Surface water in the groundwater model

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Goals

Help with understanding of how a groundwater model works

Describe simplifications we made to surface water system

Discuss how this impacts what model can and cannot "say" about surface water

Outline

Outline:
1. Brief overview of groundwater modelling & boundaries
2. Survey of surface water features and how we are modelling them

Groundwater modelling & “boundaries”

Modelling steps

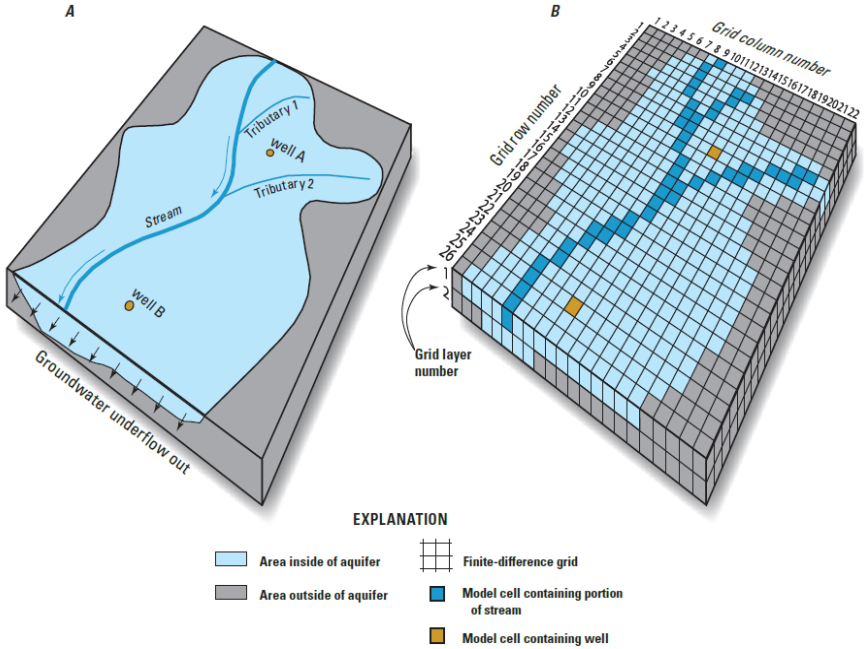

Figure 42. *A*, Part of a hypothetical stream-aquifer system. *B*, Representation of that system with a finite-difference model grid consisting of 26 rows, 22 columns, and 2 layers of rectangular finite-difference blocks.

Streamflow Depletion by Wells-Understanding and Managing the Effects of Groundwater Pumping on Streamflow (p. 60)
Paul M. Barlow and Stanley A. Leake 2012

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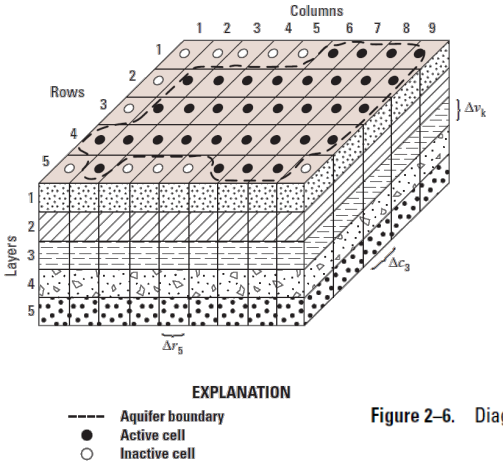
Internal to aquifer

- Water levels in each cell are calculated
- Flow between cells is proportional to water level 'slope' between cells
  - Also:
    - Hydraulic conductivity
    - Shared area
    - Distance between cells
- Math



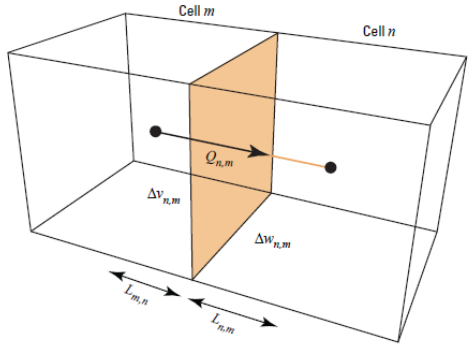


Figure 2–6. Diagram showing flow into cell n from cell m. Figure modified from Harbaugh (2005).

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)-W=S_s\frac{\partial h}{\partial t},$$

where

K_{xx}, K_{yy}, and K_{zz} are values of hydraulic conductivity in the x, y, and z directions along Cartesian coordinate axes, which are assumed to align with principal directions of hydraulic conductivity (LT^{-1}),

h is hydraulic head (L),

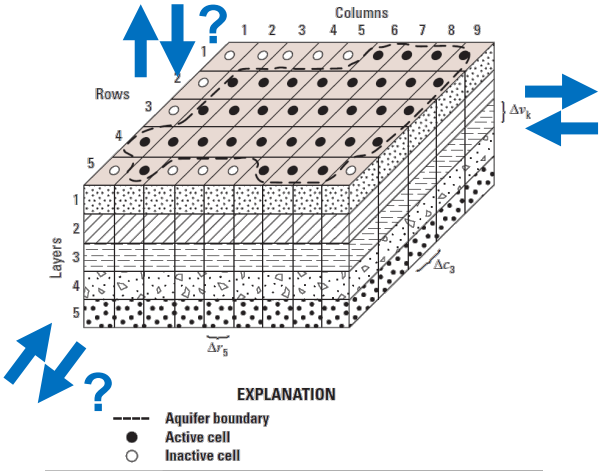
W is a volumetric flux per unit volume and represents sinks and/or sources (T^{-1}),

S_s is the specific storage of the porous material (L^{-1}), and

t is time (T).

External interactions with aquifer

- What about the boundaries?



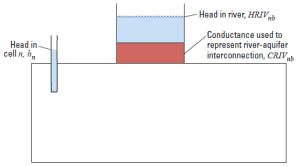


Figure 2–7. Diagram showing conceptual representation of leakage through a riverbed into a model cell. Figure modified from Harbaugh (2005).

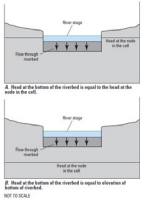


Figure 6–6. Diagram of cross sections showing the relation between head at the bottom of the riverbed layer and head in the cell. Head in the cell is equal to the water-table elevation. Figure modified from Harbaugh (2005).

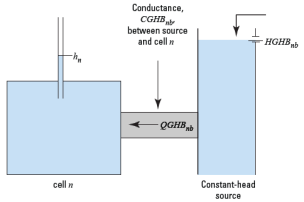


Figure 6–3. Diagram illustrating principle of the General-Head Boundary Package. Figure modified from Harbaugh (2005).

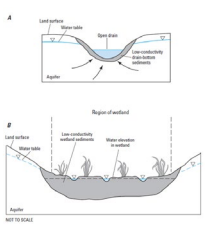


Figure 6–13. Diagram showing alternate drain conceptualizations. *A*, open drainage channel, and *B*, wetland. Figure modified from Harbaugh (2005).

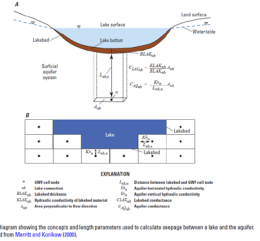


Figure 7–6. Diagram showing the concepts and length parameters used to calculate seepage between a lake and the aquifer. Figure modified from Merritt and Konikow (2000).

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)-W=S_s\frac{\partial h}{\partial t},$$

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Big Lost surface water system

Surface water in Big Lost River Valley

- Large streams
- Small streams
- Springs
- Wetlands / marshes
  - (Riparian areas)
- Mackay reservoir
- Irrigation system
  - Diversions
  - Canals
  - (Irrigation)
- Intentional recharge
- Small storage ponds

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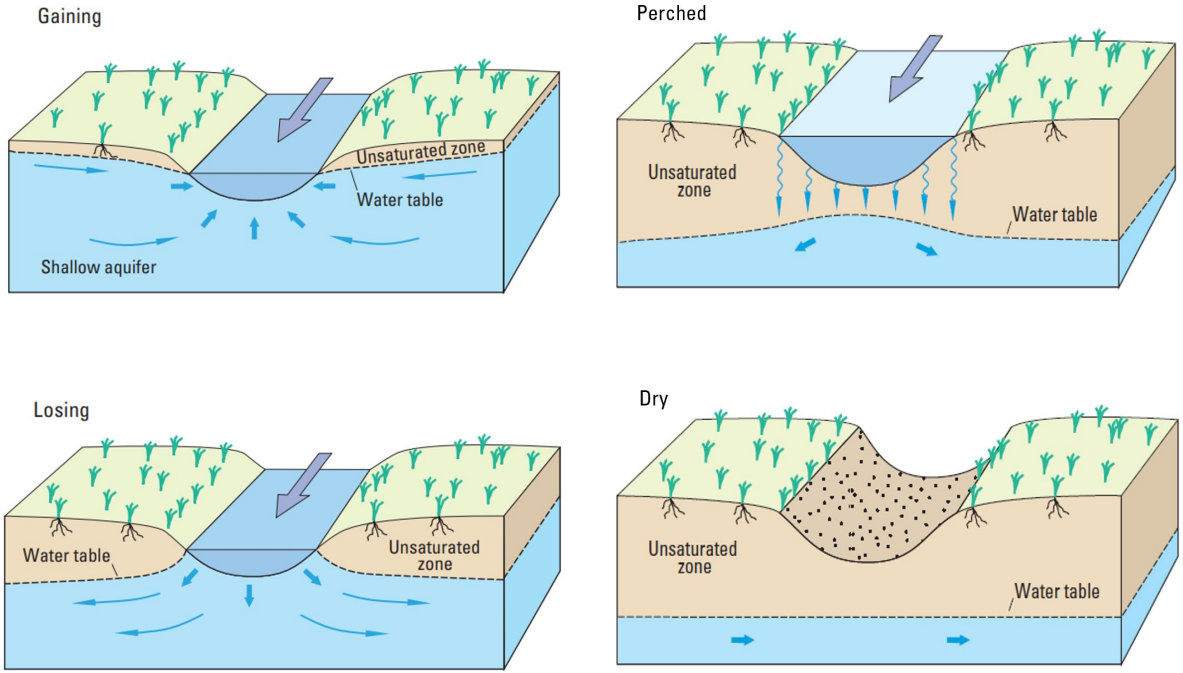
Surface water



Streamflow Depletion by Wells-Understanding and Managing the Effects of Groundwater Pumping on Streamflow (p. 7)
Paul M. Barlow and Stanley A. Leake
2012

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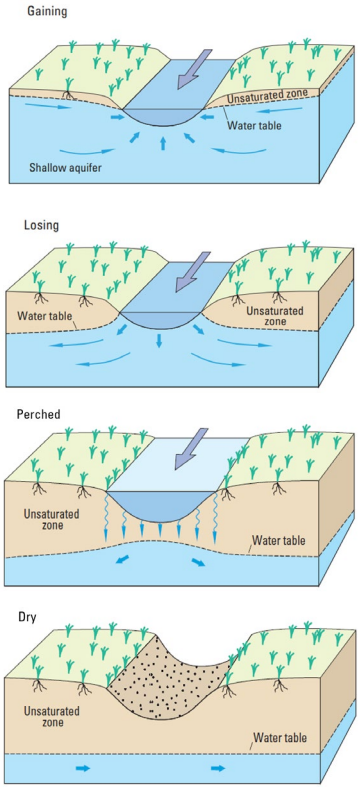
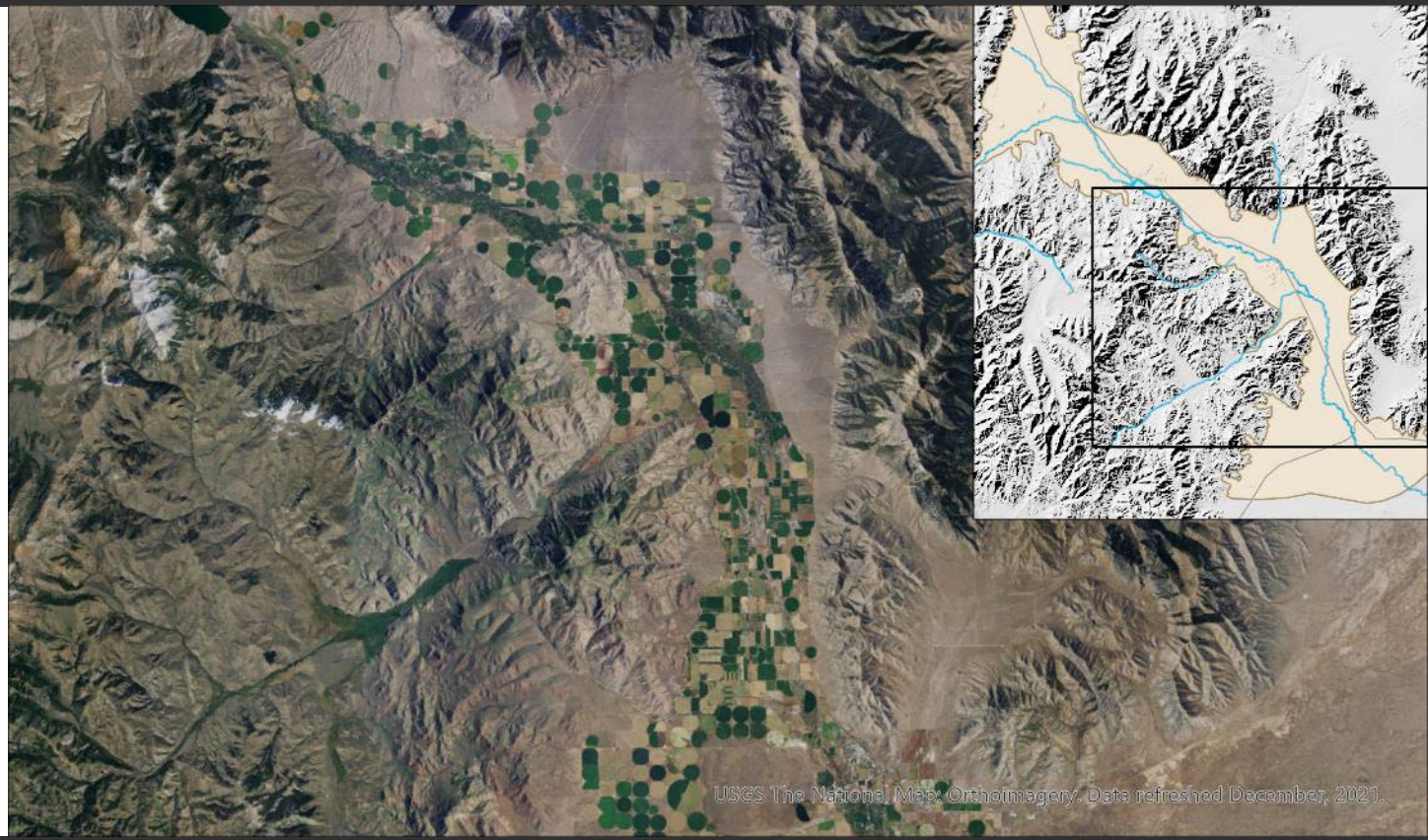
Large streams





Large streams

Big Lost River & Antelope Creek

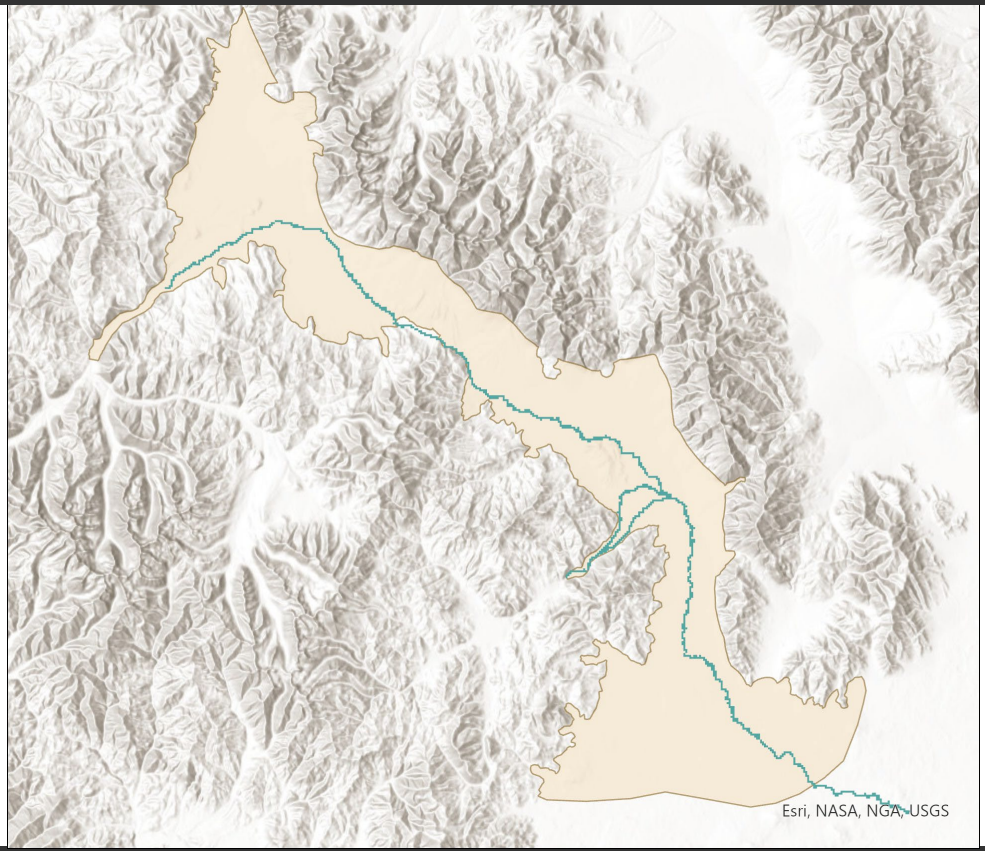
Head-dependent flux

Stream flow routing (SFR) package

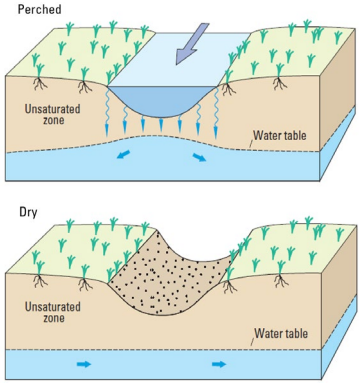
- Stream flow is calculated at each cell
- Stage is calculated from flow
- Seepage loss and gains are calculated at each cell

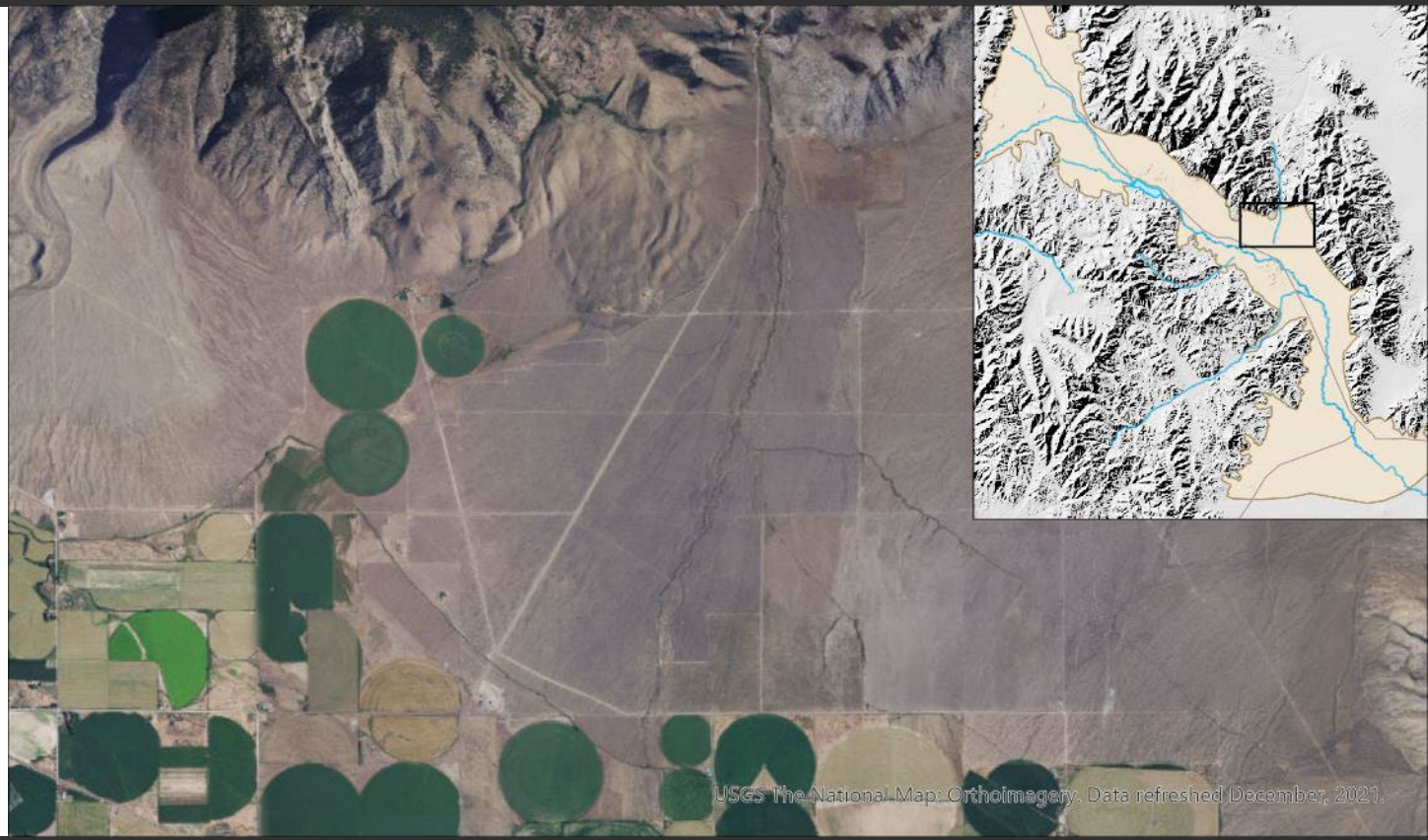
Stream flow is specified at:

- Howell
- Mackay dam
- Antelope gage



Small streams over alluvial fans





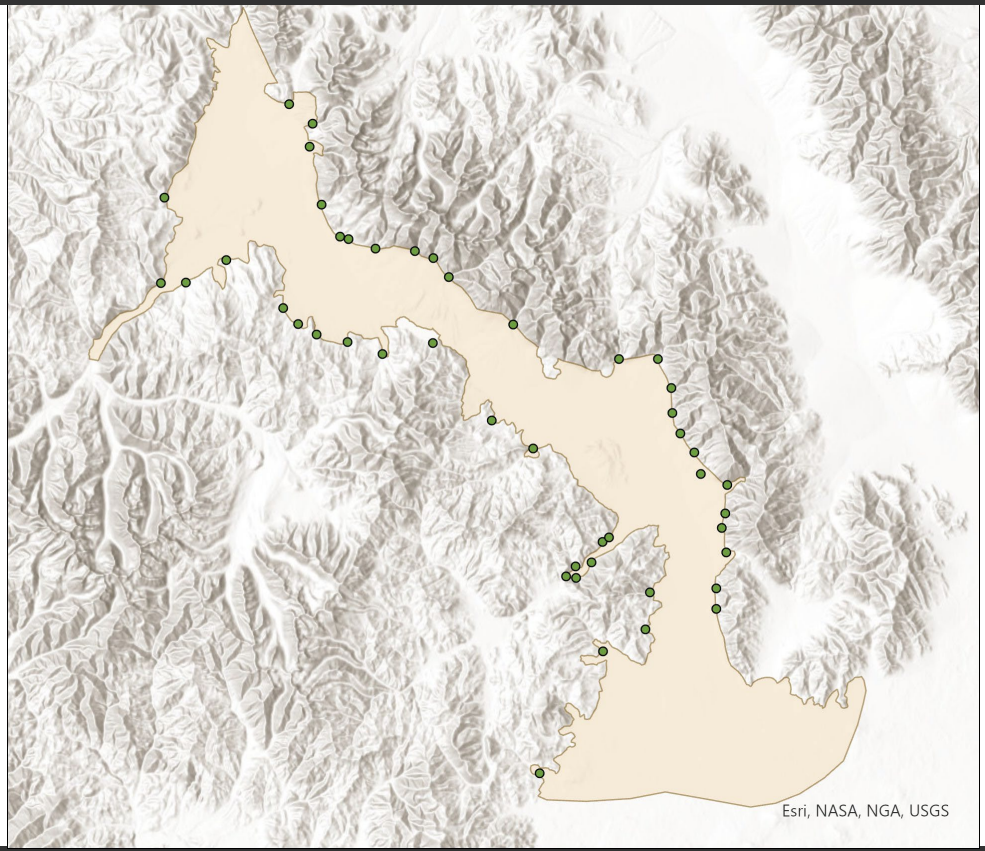
Small streams over alluvial fans

Specified recharge

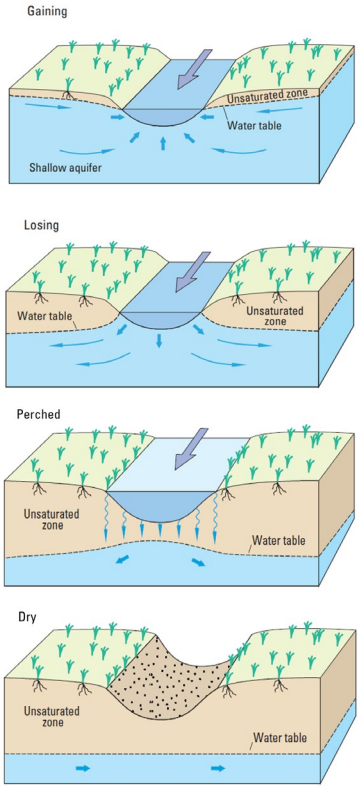
Recharge where stream intersects basin boundary

No recharge elsewhere

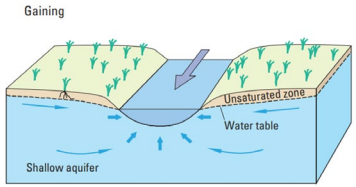
Only indirectly contributes to Big Lost River or irrigation water supply



Other small streams



Springs

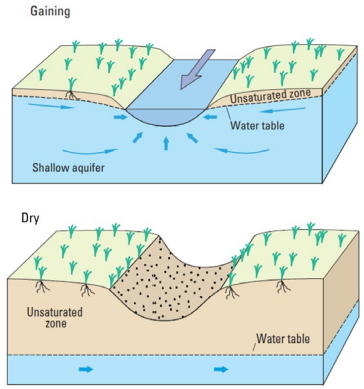


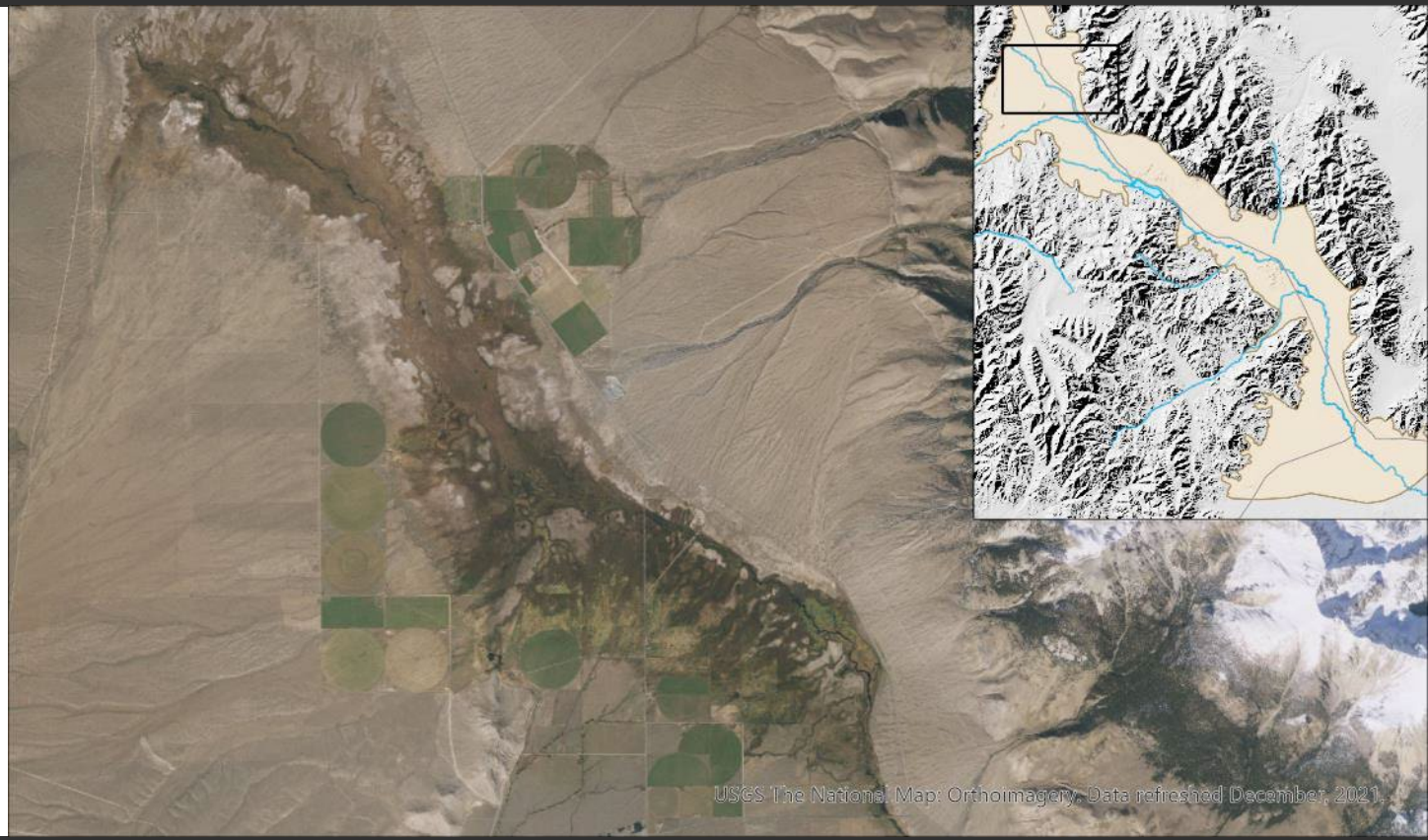
Not directly "in" model

Three options:

1. Added as supply for irrigation calculator
2. Lumped in with tributary recharge
3. Ignored (not known or understood enough to be in model)

Wetlands


Gaining
Unsaturated zone
Water table
Shallow aquifer
Dry
Unsaturated zone
Water table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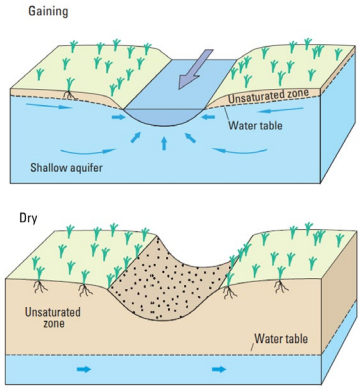
Wetlands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Unsaturated zone
Water table
Shallow aquifer
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Water table


USGS The National Map: Orthoimagery. Data refreshed December, 2021.

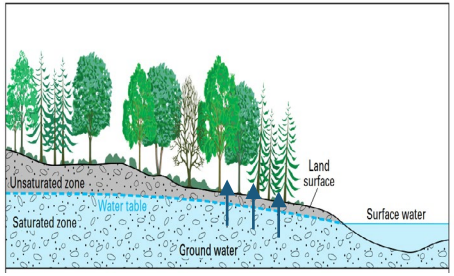
Wetlands

Thousand Springs and above Mackay

Head-dependent flux

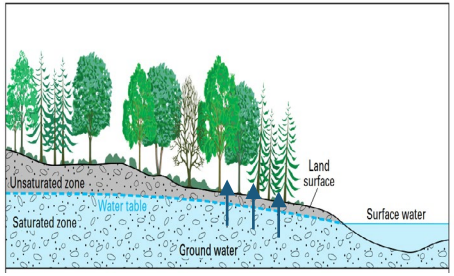
Drain (DRN) package
- Discharge from aquifer when water levels above ground surface
- No flow when water level below
- Flow contributes to Big Lost or Mackay calculations

Riparian


Unsaturated zone
Water table
Saturated zone
Land surface
Surface water
Ground water


USGS The National Map: Orthoimagery. Data refreshed December, 2021.

Riparian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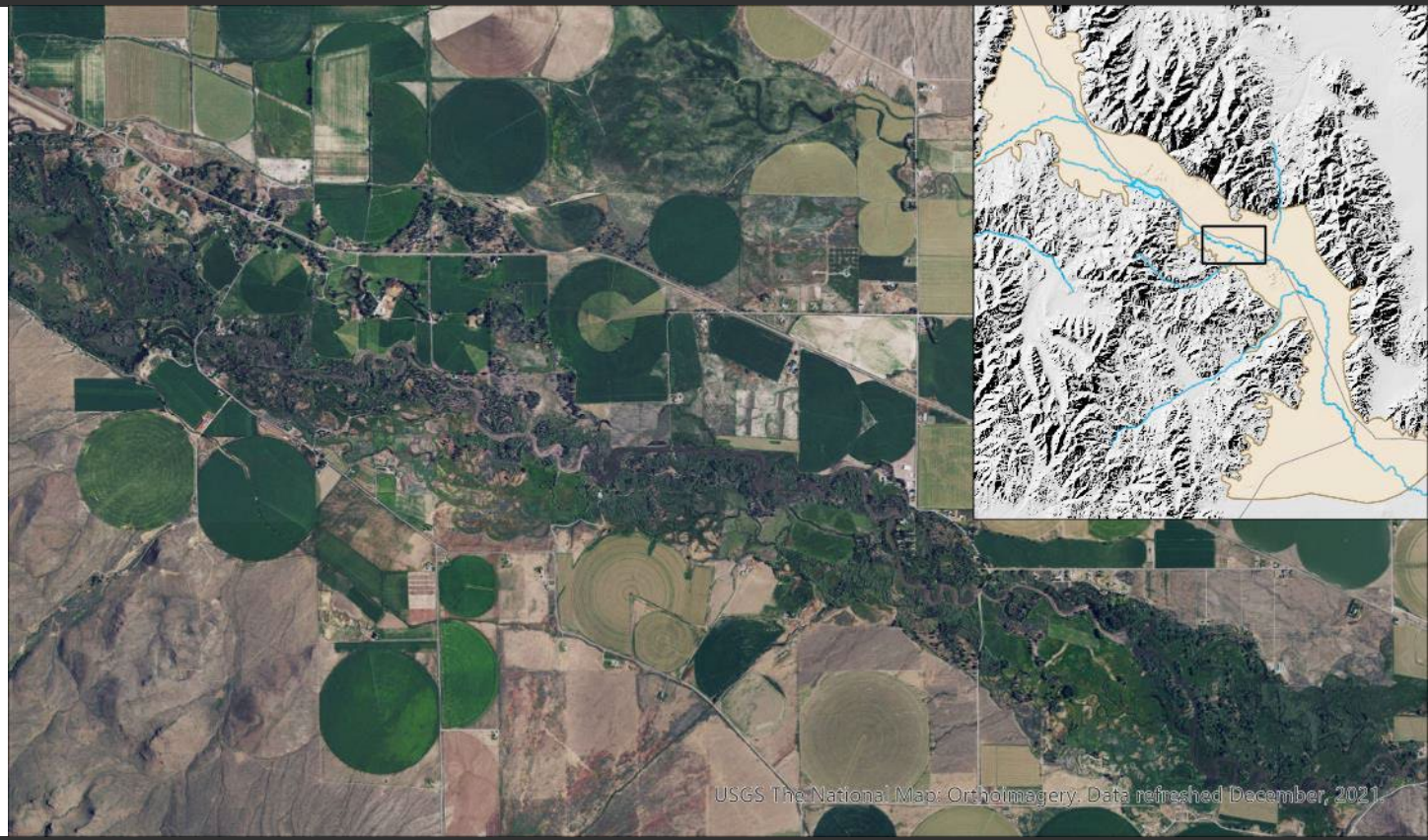
Land surface
Surface water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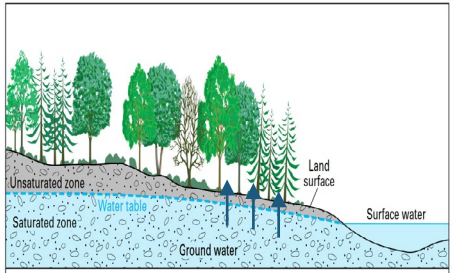
Riparian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USGS The National Map: Orthoimagery. Data refreshed December, 2021

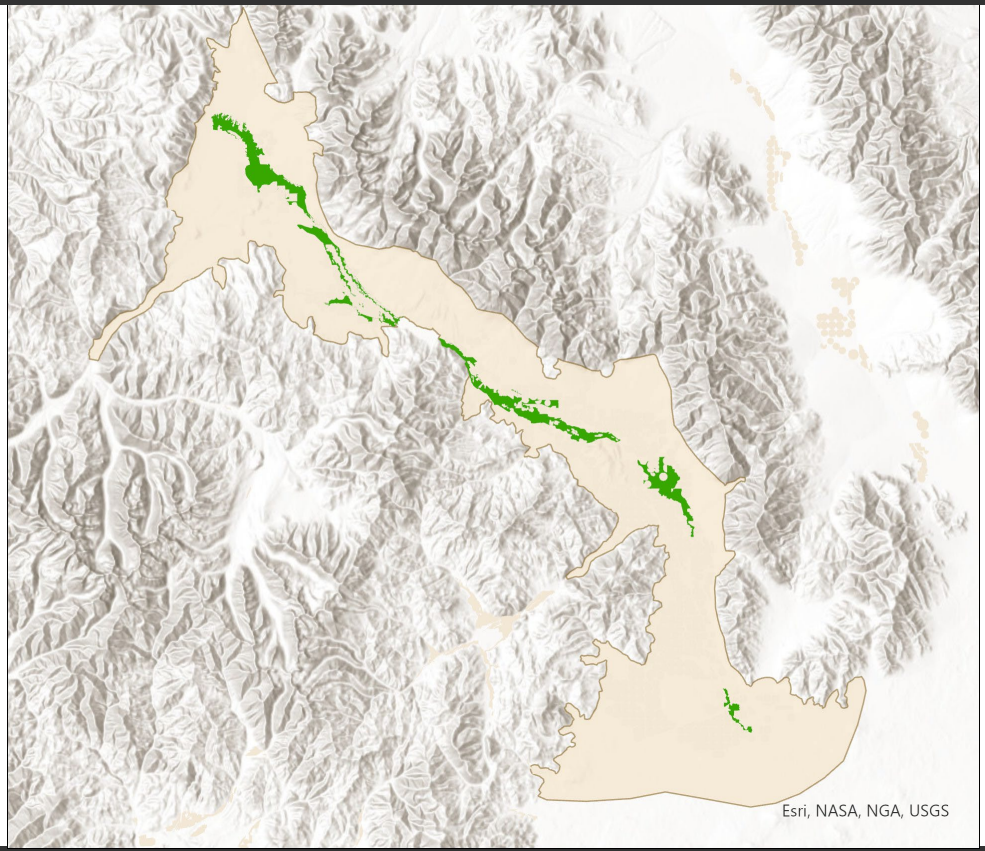
Riparian

Several places near Big Lost River
- Never present where land is classified as agricultural

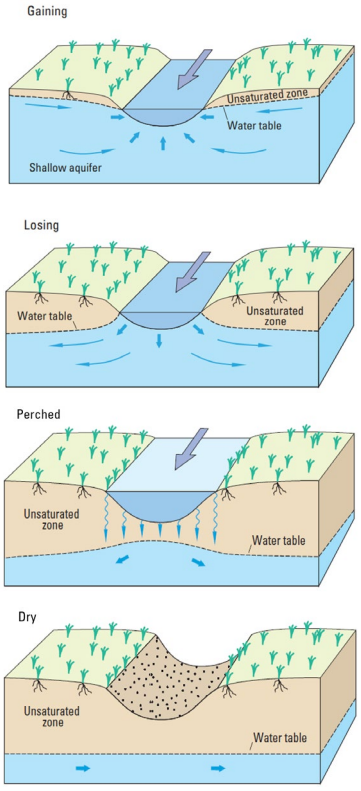
Specified flux

Well (WEL) package
- A 'well' in each cell of the riparian areas
- Discharge (flux) is equal to the monthly ET

Sometimes coincident with drains / wetlands



Mackay reservoir



Mackay reservoir

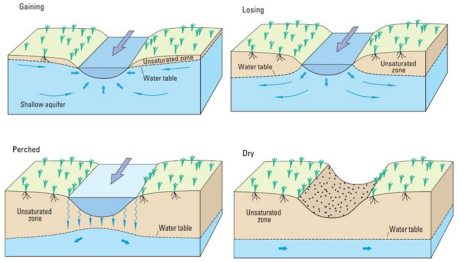
Stage calculated from water budget
- Inflows from Big Lost
- Inflows from wetland area
- Outflow from releases
- Evaporation & precipitation
- Interaction with aquifer

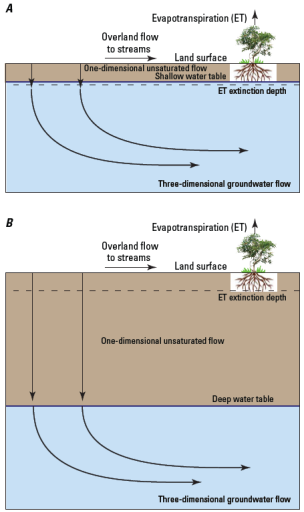
Head-dependent flux
- For aquifer interactions

Lake (LAK) package

Never coincident with wetlands / drains or riparian

Irrigation system





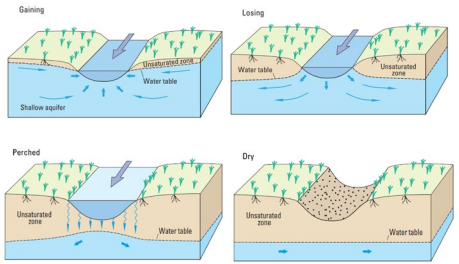
Irrigation system: diversion

Indirectly interacts with aquifer

Part of Big Lost River calculations
- Removes water from river

Part of irrigation 'service area' calculations
- Provides surface water to meet farm ET

Irrigation system: canals



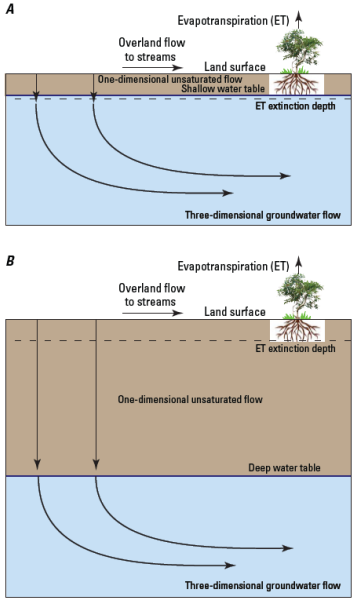
Irrigation system: canals

Estimated as percent of irrigation deliveries
- Diversions into canals
- Well pumping into canals (estimated)

Specified flux

Well (WEL) package
- Located along canals
- "Loss" rates are estimated and will be adjusted

Irrigation system: deliveries

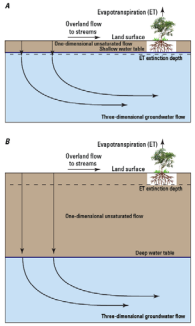


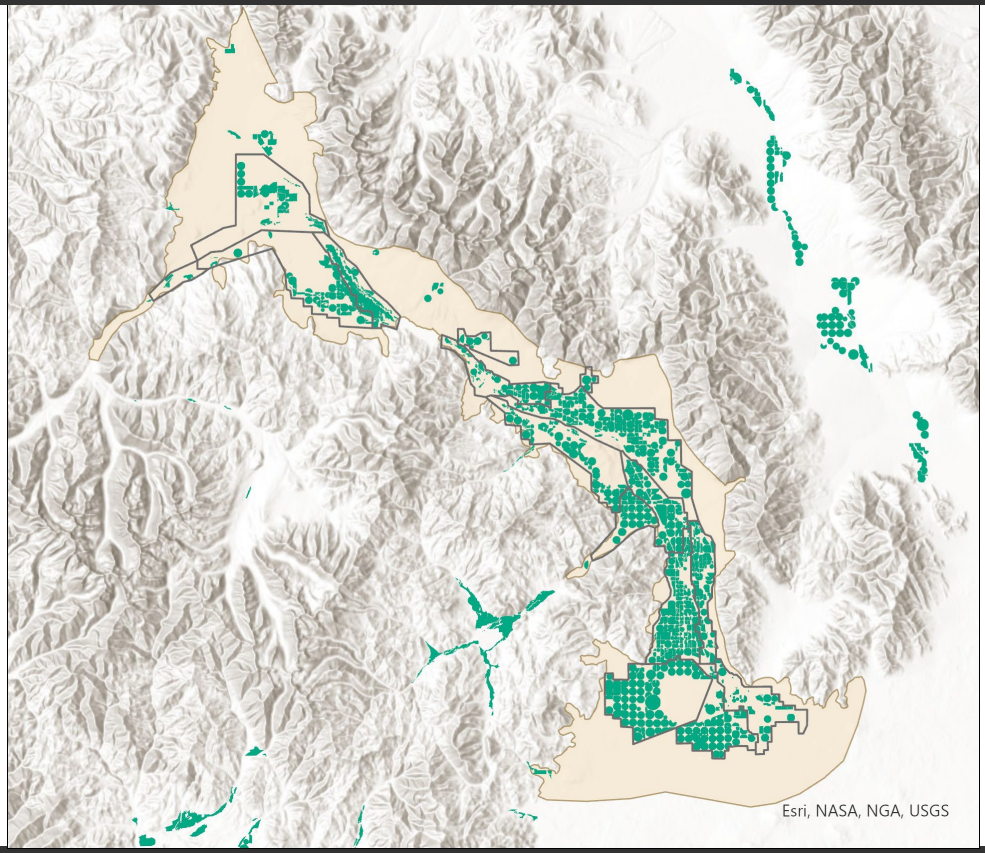
Irrigation system: deliveries

Recharge from irrigation "inefficiency"
- Crop ET x factor
- Delivered across service area

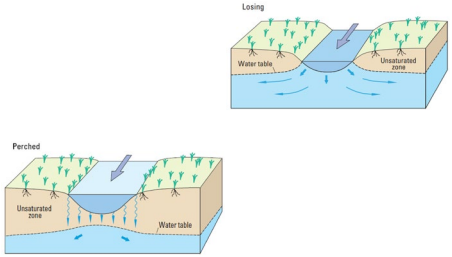
Specified flux

Well (WEL) package





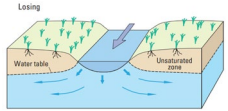
Intentional recharge

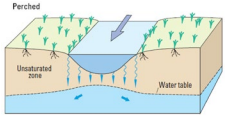


Not directly in model
- We have dates, names, and volumes, but no location information
- Indirectly applied because diverted water is applied to service areas

Spread broadly to service areas

Small storage ponds





Not directly in model
- Indirectly applied because diverted water is applied to service areas

Spread broadly to service areas

Summary

Features	Type of boundary	Package
Big Lost & Antelope	Head-dependent flux (+ surface flow calculation)	SFR
Streams on alluvial fans	Specified flux	WEL
Other small streams	-	-
Springs	None: indirect	-
Wetlands	Head-dependent flux	DRN
Riparian ET	Specified flux	WEL
Mackay Reservoir	Head-dependent flux (+ volume calculation)	LAK
Irrigation: Diversions	*Part of Big Lost & Antelope*	(SFR)
Irrigation: Canals	Specified flux	WEL
Irrigation: Deliveries / inefficiency	Specified flux	WEL
Intentional recharge	None: indirect	-
Small ponds	-	-

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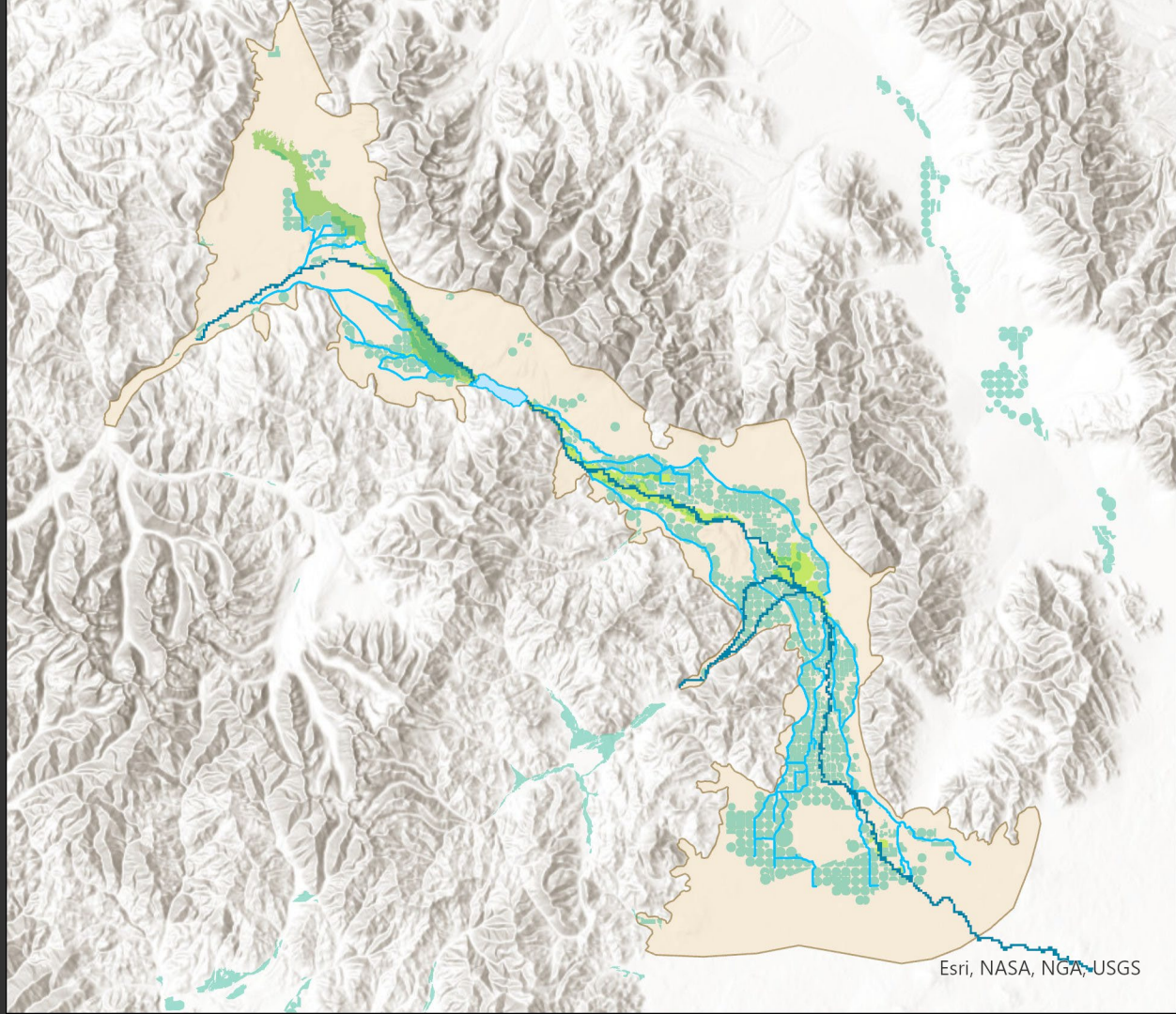
Summary



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Thanks!

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