



# How 20th Century Technology Innovations Shaped the Development and Delivery of Real-Time Water-Quality Data

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# 20<sup>th</sup> Century Technology Innovations

- **Instrument Revolution in Chemistry**
- **Data Storage Systems**
- **Communication and Environmental Sensing Satellites**
- **The Internet**

# Why Continuous Water Quality Monitoring?

**Federal Water Pollution Control legislation created a need for**

- **Surveillance monitoring under rapidly changing conditions in rivers and estuaries**
- **Spill detection**
- **Process control in water and wastewater treatment**

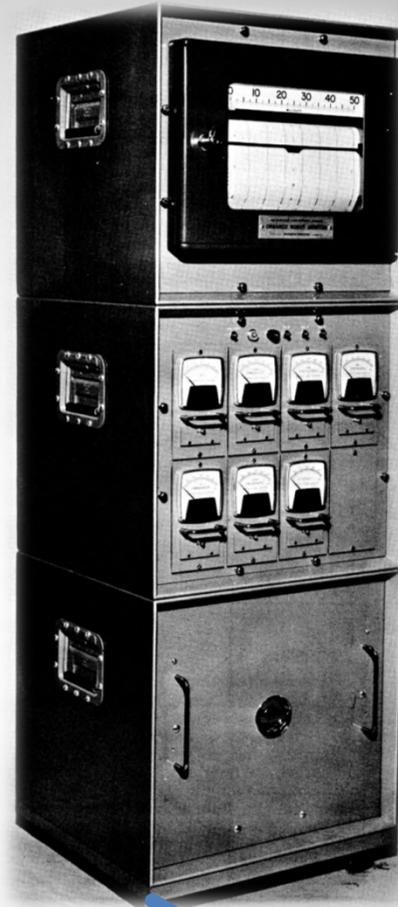
# From Daily to Continuous Measurements



Dolores River at Gateway, Colorado  
Jan 1-10, 1952

Lab. No. 8143A Max Same

Date	Time	G. H.		Resistance X° (25°C)	
		(ft.)	TOC	KCl	Sample
1	8:00a	33	21.0	328	107 3070
2	8:30a	32	21.0	328	115 2850
3	8:10a	33	20.9	328	96.7 3390
4	9:00a	33	20.9	328	174 1890
5	9:00a	34	20.9	328	108 3040
6	9:05a	33	20.9	328	81.1 4040
7	8:45a	33	21.0	328	85.1 3850
8	8:45a	33	20.8	329	77.1 4270
9	9:20a	33	20.6	330	70.7 4670
10	8:45a	32	20.7	332	87.5 3790



1940      1950      1960      1970      1980



Submersible instruments →

# Instrument Revolution in Chemistry starting in the 1930s Replaced Wet Chemical Methods (Results in Parts per Million)



1850

1875

1900

1950

# A New Generation of Instruments

A



B



C



D



- **Potentiometric Instruments**
  - pH, Specific Conductance, Dissolved Oxygen, Redox
  - Ion Selective Electrodes (+/- ions)
- **Optical Instruments**
  - Turbidimeter
  - Spectrophotometer (plus wet chemical sample preparation)
  - Fluorometer

1930

1940

1960

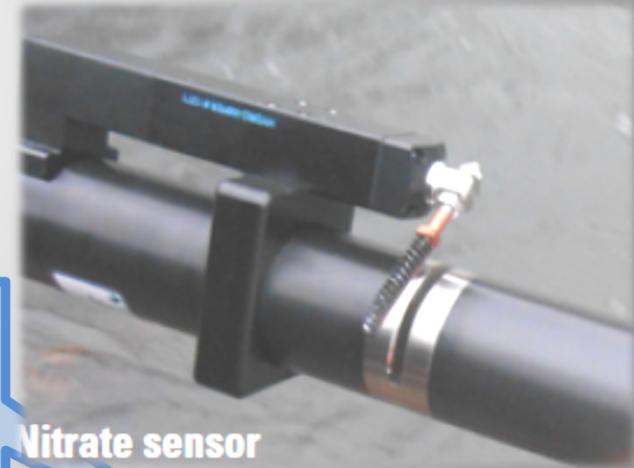
# Key Developments in Optical Instruments and Measurements

Fluorometers for Dyes, FDOM, and Algal Pigments (*in vivo*)

Advances in FDOM in vivo measurements in fresh and marine waters

Optical Nitrate and Diss. Oxygen

Optical DO sensor



Nitrate sensor

1960

1970

1980

1990

2000

# Emergence and Expansion of Continuous Monitoring; 1955-1970

- 8 Federal and 2 Interstate Agencies
- 7 State Agencies
- 2 Local Utilities
- 2 Universities
- Province of Ontario, CAN

USGS 1955-1962 Delaware River Estuary

## ORSANCO Spill Monitoring Network

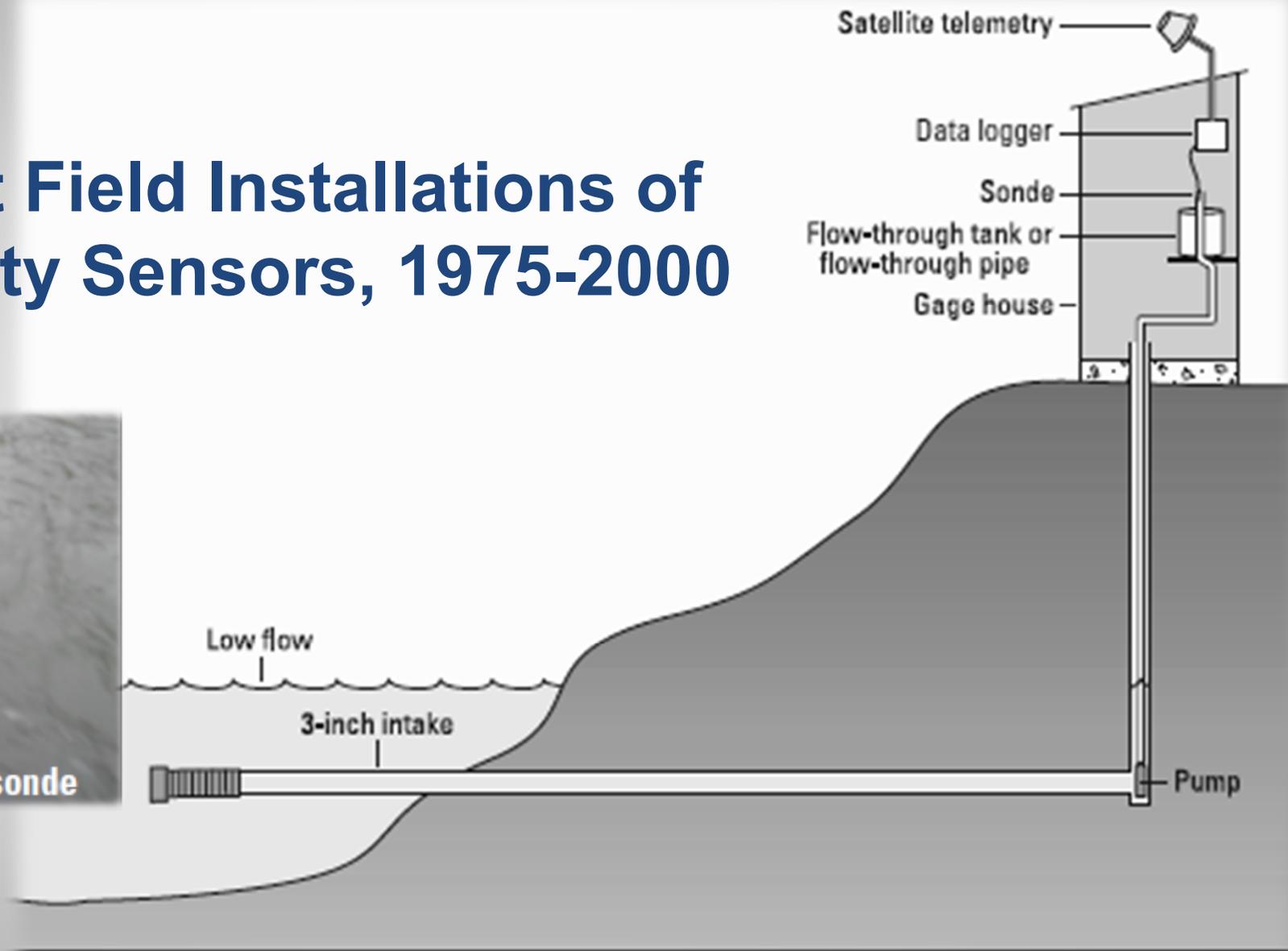


1950

1960

1970

# Permanent Field Installations of Water Quality Sensors, 1975-2000



# Submersible Instruments



Palmer, 1969



Pellerin and Bergamaschi, 2014

## Autonomous Vehicles for Mobile Deployments



U.S. Department of the Interior  
U.S. Geological Survey

**2002 MARVIN on pontoons**  
Bendis, Florida Fish and Wildlife Cons.

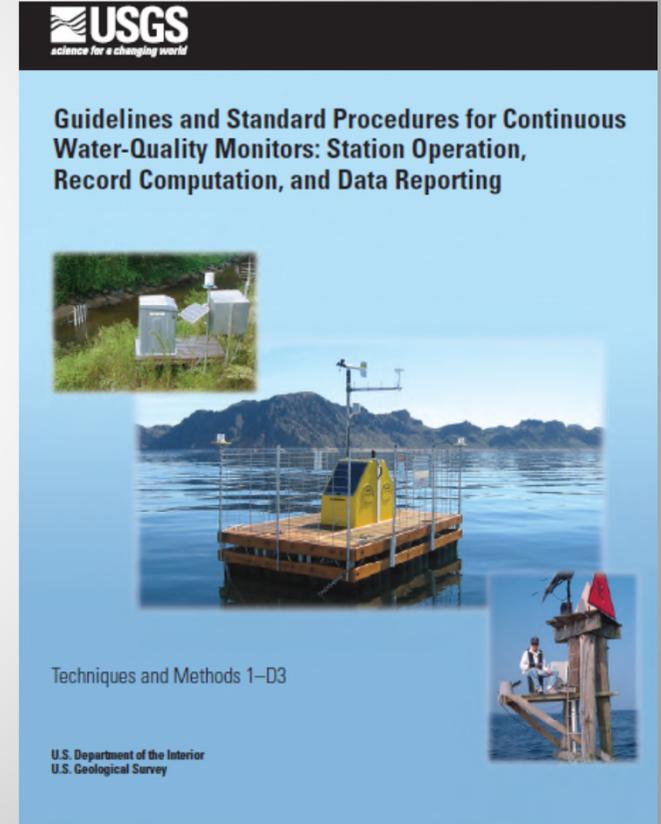
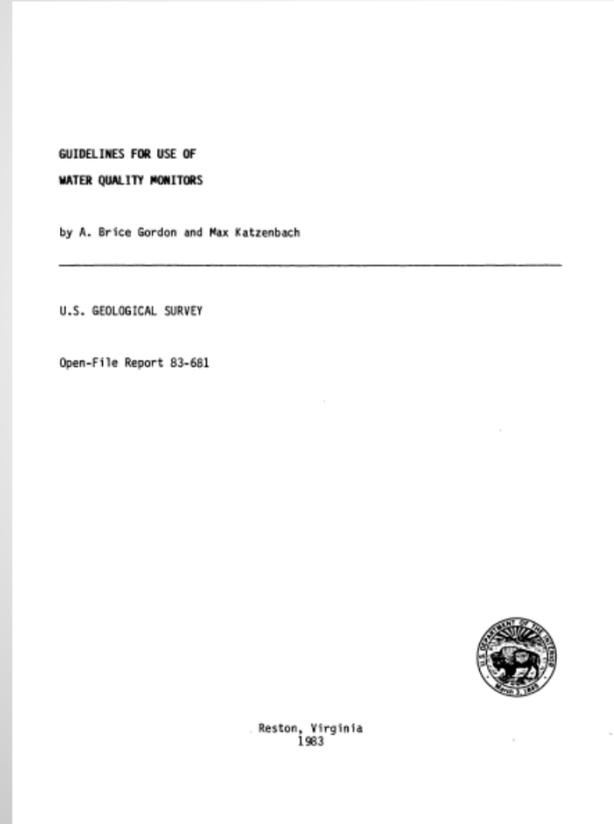


**2003 Autonomous Underwater Vehicle**  
Glasgow et al., 2004

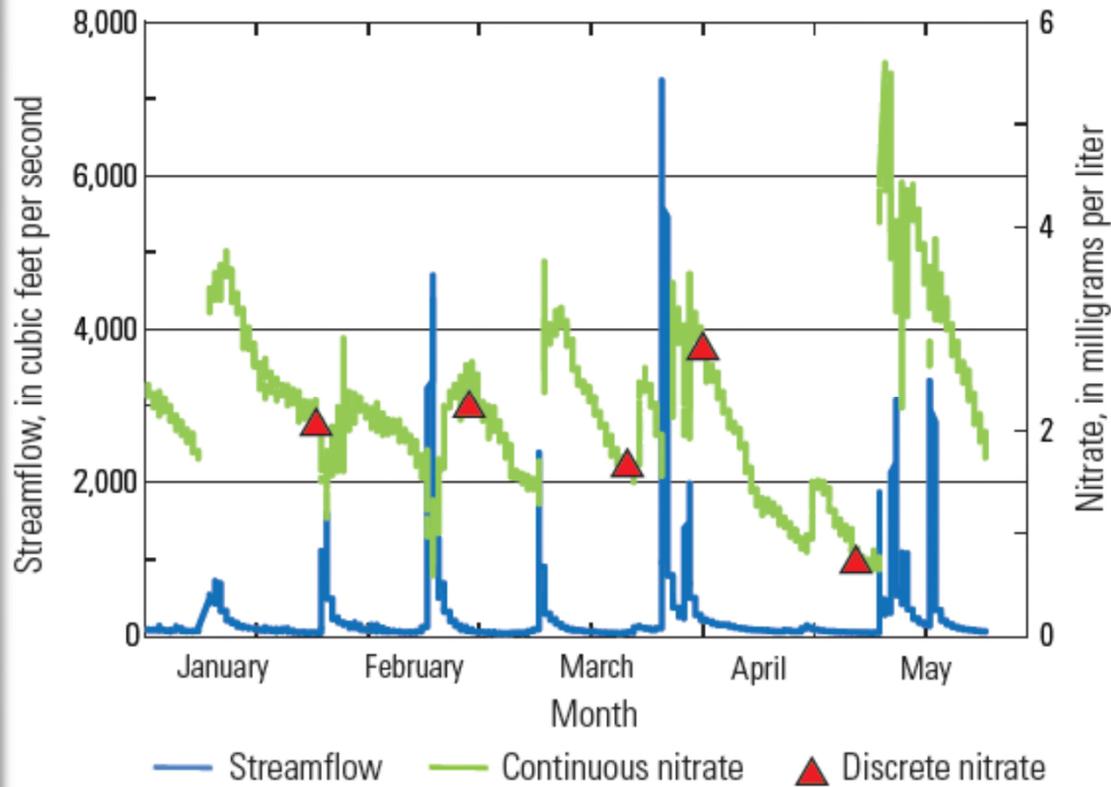
# Quality Control

1983

2006

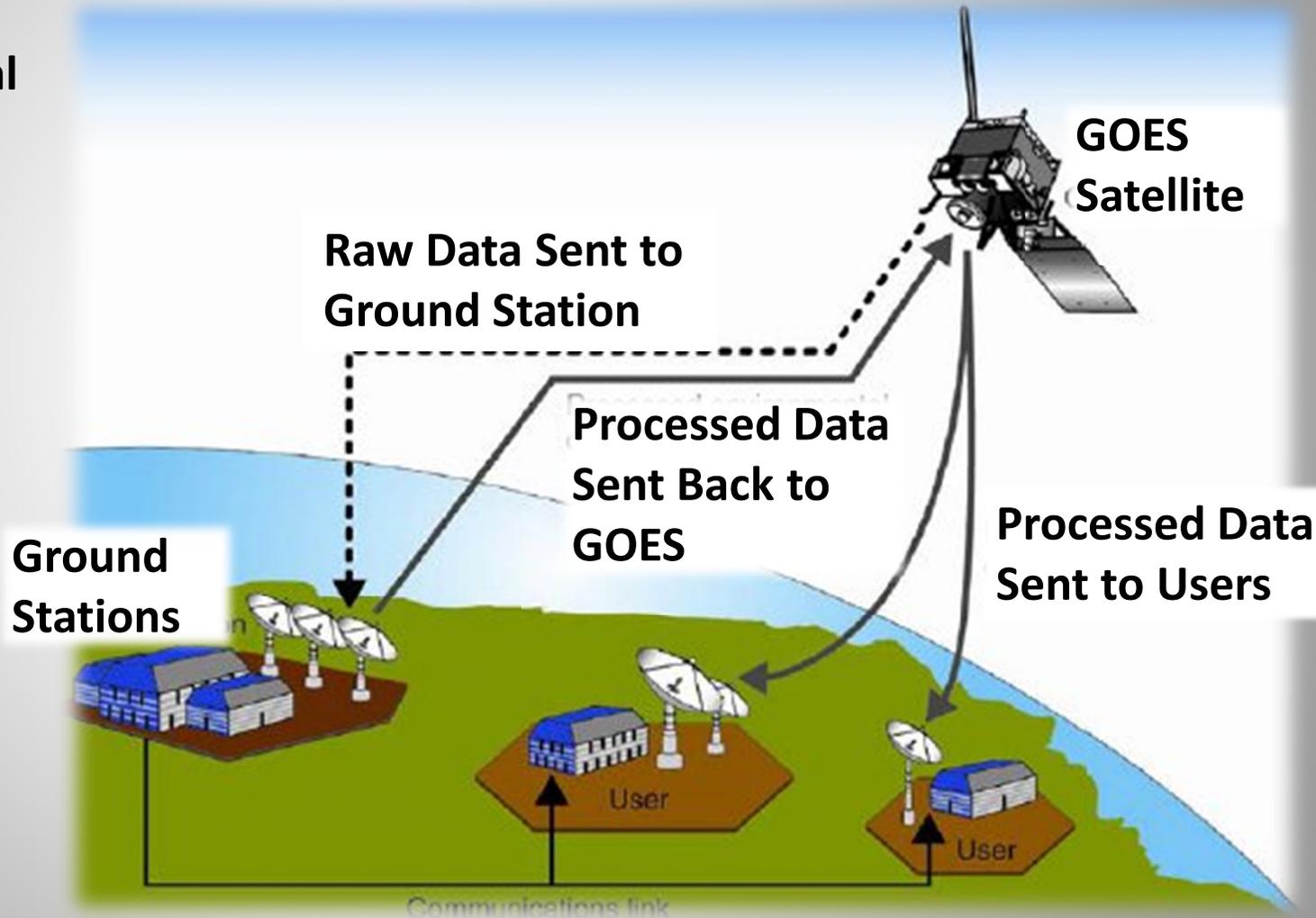


# 21<sup>st</sup> Century Modern Stream Gaging Station with Water Quality Sensors

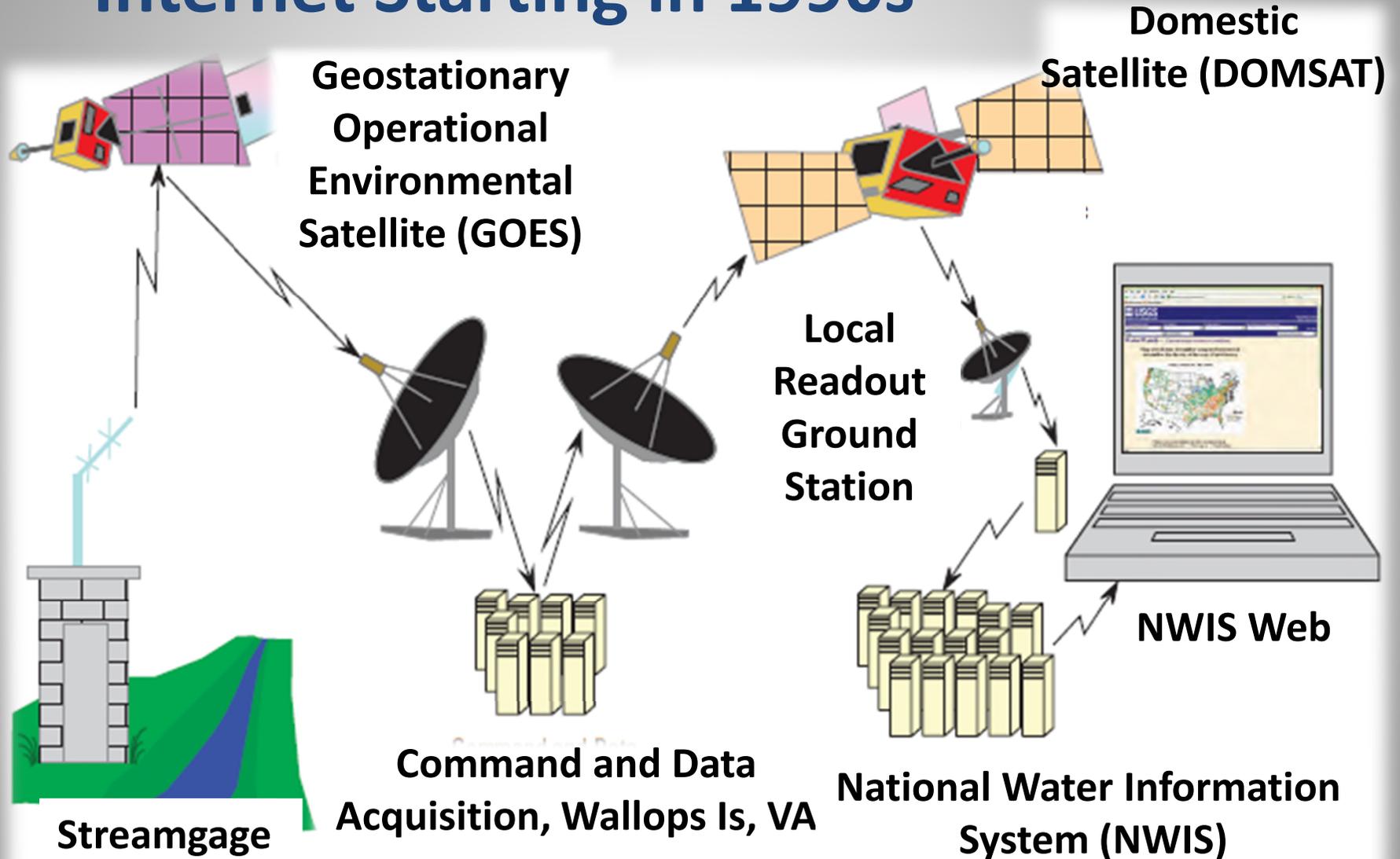


# Generic GOES Data Relay Pattern

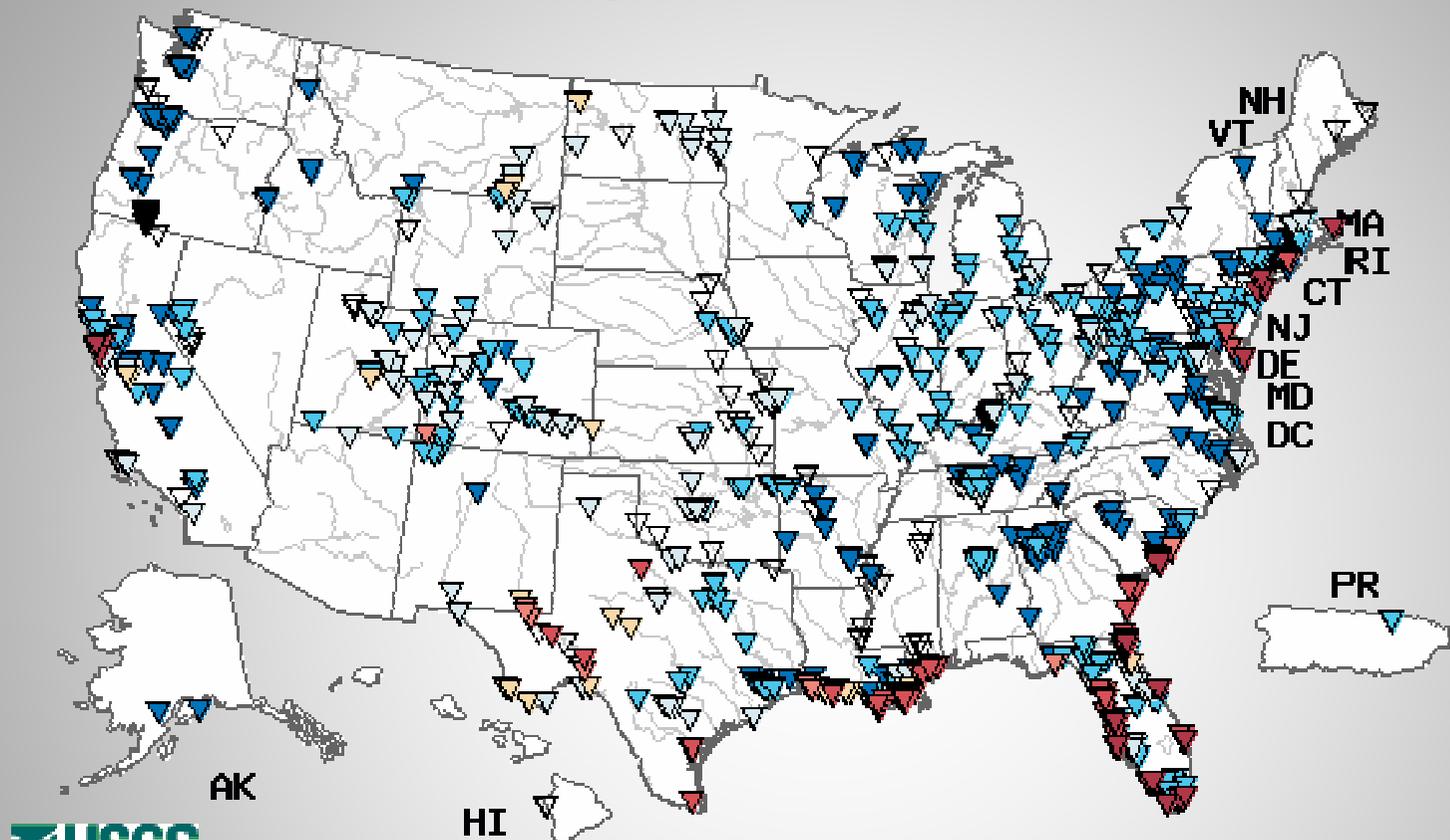
Geostationary Operational  
Environmental Satellite  
system (GOES)



# Internet Starting in 1990s



May 02, 2016 10:30ET



Specific Conductance, in  $\mu\text{S}/\text{cm}$

Explanation							
<250	250-749	750-2,240	2,250-4,990	5,000-9,990	10,000-35,000	>35,000	No Data



# Summary 1930-2000

- **Laboratory instruments from physical, chemical, biomedical, and water testing laboratories are the basis of most field sensor technology**
- **Data collection and storage systems ranged from analog (strip charts) to computer punch tapes and automated digital recorders**

# Summary Continued

- **Data retrieval and transmission evolved from site visits only to site visits plus radio, land line, cell phone, and satellite relay systems**
- **Timeliness of data dissemination improved from periodic to near real time on the Internet**

**Thank you**

**Questions?**