Land IQ Workshop

April 2, 2024

LAND IQ

Crop Mapping, Precipitation, Permanent Crop Age, and ET Developed by Land IQ.

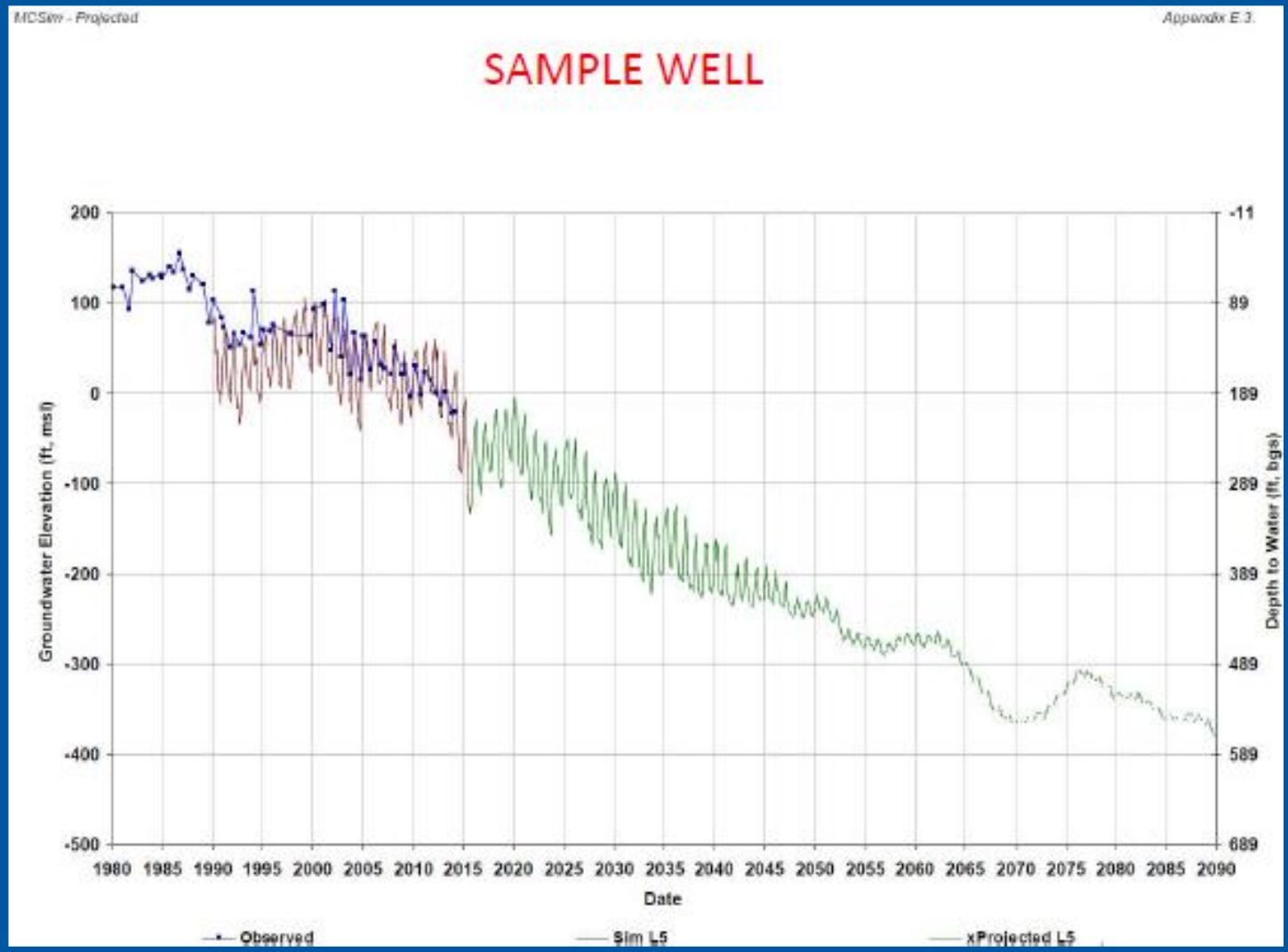
MADERA COUNTY

DAVIDS ENGINEERING, INC

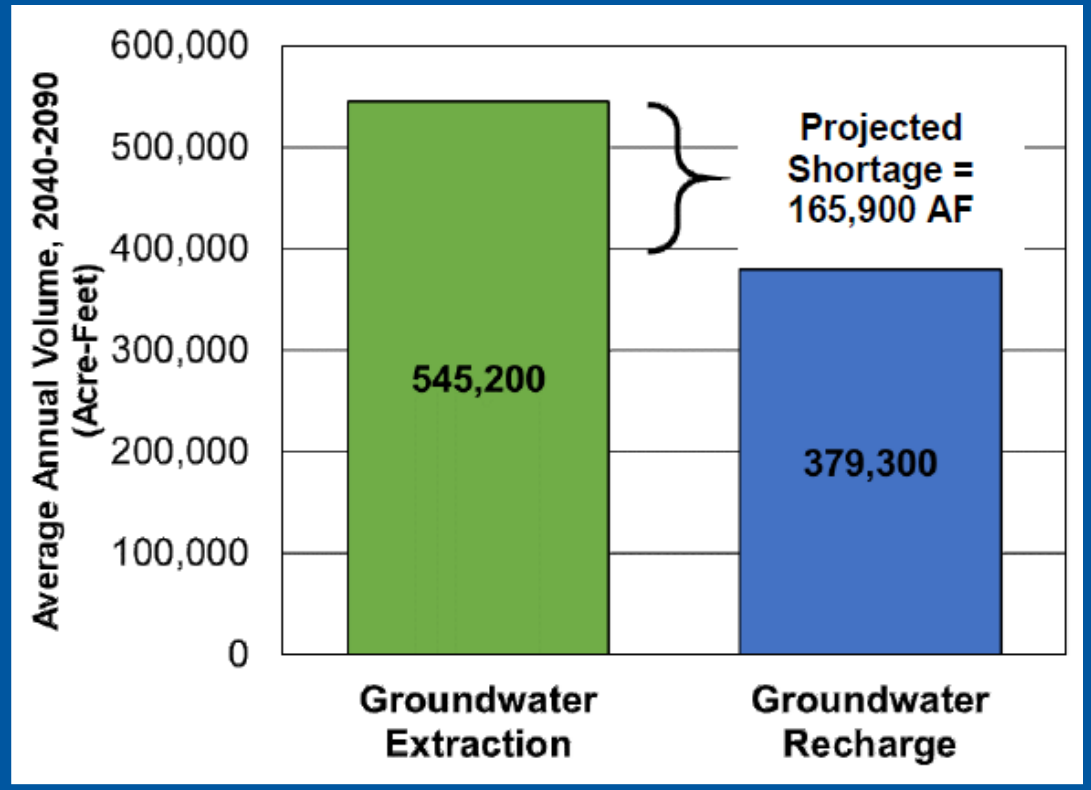
Outline

- Introduction (Stephanie - 15 min)
- Land IQ ET and Precipitation (Joel - 30 min)
- Processing Land IQ Data to Compute ETAW (Jeff - 15 min)
- Discussion (All - 60 min)

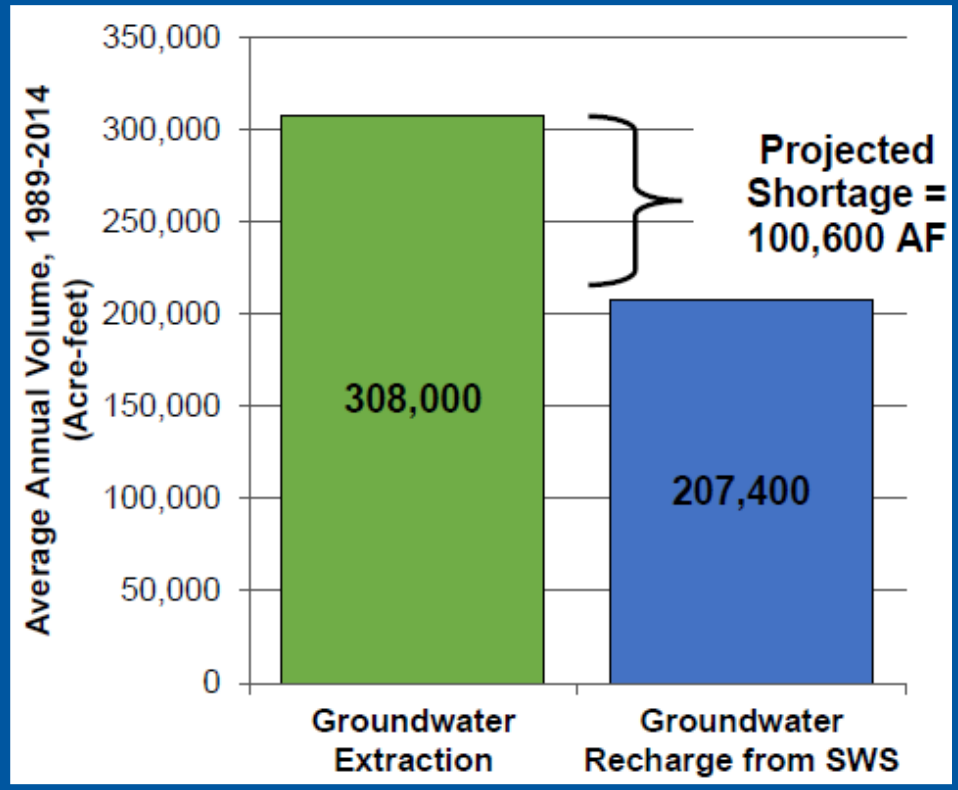
What we know…


MCSim - Projected
Appendix E.3.
SAMPLE WELL
Groundwater Elevation (ft, msl)
Depth to Water (ft, bgs)
200
100
0
-100
-200
-300
-400
-500
-11
89
189
289
389
489
589
689
1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090
Date
Observed
Sim L5
xProjected L5

What we know (Cont)…

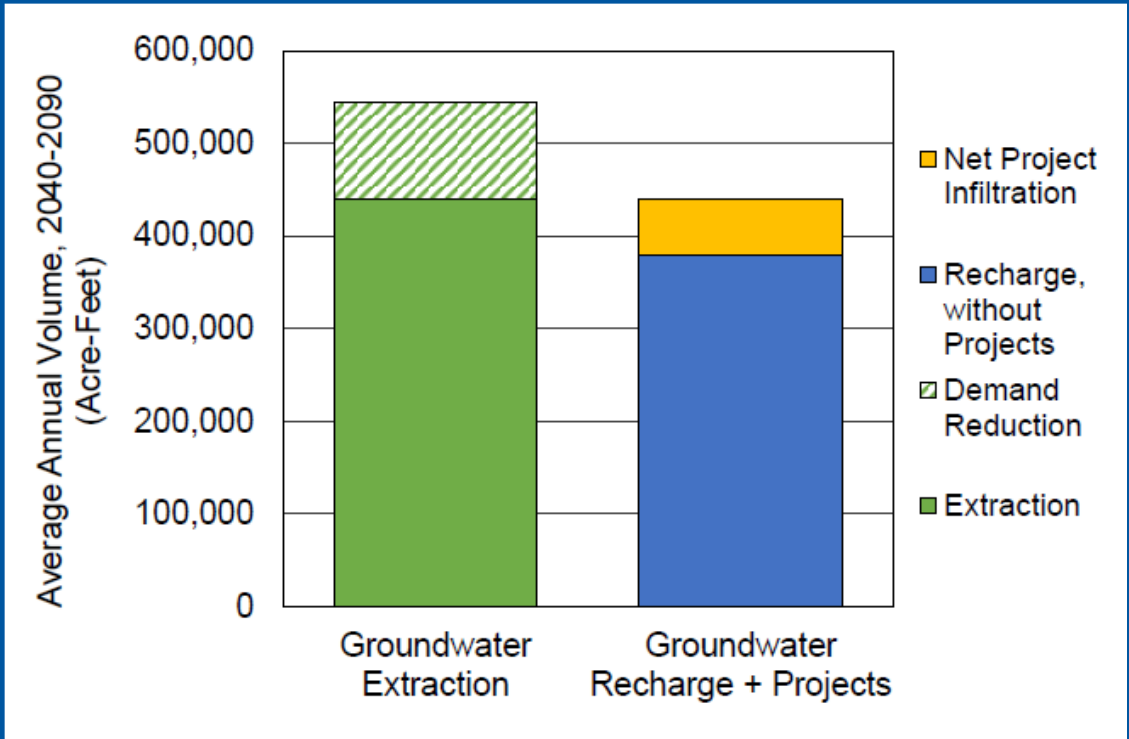


Madera Subbasin

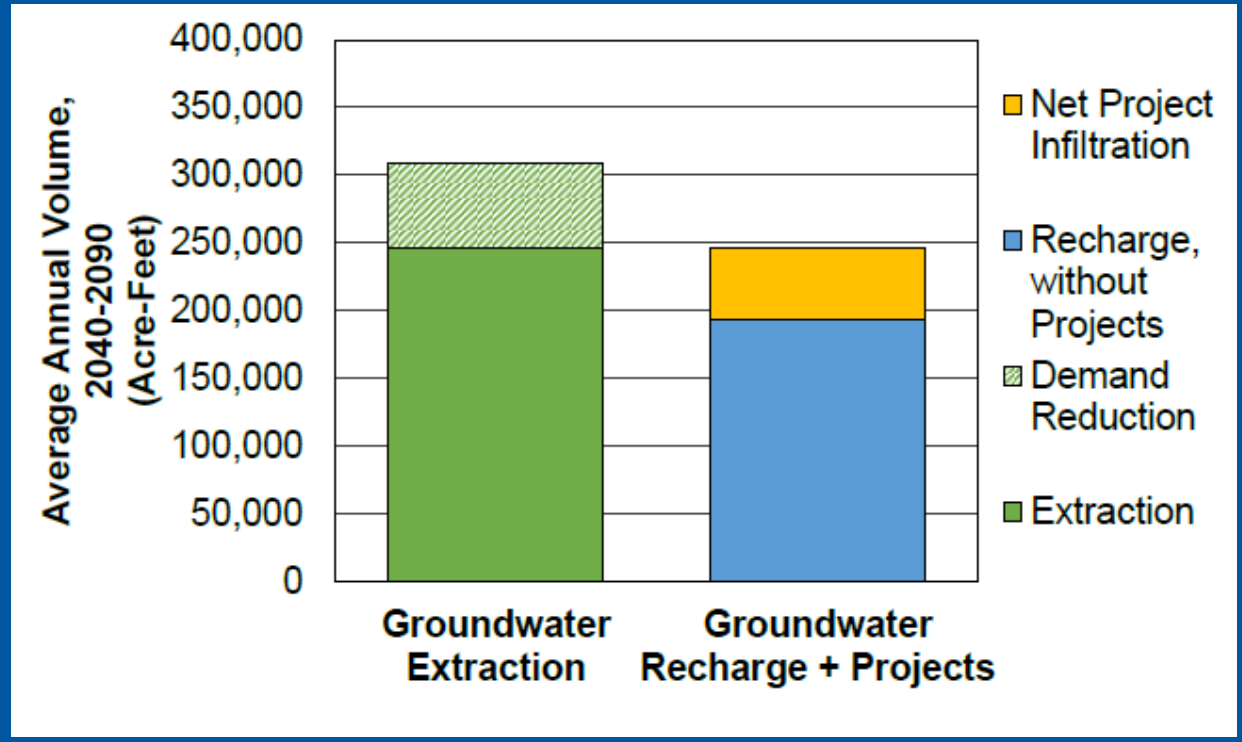


Chowchilla Subbasin

What we decided…

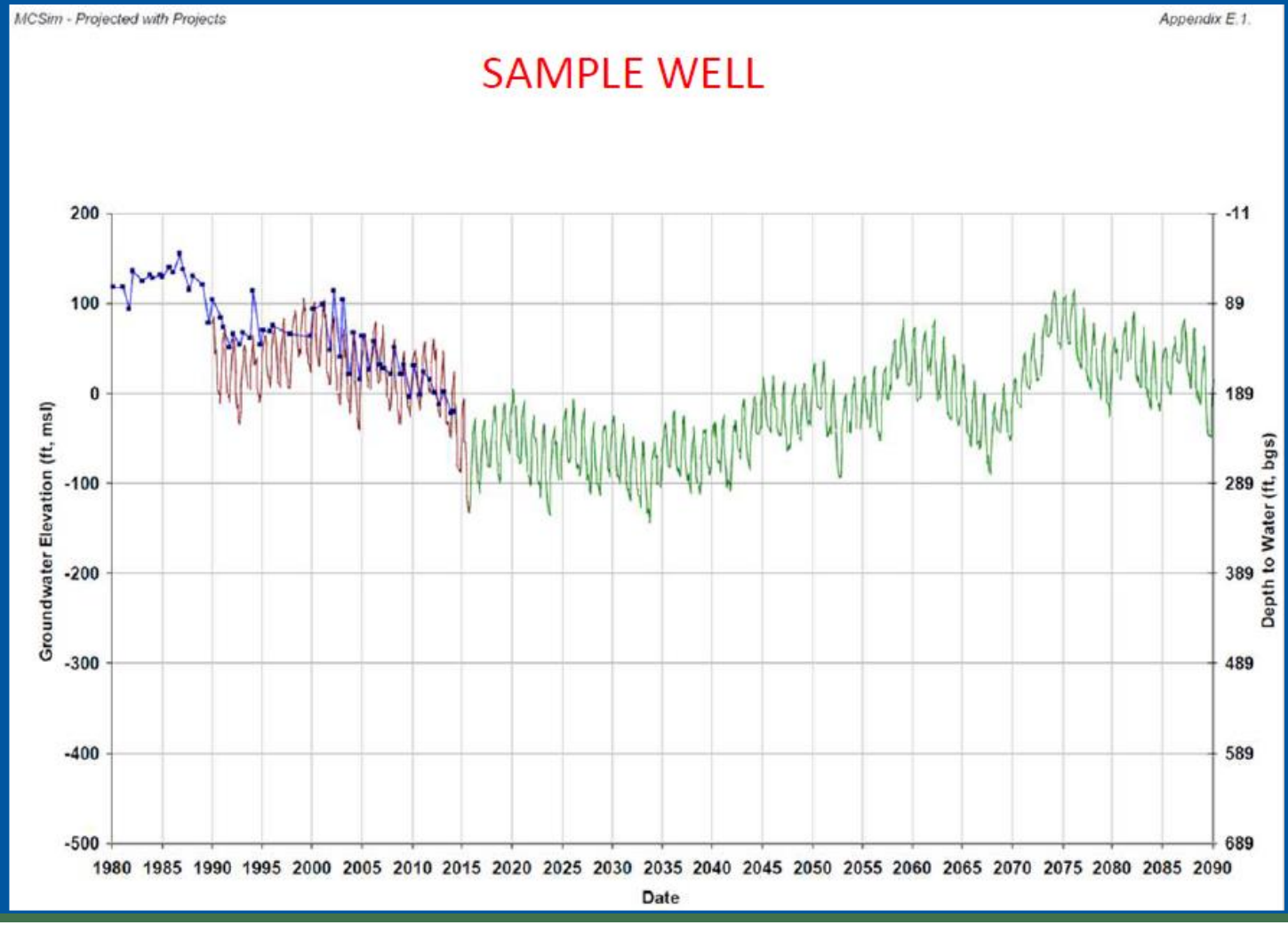


Madera Subbasin



Chowchilla Subbasin

What we decided (Cont)…



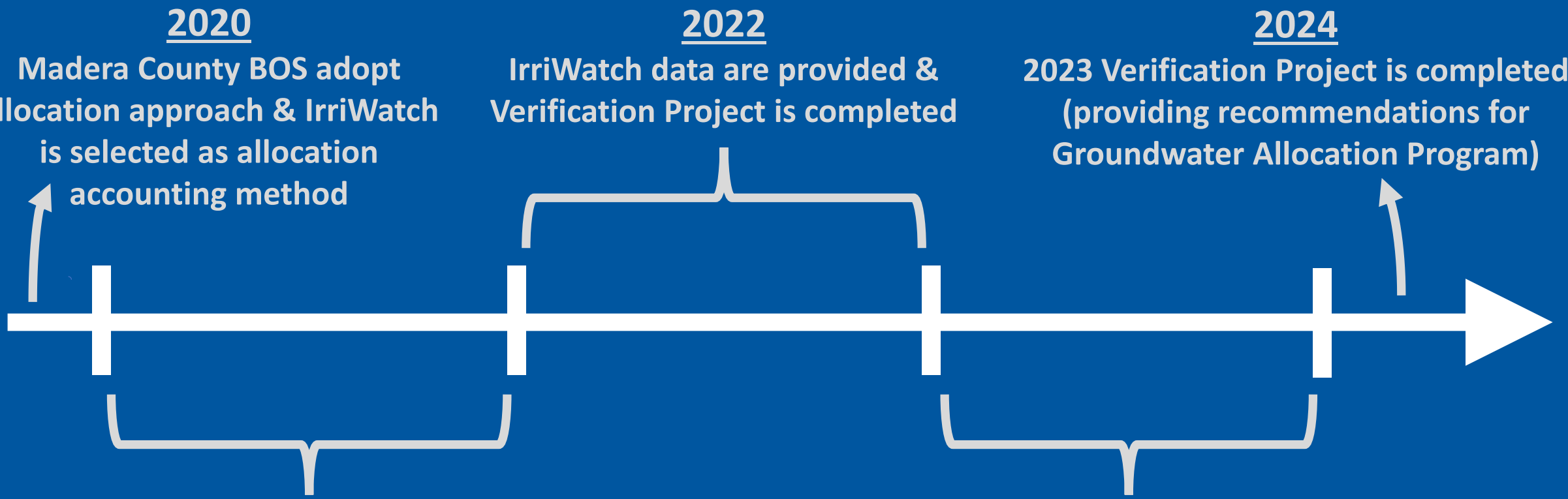
Allocations in County GSAs

- **Applied Water (AW)**
  - Volume of water delivered through irrigation system (groundwater or surface water)
  - Water flows to deep percolation and runoff as well as to evapotranspiration, depending on irrigation efficiency
  - Measured with flowmeters
- **Evapotranspiration (ET)**
  - Conversion of water liquid to water vapor (consumption) via evaporation from soil or plant surfaces (E) and transpiration (T) through plant stomata (*i.e.,* consumptive use)
- **Evapotranspiration of Applied Water (ETAW)**
  - Portion of ET coming from Applied Water
  - Should be less than Applied Water (AW)
  - ET measured with satellite data and converted to ETAW considering ET from precipitation

Allocations in County GSAs

- Key Terms
  - Allocation - a water budget based on ETAW that decreases over time (2020-2040)
  - Sustainable Yield - water that naturally exists in the subbasins from seepage and percolation
  - Transitional Water - water that is continued overdraft, but allows irrigated acres to transition to lower water use
  - Dry run - a practice time (with no associated penalties; 2021-2022)
- Allocations for Subbasins within County GSAs

Overview of Groundwater Allocations



Per Acre Allocation for Irrigated Land

- Assuming over 80 % of the parcel is irrigated
- Assuming the parcel was actively irrigated prior to 2021 (not opt-in)

Madera County GSA: Madera Subbasin	Inches of ETAW
2021	28.3
2022	28.0
2023	27.7
2024	27.4
2025	27.1

Madera County GSA: Chowchilla Subbasin	Inches of ETAW
2021	26.7
2022	26.3
2023	25.9
2024	25.5
2025	25.1

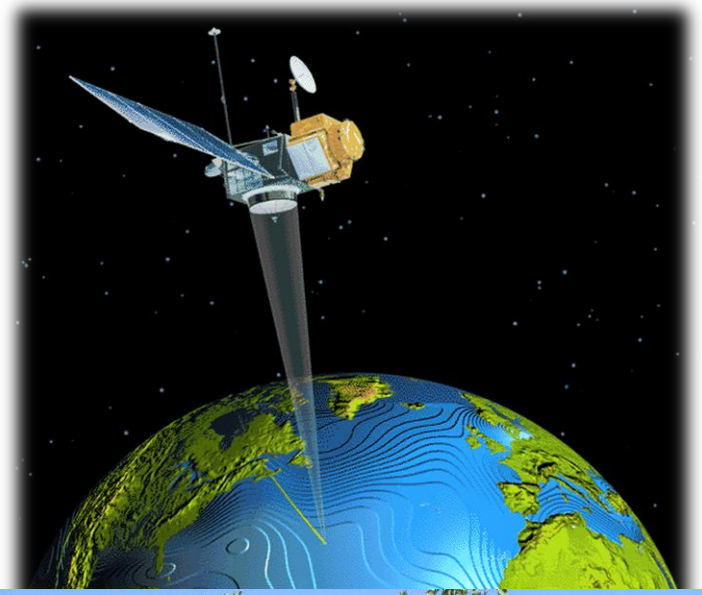
Outline

- Introduction (Stephanie - 15 min)
- Land IQ ET and Precipitation (Joel - 30 min)
- Processing Land IQ Data to Compute ETAW (Jeff - 15 min)
- Discussion (All - 60 min)

Land IQ Technical Disciplines

Land-Based Sciences: Land and Water Resources

- Agronomic assessments/soil science
- Water quality and supply evaluations
- Salinity and nutrient management
- Agricultural reuse
- Land stabilization and erosion control
- Soil reclamation and irrigation/drainage



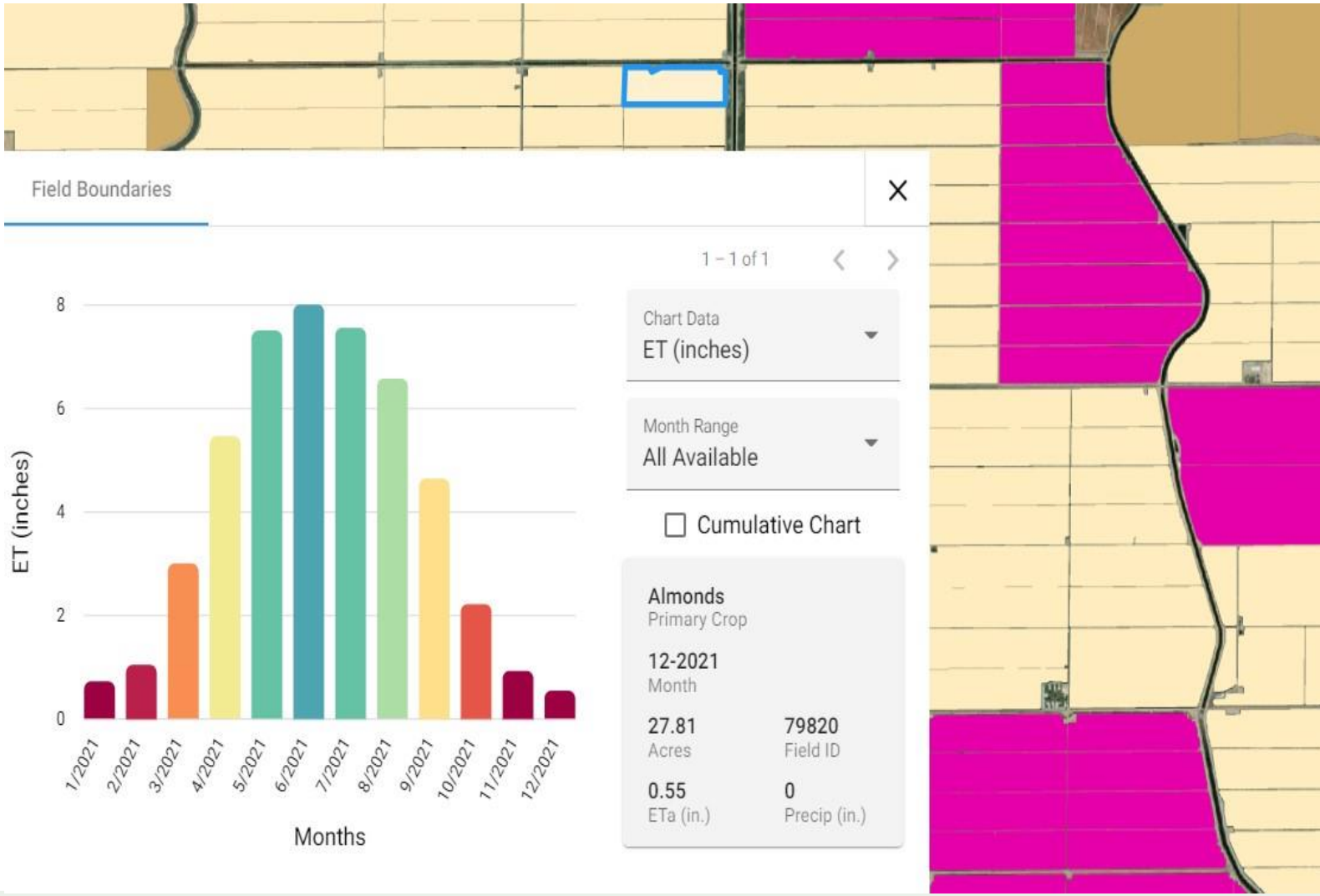
Spatial Sciences: Remote Sensing and GIS

- Consumptive use estimation and crop identification
- Large landscape evaluations
- Irrigation and drainage
- Production agriculture

Development

- Data management tools

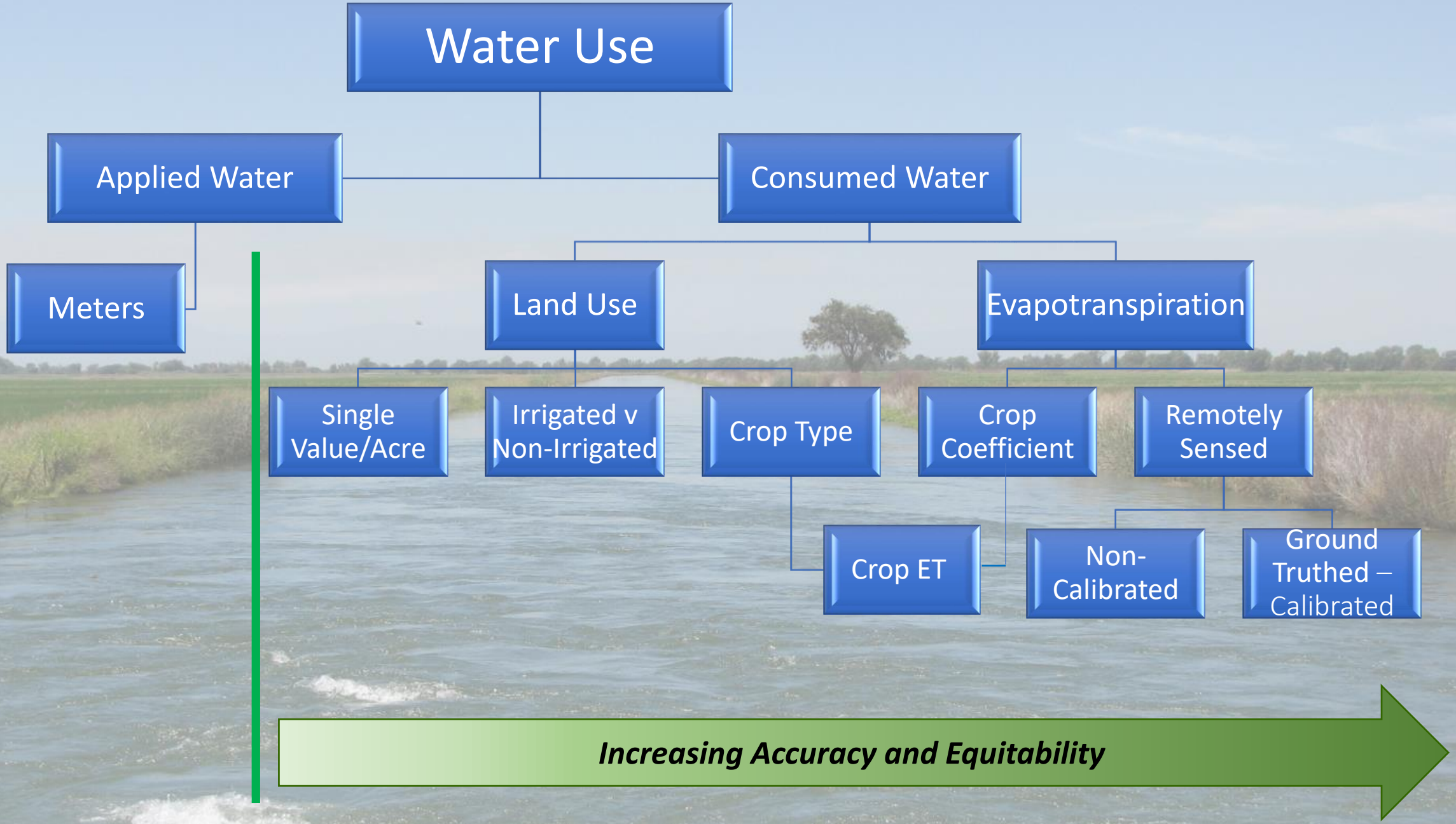
Evapotranspiration and Ground Truthing Calibration and validation



Applied Versus Consumed Water

- San Joaquin Valley experience:
  "Just tell me how much water I use"
- Applied Water
  - Water that is pumped or diverted
  - Measured via meters or other flow device
- Consumed Water
  - Water that is evapotranspired
  - Measured via knowledge of the crop type and crop coefficients, or
  - Measured via remotely sensed methods
- Applied ≠ Consumed
- Applied + Precipitation > Consumed

A Decision Tree Approach



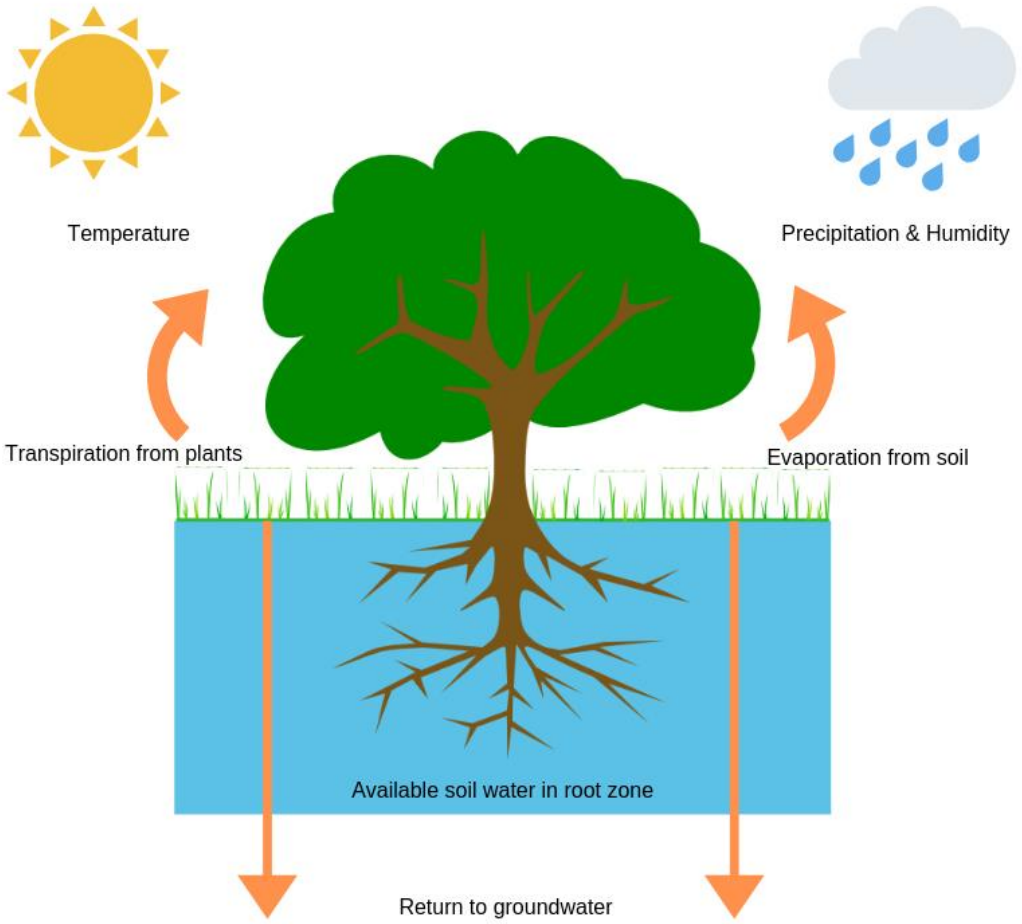
EVAPOTRANSPIRATION

Consumed Water: Evapotranspiration

Evapotranspiration = Evaporation + Transpiration

- Evaporation: Water evolved into the atmosphere from soil and plant surfaces after precipitation or irrigation (never goes through the plant)

- Transpiration: Water evolved into the atmosphere from translocation through the plant (from roots to leaves)

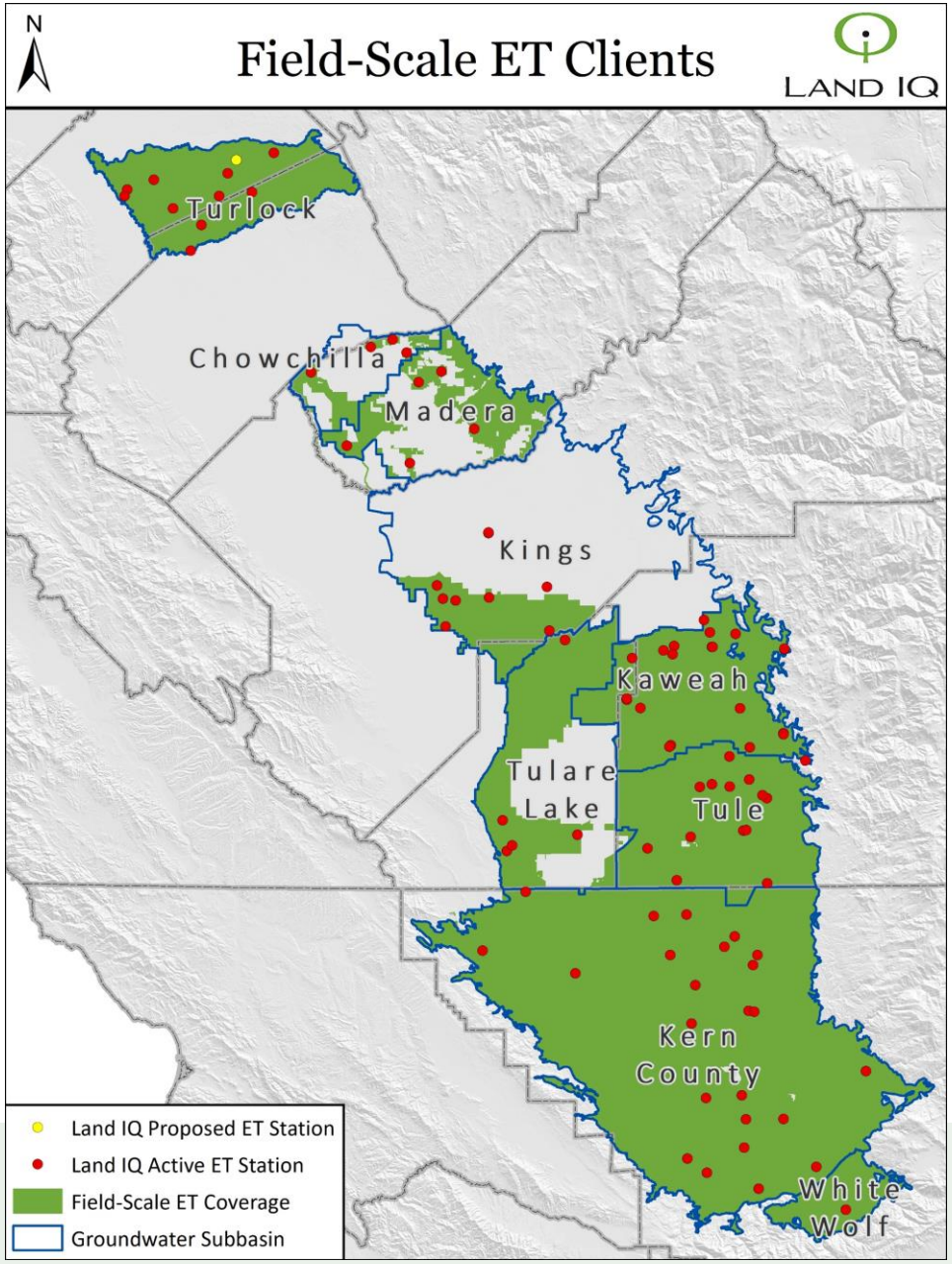


GROUND TRUTHING FOR CALIBRATION – WHY?

- Defensible
- Independent validation
- Calibration to actual conditions
- Avoiding interpolation during lengthy cloud and smoke cover
- Understanding specific field conditions and management
- Allows for crop-specific modeling
- Stations used are a combination of eddy covariance and surface renewal approaches developed through collaboration with DWR (Delta) and UC Davis researchers
- A “ground up” approach

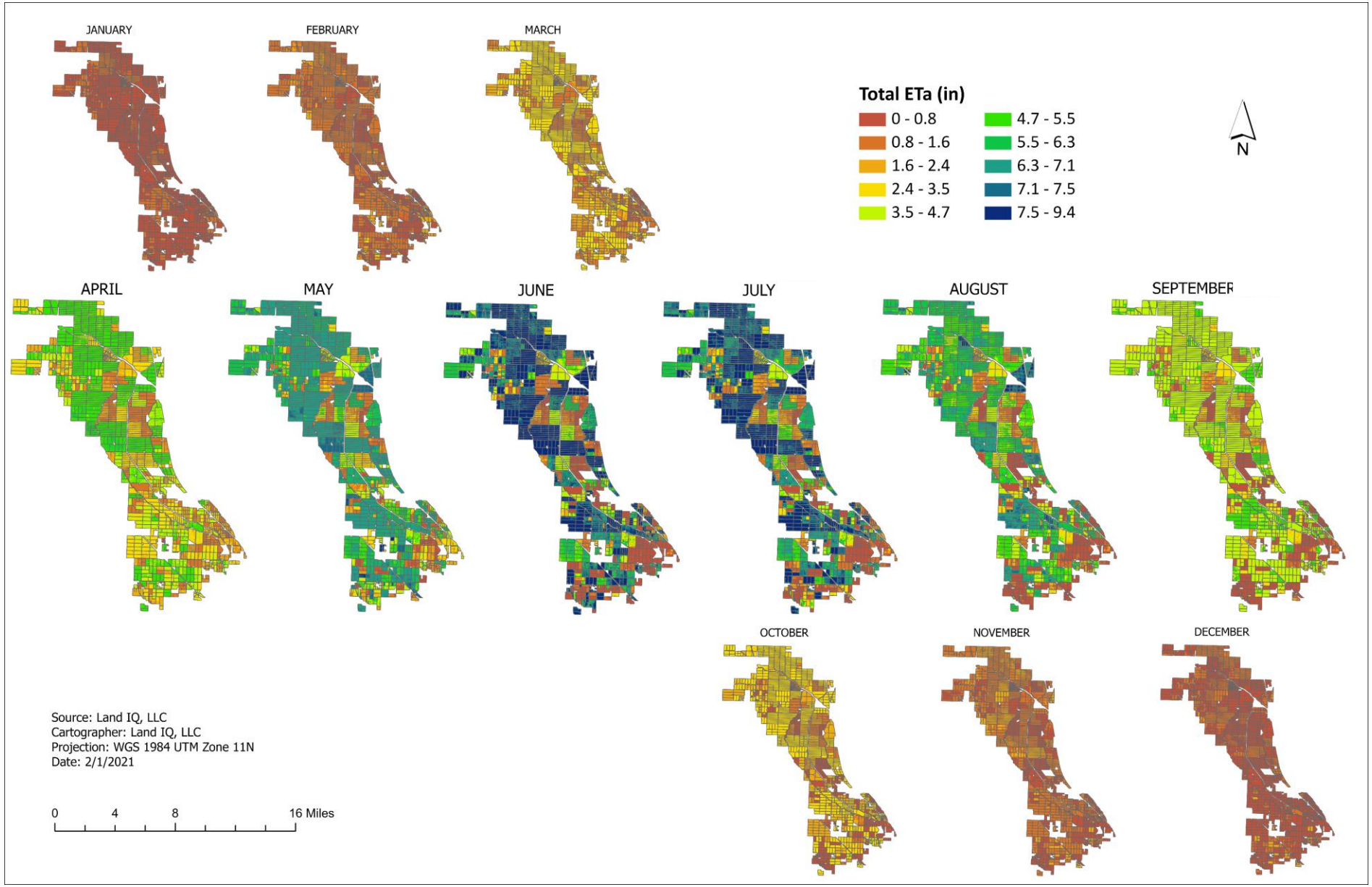
GROUND TRUTHING FOR CALIBRATION – WHERE?

- Approximately 85 stations installed in the San Joaquin Valley
- Establishment of spatial precipitation with multiple rain gauges
- For the purpose of understanding crop specific and repeated measurements
- Collaboration with UC Davis, UC Cooperative Extension and USDA Agricultural Research Service
- Necessary for more accurate estimation of consumed water in any: water allocation/market /fee-based approach



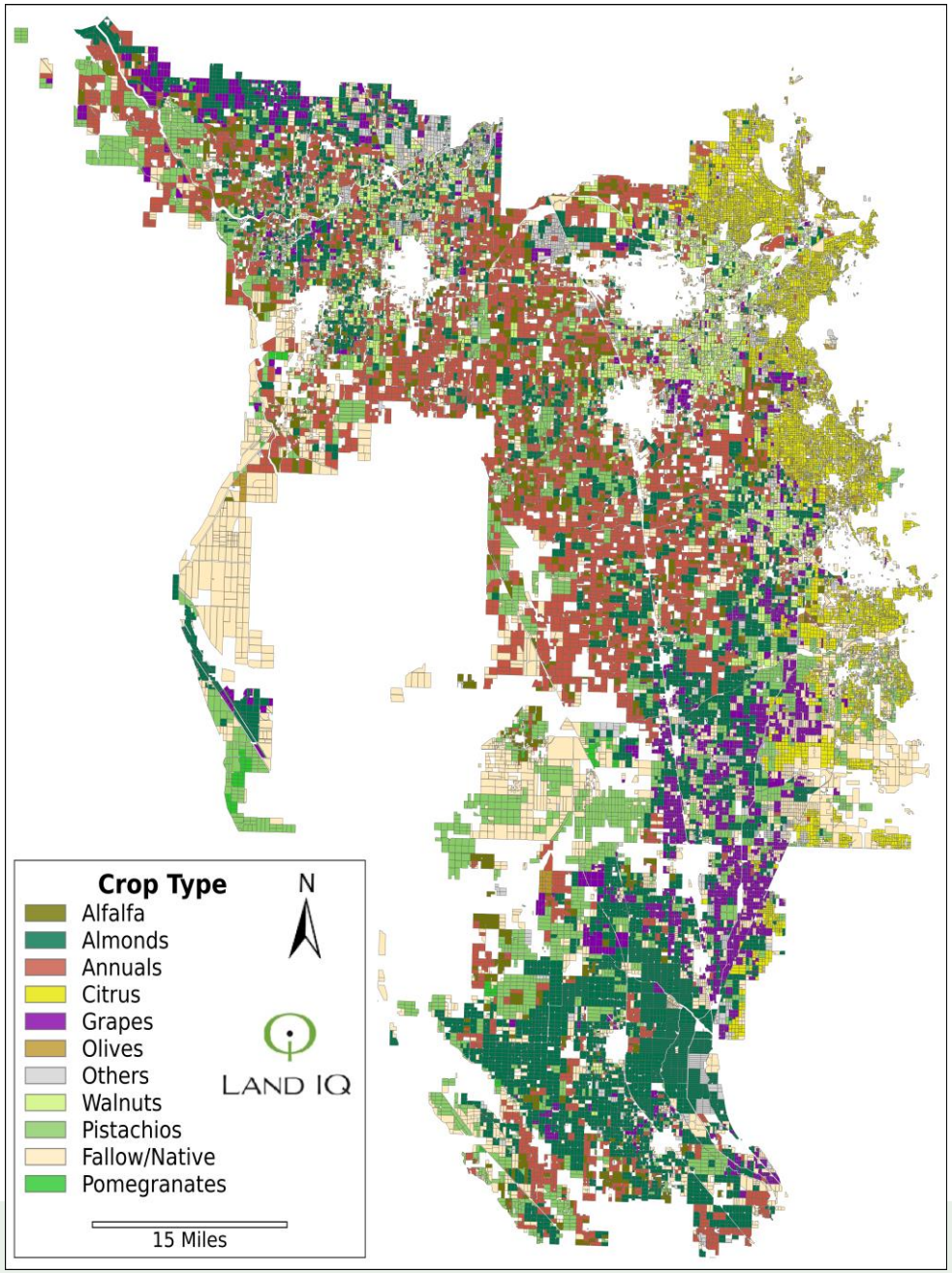
DELIVERABLE 1 – FIELD BY FIELD ET

- Monthly results delivered to the GSA within 30 days of the previous month
- Calibrated and validated by ground truthing climatic stations
- Reviewed by independent advisors
- Used for tracking water use, water management, reporting, allocations, fee structures, etc.



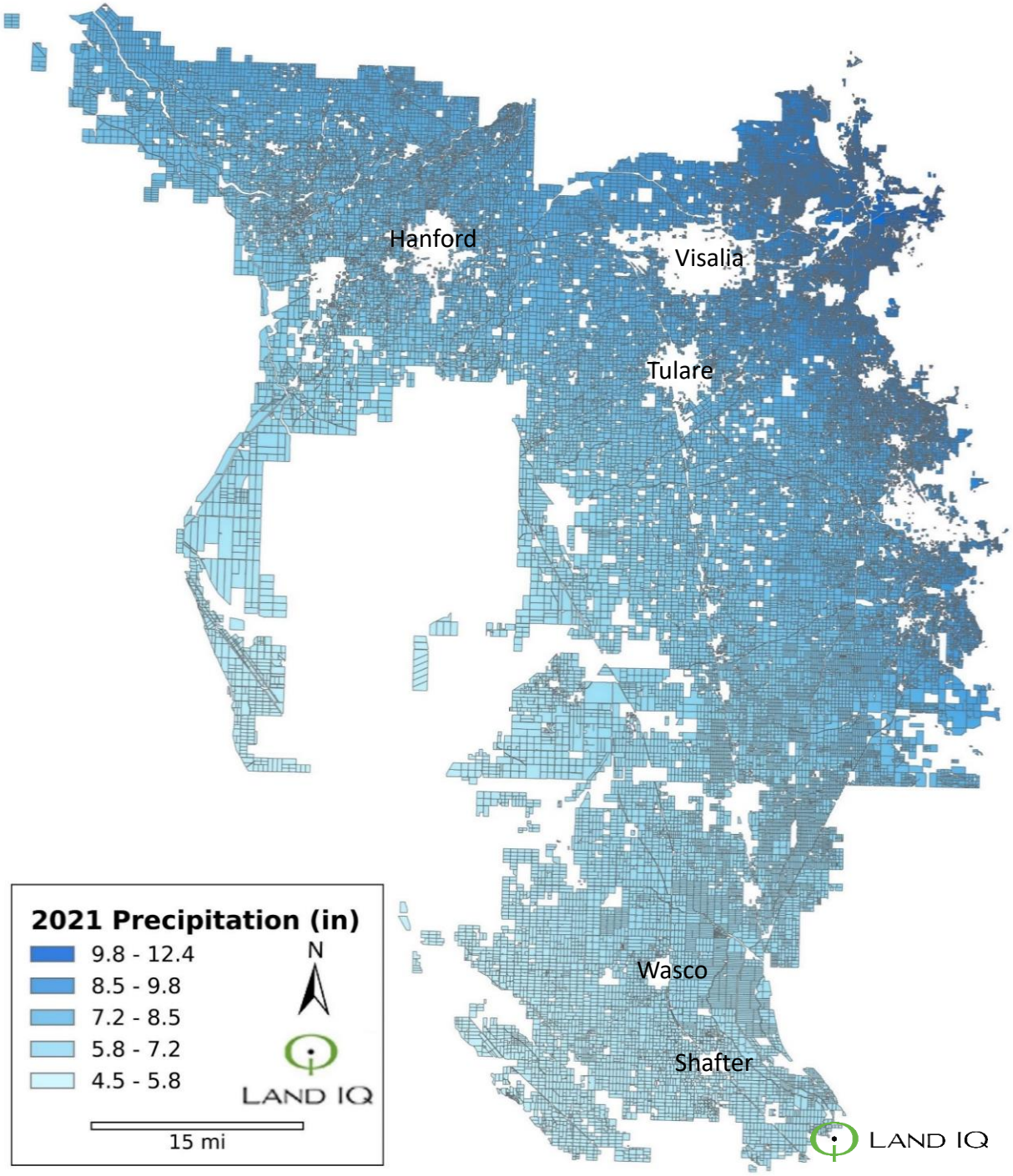
DELIVERABLE 2 – FIELD BY FIELD CROP TYPE

- Same methodology used to provide crop type to CA Dept of Water Resources as a requirement of SGMA
- Consistent with results for DWR
- Essentially real-time crop type for inclusion in modeling
- Can be used by GSAs/Districts for tracking irrigated acreage, customer base, in-season water planning and management



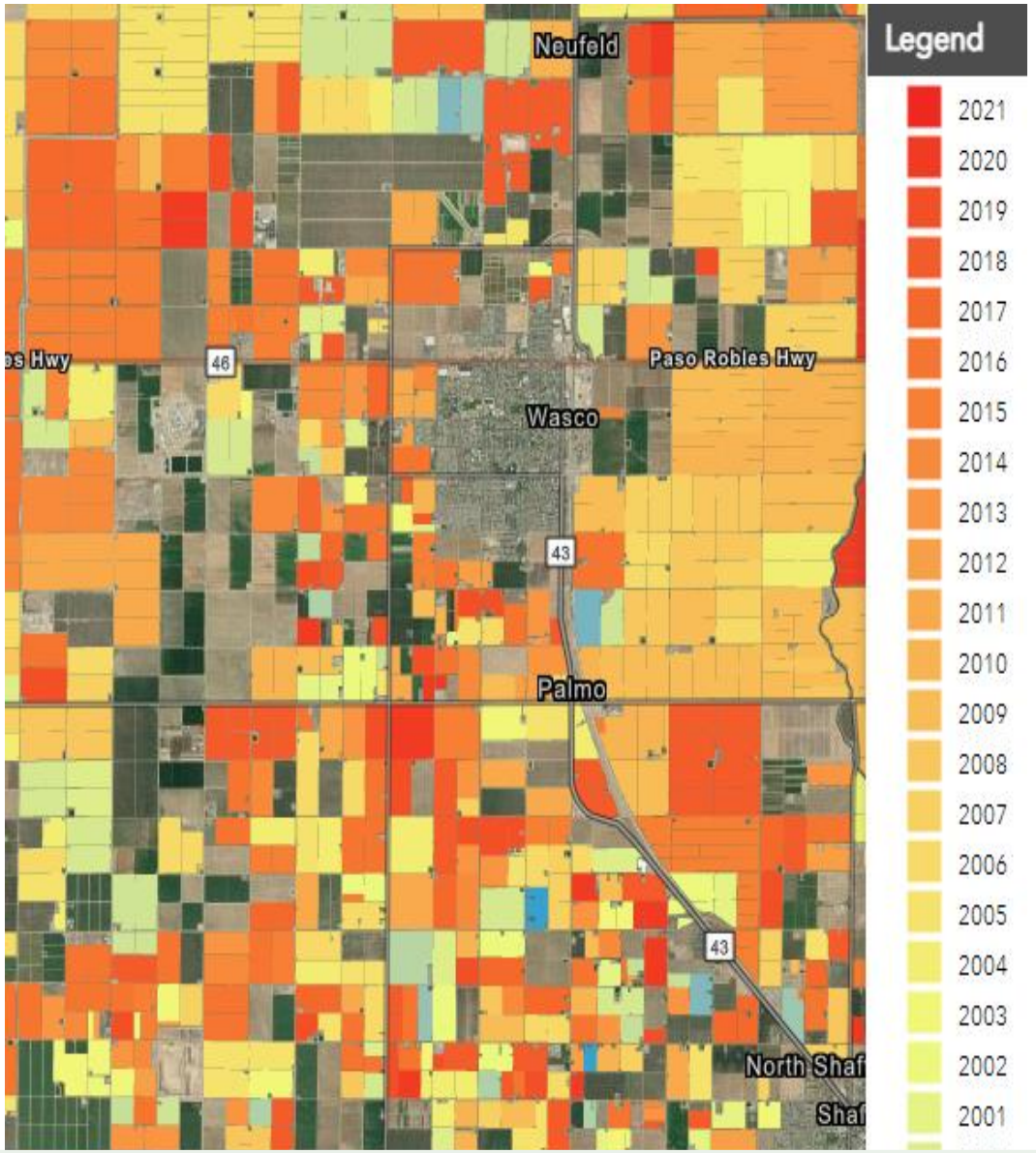
DELIVERABLE 3 – FIELD BY FIELD PRECIPITATION

- Results collected by rain gauges at ground truthing stations
- Incorporation of other public rain gauge results (e.g. CIMIS, airports, cities, etc.
- Conversion of point data into a spatial precipitation map by month and by year
- Assignment of a field-by-field precipitation for rainfall contribution to ET, water budget tracking, allocations, modeling, etc.

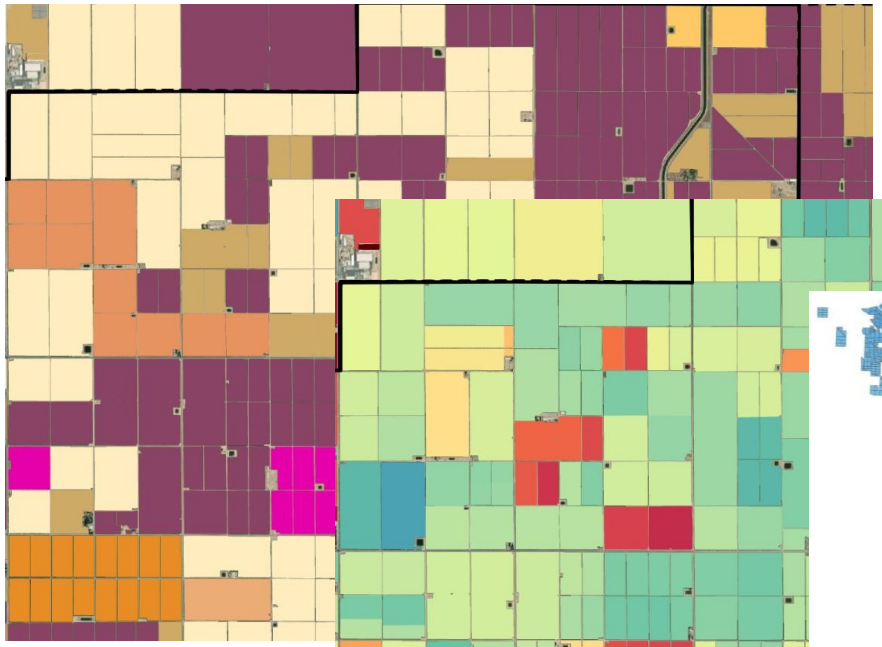


DELIVERABLE 4 – FIELD BY FIELD PERMANENT CROP AGE

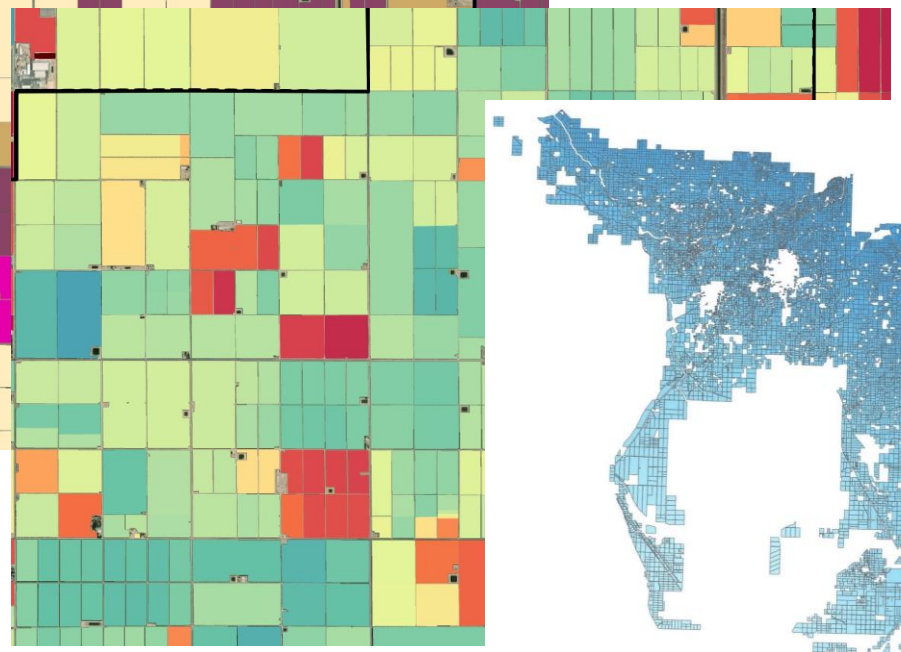
- Same methodology used to provide crop type to CA Dept of Water Resources as a requirement of SGMA
- Consistent with results for DWR
- Highly correlated to consumed water
- Yet another line of evidence that people can use to refine their water management allocations and land use forecasting



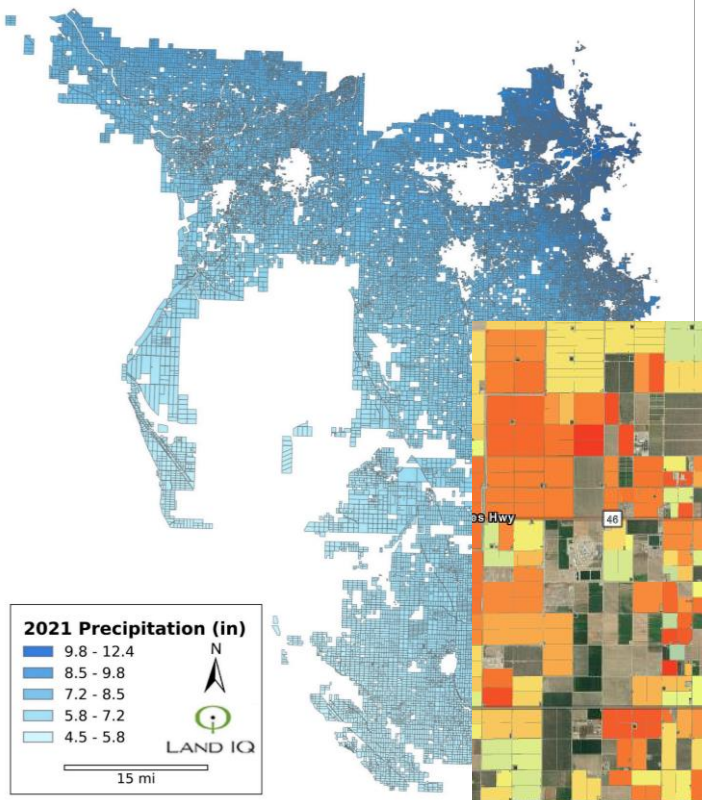
FIELD-BY-FIELD RESULTS



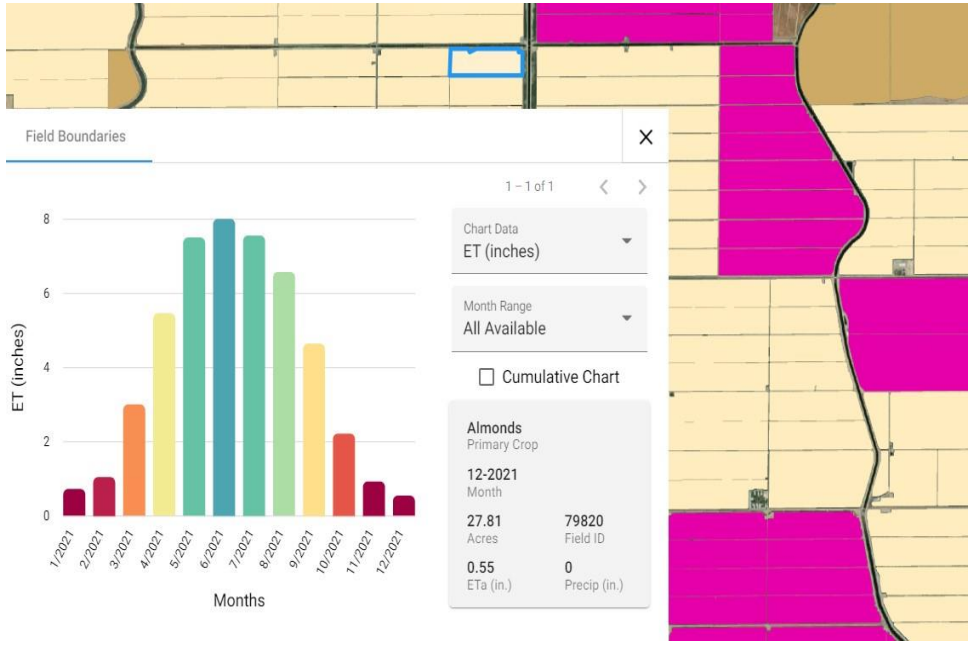
Land Use



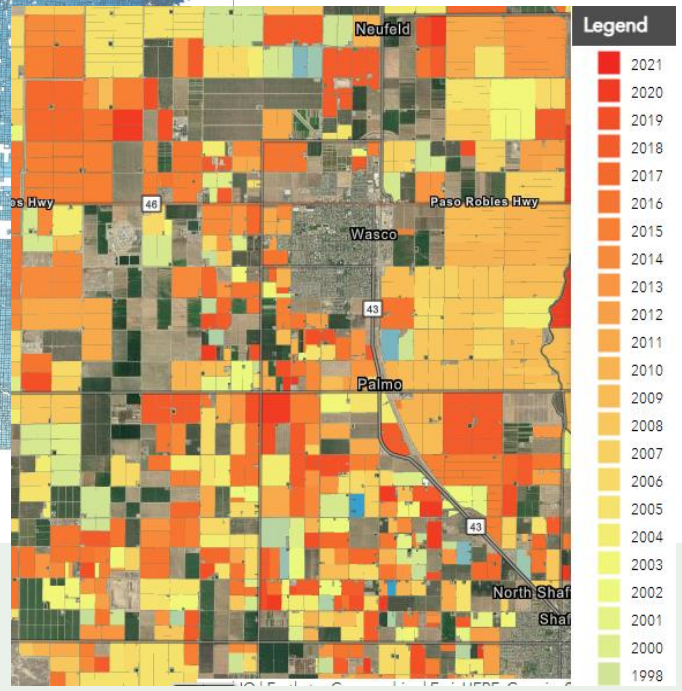
Monthly ET



Monthly Precipitation



Online Viewer and Data Download Tool

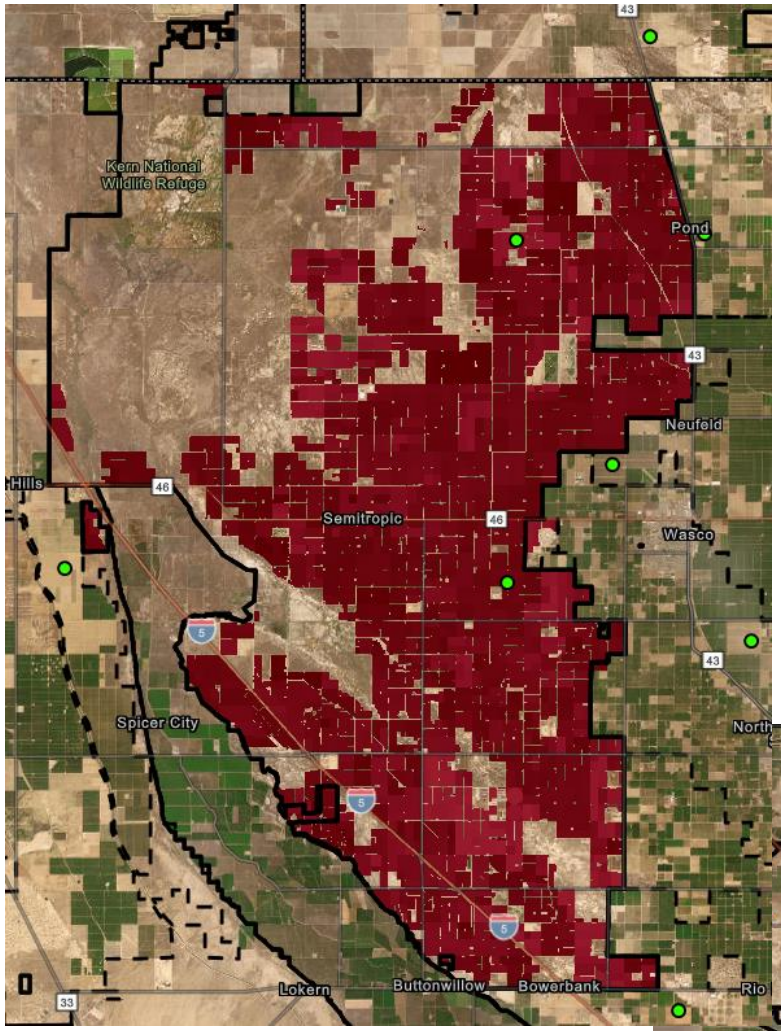


Age

LAND IQ

Results

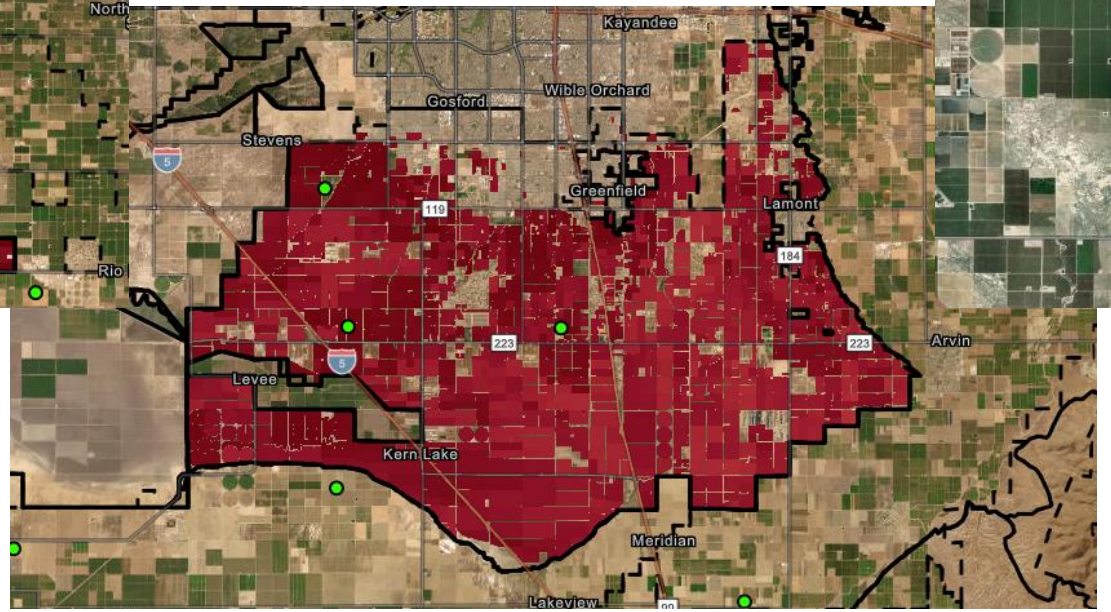
JANUARY 2023

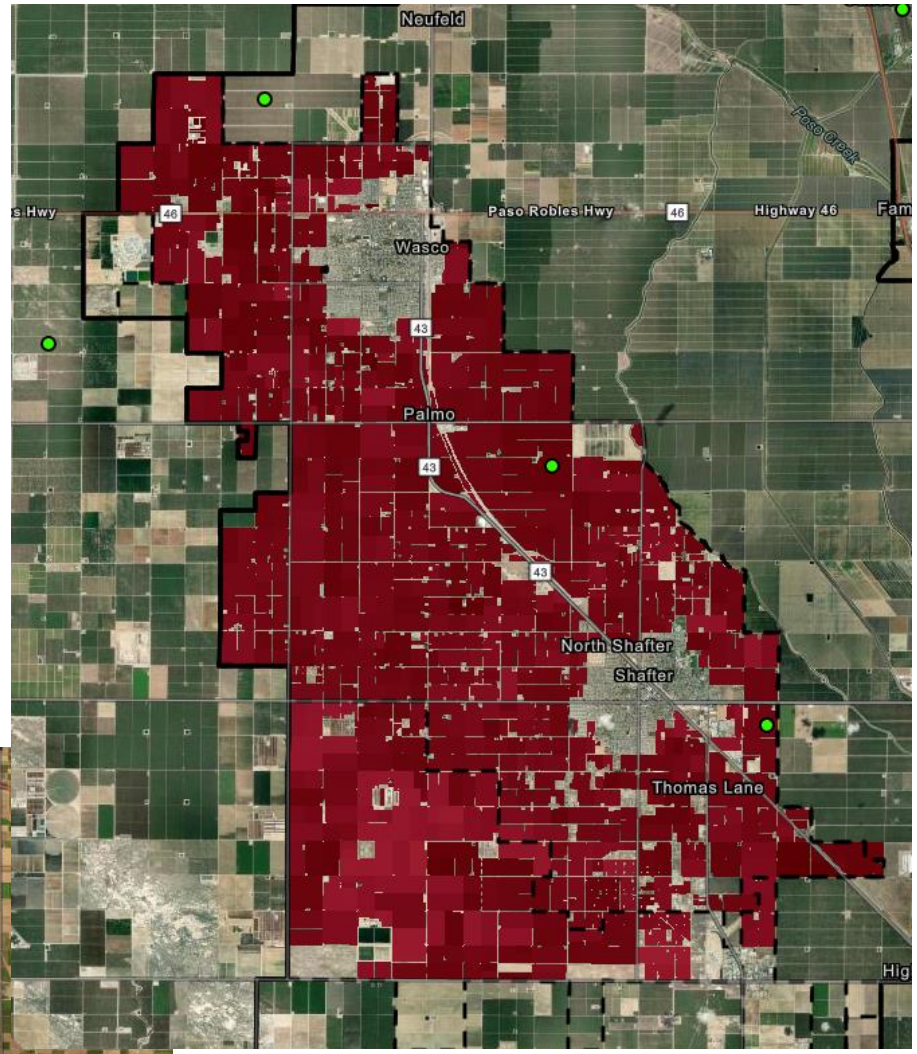


Monthly Sum of ET

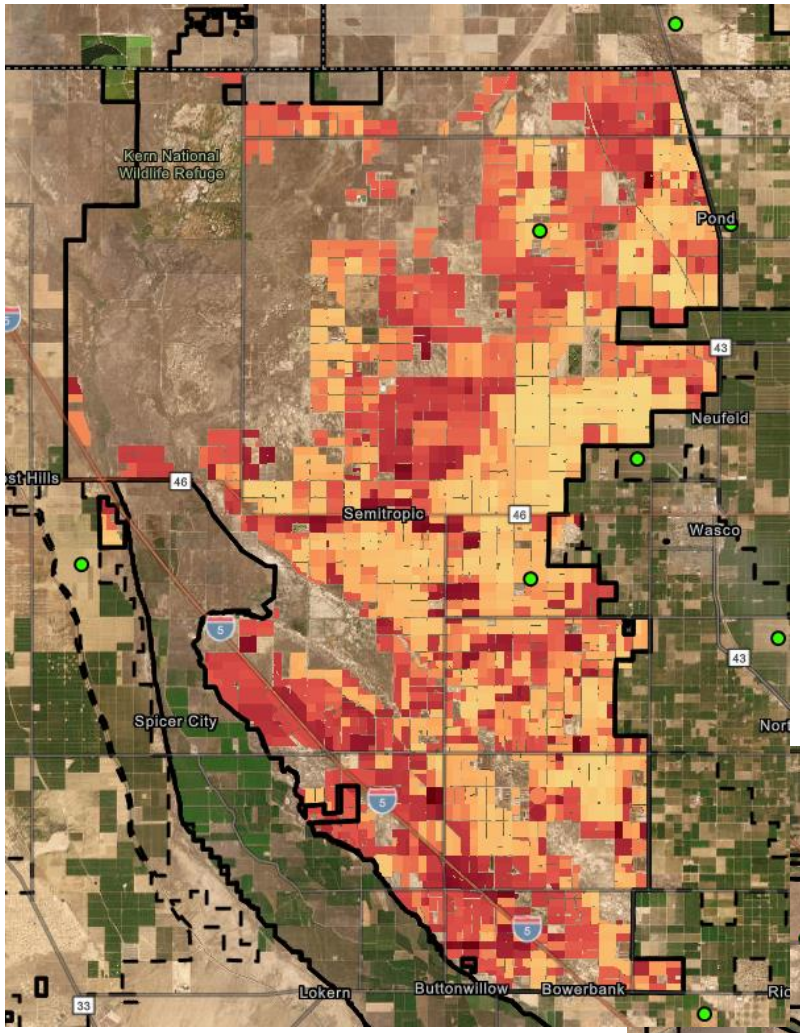
10 inches

0 inches





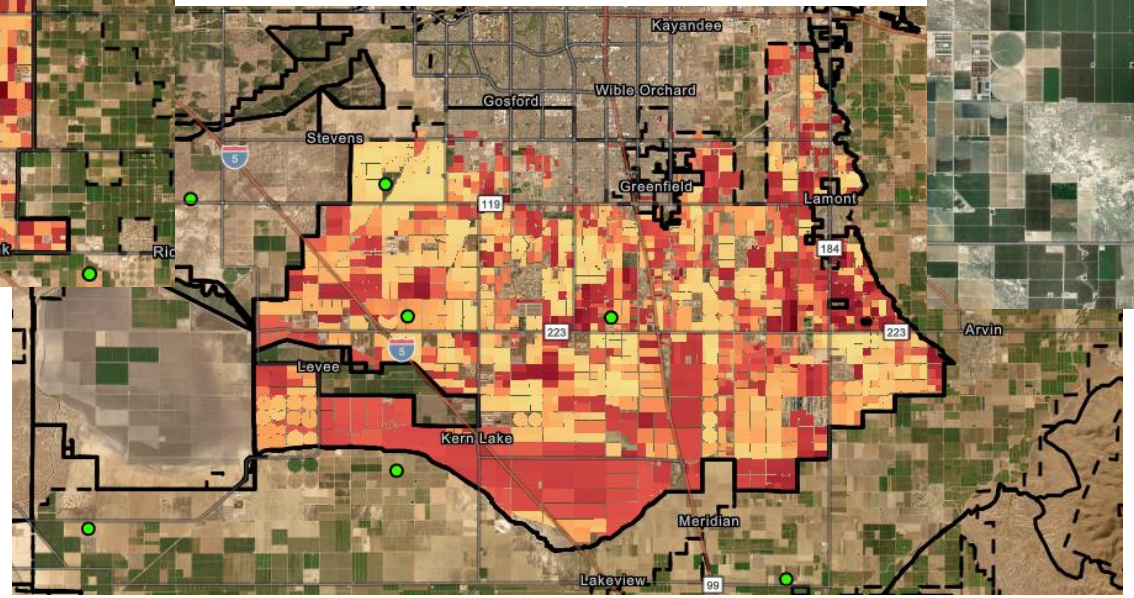
April 2023

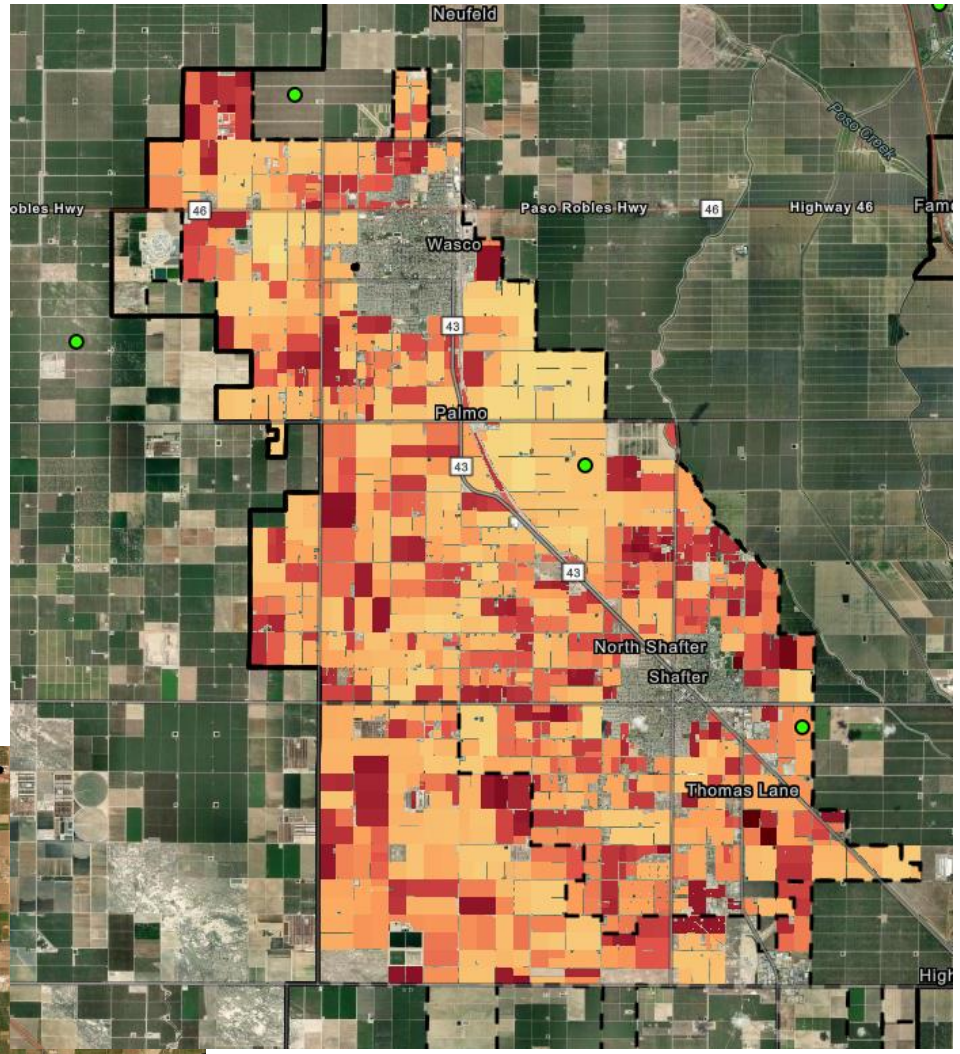


Monthly Sum of ET

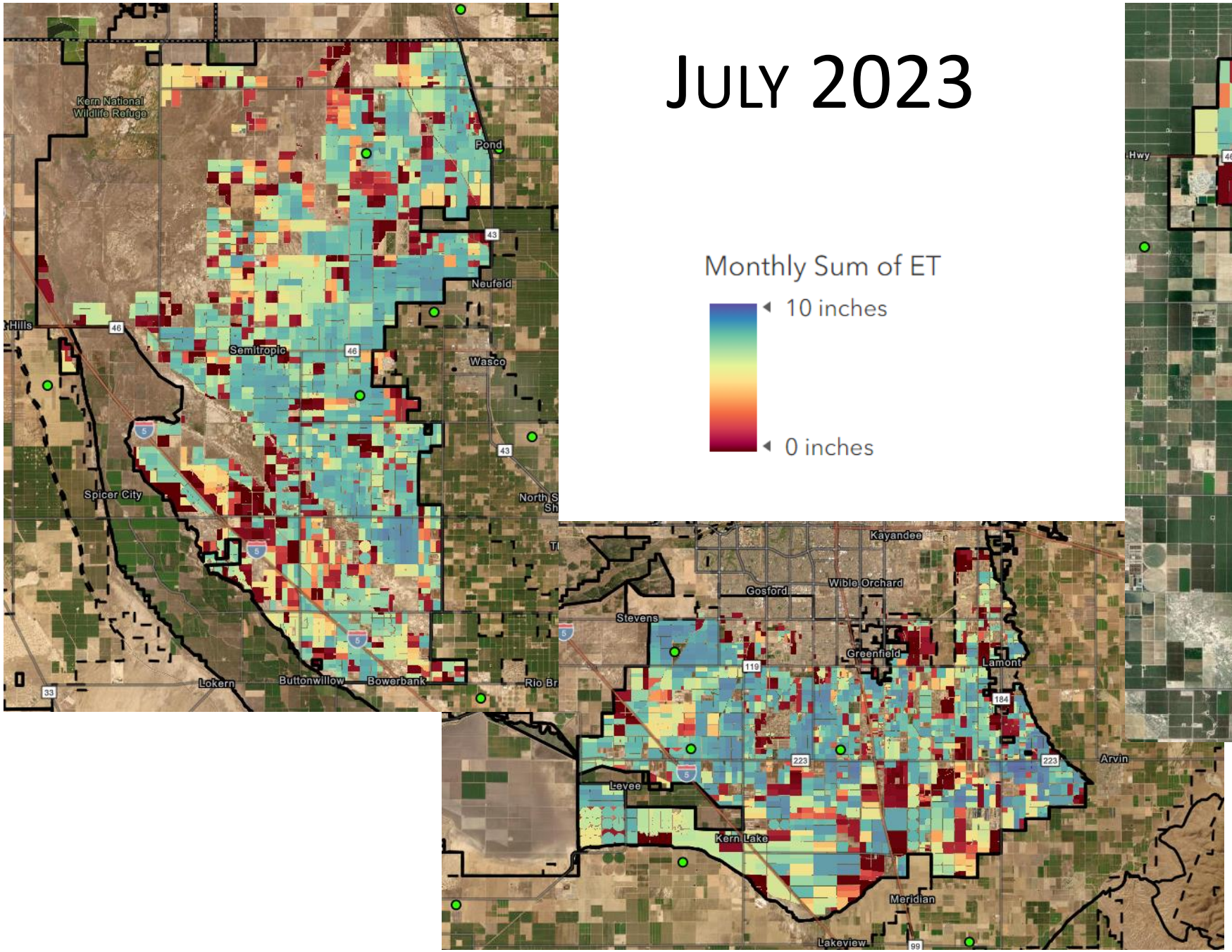
10 inches

0 inches

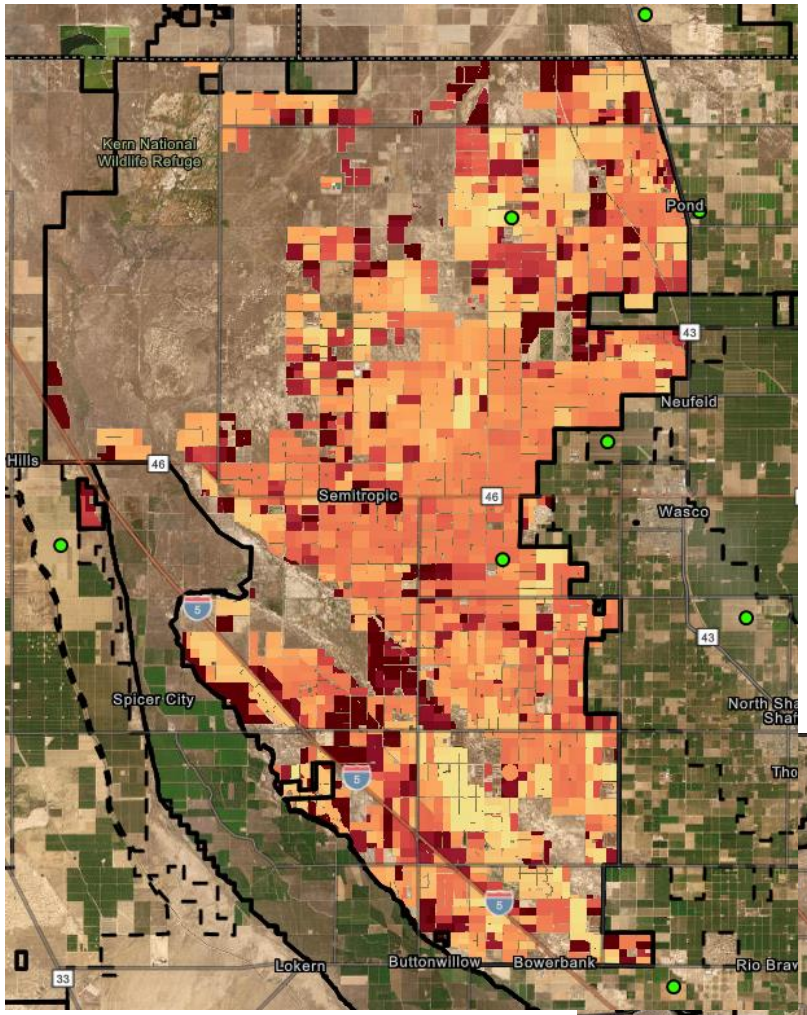




July 2023


Monthly Sum of ET
10 inches
0 inches
Kern National Wildlife Refuge
Pond
Neufeld
Semitropic
Wasco
Spicer City
Lokern
Buttonwillow
Bowerbank
Kayandee
Gosford
Wible Orchard
Stevens
Greenfield
Lamont
Arvin
Levee
Kern Lake
Meridian
Lakeview
Neufeld
Paso Robles Hwy
Highway 46
Wasco
Palmo
North Shafter
Shafter
Thomas Lane

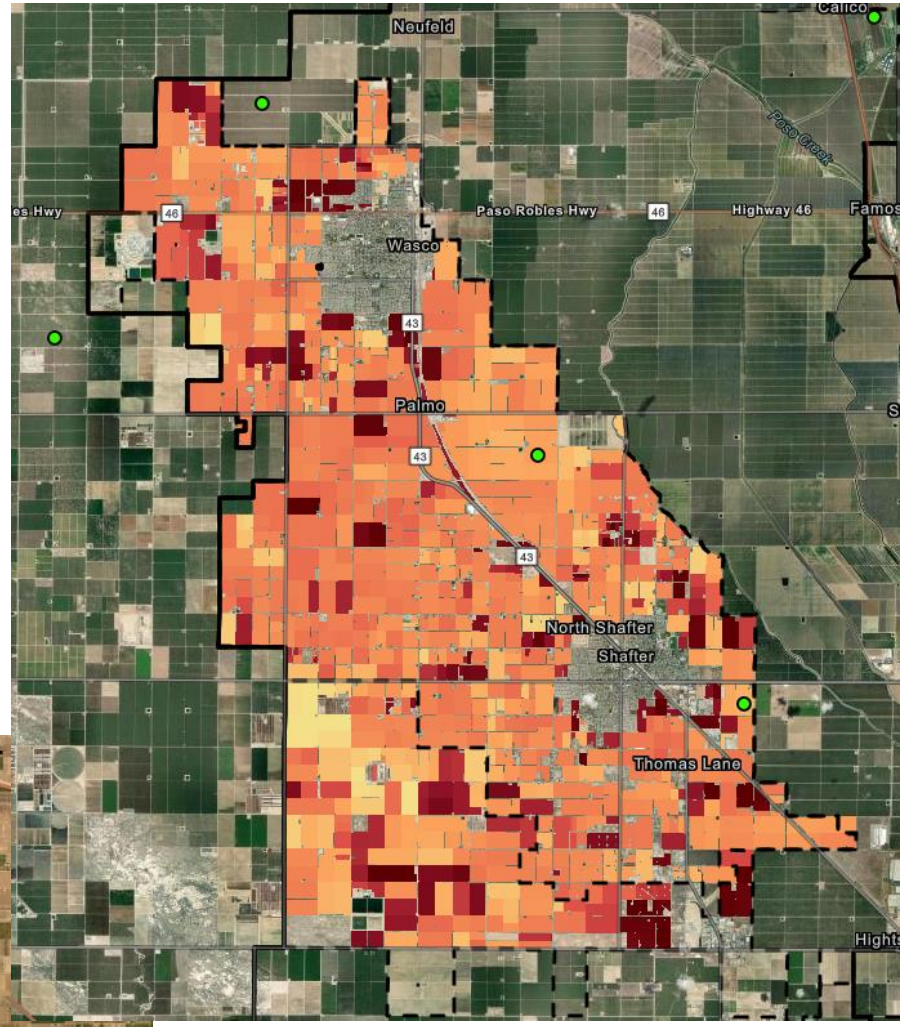
SEPTEMBER 2023

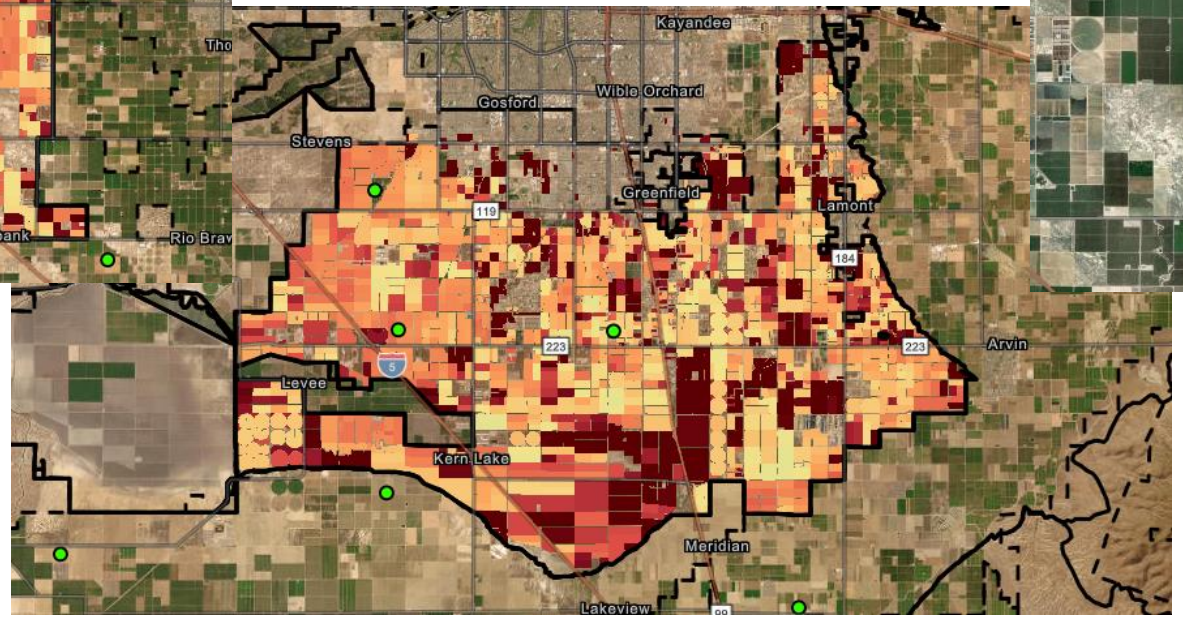


Monthly Sum of ET

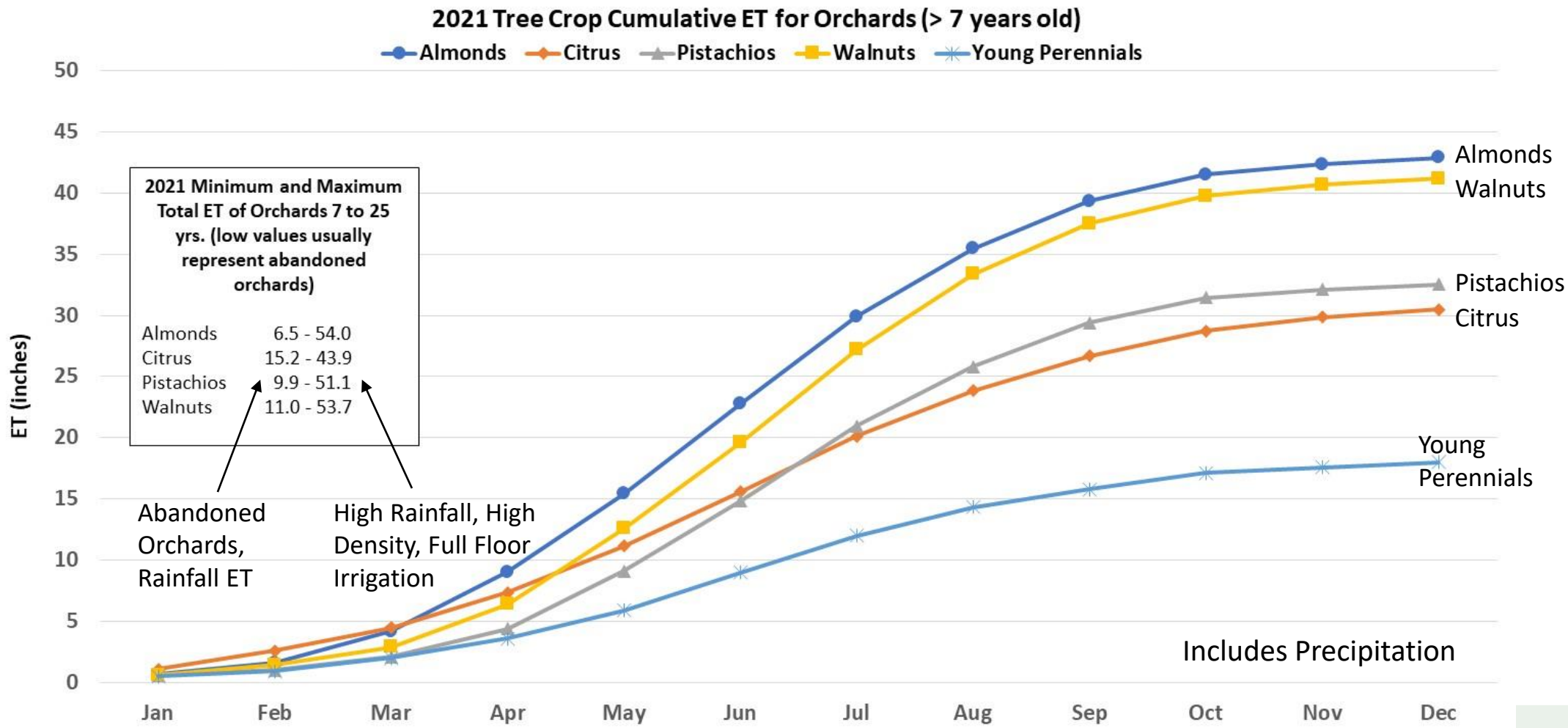
10 inches

0 inches

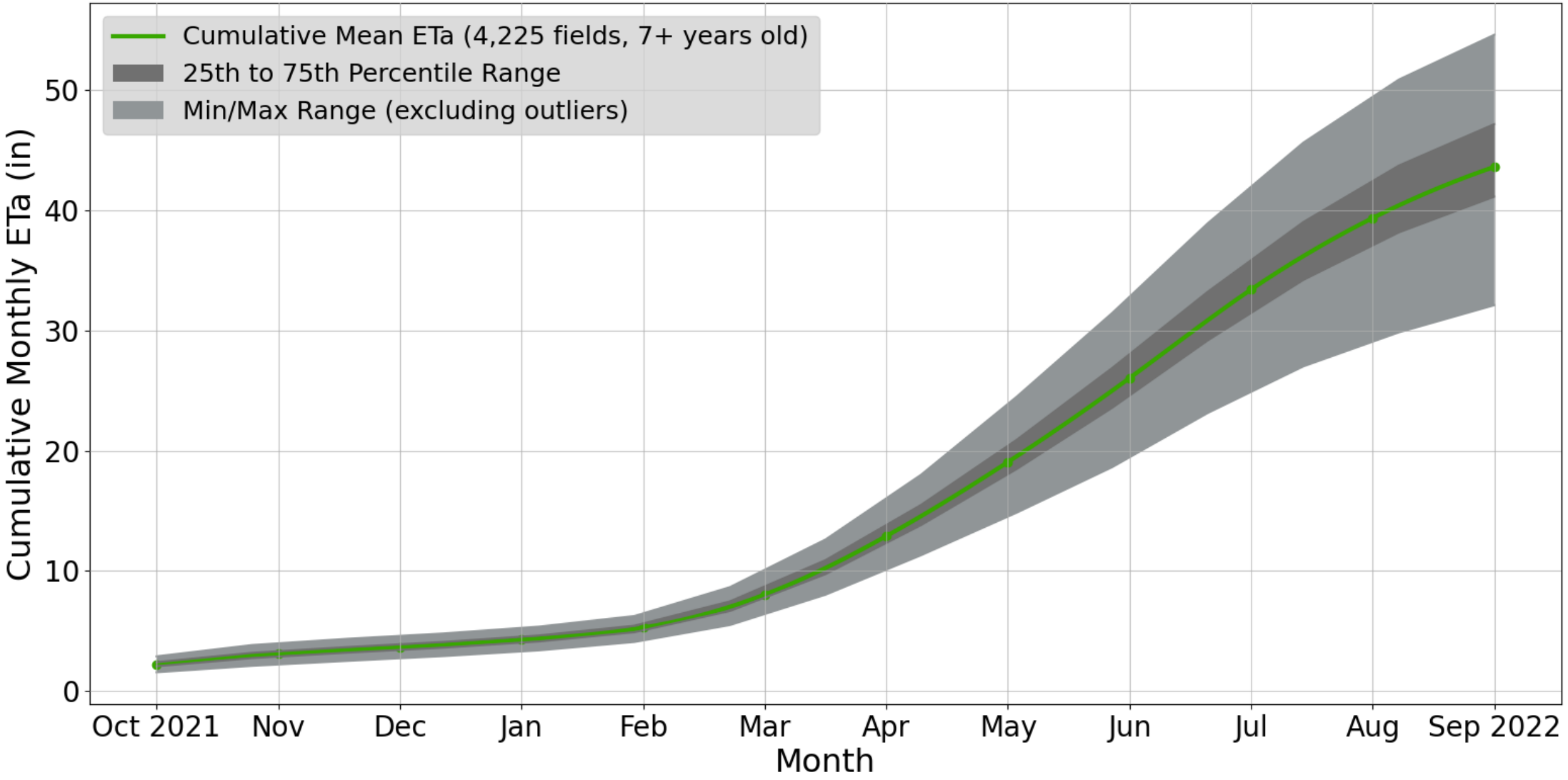




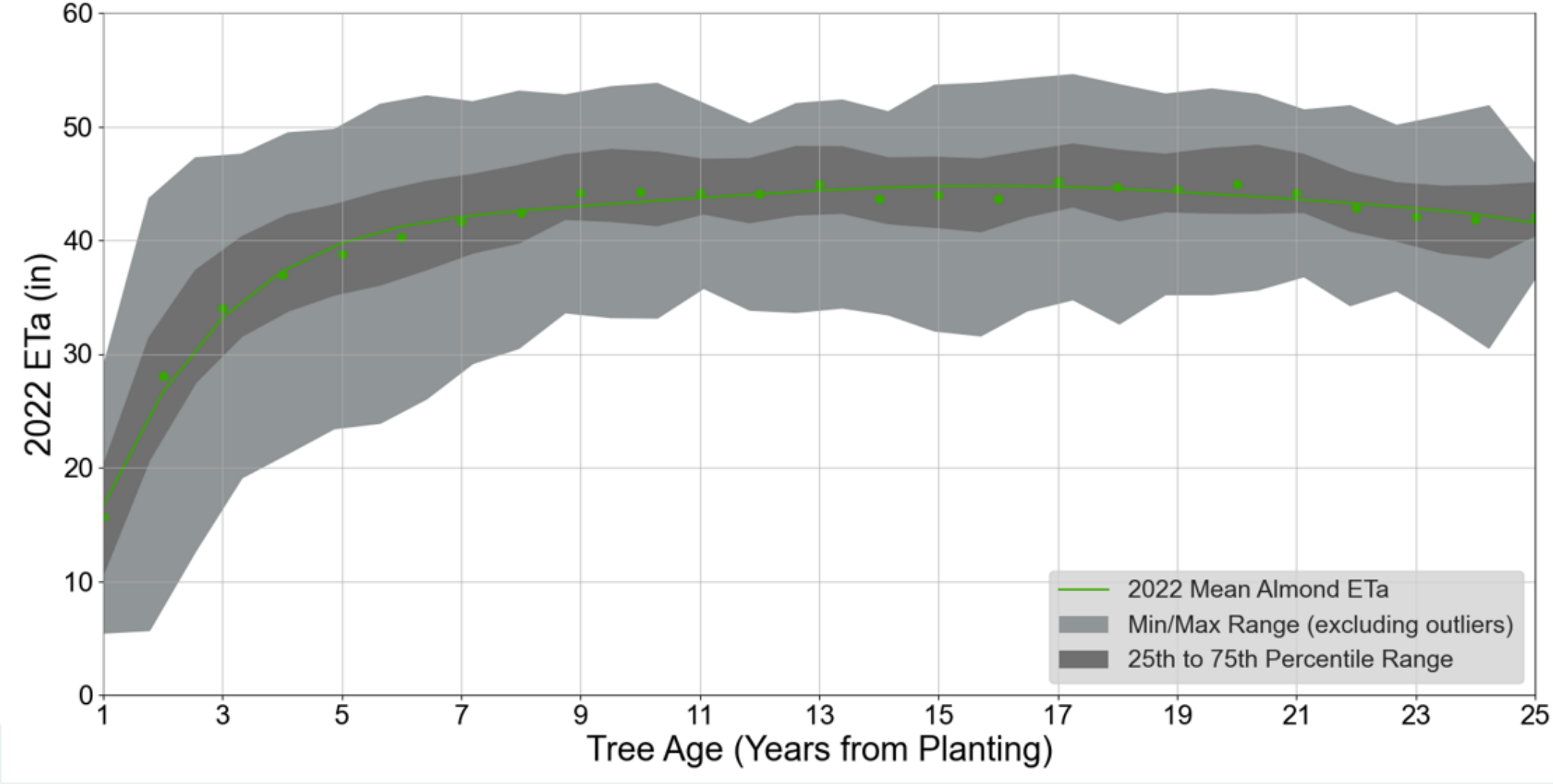
PERMANENT TREE CROP AVERAGE ANNUAL CONSUMPTIVE USE



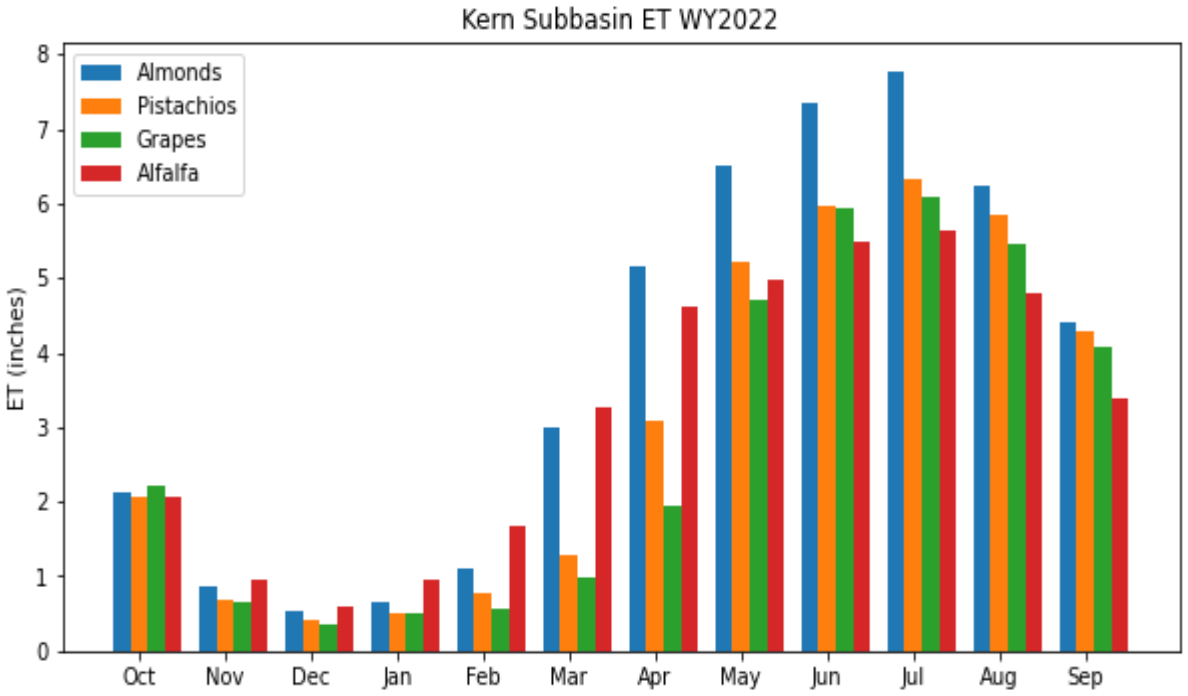
Almond Cumulative ET

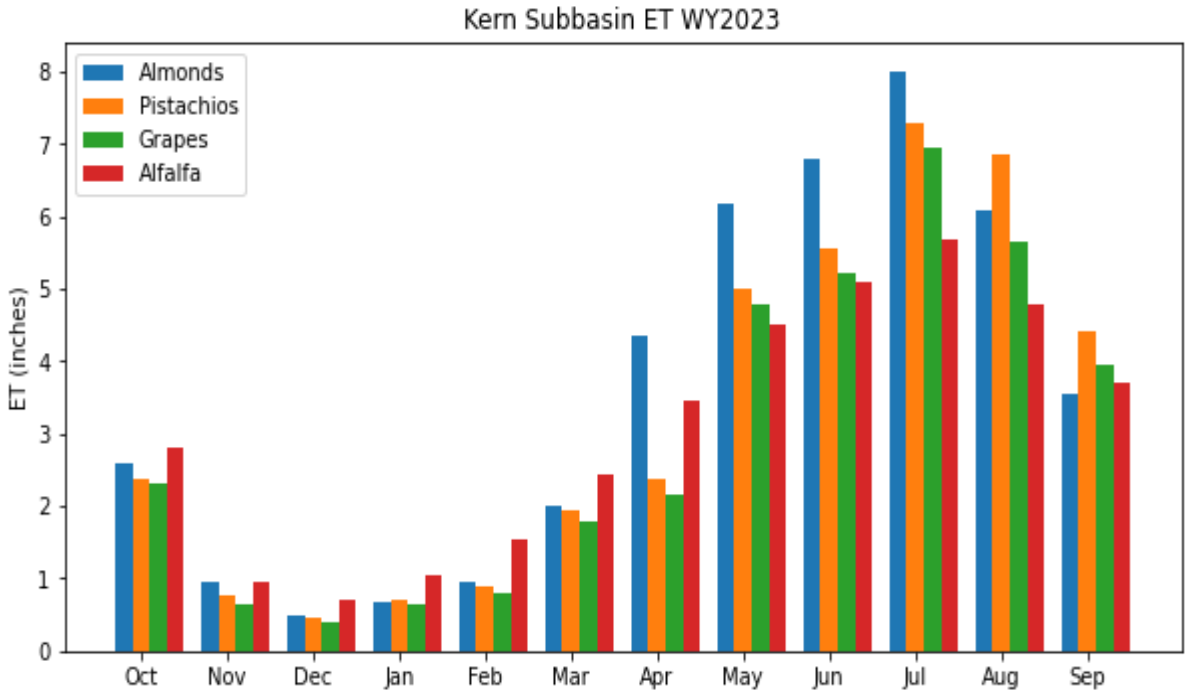


Almond Evapotranspiration By Age



Kern Subbasin – ET Summaries For Almonds, Pistachios, Grapes, and Alfalfa – Water Years 2022 and 2023





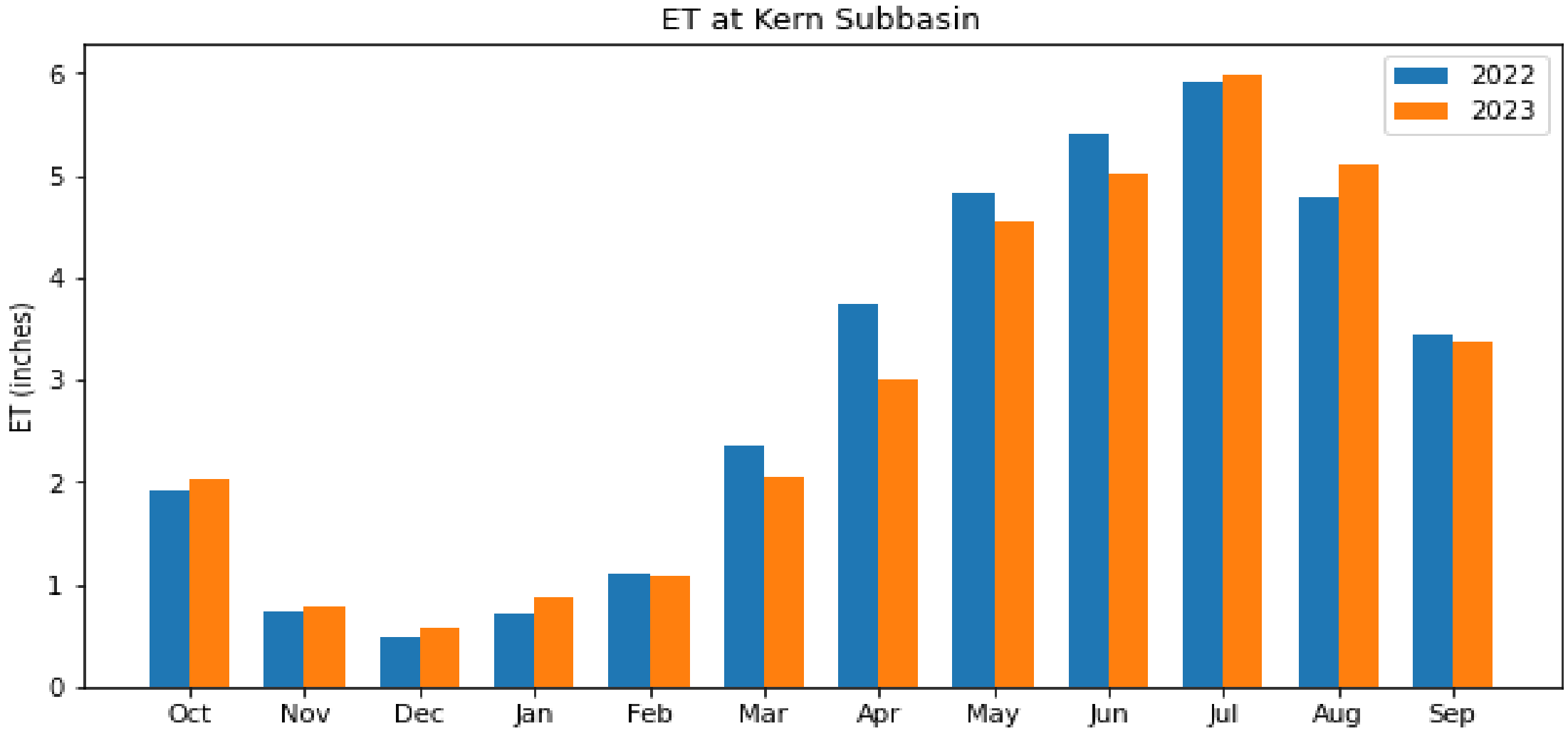
Crop 2022	Avg	Max
Almonds	45.9	55.4
Pistachios	37.1	48.6
Grapes	35.5	50.6
Alfalfa	36.8	51.4

Crop 2023	Avg	Max
Almonds	42.3	52.2
Pistachios	38.3	45.6
Grapes	36.9	48.4
Alfalfa	35.9	47.0

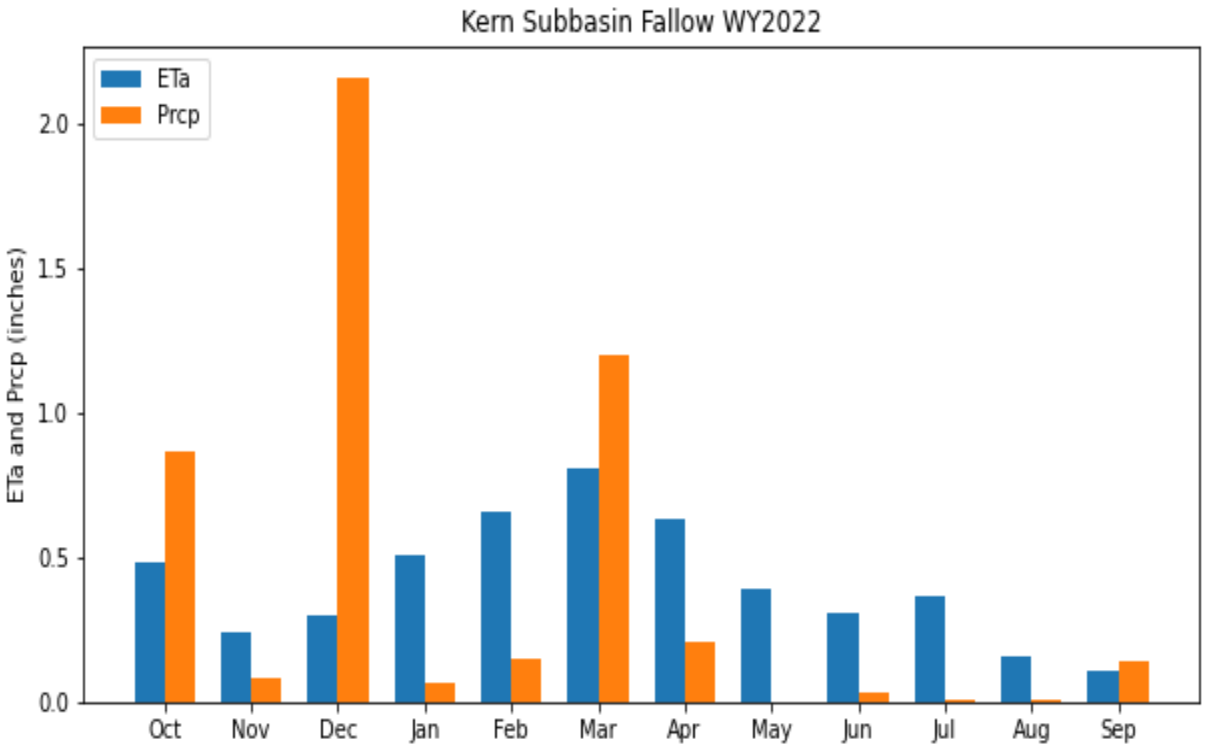
Kern Subbasin – Average Irrigated Crop ET

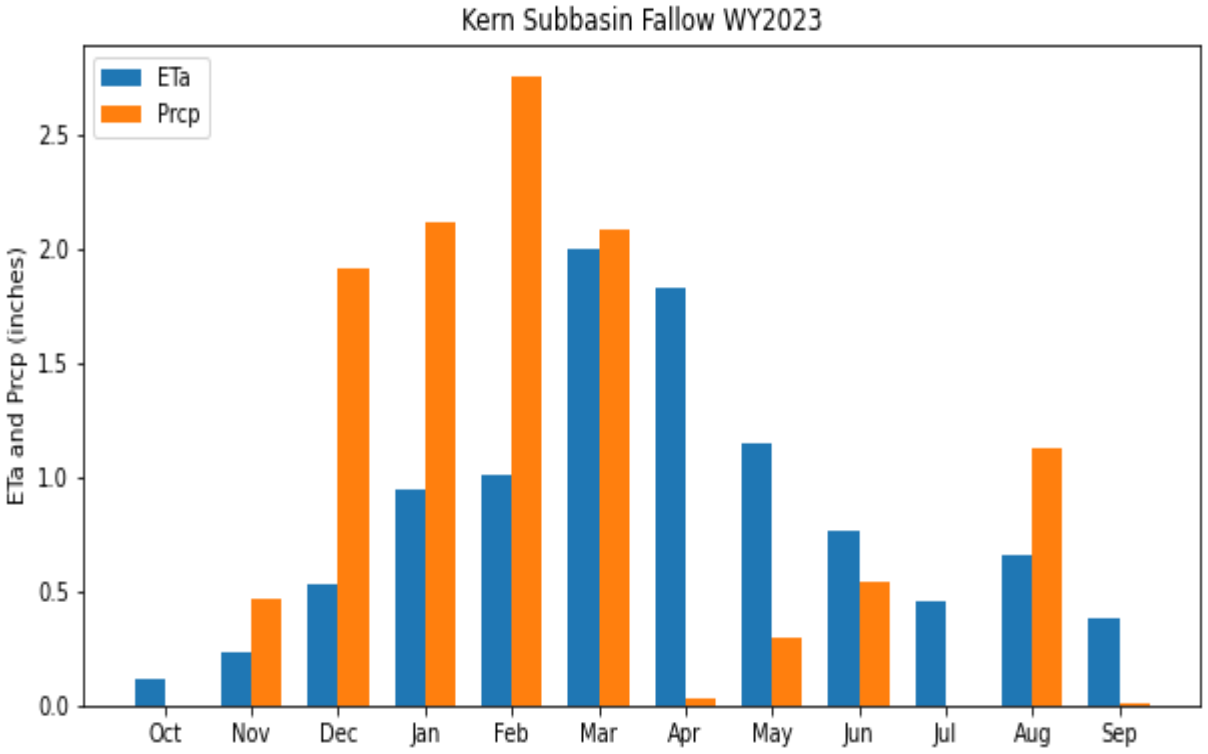
Non-Irrigated Fields Excluded
Includes ET from Irrigation and Precipitation

2022 ET: 34.5 in
2023 ET: 35.5 in



Kern Subbasin – Precipitation and ET Comparisons for Fallow Fields – WY 2022 and WY 2023

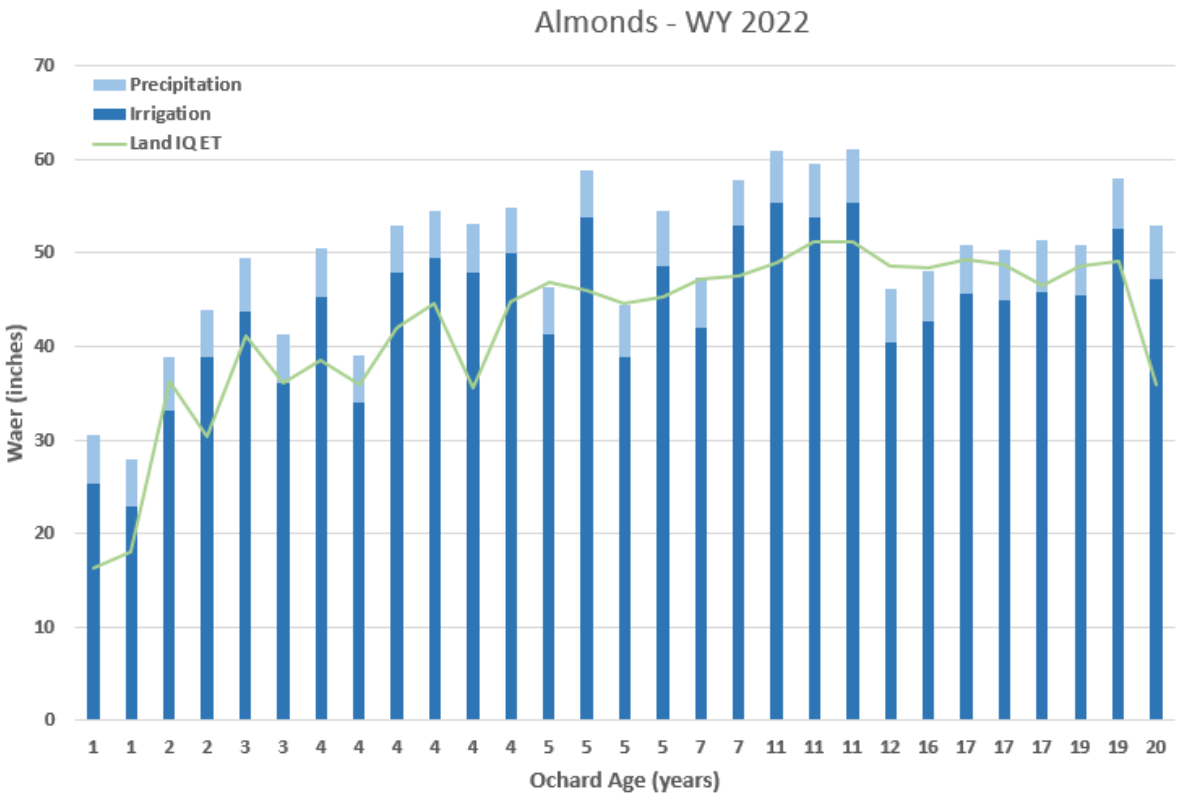


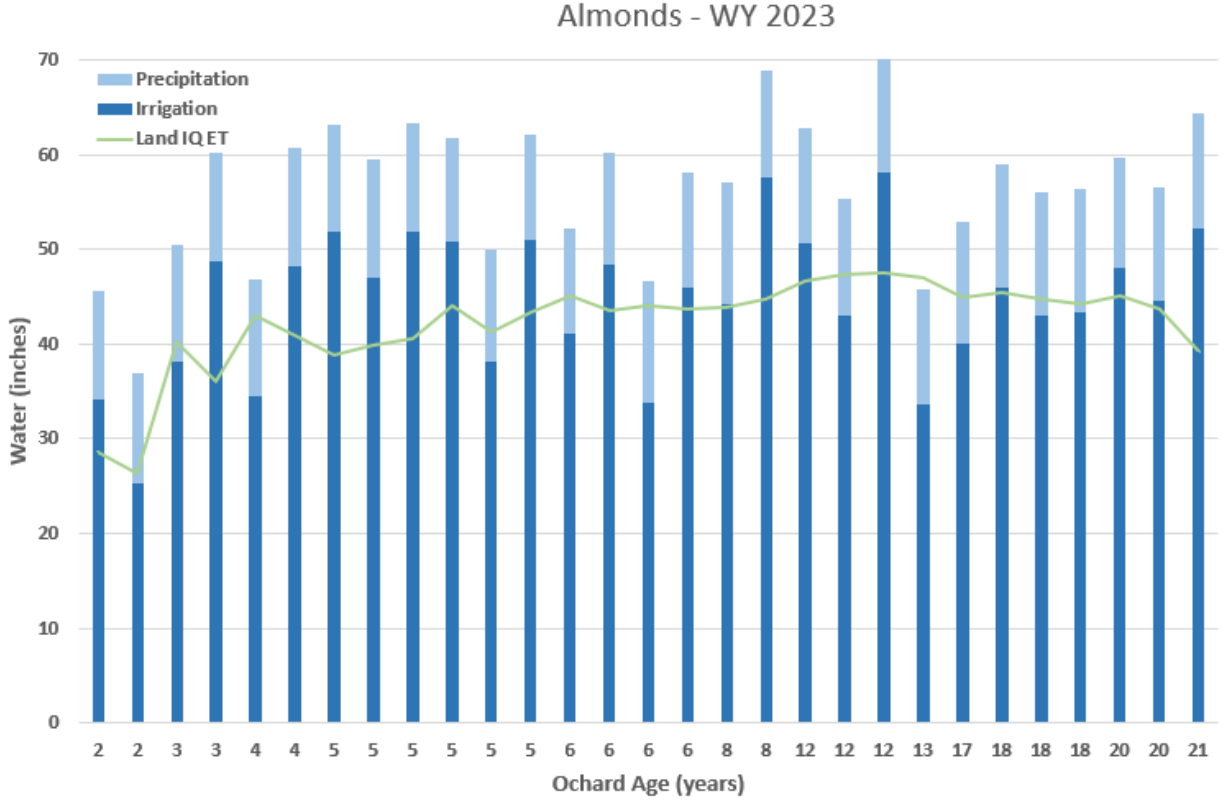


WY 2022 Precip: 4.9 inches
WY 2022 ET: 4.9 inches
~ 100% of Precip was ET

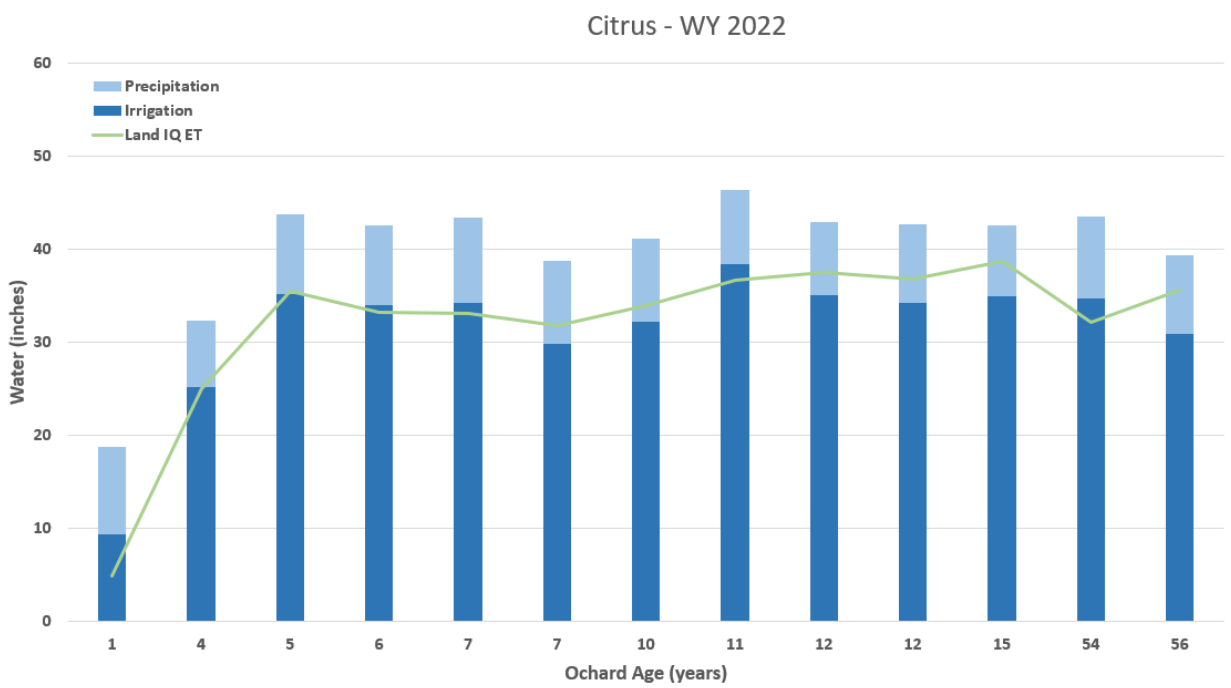
WY 2023 Precip: 11.3 inches
WY 2023 ET: 10.1 inches
~ 89% of Precip was ET

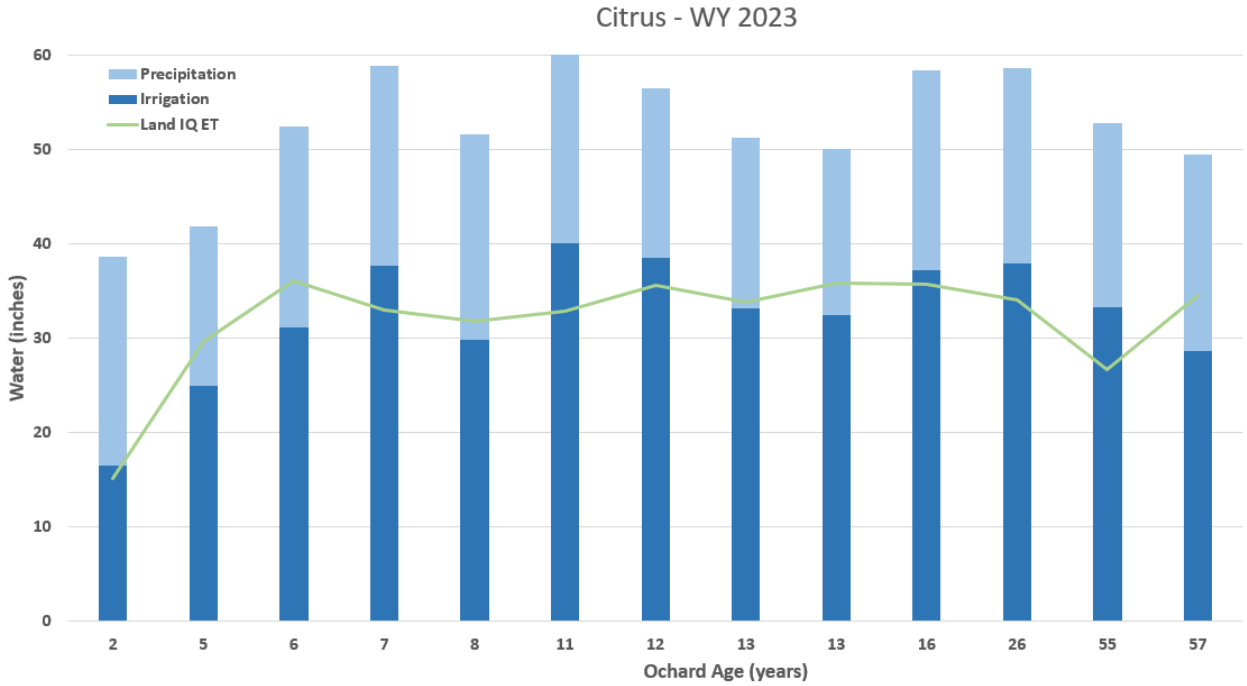
Water Received versus Consumed by Age - Almonds



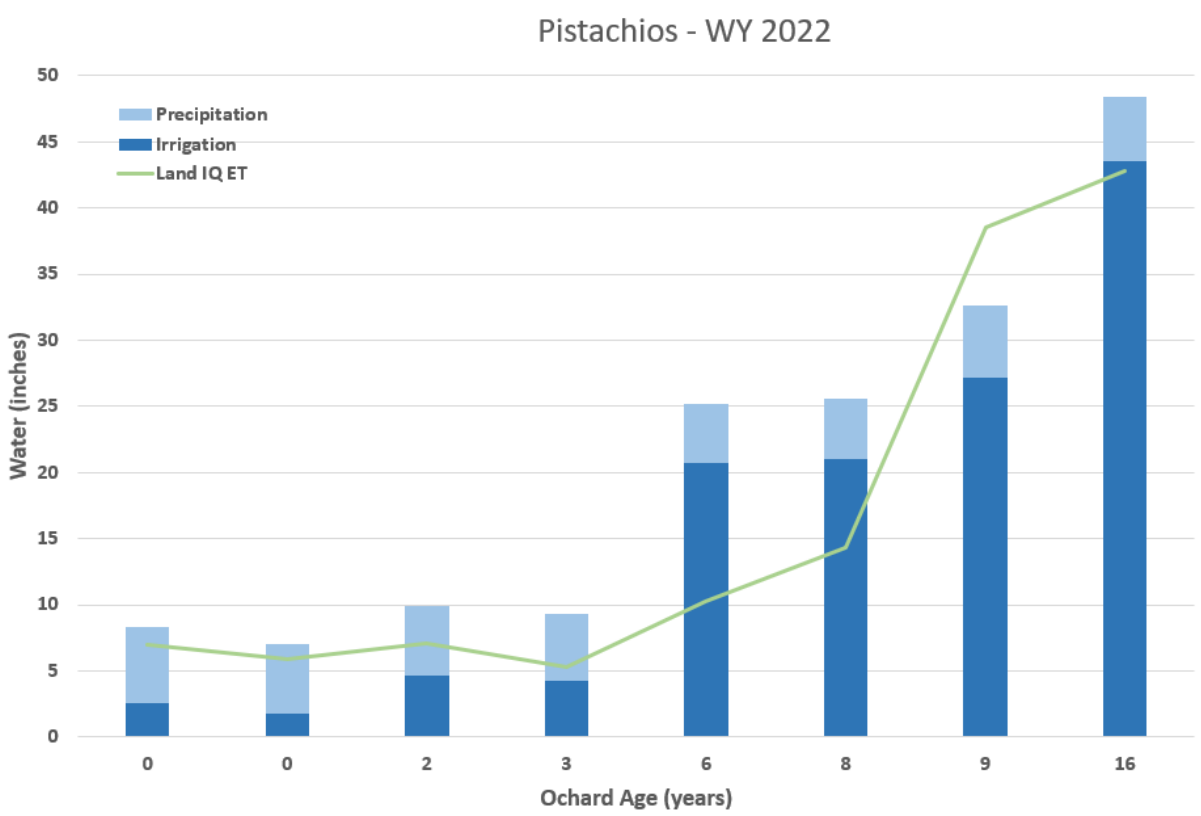


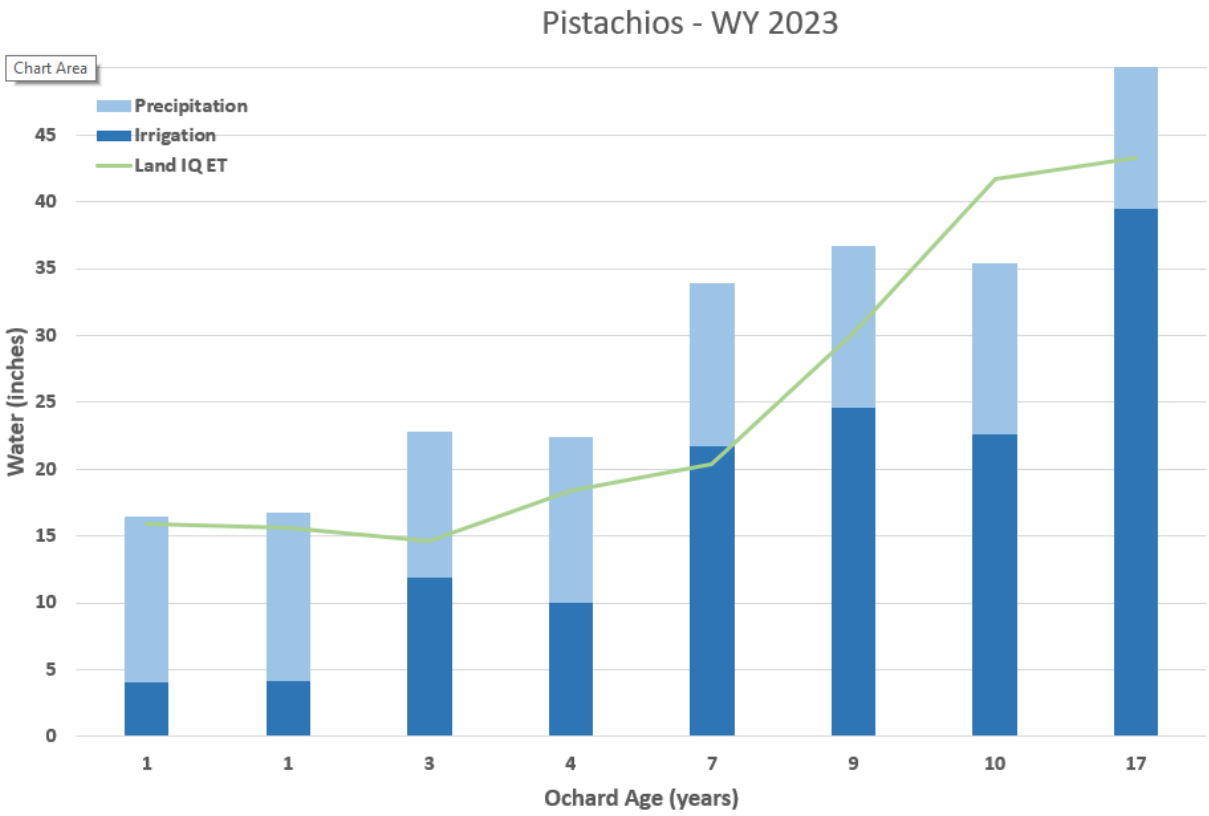
Water Received versus Consumed by Age - Citrus





Water Received versus Consumed by Age - Pistachios





Questions
jkimmelshue@landiq.com
916.517.2482

FIELD-BY-FIELD EVAPOTRANSPIRATION, CROP TYPE, AND PRECIPITATION – LAND IQ APPROACH AND RESULTS

LAND IQ

Questions and Discussion

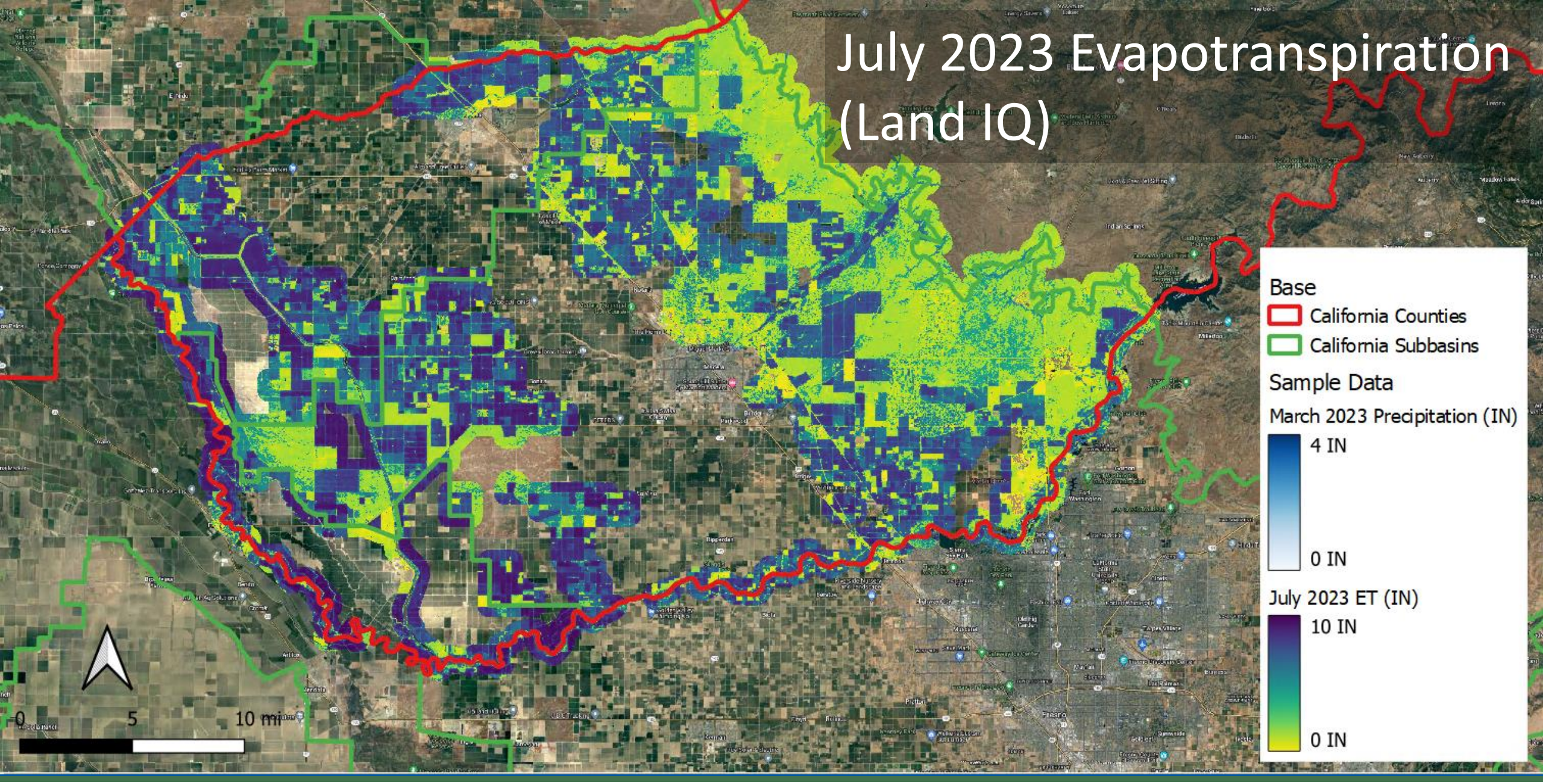
Land IQ ET and Precipitation

Outline

- Introduction (Stephanie - 15 min)
- Land IQ ET and Precipitation (Joel - 30 min)
- Processing Land IQ Data to Compute ETAW (Jeff - 15 min)
- Discussion (All - 60 min)

March 2023 Precipitation (Land IQ)

July 2023 Evapotranspiration (Land IQ)



Crop Mapping, Precipitation, Permanent Crop Age, and ET Developed by Land IQ.

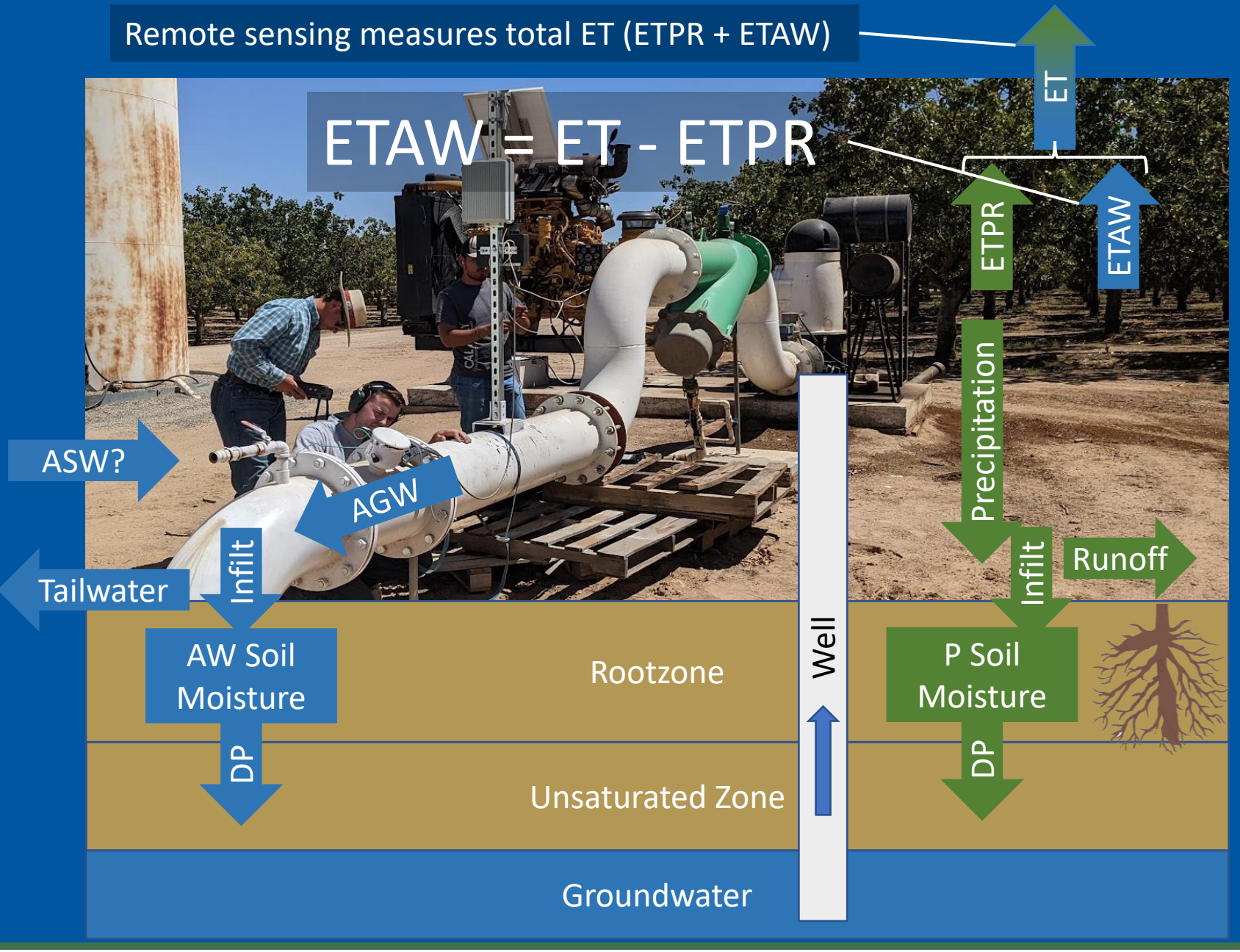
Processing Land IQ Data to Compute ETAW

- Effective precipitation (PEFF) - amount of precipitation that is available for ET from a given month
- Total effective precipitation (TPEFF) - running total amount of precipitation that is available for ET
- Evapotranspiration of Precipitation (ETPR) - ET from precipitation (not applied water)
- Evapotranspiration of Applied Water (ETAW) - ET from applied water (not from precipitation)

Conceptual Soil Water Budget

Notes
- Green arrows/boxes are precipitation related
- Blue arrows/boxes are applied groundwater related

Legend
- AGW = Applied groundwater
- ASW = Applied surface water
- DP = Deep percolation
- ET = Total Evapotranspiration
- ETAW = ET from Applied Water
- ETPR = ET from Precipitation
- Infilt = Infiltration
- DP = Deep Percolation



Crop Mapping, Precipitation, Permanent Crop Age, and ET Developed by Land IQ.

Effective Precipitation (PEFF)

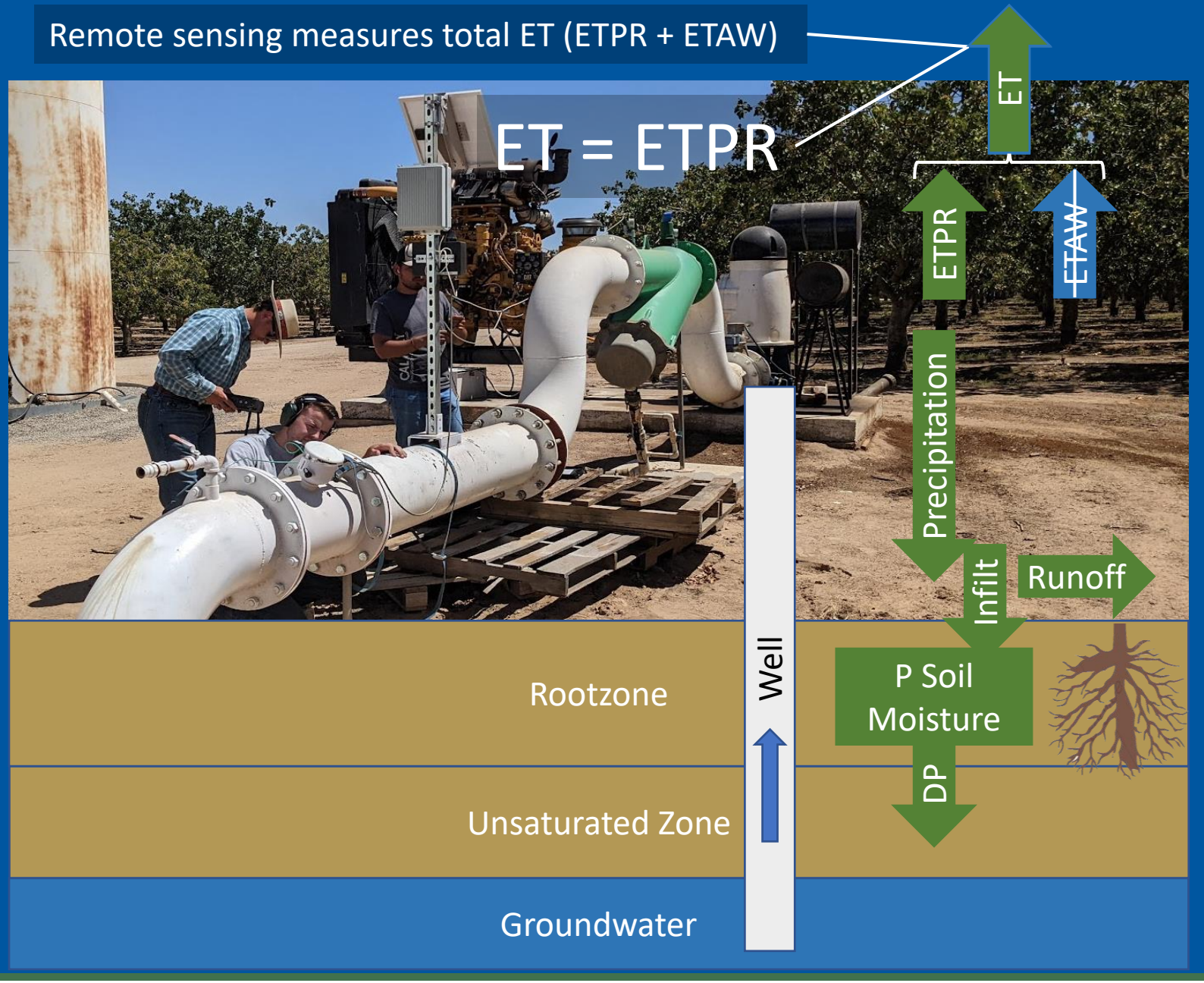
- Effective precipitation method originally proposed by the United States Bureau of Reclamation (USBR) in 1967 (USBR method)
- Initially refined/localized to match modeling results from GSP preparation
- Further refined/localized based on actual observations of ET from fallowed fields (*i.e.,* fields with no applied water)

Monthly Precipitation Increment (in)	Effective Precipitation (%)
0.0 - 0.5	95
0.5 - 1.0	85
1.0 - 1.5	75
1.5 - 2.0	70
2.0 - 2.5	65
2.5 - 3.0	60
> 3.0	50

Fallow Fields Water Budget

Notes
- Green arrows/boxes are precipitation related
- Blue arrows/boxes are applied groundwater related

Legend
- AGW = Applied groundwater
- ASW = Applied surface water
- DP = Deep percolation
- ET = Total Evapotranspiration
- ETAW = ET from Applied Water
- ETPR = ET from Precipitation
- Infilt = Infiltration
- DP = Deep Percolation



USBR PEFF Example

- Example: Calculate effective precipitation (PEFF), for May with 2.3 IN of precipitation.
- Result: For May, effective precipitation (PEFF) was 1.8 IN or 78% of precipitation (2.3 IN)

(1) Precipitation Increment (IN)	(2) Standard Average Effectiveness (%)	(3) Precipitation (P) within Increment (IN)	(4) Effective Precipitation (PEFF) within Increment (IN)
0.0 - 0.5	95	0.5	0.5 * 0.95 = 0.48
0.5 - 1.0	85	0.5	0.5 * 0.85 = 0.43
1.0 - 1.5	75	0.5	0.5 * 0.75 = 0.38
1.5 - 2.0	70	0.5	0.5 * 0.70 = 0.35
2.0 - 2.5	65	0.3	0.3 * 0.65 = 0.20
2.5 - 3.0	60	0.0	0.0 * 0.60 = 0
Greater than 3.0	50	0.0	0.0 * 0.50 = 0
	Totals ->	0.5 + 0.5 + 0.5 + 0.5 + 0.3 = **2.3**	0.48 + 0.43 + 0.38 + 0.35 + 0.20 = **1.8**

Summary of Effective Precipitation (PEFF)

Water Year	Water Year Type	Average Precipitation (IN)	Average Effective Precipitation (IN)	Percent of Precipitation
2021 *	Critical	7.2	5.7	79%
2022 *	Critical	6.6	5.2	79%
2023	Wet	17.4	11.9	68%
2024 **	Below Normal***	4.3	3.5	81%

Notes:

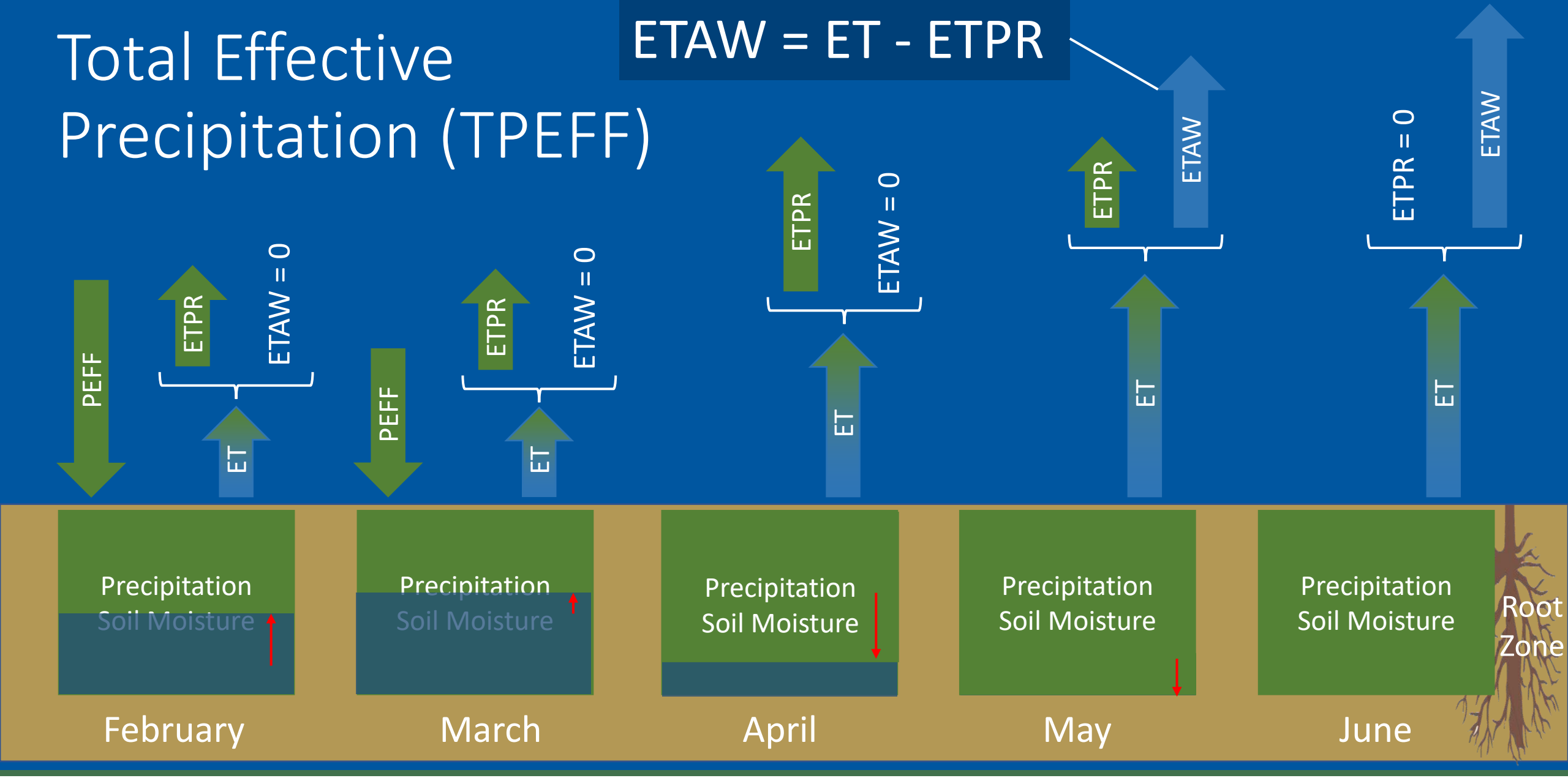
* Uses PRISM Data

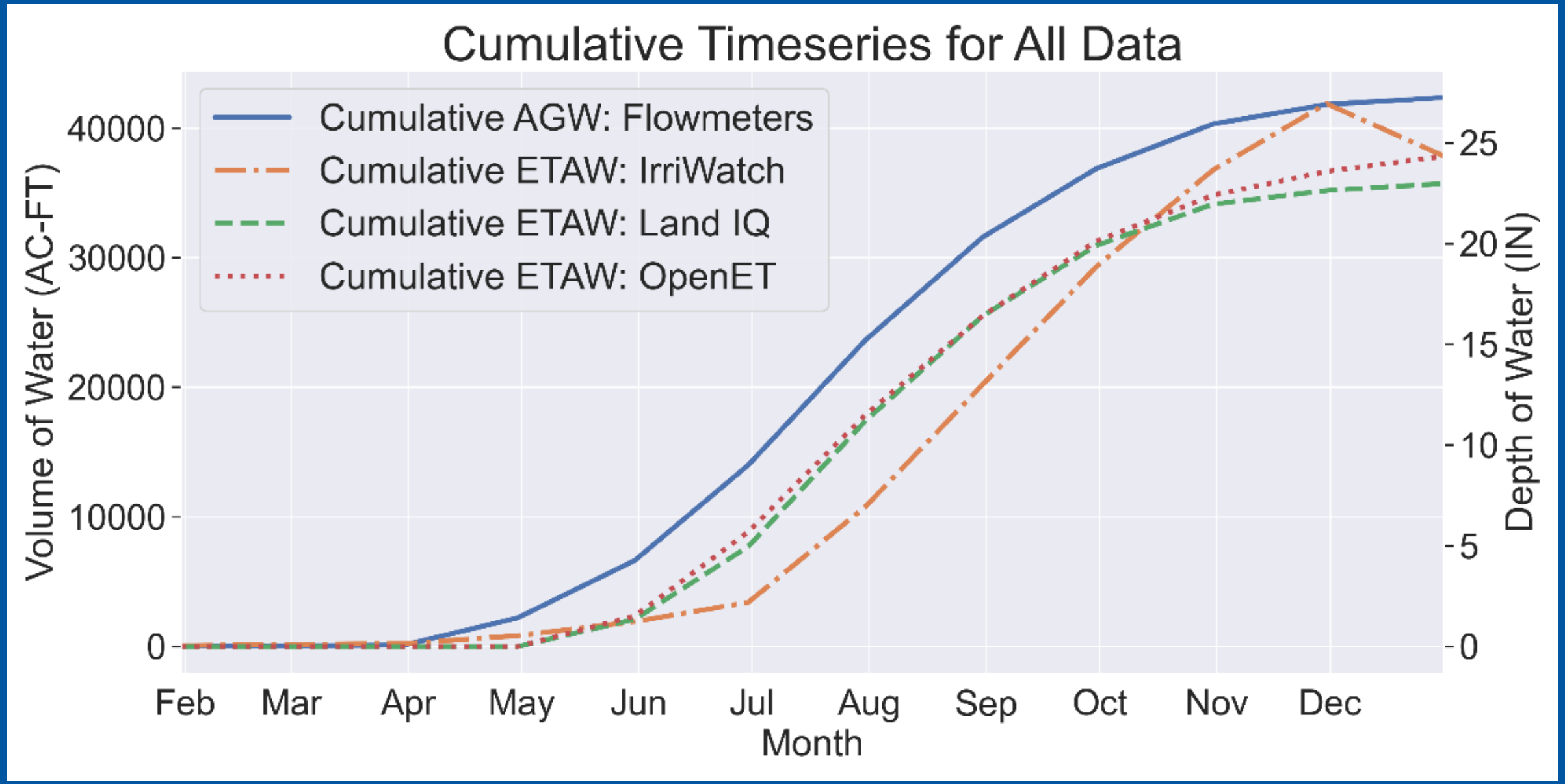
** Data up to end of January 2024

*** Based on Current and Projected Precipitation Trends for WY 2024

Total Effective Precipitation (TPEFF)

ETAW = ET - ETPR

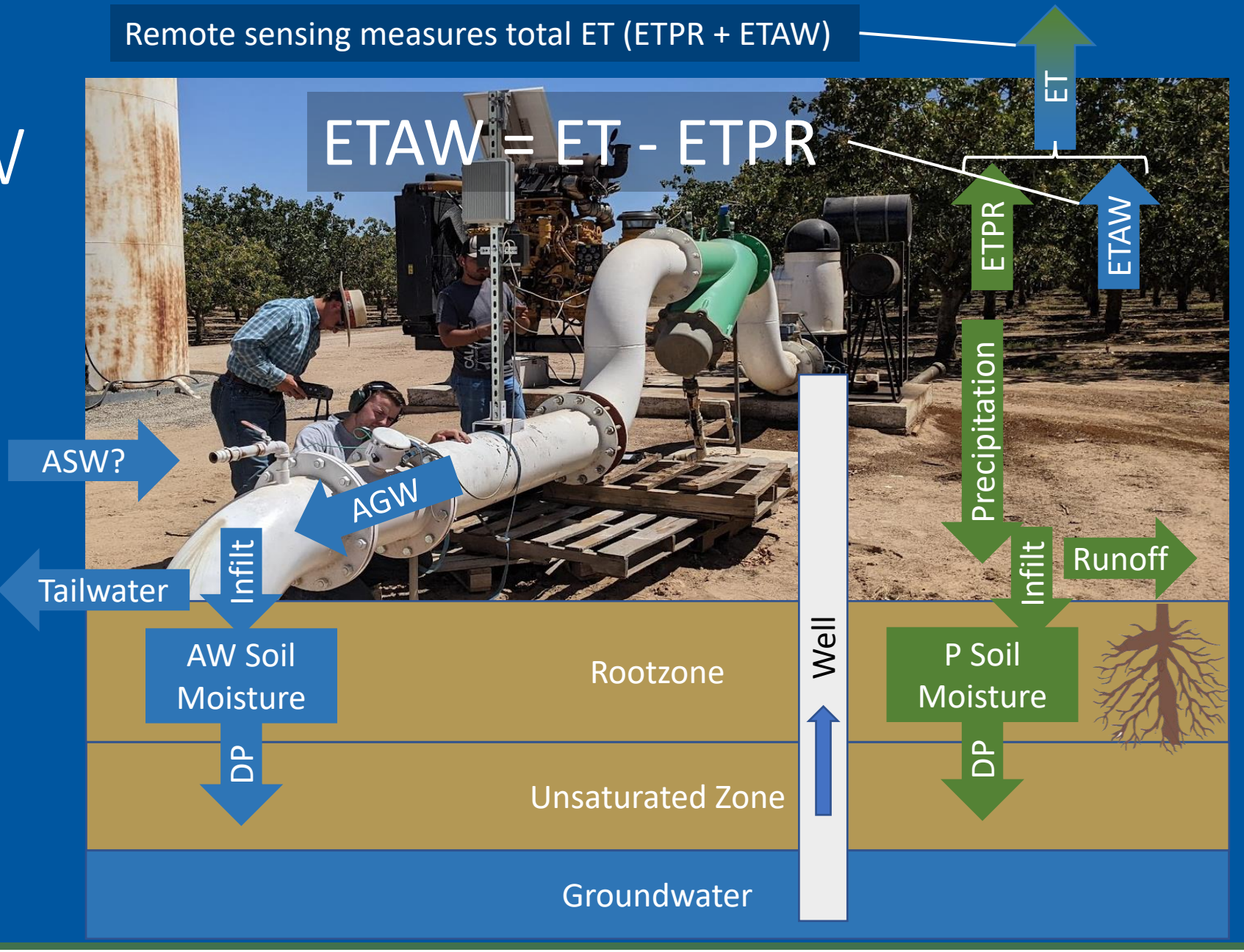




Crop Mapping, Precipitation, Permanent Crop Age, and ET Developed by Land IQ.

Summary of Computing ETAW

- Use precipitation data to compute effective precipitation (PEFF)
- Add to cumulative tracking of total effective precipitation (TPEFF)
- See how much ET should come from precipitation (ETPR)
- If there isn't enough TPEFF to supply all ET, the remainder of ET must come from applied water (ETAW)



Questions and Discussion

Processing Land IQ Data to Compute ETAW

Additional Slides

Sample Allocation Report

- Land IQ allocation report summarizes account details by farm unit
- Total Allocation = 2023 Allocation + Carryover + 2023 Adjustments
- ETAW = ET - ETPR
- If Remaining is positive, the Farm Unit has Carryover for the next year
- If Remaining is negative, the Farm Unit is in Penalty and has zero Carryover for the next year

Master Account Summary

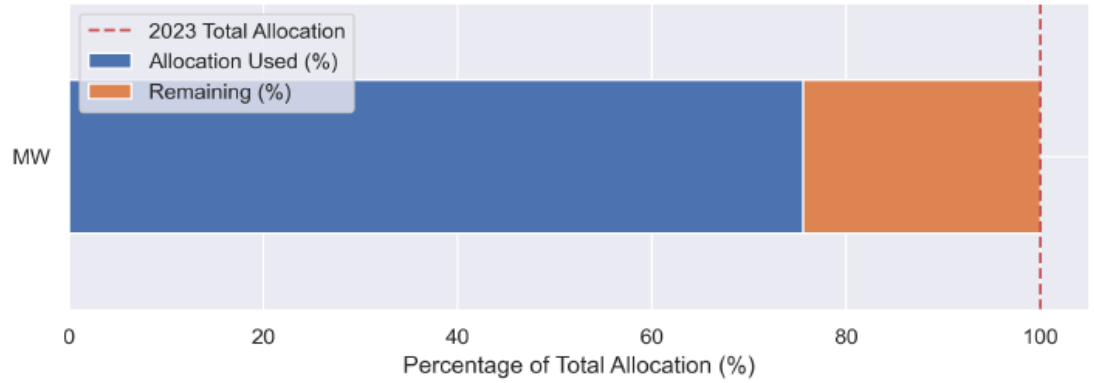
Note: For additional information about Master Account information, contact the Madera County Water and Natural Resources Department Office at (559) 662-8015 or WNR@maderacounty.com for information.

Description	Value
Master Account ID:	[redacted]
Master Account Name:	[redacted]
Mailing Address:	[redacted]
Start Date (YYYY-MM-DD):	2023-01-01
End Date (YYYY-MM-DD):	2023-12-31
Measurement Method:	Land IQ

Farm Unit Summary

Note: For additional information about Allocations, ETAW, Remaining Allocation, and Carryover Water, contact the Madera County Water and Natural Resources Department Office at (559) 662-8015 or WNR@maderacounty.com for information. Total Allocation (AF) is equal to the sum of 2023 Allocation (AF), Carryover (AF), and 2023 Adjustment(s) (AF).

Farm Unit	Assessed Acreage (AC)	Irrigated Acreage (AC)	2023 Allocation (AF)	Carryover (AF)	2023 Adjustment (s) (AF)	Total Allocation (AF)	ETAW (AF)	Remaining (AF)	Remaining (%)
[redacted]	252.3	233.0	582.5	115.3	0.0	697.8	527.8	169.9	24.4



Sample Allocation Report (Parcel Summary)

Farm Unit Parcel Summary

Note: For additional information about Allocations, ETAW, Remaining Allocation, and Carryover Water, contact the Madera County Water and Natural Resources Department Office at (559) 662-8015 or WNR@maderacounty.com for information. Total Allocation (AF) is equal to the sum of 2023 Allocation (AF), Carryover (AF), and 2023 Adjustment(s) (AF).

Parcel	Assessed Acreage (AC)	Irrigated Acreage (AC)	2023 Allocation (AF)	Carryover (AF)	2023 Adjustment (s) (AF)	Total Allocation (AF)	ETAW (AF)	Remaining (AF)	Remaining (%)
[redacted]	15.7	15.7	36.2	0.0	0.0	36.2	64.9	-28.7	-79.4
[redacted]	96.6	77.3	223.1	50.3	0.0	273.4	173.7	99.6	36.4
[redacted]	100.0	100.0	230.9	65.1	0.0	295.9	170.2	125.7	42.5
[redacted]	40.0	40.0	92.3	0.0	0.0	92.3	119.0	-26.6	-28.8

Allocation Report (Parcel Details)

- Additional allocation reports with details at the parcel-level are available upon request
- Summarizes parcel details and computation of allocation, adjustments, ETAW, and remaining

Groundwater Allocation Information

Note: The following information is based on the Madera Joint GSP and Madera County Board of Supervisors resolutions. Contact the Madera County Water and Natural Resources Department Office at (559) 662-8015 or WNR@maderacounty.com for information. If the parcel is opting into the allocation program with new irrigation, the Sustainable Yield Acreage Basis is equal to the Irrigated Acreage. Allocation values expressed as depths (i.e., IN or FT) use total Parcel Acreage.

Sustainable Yield Acreage Basis: 40.0 AC
Base Sustainable Yield (B-SY): 6.0 IN
Reallocated Sustainable Yield (Re-SY): 6.7 IN
Sustainable Yield (SY): 6.0 IN + 6.7 IN = 12.7 IN
Sustainable Yield (SY): (12.7 IN / 12) * 40.0 AC = 42.3 AF
Irrigated Ratio: (40.0 AC / 40.0 AC) * 100 % = 100.0 %
CAFO Acreage: 0.0 AC

Note: If Irrigated Ratio is less than 80 %, then Transitional Water Allocation is based on Irrigated Acreage; otherwise, the full Parcel Acreage is used. If CAFO Acres are present, then the Transitional Water Acreage Basis will be the sum of CAFO Acreage and Irrigated Acreage, not to exceed total Parcel Acreage.

Transitional Water Acreage Basis: 40.0 AC
Transitional Water (TW): 15.0 IN

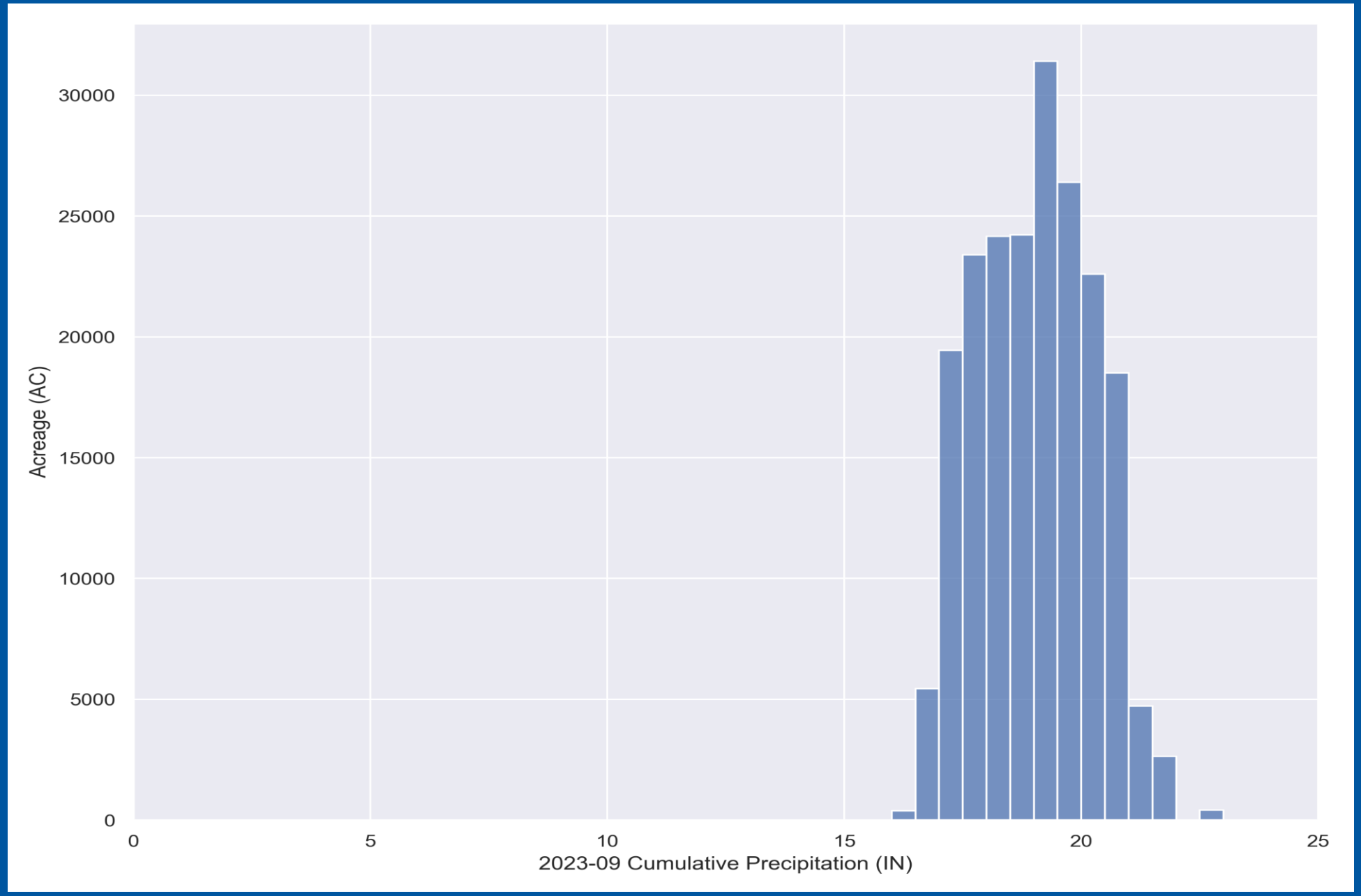
December 2023 Parcel Groundwater Allocation Report - Page 1 / 4

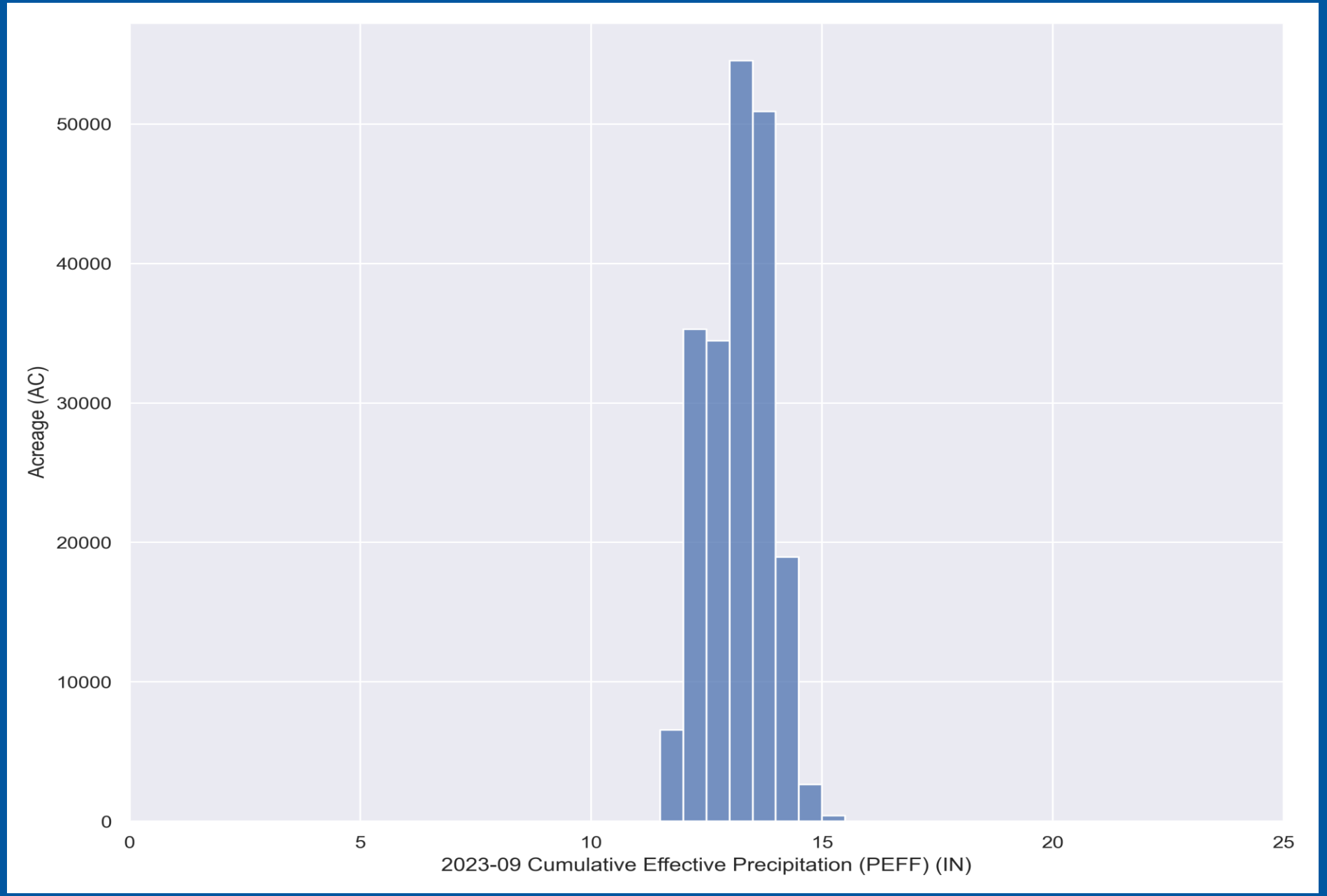
LAND IQ
Crop Mapping, Precipitation, Permanent Crop Age, and ET Developed by Land IQ.

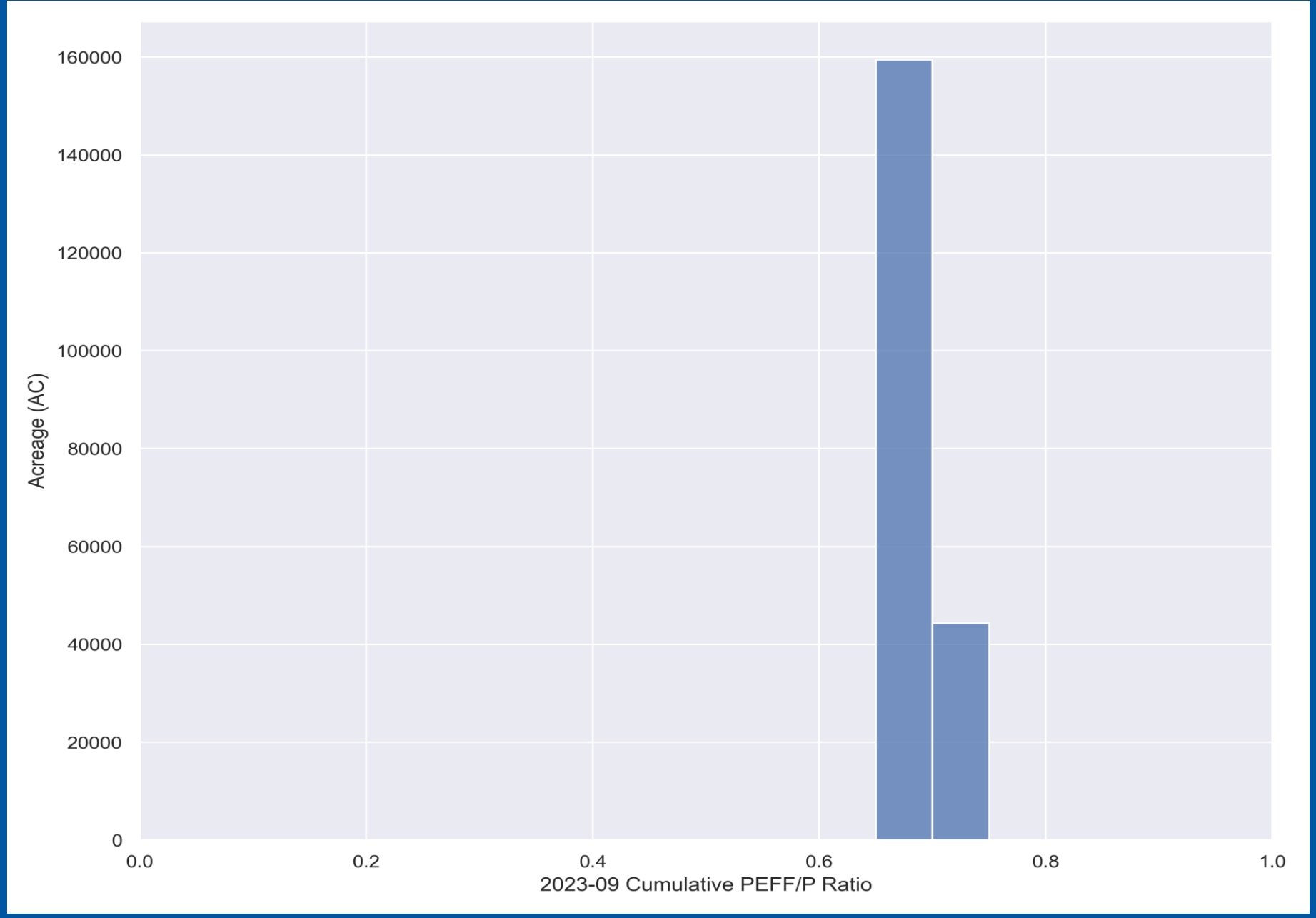
December 2023 Parcel Groundwater Allocation Report

MADERA COUNTY

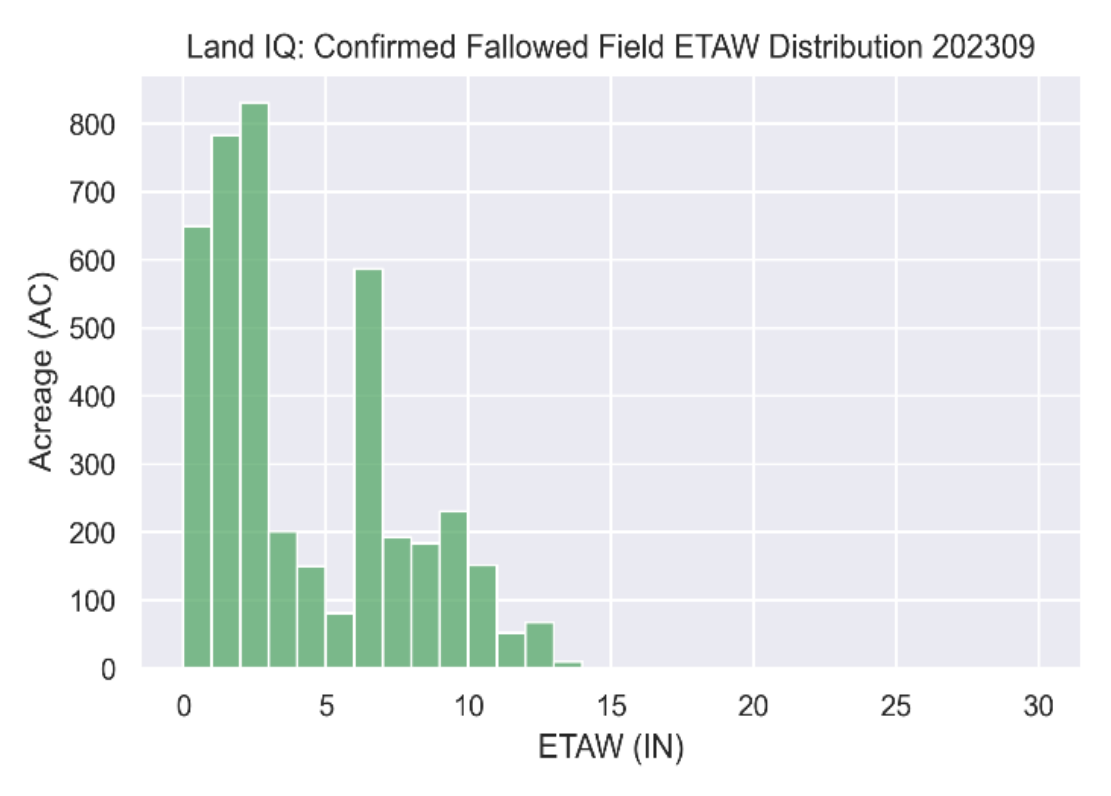
Transitional Water (TW): (15.0 IN / 12) * 40.0 AC = 50.0 AF
Carryover: 0.0 AF
2023 Allocation: 42.3 AF + 50.0 AF = 92.3 AF
Total Allocation (2023 Allocation + Carryover + 2023 Adjustment(s)): 92.3 AF + 0.0 AF + 0.0 AF = 92.3 AF

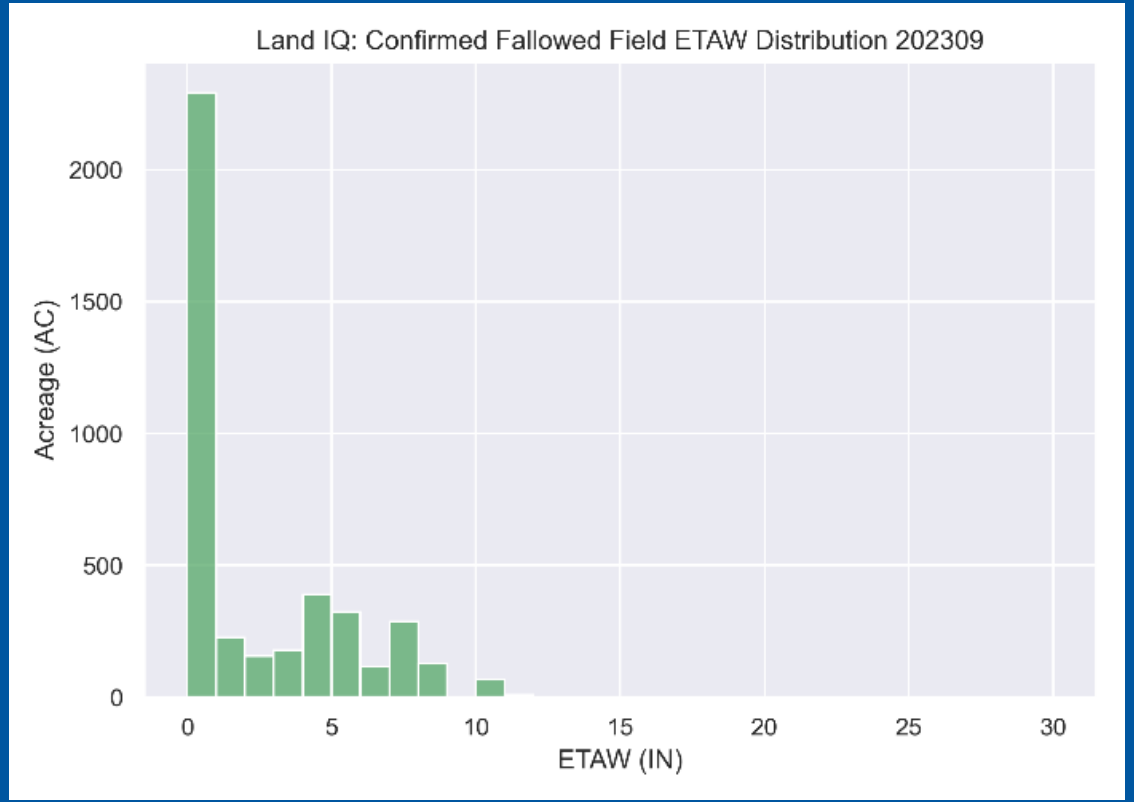

30000
25000
20000
15000
10000
5000
0
Acreage (AC)
0
5
10
15
20
25
2023-09 Cumulative Precipitation (IN)


Acreage (AC)
50000
40000
30000
20000
10000
0
0
5
10
15
20
25
2023-09 Cumulative Effective Precipitation (PEFF) (IN)


160000
140000
120000
100000
80000
60000
40000
20000
0
Acreage (AC)
0.0
0.2
0.4
0.6
0.8
1.0
2023-09 Cumulative PEFF/P Ratio

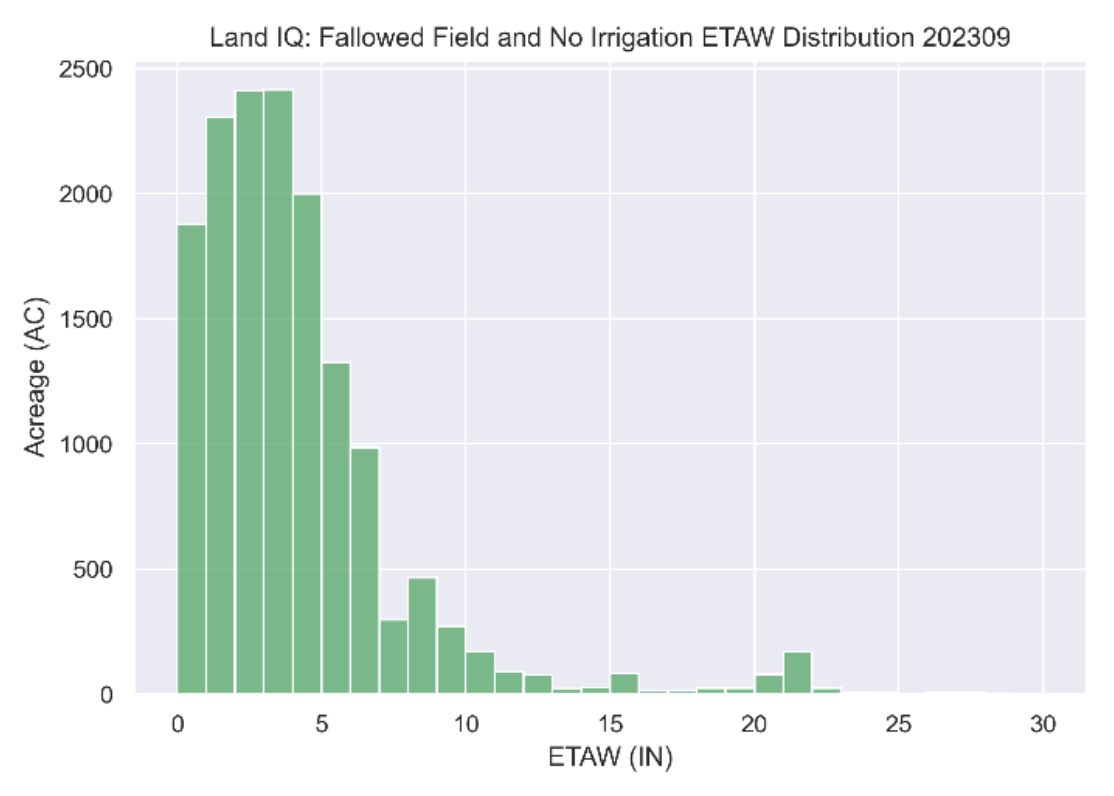
USBR Calibration of Confirmed Fallowed Fields

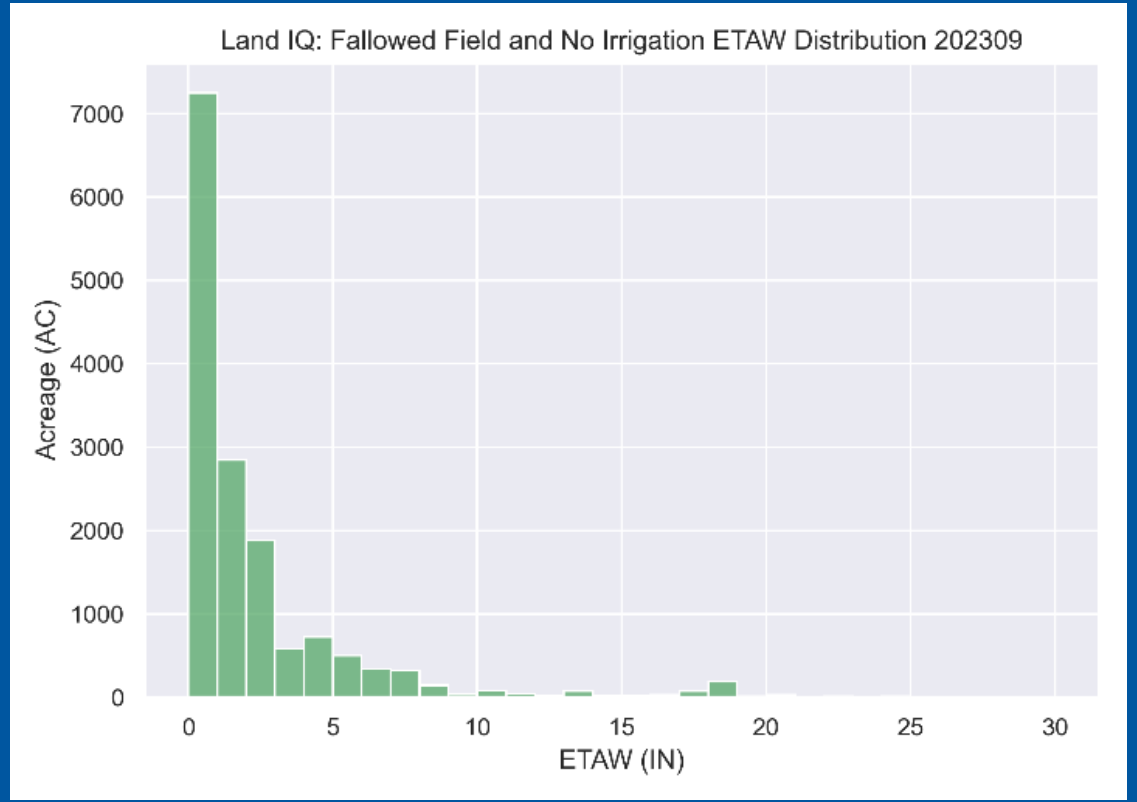




September 2023 Distribution of ETAW (IN) of DE Confirmed Fallowed Fields. The chart on the left portrays before re-calibration and the right portrays post re-calibration. It can clearly be seen that after recalibration more fallowed fields have zero ETAW, which in an ideal world is how it should be.

USBR Calibration of Fallowed Fields





September 2023 Distribution of ETAW (IN) of Fields that are either set to Fallow or have an irrigation type of No Irrigation in the Allocation Database. The chart on the left portrays before re-calibration and the right portrays post re-calibration.. It can clearly be seen that after recalibration more Fallowed or No Irrigation fields have zero ETAW, which in an ideal world is how it should be.