The LabView Enabled Watershed Assessment System (LEWAS)

An NSF Transforming Undergraduate Education in STEM (TUES) Project:
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LEWAS LAB
LABVIEW ENABLED WATERSHED ASSESSMENT SYSTEM

NSF/TUES Project

Project Title: *Integration of a Remote Water Sustainability Lab to Enhance Undergraduate Engineering Education*

Project Goal: The goal of this project is to implement the use of a remote lab (i.e., LEWAS) to enhance the quality of undergraduate instruction at Virginia Tech and Virginia Western Community College (VWCC). At VT, develop and integrate LEWAS-based learning module(s) into EngE 1024 (Engineering Exploration) and CEE 4304 (Hydrology)

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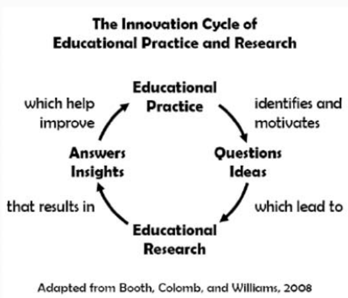
Engineering Education Research



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Hydrology (CEE4304) Key Topics Covered

- Hydrologic Cycle
- Watersheds, Characteristics: slope, land cover, travel time
- Precipitation, gages, radar, design storms
- Peak Discharge Computations: Rational, SCS, Empirical
- Flood/Drought Frequency Analysis
- Hydrograph Separation, Baseflow, Infiltration
- Unit Hydrographs
- Detention basins, Reservoir routing
- Channel routing, watershed modeling
- Urban hydrology issues, storm sewer, BMPs

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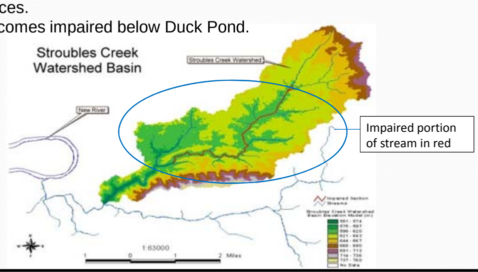
Local VT Water Issues

- Stroubles Creek Watershed – Sub-watershed of New River Watershed
- Natural headwaters above downtown Blacksburg
- Flows through the downtown area and campus to VT's Duck Pond.
- Picks up sediment and runoff from urban, residential and agricultural surfaces.
- Becomes impaired below Duck Pond.



Watershed urbanization

Google Earth image (24 Oct 2011) of Blacksburg and surrounding area, showing dichotomy between urbanized and non-urbanized areas.

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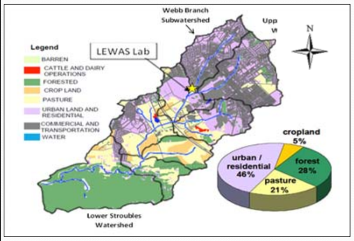
Watershed Areas and Land Cover



Stroubles Creek Watershed Impaired Segment Modified *from: Yagow 2006*

Impaired Stroubles:
- 6119 acres or 24.76 km^2 *(Yagow 2006)*

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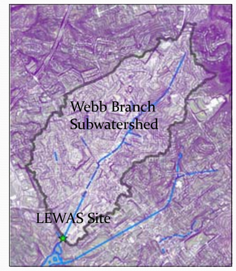
Watershed Areas and Land Cover



Webb Branch subwatershed delineated

Webb Branch:
- 687 acres or 2.78 km^2

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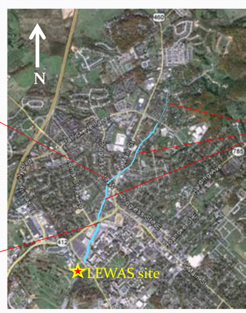
Webb Branch Land Cover

Business area



Residential areas

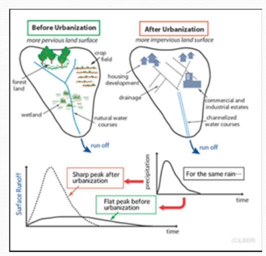
VT campus

Approximately >95% urban
Approximately <5% forest

Significant amount of impermeable surface!

9/5/2012 LEWAS LAB 9

Urbanization and water quantity



Land use and hydrograph shapes.
http://www.lberi.jp/root/en/12view/english/lw/03.html

- **The Rural hydrograph** is flatter and elongated.
  - A lower amount of runoff results in a lower (or flat) peak.
  - Runoff travels slowly through forests and pasture
  - Hydrograph is elongated
- **The Urban hydrograph** peak is sharper and comes earlier.
  - A large amount of runoff results in high peak.
  - Runoff travels faster on concrete and asphalt.
  - Stream flow comes and goes in a shorter amount of time.

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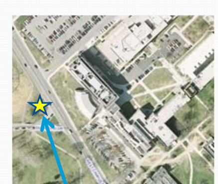
Urbanization and water quality

- Loss of forest cover
  - Lack of riparian area
    - Increase in temperature
    - Decrease in bank stability
- Soil compaction
- Residential runoff
  - Lawn fertilizers
  - Pet waste
- Road runoff
  - Oil, gravel, trash
- Impermeable surfaces
  - Lack of infiltration leads to higher runoff rates and total suspended solids (TSS)

9/5/2012 LEWAS LAB 11

LabVIEW Enabled Watershed Assessment System (LEWAS)

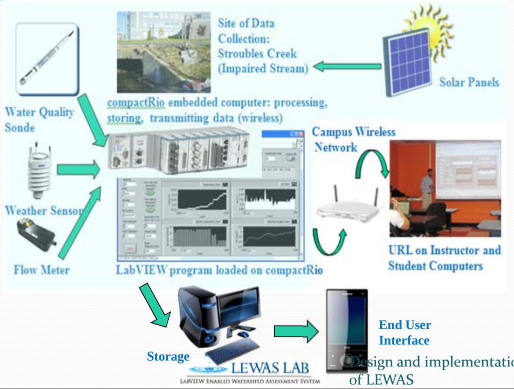
- A remote water quality and quantity monitoring station on VT campus along Stroubles Creek.
- Objective:
  Collect weather, water quantity and water quality data in real-time for water sustainability research and education



Installation Location: Webb branch of Stroubles Creek across Hahn Hall

LEWAS LAB Implementation of LEWAS in ENGE 1024 12

LEWAS OD: Acquiring, Processing, Communicating, and Presenting Environmental Data: Communication Design



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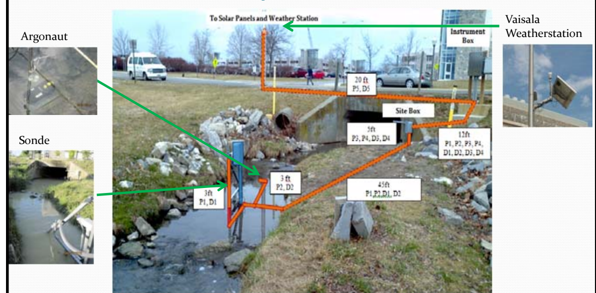
Design and implementation of LEWAS 13

LEWAS Lab layout



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LEWAS Sensors and Measured Parameters

- Water Quality Sonde
  - pH, Dissolved Oxygen, turbidity, specific conductivity and Temperature as indicators of stream health

- Acoustic Doppler Current Profiler
  - Water flow as indicator of type of land use and stream health

- Weather station
  - Barometric pressure, humidity, precipitation, wind speed and direction

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Implementation of LEWAS in ENGE 1024 15

Water Quality Sonde Parameters

- Dissolved oxygen (DO) is essential for all living organisms. If DO levels fall too low (less than 2 mg/L), many species of fish and plants cannot survive.
- Specific Conductivity (SC) can be a good indicator of the amount of dissolved material in water, high specific conductivity may be indicative of unpleasant taste or odor.

LEWAS LAB 16

Water Quality Sonde Parameters

- pH of the water determines the solubility and biological availability of nutrients and toxicity of heavy metals. Metals tend to be more toxic at lower pH because they are more soluble.
- Temperature changes directly impact other water quality parameters and rate of chemical reactions. Temperature has a major influence on the biological activity, growth, and reproduction of aquatic organisms since most of them are cold-blooded.

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HydroLab MS5 Sonde Calibration

- Sonde must be calibrated every two weeks
- Use of HYDRAS3 LT software and solutions for calibration
- Example: conductivity calibration

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Drift of Sonde data

- Collecting data from calibrations to determine how much datum tend to "drift" between calibrations
- Only 3 data points; ongoing effort to ensure validity of data

3-Jul			18-Jul		31-Jul	
Parameter	Actual Value	Sonde Reading	Actual Value	Sonde Reading	Actual Value	Sonde Reading
pH	4	3.95	4	3.96	4	3.93
	7	7.04	7	7.05	7	7.08
	10	9.97	10	10	10	9.95
DO (% sat)	100	95.5	100	99	100	98.6
Turbidity (NTU)	100	102	100	102	100	102
Conductivity (ms/cm)	1.412	1.4	1.412	1.4	1.412	1.399

9/5/2012 LEWAS LAB 19

Vaisala Weather Station

- Measures:
  - Barometric Pressure
    - Force per unit area exerted into a surface by the weight of air
  - Relative Humidity
    - Amount of water vapor in the air
  - Air Temperature
  - Wind Speed/Direction
  - Precipitation
    - Rain accumulation (mm)
    - Rain duration (s)
    - Rain intensity (mm/h)
    - Hail

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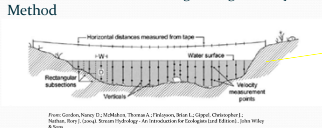
Acoustic Doppler Current Profiler

1. Determination of Discharge using Velocity Area Method



Mark Rogers and Stephanie Welch take velocity point measurements using the Sontek FlowTracker at our Webb Branch Site.

2. Measurement of Velocity at Center Channel

The Sontek Argonaut (ADCP) measures the velocity of center channel (i.e. Index Velocity) for each discharge measurement.

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Determination of Discharge in Real-Time

Regression Equation for Mean Channel Velocity (V_m) vs. Index Velocity (V_i)

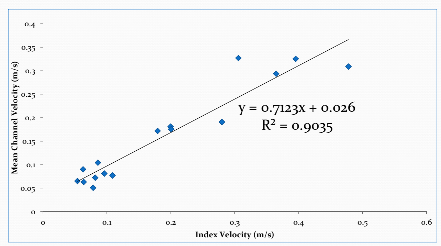

Figure 1. Regression of mean channel velocity (from step 1) and index velocity (from step 2).

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Case Study #1

Water Main Break

Effect of Infrastructure Failures On Webb Branch Water Quality

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Broken Water Main

- On June 26th, 2012 at 4:30 pm a water main broke in the town of Blacksburg, VA
- By 9:00pm spill was contained
- Approximately 760 m^3 of treated water were spilled
- Significant impact in the water quality of Webb Branch
  - Turbidity increased significantly
  - pH decreased
  - Conductivity decreased
  - Significant fish kill
  - Strong fishy odor from water

Intersection of Progress St and Winston Ave

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LEWAS site

Base flow (June 13, 2012)

Broken Main (June 26, 2012)

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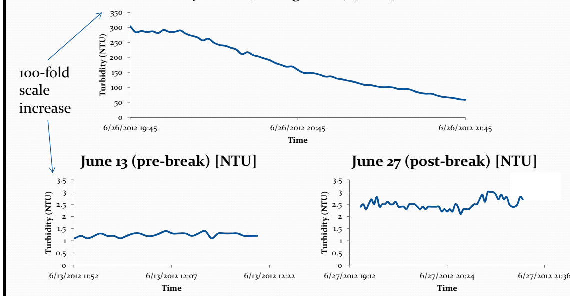
Effect on turbidity



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Case Study #2

July 23-25 Rain Events

Effect of Storm Flow On Webb Branch Water Quality

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July 23-25 rain events

- Multiple heavy rain events on July 23-25, 2012
- Significant runoff volume and water quality parameter impairments
  - Production of pollutographs

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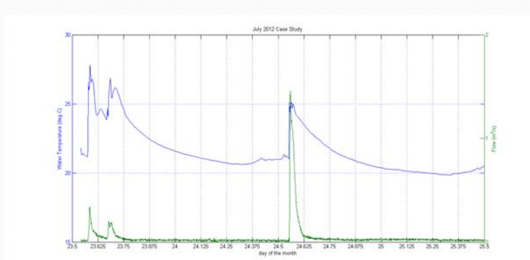
9/5/2012 28

Water temperature vs flow



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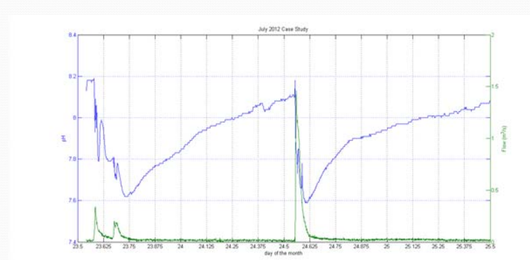
9/5/2012 29

pH Pollutograph



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9/5/2012 30

Ecological impacts of rain events

- Dead crayfish have been found at the site after rain events
- Possible cause of death is high turbidity and moving into buried section during low flow (Dr. Benfield, Dept. of Biological Sciences)

Ecological water quality standards

- Temperature
  - Webb Branch would ideally be cooler
  - Varies by location/biota
- Conductivity
  - Webb Branch has high conductivity due to geology
  - Varies by location
- Turbidity
  - <30 NTU
- pH
  - 6.5-8
- DO
  - >5 mg/L

Species	Max. weekly average temp.	Max. temp. for survival of short exposure
Atlantic salmon	20 °C (68 °F)	23 °C (73 °F)
Bluegill	32 °C (90 °F)	35 °C (95 °F)
Brook trout	19 °C (66 °F)	24 °C (75 °F)
Channel catfish	32 °C (90 °F)	35 °C (95 °F)
Largemouth bass	32 °C (90 °F)	34 °C (93 °F)
Rainbow trout	19 °C (66 °F)	24 °C (75 °F)
Smallmouth bass	29 °C (84 °F)	---
Sockeye salmon	18 °C (64 °F)	22 °C (72 °F)

Maximum average temperatures for growth and short-term maximum temperatures for selected fish (°C and ° F)

Source: http://water.epa.gov/type/rsl/monitoring/vms50.cfm

LEWAS Integration Plan into CEE4304

Three LEWAS Modules

1. *Storm Characteristics Module*
2. *Land Cover-Water Quality Correlation Module*
3. *Watershed Wiki Module*

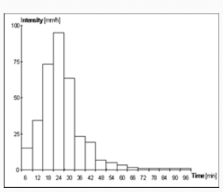
LEWAS Modules in CEE4304

1. Storm Characteristics Module

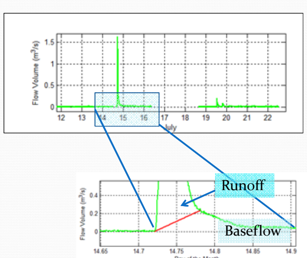
Integrated into Runoff Coefficient Homework

- Record a set of rainfall, flow, and water quality data (real-time or archived) Compute runoff-rainfall ratio
- Reflection and conclusions

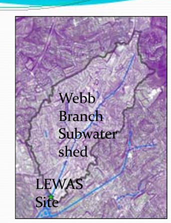
Hyetograph & Hydrograph Analysis



Hyetograph



Rainfall Runoff Ratio



Total Runoff = 3973 m³

Total Rainfall = 4289 m³

$$\text{Runoff Coefficient} = \frac{\text{Total Runoff}}{\text{Total Rainfall}} = 0.93$$

LEWAS Modules in CEE4304

2. Land Cover/Water Quality Module

Upcoming Assignment (built into existing Homework):

- Analyze land cover data of Webb branch.
- Compute mass of pollutants for a storm.
- Develop relationship between land cover and water quality parameters.

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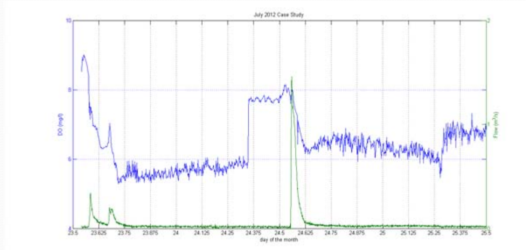
DO Pollutograph



9/5/2012 LEWAS LAB 38
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LEWAS Modules in CEE4304

3.Watershed Wiki Module

Upcoming Assignment:

- Ten student groups will visit and monitor the LEWAS site on weekly basis and write reports on class Wiki (blog). We'll have to define the format and content of the report.
- At the end of the semester, each group will use the 10 reports to analyze variations in water/weather parameters and draw appropriate conclusions for the full semester of operations.

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Hydrology (CEE4304) Fall 2012

CEE 4304: Hydrology
TENTATIVE Course Schedule
Fall 2012

	Week No. Date	Class and Subject	Assigned Reading
	1 Aug. 27	Hydrologic cycle, Water budget, Watershed boundaries, delineation	Ch 1, 3
LEWAS Intro	2 Sept 3	Watershed Characteristics, slope, shape, land cover, watershed monitoring issues	Ch 3
Runoff Coeff HW	3 Sept. 10	Time of concentration, Land Use, Travel time, Curve (Runoff) Numbers	Ch 3
Wiki begins & WQ HW	4 Sept. 17	Precipitation, Rain gages, Rainfall averaging methods, hyetographs, IDF curves, Design Rainfall	Ch 4
	5 Sept. 24	Peak Discharge Methods: Rational and SCS	Ch 7
	6 Oct 1	Peak Discharge Methods: Index methods, Intro to Flood Frequency Analysis	Ch 7, 2
	7 Oct. 8	**Exam 1** Flood Frequency Analysis	Ch 2, 5

Questions?

- About LEWAS: http://lewas.weebly.com/

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