX DEVELOPED FOR THE TURLOCK SUBBASIN.

Month	Average ETo (in)	Open Water Kc[2]	Open Water ET (in)	Cumulative Open Water ET (in)
January	1.33	1.1	1.5	1.5
February	2.23	1.1	2.5	3.9
March	3.6	1.1	4.0	7.9
April	5.3	1.1	5.8	13.7
May	6.99	1.1	7.7	21.4
June	8.13	1.1	8.9	30.3
July	8.47	1.1	9.3	39.7
August	7.34	1.1	8.1	47.7
September	5.45	1.1	6.0	53.7
October	3.63	1.1	4.0	57.7
November	1.86	1.1	2.0	59.8
December	1.17	1.1	1.3	61.1

TABLE 4: POTENTIAL EVAPOTRANSPIRATION FOR OPEN WATER BASED ON DATA FROM STATION 206 – DENAIR 2 AND "CROP" COEFFICIENT VALUES FOR OPEN WATER FROM THE DEPARTMENT OF WATER RESOURCES[2]. THE CUMULATIVE POTENTIAL ET FOR OPEN WATER BETWEEN DECEMBER-MARCH IS 9.2 INCHES.

As described previously, 2,304 acres of estimated potentially suitable pond area were identified within ETSGSA consisting of 75 pond areas encompassing 500 acres suitable for direct recharge and 264 pond areas encompassing 1,804 acres suitable for water retention and irrigation use. The amount of water available to fill the recharge ponds is assumed to be a fraction of the total runoff generated within the ETSGSA basin. Following a rule of thumb of at least 10 acres of watershed for every 1 acre-foot of pond storage, the total watershed area required was computed to fill the pond surface area. A factor based on the total watershed area available to the area required to fill the pond was developed to estimate the runoff fraction that could be captured. The mean runoff in the direct recharge portion of the watershed was reduced using a factor of 0.75, while for the in-lieu recharge portion, a factor of 0.60 was applied. The final water available for irrigation and recharge was estimated by subtracting the water lost through the ponds as evaporation.

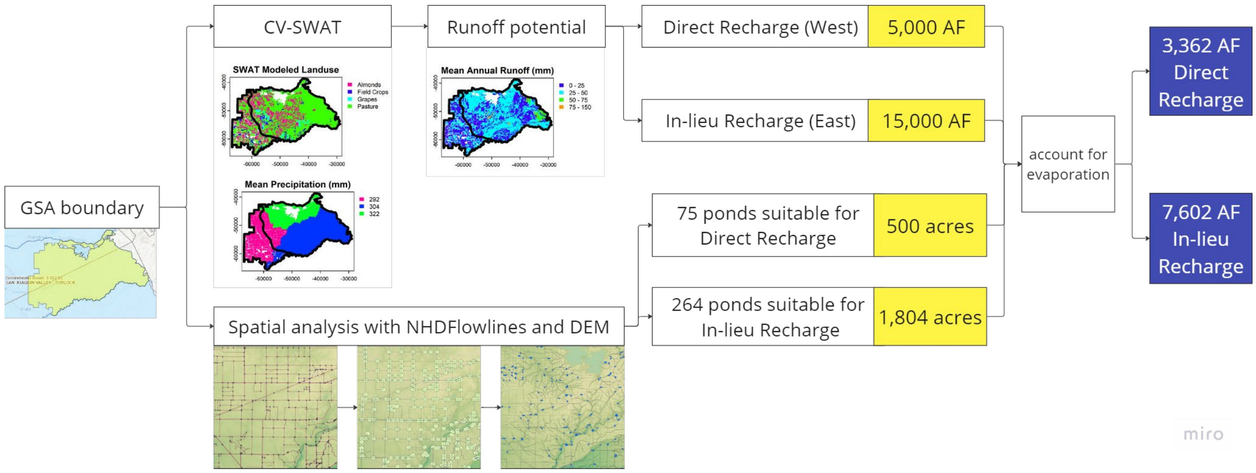

FIGURE 10: ASSESSMENT PROTOCOL FOR ESTIMATING RUNOFF AND DIRECT AND IN-LIEU RECHARGE VOLUMES WITHIN ETSGSA.

3 RECOMMENDED MODELING APPROACH AND IMPLEMENTATION TIMELINE

It is estimated that approximately 21,000 acres of irrigated land will be converted to non-irrigated uses to help reach ETSGSA's demand reduction goals. It is assumed that additional acreage above the 17,112 acres estimated in Section 2 can be achieved through miscellaneous repurposing practices that include crop removal, such as installation of solar power facilities or other habitat restoration or enhancement projects, or through strategies that result in a reduction in groundwater demand, such as recropping, reduced density cultivation, cover cropping or irrigation efficiency improvement. Deficits in the achieved MLRP acreage goals would be addressed through implementation of a land purchase and fallowing program. The Adaptive Management Framework of the Groundwater Overdraft Reduction Plan will provide the monitoring data and prescribes action triggers allowing for timely course correction, priority action, or intervention to address MLRP shortfalls and rapidly respond to emergent undesirable conditions. The projected implementation timeline and recommended modeling for each practice is summarized in Table 5.

MLRP Practice	Recommended Modelling Approach	Implementation Timing
Restoration of Pre-Development Hydrology and Floodplain Reconnection	Decrease irrigated crop acreage by the amounts within the Floodplain Reconnection polygons; Apply direct recharge amounts as distributed in the polygons along Dry Creek and Mustang Creek	
Off-Stream Recharge and Storage Facilities	Included with above	
Flood Flow Dispersal and Flood-MAR	Decrease the irrigated acreage and apply direct recharge within the 4,479-acre Sand Creek Flood Control Projects polygon	10% by 2026 20% by 2027 50% by 2032 100% by 2037
Orchard Swale Re-wilding	Decrease irrigated orchard acreage by the amounts within the Orchard Swale Rewilding polygons	
On-Farm Retention Basins	Decrease irrigated crop acreage by the amounts within the On-Farm Retention Basin Polygons; Apply direct and in lieu recharge amounts as distributed in the polygons	
Agricultural Buffer Zones	Decrease irrigated crop acreage by the amounts within the Buffer Zones polygons	
Rotational Fallowing	Decrease almond acreage by 3/28ths throughout all remaining almond acreage after the above MLRP Practices have been applied	20% by 2026 40% by 2027 100% by 2032
Miscellaneous Repurposing Scenario 1[1]	Decrease remaining irrigated acreage by 3,880 acres proportionally for all crops spread proportionally across the model domain within ETSGSA.	50% by 2032 100% by 2037
Miscellaneous Repurposing Scenario 2[1]	Decrease remaining irrigated acreage by 12,880 acres proportionally for all crops spread proportionally across the model domain within ETSGSA.	50% by 2032 100% by 2037

1. Miscellaneous Repurposing included additional crop removal and conversion to non-irrigated use as predicted to be needed to meet the Subbasin Sustainability Goal. The distribution of miscellaneous repurposing is not yet known and will be conducted in response to the Action Triggers included in the Adaptive Management Framework. In addition,

TABLE 5: RECOMMENDED MODELING APPROACH AND IMPLEMENTATION TIMELINE FOR MLRP PRACTICES WITHIN ETSGSA.

In addition to the MLRP practices described in this document, Group 2 projects summarized in Table 5 will be implemented and should be simulated to assess the effectiveness of the proposed Projects and Management Actions to achieve the Sustainability Goals and meet the Sustainability Management Criteria of the GSP. A summary of the Projects and Management Actions recommended to be Simulated, their implementation timelines and their direct and in lieu recharge yields are summarized in Table 6.

P&MA	Description and Location	Implementation Timeline	Acres Repurposed to Non-Irrigated	In-Lieu Recharge (AFY)	Direct Recharge (AFY)
MLRP	Simulate as in Tables 1 and 5, including 3,880 acres of miscellaneous repurposing.	As Indicated in Table 5	21,102	7,602	27,311
Phase I Agricultural Recharge	Simulate based on Project 9 in the GSP	In Lieu: 100%; Direct Recharge: 100% in 2027	--	3,400	1,600
Phase II Agricultural Recharge	Consists of a long-term average of 5,100 AFY of replenishment water for irrigation use (in lieu recharge) on parcels within approximately 1 mile east of the Highline Canal, and an additional 2,400 AFY of water for direct recharge on parcels within 1 mile east of the Highline Canal.	Buildout starting in 2027 and reaching 100% in 2032	--	5,100	2,400
Phase III Agricultural Recharge	Long-term average of 12,500 AFY of replenishment water for irrigation use (in lieu recharge) on parcels within 3 miles south of Rouse Lake and provided during normal, above normal and wet years.	Buildout 50% in 2028 and 100% in 2029	--	12,500	--
Mustang Creek Flood Control Basin Improvement	As in Project 10 in the GSP, but assume that the project provides in lieu recharge water to parcels adjacent to the Mustang Creek Flood Control Basin.	100% in 2027	--	600	--
Upland Pipeline	As in Project 11 in the GSP, but assume the project provides direct recharge to the Floodplain Reconnection MLRP repurposing polygon along Dry Creek.	50% in 2027; 100% in 2032	--	1,100	--
Total			**21,102**	**30,302**	**31,311**

TABLE 6: SUMMARY OF PROJECTS AND MANAGEMENT ACTIONS TO BE SIMULATED UNDER SCENARIO 1.

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