Accounting for Floodplain Function

Marjorie Wolfe, PE, CFM
Conceptual model of elements (boxes) and processes (arrows) of the Green River ecosystem
Diagram by Chris Konrad
Natural processes depend on landscape position

Headwaters
- Infiltration
- Sediment Supply
- Spawning

Transfer Reaches
- Storage/Attenuation
- Agriculture
- Fish Passage, Refuge, Food Webs

Delta/Estuary
- Storage
- Rearing
- Water Quality
Increased Runoff + Floodplain Development = Increased Flooding, Increased Erosion, Loss of Habitat, Degraded Water Quality
Storage
Attenuation
Habitat
Water Quality

Incision
Flood Risk
Pollution
Historic Native Habitats: 224,081 acres
Historic ‘Priority’ Native Habitats overlay
Present Native Habitats (green) = 123,266 acres

Habitat lost since 1870’s: 114,050 acres
If you prevent floodplain fill, you keep existing development safe.
Today’s Floodplain Is Not Necessarily Tomorrow’s Floodplain

Floodplain Before Filling

Factories Now Liable to Flood

Increase in Flood Level

Both Houses Previously Unaffected by Floods Now Liable to Flood

Floodplain After Filling
Risk = Probability x Consequence
The Cost of Flooding has Dramatically Increased

<table>
<thead>
<tr>
<th>Decade</th>
<th>Cost (Billions, adjusted to 1999 dollars)</th>
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<tbody>
<tr>
<td>1910s</td>
<td>$2.2</td>
</tr>
<tr>
<td>1920s</td>
<td>$2.0</td>
</tr>
<tr>
<td>1930s</td>
<td>$2.9</td>
</tr>
<tr>
<td>1940s</td>
<td>$2.4</td>
</tr>
<tr>
<td>1950s</td>
<td>$3.4</td>
</tr>
<tr>
<td>1960s</td>
<td>$2.2</td>
</tr>
<tr>
<td>1970s</td>
<td>$4.9</td>
</tr>
<tr>
<td>1980s</td>
<td>$3.3</td>
</tr>
<tr>
<td>1990s</td>
<td>$5.6</td>
</tr>
<tr>
<td>2000s</td>
<td>$25</td>
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</tbody>
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Slides by Ed Thomas
NO “Adverse Impact”

“...an approach that ensures the action of any property owner, public or private, does not adversely impact the property and rights of others” —ASFPM definition
FEMA-NMFS BiOP – Compensatory Mitigation
“no net loss or beneficial gain” of natural floodplain functions

a. The addition of fill, structures, levees, and dikes, which reduces flood storage and fish refugia, impedes habitat forming processes, increases flow volume and velocity thereby eroding stream banks and beds, and alters peak flow timing thereby increasing risk of injury to redds, fry, and alevin;
b. The addition of impervious surfaces, which reduces hyporheic function and stream recharge, increases storm water, pollutant loading, water temperature, velocity, and scour, and modifies peak and base flows;
c. Vegetation removal, which reduces shade, detrital input, velocity refuge, and habitat complexity and increases storm water and erosion; and
d. Bank armoring, which reduces instream habitat values and impedes habitat forming processes.
Connecting Upland and Floodplain Function

Infiltrate 1-2 inches a day AND
Protect and restore floodplains
Instead of building detention

When detention ponds don’t work!

• Effective flow thresholds are lower than expected
• Pre-developed condition is impervious
Flows most affected by urbanization are those that do the most geomorphic work.
Clark Creek Effective Discharge Curves

- Total Bedload (tons/day)
- 15-minute Peak Discharge (cfs)

Existing Conditions
Predevelopment Conditions

0.5 \( Q_2 \) existing developed conditions
Battle Creek Effective Discharge Curves

Total Bedload (tons/day) vs. 15-minute Peak Discharge (cfs)

- Existing (developed) conditions
- Predevelopment conditions

Legend:
- $0.1Q_2$
- $0.5Q_2$
- $Q_2$
Feasible even in tight soils within 10% of development area
# Cost Comparison for Stormwater Detention

<table>
<thead>
<tr>
<th></th>
<th>LID</th>
<th>ON SITE POND</th>
<th>Regional Facility</th>
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<tbody>
<tr>
<td># of facilities</td>
<td>80</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Initial Construction</td>
<td>$400,000</td>
<td>$500,000</td>
<td>$400,000</td>
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<tr>
<td>Establishment</td>
<td>$16,000</td>
<td>$0</td>
<td>$20,000</td>
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<tr>
<td>Annual Maintenance</td>
<td>$1,600</td>
<td>$30,000</td>
<td>$4,000</td>
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<tr>
<td>Inspection (4 yr cycle)</td>
<td>$4,000</td>
<td>$3,200</td>
<td>$400</td>
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<tr>
<td>$ over 50 year</td>
<td>$546,000</td>
<td>$2,040,000</td>
<td>$625,000</td>
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**Disclaimer:** These cost estimates are based on broad assumptions from various sources. Actual costs should be based on local data.
Unique Topography

Active floodplain widths up to 400ft

City Park Wetlands
Connected Floodplain
Confined Channel - limited floodplain
Clean Water Services Riparian Assessment

Shade Credit Program

- Beaver activity
- Floodplain Storage
- Ecological Diversity

Bank Erosion
Incision
EPA/DEQ - MS4
- Hydromodification
- Green Infrastructure/LID(A)
- Adaptive Management
Stormwater Regulations

What is the problem we are trying to solve?
Ecological Resilience

Streams and Wetlands

- Floodplains
- Water Quality
- Land Use

USACE/DSL/NMFS/USFW
- Wetland protection/Mitigation
- Stream protection/Mitigation
- Endangered Species Act (ESA)
Habitat and Water Quality
FEMA/Local Ordinance
- Buffers
- Natural & Beneficial Functions
- ESA protections
- Flood Protection
What is the problem we are trying to solve?
Ecological Resilience

- Floodplains
- Streams and Wetlands
- Water Quality
- Vegetated Corridors
- Density
- Urban Growth Boundaries
Land Use

What is the problem we are trying to solve?
Integrated Approach

*Graph showing runoff over time for Pre-development, Post-development, Post-development (with traditional controls), and Post-development (with LID/GI).*

*Adapted from David Nyman, ENSR*
### Ecological Resilience

#### Streams and Wetlands
- Floodplains
- Water Quality
- Land Use

#### GOALS
- Flow Reduction
- Flow Attenuation
- Coarse Sediment Supply
- Stream Resiliency

#### STRATEGIES

<table>
<thead>
<tr>
<th>Stormwater Regulations and Code</th>
<th>Infiltration</th>
<th>Open channel flow</th>
<th>Detention</th>
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<tbody>
<tr>
<td>Floodplain and Natural Areas Regulations</td>
<td>Setbacks/Buffers</td>
<td>Floodplain Protection</td>
<td>Wetland protection</td>
</tr>
<tr>
<td>Planning and Projects</td>
<td>Daylight piped streams</td>
<td>Stream and floodplain restoration</td>
<td>Riparian buffer restoration</td>
</tr>
</tbody>
</table>
Changing paradigms of water management

Cumulative Socio-Political Drivers

- Water supply access & security
- Public health protection
- Flood protection
- Social amenity, environmental protection
- Limits on natural resources
- Intergenerational equity, resilience to climate change

Service Delivery Functions

- Water Supply City
  - Supply hydraulics
- Sewered City
  - Separate sewerage schemes
- Drained City
  - Drainage, channelisation
- Waterways City
  - Point & diffuse source pollution management
- Water Cycle City
  - Diverse, fit-for-purpose sources & conservation, promoting waterway protection
- Water Sensitive City
  - Adaptive, multifunctional infrastructure & urban design, reinforcing water sensitive behaviours

If Walmart can do it?