K·STATE
Research and Extension

What is a Watershed? Understanding Surface Runoff. Controlling Erosion and Sediment.

Aleksey Sheshukov

Assistant Professor and Water-Quality Specialist
Biological & Agricultural Engineering
ashesh@ksu.edu, (785)-532-5418

http://www.kcare.k-state.edu
http://www.bae.ksu.edu/watershed/extension/training/
http://erosion.ksu.edu

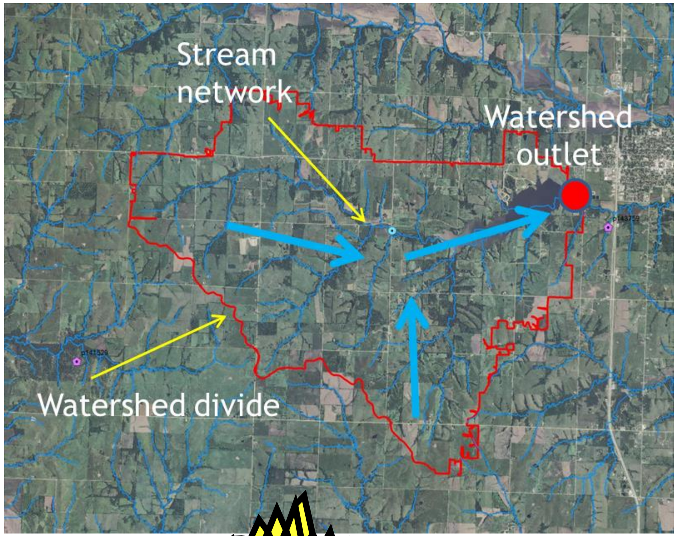
Knowledge for Life

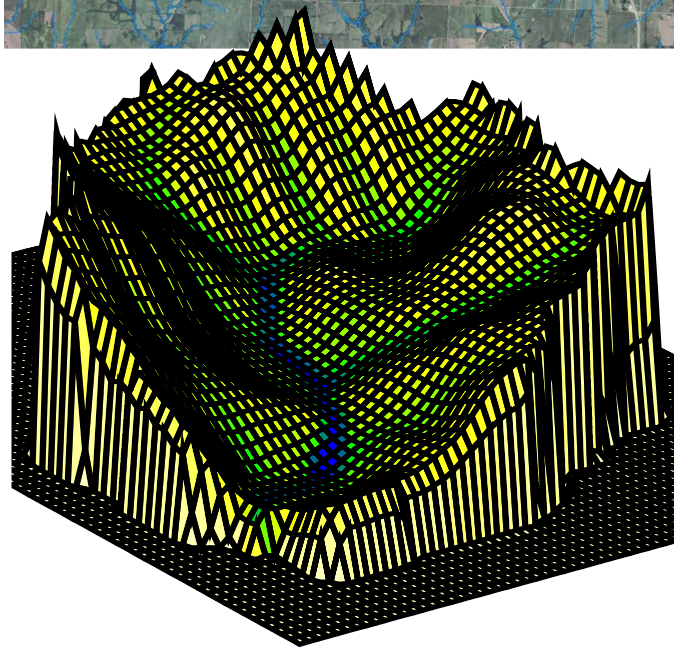
WHAT IS A WATERSHED?
HOW MANY WATERSHEDS IN KANSAS?
HOW TO DEFINE A WATERSHED?

Watershed Terminology

- A watershed refers to an area of land that drains to a common water body such as a lake or a stream

- Watershed characteristics:
  - Watershed divide
  - Stream network
  - Watershed outlet
  - Subwatersheds



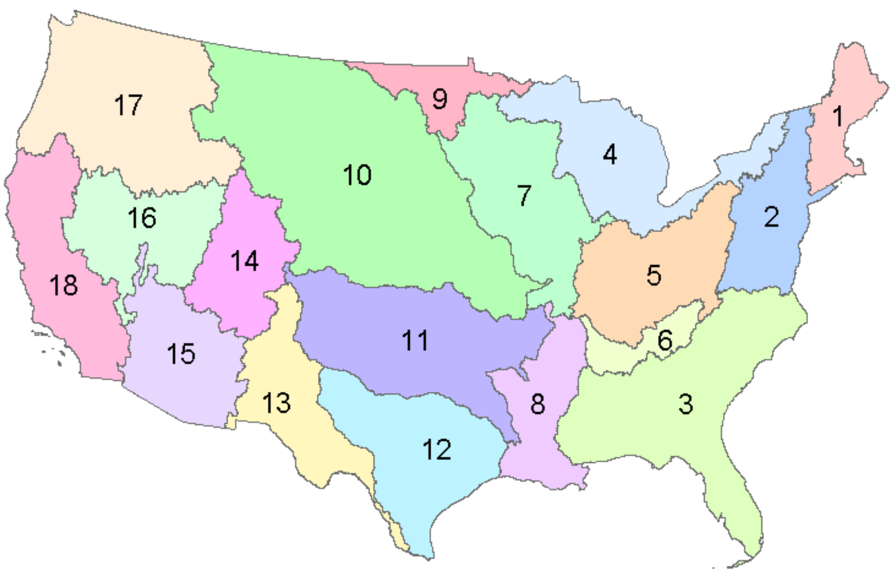


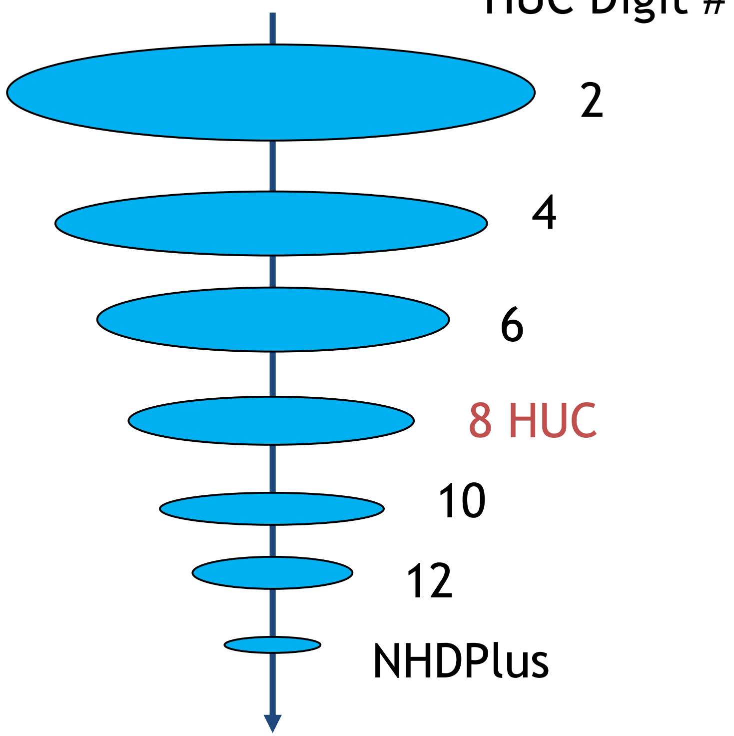
Knowledge for Life

Watershed Hierarchy

- National Program by USGS and USDA-NRCS
- Hydrologic Unit Code, or HUC, is used to identify specific watersheds at different scales
- The number of digits in a HUC indicates the relative size of the watershed
- Large watersheds are comprised of smaller or "nested" watersheds

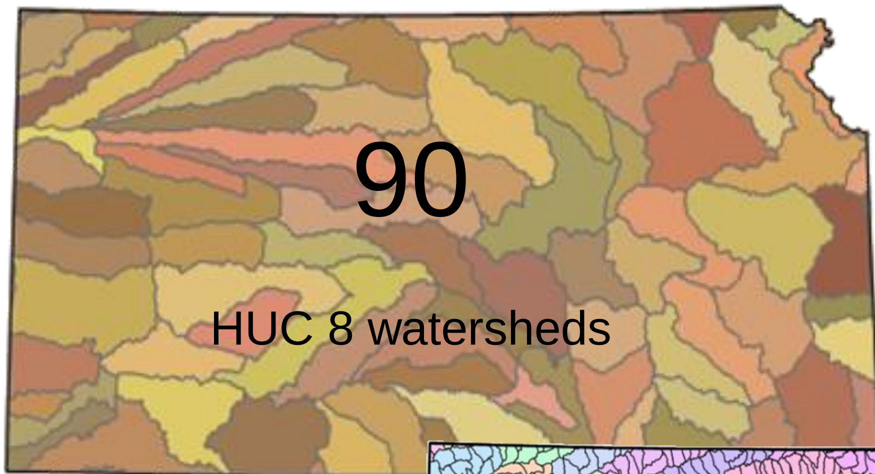
HUC-2

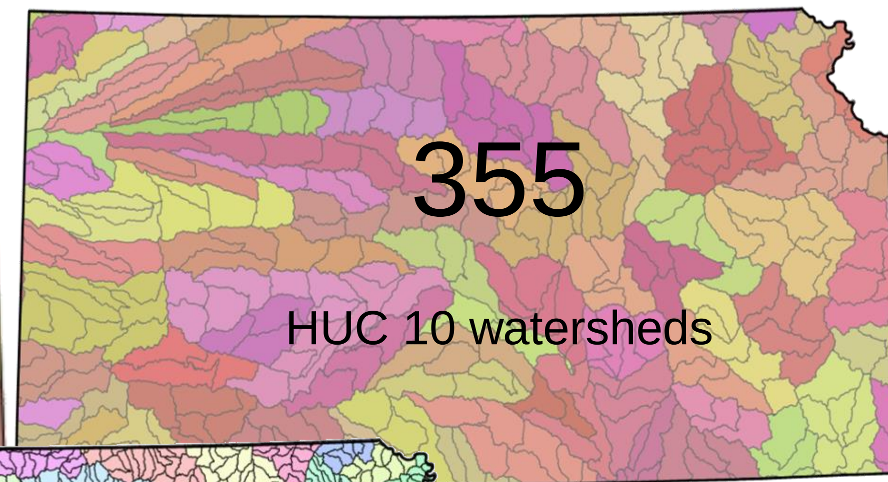




Knowledge for Life

HUCs in Kansas





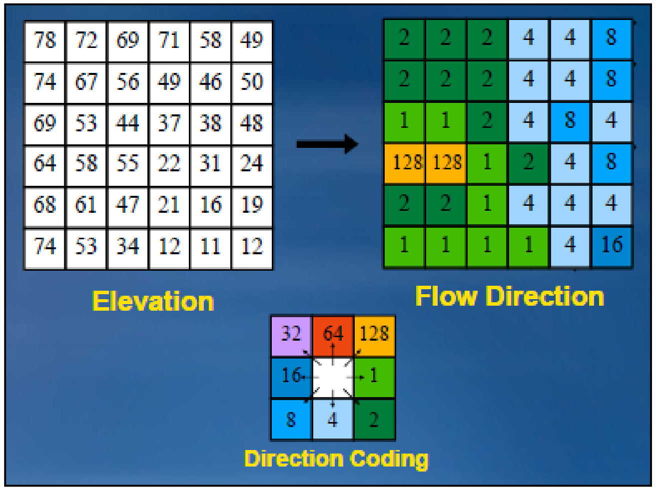
Watershed Delineation

- Process of defining watersheds called *delineation*
- Watersheds can be delineated using GIS
- Digital Elevation Model (DEM) required as input
- Sources of DEM (raster files):
  – USGS DEM, NED, …
    - http://viewer.nationalmap.gov/viewer/
    - http://www.kansasgis.org
    - http://datagateway.nrcs.usda.gov
  – Compiled from contour maps
  – Interpolated from points and lines
  – Generated photogrammetrically

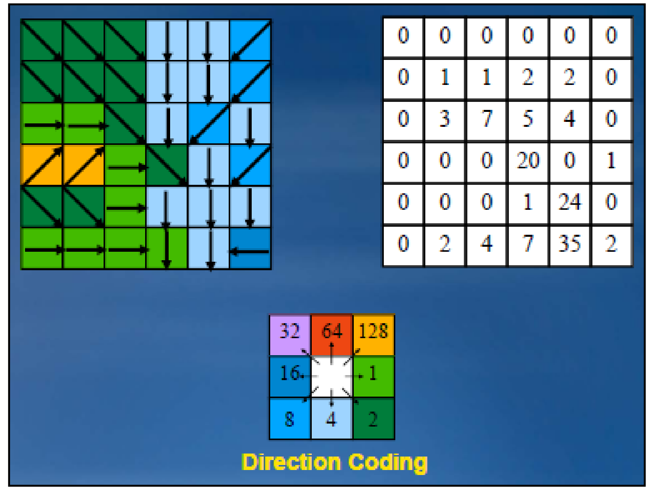
K·STATE
Research and Extension

Watershed Delineation Steps

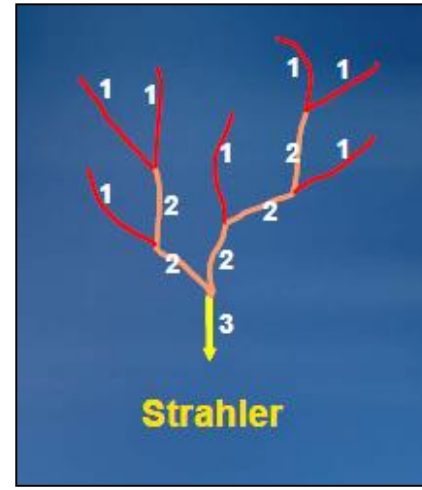
Flow direction



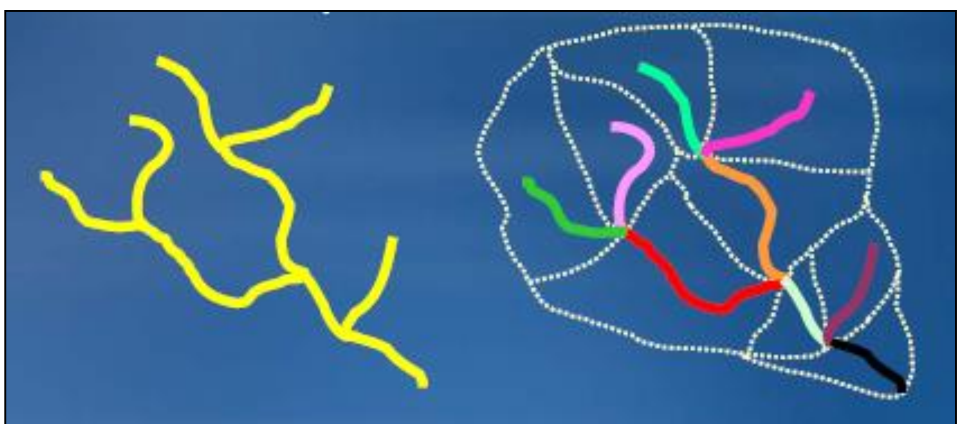
Flow accumulation

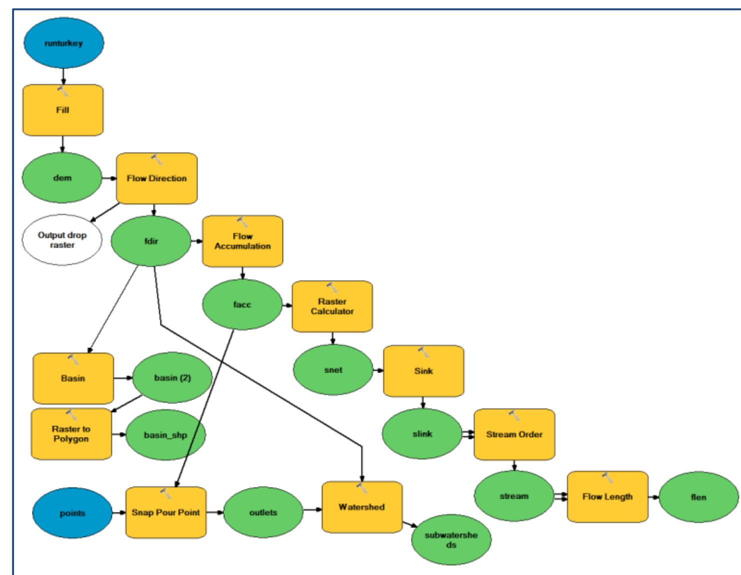


Stream network



Watershed system

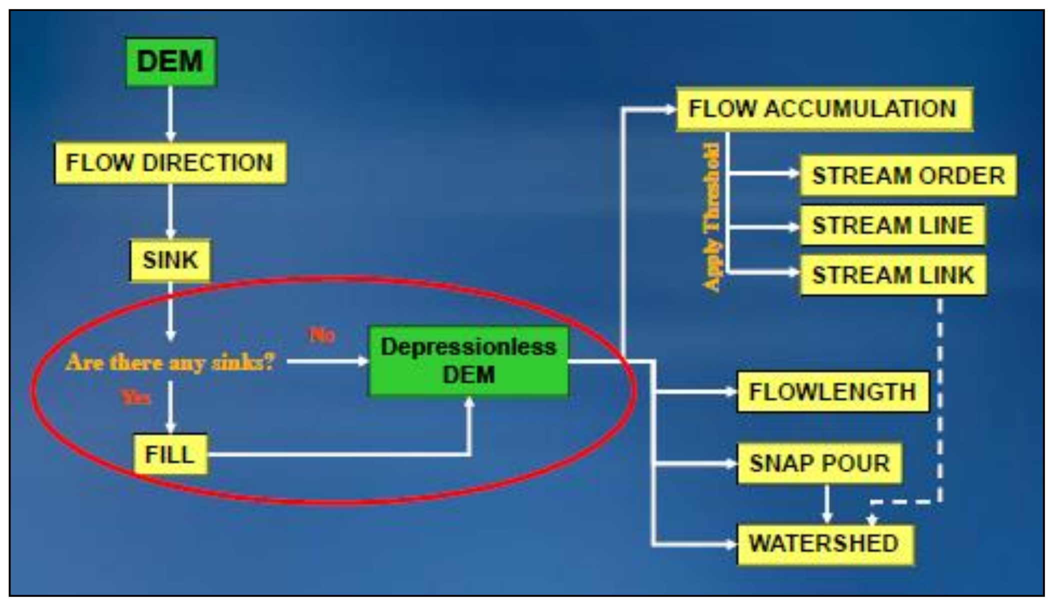




Knowledge for Life

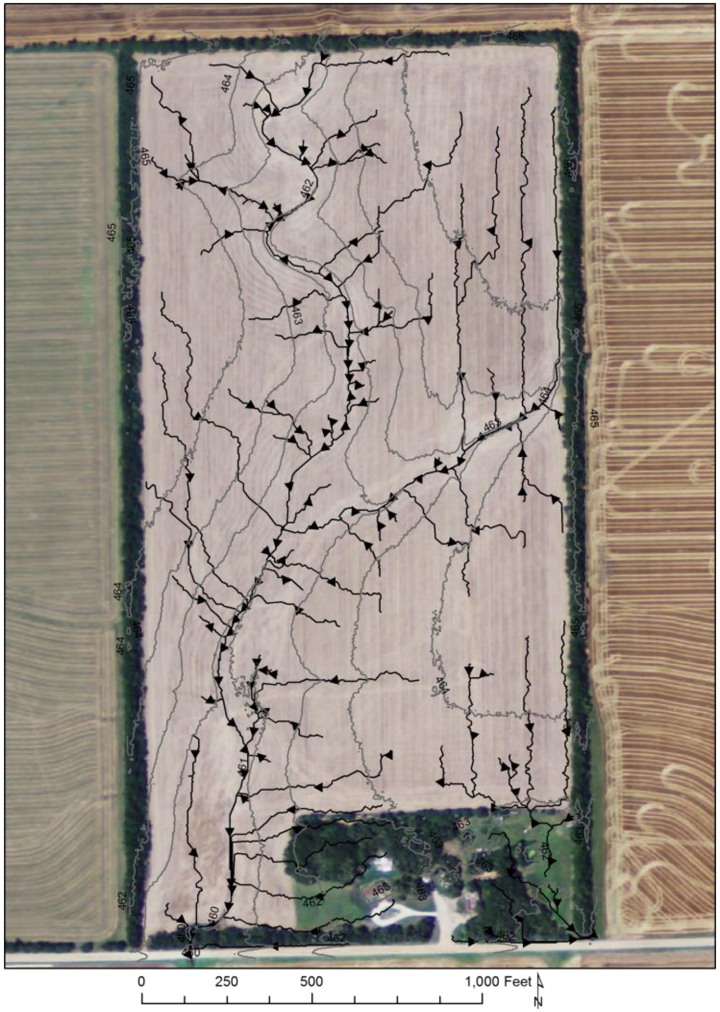
GIS and Delineation Tools

- GIS Tools
  - ArcGIS Spatial Analyst Toolbox
  - ArcGIS ArcHydro Toolbox
  - ArcSWAT
  - BASINS
  - QGIS Delineation Toolset
  - …



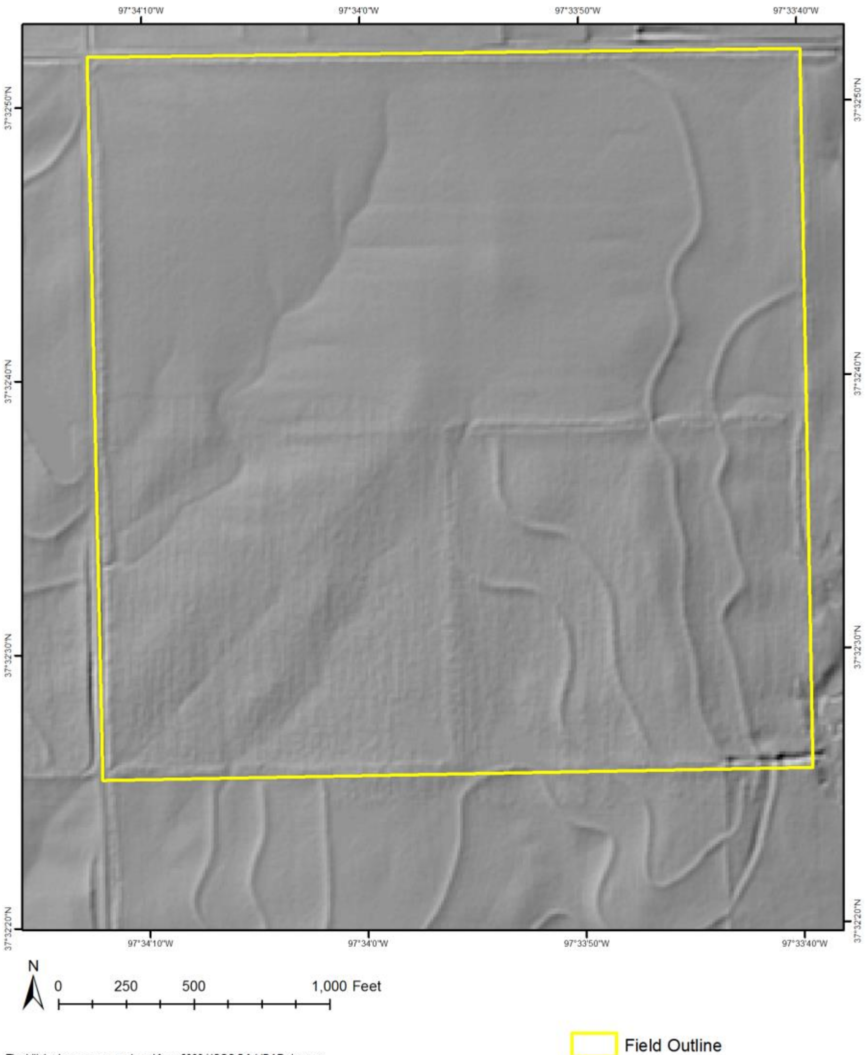
Examples and applications

- Delineated watershed and catchments
- Created streams
- Identified areas of swale
- Identified potential areas for erosion
- Identified potential terraces and diversions



Example: Flow Drainage Pathways

Background contains imagery from the USDA National Agriculture Imagery Program (NAIP) of 2014. Image was published on 17 September, 2014.

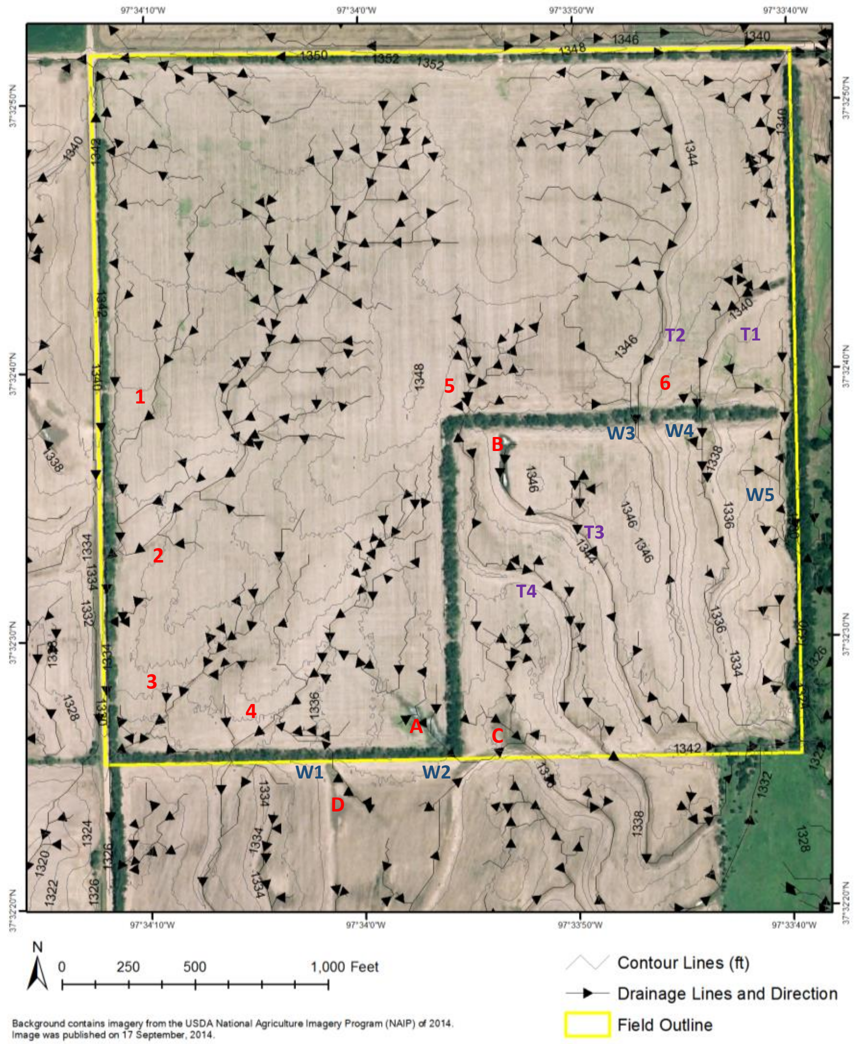


The hillshade map was produced from 2008 USGS 5-ft LiDAR dataset.

Example: Flow Drainage Pathways

Before

After



HYDROLOGIC CYCLE. WATER BUDGET. SURFACE RUNOFF.

K·STATE Research and Extension

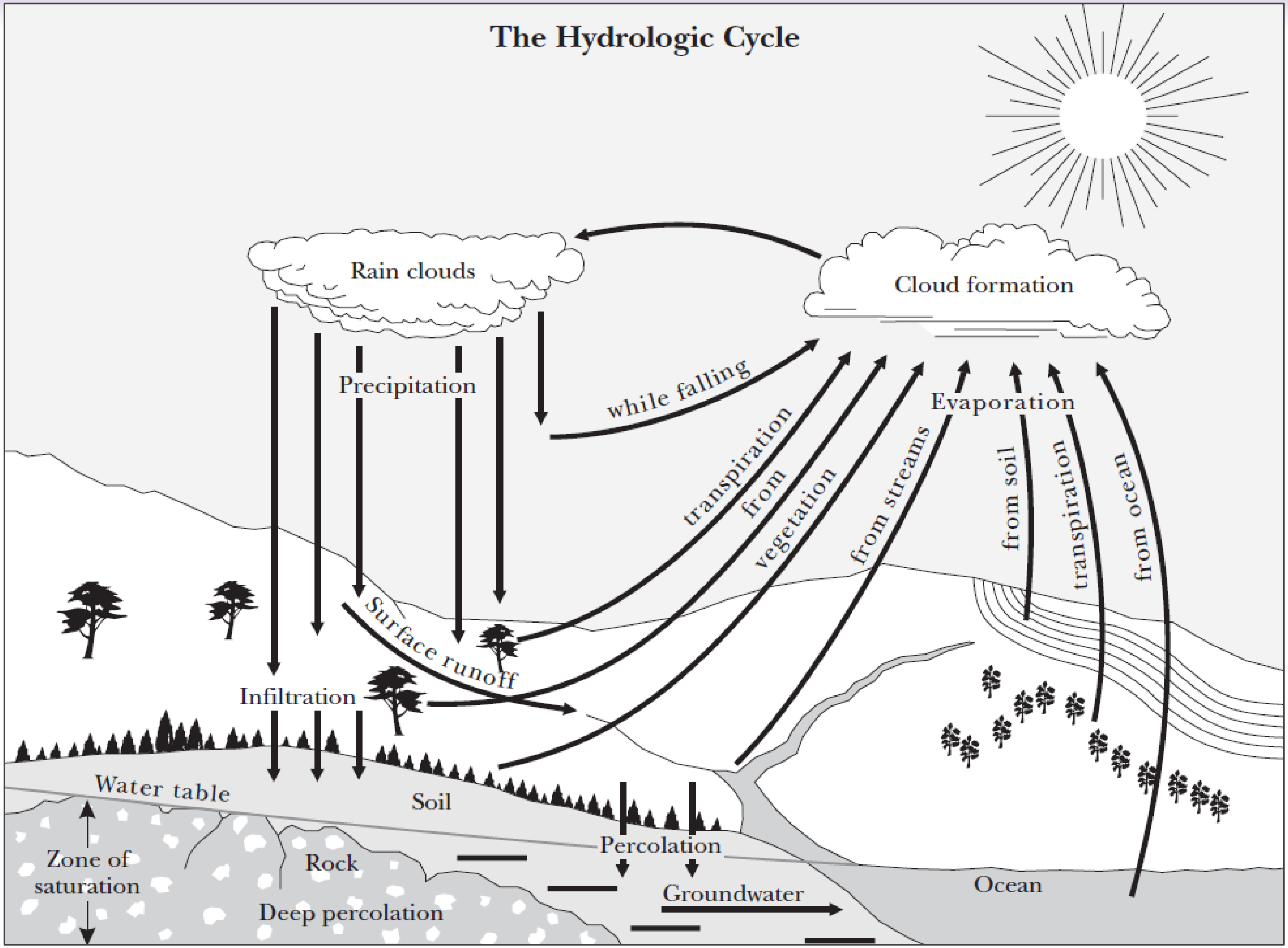
Distribution of Earth's Waters

Location of storage	Total water (acre-feet)	% of total	% of fresh water	Residence time (years)
Total water on earth	1.033×10^{15}	100.0		
Oceans	1.0×10^{15}	96.8		
Total Fresh Water	3.314×10^{13}	3.2	100.0	6,977
Ice and Glaciers	2.475×10^{13}		75.4	5,210
Groundwater Deep	4.62×10^{12}		14.0	973
Groundwater Shallow	3.63×10^{12}		11.0	764
Lakes	9.9×10^{10}		0.3	21
Biosphere	8.1×10^{10}		0.24	17.1
Soil Moisture	1.98×10^{10}		0.06	4.2
Atmosphere	1.155×10^{10}		0.035	2.4
Rivers	9.9×10^{10}		0.003	2.1

Residence time (yr) = total amount stored (volume) / total annual inflow (volume/yr)

Knowledge *for* Life

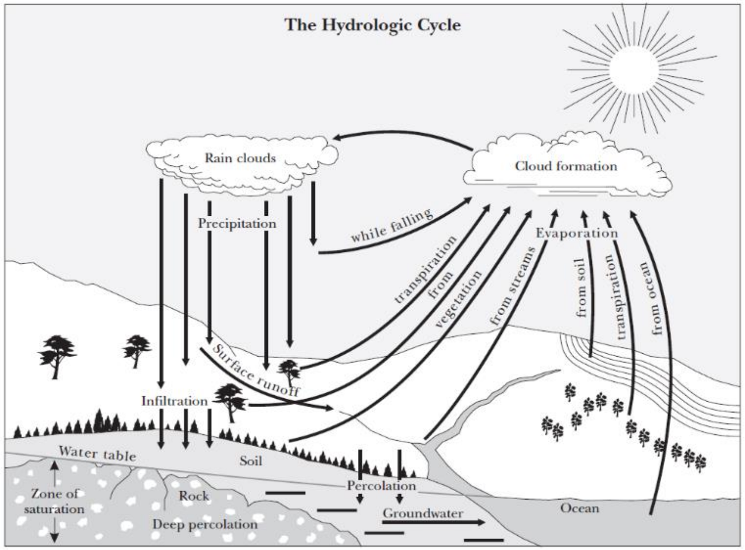
The Hydrologic Cycle



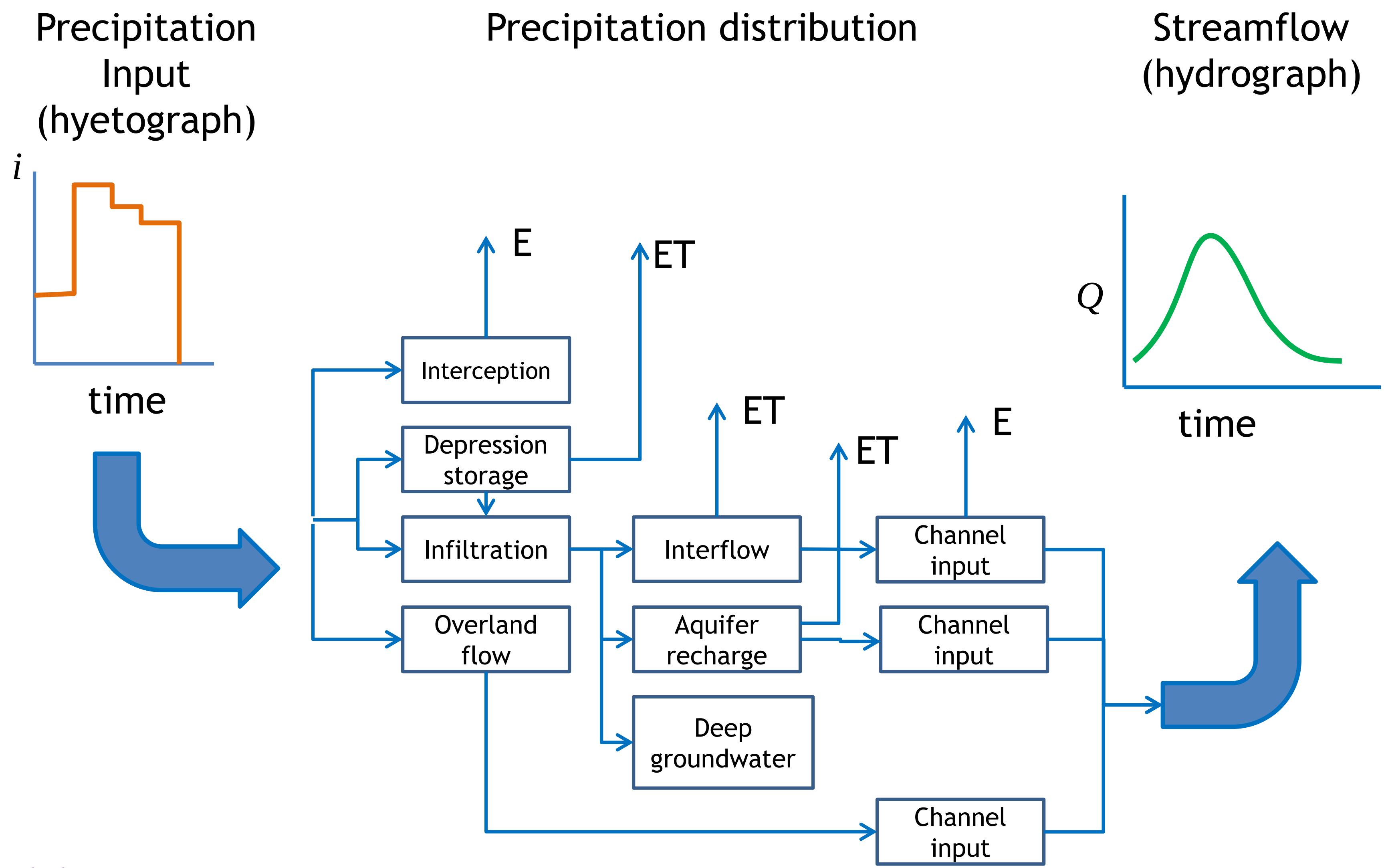
From: 1955 Yearbook of Agriculture, USDA

Hydrologic Cycle Components

- Precipitation
  - rain, snow, hail, freezing rain, fog, etc…
- Depression storage / Interception
- Infiltration / Interflow
- Percolation / Aquifer recharge
- Overland flow / Surface runoff
- Baseflow / Deep groundwater
- Channel flow



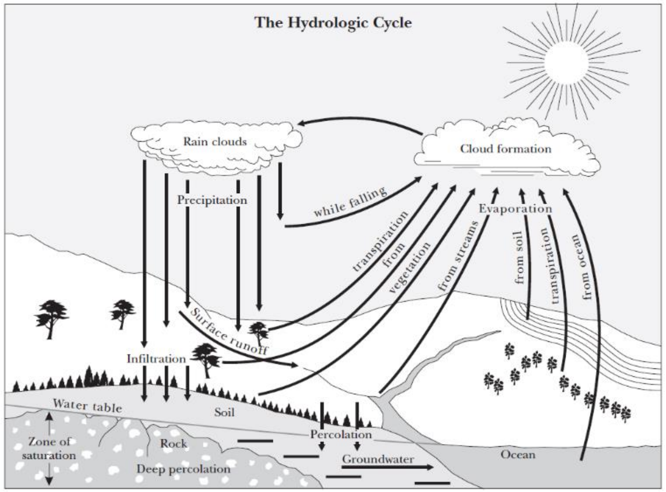
Distribution of Precipitation Input



The Water Budget

$$PR - RO - GW - ET = \Delta S$$

- PR – precipitation
- RO – surface runoff
- GW – groundwater flow
- ET – evapotranspiration
- ΔS – change in storage



Surface Runoff Types

What causes water to run across the soil rather than into it?

- Infiltration Excess Runoff
  - Rainfall rate exceeds soil Infiltration capacity.
    - Areal source of runoff tends to be widespread
    - More common in
      - arid/semi arid regions
      - areas with disturbed soil
      - areas with sparse vegetation
    - Function of storm, soil permeability
  - Modeled by CN Method.

- Saturation Excess Runoff
  - Runoff occurs from saturated soil.
    - Source of runoff tends to be local, often lower in the landscape
    - Function of position on landscape, antecedent soil moisture
    - "Partial source-area" hydrology
  - Requires other modeling approach.

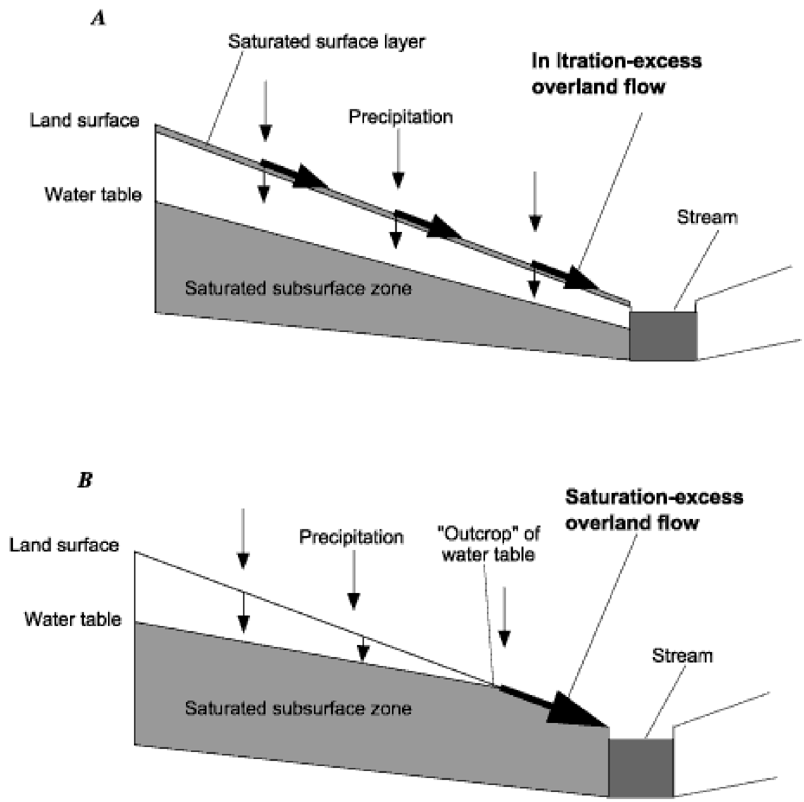


Figure 2. Schematic diagrams illustrating (A) infiltration-excess overland flow and (B) saturation-excess overland flow.

Surface Runoff

Surface Runoff Rate =

Rainfall Rate – Storage Rate

Storage (abstractions) are defined as those processes that remove rainfall from surface runoff:

Storage (Rainfall abstraction) rate =

Vegetative interception rate +

Depressional storage rate +

Infiltration rate +

Evaporation rate +

Other losses

Curve Number (CN) Model

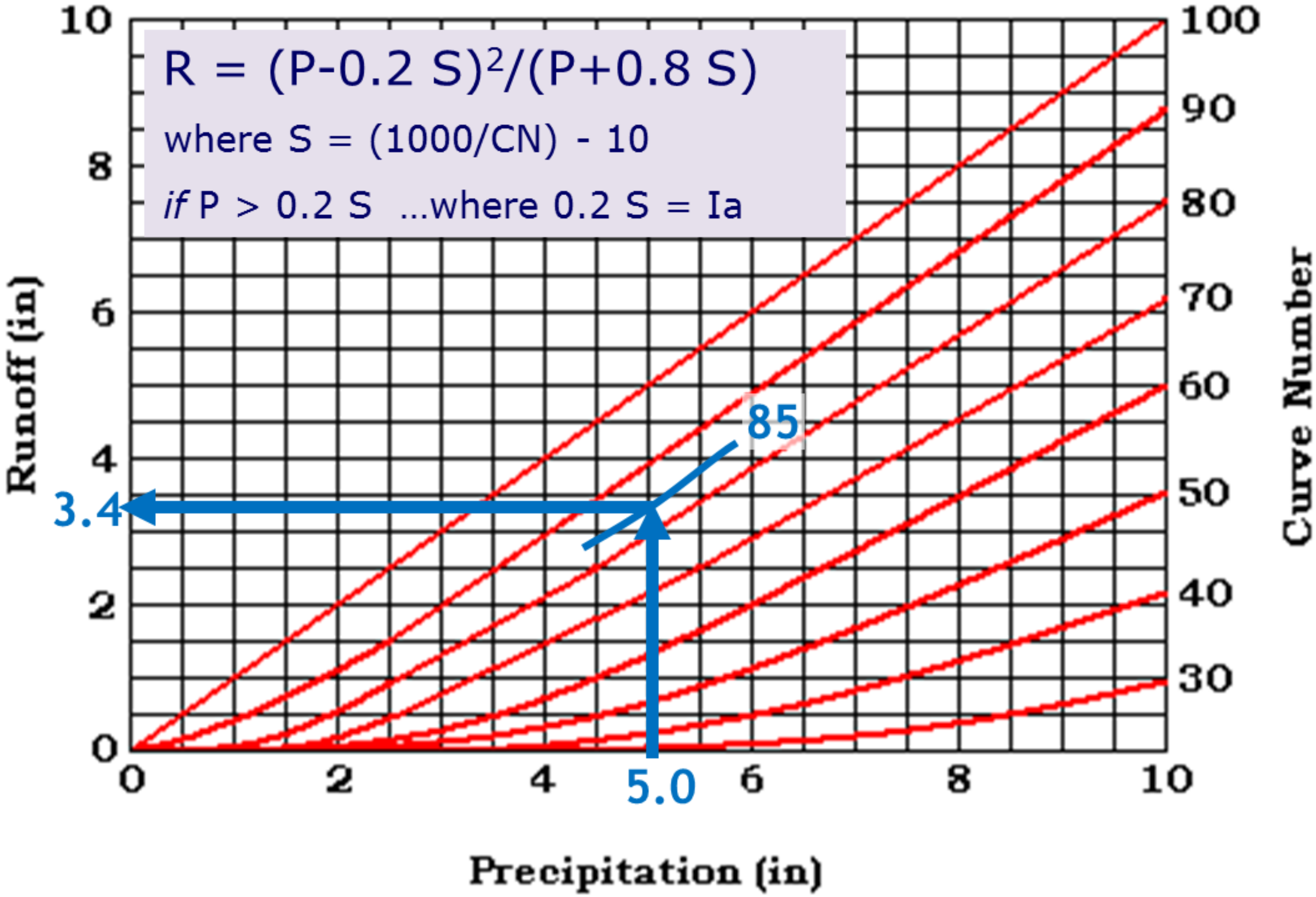
$$\boxed{RO = \frac{(PR - Ia)^2}{PR - Ia + S}}$$

- Where

$$\boxed{S = 1000/CN - 10}$$

- Value of CN found from table
- No surface storage: CN = 100 or S = 0
- No runoff: CN = 0 or S=infinity
- From experimental data: $I_a = 0.2\ S$

CN Method



- Find rainfall amount (in) → read up to CN → read left to find runoff (in)

CN Estimation

LAND USE	COVER TREATMENT OR PRACTICE	HYDROLOGIC CONDITION	HYDROLOGIC SOIL GROUP A	B	C	D
fallow	straight row		77	86	91	94
row crops	straight row	poor	72	81	88	91
	straight row	good	67	78	85	89
	contoured	poor	70	79	84	88
	contoured	good	65	75	82	86
	contoured and terraced	poor	66	74	80	82
	contoured and terraced	good	62	71	78	81
small grain	straight row	poor	65	76	84	88
		good	63	75	83	87
	contoured	poor	63	74	82	85
		good	61	73	81	84
	contoured and terraced	poor	61	72	79	82
		good	59	70	78	81
close-seeded	straight row	poor	66	77	85	89
legumes	straight row	good	58	72	81	85
or	contoured	poor	64	75	83	85
rotation	contoured	good	55	69	78	83
meadow	contoured and terraced	poor	63	73	80	83
	contoured and terraced	good	51	67	76	80
pasture or range		poor	68	79	86	89
		fair	49	69	79	84
		good	39	61	74	80
	contoured	poor	47	67	81	88
	contoured	fair	25	59	75	83
	contoured	good	6	35	70	79
meadow		good	30	58	71	78
woods		poor	45	66	77	83
		fair	36	60	73	79
		good	25	55	70	77
farmsteads			59	74	82	86
roads (dirt)			72	82	87	89
roads (hard surface)			74	84	90	92

Land Use:

- What is covering the ground?

Treatment or Practice:

- How is cover managed?

Hydrologic Condition:

- How well does the land use protect the ground?

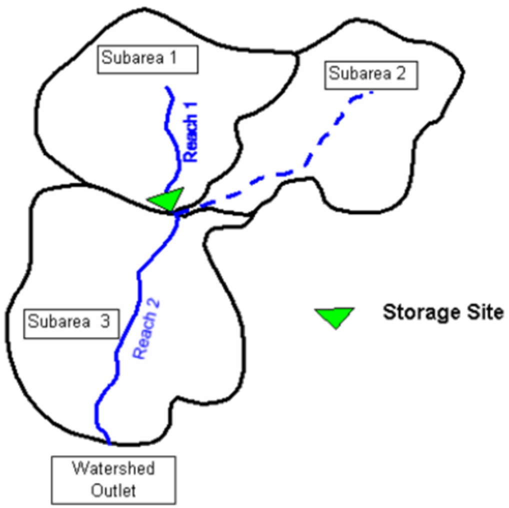
Hydrologic Soil Group: How much runoff (infiltration) does the soil allow?

  - A: high infiltration (low runoff)
  - D: low infiltration (high runoff)

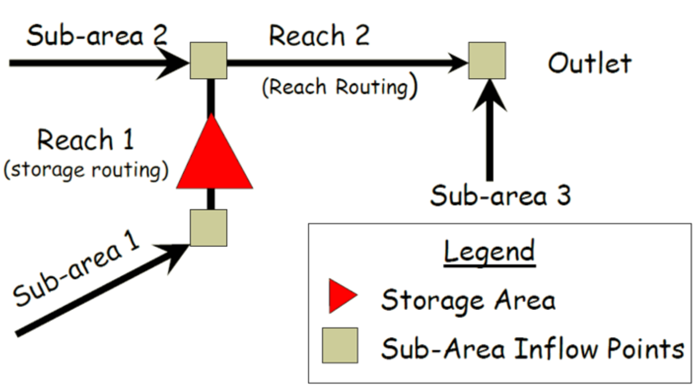
Watershed Models

- Watershed model is a representation of an environmental system through the use of mathematical equations
- Model types
  - Physically-based vs. lumped (mechanistic vs. empirical)
  - Field scale vs watershed scale (small single area vs. multi-area basin)
  - Continuous vs. event-based

Watershed system



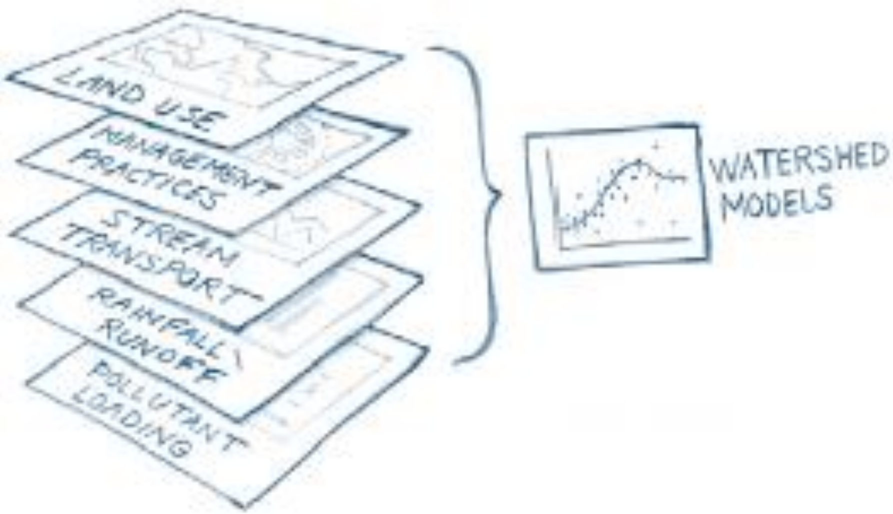
Model schematic



Knowledge for Life

Input to Watershed Models

- Weather data
  - Precipitation, Temperature, Relative humidity, Solar radiation, etc
- Soil type distribution within the watershed
- Topography
- Land Use / Land Cover
- Hydrography / Stream channel network
- Monitoring data
- Land management
- Other items?



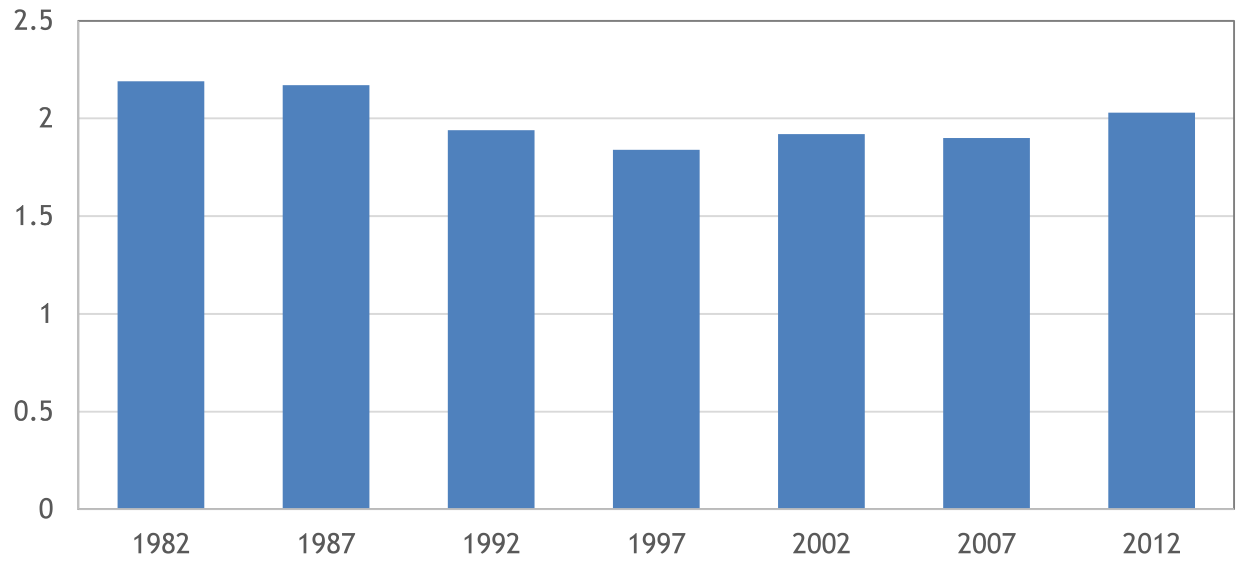
Examples and Applications

- Models
  - WinTR-55; TR-20
  - SWAT; APEX; HSPF; AGNPS
  - STEPL; Region-5; L-THIA; RUSLE
- Applications
  - Runoff analysis
  - Watershed assessment
  - Sources of NPS

SOIL EROSION AND TYPES. EROSION PROCESSES. EROSION FACTORS.

What is Soil Erosion?

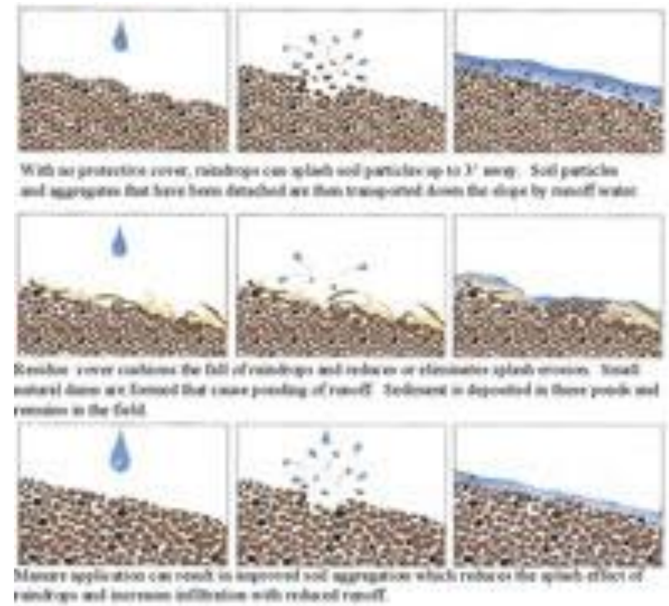
- **Soil erosion by water** is the process of detachment and transport of soil from land by water flow.
- Forms of soil erosion
- **Sheet & rill erosion rates in Kansas (in tons/acre/year)**

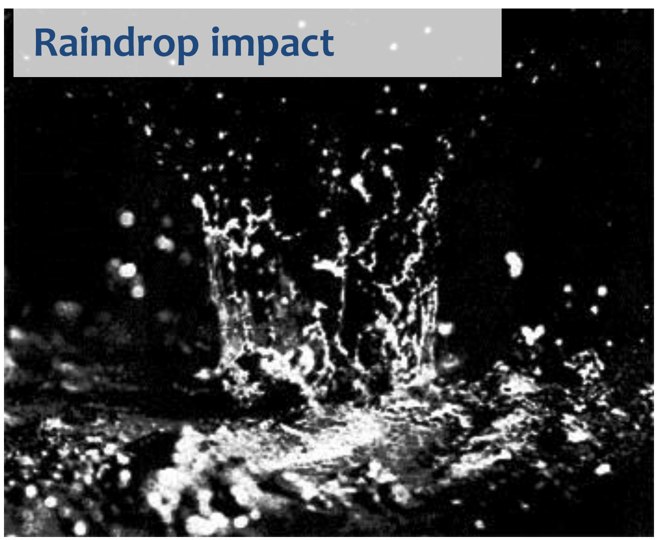


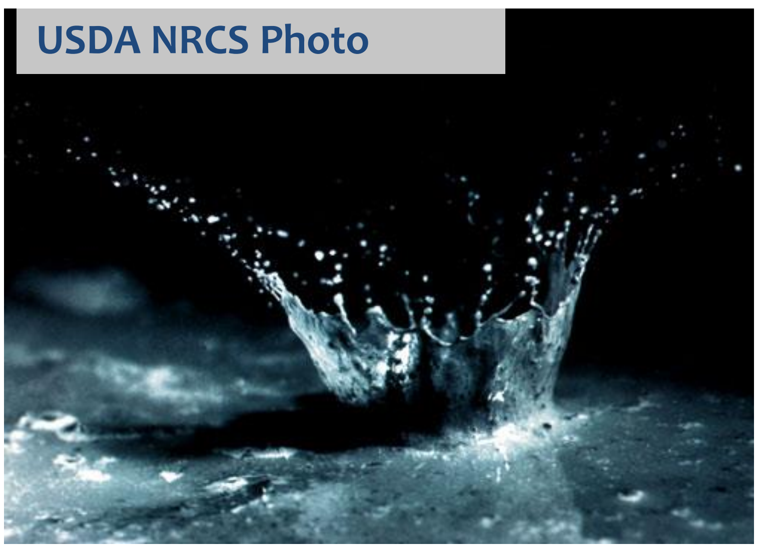
National Resources Inventory: http://www.nrcs.usda.gov/Internet/NRCS_RCA/reports/nri_eros_ks.html

Splash Erosion

- **Splash erosion**
  - Dislodges soil particles
  - Breaks soil particles into smaller pieces that are more-easily transported
  - Seals surface, which reduces infiltration





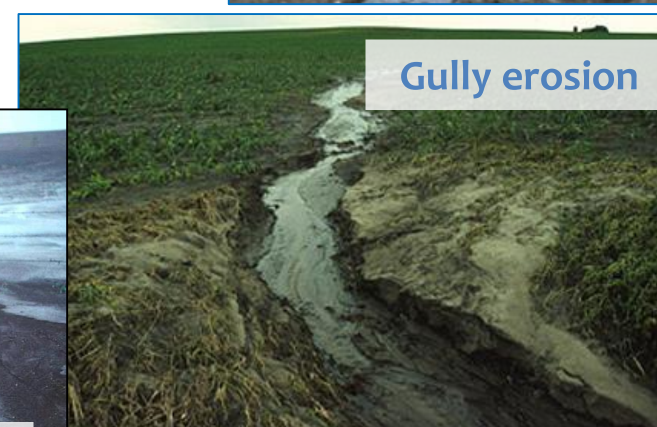


Knowledge for Life

K·STATE Research and Extension

Four Major Forms

- **Sheet (interrill) erosion**
  - Small, nondistinct rills
- **Rill erosion**
  - Larger rills (flow paths over soil)
- **Ephemeral gully erosion**
  - Larger channels, removed by tillage
- **(Classical) gully erosion**
  - Larger channels, <u>not</u> removed by tillage



Knowledge for Life

Other Erosion Forms

- **Channel erosion**
  - Streambank
  - Channel bed
  - Can be significant

Sediment Deposition

- **Where sediment can be deposited?**
  - Riparian buffers
  - Grass waterways
  - Channel bed
  - Ponds, Wetlands

Riparian buffers

K-STATE Research and Extension

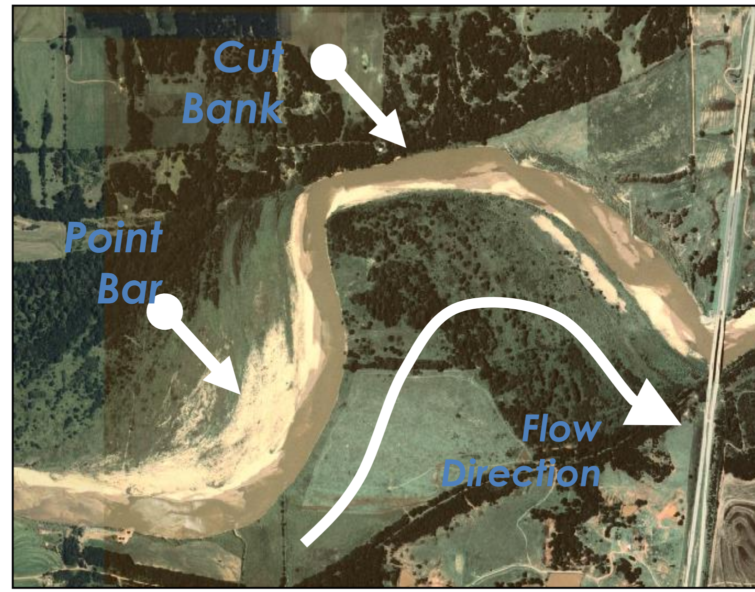
Sediment Deposition

- **Where sediment can be deposited?**
  - Riparian buffers
  - Grass waterways
  - Channel bed
  - Ponds, Wetlands

K·STATE
Research and Extension

Sediment Delivery

- **Deposition of sediment**
  - Riparian buffers
  - Grass waterways
  - Channel bed
  - Ponds, Wetlands
- Net delivery rate:
  (Holland, 1971, Fig. 5)
  - 58% (0.1 mi^2 watershed)
    to 22% (10 mi^2 watershed)
  - Larger watersheds give
    more opportunity for settling



Riparian buffer

Slow water:
Channel deposition

K·STATE
Research and Extension

Erosion Factors

Features	Rill erosion	Ephemeral gully erosion	Classical gully erosion
Tillage	Rills can be erased by tillage; Rills usually do not occur in the same places	Ephemeral gullies are temporary channels; Ephemeral gullies can be obscured by tillage; Ephemeral gullies recur in the same location	Classical gullies cannot be obscured by normal tillage operations
Size	May be of any size but are smaller than ephemeral gullies	May be of any size but are larger than rills and smaller than permanent gullies	Larger than ephemeral gullies
Geometry	Cross sections tend to be narrow relative to depth	Cross sections tend to be wide relative to depth; sidewalls frequently are not well defined; headcuts are usually not readily visible and are not prominent because of tillage	Cross sections of many gullies tend to be narrow relative to depth; sidewalls are steep; headcut usually prominent
Flow pattern	Flow pattern develops as many small disconnected parallel channels ending at ephemeral cropland gullies, terrace channels, or where deposition occurs; Rills are generally uniformly spaced and sized	A dendritic pattern develops along depressional water courses, beginning where overland flow, including rills, converge; Flow patterns may be influenced by tillage, crop rows, terraces, or other unnatural features	A dendritic pattern develops along natural water courses; Non-dendritic patterns may occur in road ditches, terrace, or diversion channels
Location	Rills occur on smooth side slopes above drainageways	Occur along shallow drainageways upstream from incised channels or gullies	Generally occurs in well-defined drainageways
Soil removal	Soil is removed in shallow channels but annual tillage causes the soil profile to become thinner over the entire slope	Soil is removed along a narrow flow path, typically to the depth of the tillage layer where the untilled layer is resistant to erosion, or deeper where the untilled layer is less resistant; soil is moved into the voided area from adjacent land by mechanical action (tillage) and rill erosion, damaging an area wider than the eroded channel	Soil may be eroded to depth of the profile and can erode into soft bedrock

Erosion Factors

- Erosion depends on several factors
  - Storm energy
  - Soil erodibility
  - Topography
  - Land cover
  - Land management

USLE–Universal Soil Loss Eq.

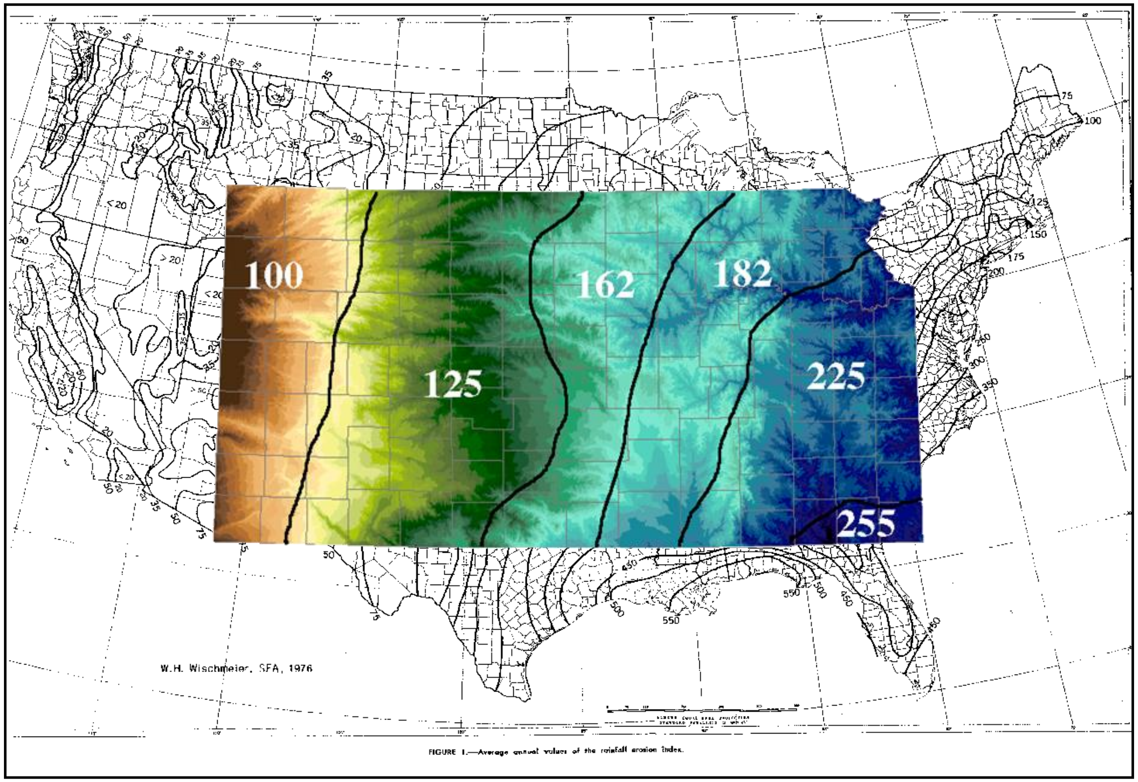
- USLE developed by USDA Soil Conservation Service
  - Published in 1965
  - Based on data collected from 1930s
  - Annual soil loss, A (tons/yr):

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

- USLE includes several factors
  - Storm energy – **R**
  - Soil erodibility – **K**
  - Topography – **LS**
  - Land cover – **C**
  - Land management – **P**

Rainfall: USLE–R Factor

- Rainfall depth and intensity pattern controls runoff dynamics during rainfall events.
  - Higher the intensity and larger rainfall depth, more water can flow on the surface and higher potential for soil erosion.
  - The timing of rainfall (spring or winter when soil is bare) can cause more soil movement



Soil: USLE–K Factor

- Soil allows water to drain and controls runoff.
  - More silty soils are less cohesive and produce higher erosion rates.
  - Soil moisture can prevent infiltration and cause higher runoff.
  - Subsurface flow toward gullies makes soils less cohesive.

- USLE-K factor available for every soil type in U.S.
  - Soil Texture, Organic Matter
  - 324 soil types in Kansas

TABLE 1.—*Computed* K *values for soils on erosion research stations*

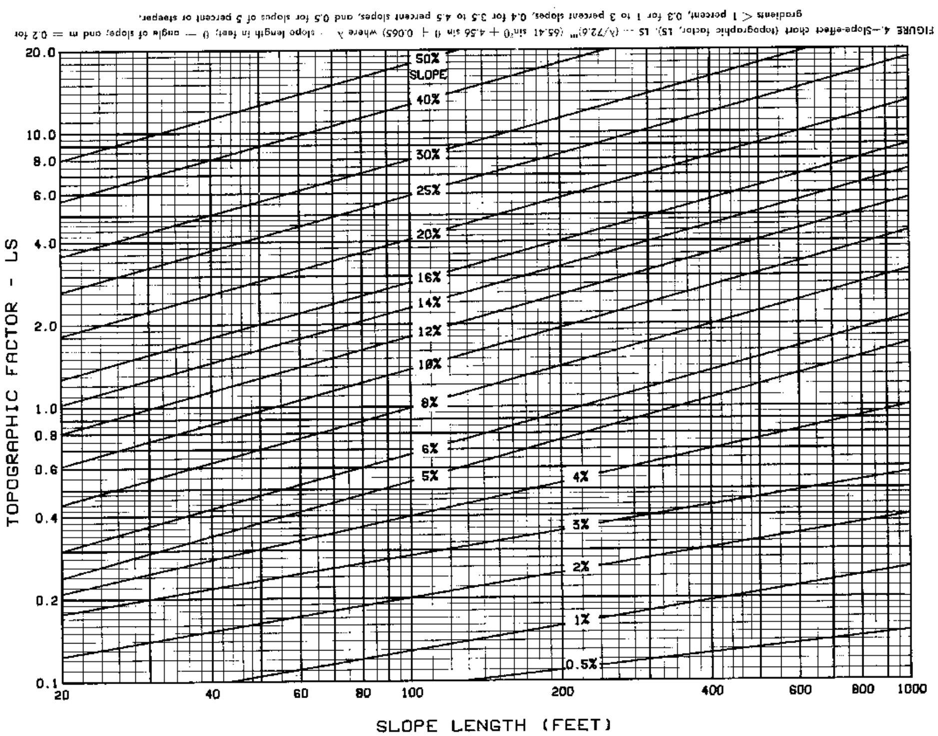
Soil	Source of data	Computed K
Dunkirk silt loam	Geneva, N.Y.	[1]0.69
Keene silt loam	Zanesville, Ohio	.48
Shelby loam	Bethany, Mo.	.41
Lodi loam	Blacksburg, Va.	.39
Fayette silt loam	LaCrosse, Wis.	[1].38
Cecil sandy clay loam	Watkinsville, Ga.	.36
Marshall silt loam	Clarinda, Iowa	.33
Ida silt loam	Castana, Iowa	.33
Mansic clay loam	Hays, Kans.	.32
Hagerstown silty clay loam	State College, Pa.	[1].31
Austin clay	Temple, Tex.	.29
Mexico silt loam	McCredie, Mo.	.28
Honeoye silt loam	Marcellus, N.Y.	[1].28
Cecil sandy loam	Clemson, S.C.	[1].28
Ontario loam	Geneva, N.Y.	[1].27
Cecil clay loam	Watkinsville, Ga.	.26
Boswell find sandy loam	Tyler, Tex.	.25
Cecil sandy loam	Watkinsville, Ga.	.23
Zaneis fine sandy loam	Guthrie, Okla.	.22
Tifton loamy sand	Tifton, Ga.	.10
Freehold loamy sand	Marlboro, N.J.	.08
Bath flaggy silt loam with surface stones > 2 inches removed	Arnot, N.Y.	[1].05
Albia gravelly loam	Beemerville, N.J.	.03

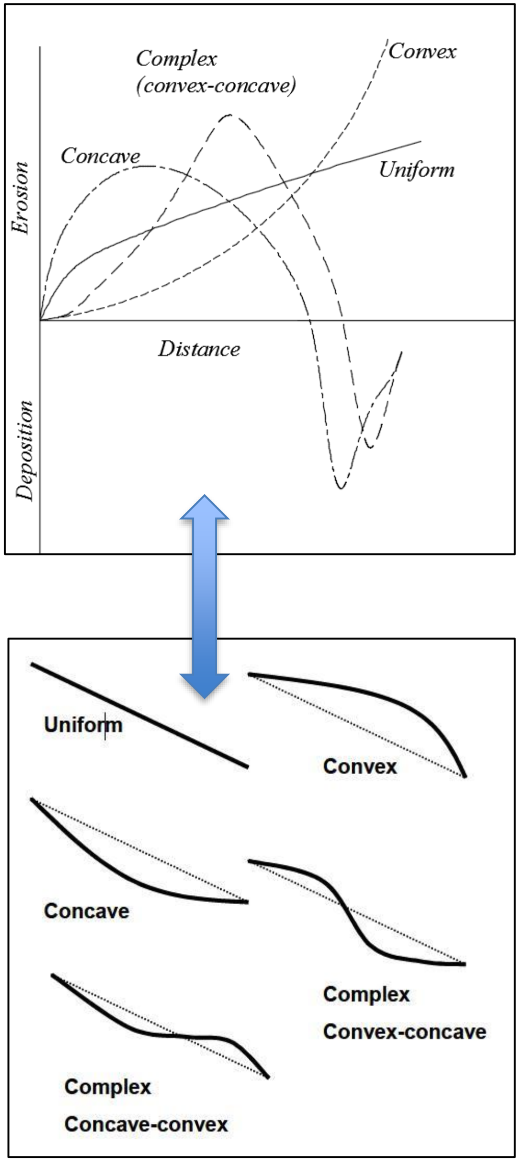
[1] Evaluated from continuous fallow. All others were computed from rowcrop data.

K·STATE
Research and Extension

Topography: USLE–LS Factor

- Slope shape plays an important role in overland flow converging from sheet flow to concentrated flow.
- Slope length and steepness determines areas of soil erosion and soil detachment.





Knowledge for Life

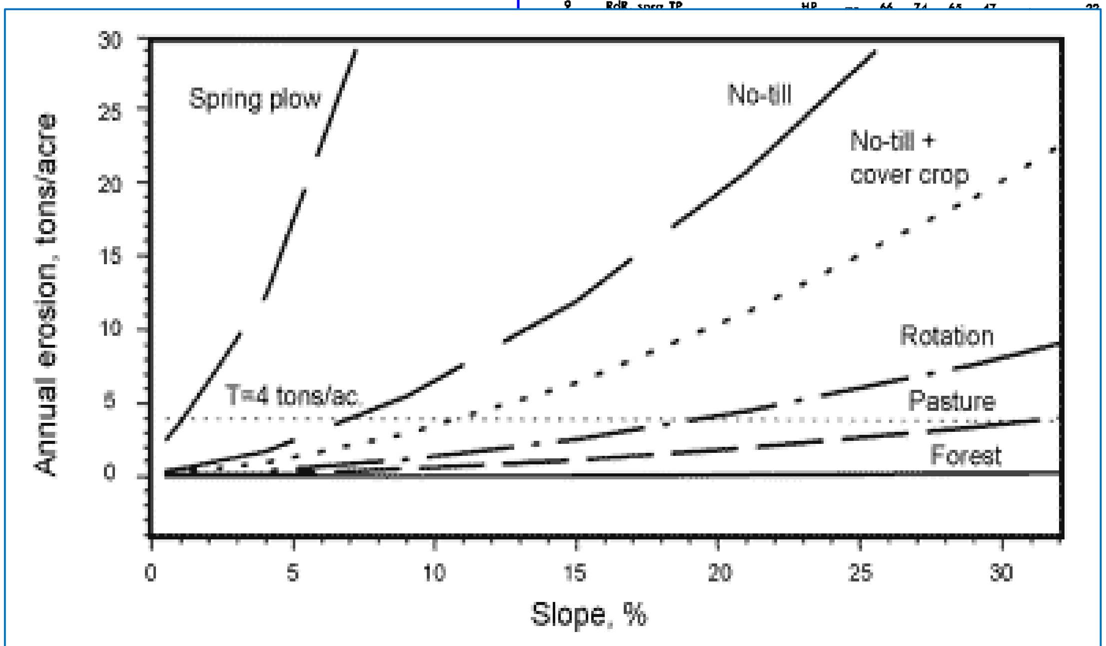
Land Cover: USLE–C Factor

- USLE-C factor is the ratio of soil loss from land cropped under specified conditions to corresponding loss under tilled, continuous fallow conditions.
- Management decisions about crop rotation and tillage system affect C.

TABLE 5.—*Ratio of soil loss from cropland to corresponding loss from continuous fallow*

Line No.	Cover, crop sequence, and management[1]	Spring residue[2]	Cover after plant[3]	F	SB	1	2	3:80	90	96	4L[6]
		Lb	Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct
	CORN AFTER C, GS, G OR COT IN MEADOWLESS SYSTEMS										
	Moldboard plow, conv till:										
1	RdL, sprg TP	4,500	—	31	55	48	38	··	—	20	23
2		3,400	—	36	60	52	41	—	24	20	30
3		2,600	—	43	64	56	43	32	25	21	37
4		2,000	—	51	68	60	45	33	26	22	47
5	RdL, fall TP	HP[2]	—	44	65	53	38	—	—	20	—
6		GP	—	49	70	57	41	—	24	20	—
7		FP	—	57	74	61	43	32	25	21	—
8		LP	—	65	78	65	45	32	26	22	—
9	RdR, sprg TP	HP	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	56
											62
											69
											74
											—
											—
											—
											—
											23
											30
											37
											47
											23
											30
											37
											47
											14
											14
											15
											19
											23
											27
											30
											36
											17
											17
											18
											19
											20
											21
											18
											18
											19
											20
											21
											22

Line No.	Cover, crop sequence, and management[1]	Spring residue[2]	Cover after plant[3]	F	SB	1	2	3:80	90	96	4L[6]
		Lb	Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct
	CORN AFTER WC OF RYEGRASS OR WHEAT SEEDED IN C STUBBLE										
	WC reaches stemming stage:										
79	No-till pl in killed WC	4,000	—	—	7	7	7	·	7	6	(13)
80		3,000	—	—	11	11	11	11	9	7	
81		2,000	·	—	15	15	14	14	11	9	
82		1,500		—	20	19	18	18	14	11	
	Strip till one-fourth row space										
83	Rows U/D slope	4,000	—	—	13	12	11	—	11	9	(13)
84		3,000	·		18	17	16	16	13	10	
85		2,000	· ·	—	23	22	20	19	15	12	
86		1,500	—	—	28	26	24	22	17	14	
87	Rows on contour[11]	4,000		·	10	10	10	—	10	8	(13)
88		3,000	·	—	15	15	15	15	12	9	
89		2,000	—	—	20	20	19	19	15	12	
90		1,500	—	—	25	24	23	22	17	14	
91	TP, conv seedbed	4,000	—	36	60	52	41	—	24	20	(13)
92		3,000	—	43	64	56	43	31	25	21	
93		2,000	—	51	68	60	45	33	26	22	
94		1,500	—	61	73	64	47	35	27	23	
	WC succulent blades only:										
95	No-till pl in killed WC	3,000	—	—	11	11	17	23	18	16	(13)
96		2,000	—	—	15	15	20	25	20	17	
97		1,500	—	·	20	20	23	26	21	18	
98		1,000	—	·	26	26	27	27	22	19	
99	Strip till one-fourth row space	3,000	—	—	18	18	21	25	20	17	(13)
100		2,000	—	—	23	23	25	27	21	18	
101		1,500	—	—	28	28	28	28	22	19	
102		1,000	—	—	33	33	31	29	23	20	
	CORN IN SOD-BASED SYSTEMS										
	No-till pl in killed sod:										
103	3 to 5 tons hay yld	—	—	—	1	1	1	—	1	1	1
104	1 to 2 tons hay yld	—	—	—	2	2	2	2	2	2	2
	Strip till, 3-5 ton M:										
105	50 percent cover, tilled strips	·		—	2	2	2	—	2	2	4
106	20 percent cover, tilled strips	—	—	—	3	3	3	—	3	3	5
	Strip till, 1-2 ton M:										
107	40 percent cover, tilled strips	—	—	—	4	4	4	4	4	4	6
108	20 percent cover, tilled strips	—	—	—	5	5	5	5	5	5	7
	Other tillage after sod:			(14)	(14)	(14)	(14)	(14)	(14)	(14)	(14)
	CORN AFTER SOYBEANS										
109	*Sprg TP, conv till*	HP	—	40	72	60	48	—	—	25	29
110		GP	—	47	78	65	51	—	30	25	37
111		FP	·	56	83	70	54	40	31	26	44
112	*Fall TP, conv till*	HP	·	47	75	60	48	—	—	25	—
113		GP	—	53	81	65	51	—	30	25	—
114		FP	—	62	86	70	54	40	31	26	—



USLE–P Factor

- Management practices that reduce the erosivity of water moving across slopes will reduce soil erosion.
- Contouring, strip-cropping, terraces, and grassed waterways are all examples of erosion control practices used to establish the USLE-P factor.

TABLE 14.—P values, maximum strip widths, and slope-length limits for contour stripcropping

Land slope percent	P values[1] A	P values[1] B	P values[1] C	Strip width[2]	Maximum length
				Feet	Feet
1 to 2	0.30	0.45	0.60	130	800
3 to 5	.25	.38	.50	100	600
6 to 8	.25	.38	.50	100	400
9 to 12	.30	.45	.60	80	240
13 to 16	.35	.52	.70	80	160
17 to 20	.40	.60	.80	60	120
21 to 25	.45	.68	.90	50	100

TABLE 15.—P values for contour-farmed terraced fields[1]

Land slope (percent)	Farm planning		Computing sediment yield[3]	
	Contour factor[2]	Stripcrop factor	Graded channels sod outlets	Steep backslope underground outlets
1 to 2	0.60	0.30	0.12	0.05
3 to 8	.50	.25	.10	.05
9 to 12	.60	.30	.12	.05
13 to 16	.70	.35	.14	.05
17 to 20	.80	.40	.16	.06
21 to 25	.90	.45	.18	.06

[1] Slope length is the horizontal terrace interval. The listed values are for contour farming. No additional contouring factor is used in the computation.

[2] Use these values for control of interterrace erosion within specified soil loss tolerances.

[3] These values include entrapment efficiency and are used for control of offsite sediment within limits and for estimating the field's contribution to watershed sediment yield.

USLE–Example

- Input

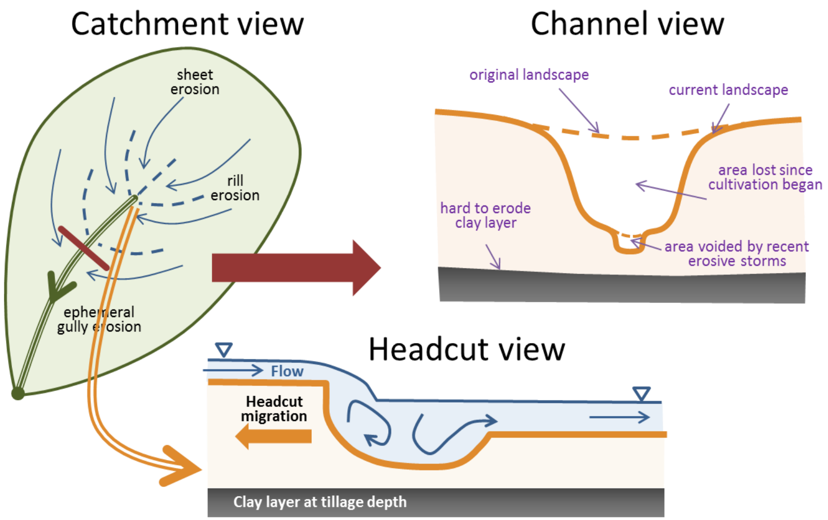
		Rangeland	Cropland
–	Manhattan – **R**	**190**	**190**
–	Clay loam soil – **K**	**0.21** (4% OM)	**0.25** (2%)
–	500 ft – **LS**	**1.2** (5%)	**0.5** (3%)
–	Crop cover – **C**	**0.04**	**0.30**
–	No terraces – **P**	**1.0**	**1.0**

A (tons/yr) = R K LS C P

- Rangeland: **A = 190 × 0.21 × 1.2 × 0.04 × 1.0 = 1.9 t/ac**
  - Construction (C = 1.0) → A = 47.9 t/ac !!
- Cropland: **A = 190 × 0.25 × 0.5 × 0.3 × 1.0 = 7.1 t/ac**
  - Add terraces (P = 0.5) → A = 3.5 t/ac (*erodes*)
  - Add terraces (P = 0.1) → A = 0.7 t/ac (*leaves field*)
  - Less slope (S = 2%, LS = 0.35) → A = 5.0 t/ac

Ephemeral Gullies

- ***Ephemeral gullies*** form in drainageways or where opposing slopes meet
  - Gullies are termed **ephemeral** because their occurrence is ephemeral, depending on rainfall and runoff conditions, the soil's resistance to erosion, and land use and treatment.
  - Normal farming practices may completely or partially fill gullies with sediment, but occasionally, gullies recur in the same place later in the year.



- Active ephemeral gullies are recognized by headcuts (initiation or nick points), where there is an abrupt change in elevation.
  - The channel below the headcut is formed by plunging flow and soil erosion, and reminds shallow river channels.
  - Secondary nickpoints may be located downstream due to sudden grade change, field management, or crop canopy.
  - Nick points travel upstream as gully system enlarges and expand in response to runoff flow and cover conditions

CONSERVATION PRACTICES TO CONTROL SURFACE RUNOFF AND EROSION

BMP Processes

- Reduce sediment availability
  - Amount, timing, placement
- Increase infiltration
  - Reduces runoff
  - Less runoff energy and reduced transport capabilities
- Reduce erosion
  - Reduces sediment yield
- Trap sediment in a structure
  - Detain water, sediment
- Stream processes?

BMPs for Cropland

- Runoff/Erosion Control
  - Conservation practices
    - (1) No-till or Conservation tillage (residue > 30%)
    - (10) Critical planting area (perennial plants in ↑ erodible land)
    - (2) Conservation farming (follow contour)
    - (5) Contour strip crop (2+alt. crop)
  - Conservation structures (“in-field”)
    - (3) Gradient terraces (drain toward waterway)
    - (4) Level terraces (hold water behind terrace)
  - Treatment structures (“between field and surface water”)
    - (6) Grass waterway (carries field runoff)
    - (7) VFS (between field and water)
    - (8) Constructed wetland (shallow water w/ plants)
    - (9) Sediment-control basin (detains water)

K·STATE
Research and Extension

CROP RESIDUES: Conservation tillage (residue > 30%)

WHEAT

25%

50%

75%

90%

CORN

25%

50%

75%

90%

Knowledge for Life

Contour Strip Cropping


Gradient terraces/Contour farming
Grass waterway (carries field runoff)

Vegetative Filter Strip (or Vegetative Buffer Strip)

Diversion

A diversion is a channel running across a slope that directs water to a safe discharge area.

Sediment basin

A temporary pond built on a site to capture eroded soil during rain storms

K·STATE
Rese

	Nutrients			Suspended Solids
	Soluble Phosphorus	Total Phosphorus	Nitrogen	
Conventional tillage				
Crop rotations	25	25	25	25
Establish vegetative buffer strips	25	50	35	50
Conservation tillage farming (>30 percent residue cover following planting)	0	35	15	30
No-till farming	0	40	25	75
Contour farming (without terraces)	20	30	20	35
Terraces with tile outlets	10	30	10	30
Terraces with grass waterways (with contour farming)	30	30	30	30
Cover Crops (fall, winter, spring)	40	50	25	40
Sediment Basin	50	50	30	50
Wetlands	30	30	25	30
Best Management Practice for No-till				
Crop rotations	25	25	25	25
Establish vegetative buffer strips	25	50	35	50
Contour farming (without terraces)	20	30	20	20
Terraces with tile outlets	10	30	10	30
Terraces with grass waterways (with contour farming)	30	30	30	30
Cover Crops (fall, winter, spring)	Insufficient data			
Sediment Basin	50	50	25	50
Wetlands	30	30	25	30

Kn
fo

KSRE Resources

- Water Primer
  - MF3021: Part2, Hydrologic Cycle
  - MF3023: Part 4, Surface Water
  - MF3024: Part 5, Water Law
  - MF3210: Part 9, The Kansas Water Budget and Water Footprint

- Water Quality and BMPs
  - MF2572: Water Quality Best Management Practices
  - MF2501: Total Maximum Daily Loads #6: Suspended Solids: A Water Quality Concern for Kansas
  - MF3030: Cheney Lake Watershed: Erosion From Ephemeral Gullies
  - MF2907: Impacts of No-till on Water Quality
  - MF2682: Effects of Conservation Practices on Water Quality: Sediment

K-STATE
Research and Extension

Thank You!

Questions?

Aleksey Sheshukov

ashesh@ksu.edu

(785)-532-5418

http://www.kcare.k-state.edu

http://www.bae.ksu.edu/watershed/extension/training/

http://erosion.ksu.edu