Reclamation 101

Surface Water & Erosion

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Overview

- Hydrology: Surface Water Processes
- Oil and Gas Development
  - Impacts on surface water processes
  - Erosion
- Short and long term reclamation objectives
- On the ground approaches
- Models and tools
  - Monitoring

Surface Water Processes

Surface Water Processes

- Infiltration
- Runoff
- Erosion - Sediment transport (and other contaminants)

Affected by:

- Land management practices/changes
- Climatic input

Infiltration

- Infiltration: process by which water enters the soil surface
- Infiltration capacity: maximum rate at which water can enter the soil
- Soil Hydraulic Conductivity: movement of water through soil (saturated and unsaturated flow)
- Soil Water: water held in soil pores
  - Plant available water

Factors which affect infiltration:

- Soil – type, texture, structure
- Biological factors-
- Vegetation
  - Type (forb, grass, shrub, trees, etc.)
  - Distribution
  - Shrublands
  - Grasslands
    - type of grass

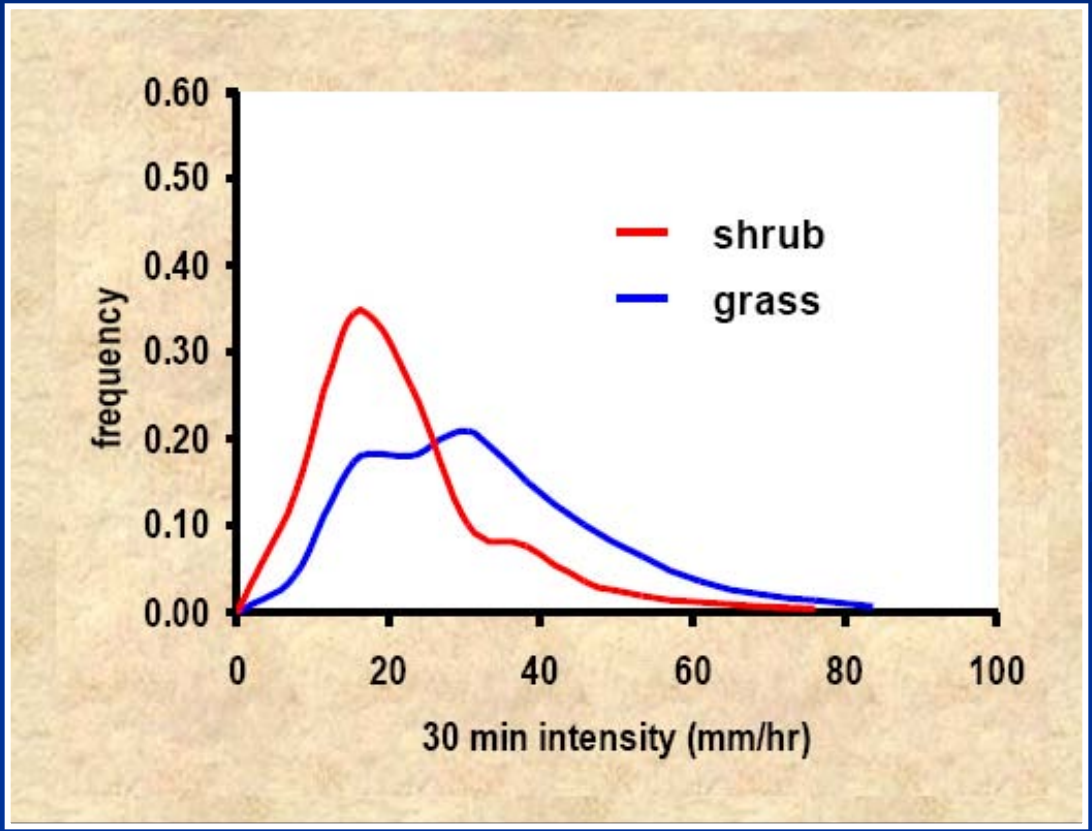
Runoff Production

- Rainfall (Infiltration) Excess

- Pathways
  - Overland flow (hortonian or saturation excess)
  - Subsurface flow
  - Stream channel flow
  - Variable source area (e.g., wetlands)

Runoff on Rangelands

Vegetation effects on runoff



Veg. Type	Ave Int.
Shrub	19 mm/h
Grass	29 mm/h

It takes higher intensities to generate runoff on grasslands

Erosion

- Erosion is a *process*: work required to dislodge and move particles. Work – requires energy
  - Momentum = mass * velocity
  - Energy = mass * velocity^2

Erosion

- 3 primary forms of erosion on uplands
  - Surface erosion
  - Gully erosion
  - Soil mass movement
- Surface Erosion: detachment and removal of soil particles and aggregates from the land surface by water or wind
  - Raindrops
  - Thin sheet flow
  - Wind

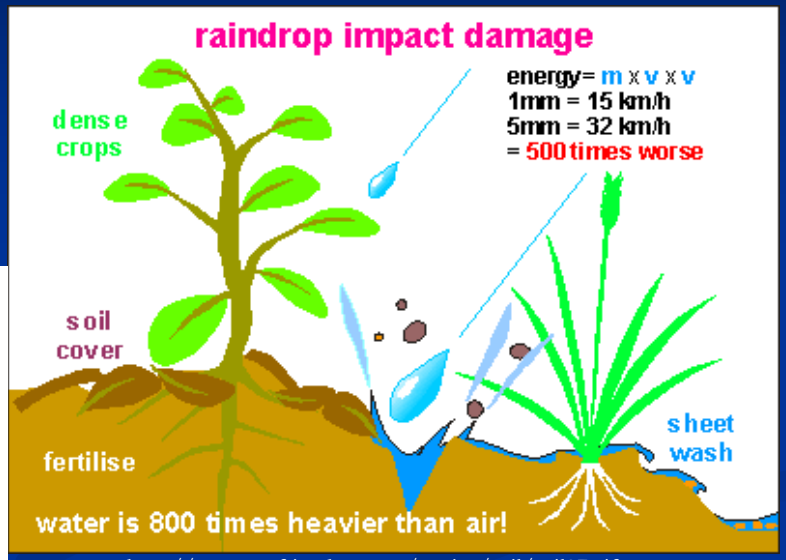
Water Erosion

- Falling raindrops are a major contributor to surface erosion

TABLE 7.1. Kinetic energy (K_e) associated with different intensities of rainfall

	Rainfall Intensity (mm/hr)	Kinetic Energy[a] (MJ/ha•mm)[b]
Drizzle	1	0.12
Rain	15	0.22
Cloudburst	75	0.28

Source: Calculated from Dissmeyer and Foster 1980.
[a] K_e = 1/2 (mass)(velocity)^2.
[b] Units are megajoules per hectare millimeter.



http://www.seafriends.org.nz/enviro/soil/soil37.gif

http://www.ipm.iastate.edu/ipm/icm/2005/5-2-2005/splash.jpg

- They are also key to soil aggregate breakdown and surface sealing

Does Overland Flow Matter?

- Yes… turbulent eddies in surface runoff are key drivers

- More important: concentrated flow paths into rills and gullies
- Break erosion down into categories
  - Rill erosion (#1 loss of soil worldwide)
  - Inter-rill erosion

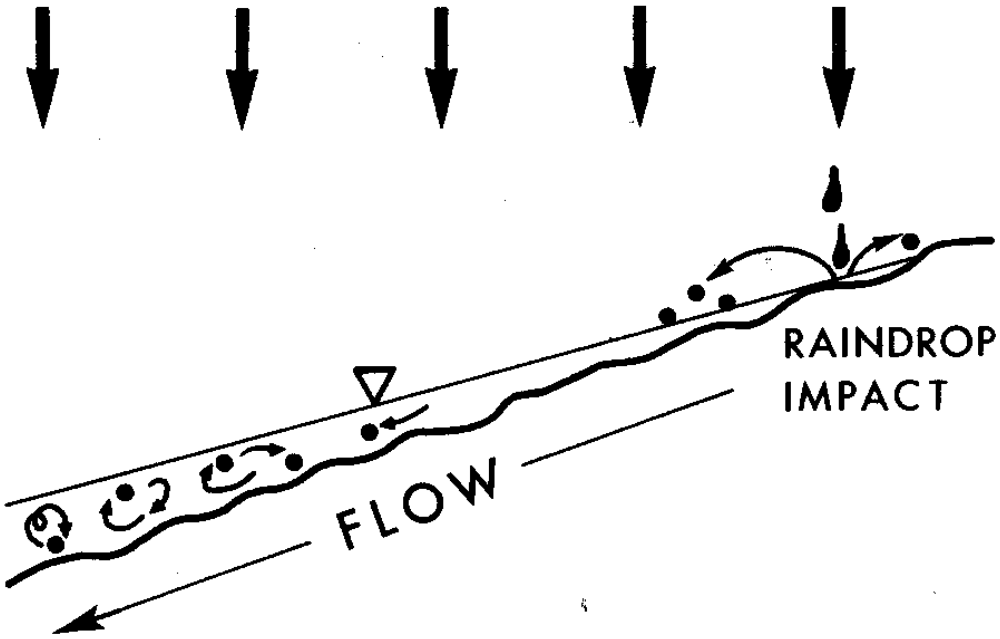


FIGURE 7.2. Surface soil erosion as a result of raindrop impact and turbulent surface runoff.

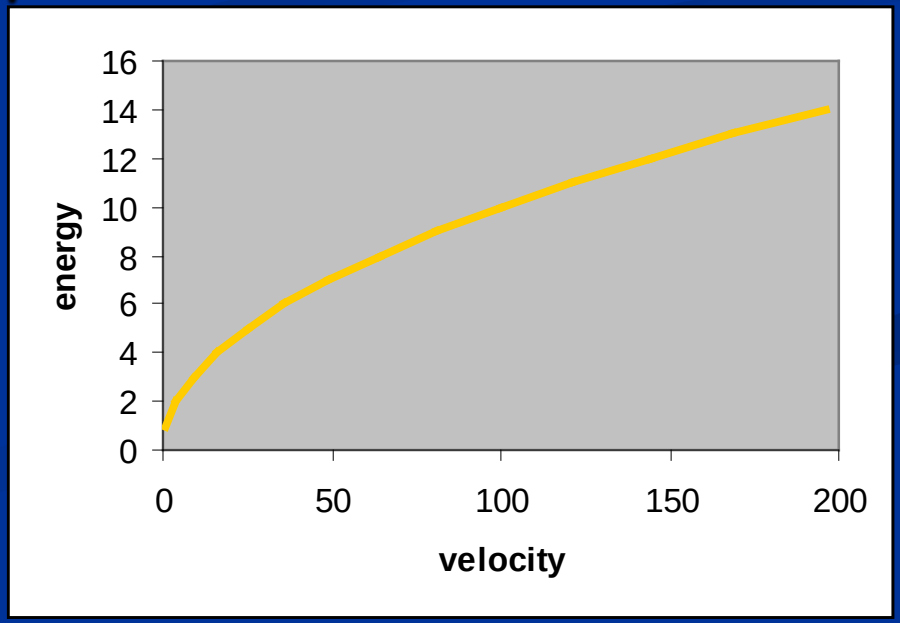

(c) Cranfield University, 2000

What Increases Energy?

- Flow velocity
  - Due to concentration in rills & decreased friction
  - Increased slope
- Mass of the suspension (water + sediment)
- Turbulent flow
  - If low flow, raindrops can magnify this
- Slope length (unobstructed pathway)
- High velocity, steep long slopes, low or little vegetative cover

Wind Erosion

- Common in dry, sparsely vegetated areas
  - <400 mm/year
  - But accelerate erosion can occur even when PPT is very high. Need good management!
- Wind as a fluid; acts very similar to water
  - Increases exponentially with velocity
  - Energy = mv^2 →



Erosion versus Sedimentation

- Erosion is the process by which the land surface is worn away by the action of water or wind.
- Sedimentation is the movement and settling out of suspension of soil particles.
- It is usually easier and less expensive to prevent erosion than it is to control sediment from leaving a site.

Oil & Gas Development

Impacts water processes / water quality across the Intermountain West:

- storm water runoff from construction activities
- pollution from pits and hydraulic fracturing
- use and disposal of CBM produced water

- Scale of disturbance: space and time
  varies with the type of development


© 2006 Europa Technologies
Image © 2006 DigitalGlobe
Image © 2006 TerraMetrics
© 2006 Navteq
Pointer 42°28'19.00" N 108°40'25.41" W elev 7237 ft
Streaming 100%


RECLAMATION
AREA
KEEP OFF

Container Trucks with Fracking Liquids at a Drilling Site, Dimock, PA.

Waste Pit of Hydro-Fracking Drilling Mud, © 2010 J. Henry Fair

Reclamation Goals….

Ecosystem “restoration” includes restoration of the natural vegetation community, hydrology, and wildlife habitats.

Reclamation "Water" Objectives:

- On going & short term
  - Minimizing accelerated erosion….
  - Water quality: protecting water bodies/ sources
- Long term
  - Returning hydrologic function

Stages of Development/Reclamation

- Project Planning
  - Define characteristics (hydrologic) of the site: soils, slope, vegetation (ecological site)
- During development:
  - Minimizing accelerated erosion
  - Protecting water sources
- Reclamation
  - Returning hydrologic function

Stabilize the site as soon as possible

Get site to final grade and either permanently or temporarily stabilize all bare soil areas as soon as possible.

Consider germination times for the grasses or other vegetation selected

Provide additional stabilization (mulches, matrices, blankets, soil binders) on erosion prone areas such as slopes and drainage ways.

Consider seasonal limitations to plant establishment and growth, such as drought or cold temperatures, ensure that areas that are not showing adequate vegetation establishment are reseeded or mulched immediately.

- **Protect slopes and channels**

  Convey concentrated runoff around the top of slopes and stabilize slopes as soon as possible.

  Use pipe slope drains or earthen berms that convey runoff around the exposed slope.

  Avoid disturbing natural channels and the vegetation along natural channels if possible.

- **Reduce impervious surfaces and promote infiltration**

Control the perimeter of your site.

Divert "run-on" coming on to your site: convey it safely around, through, or under your site.

Avoid allowing run-on to contact disturbed areas of the construction site.

To minimize runoff & erosion from the disturbed areas, install BMPs such as silt fences.

Runoff and Erosion Control

- Overall goal – maintain (vegetative) cover and not reduce infiltration capacities

- Soil Stabilization Treatments
  - Reseeding/mulching
  - Contour Logs
  - Straw Wattles
  - Silt Fences
  - Straw Bales

Mulch/Landscape Cloth

- Straw – Weed free
  - ground application
  - 2-3 inch thick layer
  - Target steep slopes – high erosion potential
- Landscape Cloth
- Cost – benefit question
- Short term

Straw Wattles

- Hillslopes or small drainages where runoff and sediment can concentrate
- Flexible enough to follow the contour
- Should be embedded in soil and secured with stakes.

Silt Fences

Comparing the effectiveness of a straw wattle after the 2000 Bitterroot Valley fires.

Silt Fence installed to decrease runoff and sediment movement into drainage

Straw Bales

- Often used in small drainages where runoff and sediment can concentrate

- Bales act as small dams – collecting sediment and slowing down runoff

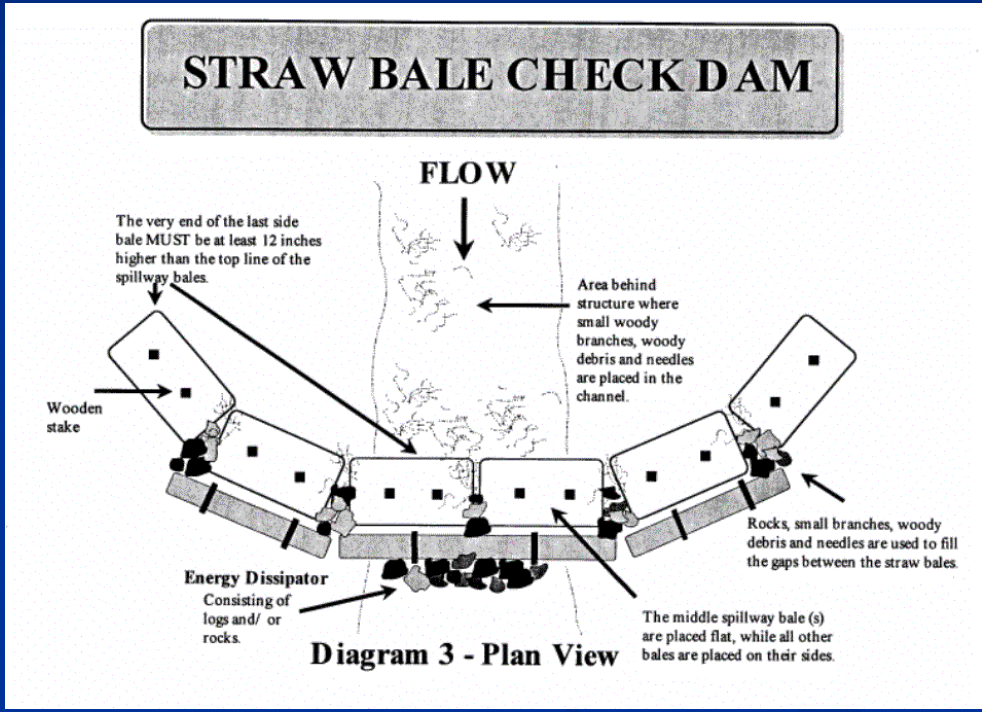


Diagram from Fish and Wildlife Service
fire.r9.fws.gov/ifcc/esr/Treatments/

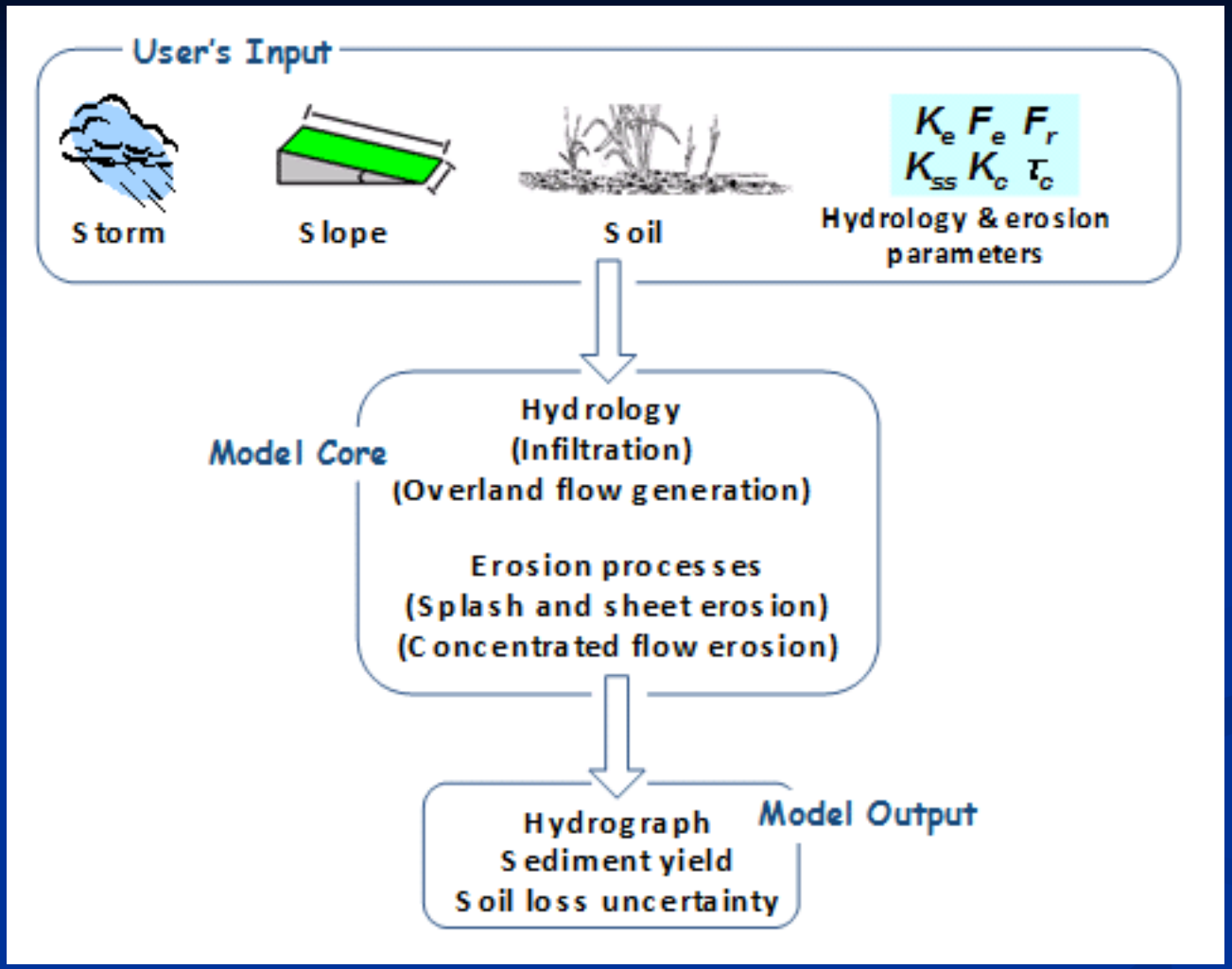
- Effectiveness: poor to good
  Best in first year - Can fill up with sediment

Runoff & Erosion Prediction Tools

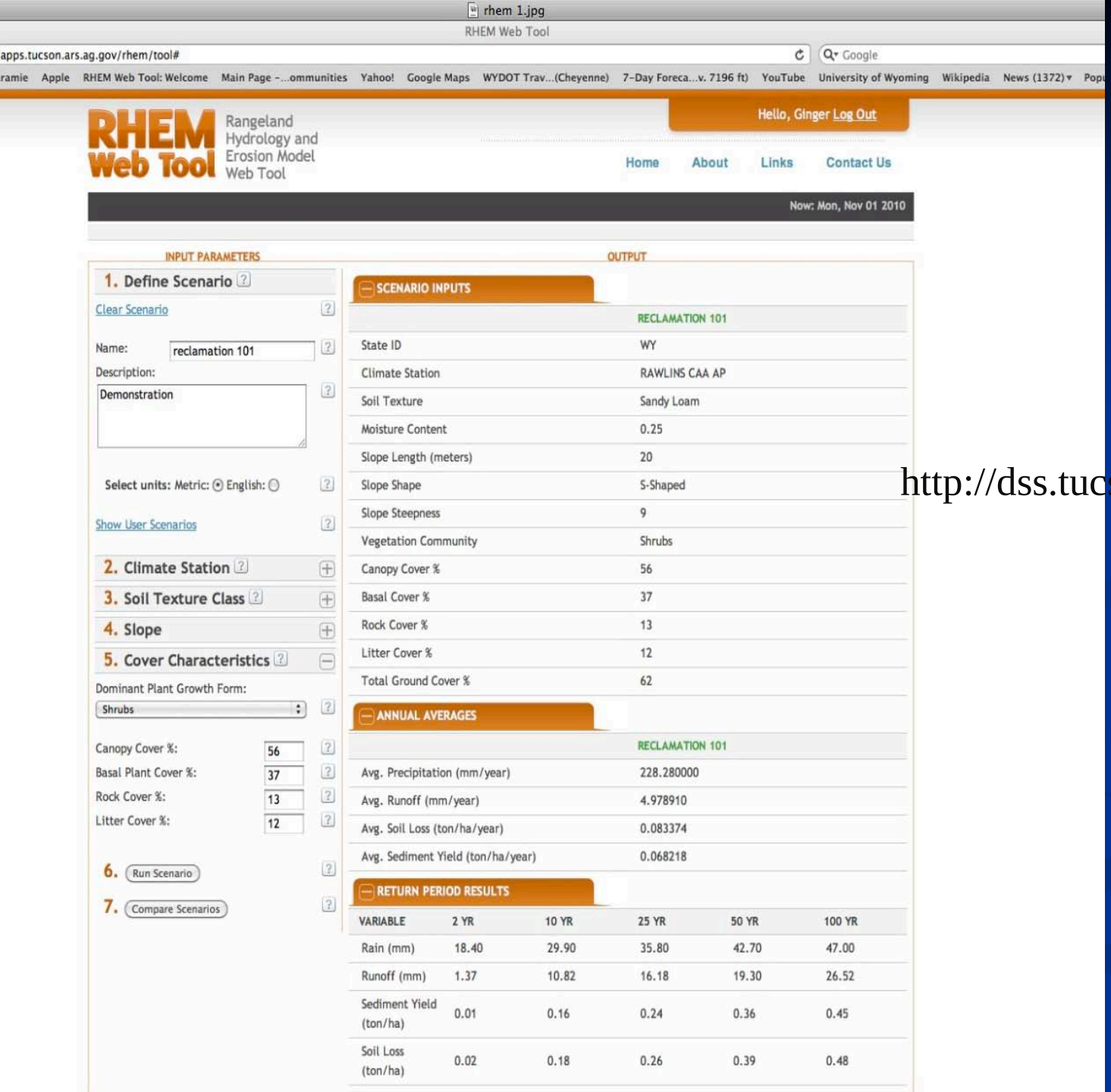
- Universal Soil Loss Equation
  - Original, modified, revised
- RHEM- Rangeland Hydrologic Erosion Model
- WEPP – Water Erosion Prediction Project
  - Forest
  - Disturbed
- AGWA – Automated Geospatial Watershed Assessment Tool

USLE / MSLE

- A = R K (LS) CP
- A = R K (LS) VM
  - A = annual soil loss (tons/acre/year)
  - R = rainfall erosivity factor
  - K = soil erodibility factor
  - LS = topographic factor
  - C = cropping factor
  - P = protection factor
  - VM = vegetation management factor



A flow chart of RHEM erosion prediction procedure



http://dss.tucson.ars.ag.gov/rhem

Monitoring

Field Evidence:

- Concentrated flow
- Rills
- Pedestals
- Sediment movement
- Reference to a known benchmark

http://www.fao.org/docrep/T0848S/t0848s00.jpg


Thanks!!
Questions?