Stream Restoration Remediation - Designing MTMs to Maximize On-site Stream Reconstruction

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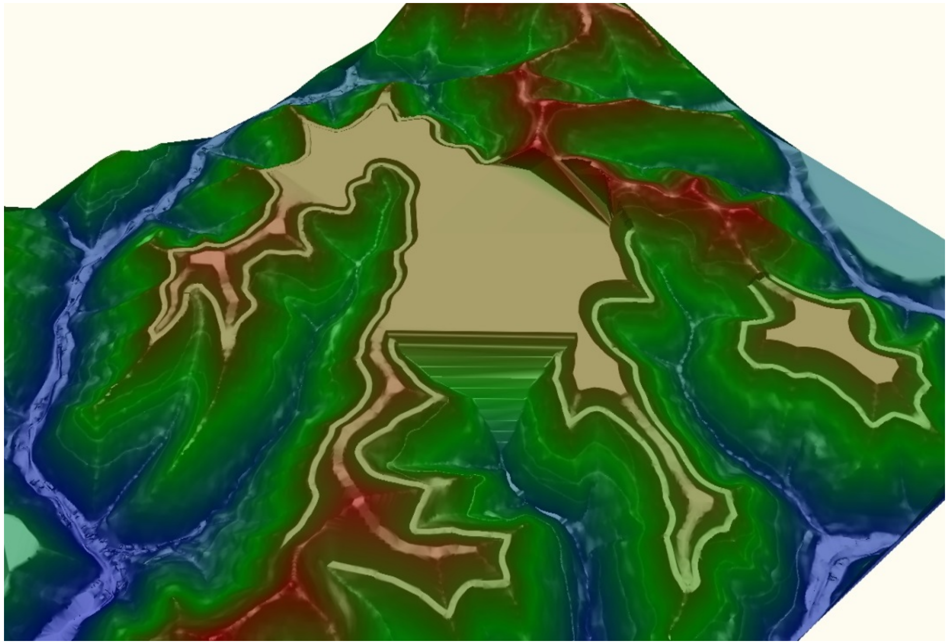
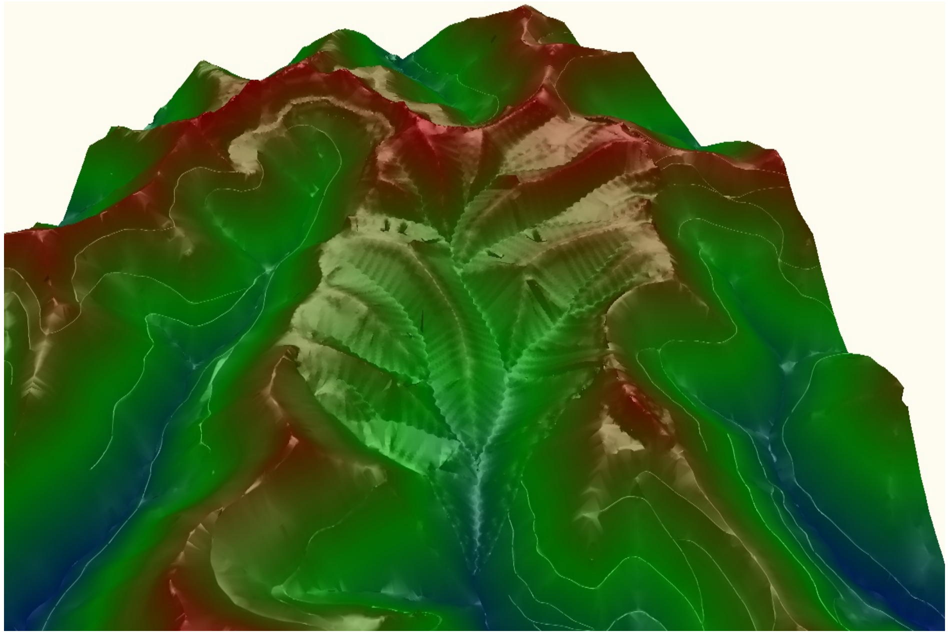
WEST VIRGINIA UNIVERSITY
Department of Civil and Environmental Engineering

Can we use *Geomorphic Landform Design* principles to rethink valley fill design?

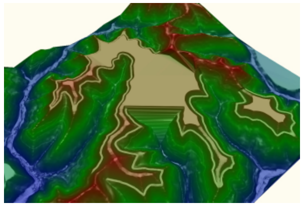
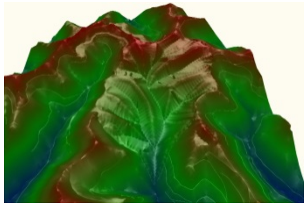


AOC Variance Valley-Fill Design



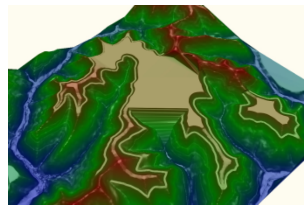
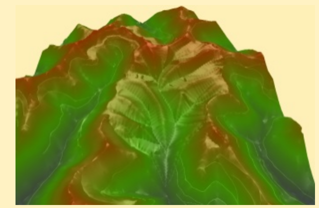
Conceptual Geomorphic Reclamation Design

Can we use *Geomorphic Landform Design* principles to rethink valley fill design?

	 **Traditional**	 **GLD**
Stability	Short-term stability with long-term erosion	Dynamic equilibrium
Appearance	Geometric	Natural appearance
Maintenance	Continuous maintenance	Suggested reduction in maintenance

Reference landform characteristics must be quantified.

Uses a reference landform design approach

	 **Traditional**	 **GLD**
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Objectives: Can stable landforms be designed such that streams are mitigated or preserved on site, while maintaining the same overall footprint as conventional reclamation?

1. Obtain and quantify characteristics of mature landforms in West Virginia.

2. Generate geomorphic valley fill designs, using data specific to Central Appalachia mining regions.

This project will define the reference landform characteristics necessary for design.

- Drainage density
- Ridge to head of channel distance

- Main channel slope
- Channel characteristics
  - Bankfull width
  - W:D
  - Sinuosity
- Bed particle size distribution
- Vegetation zones
- Subridge angle
- Baseflow (where applicable)

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Task 1: Obtain and quantify characteristics of mature landforms in West Virginia.

<u>Mature landforms</u>

Twin Falls State Park

- 2 watersheds

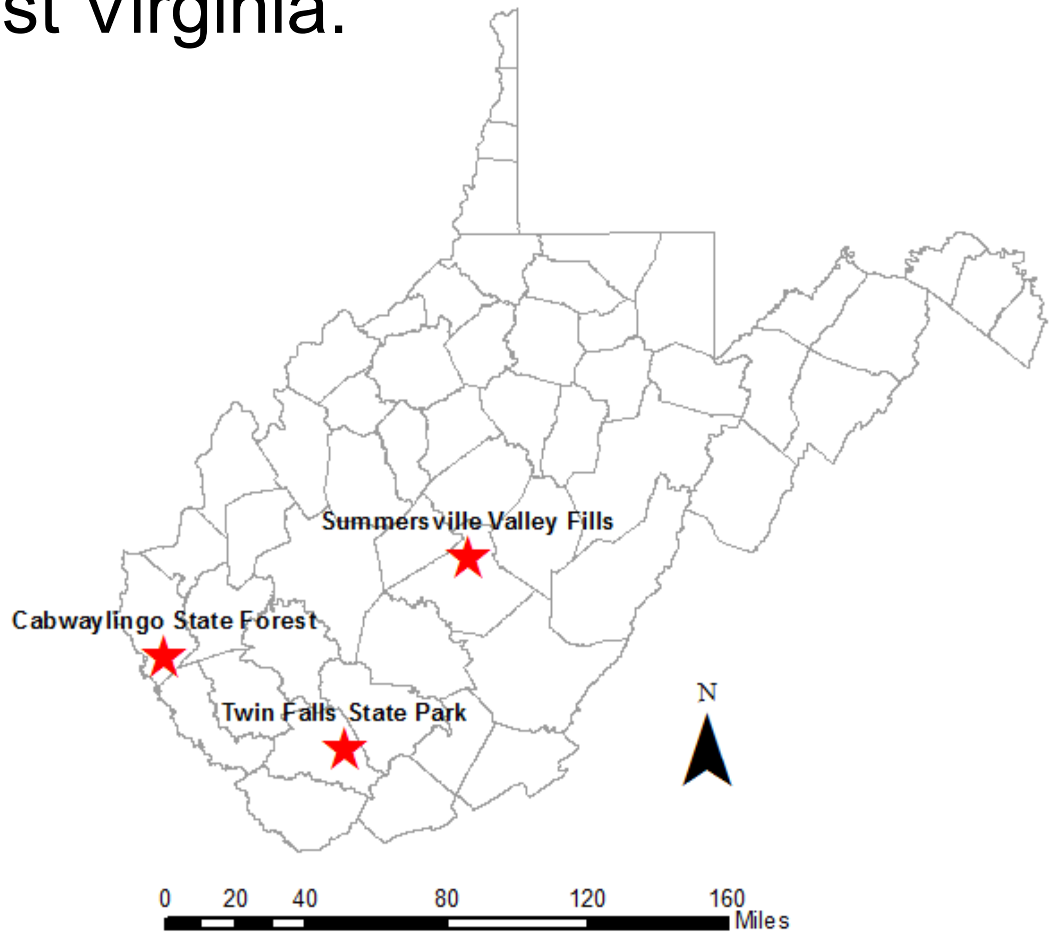
Cabwaylingo State Forest

- 1 watershed

<u>Long-term reclaimed sites</u>

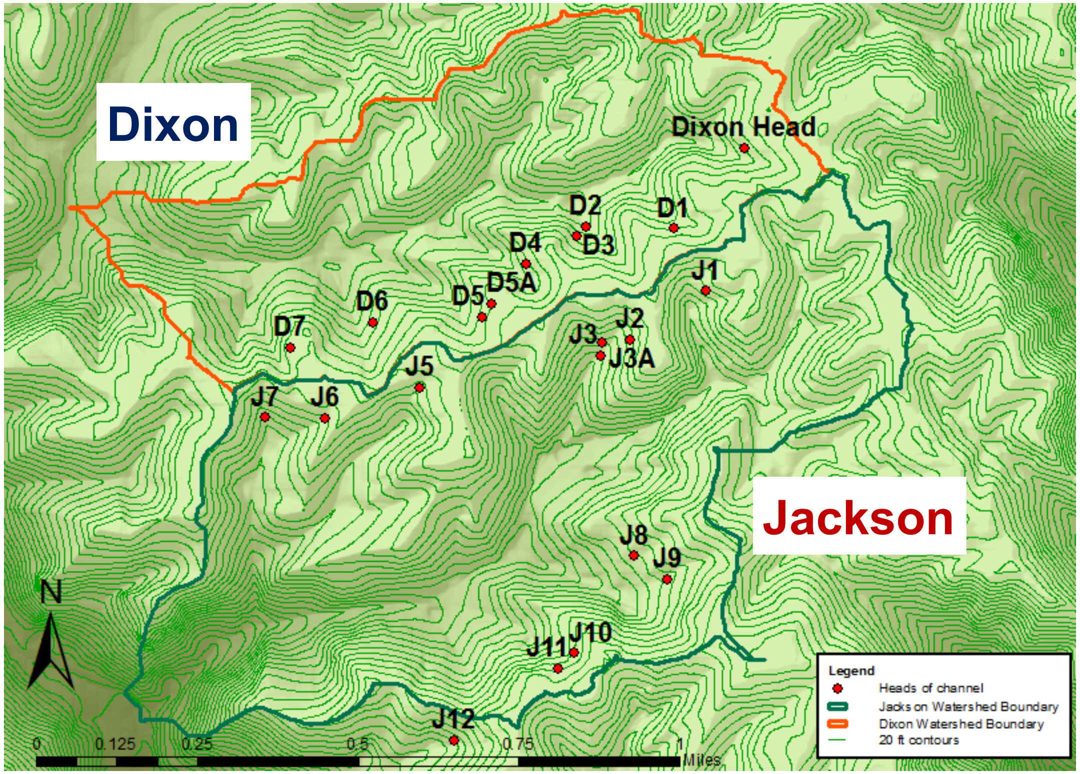
Summersville, WV

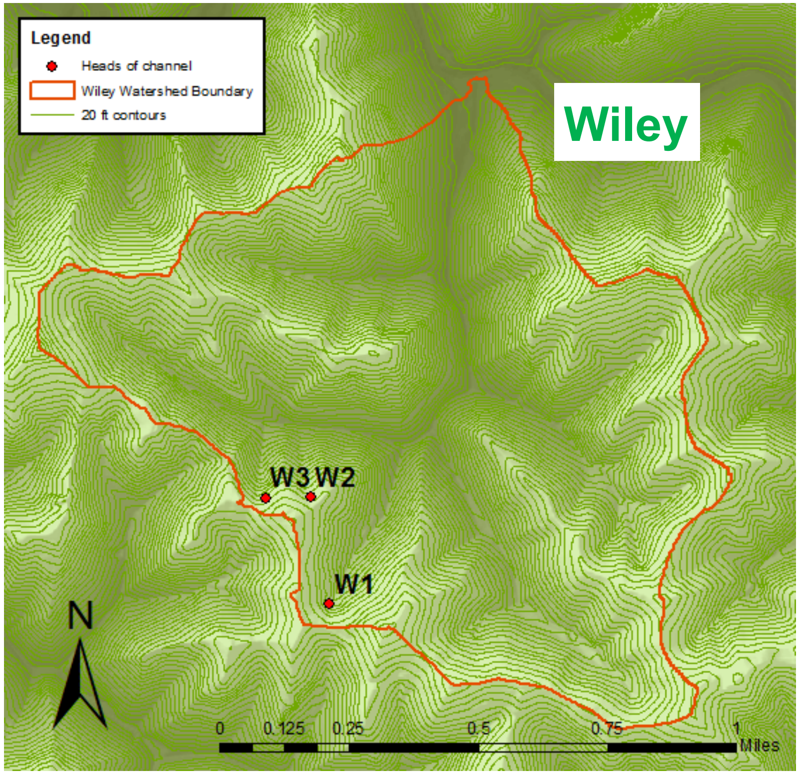
- 2 valley fills



Ridge to head of channel distance: Head of channel locations and ridge points were surveyed with a Topcon GPS.

Field data was collected at 8 heads of channel in Dixon, 11 in Jackson, and 3 in Wiley.

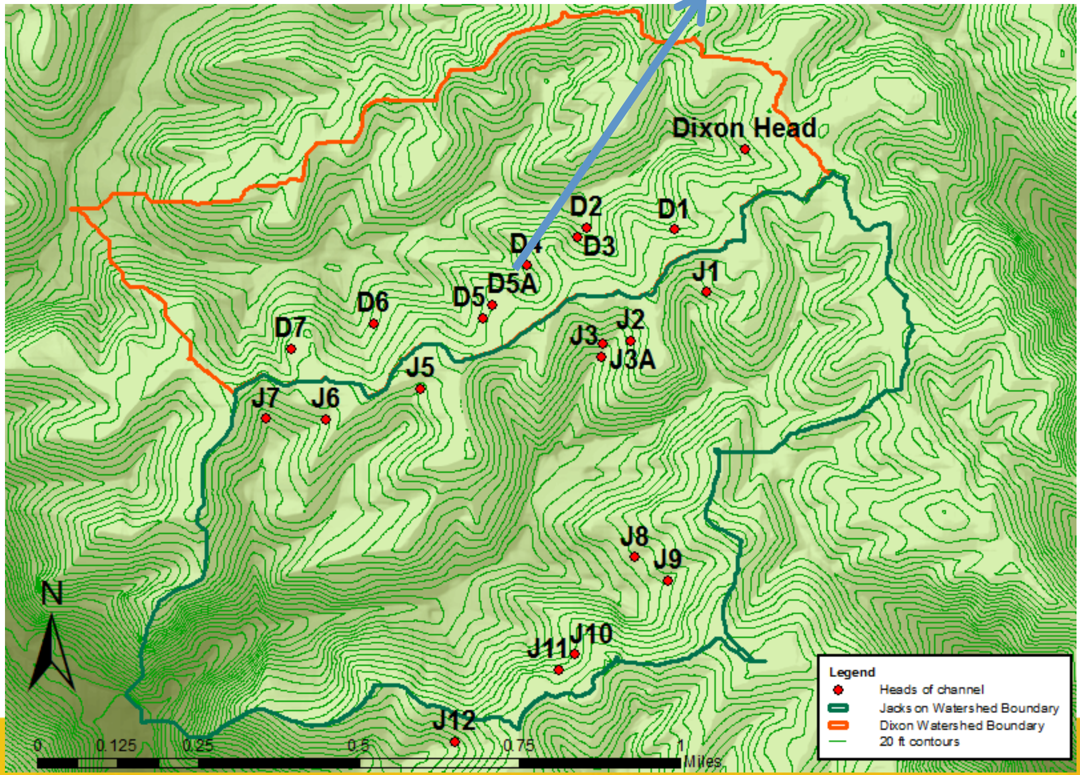




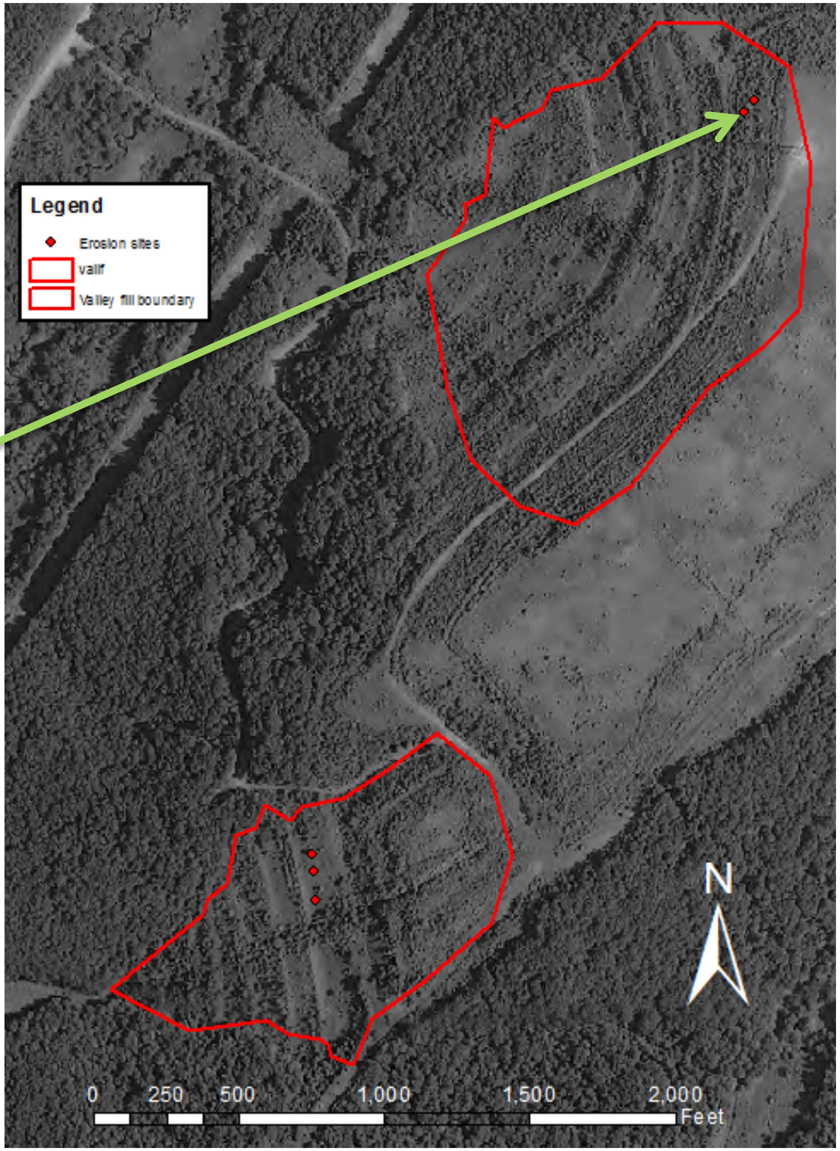
Channel/valley characteristics were defined for each site.

- Channel slope
- Channel cross-section
- Sinuosity
- Discharge
- Grain size
- Vegetation

Dixon Watershed

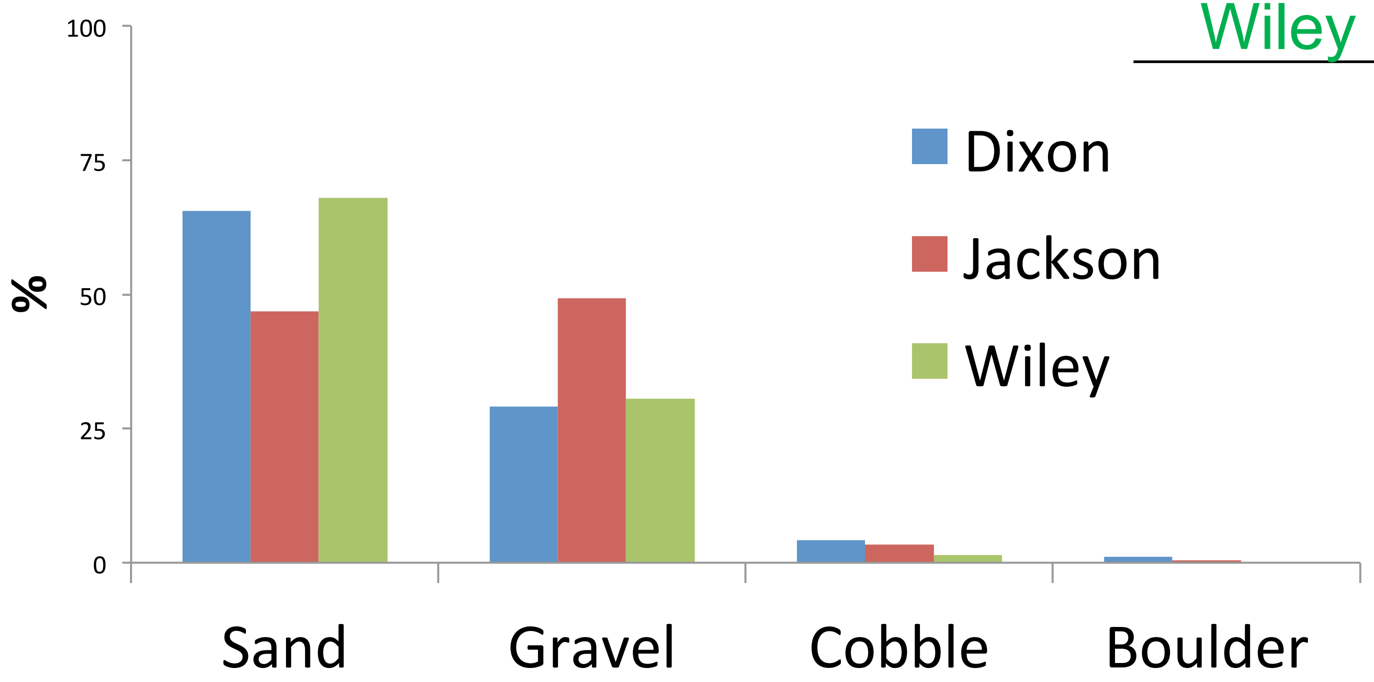


Erosion was also observed and identified on two valley fills.

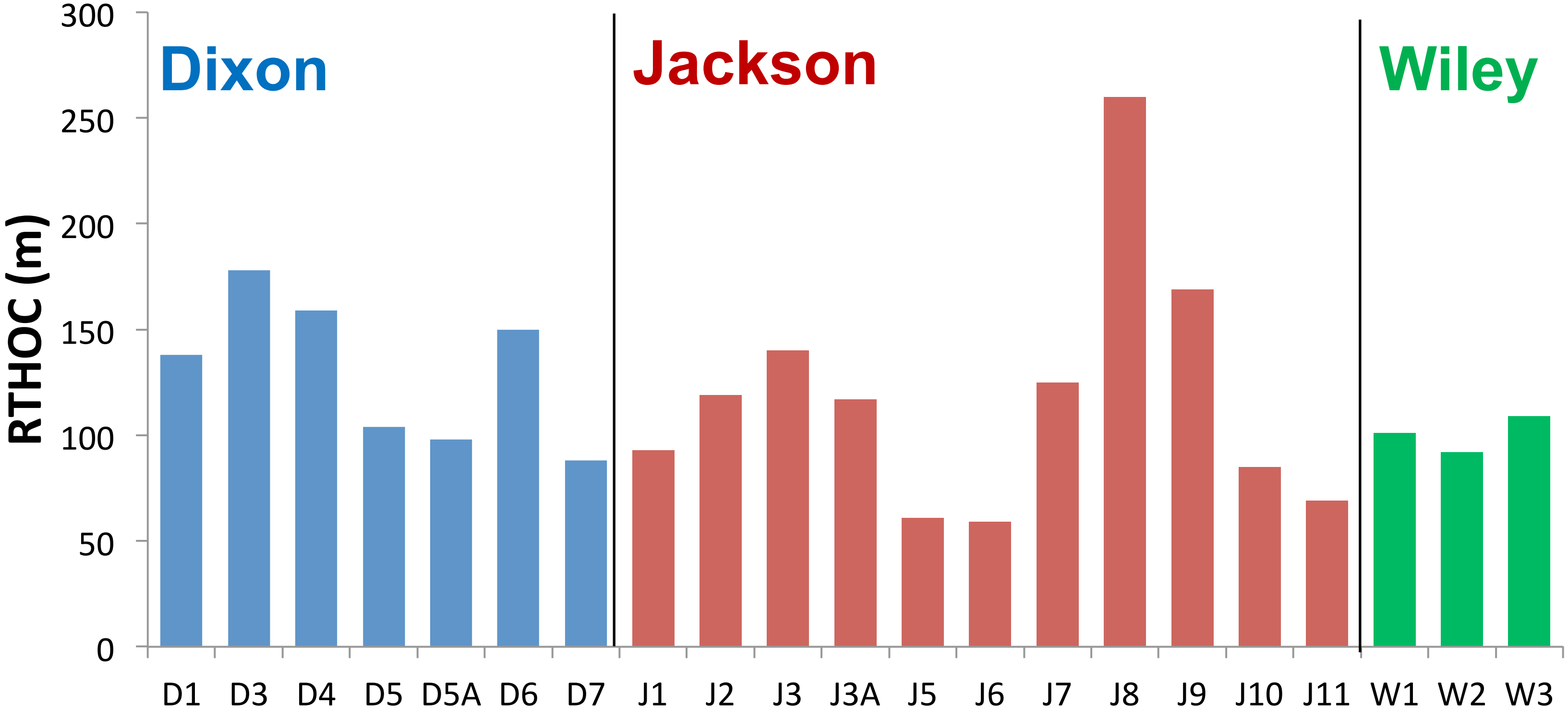


Grain size: The majority of bed material was sand and gravel.

Site	D_{50} (mm)
Dixon	2.8
Jackson	3.7
Wiley	0.8



Ridge to head of channel (RTHOC) distance was calculated as the distance from head of channel to associated ridge point.



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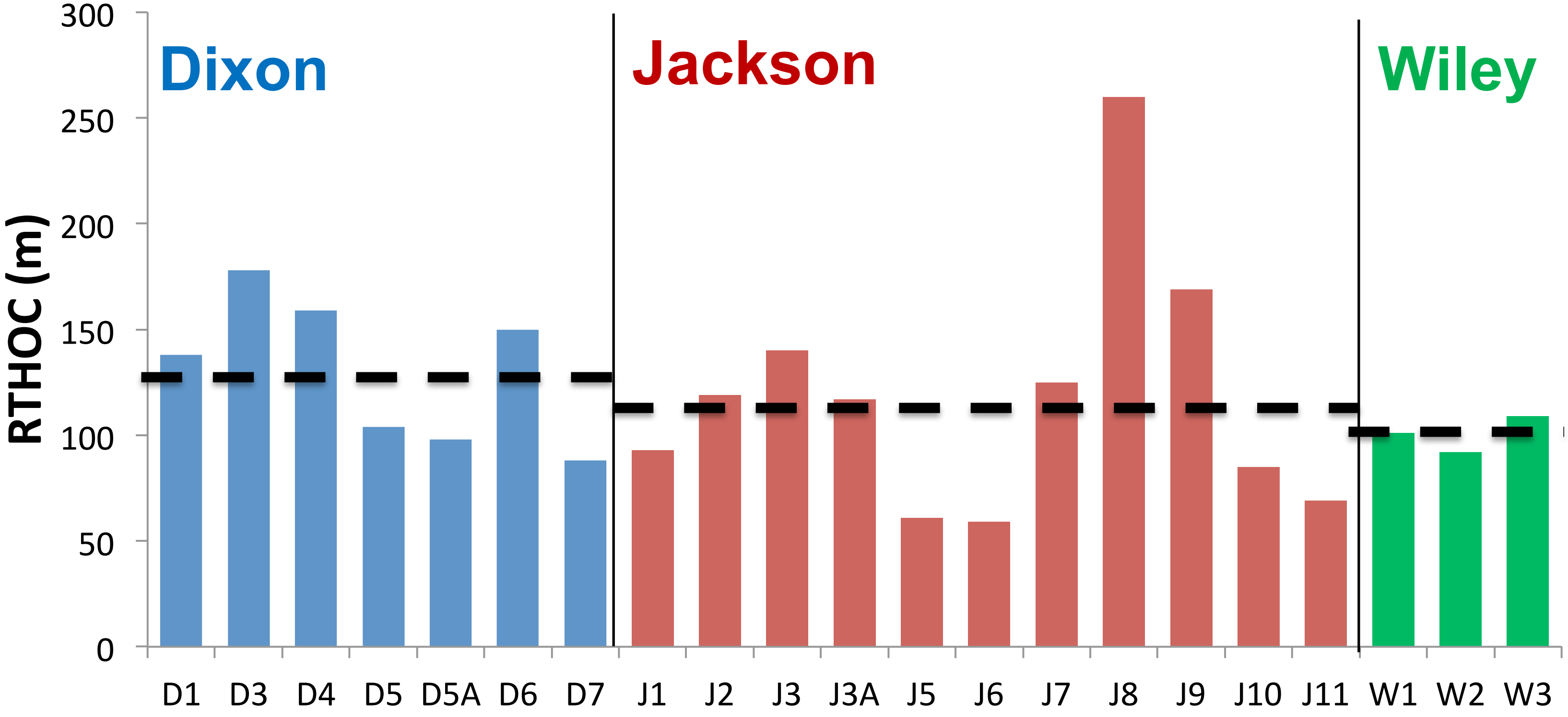
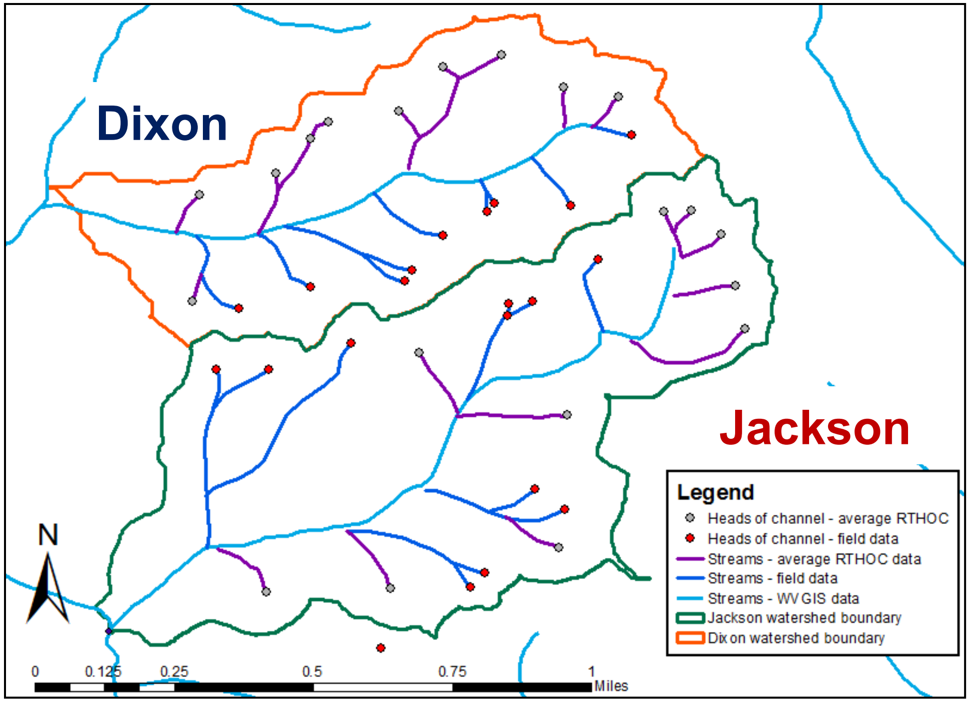
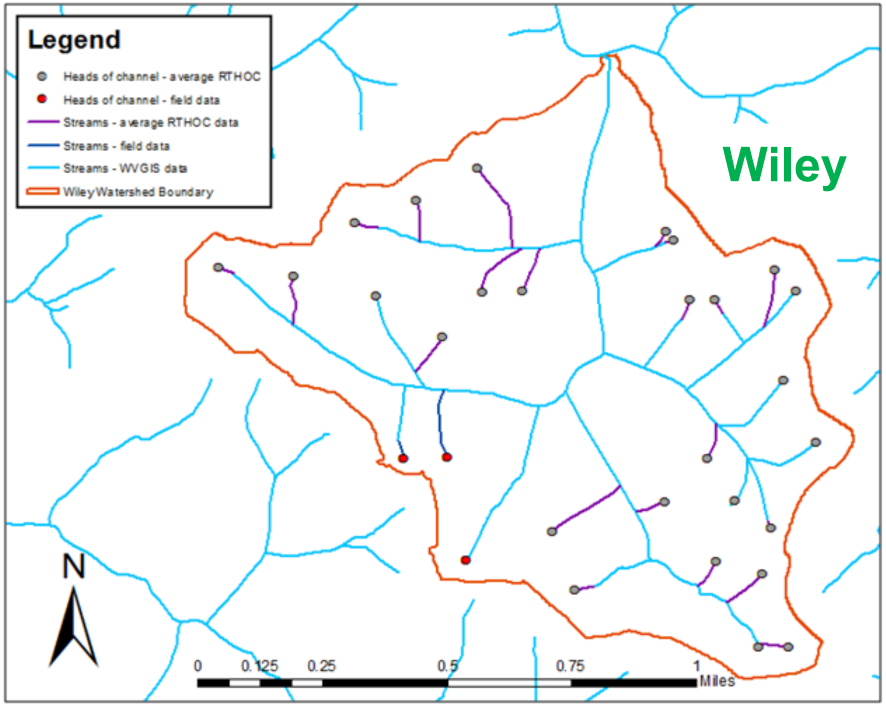


Average RTHOC distance was applied to unmapped valleys.





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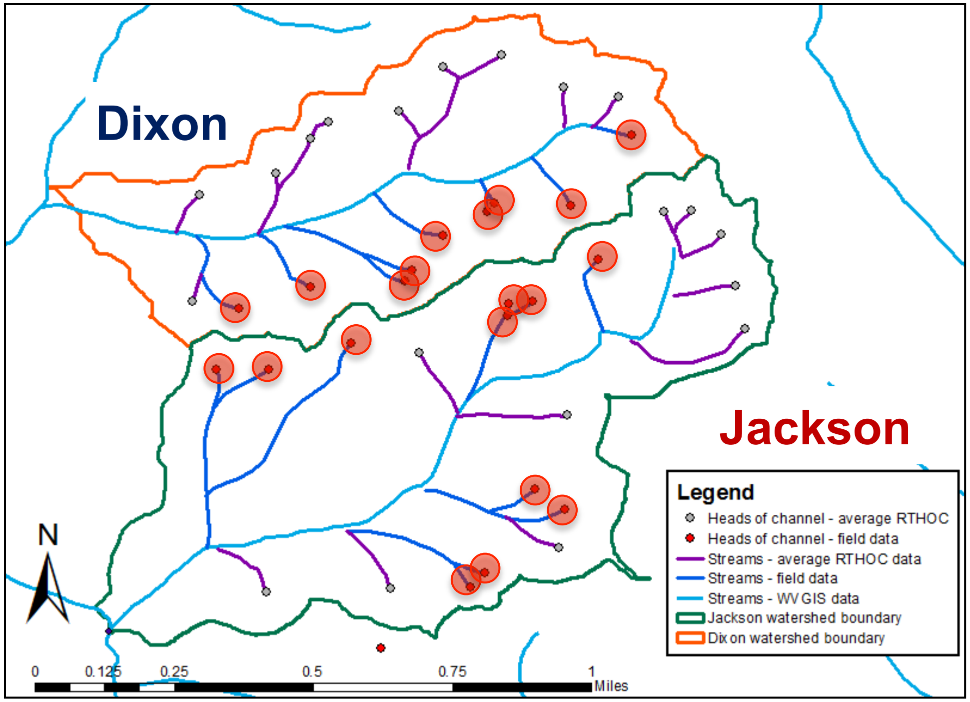
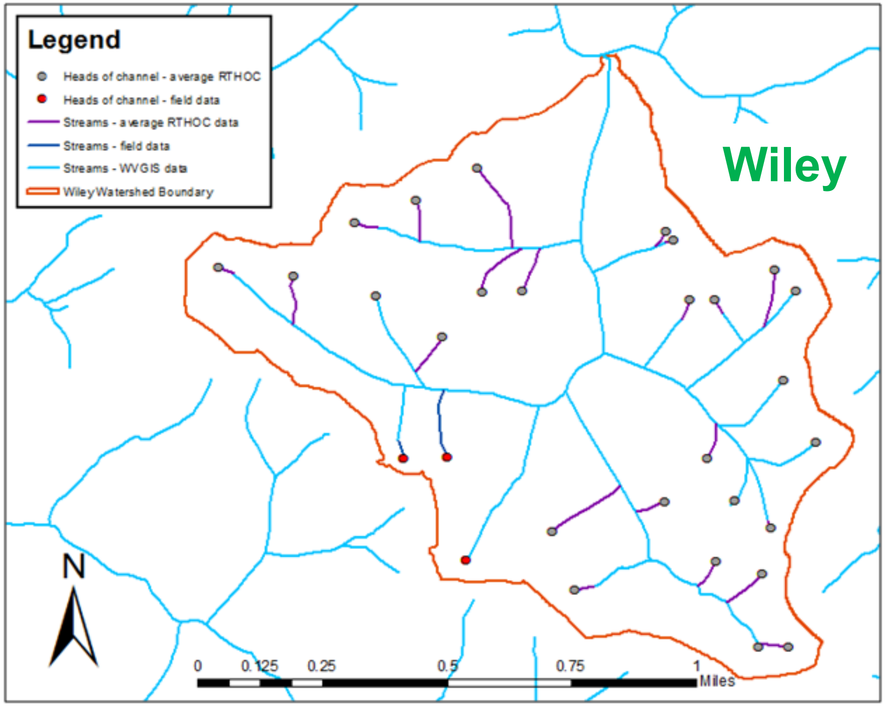
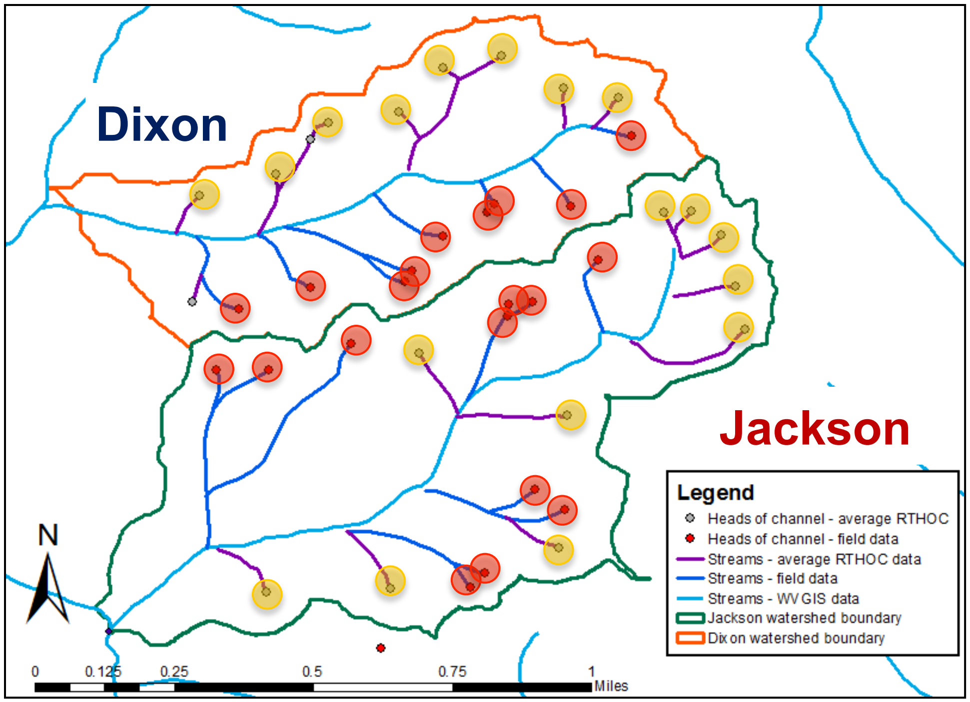
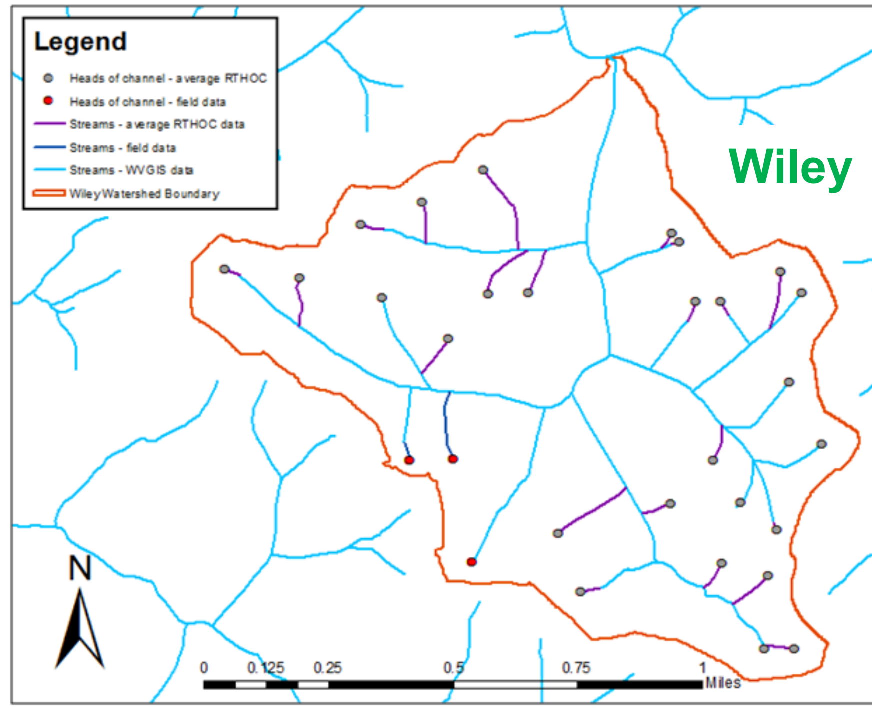


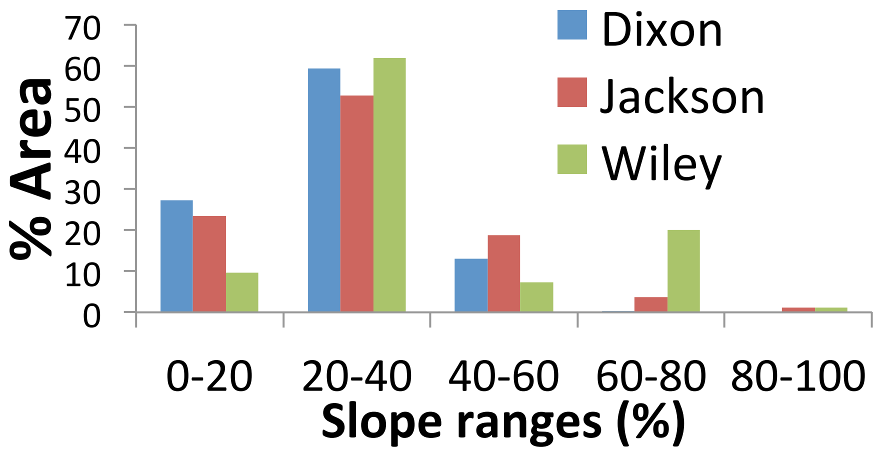


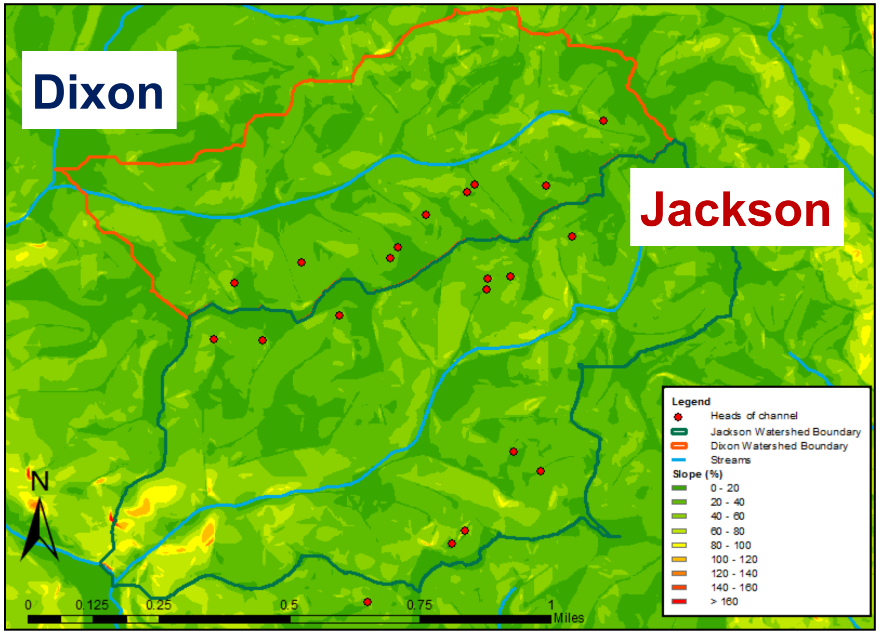
Drainage density was calculated as 61.7 ft/acre (±23%).

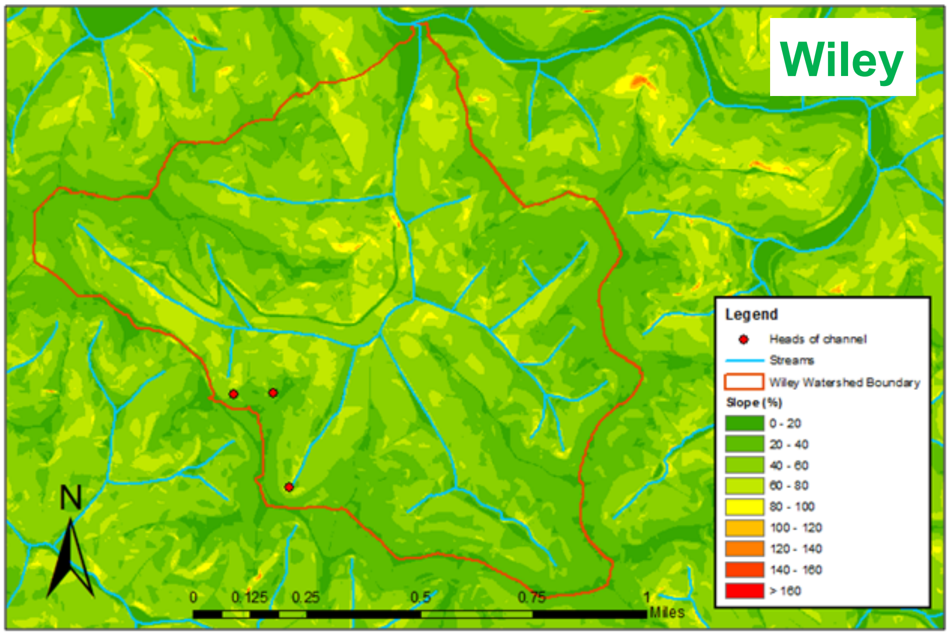




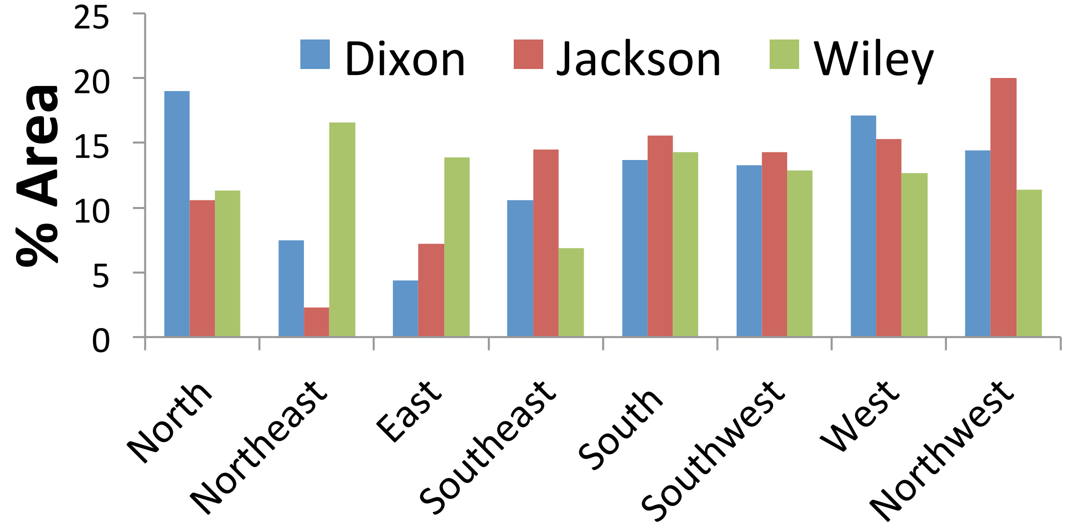
The majority of slopes were in the range of 20-40%.

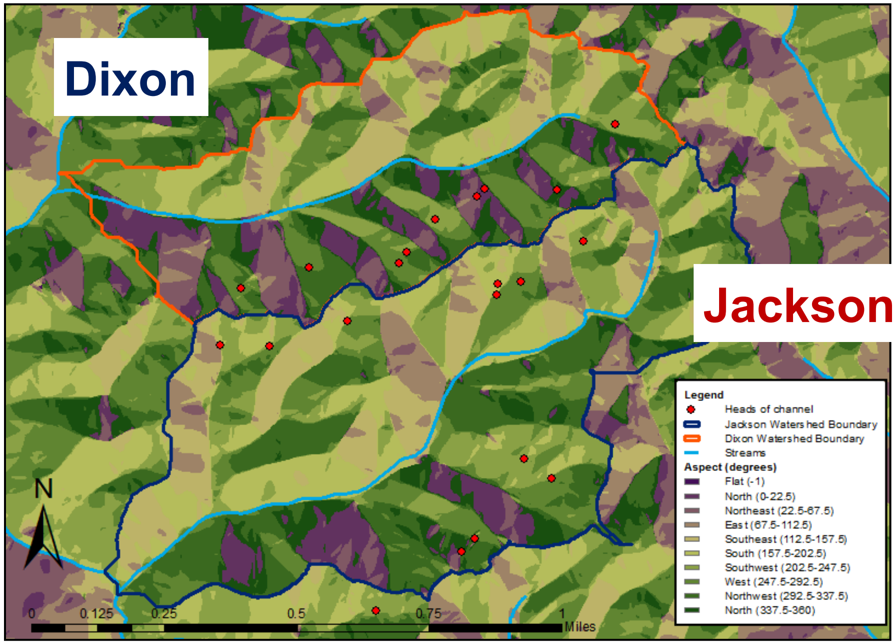


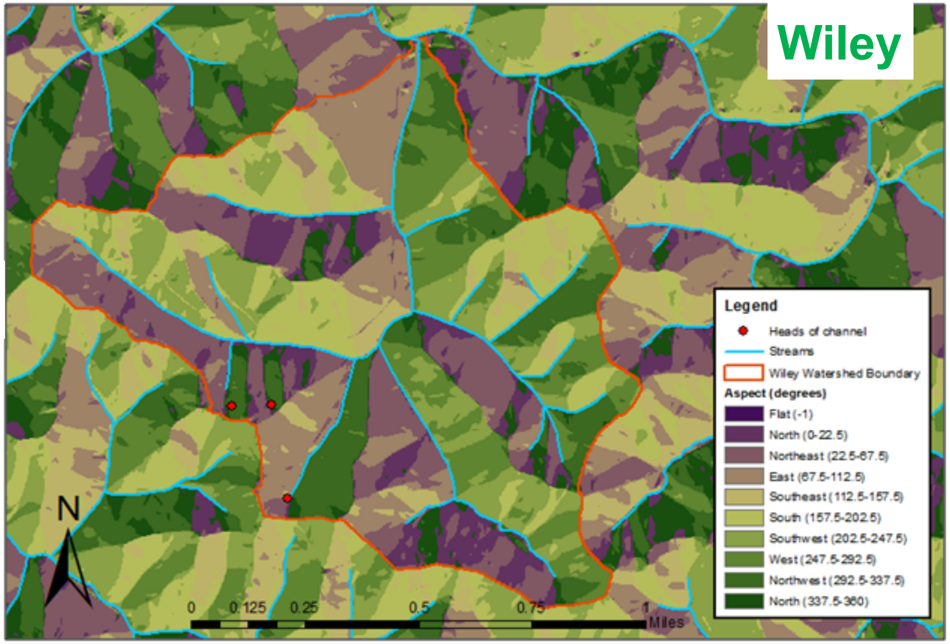




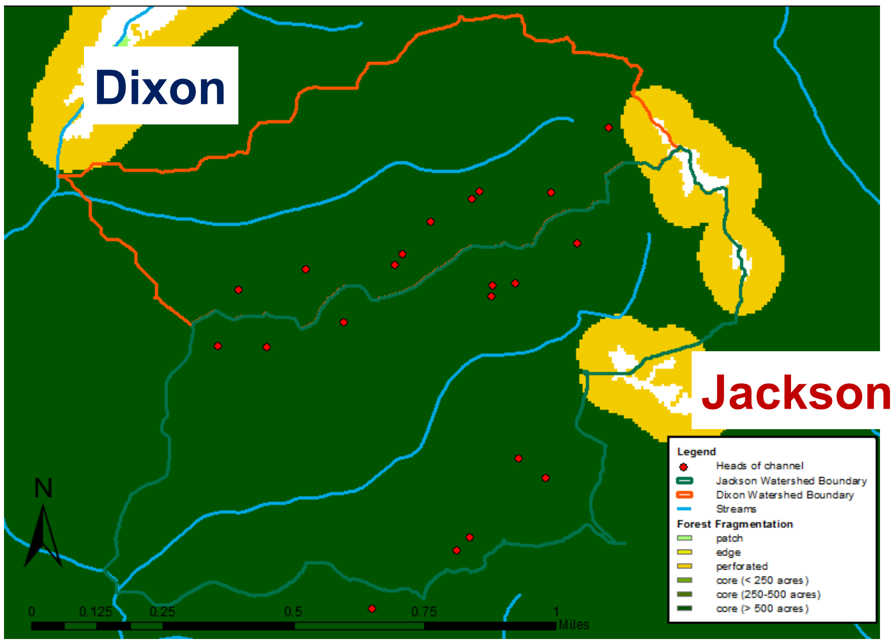
Slopes aspects were well distributed among all directions.

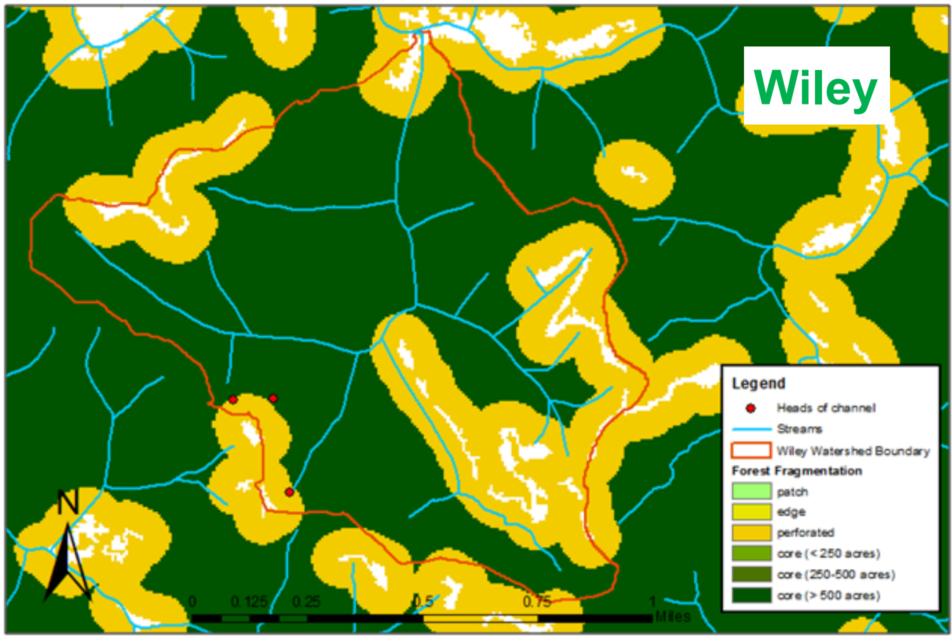




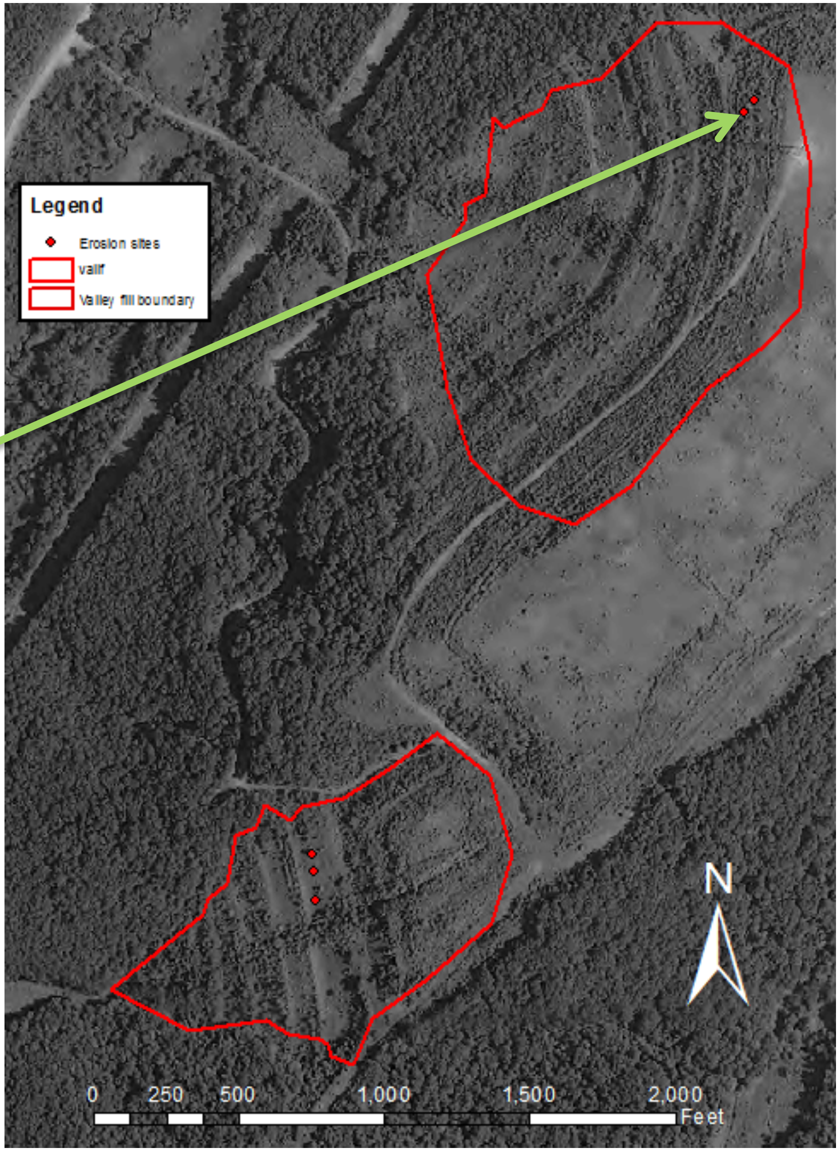


Consistent with field site selection criteria, vegetation was dense core forest.





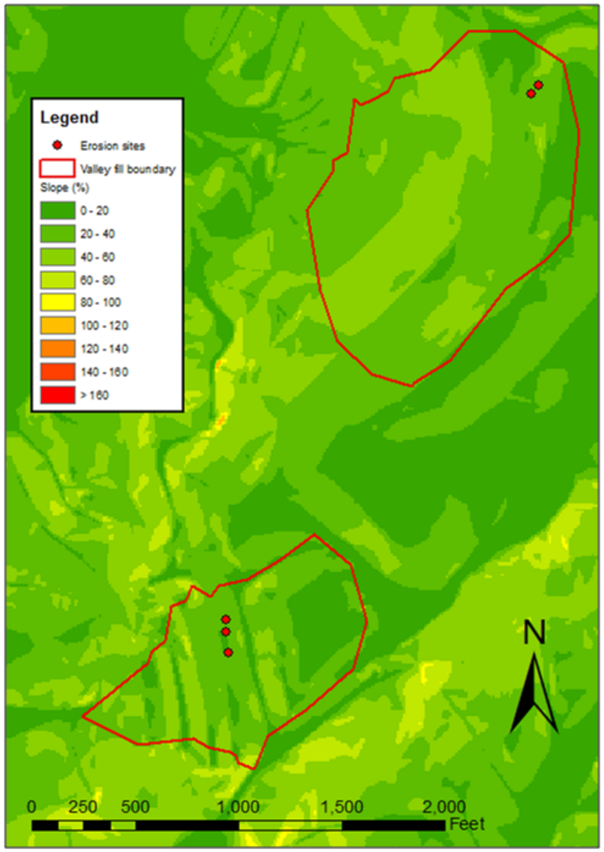
Erosion sites were found across the face of the slope at the same location between benches.



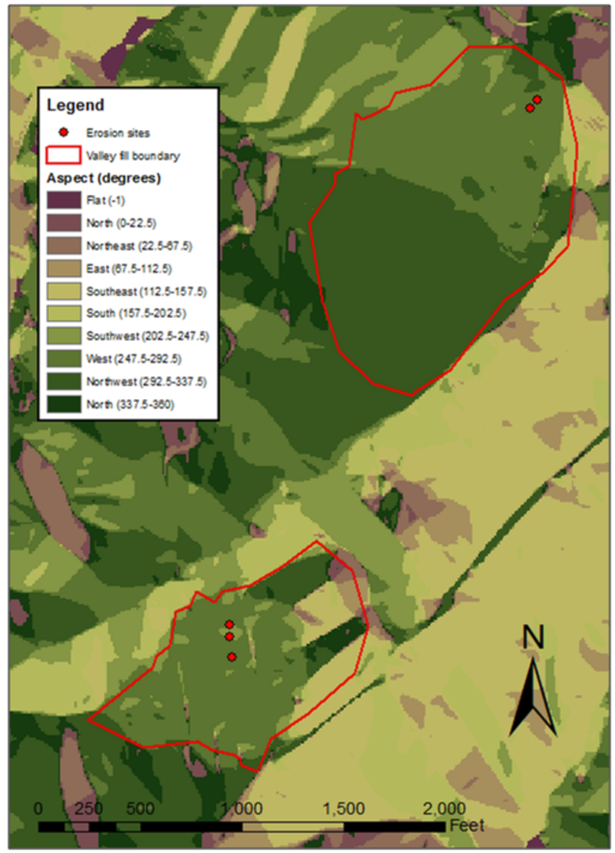
Majority of slopes ranged from 20-40%.

Majority of slopes faced in the direction the fill was pointed.

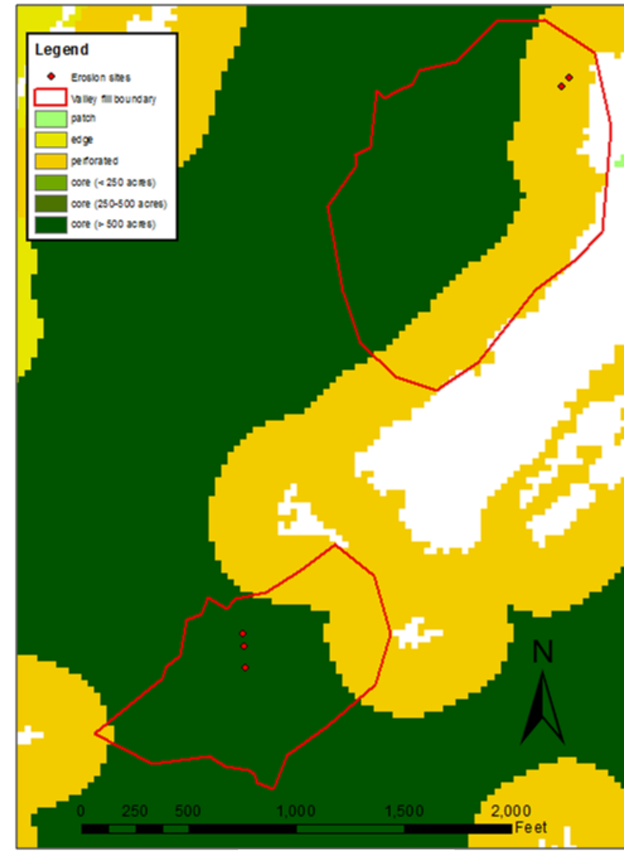
Majority of vegetation was dense core forest.



Slope



Aspect



Vegetation

Measured landform characteristic varied from software recommended values.

Input	Default	Measured
ROTC (ft)	80	408
Target drainage density (ft/ac)	100	61.7
Target drainage density variance (%)	± 20	± 23
Slope at the mouth of main valley bottom channel (%)	2	3

Task 2: Create landform designs for valley fills in southern West Virginia.

Can stable landforms be designed such that streams are mitigated or preserved on site, while maintaining the same overall footprint as conventional reclamation?

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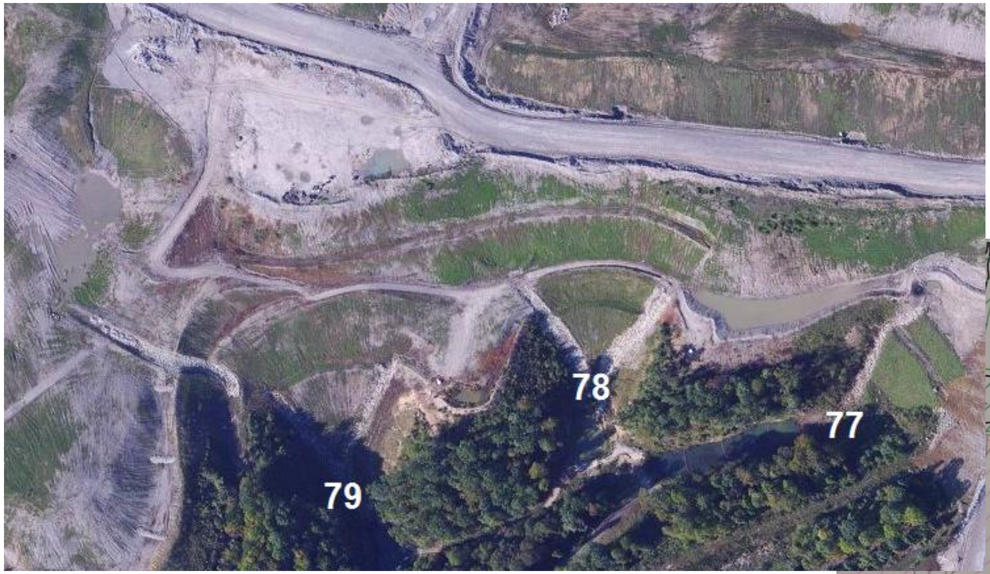
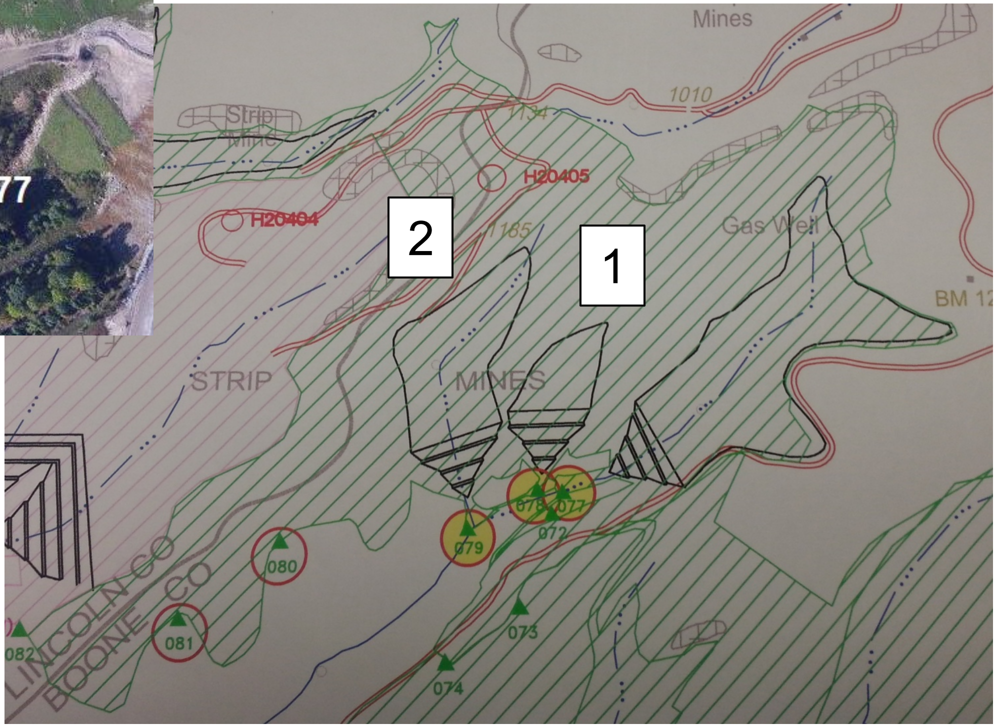
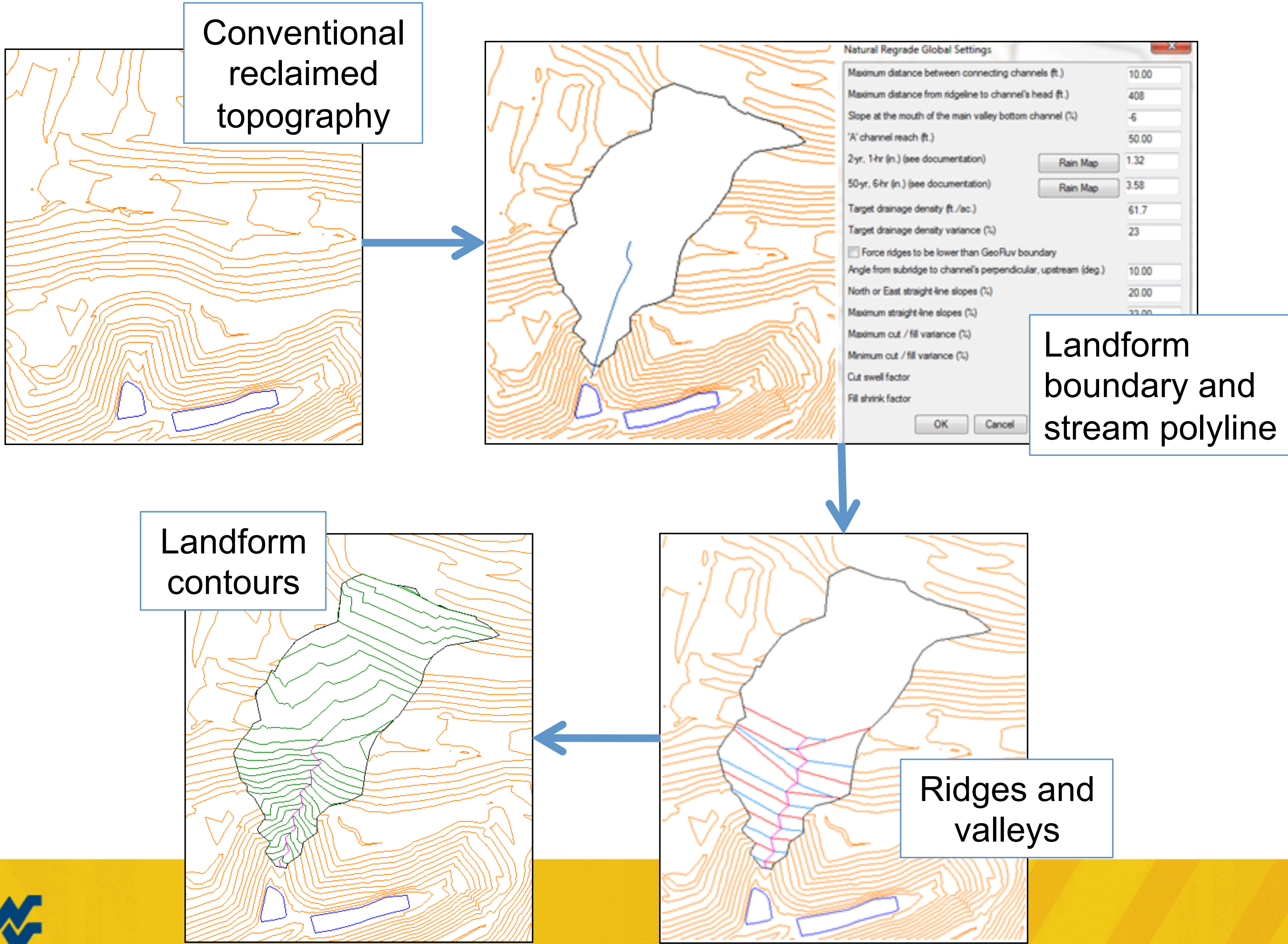


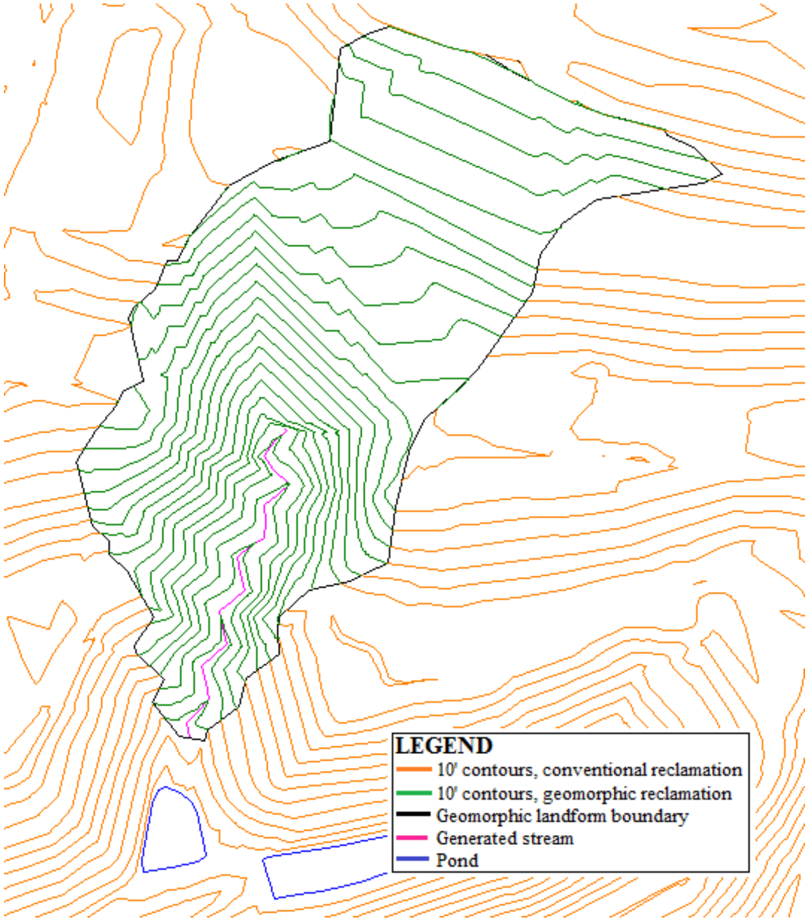


We are developing two designs for each valley fill:

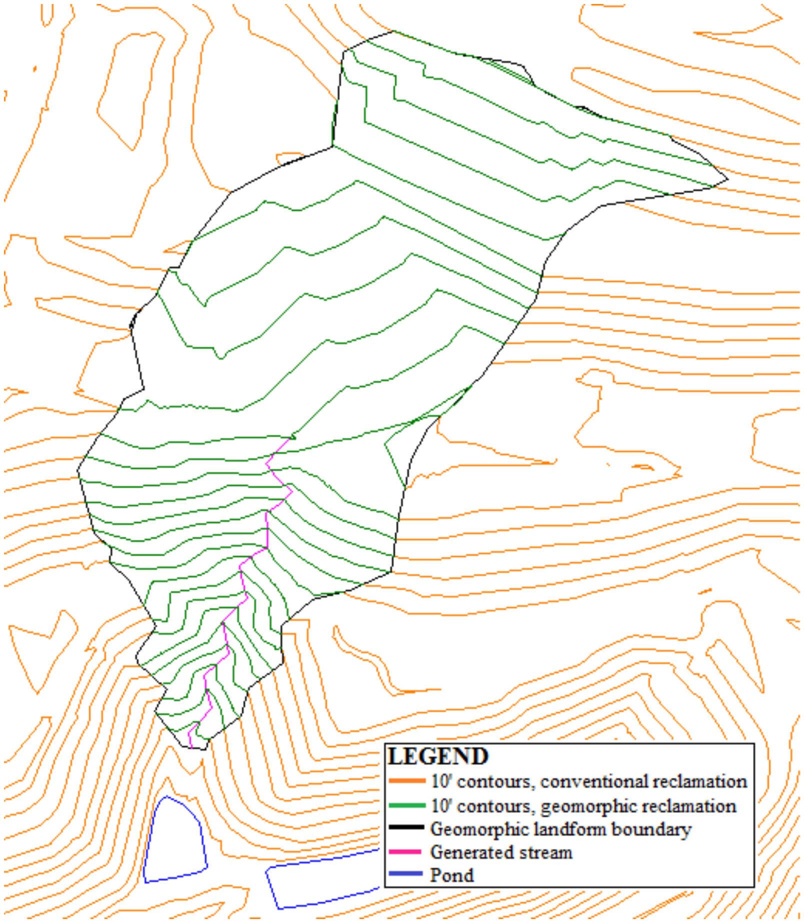
1) Preserve
2) Create


Conventional reclaimed topography
Natural Regrade Global Settings
Maximum distance between connecting channels (ft.)
10.00
Maximum distance from ridgeline to channel's head (ft.)
408
Slope at the mouth of the main valley bottom channel (%)
-6
'A' channel reach (ft.)
50.00
2-yr, 1-hr (in.) (see documentation)
Rain Map
1.32
50-yr, 6-hr (in.) (see documentation)
Rain Map
3.58
Target drainage density (ft./ac.)
61.7
Target drainage density variance (%)
23
Force ridges to be lower than GeoFluv boundary
Angle from subridge to channel's perpendicular, upstream (deg.)
10.00
North or East straight-line slopes (%)
20.00
Maximum straight-line slopes (%)
Maximum cut / fill variance (%)
Minimum cut / fill variance (%)
Cut swell factor
Fill shrink factor
OK
Cancel
Landform boundary and stream polyline
Ridges and valleys
Landform contours

VF1

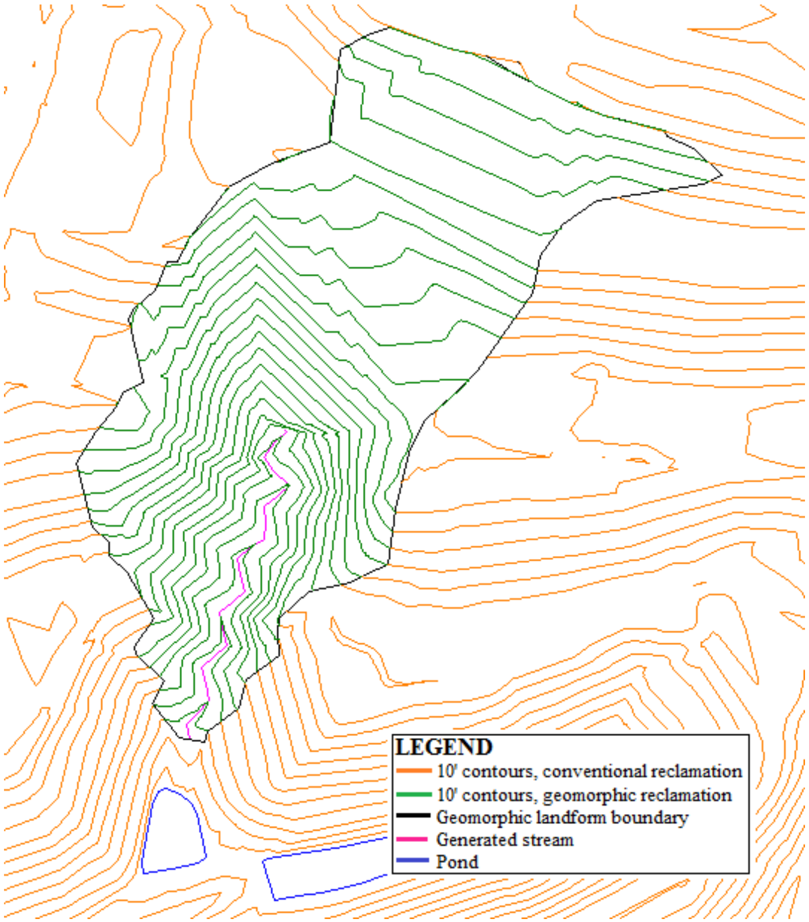


Preserved



Created

VF1: Preserving channels accounted for 65% of the overburden



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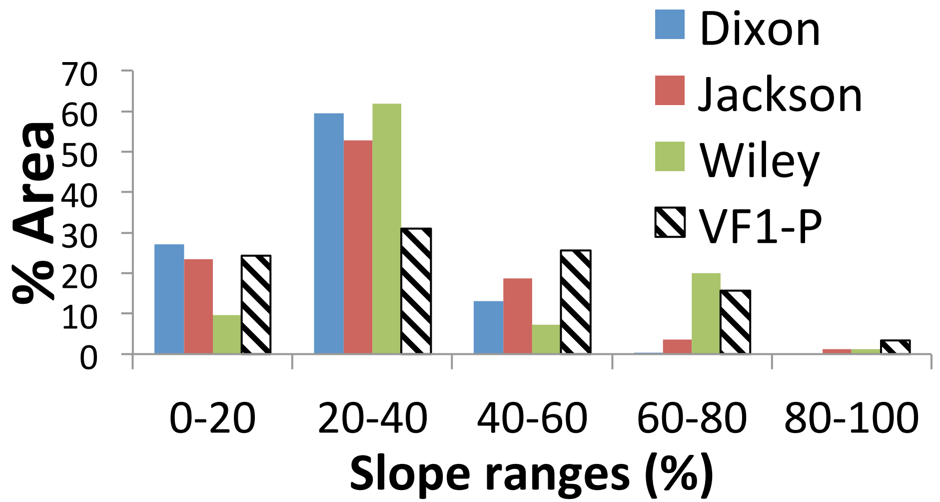
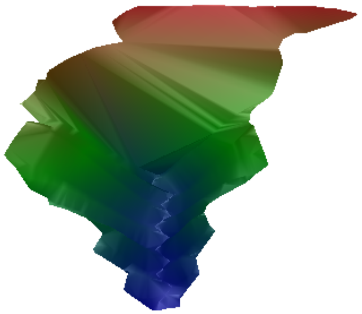


Watershed area
- 10.11 ac

Drainage density
- 48.75 ft/ac



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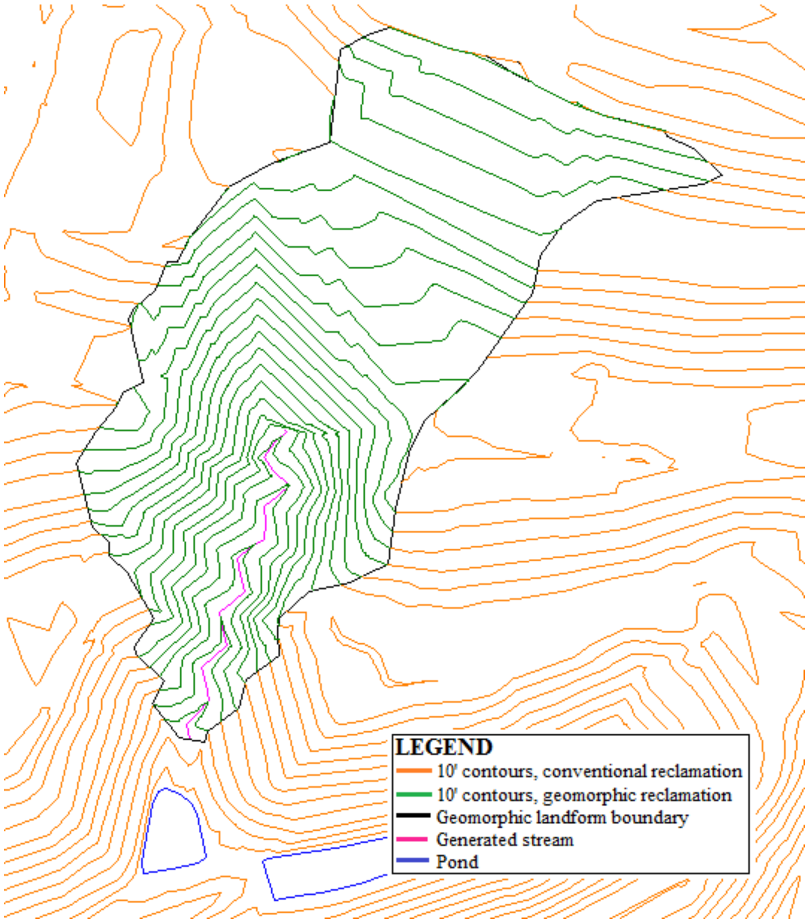

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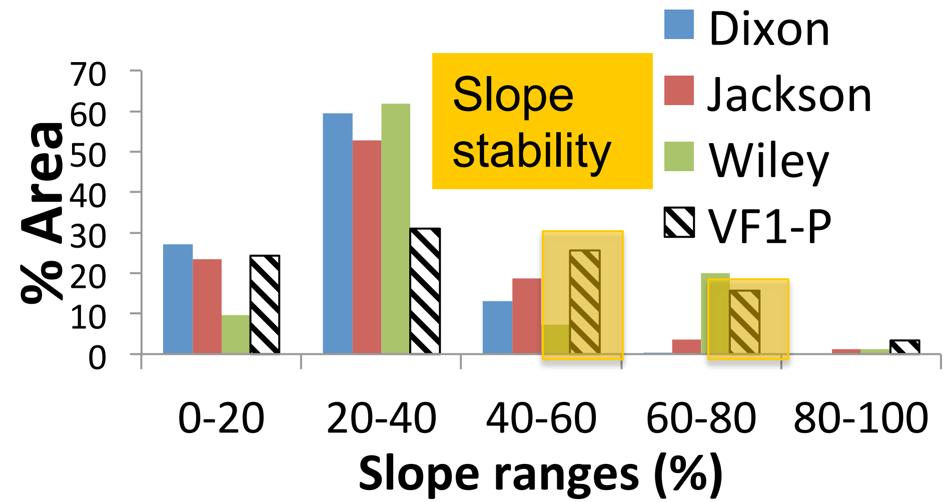

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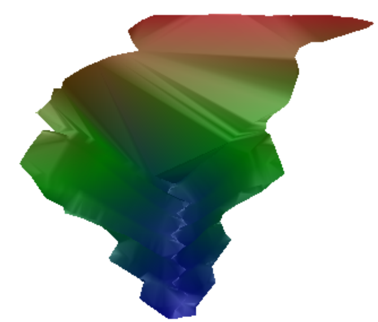
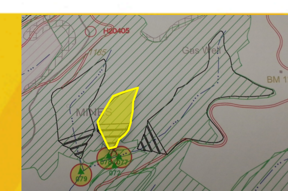
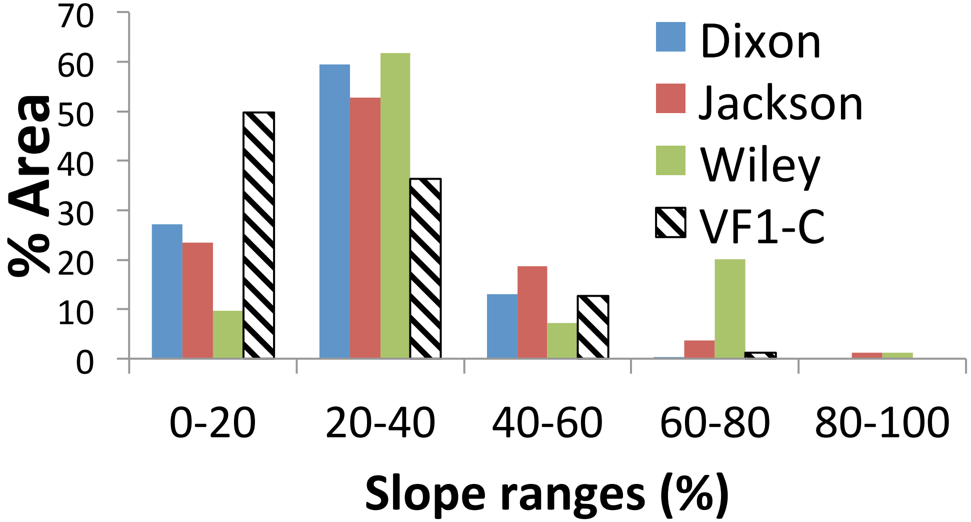
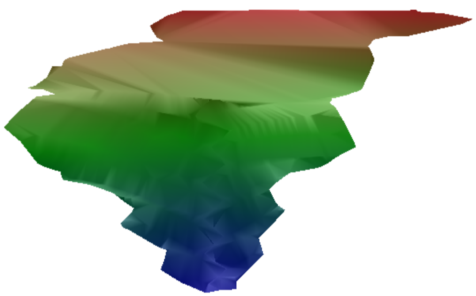




VF1: Creating channels accounted for 98% of the overburden





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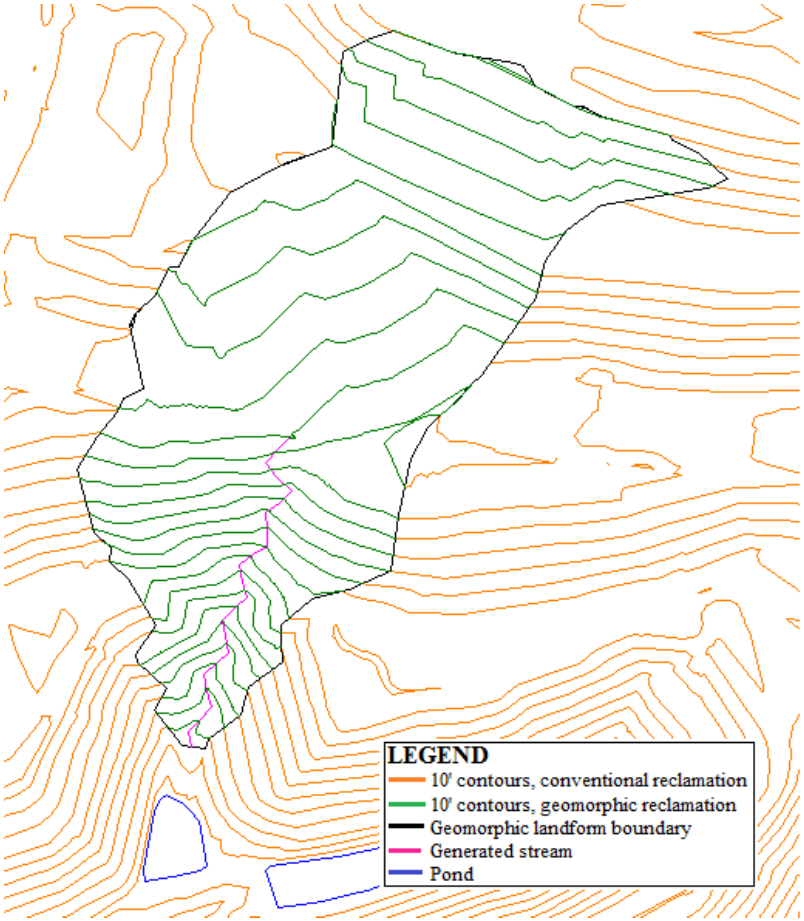

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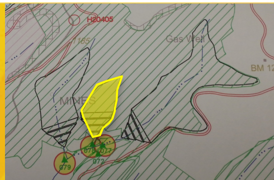

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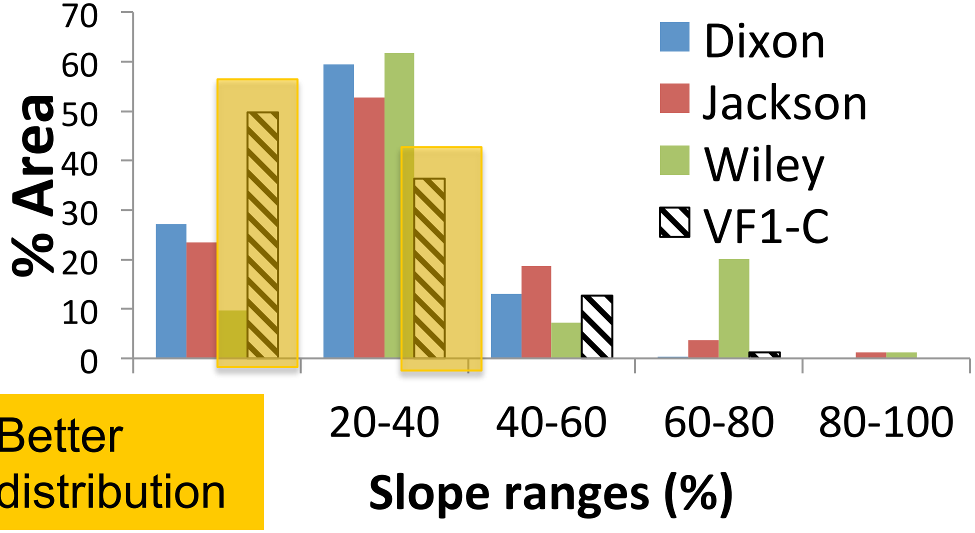
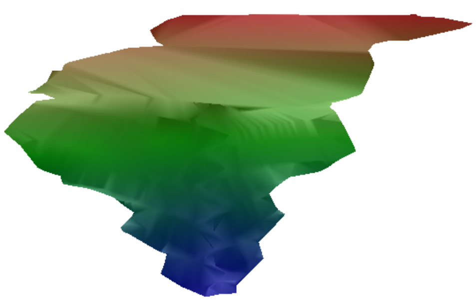


Better distribution



<u>Watershed area</u>

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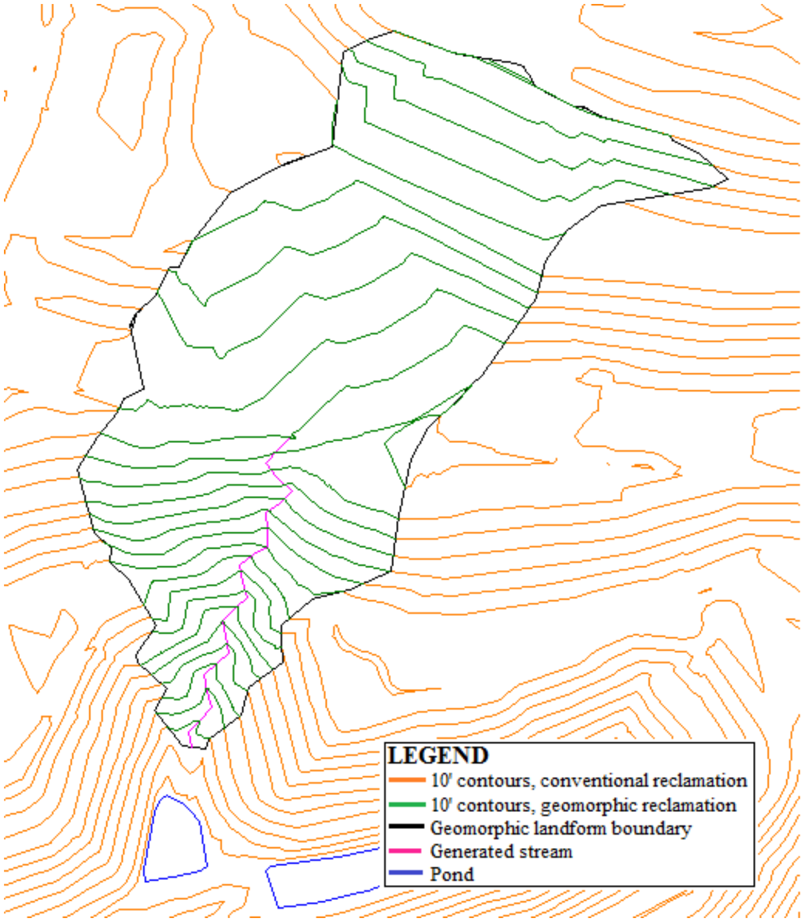

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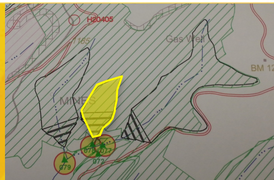
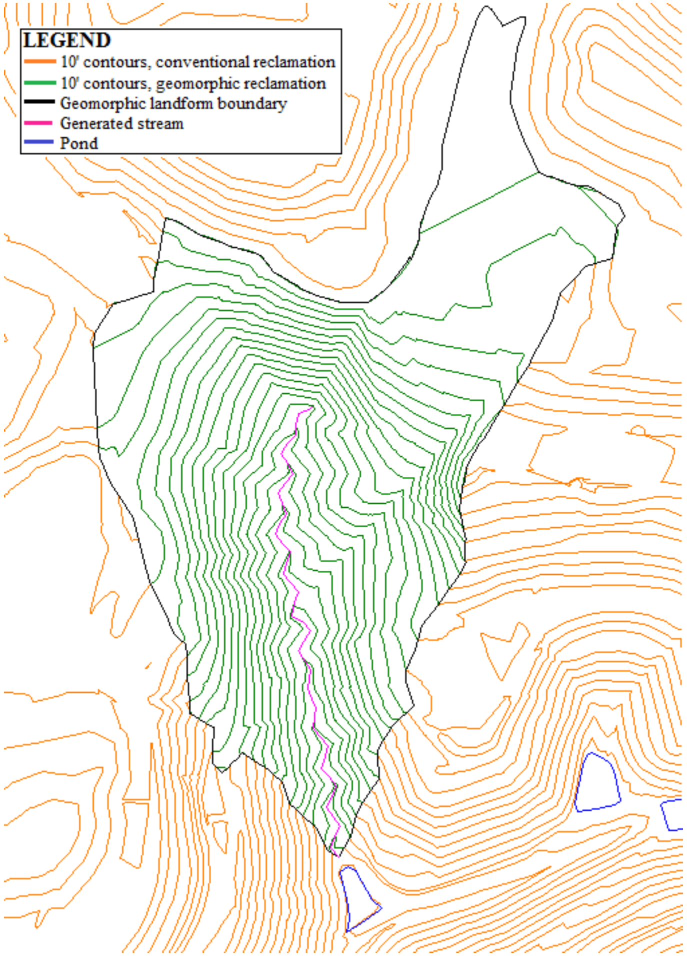
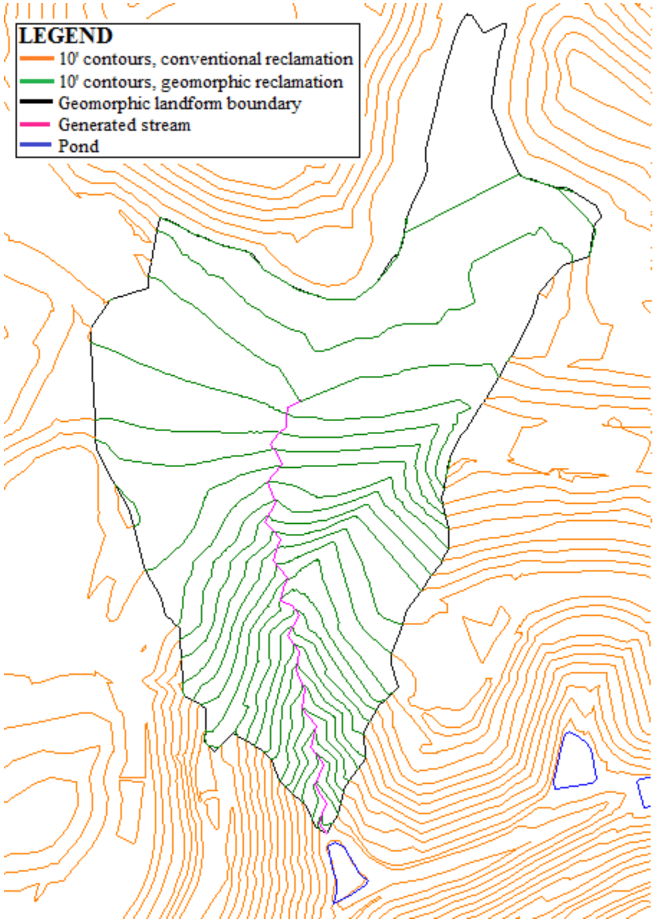


VF2

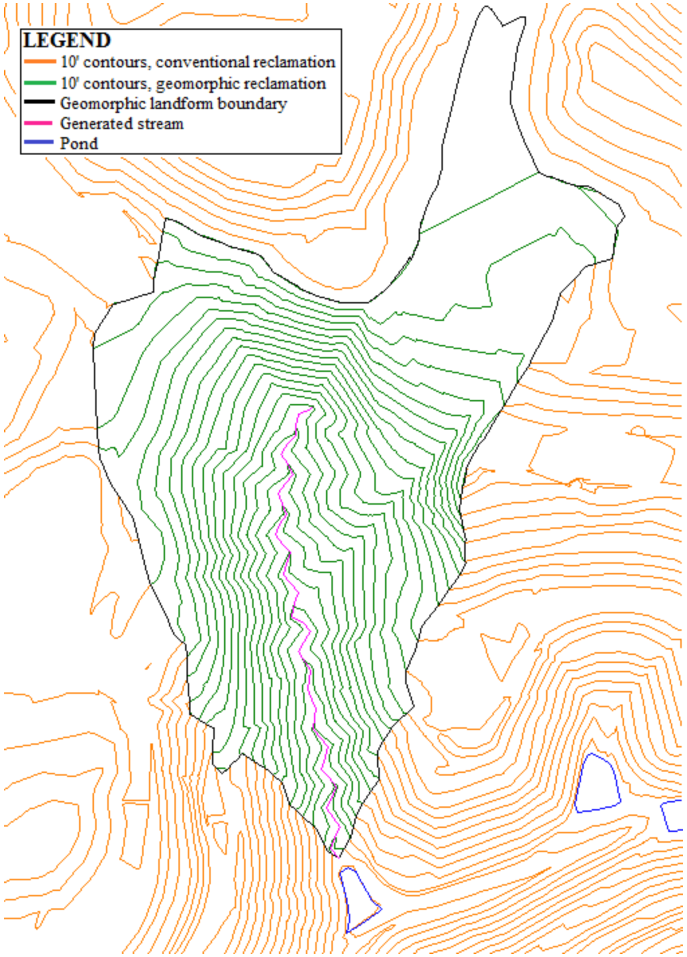


Preserved



Created

VF2: Preserving channels accounted for 53% of the overburden



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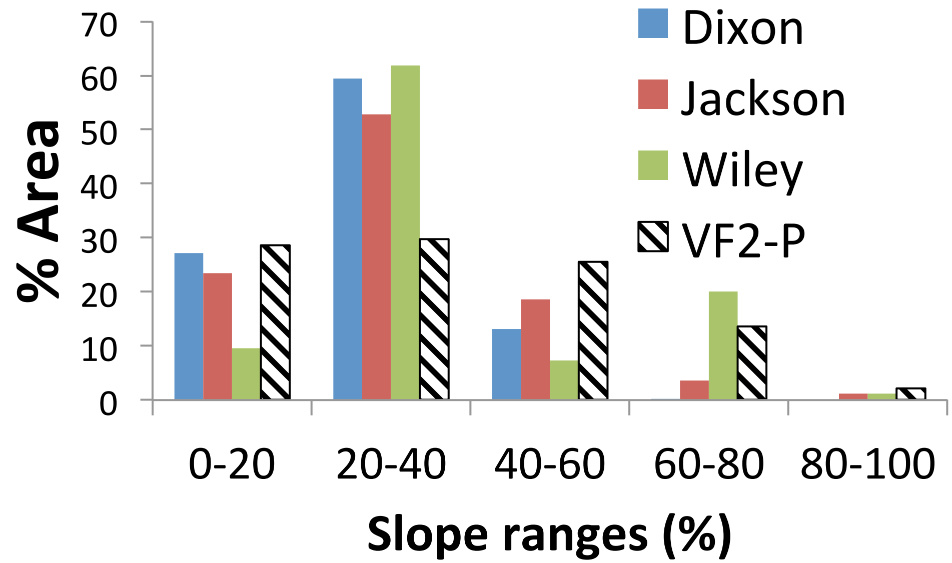
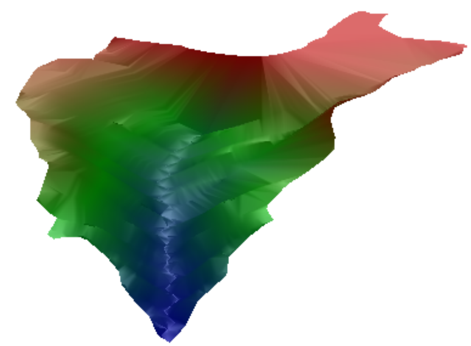


Watershed area

- 20.7 ac

Drainage density

- 48.65 ft/ac



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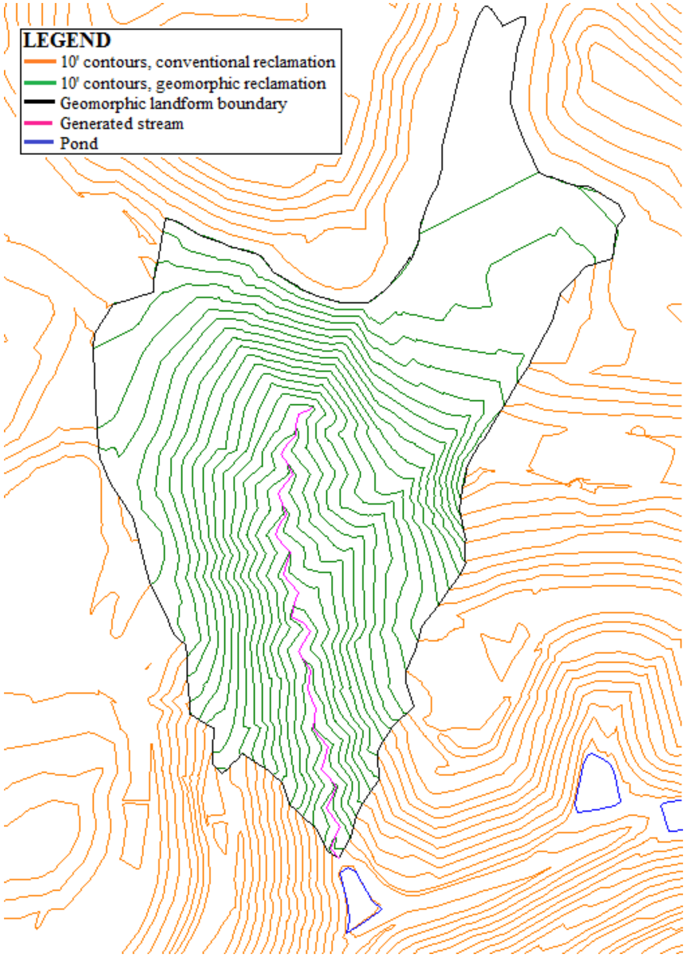

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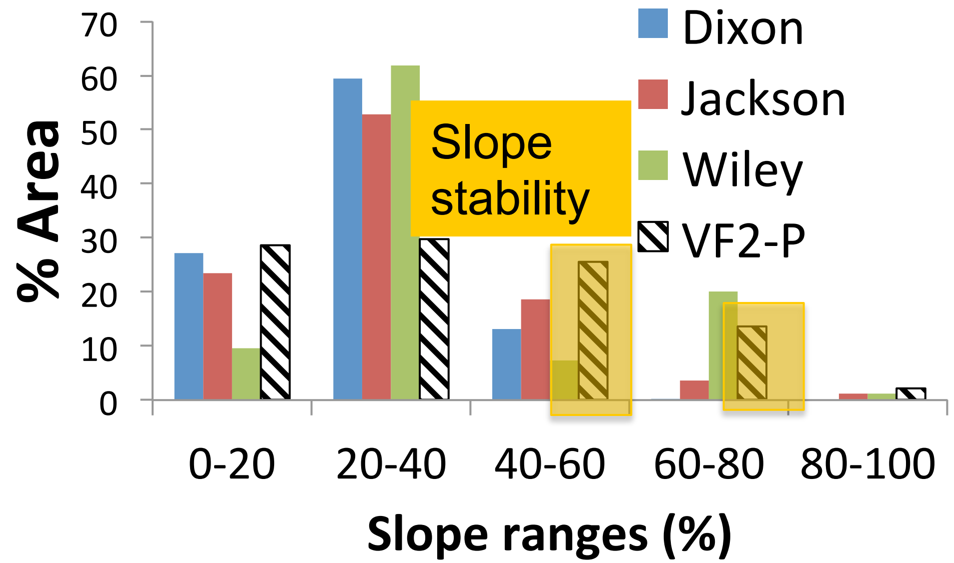

Watershed area
- 20.7 ac

Drainage density
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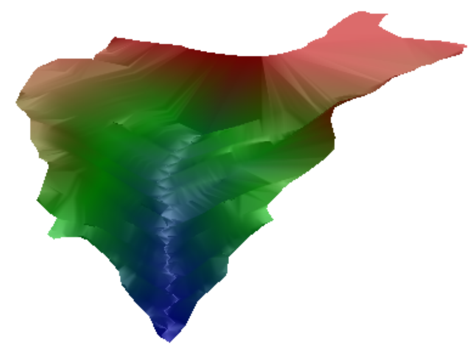
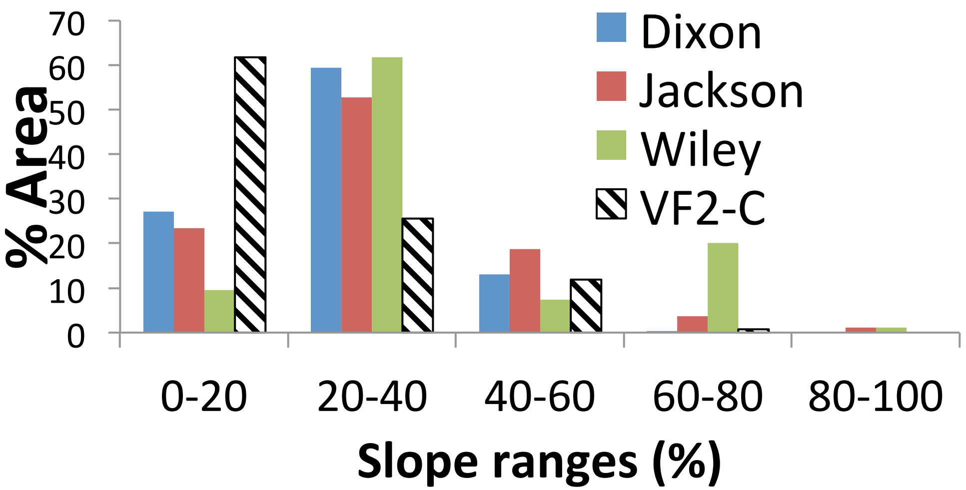


VF2: Creating channels accounted for 85% of the overburden

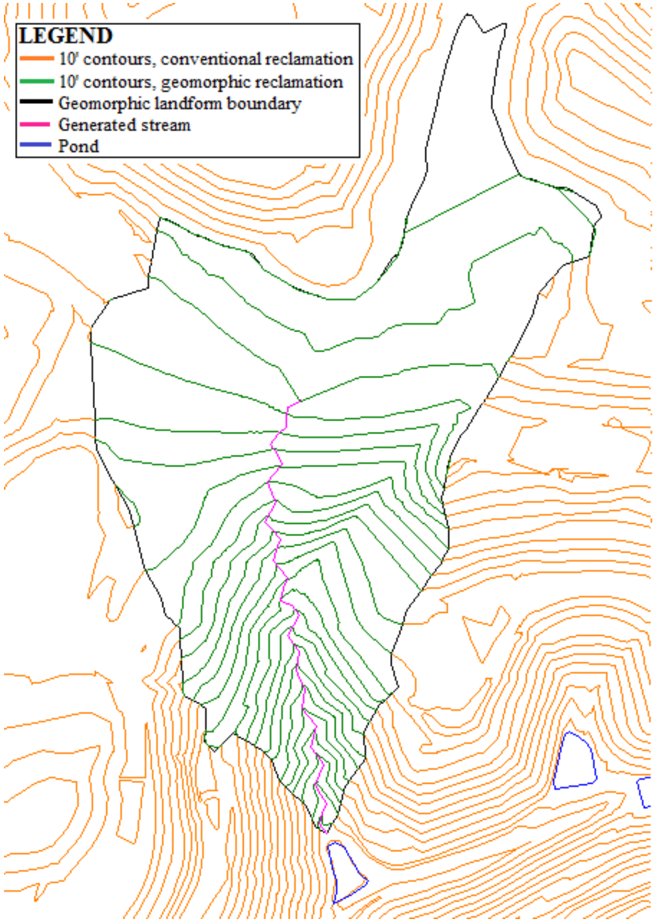


<u>Watershed area</u>

- 20.7 ac

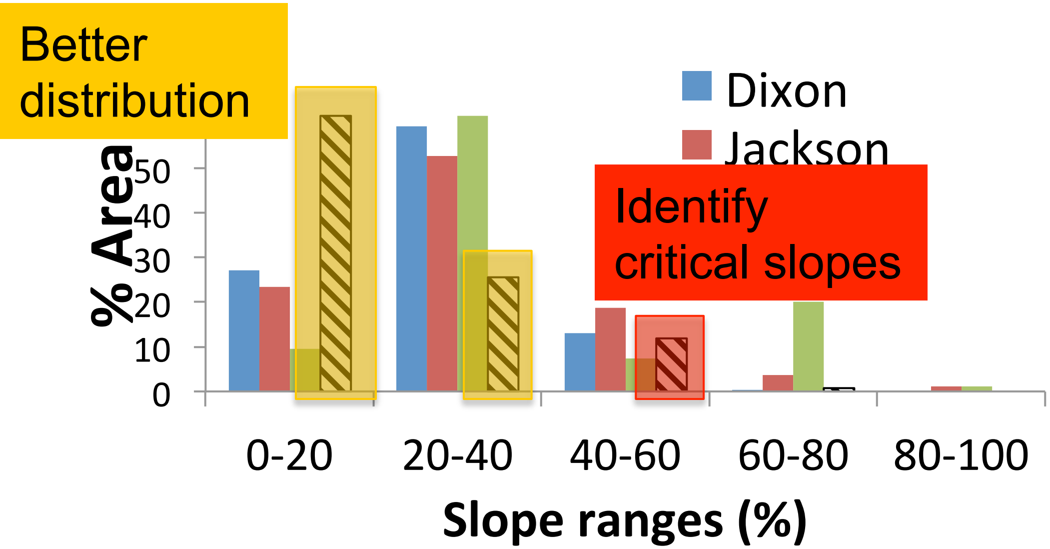
<u>Drainage density</u>

- 48.65 ft/ac



Created

VF2: Creating channels accounted for 85% of the overburden

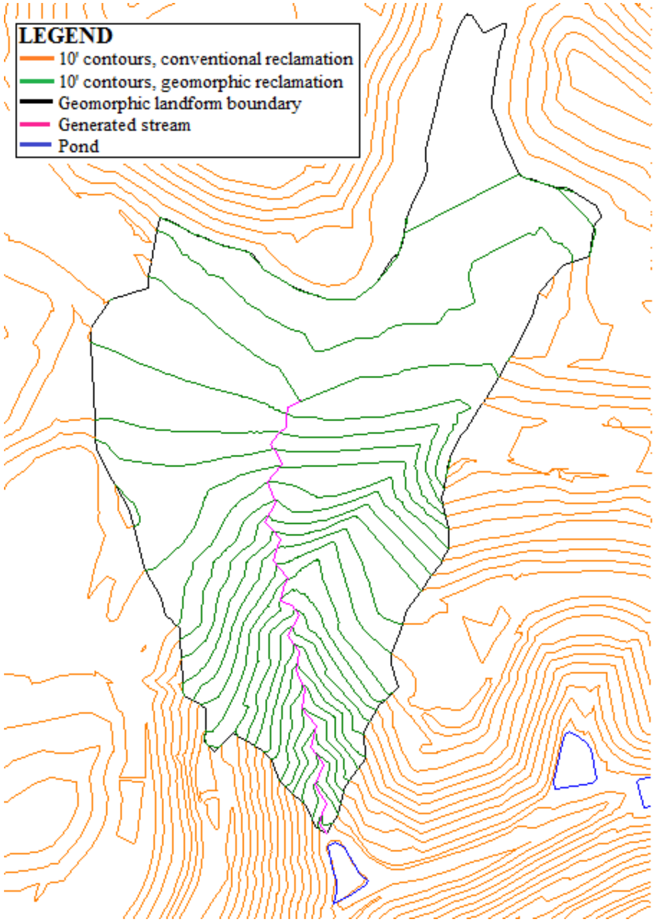


Watershed area

- 20.7 ac

Drainage density

- 48.65 ft/ac

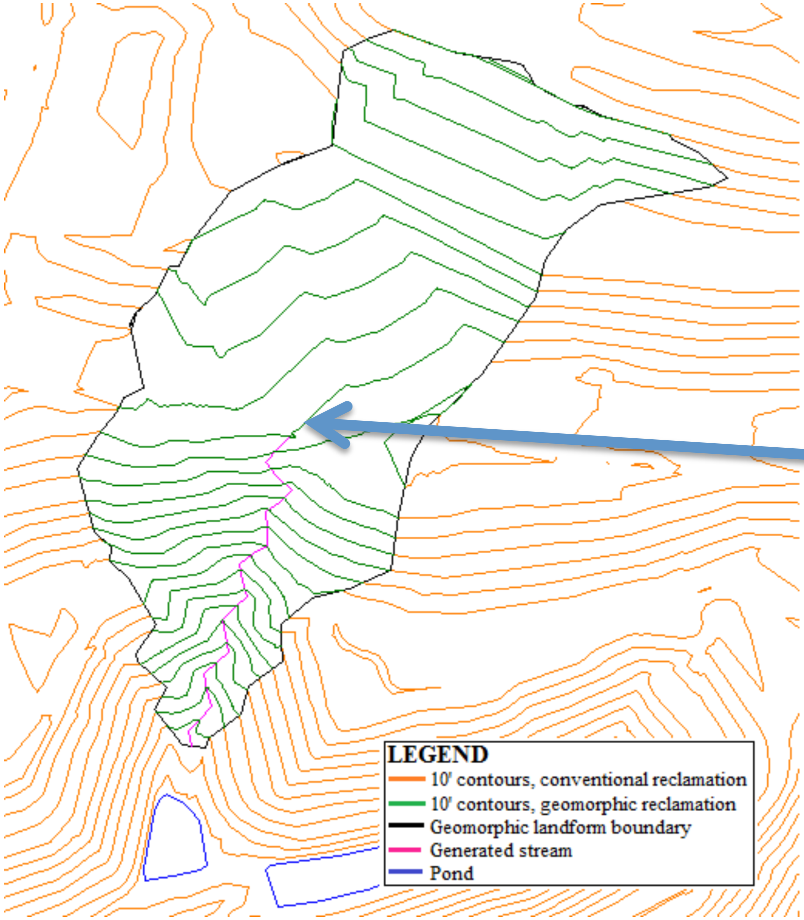


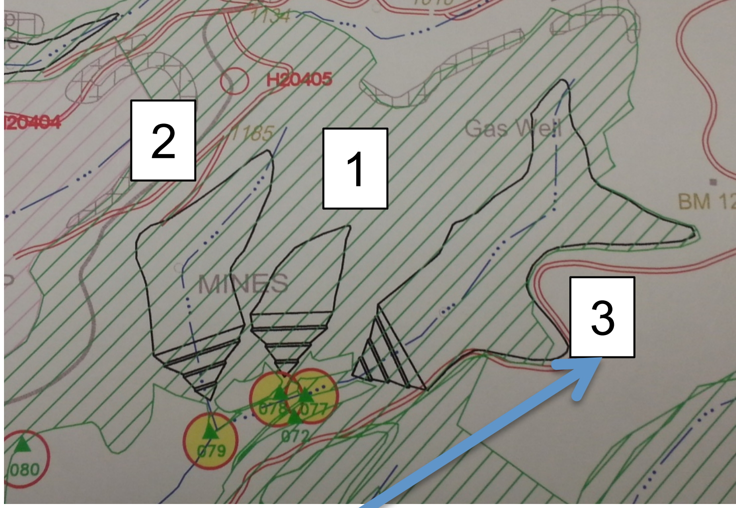
Created

Created channel designs landform and stream characteristics:

	VF1-C	VF2-C
Watershed area (ac)	10.1	20.7
Valley length (ft)	502	1007
Drainage density (ft/ac)	50	49
Head elevation (ft)	1121	1140
Base elevation (ft)	955	916
Relief (ft)	166	224
Head slope (%)	29	20
Base slope (%)	10	8
Slope range (%)	9.7 to 35	8.5 to 23.5
Bankfull width range (ft)	0.3 to 5.16	0.66 to 7.38
Bankfull depth range (ft)	0.03 to 0.52	0.07 to 0.74
Width to depth ratio, slope <4%	12.5	12.5
Width to depth ratio, slope >4%	10	10
Flood prone width range (ft)	0.63 to 10.8	1
Flood prone depth range (ft)	0.07 to 1.22	1.38 to 15.45
Entrenchment ratio	2.09	2.09

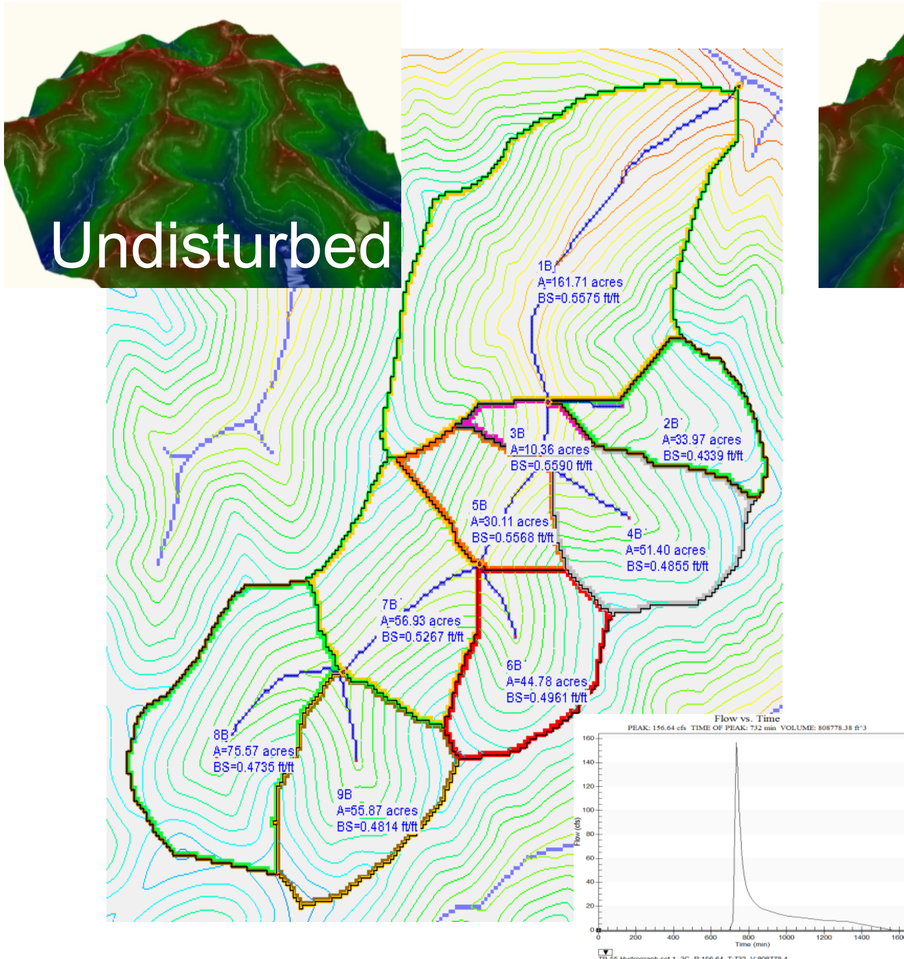
Future work:

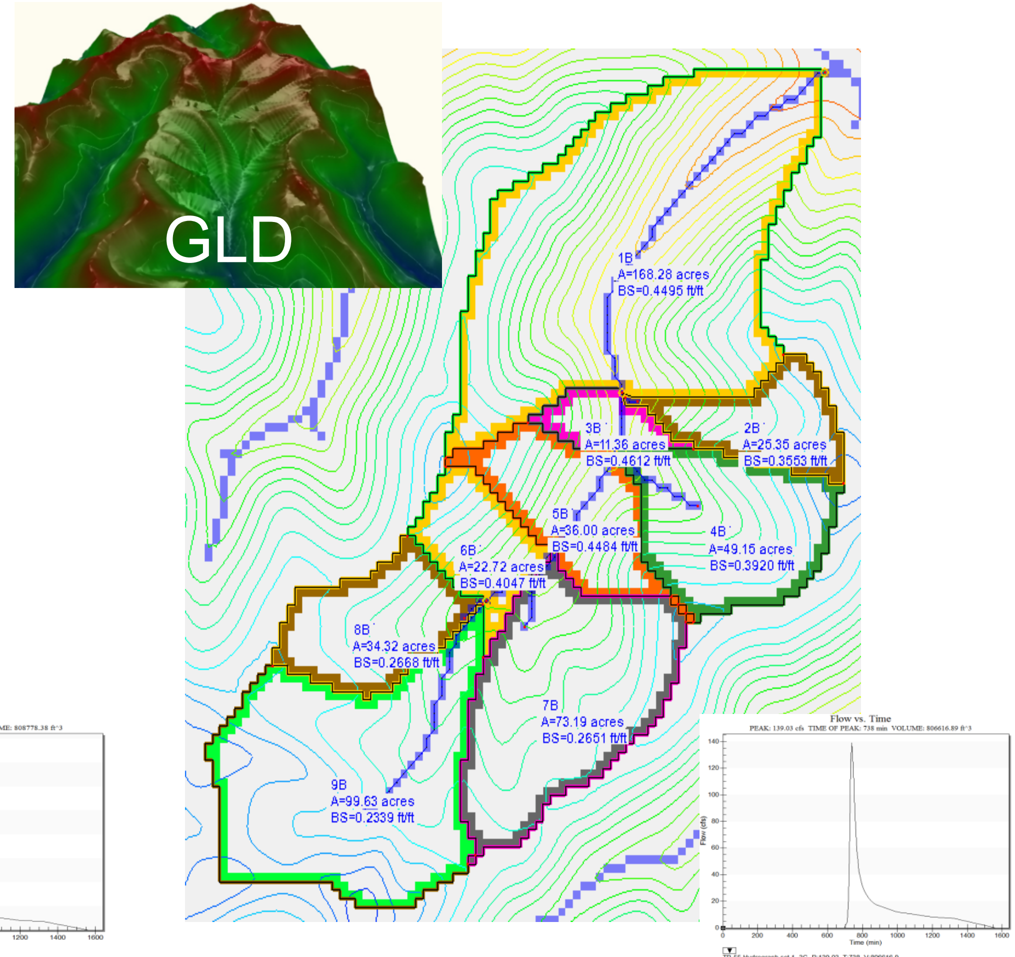




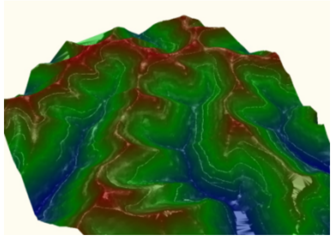
- 3rd valley fill
- Perennial streams
  - Pond design
- Slope stability analysis
- Channel characteristics
  - Erosion and sediment transport
- Hydrologic response
- Groundwater

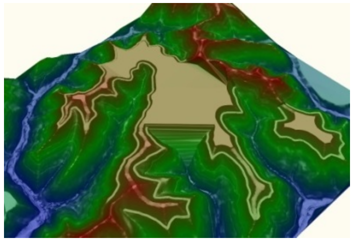
Related work: Hydrologic response

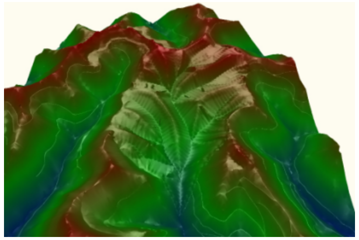


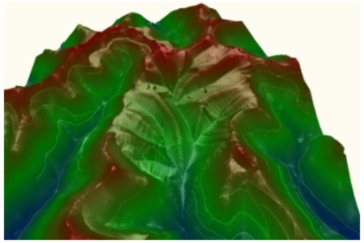


Related work: Hydrologic response

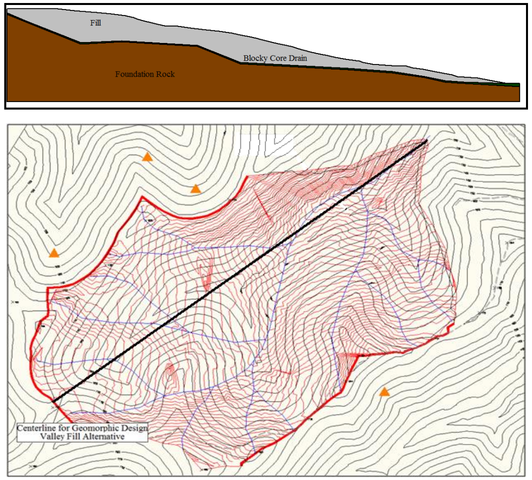


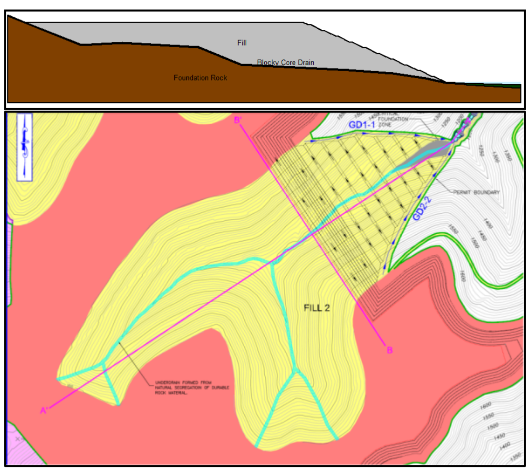






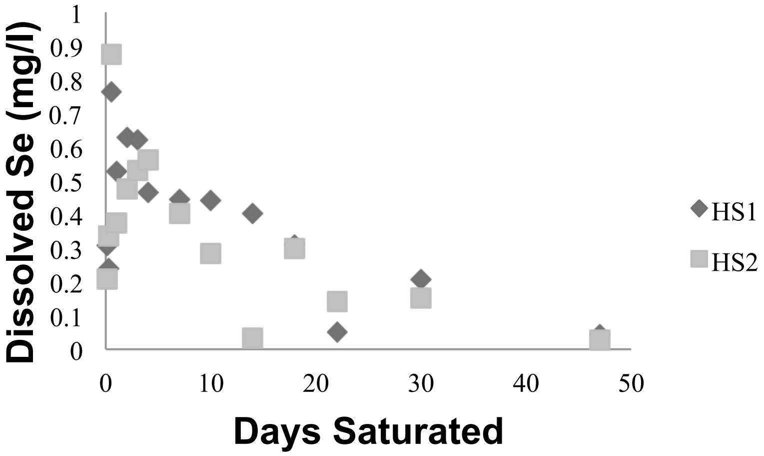
Related work: Slope stability

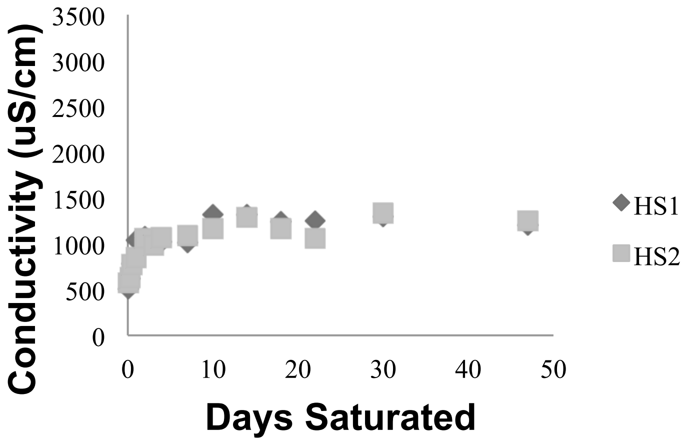




Failure Plane	Hydraulic Condition	$\beta^{o}=\tan^{-1}(y/x)$	Critical Deterministic Factor of Safety
AOC Valley Fill - Saturated			
Crest	Saturated	26.57	1.41
Toe	Saturated	26.57	1.51
Face	Saturated	26.57	1.39
Deep	Saturated	26.57	1.38
AOC Valley Fill - Unsaturated			
Crest	Unsaturated	26.57	1.67
Toe	Unsaturated	26.57	1.25
Face	Unsaturated	26.57	1.37
Deep	Unsaturated	26.57	1.30
Geomorphic - Saturated			
Crest	Saturated	11.43	2.04
Toe	Saturated	17.63	2.14
Face	Saturated	15.47	2.42
Geomorphic - Unsaturated			
Crest	Unsaturated	11.43	2.31
Toe	Unsaturated	3.84	3.49
Face	Unsaturated	7.34	2.15

Related work: Groundwater modeling





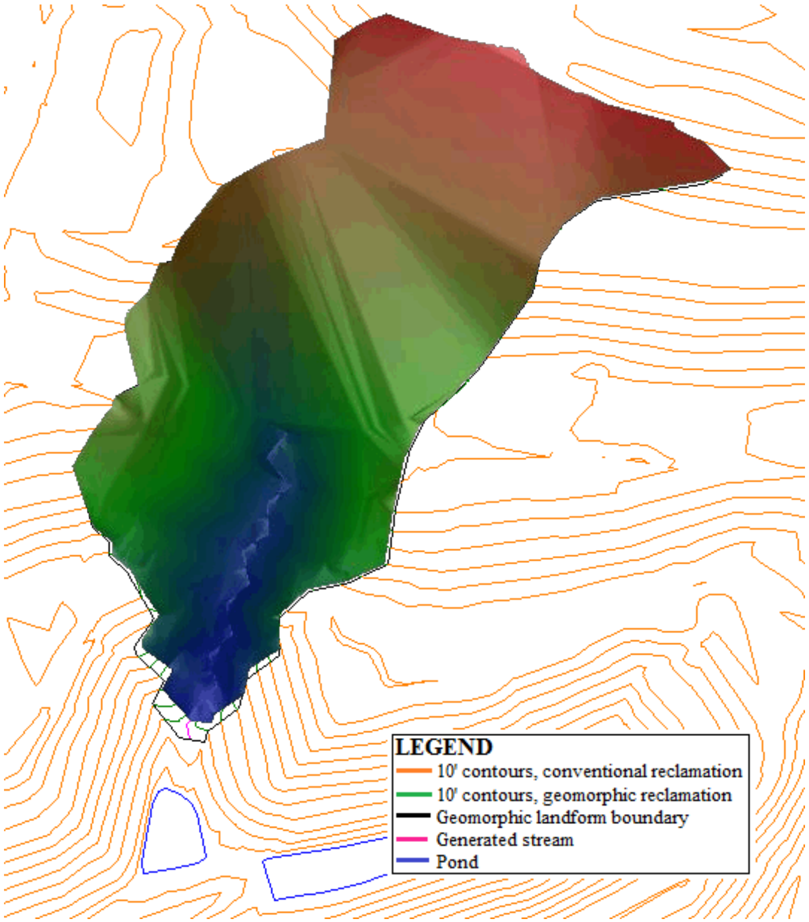
(a) (b)

Conclusions

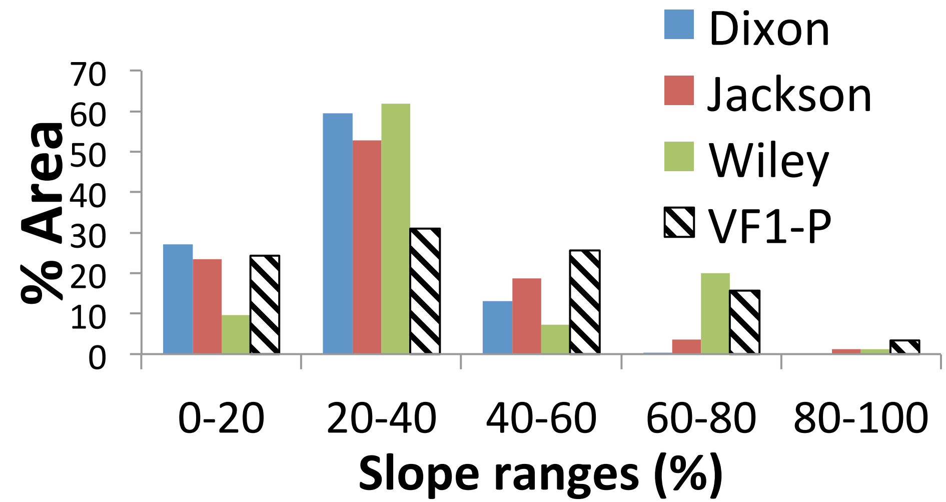
- Data on the geomorphic properties of mature and reclaimed landforms in southern WV have been compiled.
- Input values for geomorphic designs have been determined for landforms specific to Central Appalachia.
- Preliminary results indicate that landforms can be created with a similar footprint.
  – Varies by location and size
- Future work will test for stability and hydrologic response.

QUESTIONS?

VF1: Preserving channels accounted for 65% of the overburden



Preserved

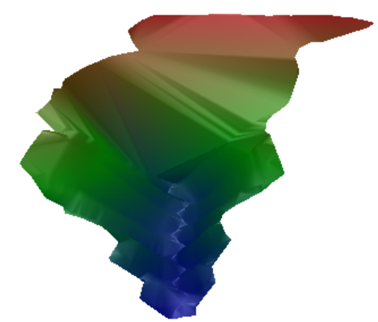


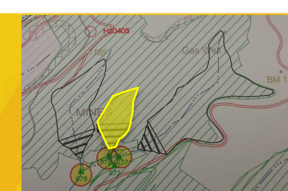
<u>Watershed area</u>

- 10.11 ac

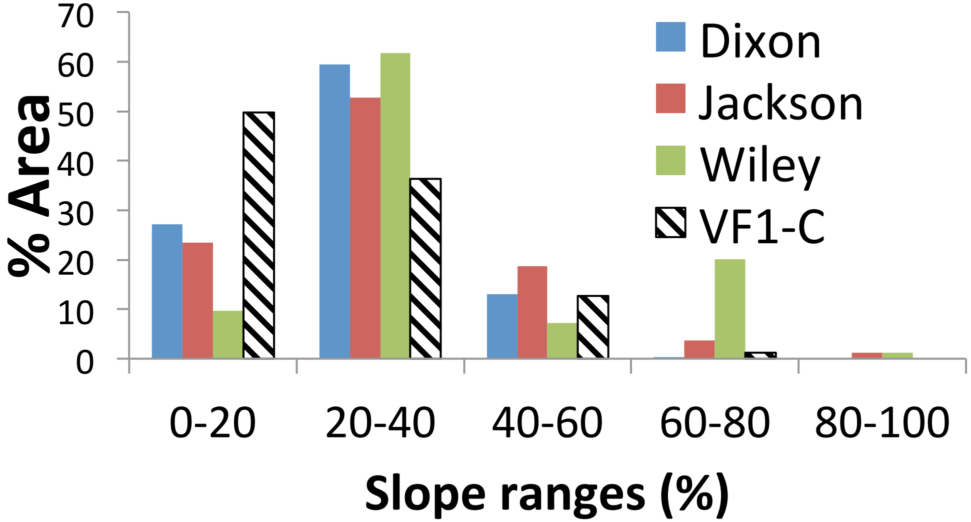
<u>Drainage density</u>

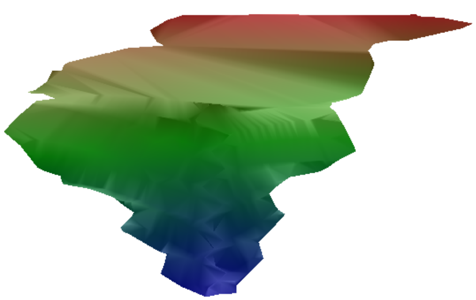
- 48.75 ft/ac





VF1: Creating channels accounted for 65% of the overburden





<u>Watershed area</u>

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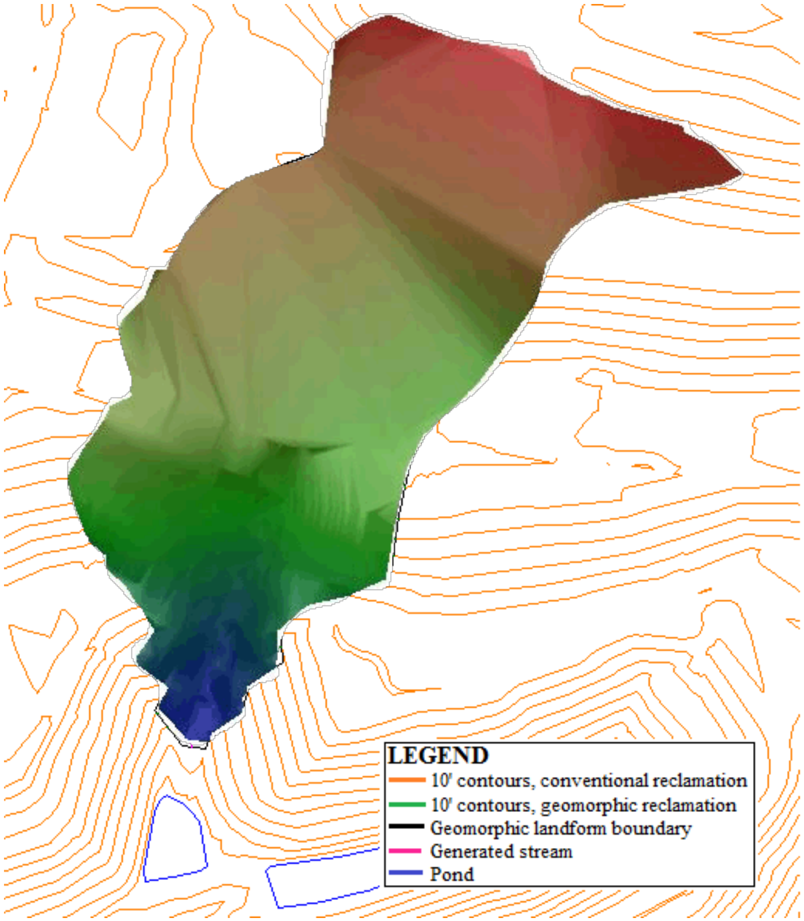
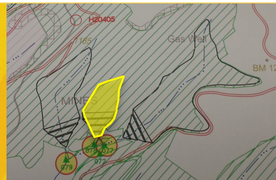
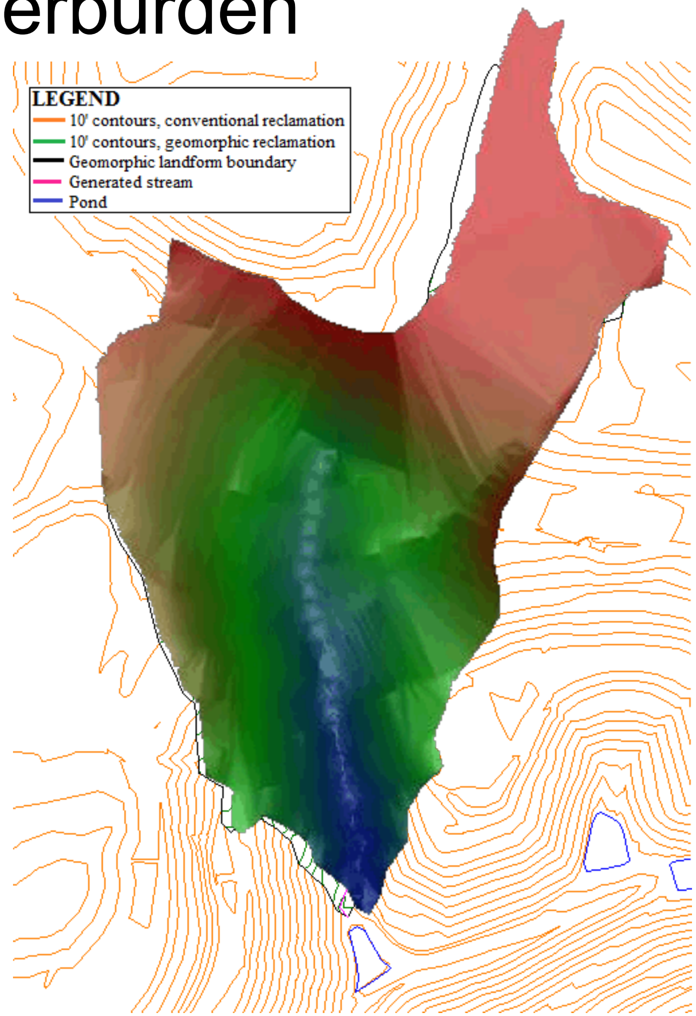


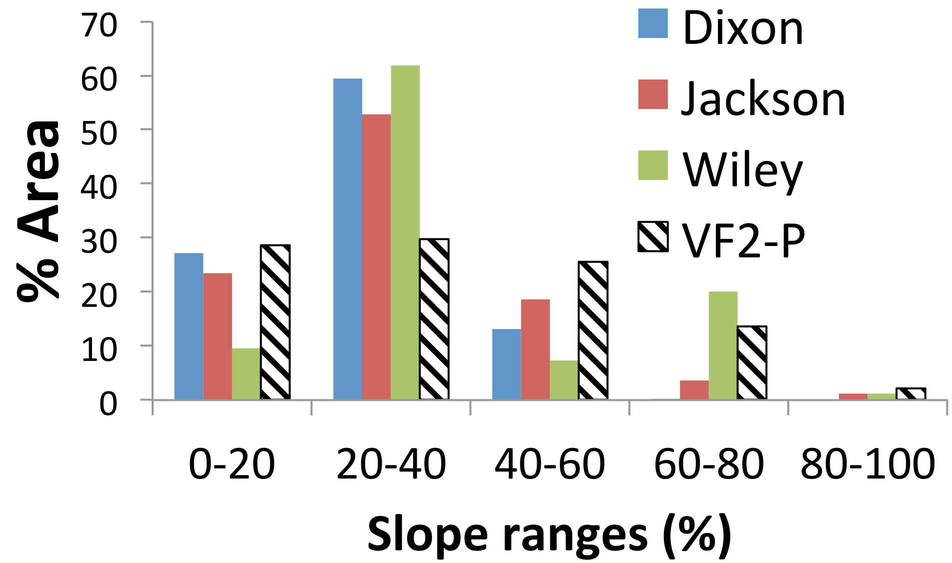
Created



VF2: Preserving channels accounted for 53% of the overburden



Preserved

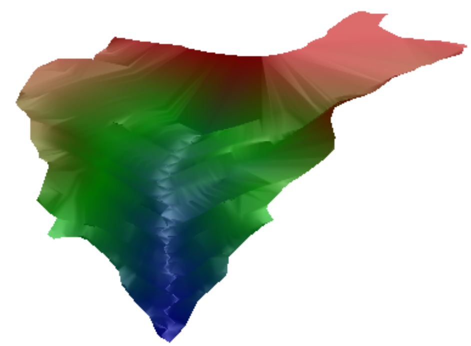


<u>Watershed area</u>

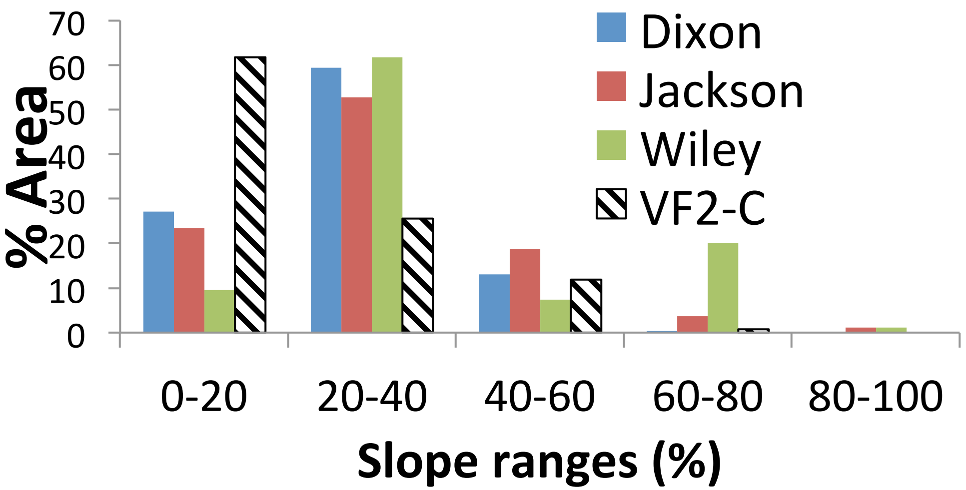
- 20.7 ac

<u>Drainage density</u>

- 48.65 ft/ac



VF2: Creating channels accounted for 85% of the overburden

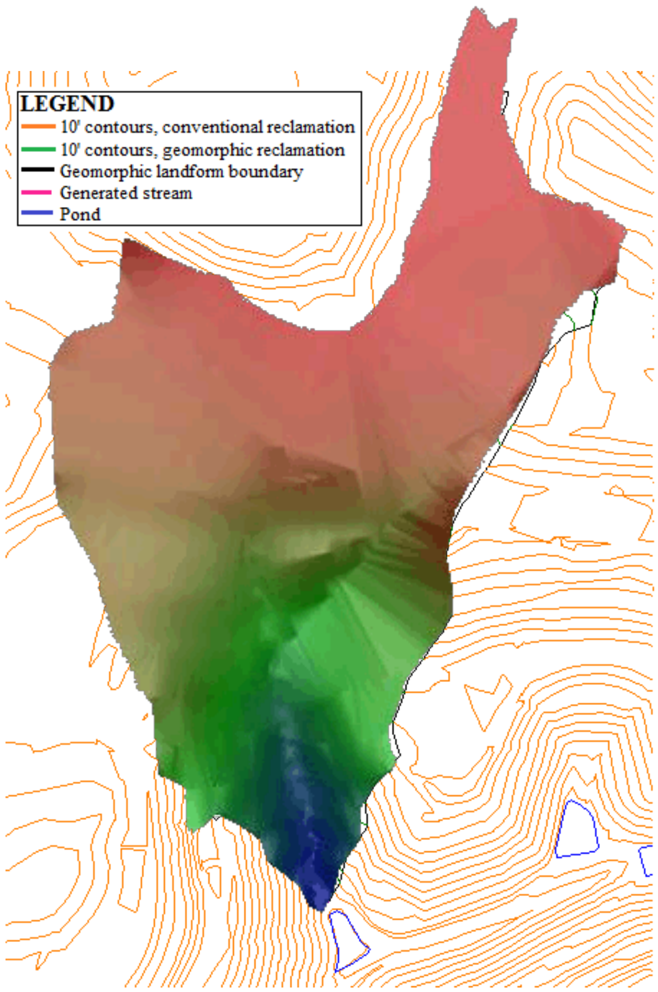


<u>Watershed area</u>

- 20.7 ac

<u>Drainage density</u>

- 48.65 ft/ac



Created