RESOLVE HYDRO

Applications of Remote Sensing in the Chesapeake Bay

Monitoring Submerged Aquatic Vegetation, Water Quality, and Land Change Using Satellite Data

Thomas Howard

November 2, 2023

Applications of Remote Sensing in the Chesapeake Bay

Thomas Howard

Founder & CEO
Resolve Hydro LLC

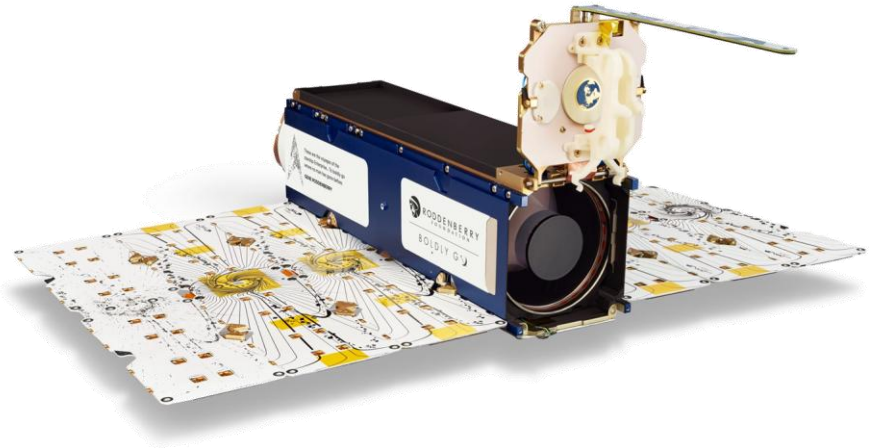
Agenda for Today's Presentation:

- Introduction and Motivation
- Background on Remote Sensing
- Applications
  - Monitoring SAV
  - Monitoring Water Quality
  - Monitoring Fields
- Future Applications and Engagement Opportunities

About Me

Tom Howard, Resolve Hydro LLC

- Bachelor of Science in Environmental Engineering – Johns Hopkins
- Engineer – Water Resources Practice Group at Hazen and Sawyer
- Founder and CEO – Resolve Hydro LLC



Planet SuperDove Satellite

Challenges with traditional water quality monitoring methods

Spatial

Grab samples and monitoring buoys are spatially limited

Temporal

Sampling campaigns gather data only a few times each year

Financial

The costs of collection, shipping, analysis, and data synthesis quickly add up

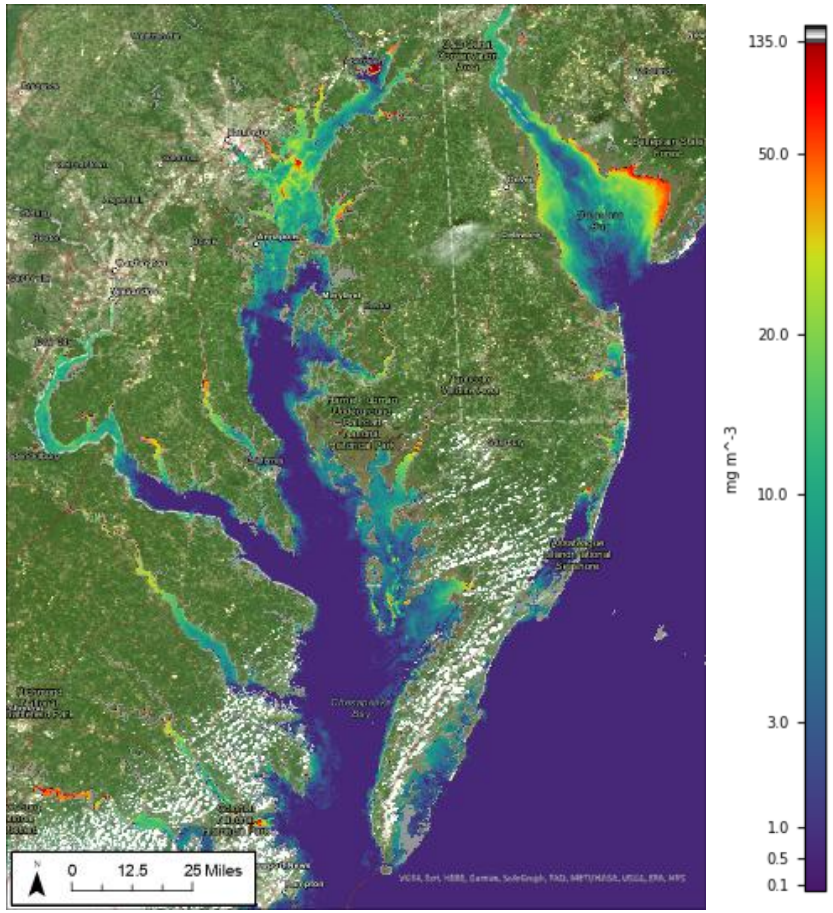
Logistical

Systemic constraints on staff time and resources limit many monitoring programs

Planet SuperDove Images
Captured July 11-12, 2023

Satellites traditionally used for aquatic remote sensing fail to resolve most inland waterbodies.

Q: Why hasn't this "game-changer" integrated into inland water quality monitoring programs in the last 50 years?

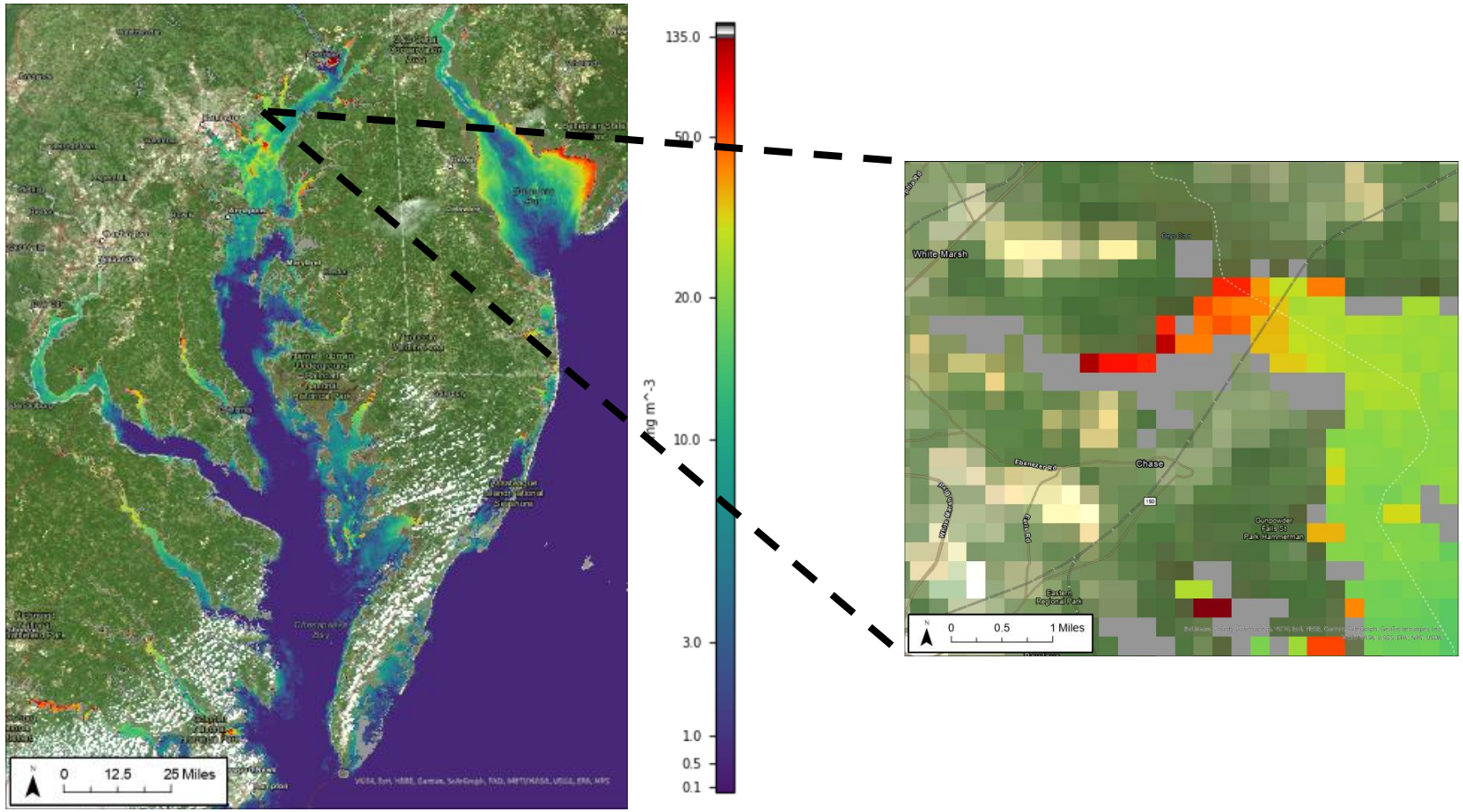


- NOAA's NCCOS Algal Bloom Beta/Experimental Products map key water quality parameters throughout major waterbodies across the US.
- The image shown here plots estimated chlorophyll-a concentration in mg/m^3 throughout the Chesapeake and Delaware Bays.
- This image was captured by Sentinel-3B/OLCI 08/20/2023 at 3:11 pm

Remote sensing, used in conjunction with traditional monitoring tools, offers a **low-cost way to synoptically describe water quality conditions through space and time**

Satellites traditionally used for aquatic remote sensing fail to resolve most inland waterbodies.

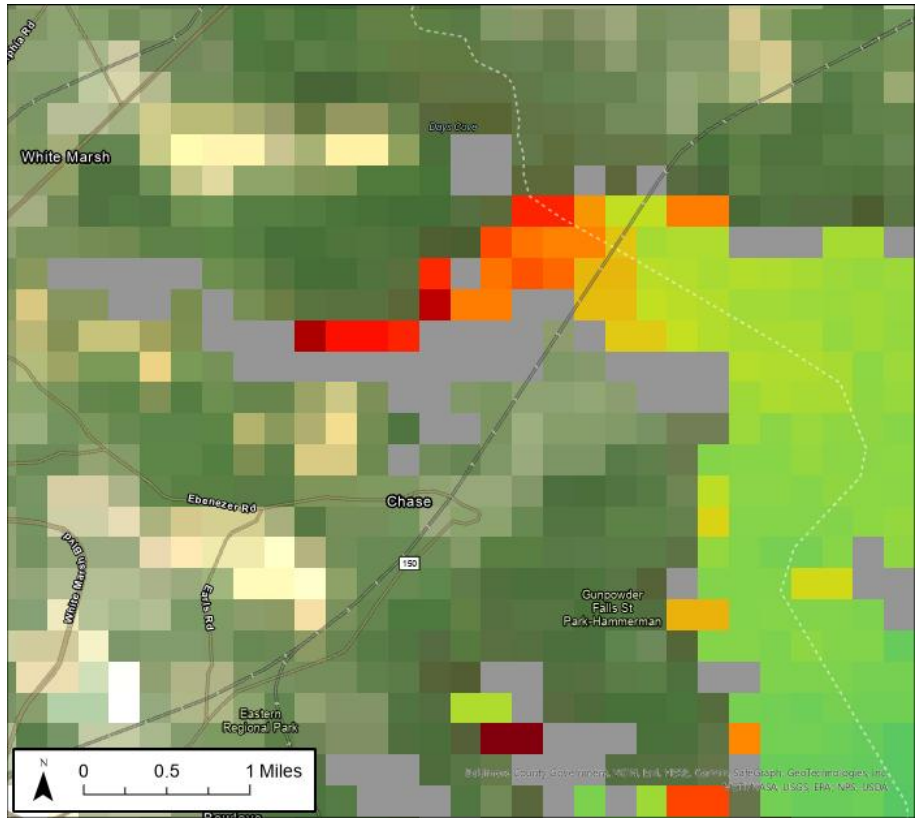
Q: Why hasn't this "game-changer" integrated into inland water quality monitoring programs in the last 50 years?



Remote sensing, used in conjunction with traditional monitoring tools, offers a **low-cost way to synoptically describe water quality conditions through space and time**

Satellites traditionally used for aquatic remote sensing fail to resolve most inland waterbodies.

Q: Why hasn't this "game-changer" integrated into inland water quality monitoring programs in the last 50 years?
A: Integration has been hindered by a **lack of suitable sensing systems, detection algorithms, and industry training.**



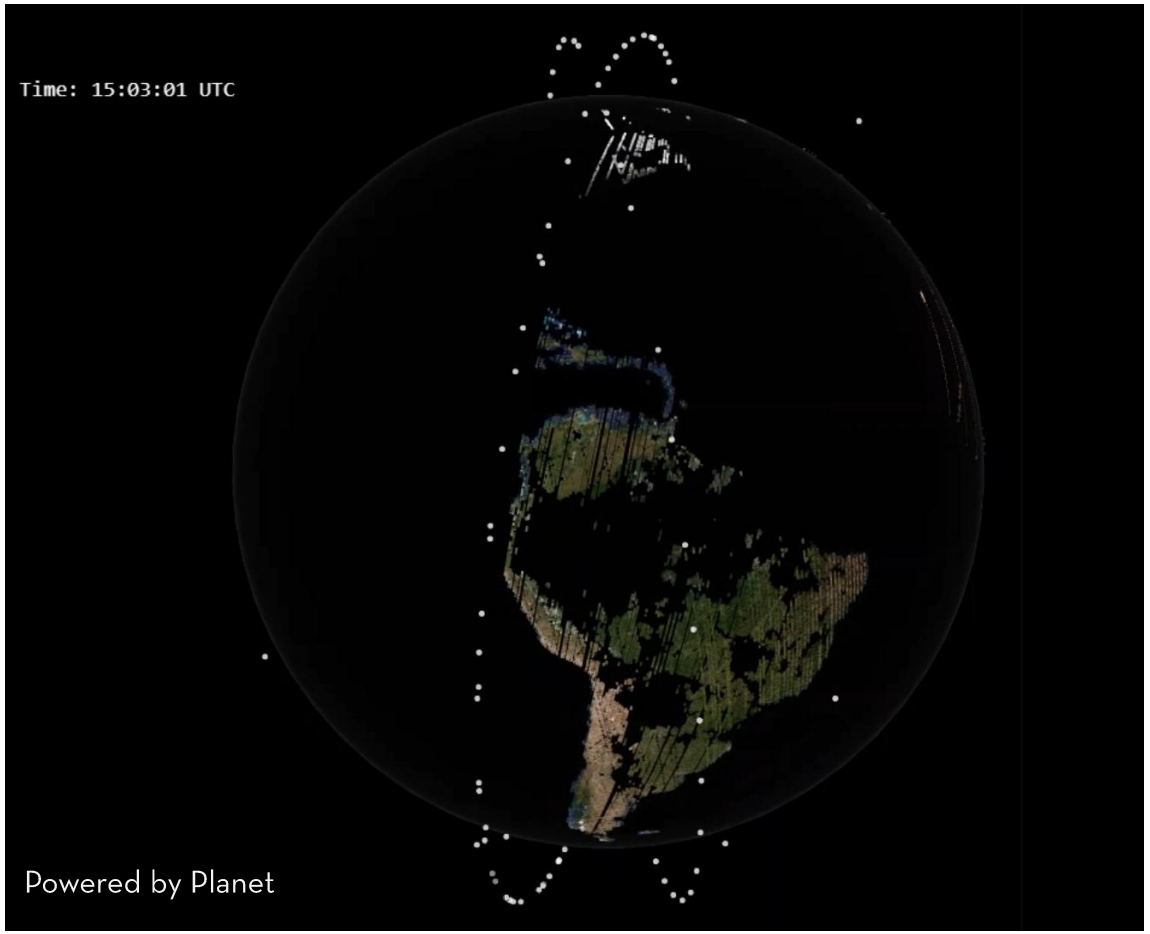
Sentinel-3B/OLCI Image Captured 08/20/2023 at 3:11 pm

Planet SuperDove Image Captured 08/20/2023 at 3:37 pm

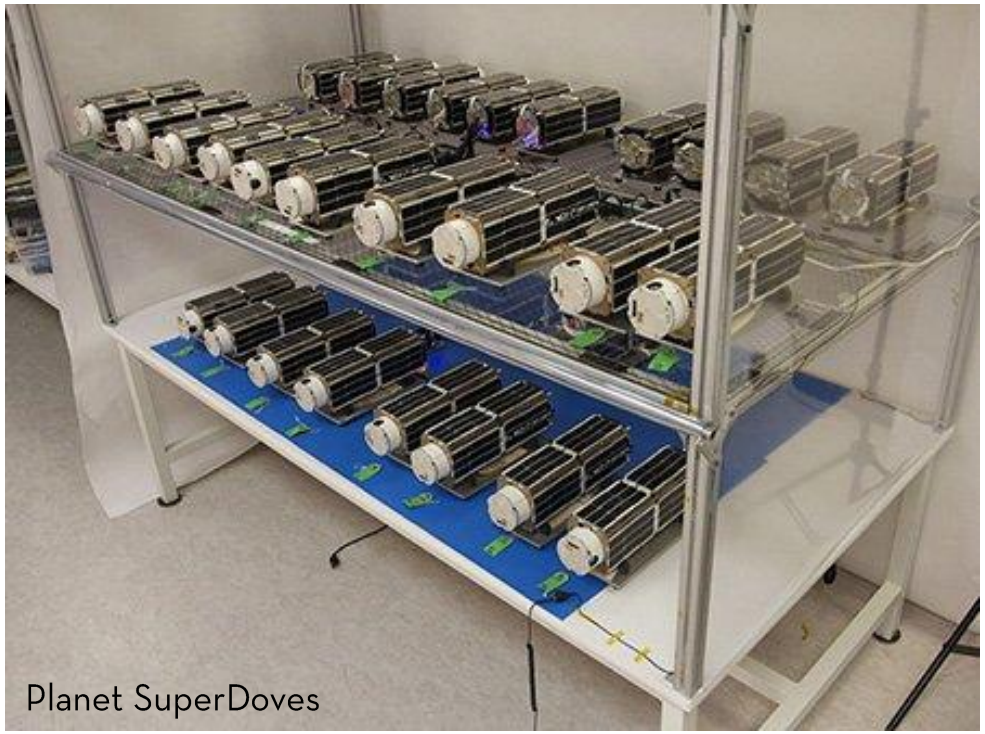
Resolve Hydro™ uses constellations of CubeSats to overcome traditional limitations with inland aquatic remote sensing

RESOLVE HYDRO

High spatial, temporal, and spectral resolution provides enhanced data for water resources applications

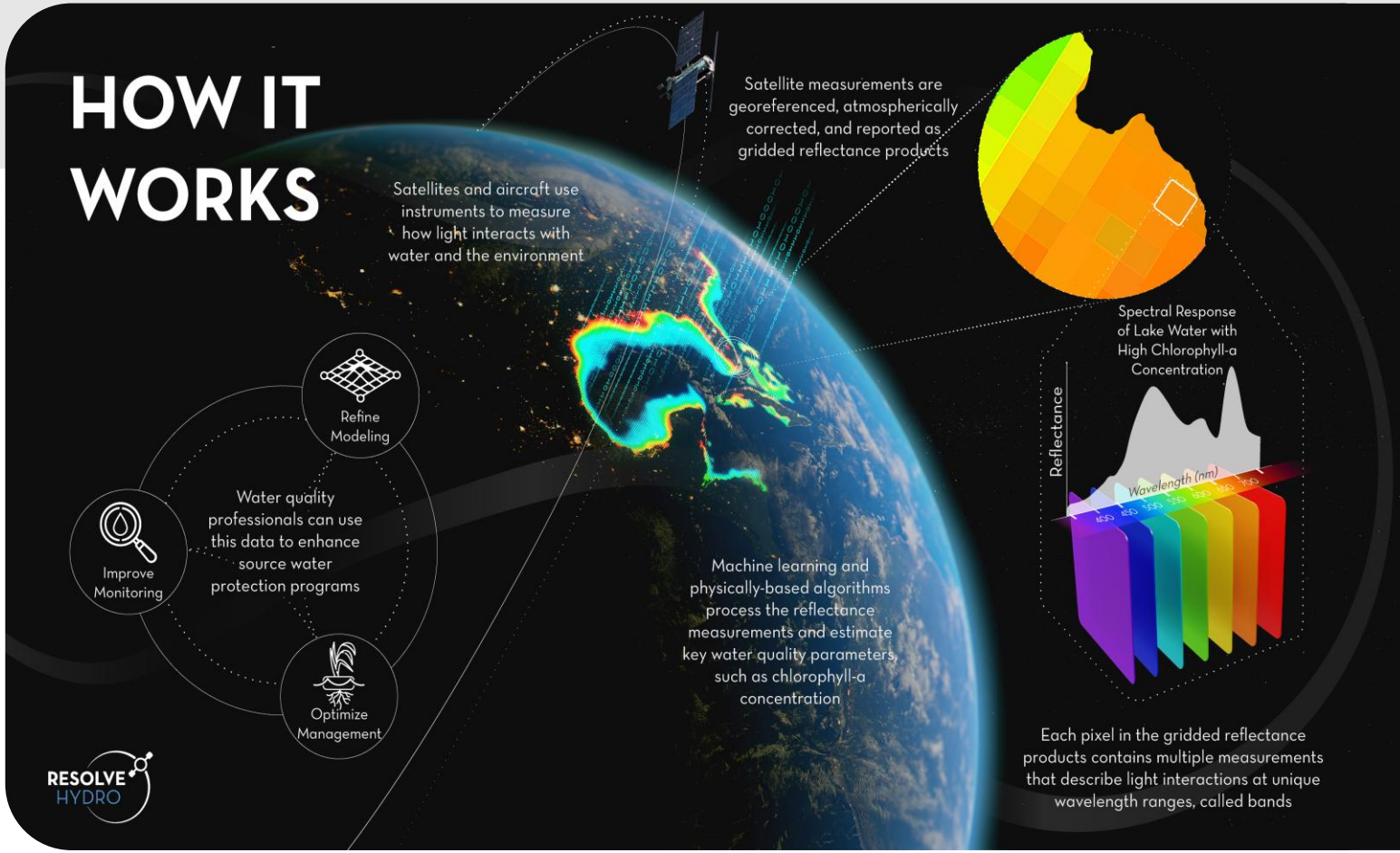


Planet SuperDoves collect daily, 8-band imagery over the Earth's entire land area. Data are available from March 2020 to the present.



Satellites measure light energy reflected into space after it has interacted with the Earth's surface and atmosphere

How can satellites 300-miles away be used to monitor water resources?

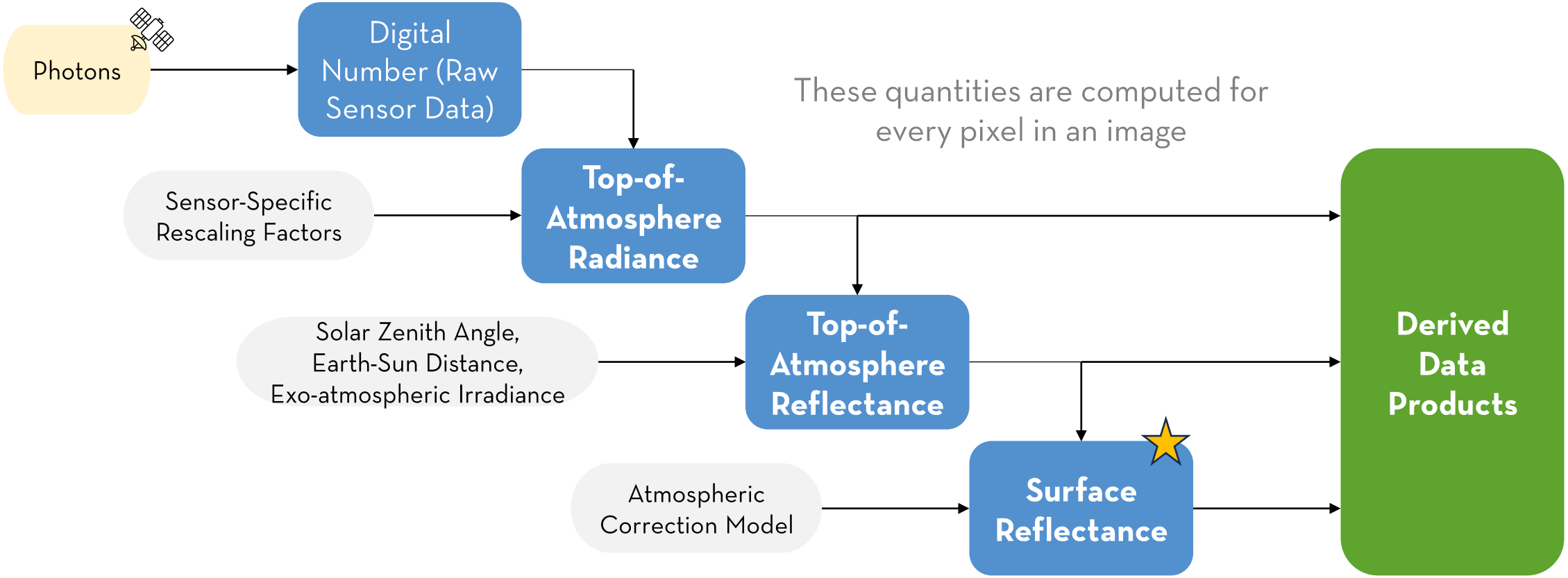


1. Radiation is emitted from the sun (or another active source)
2. Ozone, aerosols, and other atmospheric constituents absorb and scatter light energy
3. Light reaching the surface interacts with matter in wavelength-dependent, physically predictable ways
4. Light scattered back through the atmosphere is measured by satellites
5. Usable data products are created

Raw satellite measurements are converted into standard data products prior to further use in remote sensing workflows

RESOLVE HYDRO

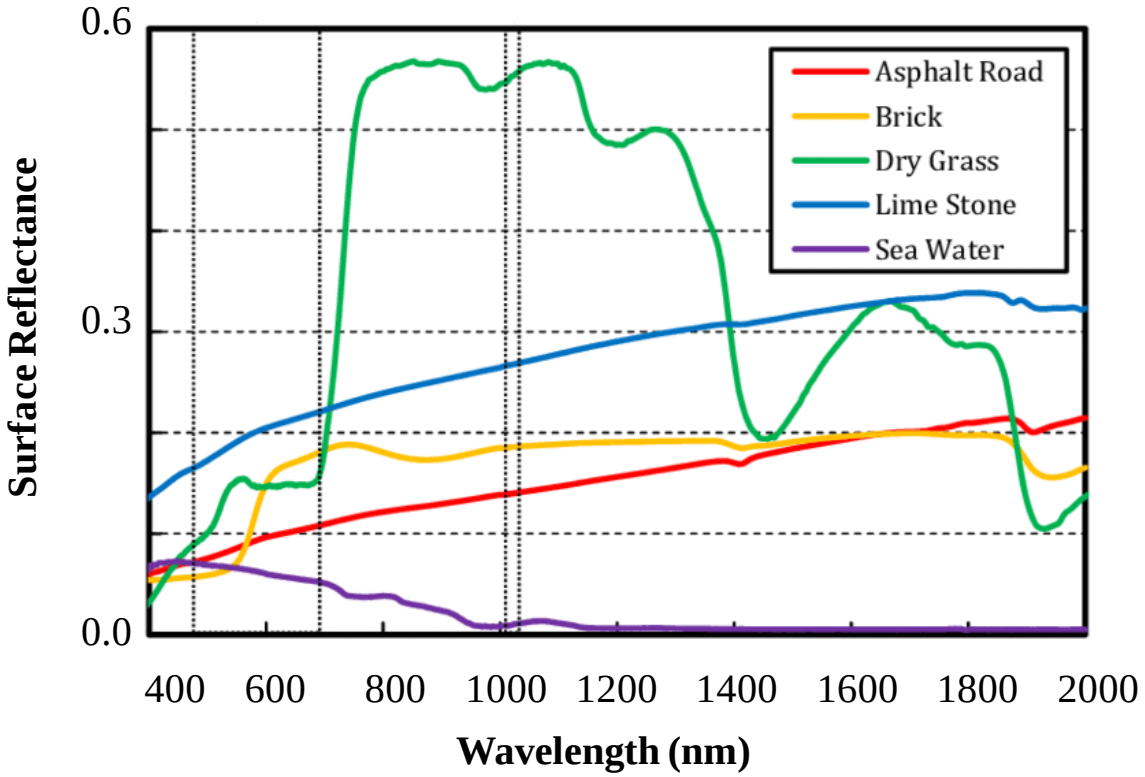
Creating Data Products from Satellite Measurements

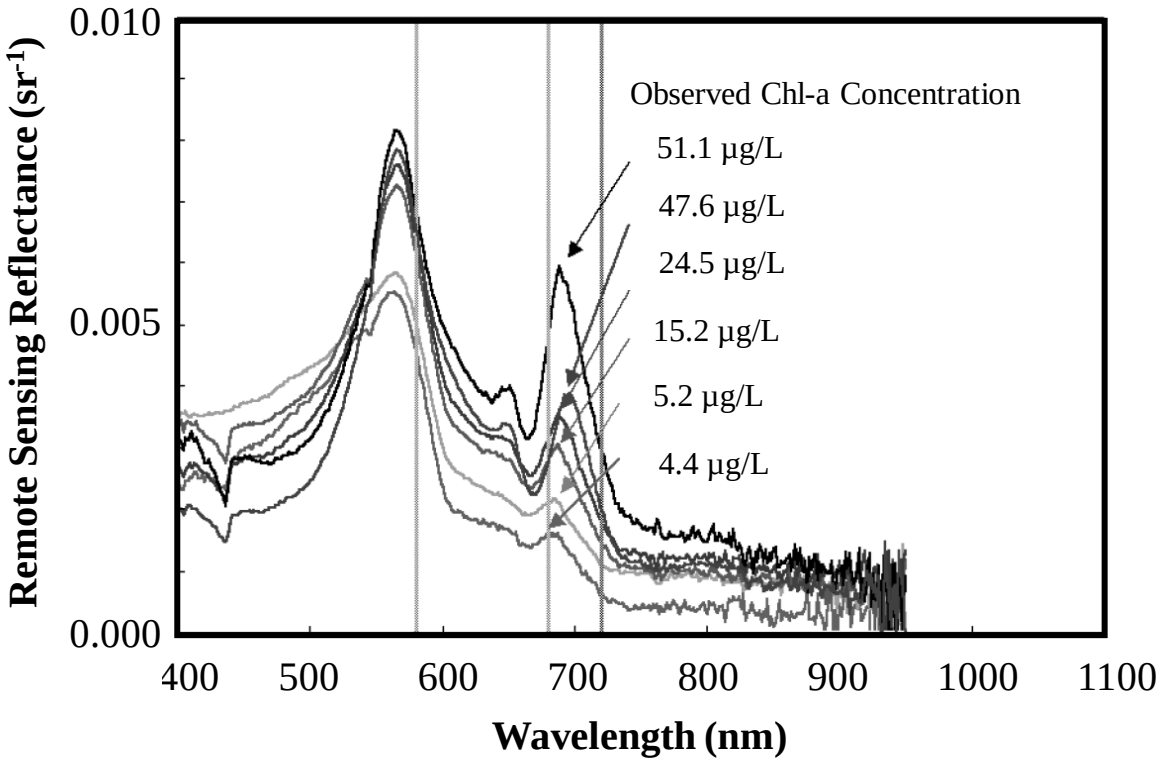


Remote sensing can identify different materials and provide quantitative and qualitative information about the material's conditions and processes

RESOLVE HYDRO

Reflectance Provides a Spectral Fingerprint for Different Materials

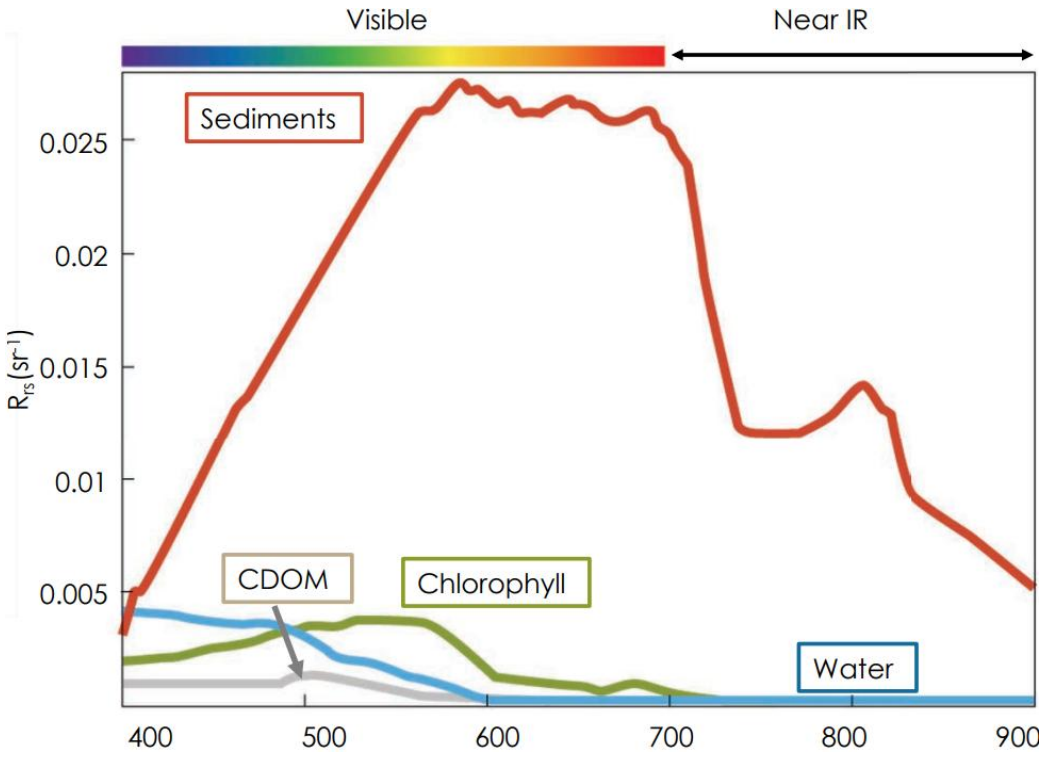


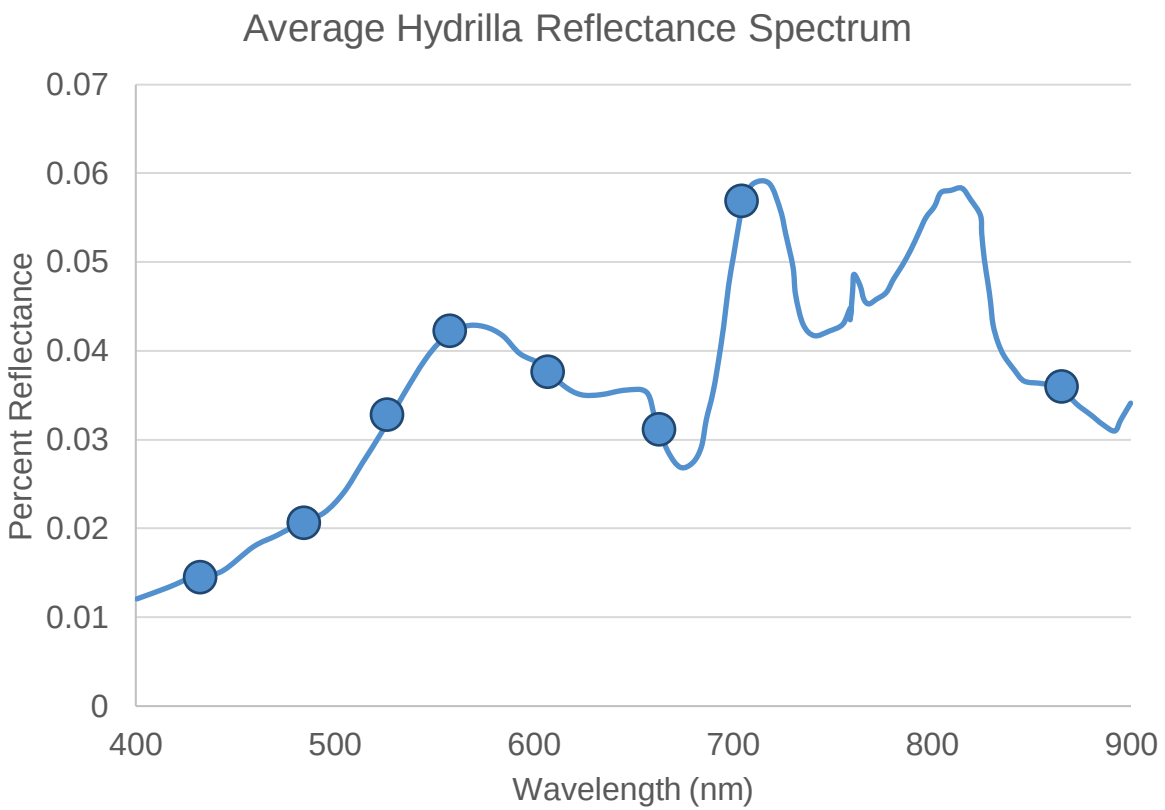


Remote sensing can identify different materials and provide quantitative and qualitative information about the material's conditions and processes

RESOLVE HYDRO

Reflectance Provides a Spectral Fingerprint for Different Materials





Processed satellite data provides information relevant to water quality monitoring

RESOLVE HYDRO

Example Quantities Measurable By Satellite

Chlorophyll-a	TSS	CDOM	Turbidity	Secchi Depth
Temperature	Phycocyanin	SAV	Salinity	Wave Height
Depth	Bottom Substrate	Water Surface Elevation	Physical Structure	Water Content

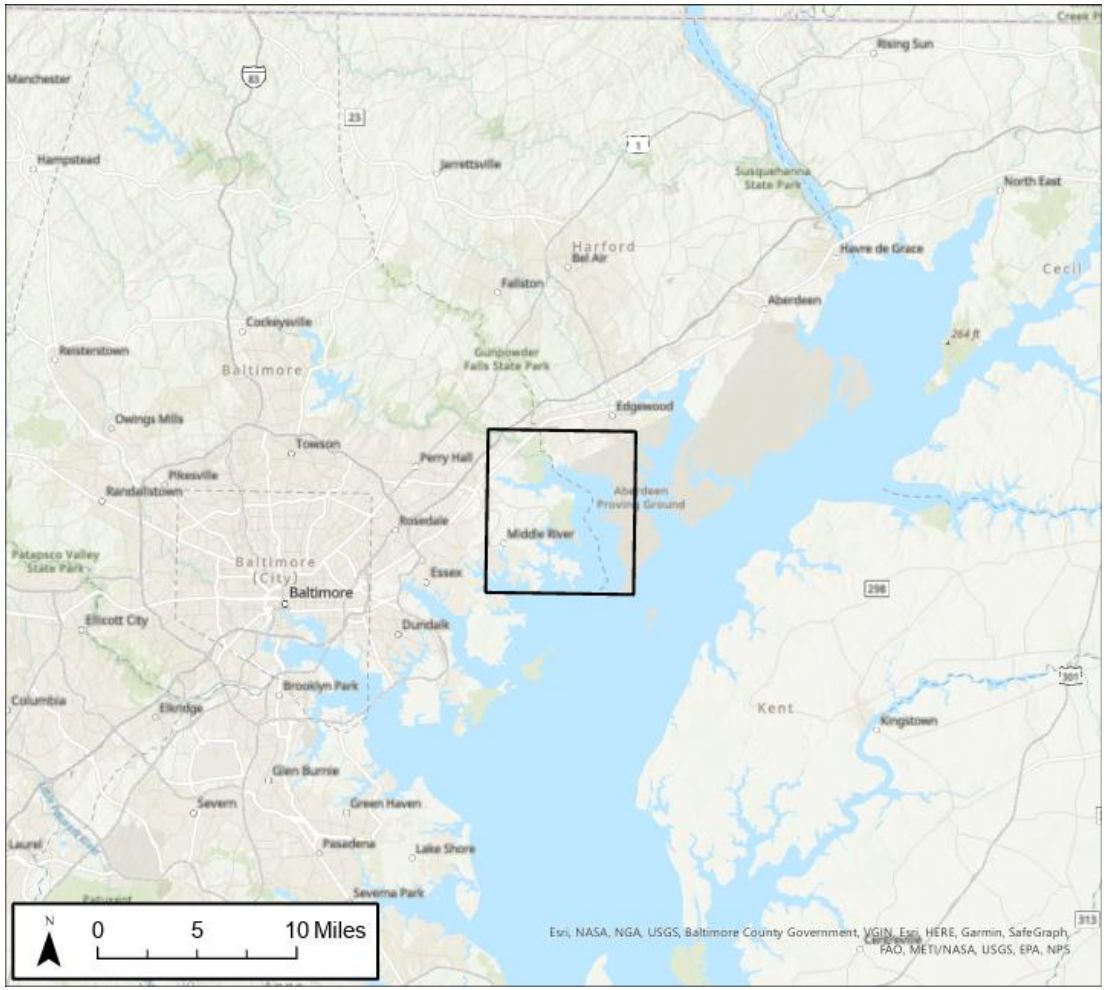
Resolve Hydro™ Case Studies in the Chesapeake Bay

Using remote sensing we can (and should) monitor our water resources more effectively

Remote Sensing of Submerged Aquatic Vegetation (SAV)

Estimating Water Quality Parameters Using Virtual Buoys

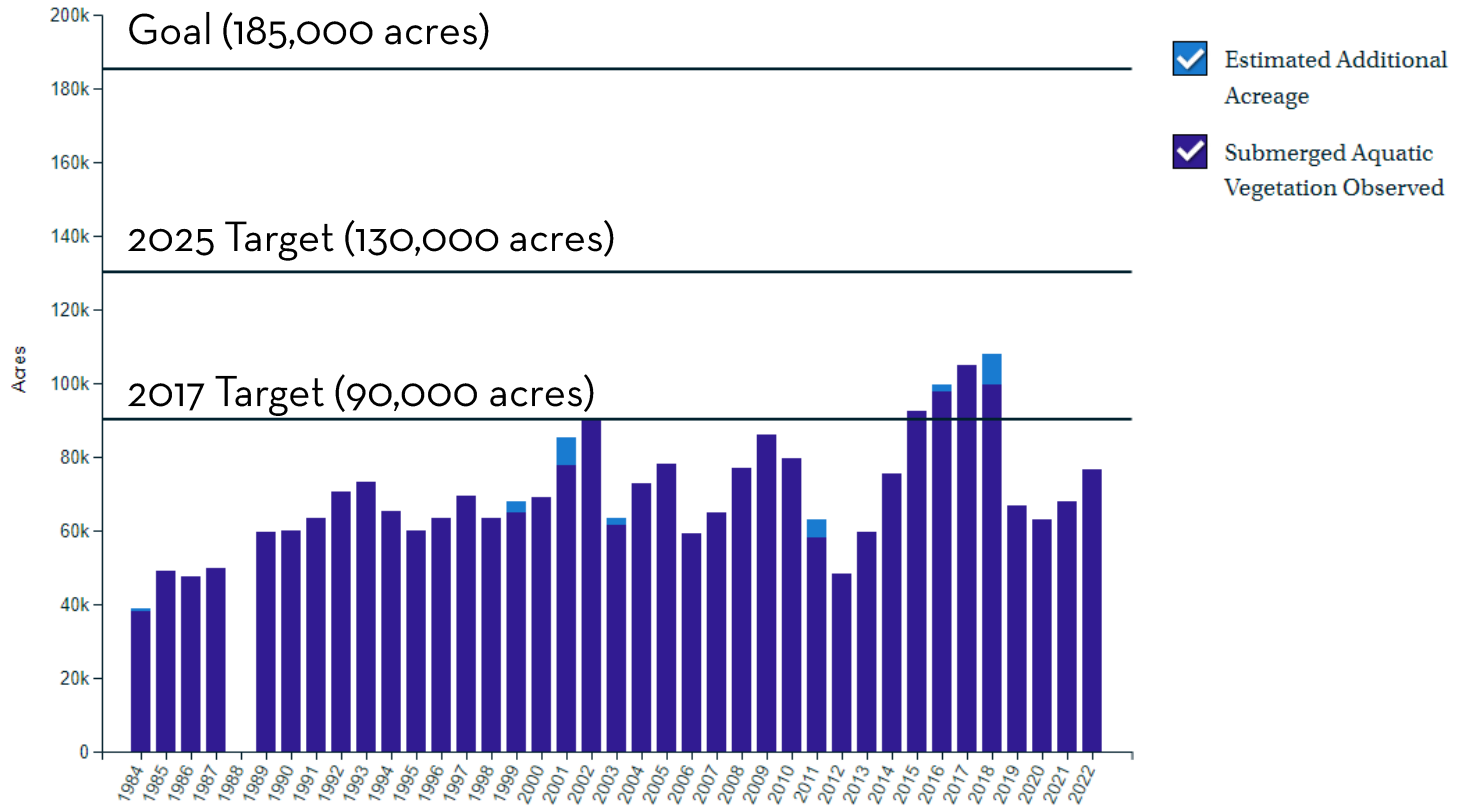
Monitoring Changes in the Watershed



Remote Sensing of Submerged Aquatic Vegetation

The Chesapeake Bay Program has set a goal to achieve and sustain 185,000 acres of SAV Bay-wide

- Since 1984, the Chesapeake Bay Program has worked with Virginia Institute of Marine Science (VIMS) to conduct an annual survey of SAV throughout the Chesapeake bay and its tidal waters
- In 2017, the cost for aerial imagery alone was $140,000
- Beginning in 2021, the price for aerial imagery was expected to increase 1.7-2.1 times ($238,000 - $294,000)
- The cost to collect PlanetScope imagery for the entire Bay would cost under $20,000



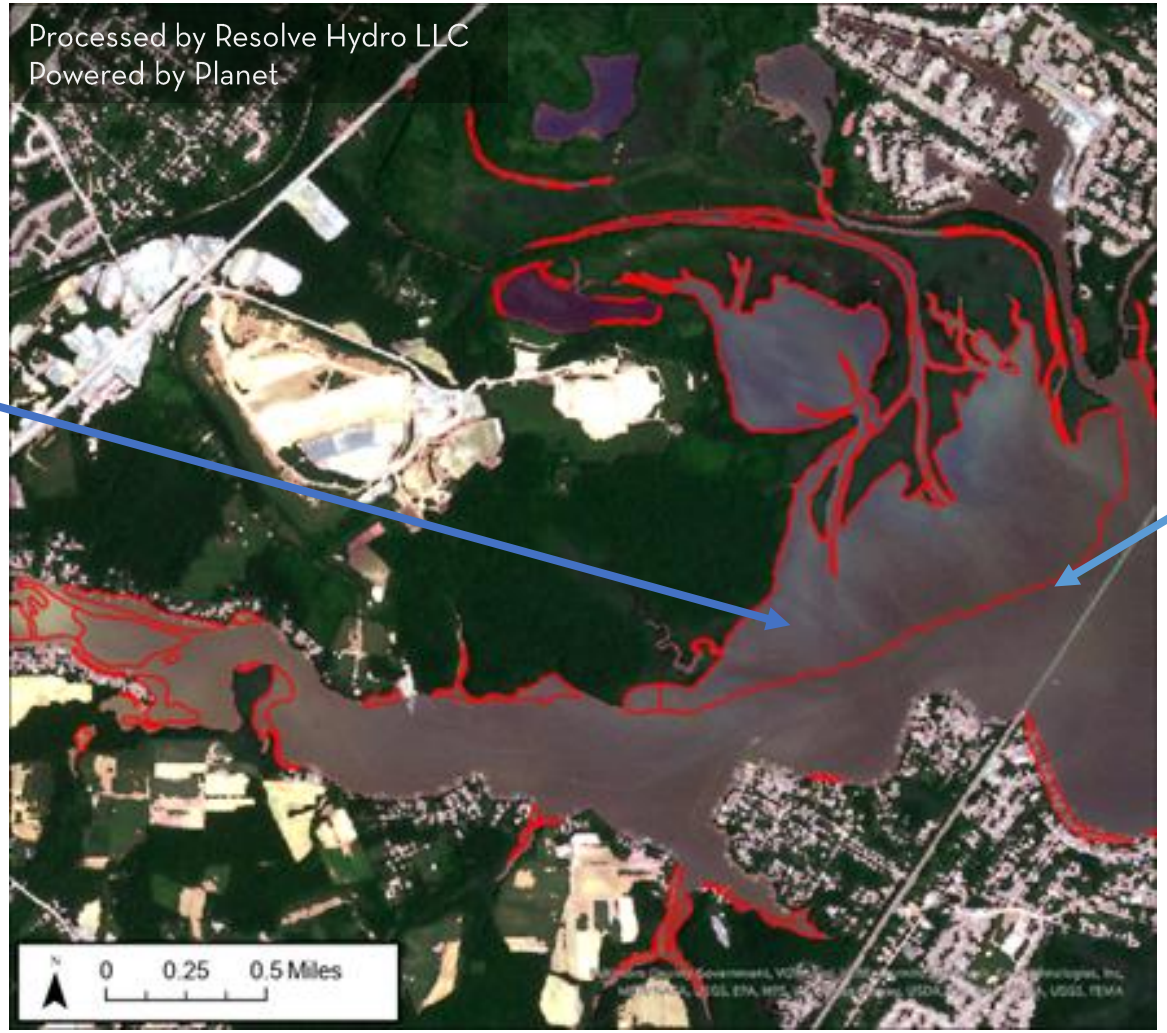
Remote Sensing of Submerged Aquatic Vegetation

RESOLVE HYDRO

False color imagery can quickly show estimated SAV coverage with minimal processing

June

Planet SuperDove image captured 06/15/2022



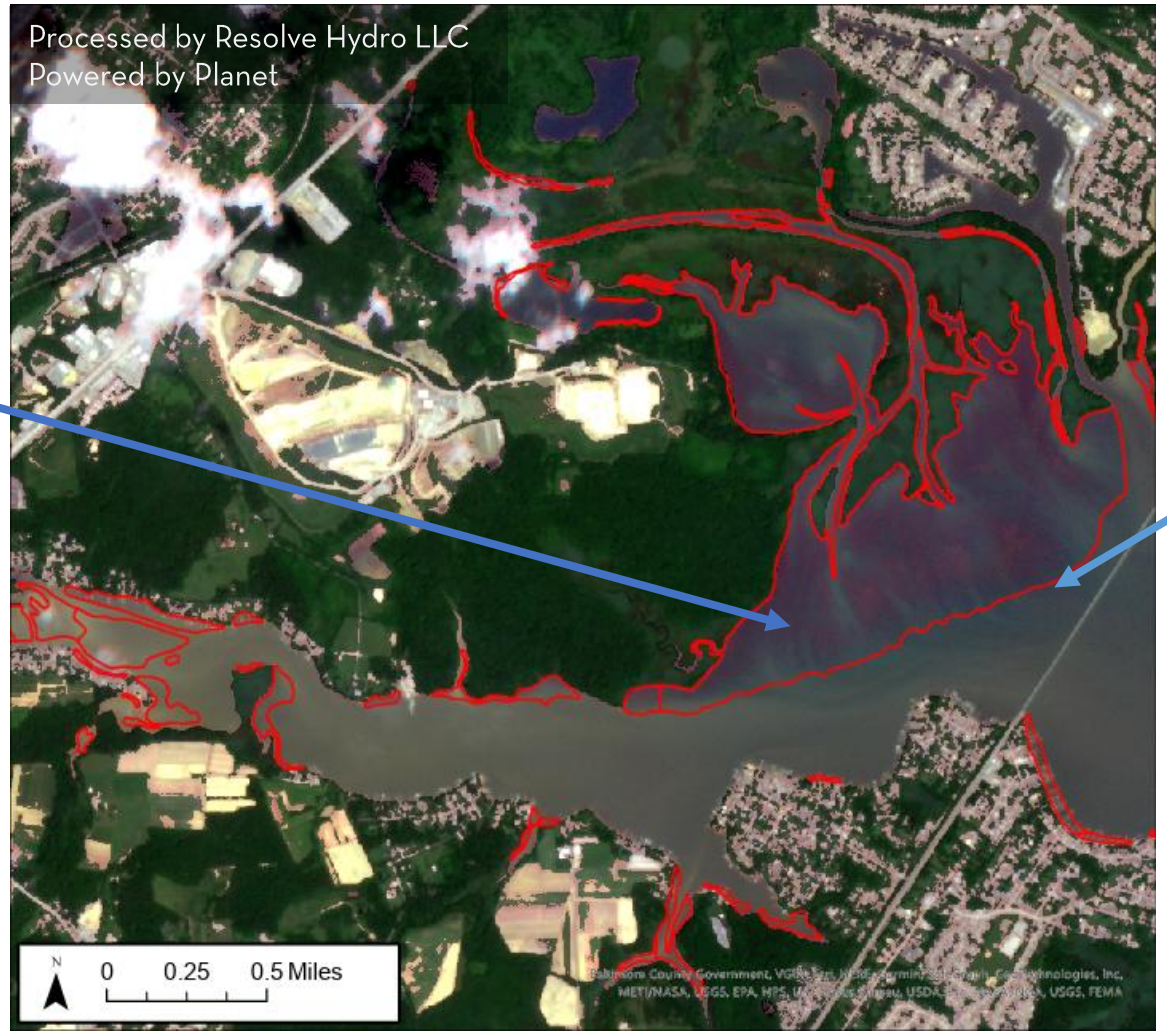
2022 SAV Bed Outline (VIMS)

Remote Sensing of Submerged Aquatic Vegetation

False color imagery can quickly show estimated SAV coverage with minimal processing

July

Planet SuperDove image captured 07/13/2022



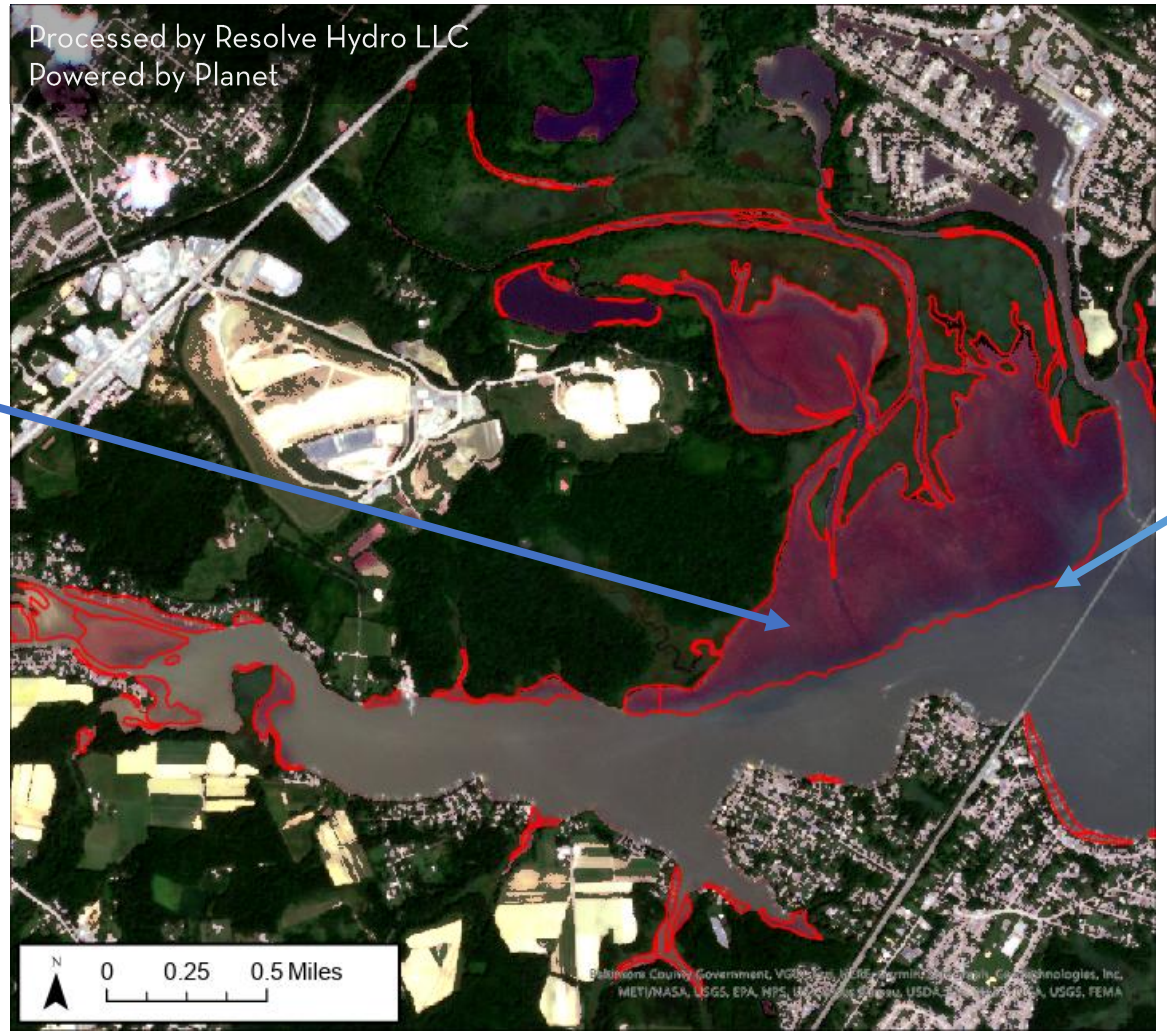
2022 SAV Bed Outline (VIMS)

Remote Sensing of Submerged Aquatic Vegetation

False color imagery can quickly show estimated SAV coverage with minimal processing

August

Planet SuperDove image captured 08/20/2022



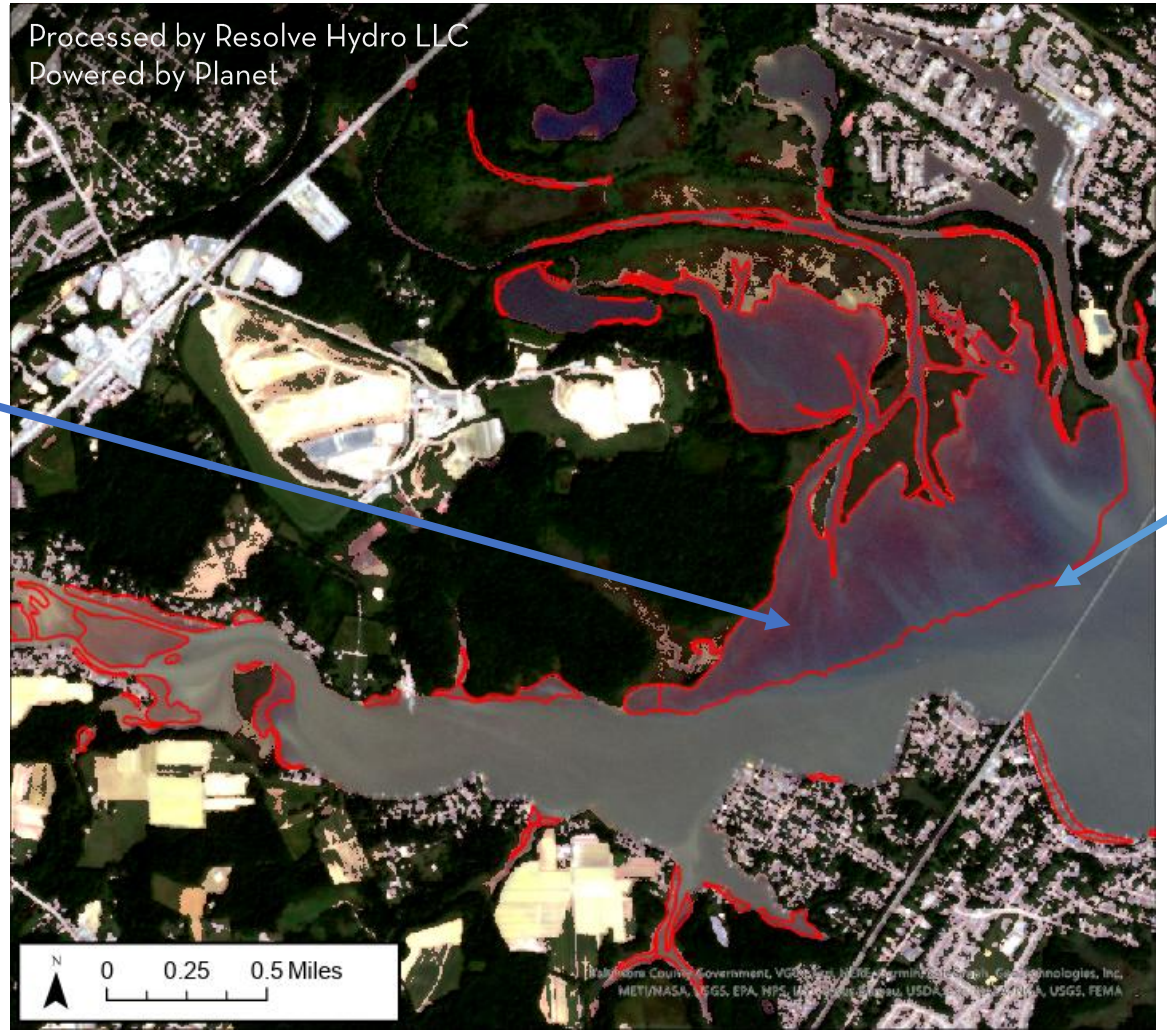
2022 SAV Bed Outline (VIMS)

Remote Sensing of Submerged Aquatic Vegetation

False color imagery can quickly show estimated SAV coverage with minimal processing

September

Planet SuperDove image captured 09/20/2022



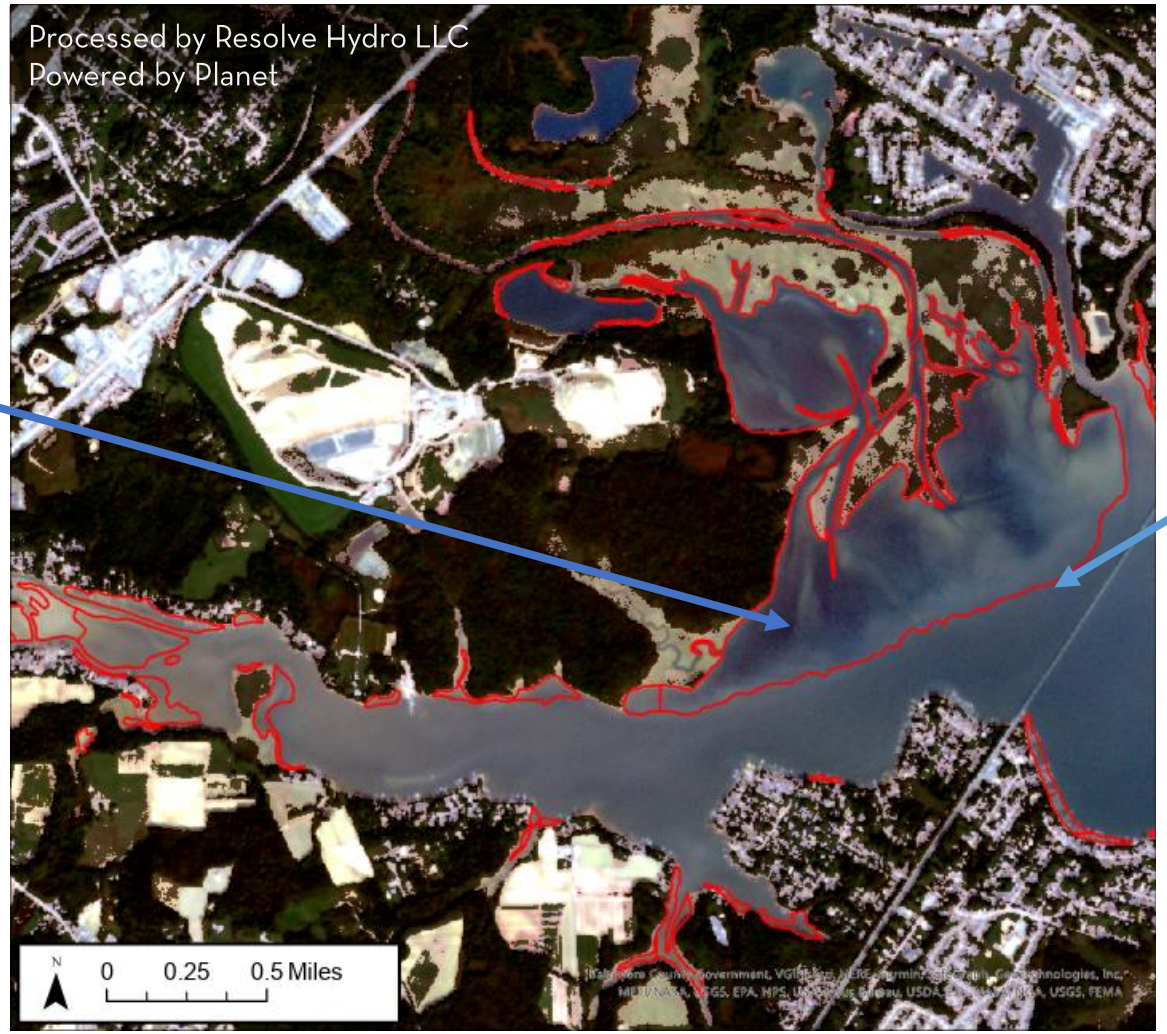
2022 SAV Bed Outline (VIMS)

Remote Sensing of Submerged Aquatic Vegetation

False color imagery can quickly show estimated SAV coverage with minimal processing

October

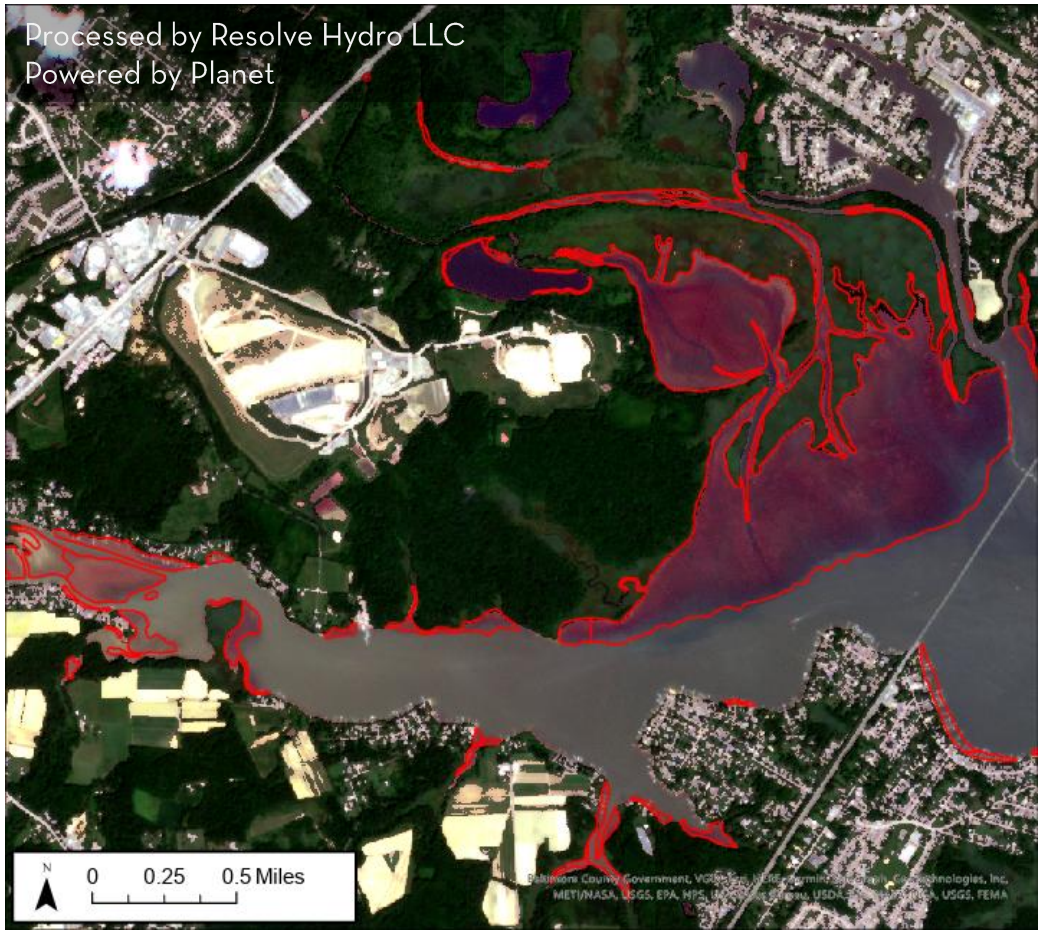
Planet SuperDove image captured 10/20/2022



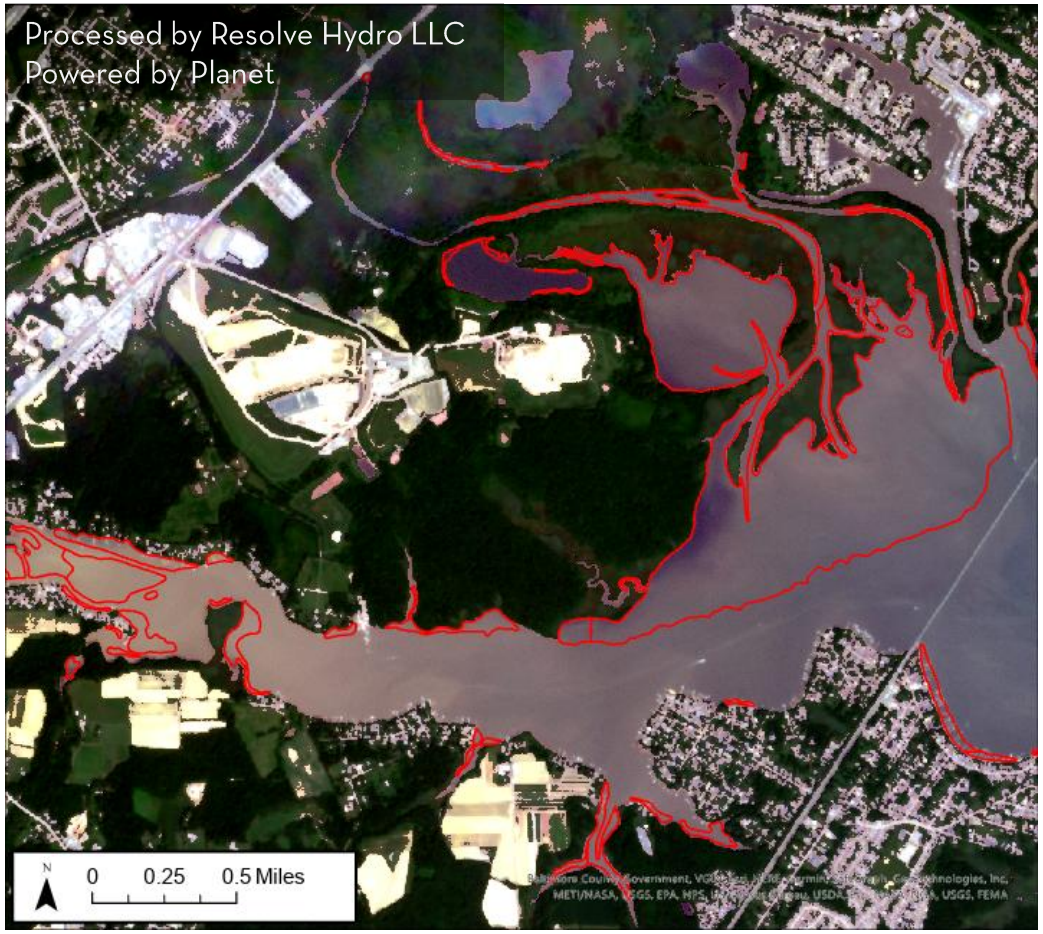
2022 SAV Bed Outline (VIMS)

Remote Sensing of Submerged Aquatic Vegetation

False color imagery can quickly show estimated SAV coverage with minimal processing



Planet SuperDove image captured 08/20/2022



Planet SuperDove image captured 08/20/2023

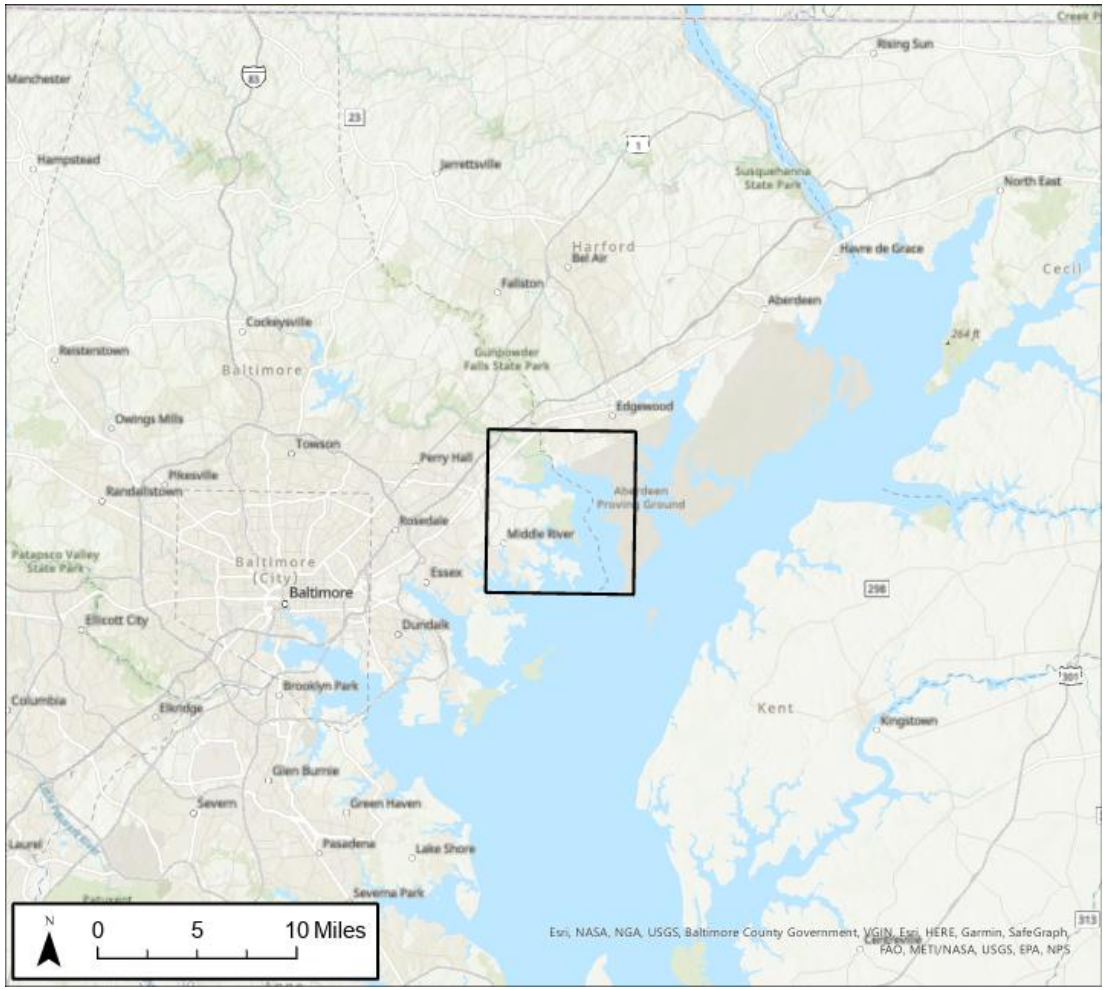
Resolve Hydro™ Case Studies in the Chesapeake Bay

Using remote sensing we can (and should) monitor our water resources more effectively

Remote Sensing of Submerged Aquatic Vegetation (SAV)

Estimating Water Quality Parameters Using Virtual Buoys

Monitoring Changes in the Watershed



Summary of model development methodology

RESOLVE HYDRO

Workflow Summary

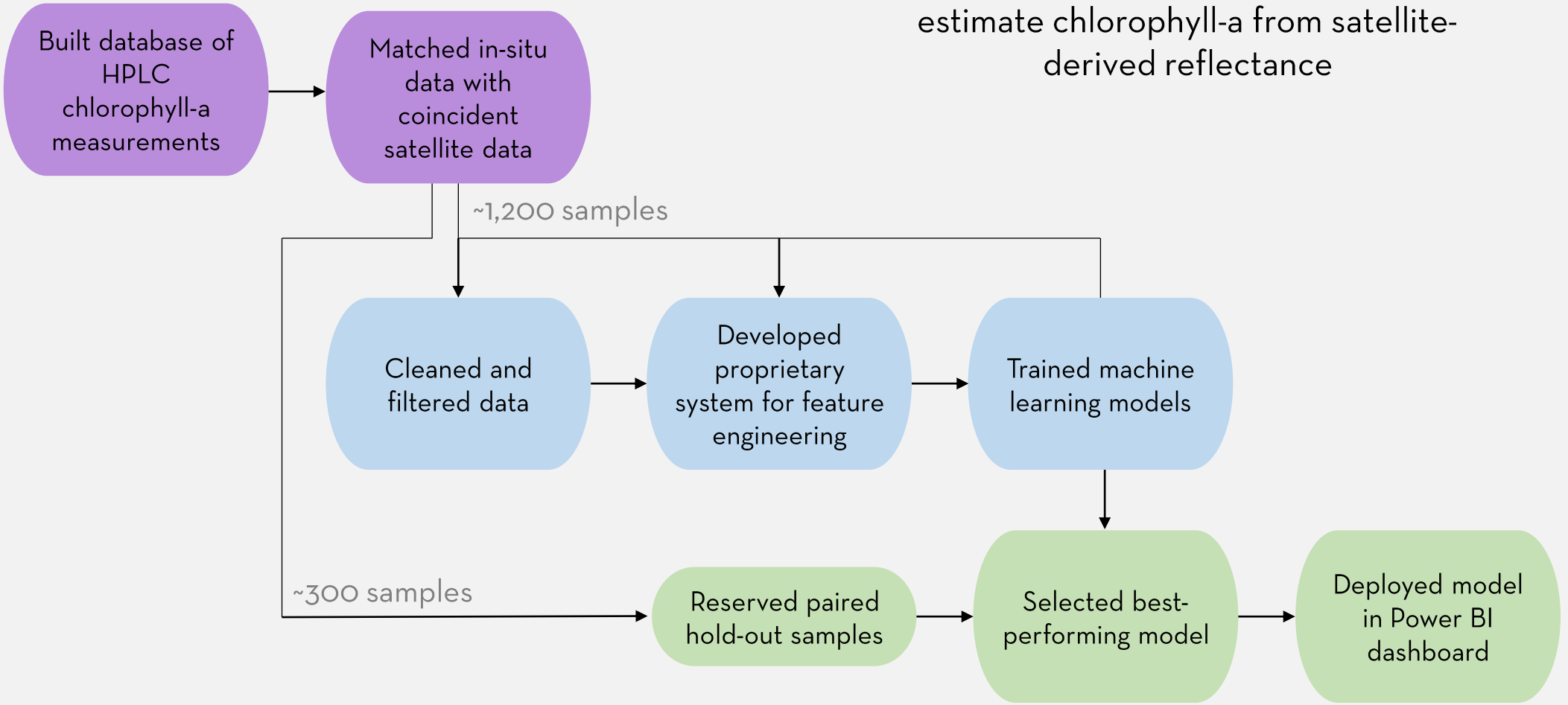
Step 1: Data Collection

Step 2: Model Training and Development

Step 3: Model Testing and Deployment

Model Development and Deployment

This diagram shows the workflow used to estimate chlorophyll-a from satellite-derived reflectance



Summary of model development methodology

RESOLVE HYDRO

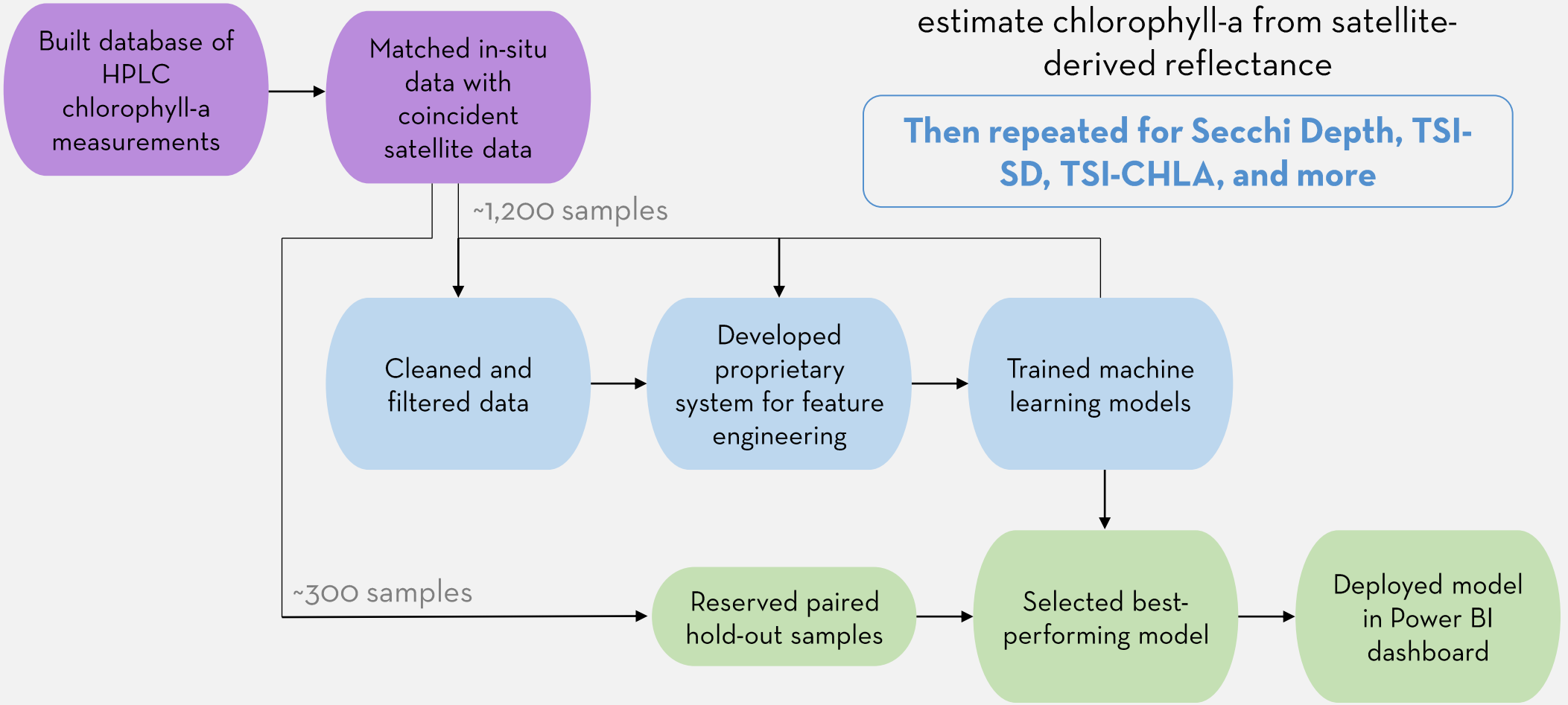
Workflow Summary

Step 1: Data Collection

Step 2: Model Training and Development

Step 3: Model Testing and Deployment

Model Development and Deployment



This diagram shows the workflow used to estimate chlorophyll-a from satellite-derived reflectance

Then repeated for Secchi Depth, TSI-SD, TSI-CHLA, and more

Remote Sensing of Water Quality

Planet SuperDove imagery can demonstrate local changes in water quality

Planet SuperDove image captured 09/02/2021

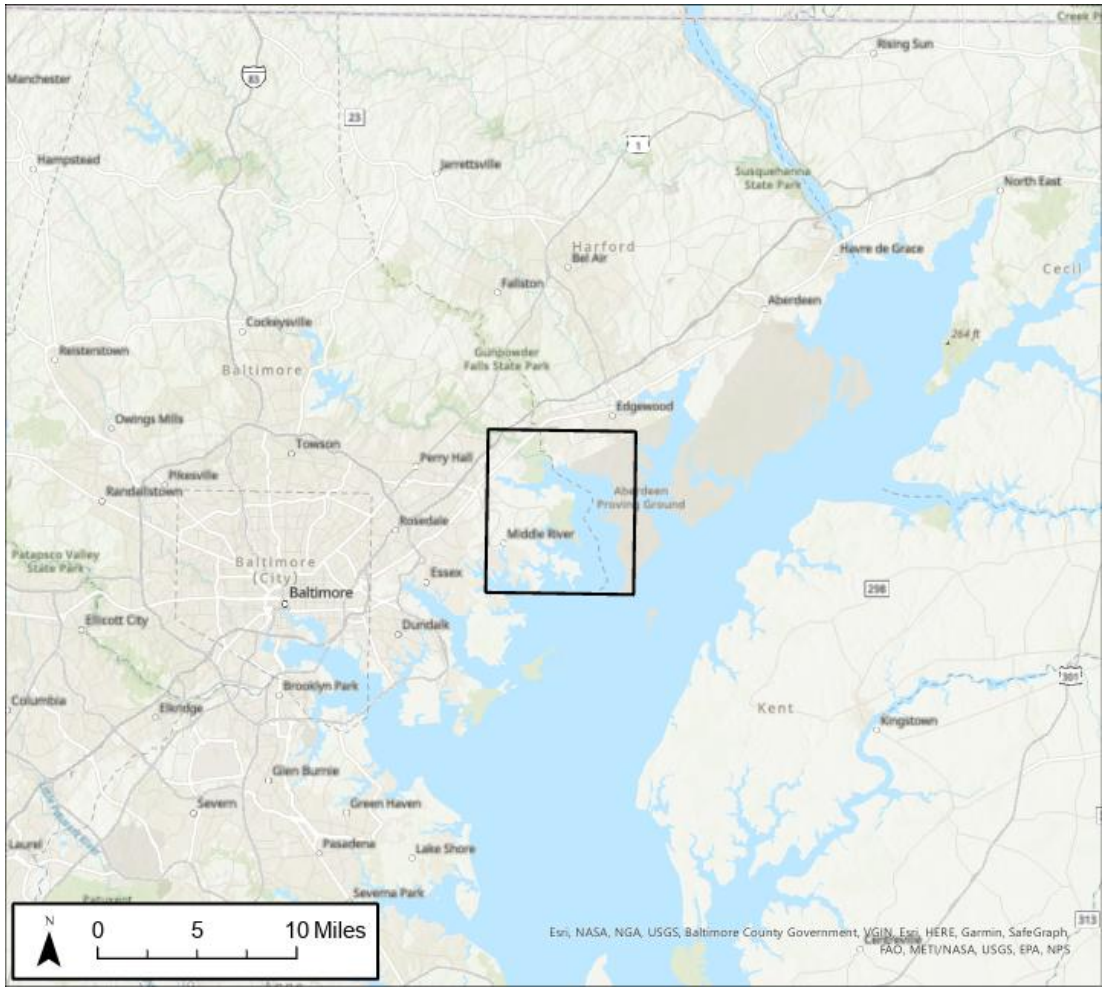
Resolve Hydro™ Case Studies in the Chesapeake Bay

Using remote sensing we can (and should) monitor our water resources more effectively

Remote Sensing of Submerged Aquatic Vegetation (SAV)

Estimating Water Quality Parameters Using Virtual Buoys

Monitoring Changes in the Watershed



Monitoring Changes in the Watershed

Planet SuperDove imagery can demonstrate local land changes at the sub-field level

RESOLVE HYDRO

THANK YOU

Tom Howard

215-498-0717

thoward@resolvehydro.com