An Analytical Model of Surface Water/Groundwater Interactions in a Western Watershed Experiencing Changes to Water and Land Use
Upper Teton Watershed, Idaho

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Introduction

- Changes in irrigation practices lead to changes in hydrology
  - Earthen canals being lined, placed into pipes, or abandoned
- These impact human water use and ecological processes
- Important to conjunctively manage limited water supply
  - Both surface flow and groundwater levels
Introduction

- Conversion from flood to sprinkler irrigation and/or replacement/abandonment of earthen canals can lead to decreased groundwater recharge
- Future changes could affect recharge
Map of Upper Teton Valley Watershed

Active Gaging Stations
Inactive Gaging Stations
SNOTEL Stations

10 miles
Study Area: Irrigation History

- Late 1800s: European settlement and agriculture
  - Earthen conveyance systems developed on the alluvial fans
    - Alluvium is highly permeable, canals lose water to the aquifer on these fans
- Pre-1960s, water was applied by flooding fields
- 1970s-1990s: A conversion to sprinkler systems
Study Area: Diagram

Teton River

Springs

Tributary

Groundwater

Crop

ET

Total Supply

Teton Range

Canal

ET
Objectives

- Investigate effect of changing water management on hydrology
- Develop model to estimate total water budget for tributaries and irrigation systems under:
  - Natural system
  - Flood irrigation
  - Actual 1979-2008 conditions
  - 90% sprinkler irrigation
  - Place system in pipes
Methods: Seepage Models

- Channel loss rates: canals versus streams
- Designated reaches with no surface in/outflow
- Measured discharge at top and bottom of reach
- Wetted area: maps, satellite imagery, field work
- Loss rate is difference in discharge divided by wetted area
- 3.66 ft/day for canals; 3.34 ft/day for streams
Methods: Seepage Models

• Stream channel loss modeled by

\[
\frac{dQ}{dx} = -rw(x) = -r\alpha Q(x)^\beta
\]

\(Q(x)\) is the discharge, \([L^3/T]\), at location \(x\) downstream from the top

\(r\) is the measured loss rate \([L/T]\)

\(w(x)\) is the wetted width

\(\alpha\) and \(\beta\) are empirically determined

• Solve analytically for \(Q(x)\)
Methods: Seepage Models

- Total loss = evaporative loss + vegetation ET + groundwater recharge
- Evaporation loss = evaporation rate \times \text{wetted area}
- ET loss = ET rate \times \text{riparian area}
- Groundwater recharge = Total loss – Evaporation loss – ET loss
Methods: Seepage Models

- Canal seepage calculated similar to stream channel seepage
- Historic canal system:
  - 90 miles of canal
  - 105 acres of surface area
- Current canal system:
  - 80 miles of canal
  - 89 acres of surface area
- Note: 90 acres × 3.66 ft/day = 329 acre-ft/day
- ET rates didn’t vary much across crop type
Results
Results

- Mean annual water budget:
  - Surface flow: 46% supply under flood irrigation (lowest)
  - Surface flow: 73% under natural scenario (highest)
  - Diversion: 62,100 acre-feet under pipeline (lowest)
  - Diversion: 87,000 acre-feet under flood (highest)
  - Application seepage very low
  - Channel and vegetation ET less than 1%
  - Irrigation efficiencies: 45% to 48% for 3 irrigation scenarios, 100% pipeline scenario
Results: Surface Flow

- Trail Creek and Teton Creek: mean number of days surface flow continuous across losing reach
Results: Groundwater Recharge
Results: Groundwater Recharge

- Total groundwater recharge, under all scenarios, was an increasing function of water supply.
Results: Groundwater Recharge

- The variation across scenarios was an increasing function of water supply.
Conclusions

- Irrigation practices have lead to an increase in groundwater recharge
- Placing canals in pipes could
  - Leave more water in the tributaries
  - Increase water delivered to crops
  - Greatly decrease groundwater recharge
- Whether changes are good or bad depends on the resources being considered
  - Native aquatic species versus downstream irrigators
Thank You!!!

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