

# Physical, chemical, and biological characteristics of streams in urbanizing areas near Denver, Colorado

Lori Sprague  
Hydrologist

Robert Zuellig  
Ecologist

U.S. Geological Survey  
Denver, CO

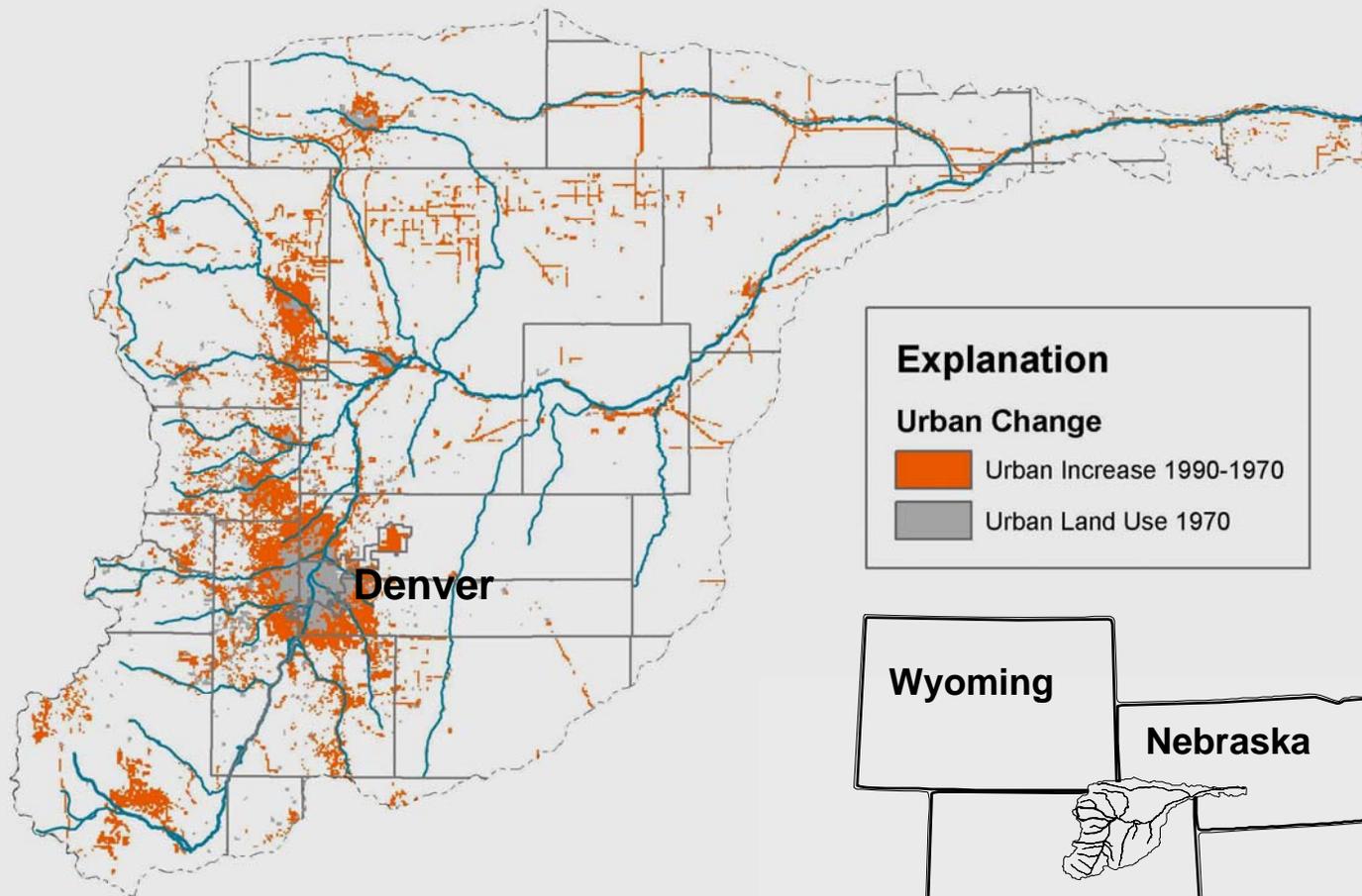
May 2006

# Study Objectives

- Determine the effects of urbanization on hydrologic, geomorphic, chemical, habitat, and biological conditions
- Determine the most important urban stressors related to the responses
- Compare these responses over a range of environmental settings throughout the Nation



Population in the South Platte River Basin increased by about 670,000 people from 1990 through 2000, to over 2.8 million



**Explanation**

**Urban Change**

-  Urban Increase 1990-1970
-  Urban Land Use 1970

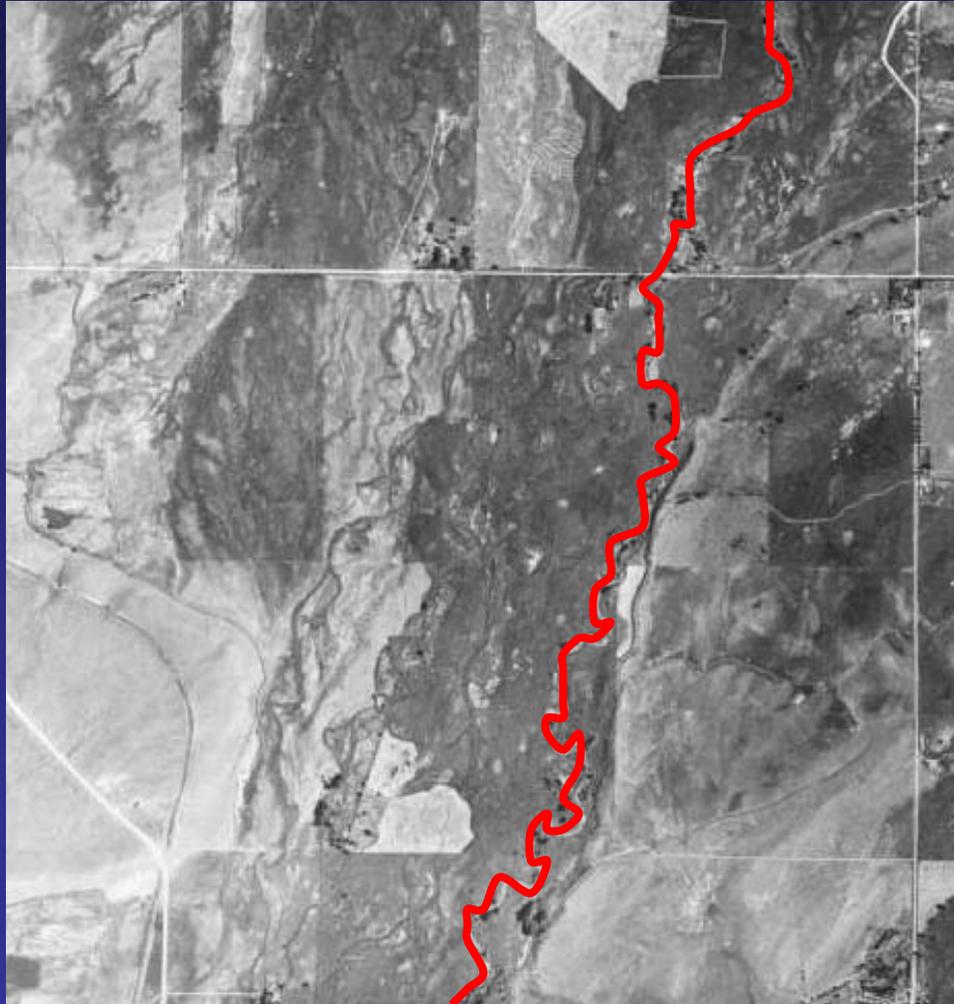
Wyoming

Nebraska

Colorado

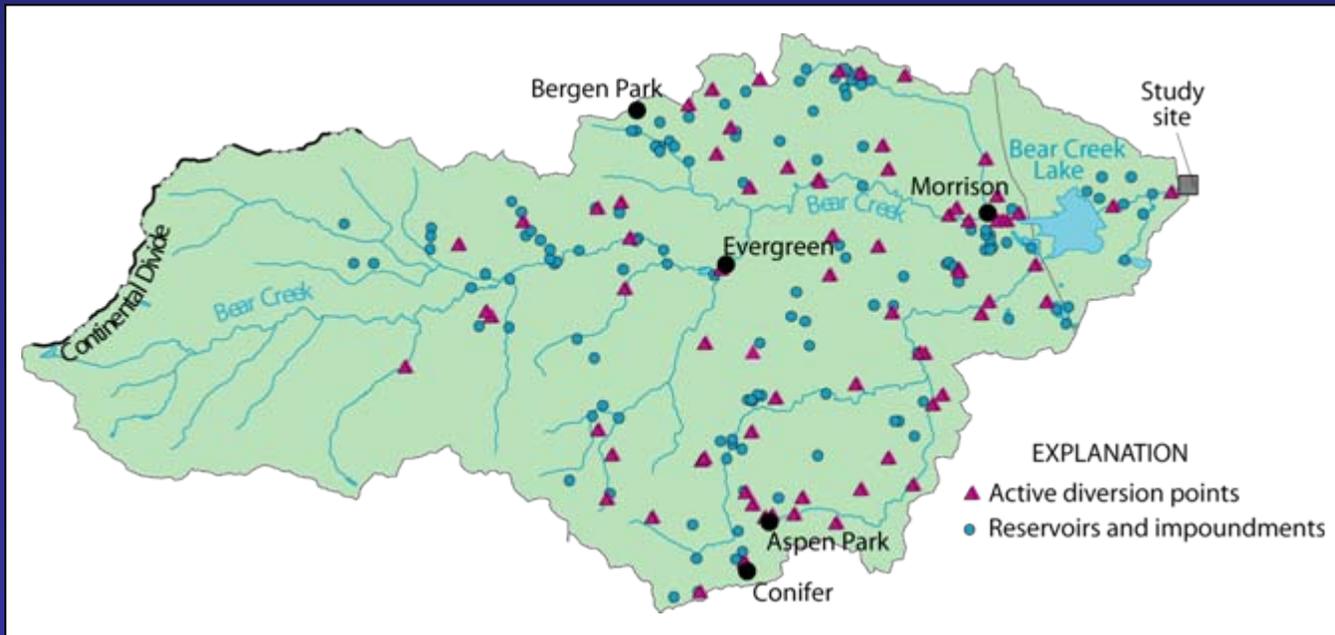
# South Boulder Creek 1937

# South Boulder Creek 1987



Photos courtesy of USFS  
<http://bcn.boulder.co.us/basin/gallery/sboulder50yrs.html>

# Water management



# Site Selection

- Environmental characteristics – homogeneous environmental framework controlled for “natural” sources of variability
- Urban intensity – sites represented a gradient of urbanization (urban intensity index)





# Stream with high-level urban intensity

Urban Intensity Index = 100



# Stream with mid-level urban intensity

Urban Intensity Index = 40



# Stream with low-level urban intensity

## Urban Intensity Index = 3

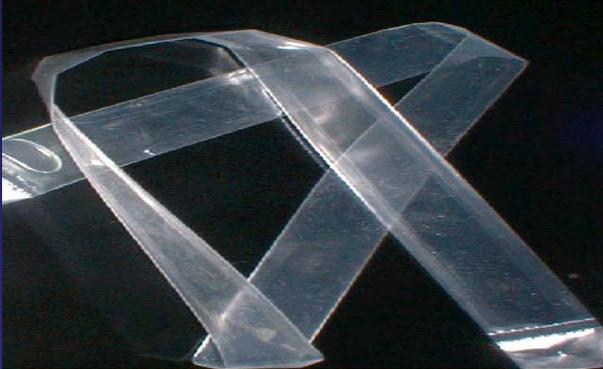


# Study Design

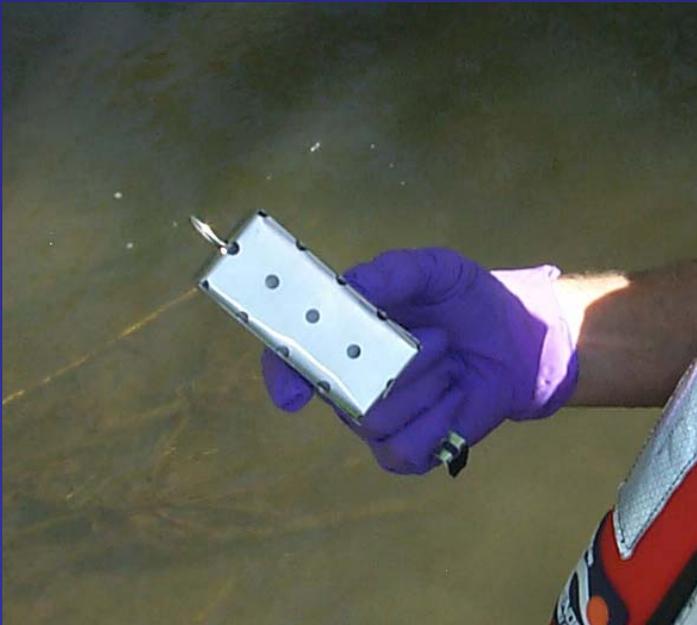


- **Chemical characteristics**  
nutrients, pesticides, sediment, chloride, sulfate, bacteria (spring and summer base flow)
- **Physical characteristics**  
habitat (summer low flow), streamflow, water temperature (continuous for 1 year)
- **Biological characteristics**  
algae, invertebrates, fish (summer low flow)

# Time and flow integrated chemical parameters



- Semi-permeable membrane devices (SPMDs)
- Placed at all 28 sites for 4 weeks
- Sequesters hydrophobic organics
- Mimics bioaccumulation in fish



# Conceptual model



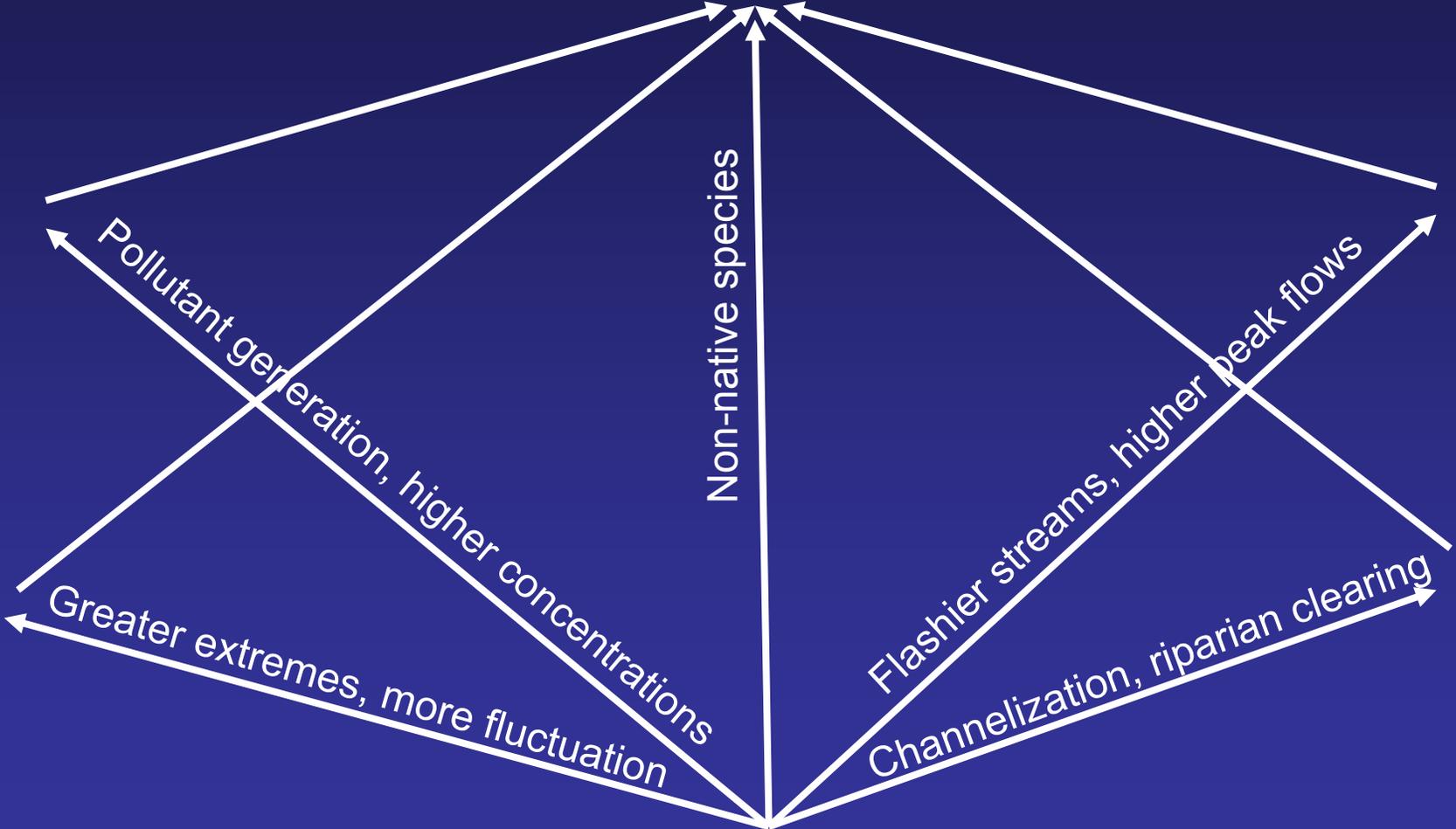
Chemistry

Temperature

Hydrology

Habitat

Urbanization



Fish

Algae

Invertebrates

Chemistry

Sediment Sulfate

Base-flow chemistry

- Suspended sediment related to housing age
- Sulfate related to population density

Hydrology

Temperature

Housing age

Habitat

Population density

Urbanization

Fish

Algae

Invertebrates

Chemistry

Hydrology

Habitat

PAHs

SPMD chemistry

- PAHs related to stream flashiness and many measures of urbanization
- Variability in PAHs best explained by distance from stream to nearest road

Flashiness

Temperature

- Land cover
- Road density
- Housing age
- Housing density
- Population density
- Urban intensity index

Urbanization

**Fish**

**Algae**

**Invertebrates**

**Chemistry**

**Sediment Sulfate**

**PAHs**

Urbanization explained variability of SPMD chemistry well, but not variability of spring and summer base-flow chemistry

**Flashiness**

**Hydrology**

**Temperature**

- Land cover
- Road density
- Housing age
- Housing density
- Population density
- Urban intensity index

**Habitat**

**Urbanization**

Fish

Algae

Invertebrates

Chemistry

Hydrology  
No strong relations between hydrology and urbanization

Hydrology

Temperature

Habitat  
No strong relations between habitat and urbanization

Habitat

Urbanization

Fish

Algae

Invertebrates

Chemistry

Water temperature  
Temperatures related to high-intensity development near the stream

Hydrology

Temperature

Duration of falling temperatures

Land cover

Habitat

Urbanization

**Fish**

**Algae**

**Invertebrates**

**Chemistry**

**Sediment**

**Chloride**

**Temperature**

Fish communities were related predominantly to housing age, fine suspended sediment, and chloride

**Hydrology**

**Habitat**

**Housing age**

**Urbanization**

Fish

Algae

Invertebrates

Chemistry

Conductivity  
Nutrients  
Pesticides

Duration of  
high flows  
Flashiness

Hydrology

Temperature

Algal biomass was related predominantly to conductivity, nutrients, pesticides, the duration of high flows, and stream flashiness

Habitat

Urbanization

Fish

Algae

Invertebrates

Chemistry

Nutrients  
Pesticides

Duration of  
high flows  
Flashiness

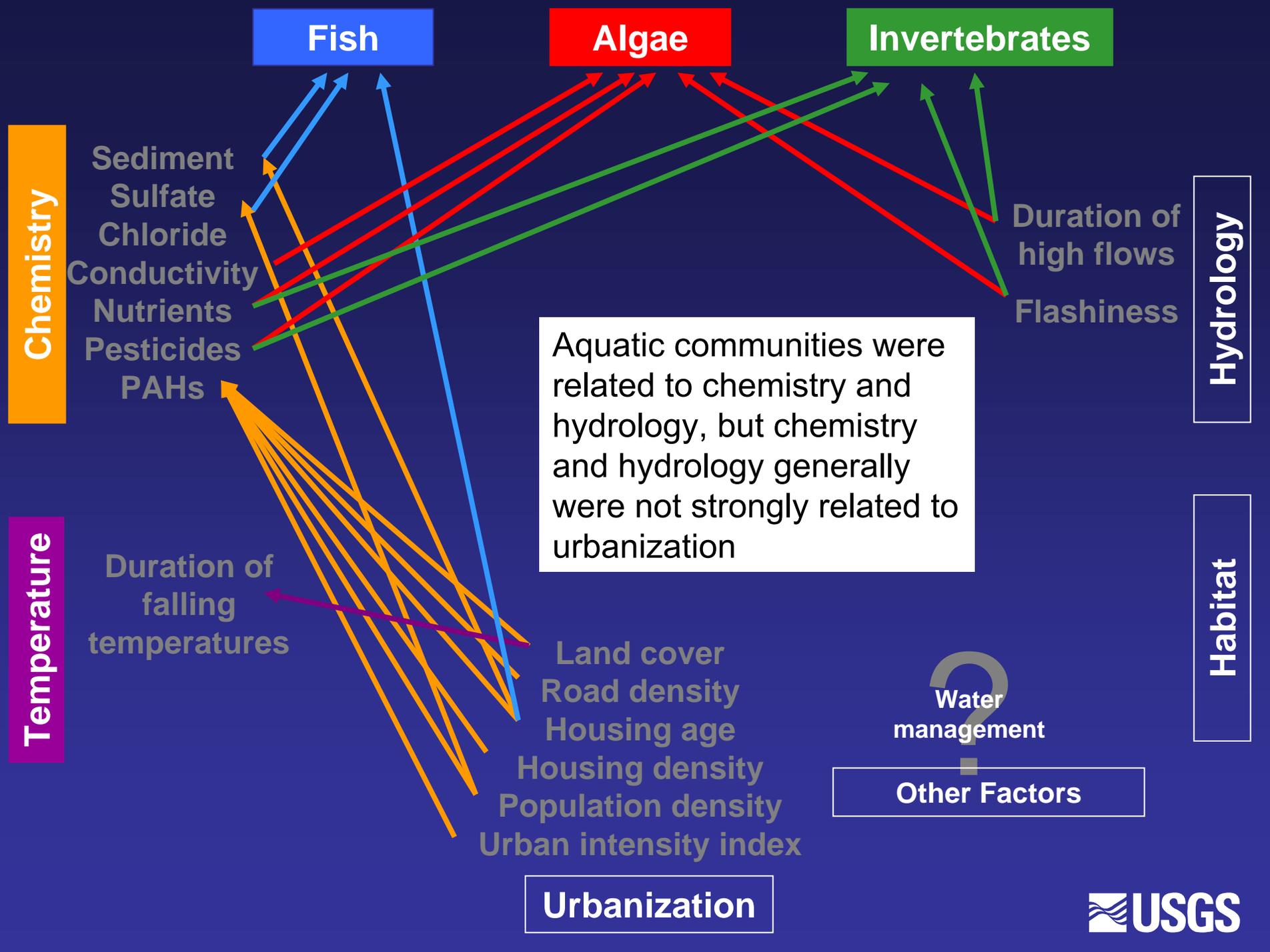
Hydrology

Temperature

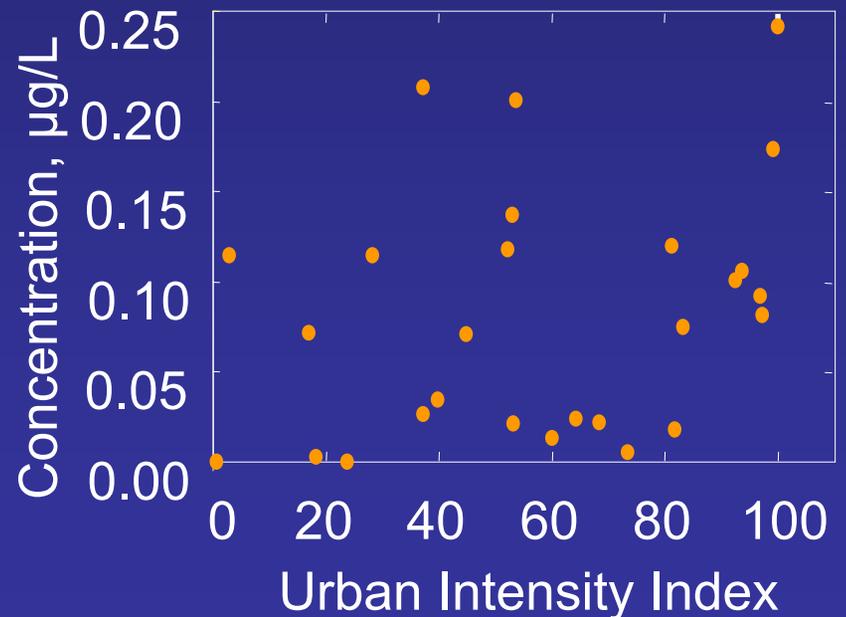
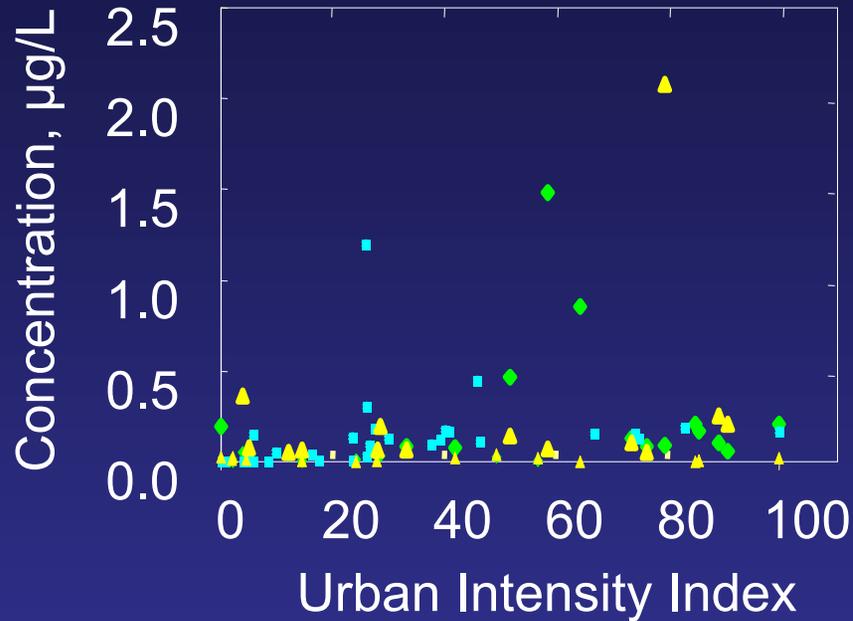
Invertebrate communities  
were related predominantly  
to nutrients, pesticides,  
duration of high flows, and  
stream flashiness

Habitat

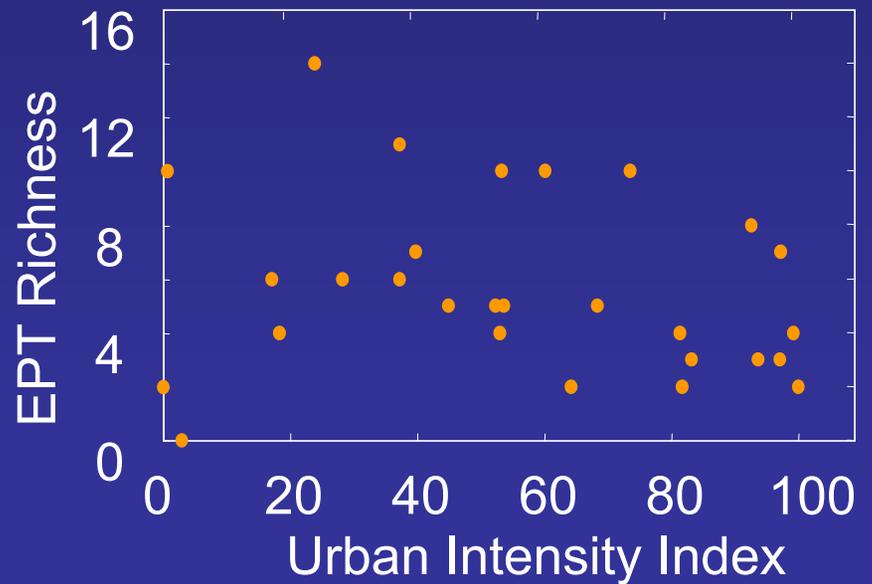
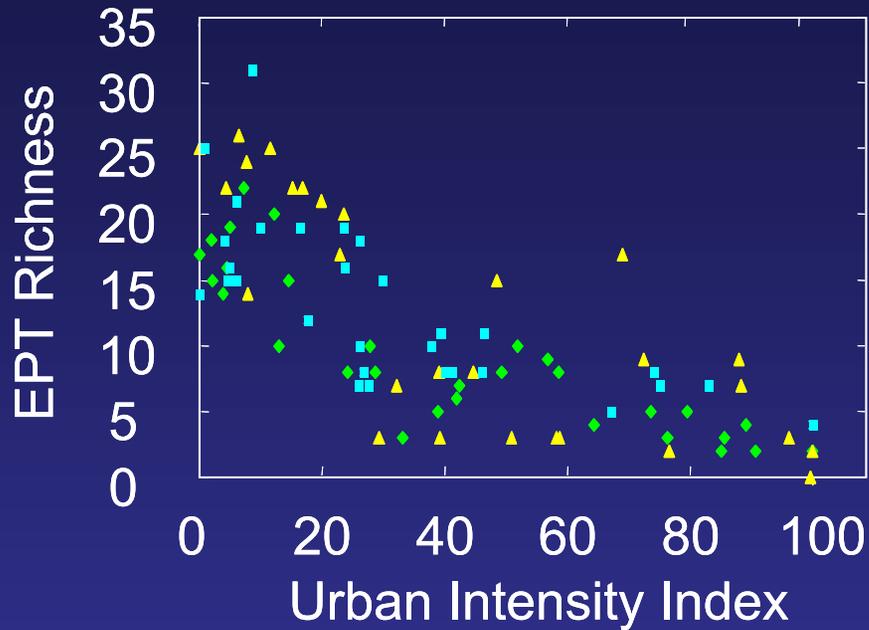
Urbanization



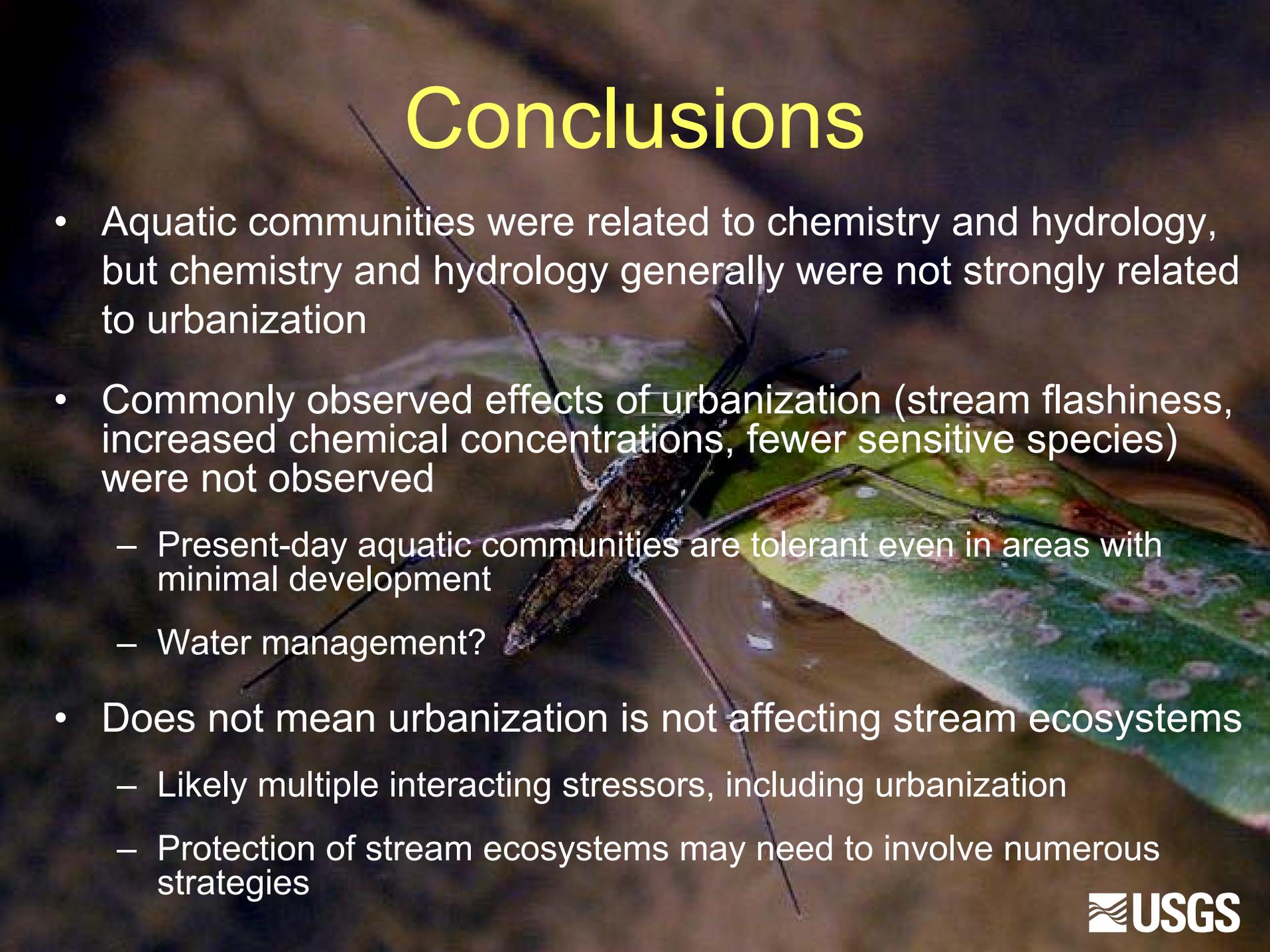
# Comparison – Total Pesticide Concentration



# Comparison – EPT Richness



# Conclusions



- Aquatic communities were related to chemistry and hydrology, but chemistry and hydrology generally were not strongly related to urbanization
- Commonly observed effects of urbanization (stream flashiness, increased chemical concentrations, fewer sensitive species) were not observed
  - Present-day aquatic communities are tolerant even in areas with minimal development
  - Water management?
- Does not mean urbanization is not affecting stream ecosystems
  - Likely multiple interacting stressors, including urbanization
  - Protection of stream ecosystems may need to involve numerous strategies

# CONTACT INFORMATION

Lori Sprague

[lsprague@usgs.gov](mailto:lsprague@usgs.gov)

303-236-4882 x262

Robert Zuellig

[rzeuellig@usgs.gov](mailto:rzeuellig@usgs.gov)

303-236-4882 x278

U.S. Geological Survey  
Colorado Water Science Center  
Denver Federal Center  
Building 53 MS 415  
Denver, CO 80225