Ground Water Protection Council
2017 Annual Forum
Boston, Massachusetts

Protecting Groundwater Sources from Flood Borne Contamination

Ben Binder
(303) 860-0600

Digital Design Group, Inc.
The Problem
Houston 2017

Flooded sewers are stoking fears of cholera, typhoid and other infectious diseases. Runoff from the city’s sprawling petroleum and chemicals complex contains any number of hazardous compounds. Lead, arsenic and other toxic and carcinogenic elements may be leaching from some two dozen Superfund sites in the Houston area.
September 2013 Flood
Boulder County, Colorado
Under a new statewide rule adopted in 2015, oil & gas operators in Colorado have stricter guidelines for operations in floodplains.
State of Tennessee

Guidance for What to do with a Water Well After a Flood

WARNING! DO NOT DRINK OR WASH WITH WELL WATER THAT MAY HAVE BEEN IMPACTED BY FLOOD WATER.
Goals

1. Keep sites with hazardous materials out of known flood zones;

2. Locate private and municipal wellheads outside of flood zones.
Determining the boundaries of Flood Zones

Floodplain Delineation
Types of Floods
Coastal (Surge Flood)
Produced when high winds from hurricanes and other storms push water onshore. Can be exacerbated by heavy rainfall and high tides.
Fluvial (Riverine Flood)

Occurs when excessive rainfall causes a river to exceed its capacity.

- Rapid high-velocity flash floods in steep mountainous drainage basins.
- Slowly rising flooding in more level terrain.
Pluvial
(Surface Flood)

• Caused when heavy rainfall creates a flood event independent of an overflowing water body.
• Urban drainage systems are overwhelmed. You don’t need to be near a body of water to be at risk.
• Houston’s recent floods were predominantly pluvial but there was some fluvial flooding as well.
Houston’s Flood
Flood waters invade the City with no Mercy
Let’s all pray that a disaster such as this never darkens our door again.
Classifying Flood Intensities

- **Flood Crest Height or Stage**
- **Peak Flow in Cubic Feet per Second**
- **Return Period (Recurrence Interval)**
  Each return period has its own flood zone
  
  - 10-Year = 10% chance of occurring each year
  - 50-Year = 2%
  - 100-Year = 1%
  - 500-Year = 0.2%

- **Probable Maximum Precipitation**

  > Probable Maximum Flood

  *The greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographical location.*
Figure 5: Flood hydrograph of 10, 25, 50- and 100 year return period for Wadi Rajil catchment area
Defining Flood Zones
Floodplain Map of Boulder, Colorado
Historic photos of past floods provide valuable information.
Dr. Gilbert F. White

*The father of floodplain management*

Helped establish the fields of natural hazards research and resource management.

• National Medal of Science - the nation's highest scientific honor;

• In his 1942 PhD thesis Dr. White wrote: "Floods are 'acts of God,' but flood losses are acts of man."

• Dr. White headed a task force that led to the establishment of the National Flood Insurance Program, which resulted in the national floodplain mapping program.
FEMA Flood Insurance Rate Maps (FIRMS)

FEMA floodplain maps were developed primarily for federal flood insurance purposes, but have been adopted by numerous communities throughout the U.S. as the basis for floodplain management.

FEMA floodplain maps are based on 100-year frequency of flooding and are intended as the minimum requirement for floodplain management.
FEMA GeoPlatform
Providing geospatial data and analytics in support of emergency management

- Hurricanes and Typhoons
- Flooding
- Earthquakes
- Tornadoes
FEMA Flood Mapping Coverage
FEMA’s National Flood Hazard Layer
FEMA's National Flood Hazard Layer (Official)

Data from Flood Insurance Rate Maps (FIRMs) where available digitally. Try http://bit.ly/1bPpUjq (Unofficial) if this map is down.
In addition to FEMA and the US Army Corps of Engineers, many state and local jurisdictions have sections which deal with floodplains and have floodplain managers who can provide maps and other useful information.
How are Floodplains Delineated, and How Reliable are Floodplain Maps?
Computer Floodplain Models

USACOE Hydrologic Engineering Center - HEC-RAS
Danish Hydraulic Institute - MIKE FLOOD, MIKE 11, MIKE 21

Inputs
• Topography – Digital Elevation Model
• Bridges and Culverts
• Ground Coverage and Roughness
• Soils & Moisture Contest
• Rainfall
• Etc.

Outputs
• Water Surface Elevations
• Flows
City of Boulder, CO
1979 Pre-Mining FEMA 100-yr Floodplain
1988 Post-Mining  
FEMA 100-yr  
Floodplain  

Mining of 4 million cubic yards of sand & gravel lowered topography 15’.  

But the property was removed from the 100-yr floodplain by a 6,000’ berm, which was NOT permitted, NOT part of the reclamation plan, and NOT built to FEMA specifications.  

Floodplain map approved by:  
• City  
• County  
• Flood Control District  
• FEMA
Feds tour ravaged areas

CSU bill could top $120 million

By Kieran Nicholson

Federal officials touring flood-ravaged Fort Collins and Colorado State University Saturday pledged support from Washington as repair estimates at the school hit at least $120 million.

"It looks to me like there is really good coordination going on here" between local, state and federal agencies, said Sen. Wayne Allard, R-Colo.

"We need to make sure federal agencies are there. So far, they have been very responsive."

Rep. Bob Schaffer, R-Colo., also toured the stricken areas, along with Alvin Brown, director of special actions with the U.S. Department of Housing and Urban Development, and David Grier, director of response and recovery with the Federal Emergency Management Agency.

Aid will come from federal, state and local levels.

"We have reserve funds that are available by executive and legislative order" to aid flood victims, said Tom Norton, president of the Colorado Senate. "All we need now are good solid estimates."

A tally of the costs of damage to homeowners and businesses in Fort Collins hasn't been determined, but Al Yates, president of CSU, said the school suffered $120 million to $135 million in damages.

"We have preliminary numbers at the moment. Unfortunately, it's much higher than we initially figured," Yates said.

The damage estimate for the campus library is $40 million alone.

We need to make sure federal agencies are there.

Sen. Wayne Allard, R-Colo.

"Damage to buildings, cleanup, replacement of books, records, and supplies, loss of business. It adds up," Yates said.

Damaged instruments were laid out in front of the university's musical hall Saturday. Broken chairs and furniture were piled high in front of Lory Student Center.

Fort Collins Police Chief Dennis Harrison, Poudre Fire Authority Chief John Mulligan and Battalion Chief Glenn Levy led the tour through the destroyed trailer parks off South College Avenue.

Some former residents were attempting to salvage belongings.

"It's not habitable, to salvage some of my Clarke."

Ninety-two trails stroyed in the parks zero for the Spring C

"This was truly an hood," Harrison told three generations h some coming back.

The delegation b shortly before noon sern Colorado, where from Logan and M

All three counties major disaster areas are and eligible fo

"This is just the st work ahead. It's got before we completel Allard said.

Figure 6 shows the areas of campus that were flooded and the buildings receiving damage. The map also shows estimated flows from the SWMM model for the 1997 event and the 100 year event. Note that actual 1997 flows (as estimated after the flood) exceeded modeled 100-year flows by large factors, such as 18.6 from the Lagoon area into the Engineering parking lot.
Blockage at Major Underpass
Fort Collins, CO subsequently adopted the 200-year floodplain for land use regulations, and assumes culverts will be 100% blocked during major storm events.
Urbanization and construction projects, such as concrete highway median barriers, which occur after a floodplain has been mapped can significantly change the boundaries of a floodplain.
Forecasting 100-year Storms
Boulder scientists see huge increase in future extreme downpours
A new study by scientists at Boulder's National Center for Atmospheric Research indicates that at the end of this century, **the number of summer storms producing extreme downpours** could increase by more than 400 percent across parts of the United States.

The study, published in the journal Nature Climate Change, also finds that **the intensity of individual extreme rainfall events** could increase by as much as 70 percent in some areas.
We are fortunate to now have the power of modern computers, comprehensive natural resource databases, and excellent flood modeling software. But those tools need to be judiciously applied with sound judgement and good common sense. And don’t try to fool her!