Analyzing AMD Treatment Costs

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Background

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AMD is a major environmental challenge in the Appalachian Mountains

AMD occurs when sulfide minerals oxidize, leading to highly acidic and metal-laden water.

300 treatment systems built in Pennsylvania over 35 years

High-cost: annual protection costs averaging $5,700 per km of stream (Black & Weber, 2024; Jeremy, 2024)

Knowledge gap

Few studies predict AMD treatment costs

Existing tool AMDTreat estimates treatment costs and determine system size

Decision makers lack practical tools to estimate and compare treatment alternatives

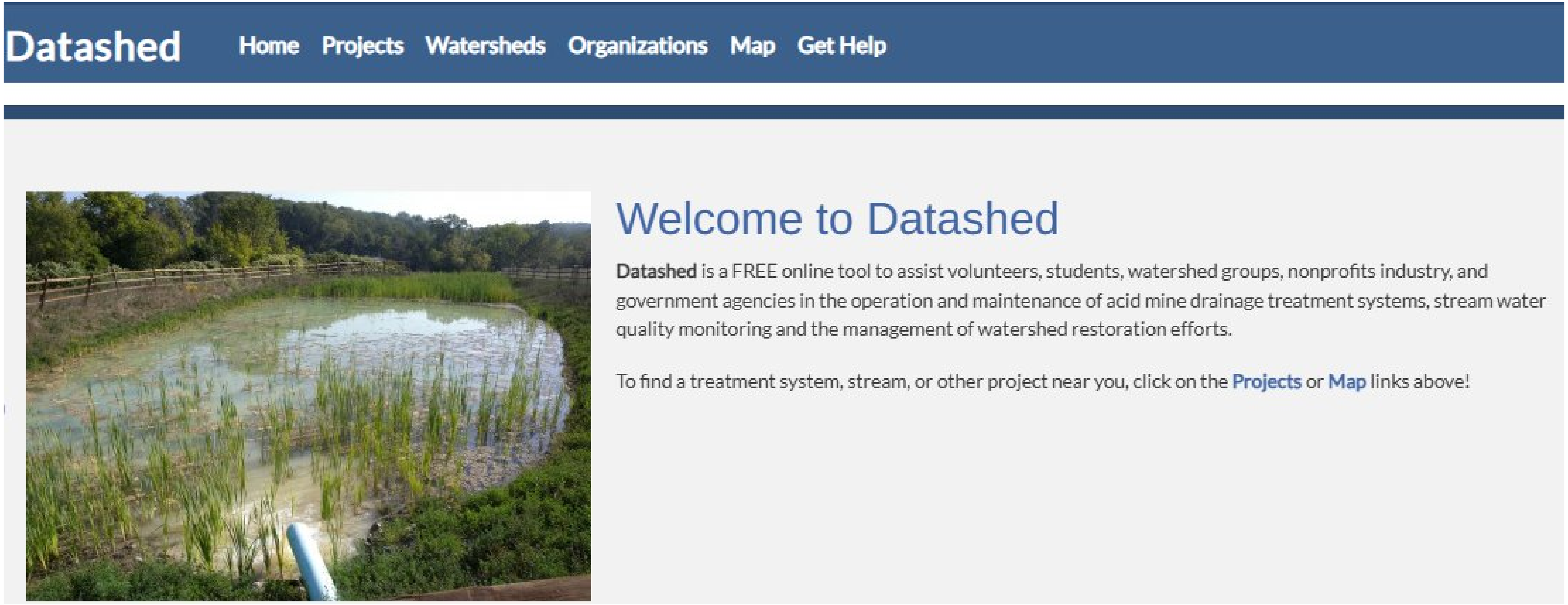
Need to understand the key drivers controlling the AMD treatment costs

Goal

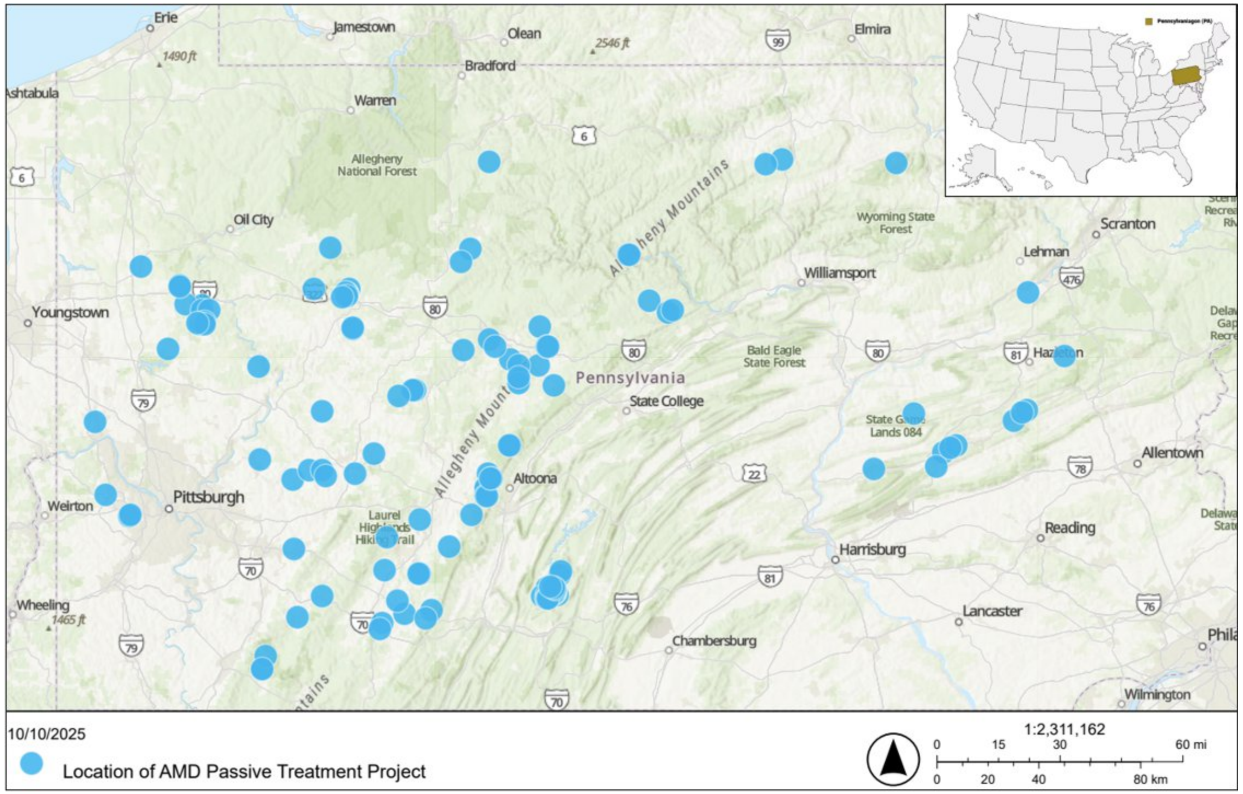
Develop a practical screening tool to predict AMD treatment costs to support watershed planning

Dataset

- Data comes from *Datashed, a*vailable at: https://www.datashed.org/
- Free publicly online database, to water quality data, project information, and documents for passive and active AMD treatment systems, developed by Stream Restoration Incorporated (SRI)
- **Purpose:** support management, monitoring, and restoration of watersheds impacted by abandoned mine drainage



Project site locations



- Passive treatment only
- All total cost values were adjusted for inflation to 2023 USD
- A total of 123 sites for the analysis
- AMD treatment projects in Pennsylvania

Approach

- **Hypothesis:** There is a relationship between passive AMD treatment system type, water quality parameters, and total treatment cost
- Exploratory and statistical analyses were conducted
- Use JMP software

Tool: JMP Pro 18.0.2

Passive treatment system types

Photo - Bear Rock Run (Datashed)

Wetland-Based Systems

Use natural or constructed wetlands to treat AMD

Intended to reduce metals and sulfate through biological activity and sedimentation

Photo – Mon 71 (Datashed)

Limestone-Based Systems

Use limestone to neutralize acidic mine drainage

Intended to increase pH, generate alkalinity, and promote metal precipitation

Photo - Wells creek onstead (Datashed)

Settling Pond-Based Systems

Use engineered ponds to allow particulates and metals to settle out

Intended to remove metals by allowing precipitates and solids to settle

Photo – Site 26A (Datashed)

Other Designs

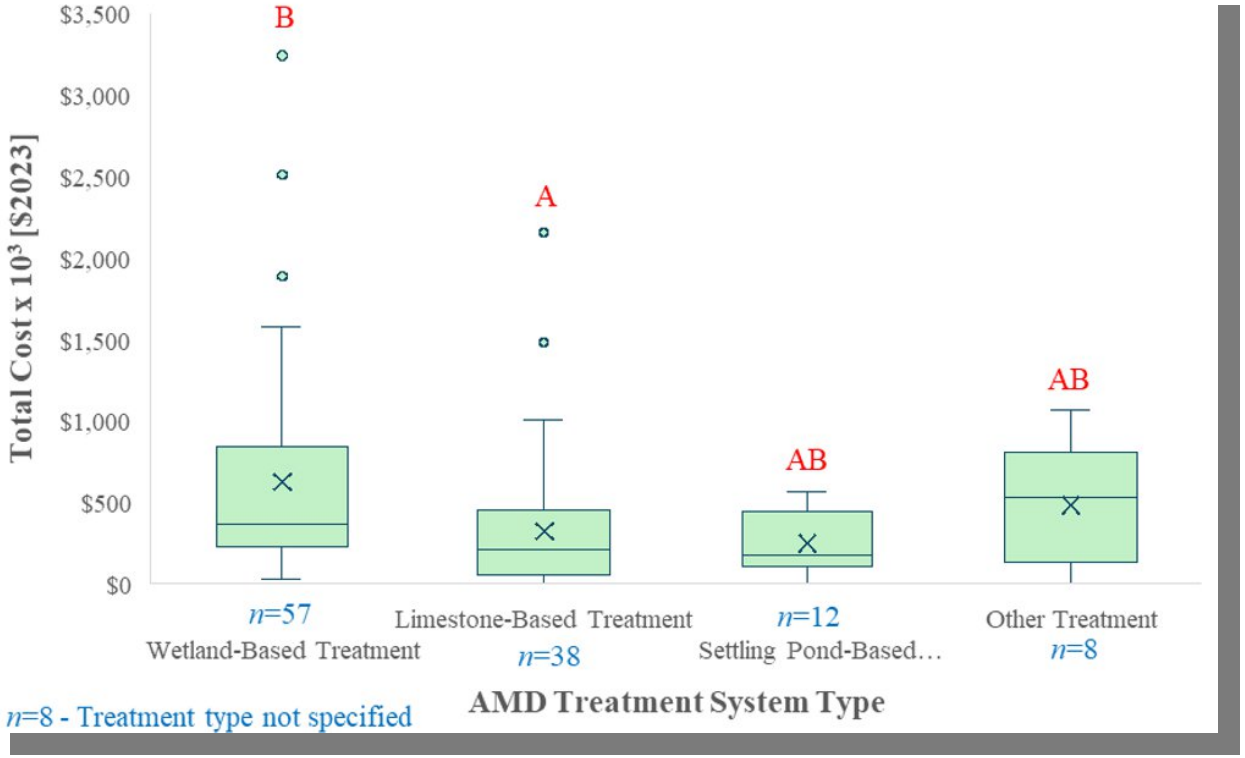
Passive technologies outside the main categories, target specific contaminants

Intended to enhance biological or chemical reactions for metal or sulfate removal

Results - Comparative analysis of treatment costs

- Total treatment costs varied significantly across system types (p = 0.0059).

- Wetland-Based Treatment (B) is significantly different from Limestone-Based Treatment (A)



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Results – Partition Analysis

Effluent flow rate > 137.76 gal/min
Mean: $844,278.76

Effluent flow rate < 137.76 gal/min
Mean: $249,449.26

Limestone-based system

Influent flow rate >147 gal/min
Mean: $968,633.1

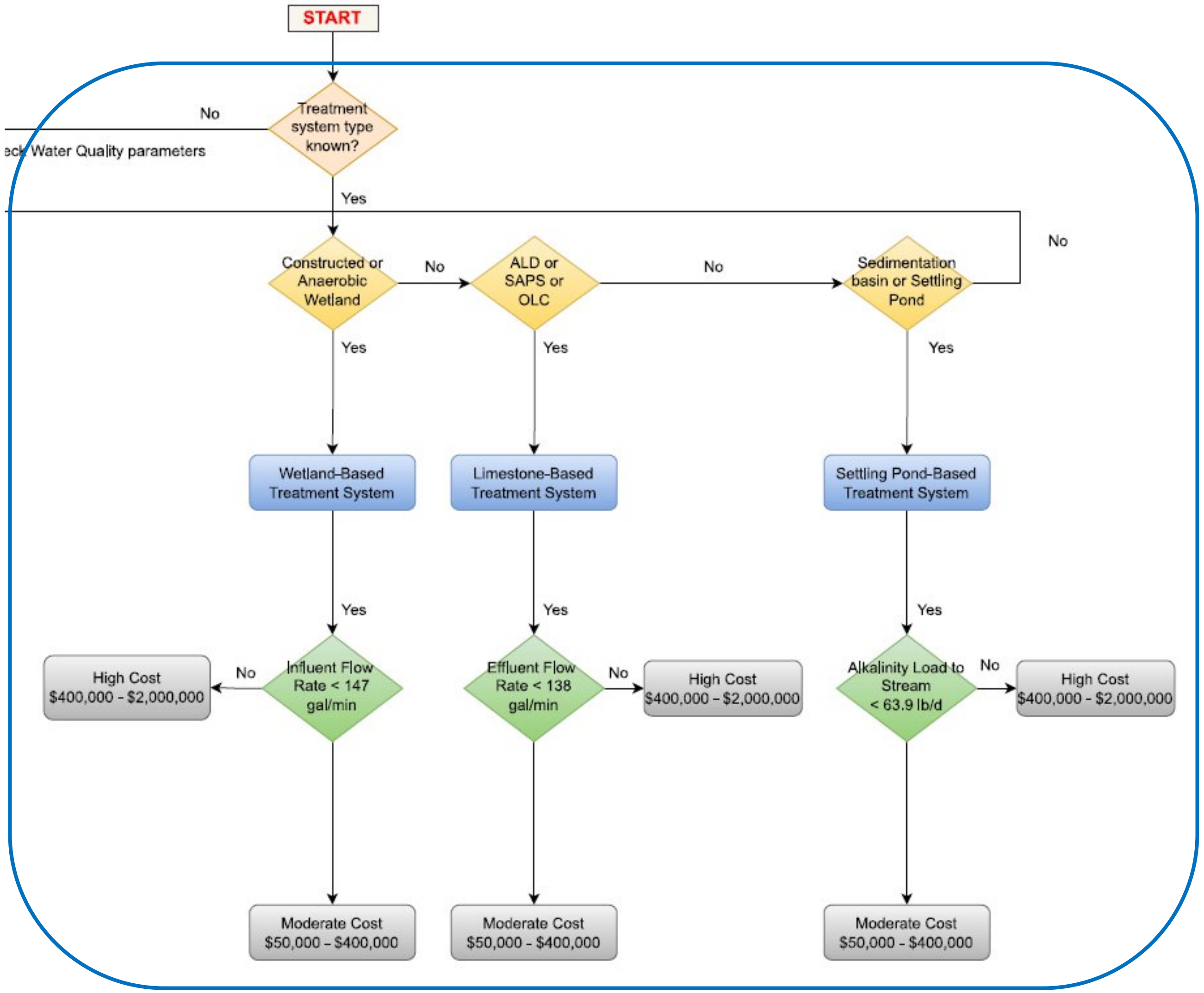
Influent flow rate < 147 gal/min
Mean: $353,898.37

Wetland-based system

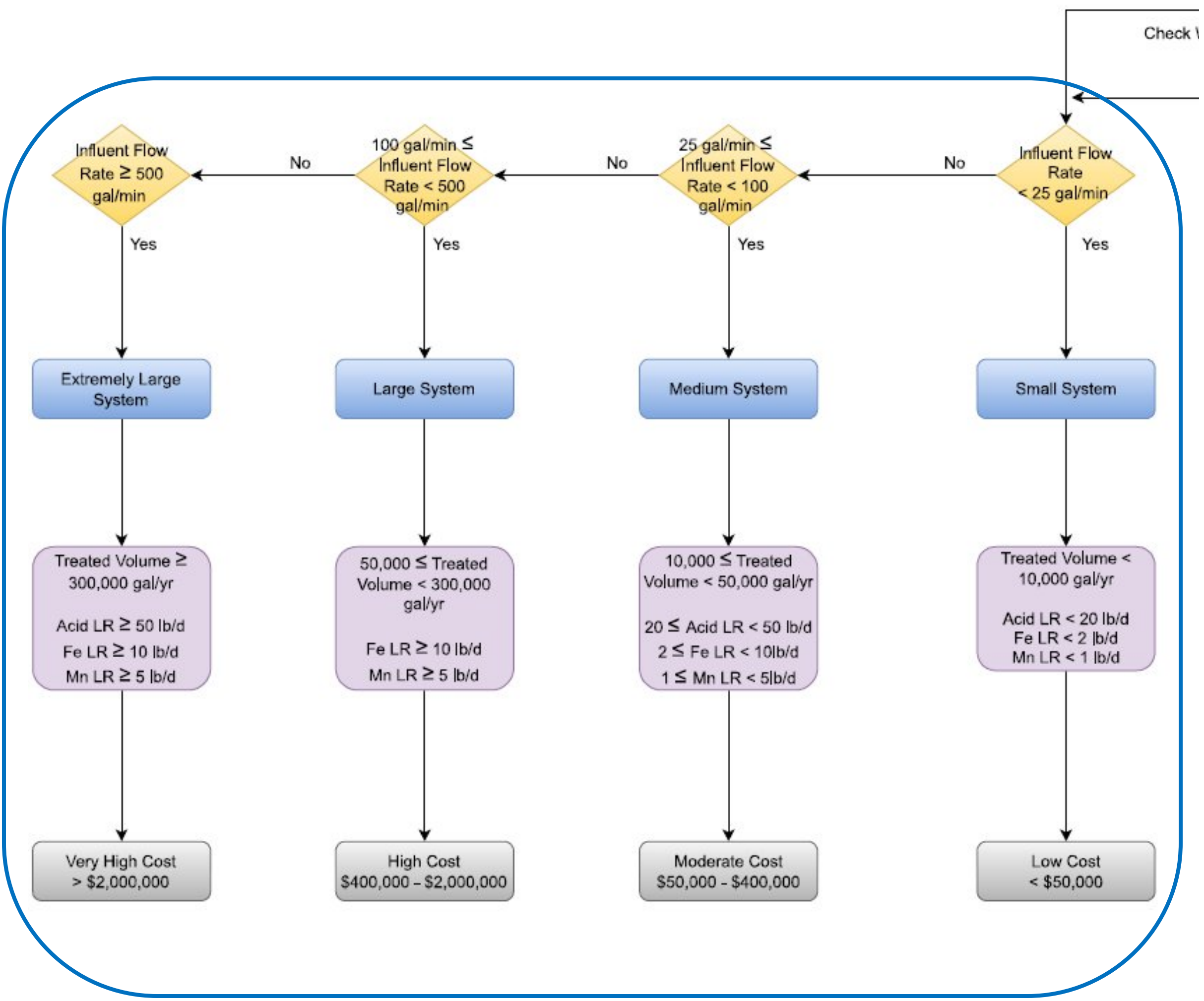
Alkalinity load to stream > 63.9lbs/day
Mean: $422,250.85

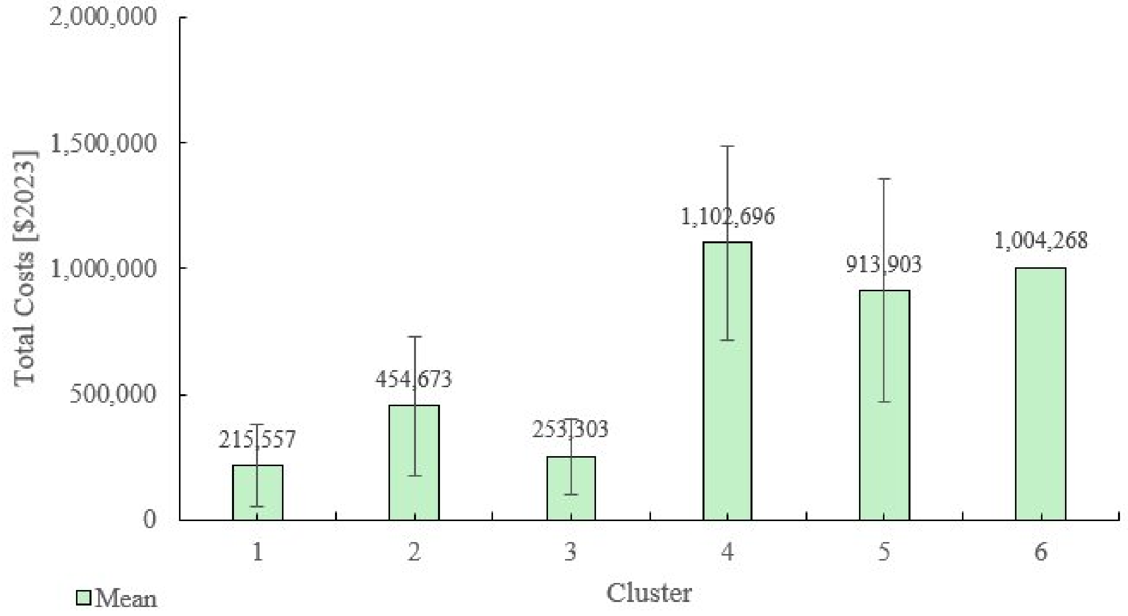
Alkalinity load to stream < 63.9lbs/day
Mean: $137,445.83

Settling pond-based system



Results – Hierarchical Clustering

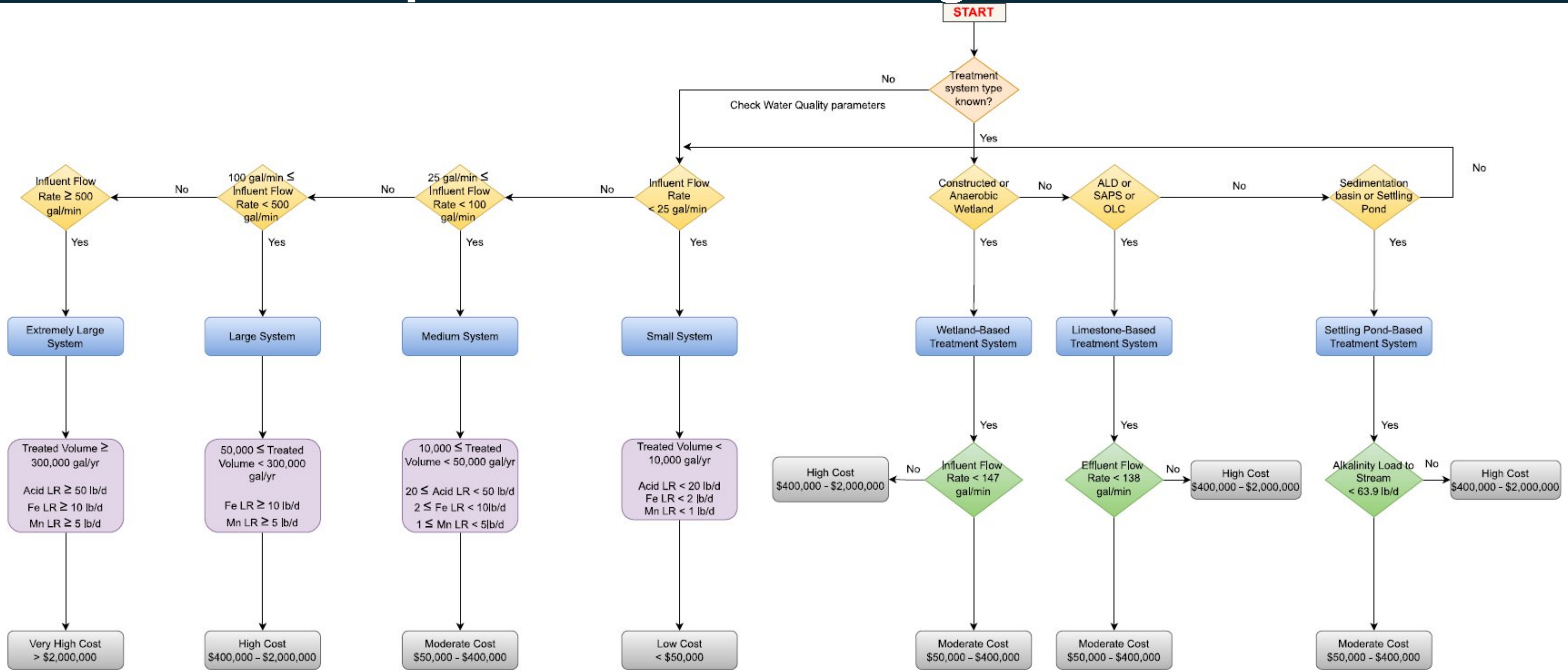




Mean Total Cost by Cluster with Standard Deviation Error Bar
n = 26, 35, 4, 4, 2, and 1 for clusters 1, 2, 3, 4, 5, and 6, respectively

- Hierarchical clustering grouped treatment systems into six (06) clusters, explaining 50% of the variation in treatment costs
- Smaller systems (low flow and pollutant load) were associated with lower costs
- Larger systems were associated with higher costs and greater variability, as indicated by error bars

Results – Development of a screening tool



Acronyms:
ALD: Anoxic Limestone Drain
SAPS: Successive Alkalinity Producing System
OLC: Open Limestone Channels
LR: Load Removal

Key Findings

Key Findings

Hypothesis: The overall analysis failed entirely to reject the null hypothesis and confirmed that cost-related patterns are partly influenced by treatment systems and key factors such as flow rate, metal load removal, and alkalinity discharge.

Reliability: The screening tool is moderately effective, being accurate for low- and very high-cost projects, but less reliable for moderate and high-cost ranges.

Contribution: It provides a foundation for investment decisions and offers the potential for application across diverse passive treatment systems.

Note: It was never intended to replace AMDTreat, but rather complement it, as it serves a different purpose by providing quick, first-level cost predictions without requiring detailed design inputs.

Acknowledgements

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Questions?

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