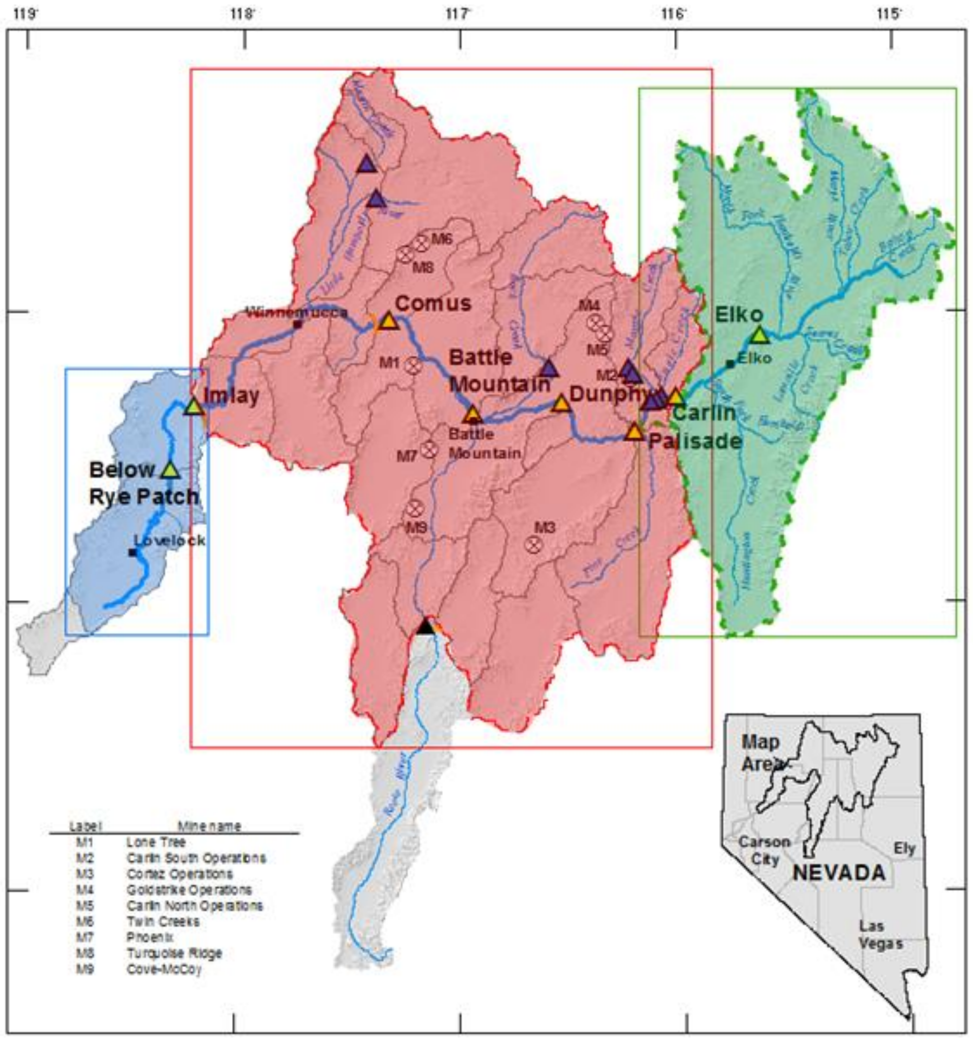
USGS science for a changing world

DRI Desert Research Institute

NEVADA DIVISION OF WATER RESOURCES

Nevada Department of CONSERVATION & NATURAL RESOURCES



Humboldt River Region Water Resources update

Humboldt River Basin Stakeholder update

March 8, 2022, Lovelock and Winnemucca
March 9, 2022, Elko NV

NDWR, USGS, DRI

Humboldt River Region Water Resources Update - Outline

- Intro and other NDWR updates (**Adam Sullivan**, State Engineer)
- Water supply update and forecast (**Levi Kryder**, Chief of Hydrology, NDWR)
- Capture 101 and Capture Study overview (**Kip Allander**, Hydrogeologist, NDWR)
- Model results and Tools (USGS and DRI)
  - Regionwide ET Analysis (**Justin Huntington**, Research Professor, DRI)
  - Upper Basin Model (**Rosemary Carroll**, Assoc. Research Professor, DRI)
  - Middle Basin Model (**Kyle Davis & William Eldridge**, Hydrologists, USGS)
  - Lower Basin Model (**Cara Nadler**, Hydrologist, USGS; **Susan Rybarski**, Asst. Research Scientist, DRI)
- Break (10 mins)
- Order 1329 overview (**Jon Benedict**, Hydrogeologist, NDWR)
- Moving forward with Conjunctive Management Framework (**Adam Sullivan**, SE)
- Q & A

INTRO AND OTHER NDWR UPDATES

NDWR

The "Watermaster" is Retiring

The Watermaster: Commissioner watches over the Humboldt River

Flooding allows everyone to get the precious water they need

By Forrest Newton
The Humboldt Sun

WINNEMUCCA — All that water running down the Humboldt River is not available to just anybody that wants it and has not been since 1939, because it already belongs to somebody.

"Basically there isn't any other water for appropriation," Humboldt Water Distribution District Water Commissioner Steve Del Soldato said.

From Battle Mountain to Rye Patch Reservoir, he watches over the flow of water and does his best to make sure those who are allocated the water actually get it — if it is available.

"There's been years where some of these ranches don't get irrigated at all," he said.

Additionally, Del Soldato's area ranges from Quinn River to Paradise to Kingston Creek.

The Pershing County Water Conservation District takes over at Rye Patch.

The Sixth District Court oversees the entire Humboldt

FORREST NEWTON • The Humboldt Sun

Humboldt Water Distribution District Water Commissioner Steve Del Soldato holds a top setting wading rod with an attached current meter used to measure depth and velocity of a stream or river.

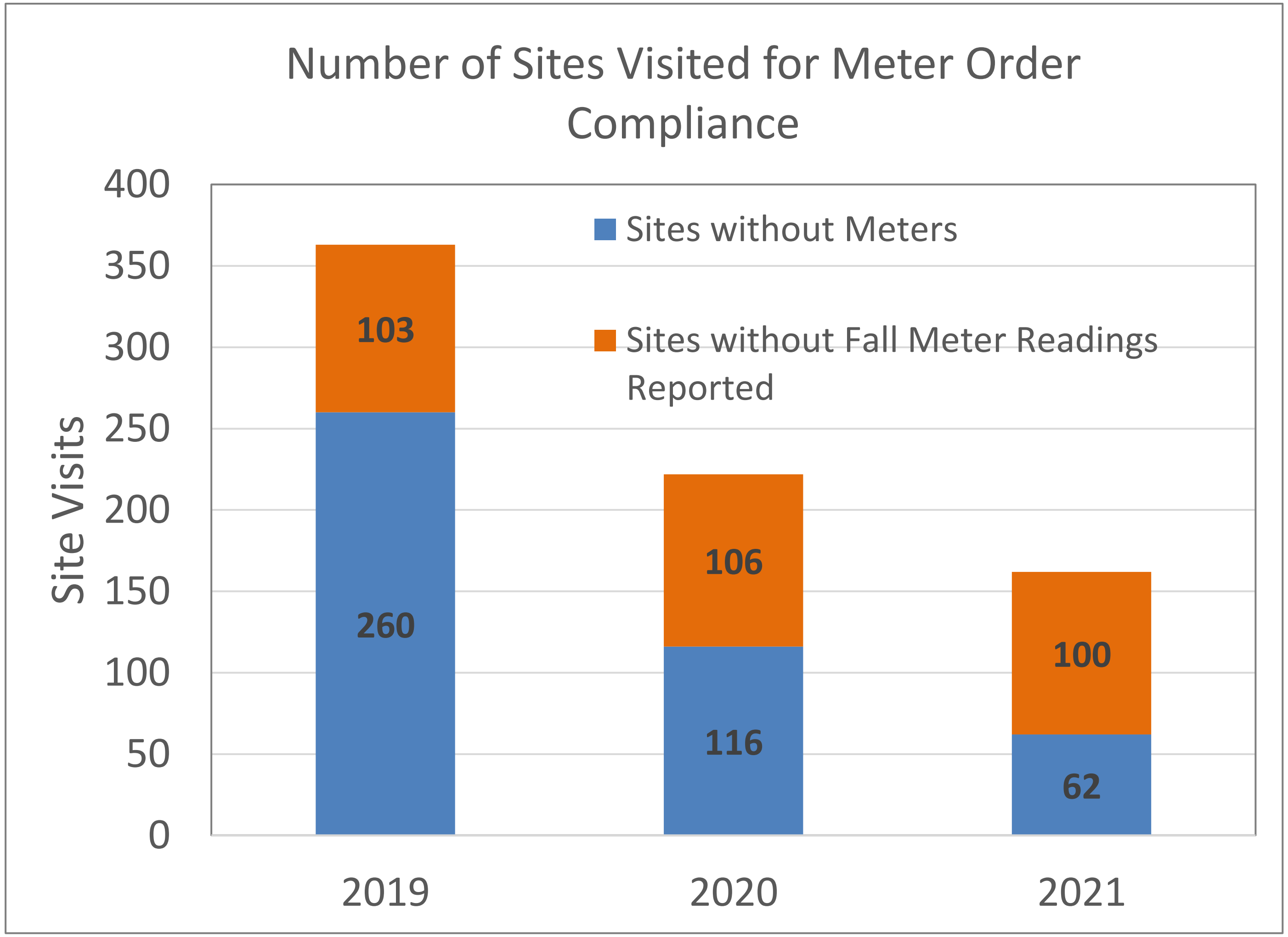
Steve Del Soldato is retiring March 29th

Winnemucca District water commissioner 1992 – 2022

Colton Brunson will be filling his waders

IMPROVEMENTS IN GROUNDWATER PUMPING DATA

Meter order 1251:
>95% self-reporting



2022: Repairs at South Fork Dam

PUBLIC NOTICE OF RECENT WELL DRILLING SCAMS

Property owners are encouraged to take these steps to ensure they are working with a licensed driller:

- Check the NDWR website to make sure the well driller has an active license
- Contact NDWR to confirm the well driller has submitted notification and received approval to drill

Water Supply Update and Forecast

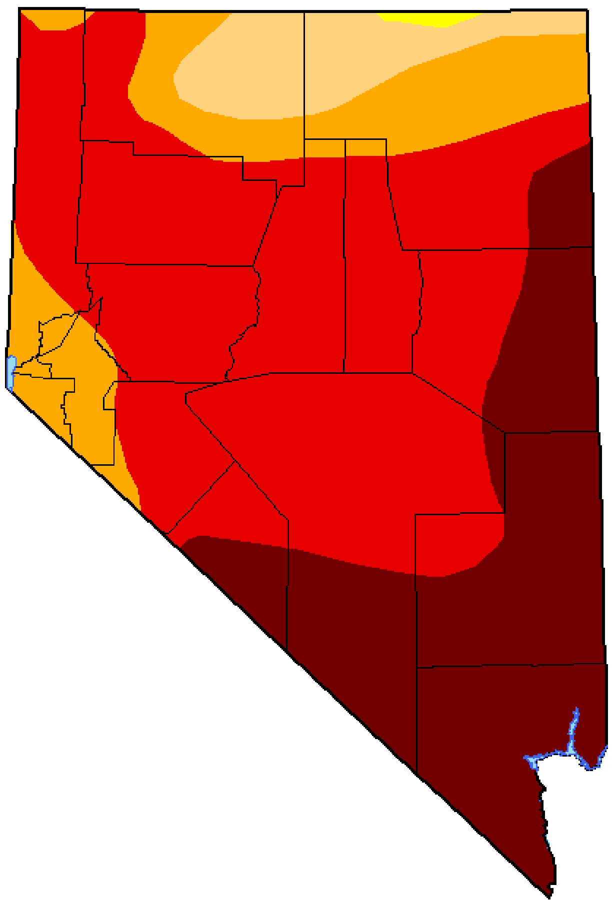
NDWR

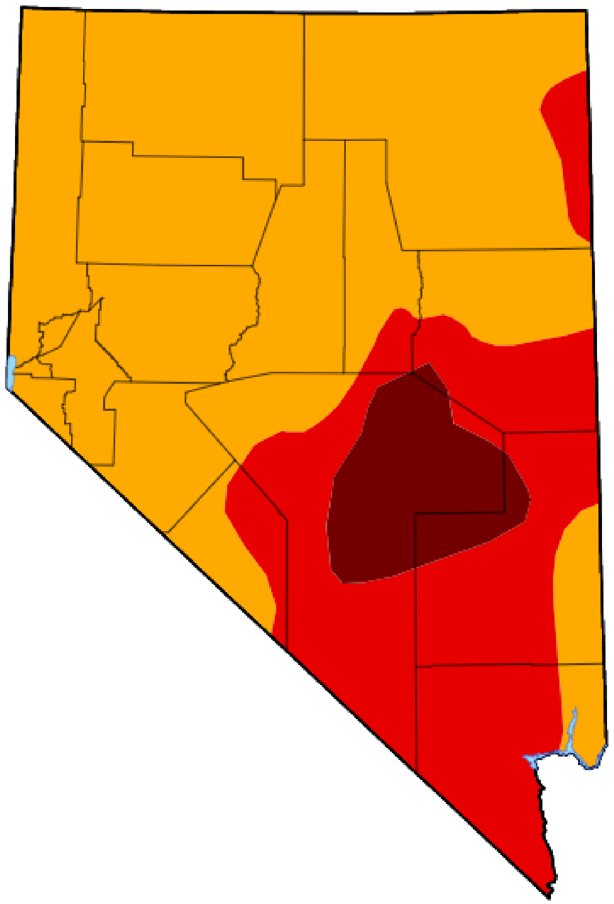
January 26, 2021

March 3, 2022

U.S. Drought Monitor

Nevada





Map released: Thurs. March 3, 2022

Data valid: March 1, 2022 at 7 a.m. EST

Intensity

- None
- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)
- No Data

Authors

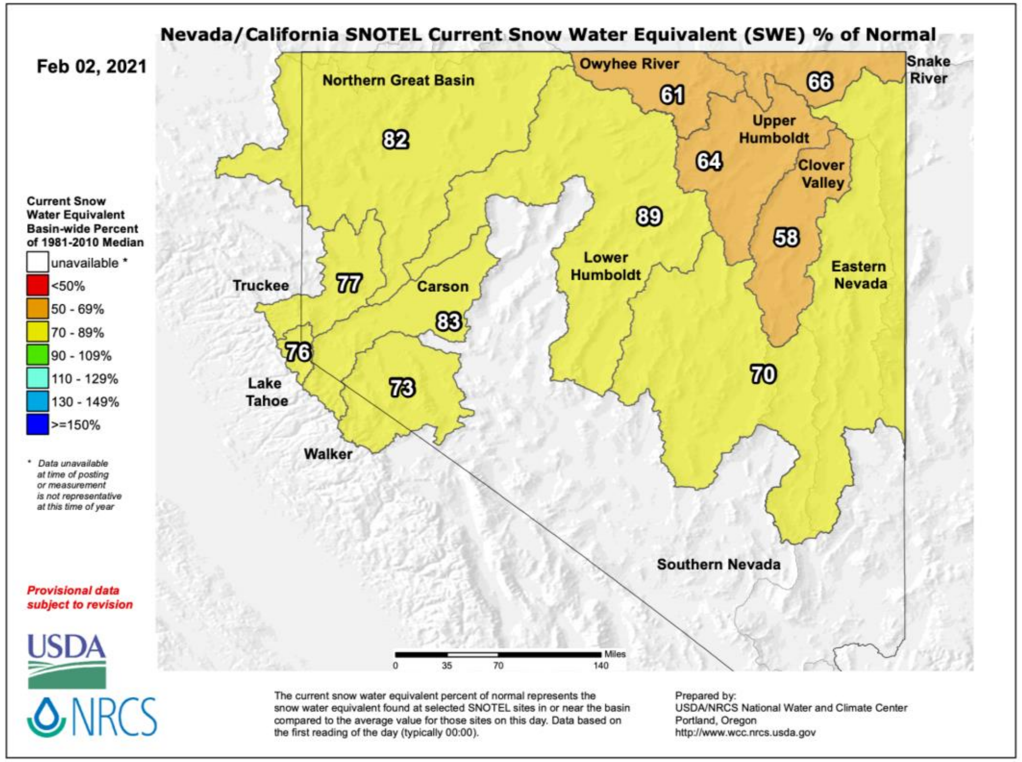
United States and Puerto Rico Author(s):
Brad Rippey, U.S. Department of Agriculture

Pacific Islands and Virgin Islands Author(s):
Ahira Sanchez-Lugo, NOAA/NCEI

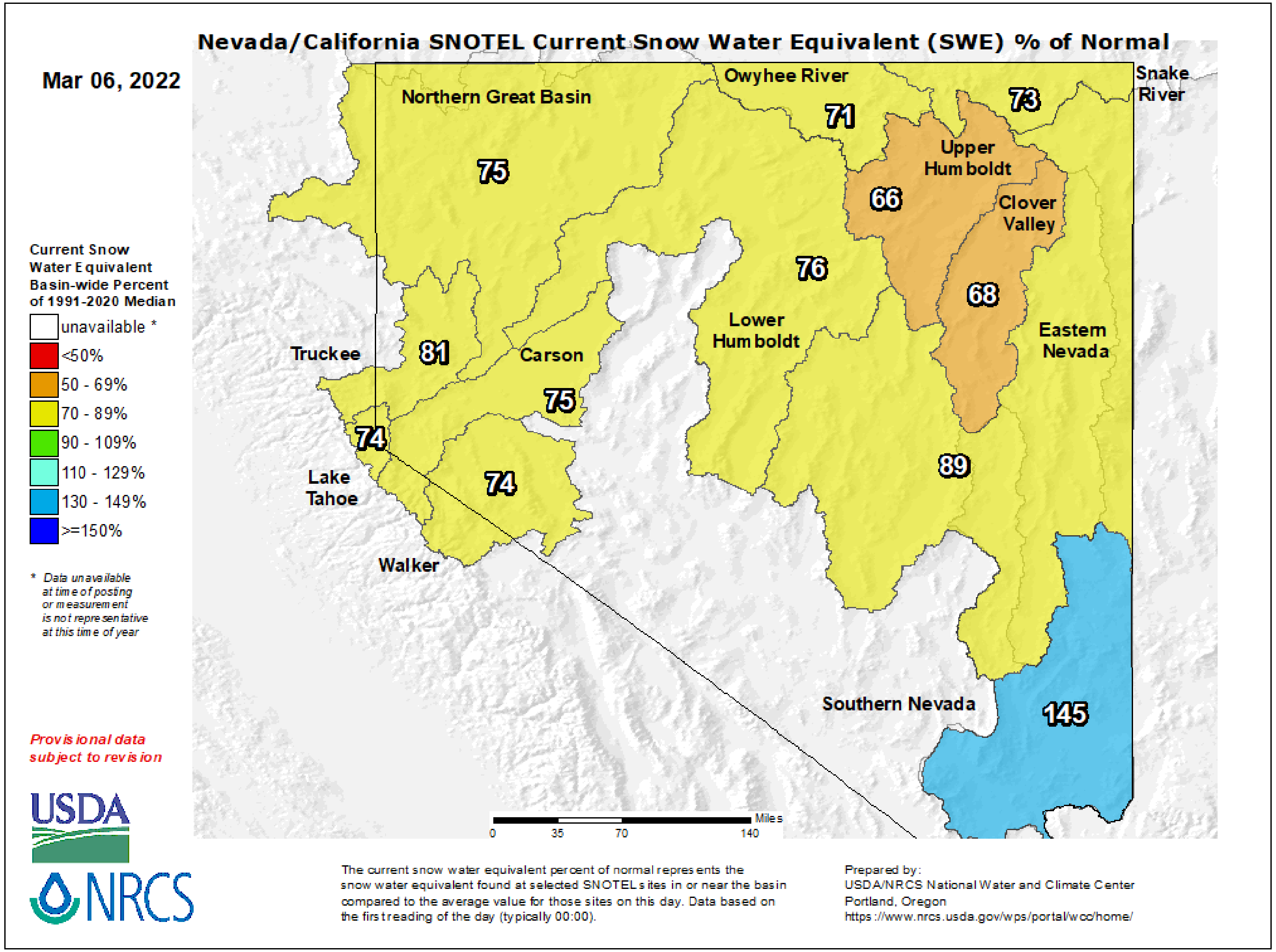
The Drought Monitor focuses on broad-scale conditions.

https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?NV

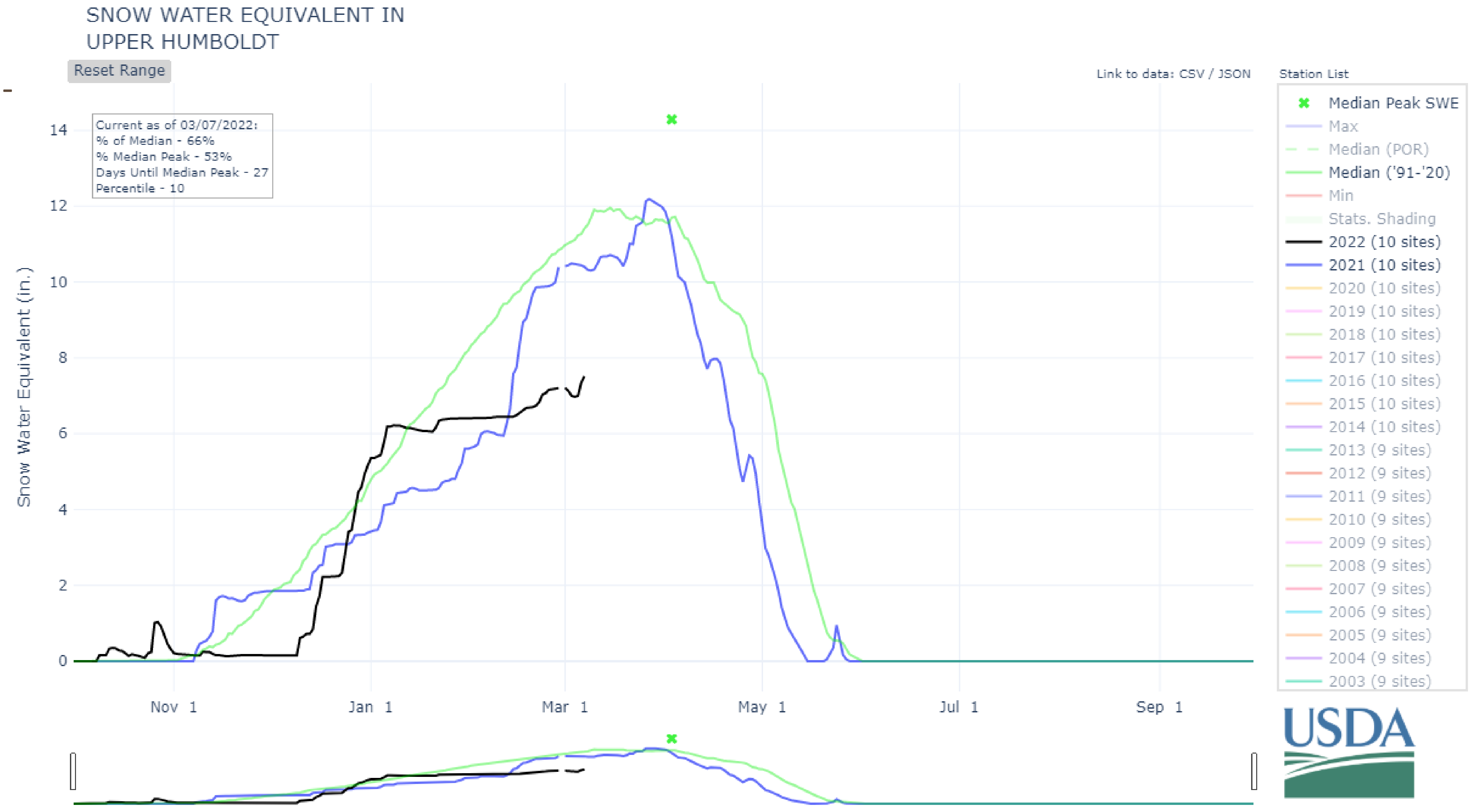
Last year



This year



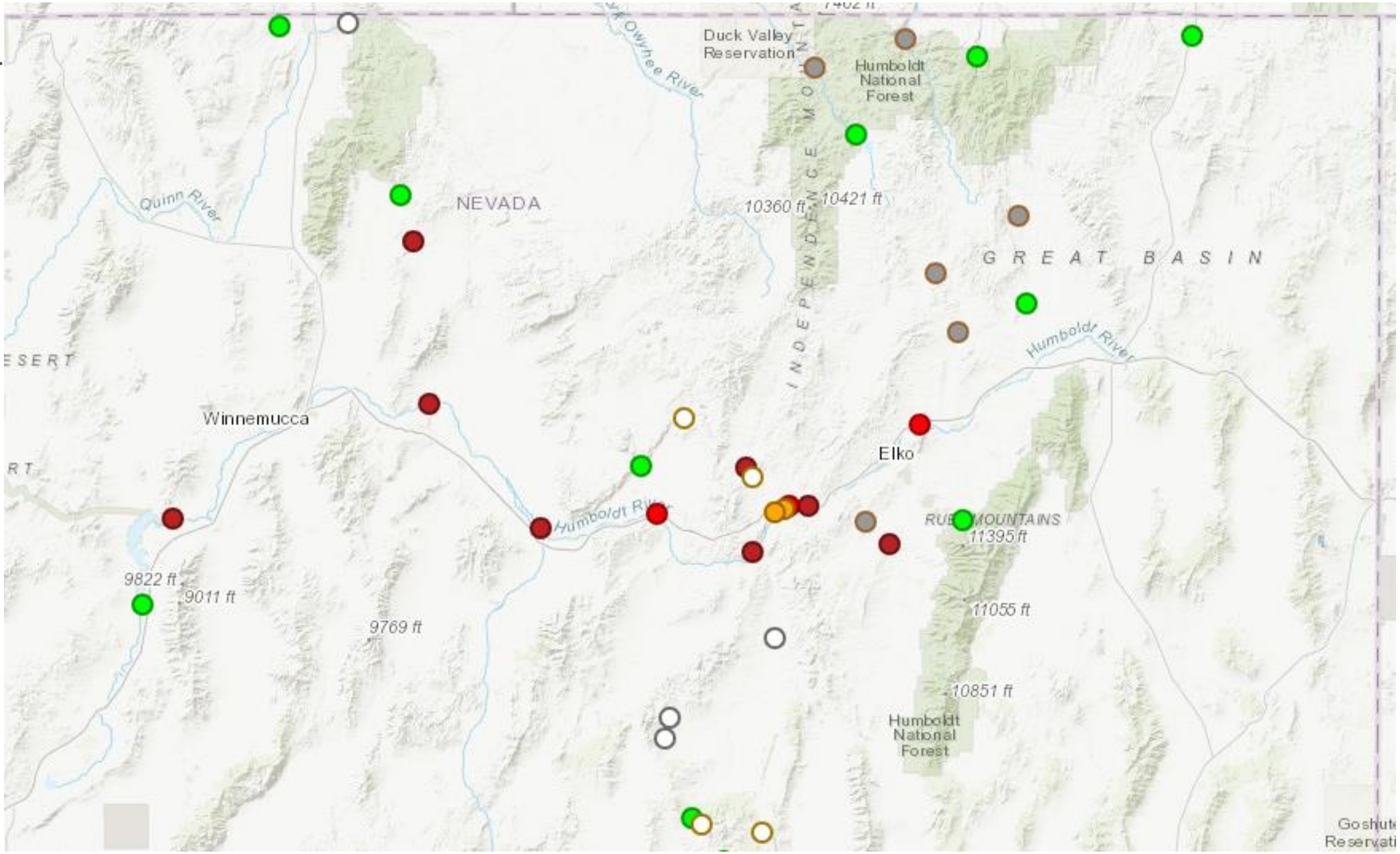
https://www.nrcs.usda.gov/wps/portal/wcc/home/snowClimateMonitoring/snowpack/snowpackMaps/



USDA

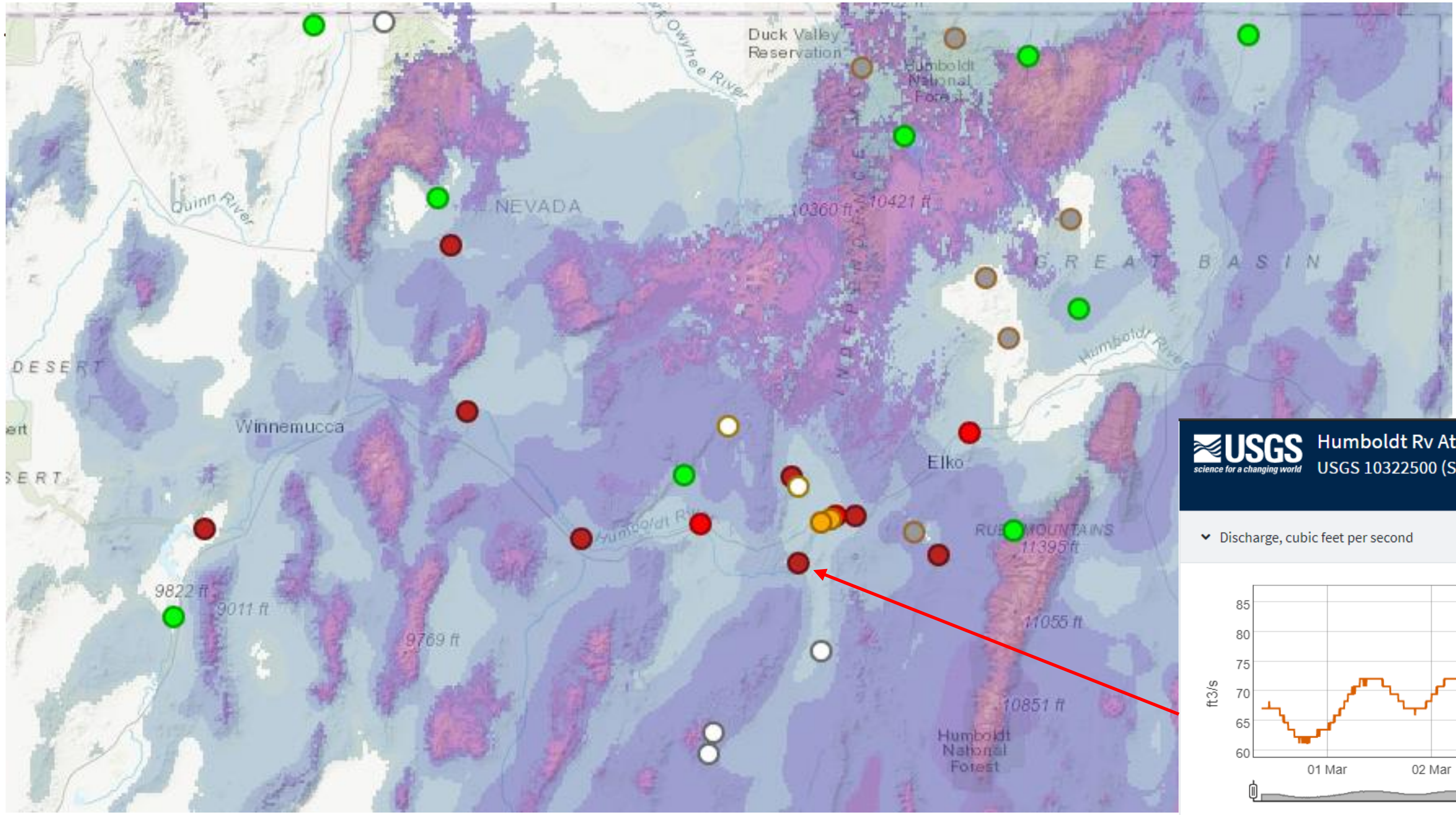
https://www.nrcs.usda.gov/Internet/WCIS/AWS_PLOTS/basinCharts/POR/WTEQ/assocHUCnv_8/upper_humboldt.html

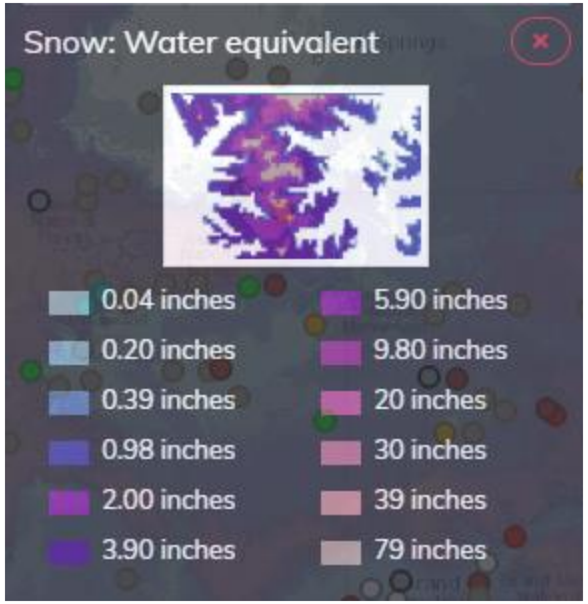
March 7, 2022

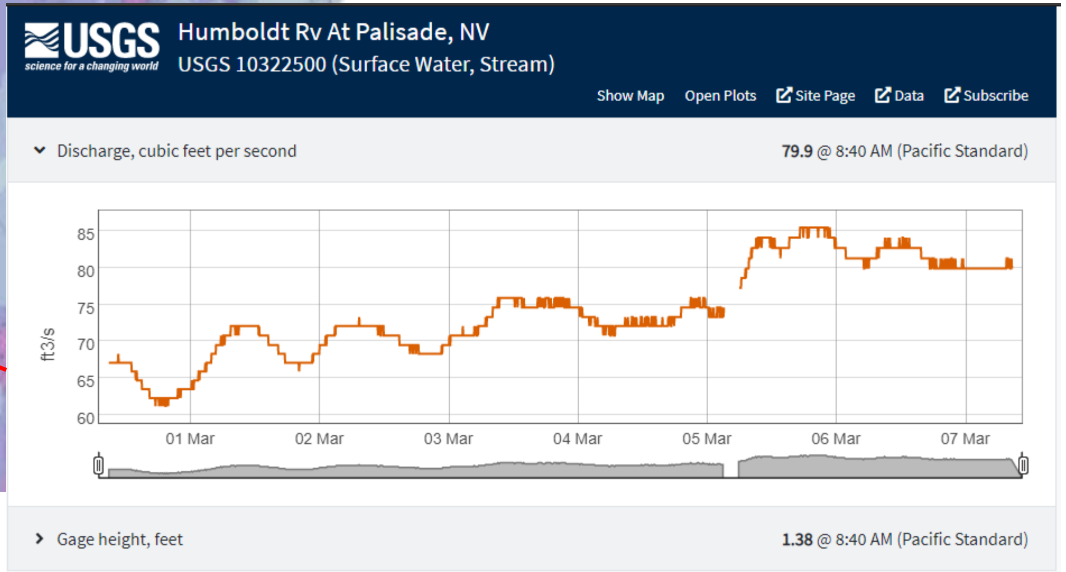


https://dashboard.waterdata.usgs.gov/app/nwd/?region=lower48&aoi=default

March 7, 2022



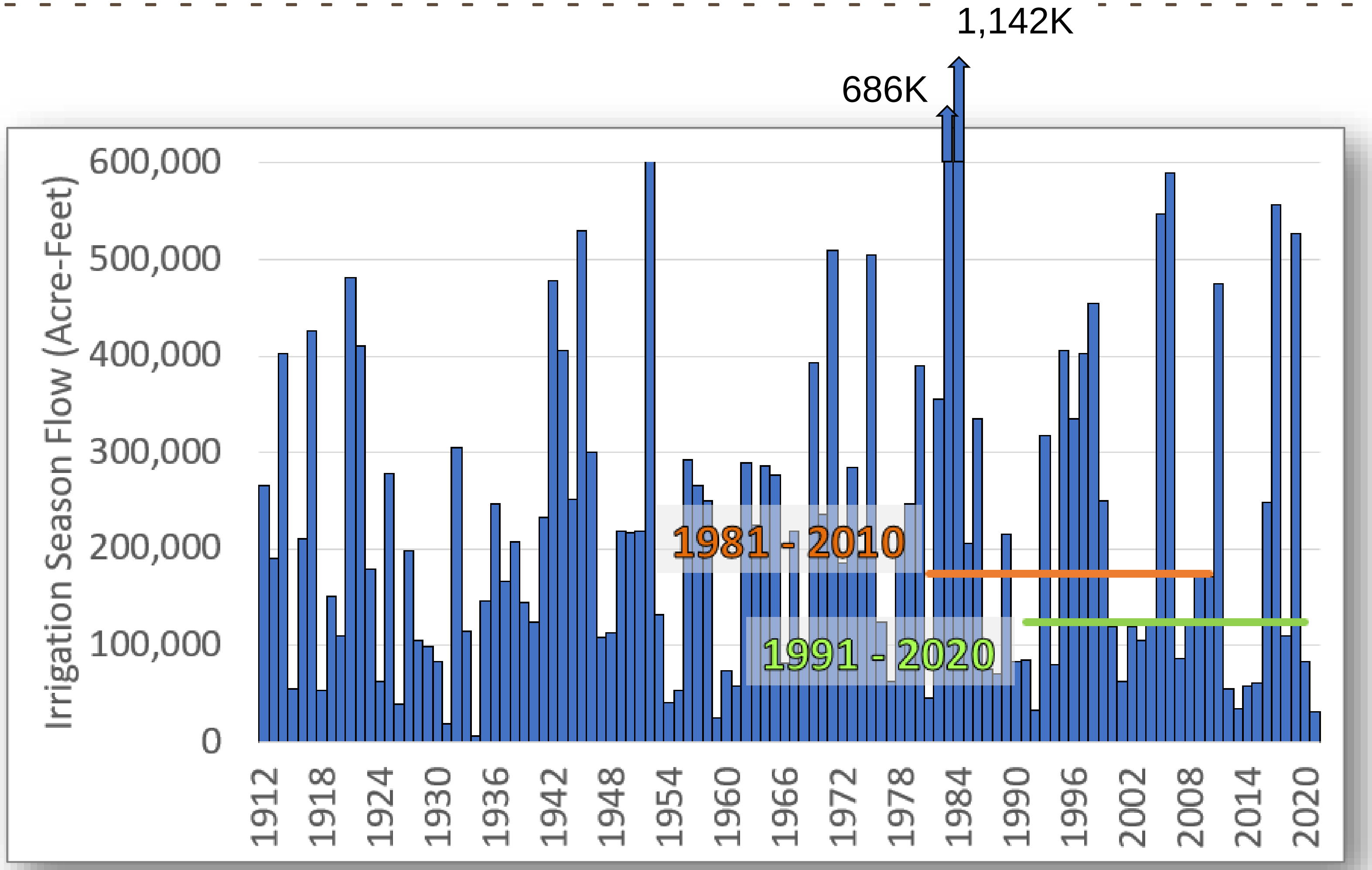




https://dashboard.waterdata.usgs.gov/app/nwd/?region=lower48&aoi=default

Irrigation Season Flow at Palisade

50,000 acre-feet less median flow during 1991 – 2020 period than during 1981 – 2010 period.



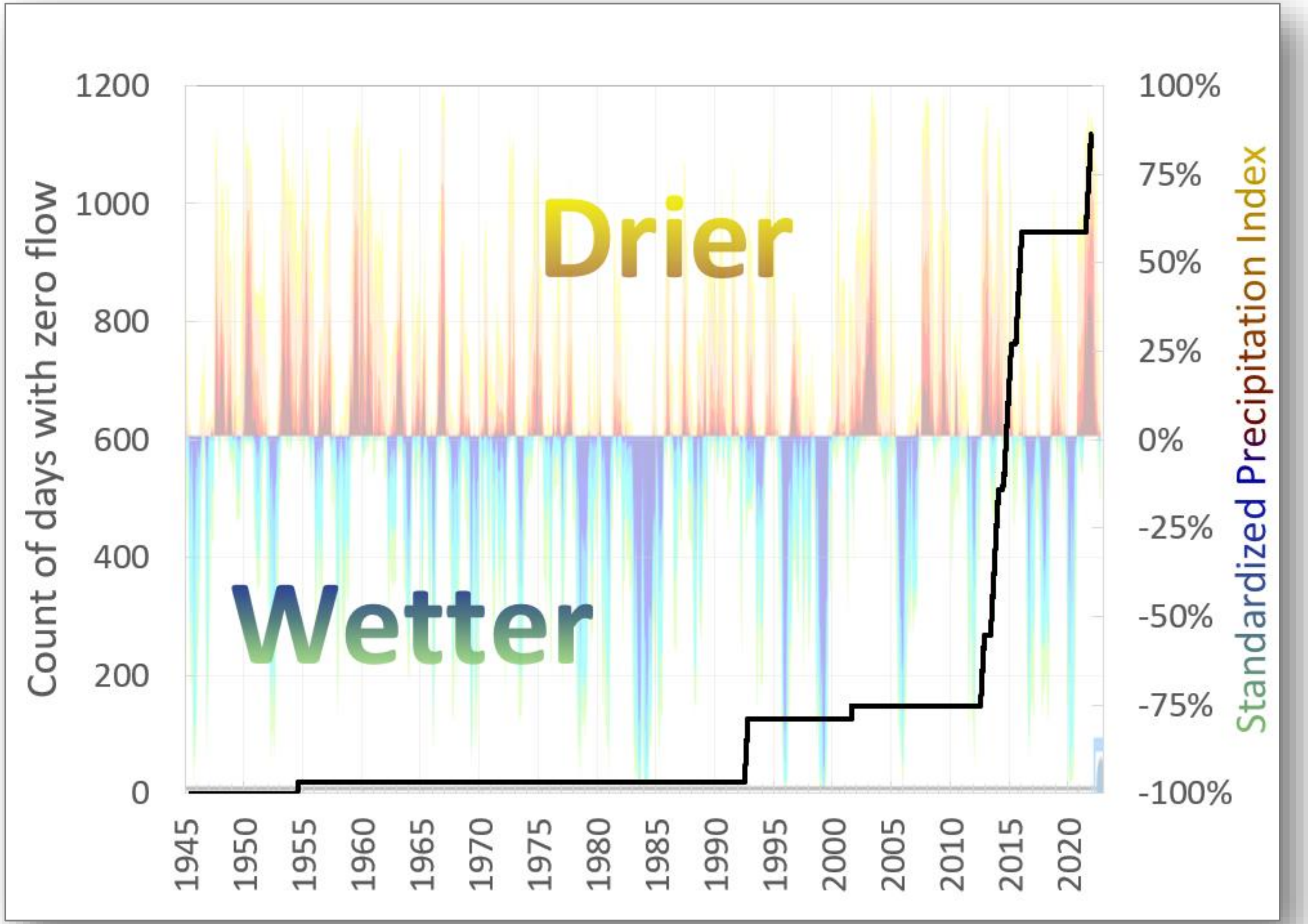
End of FEB 2022: NRCS Reservoir Storage Comparison

Rye Patch Reservoir			
Current		Last Year	
KAF	% of Capacity	KAF	% of Capacity
9.2	5	65	33

Lahontan Reservoir			
Current		Last Year	
KAF	% of Capacity	KAF	% of Capacity
106.8	34	108.3	35

CUMULATIVE ZERO FLOW DAYS AT IMLAY GAGE SINCE 1945

Humboldt River at Imlay is increasingly intermittent during drought periods.



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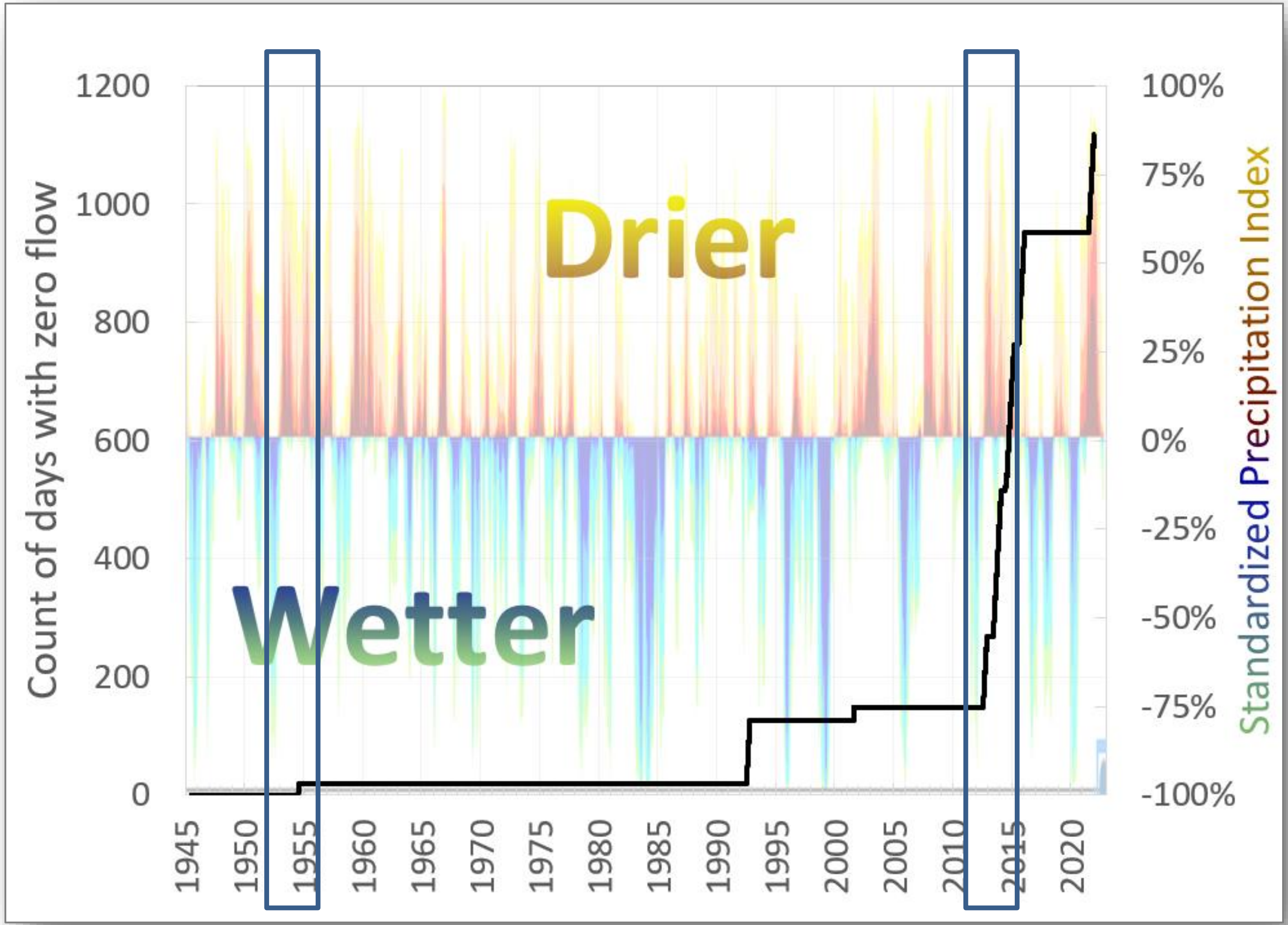
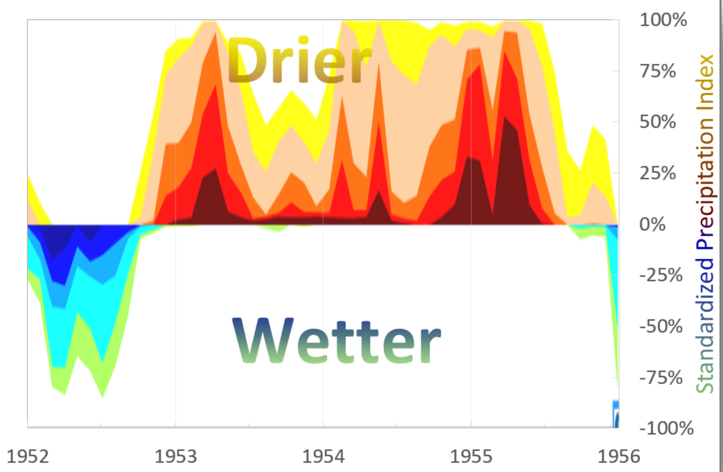


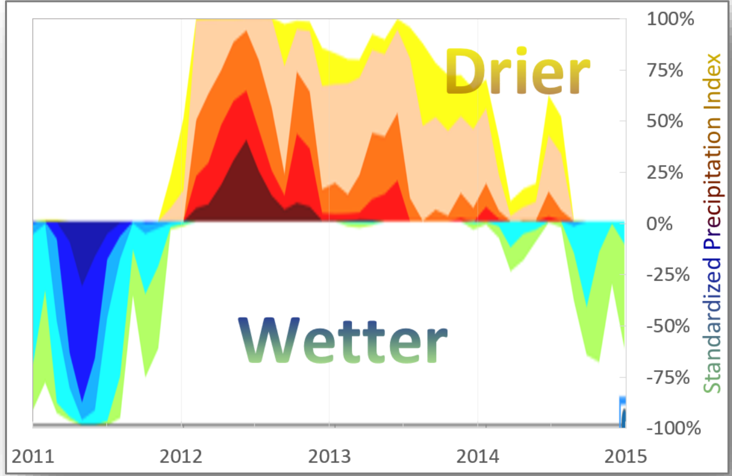
Analogous Drought Comparison

Analogous Droughts

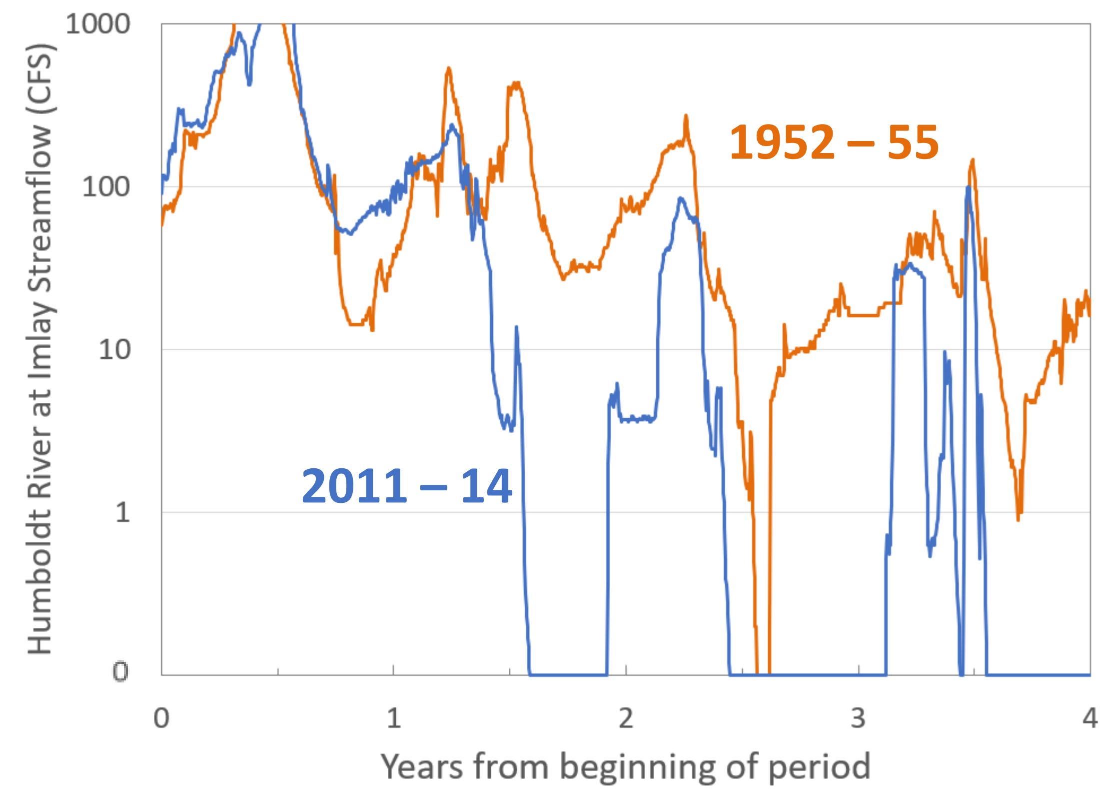
1952 – 55



2011 – 14

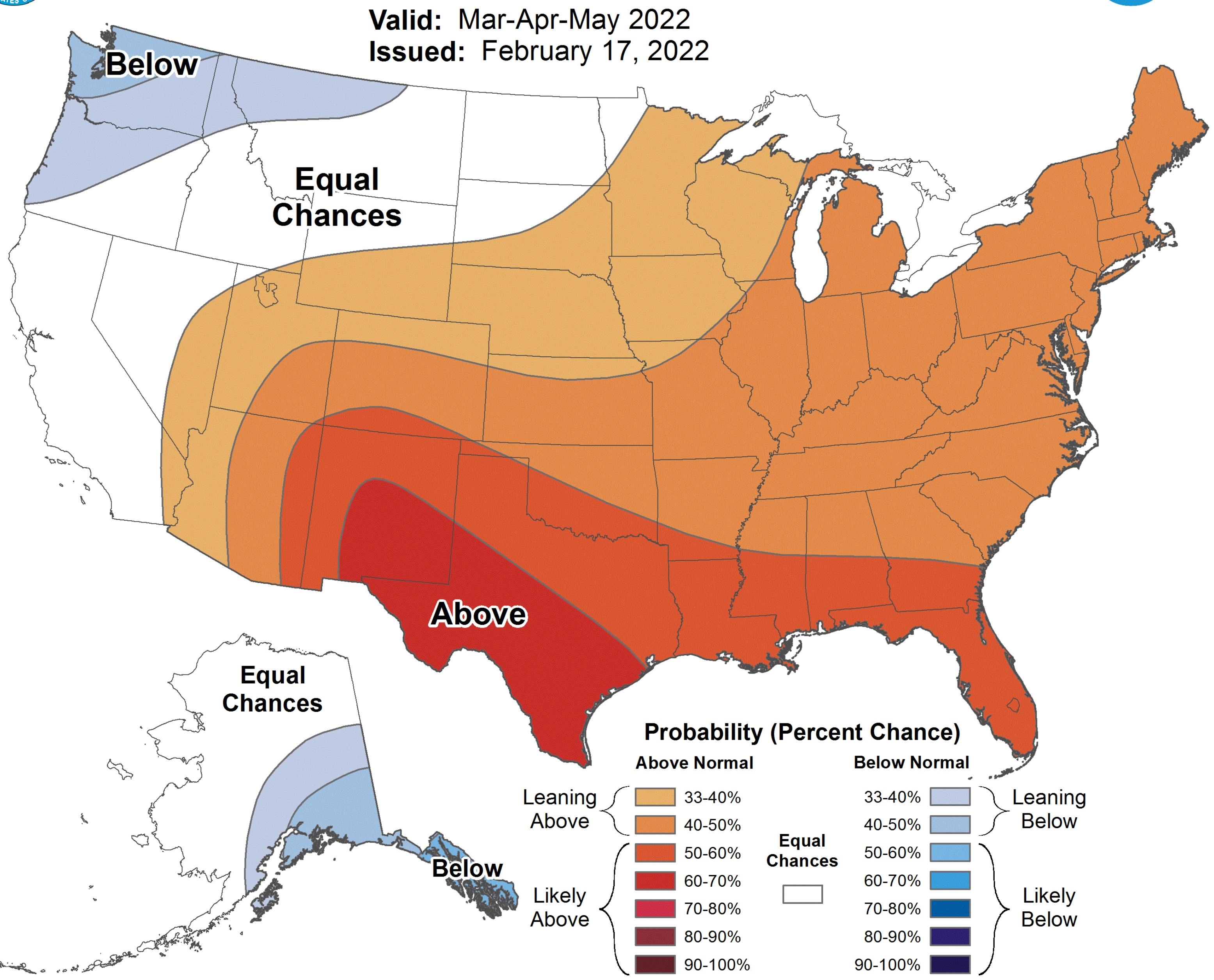


Imlay Streamflow



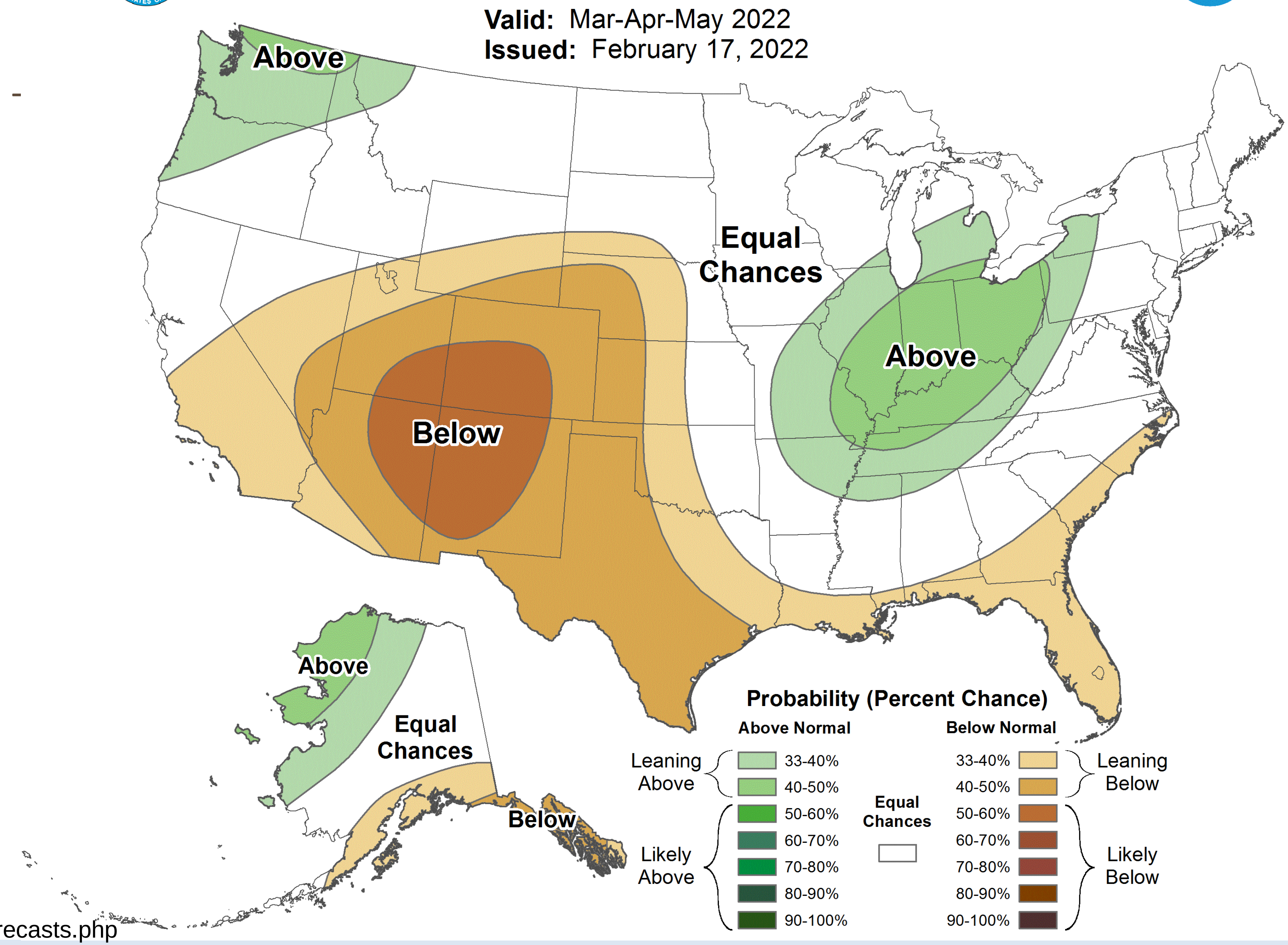
Baseflow at Imlay during drought periods is disappearing.

Seasonal Temperature Outlook



https://gbdash.dri.edu/forecasts.php

Seasonal Precipitation Outlook



https://gbdash.dri.edu/forecasts.php

Resources

National Weather Service

https://www.weather.gov

NRCS

https://www.nrcs.usda.gov/wps/portal/wcc/home/snowClimateMonitoring

Great Basin Weather and Climate Dashboard

https://gbdash.dri.edu

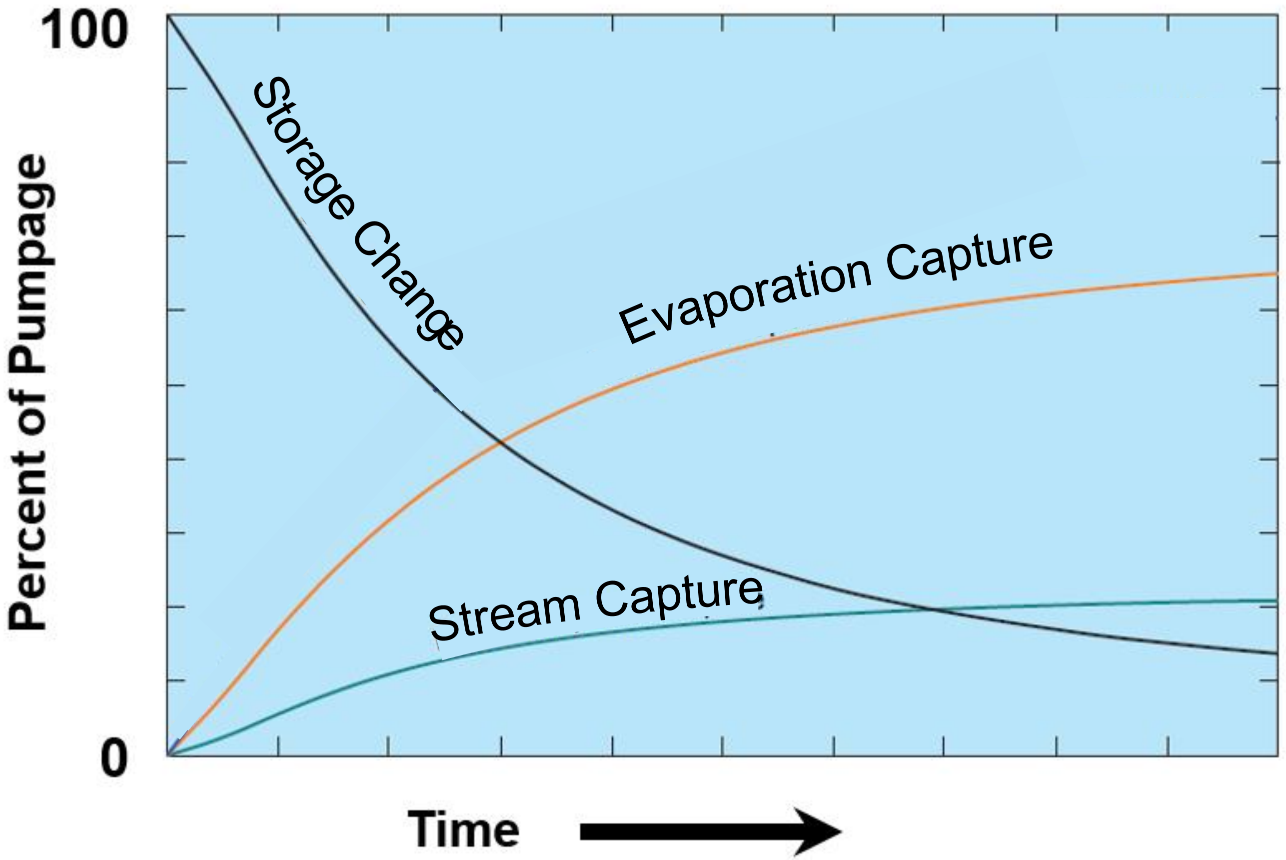
USGS National Water Dashboard

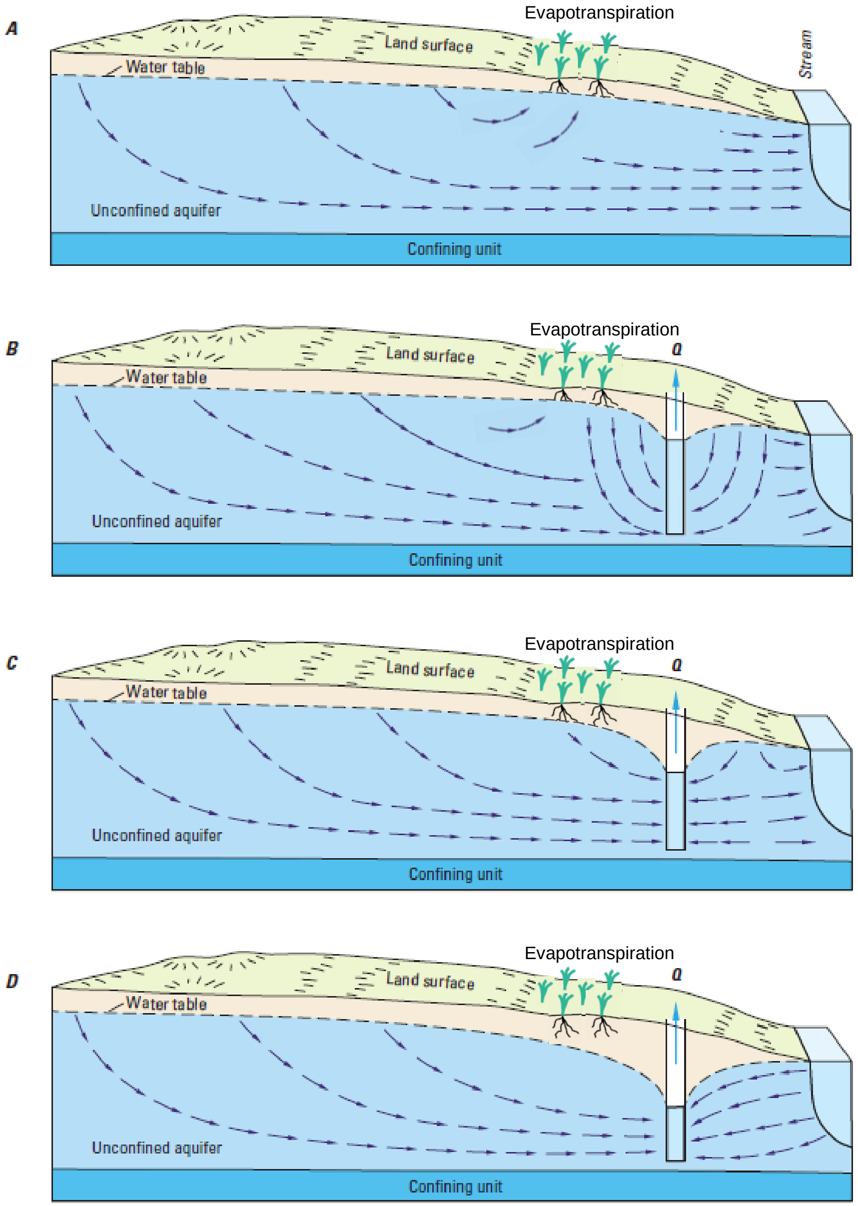
https://dashboard.waterdata.usgs.gov/app/nwd/?region=lower48&aoi=default

Capture 101 and Study Overview

NDWR

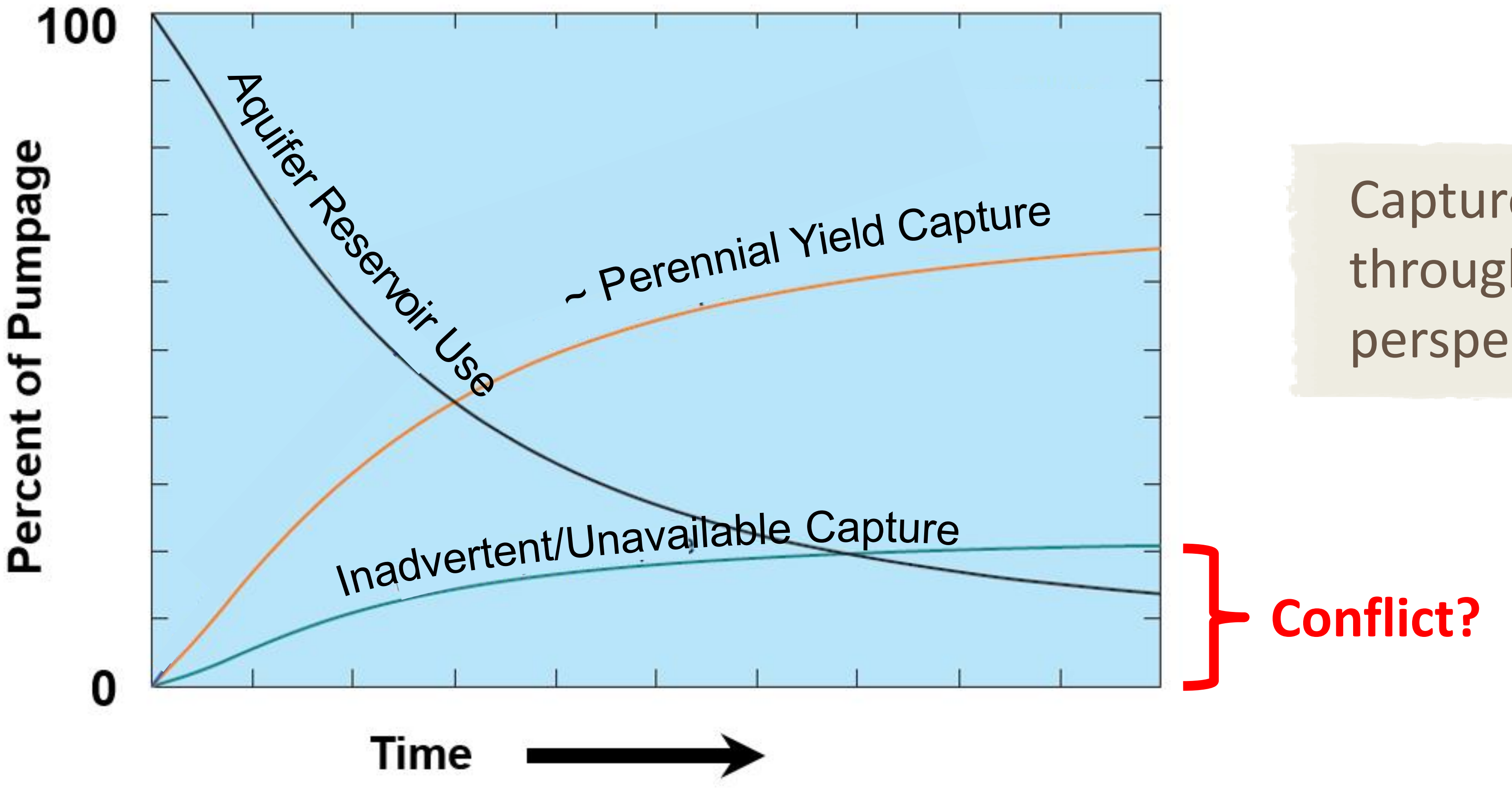
What is Stream Capture?
Capture 101





Stream Capture = Streamflow Depletion

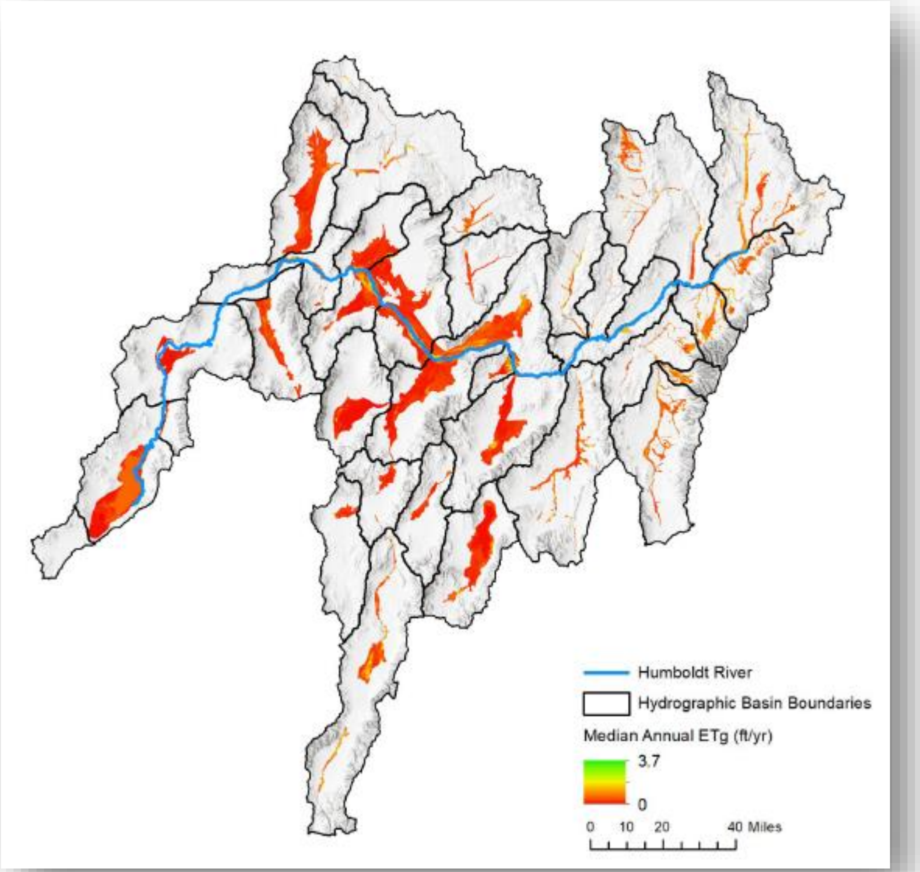
Water Management Perspective



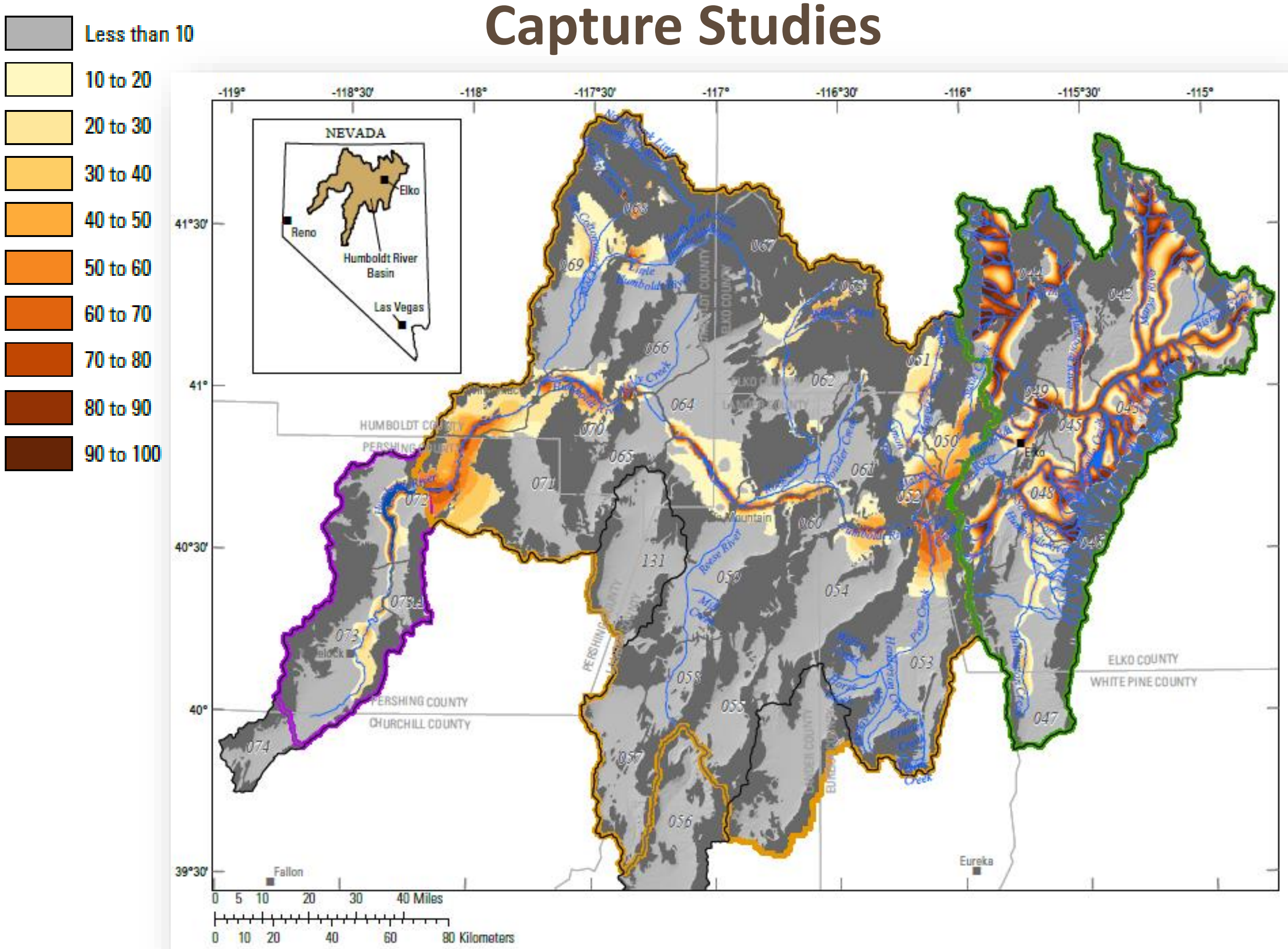
Capture curves conceptualized through water management perspective.

CAPTURE STUDY COMPONENTS

Regional Evapotranspiration Study



Capture Studies



*** Model results are provisional and subject to change***

Region Wide ET Analysis

DRI

Groundwater Discharge via Evapotranspiration

Paradise Valley, NV

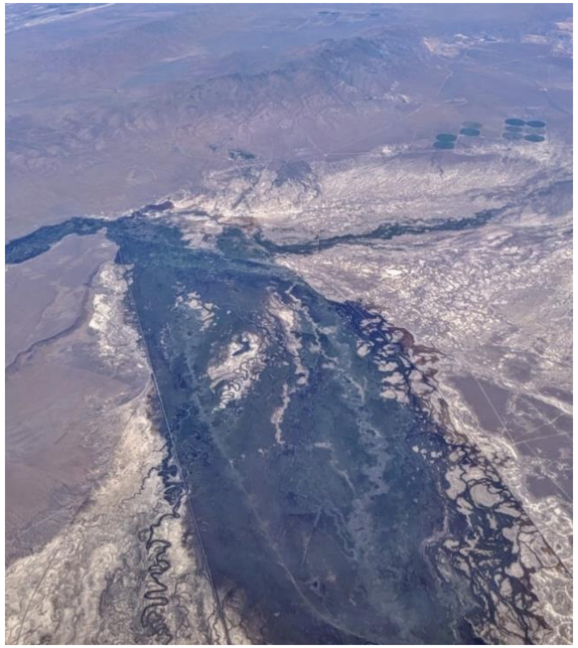
Desert Research Institute

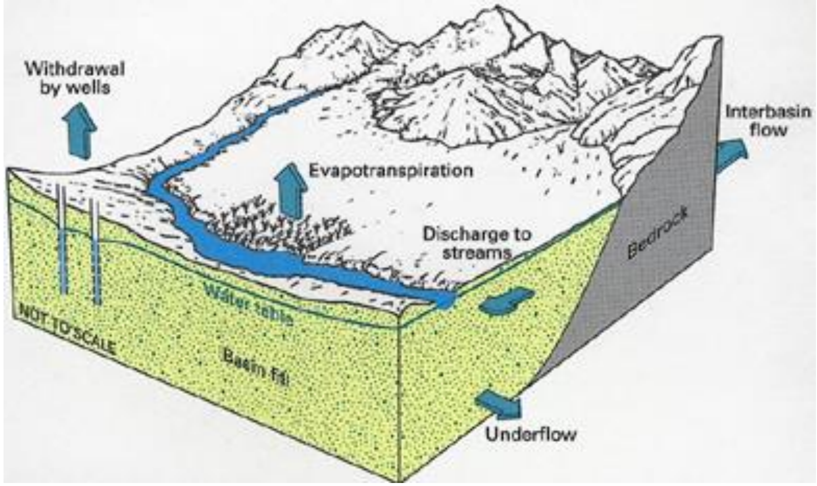
Justin Huntington, Research Professor, Hydrology

Groundwater Discharge via Evapotranspiration

Objective

- Delineate areas where phreatophytes discharge groundwater through the process of evapotranspiration
- Use best available science to estimate the rates of groundwater evapotranspiration (ETg) from phreatophyte vegetation
- Summarize and compare to previous studies, and provide results to USGS and DRI groundwater modeling groups to use for calibration of groundwater models





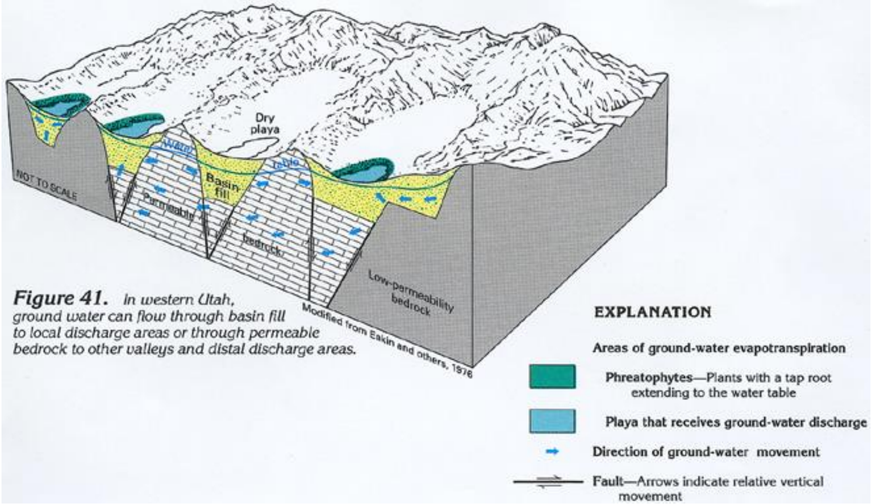
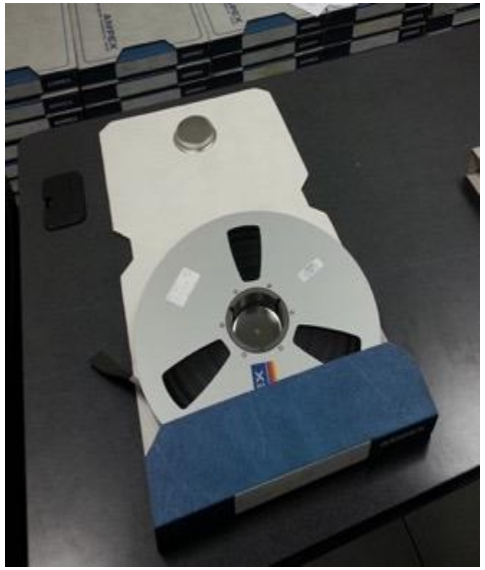


Figure 41. *In western Utah, ground water can flow through basin fill to local discharge areas or through permeable bedrock to other valleys and distal discharge areas.*

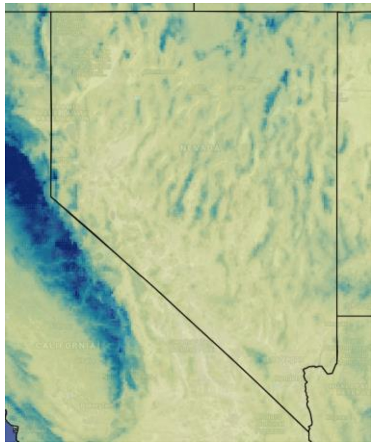
USGS HA730C – Groundwater Atlas of U.S.

Satellite and Climate Data

1960s-1980s

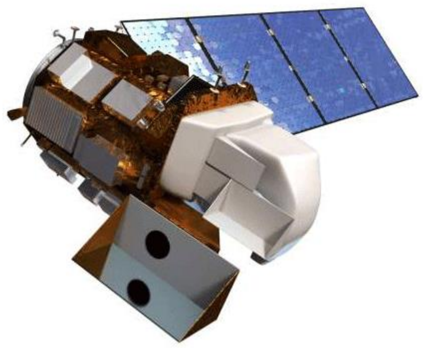


1980s-current

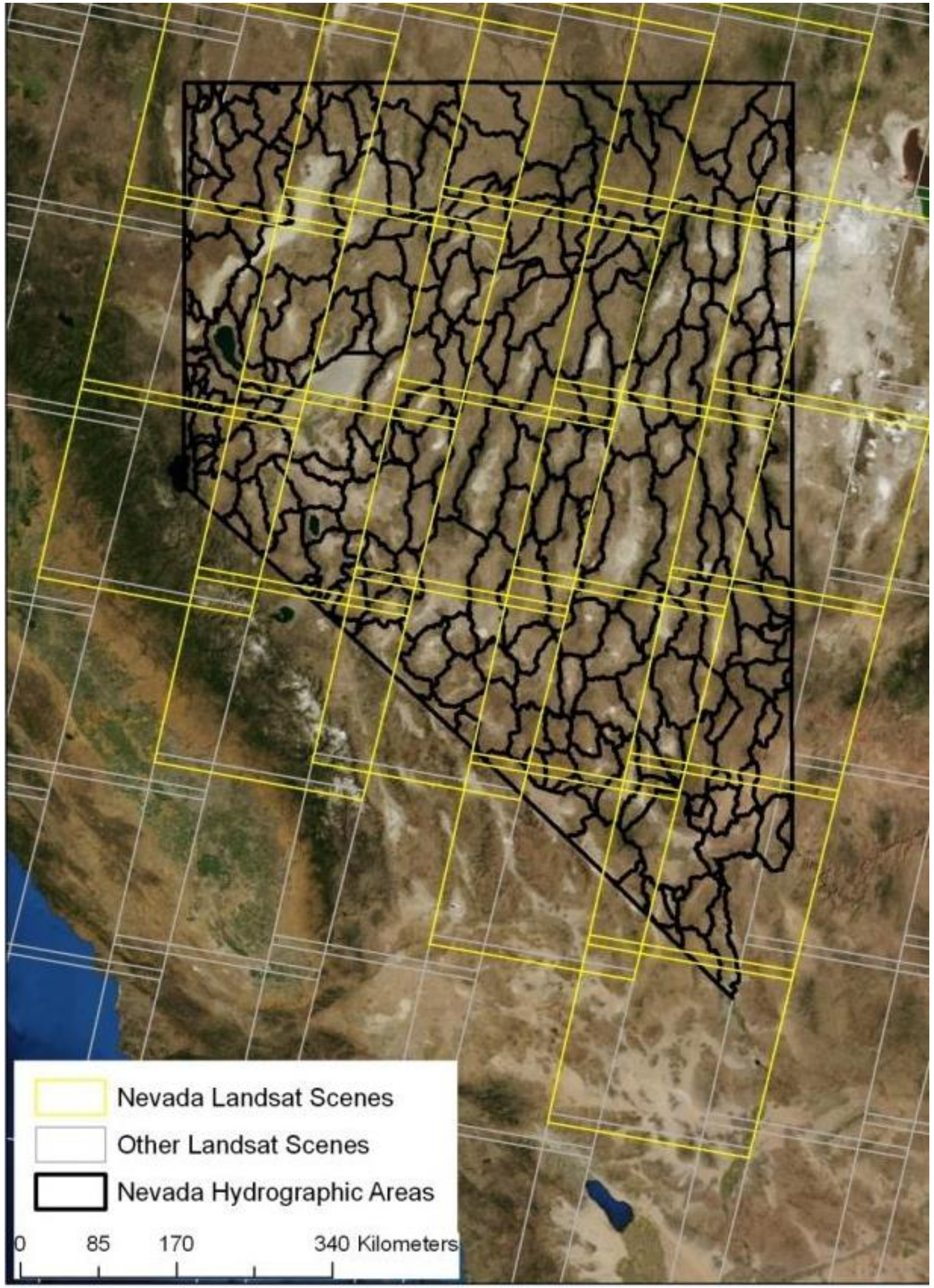


Geospatial Data Approach

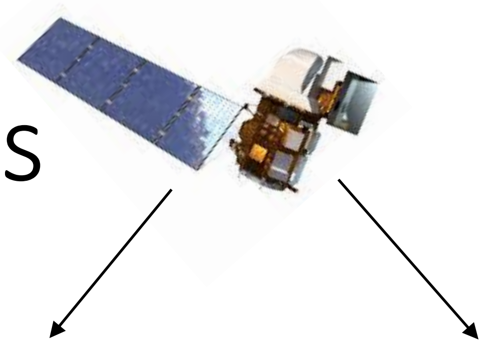
- Previous phreatophyte boundaries, aerial imagery, Landsat imagery, digital elevation models, soils data, wells and water levels, field surveys of phreatophytes
- Landsat satellite imagery to compute vegetation indices
    - 1985-2015, summer period
- gridMET weather data for estimating precipitation and evaporative demand
    - Solar radiation, temperature, humidity, and wind speed

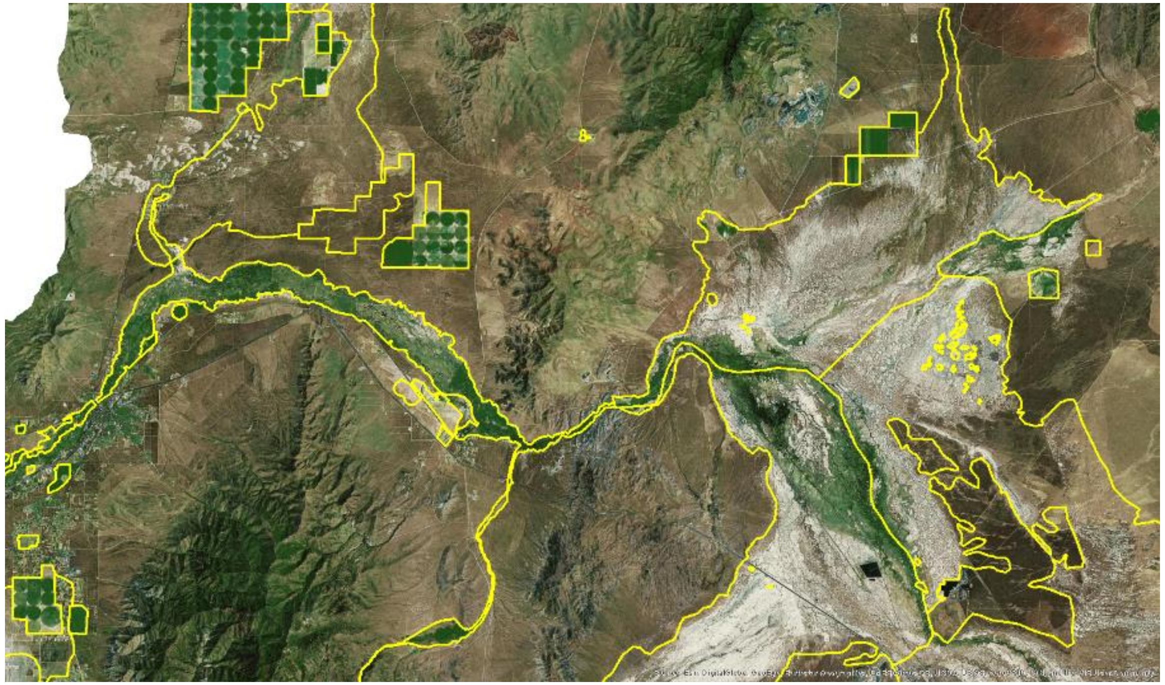


Landsat MODIS

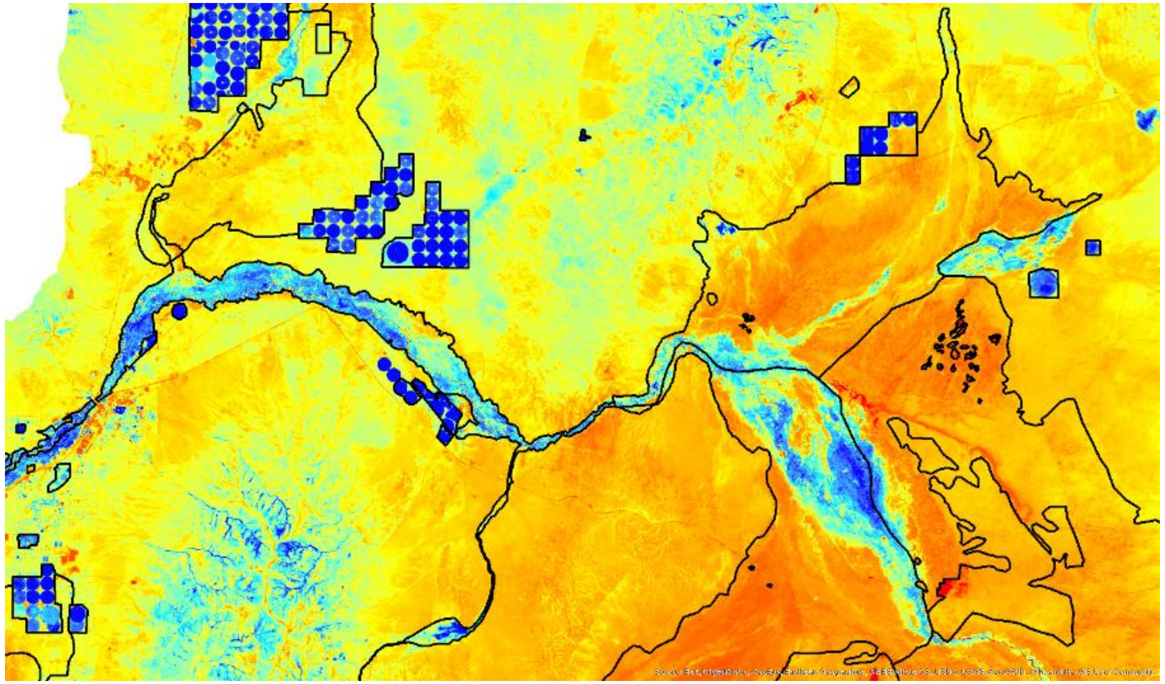


Groundwater Discharge Boundaries



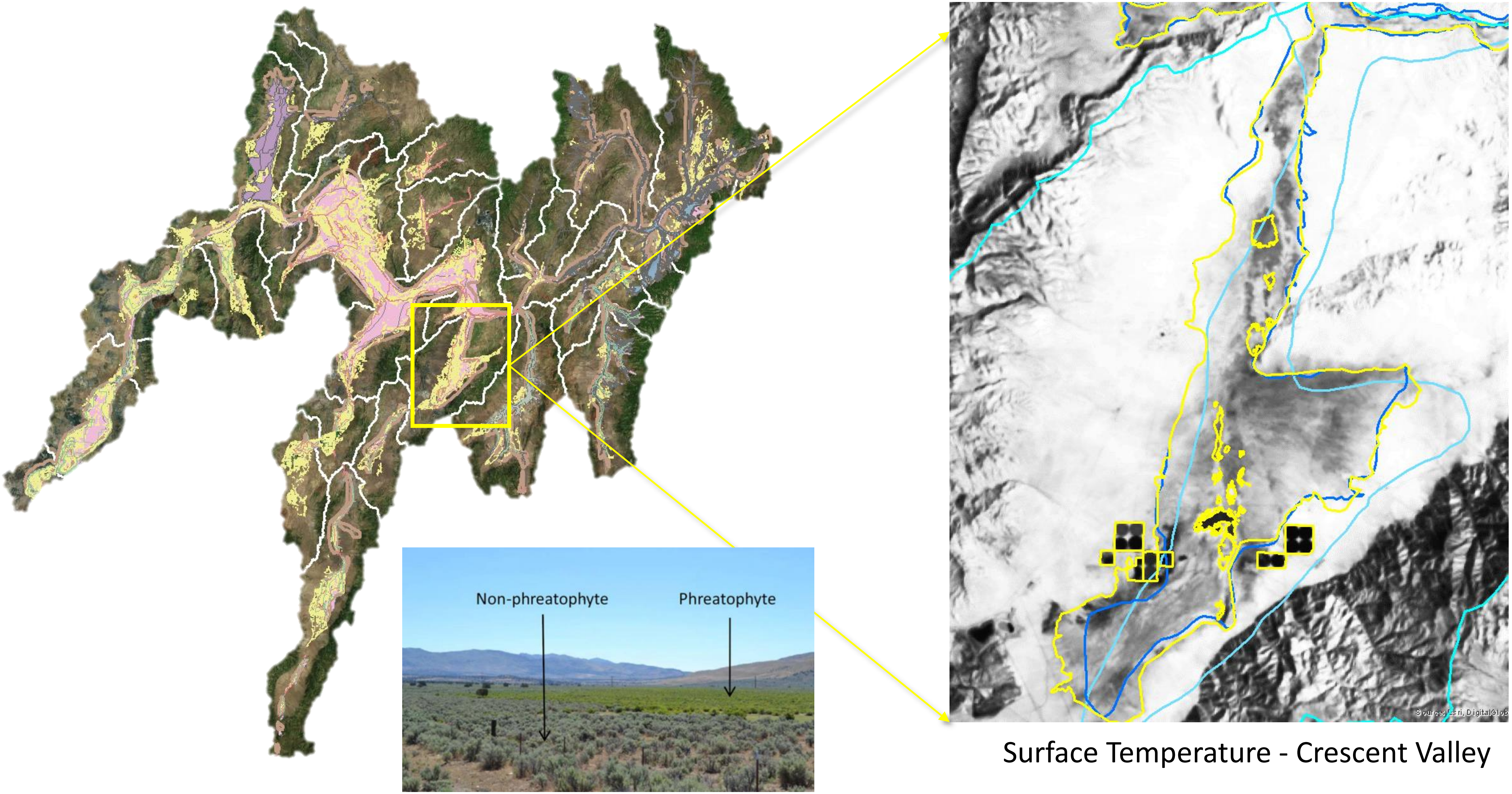


True Color NAIP Imagery



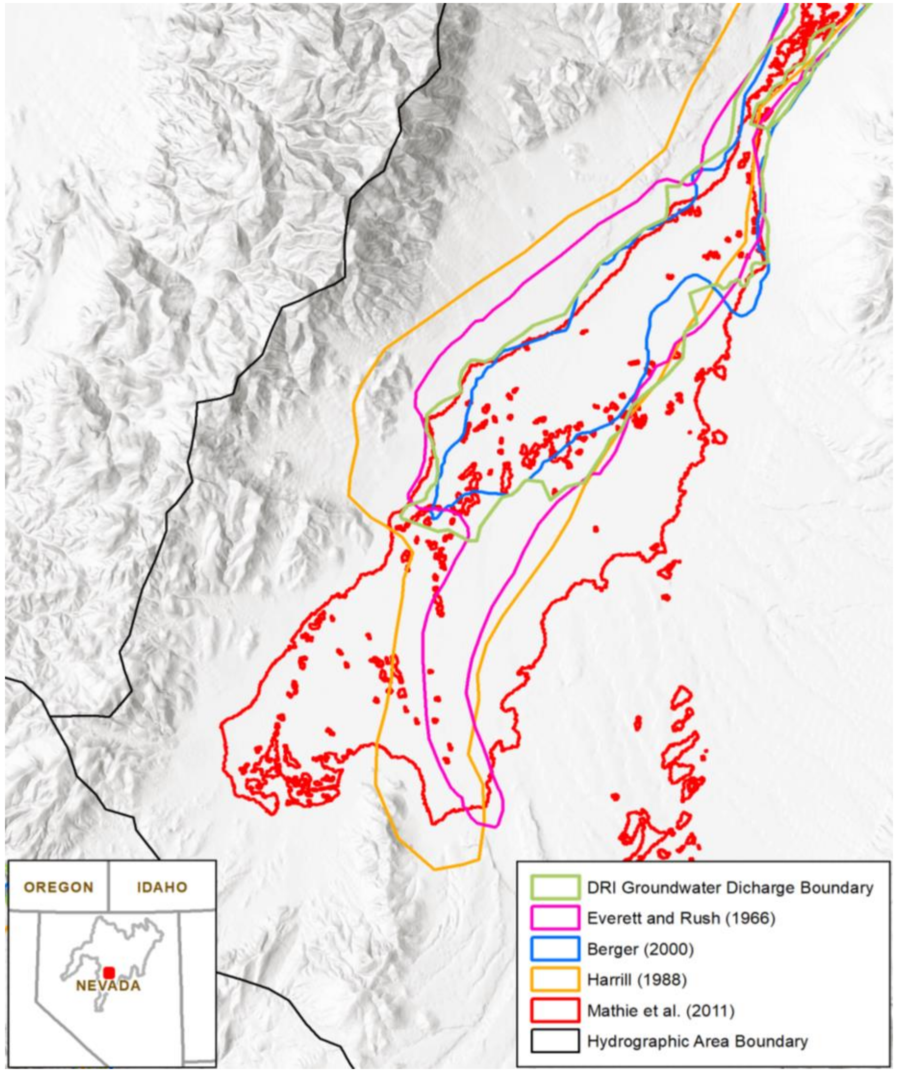
Vegetation Index (30m)

Groundwater Discharge Boundaries

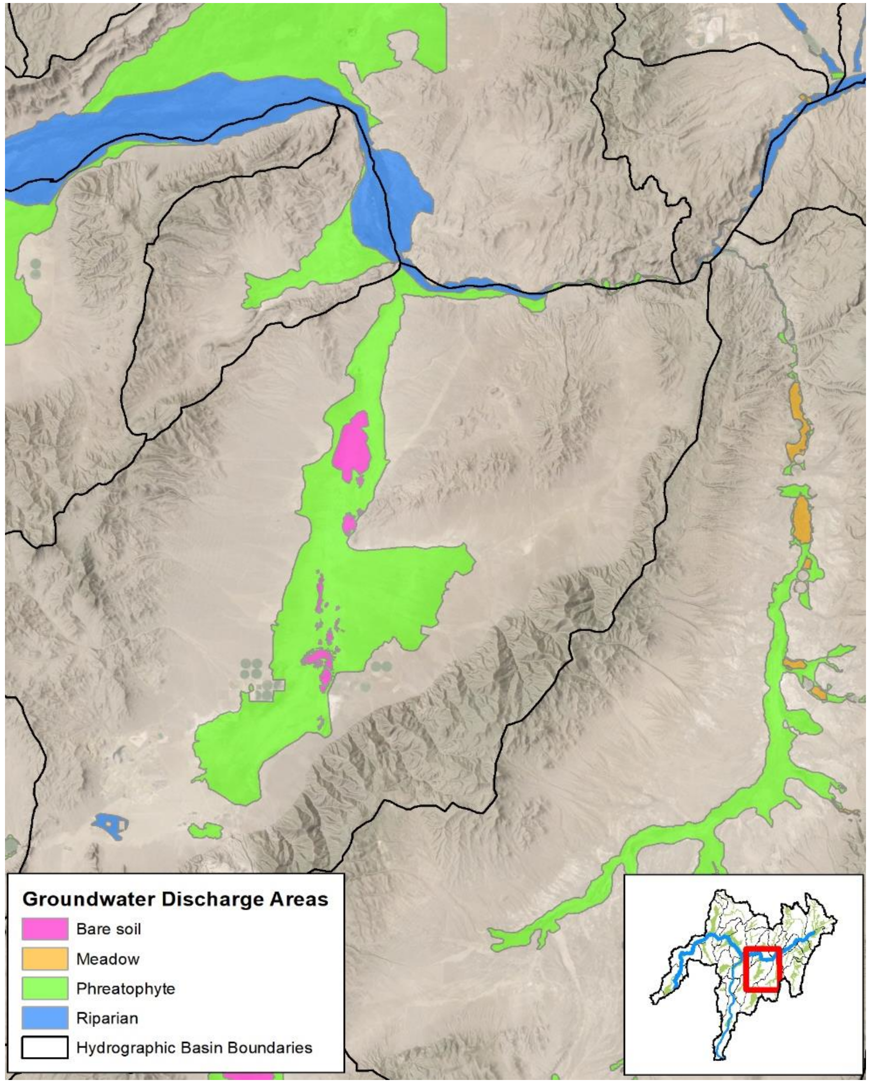


Surface Temperature - Crescent Valley

Groundwater Discharge Boundaries

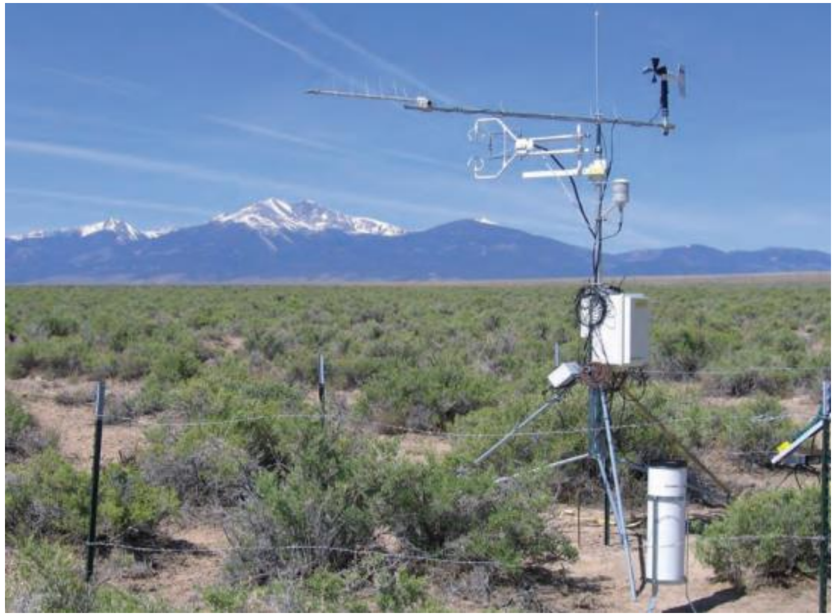


Carico Lake Valley



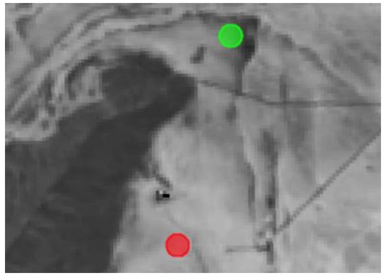
Crescent and Pine Valley Areas

Landsat and Climate -> ETg Rates



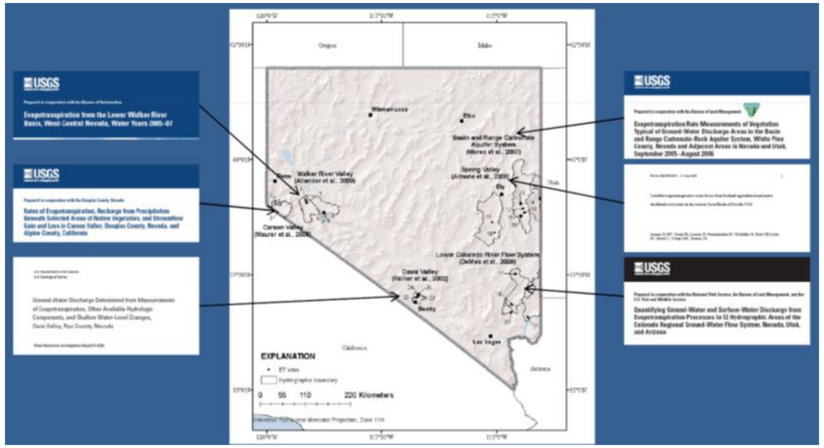
Moreo et al (2007)

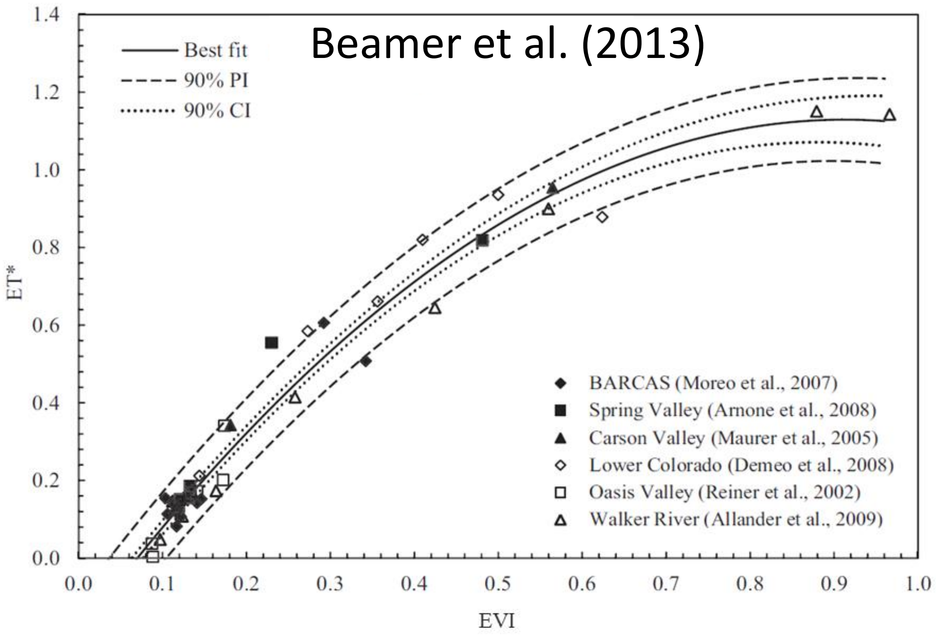
+



$$ET^* = \frac{ET - PPT}{ETo - PPT}$$

->

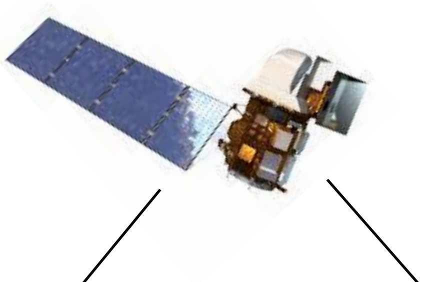


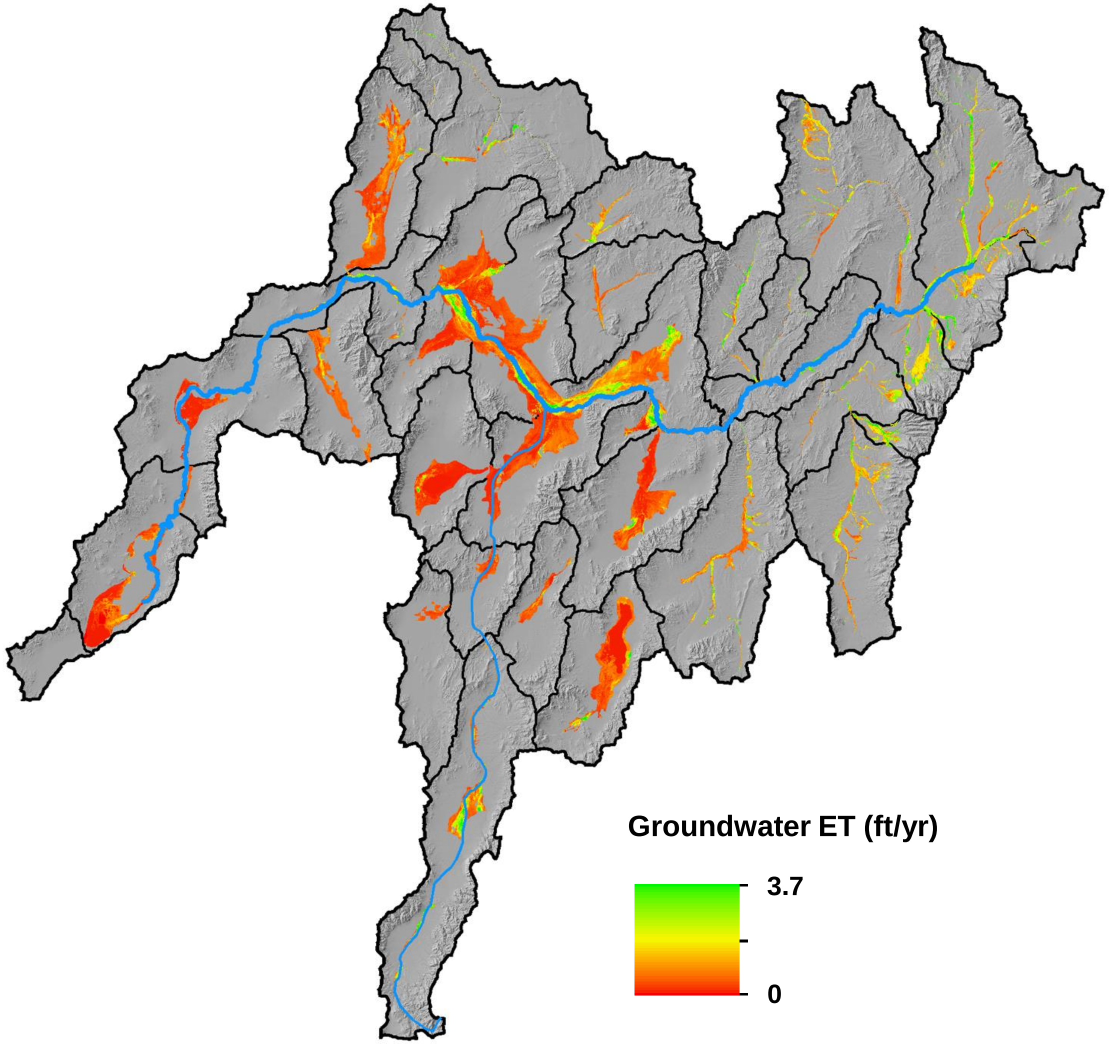


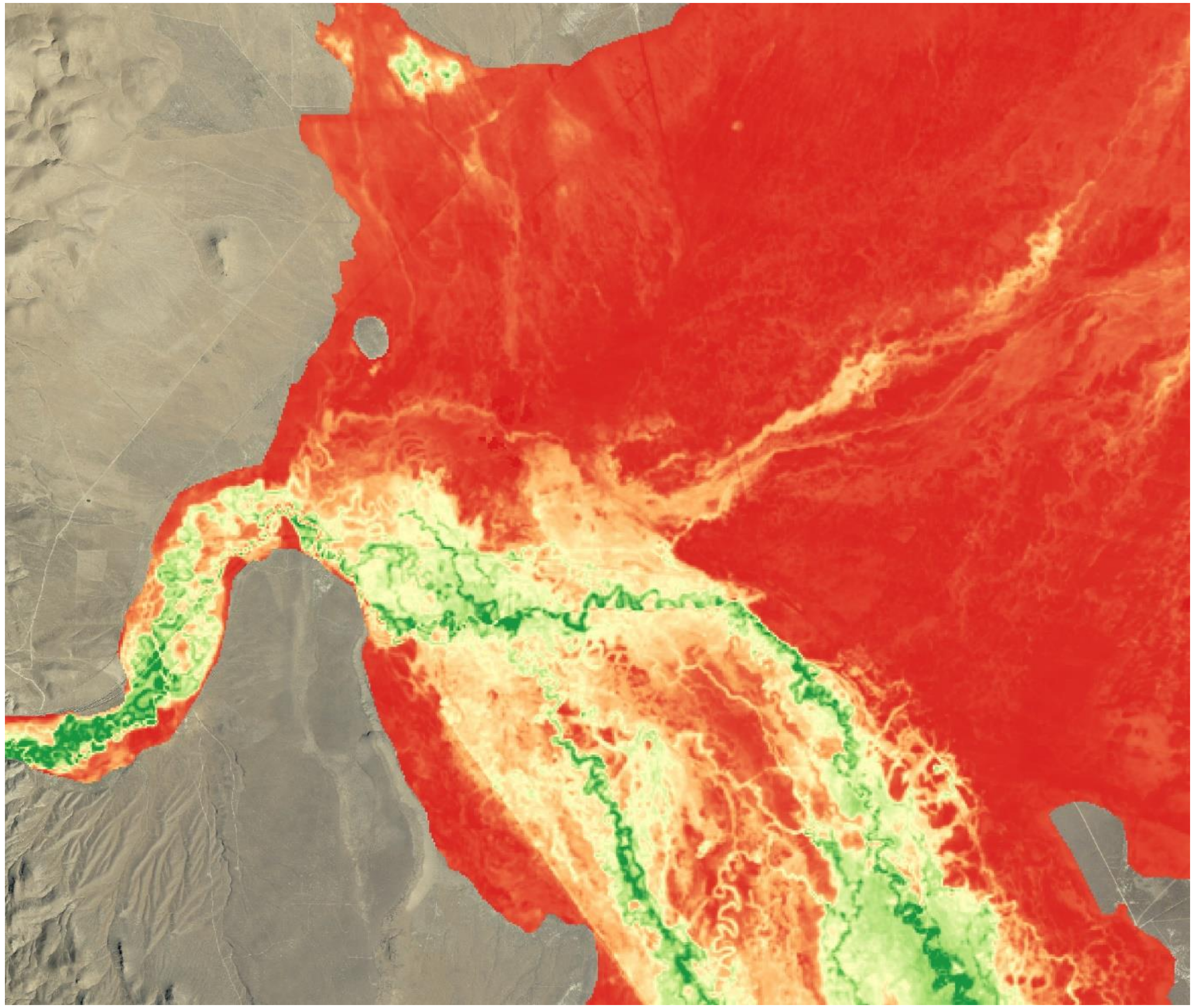
$$ET^* = \beta_0 + \beta_1 EVI + \beta_2 EVI^2$$

*Rate of ETg (ft/yr) = (ETo – PPT) * ET**

Groundwater ET Distribution



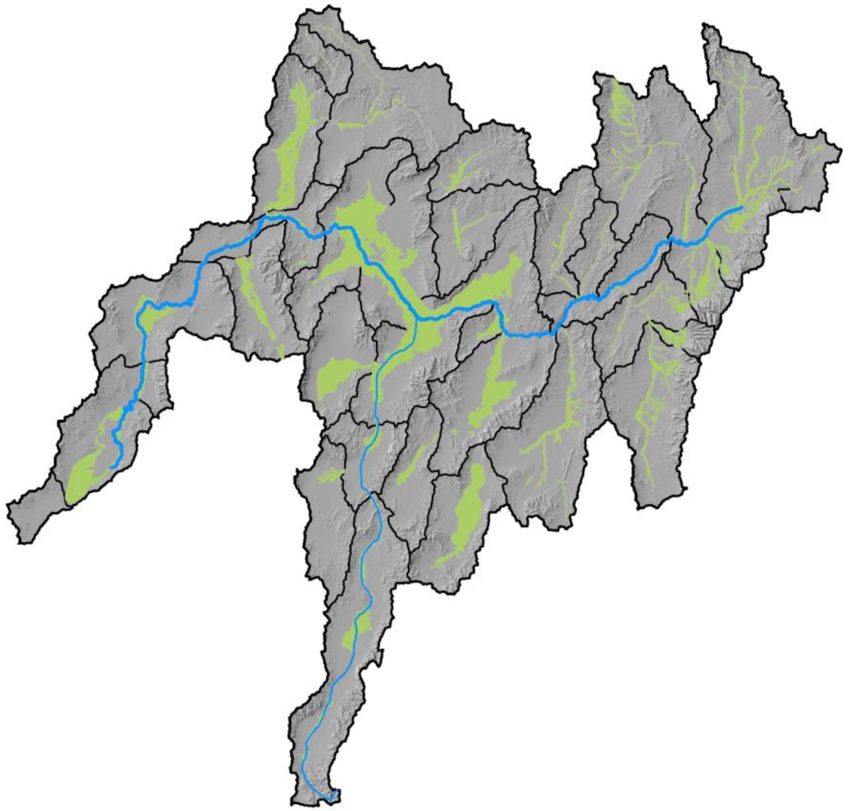




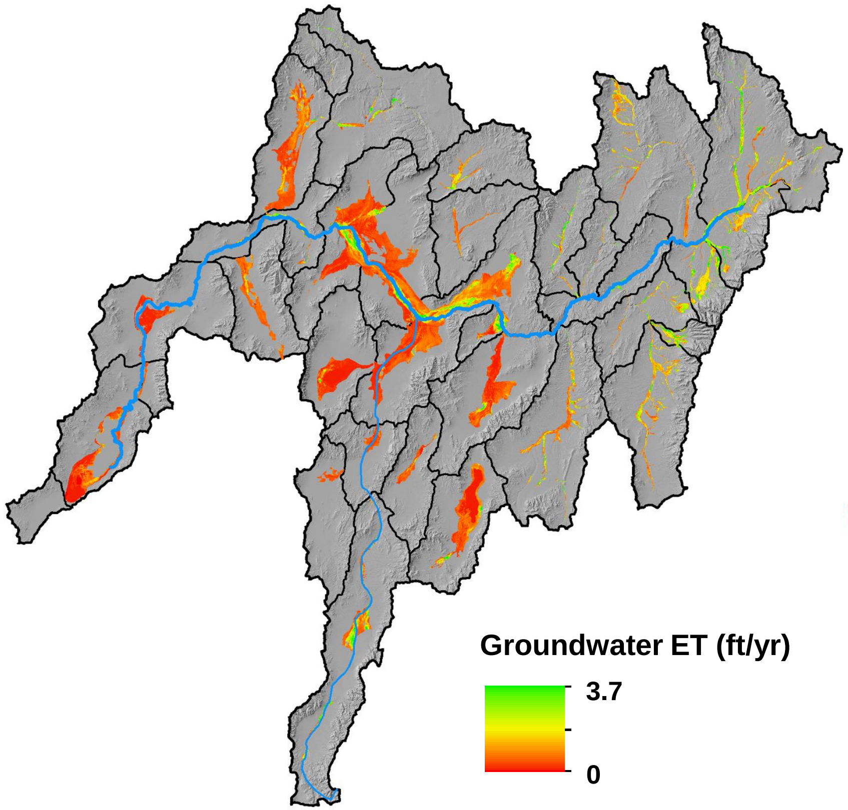
Kelley Creek Area, Clovers Area, and Pumpernickel Valley

Evapotranspiration Discharge

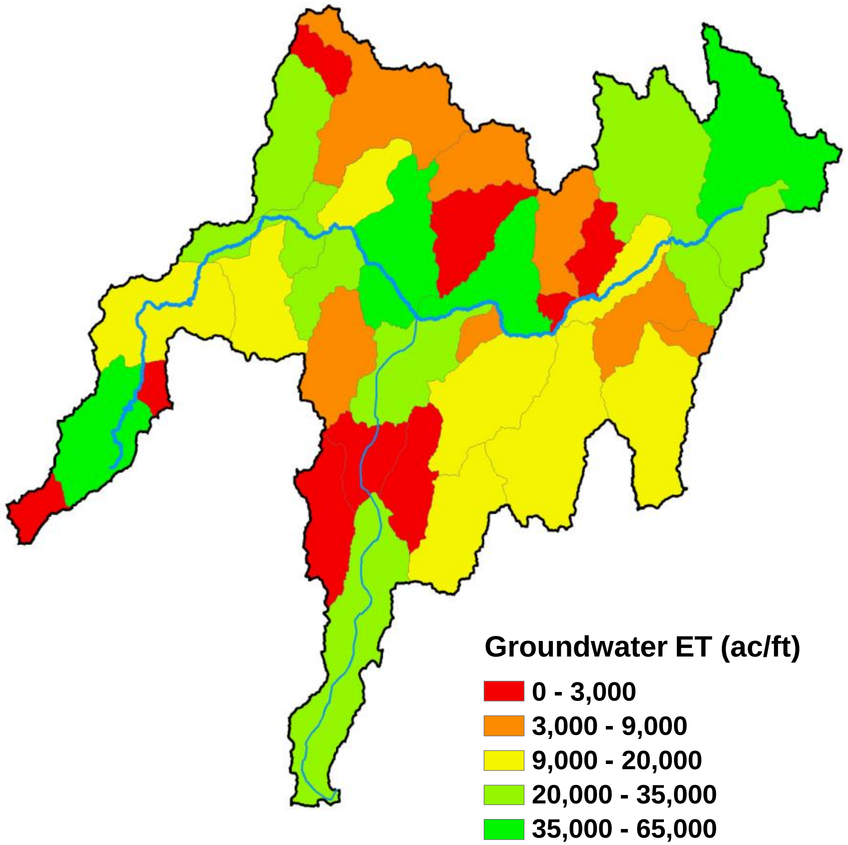
Potential areas of GW discharge



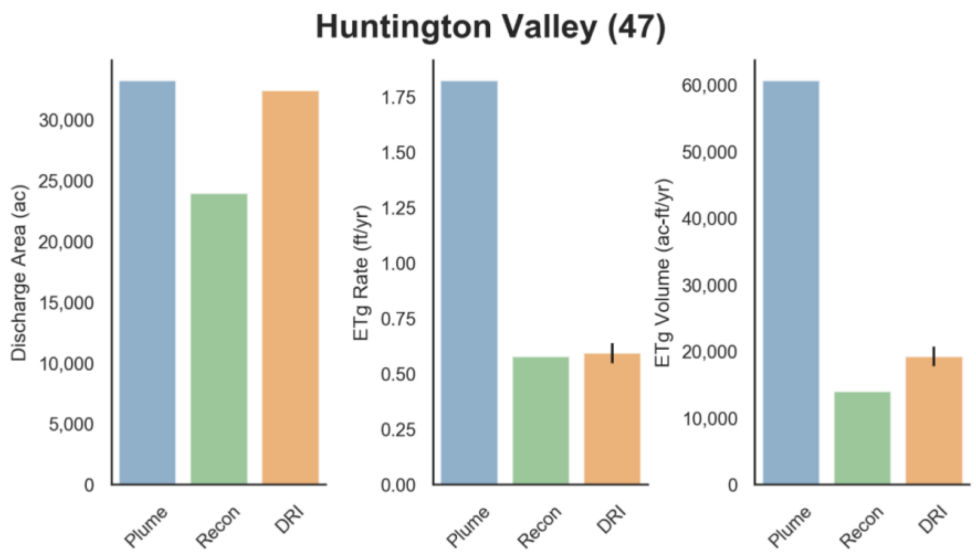
Groundwater ET

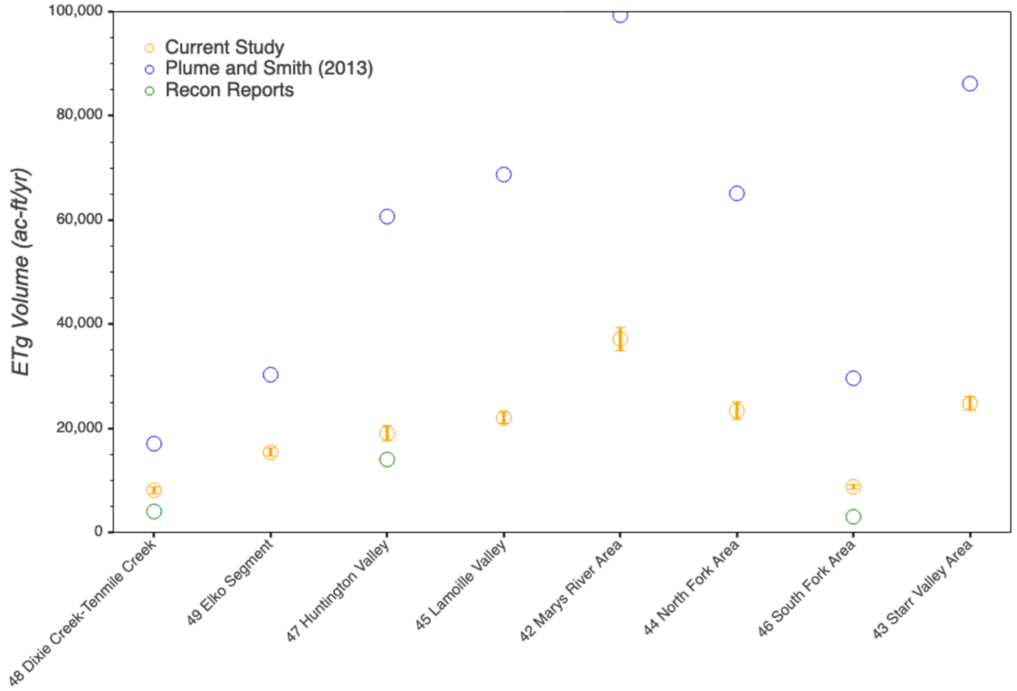


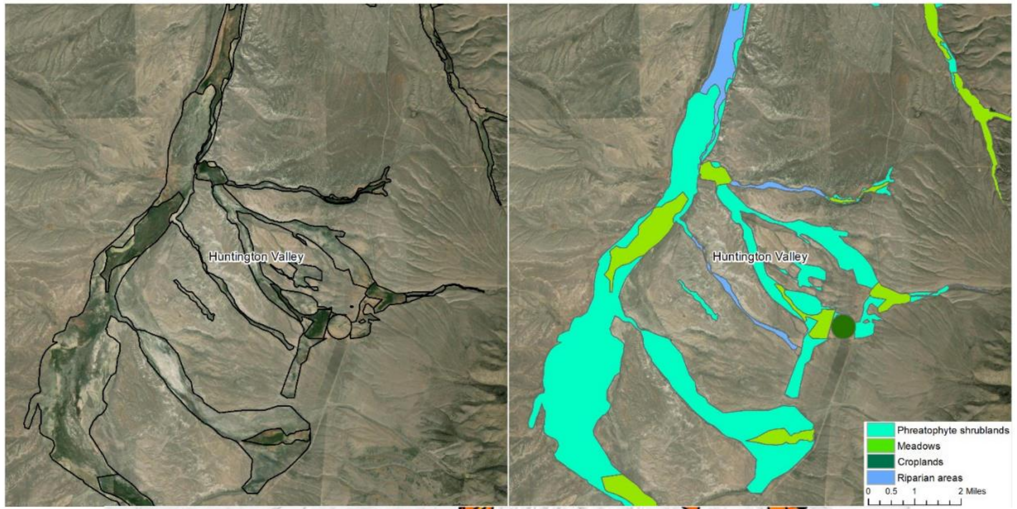
Groundwater ET



Comparison to Previous Studies







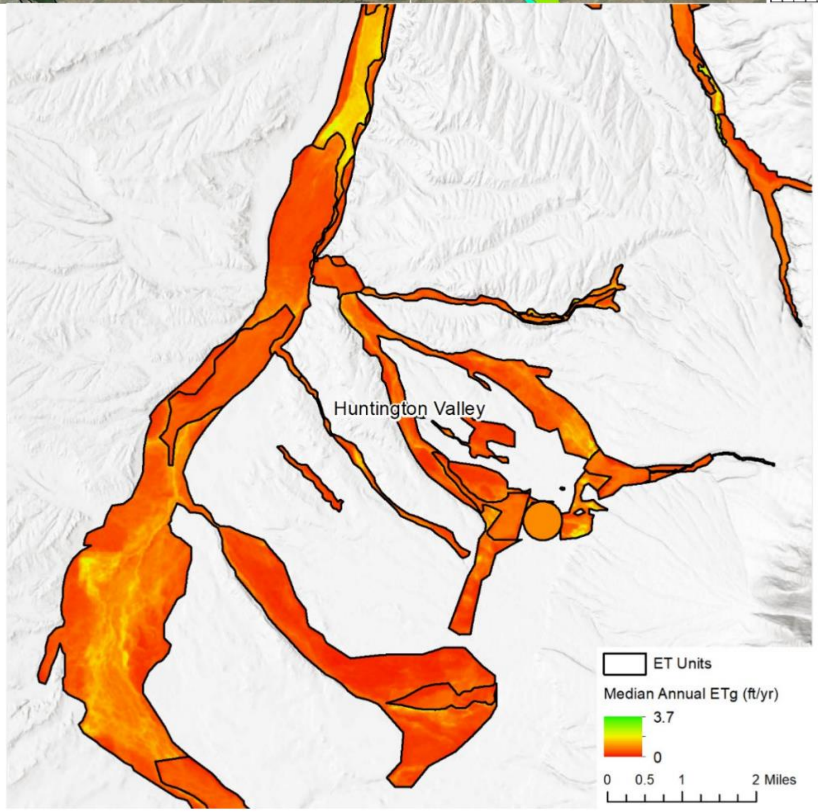
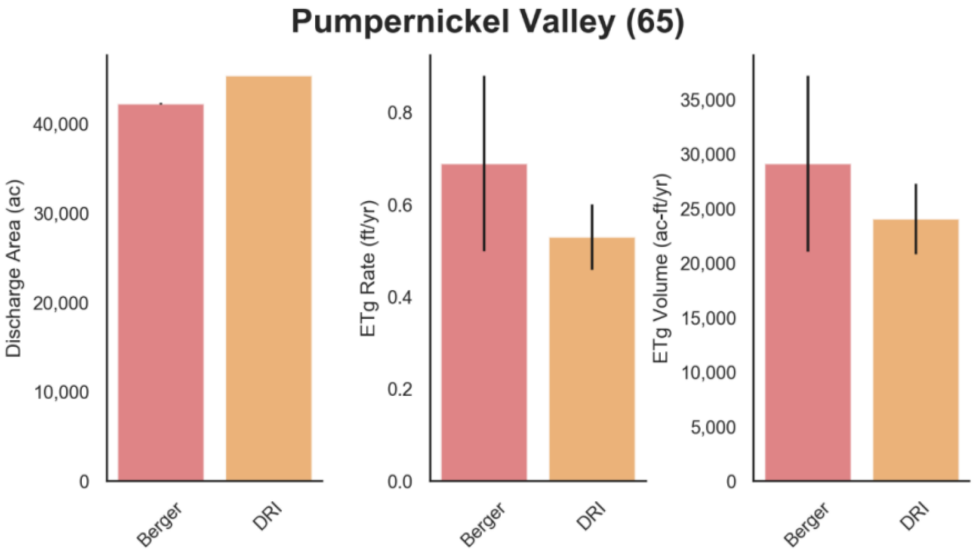
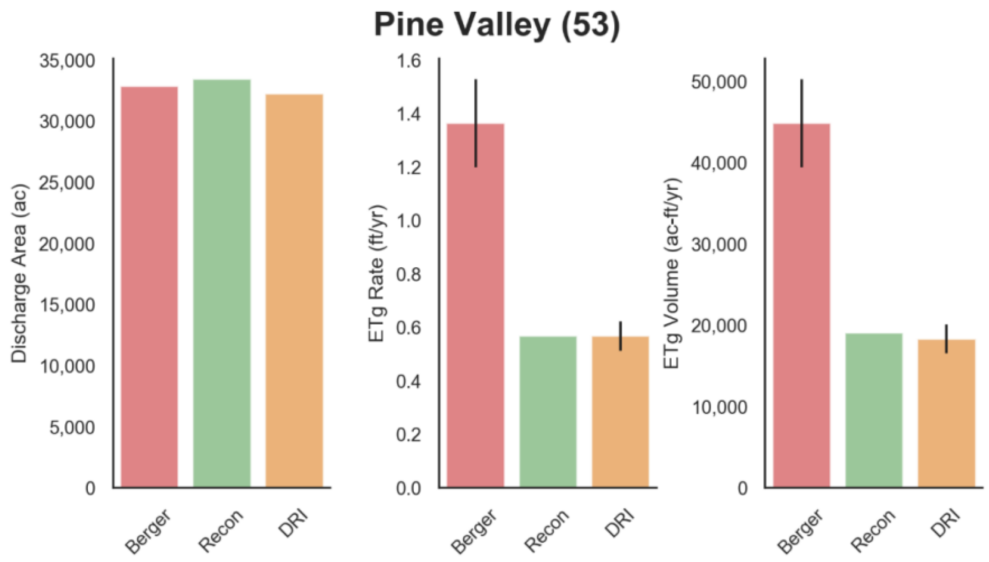
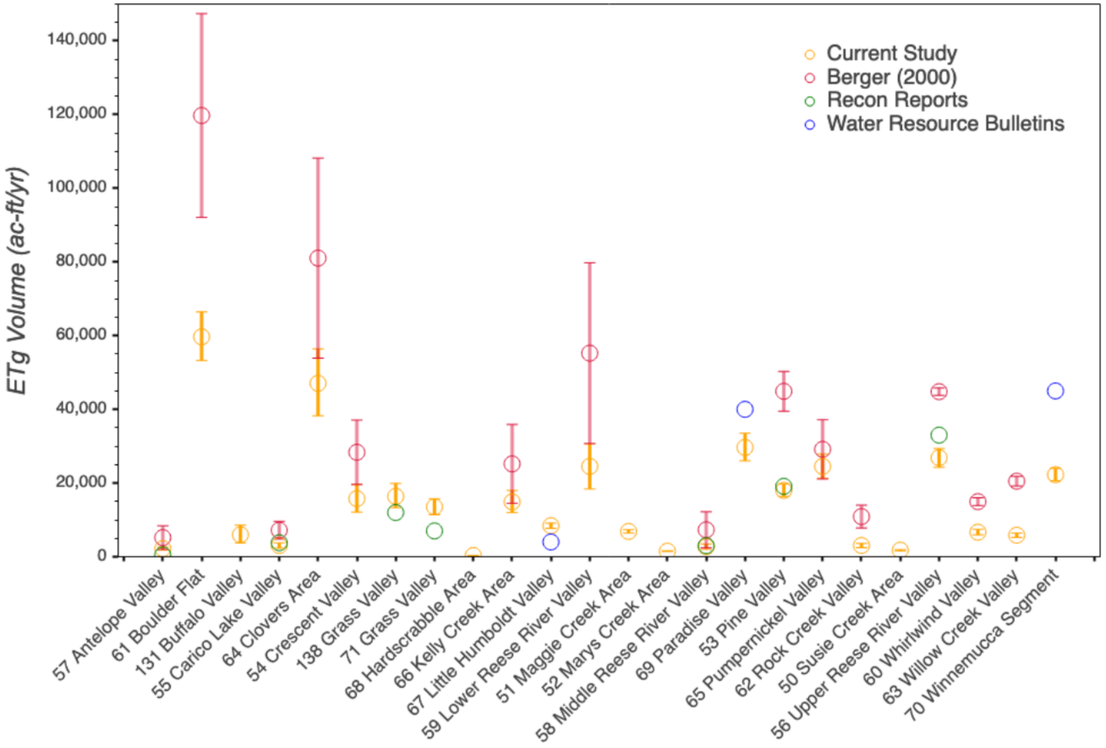


Figure 7b. Spatial distribution of ET Units and 1985-2015 median annual ETg rates for Huntington Valley, upper Humboldt River Basin.

Comparison to Previous Studies







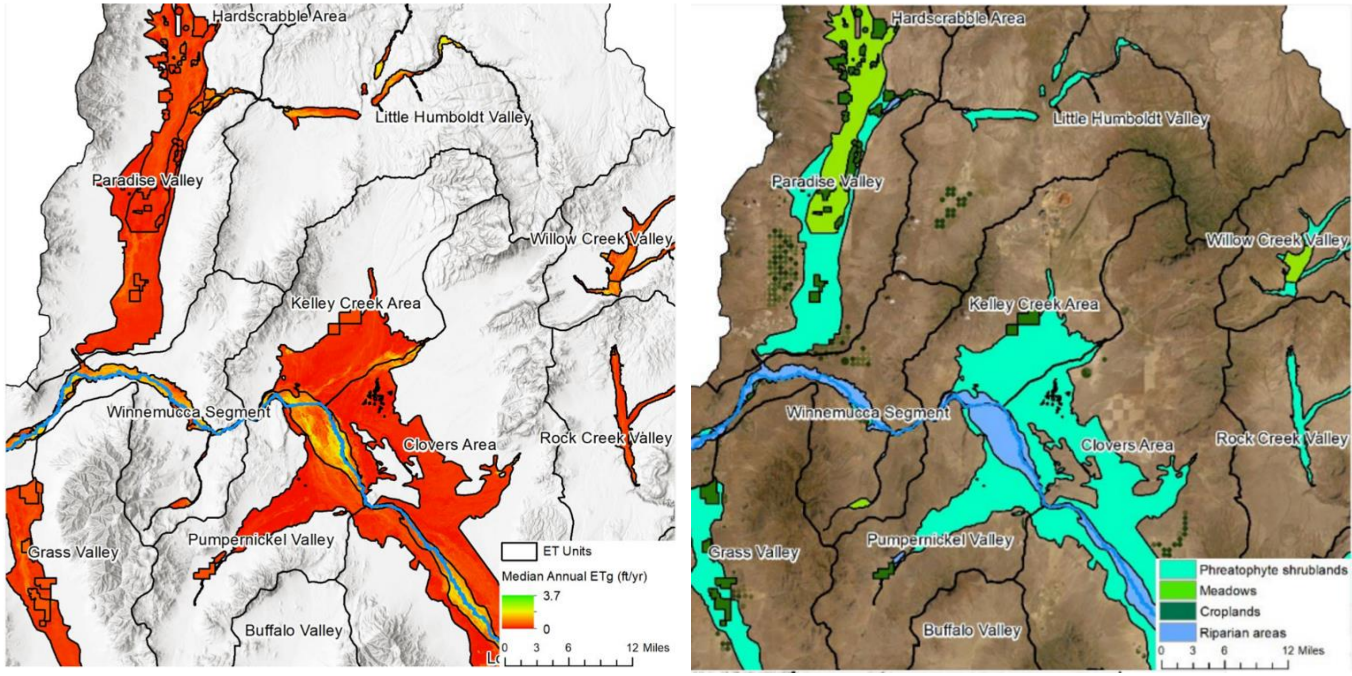


Figure 7c. Spatial distribution of ET Units and 1985-2015 median annual ETg rates for select HAs in the middle Humboldt River Basin.

Report and Data Access

Desert Research Institute

Groundwater Discharge from Phreatophyte Vegetation, Humboldt River Basin, Nevada

Justin Huntington
Matthew Bromley
Blake Minor
Charles Morton
Guy Smith

February 2022

Publication No. 41288

Prepared by
Division of Hydrologic Sciences, Desert Research Institute

Prepared for
Nevada Department of Conservation and Natural Resources, Division of Water Resources

dri.edu/project/humboldt-etg/

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Project Description

Groundwater evapotranspiration (ETg) from phreatophyte vegetation is the primary component of natural groundwater discharge within the Humboldt River Basin. This report summarizes previous study estimates of ETg, and details methods and results of updated groundwater discharge areas, ETg rates, and ETg volume estimates developed in this study. Estimates derived in this study are summarized for the period of 1985-2015 and were based on a consistent place-based approach that relies on Geographic Information System and groundwater level data and a least-squares regression model that relates Landsat vegetation indices with evaporative demand, precipitation, and in-situ estimates of phreatophyte ET. Median annual ETg rates and volumes reported in this study are representative of pre-development conditions. Where irrigated areas were identified, ETg rates were adjusted to reflect the phreatophyte vegetation that likely occupied irrigated areas prior to cultivation. Results from this study were used to inform groundwater modeling studies by the U.S. Geological Survey and the Desert Research Institute, in cooperation with Nevada Division of Water Resources, to support conjunctive water management.

Results and datasets are summarized and documented in the form of maps, graphs, tables, geodatabases, and metadata following Federal Geographic Data Committee standards and are available at www.dri.edu/humboldt-etg. Estimated pre-development total annual ETg volumes for the upper, middle, and lower Humboldt River basin are 158,500, 361,600, 55,900 ac-ft/yr, and 85,700, 248,400, and 46,100 ac-ft/yr when riparian lands are excluded, respectively. Discharge areas and median annual ETg rates and volumes were compared to previous estimates for respective ET Units and Hydrographic Areas. Results reported for the upper Humboldt River Basin indicate that potential areas of groundwater discharge are generally lower, and ETg rates and volumes are generally less than one half of the ETg rates and volumes reported by Plume and Smith (2013). Results reported for the middle Humboldt River Basin indicate that ETg volumes are higher in six, and lower in seven HAs when compared to previous estimates reported in Water Resource Bulletin and Reconnaissance Series reports. ETg rates and volumes in the middle Humboldt River Basin are also generally less than one half when compared to those reported by Berger (2000). Differences in ETg volumes are primarily due to differences in ETg rates and differences in groundwater discharge areas.

This study used place-based satellite remote sensing, climate and GIS datasets, groundwater levels, and in-situ based phreatophyte ET empirical regression models to estimate potential areas of groundwater discharge, and ETg rates and volumes within the Humboldt River Basin. Future study estimates of ETg within the Humboldt River Basin could be improved by refining delineation of groundwater discharge areas, variability in ETg with respect to climate and land use change, and collection of in-situ ET estimates in areas where large uncertainty exists.

Report – Groundwater Discharge from Phreatophyte Vegetation, Humboldt River Basin, Nevada

Appendix A – Previously Reported Groundwater Discharge Areas, ETg Rates, ETg Volumes, and Study Source Information

Appendix B – Meteorological Station Mean Annual Ratios of Station Calculated ASCE Grass Reference ET (ETo) to Estimated Gridmet ETo

Appendix C – Percent Change in Median ETg for Select Basins

Appendix D – Groundwater Discharge Areas and Median ETa Volumes for Each ET Unit and HA

Appendix E Part 1 – Annual time series of median EVI, ET, ETg, ETo, and PPT rates from 1985-2015 for all groundwater discharge areas inclusive of riparian discharge areas

Appendix E Part 2 – Annual time series of median EVI, ET, ETg, ETo, and PPT rates from 1985-2015 for groundwater discharge areas excluding riparian discharge areas

Appendix F – Bar Charts Illustrating Estimated Discharge Areas, ETg Rates, and ETg Volumes

GIS Data – Potential areas of groundwater discharge

GIS Data – Geotiff raster of median annual groundwater evapotranspiration

GIS Data – Groundwater discharge areas digitized from NDWR Water Resource Bulletin and Reconnaissance Series reports

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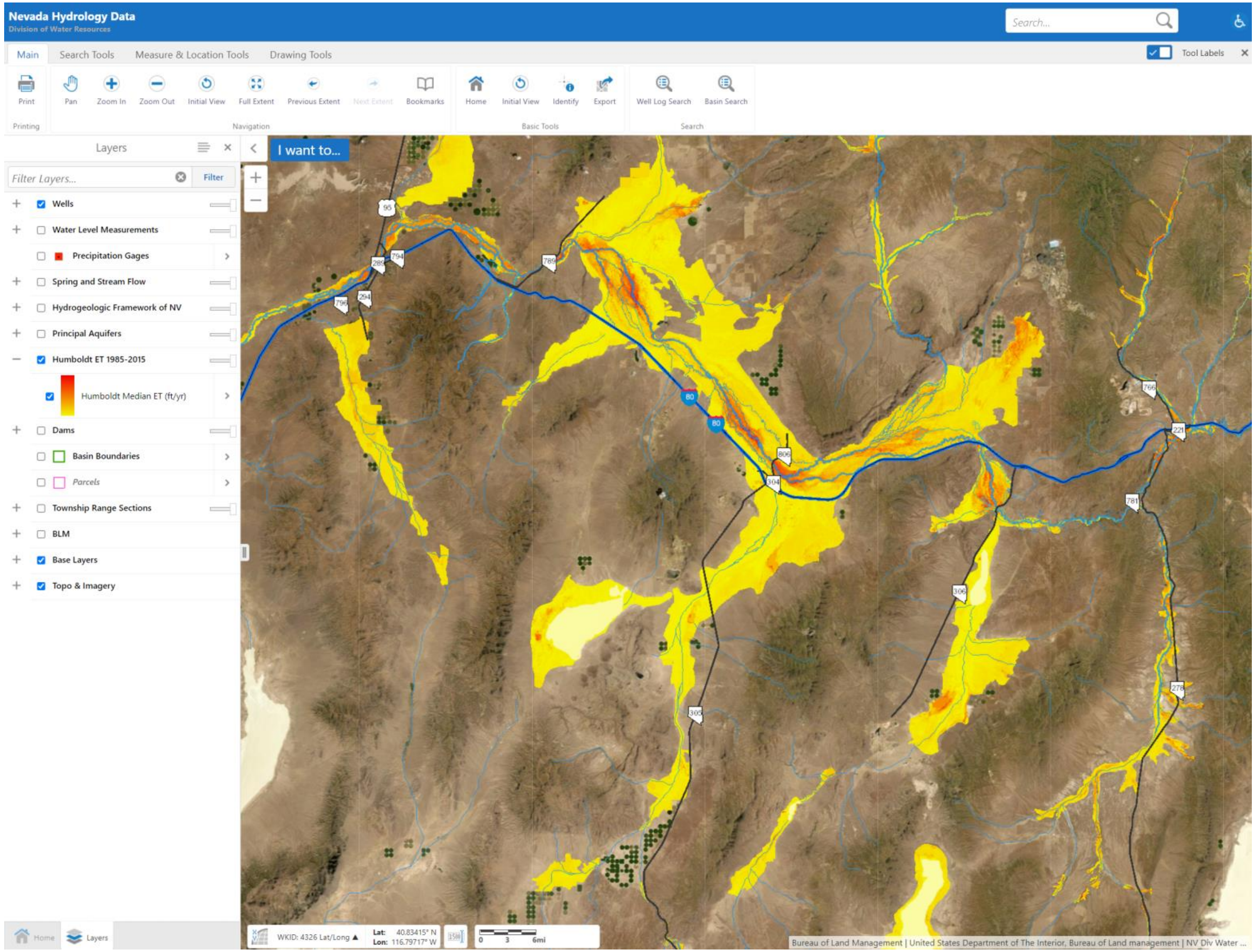
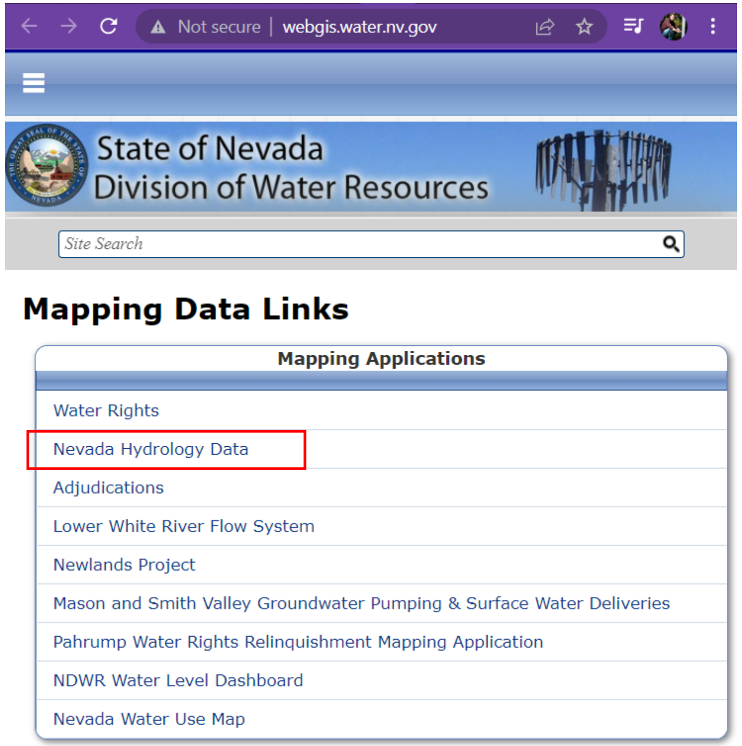
DIVISION
Hydrologic Sciences

https://www.dri.edu/humboldt-etg

Report and Data Access





IQR code

http://webgis.water.nv.gov/ -> **Nevada Hydrology Data**

Appendix D. Groundwater discharge areas and median ETg volumes for each ET Unit and HA.

Hydrographic Area	Hydrographic Area Number	Basin	Phreatophyte		Riparian		Meadow		Irrigated Cropland		Bare Soil		Total		Total w/o Riparian	
			Area (acres)	ETg Volume (ac-ft/yr)	Area (acres)	ETg Volume (ac-ft/yr)	Area (acres)	ETg Volume (ac-ft/yr)	Area (acres)	ETg Volume (ac-ft/yr)	Area (acres)	ETg Volume (ac-ft/yr)	Area (acres)	ETg Volume (ac-ft/yr)	Area (acres)	ETg Volume (ac-ft/yr)
Antelope Valley	57	Middle	6,533	1,499	-	-	-	-	2,285	703	-	-	8,818	2,202	8,818	2,202
Boulder Flat	61	Middle	63,914	28,698	31,352	30,195	-	-	1,541	793	72	4	96,878	59,690	65,526	29,495
Buffalo Valley	131	Middle	35,557	5,460	-	-	-	-	-	-	10,106	506	45,662	5,965	45,662	5,965
Carico Lake Valley	55	Middle	10,020	2,665	-	-	229	153	306	181	771	39	11,326	3,038	11,326	3,038
Clovers Area	64	Middle	107,969	28,959	15,640	17,863	-	-	536	225	409	20	124,554	47,067	108,914	29,205
Crescent Valley	54	Middle	54,774	13,820	1,164	775	-	-	782	995	3,826	191	60,546	15,782	59,382	15,007
Dixie Creek-Tenmile Creek Area	48	Upper	5,423	3,652	2,153	1,620	4,176	2,803	-	-	-	-	11,751	8,075	9,599	6,455
Elko Segment	49	Upper	790	440	11,069	13,297	164	117	1,129	1,503	-	-	13,151	15,356	2,082	2,059
Grass Valley (138)	138	Middle	45,275	14,238	-	-	857	522	754	464	23,055	1,154	69,941	16,377	69,941	16,377
Grass Valley (71)	71	Middle	31,648	10,413	-	-	-	-	6,435	3,136	-	-	38,083	13,549	38,083	13,549
Hardscrabble Area	68	Middle	-	-	532	341	-	-	-	-	-	-	532	341	0	0
Huntington Valley	47	Upper	16,751	9,584	3,705	3,385	11,724	5,802	256	241	-	-	32,436	19,011	28,731	15,626
Imlay Area	72	Lower	27,263	3,420	6,554	6,646	-	-	-	-	-	-	33,817	10,066	27,263	3,420
Kelley Creek Area	66	Middle	38,841	9,694	3,381	4,286	-	-	2,486	905	38	2	44,745	14,887	41,364	10,600
Lamoille Valley	45	Upper	8,368	7,670	2,941	3,718	14,255	9,689	884	923	-	-	26,448	22,000	23,507	18,282
Little Humboldt Valley	67	Middle	8,895	7,166	1,910	1,251	1	1	-	-	-	-	10,806	8,418	8,896	7,167
Lovelock Valley	73	Lower	54,250	13,616	3,062	3,122	-	-	45,524	27,614	11,745	588	114,581	44,940	111,519	41,818
Lovelock Valley (Oreana Subarea	73A	Lower	3,221	854	74	38	-	-	-	-	-	-	3,294	891	3,221	854
Lower Reese River Valley	59	Middle	85,284	17,313	7,071	5,732	-	-	2,893	1,478	3	0	95,251	24,523	88,180	18,791
Maggie Creek Area	51	Middle	1,735	903	6,316	5,644	-	-	301	316	-	-	8,352	6,862	2,036	1,219
Marys Creek Area	52	Middle	-	-	1,280	1,445	85	69	-	-	-	-	1,365	1,515	85	69
Marys River Area	42	Upper	13,897	7,001	22,833	23,357	6,369	4,956	4,584	1,813	-	-	47,684	37,126	24,851	13,769
Middle Reese River Valley	58	Middle	10,930	2,514	-	-	-	-	434	188	4	0	11,368	2,702	11,368	2,702
North Fork Area	44	Upper	15,288	6,401	8,838	7,887	12,153	7,171	2,154	1,918	-	-	38,433	23,378	29,595	15,490
Paradise Valley	69	Middle	43,114	12,126	744	608	39,685	12,404	13,004	4,530	-	-	96,547	29,668	95,803	29,060
Pine Valley	53	Middle	25,581	13,201	1,436	1,166	3,186	1,700	2,072	1,947	-	-	32,274	18,015	30,838	16,849
Pumpernickel Valley	65	Middle	29,835	7,006	14,375	17,028	-	-	1,170	480	14	1	45,394	24,514	31,019	7,487
Rock Creek Valley	62	Middle	9,006	2,978	-	-	-	-	98	64	-	-	9,104	3,042	9,104	3,042
South Fork Area	46	Upper	520	472	3,600	4,561	5,579	3,703	-	-	-	-	9,698	8,736	6,098	4,175
Starr Valley Area	43	Upper	4,820	3,280	11,889	14,935	11,965	6,231	684	362	-	-	29,358	24,808	17,468	9,873
Susie Creek Area	50	Middle	7	6	2,574	1,756	39	17	-	-	-	-	2,620	1,778	46	23
Upper Reese River Valley	56	Middle	41,595	25,846	-	-	50	72	1,337	961	-	-	42,982	26,879	42,982	26,879
Whirlwind Valley	60	Middle	6,874	2,347	4,084	4,308	-	-	-	-	-	-	10,958	6,655	6,874	2,347
Willow Creek Valley	63	Middle	6,944	3,653	-	-	3,584	2,186	-	-	-	-	10,528	5,839	10,528	5,839
Winnemucca Segment	70	Middle	1,684	749	19,351	20,821	848	310	480	399	-	-	22,362	22,279	3,011	1,457
Totals			**816,604**	**267,641**	**187,925**	**195,784**	**114,946**	**57,907**	**92,127**	**52,138**	**50,042**	**2,504**	**1,261,643**	**575,974**	**1,073,718**	**380,189**

Appendix D is the result of

1. computing the spatial average ETg rate for each ET Unit for each year as a table of values
2. reading the table of spatial average ETg rates for each year, and computing the temporal median for each ET Unit
3. multiplying the temporal median ETg rate by respective ET Unit areas to produce volumes
4. summing the median ETg volumes across all ET Units, and all ET Units less riparian.

Summary

- The purpose of this study was to develop and summarize new groundwater discharge areas, ETg rates, and ETg volumes within the Humboldt River Basin using best available science.

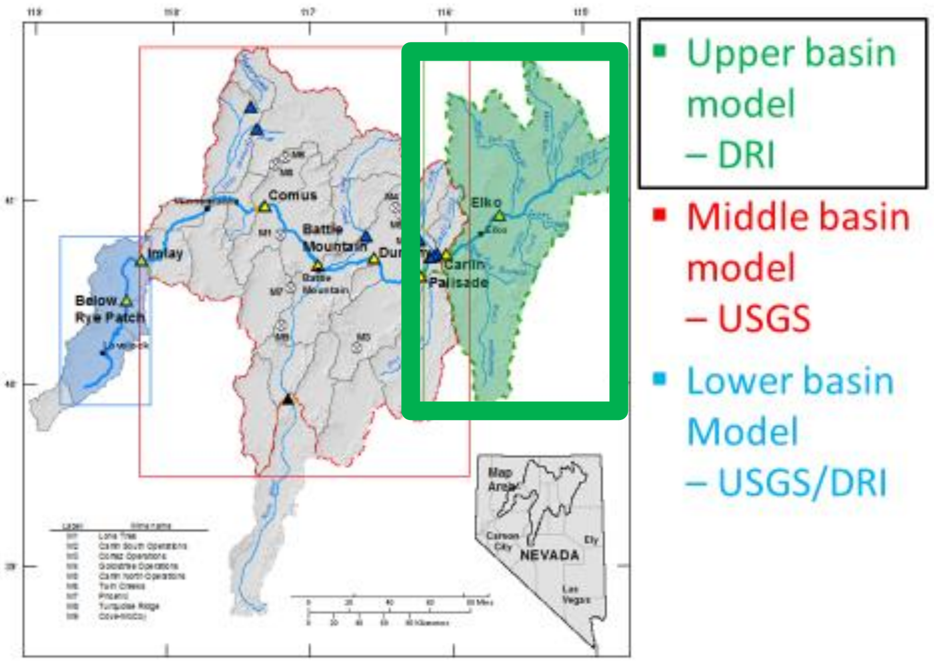
- The approaches applied in this study to estimate ETg were based on state-of-the-art satellite remote sensing, climate modeling, GIS datasets, groundwater levels, and in-situ ET estimates from phreatophyte vegetation in the Great Basin
  - Delineated and revised potential areas of groundwater discharge
  - Estimated ETg rates from phreatophyte vegetation using a measurement-based regression model

- Summarize ETg rates and volumes by land cover type (e.g. phreatophyte, riparian, meadow) and compared to previous studies

- Provided results to USGS and DRI groundwater modeling teams for integration into models

- Produced a technical report and GIS data that are publicly available - https://www.dri.edu/humboldt-etg

Upper Humboldt River Basin Model



DRI

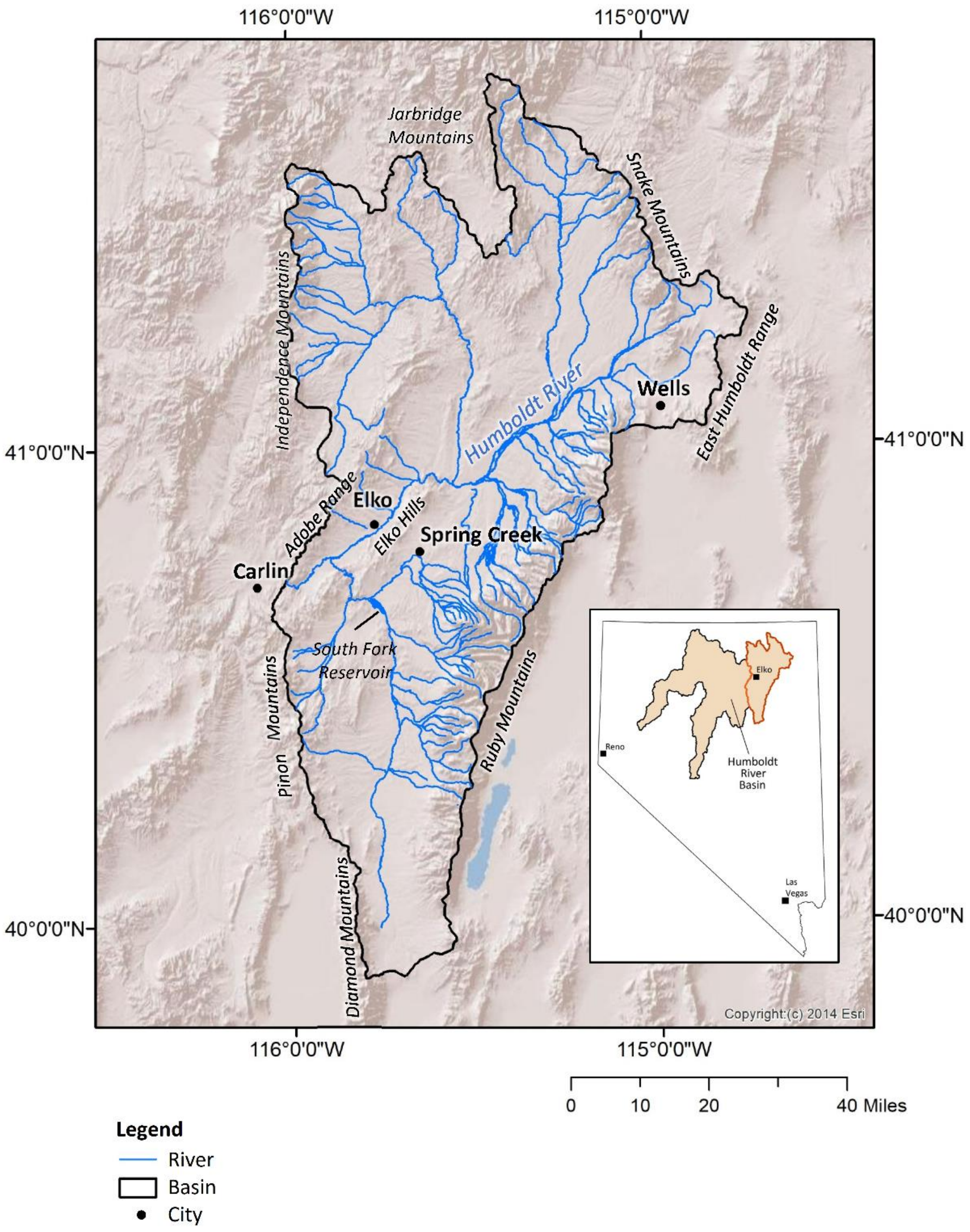
Upper Humboldt River Capture Model

Rosemary Carroll

Desert Research Institute

Humboldt Stakeholder Meeting

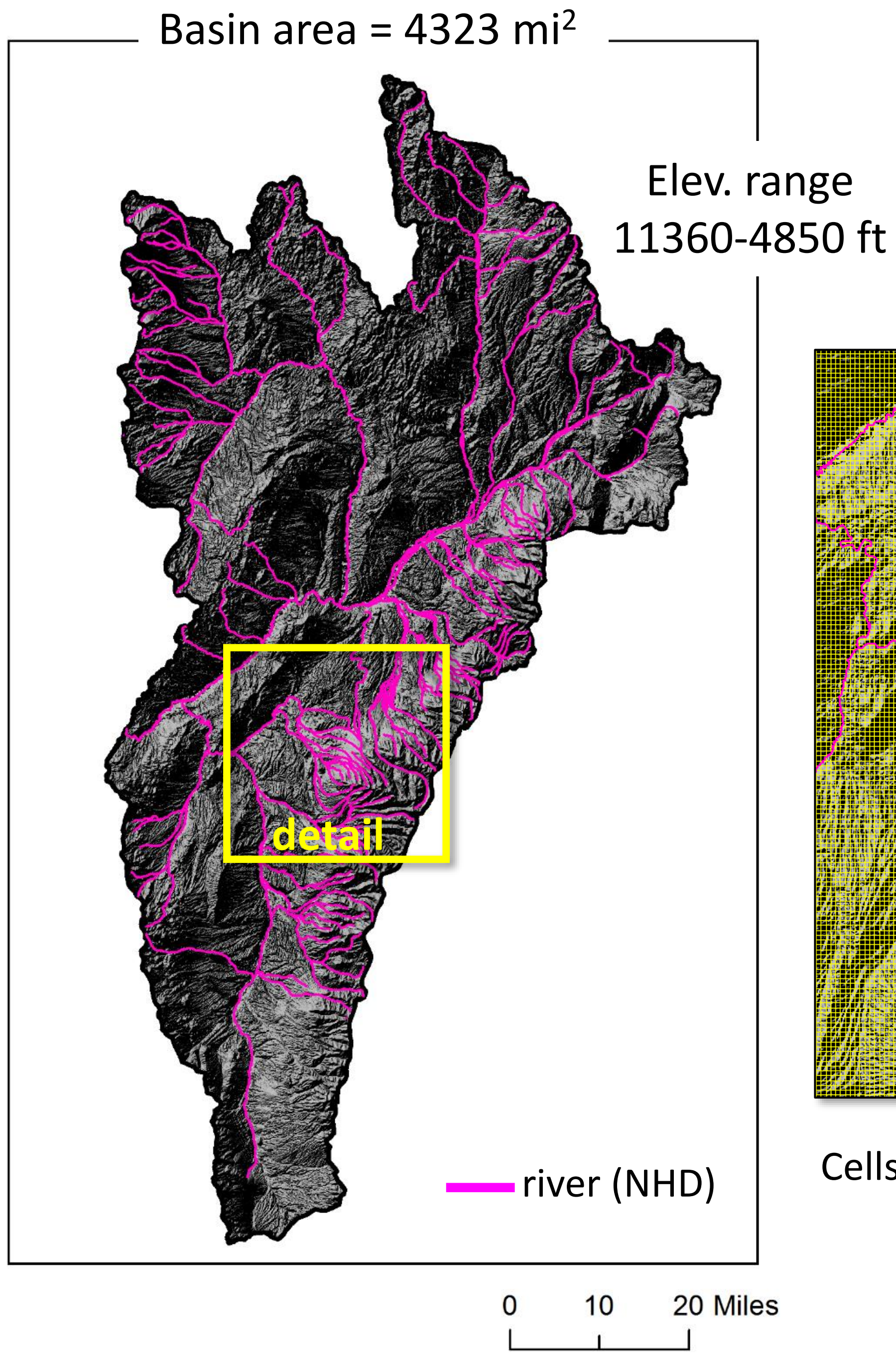
March 8-9, 2022

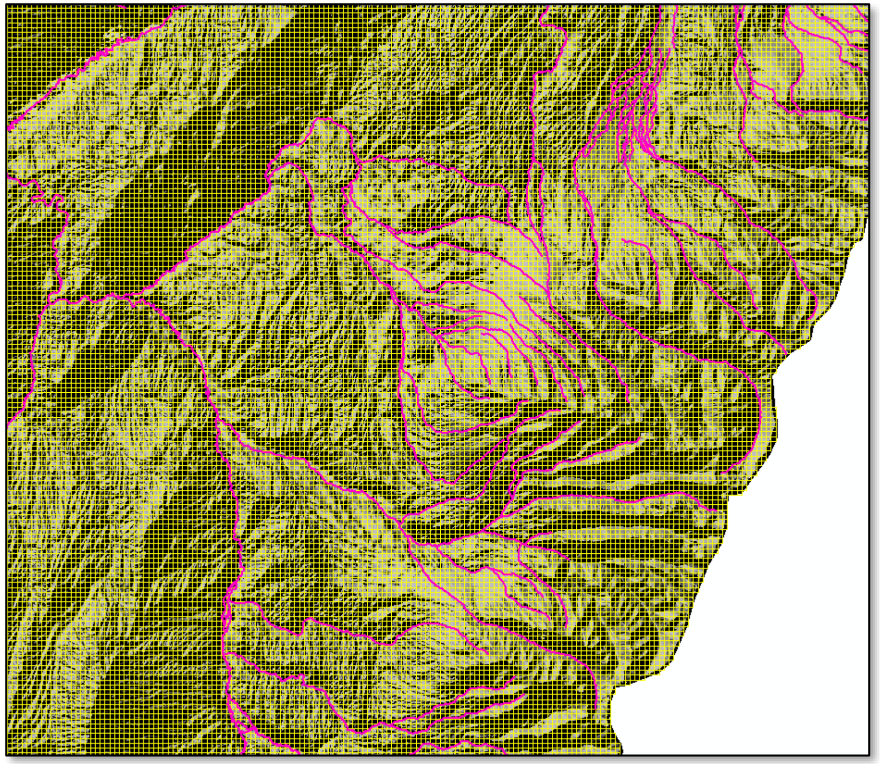


Outline

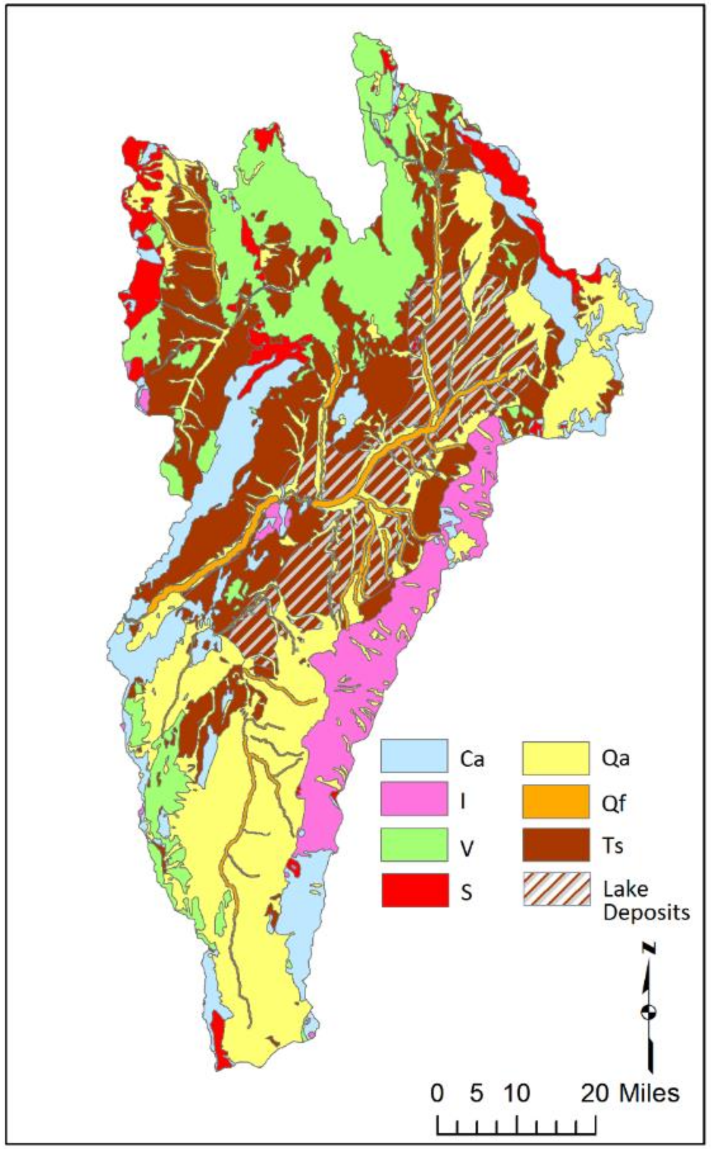
- Upper Basin Modeled Characteristics
- Water Budget
- Capture
  - Historical (1960-2016)
  - Predictive (2017-2116)
  - Analysis
- Project Status

Model Characteristics



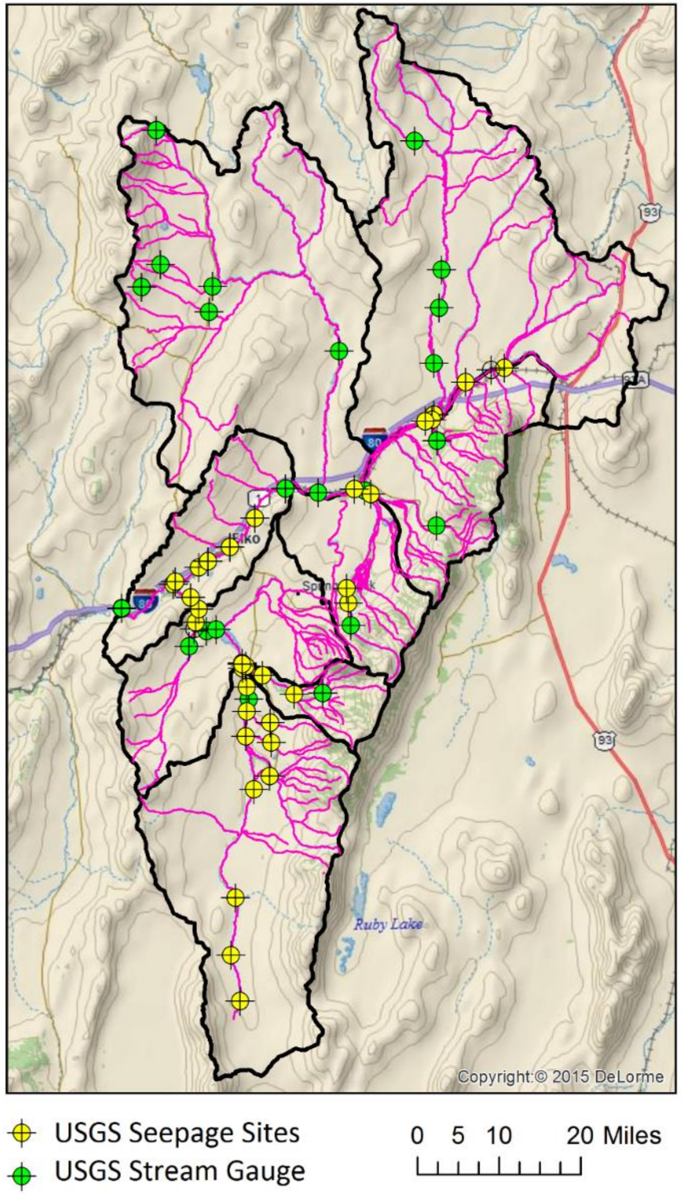


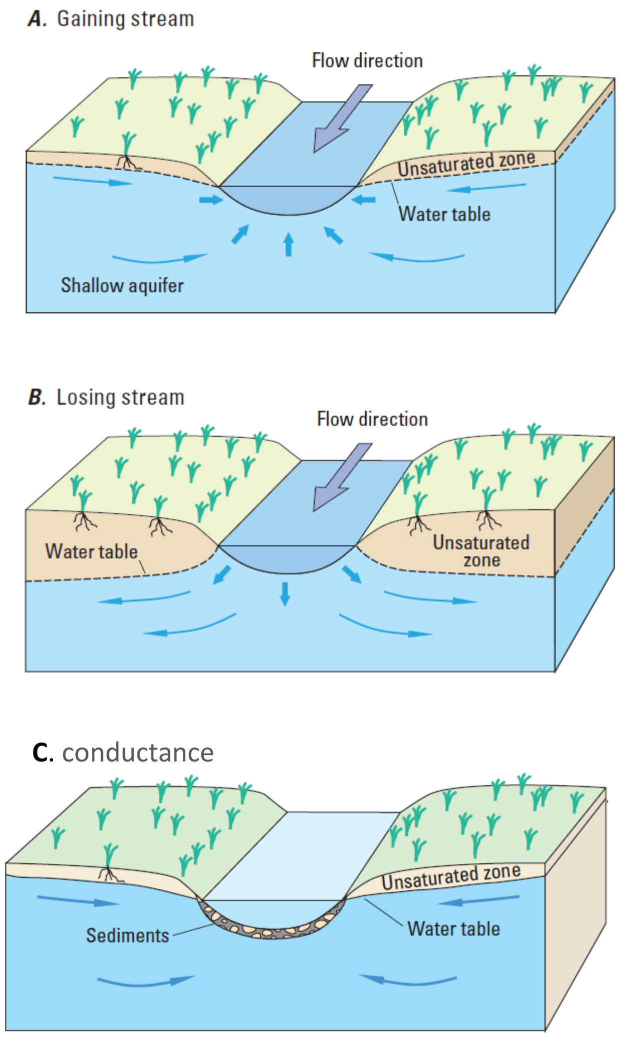
Cells 900 ft x 900 ft: ~half a million active cells



Simulating Rivers

- MODFLOW RIV package
- Allows gaining and losing based on water table elevation.
- Does not allow for ephemeral conditions.
- Riverbed conductance calibrated to match observed streamflow
- Riverbed conductance is important to estimated stream capture.





Stream with streambed and streambank sediments less permeable than surrounding aquifer sediments.

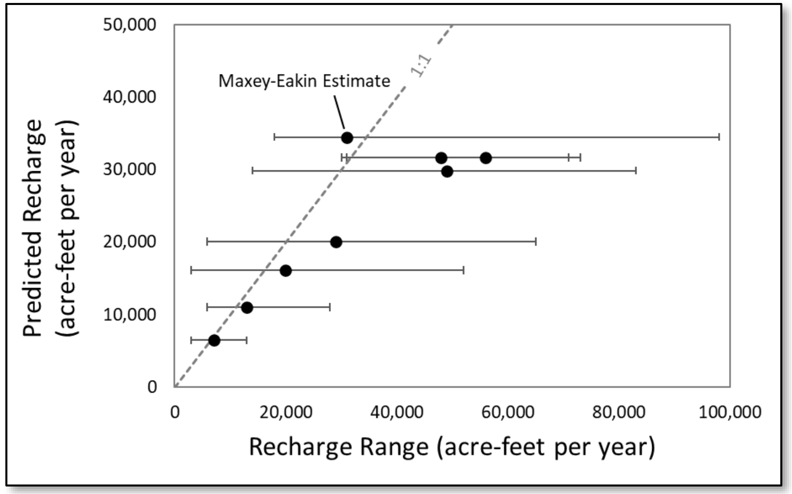
Barlow and Leake, 2012

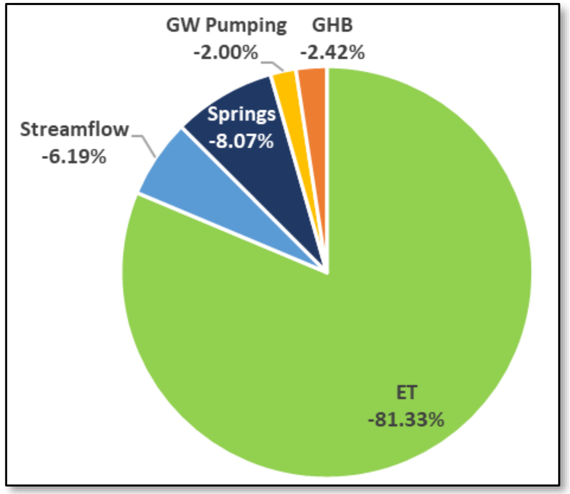
Pre-GW Development Water Budget

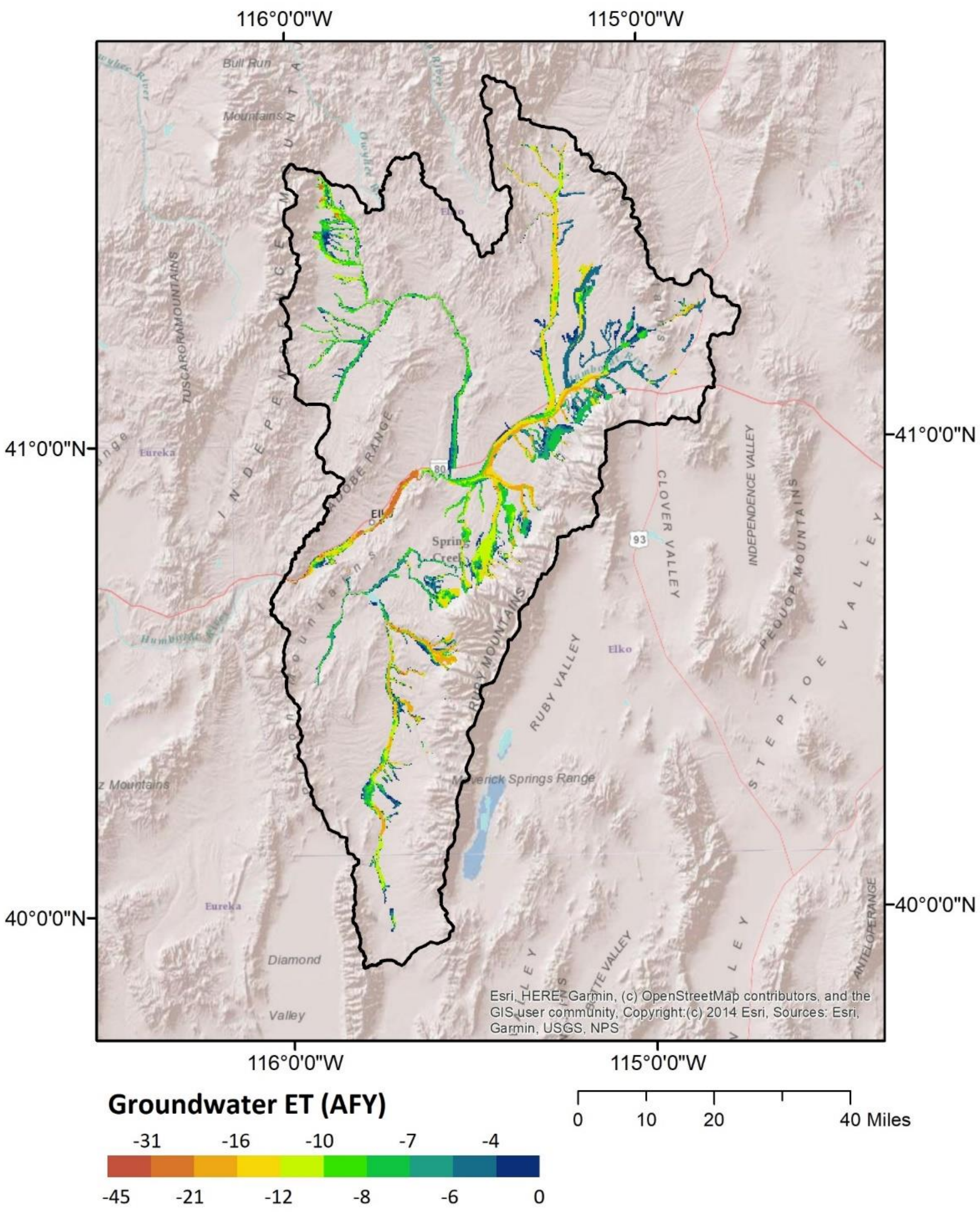
<u>Inflows:</u> Recharge adjusted at hydrographic basin scale to match estimated outflows.

- Previous Studies: 147,300-470,000 AFY
- Updated Maxey-Eakin: 253,000 AFY
- Simulated Total=177,443 AFY

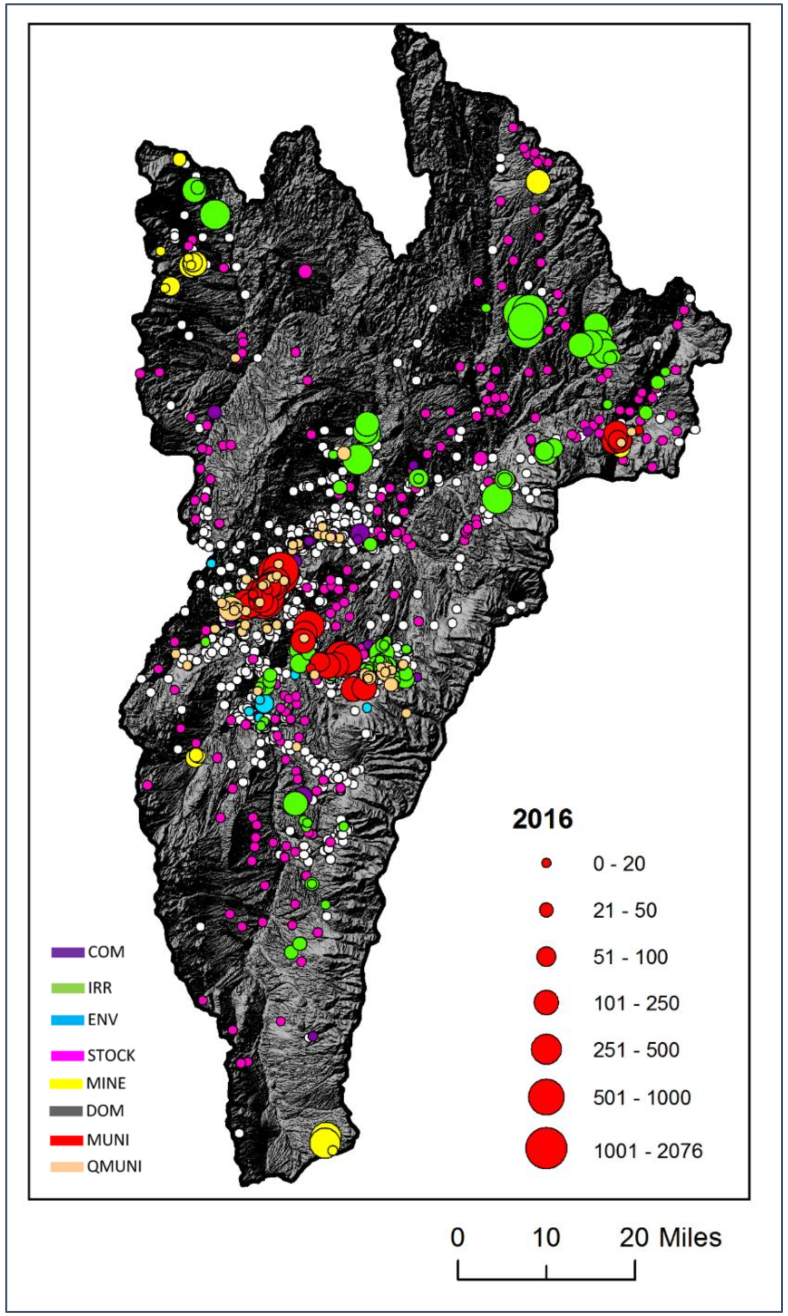
<u>Outflows</u>: Streamflow, springs, interbasin gw flow and phreatophyte Evapotranspiration (ET)

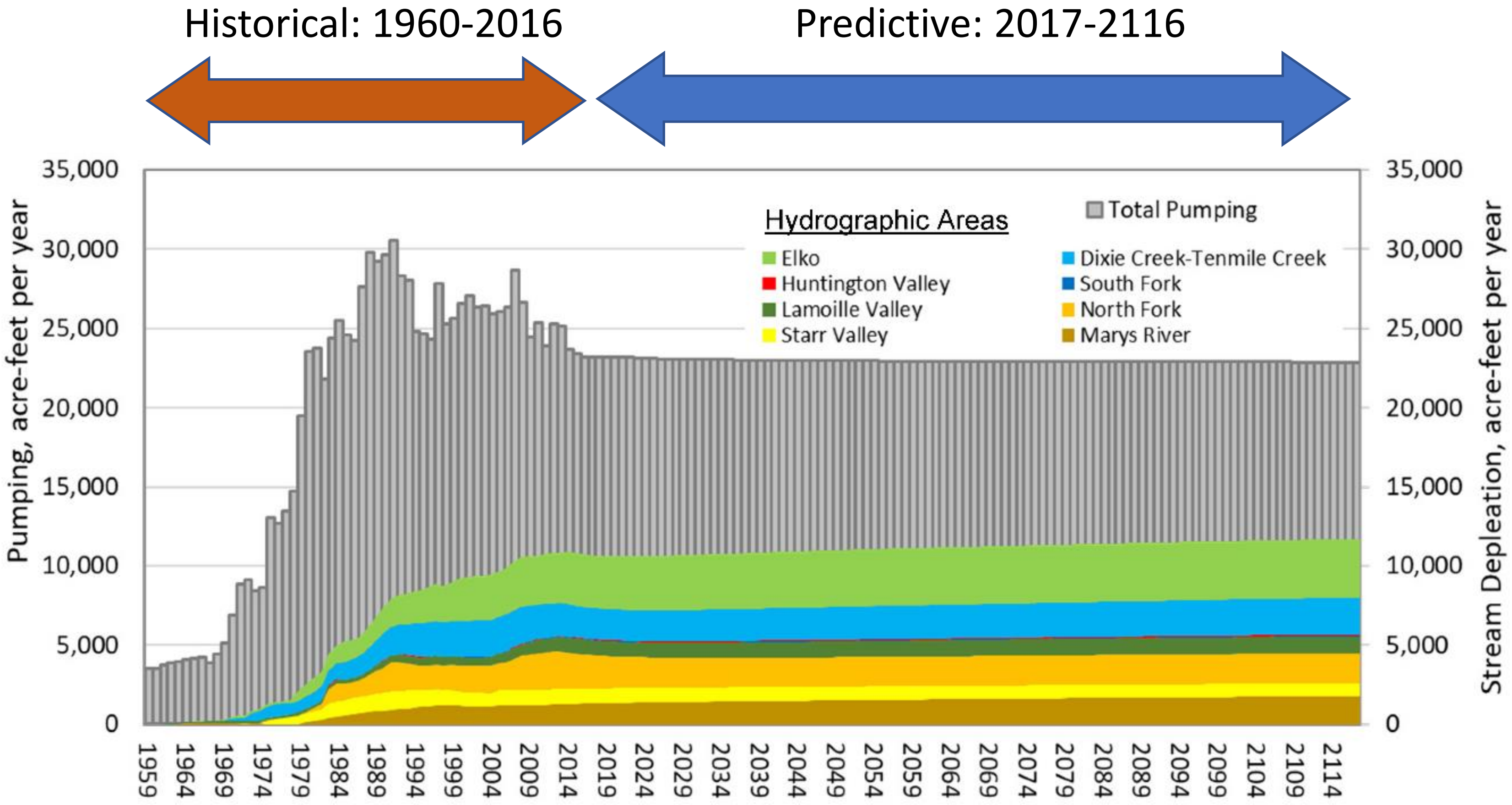






River Capture



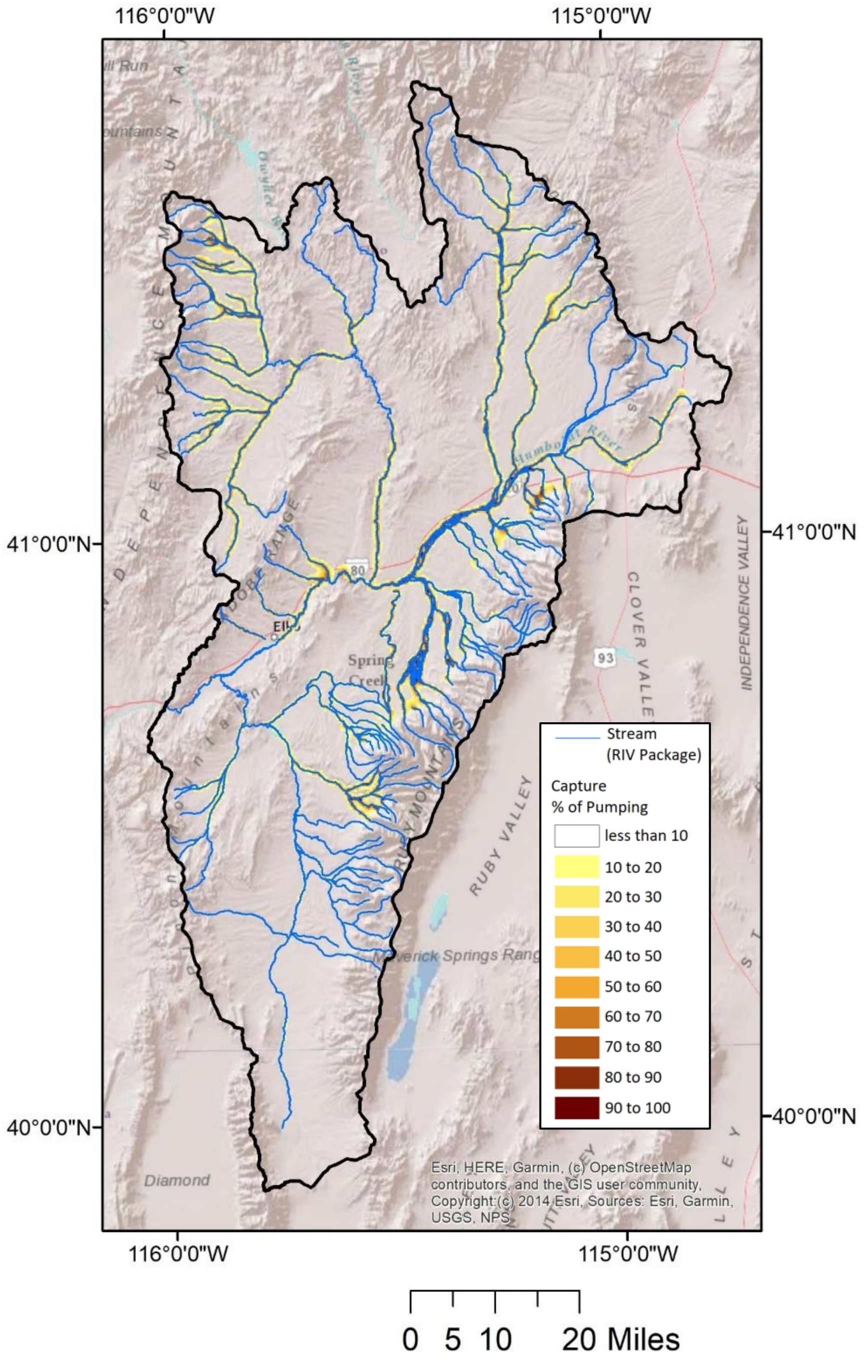


The amount of pumping in each basin explains a significant component of stream capture (r^2=0.65). The remaining variability is due to proximity to stream, subsurface hydraulic properties, riverbed permeability (conductance).

River Capture Maps

Year 1

- River capture to satisfy hypothetical pumping is very low & limited to locations immediately adjacent to a river.



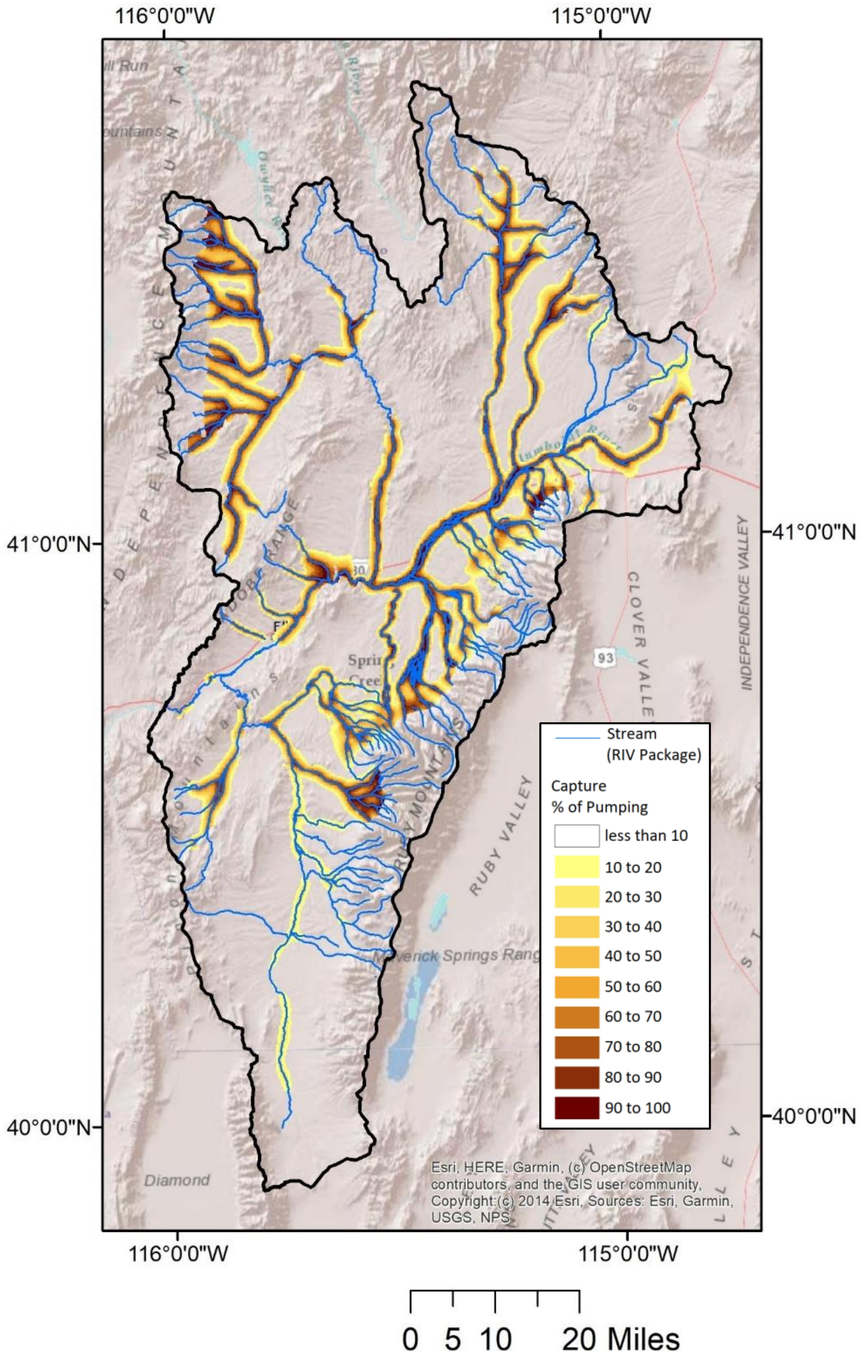
River Capture Maps

Year 1

- River capture to satisfy hypothetical pumping is very low & limited to locations immediately adjacent to a river.

Year 10

- Capture increases, expands away from the river and spatial variability along river reaches emerges.



River Capture Maps

Year 1

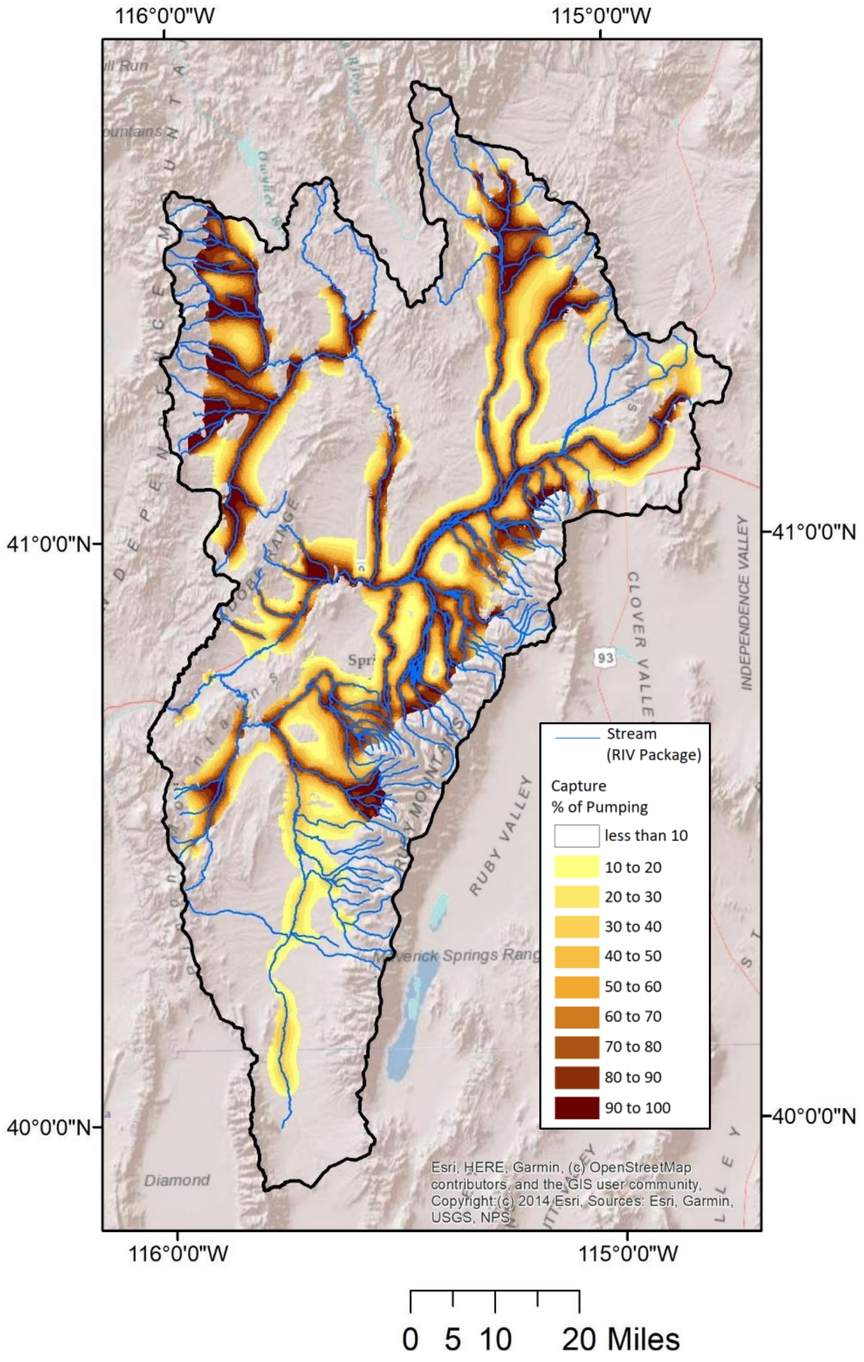
- River capture to satisfy hypothetical pumping is very low & limited to locations immediately adjacent to a river.

Year 10

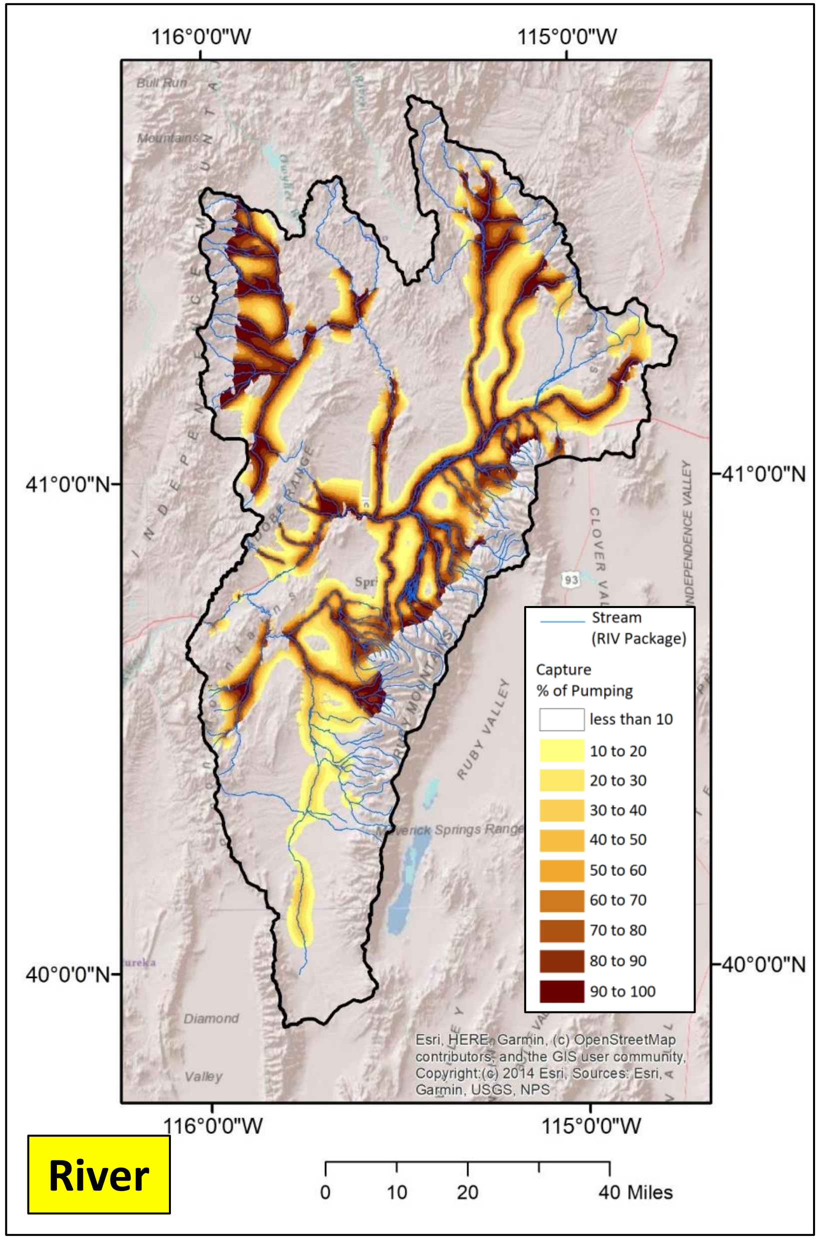
- Capture increases, expands away from the river and spatial variability along river reaches emerges.

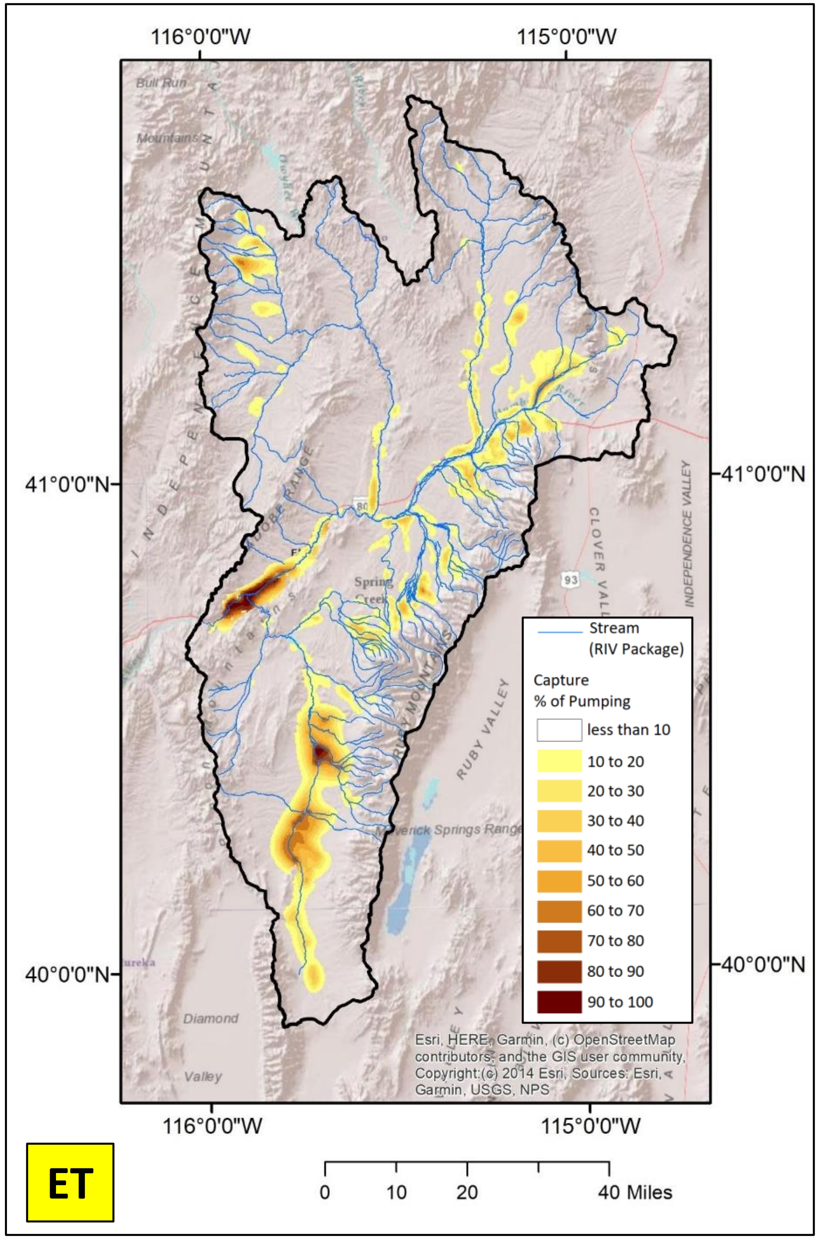
Year 50

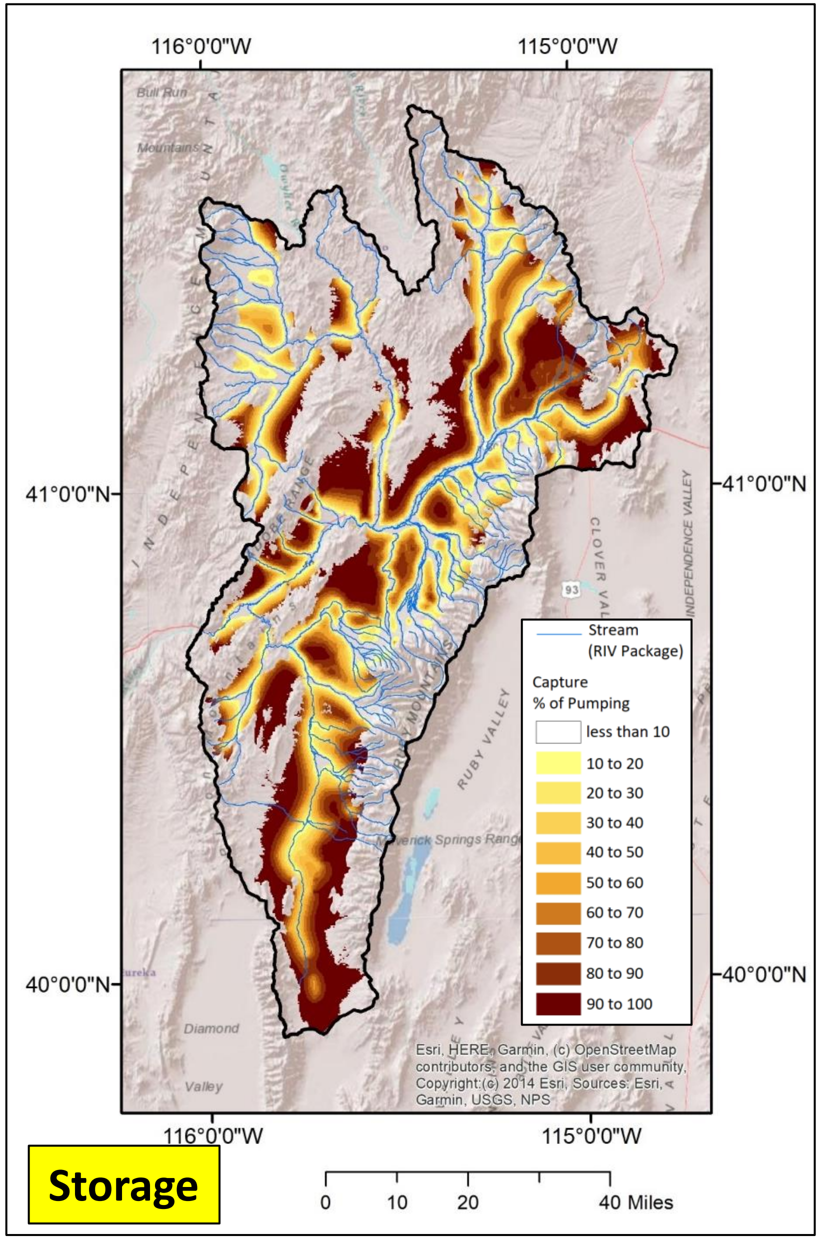
- Capture continues to increase and expand away from the river corridors
- Capture in dense stream networks merge.



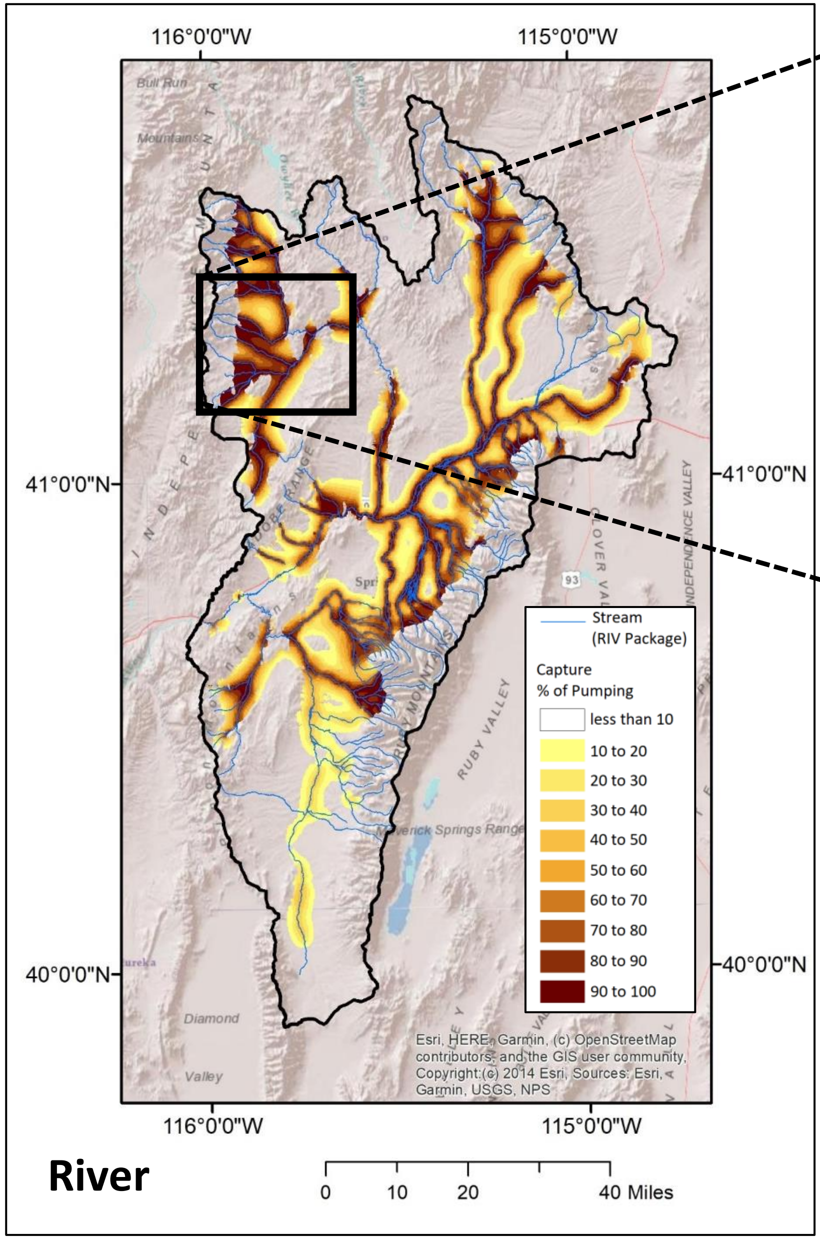
50-year Capture Maps

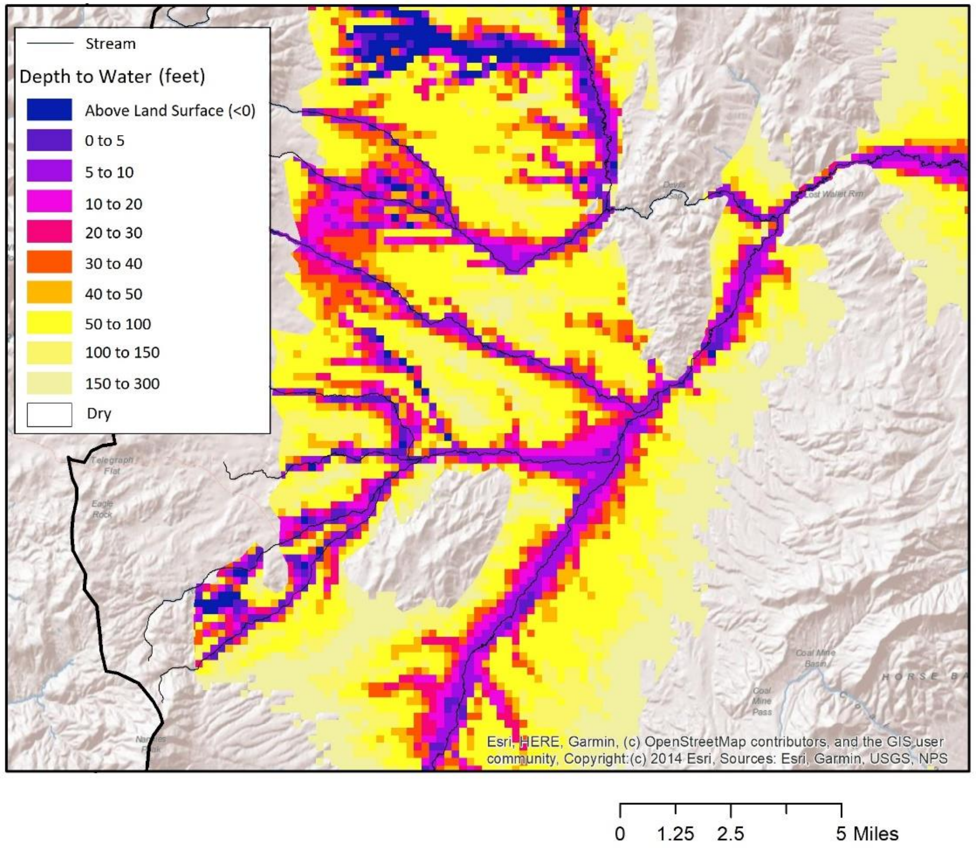






50-year Capture Maps

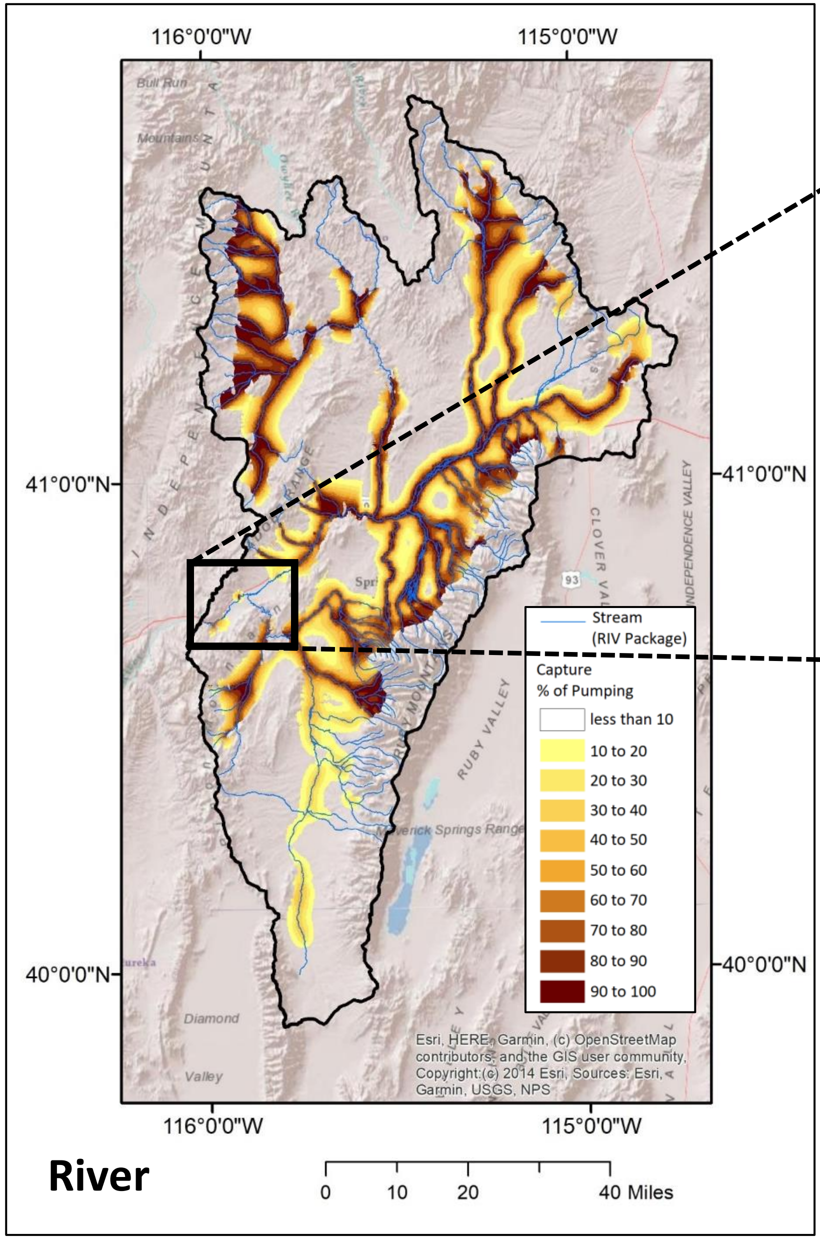


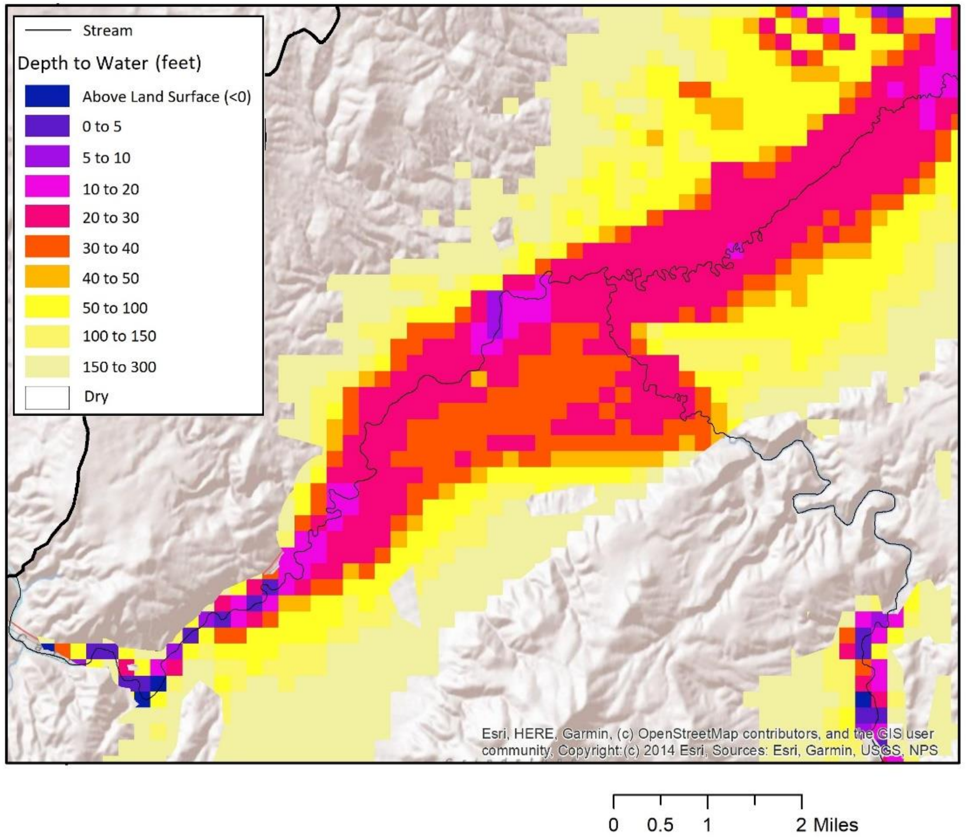


High River Capture (e.g. Independence Mountain Area)

- A lot of water
- shallow/daylighting groundwater
- Net gaining river reaches
- Very dense stream network
- *High simulated stream bed conductance*

50-year Capture Maps



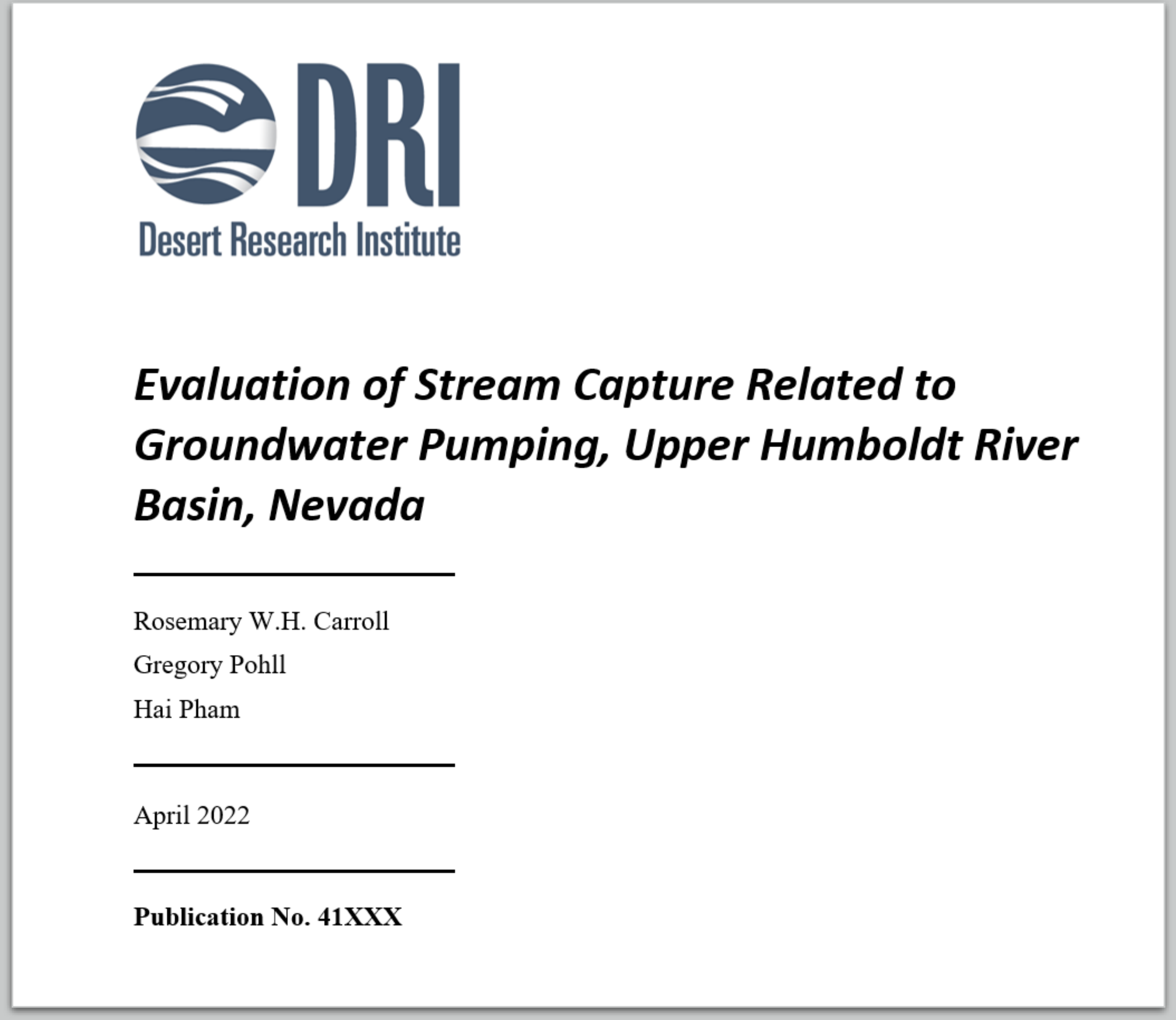


Low River Capture (e.g. Mid-Elko Segment)

- Groundwater deeper
- Losing river reach
- Sparse stream network
- Phreatophytes are more important
- *Low simulated stream bed conductance*

Project Status

- **Report written**: August 2021
- **Reviewed by Co-Authors**: September 2021
- **Internal & External Review**: October-November 2021
- **Report Revisions:** December 2021
- **Review by NDWR**: anticipate completion March 2022
- **Possible Revisions**: April 2022
- **Final Review**: May 2022.



DRI
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Evaluation of Stream Capture Related to Groundwater Pumping, Upper Humboldt River Basin, Nevada

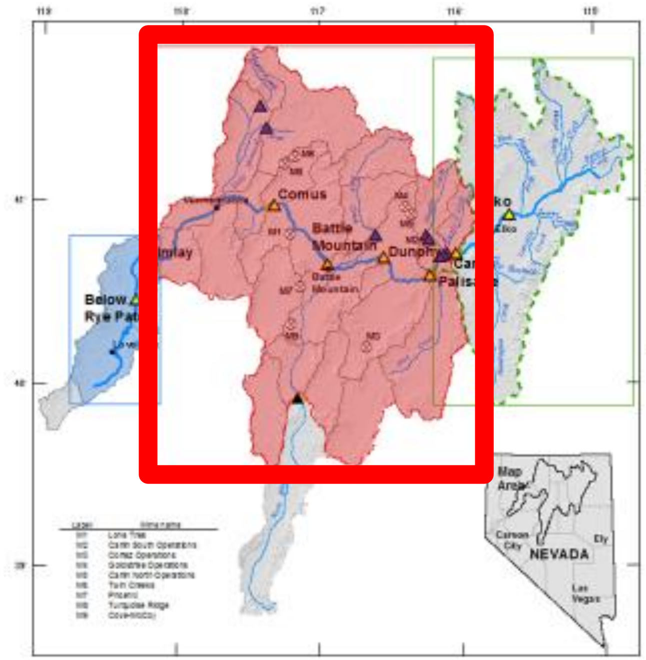
Rosemary W.H. Carroll
Gregory Pohll
Hai Pham

April 2022

Publication No. 41XXX


Questions

Middle Humboldt River Basin Model



- Upper basin model – DRI
- Middle basin model – USGS
- Lower basin Model – USGS/DRI

USGS

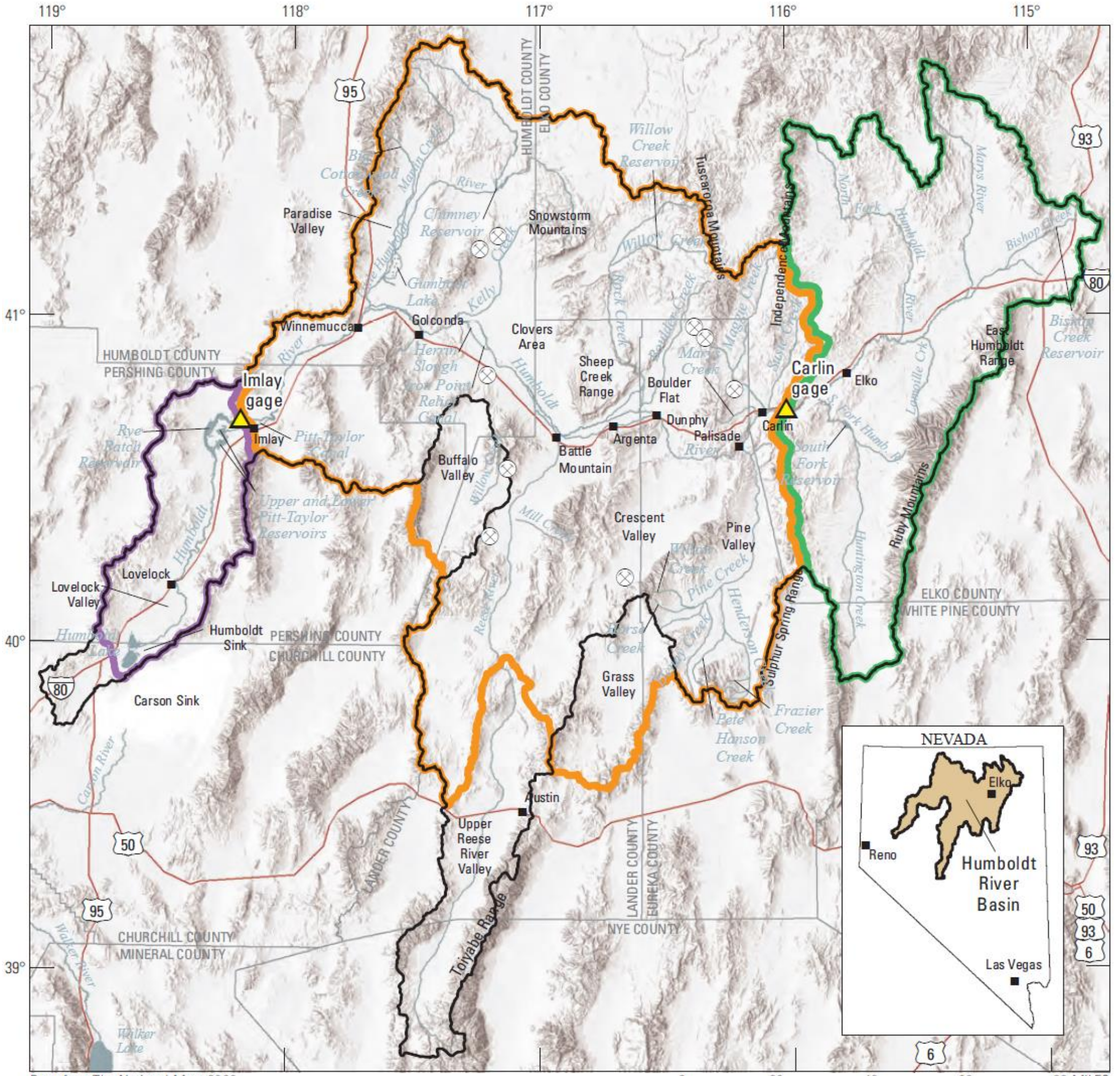
Middle Humboldt Capture Model

Middle Humboldt Team:
Kyle Davis, William Eldridge

USGS, Nevada Water Science Center

Humboldt Stakeholder Meeting:

March 8/9, 2022



Base from The National Map, 2022.
Universal Transverse Mercator projection, Zone 11,
World Geodetic System of 1984
Shaded-relief image is the intellectual property of Esri and is used herein under license.
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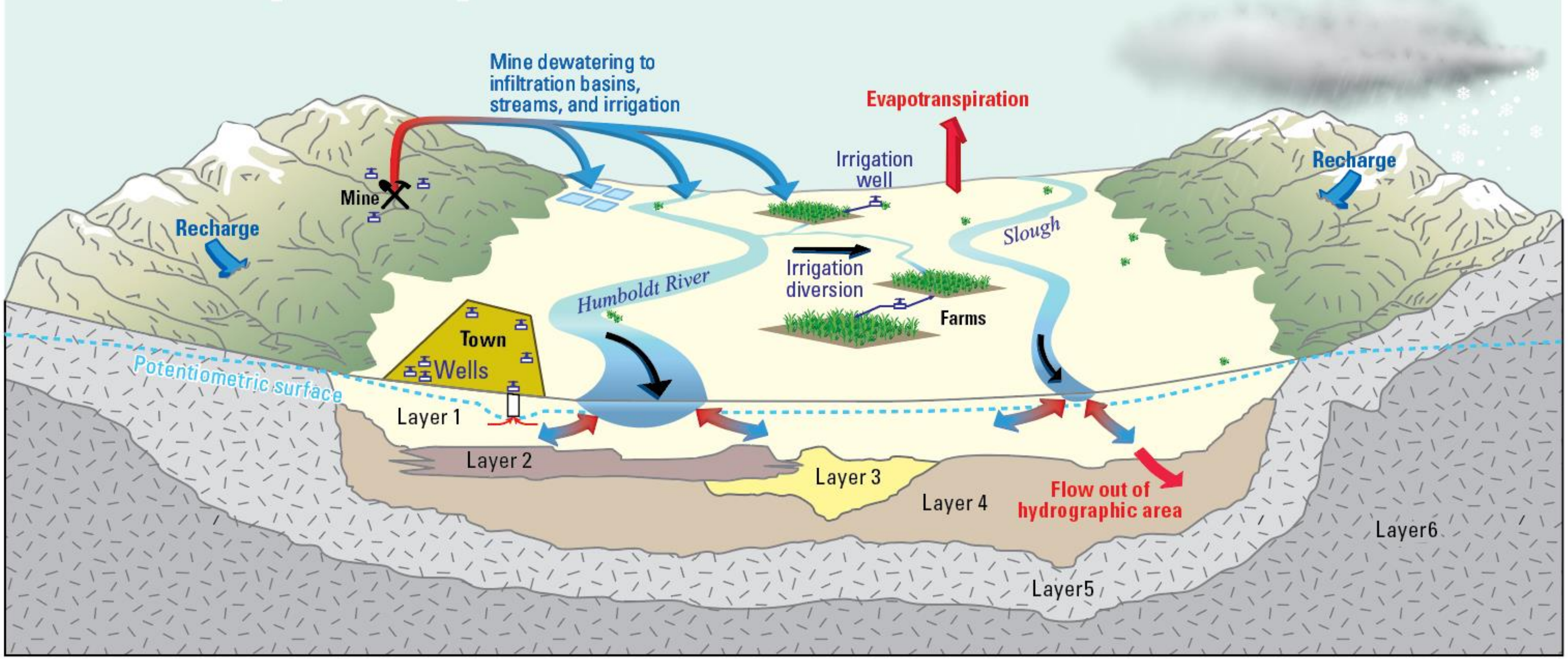
0 20 40 60 80 MILES
0 20 40 60 80 KILOMETERS

All model results are provisional and subject to change

Humboldt River depletion conceptual model



EXPLANATION

- **Layer 1: Basin fill deposits**—playa, valley floor, alluvial slope, fluvial deposits (thickenss 25 to 50 feet)
- **Layer 2: Clay layer below layer 1 (thickness 10 to 130 feet)**
- **Layer 3: Lower basin fill**—valley floor, fluvial deposits (thickness up to 400 feet)
- **Layer 4: Older basin fill**—Tertiary fine-grain semi-consolidated sediments (thickness up to 1,000 feet)
- **Layer 5: Upper hard rock**—clastic sedimentary, carbonate and mixture, intrusive, metamorphic, clastic sandstones (thickness 1,200 feet)
- **Layer 6: Lower hard rock**—clastic sedimentary, carbonate and mixture, intrusive, metamorphic, clastic sandstones (thickness variable ~1,800 feet)
- **Groundwater inflow**
- **Groundwater outflow**
- **Surface water flow direction**

Model Boundaries

EXPLANATION

Mine

Stream

Drain (DRN) Package

Streamflow Routing (SFR) Package

Point of diversion

Bifurcation

Diversion

Recharge (RCH) Package

Gumboot Lake

Recharge from mine dewatering

Paradise Valley Irrigation

Well (WEL) Package

Irrigation

Power generation

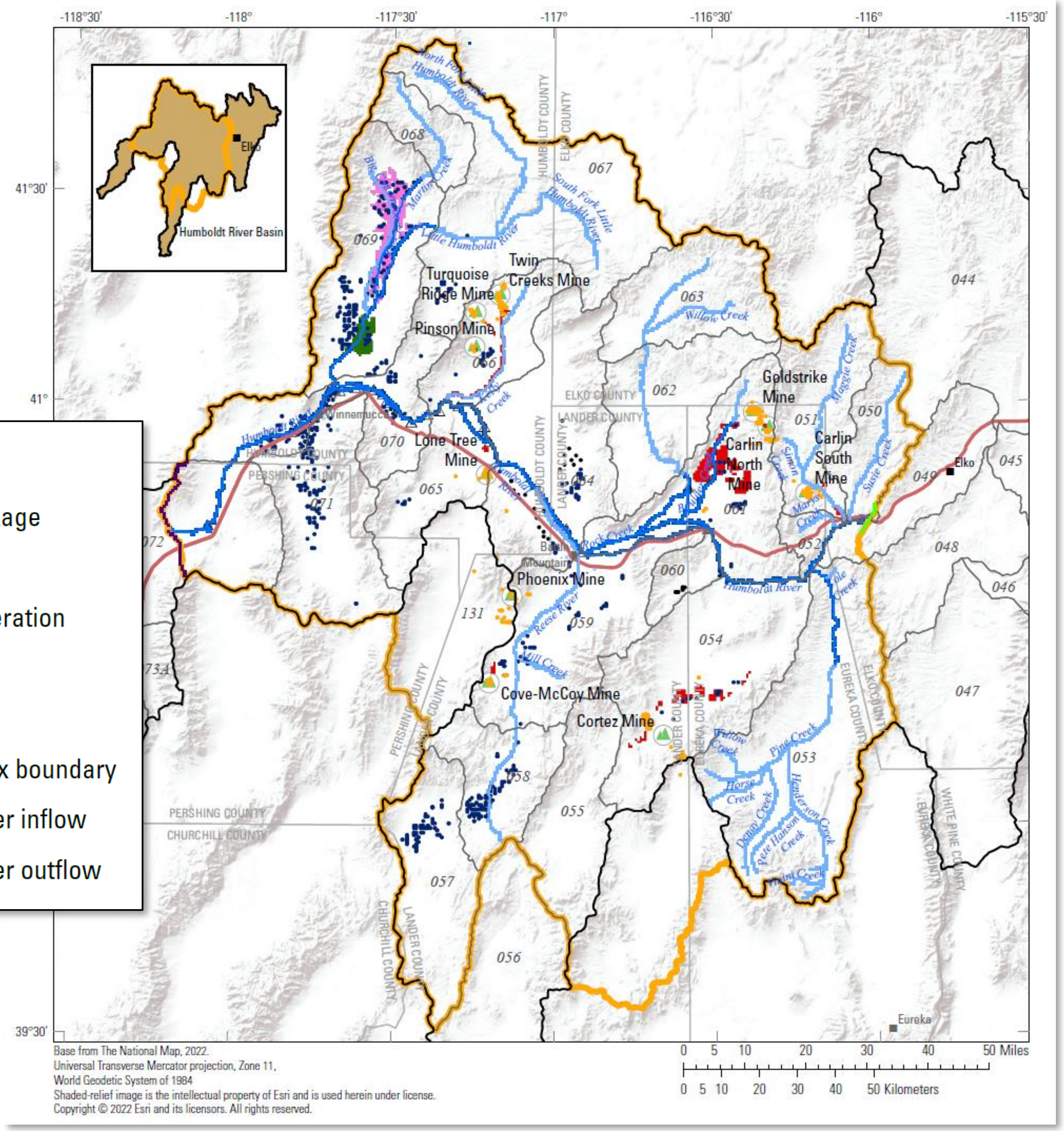
Production

Mining

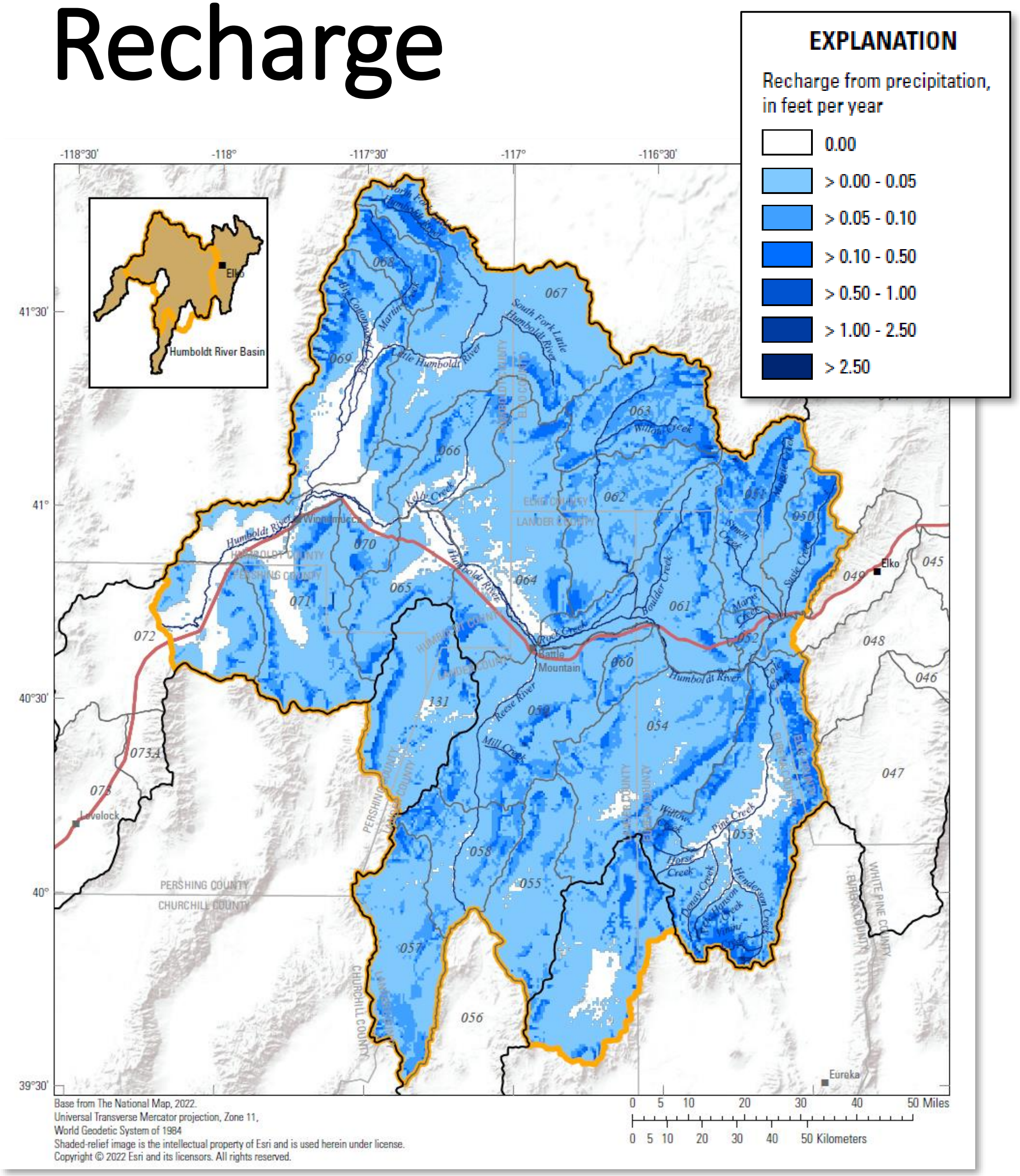
Groundwater flux boundary

Groundwater inflow

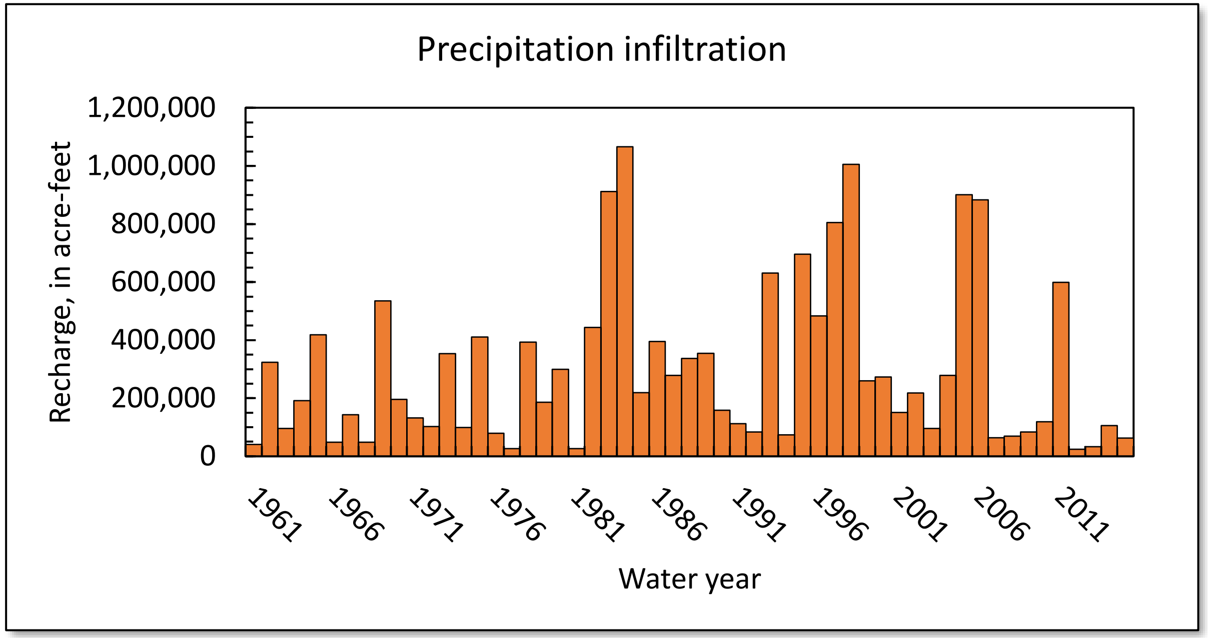
Groundwater outflow

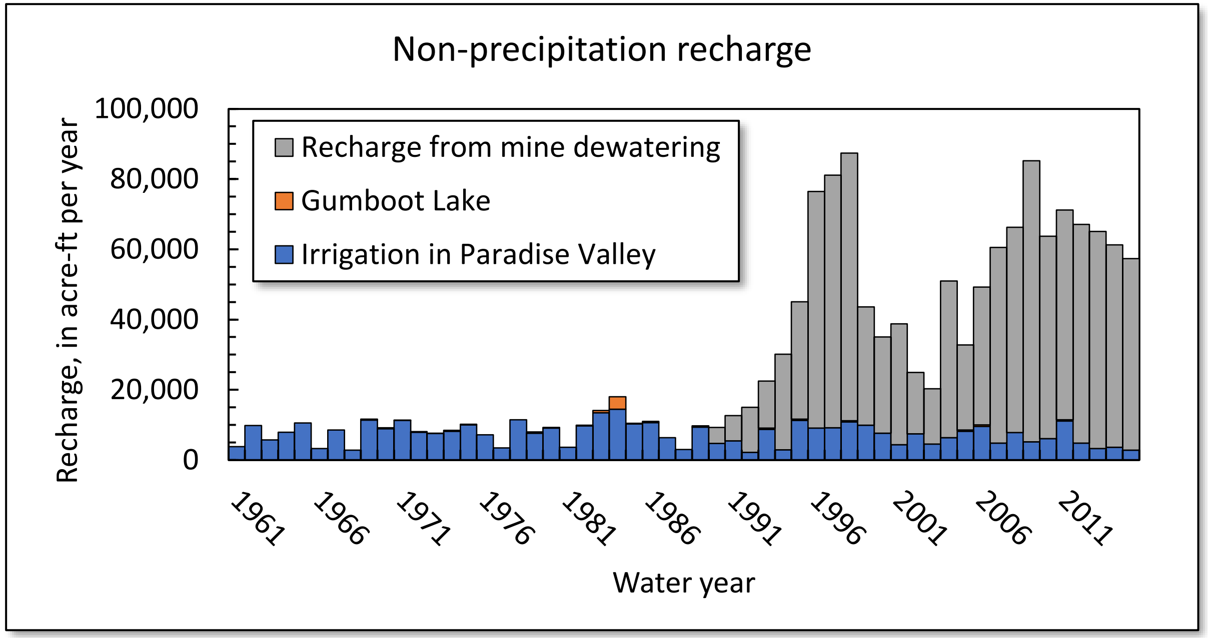


Recharge



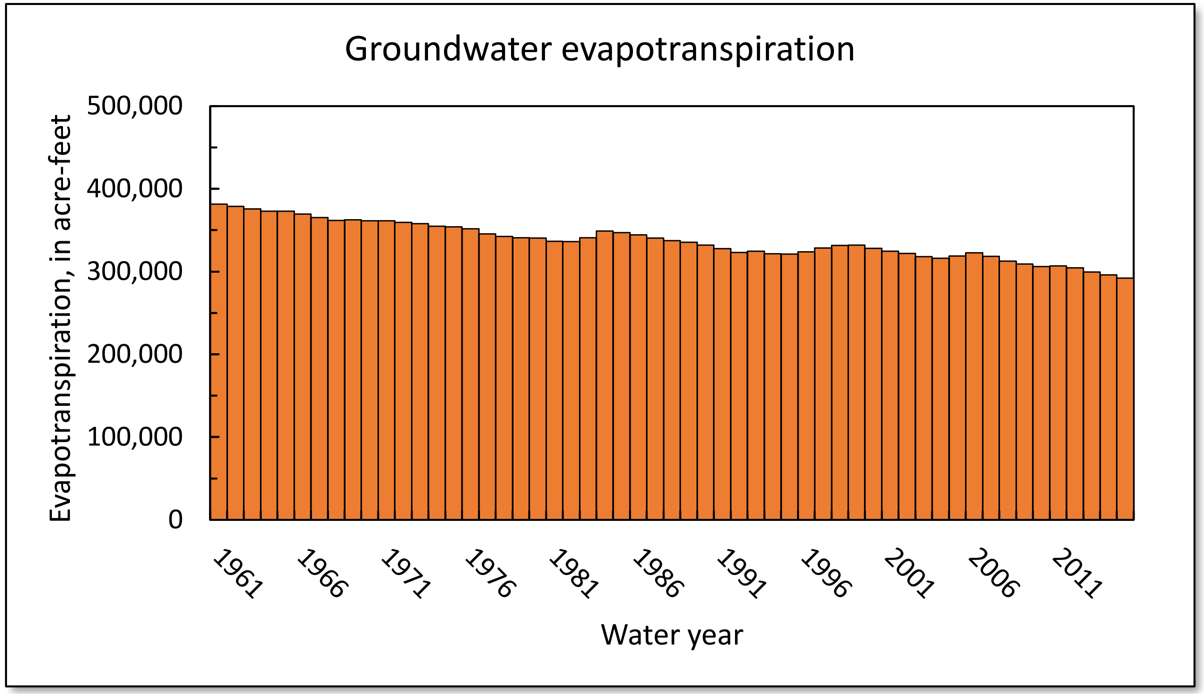
Steady-state distribution

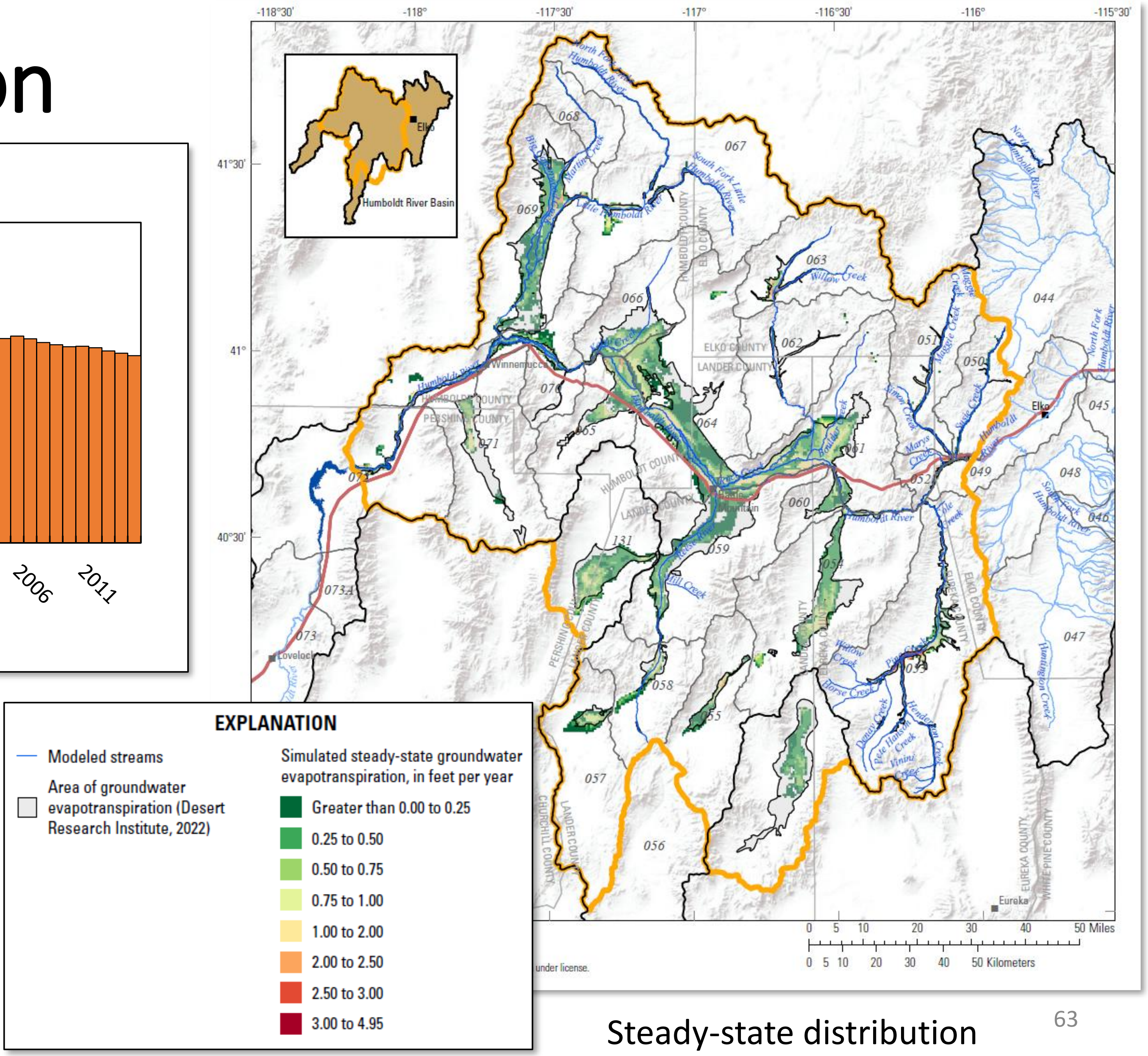




All model results are provisional and subject to change

Evapotranspiration

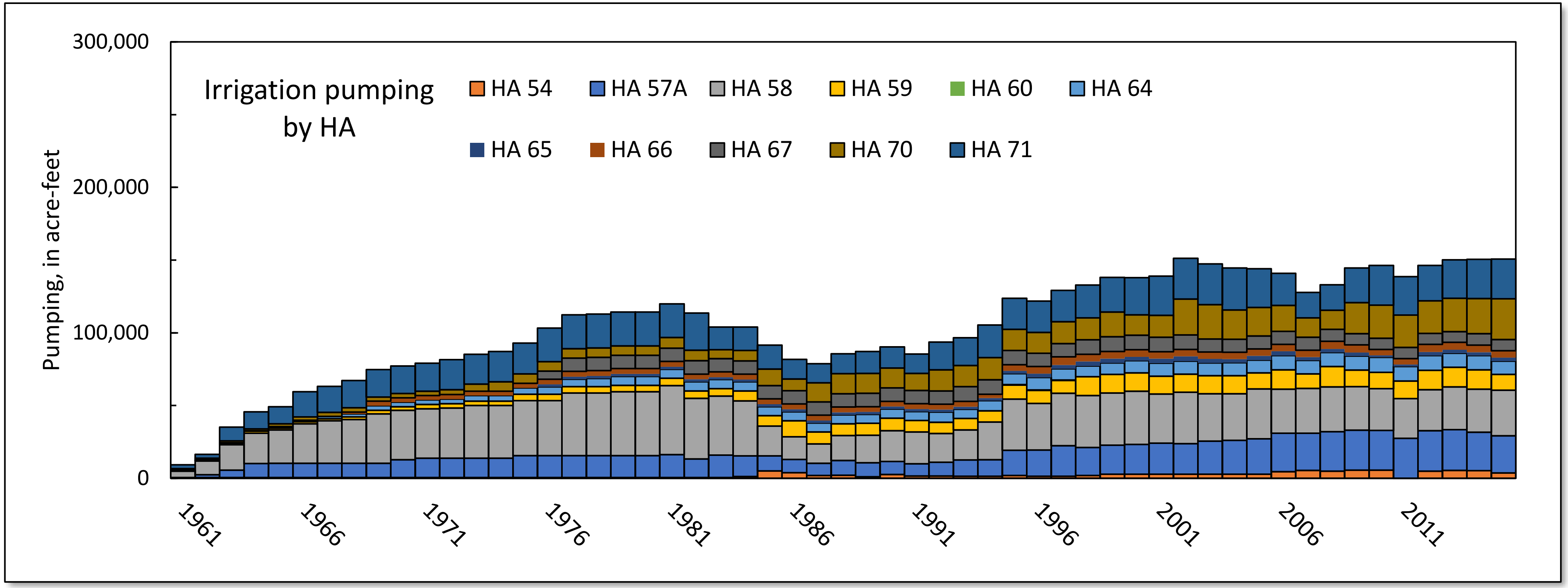


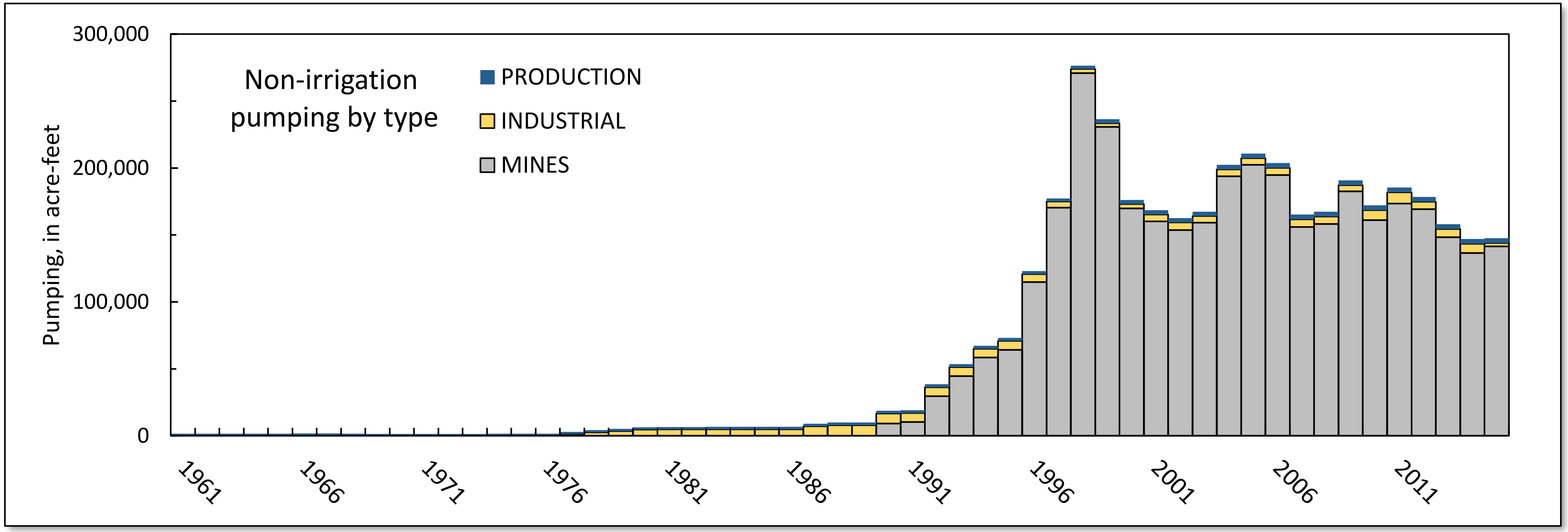


Steady-state distribution

All model results are provisional and subject to change

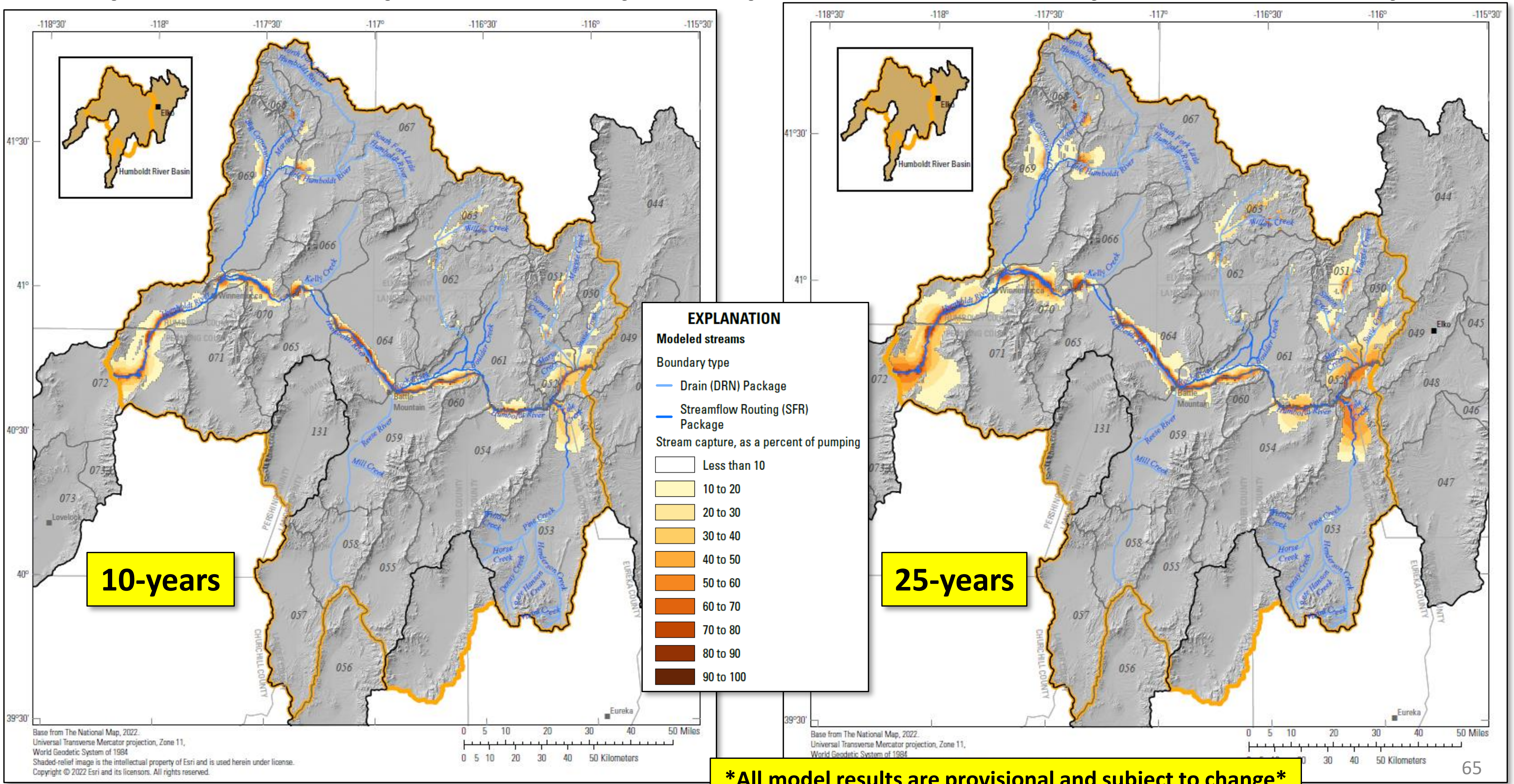
Pumping





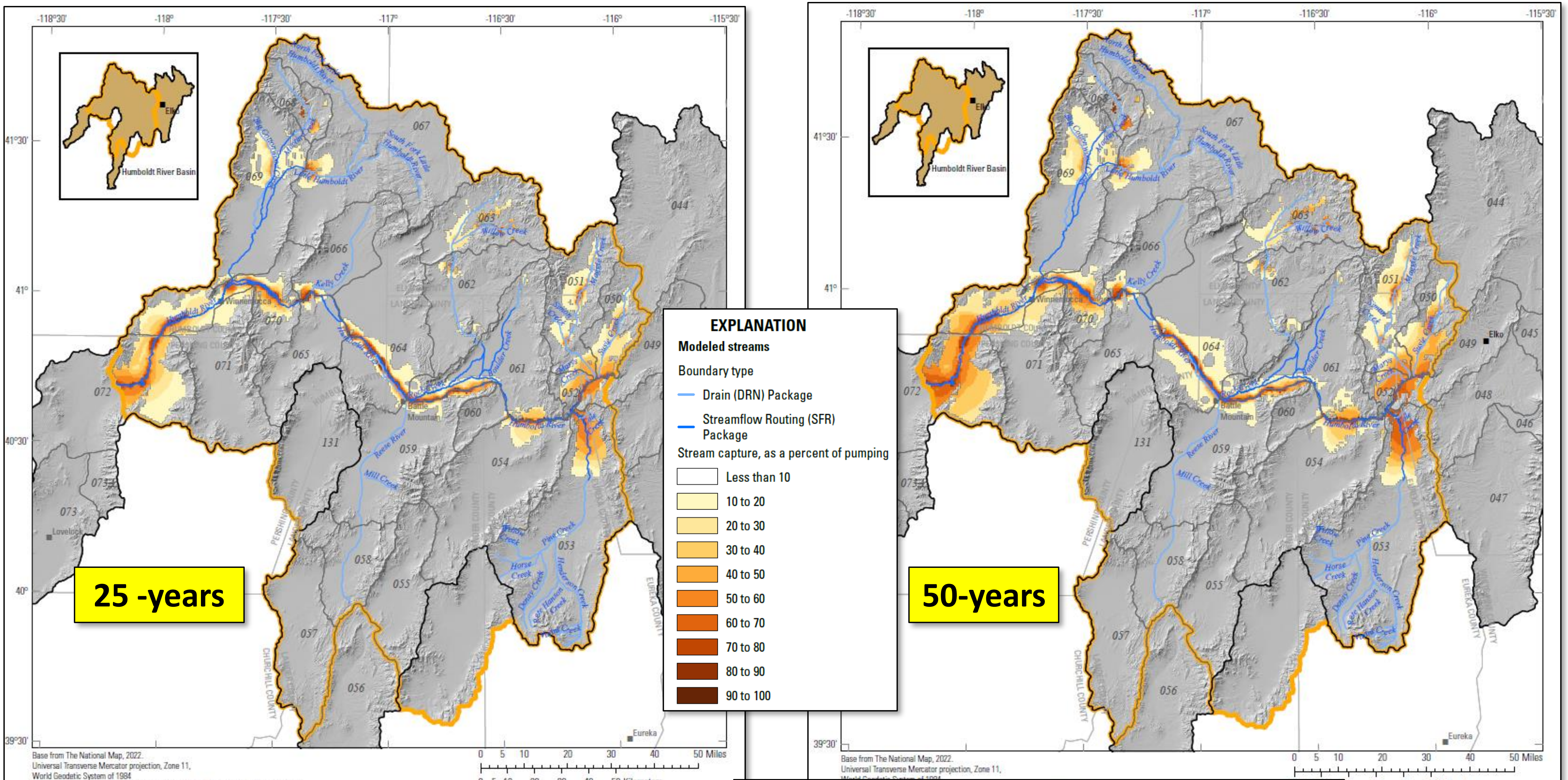
All model results are provisional and subject to change

Capture Map – Imlay Depletion: 10-yr and 25-yr



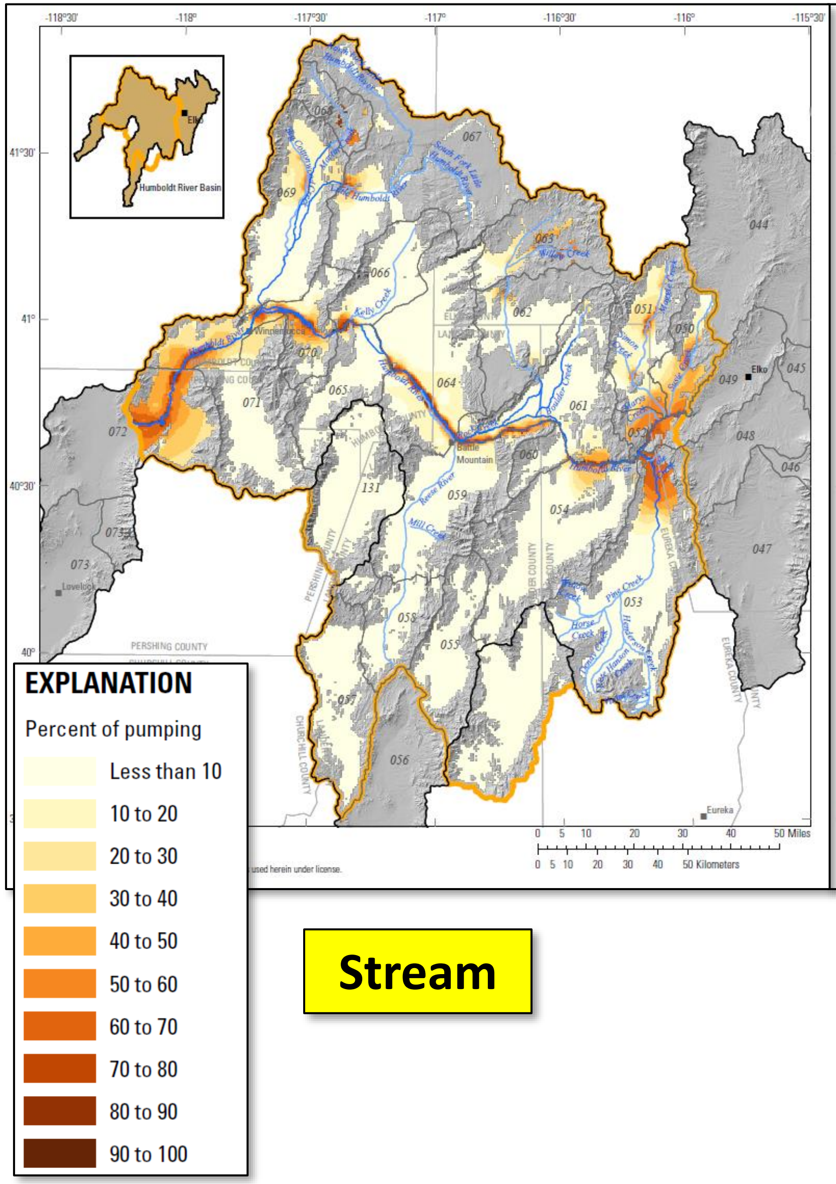
All model results are provisional and subject to change

Capture Map – Imlay Depletion: 25-yr and 50-yr

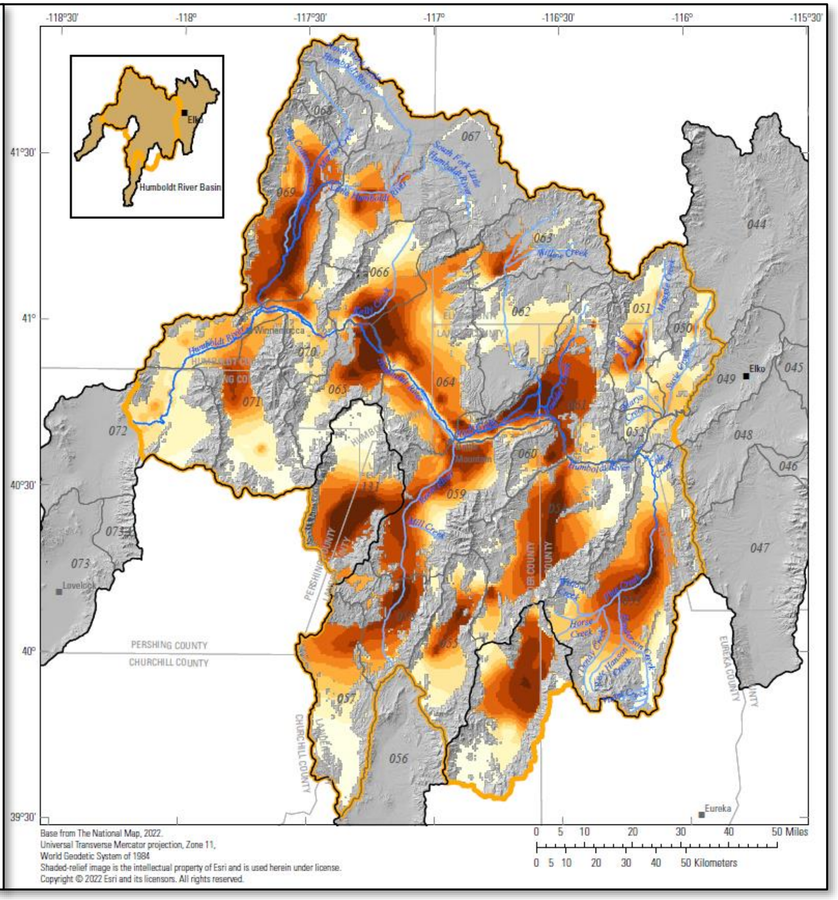


All model results are provisional and subject to change

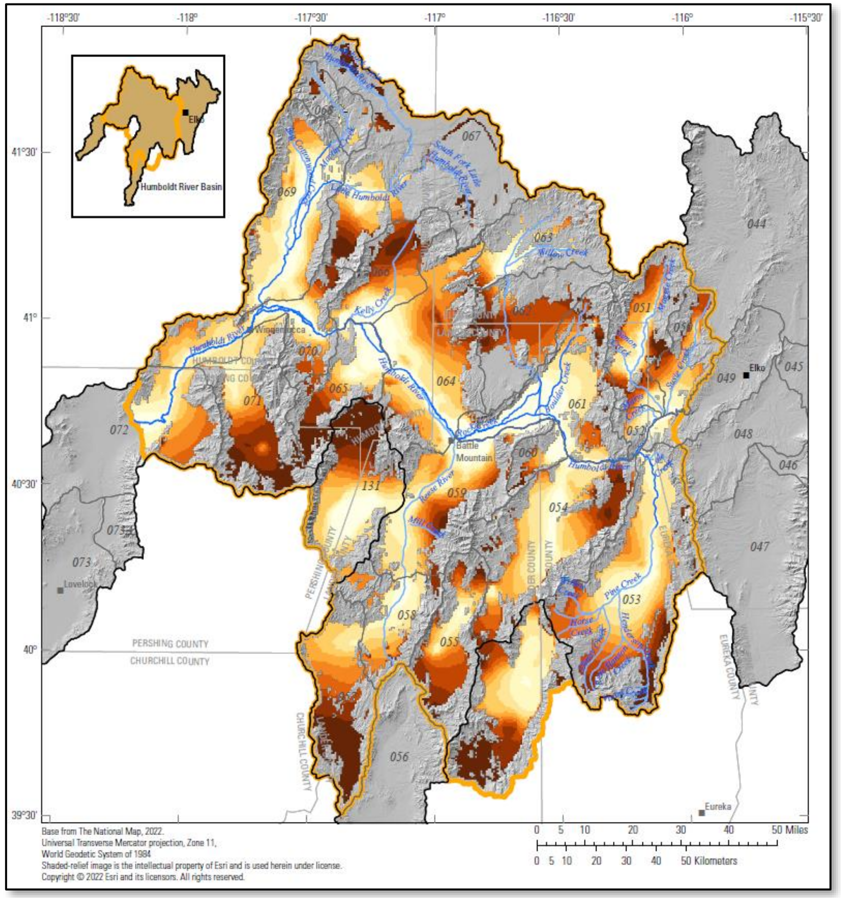
Capture Maps – Stream, ETg, and Storage (50-yr)



Stream



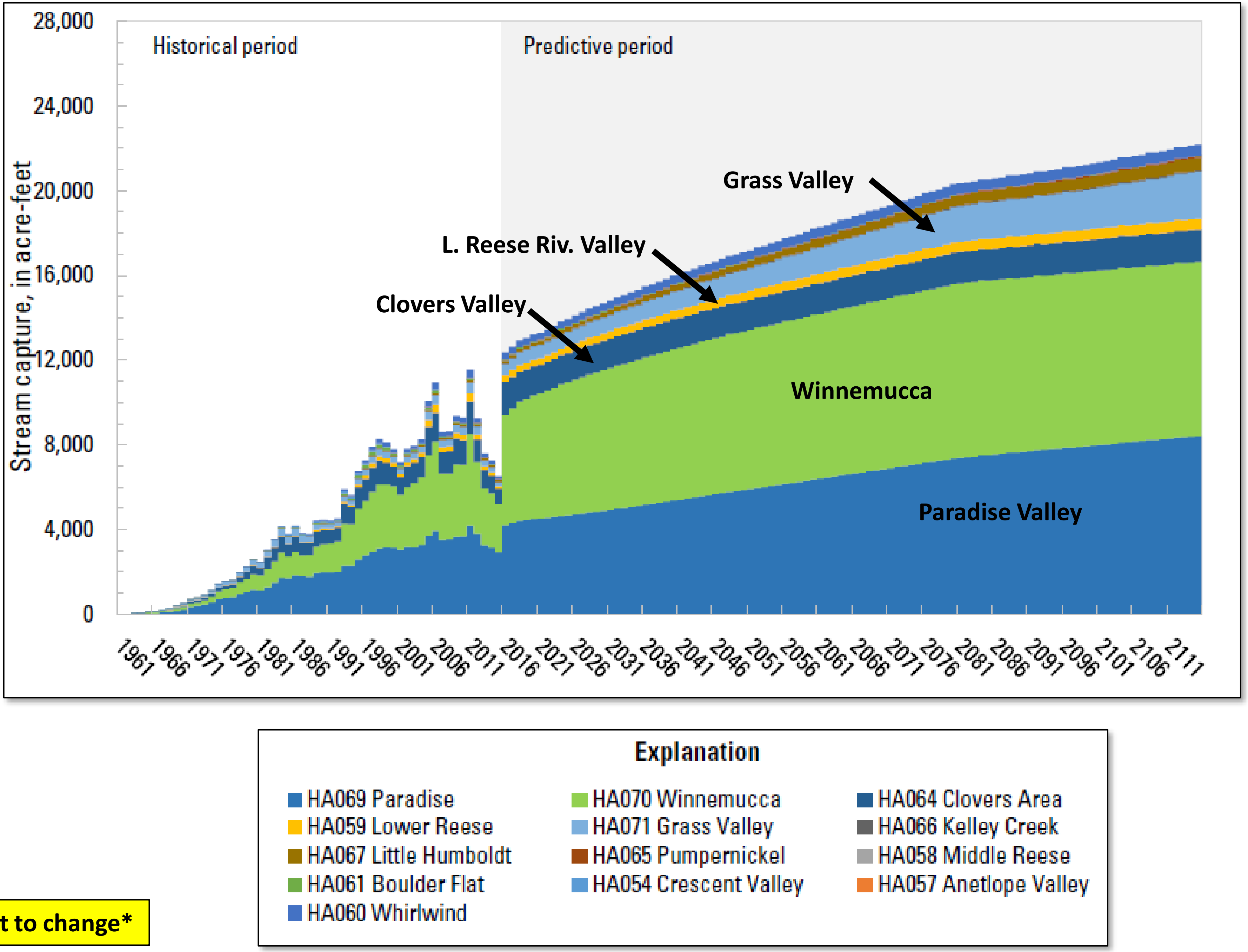
ETg



Storage

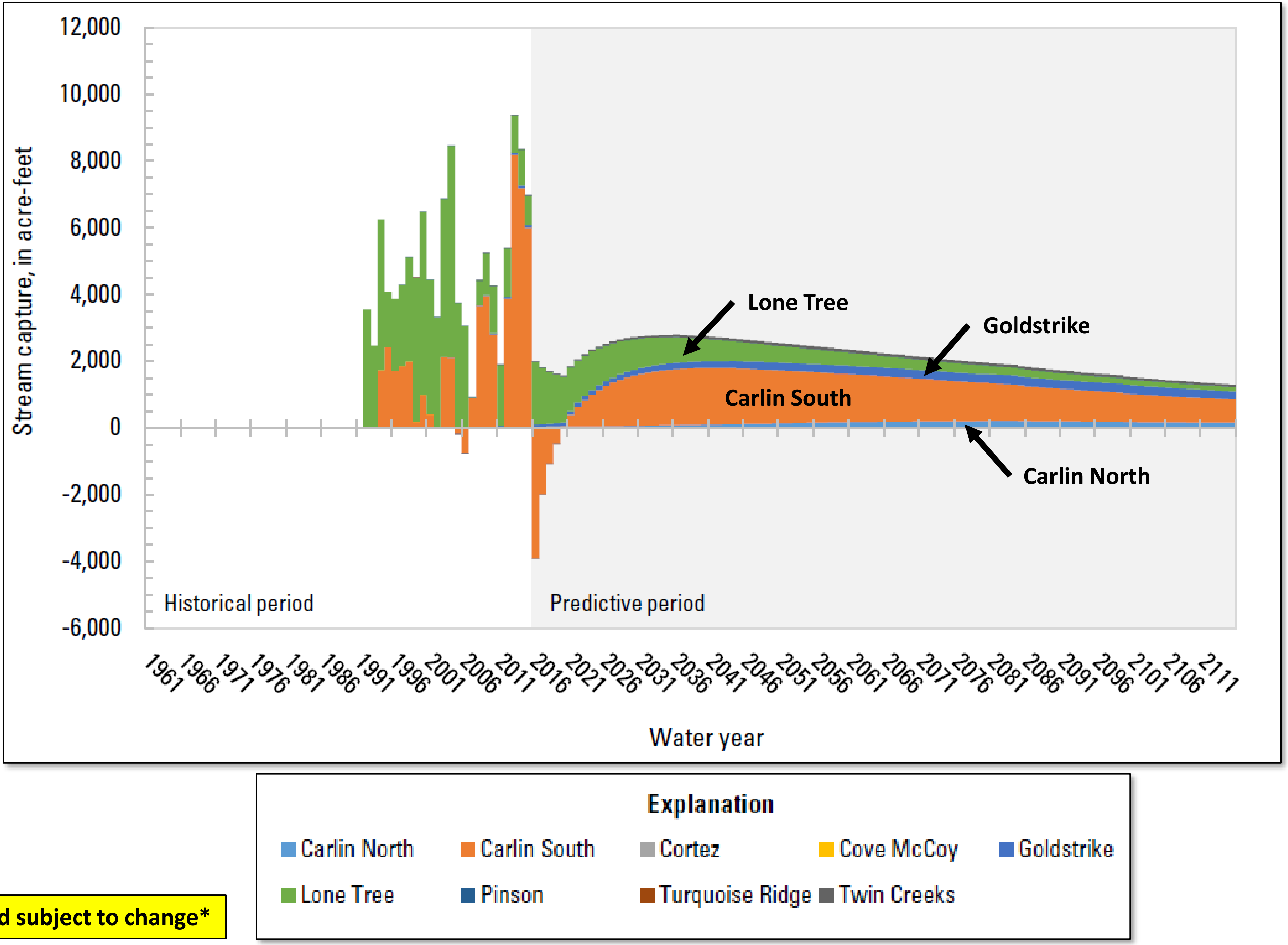
All model results are provisional and subject to change

Stream Capture: Non-Mining Pumping



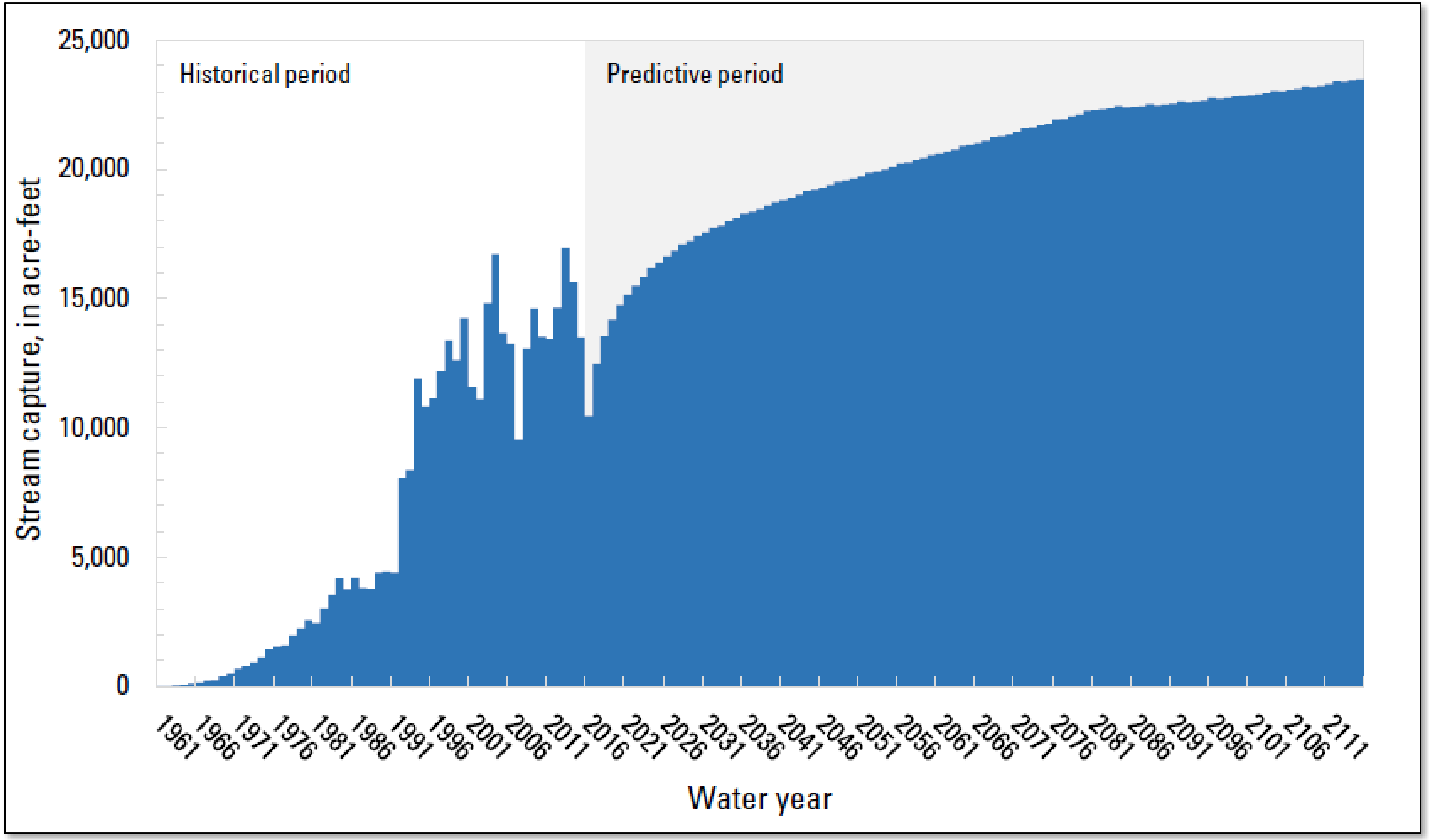
All model results are provisional and subject to change

Stream Capture: Mining Pumping



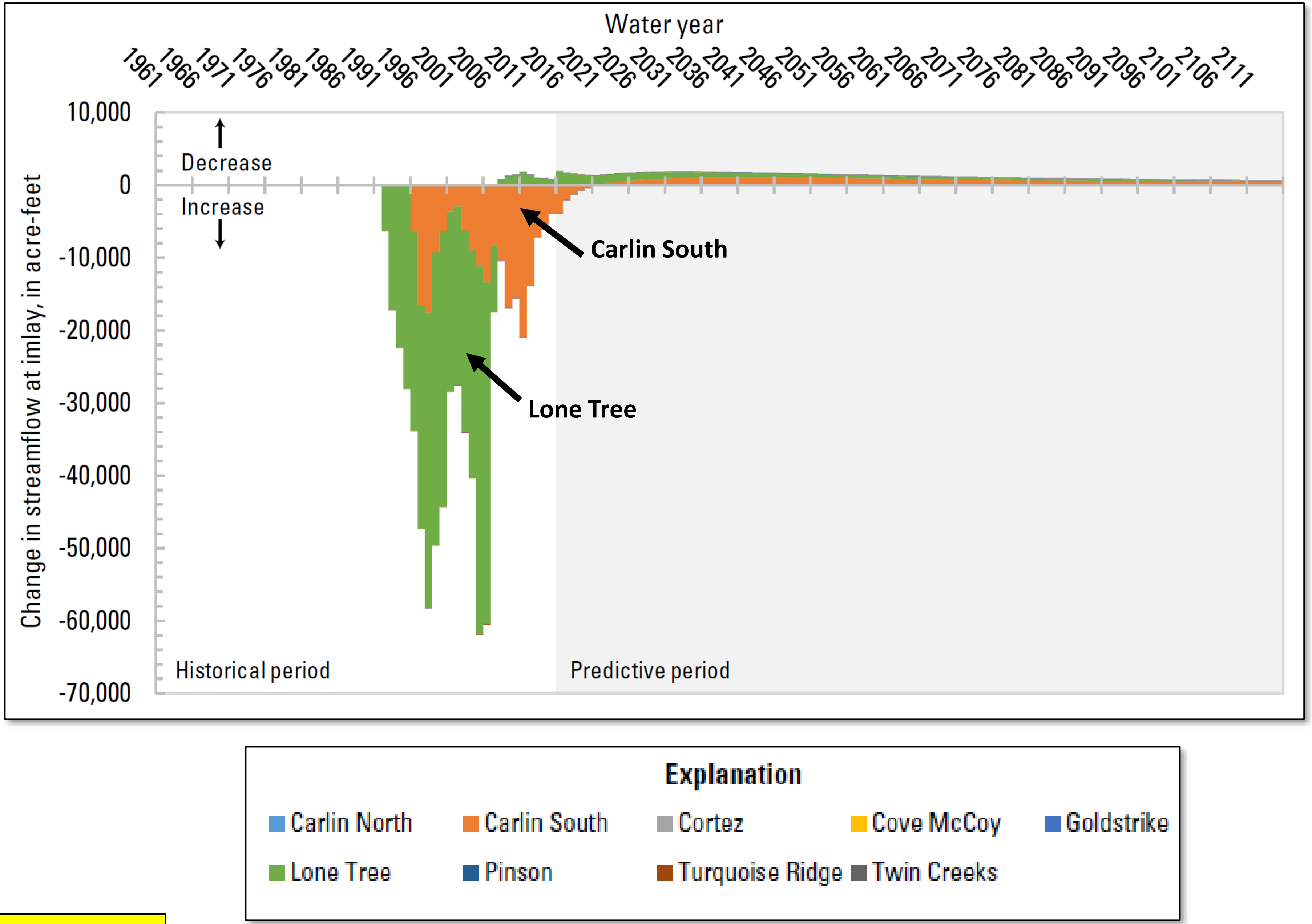
All model results are provisional and subject to change

Stream Capture: All Sources



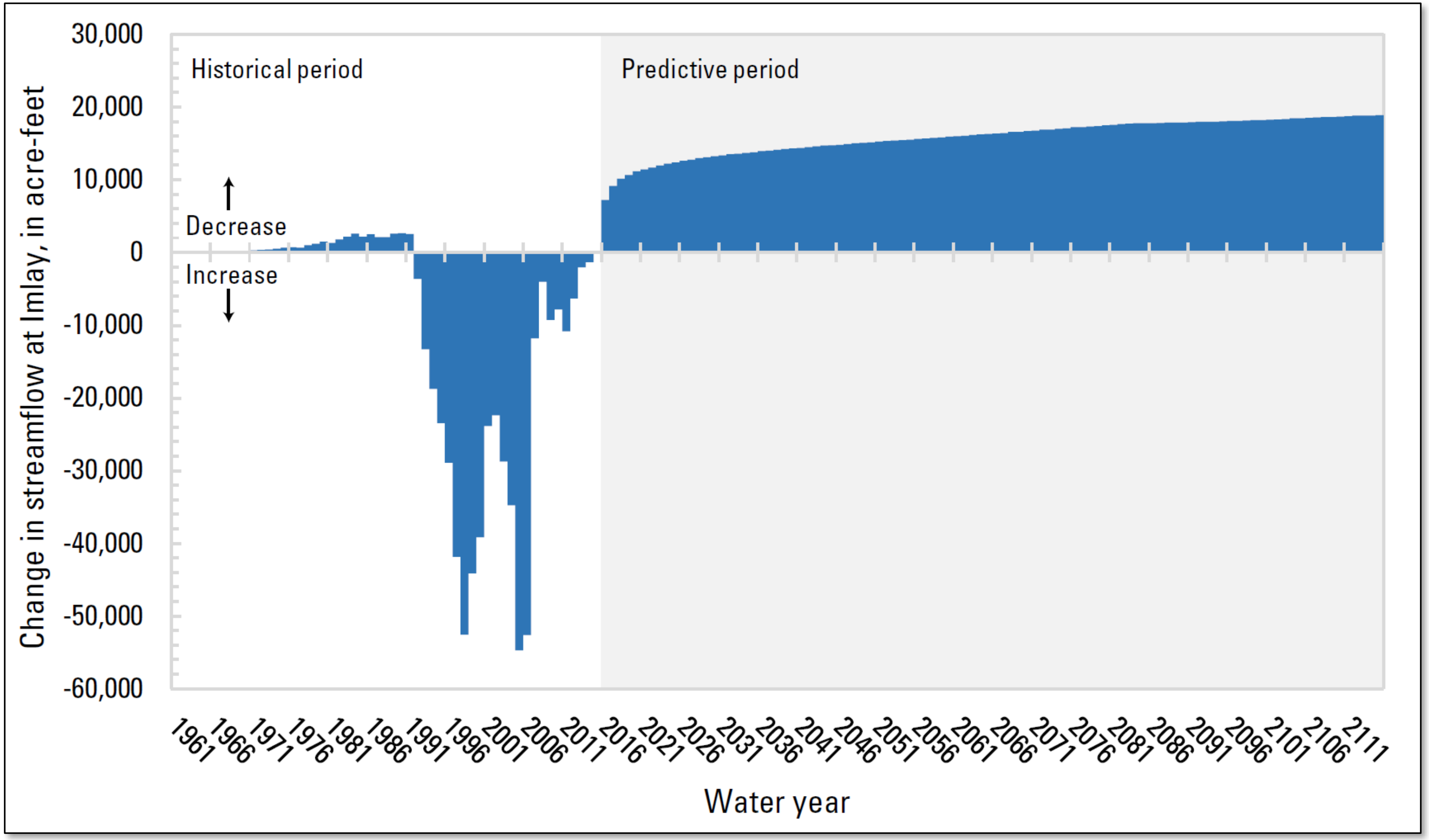
All model results are provisional and subject to change

Change in Streamflow at Imlay: Mining Operations



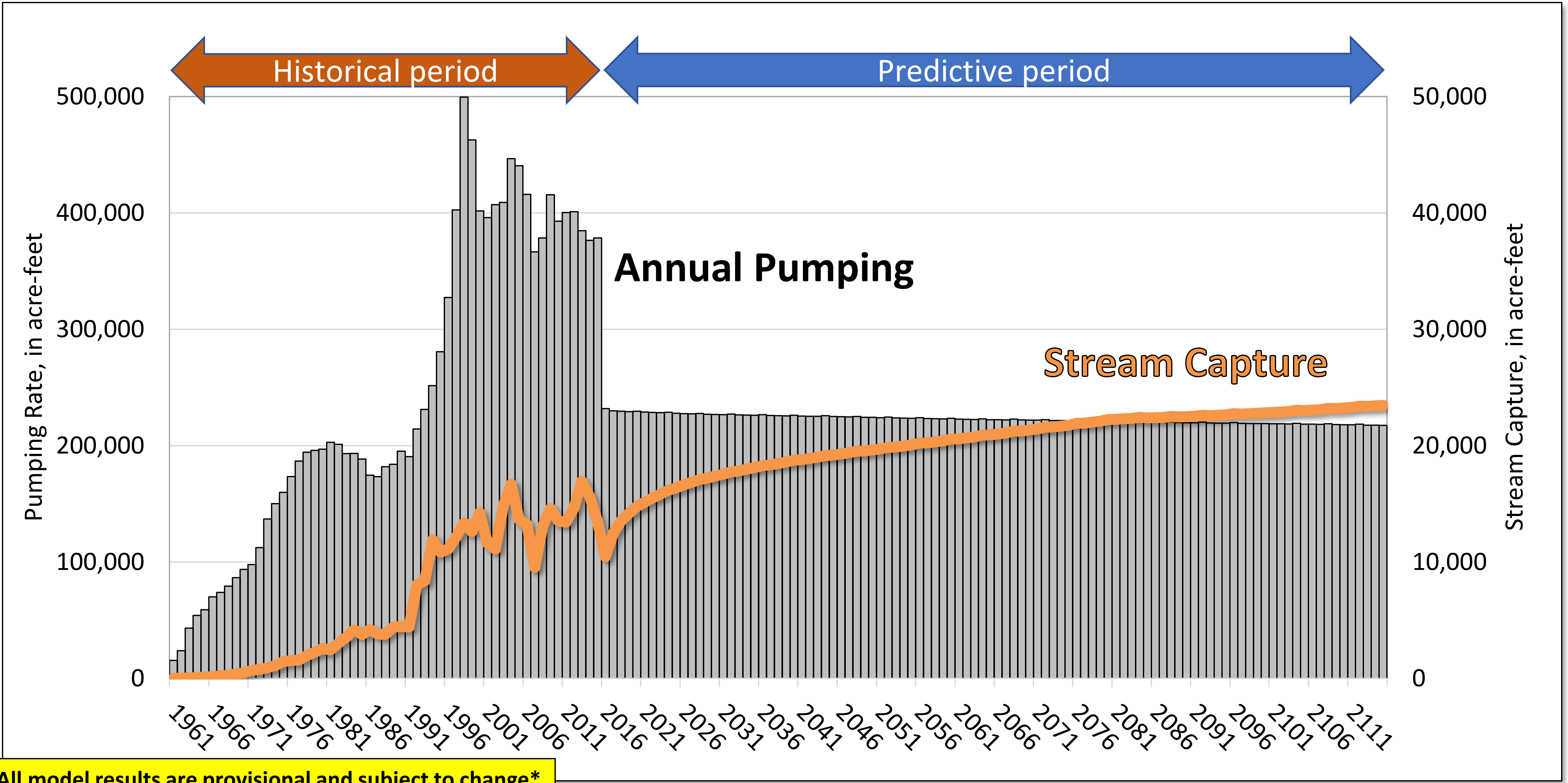
All model results are provisional and subject to change

Change in Streamflow at Imlay: Mining Operations and All Other Pumping



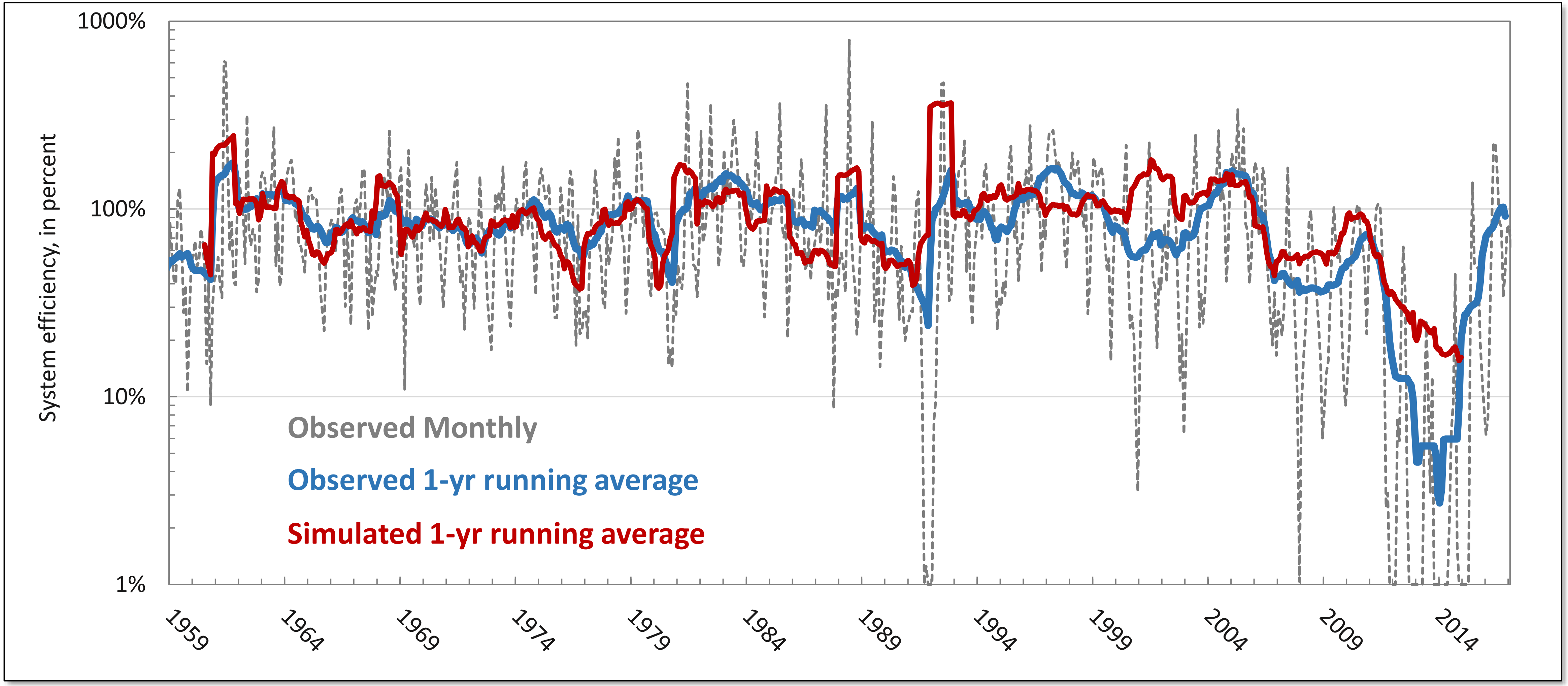
All model results are provisional and subject to change

Groundwater Pumping and Stream Capture



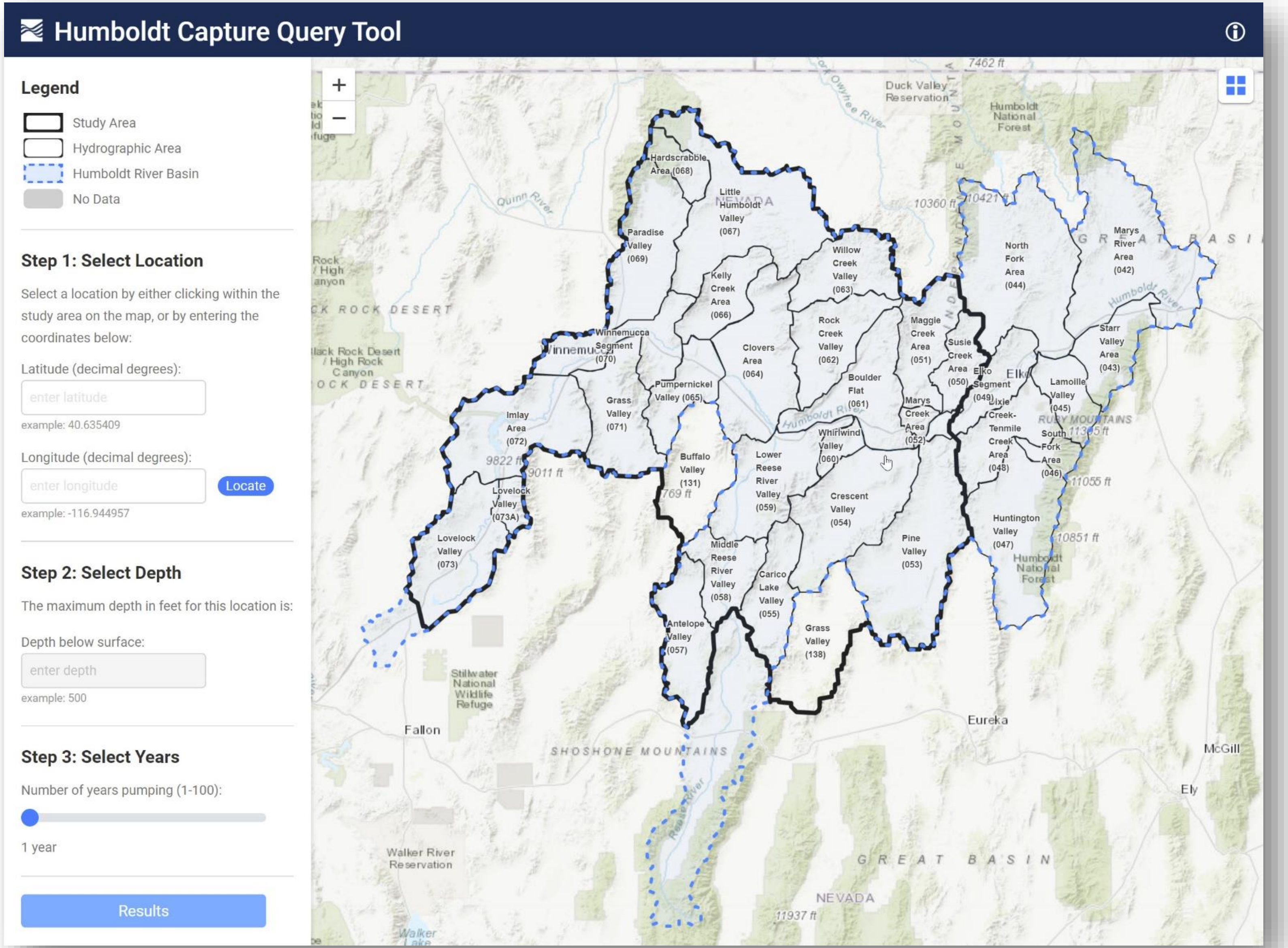
All model results are provisional and subject to change

System efficiency: percentage of Palisade streamflow measured at the Imlay gage–observed and simulated

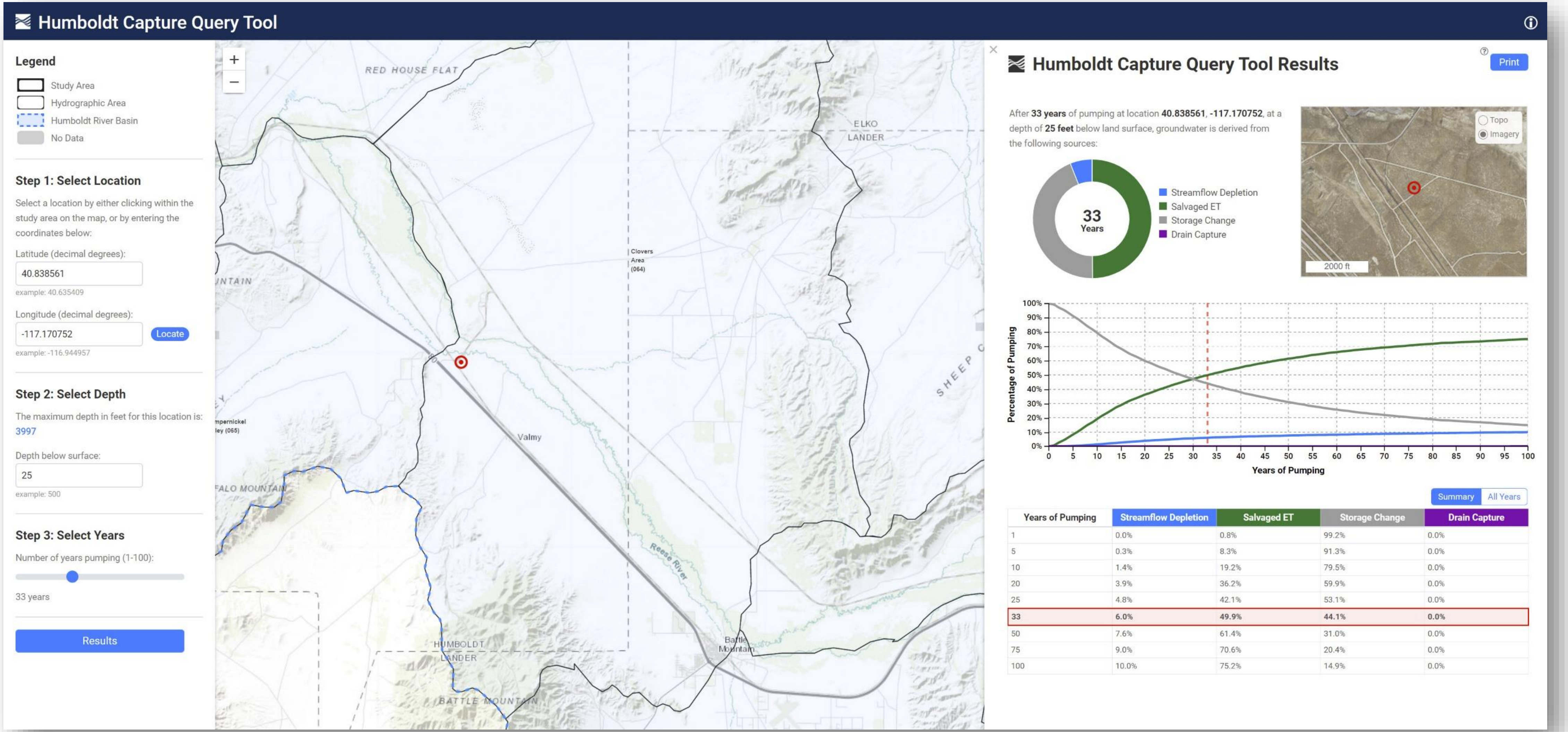


All model results are provisional and subject to change

Humboldt Capture Query Tool – Query page



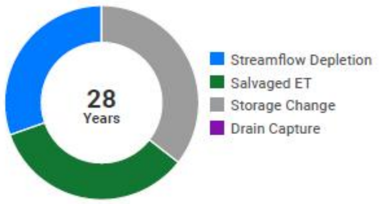
Humboldt Capture Query Tool – Results page

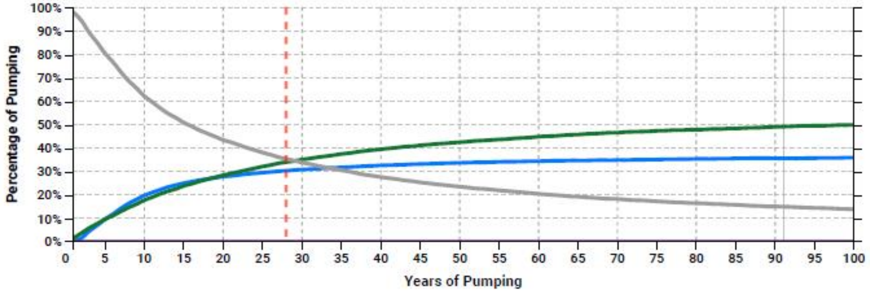


Humboldt Capture Query Tool – Exported results

Humboldt Capture Query Tool Results

After **28 years** of pumping at location **40.718702, -117.004395**, at a depth of **10 feet** below land surface, groundwater is derived from the following sources:





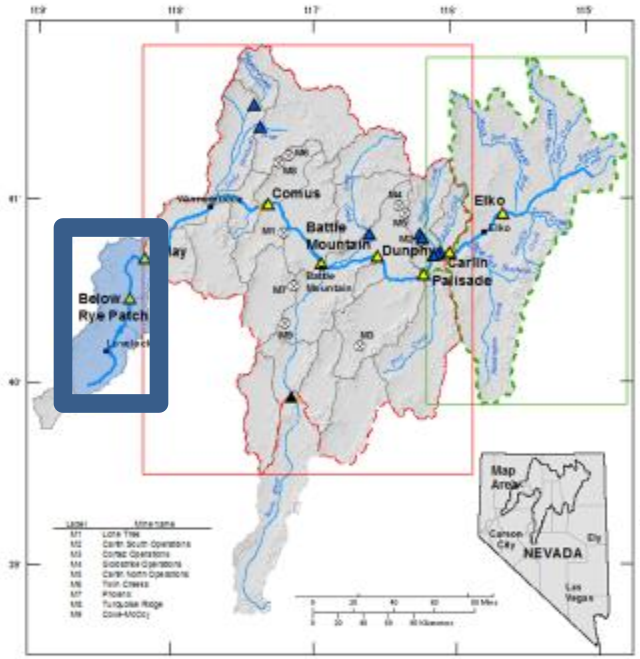
Years of Pumping	Streamflow Depletion	Salvaged ET	Storage Change	Drain Capture
1	0.1%	1.4%	98.5%	0.0%
5	9.6%	9.6%	80.8%	0.0%
10	19.8%	17.8%	62.4%	0.0%
20	27.9%	28.5%	43.6%	0.0%
25	29.6%	32.2%	38.2%	0.0%
28	30.4%	34.1%	35.5%	0.0%
50	33.8%	42.6%	23.6%	0.0%
75	35.2%	47.5%	17.3%	0.0%
100	36.0%	50.1%	13.9%	0.0%

Middle Humboldt Product Status

- Report, Capture Query Tool, and Model Data Release in production
- Report to colleague review this month (March 2022)
- Capture Query Tool and Model Data Release after return of report colleague reviews

- Anticipated availability of products: **October 1, 2022**

LOWER HUMBOLDT RIVER BASIN MODEL



- Upper basin model – DRI
- Middle basin model – USGS
- Lower basin Model – USGS/DRI

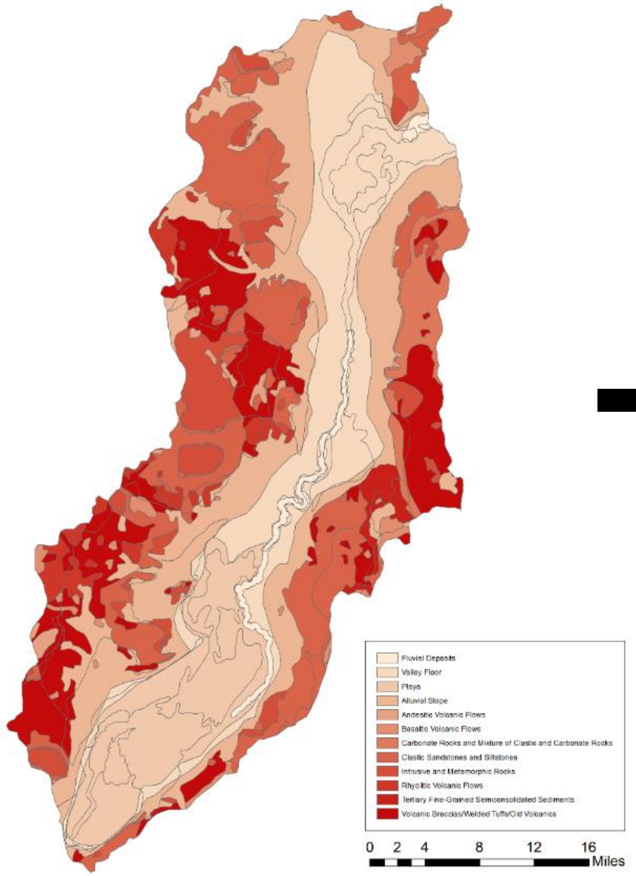
DRI/USGS

Lower Humboldt River Basin Model Update

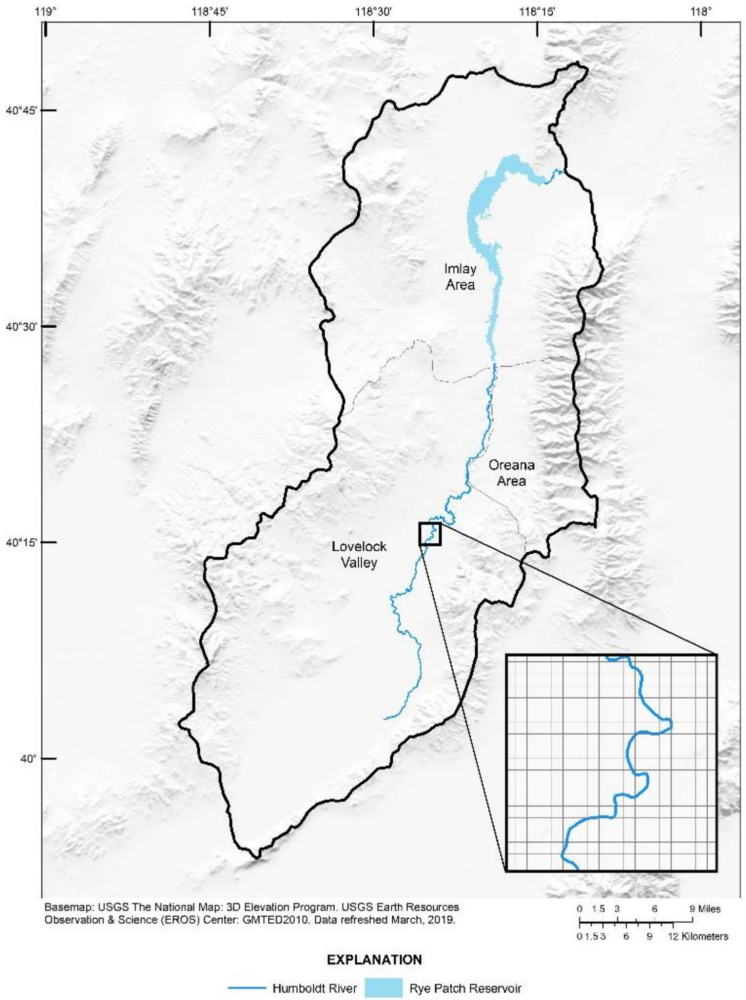
Susie Rybarski/Cara Nadler
March 8-9, 2022
DRI/USGS

*** Model results are provisional and subject to change***

Model Domain



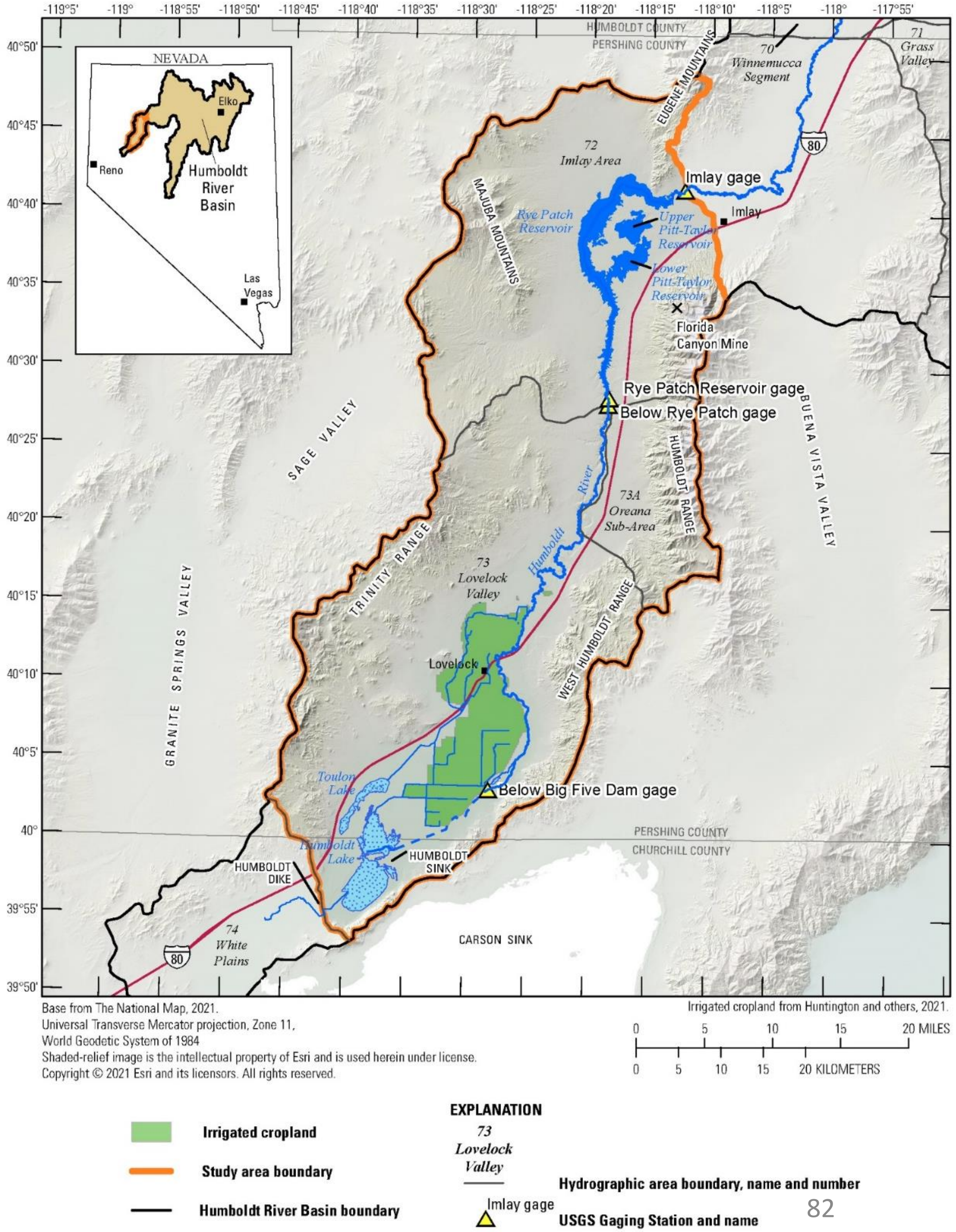
Modified from Maurer and others (2004)



- 500 ft grid cell resolution
- Includes mountain block/bedrock
- 3 layers, generally representing clay (layer 1), alluvium/valley fill (layer 2), bedrock (layer 3)
- Thickness of clay layer set to 50 feet
- Depth to basement based on Ponce and Damar (2017) and used to define elevation of top of layer 3, with a minimum depth of 20 feet below land surface

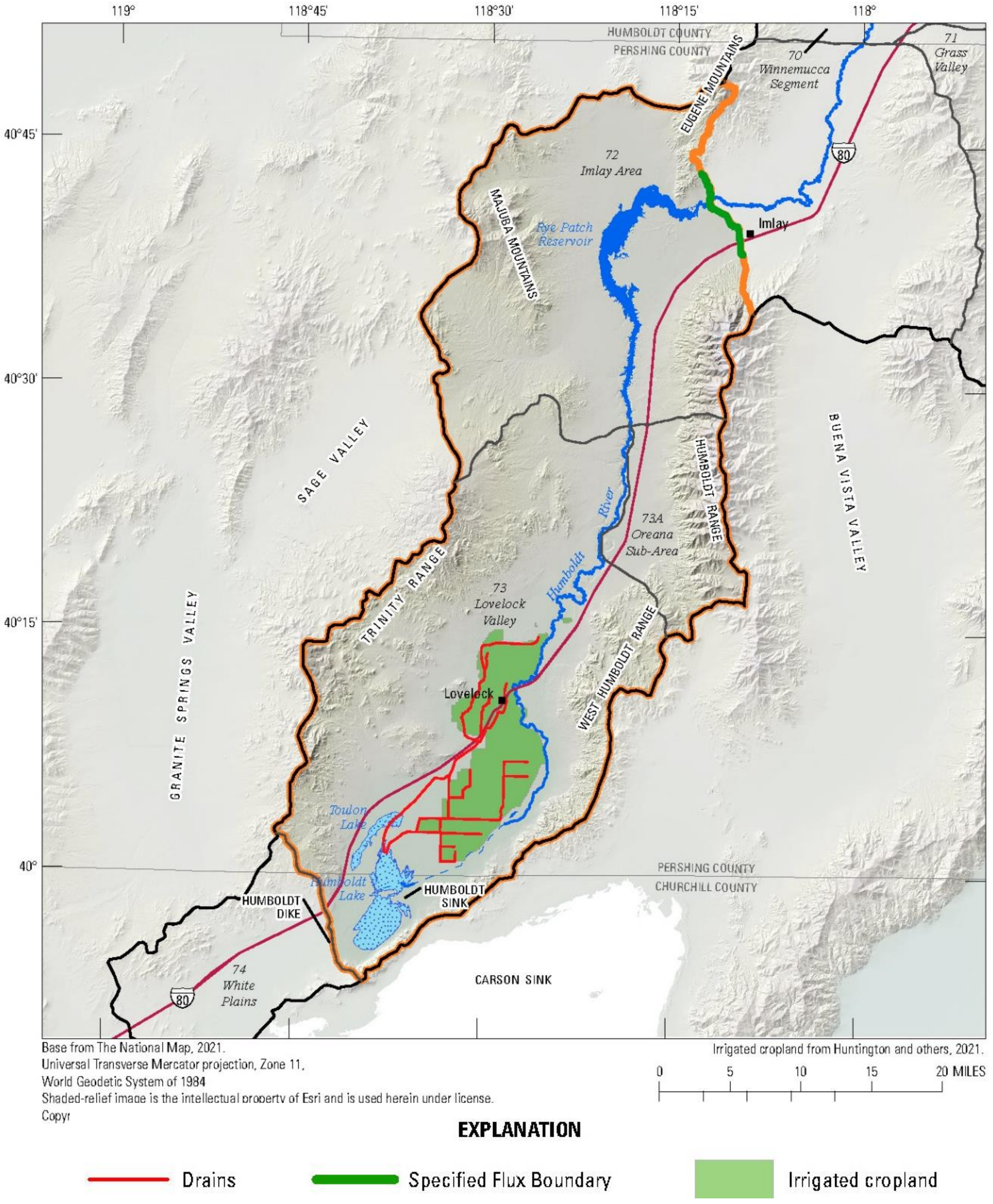
Lakes and River

- Humboldt River simulated using River package (RIV)
- Rye Patch Reservoir simulated as a constant head boundary (CHD) using mean annual stage
- Pitt-Taylor Reservoirs, Toulon Lake, and Humboldt Lake not simulated as they are frequently dry and heads are unknown
- River conductance calibrated to estimated steady-state river loss of 9,900 acre-feet/year
- Simulated loss of 100 AFA determined by model given calibration to ET in Imlay area and local heads



Interbasin Flow

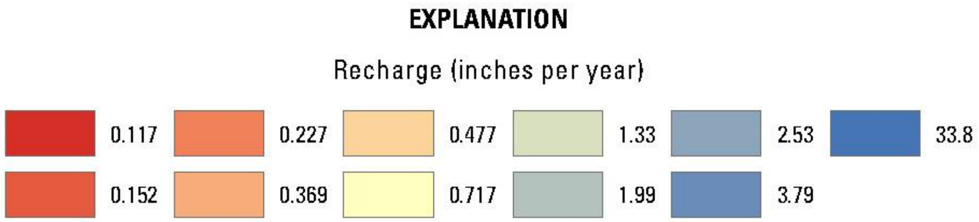
- Specified flux boundary applied along shared boundary with Middle Humboldt model (in review)
- Limited to extent of alluvial slope/fluvial deposits/playa/valley floor
- Inflow of 771 acre-feet per year based on current outflow from Middle Humboldt model

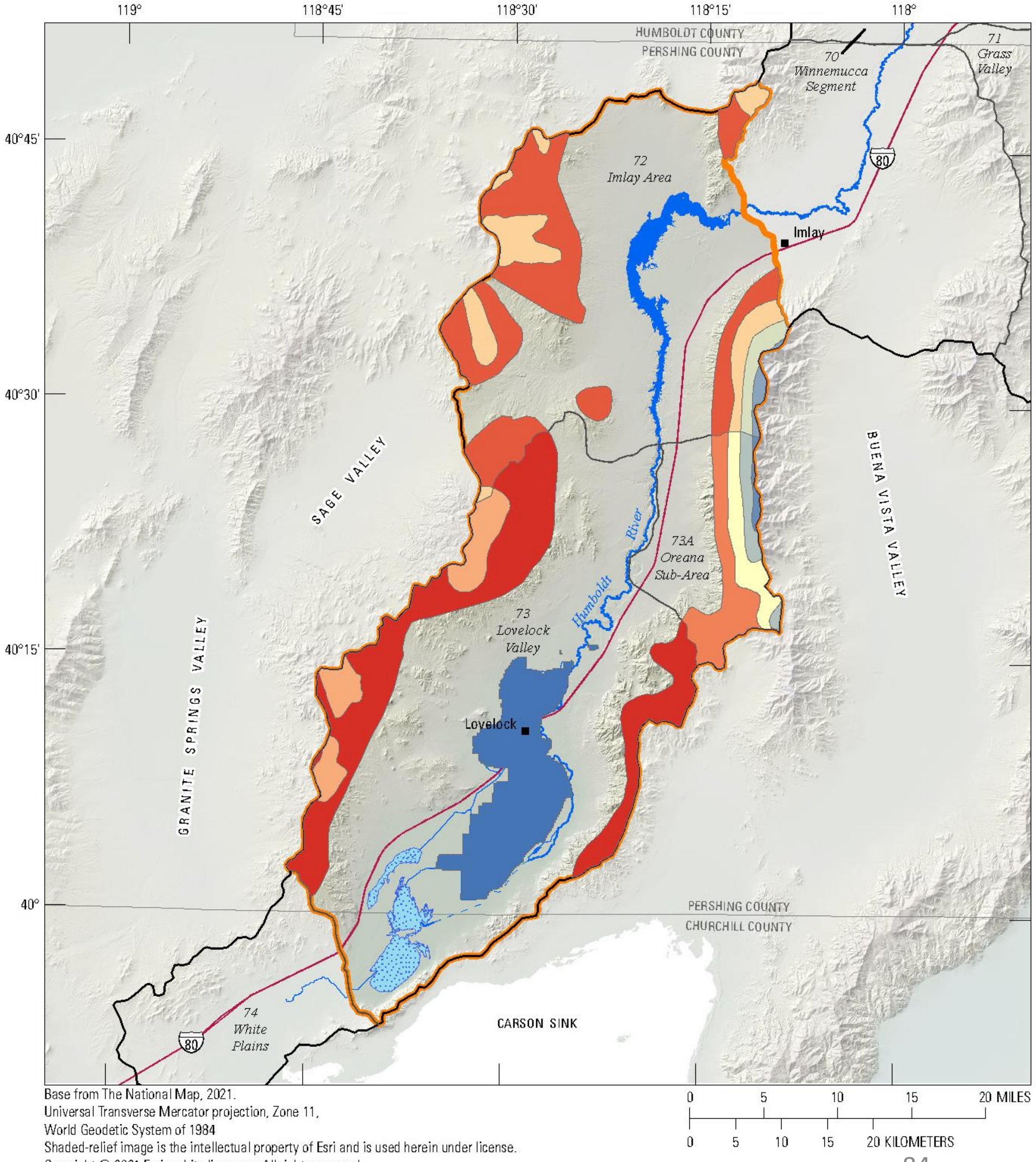


Recharge

	Mountain Block Recharge (AFY)				
Reference	**Lovelock**	**Oreana**	**Imlay**	**Model Domain**	**Methodology**
Everett and Rush, 1965	1,200	2,000	--	--	Maxey-Eakin, 1949
Eakin, 1962	--	--	4,000	--	Maxey-Eakin, 1949

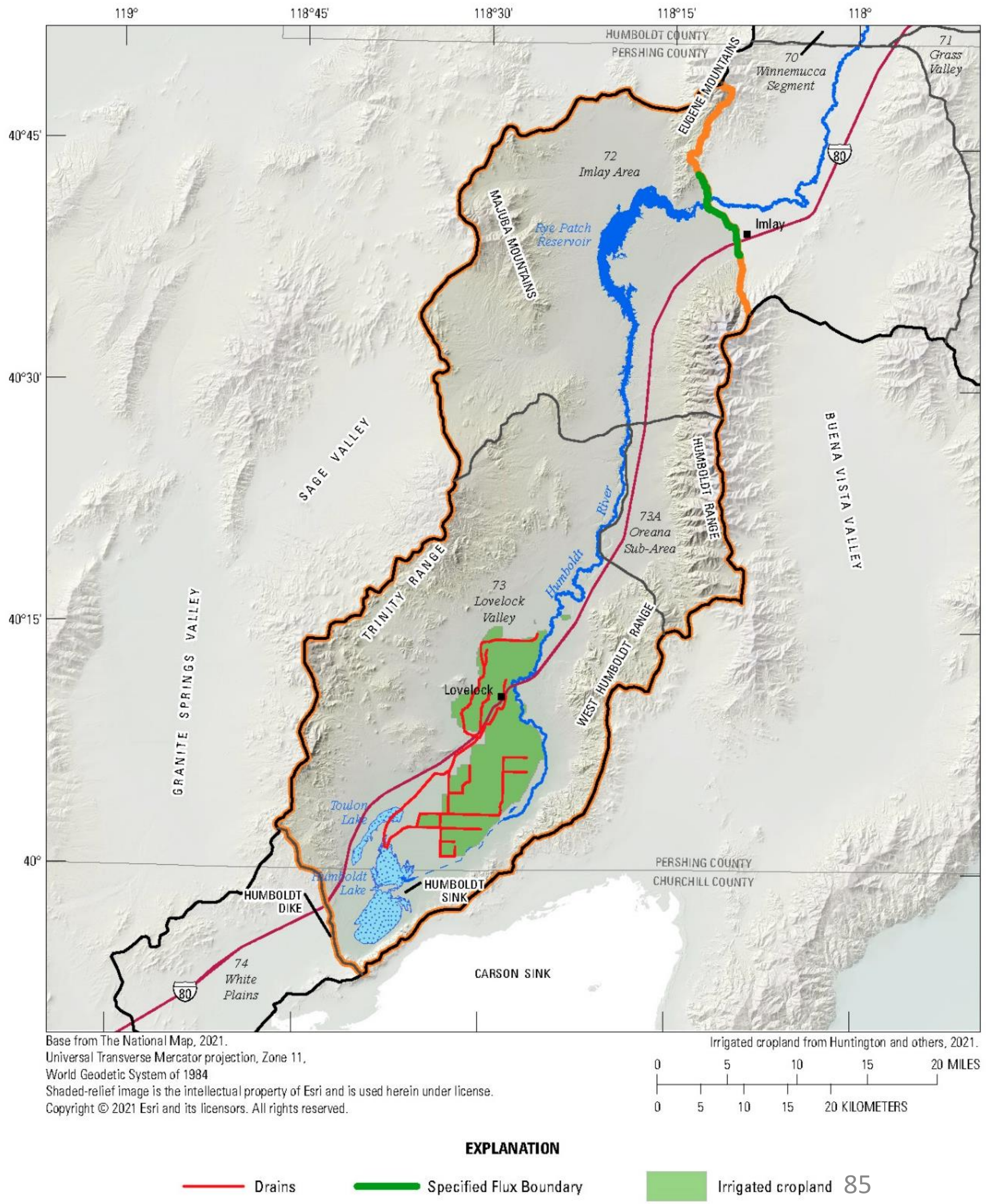
- Mountain block recharge estimates from USGS Recon Reports distributed proportionally over Hardman map intervals
- Ag recharge rate applied as median of 1960-1990 regression (127,800 acre-feet per year)
- Simulated mountain block recharge = 5,700 acre-feet per year





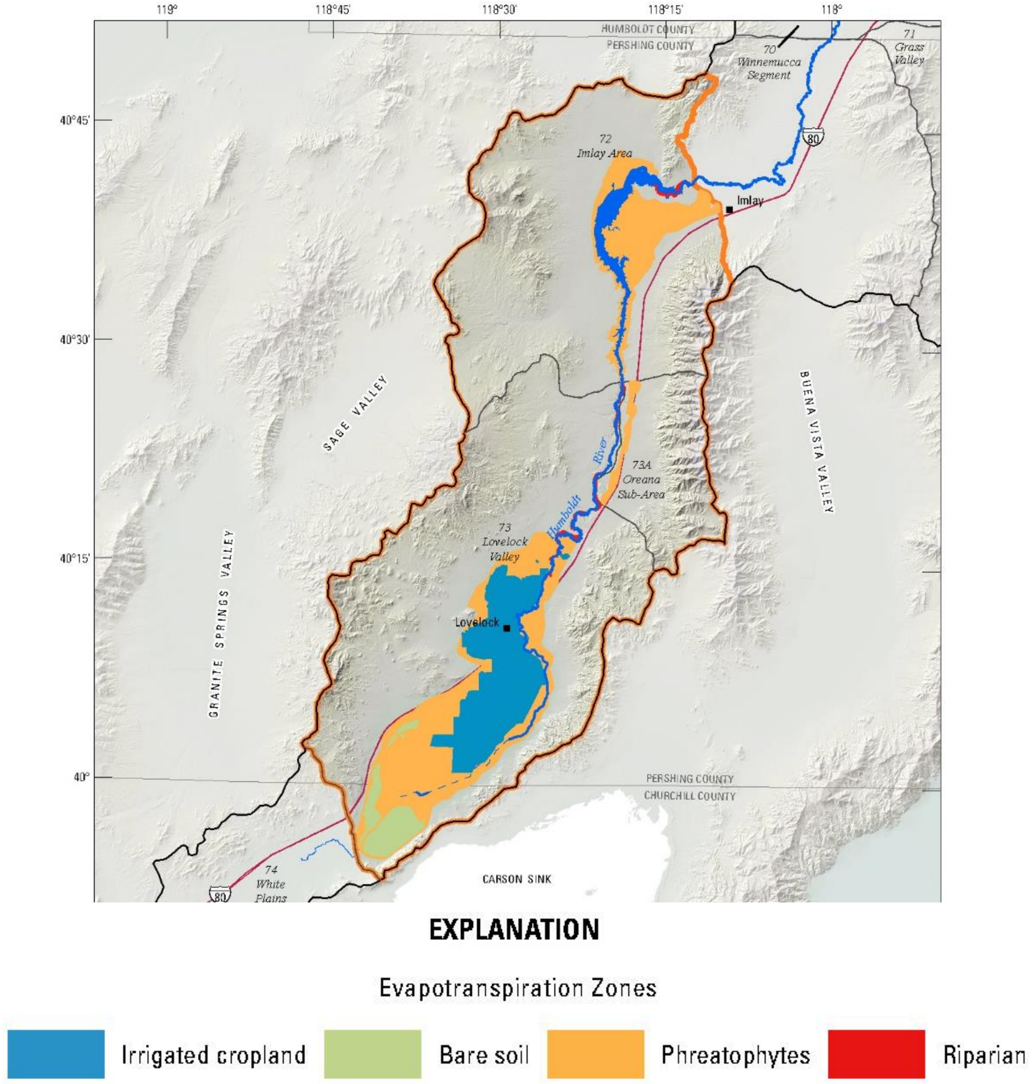
Drains

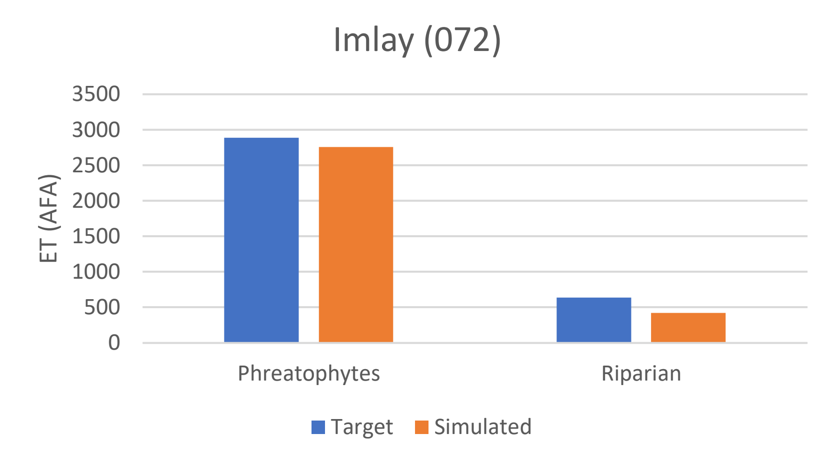
- Represents agricultural runoff/recharge lost to sink; simulated using the MODFLOW Drain (DRN) package
- Drain bottoms set to 9 ft bls
- Drain outflow estimated to be ~18,000 AFA

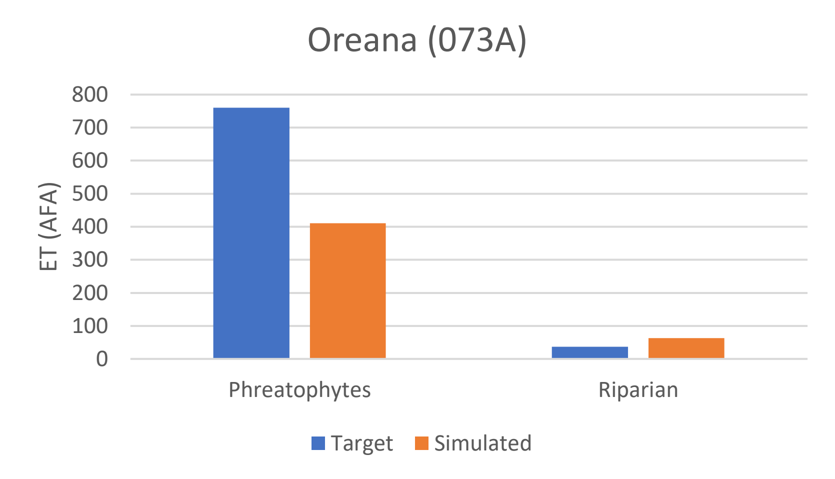


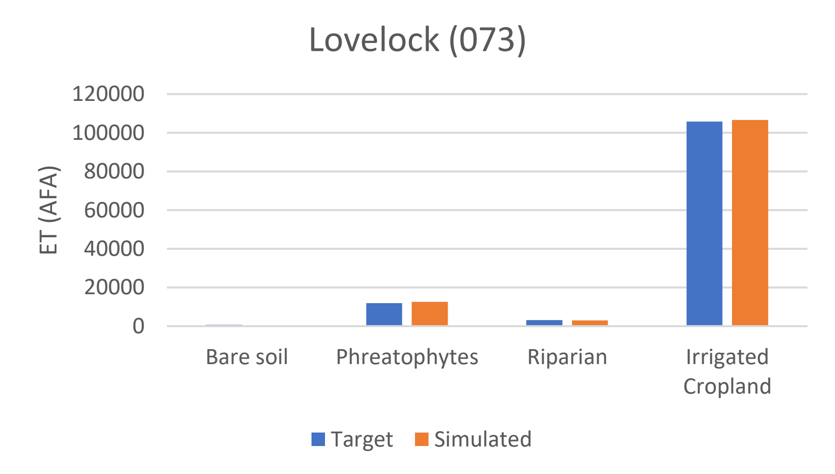
Evapotranspiration

- ET zones applied over DRI polygons, estimated at 126,000 acre-feet per year (AFA).



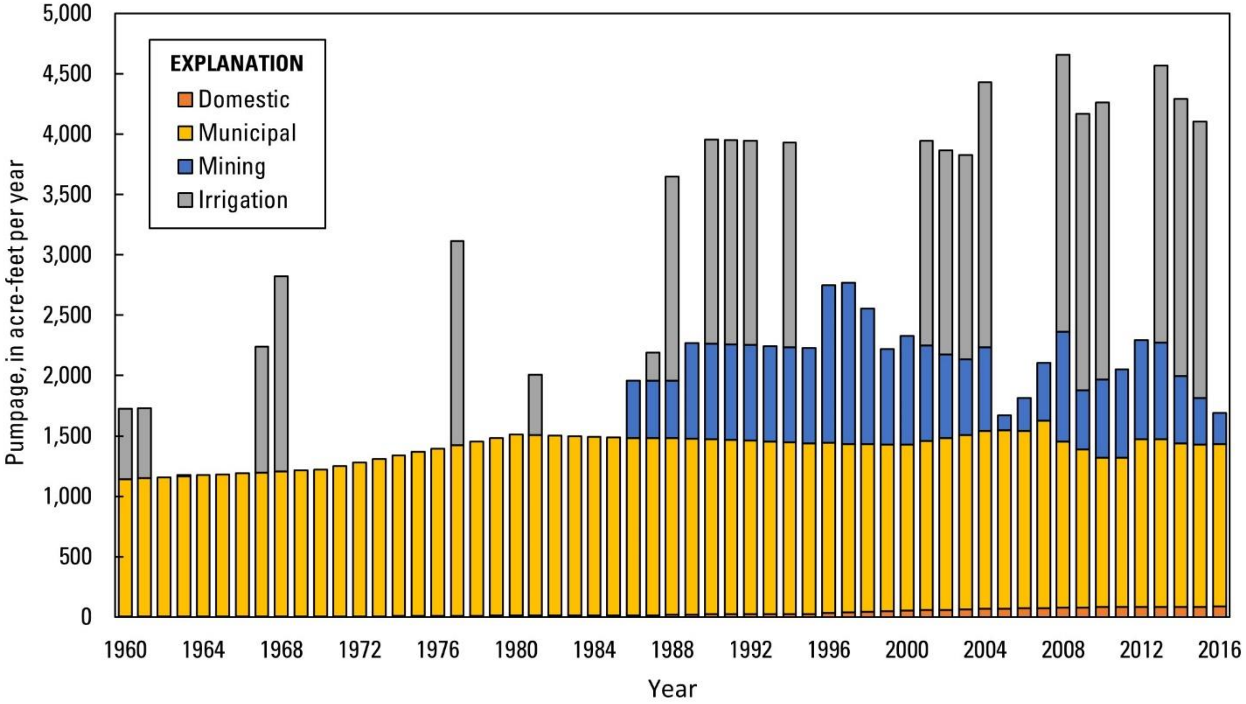


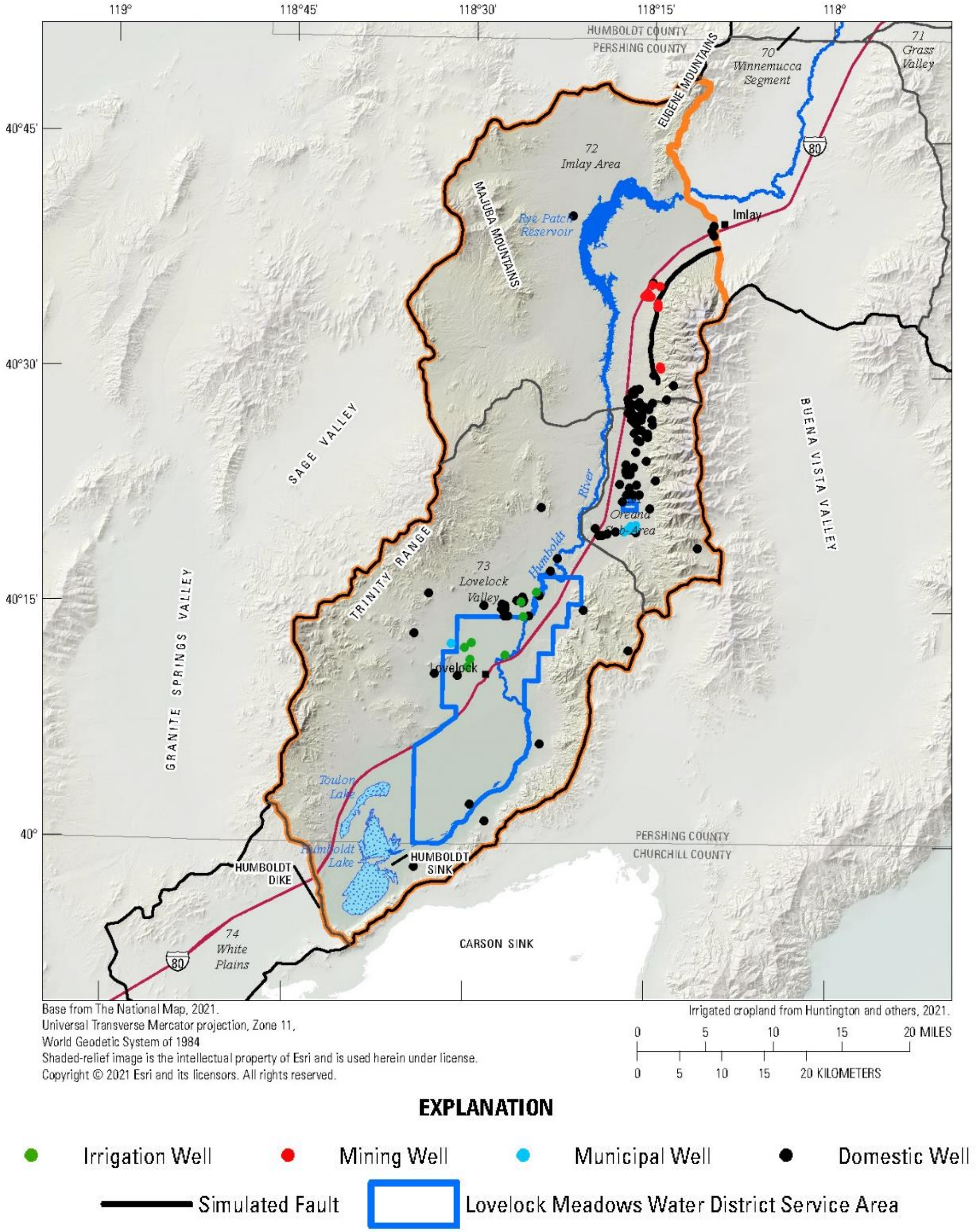




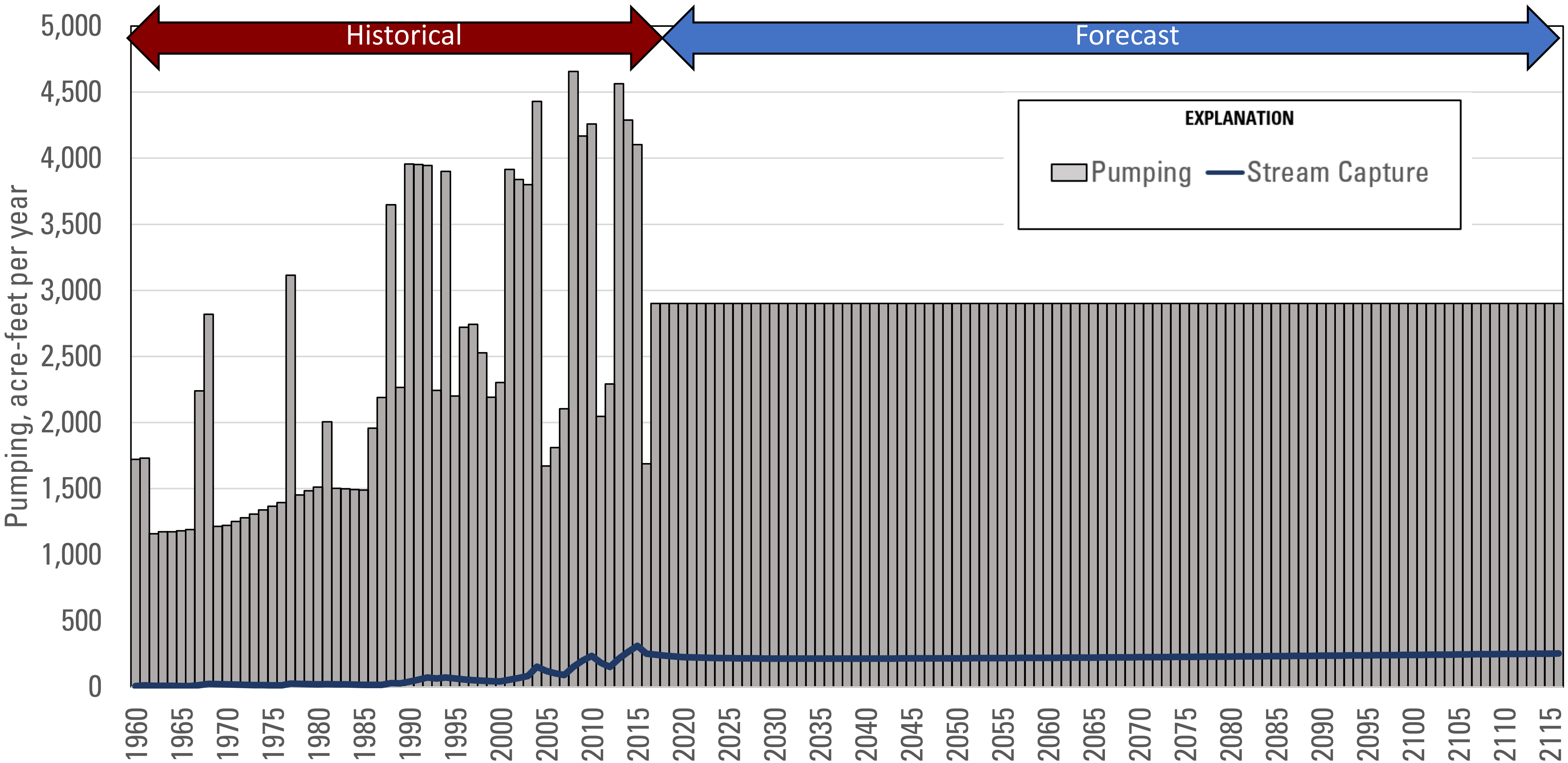
Transient Pumping

- Domestic wells pumping outside of Lovelock Meadows service area simulated at 0.7 acre-feet per year.
- Public supply wells pumped at rates extrapolated backwards to 1960 based on population.
- Mining well pumpage extrapolated earliest known rates backwards to 1986.
- Irrigation well pumpage inversely proportional to the ratio of estimated ag recharge relative to the mean agricultural recharge 1960-1990.



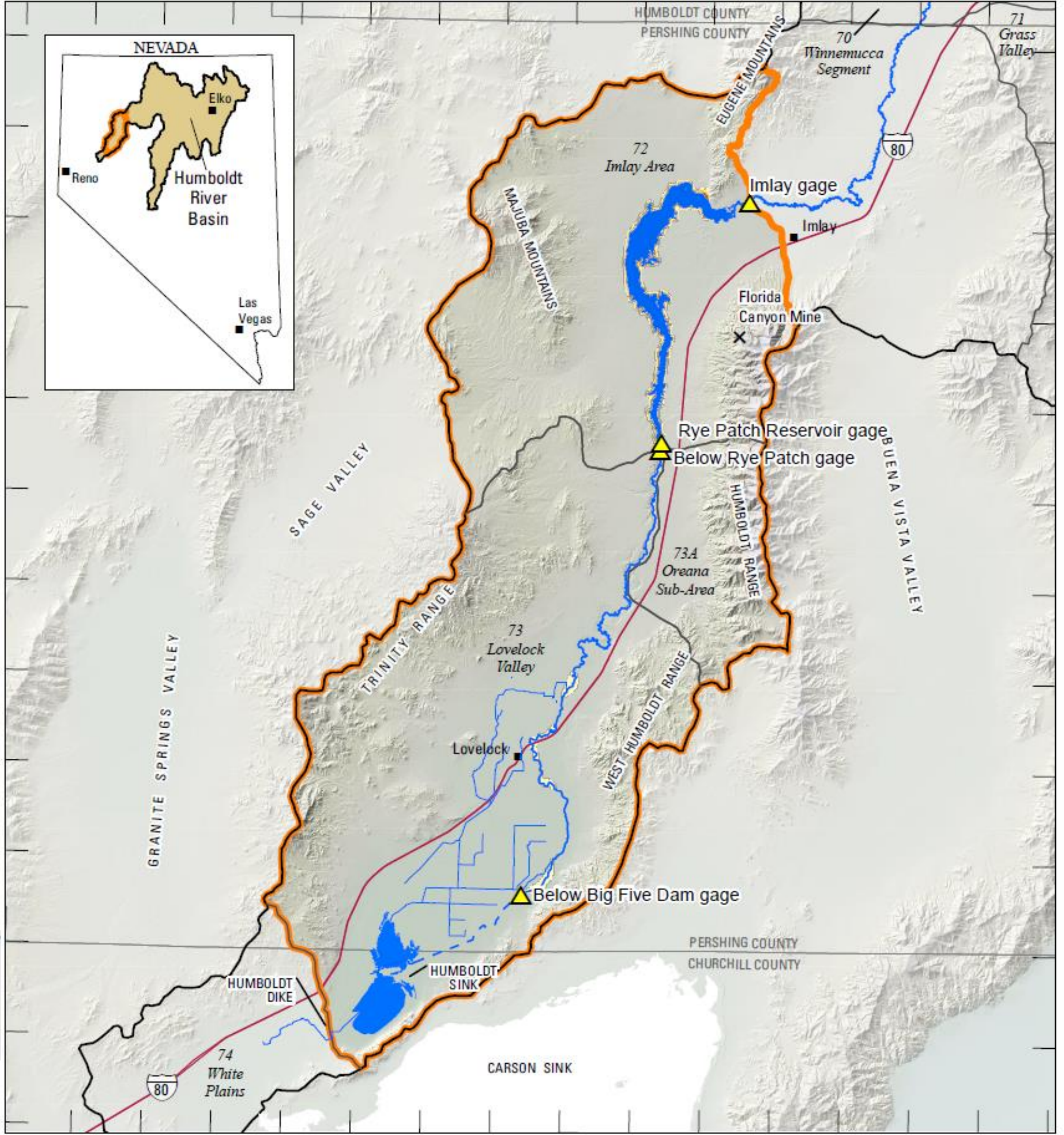


Estimated Humboldt River Historical and Predictive Stream Capture



* Model results are provisional and subject to change*

1 year, 10% or more Stream Capture



Percentage of Pumping

0 - 10	21 - 30	41 - 50	61 - 70	81 - 90
11 - 20	31 - 40	51 - 60	71 - 80	91 - 100

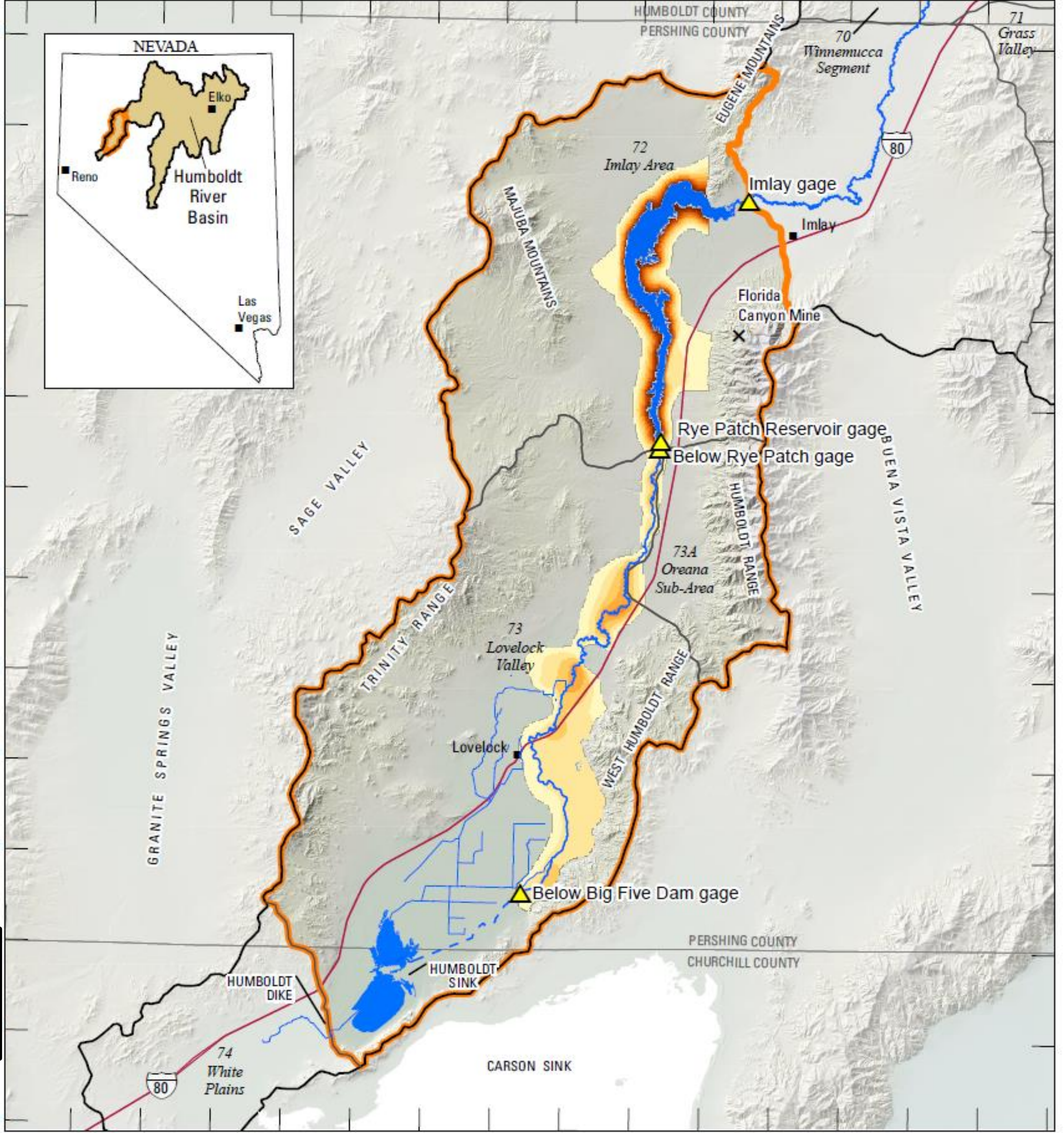
*** Model results are provisional and subject to change***

50 years, 10% or more Stream Capture

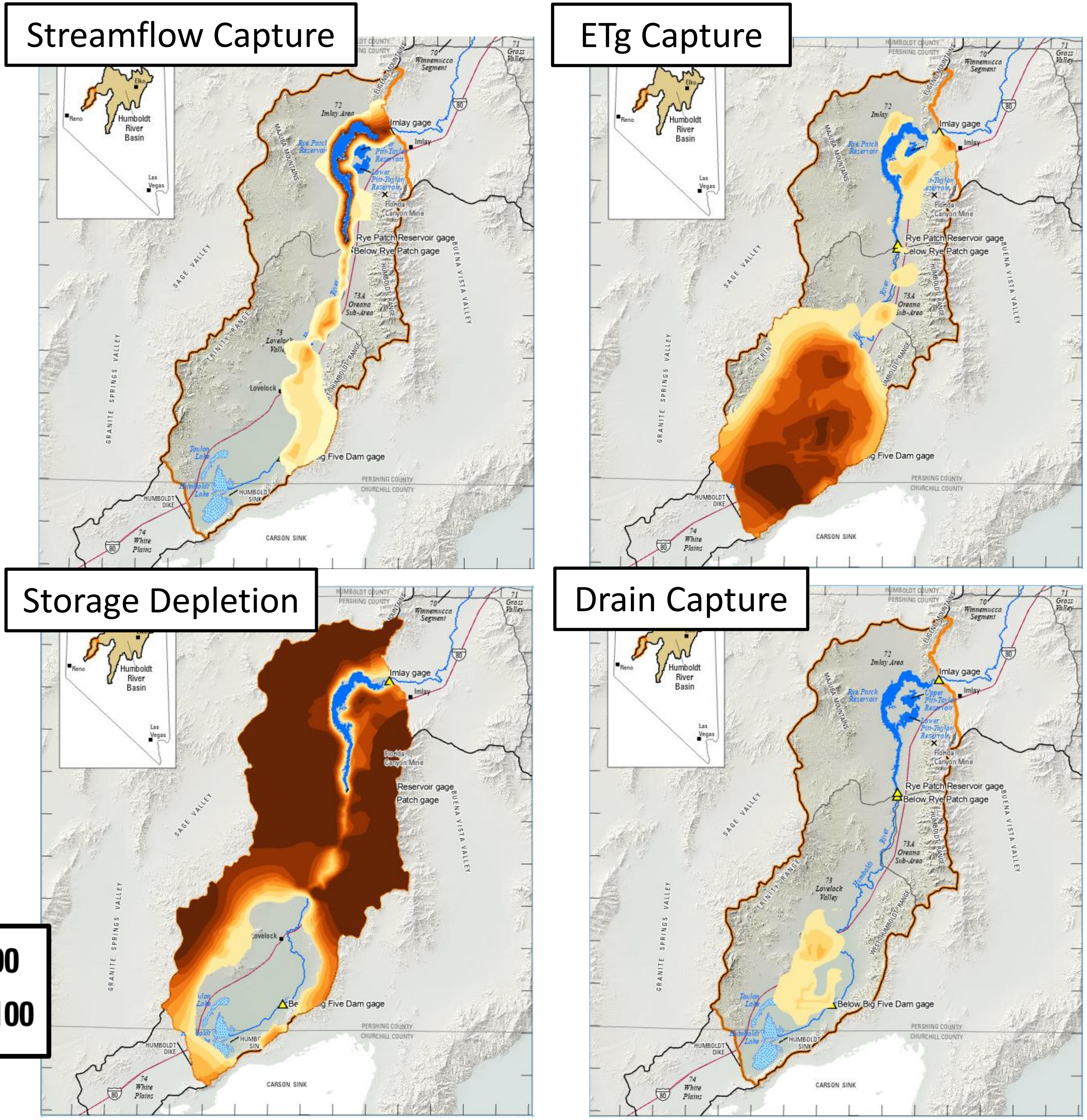
Percentage of Pumping

0 - 10	21 - 30	41 - 50	61 - 70	81 - 90
11 - 20	31 - 40	51 - 60	71 - 80	91 - 100

*** Model results are provisional and subject to change***



50 years, 10% or more all capture sources



Percentage of Pumping

0 - 10	21 - 30	41 - 50	61 - 70	81 - 90
11 - 20	31 - 40	51 - 60	71 - 80	91 - 100

*** Model results are provisional and subject to change***

Information Product Status

- **Report written:** March 2021
- **Report reviewed by supervisor, colleagues, and specialist:** April-September 2021
- **Sent to publisher:** December 2021
- **Anticipated availability:** Fall 2022

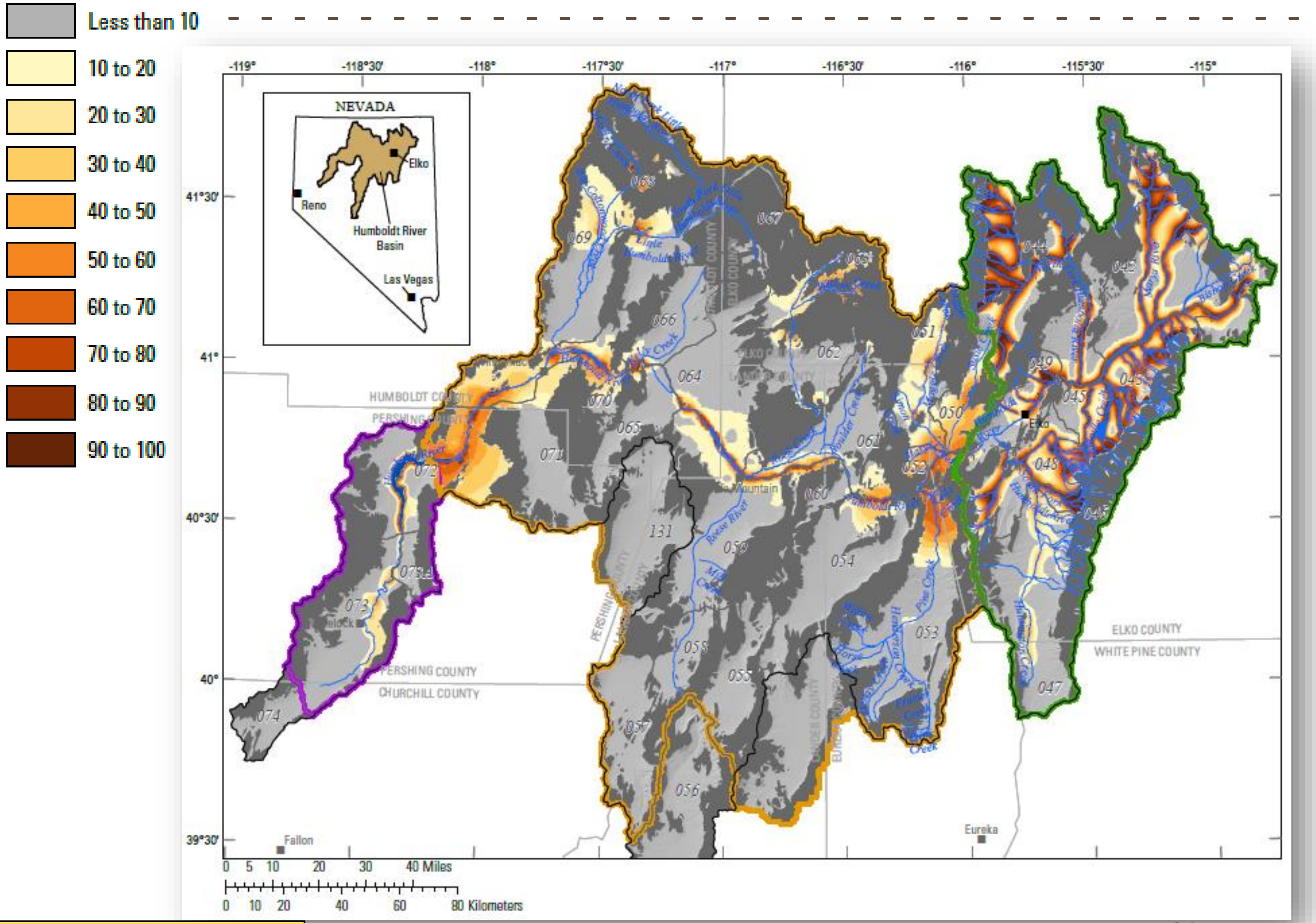
- **Model archive drafted:** March 2021
- **Model archive reviewed:** April 2021
- **Second review:** Spring 2022
- **Anticipated availability:** Fall 2022

Composite 50-year Capture Map

NDWR

HUMBOLDT RIVER REGION 50-YEAR CAPTURE MAP

- Some disconnected reaches
- Mountains are masked
- Capture between models has different character
  - Upper has dense stream network.
  - Middle has many ephemeral/intermittent streams.
  - Lower represents finer/tighter aquifers
  - ET capturability differences.
- Boundary effects
  - External boundaries ‘reflect’ drawdowns



*** Model results are provisional and subject to change***

END OF TECHNICAL PRESENTATIONS

BREAK

ORDER 1329 OVERVIEW

NDWR

ORDER 1329 OVERVIEW

Acknowledges that groundwater pumping is causing stream capture that results in conflict.

New appropriations or water right changes that would increase capture from fully appropriated sources aren't being approved.

All applications reviewed and assessed for stream capture.

Capture is permissible if it can be offset by:

- Replacement surface water
- Withdrawn groundwater right with existing capture.

Establishes interim thresholds for capture offset.

Establishes goal of using Capture Studies for future capture management.

Articulates intent to establish public process to develop capture management framework.

IN THE OFFICE OF THE STATE ENGINEER
OF THE STATE OF NEVADA

ORDER **#1329**

ESTABLISHING INTERIM PROCEDURES FOR MANAGING GROUNDWATER APPROPRIATIONS TO PREVENT THE INCREASE OF CAPTURE AND CONFLICT WITH RIGHTS DECREED PURSUANT TO THE HUMBOLDT RIVER ADJUDICATION

I.

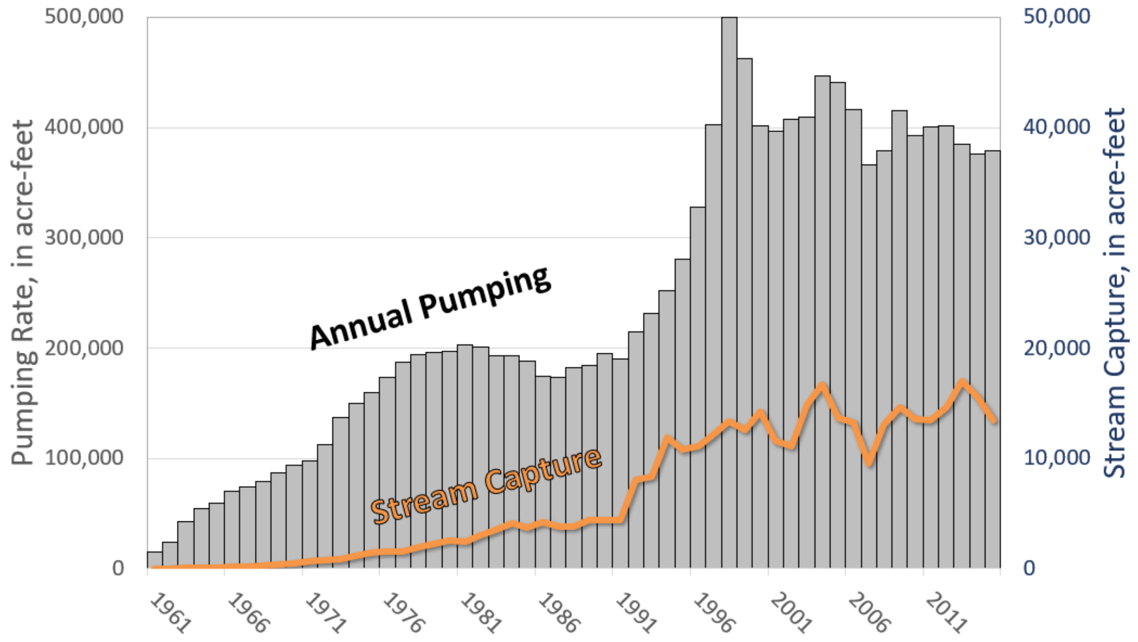
OVERVIEW

WHEREAS, it is well established that the source of water to a pumping well originates from three primary sources; first from groundwater storage, then increasing over time from capture of streamflow (where present in a hydrographic system) and evapotranspiration.[1,2] The terms "stream capture" or simply "capture," as used in this Order, refer to a reduction in streamflow caused by groundwater pumping. Decades of groundwater pumping in the Humboldt River Region (Region) has led to increasing capture of the Humboldt River and its tributaries, resulting in growing conflict with rights of the Humboldt Decree.

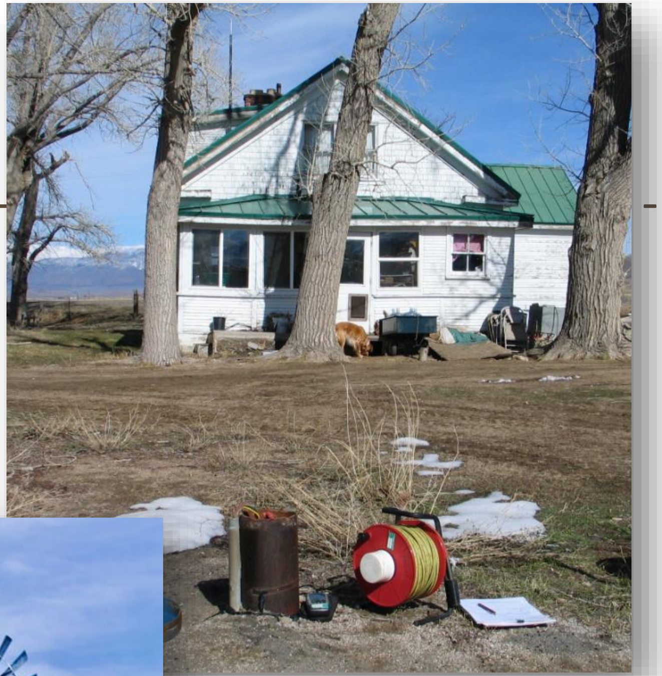
Order 1329 Does Not:

Predetermine the final capture management framework.

Apply to domestic well use or minor stock water use (<5 afy of capture in 50 yrs).



Provisional estimated Historical Capture for middle Humboldt River Basin*



TECHNICAL ASPECTS

***Objective*:**
Utilize existing SW or GW right to avoid increasing capture that would otherwise cause conflict

Interim Thresholds:

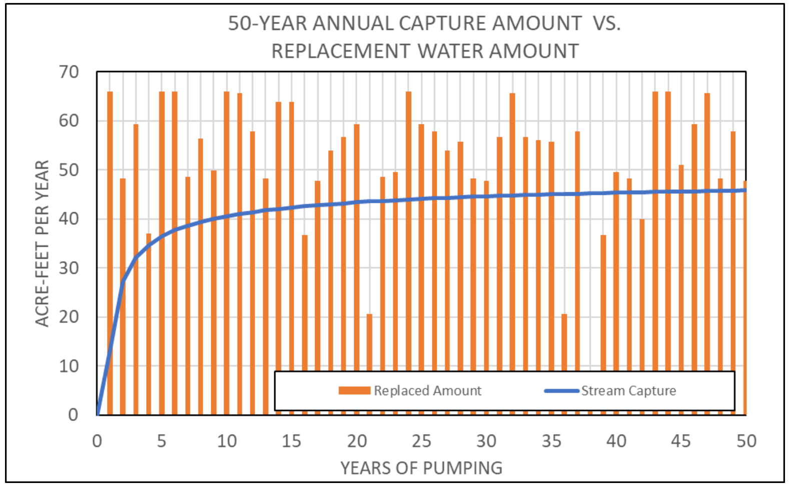
- **Evaluation Threshold**

  >10% capture after 50 years

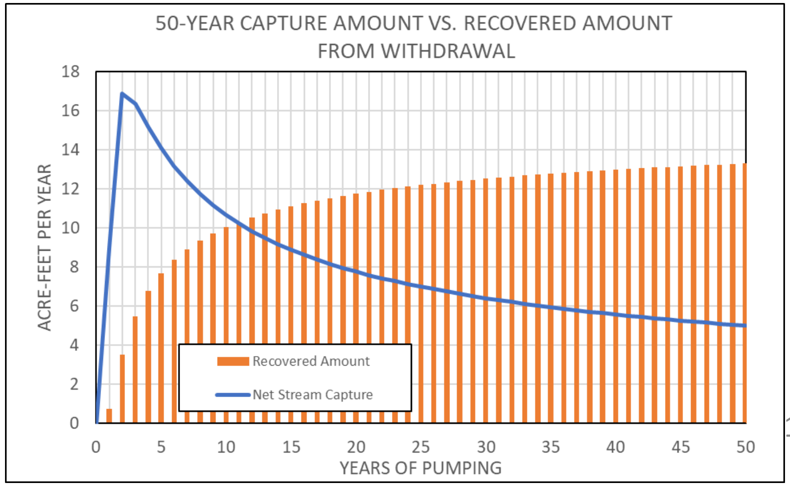
- **Long-term Threshold (50-yr Rule)**

- **Annual Threshold (80% Rule)**

Replacement by SW Right



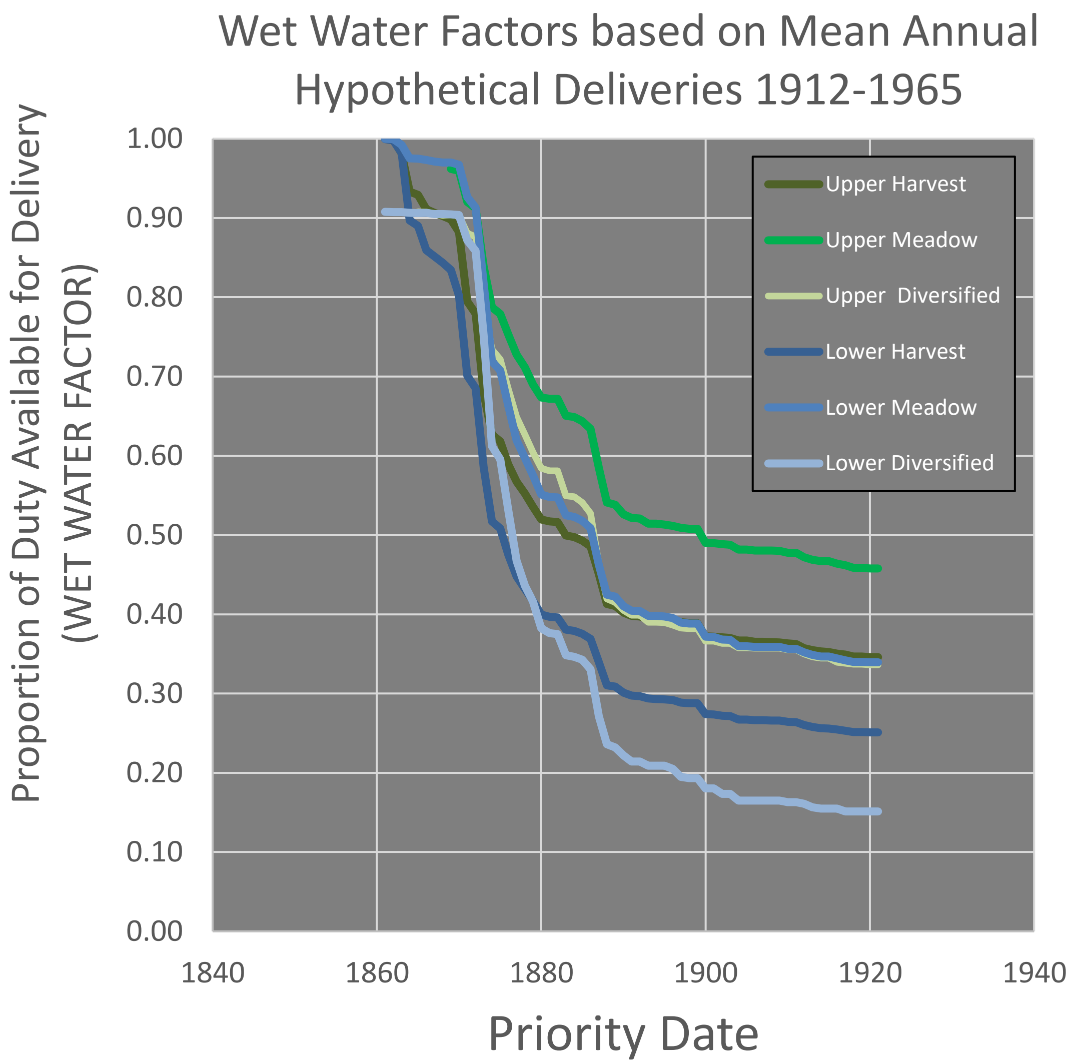
GW Right Withdrawal



DETERMINATION OF SURFACE WATER AVAILABILITY FOR REPLACEMENT ("WET WATER")

WET WATER FACTORS BASED ON 1912-1965 FLOW PALISADE GAGE						
Priority	Upper			Lower		
	Upper Harvest	Upper Meadow	Upper Diversified	Lower Harvest	Lower Meadow	Lower Diversified
1861				1.000	1.000	0.908
1862	0.999			0.998	1.000	0.907
1863	0.981			0.982	0.992	0.907
1864	0.933			0.897	0.975	0.907
1865	0.929		0.908	0.890	0.975	0.906
1866	0.911		0.907	0.859	0.973	0.906
1867	0.907		0.905	0.852	0.971	0.905
1868	0.903		0.903	0.844	0.970	0.905
1869	0.898	0.962	0.904	0.834	0.970	0.905
1870	0.882	0.959	0.903	0.802	0.967	0.904
1871	0.795	0.920	0.881	0.701	0.926	0.872
1872	0.779	0.912	0.876	0.685	0.913	0.859
1873	0.680	0.839	0.791	0.586	0.818	0.752
1874	0.627	0.788	0.734	0.517	0.719	0.612
1875	0.618	0.779	0.722	0.509	0.708	0.595
1876	0.589	0.753	0.685	0.475	0.663	0.531
1877	0.567	0.728	0.649	0.448	0.619	0.467
1878	0.553	0.711	0.627	0.432	0.597	0.436
1879	0.536	0.690	0.605	0.417	0.575	0.416
1880	0.520	0.674	0.584	0.400	0.551	0.382
1881	0.517	0.672	0.581	0.397	0.548	0.376
1882	0.516	0.672	0.581	0.396	0.547	0.375

Provisional*

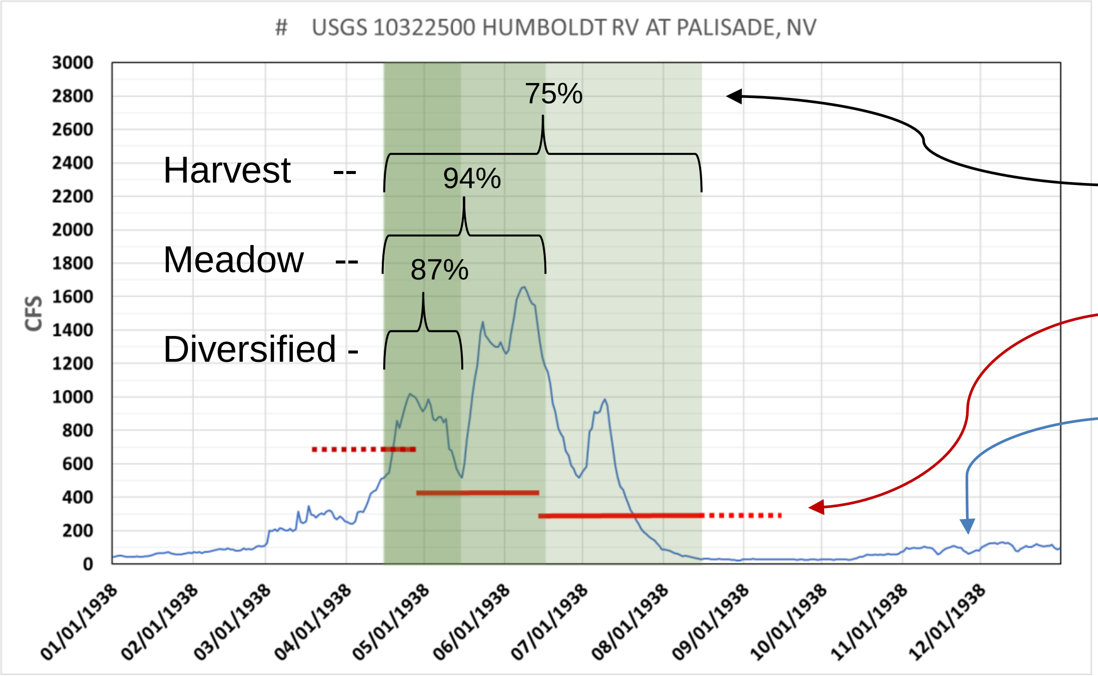


WHAT AFFECTS WET WATER DETERMINATION?

1882 PRIORITY EXAMPLE:
- **Typical Year, 208,000 afs**
- **Delivery based on Palisade Flow**

Upper Rights "wetter" than Lower Rights
- ***Shorter Season of Use***
- ***Sweet spot of runoff***

Upper Humboldt Delivery



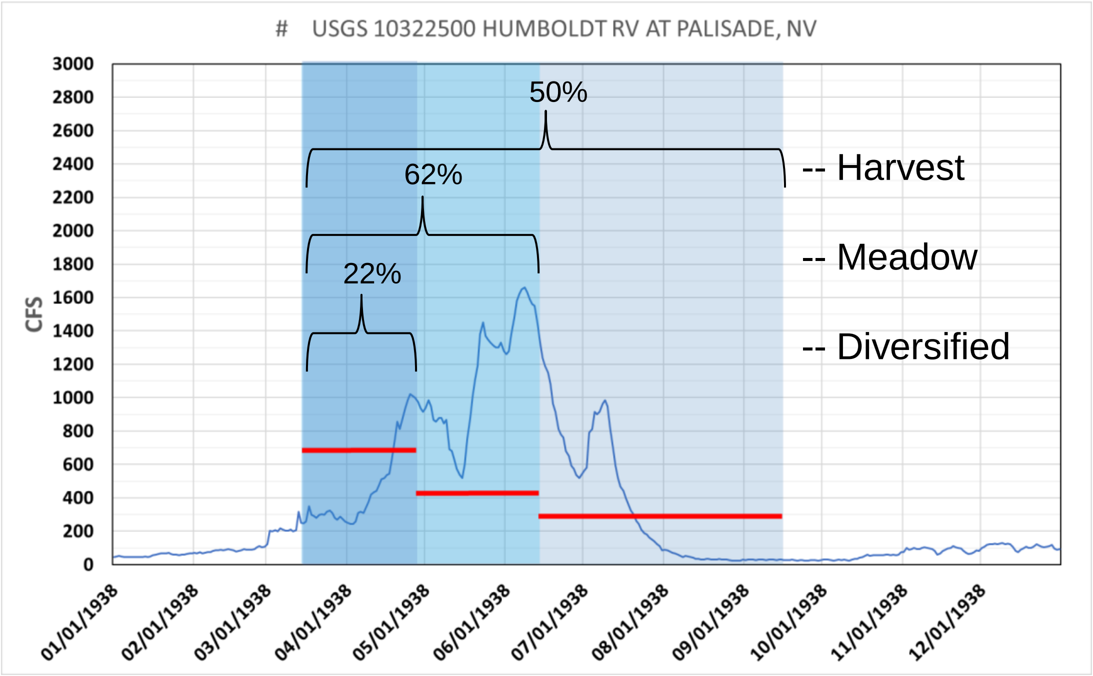
Season of use shaded

% Season 1882 is in priority

Minimum Flow to Serve 1882

Palisade Flow

Lower Humboldt Delivery

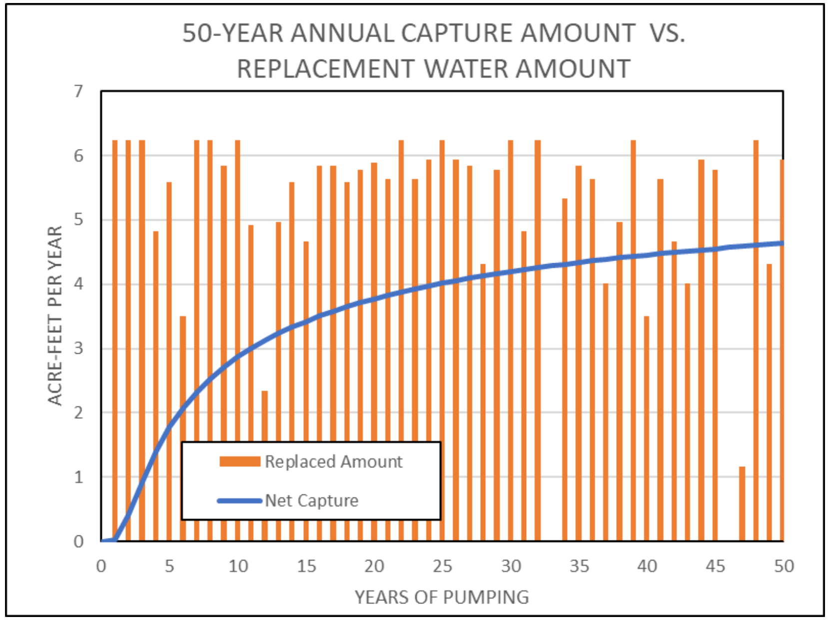


Replacement Water Example

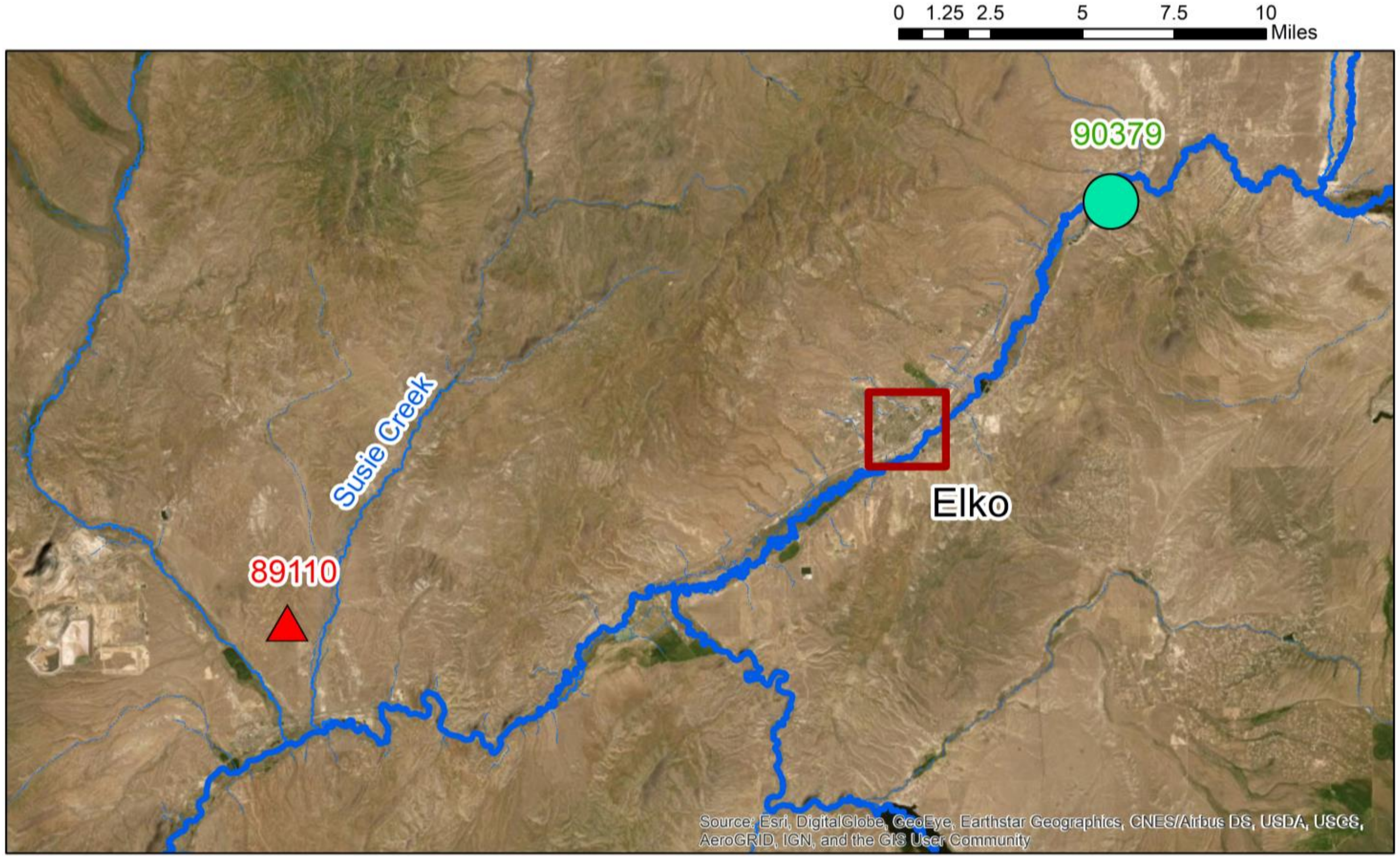
89110 (UG)
90379 (Replacement)

UG Appropriation	= 6.20 afa
Replacement Duty	= 6.64 afa

1872 Harvest



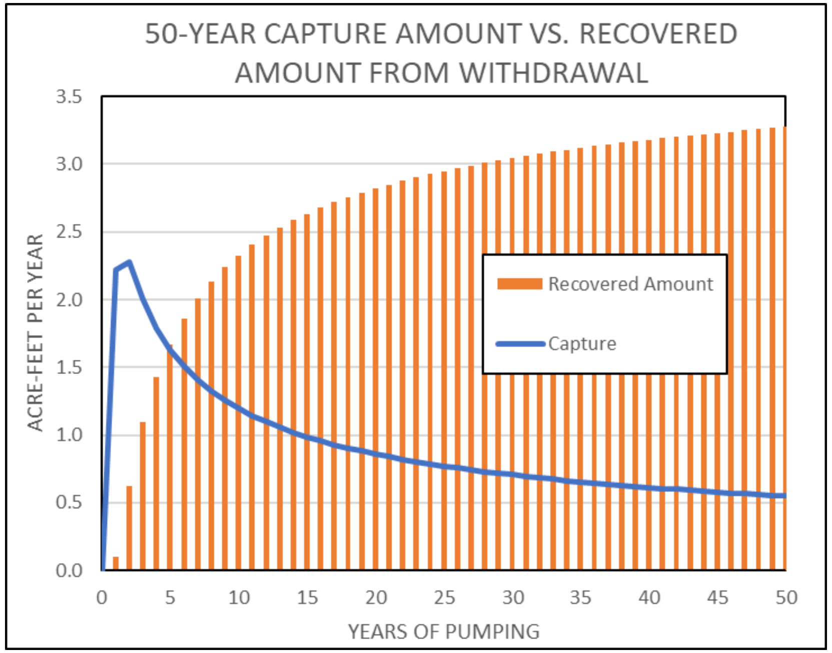
**Supports ~5% Stream Loss*

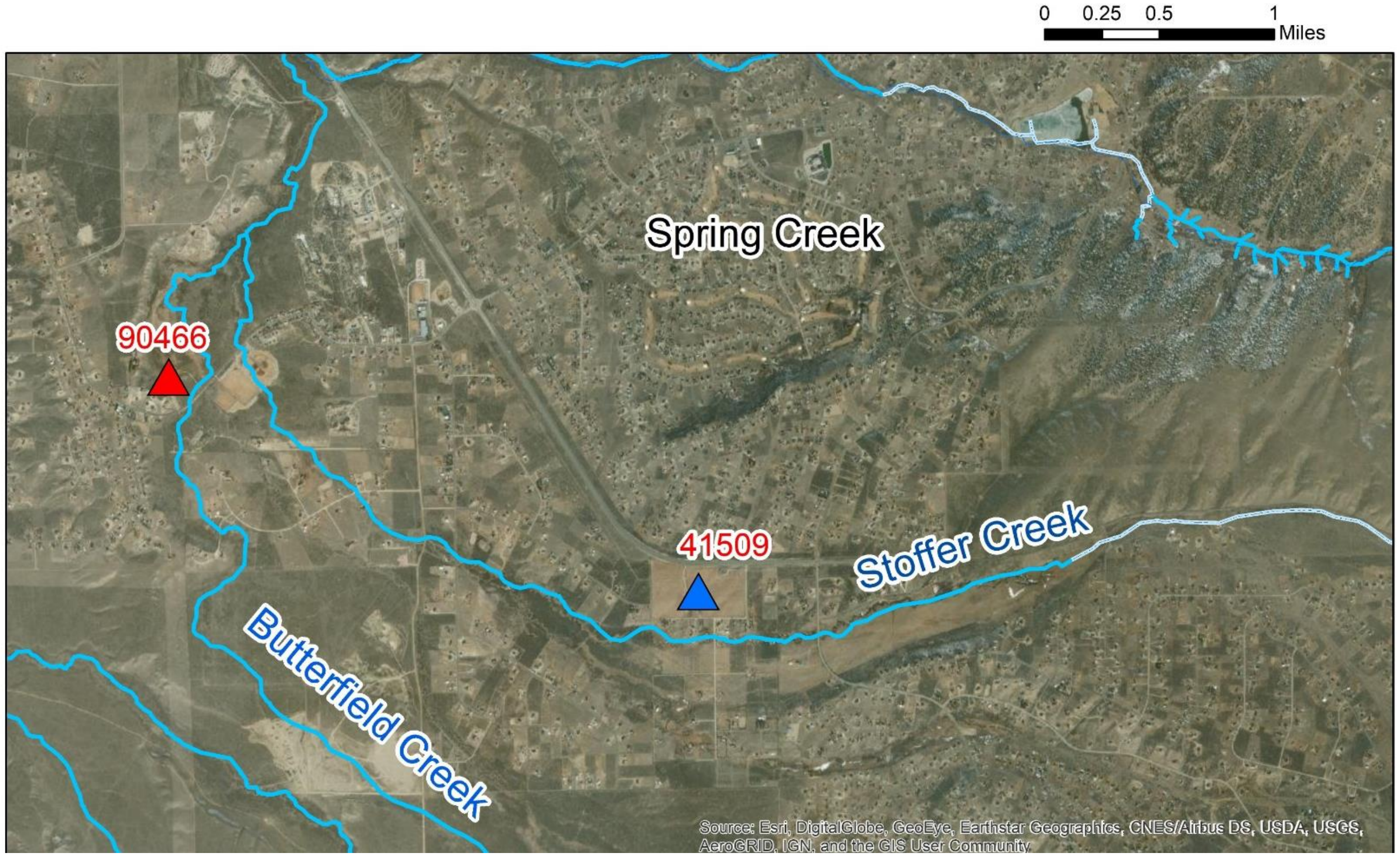


WITHDRAWAL OF GROUNDWATER EXAMPLE

41509 (Existing Right)
90466 (Proposed Change)

Existing	= 7.75 afa
Changed Duty	= 3.16 afa
Withdrawn	= 4.59 afa



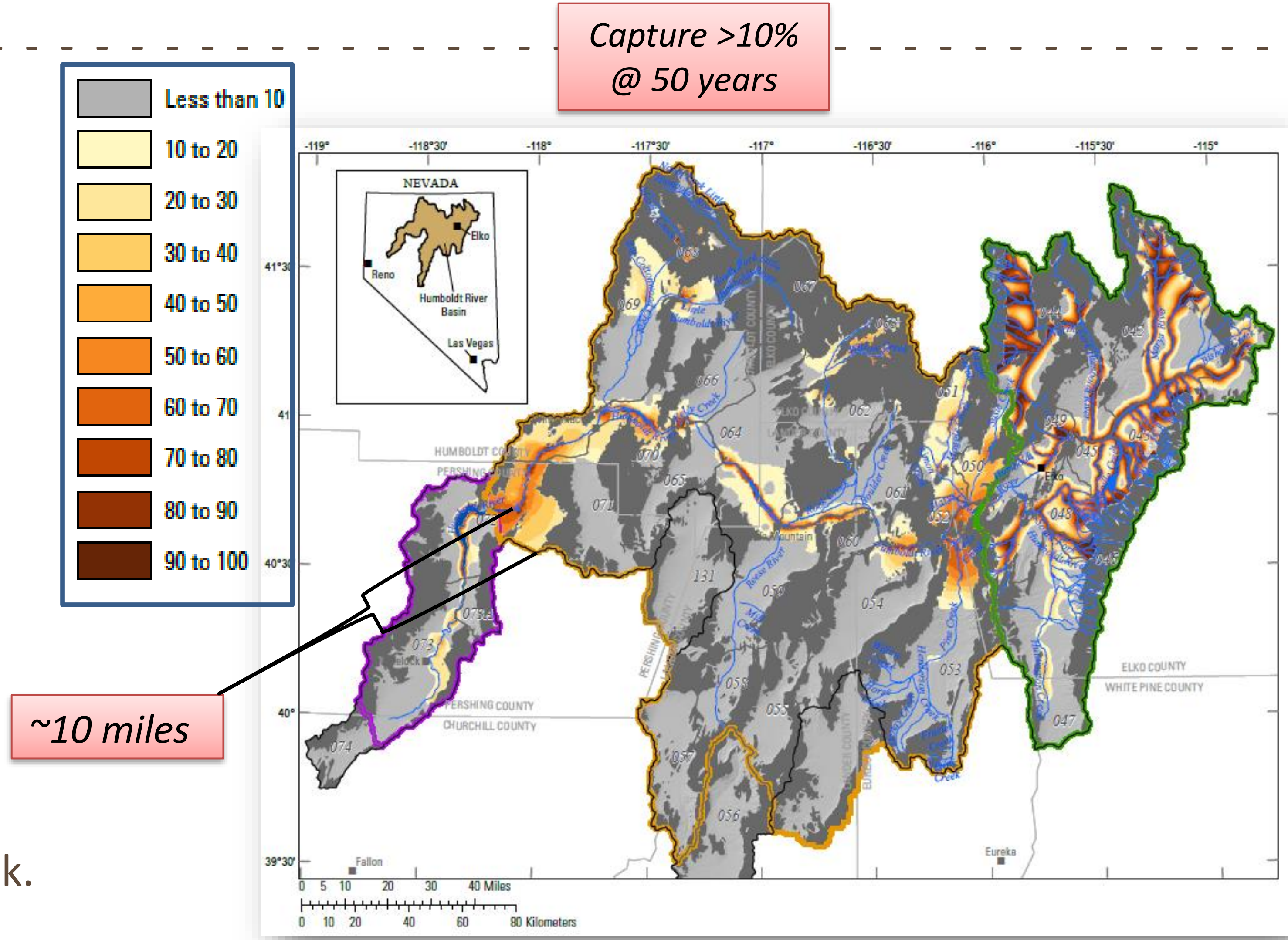


Exemptions

- Applications whose proposed PODs cause capture at <10% during 50-year period
- Change applications whose proposed PODs cause same or less capture than existing PODs
- Applications whose proposed PODs cause < 5 afy capture during 50-year period
- Temporary change applications to provide for multiple PODs from Mining, Milling, and Dewatering operations (Centralized POD)

Take Home Messages

- UG Applications within ~10 miles of fully appropriated stream likely be in capture zone.
- Applications for <5 afy are generally exempt.
- Applications that would otherwise be denied, can be approved if capture can be offset.
- Thresholds and criteria are interim and subject to capture management framework.



Humboldt River Potential Capture after 50 years of pumping*

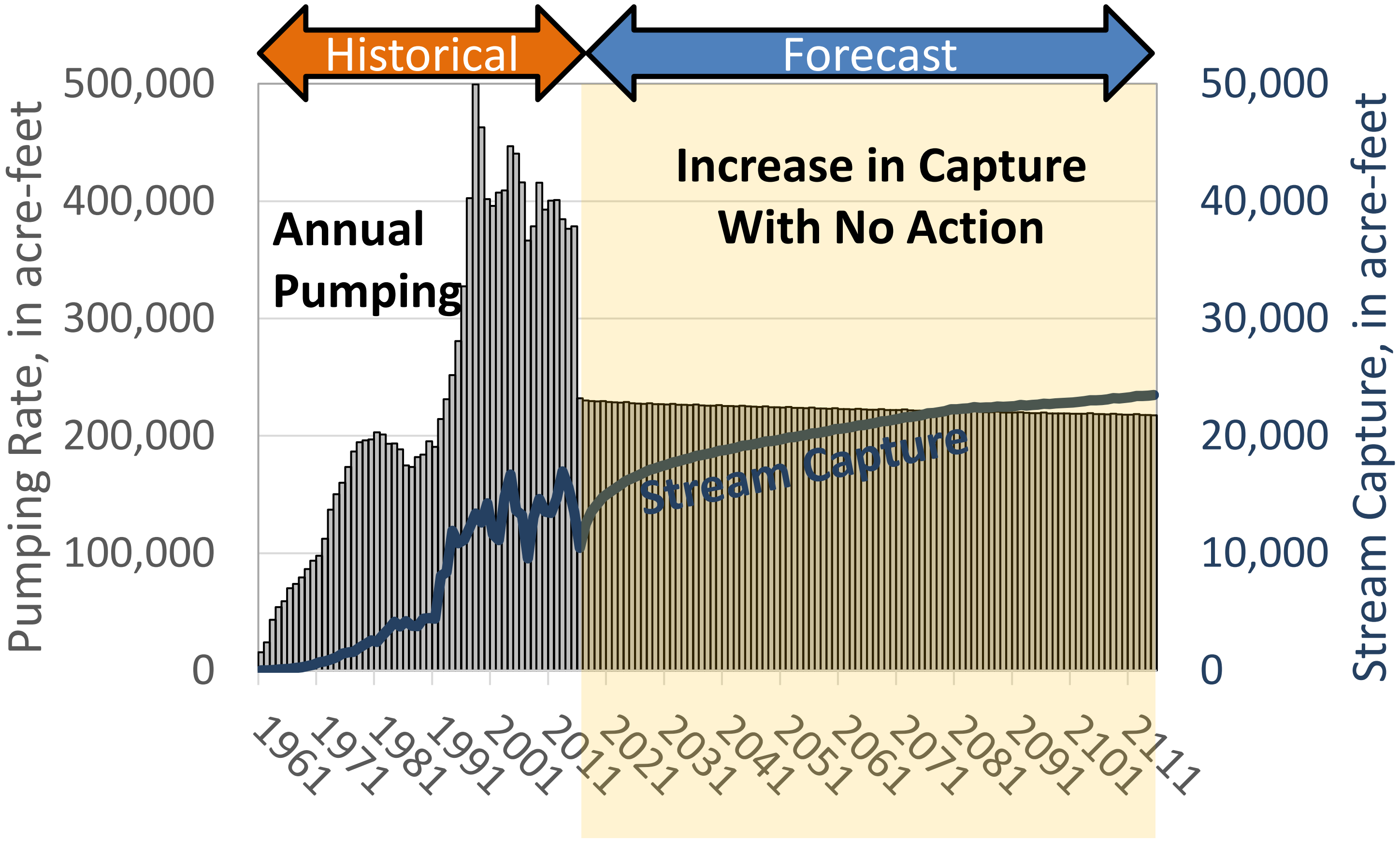
*Provisional Results

Moving forward with Conjunctive Management Framework

NDWR

WHERE ARE WE GOING FROM HERE?

Develop capture management framework with Stakeholders for managing existing capture.



Provisional estimated Historical and Forecasted Capture for middle Humboldt River Basin*

Examples of potential future strategies

- Curtailment in capture threshold areas
- Offset credit for artificial recharge
- Enhanced storage through ASR
- Conservation funds to purchase water rights with greatest conflict
- Private party agreements to resolve conflict
- Withdrawal/abandonment of committed rights

Moving Forward with Conjunctive Management

Questions?

Contact

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