Multi-Metric Stream Health Indicators – Hydraulics and Geomorphology

Chesapeake Bay Program
Science. Restoration. Partnership.

Draft Recommendations

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Purpose

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This project is conducting interviews with experts, reviewing data, creating a framework, providing a data inventory matrix, and making recommendations that may help develop multi-metric stream health indicators for hydraulics and geomorphology. The development of these additional indicators will address the significant science and management need to better understand and communicate how streams respond to management actions.

Technical Advisory Group

Stream Health Work Group

Chesapeake Bay Program

Additional Interviews

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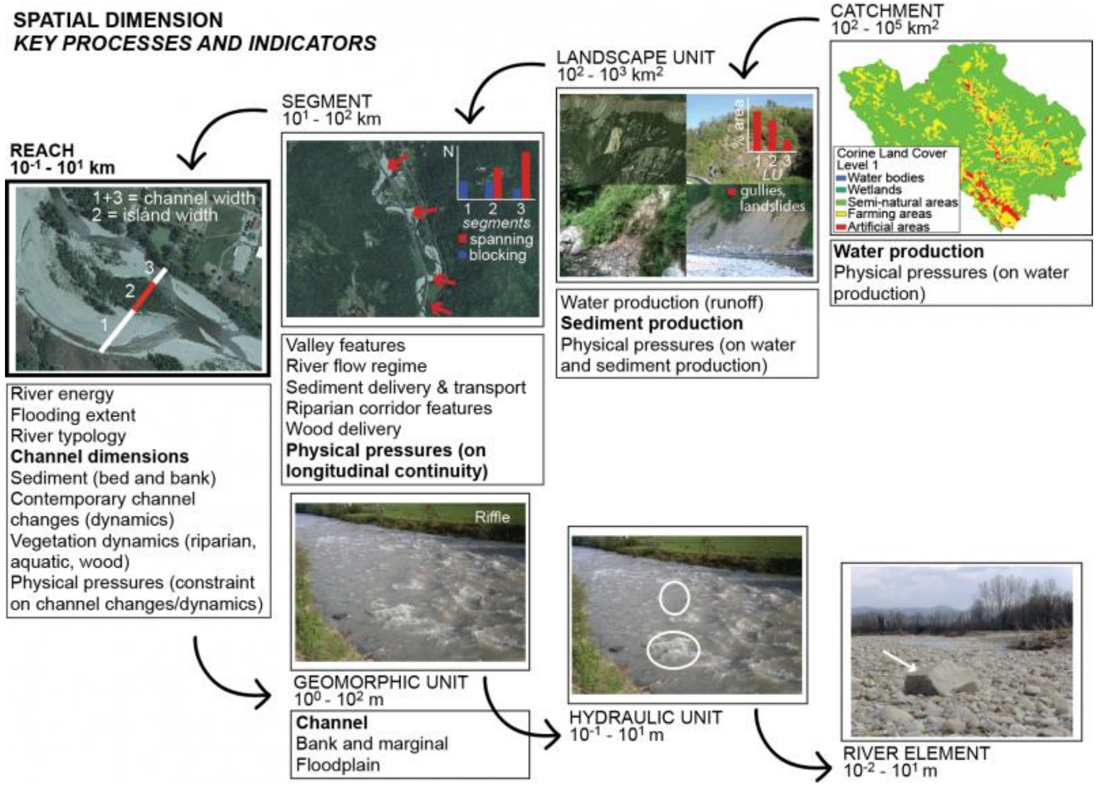
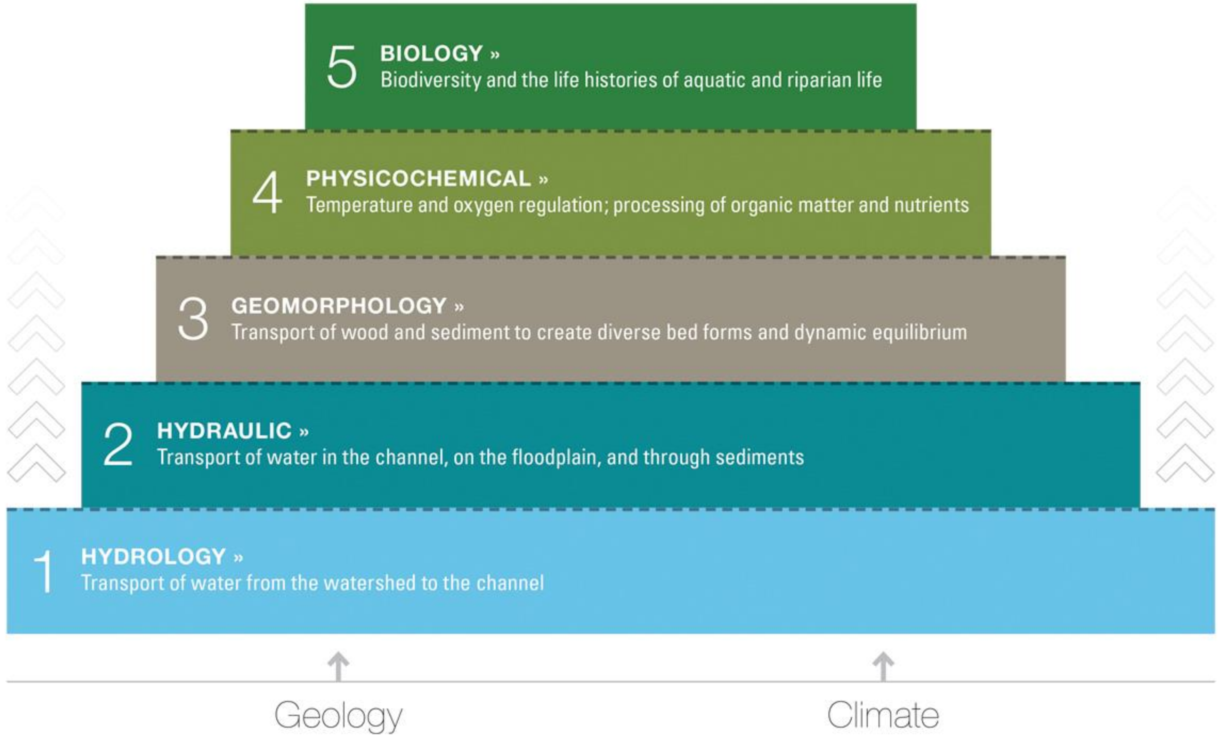
- Interstate Commission on the Potomac River Basin (ICPRB)
- UMBC (Matt Baker)
- Maryland Environmental Service (MES)
- Maryland Water Monitoring Conference (MWMC) Stream Monitoring Subcommittee
- USGS/Chesapeake Bay Program (CBP)
- USEPA Water Resources Registry (Emily Gentry)
- Virginia Tech (Tess Thompson)
- Fairfax County (Chris Ruck)
- Biohabitats (Joe Berg)
- Maryland Department of Natural Resources/Forest Service (Anne Hairston-Strang)
- FACET Team (Labeeb Ahmed, Peter Claggett, Krissy Hopkins and Greg Noe)

Holistic Approach

REFORM Spatial Dimensions



Stream Functions Pyramid



Proposed Multi-Metric Hydromorphology Indicator Framework

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River Basin and Landscape Unit/Pyramid Level 1–Hydrology

- The landscape unit scale provides the broad context for understanding conditions affecting a stream

River Segment/Pyramid Level 2–Hydraulics

- The river segment scale characterizes the relationship of the stream to its valley, how valley conditions affect stream energy, and the width of floodplain area that may be available

Reach/Pyramid Levels 2—Hydraulics and 3—Geomorphology

- The reach scale is characterized by differences in stream dimension, pattern and profile, the degree to which flow is confined within a channel, and the prevalence of riparian vegetation cover

Geomorphic Unit/Pyramid Level 3—Geomorphology

- Geomorphic units are areas containing a landform created by erosion and/or deposition of sediment, essentially the creation of a stream system network through stream energy

Prevalent Data Tools

- European Commission REFORM Project
- Watershed Resources Registry – Stream Stability Index
- Function-based Rapid Stream Assessment Protocol Revision
- Maryland Department of Transportation/State Highway (SHA) – US 301 Waldorf Area Transportation Project, Environmental Stewardship Methodologies and Results
- USEPA Dynamic Stream Systems
- Multi-jurisdictional Rapid Habitat Assessment Database
- Stream and Floodplain Geometry Mapping and Geomorphic Change Modeling
- Flow Alteration Metrics
- Maryland Healthy Watersheds Assessment – Hydrology and Geomorphology GIS Metric

Candidate Desktop Indicators

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River Basin and Landscape Unit/Pyramid Level 1–Hydrology

- Runoff – Flow regime
- Sediment Production – Potential watershed sediment load
- Geology – Used to assess runoff and sediment production
- Climate – Can influence flow regime
- LULC – Used to assess runoff and sediment production

River Segment/Pyramid Level 2–Hydraulics

- Valley confinement – Available floodplain
- Sediment Transport – Ability to process sediment

Candidate Desktop Indicators

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Reach/Pyramid Levels 2—Hydraulics and 3—Geomorphology

- Planform – Valley type and stream pattern
- Floodplain connectivity – Storm flow floodplain access, storage and attenuation.
- Channel Dimension – Width-depth ratio
- Buffer Width – Width

Geomorphic Unit Level 3—Geomorphology

- Channel dimension
- Bed stability
- Stream energy
- Lateral stability

Example Uses of GIS Data

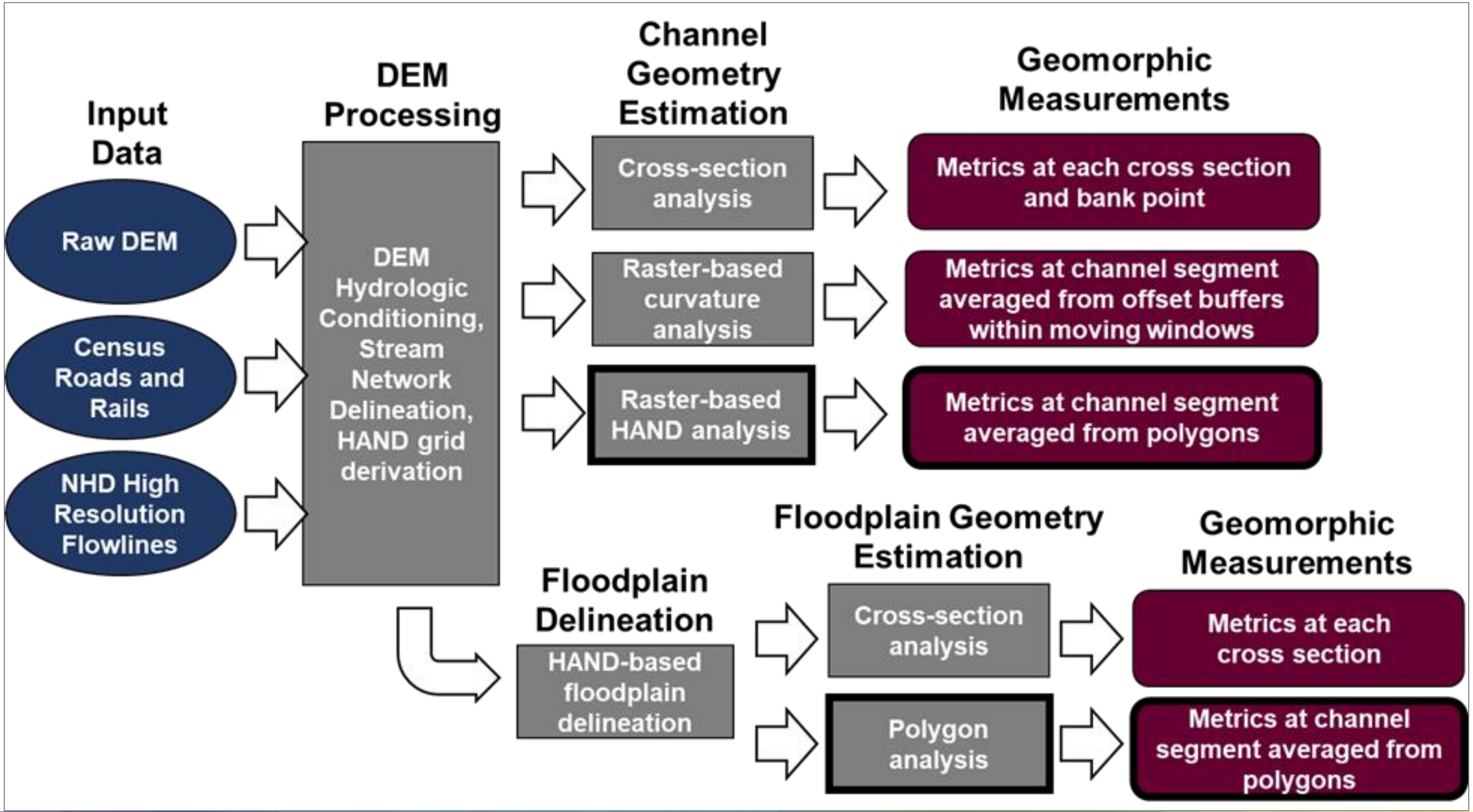
Compare to field collected stream data from 8 stream restoration projects

1. Compare physical measurements from FACET to field data
2. Compare stability predictions of desktop GIS layers with field data

8 Stream Restoration Projects

1. Broad Creek Valley West, MD
   - DA – 0.15 mi2, Coastal Plain Region, 38.970047,-76580141
2. UT Flat Creek, MD
   - DA – 0.27 mi2, Coastal Plain Region, 38.952208,-76.625244
3. Heritage Harbour, MD
   - DA – 0.39 mi2, Coastal Plain Region, 38.970773,-76.596366
4. Beck Creek, PA
   - DA – 2.42 mi2, Piedmont Region, 40.286740, -76.458800
5. Big Cove Site 1, PA
   - DA – 6.4 mi2, Ridge and Valley Region, 39.909328,-78.013957
6. Bush Creek, MD
   - DA – 7.66 mi2, Piedmont Region, 39.371655,-77.252766
7. Big Cove Site 2, PA
   - DA – 10.3 mi2, Ridge and Valley Region, 39.891018,-78.022149
8. Big Cove Site 3, PA
   - DA – 15.9 mi2, Ridge and Valley Region, 39.880632,-78.027757

Comparing FACET to Field Measurements



Comparing FACET to Field Measurements

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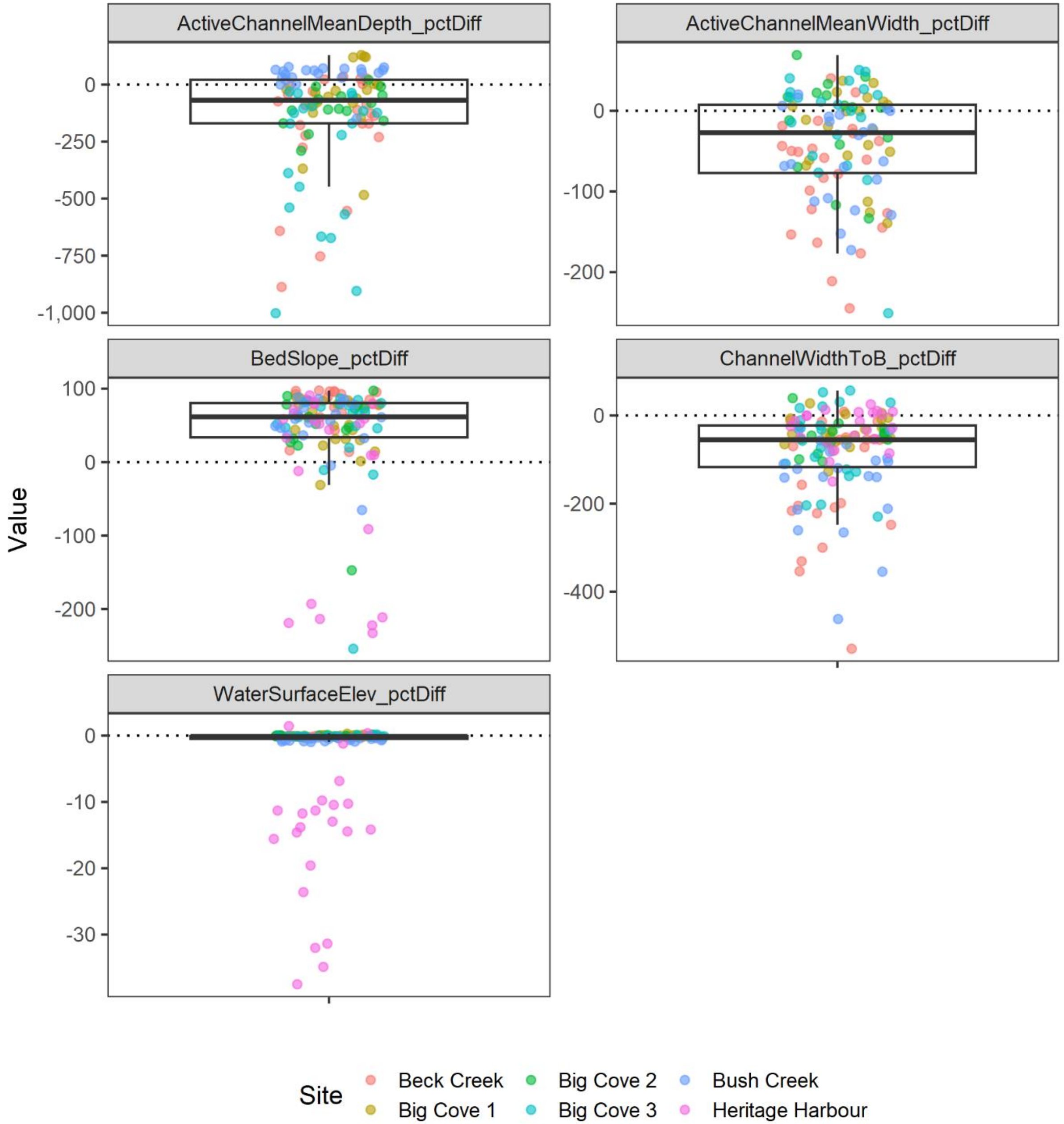
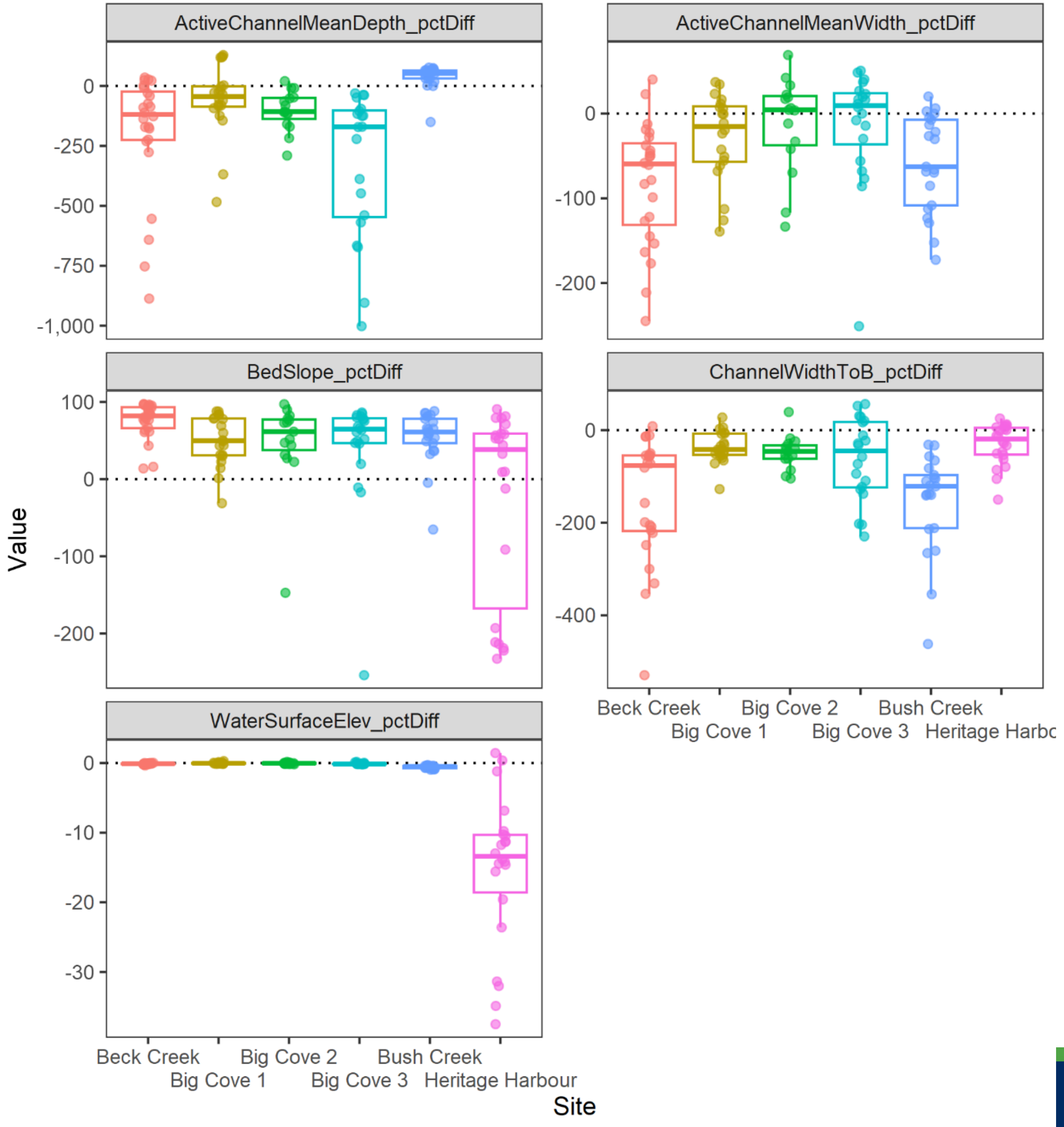


Comparing FACET to Field Measurements



Using GIS Layers to Predict Stability

Metrics from Maryland SHA 2009 to predict stream stability

- Slope
- Erodible soils
- Impervious surface
- Riparian vegetation

Using GIS Layers to Predict Stability

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Thresholds used to rate stream stability

- Slope:
  - Piedmont – greater than 2% is unstable
  - Coastal Plain – greater than 1% is unstable
- Soil K Factor:
  - <0.25 = low erosion susceptibility
  - 0.25-0.4 = moderate erosion susceptibility
  - >0.4 = high erosion susceptibility
- Impervious Cover: Greater than 15% is unstable
- Forest: Value less than 50% of the assessed buffer area is unstable

Using GIS Layers to Predict Stability

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Site	Drainage Area (mi^2)	Slope (degrees)	Slope Percent	Slope Rating[1]	Soil K Factor	Soil K Factor Rating[2]	Impervious Cover (IC) (m^2 within 25ft buffer zone on either side)	Percent IC	IC Rating[3]	Forest (m^2 within 25ft buffer zone on either side)	Percent Forest	Forest Rating[4]
Beck Creek (piedmont)	2.42	1.616996719	2.823	Unstable	0.417893636	High erosion susceptibility	2188	2%	Stable	7875	5.44%	Unstable
UT Flat Creek (western coastal plain)	0.27	3.459342216	6.044	Unstable	0.331544613	Moderate erosion susceptibility	0	1%	Stable	25236	90.41%	Stable
Heritage Harbour (western coastal plain)	0.39	0.076976543	0.1344	Stable	0.43	High erosion susceptibility	0	33%	Unstable	0	0	Unstable
Big Cove Site 3 (use carbonate curve)	15.9	2.018872549	3.525	Unstable	0.356821009	Moderate erosion susceptibility	713	3%	Stable	3436	9.5%	Unstable
Big Cove Site 1 (use carbonate curve)	6.4	1.496742763	2.613	Unstable	0.318037975	Moderate erosion susceptibility	788	3%	Stable	11061	19.78%	Unstable
Bush Creek (piedmont)	7.66	0.788379954	1.376	Stable	0.320298063	Moderate erosion susceptibility	0	15%	Stable	15404	91.45%	Stable
Big Cove Site 2 (use carbonate curve)	10.3	0.755621609	1.319	Stable	0.319986235	Moderate erosion susceptibility	219	3%	Stable	2	.0055%	Unstable
Broad Creek Valley West (western coastal plain)	0.15	0.007316921	0.01277	Stable	0.43	High erosion susceptibility	0	11%	Stable	0	0	Unstable

Recommendations for Developing a Desktop Stream Stability Tool

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1. Reevaluate recommended potential metrics/indicators.
   - Investigate potential for new indicators
2. Reevaluate potential new data sources and/or assessment methodologies.
   - Investigate potential for new indicators
3. Select measurement methods to quantify metrics/indicators.
   - Ideally, potential measurement methods would be scientifically based and proven to be effective.
4. Select data sources to conduct measurements.
   - Selection of measurement methods and data sources will likely be an iterative process.
5. Develop metric thresholds that can quantitatively describe the range of stability for each indicator/metric.
   - Determining expected (natural) state of the metrics or multi-metric indicator
   - Absolute and relative values for metric thresholds should be investigated
   - Iterative process with measurement methods and data sources.
   - Measurement method must be able to quantify the metric
   - Data source must be able to apply measure method

Recommendations for Developing a Desktop Stream Stability Tool

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6. Determine whether thresholds need vary with physiographic region, watershed size, stream order, landscape position, valley type, stream type, or other factors.
   - Statistical analyses can help tease out the thresholds from a continuum of these factors, if they exist.
7. Refine the Metrics for Hydromorphology Indicator table.
8. Develop desktop stream stability tool based on selected metrics, measurement methods, data sources, and thresholds.
9. Test accuracy of desktop analysis results to empirical data and/or models.
   - Ensures the desktop tool accurately predicts stream stability
   - Different thresholds for a given metric requires testing needs for each set of thresholds
   - Empirical data require test desktop predictions.
10. Iteratively, revise desktop stream stability tool based on testing results until tool accurately predicts stream stability.
11. Validate revised desktop stream stability tool with new data.
12. Finalize desktop stream stability tool.

Refined List of Proposed Multi-Metric Hydromorphology Indicators

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- Valley type/confinement
- Floodplain connectivity
- Riparian vegetation
- Bedform diversity/stability
- Lateral stability

Matrix of Recommended Metrics/Data for Hydromorphology Indicator Development

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Spatial Dimension	Metric	Measurement Method	Metric Thresholds			Data Source	Comments
			Stable	Partially Unstable	Unstable		
Landscape Unit (Pyramid Level 1)	IC	Percent IC				Existing GIS IC data layer	
	Runoff	Flashiness				Existing GIS LULC and IC data layers; Flow Alteration Metrics (Kelly Maloney et al. 2021)	
	Sediment Production	Sediment Load				Existing GIS LULC, IC, soils, and riparian vegetation data layers and flow regime analysis results; Gridded Soil Survey Geographic Database (gSSURGO) and Parameter-elevation Regressions on Independent Slopes Model (USGS under development)	
River Segment (Pyramid Level 2)	Valley	Anthropogenic Confinement				FACET and valley type base on landscape position; Hyper-Resolution Terrain-based Hydrography Mapping (UMBC under development)	
	Sediment Transport	Degrading or Aggrading				FACET and floodplain connectivity and channel dimension analysis results; Multi-jurisdictional Rapid Habitat Assessment Database (USGS under development); Gridded Soil Survey Geographic Database (gSSURGO) & Parameter-elevation Regressions on Independent Slopes Model (USGS under development)	
Reach (Pyramid Levels 2 & 3)	Floodplain Connectivity	BHR				FACET and bankfull channel dimensions regional curves;	
		ER				Hyper-Resolution Terrain-based Hydrography Mapping (UMBC under development); Stream and Floodplain Geometry Mapping (USGS in revision)	
	Riparian Vegetation	Width				Existing GIS data layer(s)	
	Planform	Sinuosity/Meander Pattern based on Valley Type				FACET and potential stream planform based on valley type; Multi-jurisdictional Rapid Habitat Assessment Database (USGS under development); Hyper-Resolution Terrain-based Hydrography Mapping (UMBC under development); Stream and Floodplain Geometry Mapping (USGS in revision)	
		Meander Width Ratio (C and E Stream Types)				FACET and potential stream planform based on valley type; Hyper-Resolution Terrain-based Hydrography Mapping (UMBC under development)	
Geomorphic Unit (Pyramid Level 3)	Channel Dimension	W/D Ratio				FACET and bankfull channel dimensions regional curves	
	Bed Stability	Channel Slope				Existing GIS data layer(s)	
		Erodible Soils				Existing GIS data layer(s)	
		Percent IC				Existing GIS data layer(s)	
	Stream Energy	Stream Power				FACET and stream power equation; Stream and Floodplain Geometry Mapping (USGS in revision)	
	Lateral Stability	Bank Erosion Rate				Multi-jurisdictional Rapid Habitat Assessment Database (USGS under development); Gridded Soil Survey Geographic Database (gSSURGO) & Parameter-elevation Regressions on Independent Slopes Model (USGS under development); Stream and Floodplain Geometry Mapping (USGS in revision)	
		Riparian Width				Existing GIS data layer(s)	

Discussion and Next Steps

- Data Inventory Matrix and Recommendations for Further Indicator Evaluation due April 14, 2023
- Presentation to TAG and SHWG by April 21, 2023

- Draft Report due June 30, 2023
- Final Report and Factsheet due August 31, 2023