**EnviroDIY in the Delaware River Basin Where have we come from and where are we going?** 2021 Watershed Congress, Thursday September 23, 2021, 4:30-5:30p David Bressler, Stroud Water Research Center



# Today

 Main Point today: Stroud Center is supporting EnviroDIY in the DRB – how it's happening, who's involved, what's being learned, what's happening, and how can others get involved.



# Today more specifically

- Overview of EnviroDIY
- Overview Monitor My Watershed
- Overview of "EnviroDIY in the DRB" program past, present, future; including:
  - History, for context
  - Case studies of how stations/data can be used
  - Resources for users
  - Options for how individuals/groups can get involved



• EnviroDIY is "a community for do-it-yourself environmental science and monitoring. EnviroDIY is part of <u>WikiWatershed</u>, a web toolkit designed to help citizens, conservation practitioners, municipal decision-makers, researchers, educators, and students advance knowledge and stewardship of fresh water." (from EnviroDIY.org)





• EnviroDIY is focused around the Mayfly Data Logger



The EnviroDIY Mayfly Data Logger is a powerful, userprogrammable microprocessor board that is fully compatible with the Arduino IDE software.

Designed by Shannon Hicks, Stroud Center engineer



Lots of possibilites



Building a Low-Cost Electrical Conductivity Sensor Using the Mayfly Platform

The "Frankenlog" Network: A Forest Floor Ecohydrology Sensor Network Using the Mayfly Data Logger

By David Lutz on 2021-02-05

#### Building a Continuous Temperature Logger with the EnviroDIY Mayfly

By <u>Robert S</u> on 2020-05-11



In the stream, sensors were mounted on standpipes and, later, on a

boom extending over open water.



# EnviroDIY globally

#### EnviroDIY monitoring stations across the world

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|--|--|---|--|--|--|--|--|--|
| Browse Data Collection Sites   | Browse all sites that have been registered in the database by all users. Clicking on a site shows its details and provides a link to view the data col   | llected at that site.                     |  |  |  |  |  |  |
| Auto Zoom  |  |   |  |  |  |  |  |  |
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| American Littoral Society  | TX CLAY OCCAN Morocco Algeria Libya Egypt  | Iran Pakistan Nepal A                     |  |  |  |  |  |  |
| Aquashicola Pohopoco Watershed<br>Conservancy  | 2<br>Mexico<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto<br>Cuto  | Saudi Arabia<br>Omen<br>Yemen<br>Thailand |  |  |  |  |  |  |
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| Berks County Conservation District   | The second secon | Somalia                                   |  |  |  |  |  |  |
| Berks County Parks and Recreation<br>Department  | + Brazil province and a second | bique                                     |  |  |  |  |  |  |
| Berks Nature   | Paraguay of Paragu | Madagascar Indian<br>Ocean                |  |  |  |  |  |  |

## Monitor My Watershed®



# EnviroDIY in the U.S.

#### Most stations are in the eastern U.S.



# EnviroDIY in the U.S.

Greatest density of stations is in the Delaware River Basin



6



# The Standard EnviroDIY Station

Stroud Center's standard EnviroDIY Monitoring Station

## **EnviroDIY in the DRB**



Also designed by Shannon Hicks



# The Standard EnviroDIY Station





#### The Standard EnviroDIY Station, Logger Box and solar panel



# The Standard EnviroDIY Station, Mayfly

#### Features of the EnviroDIY Mayfly Data Logger





## The Standard EnviroDIY Station, Cell Board



# 4G/LTE cell board – transmit data to Monitor My Watershed



## The Standard EnviroDIY Station, Sensor Bundle





# The Standard EnviroDIY Station, Sensors



#### CTD Sensor (Meter Hydros 21)

#### Turbidity Sensor (Campbell OBS 3+)



## The Standard EnviroDIY Station, microSD card

#### microSD card files are generally the most secure data





## The Standard EnviroDIY Station, data points

| DateTime        | TimeOffse | DateTimeUTC     | Decagon_CTD-10_Cond | Decagon_CTD-10_Temp | Decagon_CTD-10_Depth | EnviroDIY_Mayfly_Temp | EnviroDIY_Mayfly_Batt | Digi_Cellular_SignalPercent |
|-----------------|-----------|-----------------|---------------------|---------------------|----------------------|-----------------------|-----------------------|-----------------------------|
| 4/26/2021 13:30 | -5:00     | 4/26/2021 18:30 | 302.2               | 14.3                | 210.8                | 4.215                 | 26                    | 109                         |
| 4/26/2021 13:35 | -5:00     | 4/26/2021 18:35 | 306.5               | 14.3                | 212.8                | 4.215                 | 29.25                 | 51                          |
| 4/26/2021 13:40 | -5:00     | 4/26/2021 18:40 | 308.8               | 14.3                | 206.7                | 4.23                  | 30                    | 90                          |
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| 4/26/2021 13:55 | -5:00     | 4/26/2021 18:55 | 309                 | 14.4                | 202.8                | 4.23                  | 29.75                 | 109                         |
| 4/26/2021 14:00 | -5:00     | 4/26/2021 19:00 | 308.2               | 14.5                | 203                  | 4.215                 | 29.25                 | 51                          |
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## Data points collected every 5 minutes



### The Standard EnviroDIY Station, MonitorMW data portal

• Data sent in real-time to Monitor My Watershed data portal via cell signal









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• Monitor My Watershed is where you access and see the data

#### http://monitormywatershed.org/





Clickable map with color legend provides quick view of station online status





Clickable site and then click "View data for this site" to get to site's homepage





Site home page contains site info, station owner, deployment date, etc., along with 72hr data panels with real time feed



#### Data panels provide real-time (most recent) readings



## Easy to access on a smart phone



Time Series Analyst (TSA) graphs provide ability to see past data trends, multiple parameters, multiple sites



90%

Number of Observations

272.80

8 860

NTER

Seasonal and day/night (diel) patterns in stream water temperature



Dilution of stream water during storms – conductivity decreases as depth increases



Naylors Run – urban watershed, high conductivity and lots of dilution during storms



Spikes in conductivity during/after winter storms – flushes of road salt/de-icer



Water Research Center

Tributary to Cobbs Creek in Philadelphia area

Data signals of unknown source – pollutant, sensor fouling, malfunction?



Palmer Run, a heavily forested stream in First State National Historical Park, DE



Increased turbidity during storms



Valley Creek at Ecology Park



## Where have we come from and where are we going?

- Overview of "EnviroDIY in the DRB" program past, present, future; including:
  - History, for context
  - Resources for users
  - Case studies of how groups and schools are using the data
  - Options for how individuals/groups can get involved



### Where have we come from and where are we going? Vision

- Vision: make it increasingly easier for people to
  - Monitor water using EnviroDIY
  - Understand, analyze, apply data for management, education, outreach
- \*This DRB work is a pilot of sorts for what is starting to happen more broadly



## Where have we come from? Stroud Center Perspective on EnviroDIY in DRB

- Primary Goal
  - Support Station owners, managers, and volunteers
    Use stations for local purposes
- Secondary Goal
  - Analyze basin-wide data set
  - Develop tools to characterize and contextualize watersheds





# Delaware River Watershed Initiative (DRWI)

## https://4states1source.org/

OUR WATER OUR WORK FIELD NOTES TAKE ACTION

DELAWARE RIVER WATERSHED INITIATIVE

## Working across four states to protect one shared source of clean water



4States1Source

The Delaware River Watershed Initiative




#### https://www.c-saw.info/



#### What is C-SAW?

The Consortium for Scientific Assistance to Watersheds (C-SAW) is a team of specialists who provide *free* organizational and scientific technical assistance to Pennsylvania-based watershed and conservation organizations.

C-SAW does not conduct watershed monitoring or assessments. Instead, C-SAW helps watershed organizations do a better job with their own monitoring and assessments.



## Who is "we"?

 Watershed groups, schools, and universities using EnviroDIY monitoring stations in the Delaware River Basin (DRB) with Stroud Center support via the Delaware River Watershed Initiative (DRWI)



## Who is "we"?

Abby Weinberg, OSI American Littoral Society Angelica Creek Watershed Association Bartrams Gardens Berks County Conservation District Berks Nature Berks Nature; DCNR; Nolde St Forest Brandywine River Museum Brodhead Watershed Assocation Darby Creek Valley Association **Deerpark Rural Alliance Delaware Riverkeeper** East Stroudsburg University Easter DE Co. Stormwater Coal., Villanova-WPF Great Marsh Institute Green Valleys Watershed Association Independence School Lake Committee, Somerset Lake Community Lawrenceville School Lopatcong Creek Initiative; NJ Highlands Coalition Master Watershed Stewards, Berks Co. **Musconetcong Watershed Association** Natural Lands Trust, Woodstown High School

Pennypack Ecological Restoration Trust Perkiomen Creek Trout Unlimited Poconos-Kittatinny Cluster/East Stroudsburg University Primrose Creek Watershed Association PSU MWS, Aquashicola/Pohopoco Watershed Conservancy Schuylkill River Greenways Silver Lake Nature Center South Jersey Land & Water Trust Stroud Water Research Center The Land Conservancy for Southern Chester County The Schuylkill Center for Environmental Education The Watershed Institute TNC/FSNHP Tookany/Tacony-Frankford Watershed Partnership **Trout Unlimited** Trout Unlimited, NJ Valley Forge Trout Unlimited Wallkill River Watershed Management Group West Chester University White Clay Wild and Scenic Wildlands Conservancy Willistown Conservation Trust Wissahickon Trails

And growing – ongoing need for capacity building among groups and collaborative support for the network



- How is it that Stroud Center was able to provide this resource?
  - Technology development by Shannon Hicks for 20+ years



How is it that Stroud Center was able to provide these stations?
DIY tech development by Shannon Hicks for 20+ years



 Fortunately, ~2015-16 Shannon's technology was ready for standardization and public availability



 Fortunately, ~2015-16 Shannon's technology was ready for standardization and public availability





# Where have we come from? EnviroDIY.org

- Anthony Aufdenkampe (LimnoTech) and Shannon Hicks (with Stroud Center support) started EnviroDIY.org
  - Open Source access to technology, code (via GitHub)



## Where have we come from? Data portals

• Dreamhosters was the original data portal





# Where have we come from? Data portals

 Monitor My Watershed – this is the long term data portal for EnviroDIY, ongoing development, plans for upgrades





# Where have we come from? Timeline

- 2017-2018, Station grants
  - ~60 EnviroDIY monitoring stations granted to groups in DRB, 1yr contract
  - Developing resources temporary data portal, workshops/classes/trainings
  - Everyone learning



WATER RESEARCH CENTER

# Where have we come from? Timeline

- 2018-2019, Transition
  - Updated tech and guidance (operations manual, 0 field data sheets videos, guidance materials, workshops, on-site assistance)
  - Resources page: https://wikiwatershed.org/drwi/ 0









# Where have we come from? Timeline

#### 2019-21, Stabilization and planning

- Standard EnviroDIY CTD build workshop, comprehensive manual, video tutorials
- Monitor My Watershed fully functional, planning for upgrades
- Building out resources

\*Stroud Center technical support throughout the process

Sensor Maintenance: Sensor Cleaning and Bundle Removal



# Where are we now? Support

- 2017-2021 support materials summary
  - Field Visit Data sheets w online entry and storage
  - EnviroDIY and MonitorMW manuals and Quick Guides
  - Videos
  - Workshops
  - Resources page (<u>https://wikiwatershed.org/drwi/</u>)
  - Online group station troubleshooting updates
  - Ongoing assistance and troubleshooting



WATER RESEARCH CENTER

# Now, 2021, lots of stations, lots of groups

- Over 100 stations across DRB
- Owned by over 50 groups
- ~Median watershed size = 10 km<sup>2</sup> (much smaller than USGS watersheds)





- Number of stations installed each year in DRB
  - 2017 55 stations
  - 2018 35 stations
  - 2019 25 stations
  - 2020 12 stations
  - 2021 4 stations
  - TOTAL 131 stations deployed



#### • Numbers of data points

- 840,000 data points per station per year
- Stations installed in 2017: 136,000,000
- Stations installed in 2018: 56,000,000
- Stations installed in 2019: 20,000,000
- Stations installed in 2020: 14,400,000
- >227,000,000 data points

| DateTime        | TimeOffse | DateTimeUTC     | Decagon_CTD-10_Cond | Decagon_CTD-10_Temp | Decagon_CTD-10_Depth | EnviroDIY_Mayfly_Temp | EnviroDIY_Mayfly_Batt | Digi_Cellular_SignalPercent |
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Water Research Center

#### Number of EnviroDIY station sites by organization



#### Station maintenance

- >3000 site maintenance visits by groups/volunteers since July 2018
- ~900 Quality Control efforts conducted since July 2018
- >350 troubleshooting site visits by Stroud Center in 2019-2020

# Where are we now? Support

- Support resources
  - https://wikiwatershed.org/drwi/
  - http://monitormywatershed.org/ (help tab)
  - https://www.envirodiy.org/



#### Where are we now? Examples of station usage

- Examples of work being done (see <u>https://wikiwatershed.org/drwi/#project-updates</u>):
  - Musconetcong and NJ TU flow/WWTP effluent; temperature and brook trout
  - DE TNC/First State NHP pollution into national park
  - East Stroudsburg Univ DRWI PKC cluster; class work
  - Watershed Hydrological Analysis Team stormwater and sediment
  - White Clay Wild Scenic working with municipalities
  - Wallkill and Lopatcong Watershed Characterization collaboration, local decision makers
  - TNC NJ Paulins Kill temperature and sediment from dams
  - Deerpark Rural Alliance Dragon Springs development pollution, Basha Kill monitoring
  - Brodhead Watershed Assoc salt sleuthing and municipal infractions on Forest Hill Run
  - West Chester Univ salt from WCU and WC borough
  - Primrose Creek Watershed Assoc quarry monitoring



 Monitoring of the streams in First State National Historical Park by The Nature Conservancy (DE/PA) Stream Stewards





 Monitoring of the streams in First State National Historical Park by The Nature Conservancy (DE/PA) Stream Stewards



- Monitoring of the streams flowing into First State National Historical Park by The Nature Conservancy (DE/PA) Stream Stewards
  - Sleuthing out and fixing sources of the elevated conductivity working with New Castle Co and the mall





• Pickering CreekMontgomery School, investigation of patterned conductivity spikes (unknown upstream inputs)





Pickering Creek at Montgomery School, investigation of patterned conductivity spikes



 East Stroudsburg University – longitudinal monitoring of Cherry Creek, DRWI Poconos-Kittatinny Cluster



East Stroudsburg University – integration of station
management and data into classes and labs



 West Chester, PA – Patty Haug (MWSteward), George Seeds (MWSteward), and Elisabeth R (Conestoga High School)











 West Chester, PA – Patty Haug, George Seeds (Master Watershed Stewards)

Variability in pollution status of local streams, new knowledge of these streams





• West Chester, PA – Patty Haug, George Seeds

Winter storm conductivity data show different timing and duration of events





 Longitudinal sampling to determine sources and extent of contamination – Elisabeth Ruschmann, Conestoga High School



East Branch Plum Run



 Longitudinal sampling to determine sources and extent of contamination – Elisabeth Ruschmann, Conestoga High School



WATER RESEARCH CENTER

 Paulins Kill at Sussex County Community College, Watershed Characterization





Collaboration between Walkill Watershed Management Group (Kristine Rogers), New Jersey Highlands Coalistion, and the Stroud Center

This water quality report was produced by the Wallkill River Watershed Management Group and Stroud Water Research Center as part of a Delaware River Watershed Initiative citizen science effort funded by the William Penn Foundation. The report begins with an Executive Summary that reviews New



#### Case Study, Watershed Characterization

#### Water temperature in relation to state trout criteria





#### Case Study, Watershed Characterization

#### Water temperature in relation to local forested "reference" sites




### Case Study, Watershed Characterization

### Conductivity (and chloride) in relation to state criteria





### Case Study, Watershed Characterization

### Conductivity (and chloride) in relation to local forested "reference" sites





- Ways to get involved
  - Build a station
  - Help manage a station
  - Use the data
  - Attend monthly meetings/workshops/trainings
  - Support others, collaborate



- Build and Deploy a station, Methods:
  - Via EnviroDIY Build Workshop (<u>https://www.envirodiy.org/event/virtual-workshop-building-envirodiy-monitoring-station/</u>)
    - \*Next workshop is planned for early 2022 contact Dave Bressler if you'd like to be added to the early access list
  - Via EnviroDIY Monitoring Station Manual (<u>https://www.envirodiy.org/mayfly-sensor-station-manual/</u>)
  - Via Video Tutorials (<u>https://www.envirodiy.org/videos/</u>)



- Build and Deploy a station, Supplies:
  - EnviroDIY Monitoring Kit from the Stroud Center (<u>https://www.envirodiy.org/pro</u> <u>duct/envirodiy-monitoring-</u> <u>station-kit/</u>)
  - CTD sensor

(https://www.metergroup.com/ environment/products/hydros-21-water-level-monitoring/)



EnviroDIY Monitoring Station Kit \$475.00



- Volunteer to help manage a station
  - Management oversight ensure functionality (below tasks completed), data usage, pay cell plane, etc.
  - Desktop monitoring of station function On check station function and data readings on MonitorMW <u>daily</u>
  - 3. Maintenance clean sensors <u>once a week</u>
  - 4. Quality Control do data cross checks quarterly



- Volunteer to help manage a station
  - Desktop monitoring of station function check station function and data readings <u>daily</u>





- Volunteer to help manage a station
  - Maintenance clean once a week (or as needed)



- Volunteer to help manage a station
  - Quality Control do data cross checks <u>quarterly</u> (or as needed)



### Use the data and resources

- For outreach
- For education



### Use available lesson plans, make your own, or do informal class work

#### **Understanding Temperature Patterns in Our Watersheds**

#### Overview

In this lab we will use data from Mayfly Data Logger Board<sup>TM</sup> Sensor Stations installed in rivers and streams to learn more about the patterns of temperature in nature. These Sensor Stations measure and transmit important data to the <u>Monitor My Watershed®</u> web portal that can be accessed by scientists, educators, students, and various organizations interested in understanding and monitoring watersheds in our area. Throughout these activities, you will learn how to use the portal to view and interpret data collected at the sensor stations, investigate significant events, analyze the information, and create new understandings about the dynamics and interactions of variables in your local waterways. As you go through the activities, be sure to record the data and your analyses on your lab sheet.

#### Learning Objective:

By the end of this lab you will explain temperature patterns in watersheds and develop analytical and reasoning skills by accessing and interpreting real world data.

#### Introduction

What do you think of when you hear the word "temperature?" Write your definition for temperature below.

### • Learn

Attend EnviroDIY-DRWI Monthly Meetings (virtual via Zoom) – every third Thursday of the month, 2:30-3:30p; recordings:

https://wikiwatershed.org/drwi/#user-group-meetings

Attend workshops/trainings, examples in following slides



### Support others

- Different groups have different resources
- Consider opportunities to collaboratively build/install/manage a station for a specific purpose



## Where are we going? Support Resources

- Stroud Center EnviroDIY support
  - MEETINGS: Monthly EnviroDIY-DRWI meetings (contact <u>dbressler@stroudcenter.org</u> to be added to list)
  - DIRECT SUPPORT: On-site assistance and training
  - TECHNOLOGY: Updated Mayfly data logger, cell boards, sensors, supporting code; Monitor My Watershed upgrades
  - EQUIPMENT: EnviroDIY Monitoring Kits via EnviroDIY shop and other new inventions by Shannon
  - WORKSHOPS:
    - EnviroDIY build workshops (e.g., Feb 9-10, 2020 Build Workshop)
    - Support workshops (e.g., troubleshooting workshop June 23, 2020)
  - CERTIFICATIONS?: For managing high priority stations
  - GUIDANCE MATERIALS: Manual, Quick Guides, Videos, etc ongoing development, <u>https://wikiwatershed.org/drwi/</u>



## Where are we going? Infrastructure

- Longer term planning
  - Developing ways to summarize continuous data for rapid assessment of stream conditions
  - Developing mechanisms to apply data for management
  - Building out Monitor My Watershed to include
    - Data correction/Quality Control
    - Metadata
    - Key statistics (metrics) and thresholds
    - Rating curves (e.g., apply equations to convert depth to discharge, conductivity to chloride)



### Lessons Learned

- Get very familiar with the Mayfly data logger and sensors
- Using Monitor My Watershed to track station function daily is IMPORTANT
  - Become fluent in MonitorMW usage
- Cleaning sensors and doing QC is the only way to ensure good data
- PEOPLE are important! Reliable individuals to perform specific tasks ensures good station function (and good data)
  - Having a schedule/roles/responsibilities has been effective for many groups



### Lessons Learned

- Ongoing dialogue on station function with Stroud team
  can help ensure sustained collection of good data
- Backup funds are important to replace broken or malfunctioning parts
- Before putting stations out know exactly how you will use the data
  - "What to do with all this data?" is a big question for some
  - Know what the data can and can't tell you before getting started
  - Define your goals for the data and for the station's usage



# This is all new – new inventions, new technology, new guidance materials

### **Product Adoption Curve**



accessible, those who want to get involved, get in touch!

Water Research Center

https://www.crazyegg.com/blog/product-adoption-to-transform-marketing/

## Staying in the loop

- If you'd like to be on the EnviroDIY in the DRB email distribution list contact <u>dbressler@stroudcenter.org</u>
  - EnviroDIY-DRWI monthly meeting updates/reminders
  - Workshop updates
  - General updates



### Thank You! Questions?

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