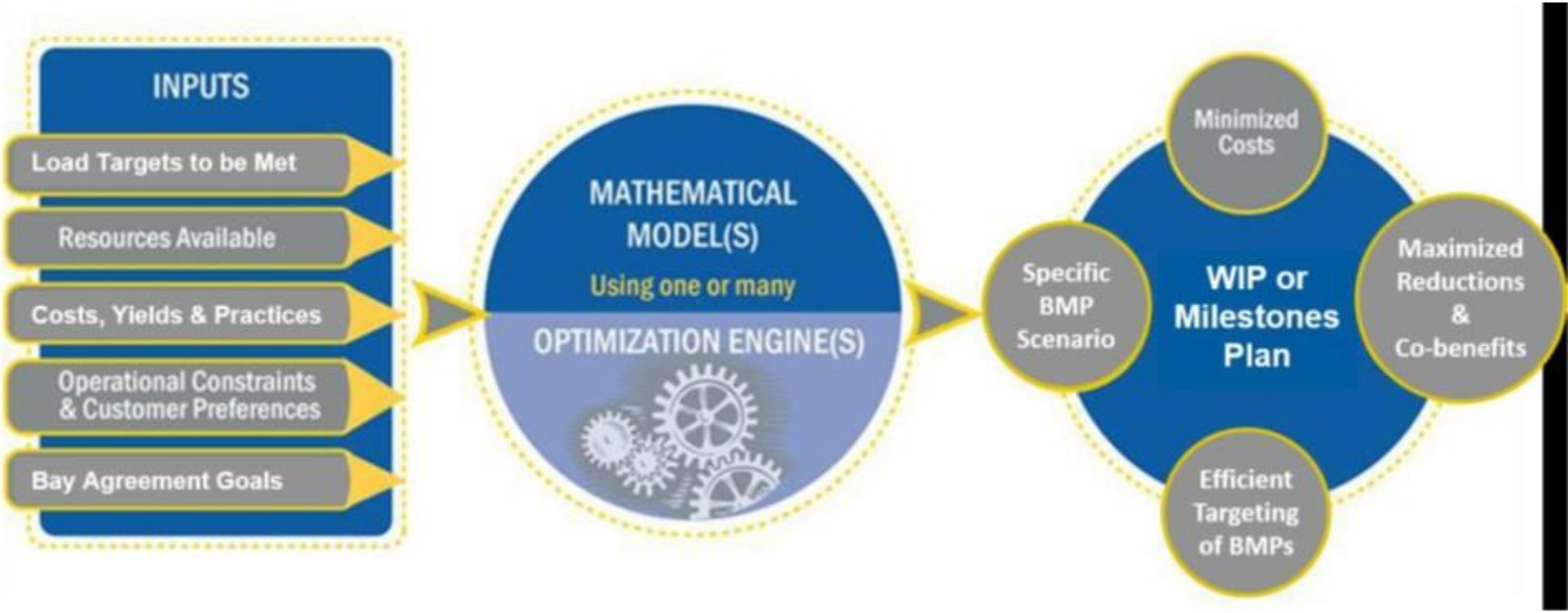
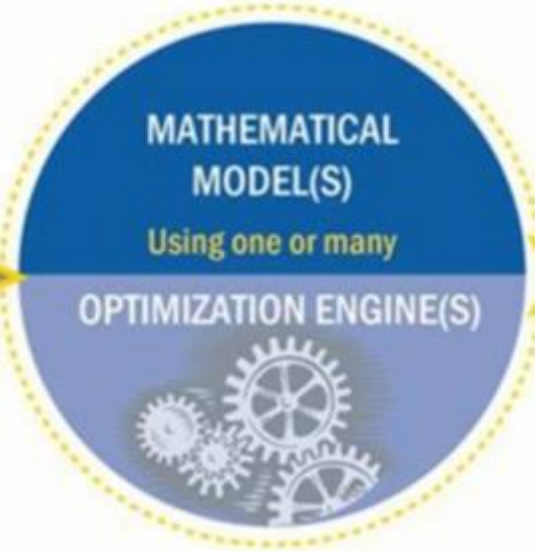
CBP Model
“the function evaluation”

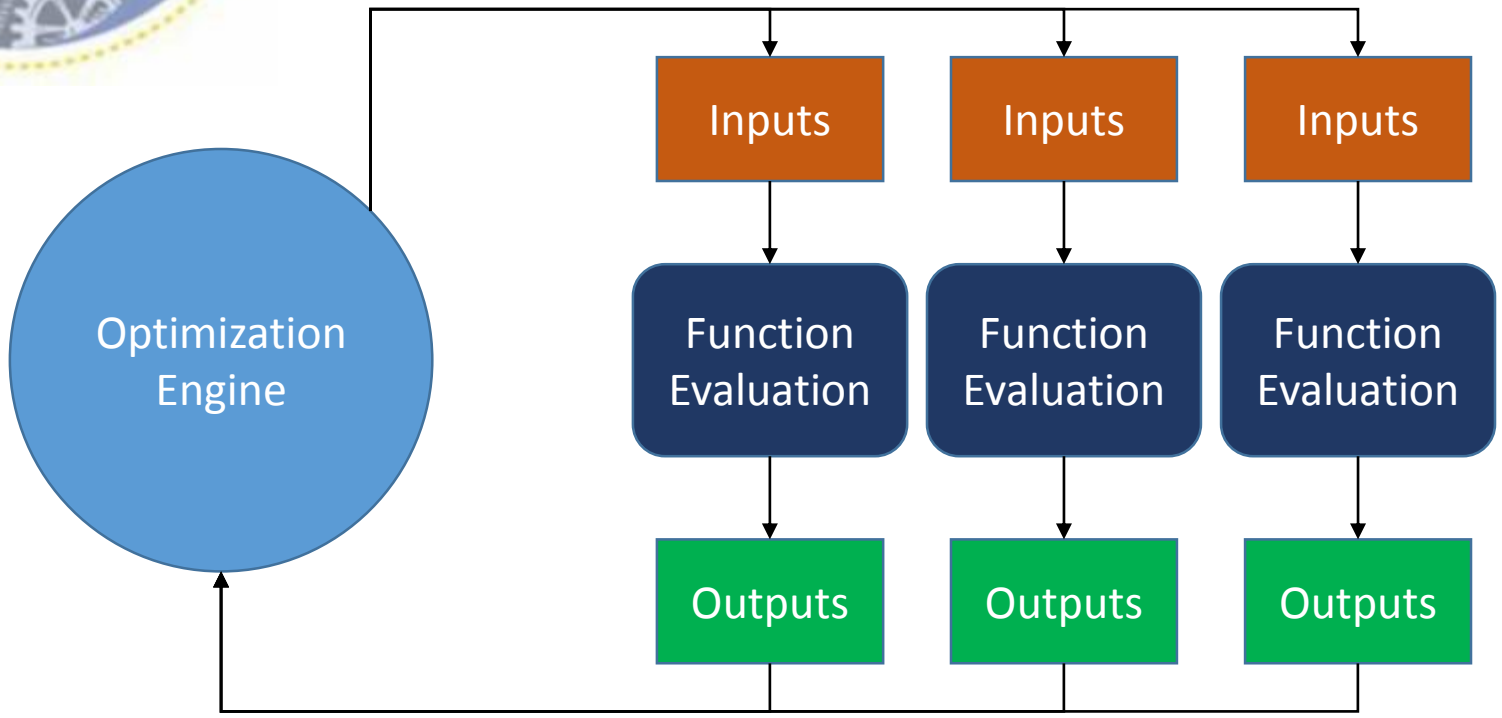
Optimization Workshop

Gary Shenk

2/17/16


INPUTS
Load Targets to be Met
Resources Available
Costs, Yields & Practices
Operational Constraints & Customer Preferences
Bay Agreement Goals
MATHEMATICAL MODEL(S)
Using one or many
OPTIMIZATION ENGINE(S)
Minimized Costs
Specific BMP Scenario
WIP or Milestones Plan
Maximized Reductions & Co-benefits
Efficient Targeting of BMPs


MATHEMATICAL
MODEL(S)
Using one or many
OPTIMIZATION ENGINE(S)


Optimization Engine
Inputs
Inputs
Inputs
Function Evaluation
Function Evaluation
Function Evaluation
Outputs
Outputs
Outputs

Load for a land use in a segment =

Average Load + Δ Inputs * Sensitivity

*

Land Use Acres

*

BMPs

*

Land to Water

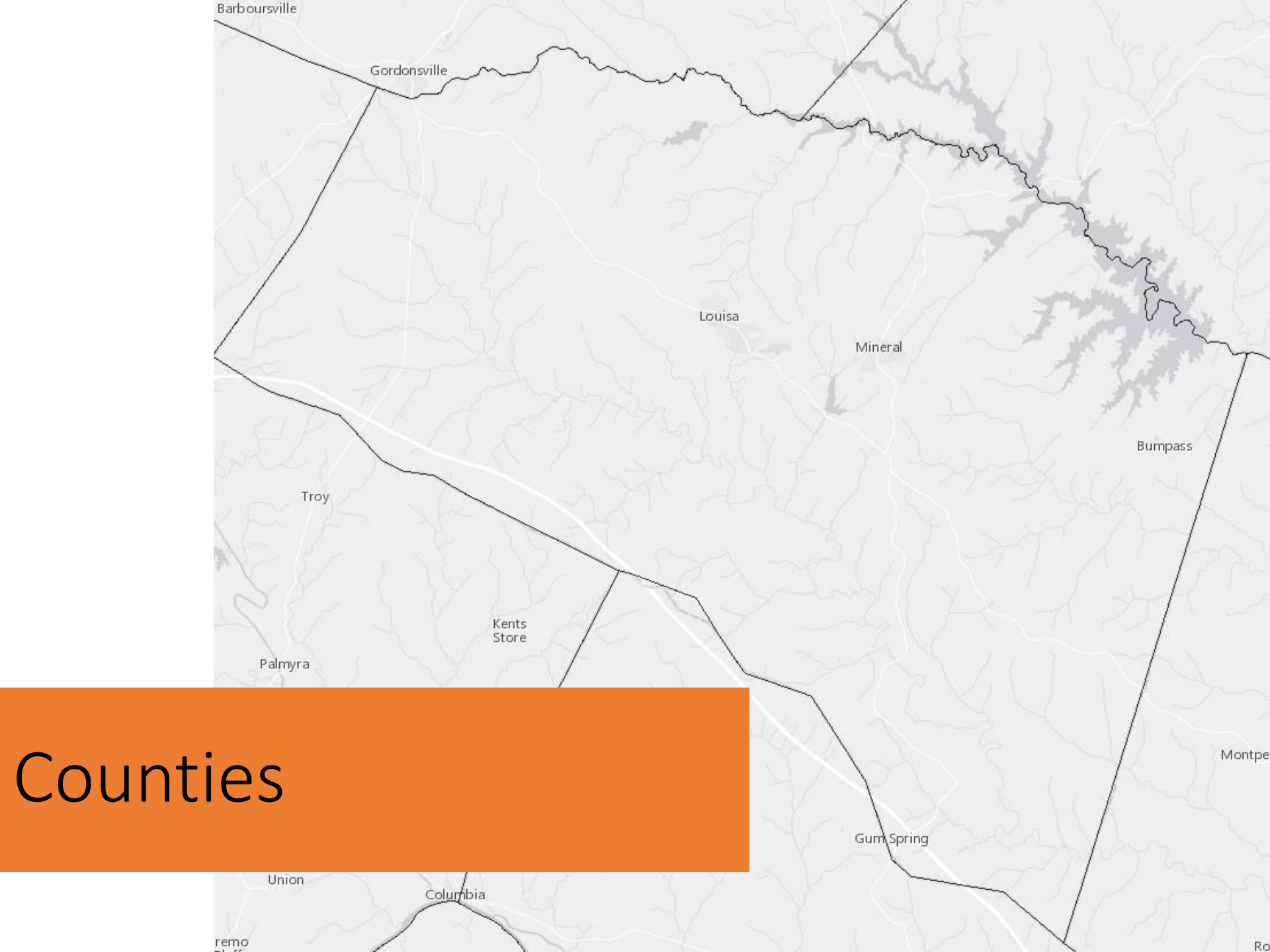
*

Stream Delivery

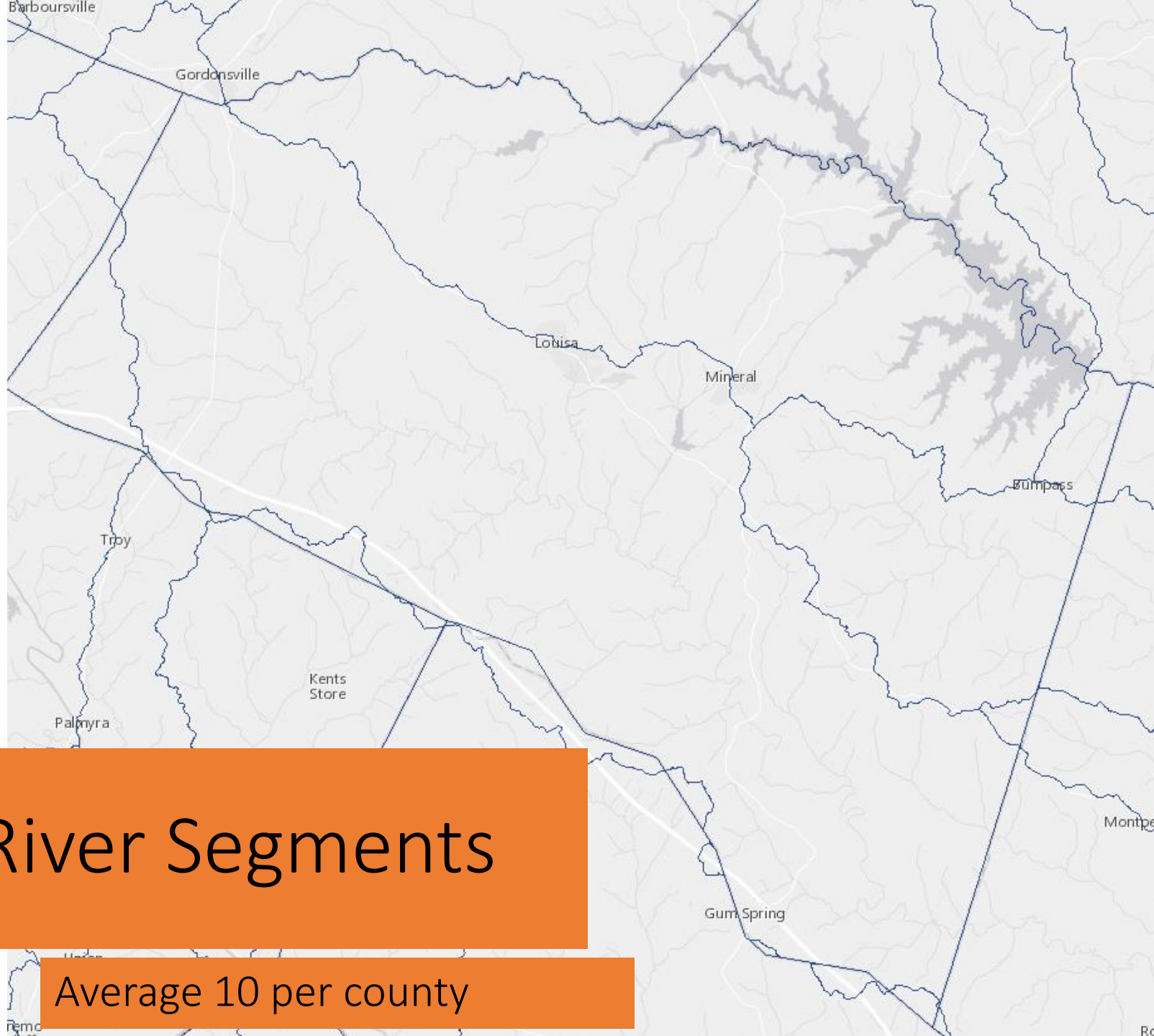
*

River Delivery

Direct Loads


Barboursville
Gordonsville
Louisa
Mineral
Bumpass
Troy
Kents
Store
Palmyra
Gum Spring
Union
Columbia

Counties



Land-River Segments

Average 10 per county

Land uses - 45

Agriculture	Developed			Natural
	Non-Regulated	MS4	CSS	
Ag Open Space	Non-Regulated Roads	MS4 Roads	CSS Roads	Disturbed Forest
Full Season Soybeans Grain with Manure	Non-Regulated Buildings and Other Non-Regulated Tree Canopy over Impervious	MS4 Buildings and Other MS4 Tree Canopy over Impervious	CSS Buildings and Other CSS Tree Canopy over Impervious	Harvested Forest Forest
Grain without Manure	Non-Regulated Tree Canopy over Herbaceous	MS4 Tree Canopy over Scrub Shrub	CSS Tree Canopy over Scrub Shrub	Palustrine Forested Wetland
Legume Hay	Non-Regulated Turf Grass	MS4 Tree Canopy over Herbaceous	CSS Tree Canopy over Herbaceous	Palustrine Scrub-Shrub Wetland
Silage with Manure		MS4 Turf Grass	CSS Turf Grass	Palustrine Emergent Wetland
Silage without Manure Small Grains and Grains		MS4 Construction	CSS Construction	Open Space Water
Small Grains and Soybeans				Non-Regulated Tree Canopy over Scrub Shrub
Specialty Crop High				
Specialty Crop Low Other Agronomic Crops				
Other Hay				
Pasture Farmstead				
Permitted Feeding Space Non-Permitted Feeding Space				





Load for a land use in a segment =

450 times

Average Load + Δ Inputs * Sensitivity

*

Land Use Acres

*

BMPs

*

Land to Water

*

Stream Delivery

*

River Delivery

Direct Loads

Load for a land use in a segment =

Look up tables

Average Load * **Sensitivity**

*

*

Land to Water

*

Stream Delivery

*

River Delivery

Load for a land use in a segment =

Δ Inputs

*

Land Use Acres

*

BMPs

*

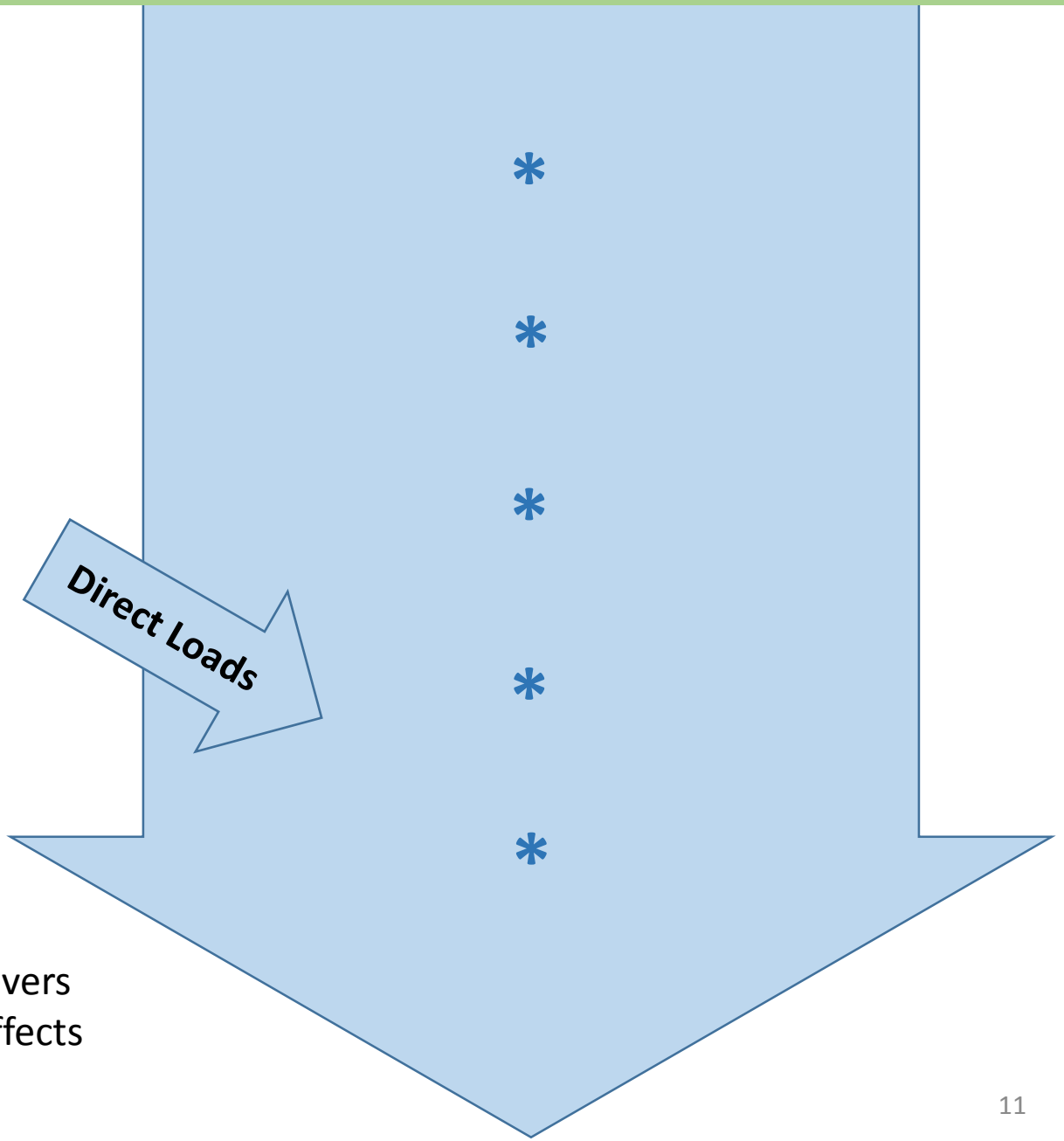
Direct Loads

*

*

Policy Levers

Load for a land use in a segment =



Policy Levers
Linear effects





Load for a land use in a segment =

Δ Inputs

*

Land Use Acres

*

BMPs

*

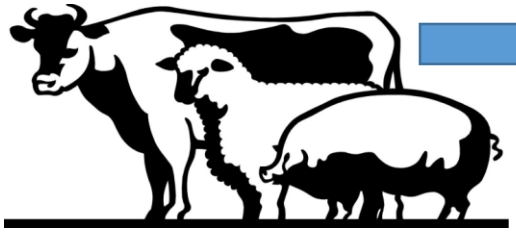
*

*

Policy Levers
With nonlinear, complex, and interlocking effects

Change in Inputs

Livestock



BMPs

Manure storage practice

BMPs

Fertilizer

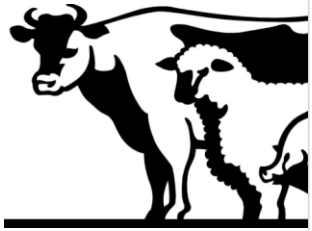
Crops

Pasture

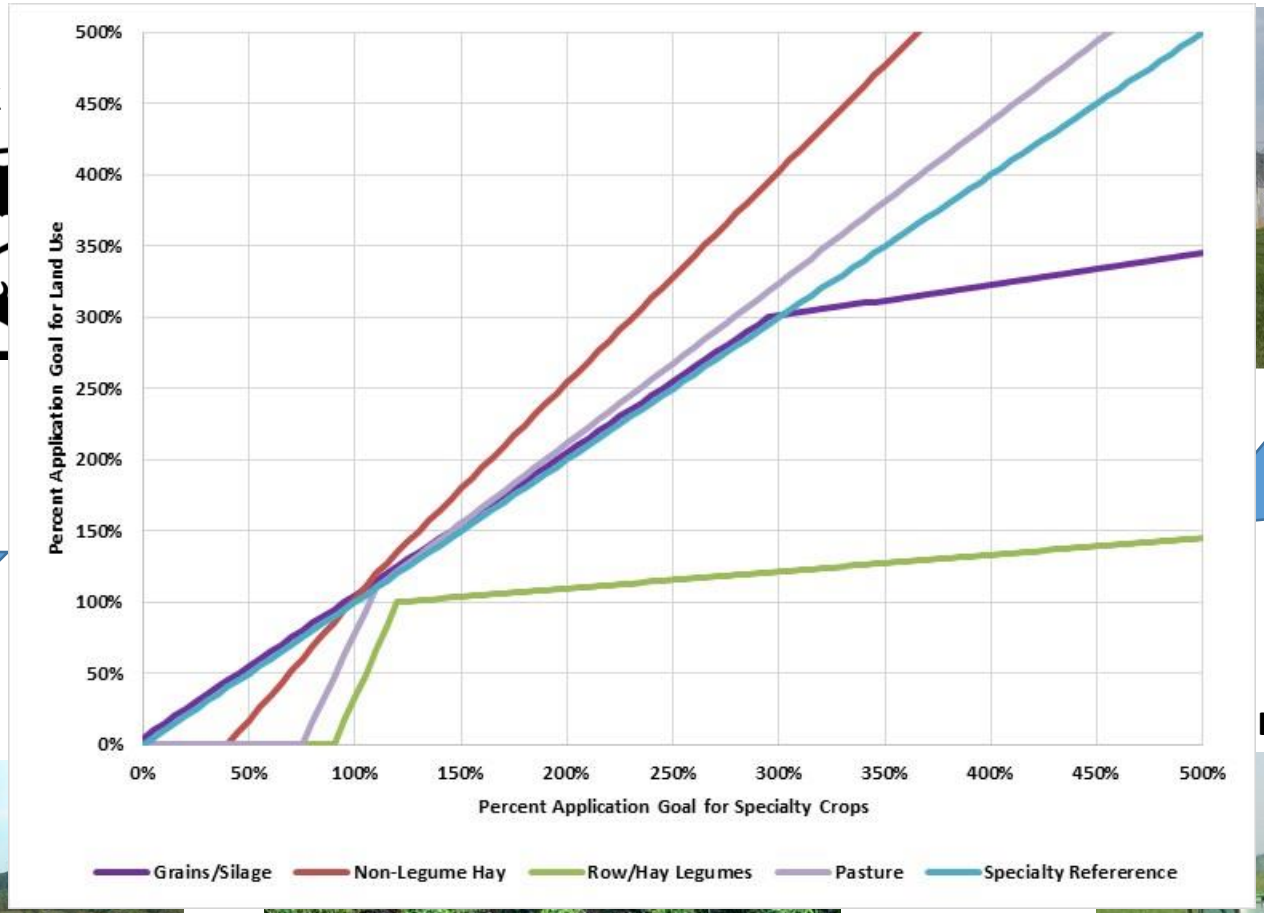
Image Credits
https://utextension.tennessee.edu/lincoln/4-H/Pages/Livestock-Skillathons-%28Beef,-Sheep-and-Swine%29.aspx
Rebelwoodsranch.com
Seaburst.com
http://pubs.ext.vt.edu/442/442-308/442-308.html

Change in Inputs

Livestock



Manure storage practice



Pasture

rtilizer

Image Credits
https://utextension.tennessee.edu/lincoln/4-H/Pages/Livestock-Skillathons-%28Beef,-Sheep-and-Swine%29.aspx
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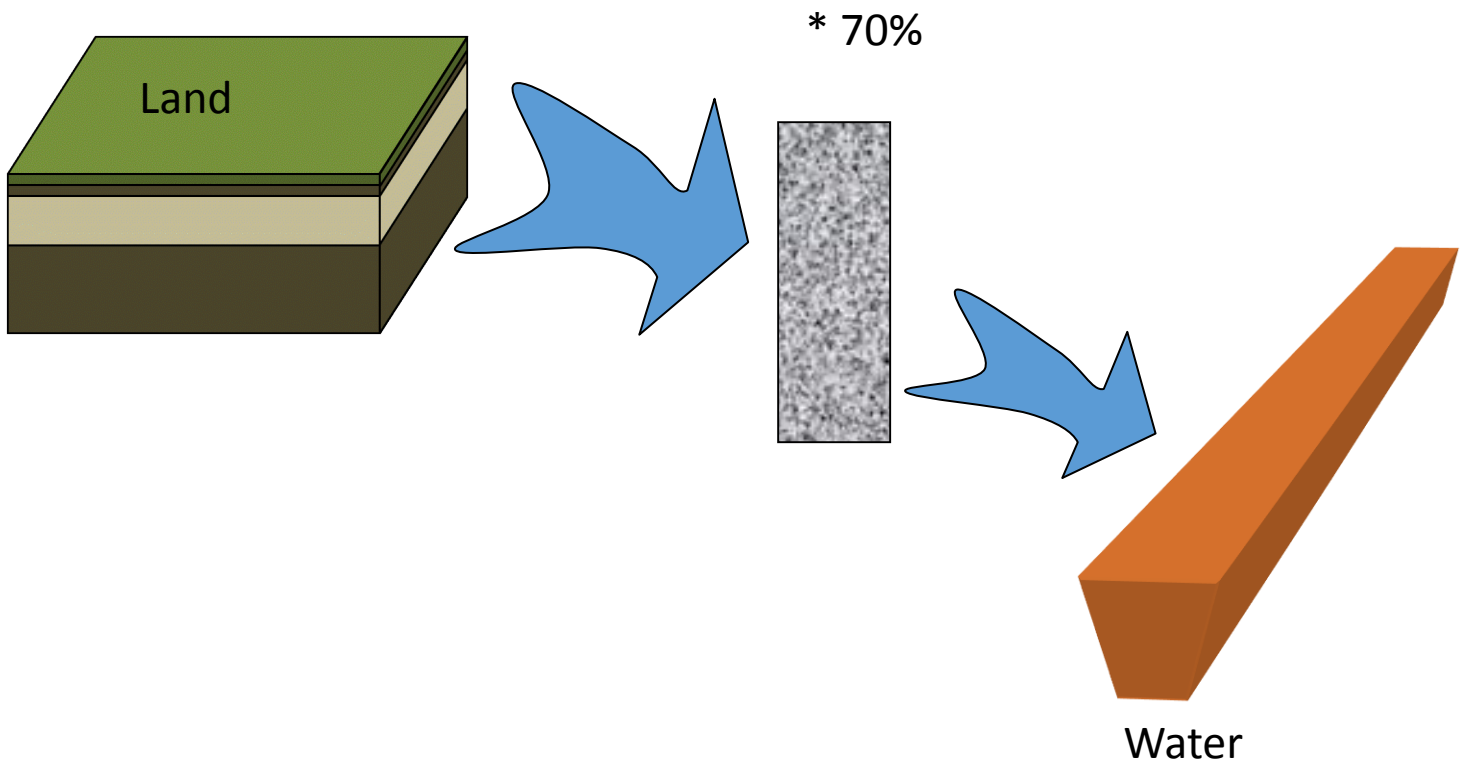
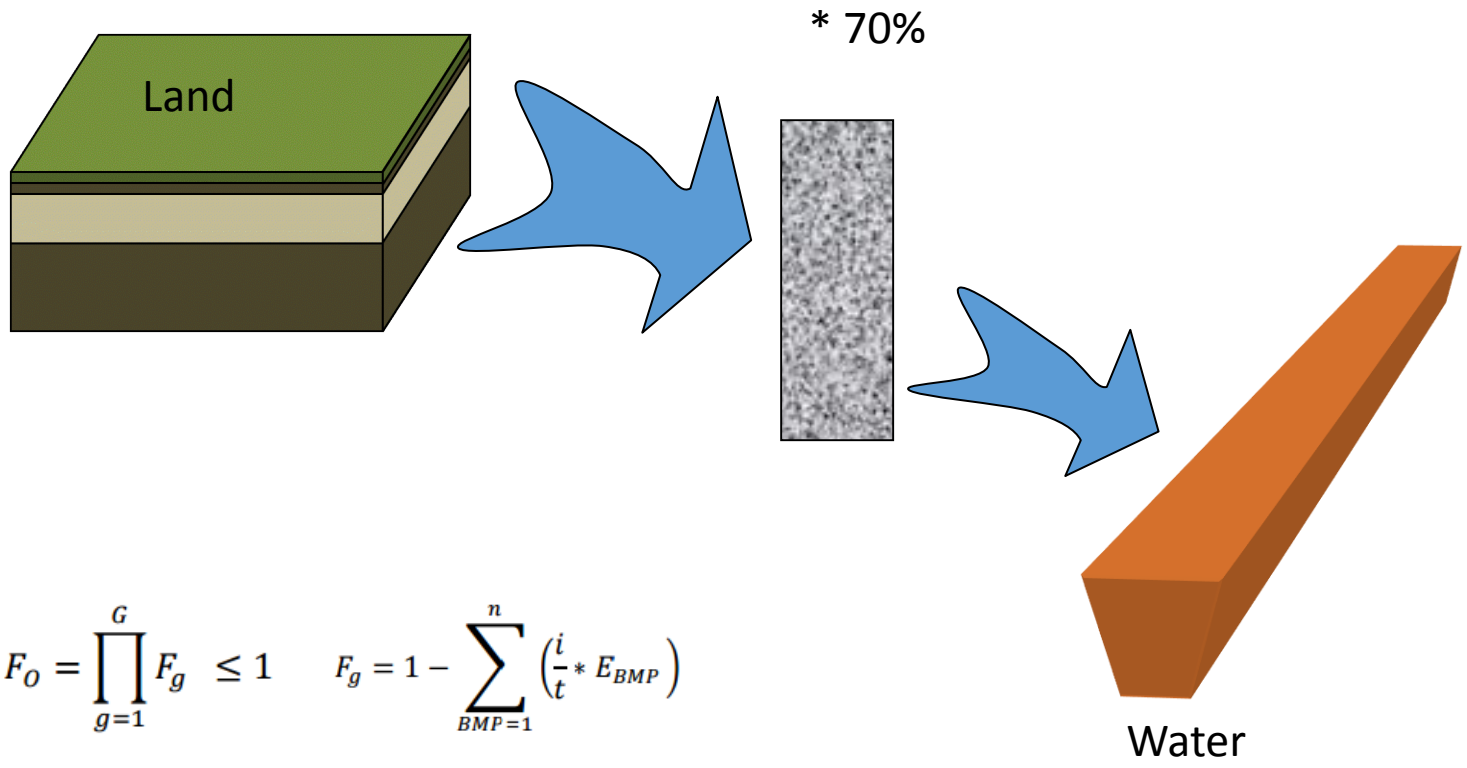
BMPs



BMPs



$$F_O = \prod_{g=1}^{G} F_g \leq 1 \qquad F_g = 1 - \sum_{BMP=1}^{n} \left(\frac{i}{t} * E_{BMP}\right)$$

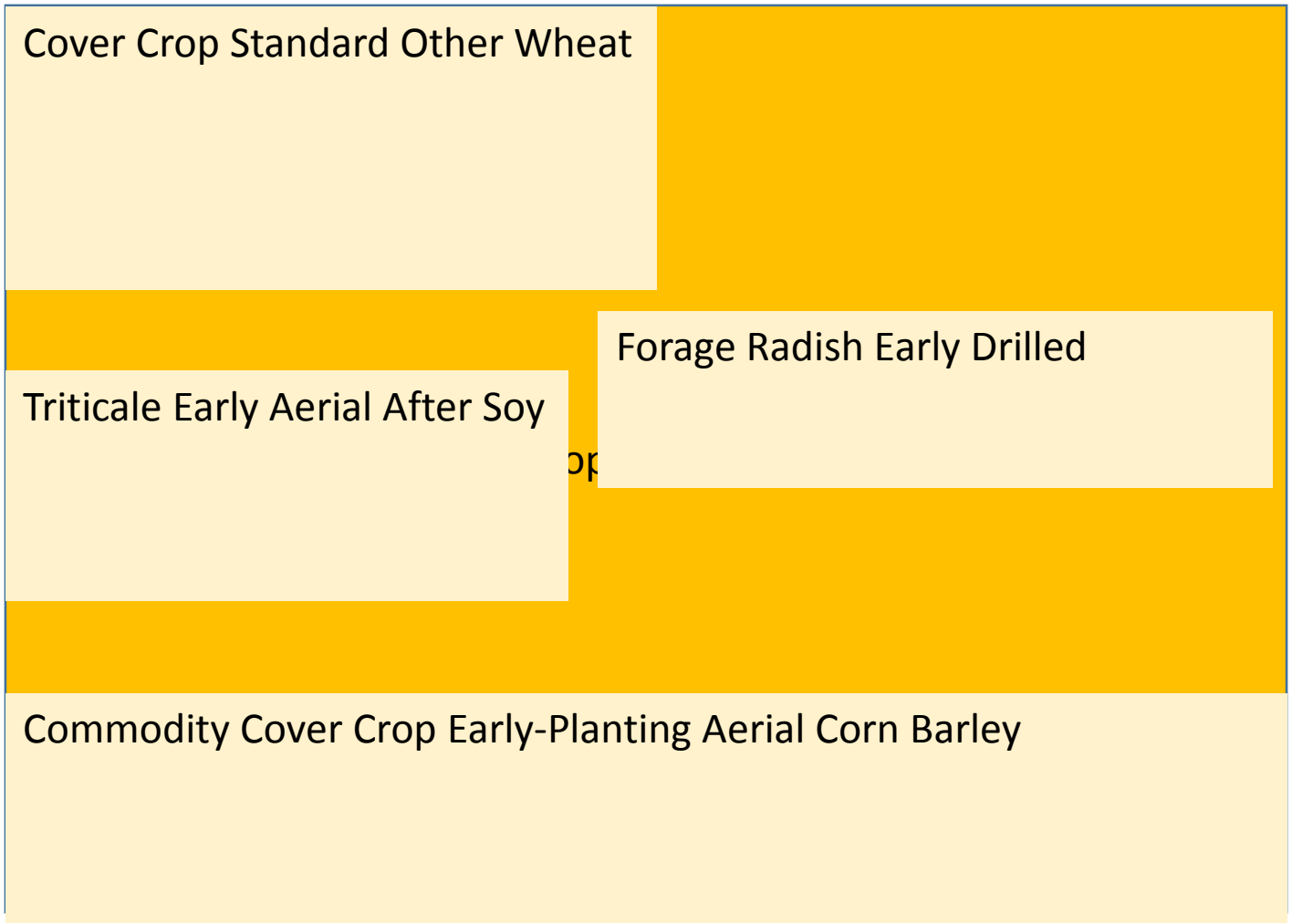
But BMPs nonlinearly related to implementation

BMPs

BMPs

Linear

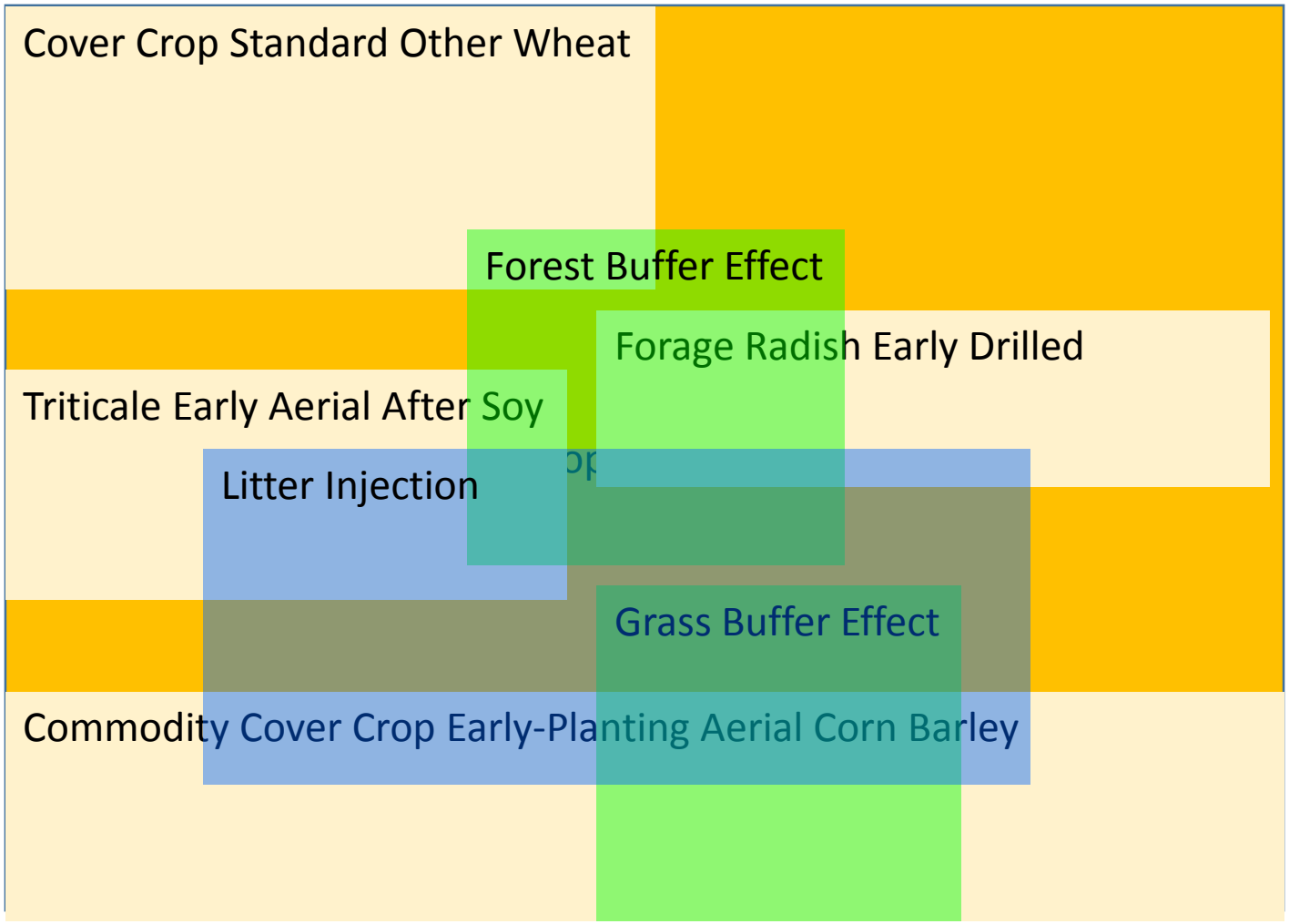
$$F_g = 1 - \sum_{BMP=1}^{n} \left(\frac{i}{t} * E_{BMP} \right)$$



BMPs

Non-Linear

$$F_O = \prod_{g=1}^{G} F_g \leq 1$$



Number of BMPs by Land Use

LoadSource	BMPs	LoadSource	BMPs	LoadSource	BMPs
Ag Open Space	20	Permitted Feeding Space	12	CSS Roads	36
Full Season Soybeans	137	Non-Permitted Feeding Space	12	CSS Buildings and Other	36
Grain with Manure	137	Non-Regulated Roads	35	CSS Tree Canopy over Impervious	36
Grain without Manure	125	Non-Regulated Buildings and Other	35	CSS Tree Canopy over Turfgrass	42
Legume Hay	40	Non-Regulated Tree Canopy over Impervious	35	CSS Tree Canopy over Scrub Shrub	7
Silage with Manure	137	Non-Regulated Tree Canopy over Turfgrass	41	CSS Turf Grass	42
Silage without Manure	125	Non-Regulated Tree Canopy over Scrub Shrub	8	CSS Construction	3
Small Grains and Grains	137	Non-Regulated Turf Grass	41	Abandoned Mines	9
Small Grains and Soybeans	137	MS4 Roads	35	Active Mines	9
Specialty Crop High	135	MS4 Buildings and Other	35	Disturbed Forest	8
Specialty Crop Low	135	MS4 Tree Canopy over Impervious	35	Harvested Forest	9
Other Agronomic Crops	137	MS4 Tree Canopy over Turfgrass	41	True Forest	8
Other Hay	40	MS4 Tree Canopy over Scrub Shrub	6	Open Space	9
Pasture	47	MS4 Turf Grass	41	Septic	7
Riparian Pasture Deposition	10	MS4 Construction	3	**Total**	**2175**

Land Use

Land Use

Seemingly straightforward

Land Use

Seemingly straightforward, but
Same manure on less land
Same BMPs on less land

Land Use

Seemingly straightforward, but
Same manure on less land
Same BMPs on less land
Additional BMPs





Load for a land use in a segment =

Δ Inputs

*

Land Use Acres

*

BMPs

*

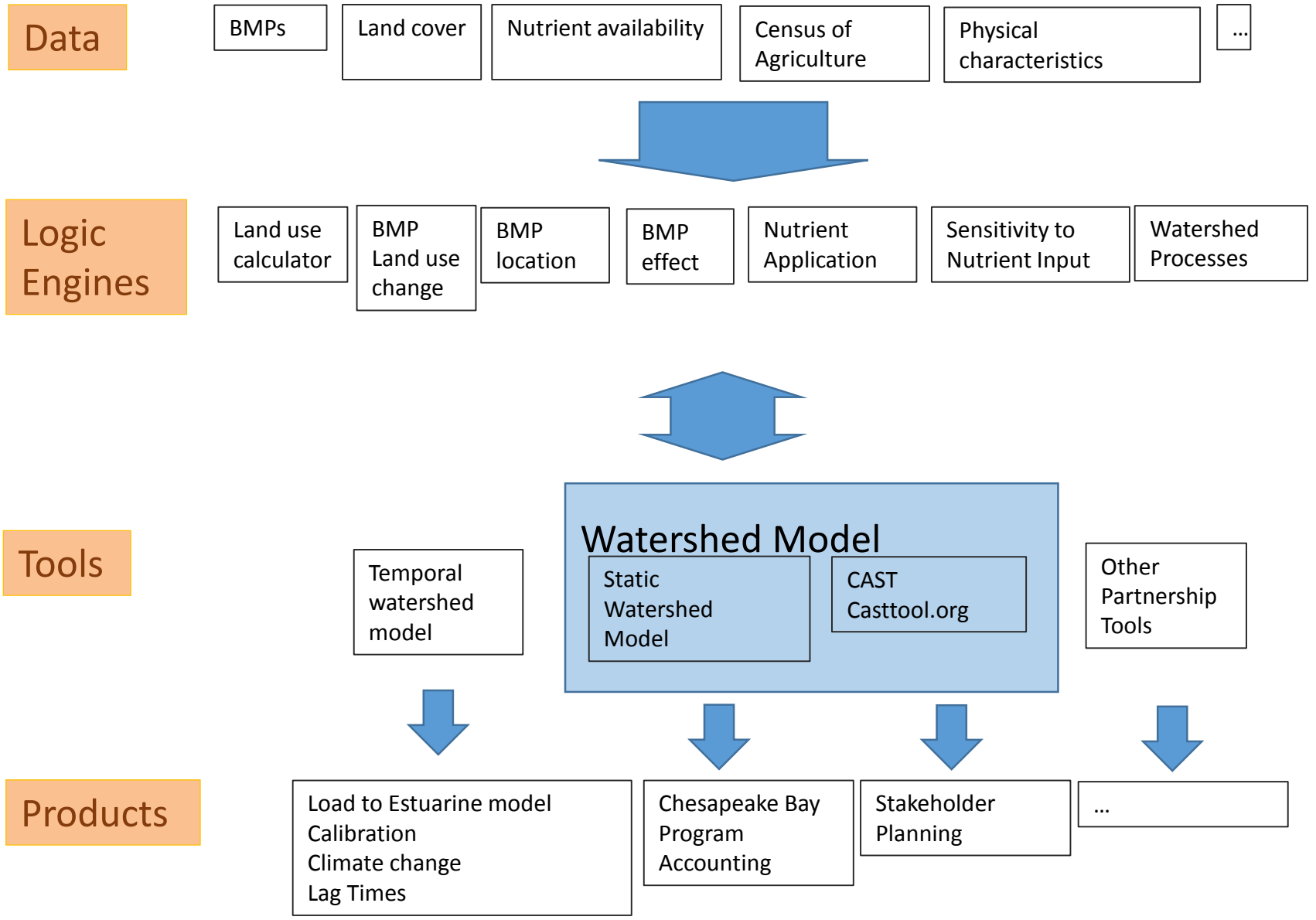
*

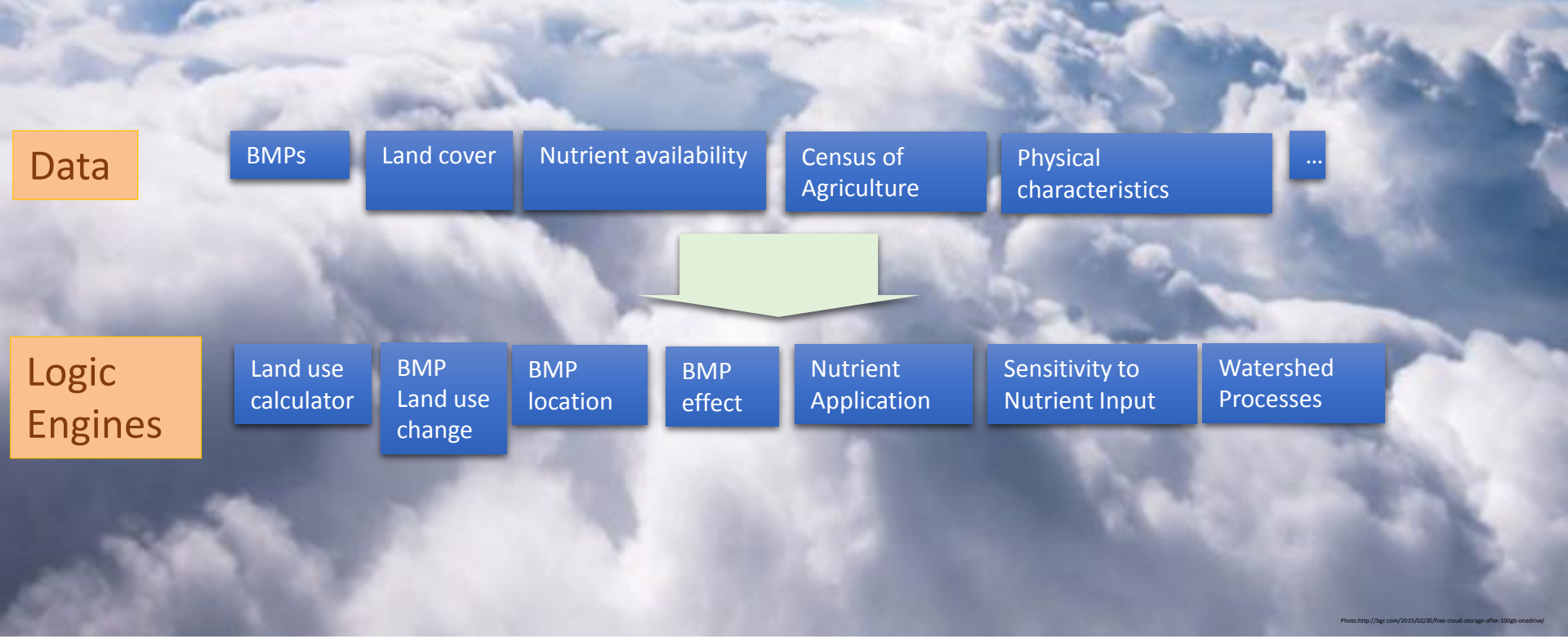
*

Can we make a simpler model?

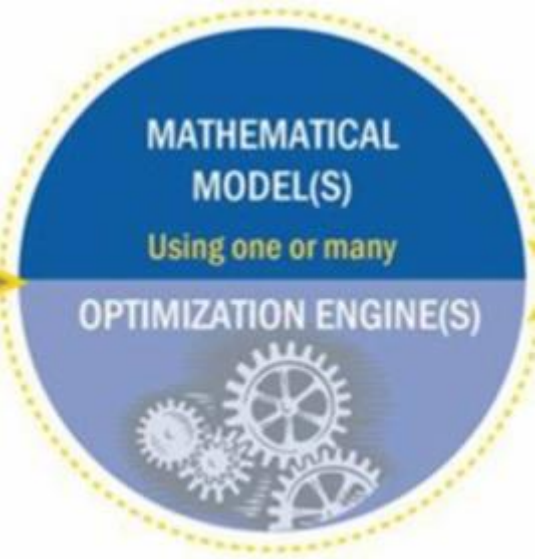
These factors will change every other year

Nonlinear effects are important


Data
BMPs
Land cover
Nutrient availability
Census of Agriculture
Physical characteristics
…
Logic Engines
Land use calculator
BMP Land use change
BMP location
BMP effect
Nutrient Application
Sensitivity to Nutrient Input
Watershed Processes
Tools
Watershed Model
Static Watershed Model
CAST Casttool.org
Temporal watershed model
Other Partnership Tools
Products
Load to Estuarine model
Calibration
Climate change
Lag Times
Chesapeake Bay Program Accounting
Stakeholder Planning
…



Function evaluation should take ~10-30 seconds
Scalable implementation



About 23000 Specifications per County
10 LR segments
X
(45 land uses +
2200 BMPs +
A few Point sources)