Idaho Geological Survey
Big Lost River Basin
Groundwater budget (2000 -19)

Big Lost Modeling Technical Advisory Committee

Mackay, Idaho

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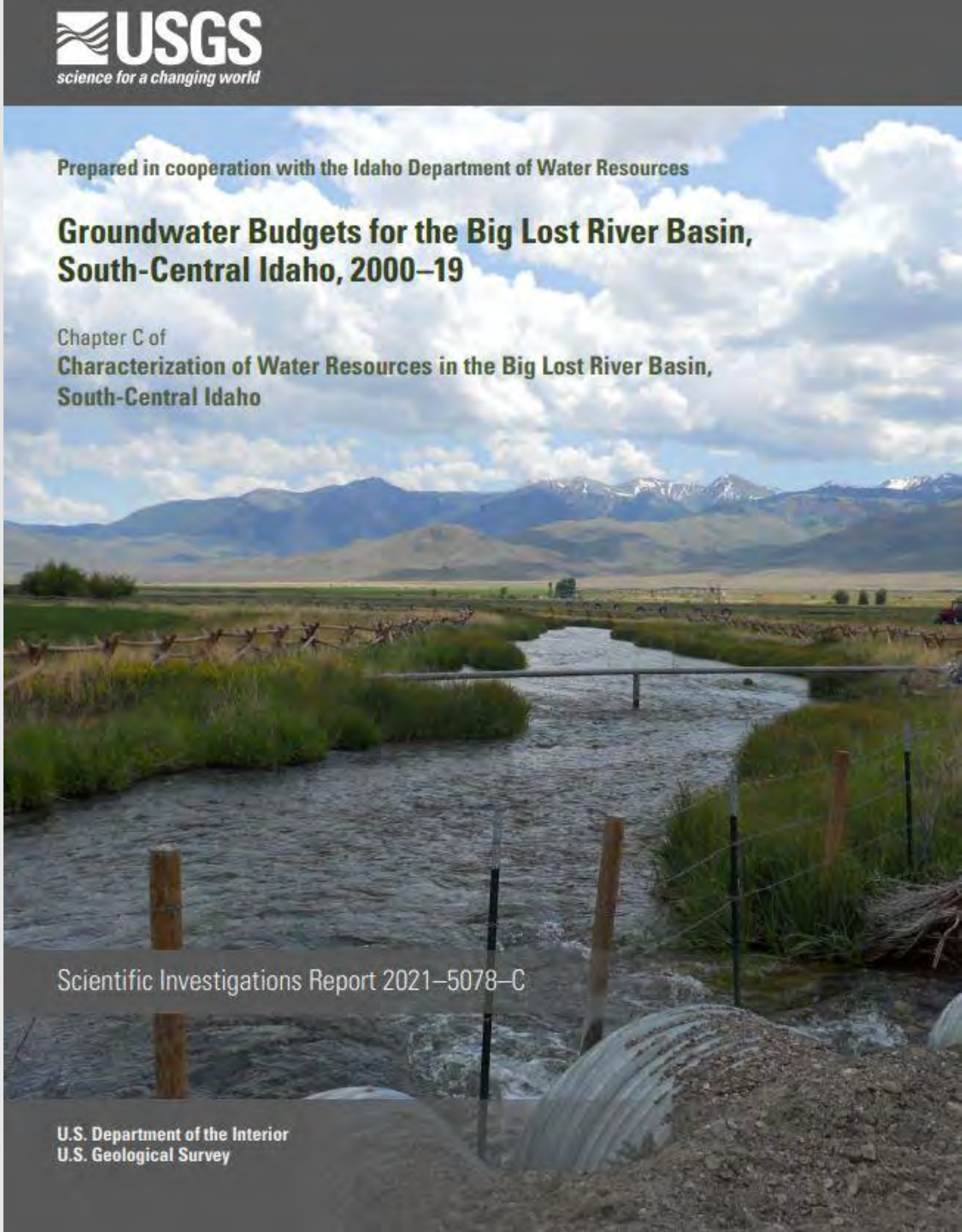
Big Lost River Basin–Hydrogeologic investigation publications

<u>Report links</u>

- USGS hydrogeologic framework: https://pubs.er.usgs.gov/publication/sir20215078A
- USGS seepage study: https://pubs.er.usgs.gov/publication/sir20215078B
- IGS groundwater budget: https://pubs.er.usgs.gov/publication/sir20215078C
- IDWR reports: https://idwr.idaho.gov/water-data/projects/big-lost/hydrologic-investigation/



Groundwater budget considerations

- *Purpose:*
  - Provides a framework for subsequent numerical modeling
  - Supports decision making
- *Process:*
  - Identify predominant inflow and outflow components
  - Compile available datasets and quantify volumetric estimates
  - Evaluate the resulting budget adequacy
- *Limitations:*
  - Data gaps, requiring estimation
  - Neglects certain processes (i.e., sublimation, soil-moisture storage, transient stresses)
  - Results are not calibrated or verified

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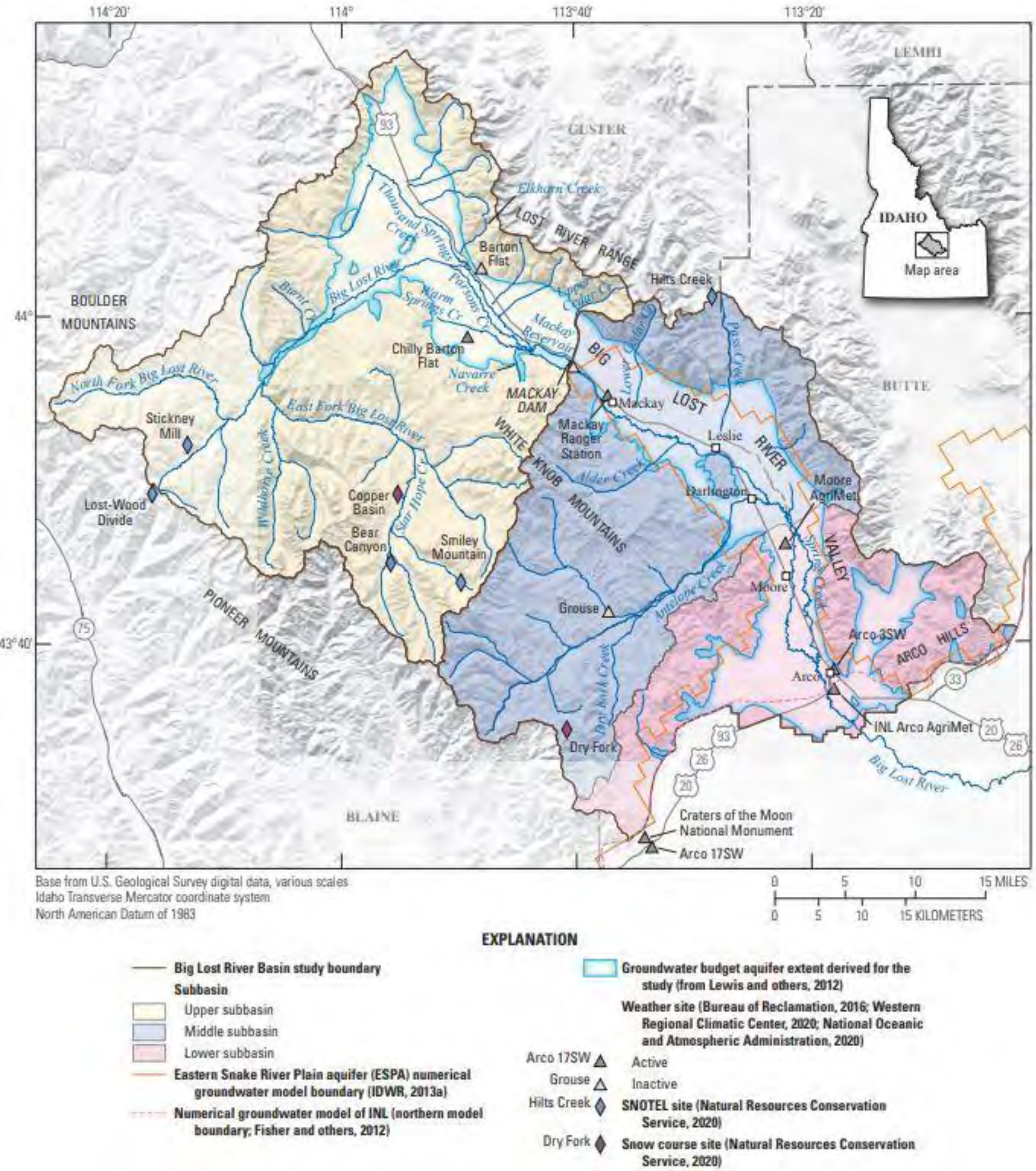

- Watershed scale – separate budgets above and below Mackay Dam
- 3 subbasins considered:
  - Upper (509,800 acres)
  - Middle (335,930 acres)
  - Lower (183,600 acres)
- 20-year groundwater budget (2000-19)
- Emphasis on dry (2014), wet (2017), and average annual conditions

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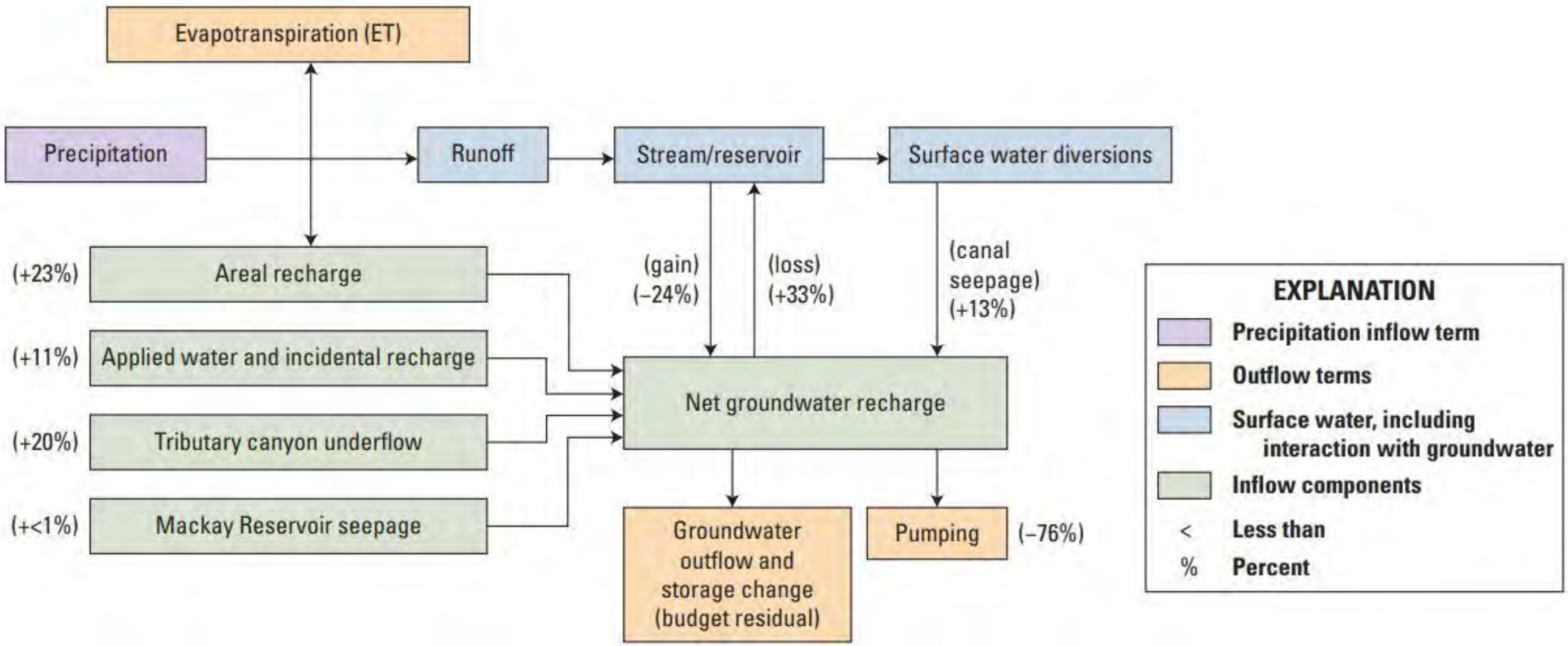
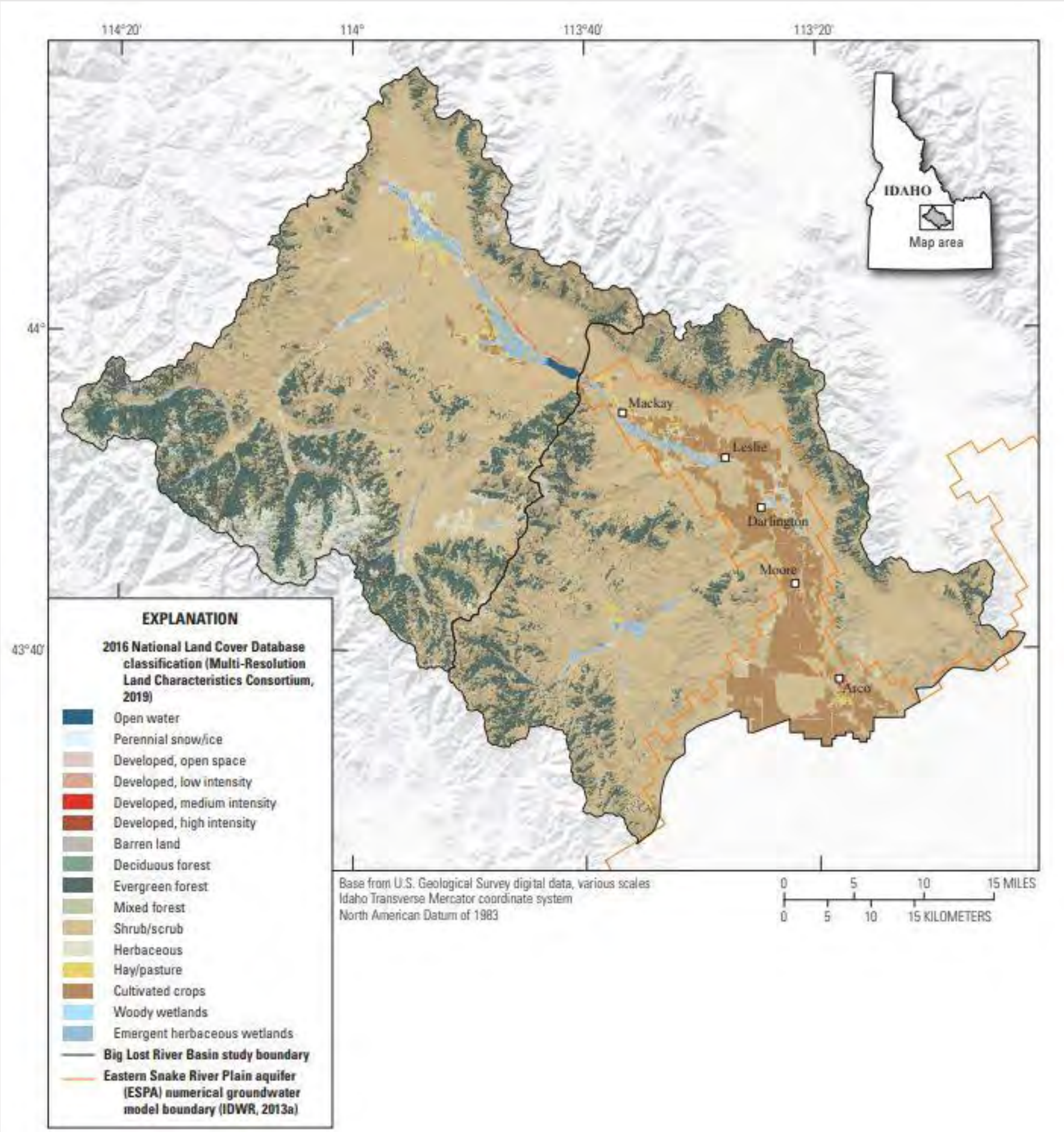
Groundwater budget components



Land coverage



- *Data sources:*
  - NLCD – National Land Cover Database
  - CDL – CropScape Data Layer
- *Applications:*
  - Evapotranspiration
  - Areal recharge
  - Irrigation recharge
- *Limitations:*
  - Missing years
  - Assumed translation to ETIdaho categories

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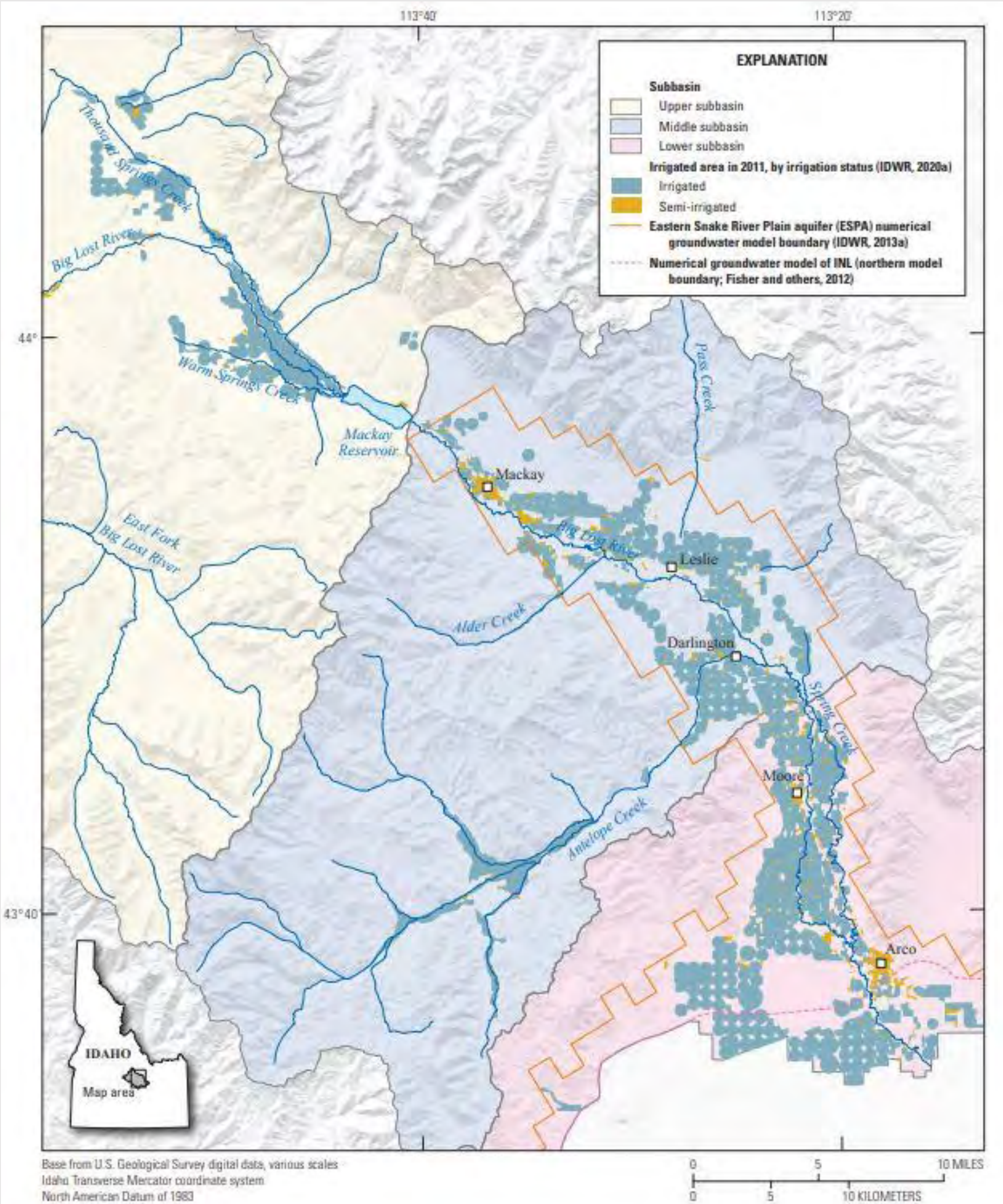
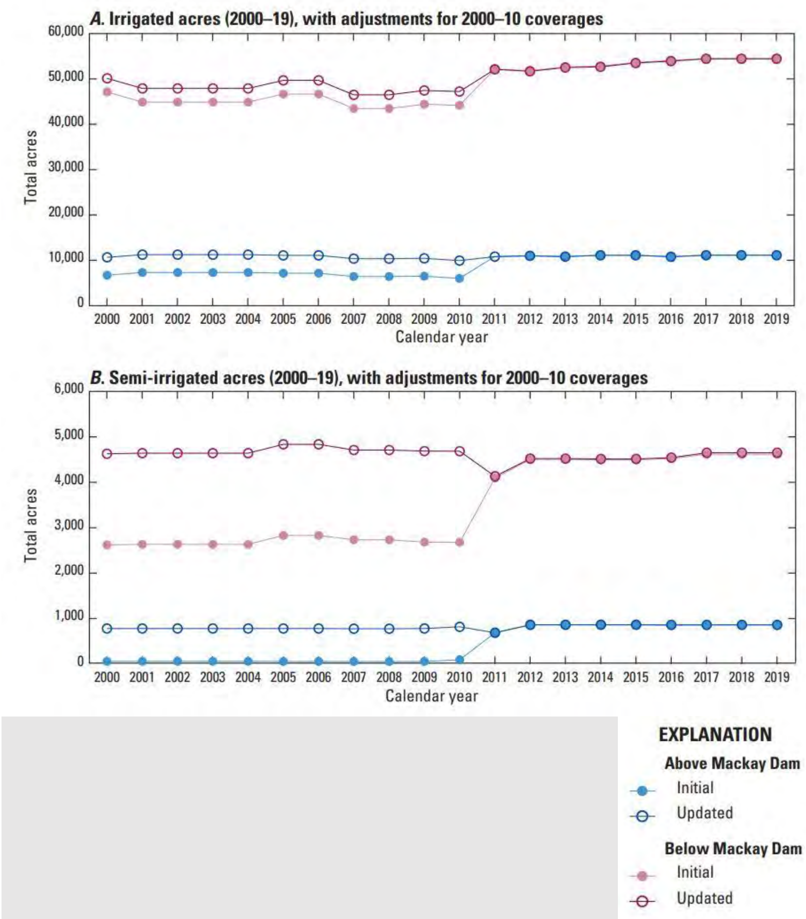
Irrigated lands





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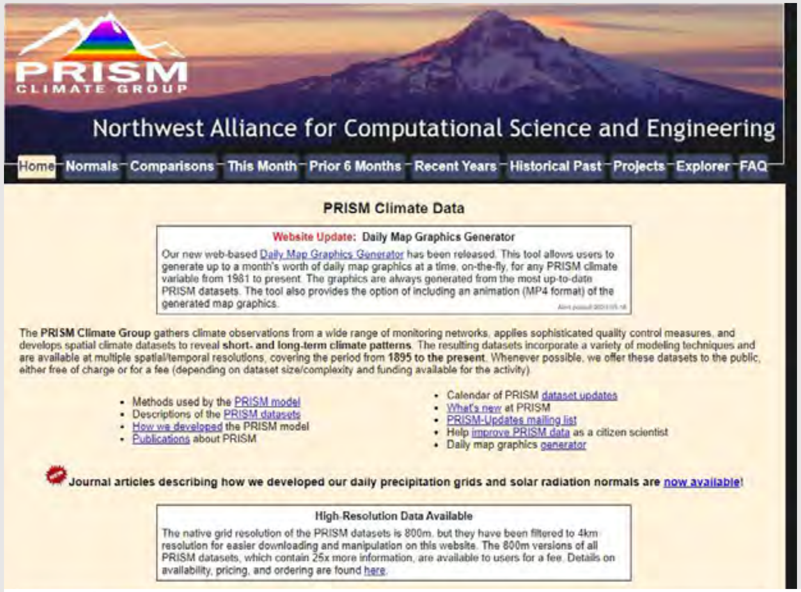
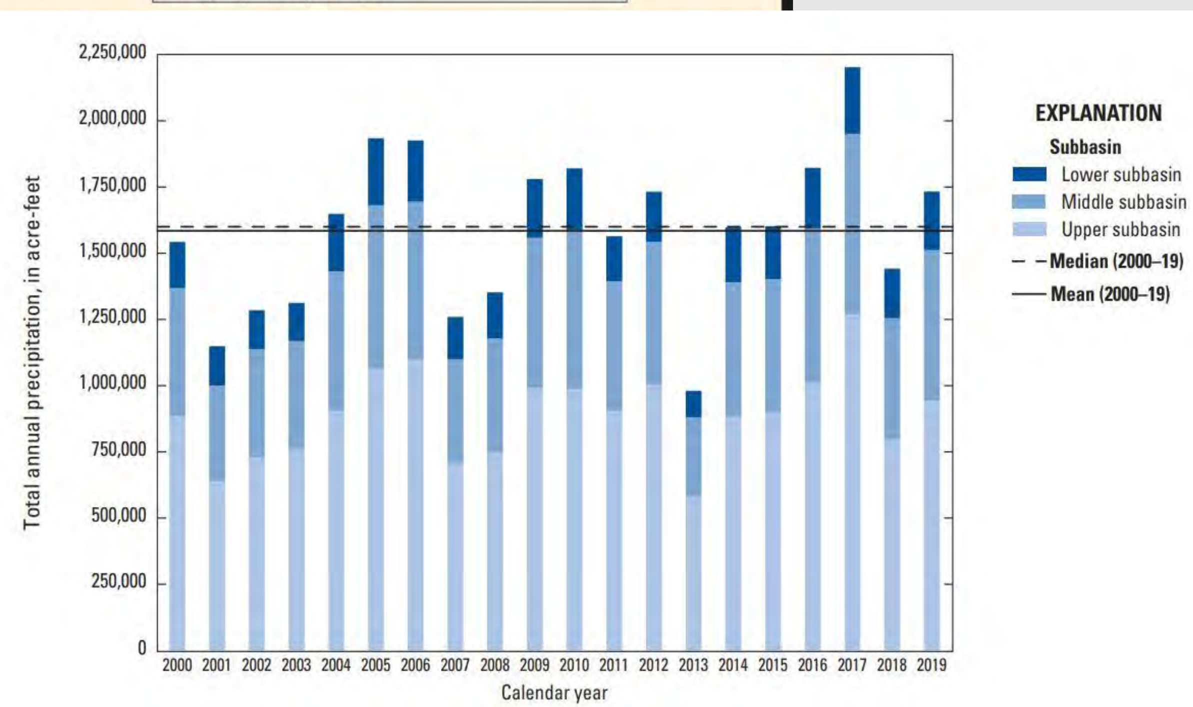
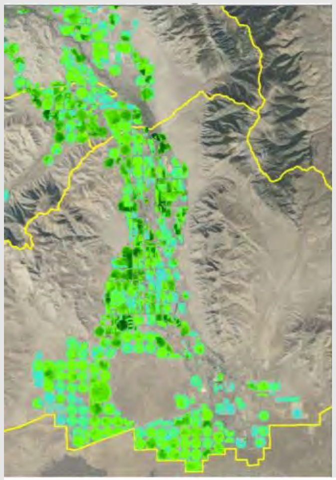
Precipitation

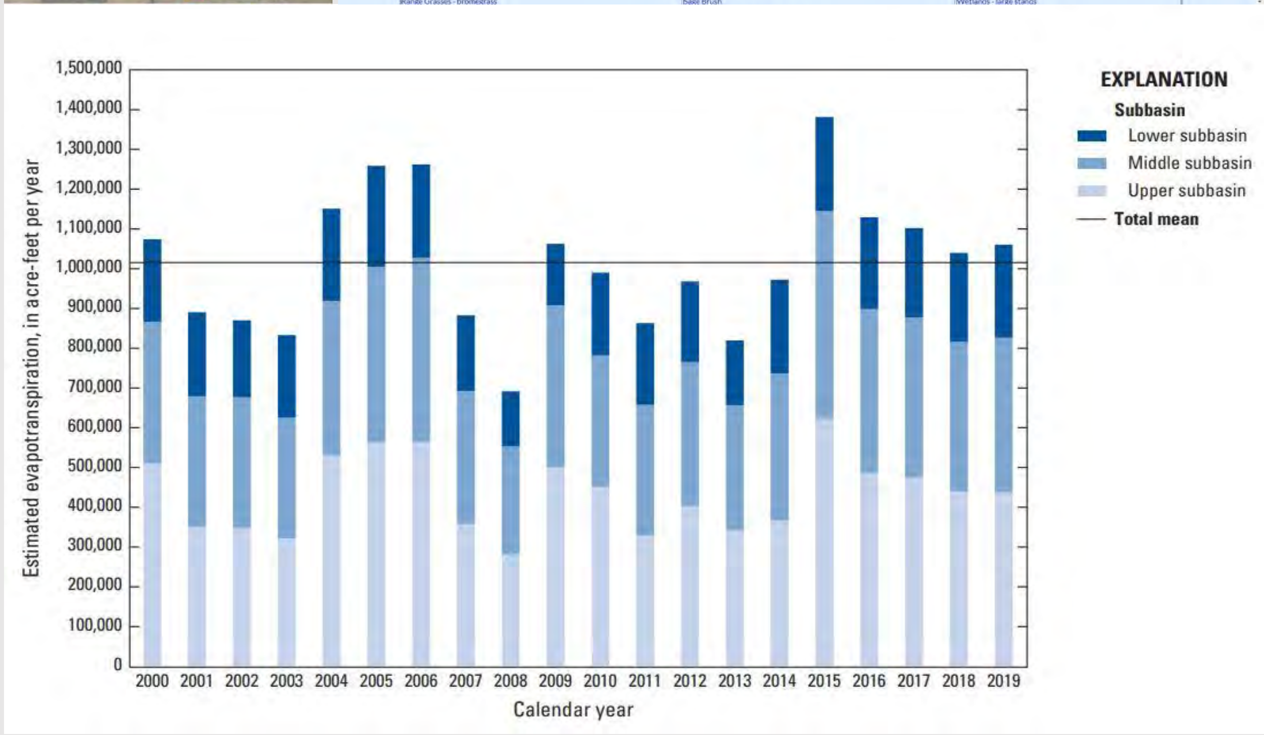


- *Data sources:*
  - Weather station datasets
  - PRISM Climate Group (4 km)
  - ETIdaho stations (areal recharge)
- *PRISM Results:*
  - Upper subbasin - highest precip
  - Lower subbasin – lowest precip
  - 2017 – highest year
  - 2013 – lowest year
- *Limitations:*
  - Neglects sublimation
  - Unmeasured precipitation (interpolated, estimated)



Evapotranspiration





- *Data sources:*
  - METRIC (IDWR)
  - ETIdaho (UI)
- *Results:*
  - Mean 1,015,200 ac-ft
  - Lowest (in 2008) 692,000 ac-ft
  - Highest (in 2015) 1,381,700 ac-ft
  - 0.9 ac-ft/ac – upper basin
  - 1.1 ac-ft/ac – middle/lower basins
- *Limitations:*
  - Interpolation effects
  - Surrogate year assumptions
  - Assigned land category and crop type

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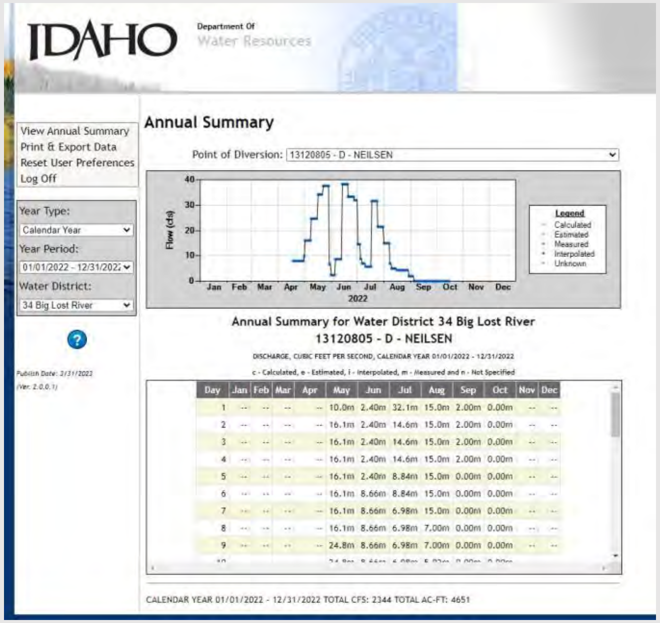
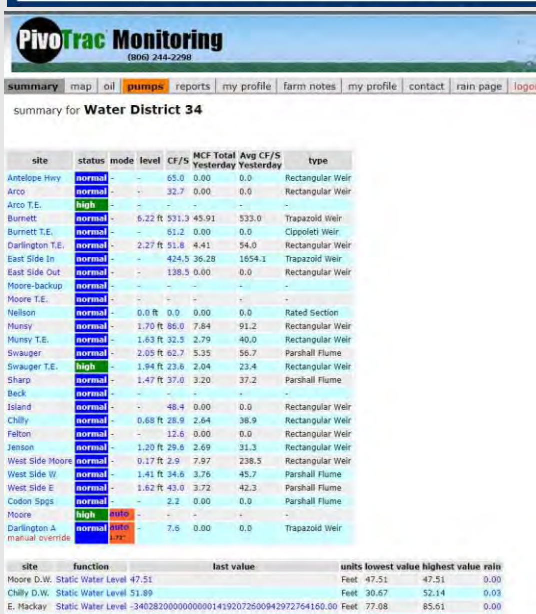
Surface-water diversions and return surface-water flows

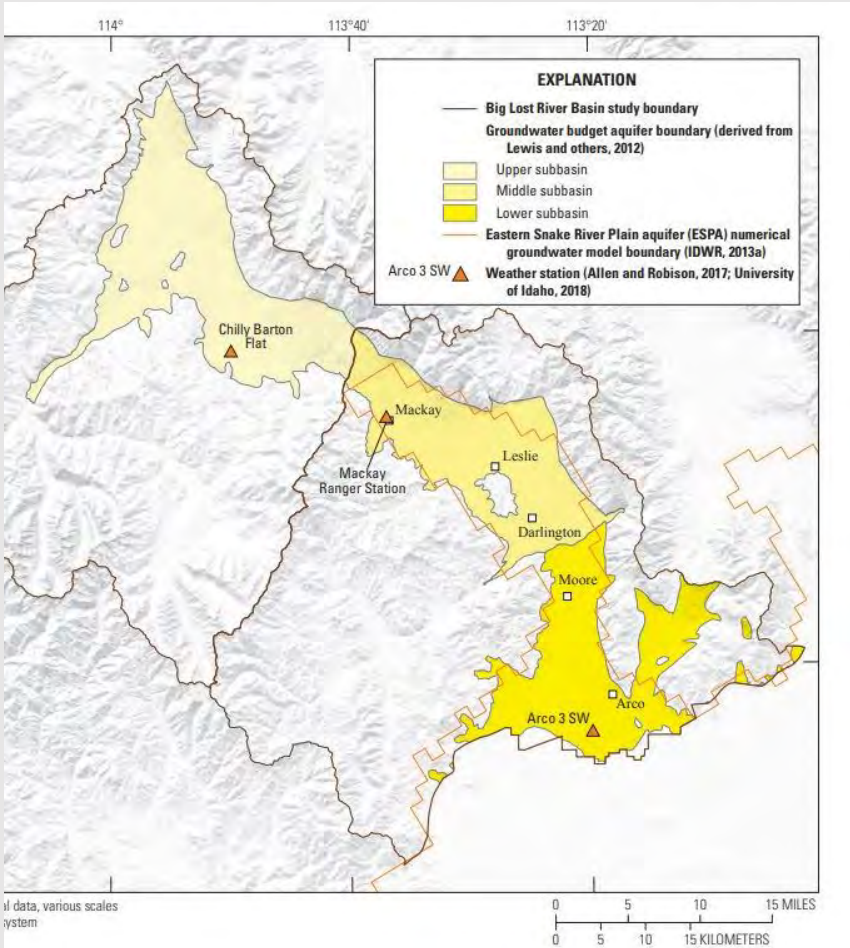


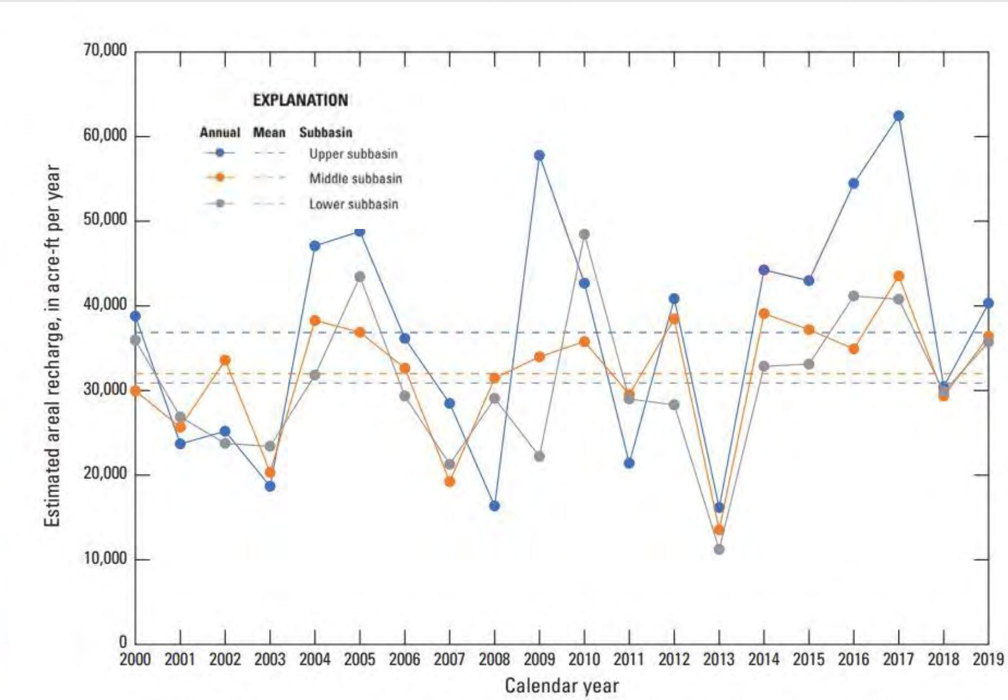
- *Data sources:*
  - IDWR surface-water diversion database (115 locations)
  - WD34 (Pivotrac) surface-water return flows (East Side Ditch and Burnett Canal)
- *Methods:*
  - Data compilation
  - Linear regression – unmeasured surface-water diversions
- *Results:*
  - Higher utilization of surface water above Mackay Dam compared to below (90% in upper subbasin; 65% in middle subbasin; 55% in lower subbasin)
  - *Highest diversions in wettest years*
- *Limitations:*
  - No SW div records above Mackay Dam or Antelope Creek (2000-02)
  - Limited return flow datasets



Sharp Canal (IGS, 2019)

Inflow – Areal recharge





- *Data sources: ETIdaho (UI), modified aquifer extent (IGS)*
- *Methods: (Precip) – (ET) – (Surface runoff)*
- *Results:*
  - *~ 100,000 acre-ft/yr (2000-19)*
  - *4.4 in/yr above Mackay Dam; 4.9 in/yr below Mackay Dam*
- *Limitations: 2017- 2019 terms estimated from linear regression; neglects soil moisture*

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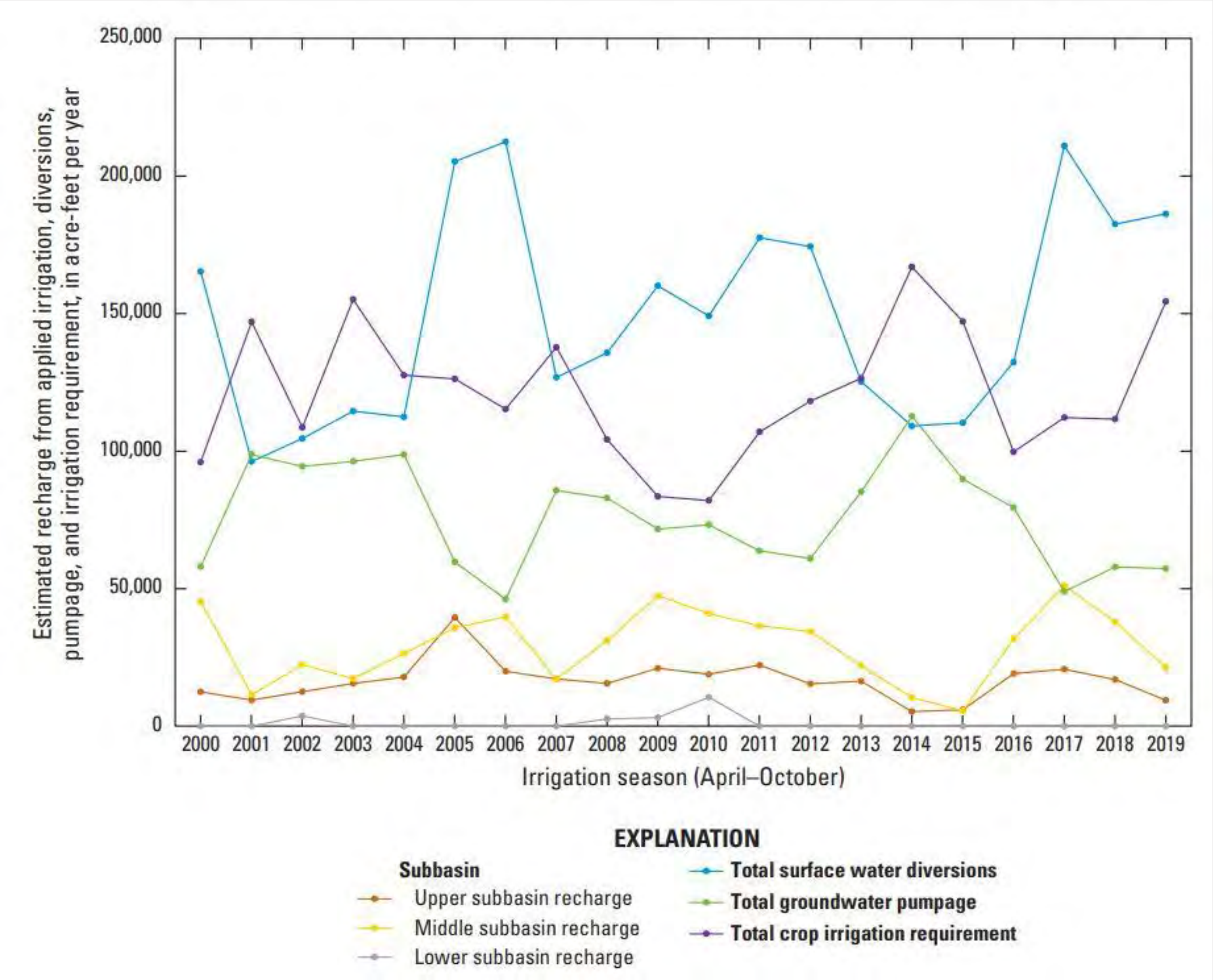
Inflow – Applied irrigation recharge



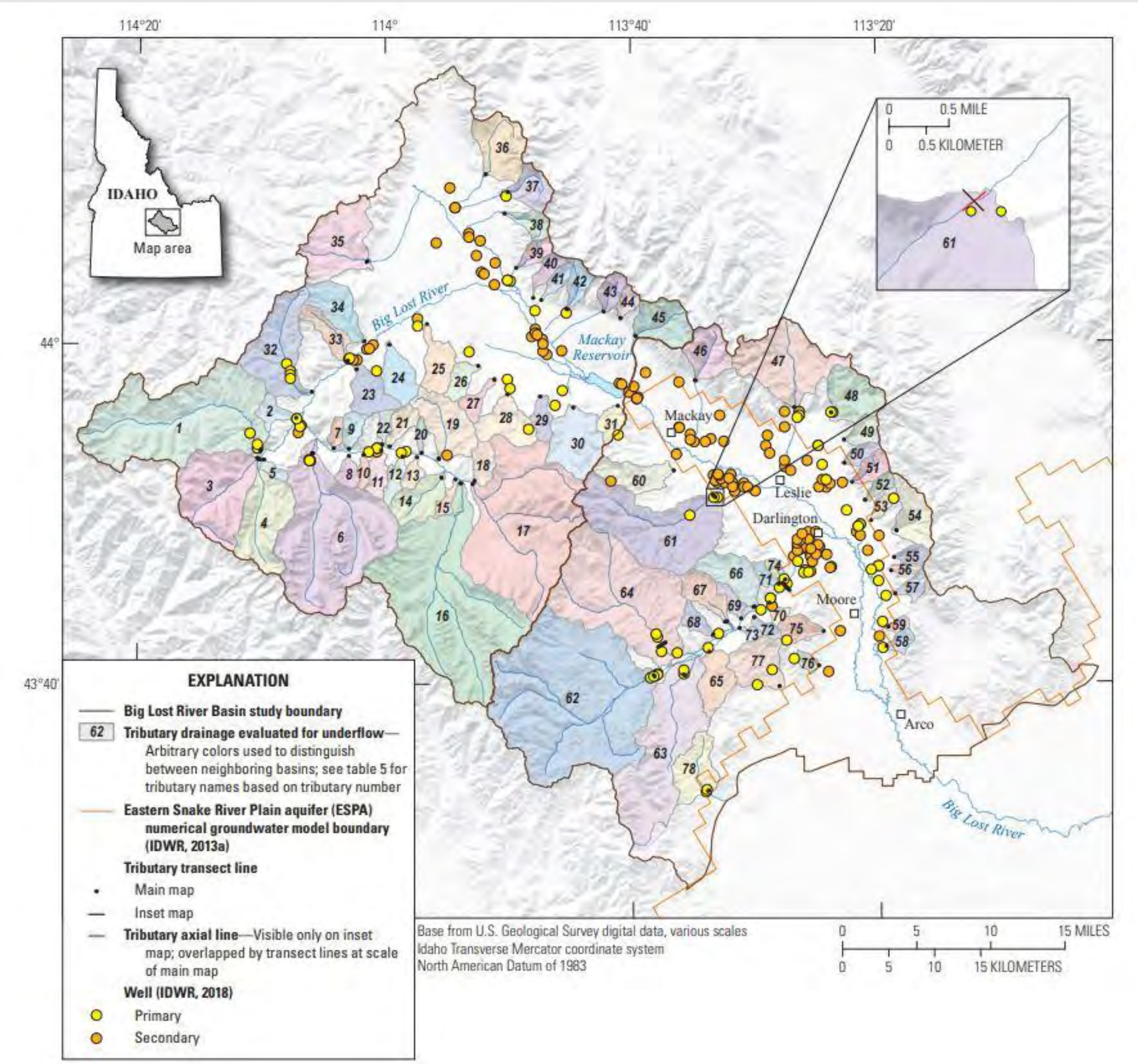
- *Data sources*:
  - IDWR: (Divsw, GW pumpage, irrigated lands, METRIC, ditch rider logs, storage balance spreadsheets)
  - UI: ETIdaho
  - Pivotrac: return flows
  - PRISM Climate Group: precip
- *Methods*:

  Q = Divsw + Divgw – Retsw – Canalseep – CIR

  [Irr and semi-irr lands]

  (Apr – Oct)
- *Results*:
  - 16,600 ac-ft/yr (above Dam)
  - 30,300 ac-ft/yr (below Dam)
- *Limitations*:
  - Uncertainty due to unmeasured parameters

Inflow – Tributary canyon underflow



- *Data sources*:
  - Tributary delineation (USGS StreamStats)
  - Precipitation (PRISM)
  - Well lithology (IDWR)
  - 1 aquifer test (USGS)
- *Methods*:
  - Tributary delineation
  - Darcy's Law ($Q = KA\frac{dh}{dz}$)
  - Annual precipitation adjustment (all canyons)
  - Small canyon scaling-factor adjustment
- *Results (mean annual, acre-ft/yr)*:
  - Upper = 50,900
  - Middle = 34,700
  - Lower = 3,000
- *Limitations*:
  - Results highly sensitive to estimated input terms

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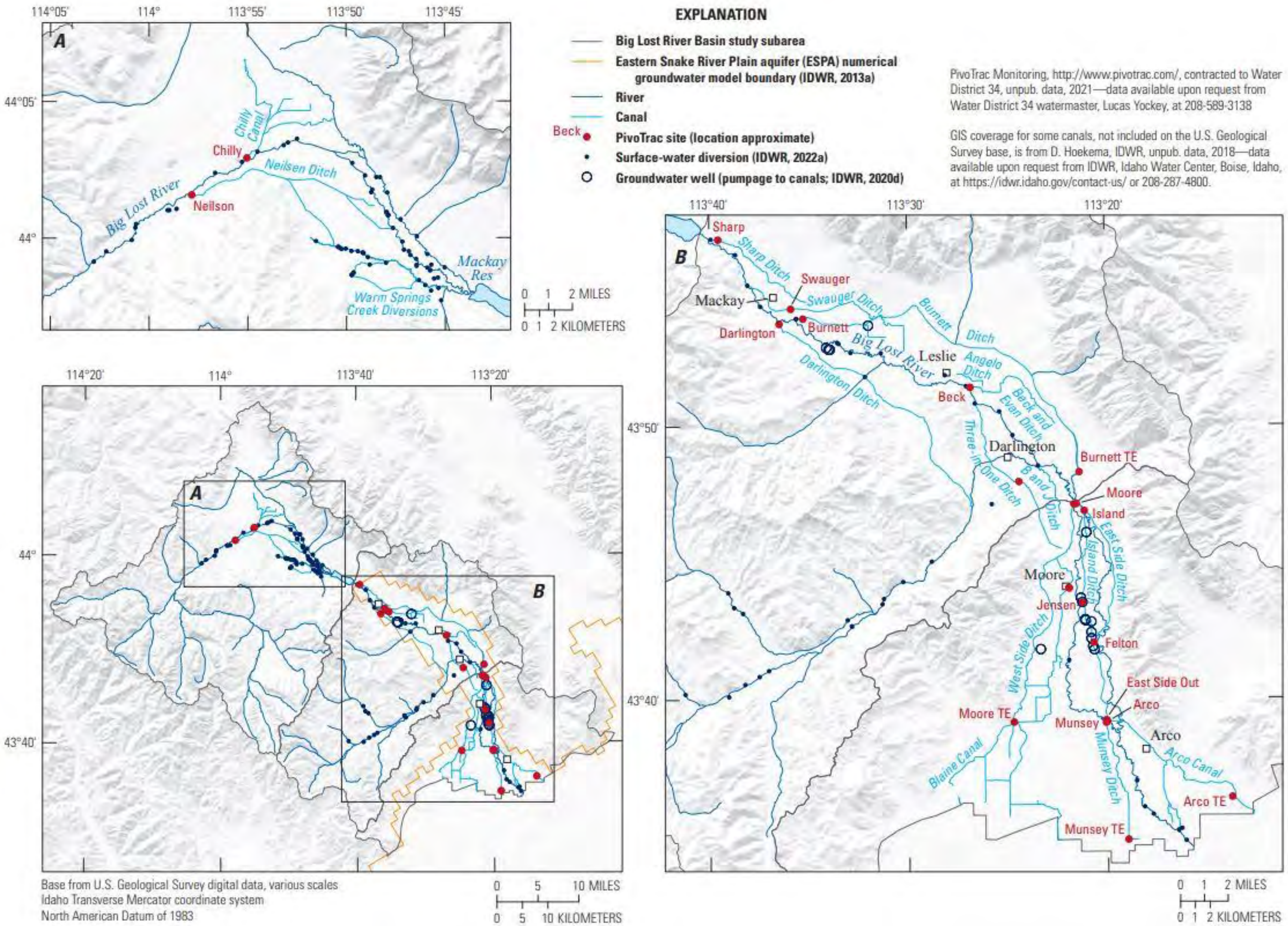
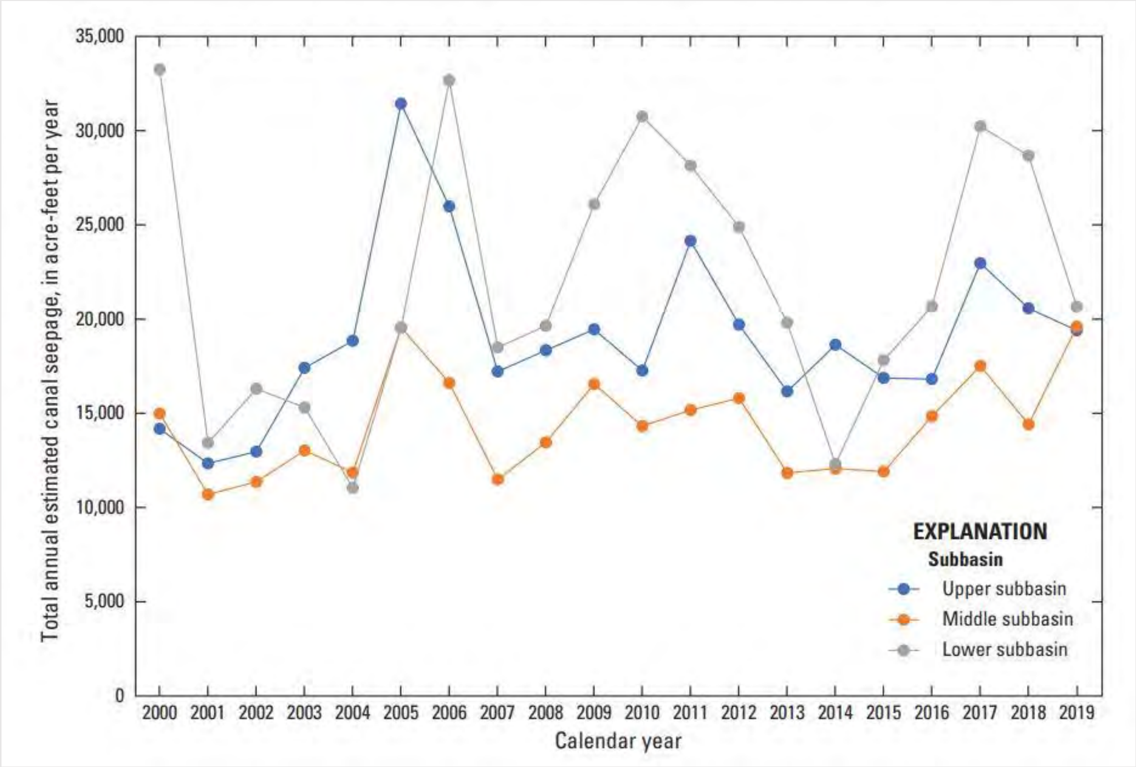
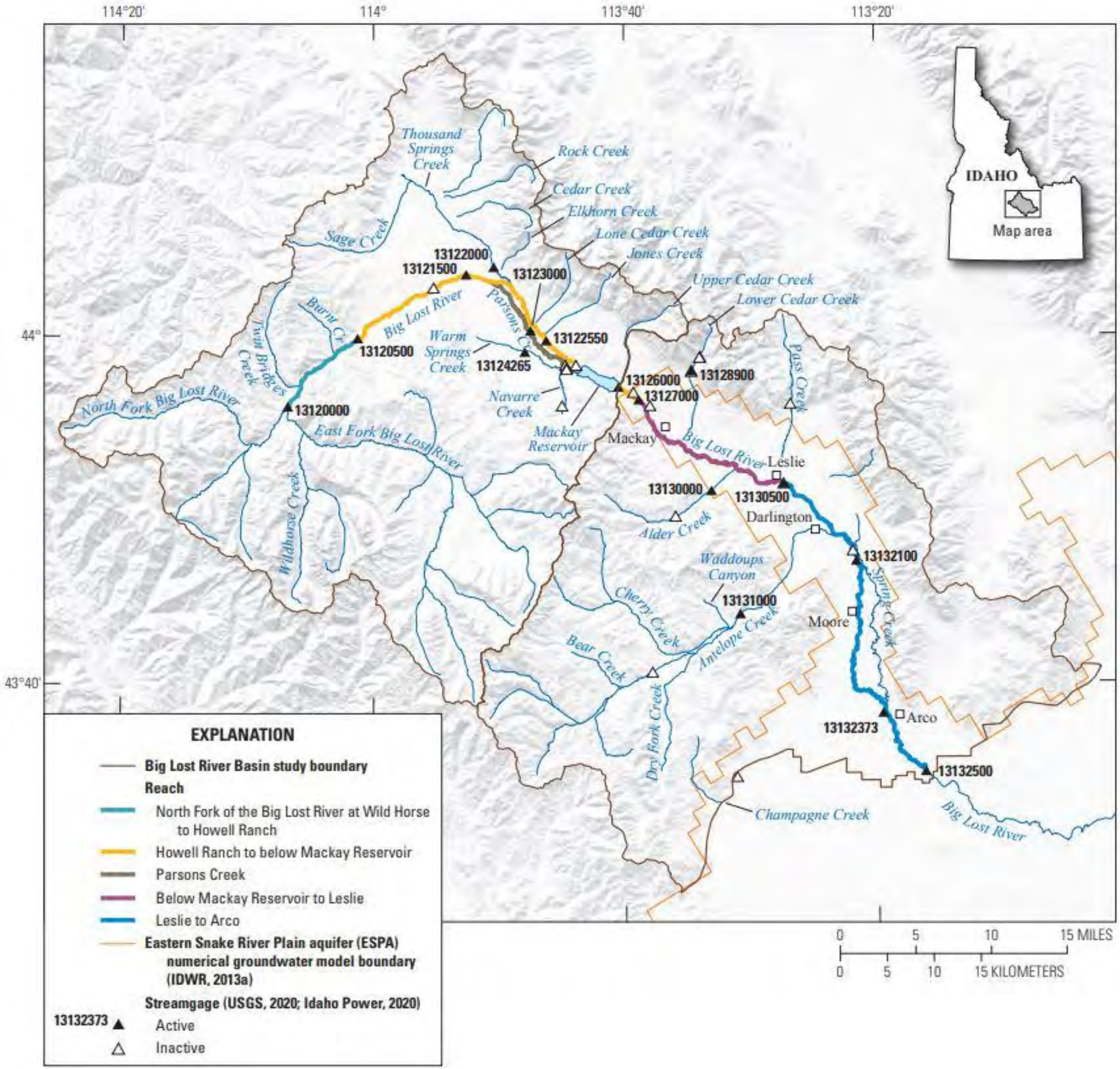

EXPLANATION
Big Lost River Basin study subarea
Eastern Snake River Plain aquifer (ESPA) numerical groundwater model boundary (IDWR, 2013a)
River
Canal
Beck
PivoTrac site (location approximate)
Surface-water diversion (IDWR, 2022a)
Groundwater well (pumpage to canals; IDWR, 2020d)
PivoTrac Monitoring, http://www.pivotrac.com/, contracted to Water District 34, unpub. data, 2021—data available upon request from Water District 34 watermaster, Lucas Yockey, at 208-589-3138
GIS coverage for some canals, not included on the U.S. Geological Survey base, is from D. Hoekema, IDWR, unpub. data, 2018—data available upon request from IDWR, Idaho Water Center, Boise, Idaho, at https://idwr.idaho.gov/contact-us/ or 208-287-4800.
A
114°05'
114°
113°55'
113°50'
113°45'
44°05'
44°
Chilly Canal
Chilly
Neilsen Ditch
Big Lost River
Neilson
Mackay Res
Warm Springs Creek Diversions
0 1 2 MILES
0 1 2 KILOMETERS
114°20'
114°
113°40'
113°20'
44°
43°40'
A
B
Base from U.S. Geological Survey digital data, various scales
Idaho Transverse Mercator coordinate system
North American Datum of 1983
0 5 10 MILES
0 5 10 KILOMETERS
B
113°40'
113°30'
113°20'
43°50'
43°40'
Sharp
Sharp Ditch
Swauger
Swauger Ditch
Mackay
Darlington
Burnett
Burnett Ditch
Big Lost River
Leslie
Angelo Ditch
Darlington Ditch
Beck
Beck and Evan Ditch
Three-in-One Ditch
Darlington
B and J Ditch
Burnett TE
Moore
Island
East Side Ditch
Island Ditch
Moore
Jensen
Felton
West Side Ditch
East Side Out
Arco
Moore TE
Munsey
Arco
Blaine Canal
Munsey Ditch
Arco Canal
Arco TE
Munsey TE
0 1 2 MILES
0 1 2 KILOMETERS

Inflow – Canal seepage



- *Data sources:*
  - *WD34: Ditch rider logs*
  - *IDWR: Storage balance (2015-19); surface-water diversion database*
- *Methods*:
  - Delivery factors (DF)
    - Diversion volume / Headgate volume
    - Seepage volume =

      (1-DF)*Swdiv volume
    - Below Mackay Dam
      - 2015-19: DF (0.73-0.77)
      - 2000-14: Linear regression DF (0.71, Middle; 0.62 Lower)
    - Above Mackay Dam, assumed DF (0.6)
  - Unmeasured canal diversions above Mackay Dam: linear regression with diversion volumes below Dam
- *Results (mean, acre-ft/yr)*:
  - 19,000 (Upper); 14,400 (Middle); 22,000 (Lower)
- *Limitations*:
  - Assumed DF above Mackay Dam
  - Estimated surface-water diversions (2000-02) above Dam
  - Extrapolating 2015-19 DF to prior years below Mackay Dam



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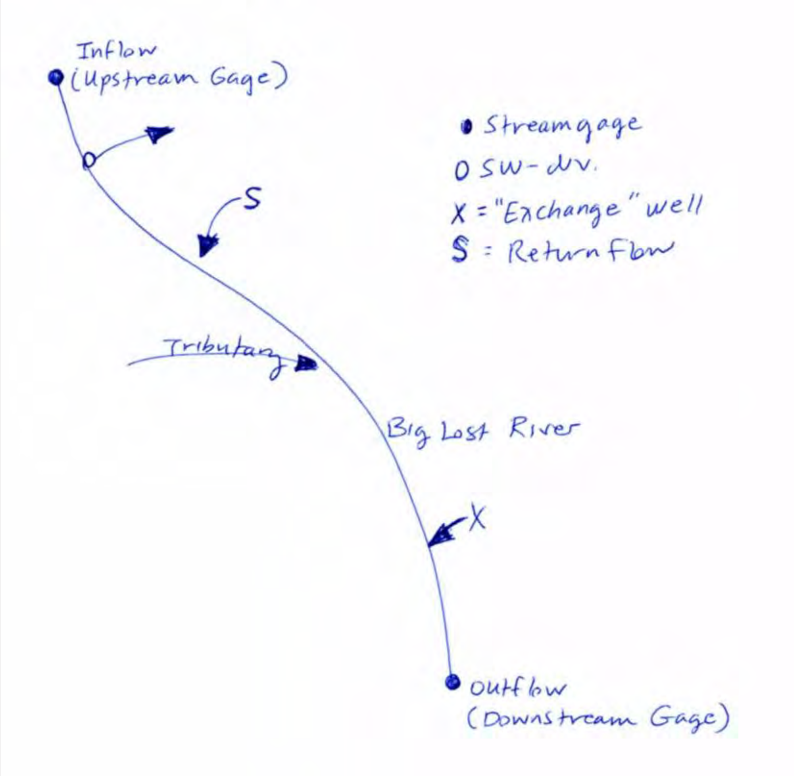
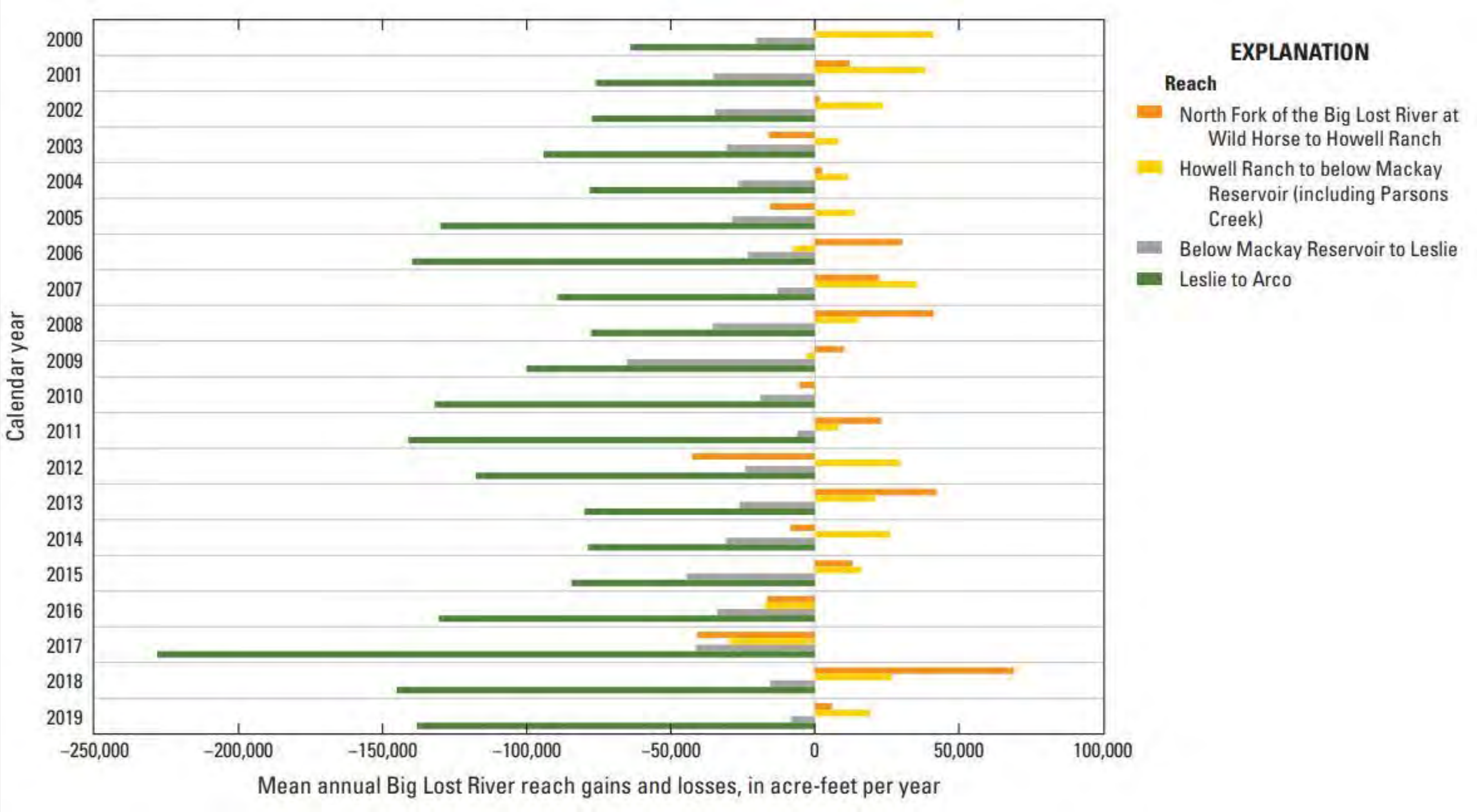
Inflow and outflow – Big Lost River gains and losses



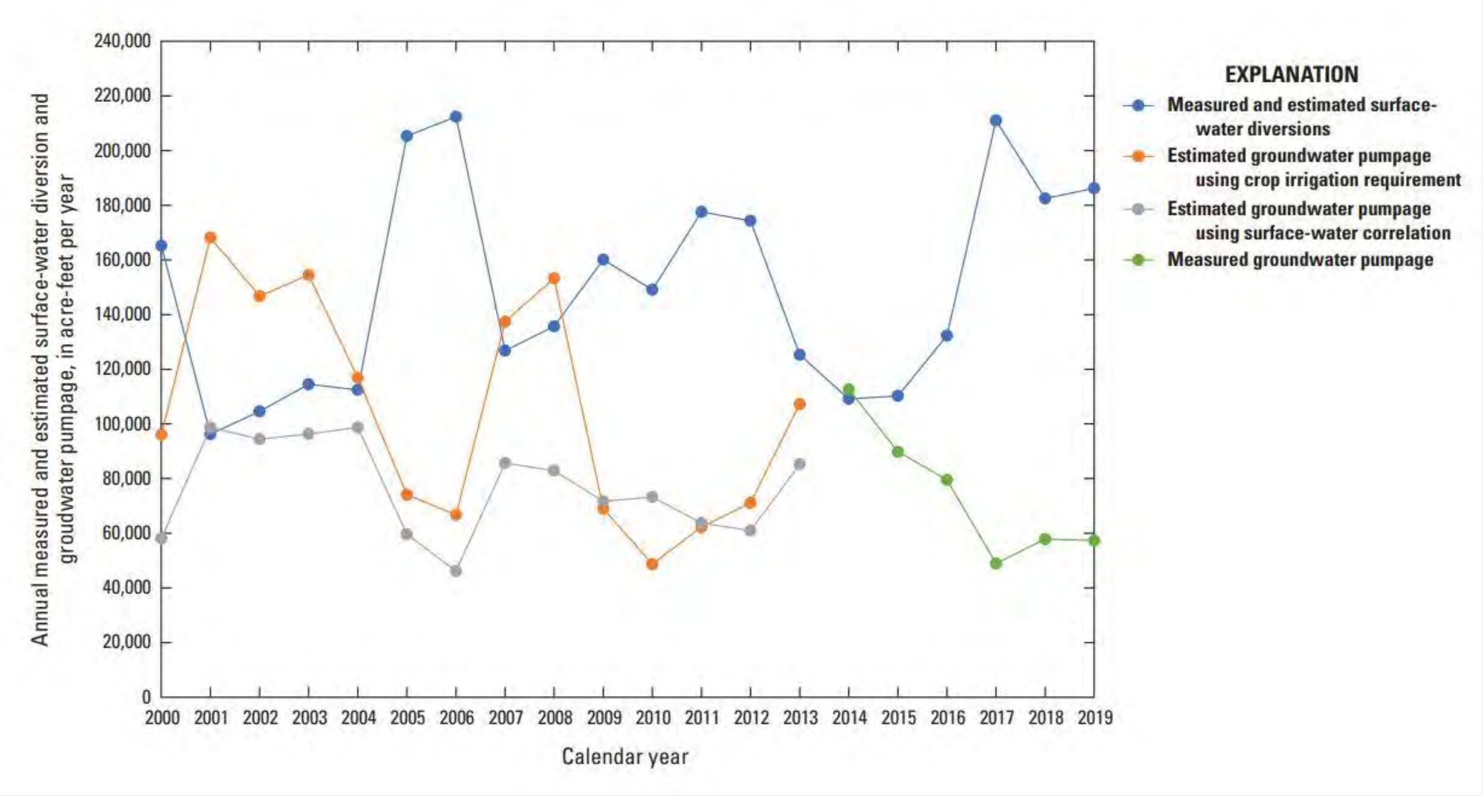
- *Data sources*:
  - IDWR: surface-water diversion database, including groundwater pumpage to canals ("exchange wells")
  - USGS: streamgage mean annual streamflow
  - Pivotrac: return surface water flows
- *Methods:*
  - Gain/loss = Outflow – Inflow – Tributary inflow +Swdiv – Gwpump to canals – Return flow
- *Results:* Next slide
- *Limitations*:
  - Tributary stream seepage neglected
  - Unmeasured tributary streamflow

Inflow and outflow – Big Lost River gains (outflow) and losses (inflow)



Outflow – Groundwater pumpage

- *Data sources:*
  - IDWR: WMIS database annual flowmeter records (2014-19) and power consumption records (2010-13)
  - IDWR: surface-water diversion database
- *Methods:*
  - Unmeasured pumpage (2000-13): Linear regression with annual surface-water diversion volumes (2014-19)
- *Results (mean annual in ac-ft/yr):*
  - Irrigation: Upper subbasin (4,250); Middle subbasin (34,000); Lower subbasin (37,800)
- *Limitations:*
  - Unmeasured pumpage estimates (2000-13)



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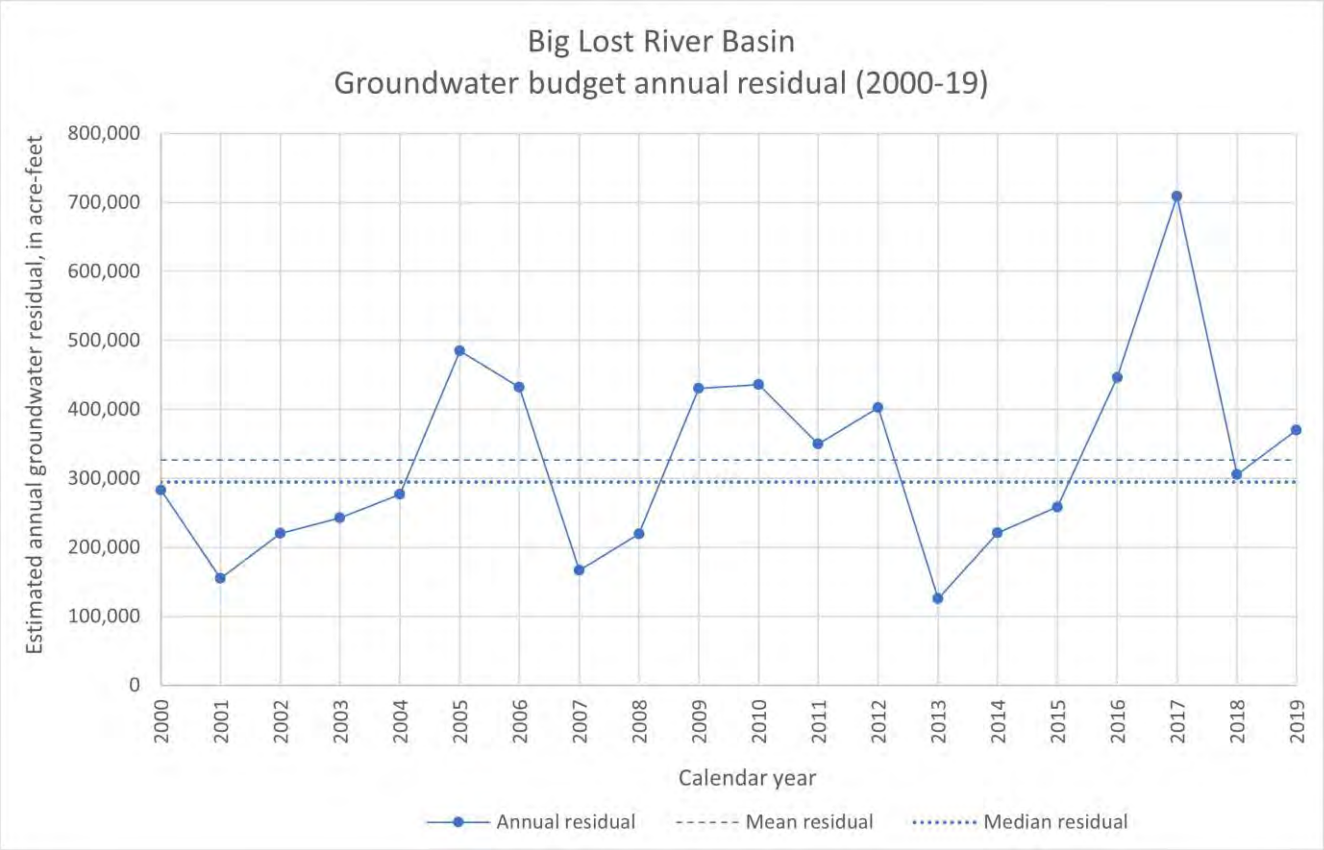
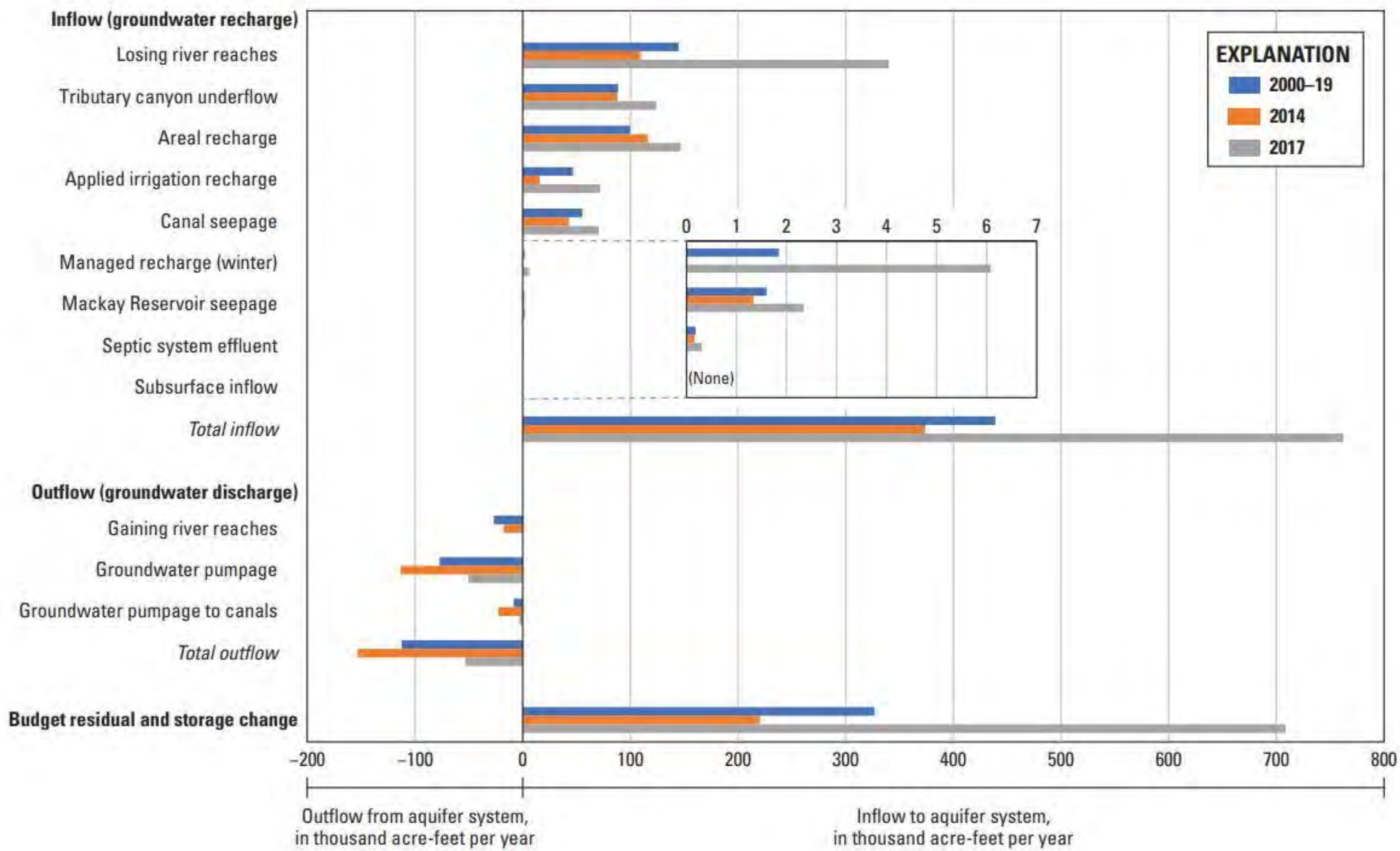
Groundwater budget residuals



- Groundwater underflow leaving the basin
- Annual changes in aquifer storage
- Errors

Groundwater budget results



Prior groundwater budgets

Source	Time period of study	Study extent	Basin discharge (acre-ft/yr)	Comments
Stearns and others, 1938	[1]1920–27	Above and below Mackay Dam	226,000	Groundwater
Mundorff and others, 1964	1921–50	Above Mackay Dam	280,000	Surface water and groundwater
		Below Mackay Dam	60,000	
Crosthwaite and others, 1970a	1944–68	Above and below Mackay Dam	307,700	Groundwater underflow above gauge near Arco
Said and others, 2005	2000	Above and below Mackay Dam	267,000	Surface water and groundwater
Sukow, 2017	1985–2010	ESPA model below Mackay Dam	204,000	Groundwater
Ackerman and others, 2010	1966-90	INL site northern model boundary	261,400	Steady state numerical groundwater-flow model input

[1]Water years (October 1–September 30)

Clark, 2022	2000 - 19	Above and below Mackay Dam	326,700	Groundwater (underflow and storage change)

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Groundwater budget key findings

- Above Mackay Dam
  - Combined surface water and groundwater provide for irrigation needs and Mackay Reservoir storage
  - Higher precipitation due to snowmelt provides for appreciable tributary canyon underflow and areal recharge
  - Additional recharge to the aquifer from applied irrigation and canal seepage
  - Overall positive groundwater residual above Mackay Dam
- Below Mackay Dam
  - Highest recharge sources include losing river reaches and groundwater inflow from above Mackay Dam
  - Less additional recharge provided from areal recharge, tributary canyon underflow, canal seepage, and applied irrigation
  - Surface-water diversions and groundwater pumping account for most of the net withdrawals of water
  - More variable surface-water and groundwater supplies due to less precipitation and less flow in the Big Lost River

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Questions?

Thank you!

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Big Lost River Basin project field trip (IGS, 2018)

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