Michigan's Statewide Mercury TMDL

Public Meeting

April 15, 2013

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Objectives

- Overview of Total Maximum Daily Loads (TMDLs)
- Overview of mercury impairment across Michigan
- Overview of draft statewide mercury TMDL development
- Receive comments on draft TMDL

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What is a Total Maximum Daily Load (TMDL)?

- Requirement of the Federal Clean Water Act
  - Section 303(d)
- States are required to:
  - List waters not attaining water quality standards
  - Define the amount of pollutant that a water body can receive and still meet water quality standards
    - This amount is defined as a Total Maximum Daily Load
    - Also referred to as maximum allowable load, loading capacity

Background on Total Maximum Daily Loads (TMDLs)

- State assesses waters every two years
  - Determine if a water body is impaired and identify designated uses not being met
  - Identify causes when a water body is impaired (chemical, biological or physical)
  - Indicate possible sources that are contributing to the impairment

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Mercury Impairments across Michigan
What Is Mercury?

- Naturally occurring elemental chemical
  - Chemical symbol Hg
  - Heavy metal
- Many industrial uses
  - Batteries
  - Paint (historical)
  - Lighting
  - Switches
  - Thermometers
  - Dental

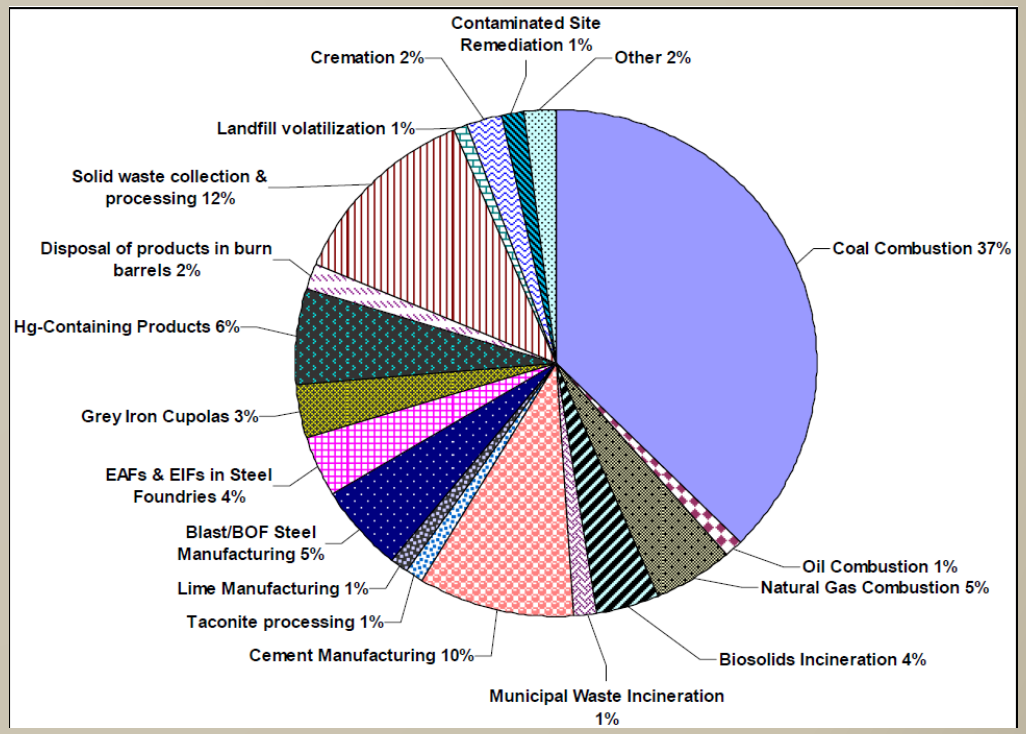
Mercury Impairments across Michigan Environmental Effects

- Causes adverse health effects
- Primary concern is methyl-mercury in fish
  - Low dissolved mercury concentrations can bio-accumulate to high levels in fish
    - 1,000,000x increases

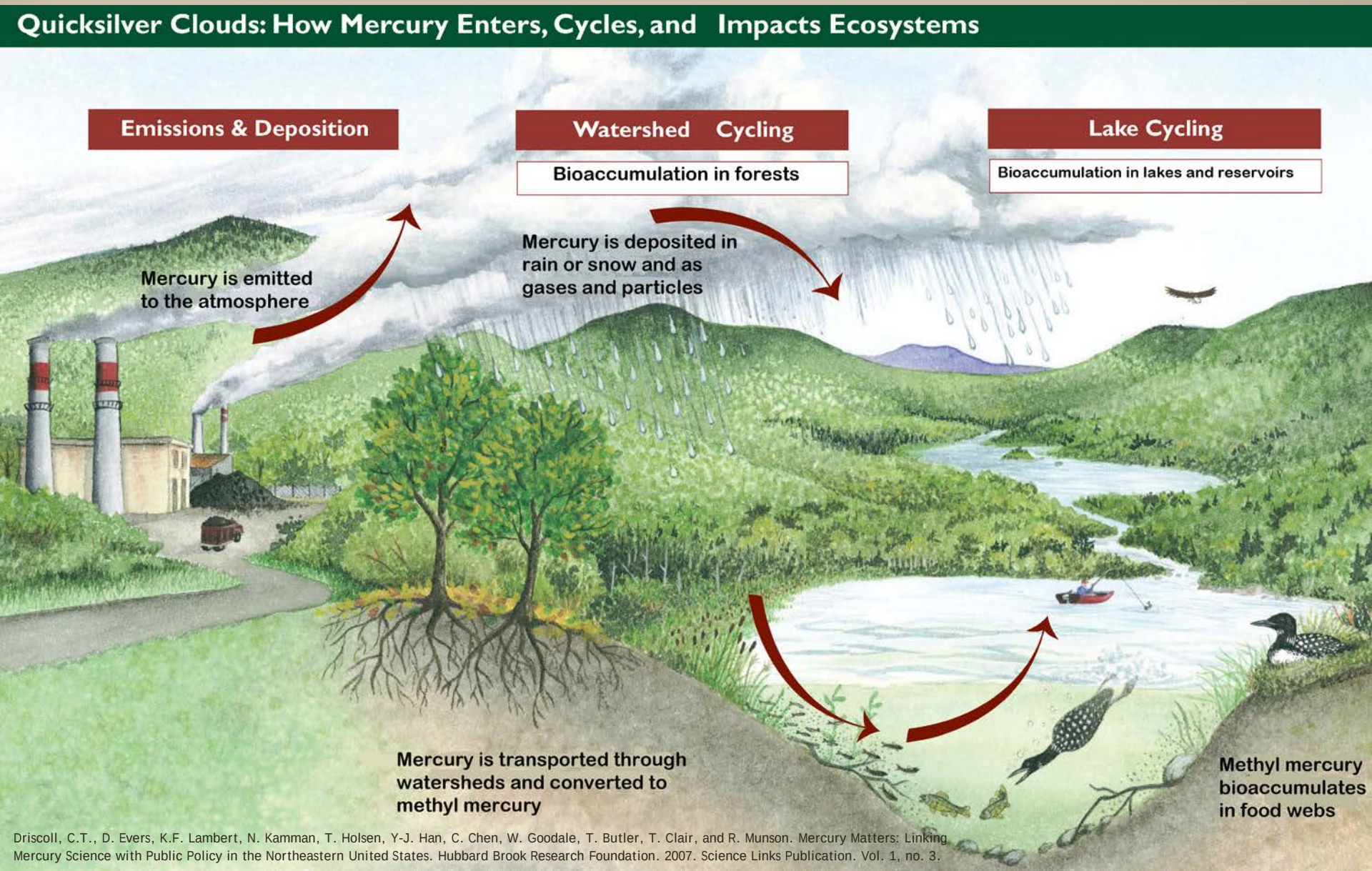
- Consumption of contaminated fish is a significant human health and wildlife concern

Mercury Sources

- MDEQ convened a Mercury Strategy Work Group in 2006
- Primary sources included fuel combustion, industrial sources, and incineration
  - Coal-fired power plants were the single largest industrial source



The Mercury Cycle



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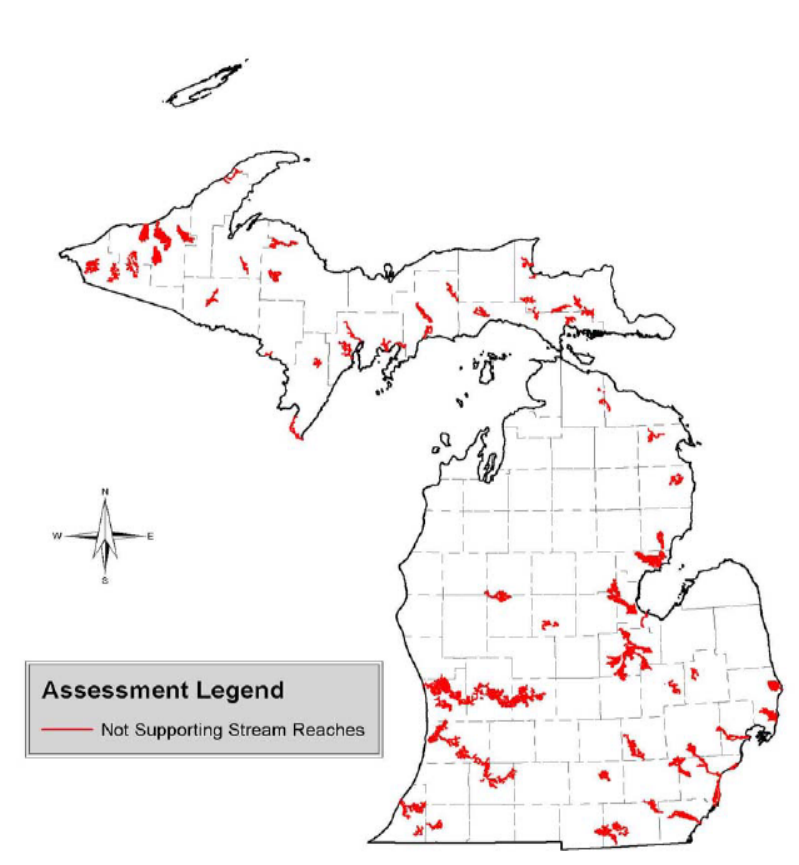
Mercury Impairments to Designated Uses

- Mercury impairments assessed in two ways
  - Water column concentration exceeds water quality standards
    - Geometric mean of at least four water column samples
  - Fish tissue concentration exceeds fish tissue residue value for mercury
    - Average of at least five fish samples of legal size

Mercury Impairments Based on Water Concentration

- 281 water body segments out of 4,709 assessed units are impaired due to mercury in the water column



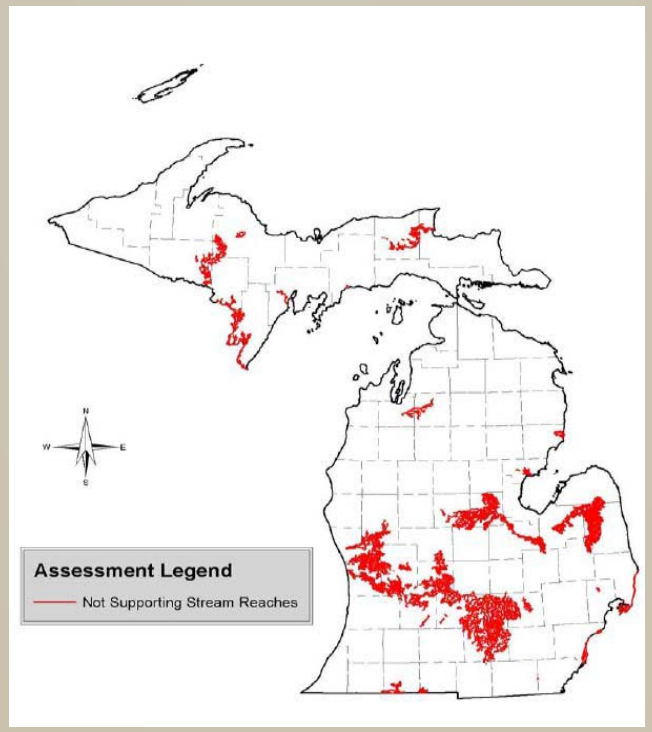
Mercury Concentrations in Surface Water

- The statewide median value of mercury in the water column is 1.1 ng/l
- Values range from 0.15 ng/l to 9.65 ng/l
- ~ 56% of river miles in Michigan are meeting the water column standard of 1.3 ng/l

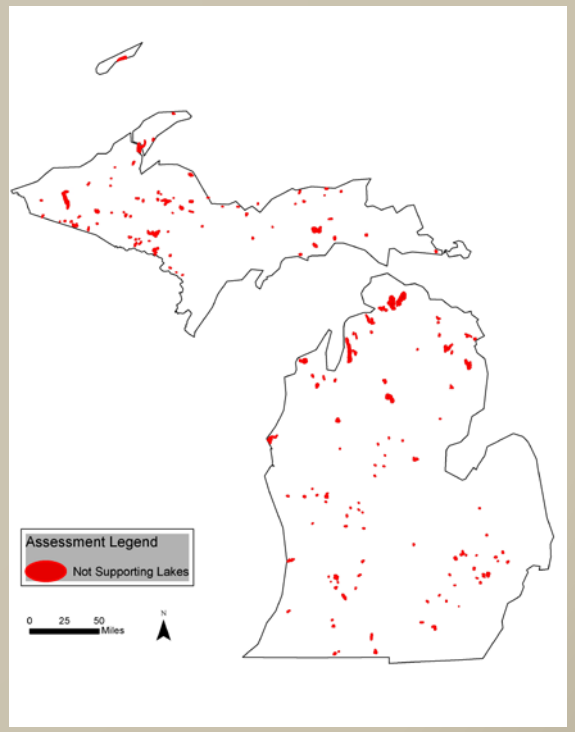
Mercury Impairments Based on Fish Tissue

483 water body segments out of 4,709 assessed units are impaired due to Hg in fish tissue

Streams and Rivers



Lakes



Mercury Impairments: Average Concentration by Fish Species

Species	Average Concentration (mg/kg)	Species	Average Concentration (mg/kg)
Black Buffalo	0.040	Freshwater Drum	0.371
Black Bullhead	0.139	Gizzard Shad	0.037
Black Crappie	0.213	Goldfish	0.100
Bluegill	0.155	Lake Herring	0.236
Brook Trout	0.179	Lake Trout	0.408
Brown Bullhead	0.150	Lake Whitefish	0.131
Brown Trout	0.156	Largemouth Bass	0.401
Bullhead	0.120	Longnose Sucker	0.500
Burbot	0.409	Mirror Carp	0.050
Carp	0.178	Muskellunge	0.483
Channel Catfish	0.185	Northern Hogsucker	0.119
Crappie	0.174	Northern Pike	0.576

Red values exceed target of 0.35 mg/kg

Mercury Impairments: Average Concentration by Fish Species

Species	Average Concentration (mg/kg)	Species	Average Concentration (mg/kg)
Pumpkinseed	0.089	Tiger Muskie	0.230
Rainbow Trout	0.141	Walleye	0.474
Redear Sunfish	0.061	White Bass	0.288
Redhorse Sucker	0.229	White Crappie	0.245
Rock Bass	0.223	White Sucker	0.153
Smallmouth Bass	0.294	Yellow Bullhead	0.303
Splake	0.158	Yellow Perch	0.317
Sunfish	0.352		

Red values exceed target of 0.35 mg/kg

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TMDL Development

- Define Waters to be Addressed
- Determine Numeric TMDL Target
  - How much can we have and not impair designated uses?
- Loading Capacity
  - What is the maximum load that will attain the target?
- Allocate Allowable Load
  - How much does each contributing source need to be reduced?

TMDL Development: Waters to be Addressed

- TMDL focused on inland waters impaired primarily by atmospheric sources
- Waters *not* covered by the TMDL
  - Great Lakes and connecting channels
    - Great Lakes will be covered in a separate TMDL
  - Legacy sites
    - Sediment remediation activities will continue to address legacy site contamination

TMDL Development

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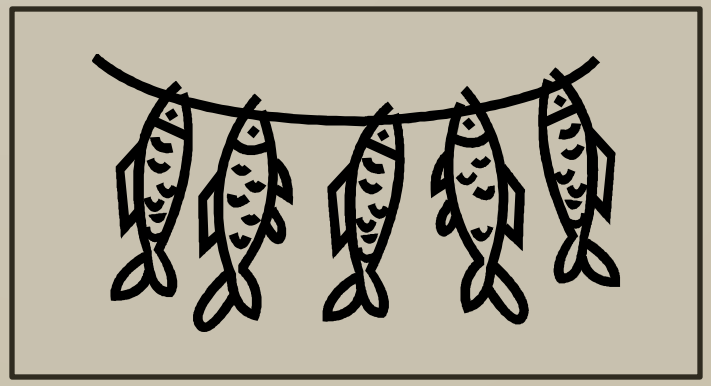
Numeric TMDL Target: Defines acceptable water quality

- TMDL targets must be expressed at a level to demonstrate attainment of State Water Quality Standards (WQS)
- Numeric WQS
  - 0.0013 µg/L for the Wildlife Value
  - 0.0018 µg/L for the Human Non-Cancer Value
  - 0.77 µg/L (as dissolved) for the Final Chronic Value
  - 1.4 µg/L (as dissolved) for the Aquatic Maximum Value

Numeric TMDL Target: Defines acceptable water quality

- TMDL target set at fish tissue mercury concentration of 0.35 mg/kg
  - Consumption of fish by humans and wildlife is the most significant route of exposure
  - Fish tissue target was determined to be consistent with Michigan water quality standards, and federal requirements for the Great Lakes basin (i.e., GLI)



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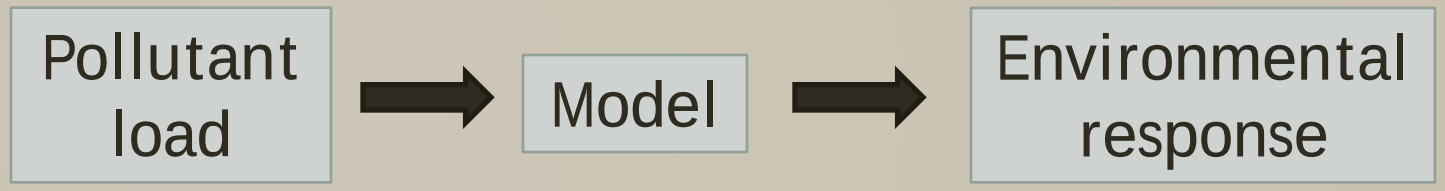
TMDL Development: Modeling

- TMDL is the maximum pollutant load that will attain water quality standards
  - Development of a TMDL requires a means to relate pollutant loading to environmental response
  - This relationship is defined using a water quality model
    - Model is mathematical equation linking pollutant load to environmental response

TMDL Development: Modeling

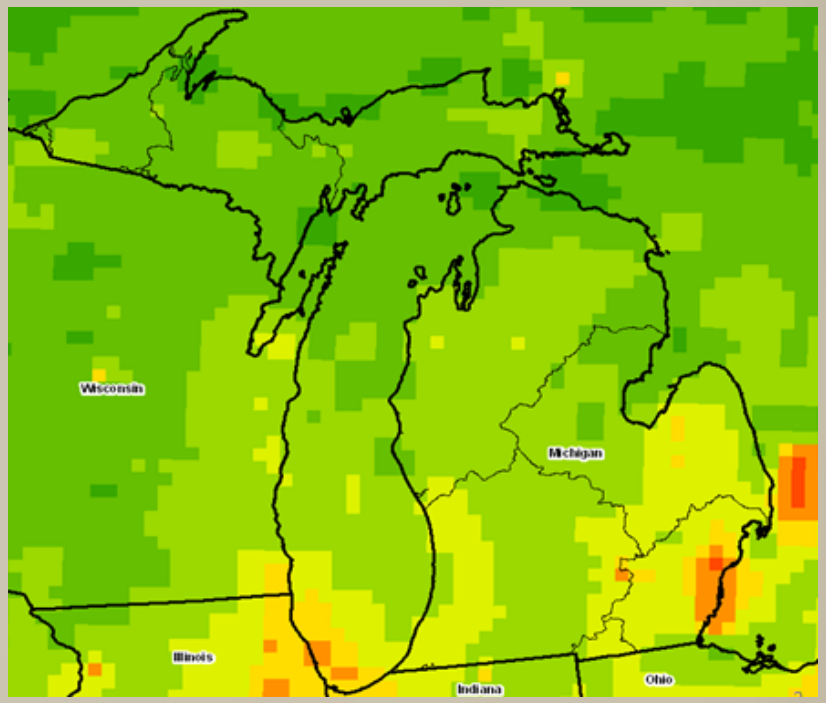
- A model is a mathematical equation linking pollutant load to environmental response



- Model development requires two steps
  - Characterize pollutant load
  - Link pollutant load to environmental response

TMDL Development: Determination of Existing Load

- Atmospheric loading based on U.S. EPA's Regional Modeling System for Aerosols Deposition (REMSAD)
- Statewide average 2001 mercury load = 18.6 $\mu g/m^2/year$



Mercury Deposition ($\mu g/m^2$)

- 4.09 - 11.58
- 11.59 - 16.73
- 16.74 - 22.11
- 22.12 - 27.55
- 27.56 - 34.44
- 34.45 - 54.33
- 54.34 - 139.60
- 139.61 - 450.55

TMDL Development: Linking Mercury Loading to Environmental Response

- Many types of models exist for relating pollutant load to concentration
- A common approach is a simple proportionality model
  - Mercury concentration in fish = a x Mercury load
    - “a” is defined as a proportionality constant

TMDL Development: Determination of Threshold Proportionality Constant

- Proportionality Constant varies from lake to lake and species to species
  - How do we select an appropriate value for a statewide TMDL?
- Follow precedent set by other statewide TMDLs
  - Select a target fish species
  - Select a target percentile

TMDL Development: Selection of a Target Fish Species

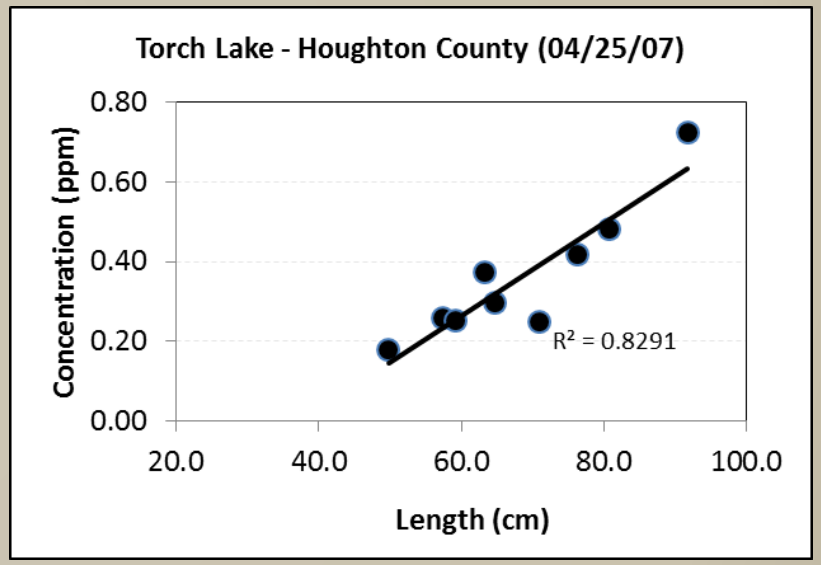
- Northern pike selected as target fish species
  - Top-predator species
  - Highest mercury tissue levels of fish species evaluated
  - Widely distributed throughout the state
  - The most common species representing the impaired waters

TMDL Development: Selection of a Target Percentile

- Not necessarily feasible to base statewide reductions on the water body with the single highest fish tissue mercury concentration
- Fish tissue mercury concentration in 90th percentile water body is used as the basis for reductions
  - Allows for outlier water bodies that may have unique circumstances
  - Consistent with other statewide TMDLs

TMDL Development: Standardization of Pike Length

- Fish tissue mercury concentrations are known to vary based on size of the fish
- Data analyzed to define mercury concentration associated with a 24 inch (61 cm) fish

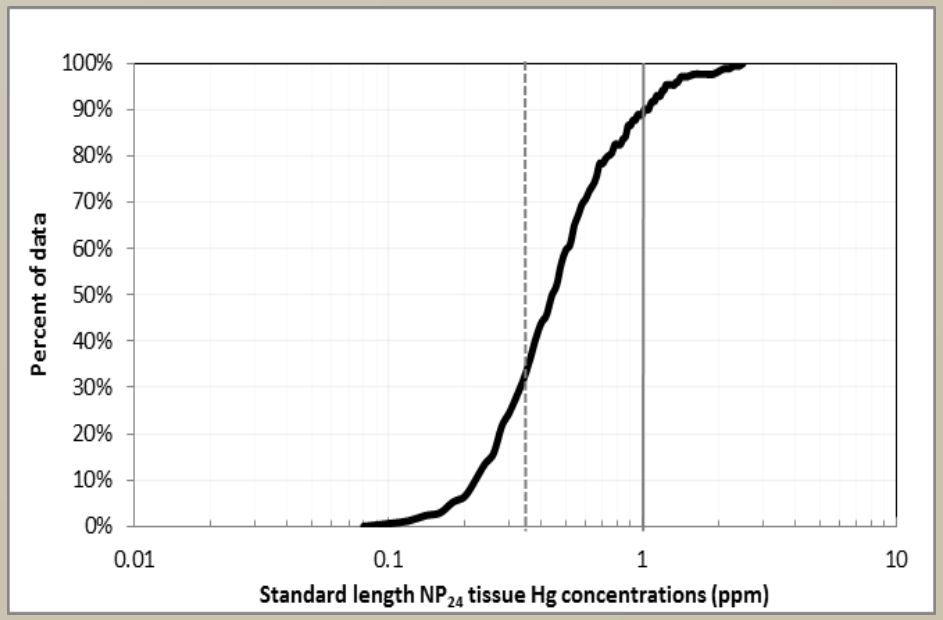


TMDL Development: Determination of Maximum Allowable Load

- Maximum allowable load that will meet TMDL target was determined through the following steps:
  1. Calculate the mercury fish tissue concentration in standard length northern pike for the 90th percentile water body in the state;
  2. Calculate the percentage by which the existing fish tissue concentrations would need to be reduced to attain the 0.35 mg/kg target; and
  3. Apply this reduction percentage to the 2001 atmospheric mercury deposition

TMDL Development: Calculating 90th Percentile Fish Tissue Concentration

- Rank all waters for which northern pike data are available in the form of a cumulative frequency graph
- 90th percentile tissue mercury concentration for a 24 inch northern pike is 1.012 mg/kg



TMDL Development: Calculating Necessary Reduction Factor

- Reduction factor depends on existing and target fish tissue mercury concentrations
  - RF = (Existing Concentration– Target)/Existing Concentration
- Existing concentration is 1.012 mg/kg
- Target concentrations is 0.35 mg/kg
- Reduction factor = (1.012 – 0.35)/1.012 = 65.42%
- Total mercury loading must be reduced 65.42% to attain fish tissue target

TMDL Development: Calculating Existing Baseline Load

- Calculation of maximum allowable load requires understanding of baseline load
  - Maximum allowable load = Baseline Load x Reduction Factor
- Baseline load = Nonpoint Source Load + Point Source Load
- Nonpoint source load consists of a mixture of natural and anthropogenic atmospheric sources
  - Research indicates atmospheric deposition of mercury in Michigan is 20% natural, 80% anthropogenic
  - 3.7 *u*g/m^2 natural, 14.9 *u*g/m^2 anthropogenic

TMDL Development: Calculating Existing Baseline Load

- NPDES permit limits for mercury are based on existing MDEQ Mercury Permitting Strategy
  - Permit limits based on level currently achievable by the permittee (or the WQS of 1.3 ng/l), and implementation of a pollutant minimization program

Type of Discharge	# Facilities	Annual NPDES-Permitted Mercury Load (lbs/yr)	Annual NPDES-Permitted Mercury Load (kg/yr)
Auto Parts Manufacturers	3	0.017	0.008
Landfills	3	0.035	0.016
Mining-related	4	0.498	0.226
Paper Mills	6	2.90	1.31
Power Plants	9	17.2	7.80
Other[1]	4	0.059	0.027
Steel Manufacturers	2	20.7	9.41
Wastewater Treatment Plants	108	45.2	20.5
Total	**139**	**86.6**	**39.3**

[1]Includes Biofuel, Glass Manufacturing, Scrap Metal Recycling, Ott-Story Clean-Up

TMDL Development: Calculating Existing Baseline Load

- The 2001 TSL is the sum of the PSL (from 2012) and NPSL (from 2001).
- NPSL is equal to the atmospheric load of mercury for 2001 provided by the REMSAD model.

Portion of Total Source Load (TSL)	**Units**	**Statewide**
Point Source Load (PSL; NPDES permitted discharge)	kg/yr	39.3
Nonpoint Source Load (NPSL; atmospheric deposition)	kg/yr	2,734
*Natural Nonpoint Source (NNPSL = 0.2 * NPSL)*	*kg/yr*	*547*
Anthropogenic Nonpoint Source (ANPSL = NPSL - NNPSL)	*kg/yr*	*2,187*
Total Source Load (TSL)	kg/yr	2,773

TMDL Development: Calculating Maximum Allowable Load

- Maximum allowable load (TMDL) equals existing baseline load (Total Source Load) multiplied by necessary reduction
  - TMDL = Total Source Load x (1 – Reduction Factor)
- Total source load = 2,773 kg/year
- Reduction factor = 65.42%

- TMDL = 2,773 kg/year x (1 – 0.6542) = 959 kg/year

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Components of a TMDL: Allocations

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$

- *TMDL process requires that the overall load be divided into three categories*
  - Wasteload allocations (WLA): Point source loads
  - Load allocations (LA): Nonpoint source loads
    - This TMDL is unique in that it focuses solely on waters primarily impaired by atmospheric deposition
  - Margin of safety (MOS)
    - Account for uncertainties in the relationship between pollutant loading and receiving water quality, technical uncertainties such as model predictions, and analysis of technical data

Allocation: Components of a TMDL

- Wasteload Allocations (WLA)
  - Wasteload allocations for point source discharges must be based on meeting the WQS of 1.3 ng/l
  - An aggregate WLA of 6.0 kg/yr has been allocated for point source discharges
  - WLA is equal to the sum of the design flows (3,075 mgd) for facilities with existing mercury limits in permits, multiplied by the WQS of 1.3 ng/l, or 5.51 kg/yr.
  - A reserve capacity of 0.5 kg/yr was added to allow the permitting of new discharges of mercury that must meet the WQS of 1.3 ng/l

Allocation: Components of a TMDL

- Mercury Permitting Strategy – Existing Mercury Discharges
- Establishment of a Multiple Discharge Variance (MDV) that was consistent with the Part 4 WQS Variance rule (R323.1103)
- MDV is a temporary measure and does not take the place of a WQS
- Requires in the NPDES permit, and effluent limitation that represents a discharge-specific, level currently achievable (LCA), and implementation of a pollutant minimization program (PMP) that furthers efforts to meet the mercury WQS of 1.3 ng/l

Allocation: Components of a TMDL

- Point sources are only a small fraction (1.4%) of the total mercury load to Michigan's waters
- The NPDES Mercury Permitting Strategy is currently in place for permitting mercury point source discharges and will continue as part of the implementation of the TMDL
- This statewide mercury TMDL is specifically designed to address waters primarily impaired by atmospheric sources
- A detailed list of NPDES-permitted point sources that discharge mercury to inland waters, and that have permit limitations for mercury, is provided in Appendix B of the draft TMDL

Allocation: Components of a TMDL

- Load allocations (LA)
  - Total load allocation determined by subtracting the WLA from the TMDL
    - TMDL = WLA + LA; LA = TMDL – WLA
    - LA = 959 kg/year – 6.0 kg/year = 953 kg/year
  - Important to recognize that the load allocation is comprised of controllable (by DEQ) and non-controllable sources
    - Controllable: Anthropogenic sources originating in Michigan
    - Non-controllable: Natural sources; Anthropogenic sources originating outside of Michigan

Allocation: Distinguishing In-State from Out-State Mercury Sources

- REMSAD model results define origin of atmospheric mercury deposited in Michigan

Source Category of Atmospheric Mercury	Load (kg)	Load (lbs)	% Load
Background	2,060	4,532	75.3%
Re-emission	93	205	3.4%
Michigan	213	469	7.8%
Loading from surrounding states and Canada	264	581	9.6%
Illinois	58	128	2.1%
Indiana	41	90	1.5%
Minnesota	5	11	0.2%
Ohio	62	136	2.3%
Wisconsin	32	70	1.2%
Canada	66	145	2.4%
Loading from other US states and Mexico	104	229	3.8%
Total	2,734	6,015	100.0%

Allocation: Distinguishing Natural from Anthropogenic Mercury Sources

Portion of Load Allocation	**Annual Result**
Load Allocation (LA)	953 kg/yr
Natural Load Allocation (NLA = Natural Nonpoint Source Load)	547 kg/yr
Anthropogenic Load Allocation (ALA = LA – NLA)	406 kg/yr

Allocation: Accounting for Controllable In-State Mercury Sources

- Michigan's deposition sources are 20% natural and 80% anthropogenic

Portion of Load Allocation	Load Allocation
Proportion of anthropogenic deposition	80%
Michigan's fraction of anthropogenic sources (7.8% ÷ 80%)	9.75%
In-state contribution to LA [0.0975*ALA]	40 kg/yr
Out-of-state contribution to LA	913 kg/yr
*Anthropogenic source contribution [1 - 0.0975*ALA]*	367 kg/yr
Natural source contribution	*547 kg/yr*

- Load allocation for Michigan-based sources is 40 kg/year

Allocation: Target Emissions

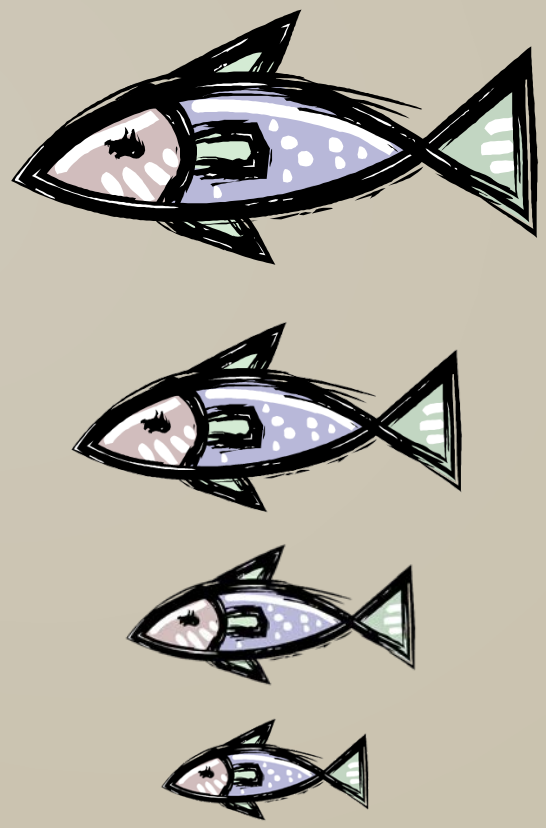
- 65.42% reduction in total deposition translates to 82% reduction in anthropogenic deposition

65.42% ÷ 80% (Anthropogenic) * 100 = 82%

Category	Unit	Atmospheric Mercury Emissions
2002 Estimated Emissions	kg/yr	3,272
Target Reduction Rate in Michigan's Anthropogenic Emissions		82%
Target Emissions [2002 emissions * (1- 0.82 reduction)]	kg/yr	589

Allocation: Components of a TMDL

- Margin of safety (MOS) - *implicit* for this TMDL
- Reductions based on species with highest levels of mercury



Calculation of Maximum *Daily* Load

- Water quality model used for TMDL is based on annual average atmospheric concentrations
  - Fish tissue concentration responds very slowly to changes in atmospheric concentration
- TMDLs should define maximum “daily” load
  - REMSAD model results do not provide daily resolution
  - Daily load estimated for TMDL consists of annual load divided 365

Summary of Michigan's Statewide Mercury TMDL

TMDL Components	Units	
Target Level and Reduction Factor		
Target Fish Mercury Concentration (Fish Tissue Residue Value)	mg/kg	0.35
Mercury Concentration for Standard Length Northern Pike	mg/kg	1.01
Reduction Factor	65%	
Mercury Load for Baseline Year 2001		
Point Source Load (PSL)	kg/day	0.11
Nonpoint Source Load (NPSL)	kg/day	7.49
Total Source Load (TSL)	kg/day	7.60
Final TMDL		
Margin of Safety	Implicit	
Wasteload Allocation (WLA)	kg/day	0.016
Load Allocation (LA) (natural and anthropogenic)	kg/day	2.61
Mercury Load Allocation for In-State and Out-of-State Deposition Sources		
In-State Contribution to LA (anthropogenic)	kg/day	0.11
Out-of-State Contribution to LA (natural and anthropogenic)	kg/day	2.50
Necessary Reduction from Anthropogenic Emission Sources		82%

Implementation

- How do we obtain the necessary reductions?
  - Unlike point source discharges to water, the TMDL program has no direct regulatory control over atmospheric sources of mercury

Implementation Actions

- Clean-up of Legacy Sources
- Voluntary Activities
- Regulatory Activities
  - Federal and State Regulations
  - Michigan Legislation
- NPDES Program Control of Mercury to Surface Waters

Implementation Actions

- Clean Up of Legacy Sources
  - Michigan currently has 86 Superfund sites, and 14 Areas of Concern; some are contaminated by mercury
  - Clean-up plans are in place for all of these sites

Implementation Actions: Voluntary Activities

- MDEQ Mercury Strategy contains goal to eliminate anthropogenic mercury use and emissions
  - Strategy contains over 60 recommendations, and 10 recommendations are prioritized.
  - MDEQ received an U.S. EPA Great Lakes Restoration Initiative grant to implement the Strategy
- MDEQ has worked to reduce mercury use and educate the public on proper ways to dispose of mercury-containing items
- Great Lakes Regional Collaboration has continued the successful efforts of the Great Lakes Binational Toxics Strategy

Implementation Actions: Regulatory Activities

- Air – State
  - MDEQ air quality regulatory programs control mercury released from point sources through the air permitting process
- Air – Federal
  - Federal Clean Air Act requires U.S. EPA to regulate emissions of toxic air pollutants, including mercury
  - MDEQ further reducing mercury emissions from coal-fired electric generating units, consistent with EPA's Mercury Air Toxics Standards
  - MDEQ will be following the federal National Emissions Standards for Hazardous Air Pollutants for cement plants

Implementation Actions: Regulatory Activities

- Michigan has passed several pieces of legislation to reduce the use and release of mercury into the air and waters of the state
  - Dental Mercury Amalgam Separators
  - Mercury-free State Purchasing
  - Mercury Thermometer Sales Ban
  - Mercury Thermostat Sales Ban
  - Legislation limiting the uncontrolled open burning of household waste

Implementation Actions: Regulatory Activities

- NPDES Program Control of Mercury to Surface Waters
  - Michigan Rules provide conditions under which variances have been granted to permit limits
    - e.g. widespread compliance issues, presence of ubiquitous pollutants or naturally high background levels of pollutant
  - MDEQ has concluded that end-of-pipe treatment is generally not the most cost-effective method to reduce mercury
  - Michigan has a commitment to the use of pollution prevention, source control, and other waste minimization programs to achieve compliance with low permit limits
    - Each NPDES permit that includes a variance for mercury contains a requirement to develop and implement a minimization plan for mercury

Summary

- The maximum amount of mercury loading to Michigan waters that will result in attainment of water quality standards has been defined
- Reductions must come from atmospheric sources
- A series of implementation actions are being undertaken to reduce mercury loading to acceptable levels

Objectives

- Overview of Total Maximum Daily Loads (TMDLs)
- Overview of mercury impairment across Michigan
- Overview of draft statewide mercury TMDL development
- Receive comments on draft TMDL

Public Participation/Involvement

Written comments are being accepted until June 30, 2013.
Please submit comments on the draft Mercury TMDL to:

Ms. Sylvia Heaton
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Water Resources Division
P.O. Box 30458
Lansing, MI 48909-7958

For additional information

Michigan DEQ website: www.michigan.gov/DEQ

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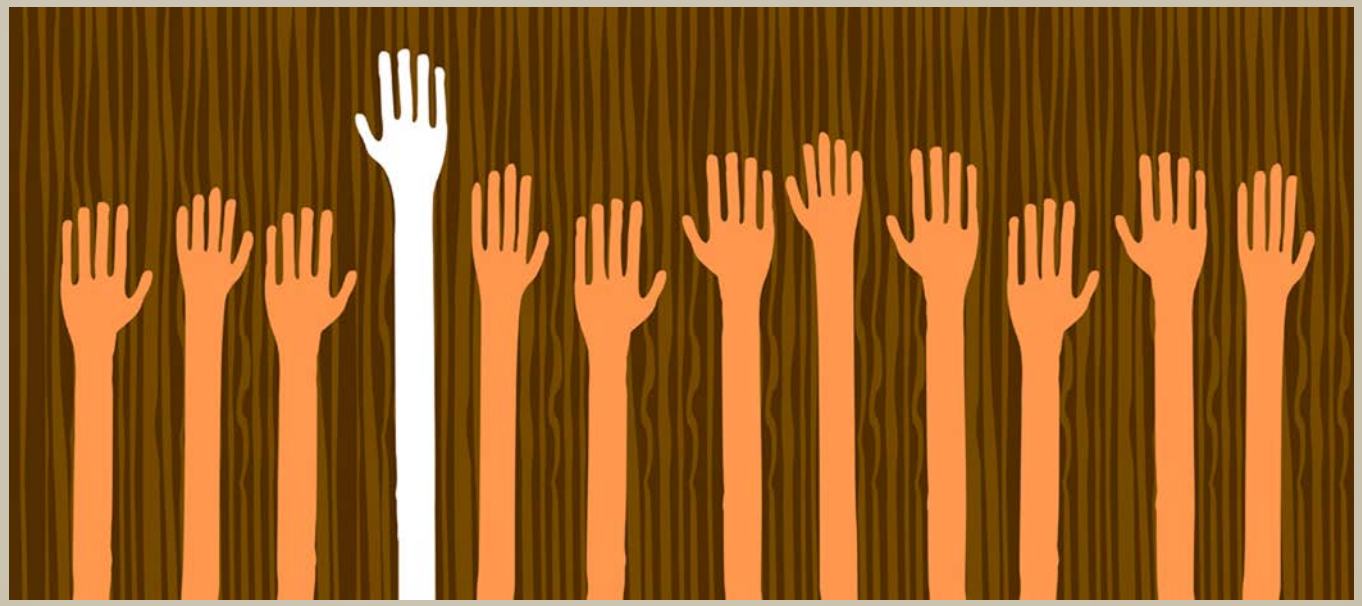
Questions or Comments on Today's Presentation?