The Effectiveness of Dry and Wet Stormwater Detention Basins as Sediment and Nutrient Processors

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Introduction

• Urban sprawl places watersheds and associated streams and rivers under increased stress in terms of impaired water quality from stormwater runoff.

• James City County, Virginia is a county that is presently experiencing rapid residential and commercial growth.

• Stormwater detention basins are constructed to mitigate the negative effects of increased runoff.
Objective

• To assess and compare the effectiveness of wet and dry stormwater detention basins in developing watersheds in terms of their ability to retain sediment and nutrients.

Hypothesis

• Wet detention basins discharge lower concentrations of sediment and nutrients, relative to dry basins.
Site Selection Process

- Selected sites based on:
  - Basin Type (wet / dry / untreated)
  - Basin Drainage Area
  - Land Use of Surrounding Area
  - Basin Condition
Sampling Locations

- JCSA Dry Basin
- JCSA Wet Basin
- JCC Courthouse
- Ironbound Village Dry Basin
Site Profile: James City County Courthouse

- **Basin Type:** Bioretention and untreated stormwater
- **Drainage Area:** 5 acres
- **Land Use:** JCC Courthouse and new commercial area
- **Watershed:** Powhatan Creek
- **Year Built:** 2003
Site Profile: Ironbound Village

- **Basin Type:** Dry Basin
- **Drainage Area:** 6.9 acres
- **Land Use:** New single family moderate income homes
- **Watershed:** College Creek
- **Year Built:** 2001
Site Profile: James City Service Authority

- Basin Type: Wet Basin
- Drainage Area: 14.9 acres
- Land Use: Municipal grounds and service vehicle parking lots
- Watershed: Powhatan Creek
- Year Built: 1991
Site Profile: James City Service Authority

- **Basin Type:** Dry Basin
- **Drainage Area:** 2.45 acres
- **Land Use:** Service vehicle parking lot and future industrial sites
- **Watershed:** Powhatan Creek
- **Year Built:** 2001
Methods

• Placement of ISCO water samplers at basin outlets

• Programming of samplers to collect 250-500mL at 15-30 minute intervals during three storm events
Methods

- Analysis of samples for:
  - Ammonium
  - Nitrate + Nitrite
  - Dissolved Phosphate
  - Total Particulate Phosphorus
  - Total Suspended Sediment (TSS)
  - Total Dissolved Solids (TDS)
Storm Event: 7/12/04

- Total Rainfall: 0.02 inches
- Maximum Rain Rate: 0.07 inches per hour at 7:20pm
- Duration: 20-30 min. between approximately 7:10pm to 7:30pm
- Sampling Time: 6:30pm to 12:00am
- Sampling Rate: 23 samples taken at 15 min. intervals
The graph shows TSS (mg/L) measurements for different locations over time on 7/12/04.

- **JCC Courthouse**
- **Ironbound Dry Basin**
- **JCSA Wet Basin**
- **JCSA Dry Basin**

Sample times are marked from 18:30 to 21:30.
Storm Event: 7/18/04

- **Total Rainfall:** 0.19 inches
- **Maximum Rain Rate:** 1.17 inches per hour at 5:30am
- **Duration:** 1 hour between approximately 5:10am to 6:10am
- **Sampling Time:** 12:00am to 11:00am
- **Sampling Rate:** 23 samples taken at 30 min. intervals
Storm Event: 7/22/04

- **Total Rainfall:** 0.24 inches
- **Maximum Rain Rate:** 1.89 inches per hour at 8:00pm
- **Duration:** 1 hour between approximately 8:00pm to 9:00pm
- **Sampling Time:** 7:45pm to 1:15am
- **Sampling Rate:** 23 samples taken at 15 min. intervals
Total P (μM)

JCC Courthouse
Ironbound Dry Basin
JCSA Wet Basin
JCSA Dry Basin

Sample Time (7/22/04 - 7/23/04)
The diagram shows the average total P (µM) for different conditions: JCC Untreated, IV Dry, JCSA Wet, and JCSA Dry. The values are as follows:

- JCC Untreated: 11
- IV Dry: 21
- JCSA Wet: 20
- JCSA Dry: 13
Conclusions

- Dry basins discharge higher concentrations of sediment and dissolved nutrients than the wet basin during storm events.
- Dry basins performed similar to or worse than untreated stormwater in:
  - Total Suspended Sediment
  - Dissolved Phosphate
  - Total Particulate Phosphorus
Recommendations

- It is suggested that:
  - Measures be taken to decrease the amount of sediment entering Ironbound Village dry basin
  - Construction of Silt Fence
  - Removal of Loose Sediment from Site
  - Stormwater bypassing the bioretention strip at JCC Courthouse be treated
    - Reengineering of Stormwater Management Plan
Significance

• There are 474 stormwater basins in James City County alone. This study showed the effectiveness of 3. The water discharged from each of these basins affects other downstream basins, streams, and watersheds.

• The failure of these basins to effectively treat stormwater leads to impairment of local streams, lakes, and ultimately the Chesapeake Bay.
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