Watershed Characterization, Monitoring and Measurements

Intent - highlight key approaches to watershed monitoring using the Fair Hill Study watershed as an example

Watershed characterization and monitoring will be essentially driven by the key question that you are trying to address -
• Understanding watershed mechanisms or solving specific environmental problems
• Long-term
• Short-term
• Intensive and focused
• Spatially distributed
• Level of funding
Basic watershed characteristics that you need to know –

- Climate, physiographic region, ecoregion
- Size of watershed, scale, stream order and other geomorphic attributes
- Topography – elevation, aspect, slopes – use of a digital elevation model (DEM)
- Geology – bedrock type
- Forest / Vegetation type, age, etc...
- Landuse and landcover and history
- Soil type and variability
Now

1877
Spatial GIS data can especially helpful in characterizing watershed features.

Data like DEMs – can help characterize additional watershed features – such as the topographic index that can provide additional insights into hydrology, moisture distribution and potential for biogeochemical activity in the catchment. This information can also help you determine where you need to place your instruments or sampling devices.

GIS maps.....
% slope - from 2 m LIDAR

Aspect of selcdem
- Flat (-1)
- North (0-22.5,337.5-360)
- Northeast (22.5-67.5)
- East (67.5-112.5)
- Southeast (112.5-157.5)
- South (157.5-202.5)
- Southwest (202.5-247.5)
- West (247.5-292.5)
- Northwest (292.5-337.5)
- No Data
Mt. Cuba Wissahickon formation undivided

Pelitic gneiss and pelitic schist with subordinate amphibolite and pegmatite. The predominant lithology is quartz-plagioclase-biotite-muscovite gneiss, with or without sillimanite and small garnets.
BaA – Baille silt loam
GaD – Gaila loam
GeA – Glenelg loam
Etc….

Soils SSURGO Map for the Fairhill watershed

Soil characterization, sampling, and analysis done at multiple locations

Soil pits or augers can be used.

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053627
Topographic Index Map for the Fairhill catchment – Derived from the 2m LIDAR DEM. On the left is the full 79 ha catchment while on the right is the 12 ha catchment.
Dominant Trees - *Fagus grandifolia* (American beech), *Liriodendron tulipifera* (yellow poplar), and *Acer rubrum* (red maple)
Why do we need to all these features – how does it influence watershed hydrochemistry??

Answer - ?????

Should also investigate the inter-relationships between these watershed attributes. The wetness or moisture distribution in the catchment may have implications for soil formation and vegetative/tree species and vice-versa!
Watershed Hydrologic Monitoring –

Weather parameters – using a climate station
- Precipitation – tipping bucket
- Snowfall amounts and melt – snow pillow
- Air temperature - thermometer
- Humidity – humidity sensor
- Wind speed - anemometer
- Wind direction – direction sensor
- Solar radiation – radiation sensor

Basic data – precipitation, daily air temps, solar radiation.

Delaware real-time weather data for watersheds -
http://deos.udel.edu/
Streamflow runoff is measured by –

- Flumes
- Weirs
- Natural channel with rating curves

Need to measure depth of water and/or velocity
Depth – pressure transducers
Velocity – radar sensors

Basic data – streamflow discharge
$120^\circ$ V-Notch Stream Gaging Station

- Gage House
  - Water-level Recorder
  - Weight
  - Float
- Stilling Well
- Cement Basin
- Intake Pipes
- Soil
- Bedrock
- $120^\circ$ V-Notch Weir
Water level stage recorder – courtesy Myron Mitchell
• Frequency of measurements dictated by the rate of which the water level changes – dictated by the size of the watershed and the types of storm events.

• Depth of flow is converted into discharge Q (liters/sec), m³/s, m³/day using a calibrated equation provided by flume manufacturer.

• Can also be expressed as depth = mm/hr or mm/day (by dividing volumetric mass of water by the catchment area) → this is compared against the rainfall input to generate runoff ratio.
Soil moisture (in-situ measurements)–

- Measured using Time Domain Reflectometry (TDR) instruments
- The transmission of the electromagnetic wave is a function of the dielectric properties and the moisture content of the soil.
- E.g., - the theta probe – provides volumetric moisture content once calibrated.
- Local point readings – not hillslope or watershed scale patterns

Basic data – soil moisture and temperature
FIGURE 2 | Hillslope-centered (e.g., piezometers, soil moisture, or ERT probes in green) and stream-centered (sampler to collect streamwater samples in purple) approaches to study hillslope–stream connectivity.

Bloom and Meerveld, 2015
FIGURE 3 | Hillslope-centered measurements: (a) subsurface flow measurements at the Panola trench showing the 2 m sections collecting diffuse subsurface flow and macropore flow collectors collecting concentrated subsurface flow, (b) tipping buckets collecting subsurface flow from the different trench sections, (c) groundwater wells for detailed measurements of saturation at the soil–bedrock interface at the Panola hillslope, showing the trench on the lower part of the hillslope, (d) dye staining in Maimai to study channelized subsurface flow at the soil–bedrock interface, (e) GPR measurements during a tracer experiment in Luxembourg (Photos: (a)–(c): Ilja van Meerveld, (d): Chris Graham, (e): Niklas Allroggen).
**FIGURE 5** | Focused hillslope–stream connectivity: water flowing out of preferential flow pathway in Luxembourg (Photo: Theresa Blume).
Watershed Perspective

Groundwater Basin Perspective

Harvey and Gooseff, 2015
Groundwater elevations and head using

Groundwater elevations – measured using a fully screened well. Elevation can be used to determine the subsurface flux or potential for soil moisture/saturation.
Groundwater heads can be determined using piezometers. Piezometers – wells which are only screened at the point of interest – provide the hydraulic head at that point.

**Total head = elevation + hydraulic head**

The total head between two piezometers can help determine the direction of flow.
Don Siegel’s graphics

Stagnant! Or towards or away from you!

Peizometers at different locations

Peizometers at different depths

Use of 3 GW wells or peizometers can provide you an initial idea of GW flow
Water Chemistry Monitoring and Sampling

- Rainfall or throughfall – performed to get an estimate of atmospheric input or deposition
- Rainfall or throughfall collectors.
- Recovered after rain events.

National Atmospheric Deposition Program (NADP) sites – Data being collected for many locations in the US for rainfall and chemistry. Helps develop a mass input budget.
http://nadp.sws.uiuc.edu/
Litter fall input
Soil and Groundwater Sampling

Zero tension soil water (30 cm)

Tension (30 psi) from A & B horizons

Tension Lysimeter
Porous Cup (5 cm diameter, 50 cm deep in soil)
Soil and Groundwater Sampling
Fig. 1. Horizontal installation of a suction cup from a trench (a), installation of a shaftless suction cup (b), installation in 45° angle (c), and vertical installation with collar (d). (e) Installed collar, (f) refilled soil, and (g) undisturbed soil.
Groundwater wells for sampling

Sampling depth, frequency, volume, etc. will depend on specific purpose
Water Chemistry Monitoring and Sampling

Stream water sampling and monitoring performed for:
- Baseflow (daily, weekly, monthly...) – very often manual sample collection
- Storm events - automated as well as manual

Streamflow water monitoring - most often by ISCO samplers – that can be programmed to collect at specific time intervals or at particular flow depths.

- Typically the samples are collected so that the chemistry of the full discharge hydrograph can be determined.
- Occasionally, samples are collected with greater weightage to high flow conditions.
- Sampling frequency
Streamflow chemistry can also be monitored continuously using water quality sondes – YSIs, InSitu, Hydrolab data sondes. Typical parameters are recorded include –

- pH
- Temperature
- Conductivity
- Turbidity (NTU)
- Flow depth
- Dissolved oxygen
- ORP

Recent advances in technology have allowed sondes to measure – (e.g., S::CAN sensors)

http://www.s-can.at/

- Nitrate
- Dissolved organic carbon
- Fluorescence
- UV absorbance
- Etc..
Water Sample type:

Dissolved < 0.2 – 0.7 μm filter
Particulate > 0.2 – 0.7 μm
Colloids = 0.001 – 1.0 μm

common filter average pore sizes: 0.45 um, 0.7 um
**Particulate matter analyses** – gravimetric approaches - sample is dried in the oven and weighed.

**Suspended sediment concentration (SSC)** – whole sample is filtered and analyzed.

**Total suspended solids (TSS)** – an aliquot (100 mL) is analyzed.

SSC analyses is typically more accurate than TSS especially when large sediment particles are involved.