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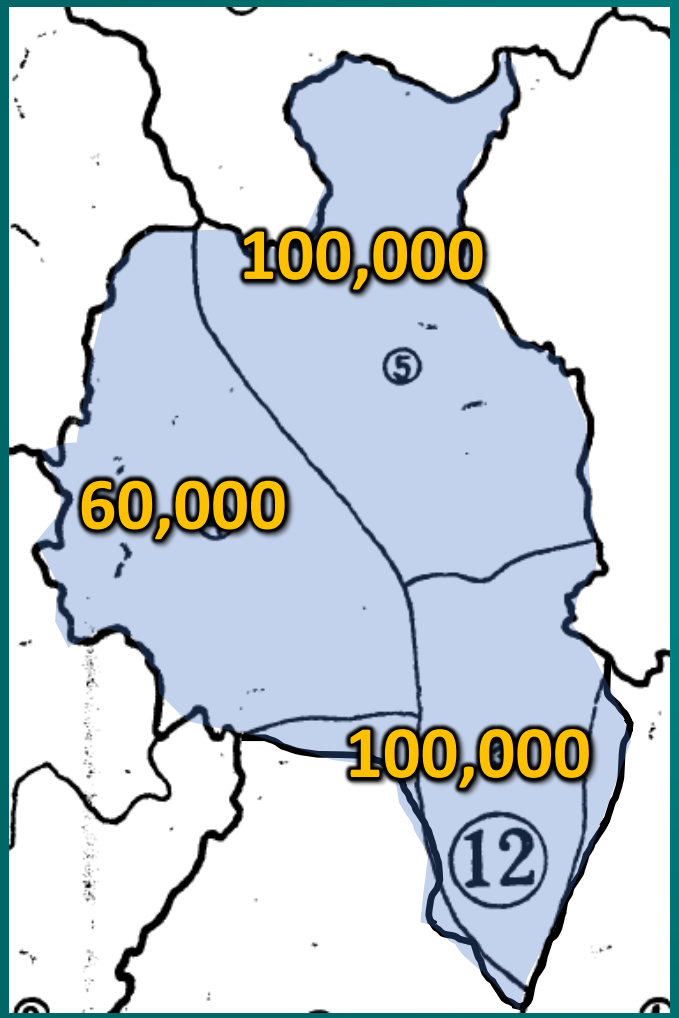
Harney Basin Groundwater Discharge

Amanda Garcia, Jordan Beamer, Mellony Hoskinson, Steve Gingerich, Nick Corson-Dosch, and Hank Johnson

U.S. Department of the Interior
U.S. Geological Survey

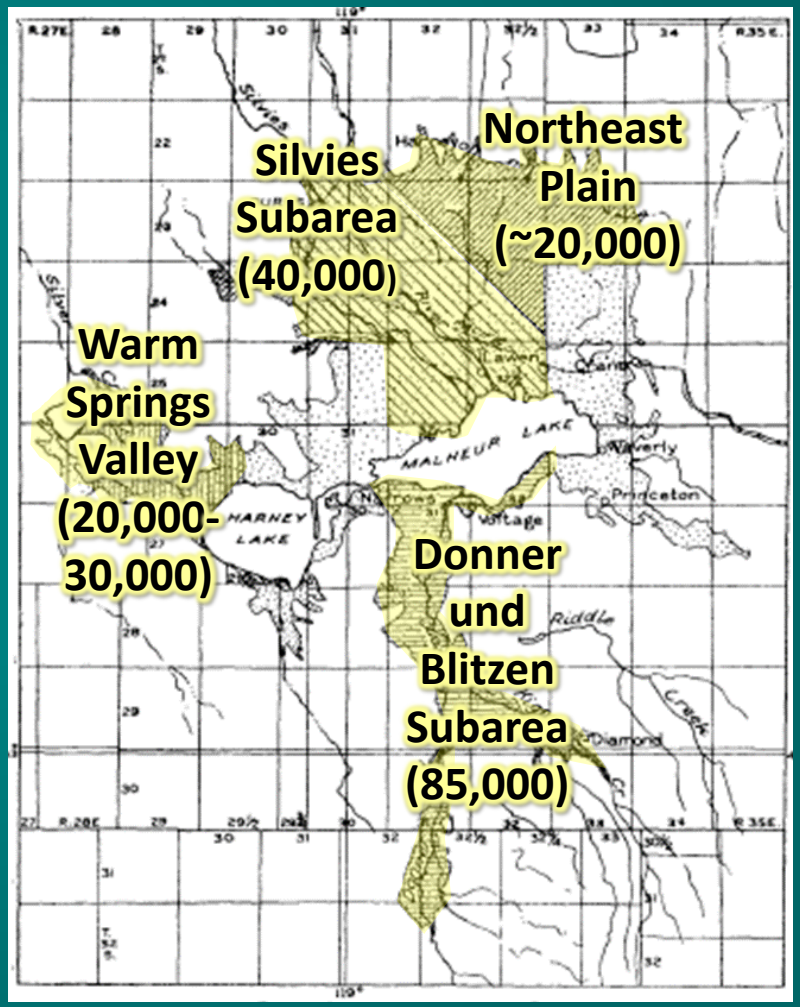
Previous Water-Budget Estimates

RECHARGE = 260,000 AF/Y



Robison (1968)

DISCHARGE ≈ 80,000 – <170,000 AF/Y



Piper and others (1939)

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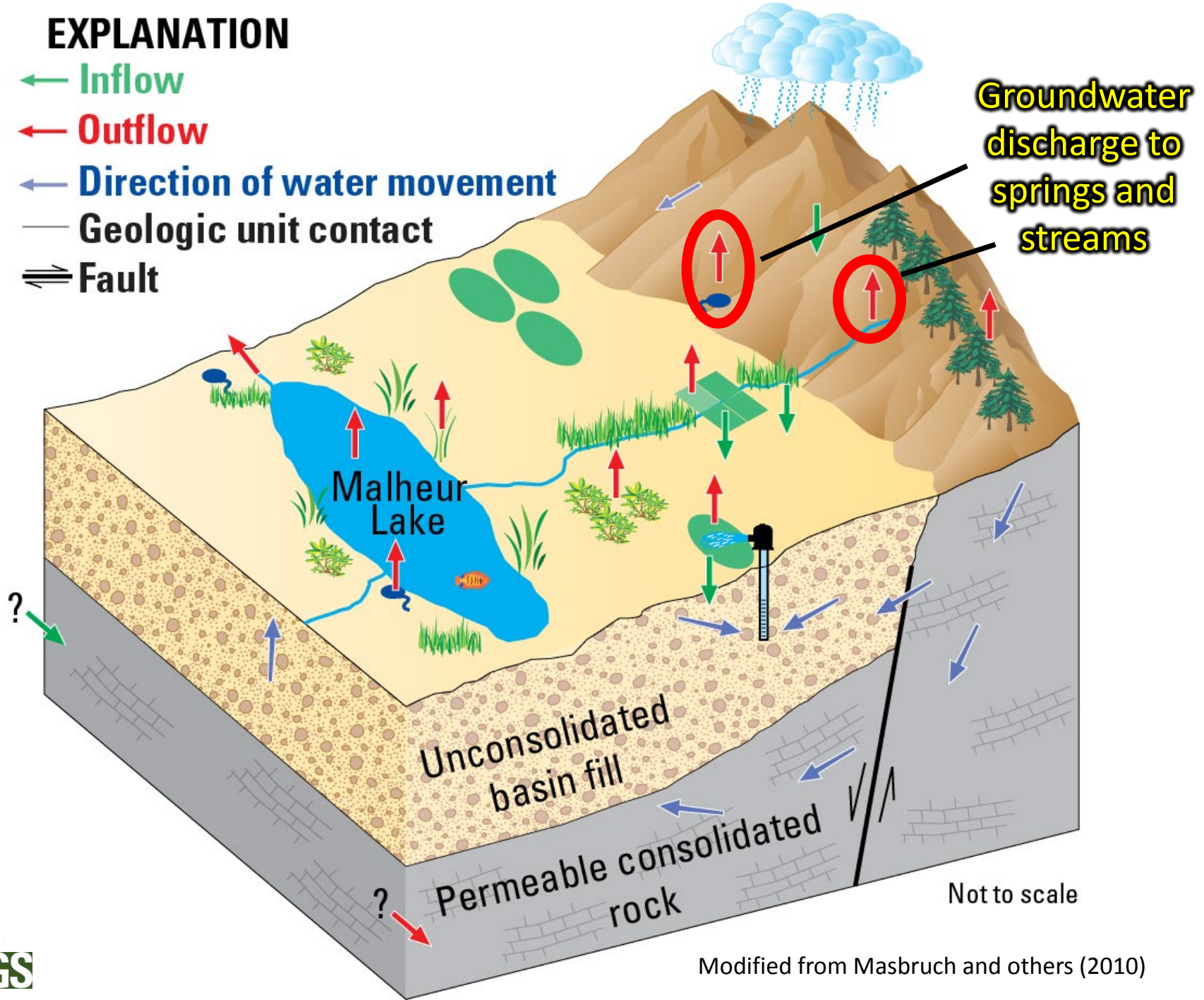

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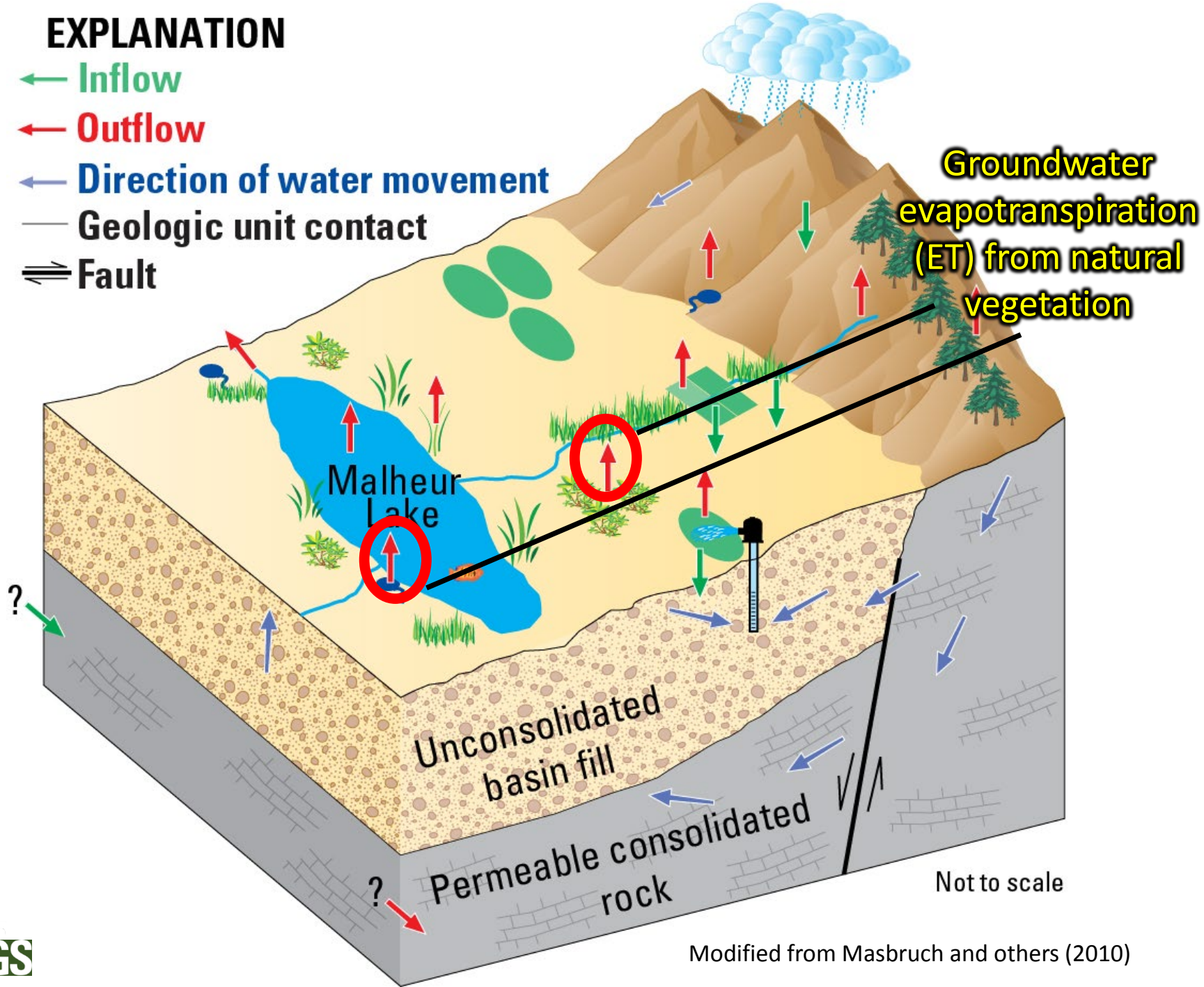
Modified from Masbruch and others (2010)



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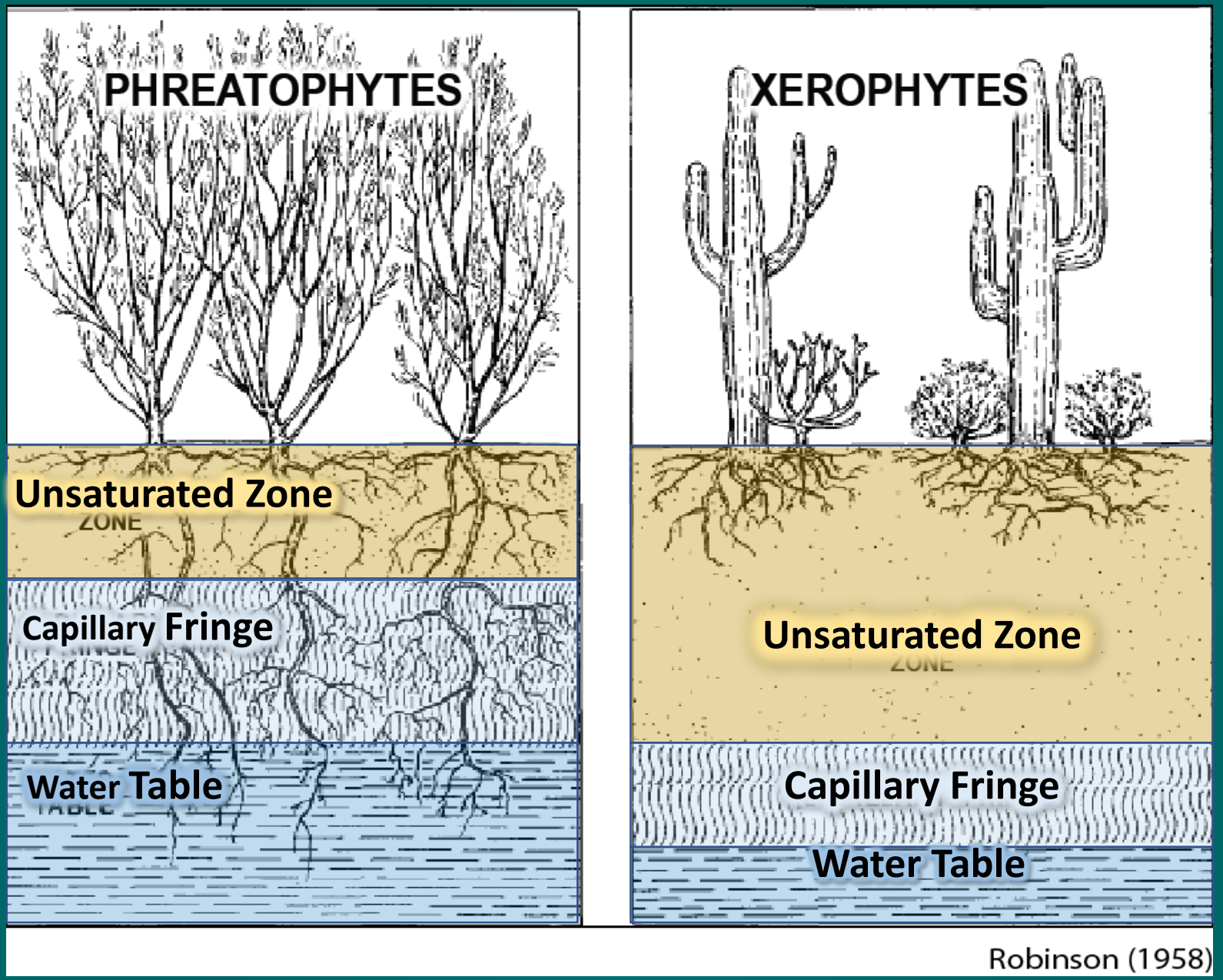
PHREATOPHYTES
Unsaturated Zone
Capillary Fringe
Water Table
XEROPHYTES
Unsaturated Zone
Capillary Fringe
Water Table
Robinson (1958)

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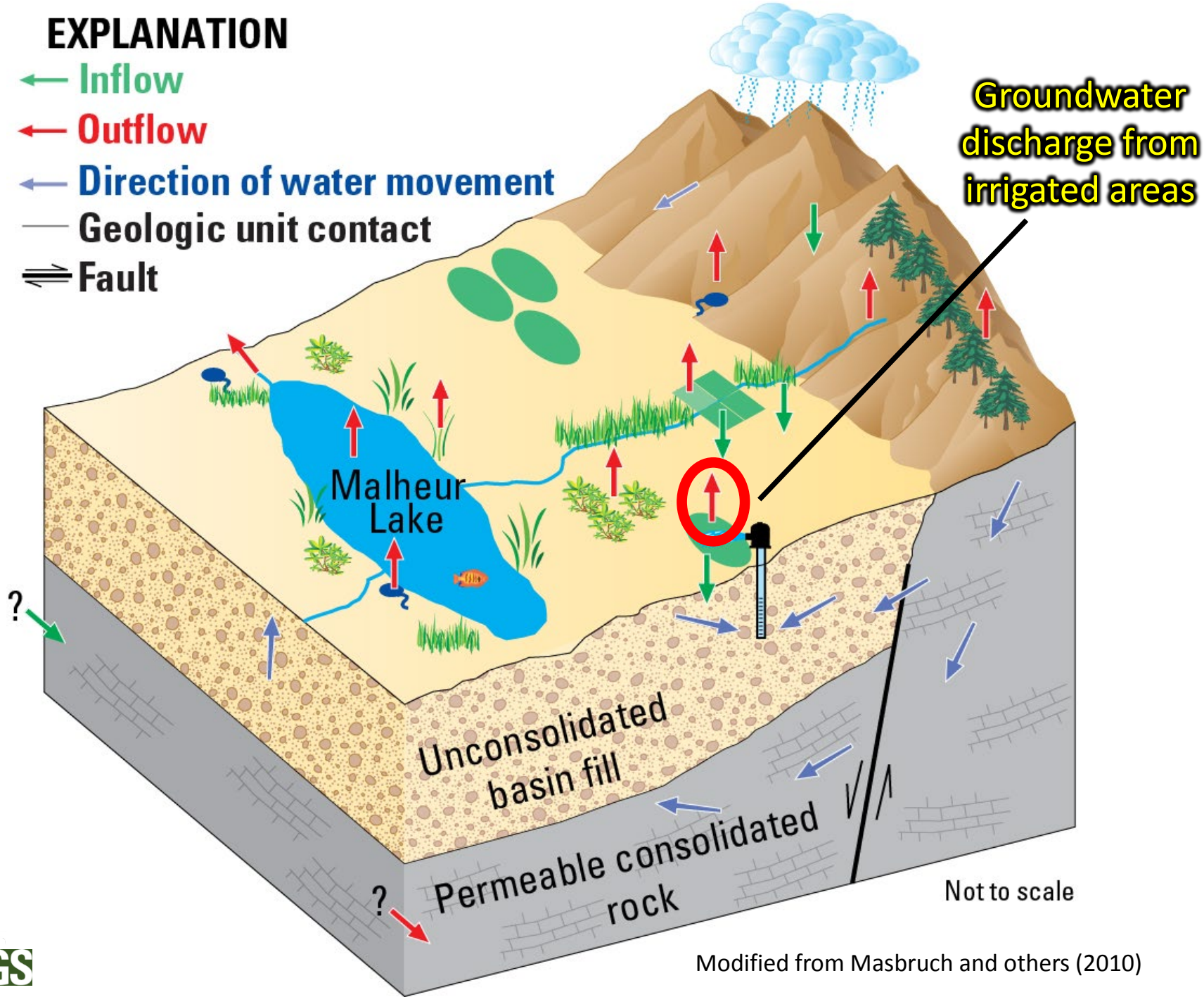
Natural Groundwater ET Areas

USGS



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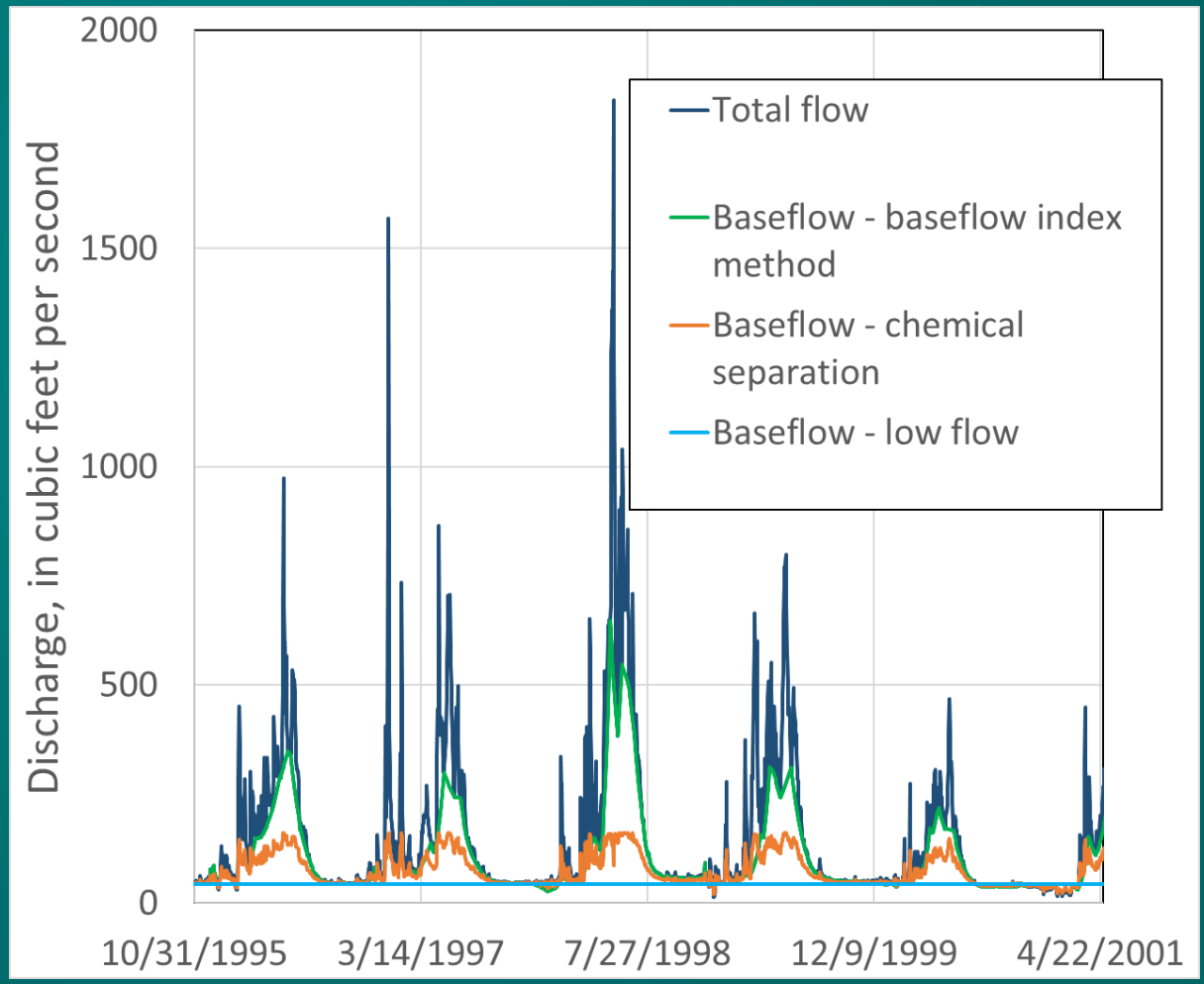
Modified from Masbruch and others (2010)

Groundwater Discharge to Streams (Baseflow)

- Predominantly in uplands
- Estimation methods
  - Baseflow index (BFI)
  - Low flow
  - Chemical separation
- Annual estimates = average of BFI and low flow

Gage: Donner und Blitzen near Frenchglen



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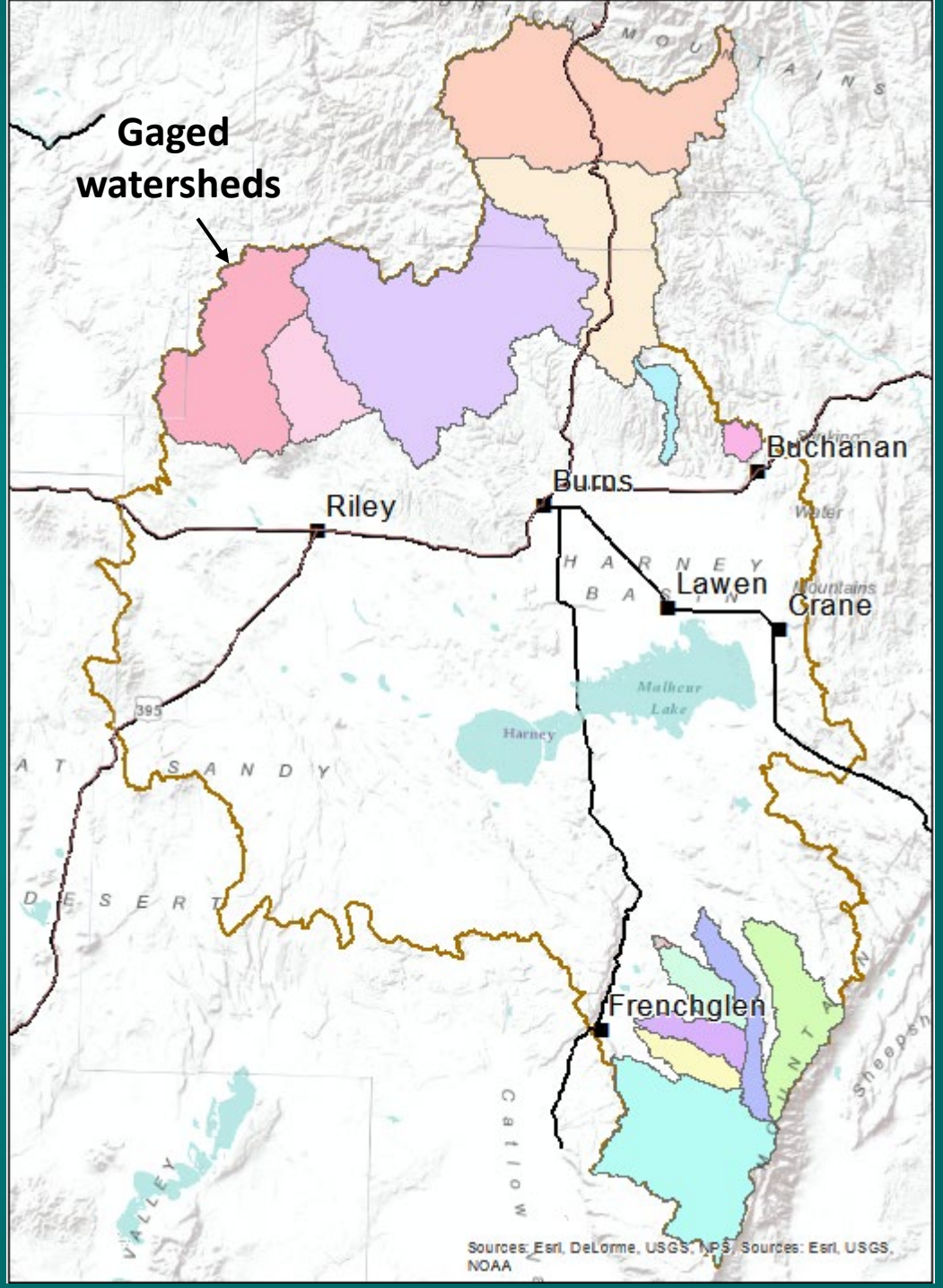
Groundwater Discharge to Streams (Baseflow)

- Total baseflow upper = ~140,000 AF/Y
- Total baseflow lower = 40,000 AF/Y



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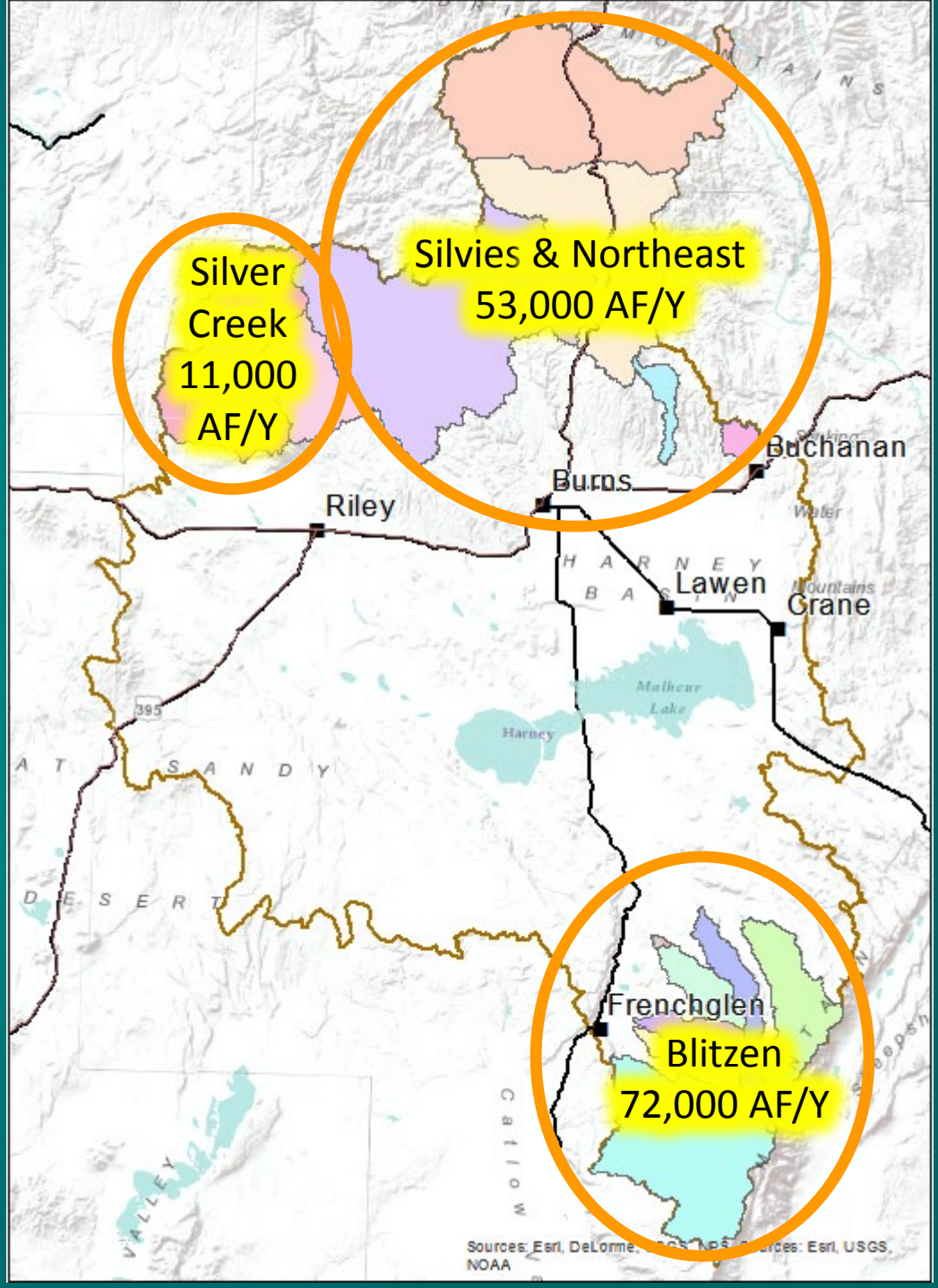

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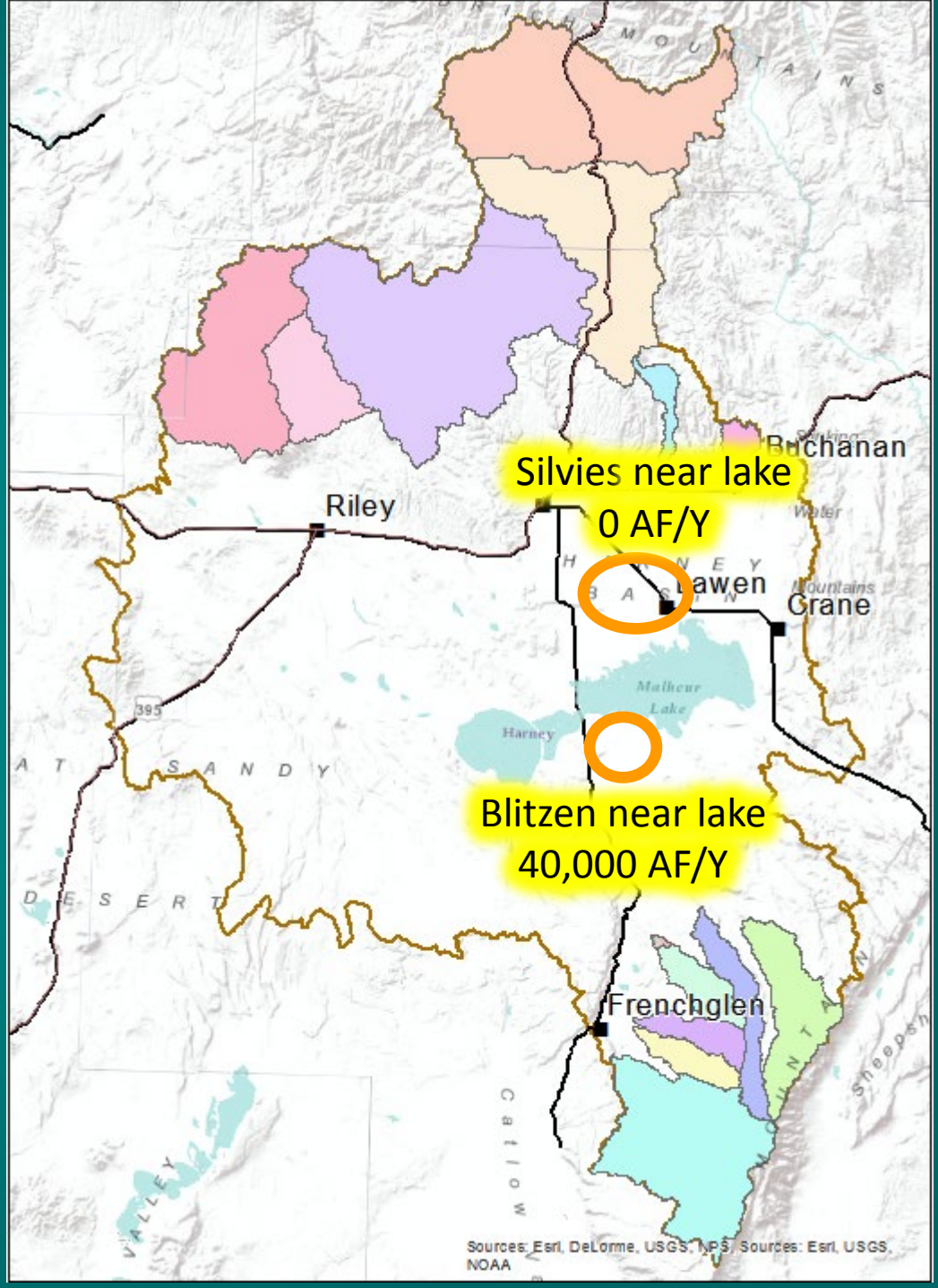
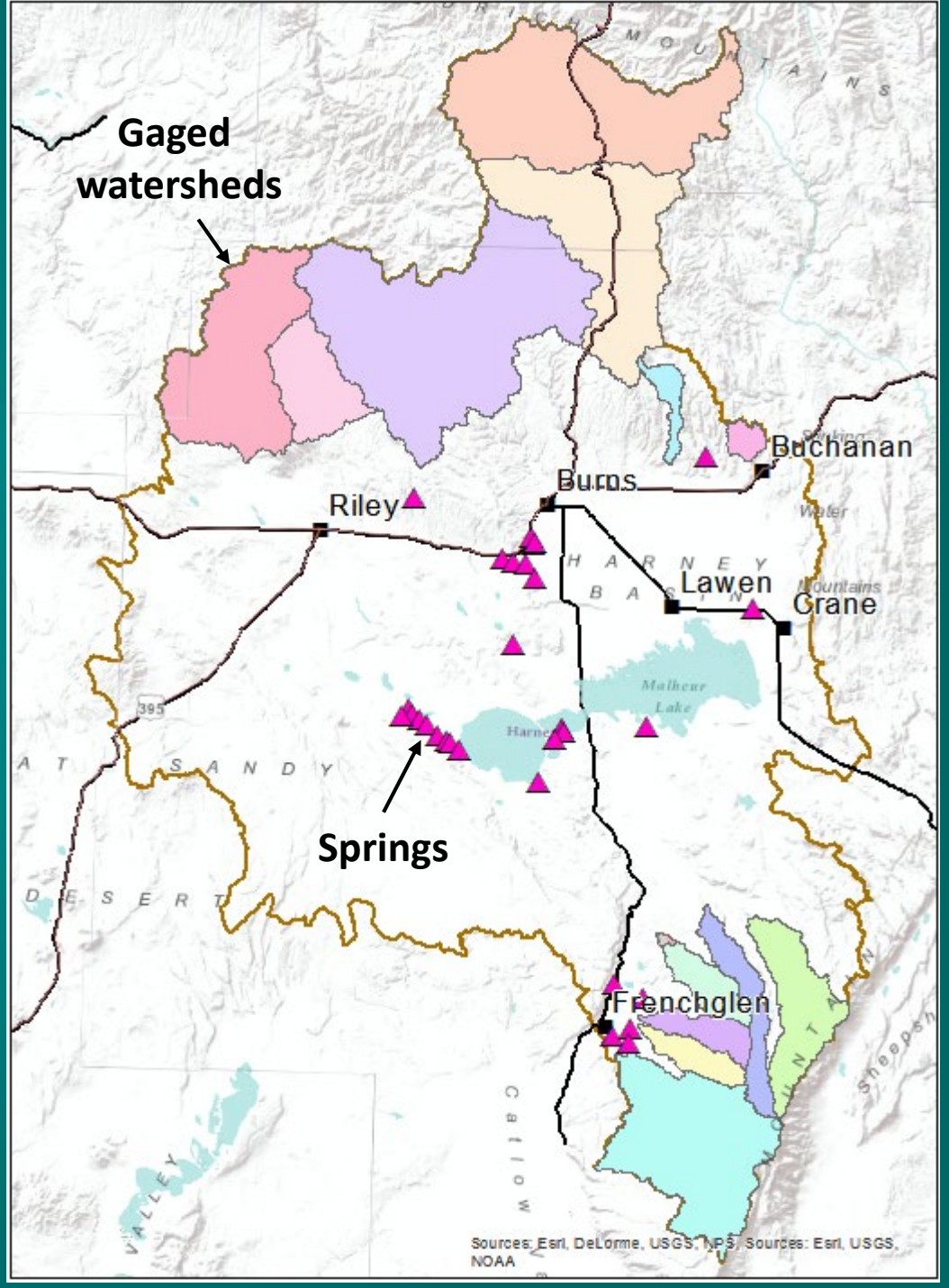


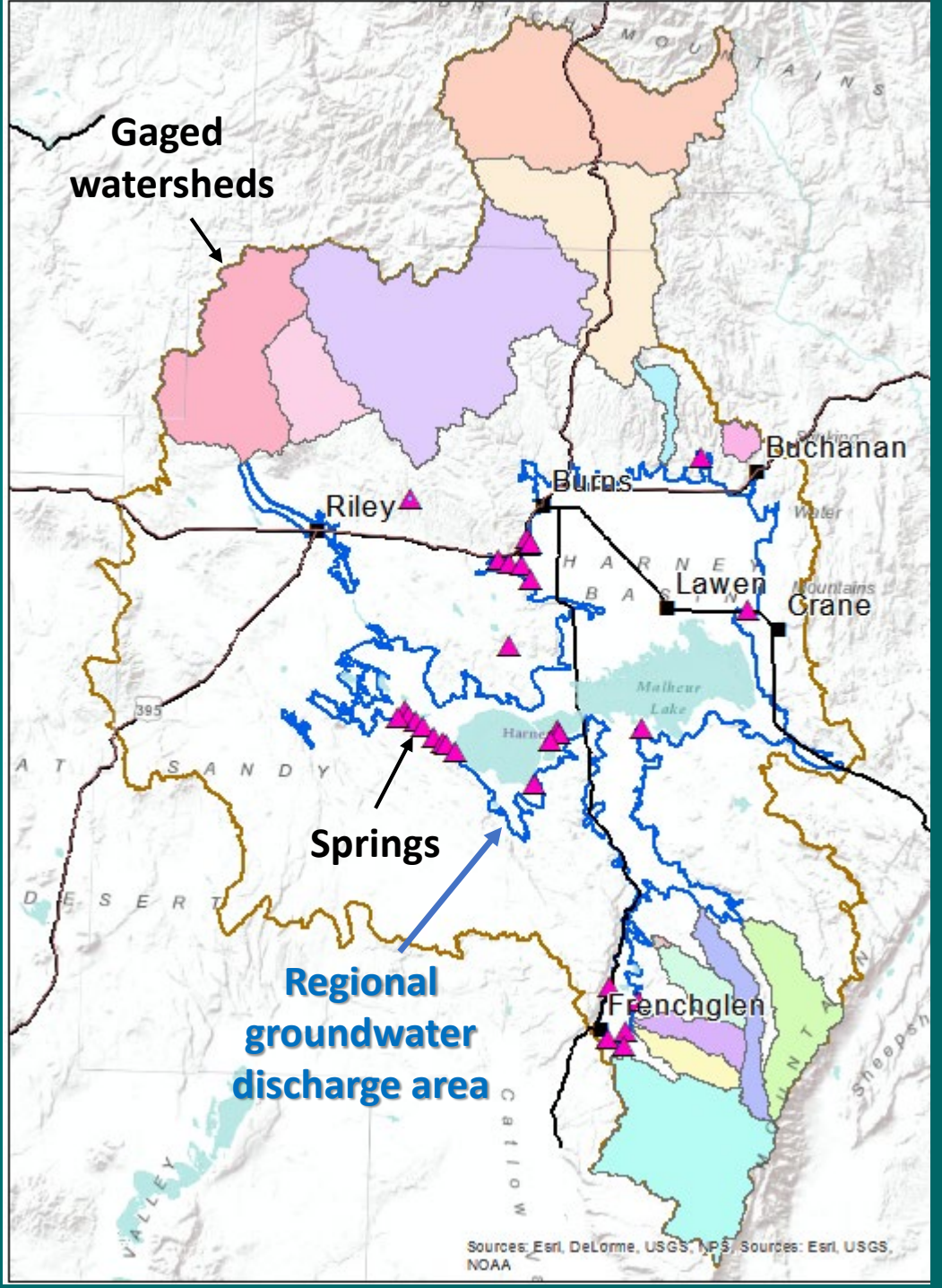
Groundwater Discharge to Springs

- Total spring discharge (Q) = 54,000 AF/Y



Groundwater Discharge to Springs

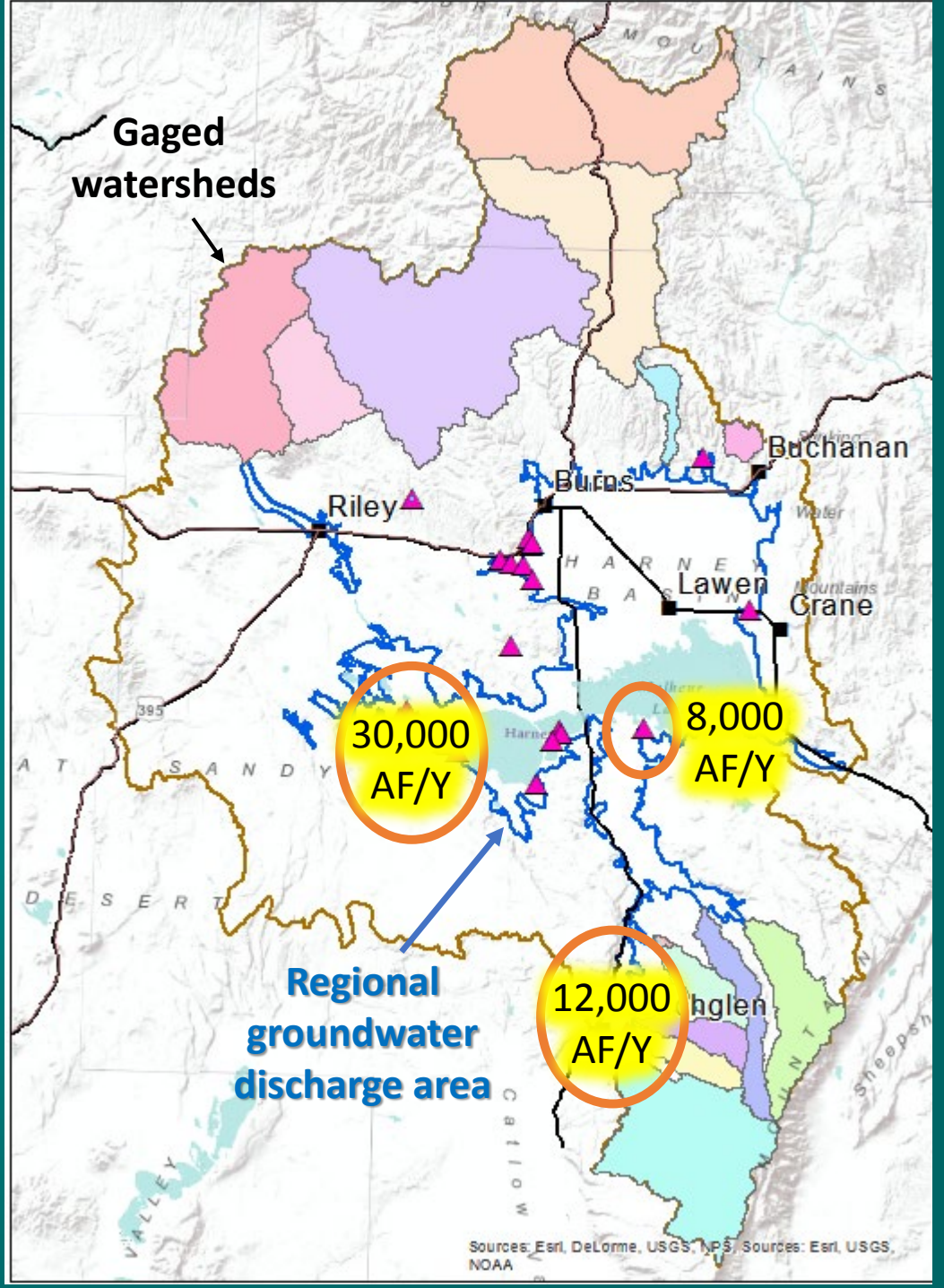
- Total spring discharge (Q) = 54,000 AF/Y
- Measured springs on valley floor or at mountain front
- Upland springs
  - Reinfiltrate
  - Included as baseflow



Groundwater Discharge to Springs

- Total spring discharge (Q) = 54,000 AF/Y

- Valley floor Q
  - Is consumed by ET
  - Flows into streams
  - Flows into lake



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Groundwater Discharge: Streams & Springs Summary

Baseflow to streams AF/Y	**Spring Discharge AF/Y**
Uplands ~ 140,000 Valley floor ~ 40,000	54,000

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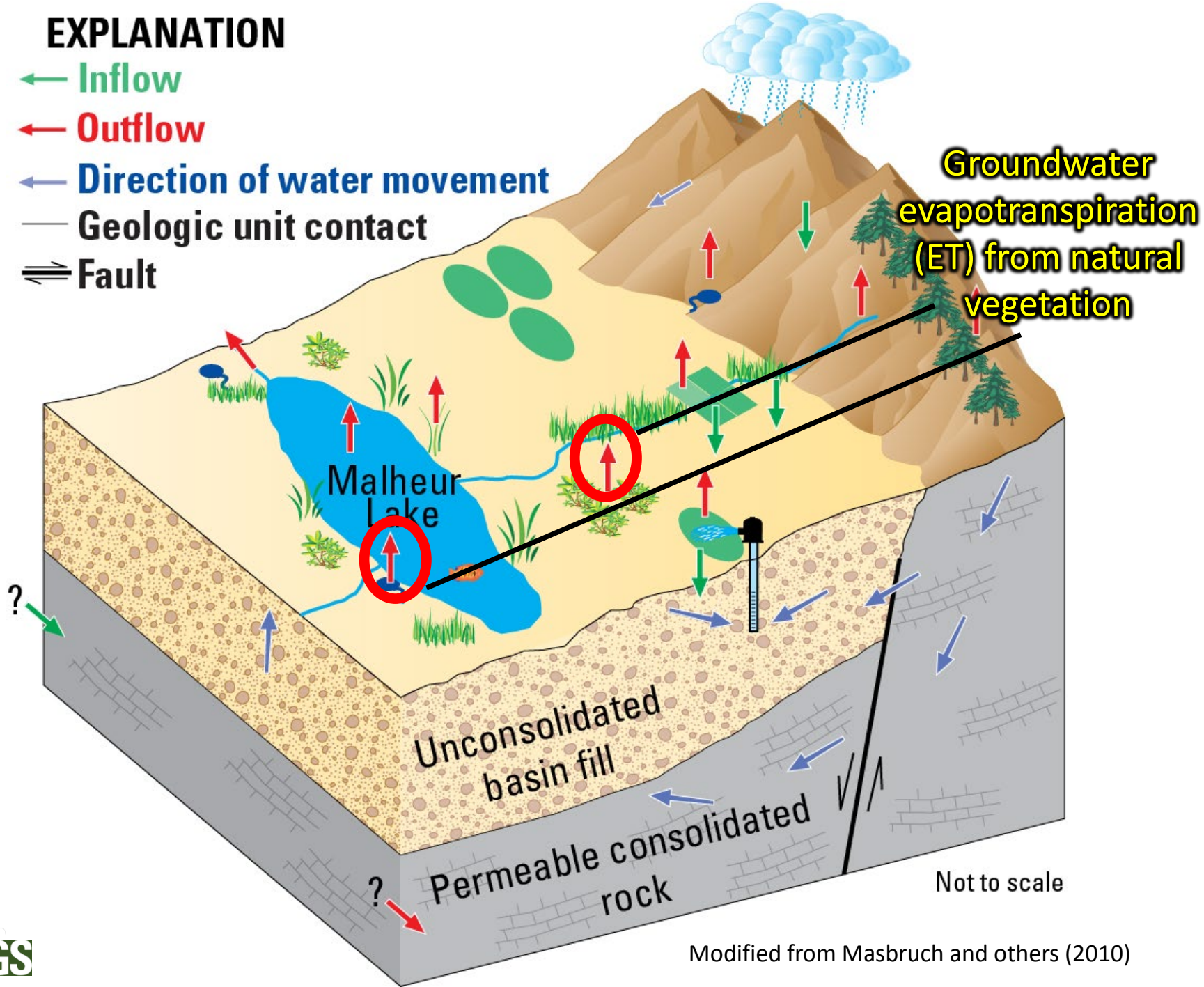

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Modified from Masbruch and others (2010)

Natural Groundwater Discharge by ET

- Map groundwater discharge area
- Group vegetation by type and water use
- Estimate ET

$$ET_{GW} = ET - P - ET_{SW\ flooding}$$

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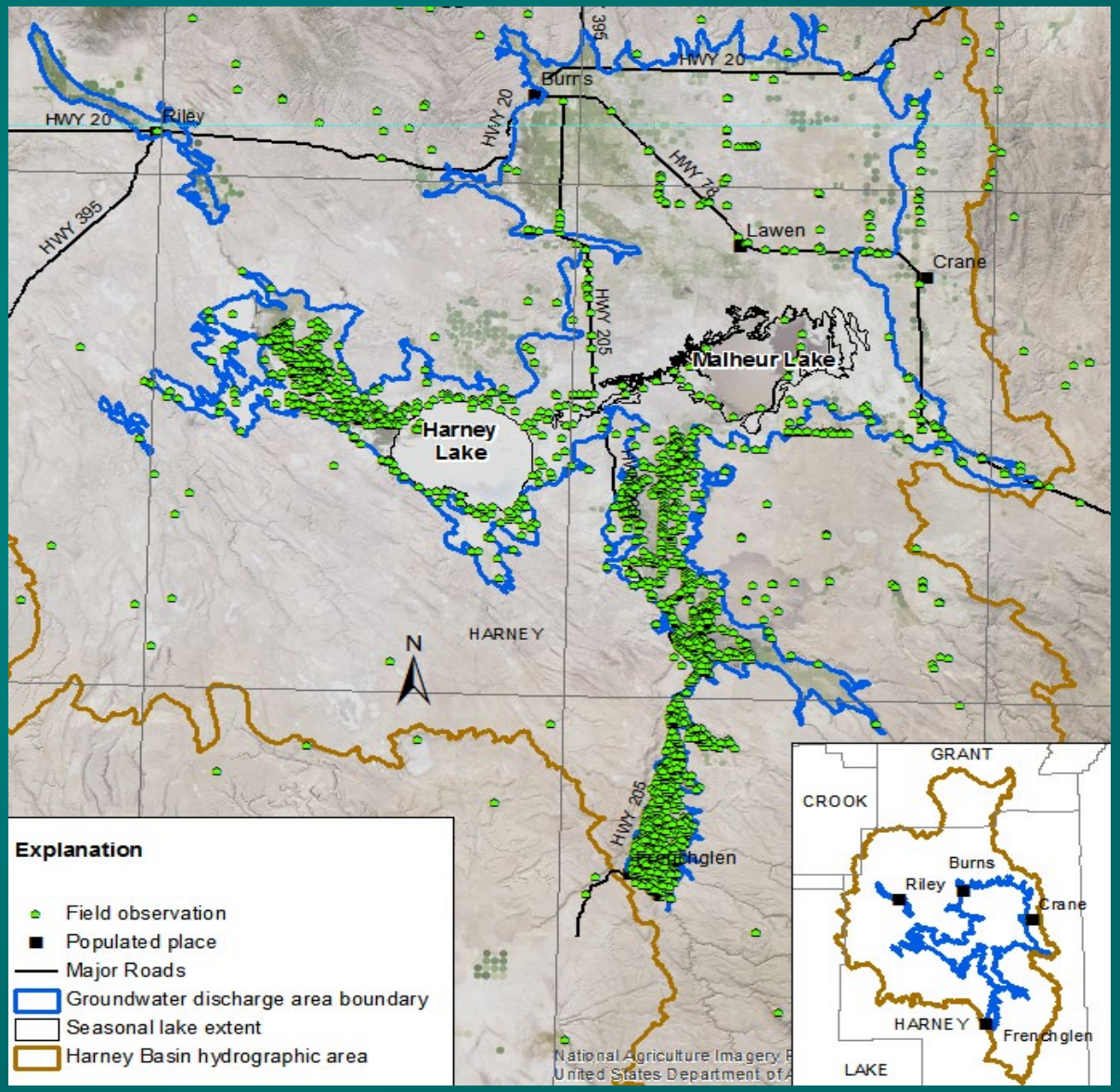
Natural Groundwater Discharge by ET

- Map groundwater discharge area



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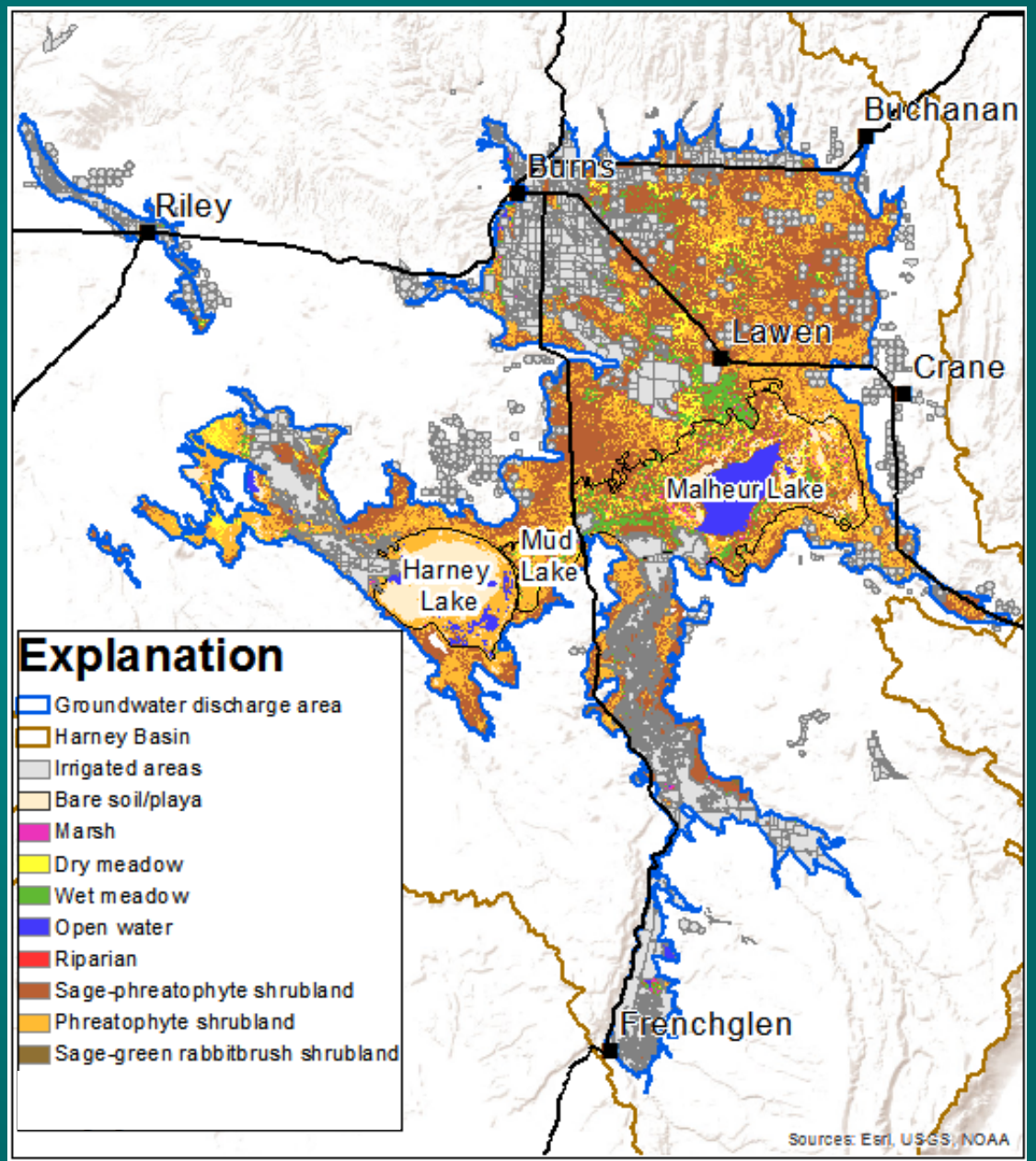

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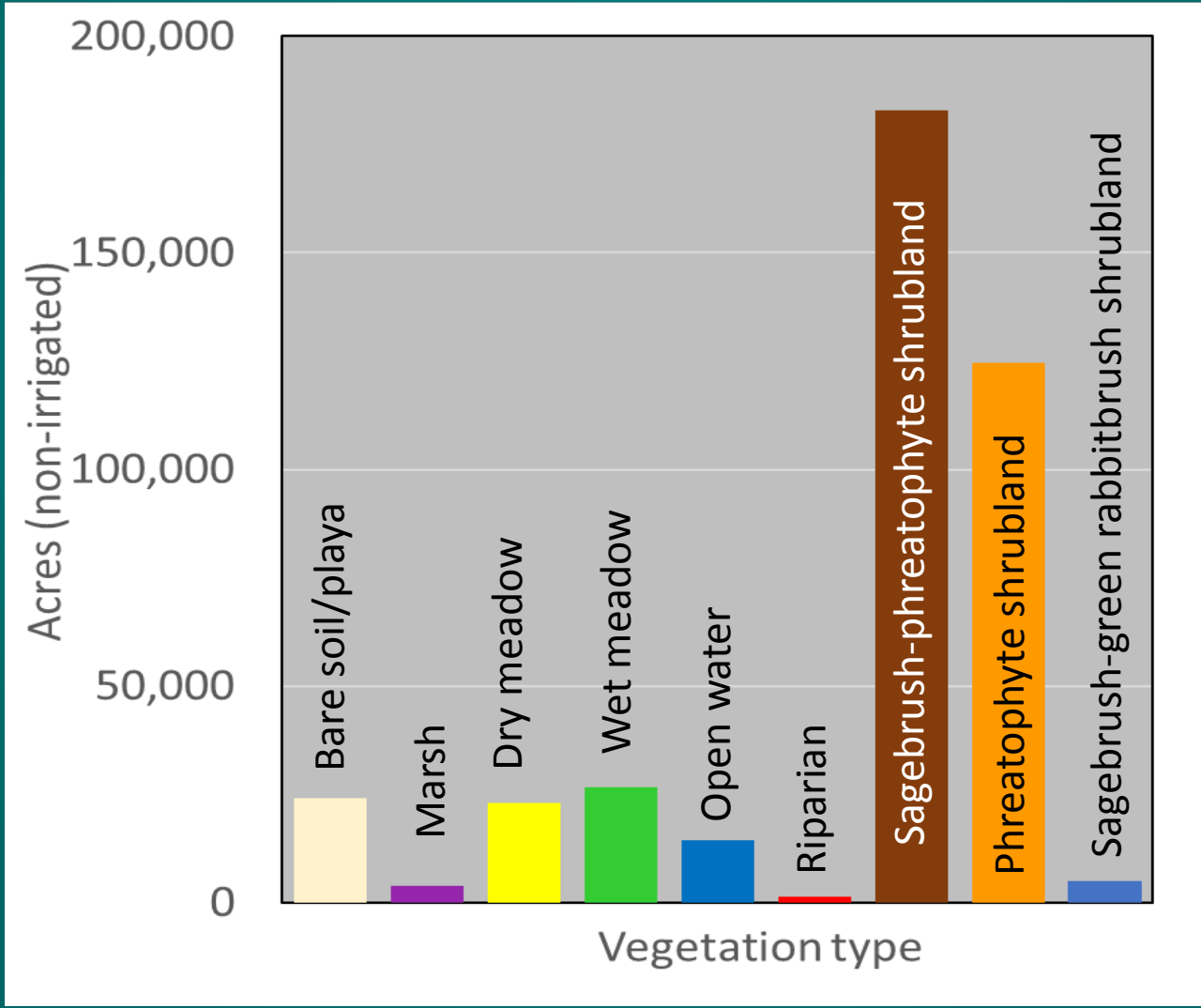

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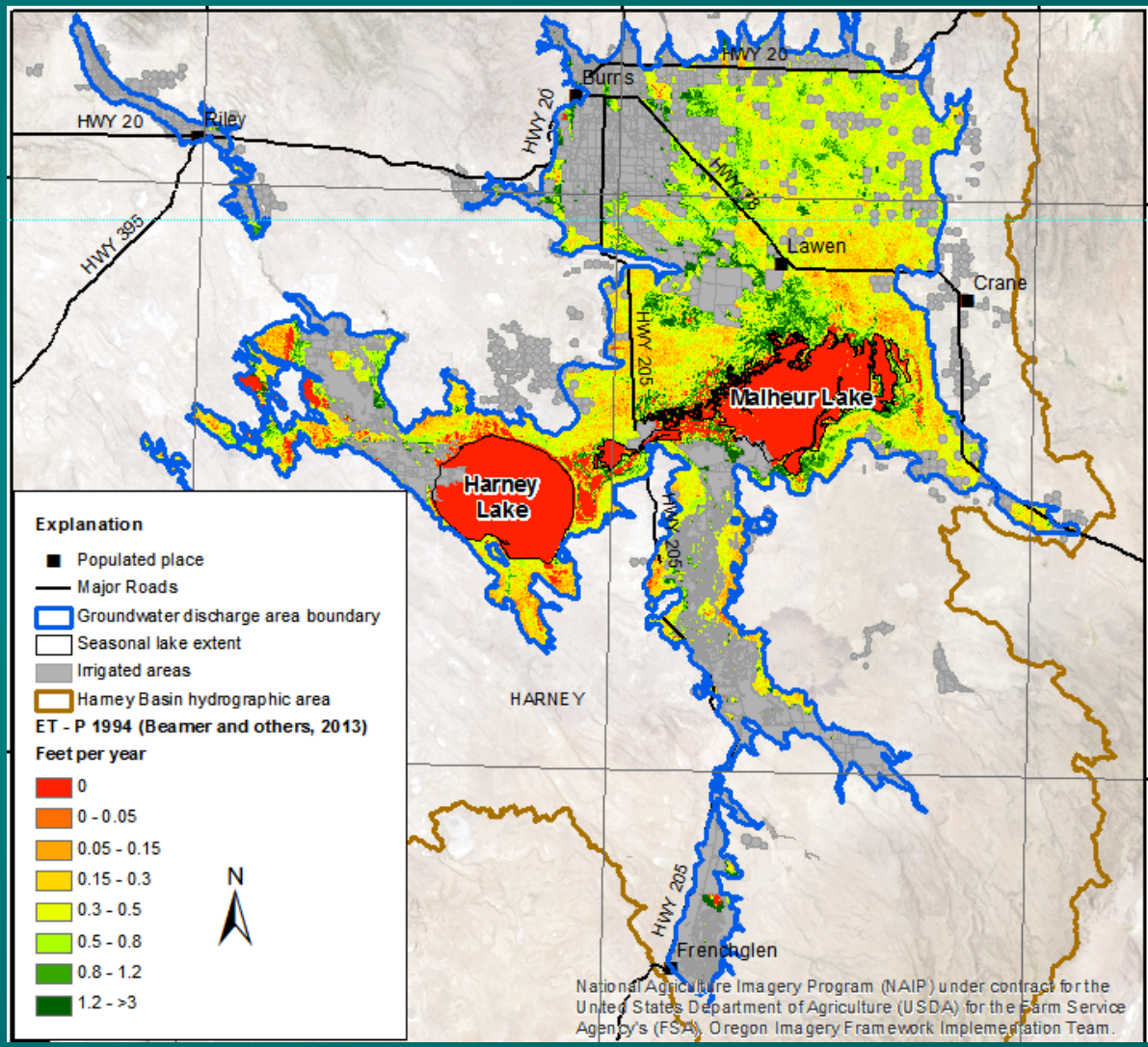
Natural Groundwater Discharge by ET

- Estimate ET
  - Vegetation index (VI) method
    - (Beamer and others, 2013)
    - 130,000 AF/Y
  - ET unit method
    - (Garcia, April 2018*)
    - 110,000 AF/Y
  - Average = 120,000 AF/Y



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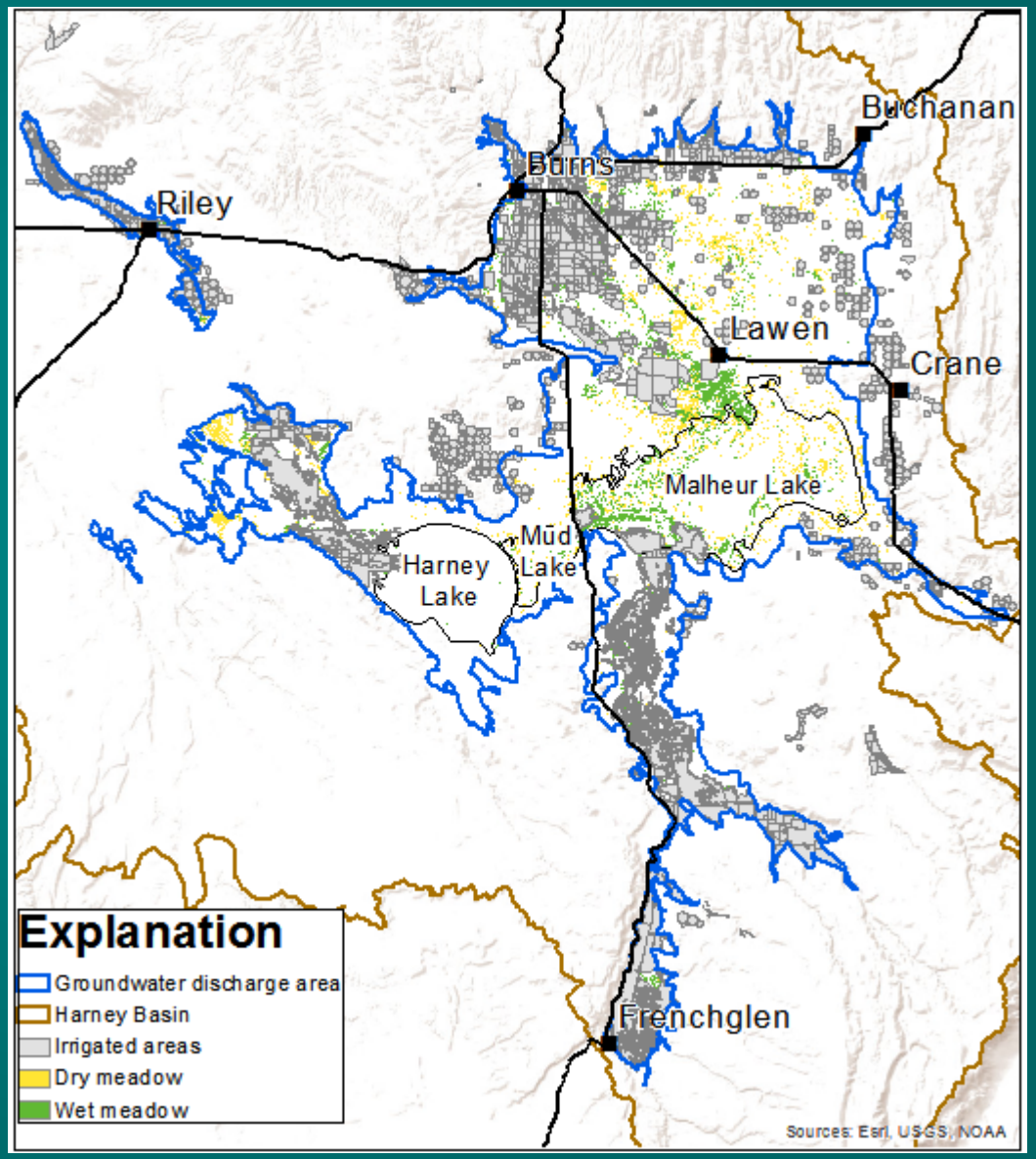
*https://apps.wrd.state.or.us/apps/misc/vault/vault.aspx?Type=WrdNotice&notice_item_id=8002

ET from Surface-Water Flooding

Most flooded areas are irrigated

$ET_{Wet\ meadow} - ET_{Dry\ meadow}$

- **13,000 ±7,000 AF/Y**



Natural Groundwater Discharge by ET

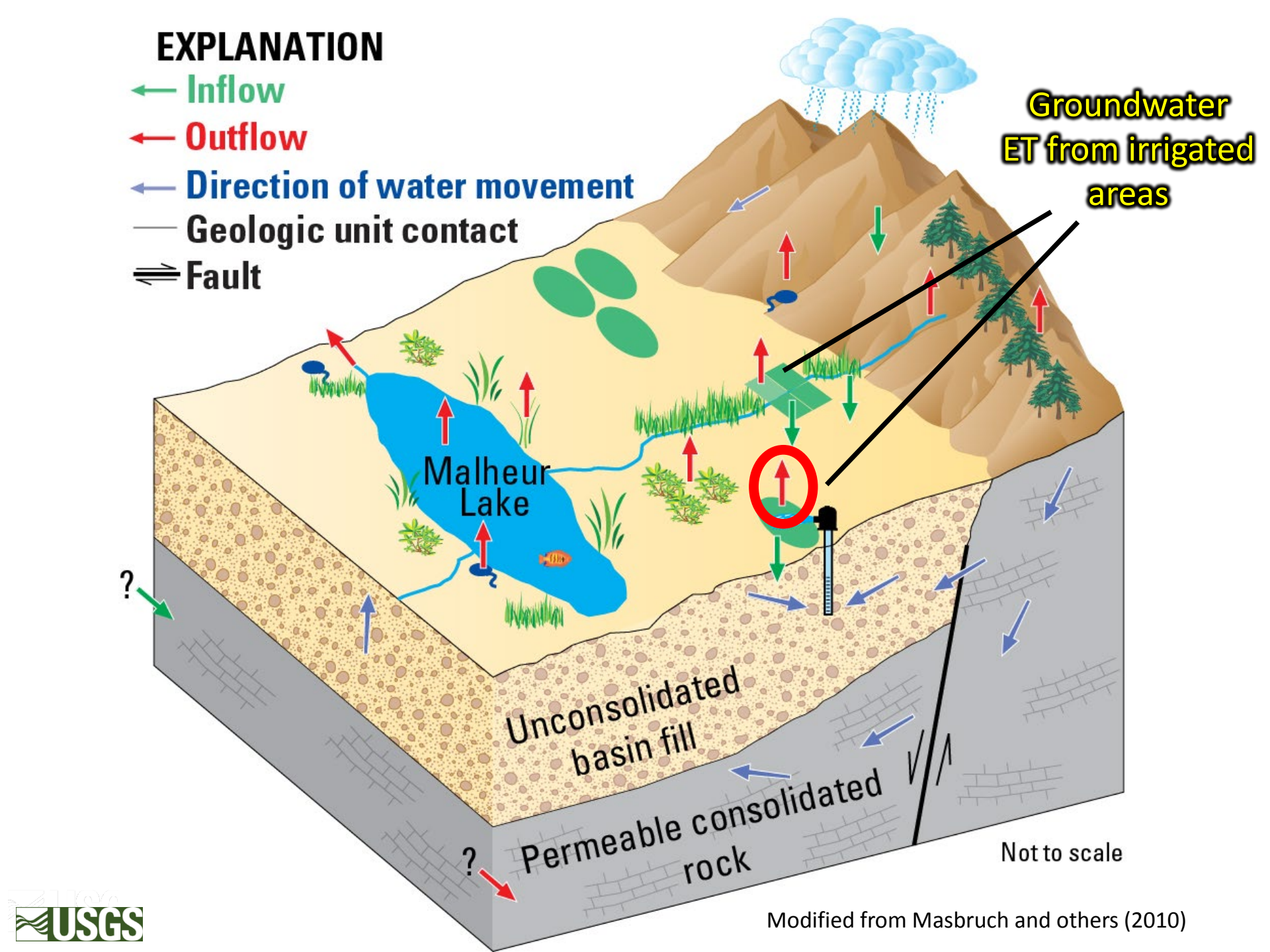
$$ET_{GW} = ET - P - ET_{SW\ flooding}$$

ET_{GW} AF/Y

$ET - P = 120{,}000 \pm 21{,}000$

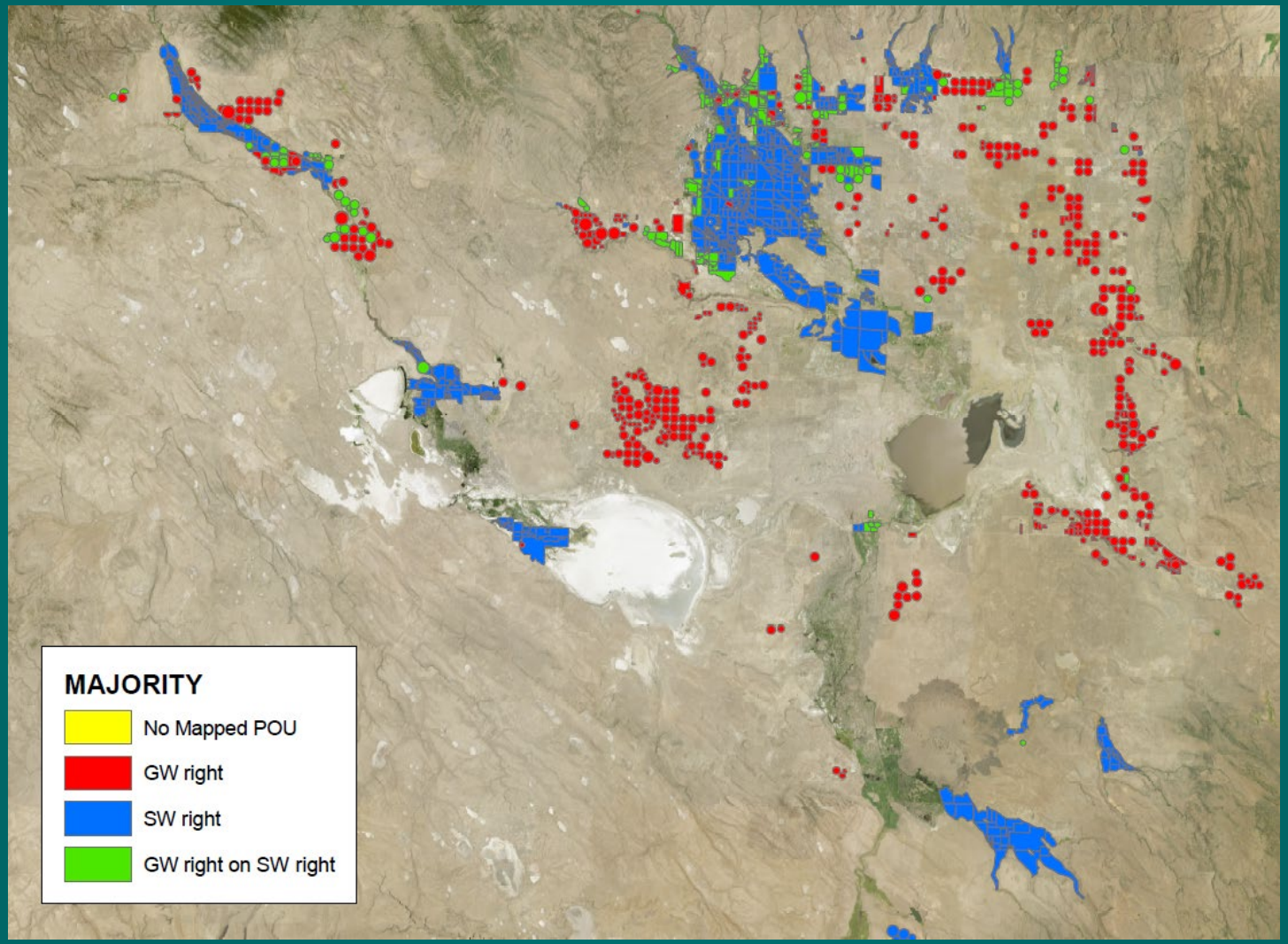
$- ET_{SW\ flooding} = 13{,}000 \pm 7{,}000$

$ET_{GW} \sim 110{,}000 \pm 22{,}000$



Modified from Masbruch and others (2010)

Crop-Irrigated Areas



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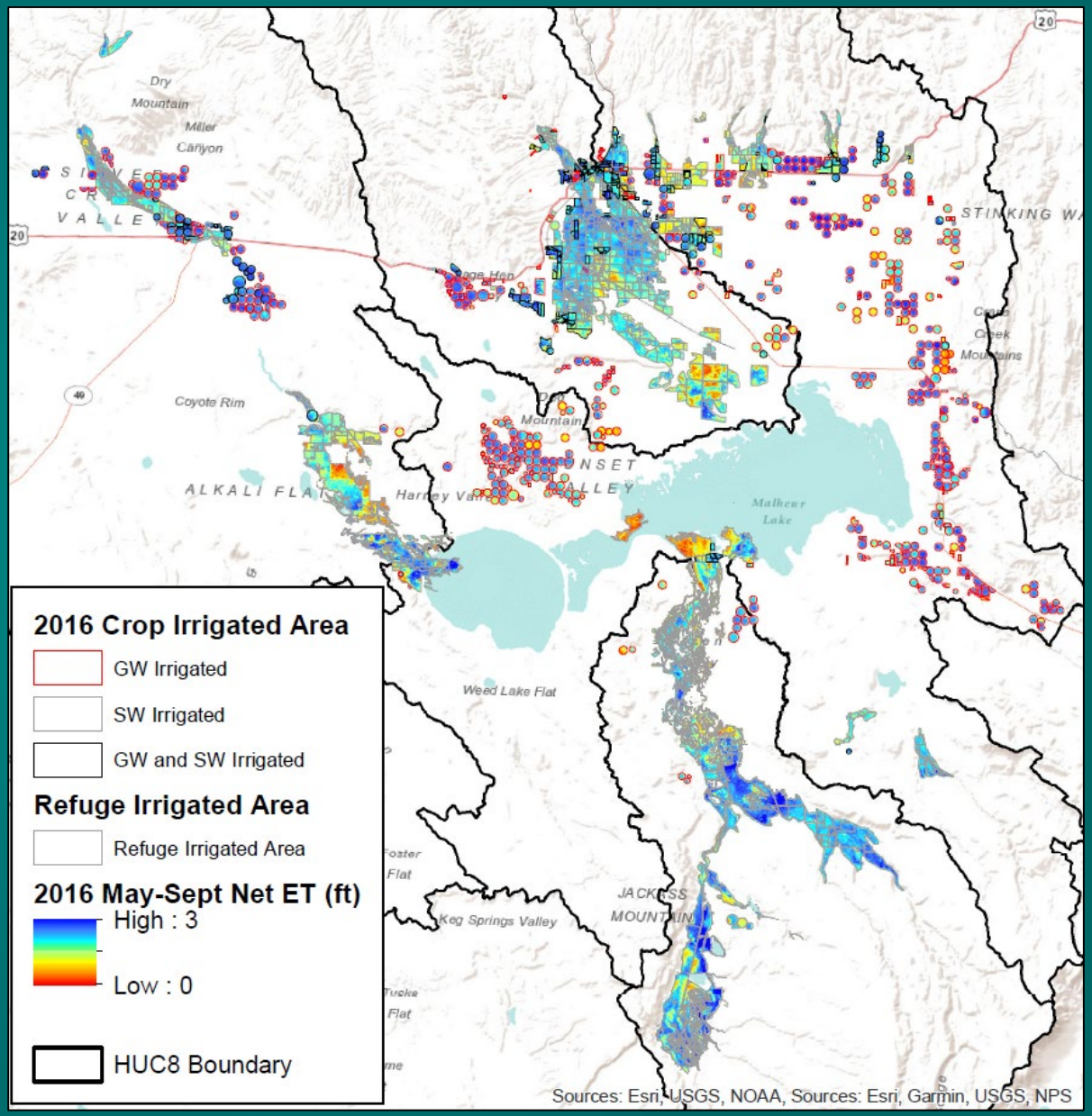
Net ET from Irrigated Areas

METRIC

Net ET volume AF/Y
(GW-irrigated)
1991 = 46,000
2016 = 120,000

Efficiency
80% pivot
65% sprinkler



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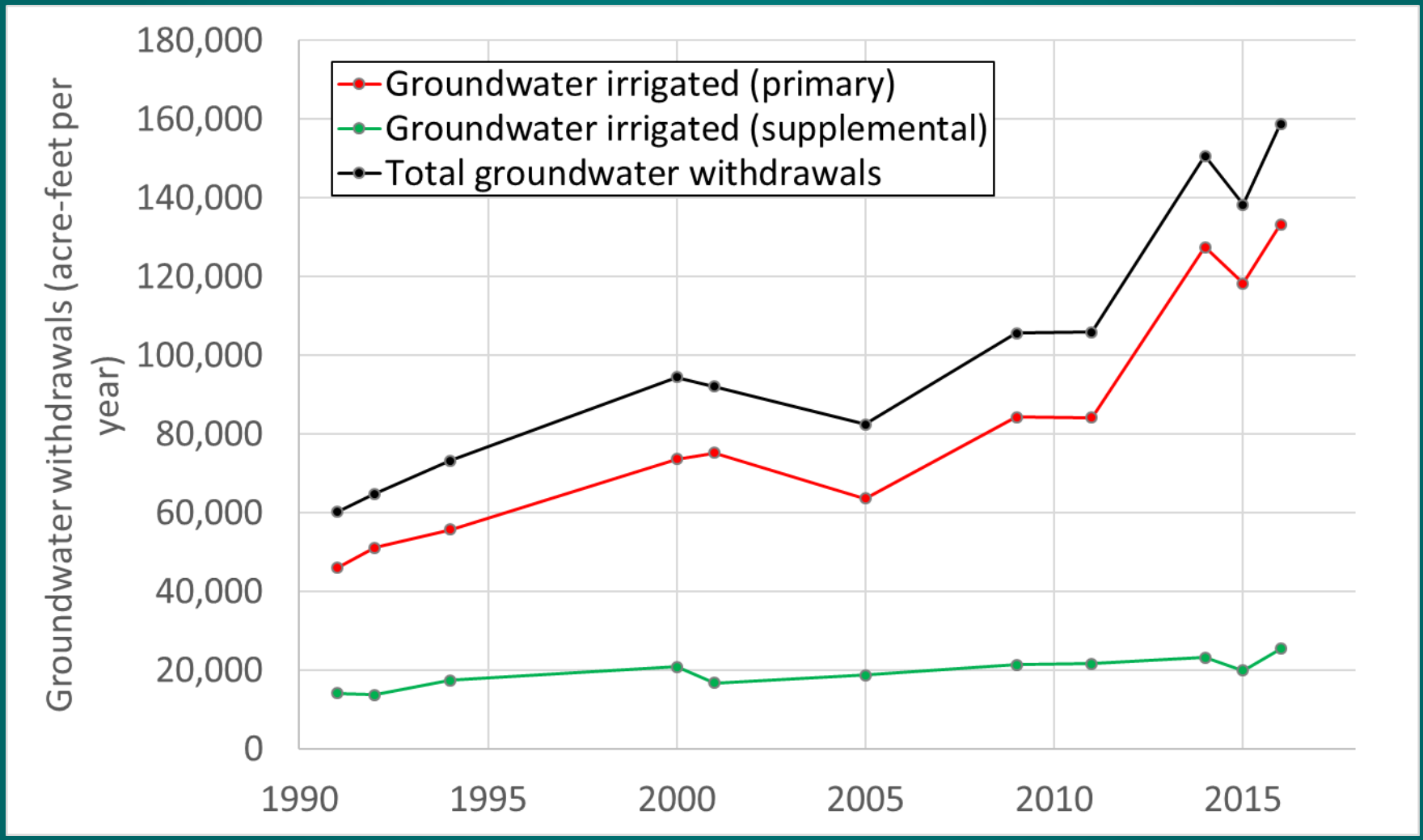
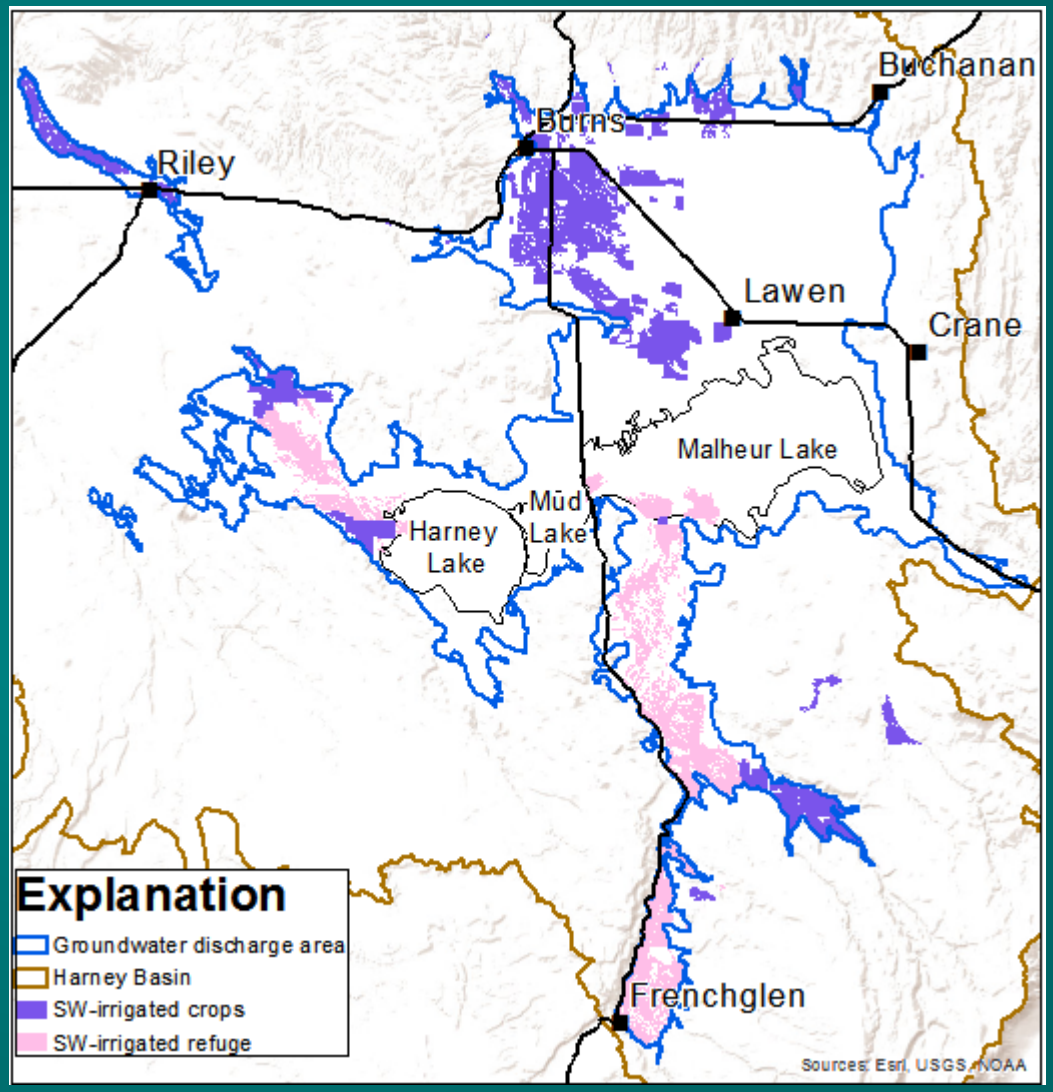
Groundwater Withdrawals for Irrigation



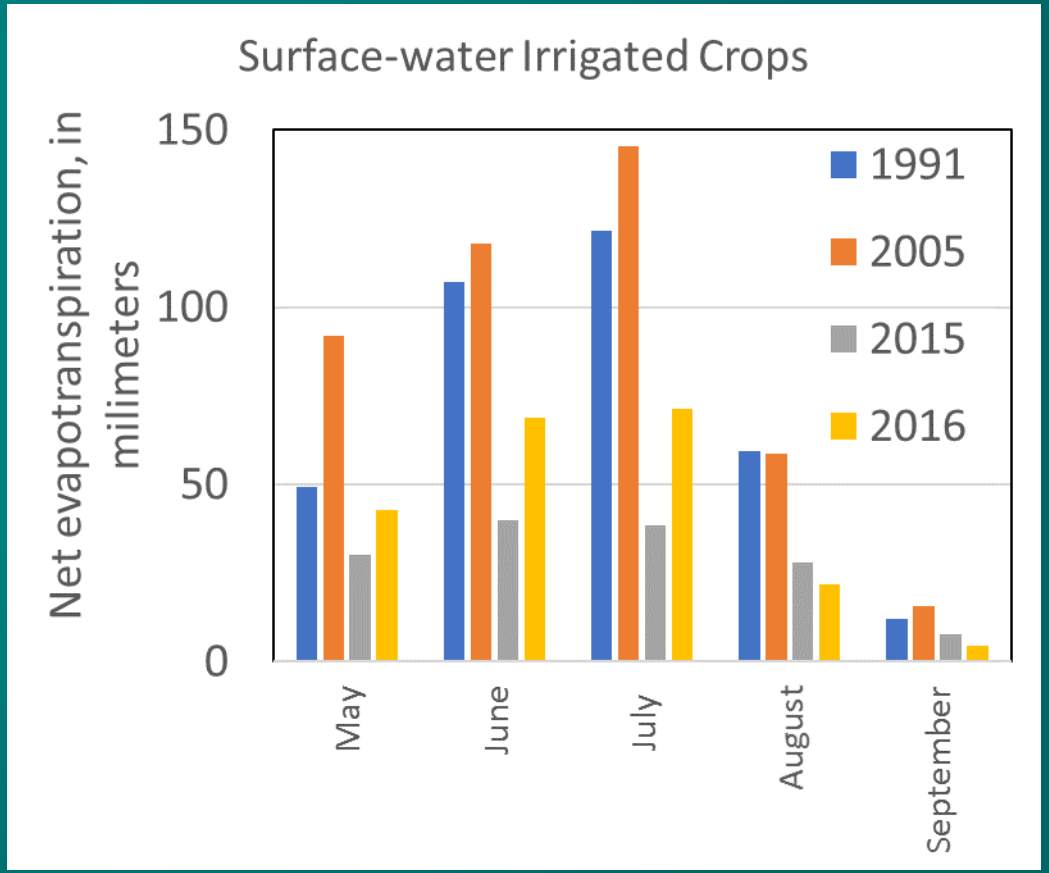
Groundwater Subirrigation

- Areas irrigated by surface water
  - 100,000 acres in GDA
  - Water table typically <10 ft below land surface



Groundwater Subirrigation

- Rate = % of dry meadow rate
  - Aug-Sept ET is 15% of total
  - Assume 50% of fields receive subirrigation
- $ET_{GW\ subirrigation}$
  - ~5,000 ± 5,000 AF/Y



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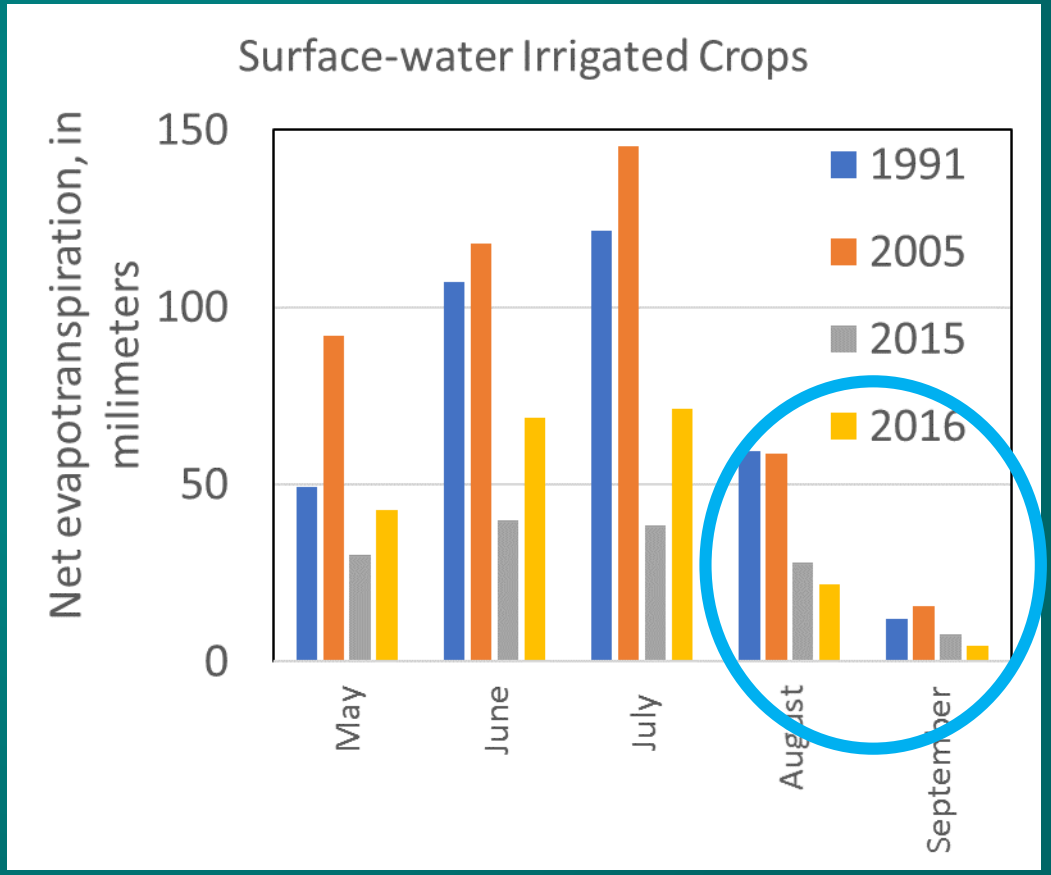
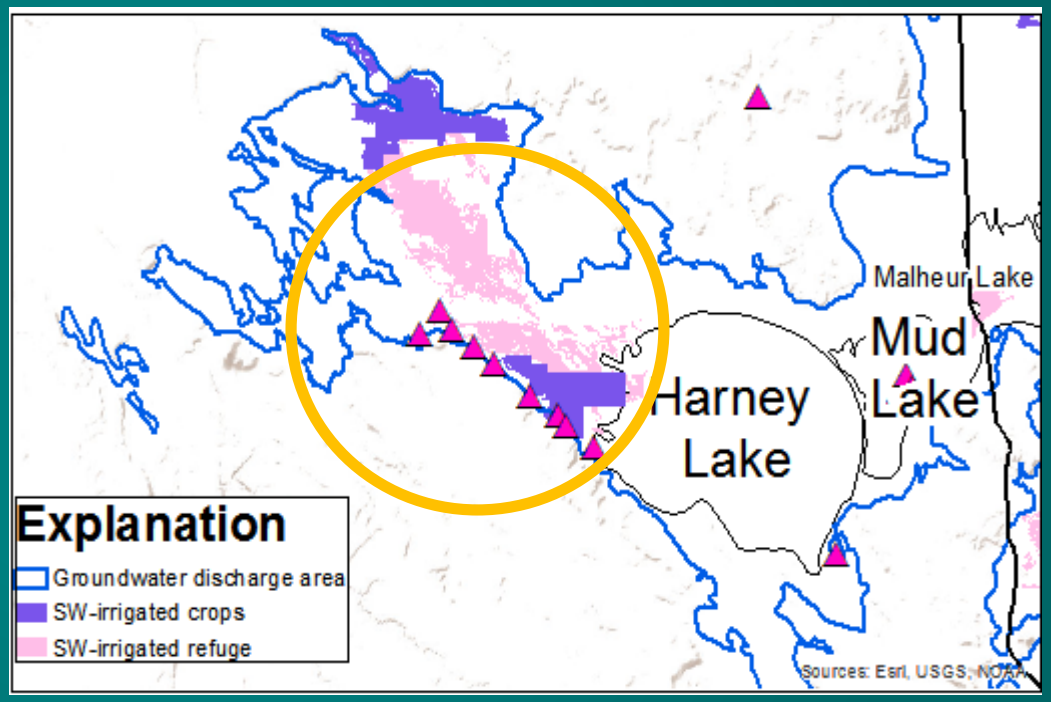


Crop Consumptive Use of Spring Discharge

- Warm Springs Valley
  - 12,000 acres irrigated near springs
  - Rate ~ 1.5 ft/yr
- $ET_{Warm\ Springs\ discharge}$
  - 18,000 ± 6,000 AF/Y
  - Rough estimate



Total Groundwater Discharge from Irrigated Areas

Groundwater Withdrawals for Irrigation = 160,000 AF/Y

+ Groundwater subirrigation = 5,000 ± 5,000 AF/Y*

+ $ET_{\text{Warm Springs discharge}}$ = 18,000 ± 6,000 AF/Y*

Total discharge ~ 180,000 ± 8,000 AF/Y

*Subirrigation and spring ET likely would occur from natural vegetation if not irrigated

**Values exclude irrigation loss to shallow aquifer

Additional Groundwater Discharges

Discharge to Malheur Lake AF/Y	**Water use (no irrigation) AF/Y**
Net = 10,000	3,000
(accounted for by historical discharge from Sodhouse Spring vicinity)	(most not consumptive)

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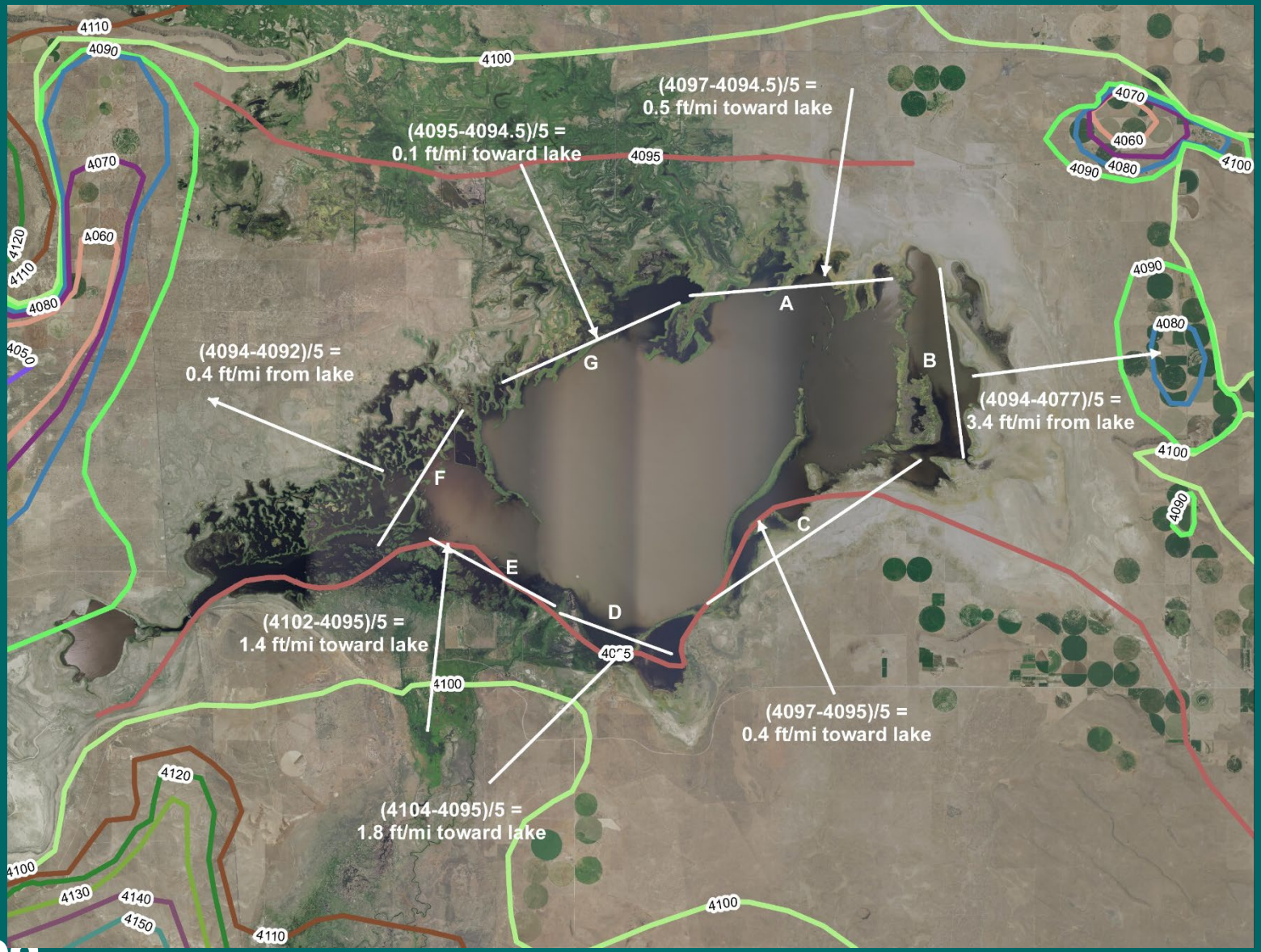
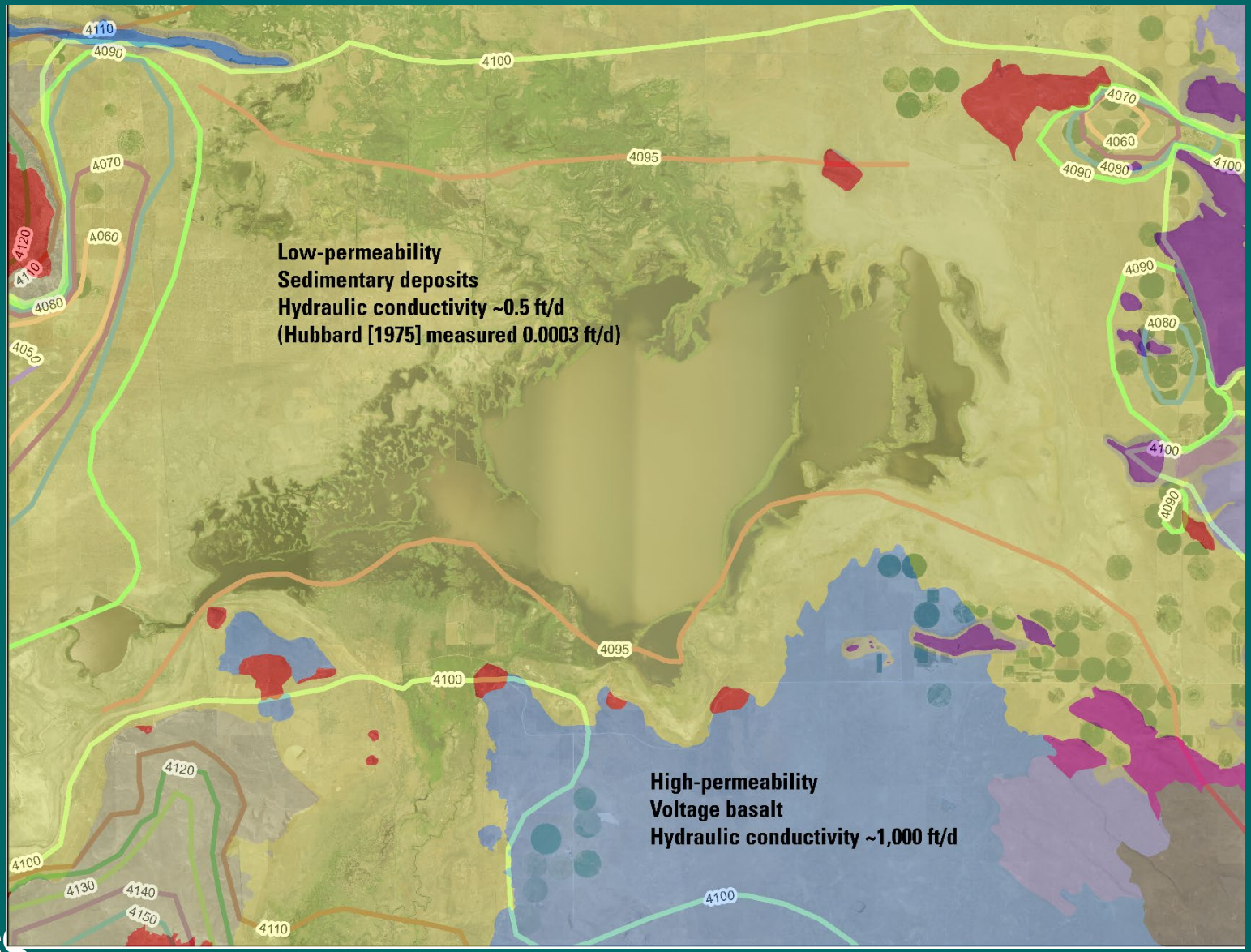
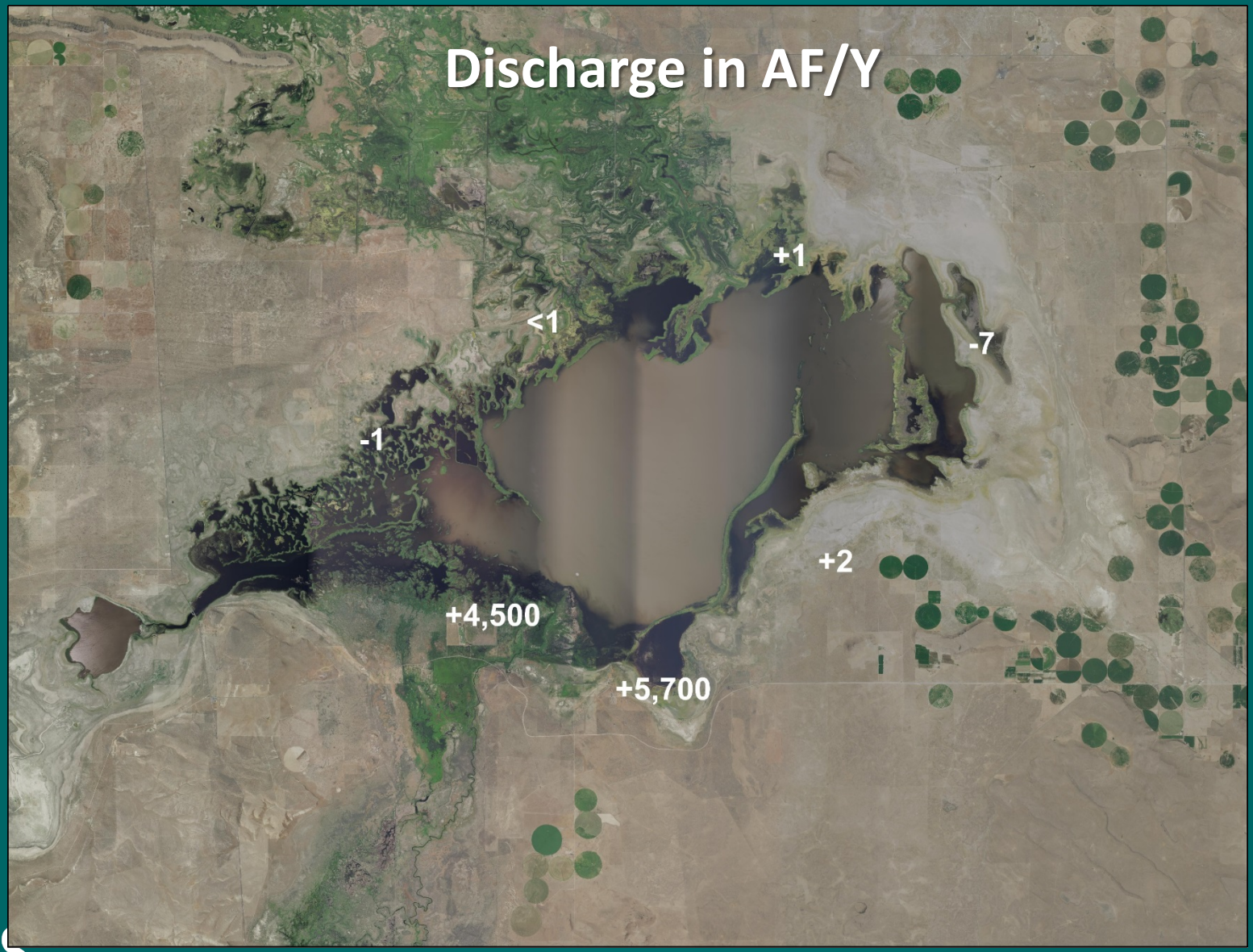
Groundwater discharge to Malheur Lake



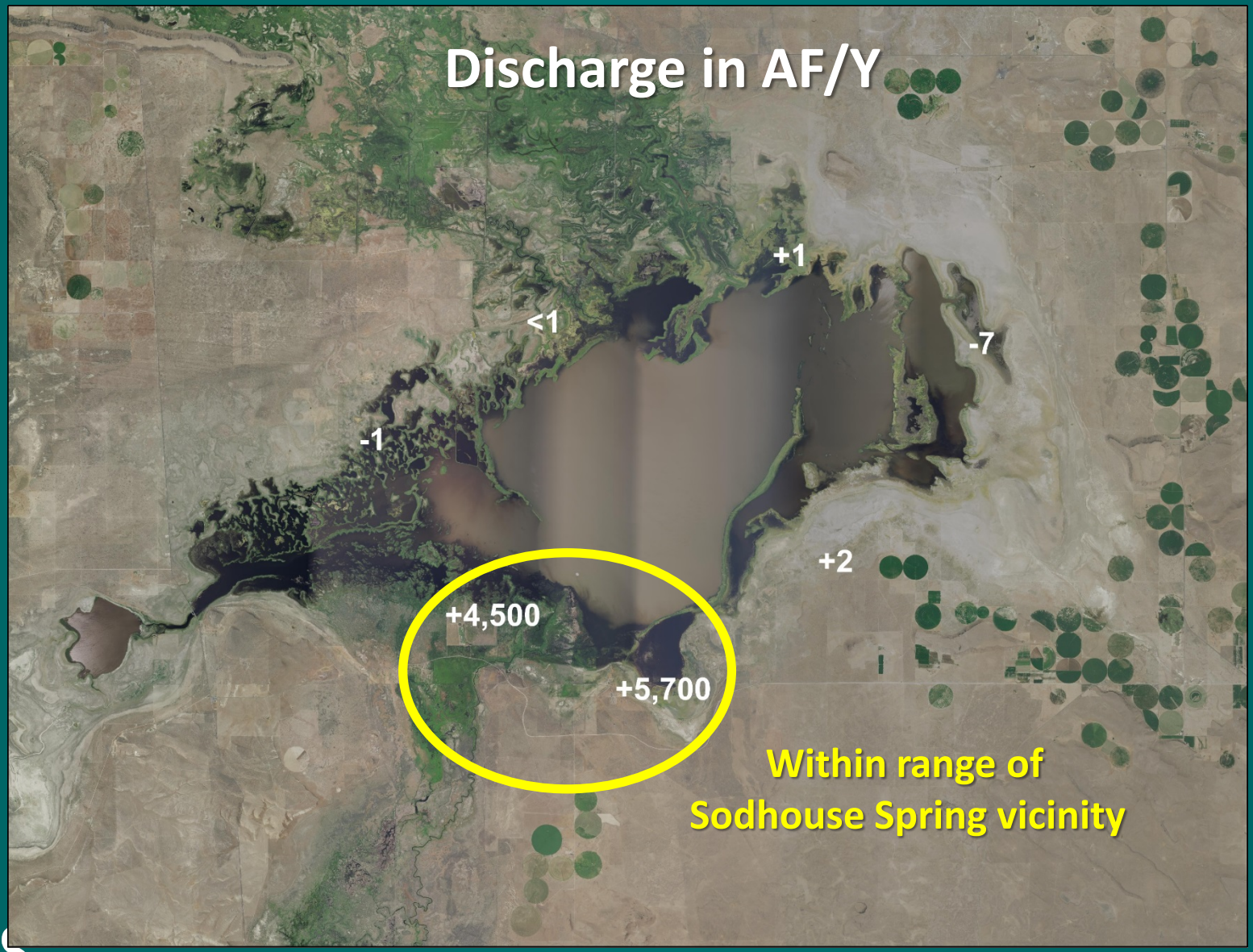
Groundwater discharge to Malheur Lake



Groundwater discharge to Malheur Lake



Groundwater discharge to Malheur Lake



Total Groundwater Discharge Summary

Type	Estimated Volume (AF/Y)	Accounting
Baseflow	140,000	>70% cycled into veg. ET <30% lost to lake
Springs	54,000	85% cycled into veg. ET 15% lost to lake
Natural vegetation ET	110,000	Consumptive use
Irrigated areas total	180,000	Consumptive use (*excludes irrigation loss to shallow aquifer)
Net Discharge	**340,000**	Consumptive use

*Irrigation loss likely <10,000 AF/Y

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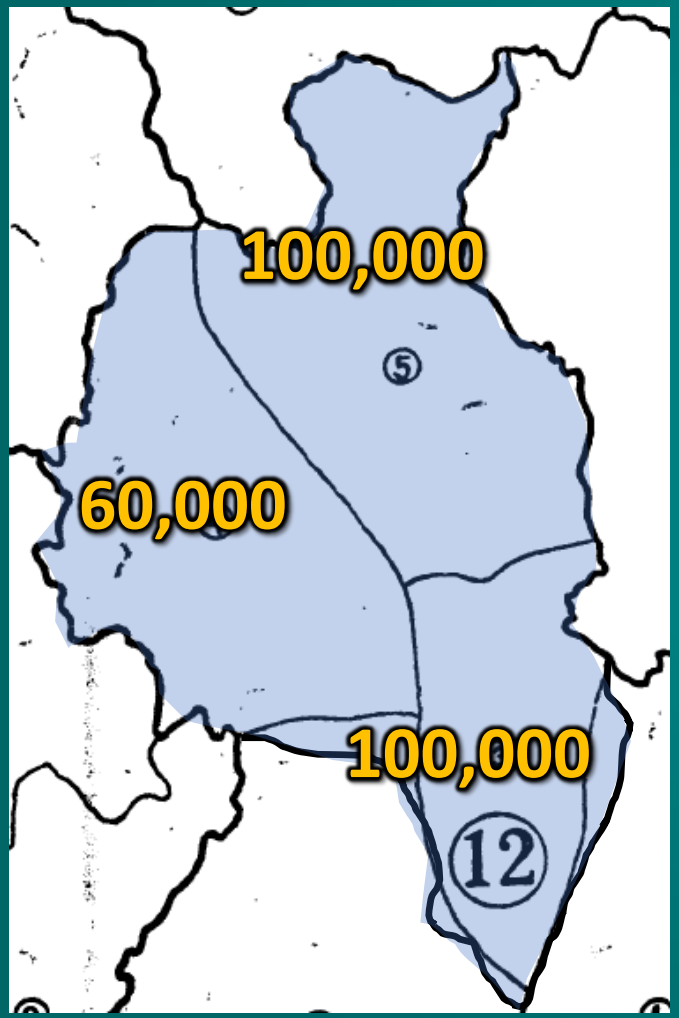
Previous Water-Budget Estimates

RECHARGE = 260,000 AF/Y



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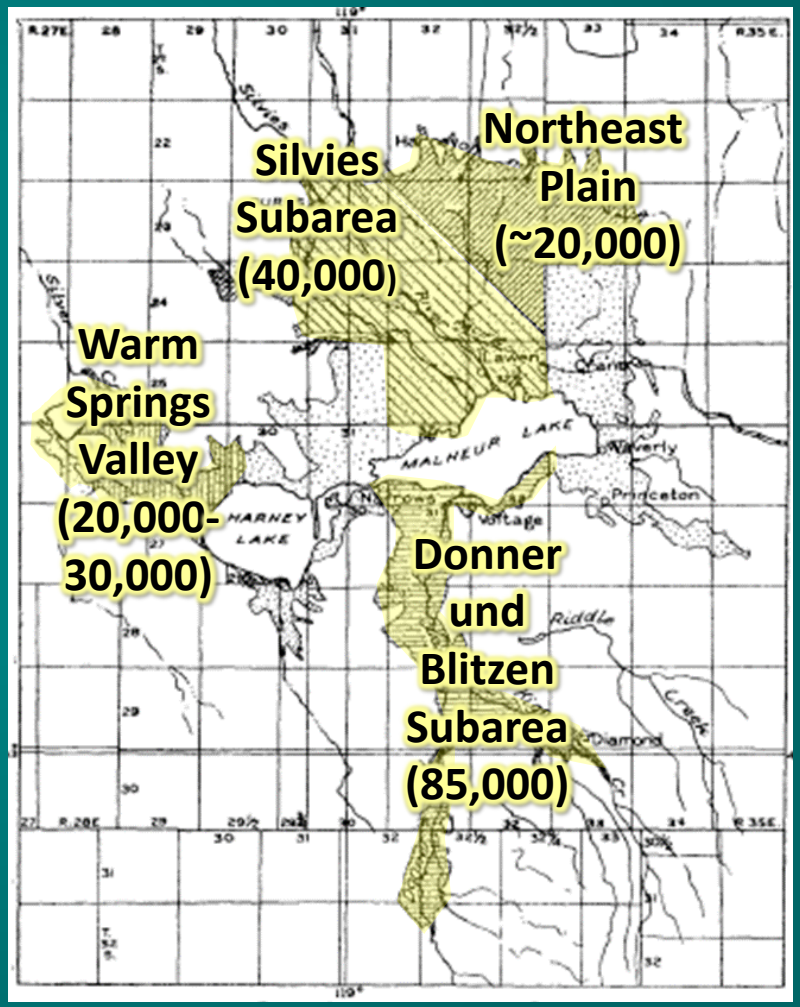

Piper and others (1939)

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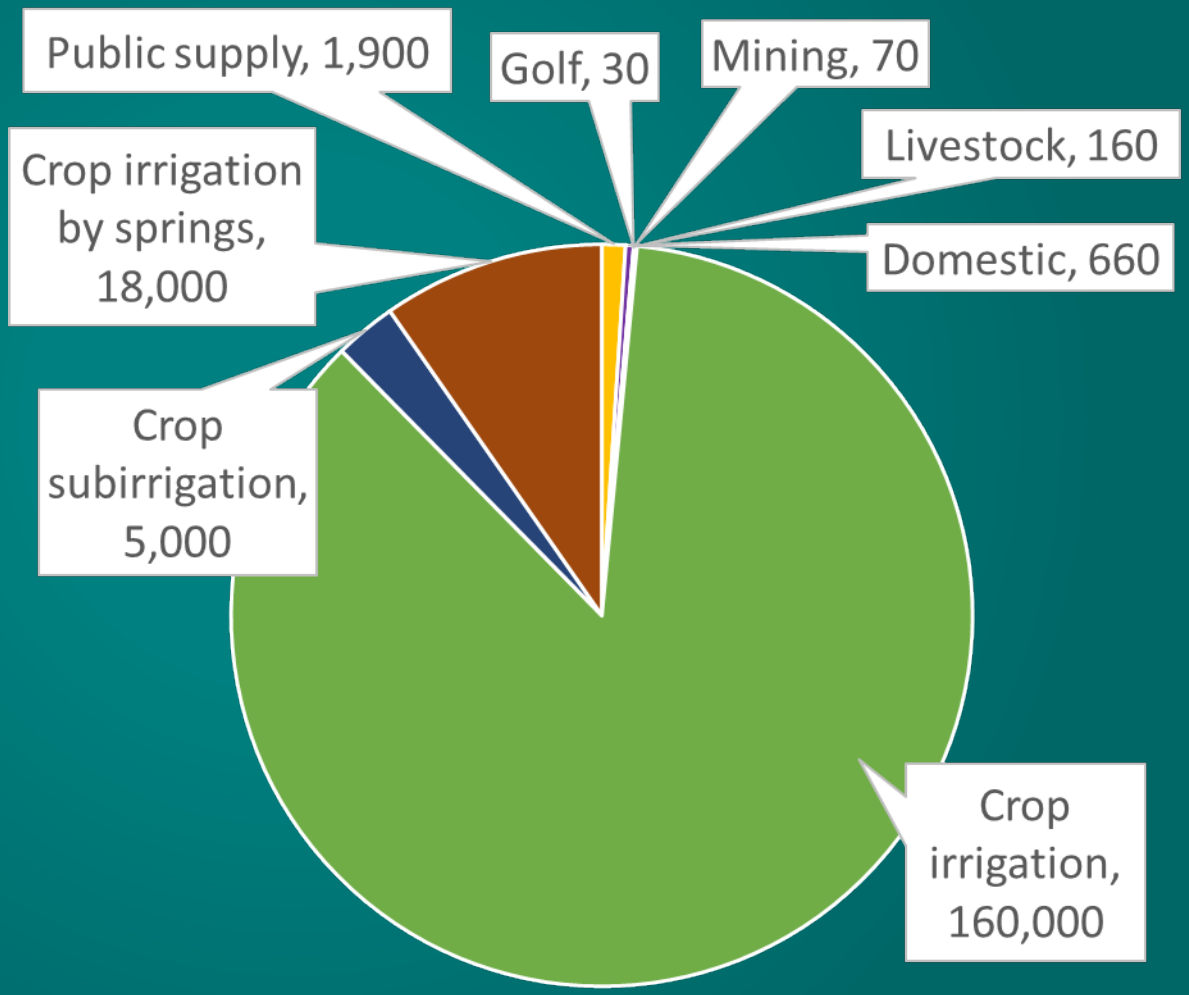
Total Anthropogenic Water Use

- ~190,000 AF/Y
- Non-irrigation use from USGS 2015 county census*
- Irrigation based on 2016 estimates
- Excludes irrigation loss to shallow aquifer



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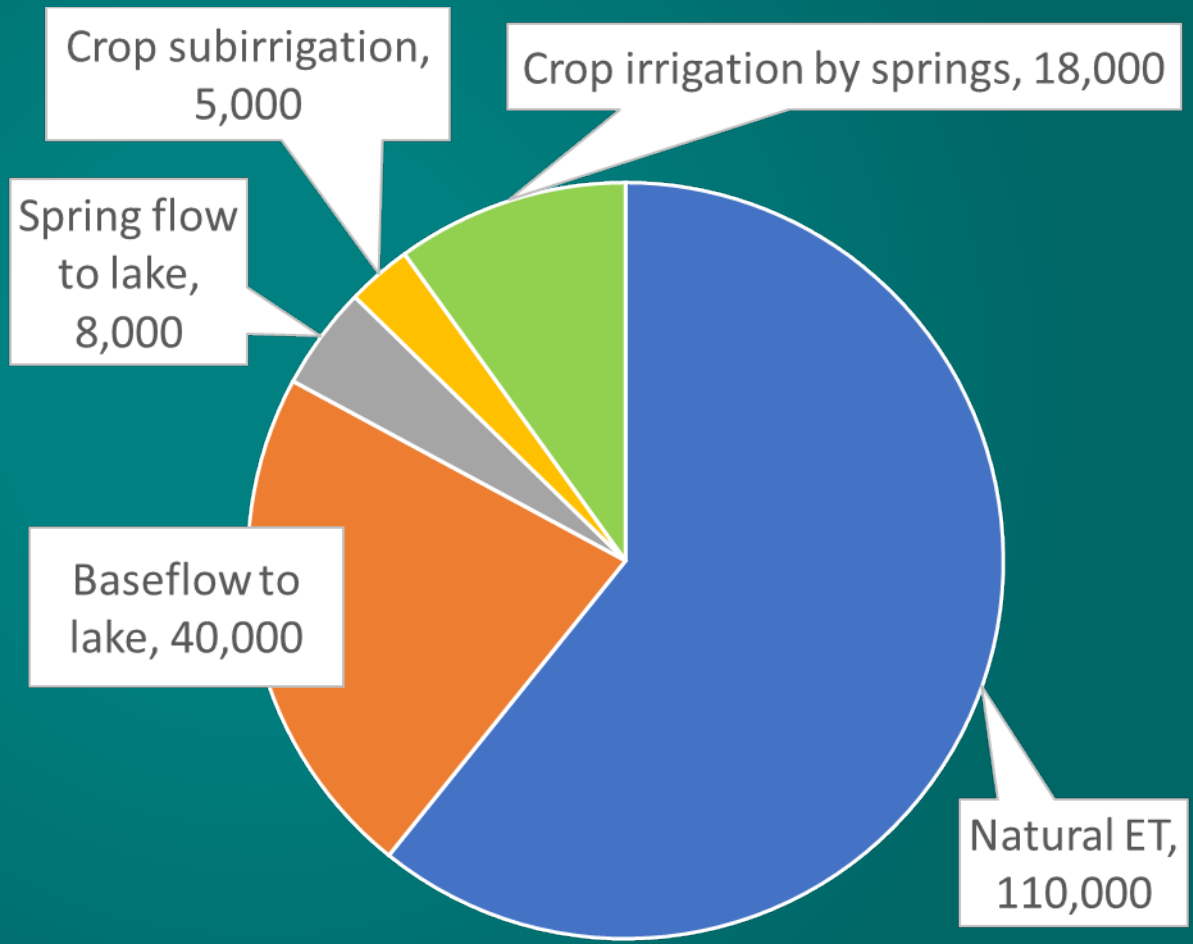
Unpublished data, subject to revision. Do not cite.

*https://waterdata.usgs.gov/or/nwis/wu

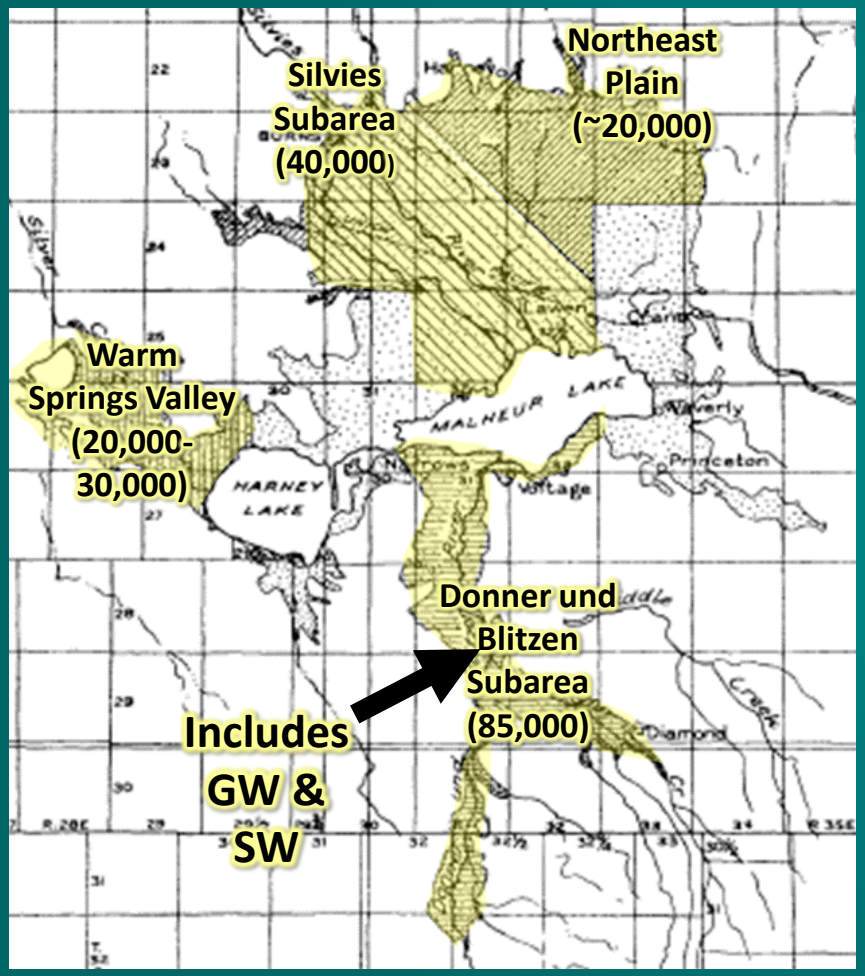
Net Natural-ish Groundwater Discharge

- ~180,000 AF/Y
- Crop uses assumed similar to prior use by native plants

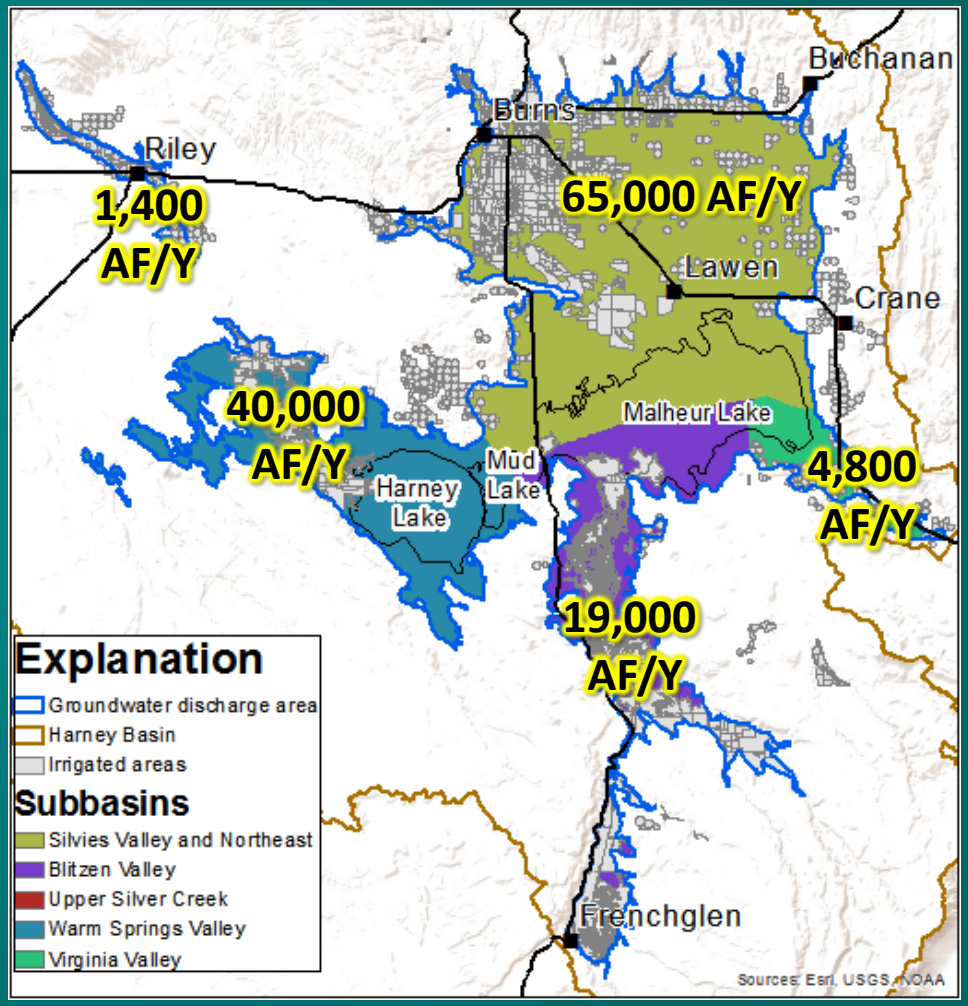


Comparison with Previous Natural-ish Groundwater Discharge Estimates

Piper and others (1939)
80,000 – <170,000 AF/Y



Current estimate
130,000 AF/Y



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References

- Beamer, J.P., Huntington, J.L., Morton, C.G., Pohll, G.M., 2013, Estimating annual groundwater evapotranspiration from phreatophytes in the Great Basin using Landsat and flux tower measurements, Journal of the American Water Resources Association, vol. 49, no. 3, p. 518-533.
- Masbruch, M.D., Heilweil, V.M., Buto, S.G., Brooks, L.D., Susong, D.D., Flint, A.L., Flint, L.E., and Gardner, P.M., 2011, Chapter D: Estimated groundwater budgets, *in* Heilweil, V.M., and Brooks, L.E., eds., Conceptual model of the Great Basin carbonate and alluvial aquifer system: U.S. Geological Survey Scientific Investigations Report 2010-5193, 191 p. Available online at: https://pubs.usgs.gov/sir/2010/5193/PDF/GreatBasinChapterD.pdf.
- Piper, A.M., Robinson, T.W., and Park, C.F., 1939, Geology and ground-water resources of the Harney Basin, Oregon, U.S. Geological Survey Water-Supply Paper 841, 189 p.

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