




Watershed Management And Modeling



## Simulating Land Use Change in GSSHA



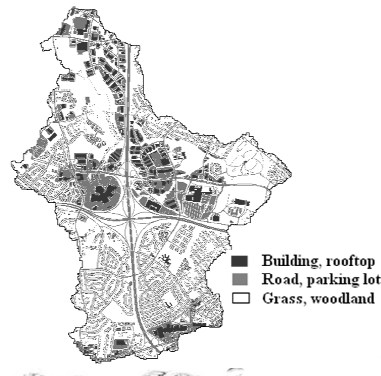

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## Land Use Change

Changing land uses leads to changes in the physical properties in the watershed and alters the system response.

- Converting natural areas to agricultural and urban areas results in more compacted soils and smoother surfaces.
- Urbanization leads to greater impervious area.
- All these changes result in more runoff.
- Drainage capacity is usually increased, exasperating the problems of increase runoff.





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## Simulating Land Use Change

- In lumped and semi-distributed models the parameters for sub-basins or other elements are changed to account for the change in land use.
- If the basin or element is large, only a portion of the element may be affected by the land use. The parameters may be adjusted based on some percentage of the basin that has changed.
- There is often considerable uncertainty in how to change the parameters because they may be empirical or may include significant implicit information related to the heterogeneity within an element.
- Selecting the proper parameter is exacerbated when the change occurs in only part of the element.
- The model may provide an option to select a land use, farming practice, etc. and have the model assign all the relevant parameters.




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## Simulated Land Use Change in GSSHA


- Land use change in GSSHA is simulated by modifying the distributed parameters in the grid.
- Small changes to drainage features may also be accounted for in the distributed parameters.
- Large changes to the drainage features can be explicitly included.
  - Changes to existing streams.
  - Ditches.
  - Subsurface drainage.
  - Reservoirs and detention basins.
- How to include a given feature depends on the scale of the feature in relation to your study.



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**Scientific Basis**

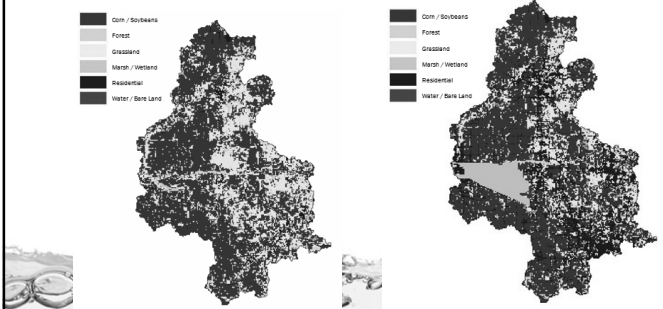
- GSSHA parameters
  - Physically based
  - Assigned based on physical attributes in the grid cell
  - Parameter values are not dependent to topology – where the grid cell is in the watershed
  - Parameters derived based on a physical condition apply to that condition all over the watershed
  - If the physical condition of a grid changes to another type, the parameter value in that grid cell changes to the other type
  - There is no need to recalibrate.



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**Methodology**

- Changing land uses can be represented with a new index map.
- The parameter values in the mapping table remain the same, unless a new type of land use is added.



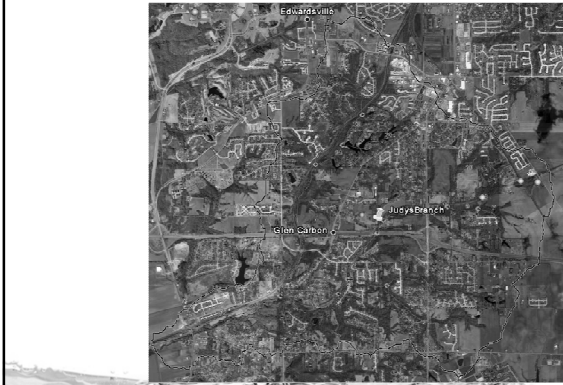

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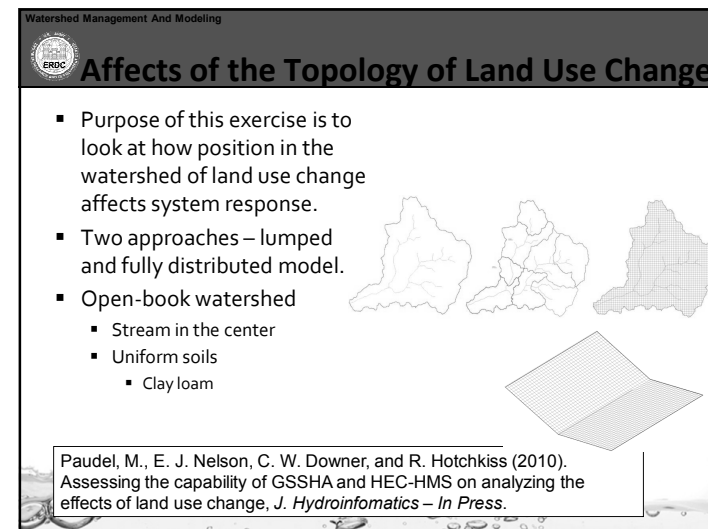
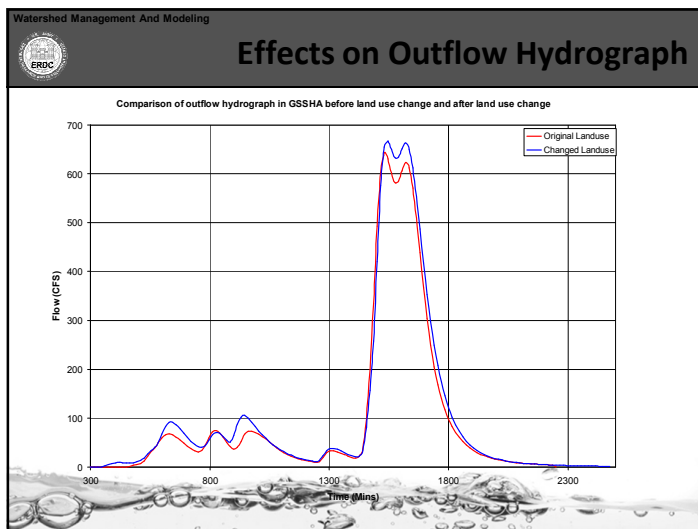
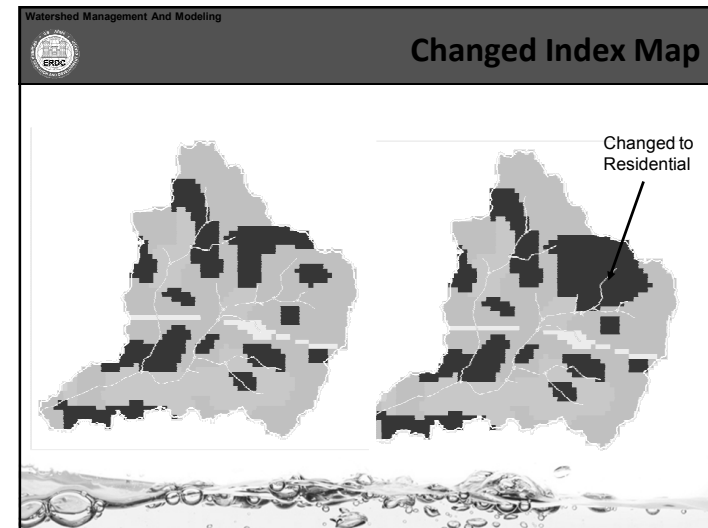
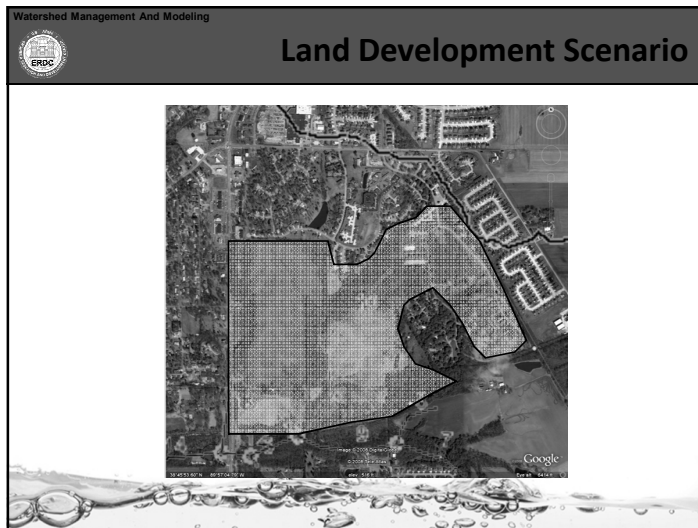
**Landuse Change Scenario**




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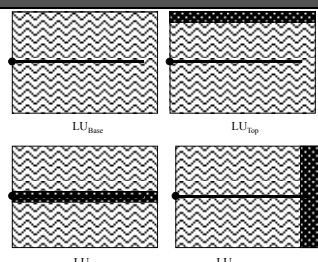
**Existing Landuse**



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## Land Use Change Scenarios

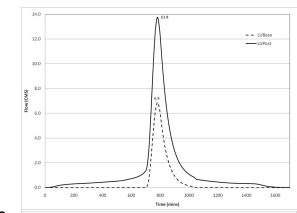


- Development consist of impermeable areas located at four points in the watershed
  - None - Base
  - Near the watershed boundary – Top
  - Evenly distributed along the stream – Center
  - Along the stream but far from outlet – Right
- Amount of development is the same in all cases.

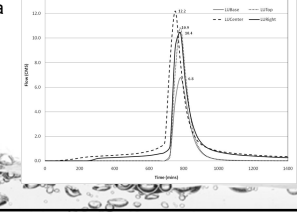
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## Results

The lumped model indicates same response regardless of land use change position.



The distributed model indicates that the position of the land use change plays a large factor in the determination of system response. The results appear intuitively correct.



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## Implications

- Where something occurs in the watershed can have a large effect on the system response.
- This occurs because the position affects the flow path.
- In a lumped model approach, only the percentage of the sub-basin occupied by the feature can be represented. This implies that the location is not important.
- Even when distributed at a very fine scale (many sub watershed or gridded point response – such as HMS) the effects of the flow path cannot easily be incorporated into the solution with simple routing methods.
- Because the fully distributed modeling approach fully accounts for the position of the feature on the landscape and the resulting flow path, it is ideally suited for analysis of many complex problems such as effects of land use change and BMPs.

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## Effect of Land Use Change on Parameters

Changing from natural (forest, grasslands, wetlands) to agriculture typically causes:

Changes to distributed parameters:

- Reduces soil hydraulic conductivity due to destroying the soil structure.
- Sparse vegetation reduces overland roughness.
- Reduces overland retention depth.
- Changes ET parameters to account for new coverage.
- Increased erodibility.

And changes to the stream/drainage system:

- Tile drains may be added.
- Ditches may be added.
- Streams may be modified.
  - Straightened.
  - Increased conveyance.
  - Reduced roughness.

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**Effect of Land Use Change on Parameters**


Changing from natural areas to residential typically causes:

Changes to distributed parameters:

- Reduces soil hydraulic conductivity due to compacting the soil structure.
- Causes impervious areas.
- Streets, drainage, etc. reduce overland flow roughness.
- Reduces overland retention depth.
- Change ET parameters to account for different vegetation.

And changes to the stream network:

- Increase in stream conveyance.
- Reduction in stream roughness.
- Streams may be straightened.
- Subsurface drains may be added.
- Ditches or other surface drainage added.




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**Effect of Land Use Change on Parameters**

Progression to Industrial/Fully Developed – typically industrial areas develop on previously agricultural or residential areas.


- Area may be completely impervious.
- Hydraulic conductivity at or near zero.
- No surface retention.
- Overland roughness very low.
- Reduced erodibility.
- Remaining drainage may be completely altered.
  - Concrete lined channels.
  - Subsurface drainage.



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**Abatement Measures**

- **Vegetative strip**
  - Slows down and reduces runoff from impervious areas.
  - Simulated in GSSHA
    - higher overland roughness
    - Higher retention depth
    - increased hydraulic conductivity.
- **Detention basin**
  - Small reservoir to control flows from impervious areas.
  - Simulated in GSSHA
    - Changes to the elevation map
    - As a detention basin in the stream network
- **Infiltration basin**
  - Captures and infiltrates excess runoff for flood control or groundwater recharge
  - Simulated in GSSHA
    - Higher hydraulic conductivities
    - Elevation map may change



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**Abatement Measures**

- **Berms**
  - Control flow and direct it away from developed areas and often toward abatement features.
  - Simulated in GSSHA as embankments.
- **Levees**
  - Protect areas from high water.
  - Simulated in GSSHA as embankments.
- **Ditches**
  - Can be added to the stream network.
  - Decreased overland roughness.
- **Subsurface drains**
  - Can be added as subsurface drains.
  - Can be simulated as surface drainage.
  - Reduced overland roughness.

