Hydrologic and water quality modeling for the Boise River Watershed

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Treasure Valley Modeling Technical Advisory Committee (MTAC)
IDWR, Boise, Idaho
Boise Metropolitan Population
(Boise, Nampa, Meridian, Caldwell)

1990: 14%
1990: 300,000
2000: 45%
2000: 500,000
2010: 33%
2010: 600,000

A LEGACY OF LEADING
Boise Watershed

Drainage: 11,000km²
Main stem: 164km

Major Cities:
- Caldwell
- Meridian
- Nampa
- Boise

Streamflow gage stations
Reservoirs

Boise

Lower Boise Watershed

Upper Boise Watershed

Idaho

Montana
Boise Watershed

Land use changes

<table>
<thead>
<tr>
<th>Land use</th>
<th>Land use (km$^2$)</th>
<th>Land use change (km$^2$)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban area</td>
<td>215</td>
<td>547</td>
<td>332</td>
</tr>
<tr>
<td>Barren/Mining</td>
<td>391</td>
<td>22</td>
<td>-368</td>
</tr>
<tr>
<td>Forest</td>
<td>3055</td>
<td>3009</td>
<td>-48</td>
</tr>
<tr>
<td>Upland or Shrub land</td>
<td>3121</td>
<td>3032</td>
<td>-88</td>
</tr>
<tr>
<td>Grass land</td>
<td>2041</td>
<td>2423</td>
<td>381</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1492</td>
<td>1293</td>
<td>-198</td>
</tr>
<tr>
<td>Water/Wetlands</td>
<td>121</td>
<td>110</td>
<td>-11</td>
</tr>
</tbody>
</table>

1992 Land use

2006 Land use

2018 Land use

Land use change from 1992 to 2006
Research Questions

- How much does urbanization affect local hydrology?
- How hydrological models can characterize urbanization effects in rainfall-runoff simulations?
- Land use change did contribute to water pollution in the river downstream?
- Low Impact Development with BMP can help non-point source (NPS) control in waterways?
- How to evaluate alternatives if LID/BMPs applicable for NPS control in the study area?
HSPF

• Hydrological Simulation Program-Fortran (HSPF)-Stanford Watershed Model (Crawford and Linsley 1966)
• Lumped model-homogeneous land segments in each delineated sub-basins
• Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) – EPA 1996
• GIS capability- Semi-distributed model (hspf)
Data Input

- Gridded Weather Data: 4km by 4km spatial resolution (NLDAS: North American Land Data Assimilation System)
- Daily time steps
- Data Periods: January 1979 – December 2013 (25 years)
- Data used: Precipitation, Minimum Temp, Maximum Temp, Mean Temp, Wind Speed, Humidity for Penmann-Monteith ET
Watershed Delineation

Gridded Weather Data Locations

- Gridded Weather Data: 4km by 4km spatial resolution
- Daily time steps
- Data Periods: 1979 – 2013 (25 years)
- Data used: Precipitation, Minimum Temp, Maximum Temp, Mean Temp, Wind Speed, Humidity

About 70 subbasins

Weather Data Used for Sub basins in HSPF
Hydrological Simulations

Lower Boise Watershed

BOISE RIVER NR PARMA (Site NO. 13212995)

Anderson Reservoir (Site No. 13190500)

Lucky peak dam (Site No. 13202000)

Mores Creek AB Robie Creek NR Arrowrock Dam (Site No. 13200000)

Boise River NR Twin Springs (Site No. 13185000)

SF Boise River NR Featherville (Site No. 13186000)

Upper Boise Watershed

A Legacy of Leading
Hydrological Simulations (Above Reservoir)

Station 1: Mores Creek near Arrow Rock Dam, USGS#: 13200000

- $R = 0.89$
- $NS = 0.79$
- $RMSE = 140.07$
- $MPE(\%) = 6.75$
Hydrological Simulations
(Above Reservoir)

- Station 2: South Fork Boise River near Feathervilee, Above Anderson Ranch Dam, USGS#: 13186000

\[ R = 0.88 \]
\[ NS = 0.75 \]
\[ RMSE = 661.03 \]
\[ MPE(\%) = 6.29 \]
Hydrological Simulations
(Above Reservoir)

Station 3: Boise River near Twin Springs above Arrow Rock Dam, USGS#: 13185000

R = 0.88
NS = 0.77
RMSE = 450.17
MPE(%): 7.1

-- After calibration --

OBS
Hydrological Simulations (Below Reservoir)

- Station 5: Right below Lucky Peak Reservoir, USGS# 13202000

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<th>Date</th>
<th>OBS</th>
<th>After Calibration</th>
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<tr>
<td>1/1/2013</td>
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</tbody>
</table>

R = 0.77
NS = 0.54
RMSE = 1458.72
MPE(%) = -89.52
Hydrological Simulations (Below Reservoir)

- Station 6: Boise River near Nampa, Mouth of Watershed, USGS#: 13212955

![Streamflow graph]

- After calibration - OBS

- $R = 0.70$
- $NS = 0.48$
- $RMSE = 904.34$
- $MPE(\%) = -17.16$
Water Quantity and Quality (WQQQ) Assessment Induced by Urbanization
Hydrological Responses to Land Use Change

Average annual streamflow (cfs) vs. Years (1980-2012)

- 1992 landuse
- 2006 landuse
- Increasing (%)

Streamflow

- 22% increase from 1992 to 2006
Hydrological Responses to Land Use Change

- 16% in 1992 land use
- 23% in 2006 land use
- 34% in rainfall

Average monthly streamflow (cfs)

Month: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

Streamflow

Average monthly rainfall (inch)

University of Idaho
A Legacy of Leading
Environmental Responses to Land Use Change

- Annual mean BOD (kg/day)
- Year range: 1980 to 2012
- Comparison between 1992 land use and 2006 land use
- Graph shows the increasing trend (23%) from 1992 to 2006
Environmental Responses to Land Use Change

Monthly mean BOD (Kg/day)

- 1992 landuse
- 2006 landuse
- Increasing(%)
Hydrological and Environmental Responses to Land Use Change

![Graph showing annual mean BOD (kg/day)]

- **1992 landuse**
- **2006 landuse**
- **Increasing(%)**

- Year range: 1980 to 2012
- Annual mean BOD (kg/day)
- Increasing percentage: 24%
Hydrological and Environmental Responses to Land Use Change

![Graph showing mean monthly TP (kg/day) for different months, with comparisons between 1992 and 2006 land use, and increasing percentages. The graph includes a legend that differentiates between 1992 land use (blue), 2006 land use (black), and increasing percentages (red).]
Environmental Responses to Land Use Change

![Graph showing environmental responses to land use change from 1980 to 2012. The graph compares the mean annual T-N (kg/day) for different years, with blue bars representing the 1992 land use, black bars representing the 2006 land use, and red dots indicating increasing percentages. The graph shows a legacy of leading with a focus on environmental responses.](image-url)
Environmental Responses to Land Use Change

- **1992 LANDUSE**
- **2006 LANDUSE**
- **INCREAING (%)**

### Mean monthly TN (kg/day)

- **Month:** 1 through 12
- **Mean monthly TN:**
  - January: 9000 kg/day
  - February: 9000 kg/day
  - March: 9000 kg/day
  - April: 9000 kg/day
  - May: 9000 kg/day
  - June: 9000 kg/day
  - July: 9000 kg/day
  - August: 9000 kg/day
  - September: 9000 kg/day
  - October: 9000 kg/day
  - November: 9000 kg/day
  - December: 9000 kg/day

### Increasing (%)

- **January:** 0%
- **February:** 0%
- **March:** 0%
- **April:** 0%
- **May:** 0%
- **June:** 0%
- **July:** 0%
- **August:** 0%
- **September:** 0%
- **October:** 0%
- **November:** 0%
- **December:** 0%
Hydrological and Environmental Responses to Land Use Change

![Graph showing mean annual sediment (kg/day) over years from 1980 to 2012 with 1992, 2006 land use, and increasing (%) categories. The graph indicates a decline in sediment with a horizontal line at 30% increase.]
Hydrological and Environmental Responses to Land Use Change

[Graph showing sediment distribution over months from 1992 to 2006 with increasing percentage changes marked.]

Sediment
Low Impact Development (LID) Techniques in Boise

Bioretention

Design Guidelines for Porous Asphalt with Subsurface Infiltration

Permeable pavement

干透

Drywell

Buffer strip
Best Management Practice (BMP) in Agriculture

Vegetative Filter Strip I

Vegetative Filter Strip II

Buffer strips of grass, trees, and other perennial plants planted along stream banks can catch chemicals and contaminated water before they run off a farmer's field.

Most farmers apply substantial nitrogen and other chemical fertilizers when growing crops such as corn and soybeans. Heavy rain can wash those chemicals off a field and into nearby streams and drainage ditches.

Grassy buffer strips can provide a physical barrier to stop and soak up runoff water.

Plants absorb nitrogen through their roots, cleansing water underground before it seeps into creeks and streams.

Phosphorus binds to soil. Muddy water can carry it straight to stream beds that seep into creeks and streams.

Source: USDA-ARS-National Laboratory for Nature and the Environment, Iowa State University

MARK BOSWELL - Star Tribune
WQ Monitoring and Data Collection

1. Water quality monitoring before and after implementation of ag (or other) BMPs

   Methodology Real-time ground sensing/Remote sensing using Unmanned Aerial System (UAS, a.k.a. drone)
UAS Applications for Water Resources
Sampling Activities

https://www.youtube.com/watch?v=DRjiYuQSUlU
SPRING 2018
iDRONE

Moscow, Boise, Pocatello
3 days each of flying drones, understanding regulations, and exploring our surrounding through the eyes of drones
for middle and high school students who want to see what drones can do for fun and for research

University of Idaho

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208-885-5819
I didn’t like STEM before this.

¡iDrone STEM is awesome!
It was very hands on and taught me about how to fly drones safely.
Messages

1. WQQ Modeling associated with urbanization
2. Real-time WQQQ monitoring and data collection using ground and remote-sensing (e.g., UAS) before and after BMP installation
3. Data clearing house (water data, GIS, and other data portal)
Questions?

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