Research, Education, and Service

IIHR—Hydroscience & Engineering

Senior College

Class 2

October 26, 2021

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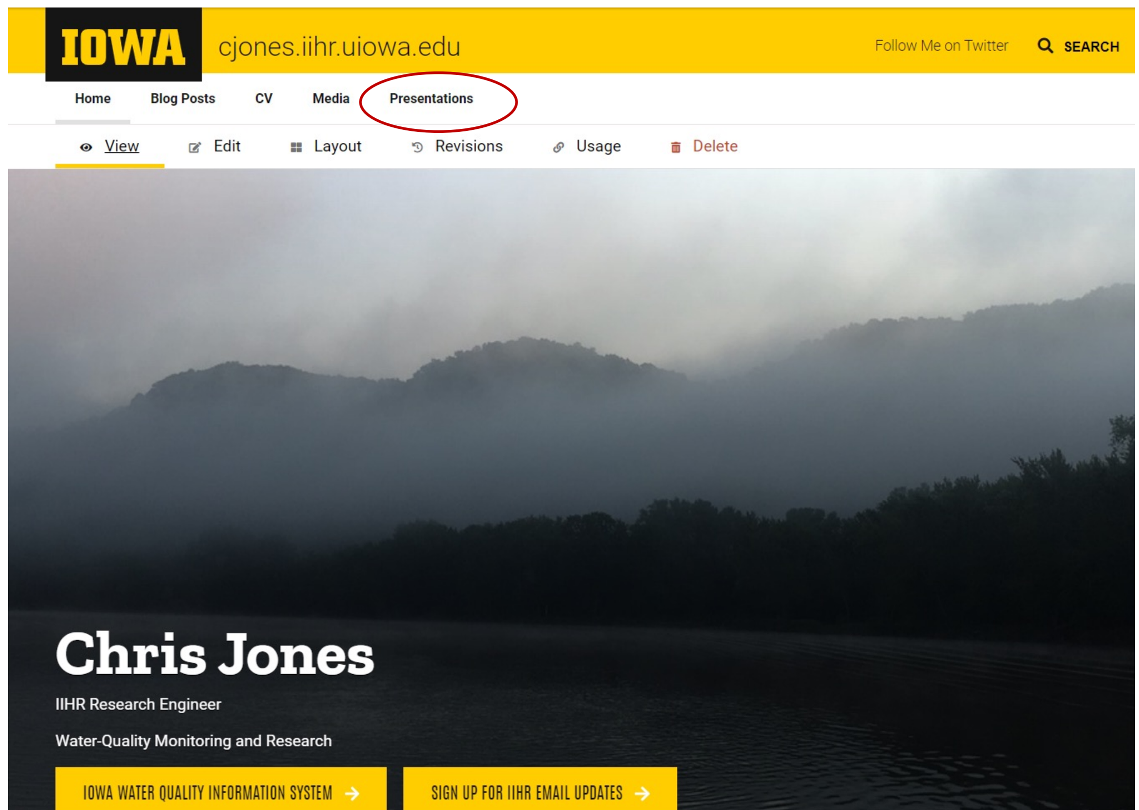
IIHR Hydroscience & Engineering

The University of Iowa College of Engineering

Slides Available at:

https://cjones.iihr.uiowa.edu/



Class 2

- Water Quality: Characteristics, Pollutants, Parameters
- Water Monitoring
- Point Source vs Non-Point Source Pollution
- Water Quality Data: Management and Assessment

Turkey River near Elkader

How do we define “WATER QUALITY”?

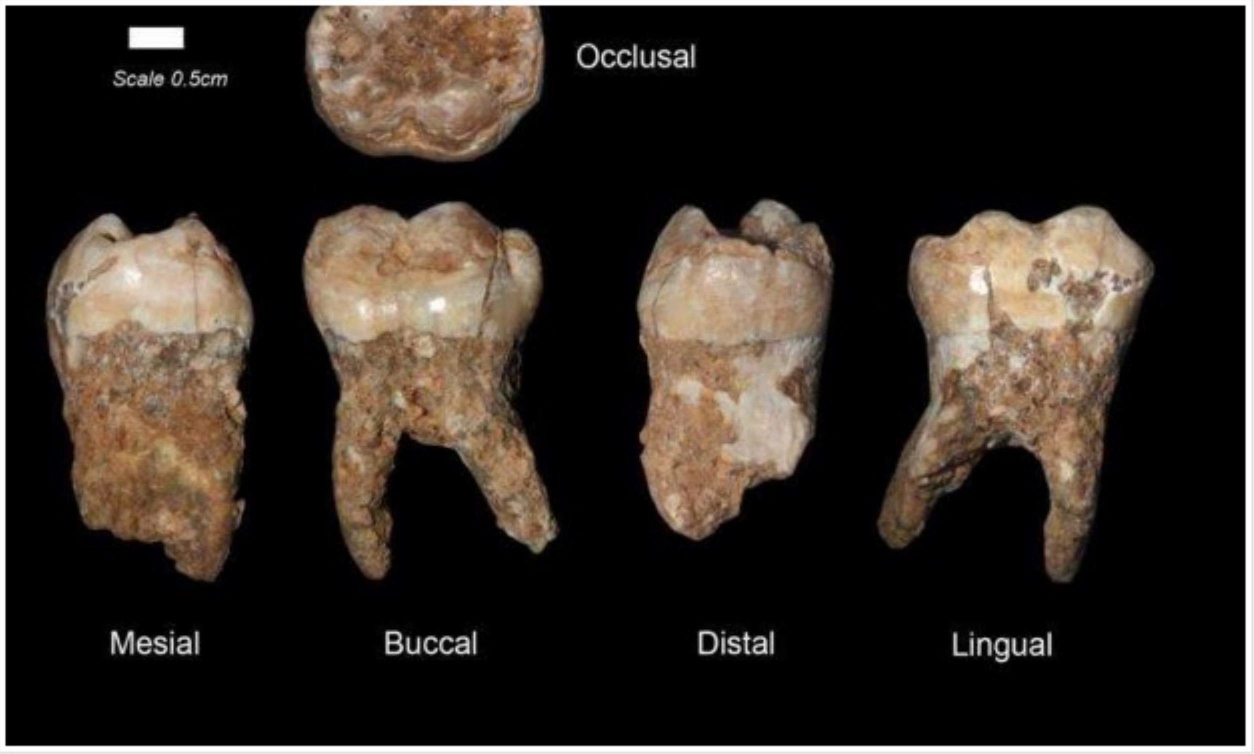
- Drinking Water
- Streams
- Lakes
- Estuaries
- Oceans
- Aquifers

How do we define "POLLUTION"?

Pollution is the introduction of contaminants into the natural environment that cause adverse change to other species and potentially threaten our own.

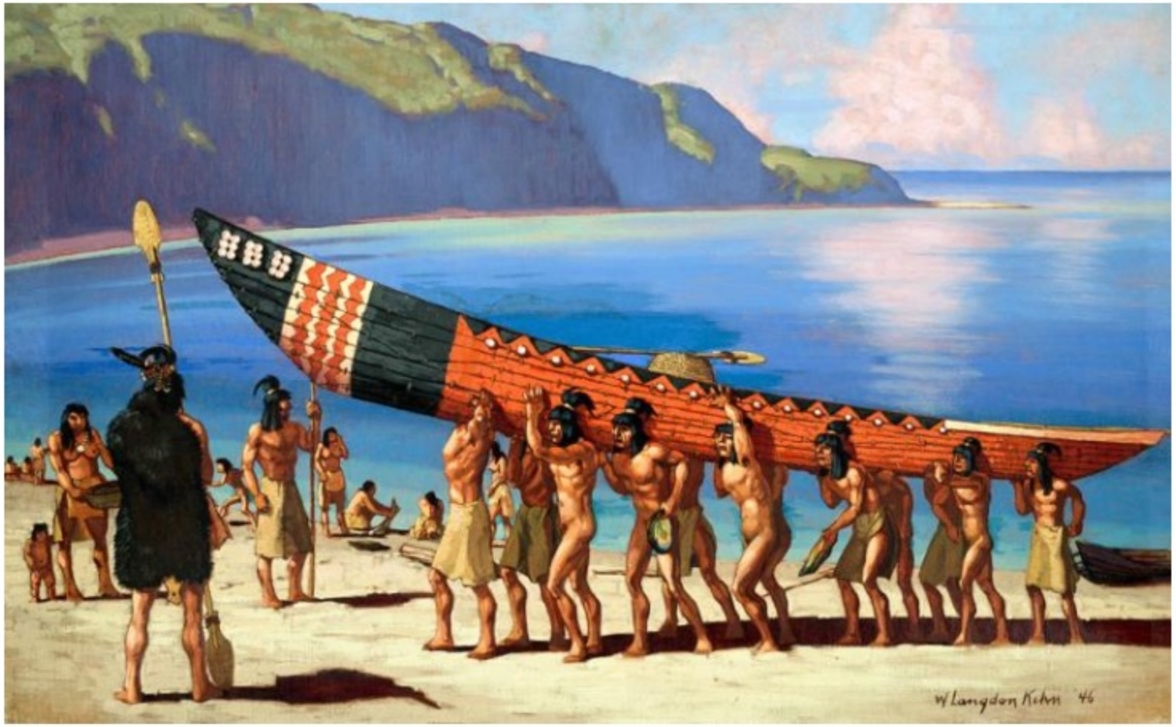
- **Chemicals**
- **Heat**
- **Noise**
- **Trash**
- **Light**
- **Microorganisms**
- **Radioactivity**

One species' pollution might be another's food or habitat!



21 JUNE, 2015 - 00:42 APRILHOLLOWAY

Ancient teeth reveal evidence of 400,000 year-old manmade pollution in Israel



The Chumash used tar to fill gaps in their plank-based canoes (artist's conception).

ILLUSTRATION BY W. LANGDON KIHN, NATIONAL GEOGRAPHIC

A long-term health decline—including a gradual shrinking—among prehistoric Indians in California may be linked to their everyday use of tar, which served as "superglue," waterproofing, and even chewing gum, scientists say.

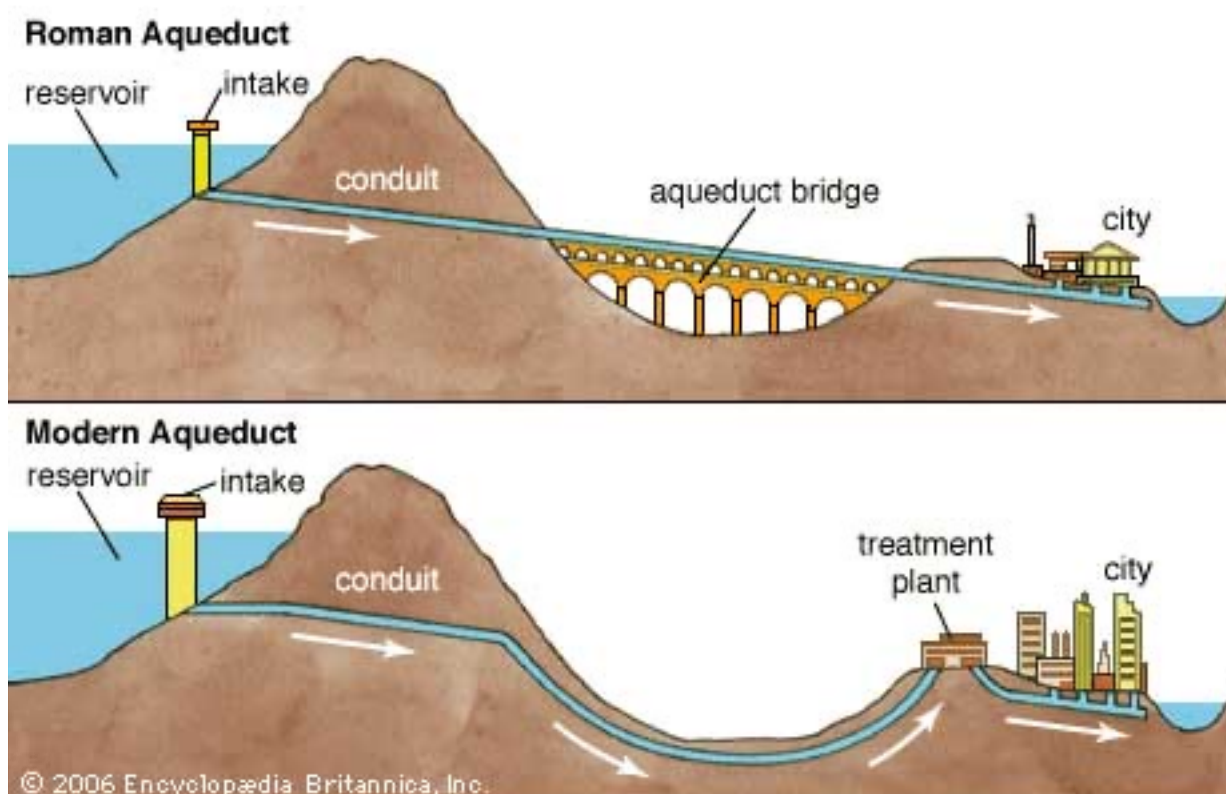
Miners Left a Pollution Trail in the Great Lakes 6000 Years Ago

Scientists find evidence of ancient copper mining in polluted lake sediments from Isle Royale National Park.

High levels of copper, lead, and potassium in sediments of bays and streams

Indigenous Farming likely caused water pollution

312 B.C. Rome


Roman Aqueduct
reservoir
intake
conduit
aqueduct bridge
city
Modern Aqueduct
reservoir
intake
conduit
treatment plant
city
© 2006 Encyclopædia Britannica, Inc.

1954 London

1883 Robert Koch isolated *Vibrio cholorea*

1883-1920 major advances in drinking water safety in the western world

John Snow

Human Wastewater Conveyance and Treatment

Industrial Revolution brought large migration to the cities

~1900 New York City

Human Wastewater Conveyance and Treatment

- Conveyance systems constructed in 1850s, Chicago and Brooklyn were the first
- Worcester, MA, first US treatment plant with chemical precipitation in 1890
- University of Manchester, 1912: discovery of activated sludge treatment
- Following WWI, slow but steady adoption of conveyance and treatment in Western World Cities


State Library of Queensland
John Oxley Library

World War II


We Can Do It!
POST FEB. 15 TO FEB. 28
WAR PRODUCTION CO-ORDINATING COMMITTEE

Industrial Discharge

1960s: Change

1962

- Birds
- Chemical Industry
- Pesticides

'Lake Erie must be saved': Lyndon B. Johnson visits Buffalo in 1966

By T.J. Pignataro Aug 22, 2016 0

Support this work for $1 a month

1 of 4

1966 Buffalo River

Johnson signed an executive order that prohibited dumping polluted sediment dredged from the federal navigational channels like the Buffalo River in open waters like Lake Erie. It's what led to the eventual construction of confined disposal facilities by the U.S. Army Corps of Engineers.

Cuyahoga River Fire: 1969

Earth Day, 1970

1970: First Earth Day
Gaylord Nelson (WI)

John Lindsay, mayor of NYC

1970s

January 1, 1970 Nixon signs NEPA bill

December 2, 1970 Nixon creates Environmental Protection Agency by executive order

Clean Water Act

Proposed in October 1971, Edmund Muskie

Passed Congress October 4, 1972

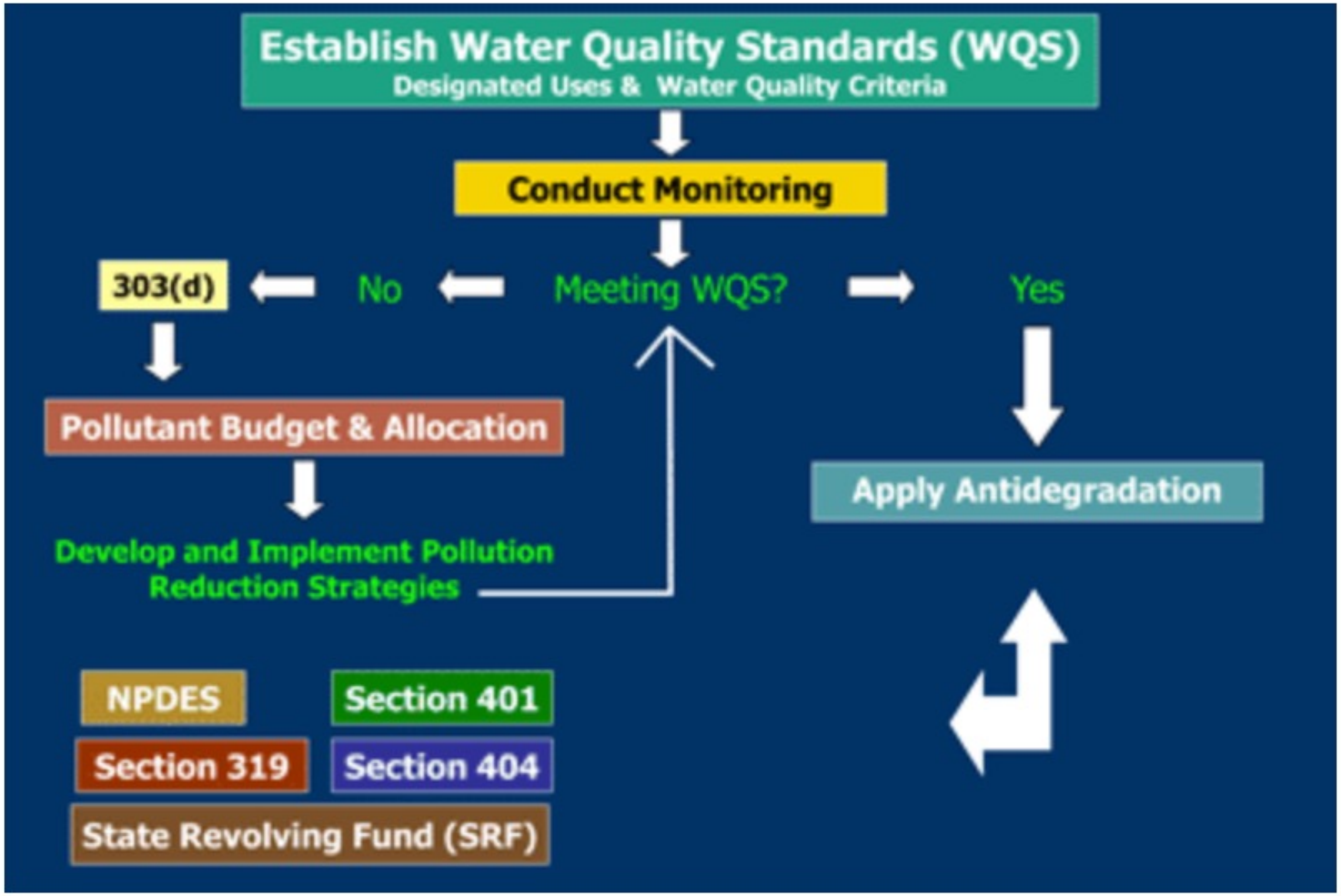
Vetoed by President Nixon on October 17, 1972

Veto override October 17 and 18, 1972

"Federal Water Pollution Control Act Amendments of 1972"

Clean Water Act

- "Restore and maintain the chemical, physical, and biological integrity of the waters of the United States"
- Navigable Waters


Establish Water Quality Standards (WQS)
Designated Uses & Water Quality Criteria
Conduct Monitoring
303(d)
No
Meeting WQS?
Yes
Pollutant Budget & Allocation
Apply Antidegradation
Develop and Implement Pollution Reduction Strategies
NPDES
Section 401
Section 319
Section 404
State Revolving Fund (SRF)

Clean Water Act

Point sources may not discharge pollutants to surface waters without a permit from the National Pollutant Discharge Elimination System (NPDES).

Clean Water Act

Technolog

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without re

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304(b)(2). … able
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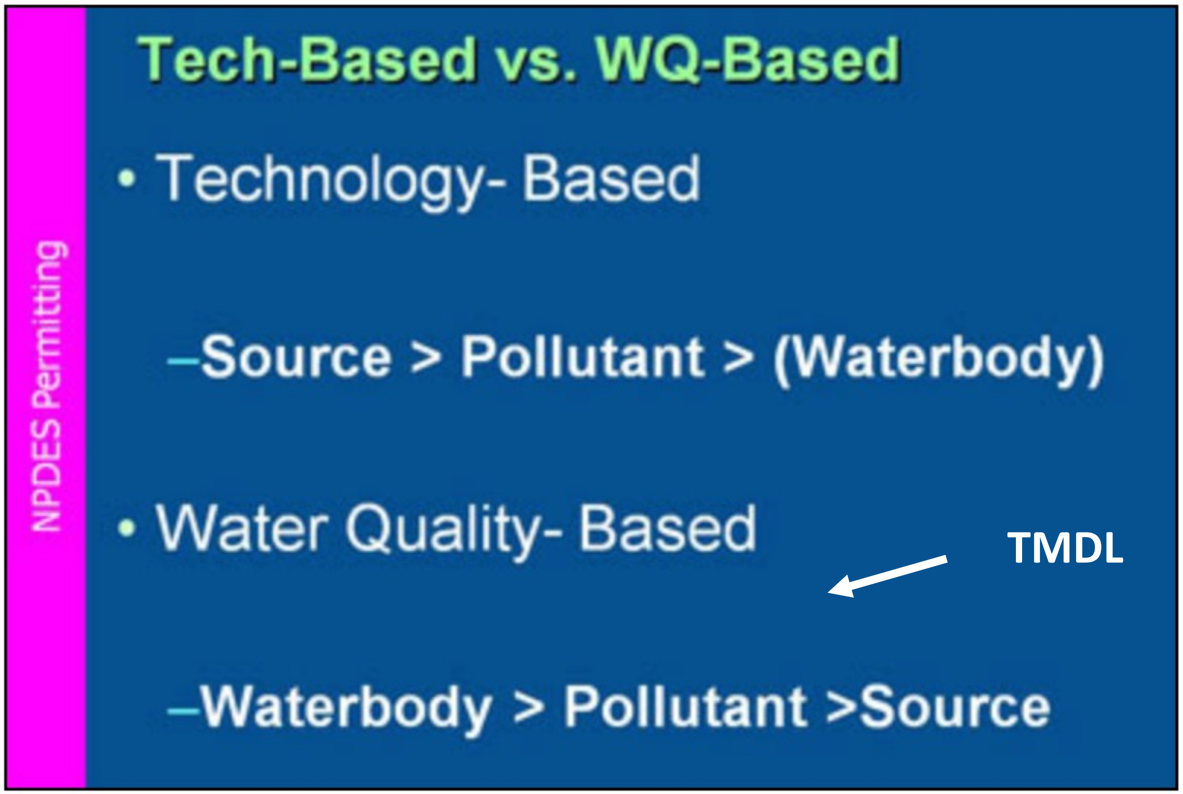


National d … Available
Technolog

The standard becomes the minimum regulatory requirement in a permit. If the national standard is not sufficiently protective at a particular location, then other water quality standards may be employed

Clean Water Act

After application of technology-based standards to a permit, if water quality is still impaired, state or EPA may add water quality-based limitations to that permit.

Designated uses
Water quality criteria
Antidegradation policy

Clean Water Act: Financing

Congress created a major public works financing program for municipal sewage treatment in the 1972 CWA.

A system of grants for construction of municipal sewage treatment plants was authorized and funded

federal portion 75%

Transitioned to Revolving Loan Fund in 1987 amendment on the principle of "polluter pays".

Secondary Treatment using biological processes/activated sludge

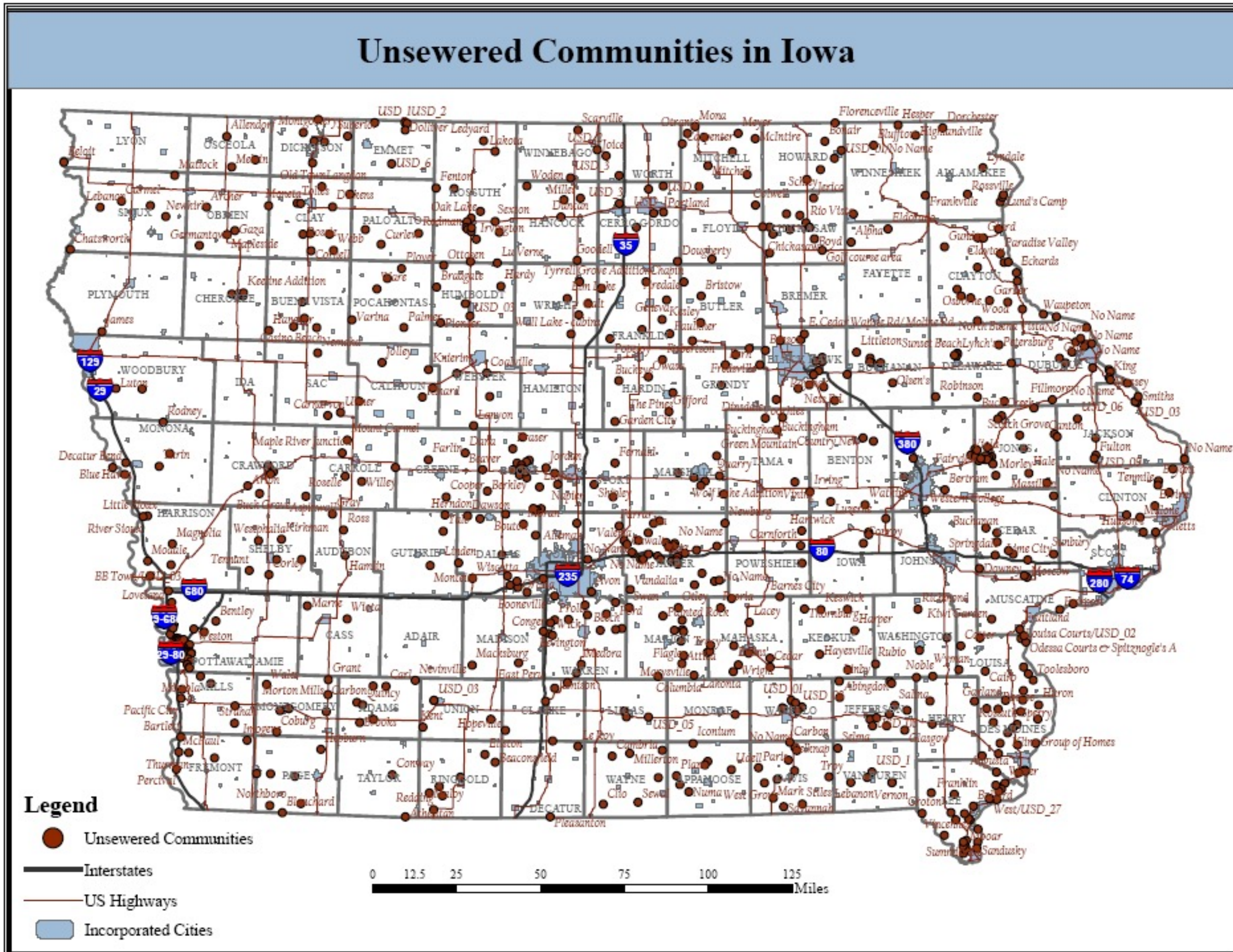
NPDES Permitting

Tech-Based Requirements (TBELs) for Municipal Discharges: "Secondary Treatment"

	30-Day Average	7-Day Average
5-Day BOD	30 mg/L	45 mg/L
TSS	30mg/L	45 mg/L
pH	6-9	--
Removal	85% of BOD_5 and TSS	--

BOD = Biochemical Oxygen Demand
TSS = Total Suspended Solids

Note: No limits on P or N


Unsewered Communities in Iowa
Legend
Unsewered Communities
Interstates
US Highways
Incorporated Cities
0 12.5 25 50 75 100 125
Miles
LYON
OSCEOLA
DICKINSON
EMMET
WINNEBAGO
WORTH
MITCHELL
HOWARD
WINNESHIEK
ALLAMAKEE
SIOUX
OBRIEN
CLAY
PALO ALTO
KOSSUTH
HANCOCK
CERRO GORDO
FLOYD
CHICKASAW
FAYETTE
CLAYTON
PLYMOUTH
CHEROKEE
BUENA VISTA
POCAHONTAS
HUMBOLDT
WRIGHT
FRANKLIN
BUTLER
BREMER
BLACK HAWK
BUCHANAN
DELAWARE
DUBUQUE
WOODBURY
IDA
SAC
CALHOUN
WEBSTER
HAMILTON
HARDIN
GRUNDY
MONONA
CRAWFORD
CARROLL
GREENE
BOONE
STORY
MARSHALL
TAMA
BENTON
LINN
JONES
JACKSON
CLINTON
HARRISON
SHELBY
AUDUBON
GUTHRIE
DALLAS
POLK
JASPER
POWESHIEK
IOWA
JOHNSON
CEDAR
SCOTT
MUSCATINE
POTTAWATTAMIE
CASS
ADAIR
MADISON
WARREN
MARION
MAHASKA
KEOKUK
WASHINGTON
LOUISA
MILLS
MONTGOMERY
ADAMS
UNION
CLARKE
LUCAS
MONROE
WAPELLO
JEFFERSON
HENRY
DES MOINES
FREMONT
PAGE
TAYLOR
RINGGOLD
DECATUR
WAYNE
APPANOOSE
DAVIS
VAN BUREN
LEE

Non-Point Sources

Not covered:

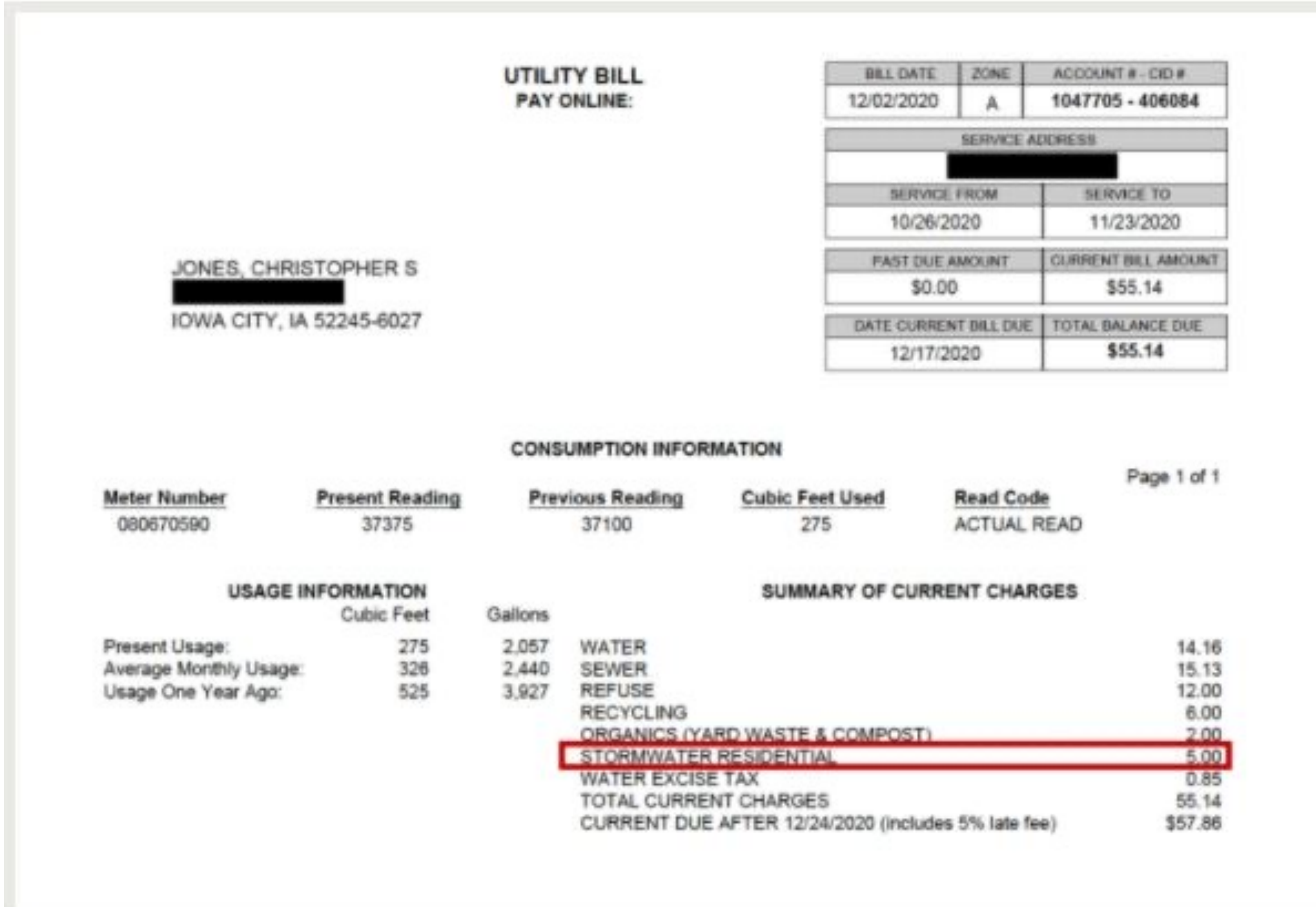
Stormwater runoff from industrial and agricultural sources

Irrigation return flows

Municipal storm drains

1999: urban stormwater regulated

$375 per acre per year!



UTILITY BILL
PAY ONLINE:

BILL DATE	ZONE	ACCOUNT # - CID #
12/02/2020	A	1047705 - 406084

SERVICE ADDRESS	
[redacted]	
SERVICE FROM	SERVICE TO
10/26/2020	11/23/2020
PAST DUE AMOUNT	CURRENT BILL AMOUNT
$0.00	$55.14
DATE CURRENT BILL DUE	TOTAL BALANCE DUE
12/17/2020	$55.14

JONES, CHRISTOPHER S
[redacted]
IOWA CITY, IA 52245-6027

CONSUMPTION INFORMATION

Page 1 of 1

Meter Number	Present Reading	Previous Reading	Cubic Feet Used	Read Code
080670590	37375	37100	275	ACTUAL READ

USAGE INFORMATION

	Cubic Feet	Gallons
Present Usage:	275	2,057
Average Monthly Usage:	326	2,440
Usage One Year Ago:	525	3,927

SUMMARY OF CURRENT CHARGES

WATER	14.16
SEWER	15.13
REFUSE	12.00
RECYCLING	6.00
ORGANICS (YARD WASTE & COMPOST)	2.00
STORMWATER RESIDENTIAL	5.00
WATER EXCISE TAX	0.85
TOTAL CURRENT CHARGES	55.14
CURRENT DUE AFTER 12/24/2020 (includes 5% late fee)	$57.86

Utility bill for my house. Stormwater utility charge outlined in red. Check your own water or utility bill to see what your charges might be.

4% of US area
80% of US population

Regulated U.S. Stormwater utilities. Source: EPA.

Non-point Sources from Ag

Non Point Sources

The 1987 amendments to the Clean Water Act (CWA) established the Section 319 Nonpoint Source Management Program.

- **Addressed the need for greater federal leadership to help focus state and local nonpoint source efforts.**
- **States receive grant money that supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific nonpoint source implementation projects.**
- **Average funding: $156M/year**

Section 319

NONPOINT SOURCE PROGRAM SUCCESS STORY

Iowa

Multi-Agency Effort Cleans Up Clear Creek

Waterbody Improved Runoff from agricultural areas and waste from leaking septic systems sent pollution to Clear Creek, causing the stream to not meet several of Iowa's water quality standards. As a result, the Iowa Department of Natural Resources (DNR) added a 7-mile segment of Clear Creek to the state's Clean Water Act (CWA) section 303(d) list of impaired waters in 2004. Watershed partners implemented agricultural best management practices (BMPs) and coordinated construction of a wastewater treatment facility to replace leaking septic systems. Water quality improved, prompting DNR to remove Clear Creek from Iowa's list of impaired waters in 2010.

Other Non-Point Source Programs

Farm Bill conservation programs
CRP: Conservation Reserve
EQIP: Environmental Quality Incentive
WHIP: Wildlife Habitat Incentive
CSP: Conservation Stewardship
AWEP: Agricultural Water Enhancement
RCPP: Resource Conservation Partnership
WRP: Wetland Reserve Program
GRP: Grassland Reserve Program

BREAK

Safe Drinking Water Act

Protect Our Health from Source to Tap • Safe Drinking Water Act • 1974-2014 • 40 years

Introduced in the Senate 1/18/73 by Warren Magnuson (WA)

Signed into law by President Ford 12/16/74

Safe Drinking Water Act

Unlike CWA, many states did have regulatory programs

Improved laboratory detection techniques showed many water supplies to be contaminated

Regulated drinking water for 155,000 public water supplies (PWSs) across the U.S.

89% of Americans drinking water regulated by SDWA

Safe Drinking Water Act

6 organic chemicals

10 inorganic chemicals (nitrate was one)

Turbidity

Coliform bacteria

Now: about 100 regulated contaminants

Safe Drinking Water Act

Utilities (PWSs) must:

- Monitor for regulated contaminants
- Install treatment to remove contaminants to safe levels (MCLs)
- Report Contaminant levels to the public

- Much less controversial than the CWA

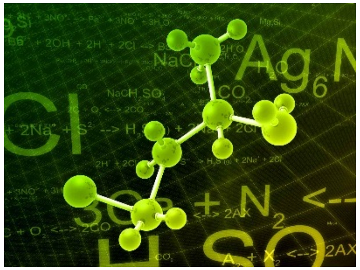
Safe Drinking Water Act

Some Contaminants Come from Water Distribution Systems

Defining the Pollutants

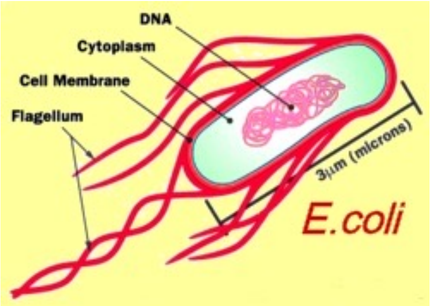
The Pollutants

Chemical
Natural or Manmade
Organic
Inorganic/salts
Medicines
Acids/Bases
Pesticides
Nutrients



Physical
Temperature
Sediment/soil
Light/cloudiness
Trash
Radioactivity

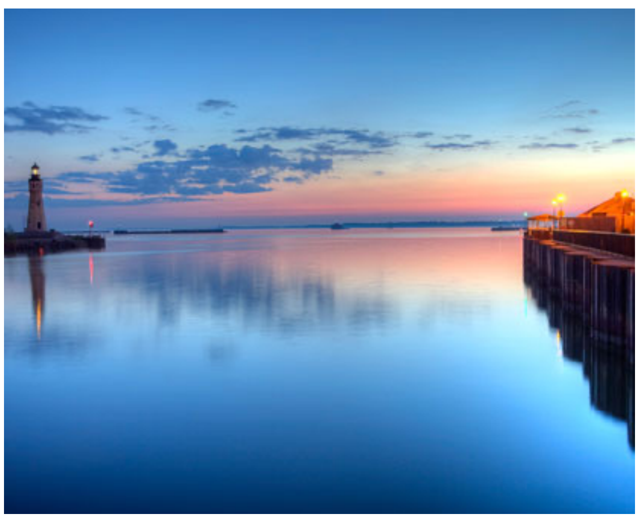
Biological
Bacteria
Viruses
Algae
Cyanobacteria
(Blue-green algae)



Pollution Can be the Absence of Something

Dissolved Oxygen

One type of pollutant can produce another



N and P

Effects of water pollution

Human Health (Ingestion)

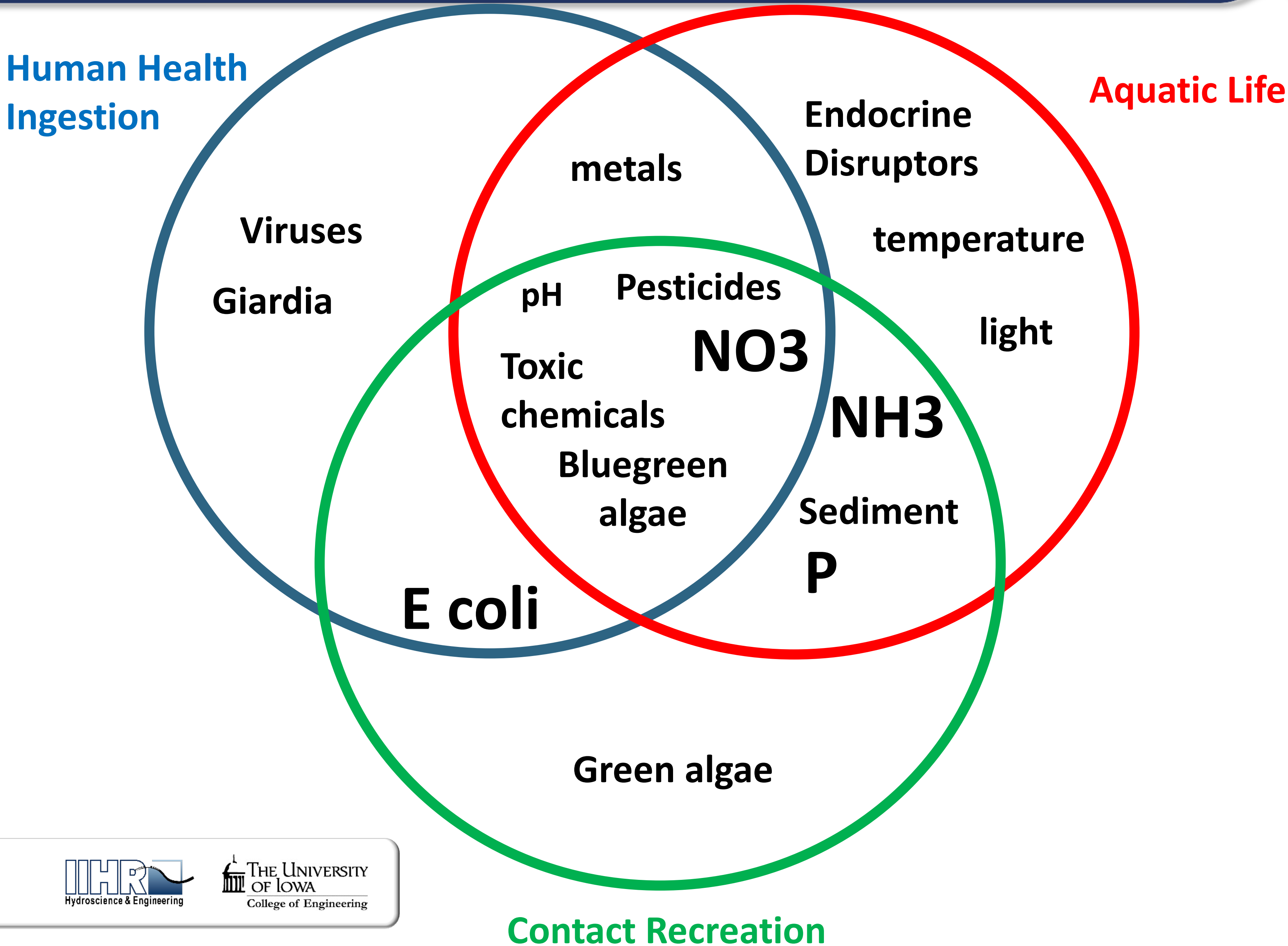
Aquatic Life

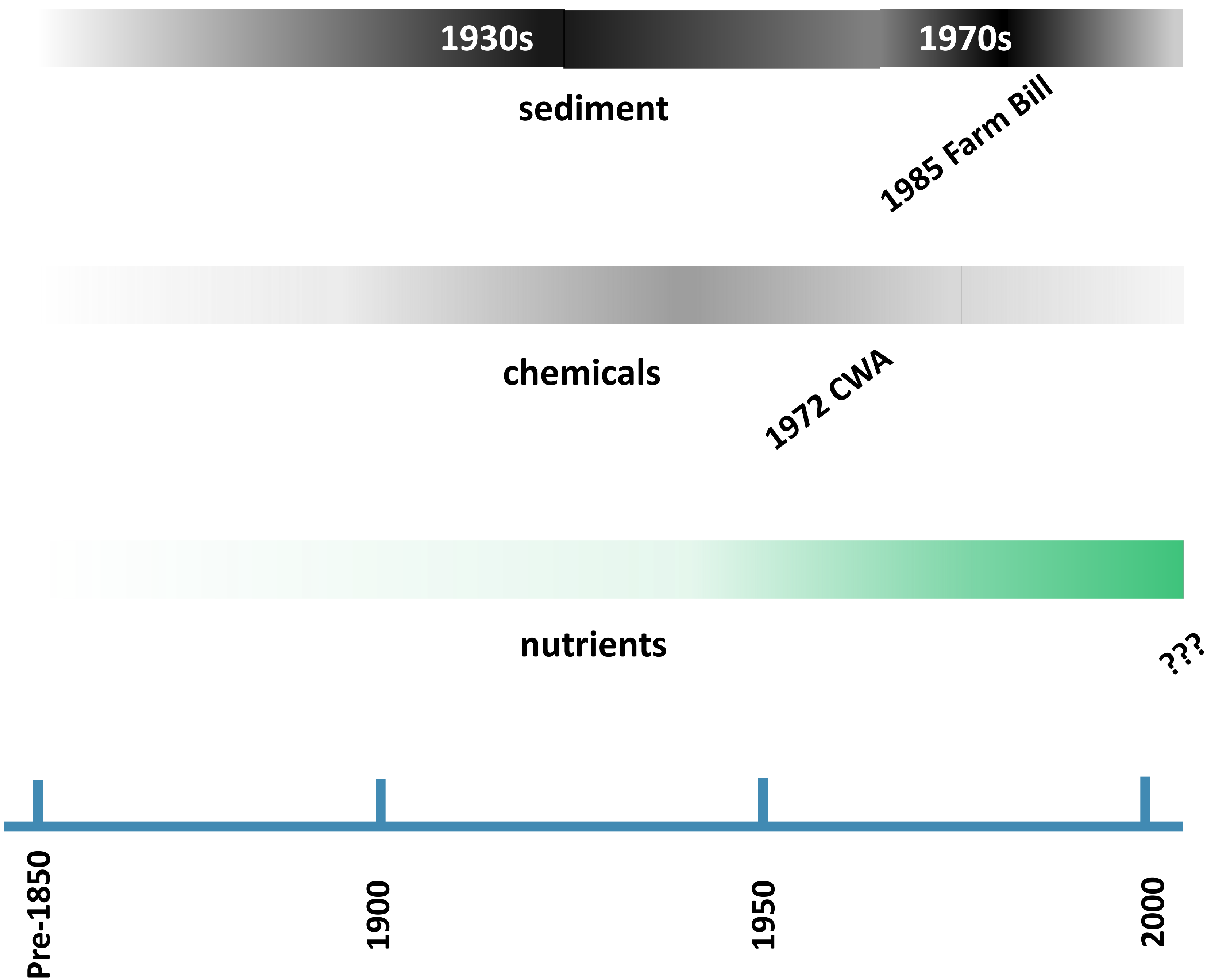
Contact Recreation

Effects of Water Pollution

Irrigation

Industrial Uses


Human Health Ingestion
Aquatic Life
Contact Recreation
Viruses
Giardia
metals
Endocrine Disruptors
temperature
light
pH
Pesticides
NO3
Toxic chemicals
Bluegreen algae
NH3
Sediment
P
E coli
Green algae


1930s
1970s
sediment
1985 Farm Bill
chemicals
1972 CWA
nutrients
???
Pre-1850
1900
1950
2000

Measurement and Monitoring

Lab

Measurement and Monitoring

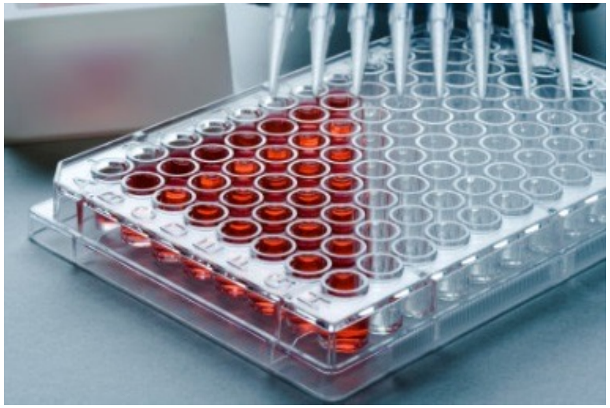
Field

Measurement and Monitoring

Human Observation

Measurement and Monitoring

Measurement technology can drive policy and science of pollution



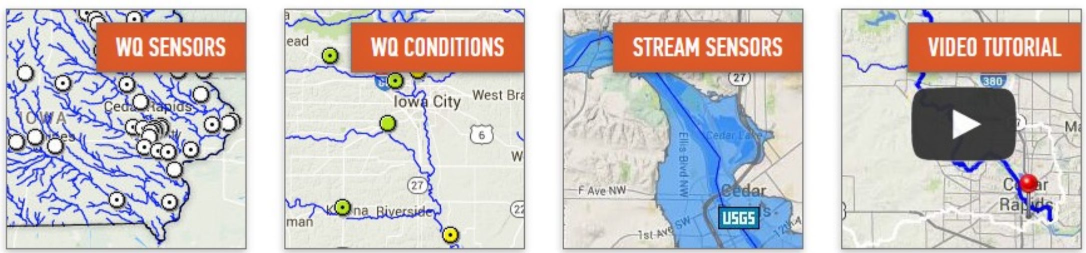
WQIS

IOWA WATER QUALITY INFORMATION SYSTEM

Welcome to the Iowa Water Quality Information System!

The IWQIS allows access to real-time water-quality data and information such as **nitrate**, **chlorophyll**, and **dissolved oxygen concentrations**, discharge rates, and **temperature**.

LAUNCH IWQIS



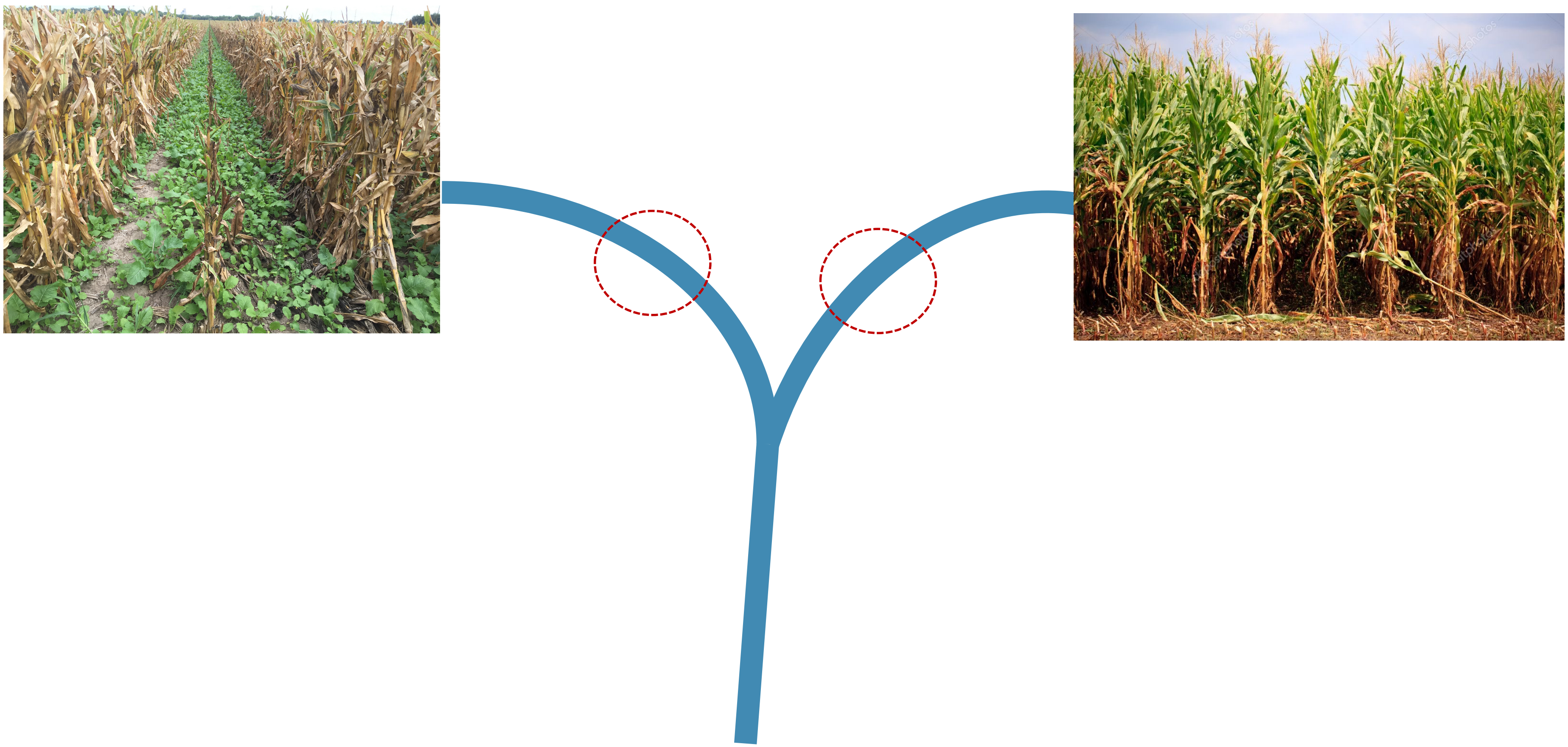
ABOUT IWQIS | TOOLS & FEATURES | HELP & TUTORIALS | DATA REQUEST | CONTACT US

The University of Iowa College of Engineering

http://iwqis.iowawis.org/

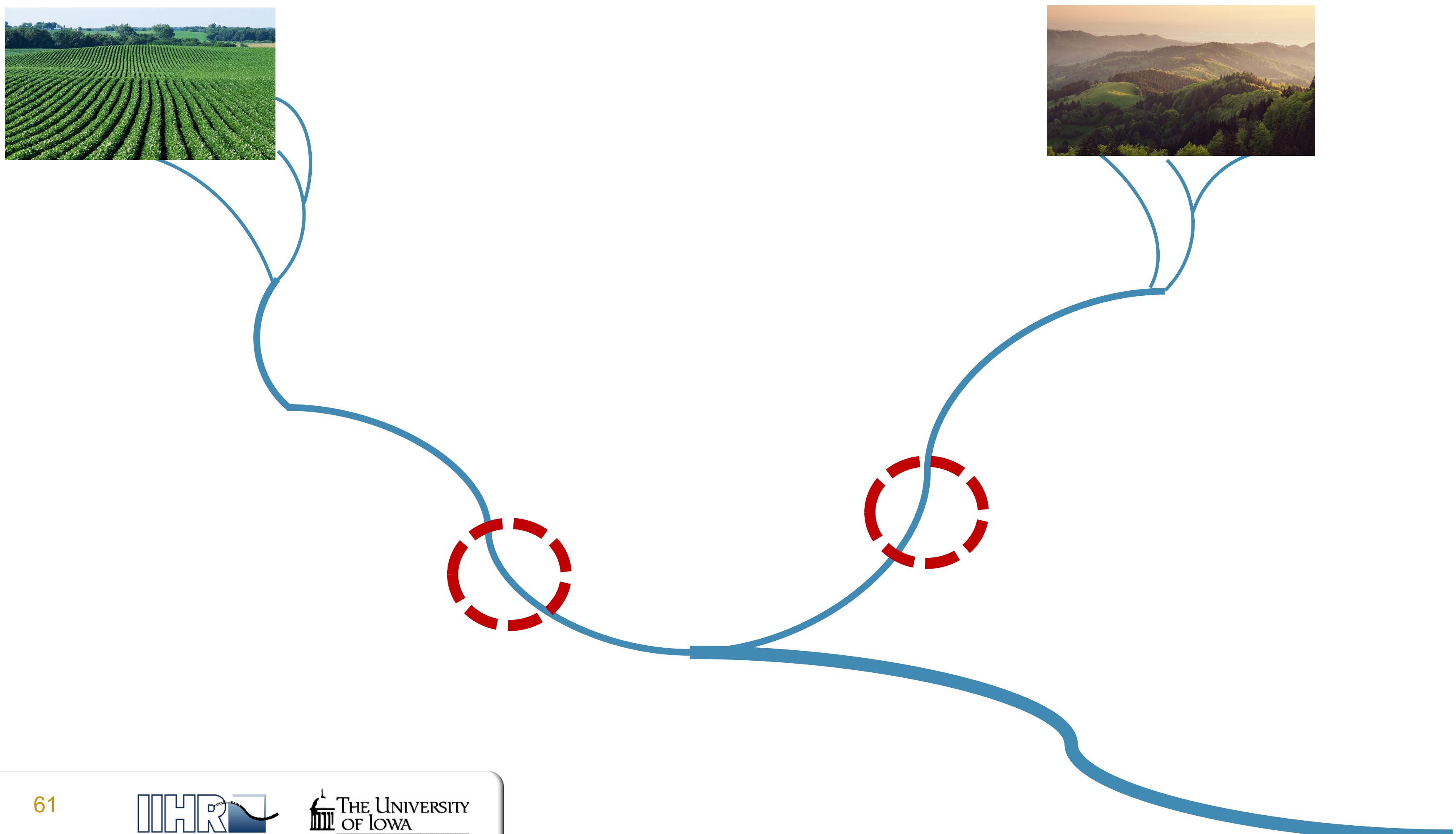
IIHR Hydroscience & Engineering

Watershed Monitoring Design: Project Scale

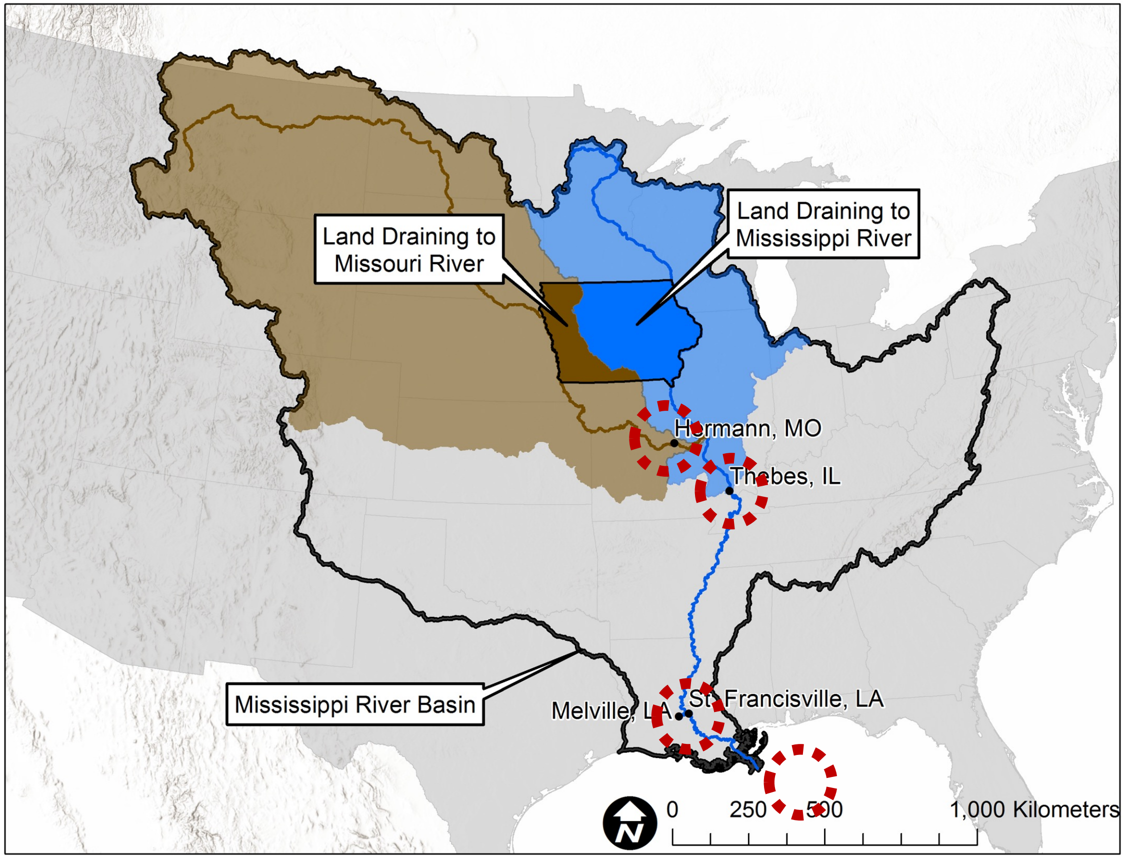


Watershed Monitoring Design: Upstream/Downstream

Watershed Monitoring Design: Reach Scale

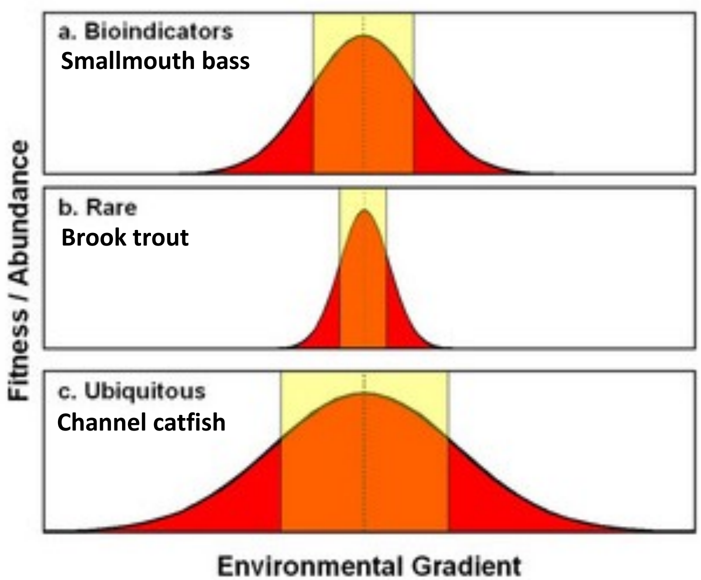


Watershed Monitoring Design: Landscape Scale



Biological Monitoring and Water Quality Indices

Bioindicators



Biological Indicators

- IBI: Index of Biotic Integrity
- BMIBI: Benthic Macroinvertebrate Index of Biotic Integrity

MONITORING IS EXPENSIVE!

Water Quality Index

- Single value index that objectively translates a body of data into one value
- Concept dates to at least 1848

Two types:

- Water Quality Index (high #'s for good water, low #'s for bad water)
- Water Pollution Index (low #'s for good water, high #'s for bad water)

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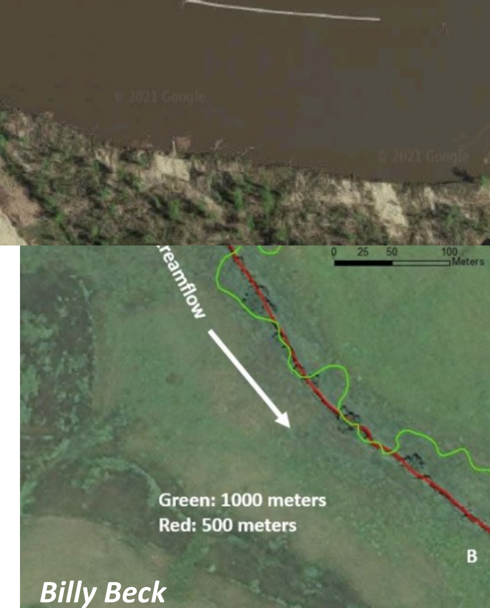
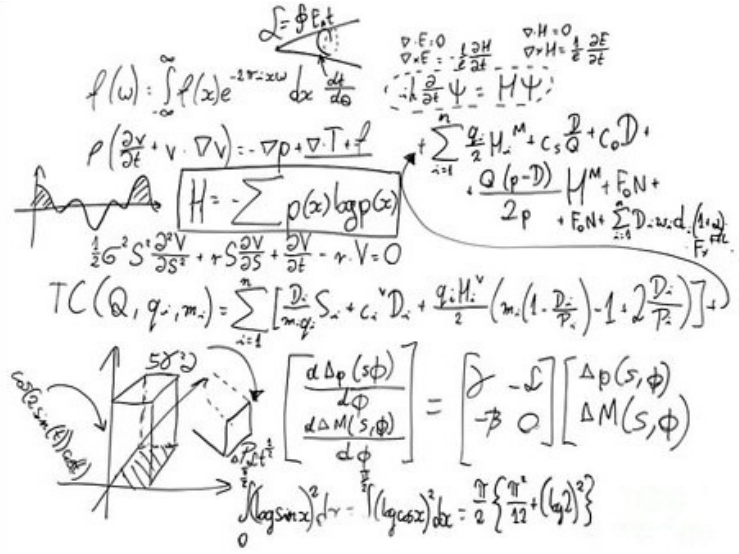


Process

1. Selection of water quality parameters that will determine the index value
2. Transformation of parameter data to common or arbitrary unit
3. Weighting of the parameter (not always done)
4. Aggregation of index values to final index score.

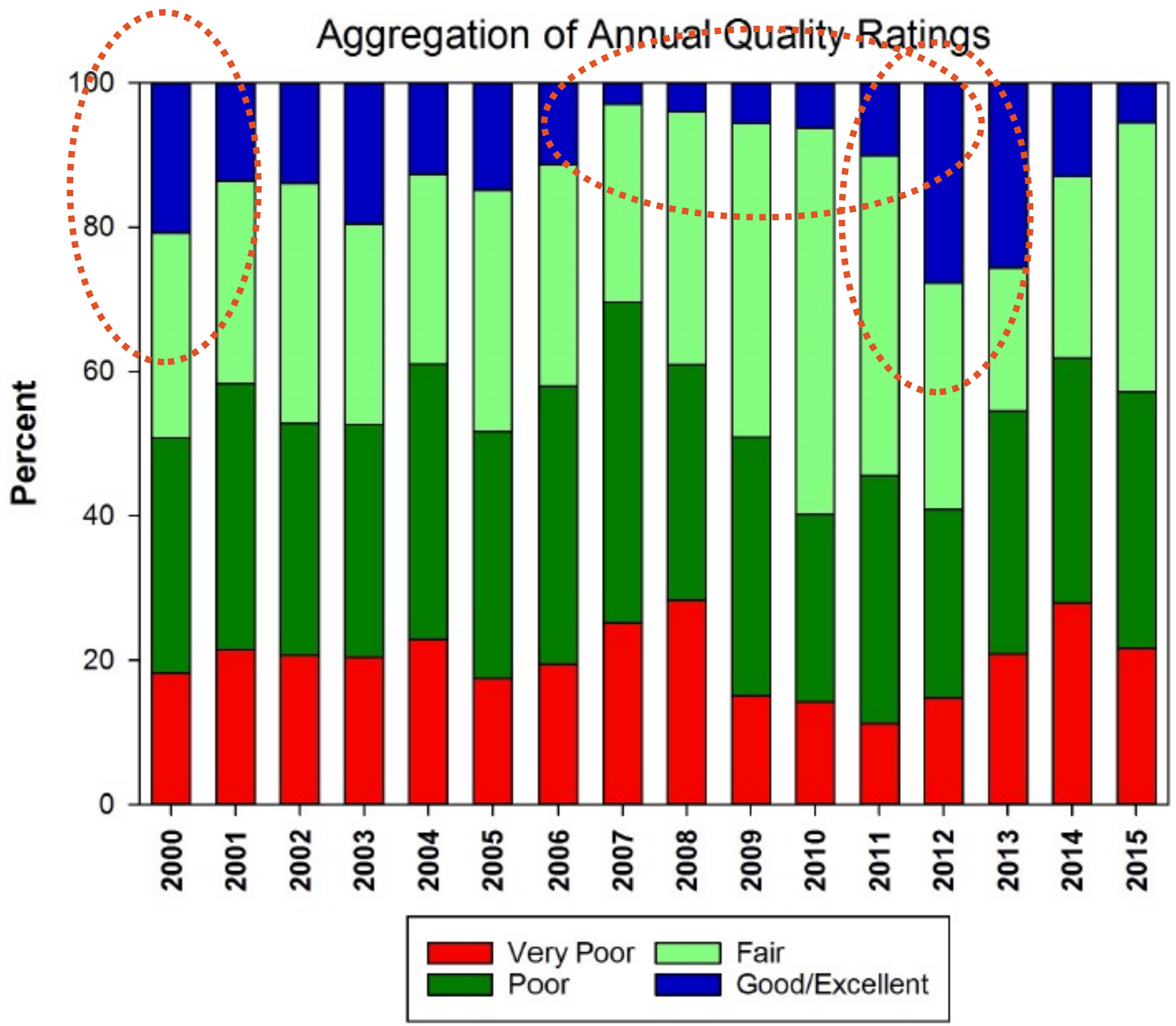


Iowa

- WQI created by DNR in 2005
- Modification of WQI created by the National Sanitation Foundation

Parameter	IWQI	NSFWQI
Biological Oxygen Demand (BOD)	Yes	Yes
Dissolved Oxygen (DO)	Yes	Yes
E. coli	Yes	No
Fecal coliforms	No	Yes
Nitrate as Nitrogen (NO3-N)	No	Yes
Nitrate + Nitrite as Nitrogen (NOx-N)	Yes	No
Pesticides	Yes	No
Temperature	No	Yes
Total Dissolved Solids (TDS)	Yes	Yes
Total Phosphorous (TP)	Yes	Yes
Total Suspended Solids (TSS)	Yes	No
Turbidity	No	Yes

Figure 1: Aggregate IWQI Ratings for Iowa Streams, 2000-2015



Rating	Index Value
Very Poor	10 to 25
Poor	25 to 50
Fair	50 to 70
Good	70 to 90
Excellent	90 to 100

Then 2014 happened

-IWQI:

- subindex of any parameter without a result to be assigned a score of 50 for that subindex.

-In 2014, budget problems ended pesticide monitoring

-IWQI with one subindex score of 50 and the rest at a maximum-best of 100 produced a total IWQI of 87

- excellent rating was mathemat

-Total pesticide levels:

- below 1.5 parts per billion (pp
- 1.5-3 ppm receive a 50;
- greater than 3 ppb received a 1
- Historically, 90% of the Iowa s

Analysis of Iowa Water Quality Index

and

Proposed Alternative

Christopher S. Jones, Ph.D., Research Engineer
University of Iowa IIHR Hydroscience and Engineering

Richard J. Langel, M.S. Research Specialist
Iowa Geological Survey

IIHR Hydroscience & Engineering

The University of Iowa

Iowa Geological Survey

IIHR – Hydroscience and Engineering
College of Engineering
The University of Iowa
Iowa City, Iowa 52242-1585

Prepared for: Iowa Department of Natural Resources

DNR

July 15, 2016

Three components of our work:

- Compare the parameters used for IWQI with those of other well-known water indices, within the context of their relevance for Iowa waters.
- Use available water quality from IDNR's water monitoring program to assess how the different indicators compare when applied to Iowa waters.
- Develop alternative(s) to IWQI that will more accurately assess Iowa waters while increasing utility of the "Index" concept for policy-makers, agencies, and lay people.

Tasks

1. Literature search and review
2. Data Aggregation
3. Apply Iowa data to existing indices
4. Develop potential alternative to IWQI
5. Reporting

Aggregated data from 12 watersheds that would be representative of the state as a whole (landforms, latitude, longitude)

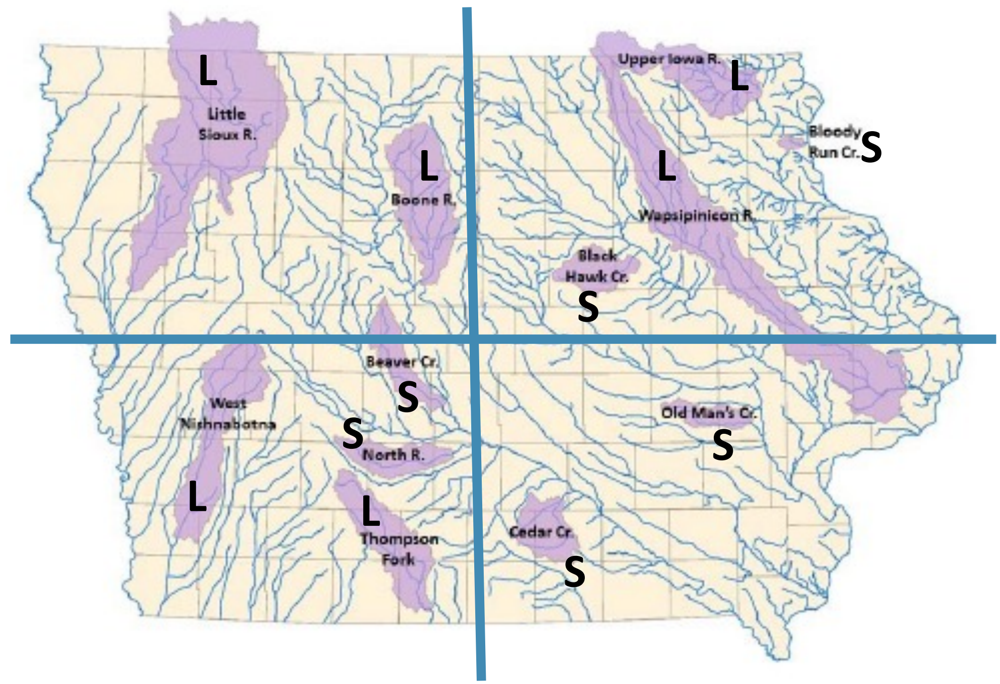


Figure 2: Watersheds of selected ambient sites.

Alberta WQI

47 variables (metals, ions, pesticides, nutrients and related variables, bacteria).

"Performance Indicator" i.e. calculated based on the fraction of samples that meet designated thresholds.

Thresholds can be set at whatever level the user wants.

Index accommodates any number of parameters ≥ 2

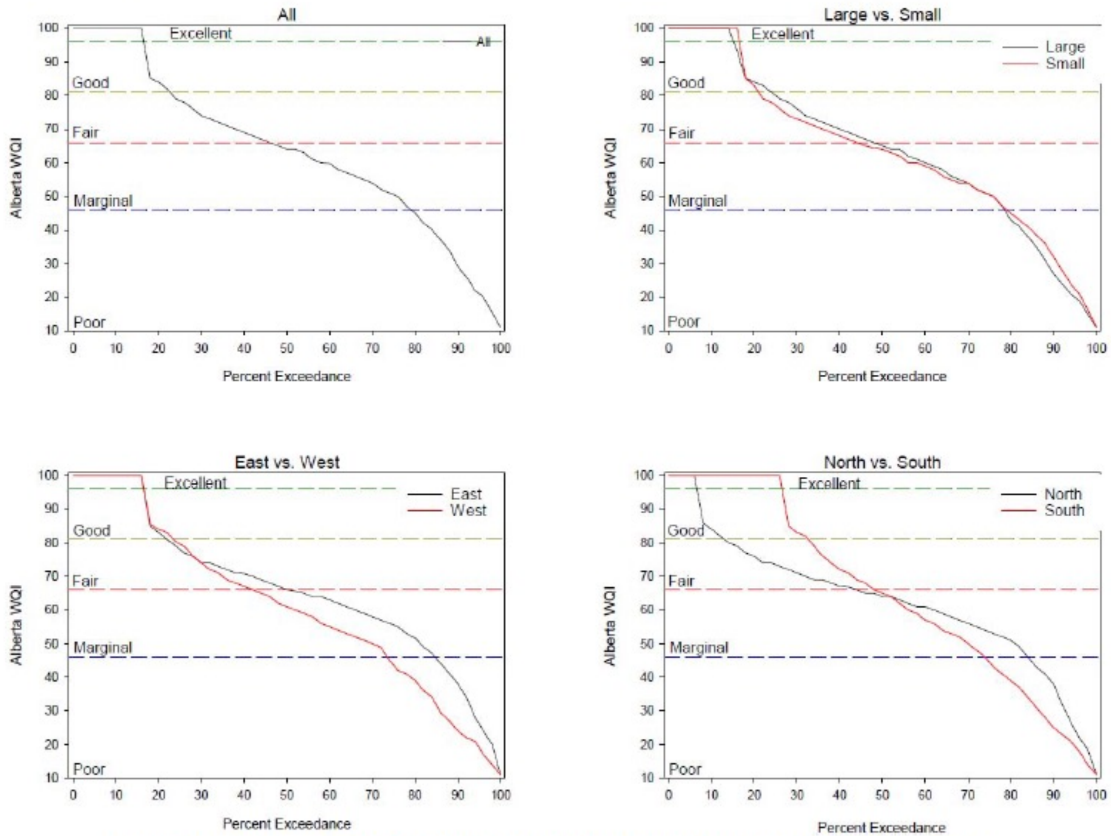


Figure 9: WQI values calculated using the Alberta WQI for 12 selected Iowa streams

Considerations

- Easy to understand by the public and policy makers.
- Focus on stressors most important to water quality in Iowa.
- Necessary monitoring is not prohibitively expensive.
- Sufficient flexibility to endure changes in budget.
- Able to allow incorporation ideas from DNR staff and scientists.
- Able to change with changing public perceptions and expectations.

What parameters are driving water quality in Iowa Streams?

What parameters can be easily and inexpensively monitored?

1. Dissolved Oxygen
2. Total Nitrogen (Kjeldahl N, Nitrate, Nitrite)
3. Total Phosphorus
4. *E. coli*
5. Turbidity

The Water Quality Index Formula takes the following form:

$$Index\ Score = 100 - \left(\frac{\sqrt{F_1^{\ 2} + F_2^{\ 2} + F_3^{\ 2}}}{1.732} \right)$$

Where:

F_1 represents the number of water quality variables that do not meet objectives in at least one sample during the time period under consideration, relative to the total number of variables measured:

$$F_1 = \left(\frac{\text{Number of failed variables}}{\text{Total number of variables}} \right) \times 100$$

F_2 represents the number of individual measurements that do not meet objectives, relative to the total number of measurements made in all samples for the time period of interest:

$$F_2 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}} \right) \times 100$$

F_3 represents the amounts by which measurements depart from objectives. This is an asymptotic capping function that scales the normalized sum of the excursions from objectives (*nse*) to yield a range between 0 and 100:

$$F_3 = \left(\frac{nse}{0.01nse + 0.01} \right)$$

The *nse* variable represents the amount by which water quality is out of compliance. This is calculated by summing the departures of individual tests from their objectives, and dividing by the total number of tests:

Threshold Scenarios

Dissolved Oxygen.

- Proposed 5 mg/L. Both Illinois and Minnesota use a standard of 5 mg/L with some caveats. Illinois rules state DO must always exceed 5 mg/L with a daily mean over a week-long period exceeding 6.25 mg/L. The Minnesota standard for Class A streams (essentially trout streams) is 7 mg/L.

Turbidity.

- 25 NTU, which is the Minnesota stream standard for all waters except Class 2A waters, where the standard is 10 NTU.
- Acknowledging the possibly natural turbidity associated with lower reaches of Missouri River tributaries, we also considered a 50 NTU threshold. North Carolina considers instantaneous turbidity of 50 NTU in aquatic life protections.

Total Phosphorous

0.18 mg/L = 45% reduction in current mean phosphorus levels ('99-'13) by Wang et al. 2013.

MN Southern Regions streams: 0.15 mg/L

Total Nitrogen

3.5 mg/L = 45% reduction in mean N concentrations ('98-'12) by Chan et al. (2013).

Also some evidence that this is protective of larval forms of some fish species (Carmargo et al. 2005).

New EPA Guidance on E. coli

Table 1. Two sets of E. coli criteria based on two different estimated illness rates.

	Recommendation 1 Estimated Illness Rate: 36 per 1,000	
Indicator Organism	Geometric Mean (cfu/100 mL)	Statistical Threshold Value (STV- 90th percentile) (cfu/100 mL)
E. coli (freshwater)	126	410

	Recommendation 2 Estimated Illness Rate: 32 per 1,000	
Indicator Organism	Geometric Mean (cfu/100 mL)	Statistical Threshold Value (STV- 90th percentile) (cfu/100 mL)
E. coli (freshwater)	100	320

Source: Anderson and Rounds (2003)

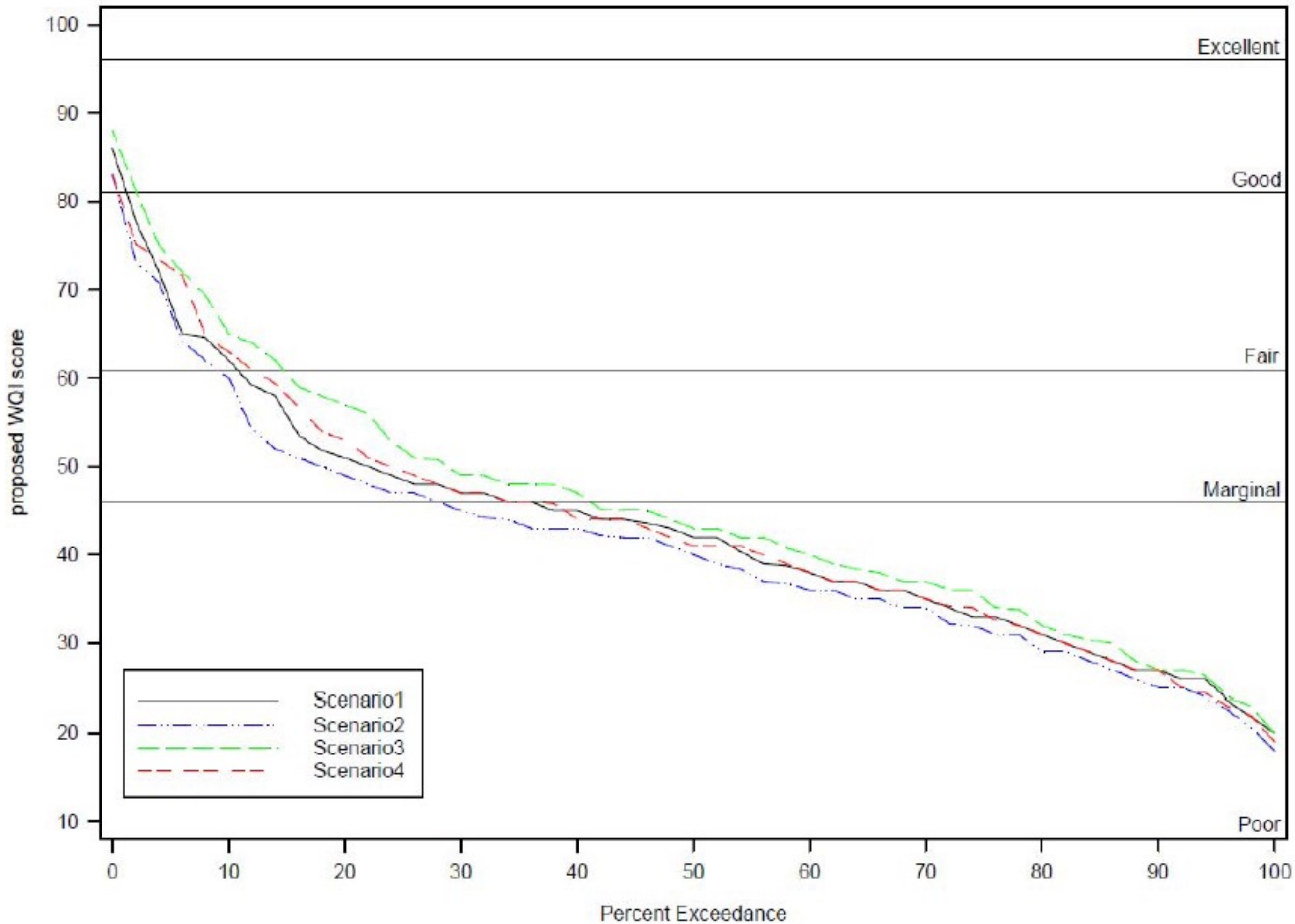
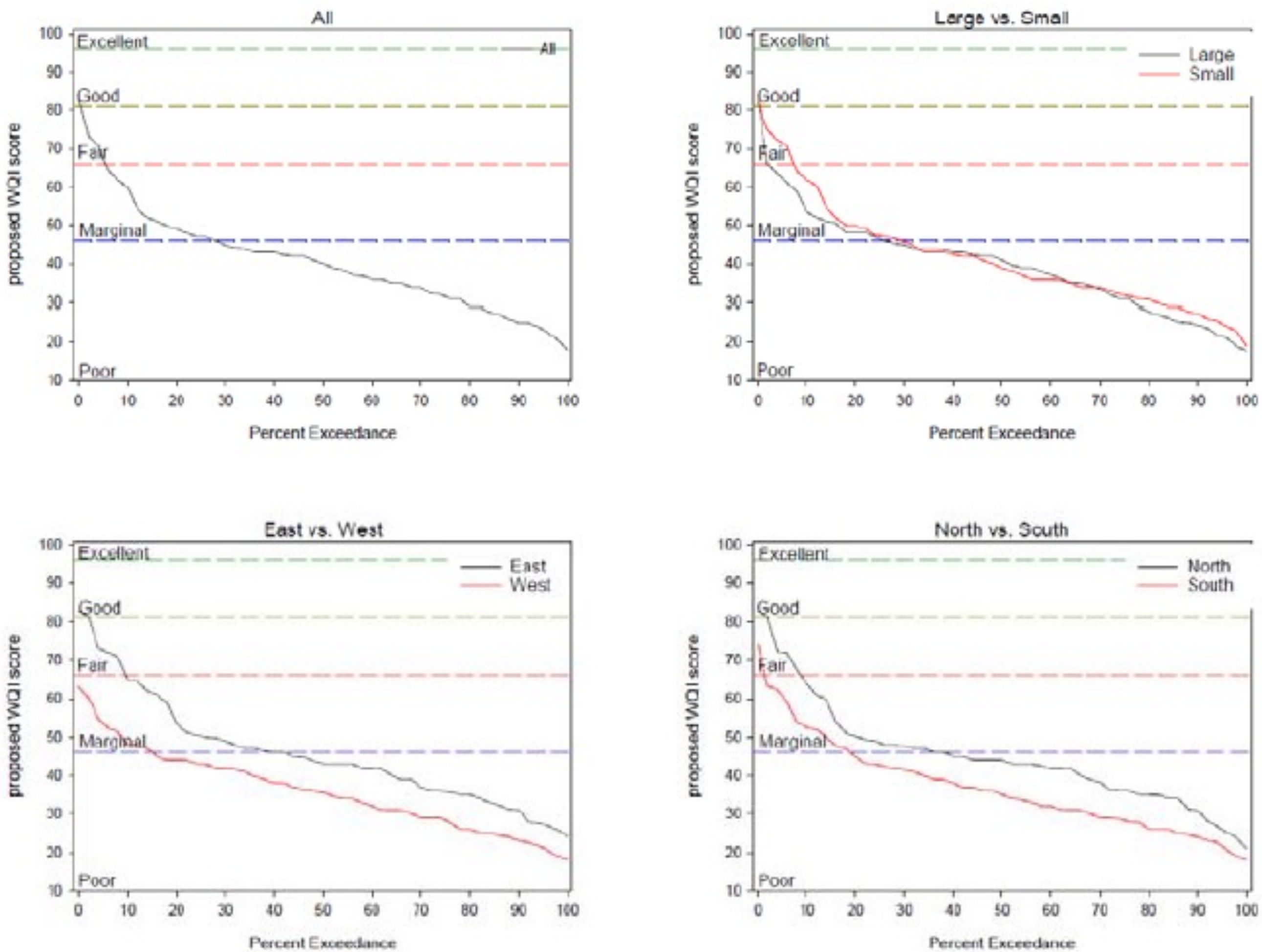


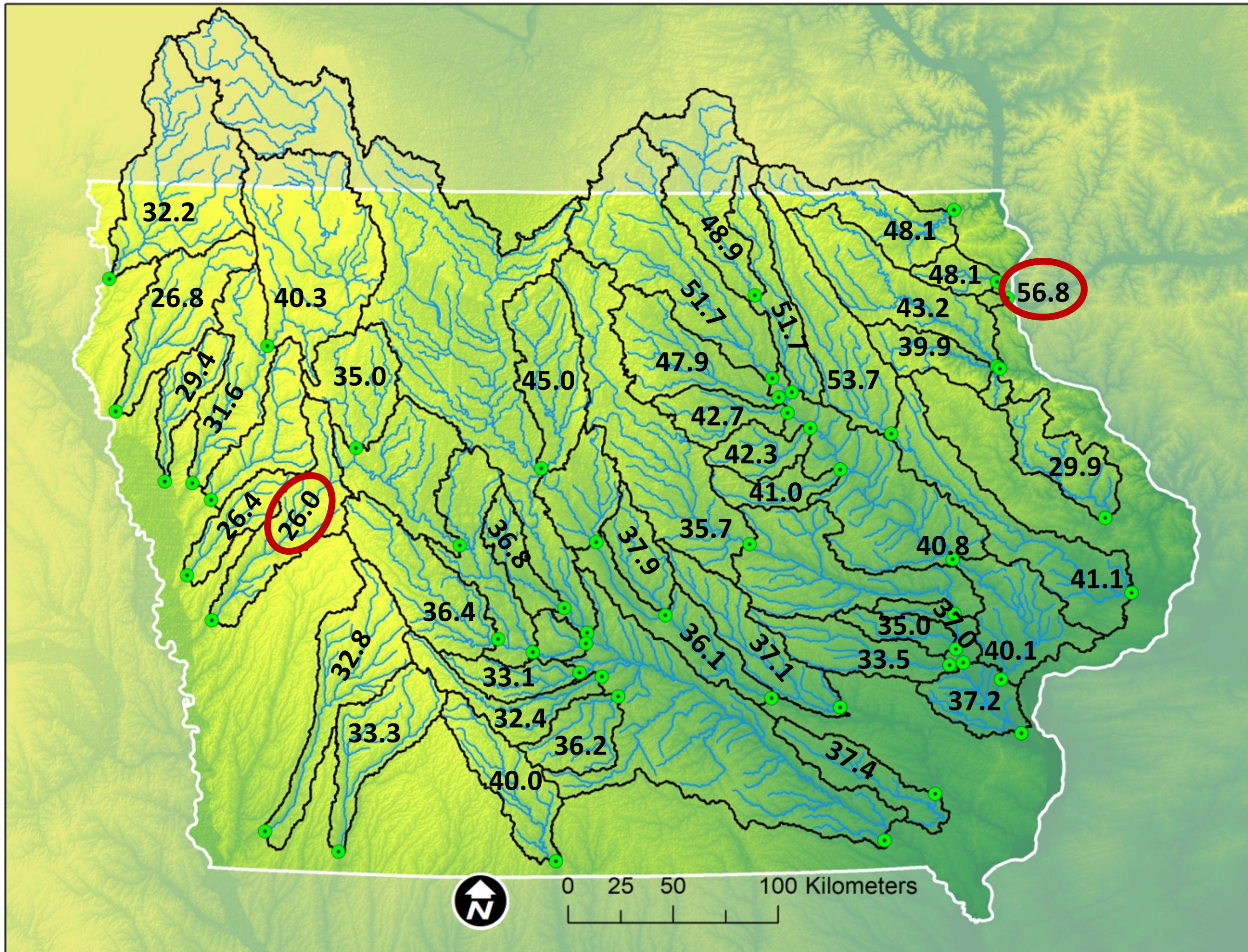
Figure 10: Scores for 12 Iowa streams using the proposed WQI under the four different threshold scenarios, 2000-2015



Scenario 2	threshold
E. coli	235 MPN/100 ml
Total N	3.5 mg/L
Turbidity	25 NTU
DO	5 mg/L
Total P	0.18 mg/L

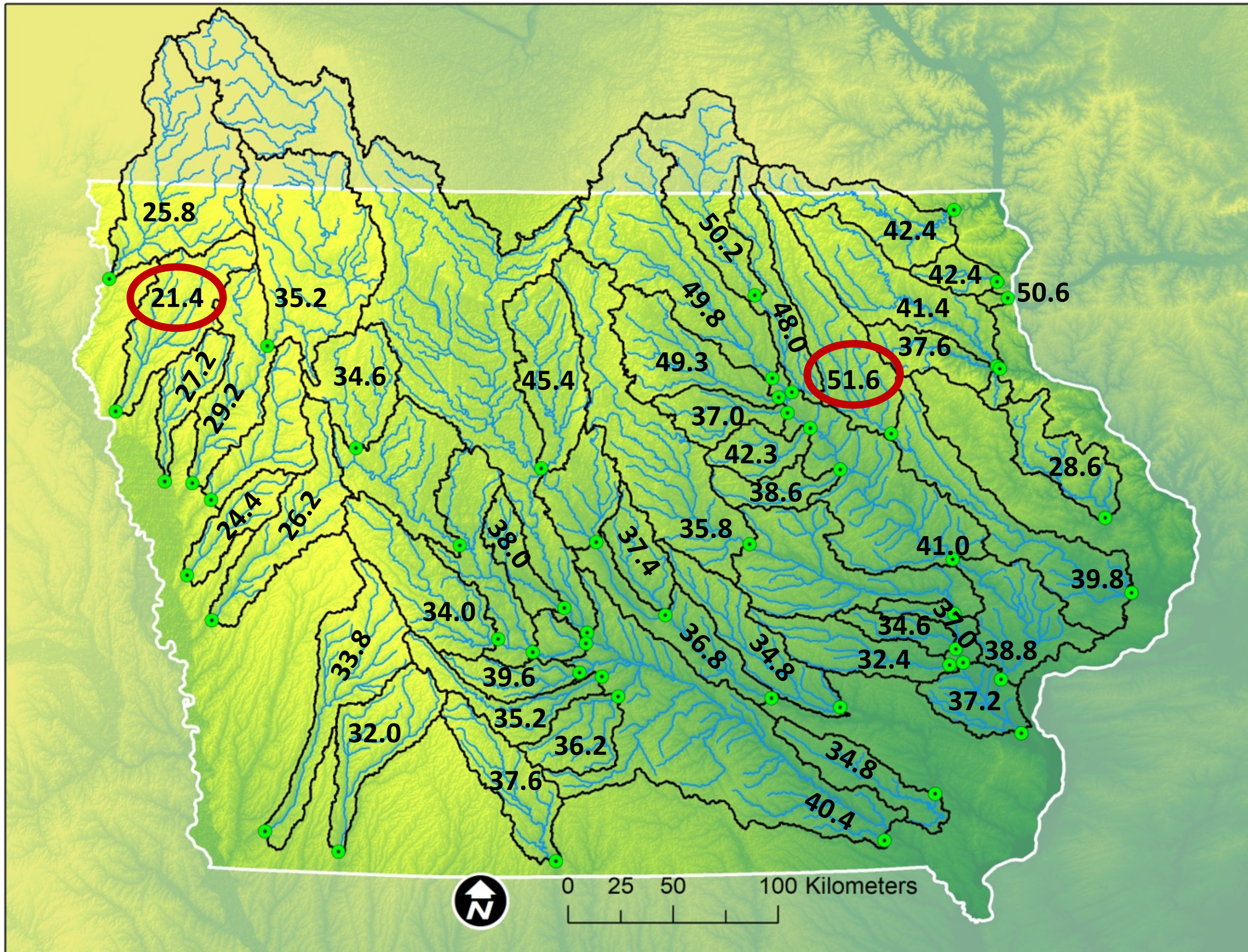
End of DNR project

2000-2020



>96=Excellent
81-95=Good
66-80=Fair
46-65=Marginal
10-45=Poor
<10=Very Poor

2016-2020



>96=Excellent
81-95=Good
66-80=Fair
46-65=Marginal
10-45=Poor
<10=Very Poor

Location	group	WQI 2016-20	Percent Change, 2016-20 versus pre-2016					
			change wqi	change DO	change EC	change N	change P	change turb
Wapsipinicon River at Independence	Iowan Surface	51.6	-5.1	-1.0	31.6	12.0	50.0	18.3
Bloody Run Cr at Marquette	Paleozoic Plateau	50.6	-14.4	-1.7	111.8	18.0	62.5	198.3
Cedar River at Charles City	Iowan Surface	50.2	4.4	-1.8	-38.1	-2.6	-9.5	-0.7
Shellrock River at Shellrock	Iowan Surface	49.8	-4.8	-5.2	30.0	-2.1	11.1	-12.3
W. Fork of the Cedar River at Finchford	Iowan Surface	49.3	2.8	-4.7	55.6	0.1	21.4	0.0
Cedar River at Janesville	Iowan Surface	48.0	-11.1	-9.8	51.5	3.3	11.8	-12.1
Boone River at Stratford	Des Moines Basin Up	45.4	1.3	-4.3	-16.8	-8.0	-16.7	-13.8
Upper Iowa River at Dorchester	Paleozoic Plateau	42.4	-14.7	-8.4	-51.7	20.5	0.0	-9.3
Yellow River at Ion	Paleozoic Plateau	42.4	-17.3	-5.8	-48.7	27.6	21.1	76.5
Blackhawk Creek at Waterloo	Iowan Surface	42.2	-0.2	0.0	-5.8	-2.3	-5.9	20.4
Turkey River at Garber	Paleozoic Plateau	41.4	-5.5	-2.7	-44.3	8.8	-10.3	5.4
Cedar River Downstream of Cedar Rapids	Iowan Surface	41.0	0.7	0.9	17.6	5.9	-13.3	31.0
Des Moines River at Keosauqua	Des Moines Basin Down	40.4	-6.5	-1.8	161.9	7.8	-17.1	53.6
Wapsipinicon River at DeWitt	Iowan Surface	39.8	-5.0	-8.2	6.0	1.1	13.6	0.3
North River at Norwalk	Des Moines Basin Down	39.6	23.0	2.1	-80.6	-19.1	-24.2	-21.1
Cedar River at Conesville	Iowan Surface	38.8	-4.2	-9.4	21.5	-0.7	-5.6	-6.0
Wolf Creek at LaPorte City	Iowan Surface	38.6	-7.4	1.0	58.3	-6.3	12.5	15.4
Beaver Creek at Grimes	Des Moines Basin Up	38.0	4.4	3.8	-11.6	-16.7	43.8	-26.8
Thompson River at Davis City	Missouri River Trib	37.6	-7.8	-4.0	-32.3	0.5	10.7	-5.8
Volga River at Elkport	Paleozoic Plateau	37.6	-7.8	-3.7	-41.3	8.2	-7.4	-2.5
Indian Creek at Colfax	Iowa-Skunk	37.4	-1.8	-1.9	25.7	-20.9	3.6	25.1
Beaver Creek at Cedar Falls	Iowan Surface	37.0	-16.7	-3.6	-39.8	11.6	-7.1	13.3
South Skunk River at Oskaloosa	Iowa-Skunk	36.8	2.5	-2.8	-28.6	-29.1	-11.8	-3.7
South River at Ackworth	Des Moines Basin Down	36.0	-0.8	1.0	-35.9	0.0	3.2	18.8
Iowa River Downstream of Marshalltown	Iowa-Skunk	35.8	0.3	-0.9	-1.3	-3.5	-13.2	67.9
Middle River at Indianola	Des Moines Basin Down	35.2	7.0	-2.8	-68.7	-19.6	-16.7	-6.6
Little Sioux River at Larrabee	Missouri River Trib	35.2	-16.0	-8.0	200.0	9.2	8.0	39.9
Cedar Creek at Oakland Mills	Iowa-Skunk	34.8	-11.2	0.0	12.1	-25.0	-6.9	-13.6
North Skunk River at Sigourney	Iowa-Skunk	34.8	-7.9	0.0	12.1	-7.7	-6.9	-13.6
Iowa River at Lone Tree	Iowa-Skunk	34.8	-8.9	0.9	75.7	0.7	22.2	34.6
North Raccoon at Sac City	Des Moines Basin Up	34.6	-3.6	-2.8	87.6	-26.9	-37.5	12.9
Old Mans Creek at Iowa City	Iowa-Skunk	34.6	-1.4	-3.8	-48.7	-18.8	3.6	45.0
South Raccoon River at Redfield	Des Moines Basin Up	34.0	-8.4	-1.8	19.3	6.8	-14.3	-36.0
South Skunk River at Cambridge	Iowa-Skunk	34.0	7.3	-1.9	-24.1	-23.3	-40.0	80.5
E. Nishnabotna at Shenandoah	Missouri River Trib	33.8	2.4	-2.8	-43.8	-5.4	-19.1	-42.2
English River at Riverside	Iowa-Skunk	32.4	-5.0	1.0	-54.8	-9.4	6.3	38.9
W. Nodaway at Shambaugh	Missouri River Trib	32.0	-5.3	0.9	-15.9	-9.6	10.8	-17.5
Little Sioux River at Smithland	Missouri River Trib	29.2	-15.1	-2.8	-23.5	10.8	9.4	32.5
N. Fork Maquoketa R. at Hurtsville	Iowan Surface	28.6	-6.8	-2.8	7.7	7.7	56.3	85.1
West Fork Ditch at Hornick	Missouri River Trib	27.2	-9.6	-1.9	-22.2	17.6	21.1	8.8
Boyer River at Missouri Valley	Missouri River Trib	26.2	0.8	-6.5	70.9	-2.2	-36.6	-36.5
Rock River at Rock Valley	Missouri River Trib	25.8	-24.8	-3.8	392.8	44.7	38.5	31.4
Soldier River at Pisgah	Missouri River Trib	24.4	-10.0	0.0	-44.5	36.8	-1.9	-20.3
Floyd River at Sioux City	Missouri River Trib	21.4	-26.5	-1.0	235.9	35.2	6.8	88.4
	Iowan Surface	42.9	-4.5	-3.7	16.3	2.3	11.3	12.7
	Paleozoic Plateau	42.9	-11.9	-4.5	-14.8	16.6	13.2	53.7
	Des Moines Basin Up	38.0	1.6	-1.3	19.6	-11.2	-6.2	-15.9
	Des Moines Basin Down	37.8	5.7	-0.4	-5.9	-7.8	-13.7	11.2
	Missouri River Trib	29.3	-11.2	-3.0	71.7	13.8	4.8	7.9
	Iowa-Skunk	35.0	-2.9	-1.0	-3.5	-15.2	-4.8	29.0

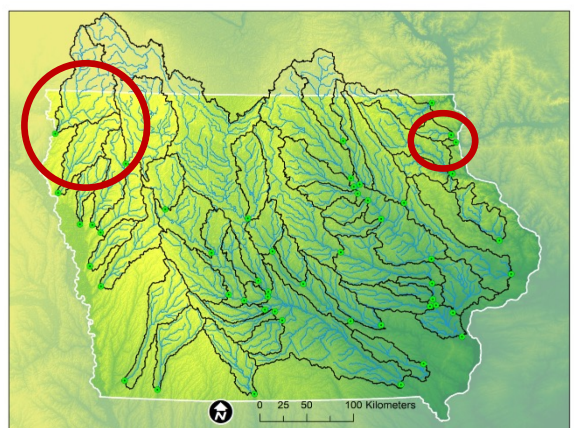
wqi	water quality index
DO	Dissolved oxygen
EC	E. coli
N	Total nitrogen
P	Total phosphorus
Turb	Turbidity
	less than 5% change
	5 to 10% improvement
	10-20% improvement
	>20% improvement
	5-10% deterioration
	10-20% deterioration
	>20% deterioration

3/44 improving (>5%)

16/44 <5% change

25/44 declining (>5%)

Category	Best ('16-20)	Biggest Improvement (%)	Worst ('16-20)	Biggest Deterioration (%)
WQI	Wapsi (Ind.)	North R.	Floyd R.	Floyd R.
DO	Bloody Run	Beaver Cr. (Grimes)	Thompson R.	Cedar R. (Janesville)
E Coli	Shellrock R.	North R.	Rock R.	Rock R.
TN	South R.	S. Skunk (Osk.)	Floyd R.	Rock R.
TP	Bloody Run	S. Skunk (Camb.)	Floyd R.	Bloody Run
Turb	Wapsi (Ind.)	E. Nishnabotna	South R.	Bloody Run



Overall Statewide Averages

2000-2006: 38.1

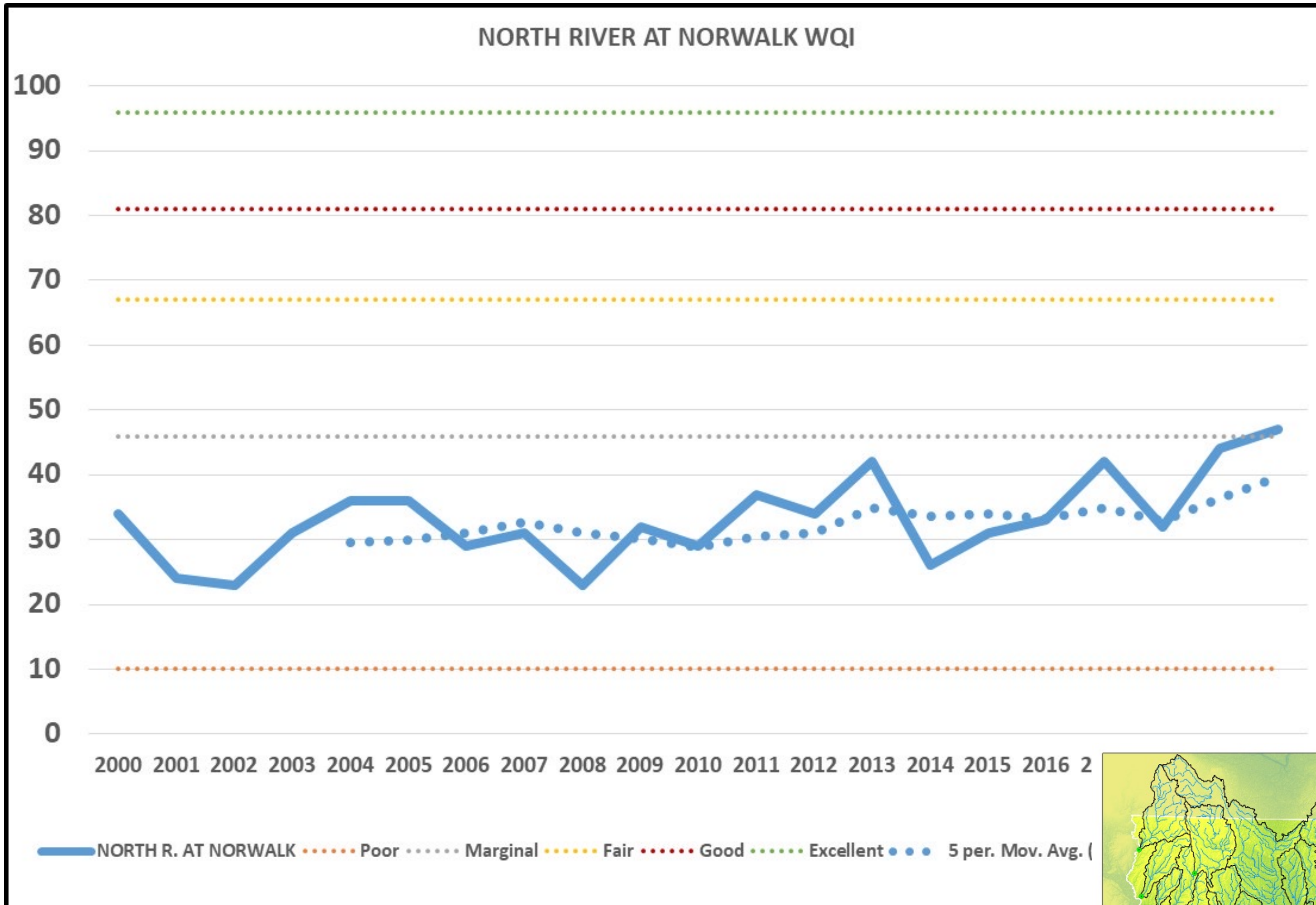
2007-2013: 40.8

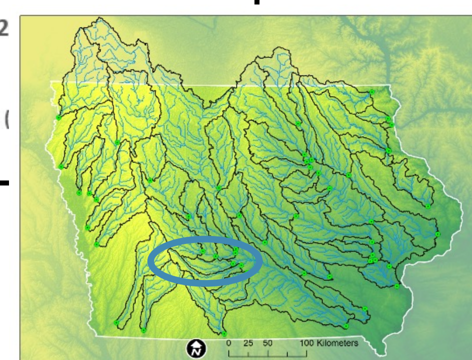
2014-2020: 37.5

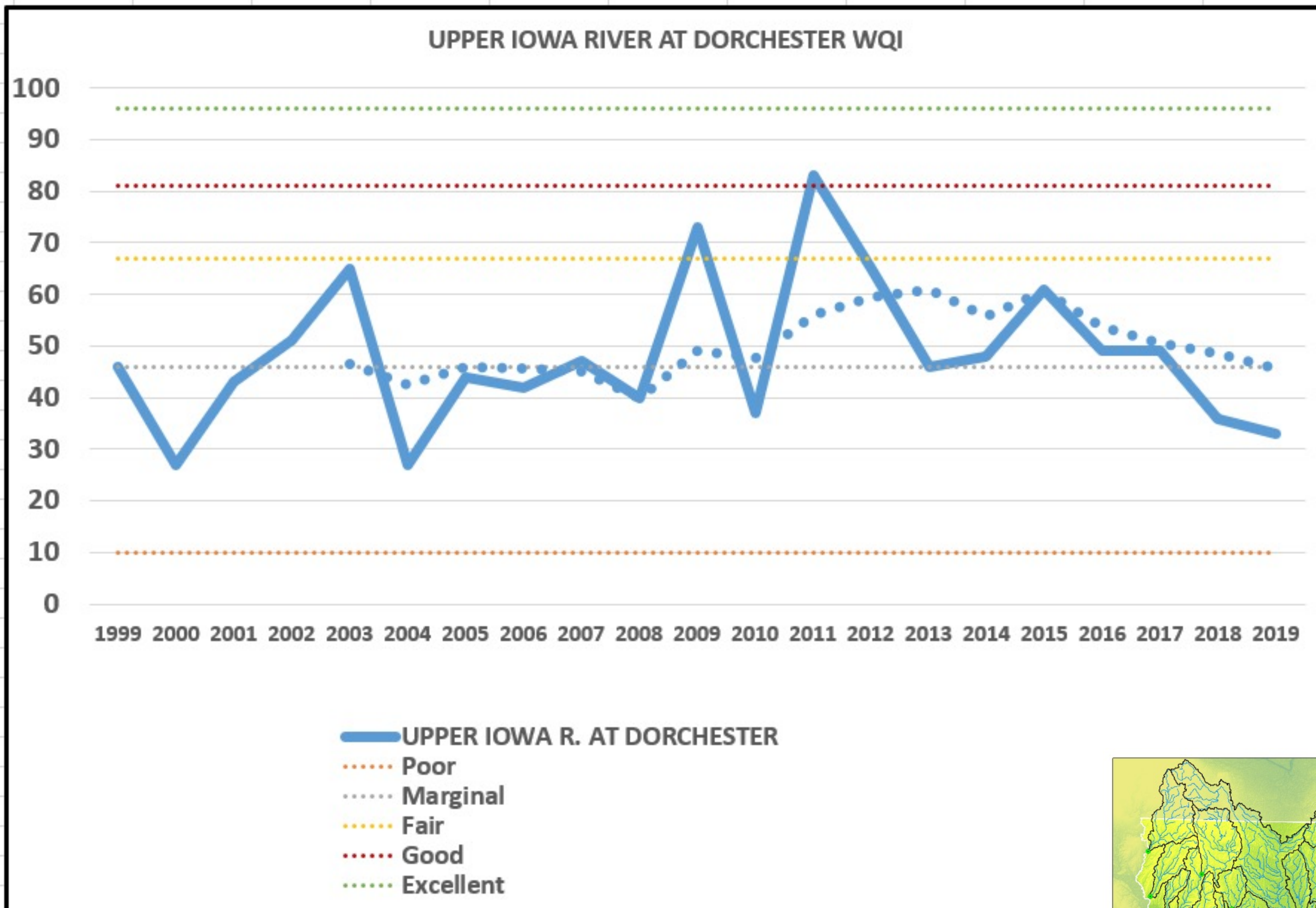
Two streams on continuous decline:

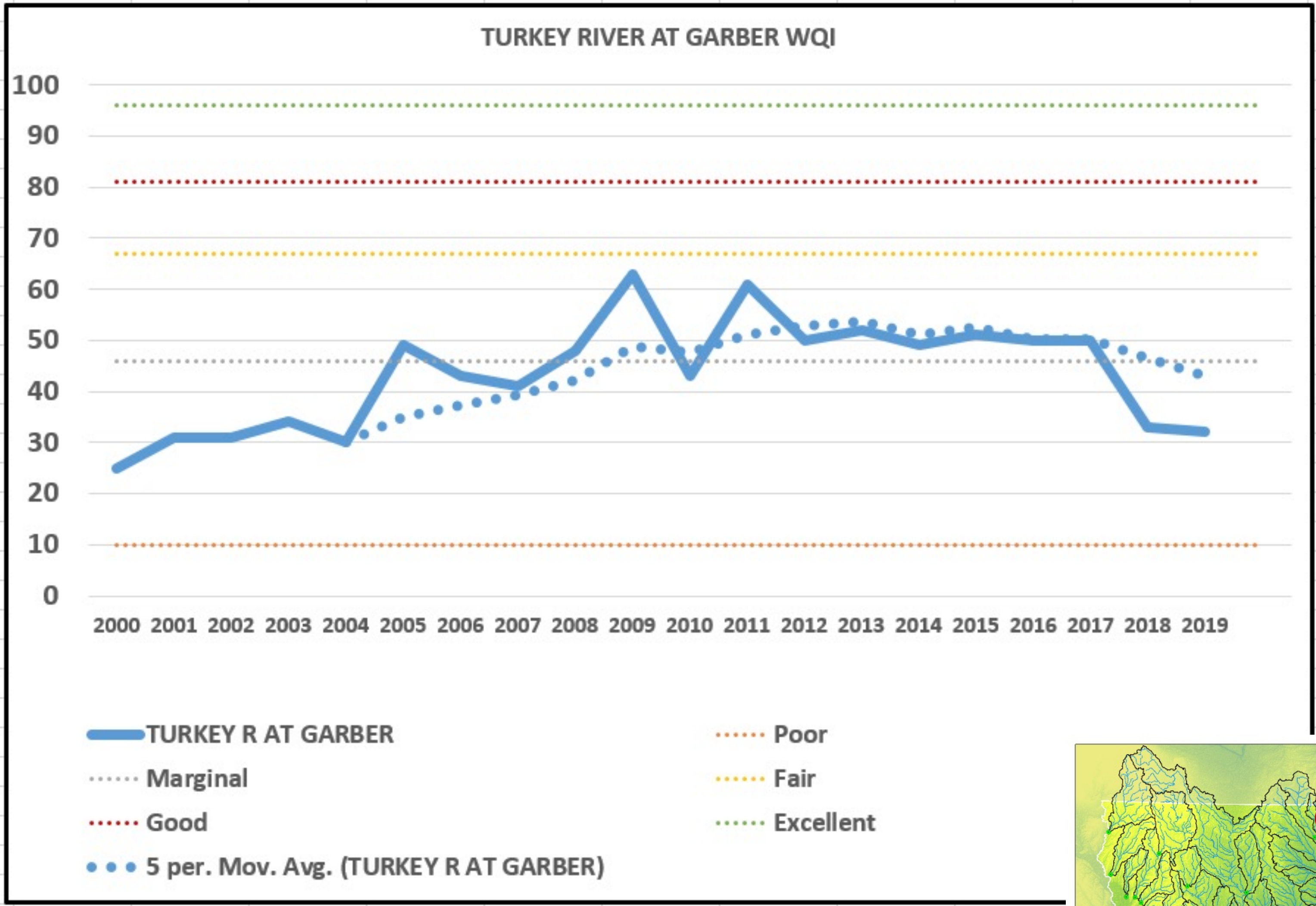
Old Man's Creek, West Nodaway

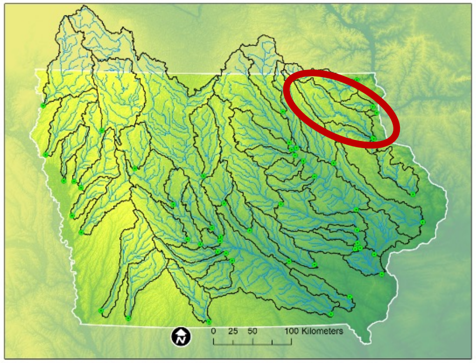
One stream on continuous improvement: North River

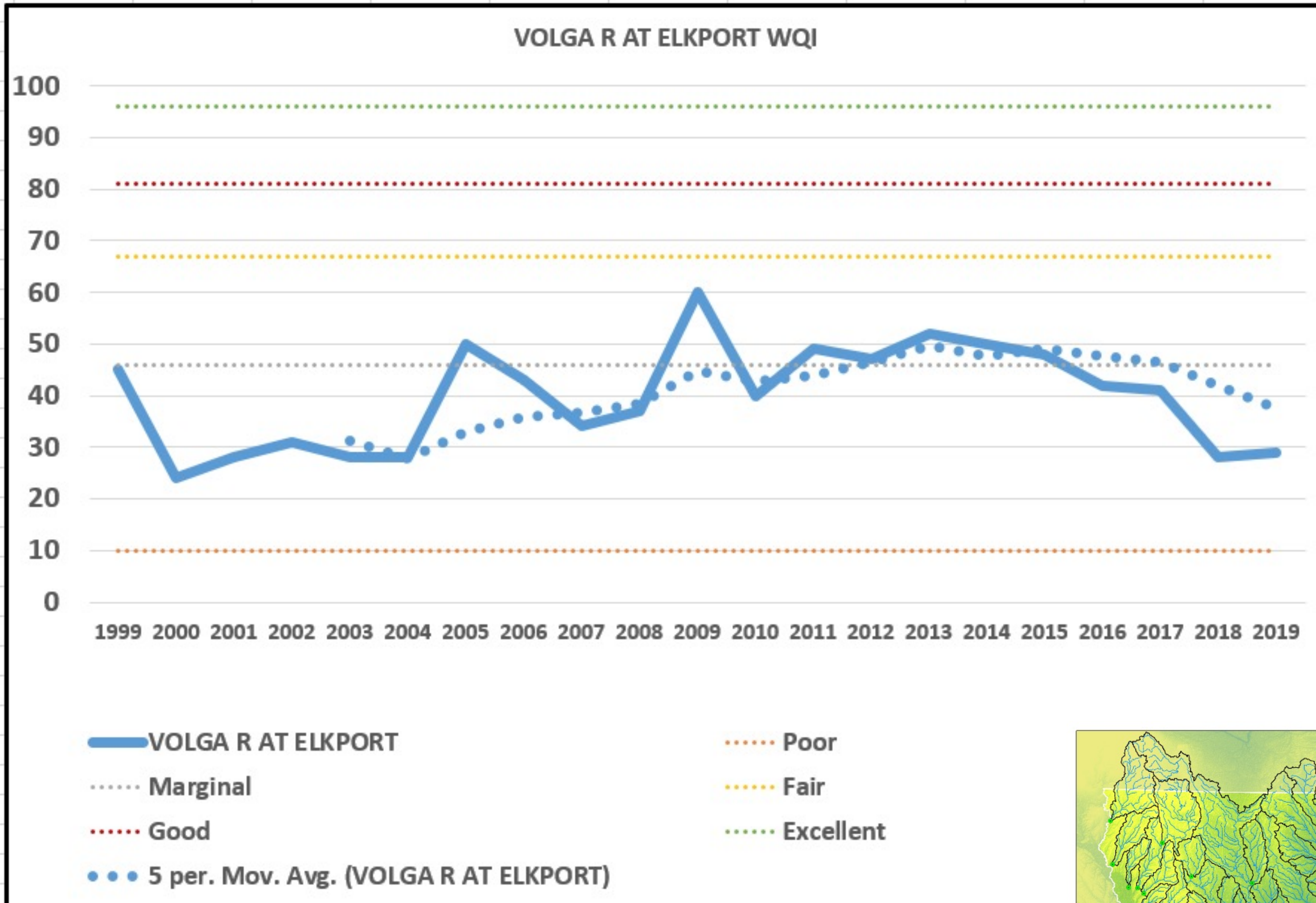

NORTH RIVER AT NORWALK WQI
100
90
80
70
60
50
40
30
20
10
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2
NORTH R. AT NORWALK
Poor
Marginal
Fair
Good
Excellent
5 per. Mov. Avg. (

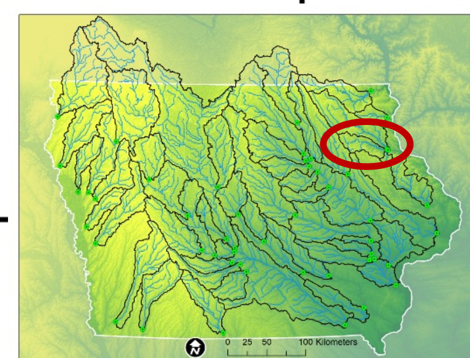

N
0 25 50 100 Kilometers

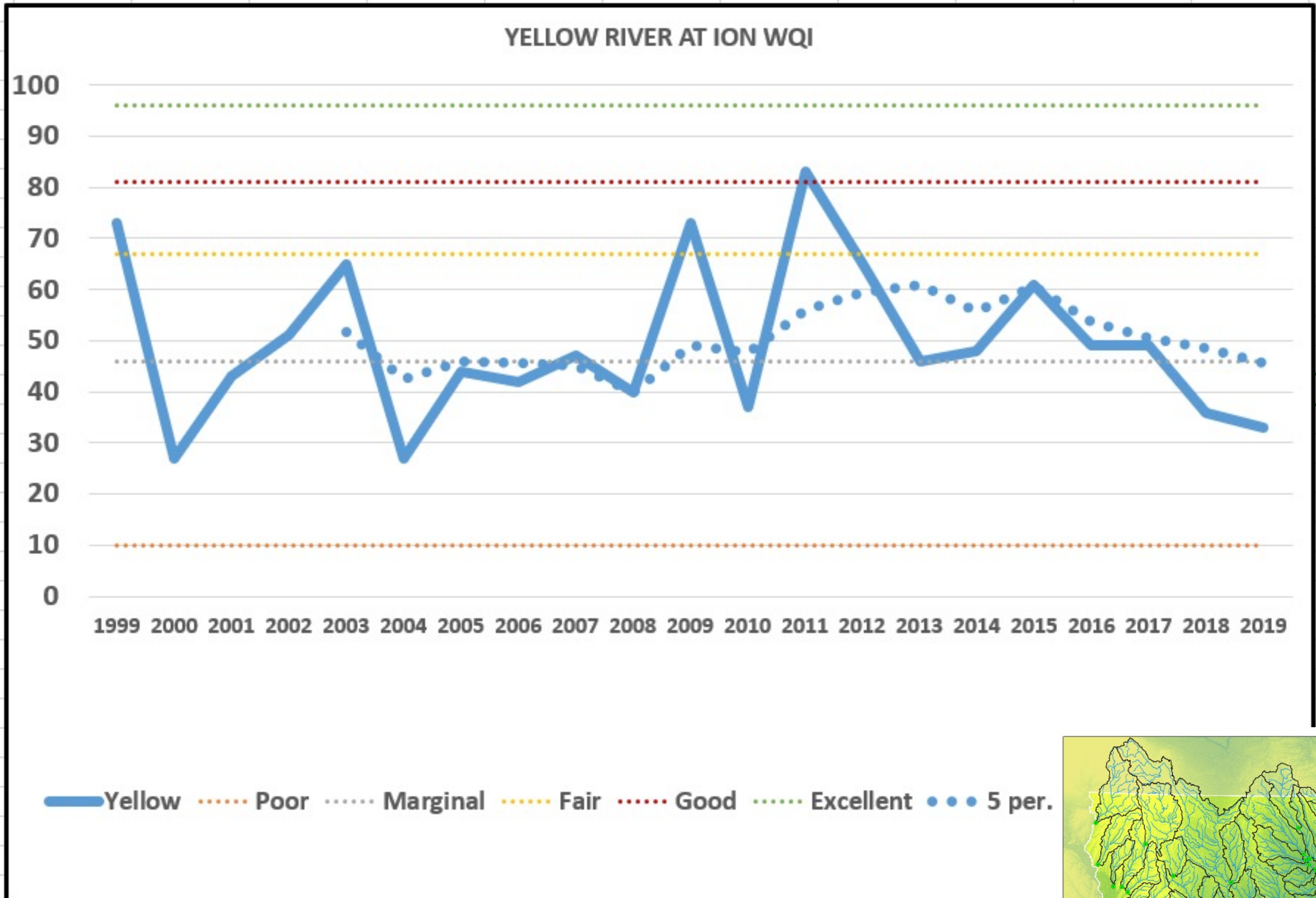

UPPER IOWA RIVER AT DORCHESTER WQI
100
90
80
70
60
50
40
30
20
10
0
1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
UPPER IOWA R. AT DORCHESTER
Poor
Marginal
Fair
Good
Excellent

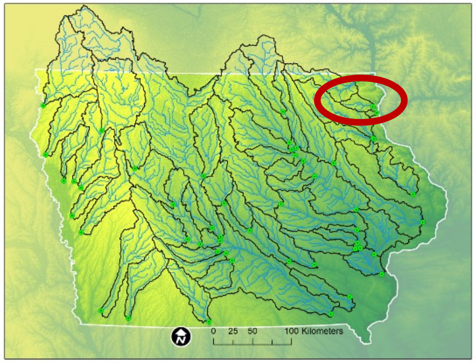

TURKEY RIVER AT GARBER WQI
100
90
80
70
60
50
40
30
20
10
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
TURKEY R AT GARBER
Marginal
Good
5 per. Mov. Avg. (TURKEY R AT GARBER)
Poor
Fair
Excellent

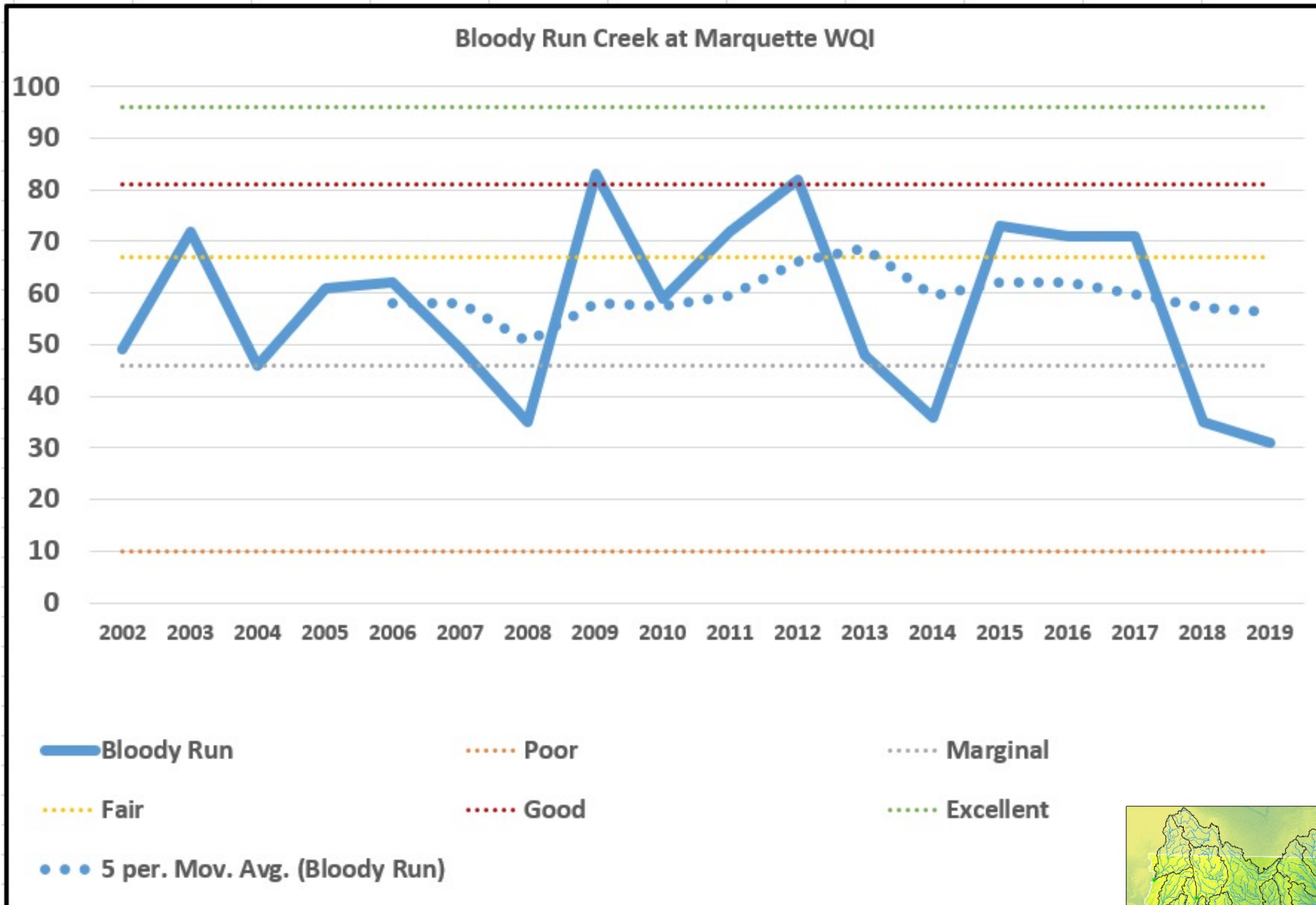


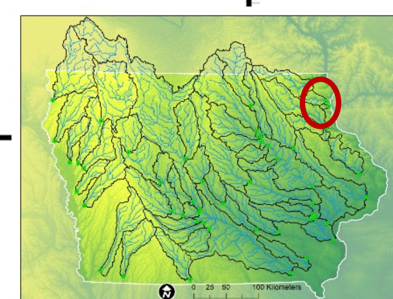

VOLGA R AT ELKPORT WQI
100
90
80
70
60
50
40
30
20
10
0
1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
VOLGA R AT ELKPORT
Marginal
Good
5 per. Mov. Avg. (VOLGA R AT ELKPORT)
Poor
Fair
Excellent

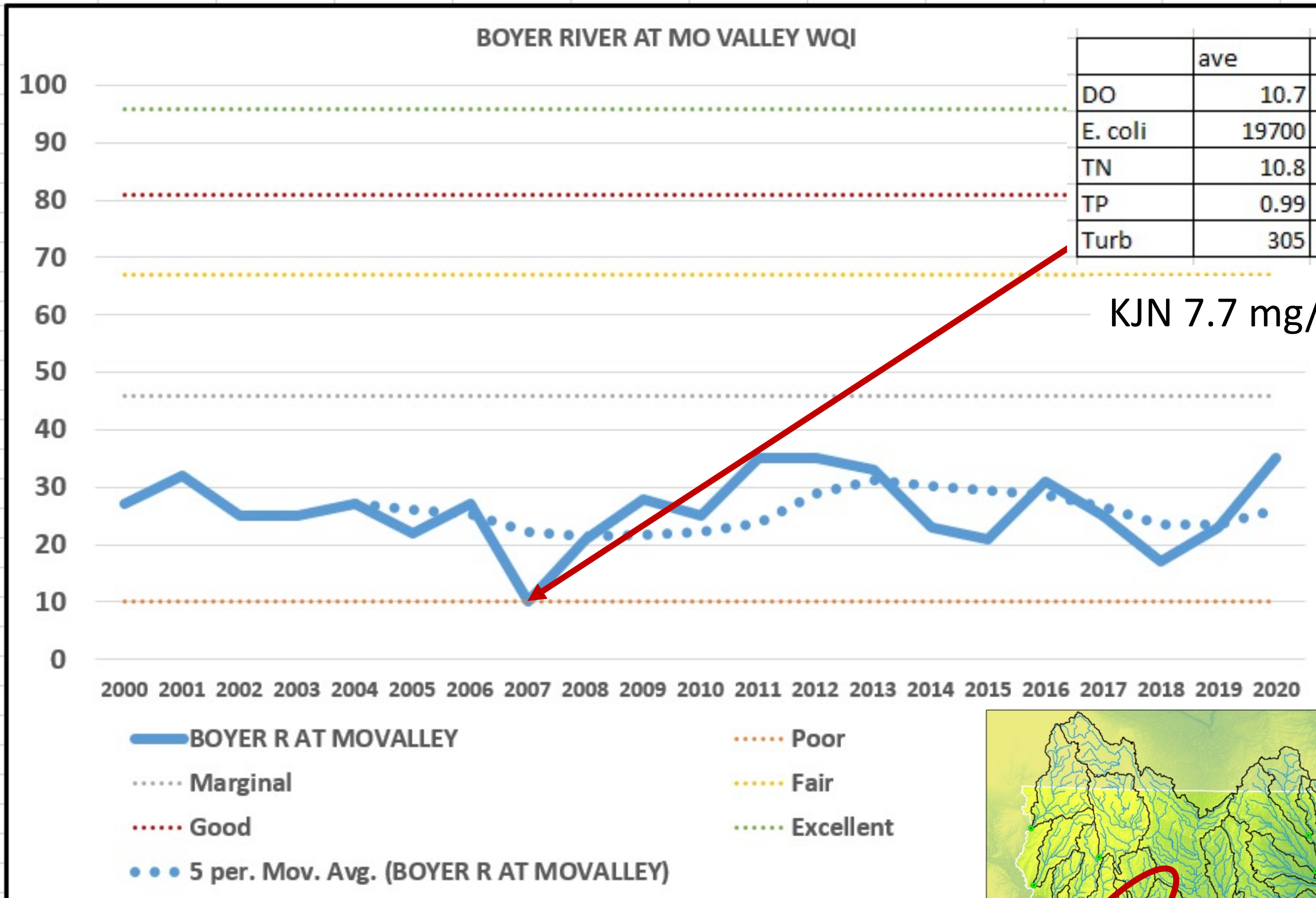



YELLOW RIVER AT ION WQI
100
90
80
70
60
50
40
30
20
10
0
1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Yellow
Poor
Marginal
Fair
Good
Excellent
5 per.



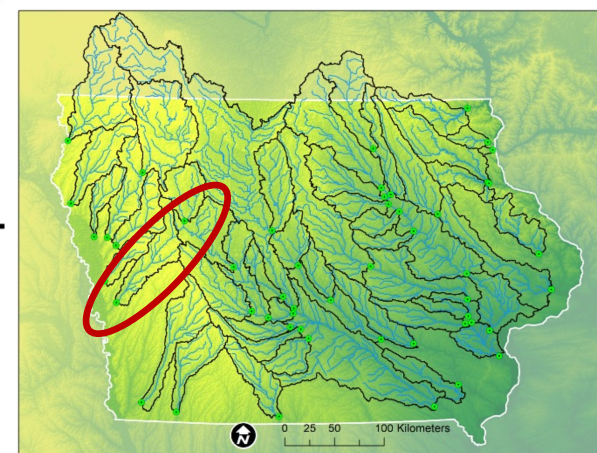

Bloody Run Creek at Marquette WQI
100
90
80
70
60
50
40
30
20
10
0
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Bloody Run
Poor
Marginal
Fair
Good
Excellent
5 per. Mov. Avg. (Bloody Run)





	ave	7-Aug
DO	10.7	4.7
E. coli	19700	220,000
TN	10.8	9.6
TP	0.99	5.4
Turb	305	2600

KJN 7.7 mg/L!



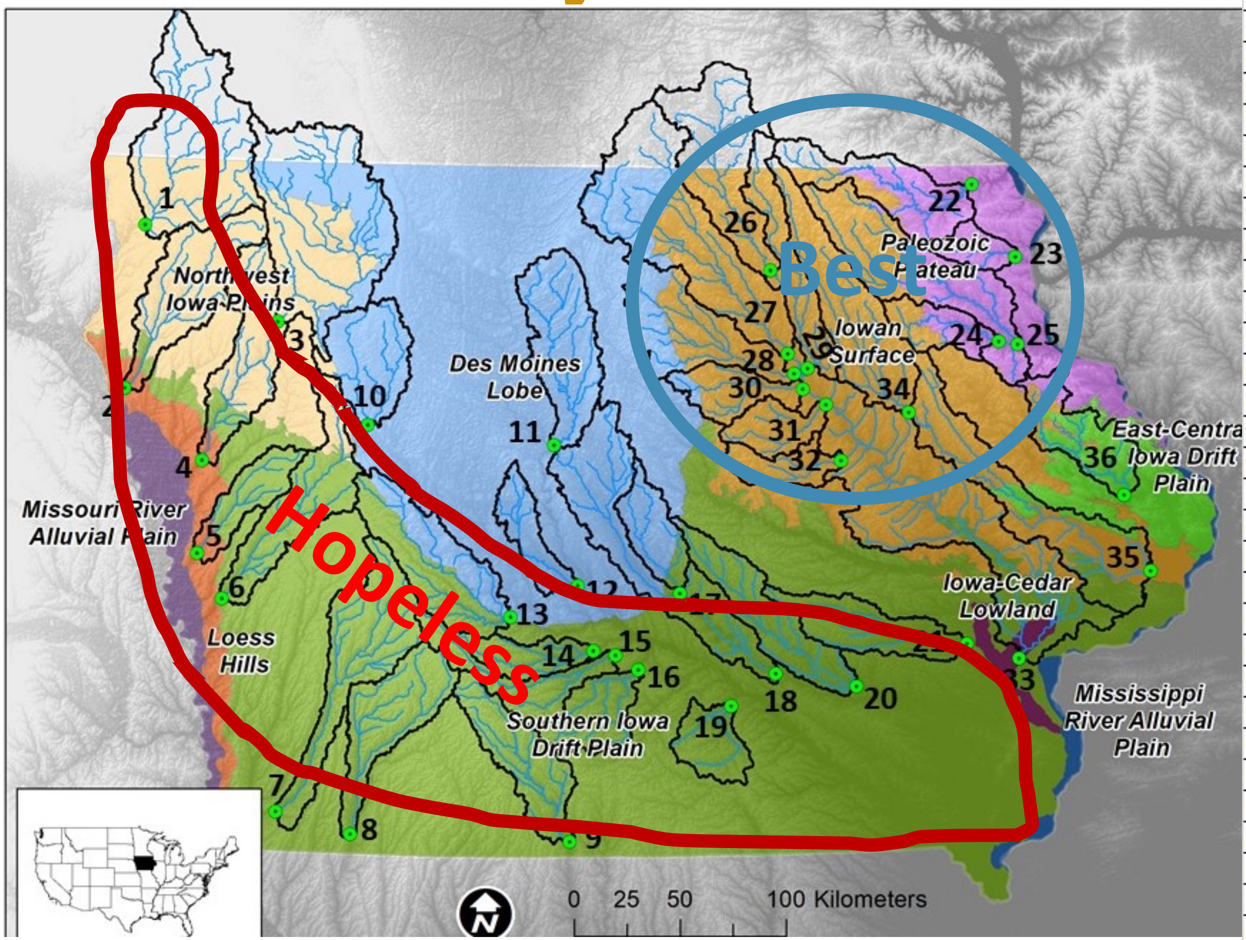
River runner

What parameter(s) are separating Iowa streams?

Parameter	%EXC	EX/TH	AVE VALUE
DO	0.04	0.03	0.24
EC	0.60	0.37	0.57
TN	0.02	0.04	0.00
TP	0.51	0.26	0.58
TURB	0.68	0.16	0.49

Table 3. R2 values calculated from linear regression equations when the percentage of samples exceeding the threshold (%EXC), the average ratio of exceedances:threshold (EXC/TH), and long term average value for the parameter are plotted versus the WQI (2000-2020).

Water Quality Index



Site	Rank	Map #	00-20
Wapsipinicon River at Independence	1	34	53.7
Cedar River at Janesville	2	29	51.7
Shellrock River at Shellrock	3	27	51.7
Cedar River at Charles City	4	26	48.9
Upper Iowa River at Dorchester	5	22	48.1
Yellow River at Ion	6	23	48.1
W. Fork of the Cedar River at Finchford	7	28	47.9
Boone River at Stratford	8	11	45.0
Turkey River at Garber	9	25	43.2
Beaver Creek at Cedar Falls	10	30	42.7
Blackhawk Creek at Waterloo	11	31	42.3
Wapsipinicon River at DeWitt	12	35	41.1
Wolf Creek at LaPorte City	13	32	41.0
Little Sioux River at Larrabee	14	3	40.3
Cedar River at Conesville	15	33	40.1
Thompson River at Davis City	16	9	40.0
Volga River at Elkport	17	24	39.9
Indian Creek at Colfax	18	17	37.9
Cedar Creek at Oakland Mills	19	19	37.4
North Skunk River at Sigourney	20	20	37.1
Beaver Creek at Grimes	21	12	36.8
South Raccoon River at Redfield	22	13	36.4
South River at Ackworth	23	15	36.2
South Skunk River at Oskaloosa	24	18	36.1
North Raccoon at Sac City	25	10	35.0
English River at Riverside	26	21	33.5
W. Nodaway at Shambaugh	27	8	33.3
North River at Norwalk	28	14	33.1
E. Nishnabotna at Shenandoah	29	7	32.8
Middle River at Indianola	30	15	32.4
Rock River at Rock Valley	31	1	32.2
Little Sioux River at Smithland	32	4	31.6
N. Fork Maquoketa R. at Hurtsville	33	36	29.9
Floyd River at Sioux City	34	2	26.8
Soldier River at Pisgah	35	5	26.4
Boyer River at Missouri Valley	36	6	26.0

What Can Be Done?

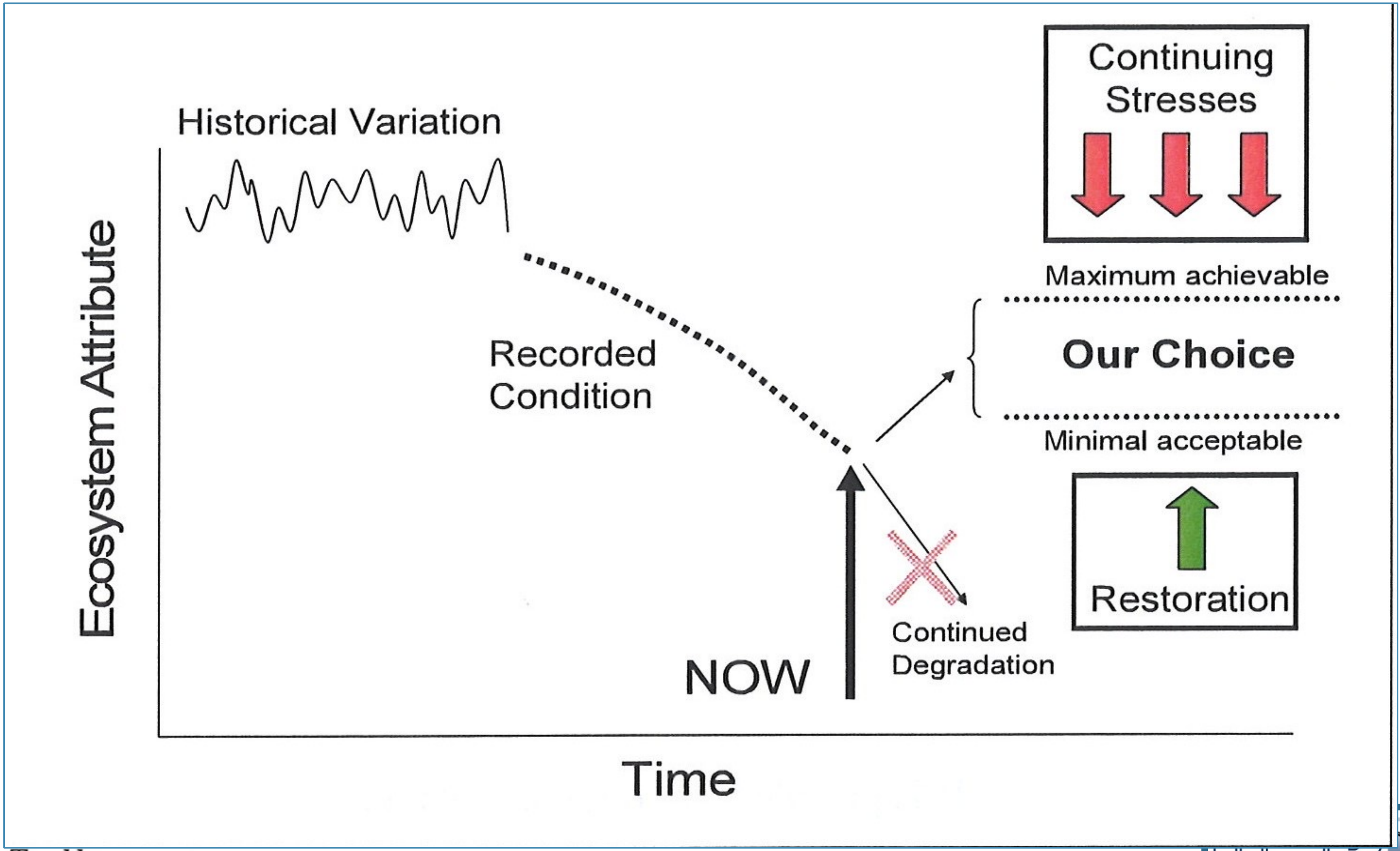
1. Ban cropping in the 2-year Flood Plain

2. Ban fall tillage

3. Ban manure on snow and frozen ground

4. Make farmers adhere to ISU fertilization guidelines

5. Reformulate CAFO Regulations


Continuing Stresses
Historical Variation
Maximum achievable
Our Choice
Minimal acceptable
Recorded Condition
Ecosystem Attribute
Restoration
Continued Degradation
NOW
Time

https://cjones.iihr.uiowa.edu/