Linking Stream Restoration Success with Watershed and Design Characteristics

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The goal of this project is to improve understanding of the conditions under which stream restoration projects are successful

- Provide insight into selecting potential restoration sites with high probability of success
- Improve overall application, design, and review of stream restoration projects

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What is project success?

Channel Stabilization

Mitigation

TMDL Credits

Improve habitat

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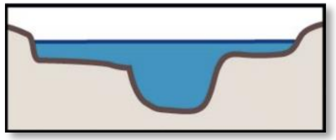
We developed three measures of project "success"



1. Field-based geomorphic function score
   - Floodplain access
   - Stable banks
   - Dense, native riparian vegetation
   - Region-appropriate bed material and bedforms

2. Field-based design score
   - Percentage of the original design still present
   - Are design features still functional

3. Monitoring report score – a mixture of function and design

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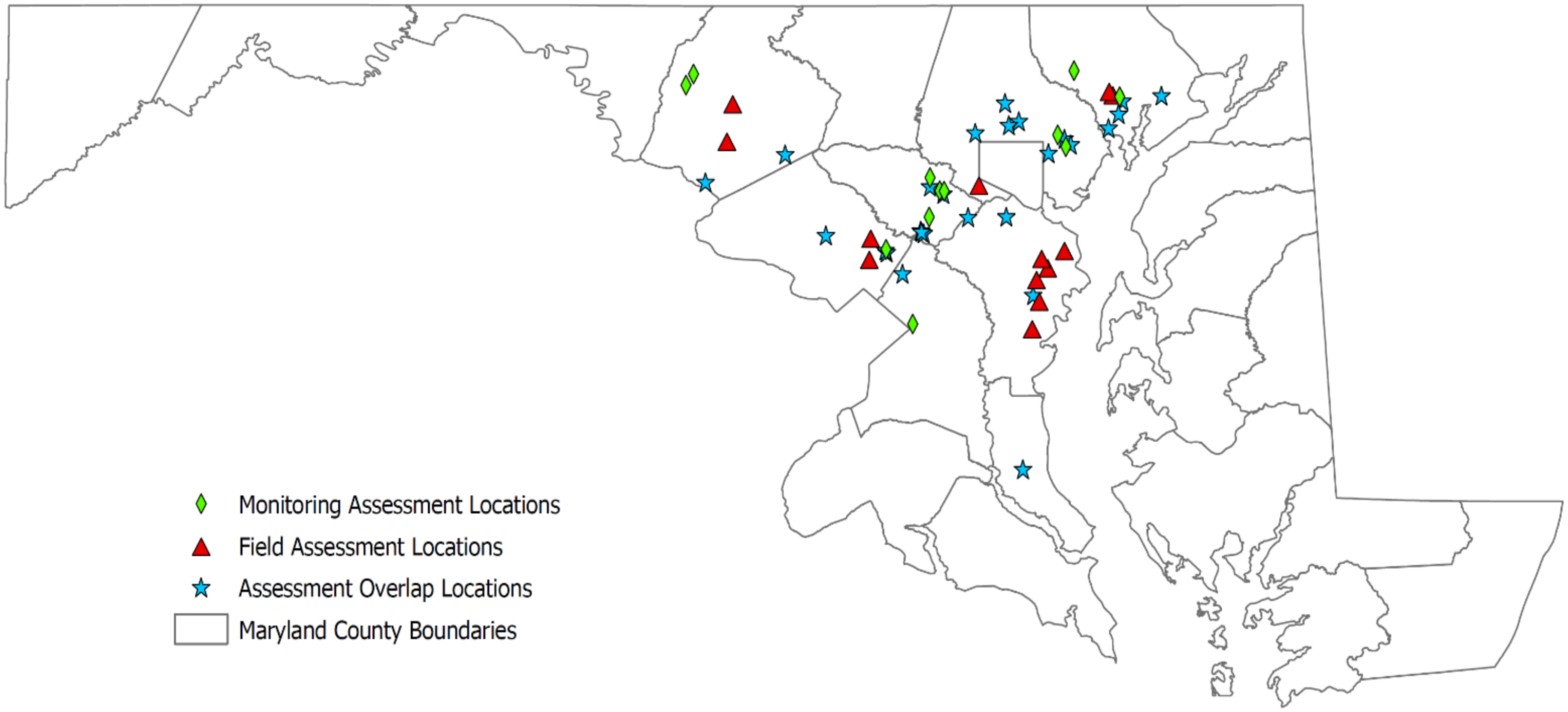
44 field and 40 desktop assessments completed



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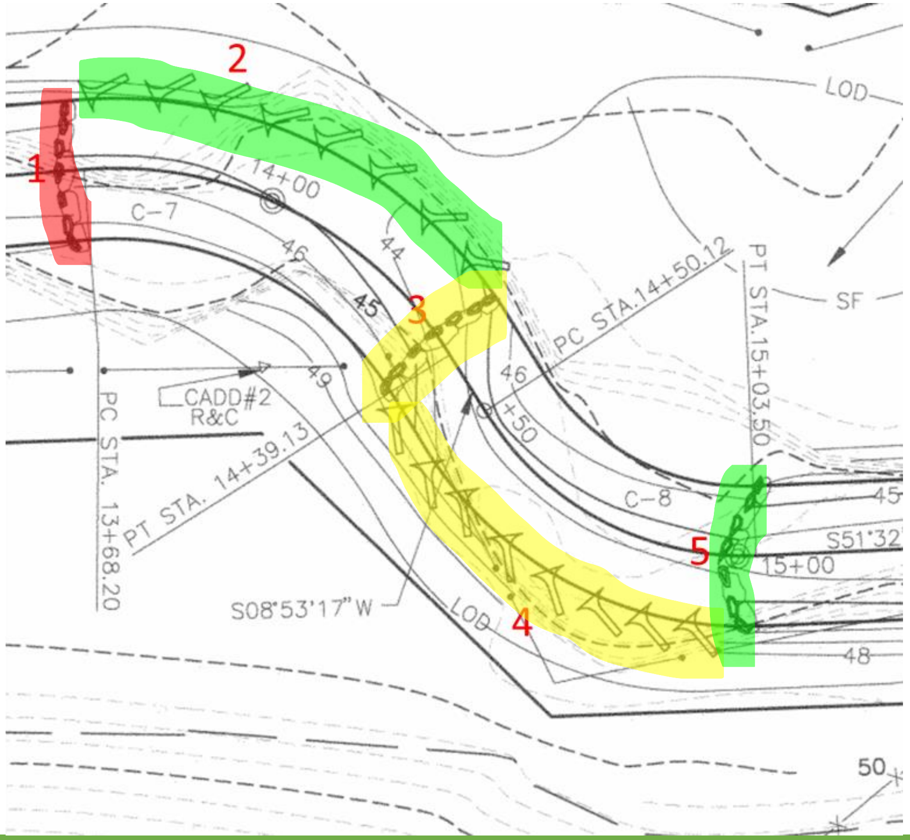
Project geomorphic function and design resilience were assessed in the field

FUNCTION (range =6-24)

	1	2	3	4
Bedform Location	<25% of bed features in proper geomorphic locations along reach	25-50% of bed features in proper geomorphic locations along reach	50-75% of bed features in proper geomorphic locations along reach	>75% of bed features in proper geomorphic locations along reach
Substrate	Significant embedded areas, poor gradation, loose, soft areas prominent in >75% of bed	Well graded particle size distribution, minimal embeddedness in 25-50% of bed	Well graded particle size distribution, minimal embeddedness in 50-75% of bed	Well graded particle size distribution, minimal embeddedness in >75% of bed
Cover/refuge	Presence of refuge areas of few types in <25% of reach	Presence of refuge areas of diverse types in 25-50% of reach	Presence of refuge areas of diverse types in 50-75% of reach	Presence of plentiful refuge areas of diverse types in >75% of reach
Bank Stability	High bank slopes, <25% of reach has good vegetation cover and no evidence of mass wasting	Low bank slopes, 25-50% of reach has good vegetation cover and no evidence of mass wasting	Low bank slopes, good vegetation cover and no evidence of mass wasting in 50-75% of reach	Low bank slopes, good vegetation cover and no evidence of mass wasting in >75% of reach
Riparian Vegetation	<25% of riparian area covered in native vegetation	25-50% of riparian area covered in native vegetation	50-75% of riparian area covered in native vegetation	>75% of riparian area covered in native vegetation
Floodplain	Evidence of flow access, sediment deposition along <25% of reach	Evidence of flow access, sediment deposition along 25-50% of reach	Evidence of flow access, sediment deposition along 50-75% of reach	Evidence of flow access, sediment deposition along >75% of reach

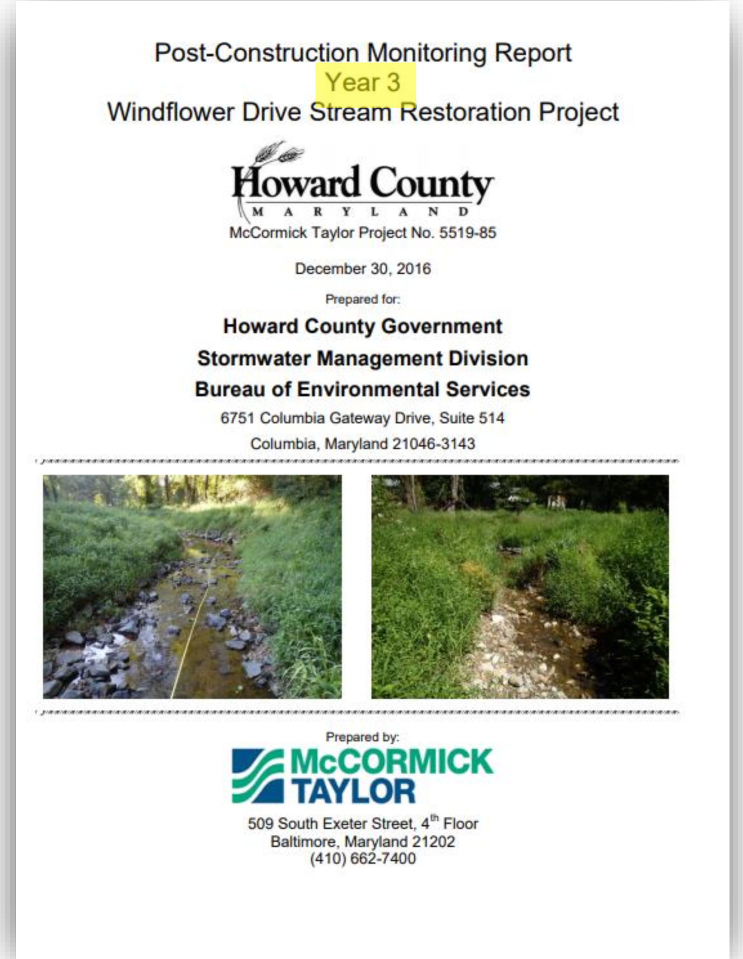
DESIGN (range=0-100%)



Geomorphic function and design success were also assessed using monitoring reports

Monitoring (range =4-12)

	1	2	3
Bed aggradation or degradation	Riffle scour or pools filling at >10% of stations	Riffle scour or pools filling at <10% of stations	No riffle scour or filling of pools
Bank stability	Bank scour >10% of stations, bank failure at any location	Bank scour <10% of stations	No bank scour noted
Riparian veg cover	>10% of project length with problem vegetation growth, heavy invasive growth	<10% of project length with problem vegetation growth, light invasive vegetation	Good vegetation cover, no problem areas, no invasive species
Structures	Problems noted with >10% of structures	Problems noted with <10% of structures	No problems with structures noted


Post-Construction Monitoring Report
Year 3
Windflower Drive Stream Restoration Project

Howard County
MARYLAND
McCormick Taylor Project No. 5519-85

December 30, 2016

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Variables at different scales were collected for each project and converted to non-dimensional forms.

Watershed Scale

Flow Energy

- Watershed area
- Average watershed slope
- Land use
- BMP density
- Stream Slope

Erosion Resistance

- Area-weighted soil erodibility (K)
- Length-weighted K of stream banks

Project Scale

Flow Energy

- Specific stream power
- Bankfull Discharge
- Channel slope
- Floodplain width
- Sinuosity
- Bankfull channel dimensions

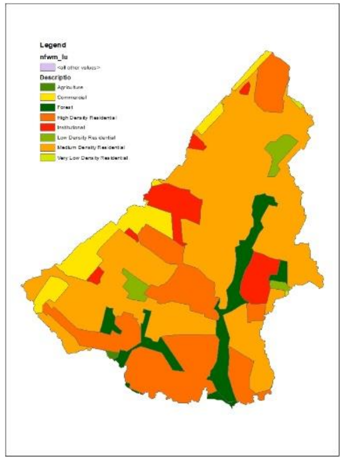
Erosion Resistance

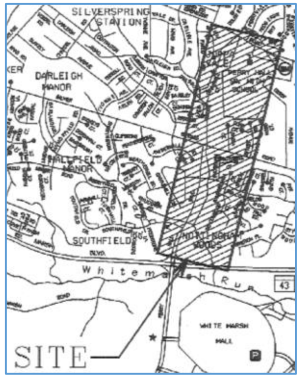
- Bed sediment size
- Length weighted K of stream banks
- Up/downstream grade control

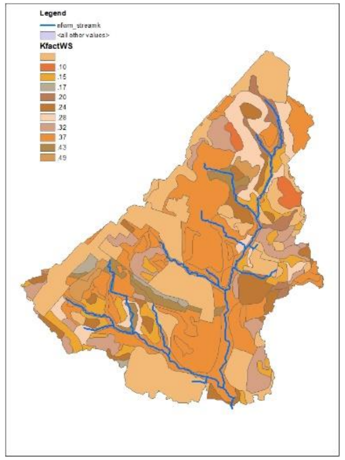
Design Approach

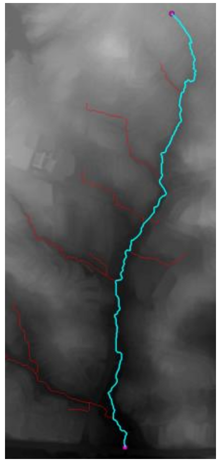
- Project age
- Project length
- Structure density (#/1000ft)
- Rosgen channel type

Watershed level data were collected using ArcGIS









Elevation data:

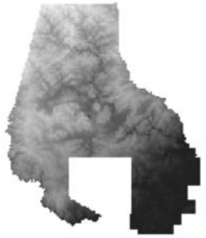
- ✓ 2m DEMs from Maryland iMAP

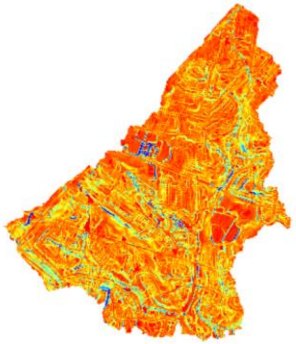
2016 Land use data:

- ✓ Maryland iMAP

Soils data:

- ✓ NRCS web soil survey





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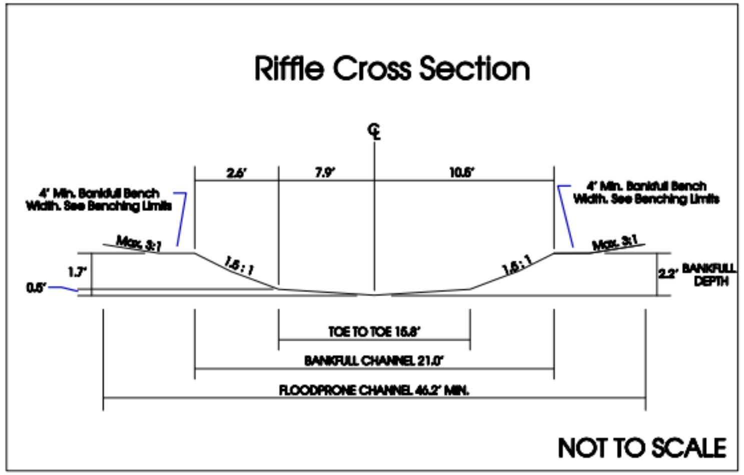
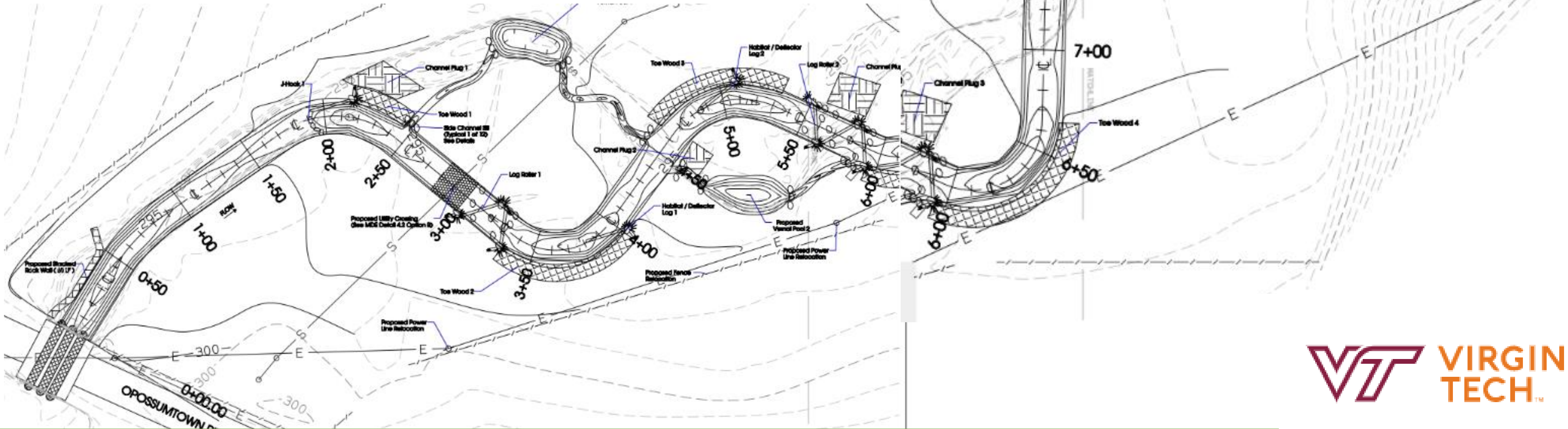
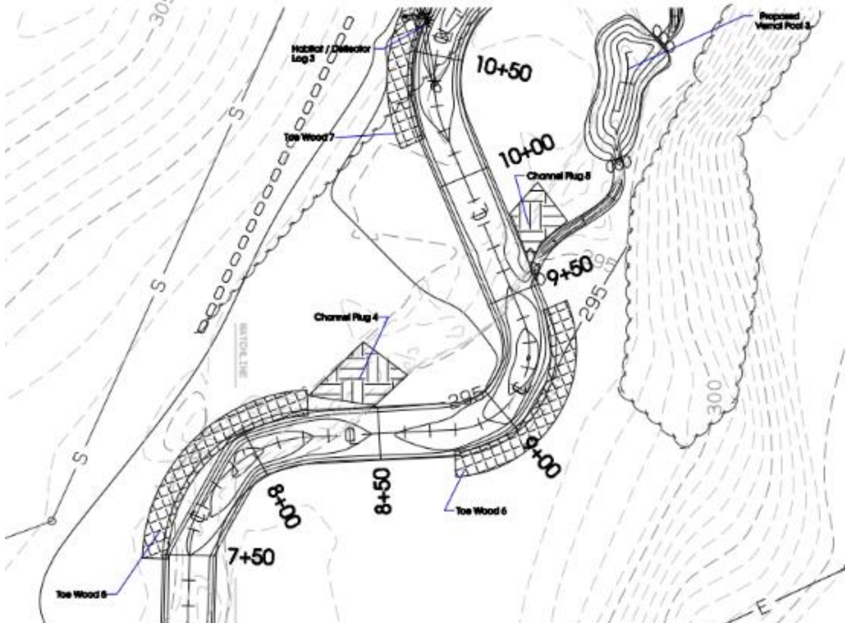
Project-level data were collected from project design plans and reports







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Regression analysis was used to determine relationships between project success and watershed and project characteristics

http://clipart-library.com/

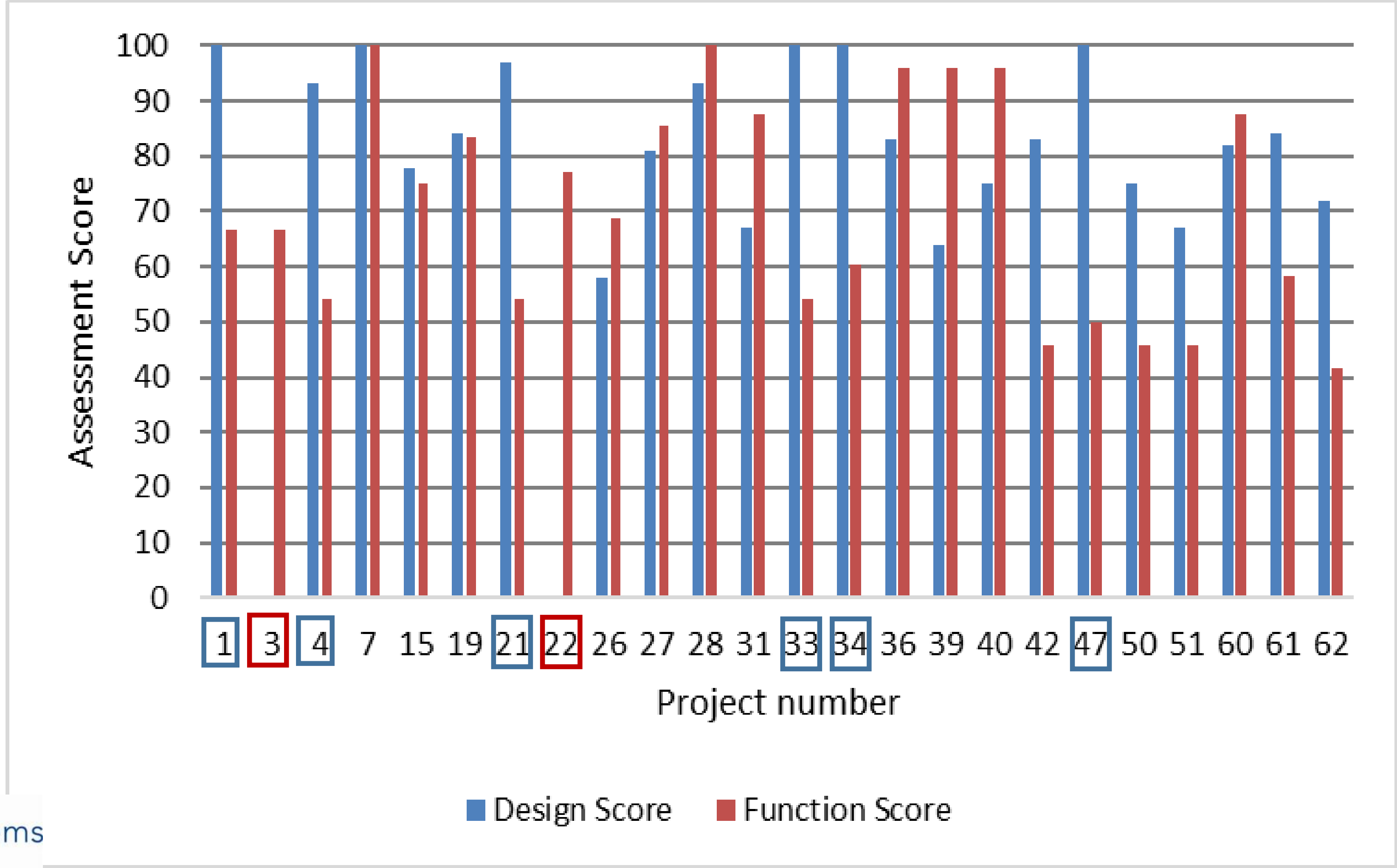
Statistical *Correlation*

Parameters which indicate:

- Flow energy
- Erosion resistance
- Design approach

Results…

Projects assessed in the field scored differently in the function and design assessments



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Example: Project 47

- 100% design score
- 50% function score
- Confined - urban subdivision
- Step-pool channel
- Rock-lined

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Projects 3 and 22 scored 0% on the design assessment but maintained high scores in the bedforms, substrate and cover categories.

Project 3
(1995)

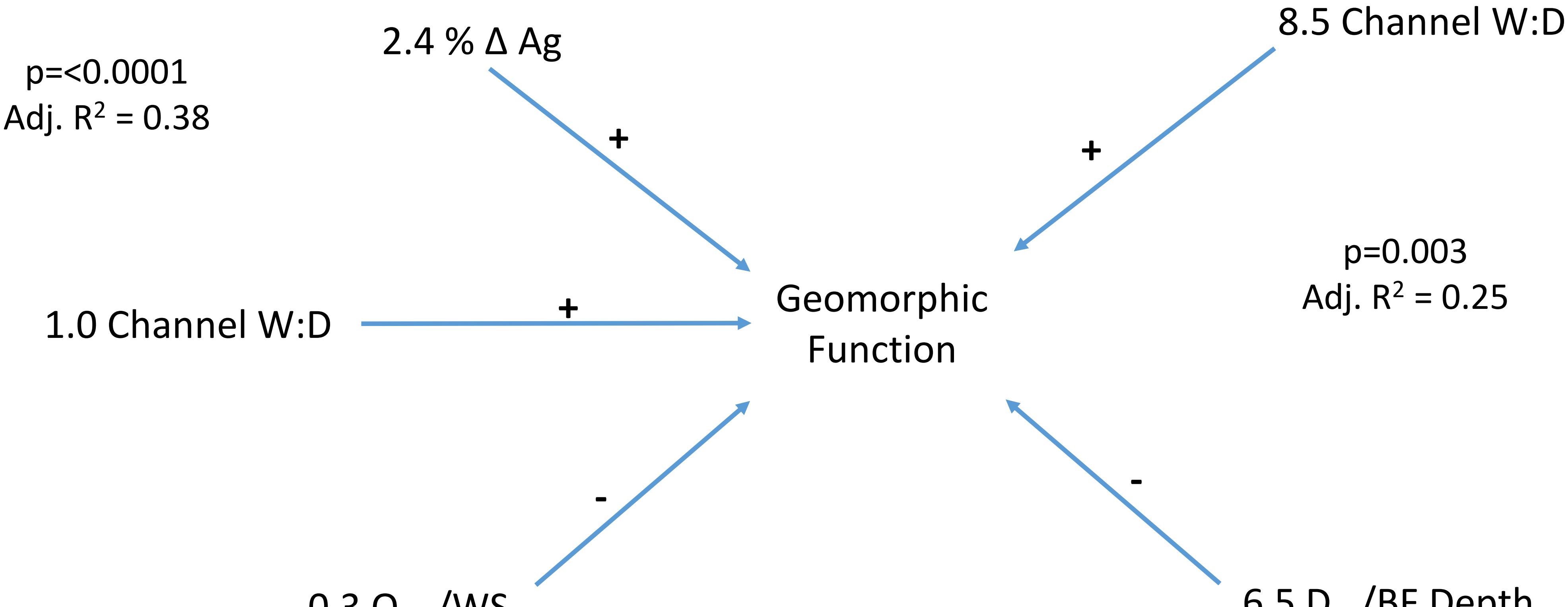
Project 22
(1999)

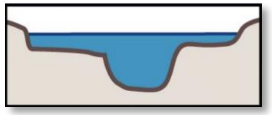
Projects with higher geomorphic function had low bank heights, native vegetation, and accessible floodplains.

Project 7

Project 28

Geomorphic function was correlated with change in landuse, channel width:depth, bankfull discharge and bed sediment size.





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Design success was primarily correlated with landuse, stormwater management, bed material size

Landuse	Relative Bed Material Size	Stormwater Practice Density	Others	Adjusted r^2	Regression p-value
-13.5 high+med development	7.5 D_{50}/BF Depth	-7.9 SCM Density	6.3 Year Constructed	0.72	<0.0001
-15.9 high+med development	10.3 D_{50}/BF Depth	-7.3 SCM Density	4.9 Entrenchment Ratio	0.72	<0.0001
-16.4 % Δ med development	7.9 D_{50}/BF Depth	-	-6.2 Unit Stream Power	0.69	<0.0001
-16.4 % Δ med development	-	-	-6.85 WS Area	0.45	<0.0001

The number of strong statistical relationships likely reflects the less subjective nature of the design score.

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Monitoring score was correlated with year constructed and project length.

5.9 Construction Year

+

Monitoring

-

-6.5 Project Length

p=0.005

Adj. R^2 = 0.21

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Site selection is critical to restoring geomorphic function

To develop a stream with good geomorphic function that can be self-sustaining, choose sites with…

- Rural watersheds or watersheds without recent development
- No constraints to decreasing bank height (increasing floodplain access)
- Landuse protections/zoning against upstream development

Design failure ≠ stream function loss

Design in urban watersheds is challenging

- Expect stream restoration design features to fail over time (~ 20 yrs.) without maintenance
- If failure is not an option (e.g. infrastructure protection):
  1. Design with large bed particle size relative to channel depth
  2. Create as much floodplain access as possible
  3. Plan on ongoing maintenance

Questions?

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