Madison River

Overview of Proposed Arsenic Criteria Development and Preliminary Modeling Results

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Montana's Current Arsenic Standard

- Human health standard for surface water and groundwater – **10 ug/L**
- Aquatic life standards
  - Acute – 340 ug/L
  - Chronic – 150 ug/L
- Yellowstone, Madison and Missouri Rivers "use" designations – "*drinking water with conventional treatment*"

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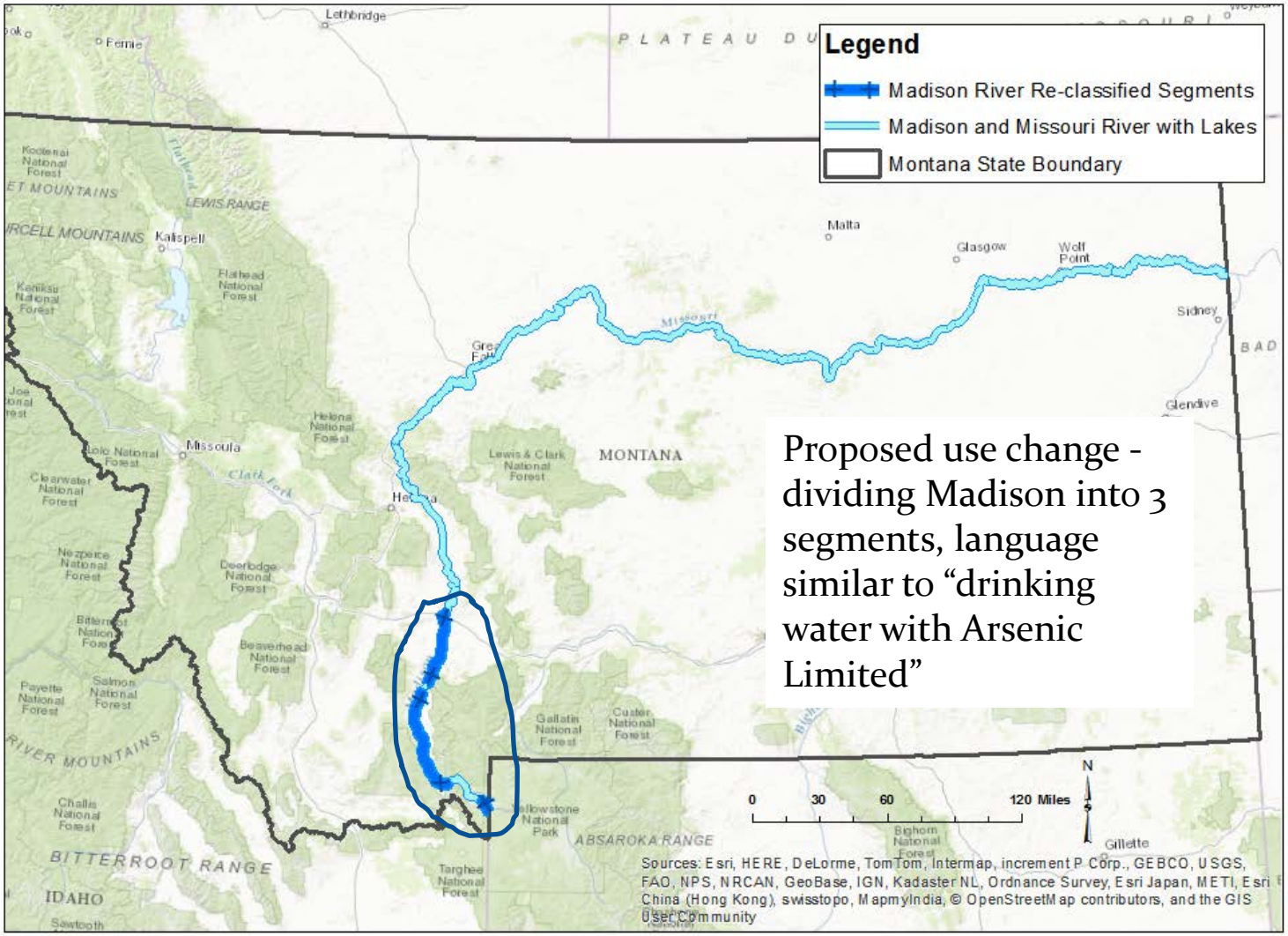
Proposed Re-Classified Segments for Madison River



Proposed use change - dividing Madison into 3 segments, language similar to "drinking water with Arsenic Limited"

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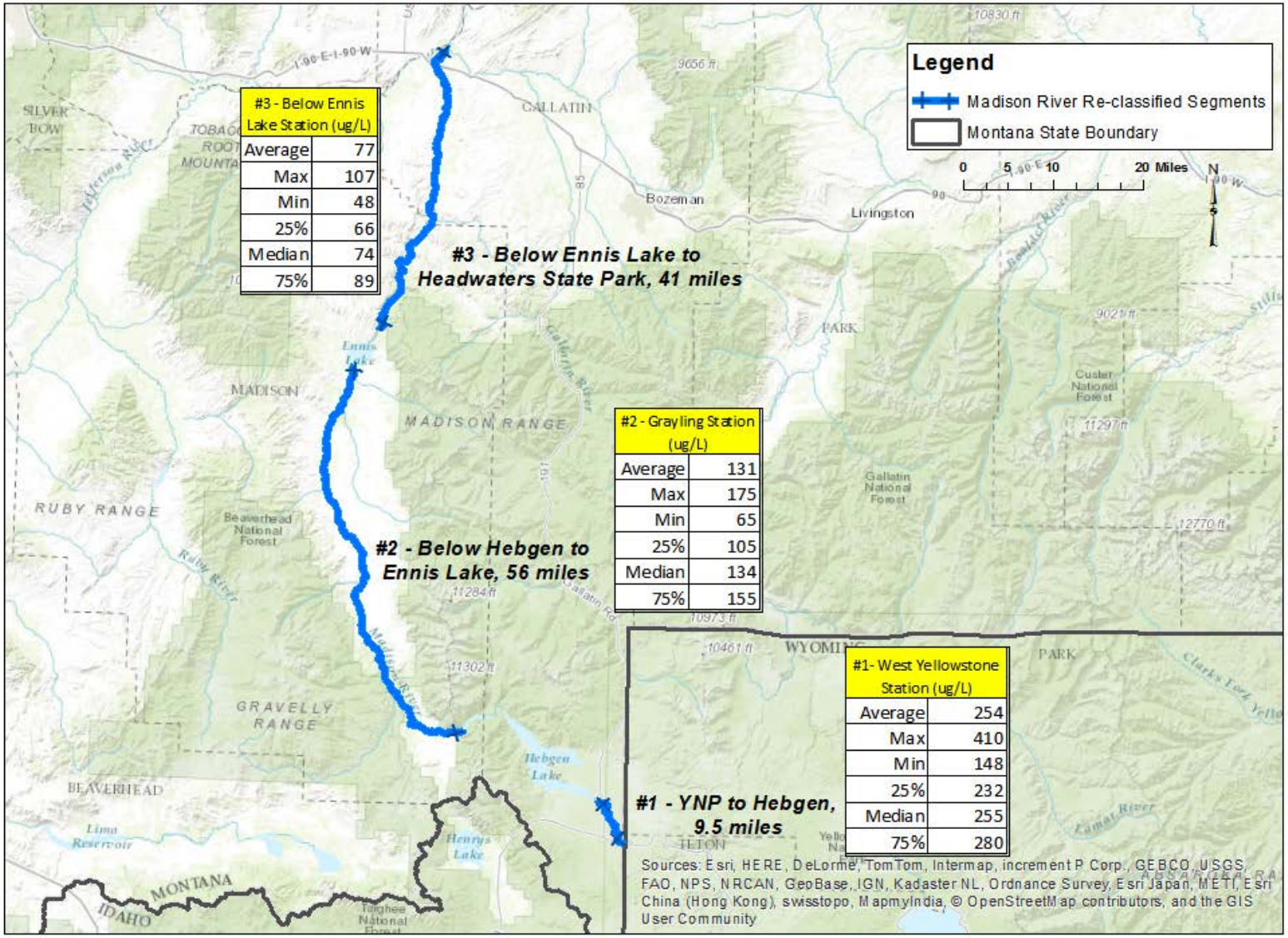
Proposed Re-Classified Segments for Madison River

With Baseflow Concentrations Based on Daily Modeled Estimates (1995 - 2015)



#3 - Below Ennis Lake Station (ug/L)	
Average	77
Max	107
Min	48
25%	66
Median	74
75%	89

#2 - Grayling Station (ug/L)	
Average	131
Max	175
Min	65
25%	105
Median	134
75%	155

#1- West Yellowstone Station (ug/L)	
Average	254
Max	410
Min	148
25%	232
Median	255
75%	280

***Preliminary Results – Concentrations represent both Anthropogenic and Non-anthropogenic inputs.**

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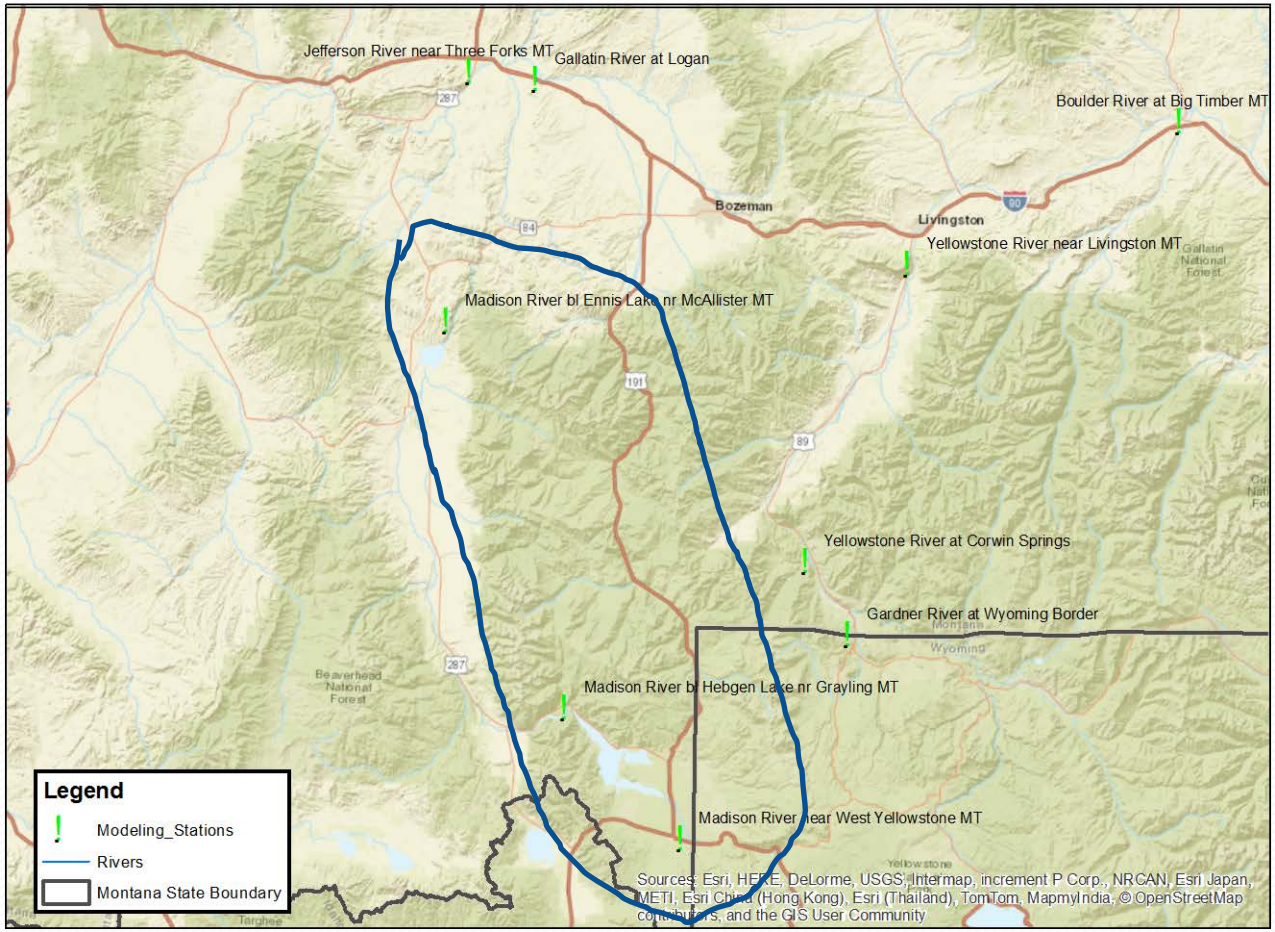
Existing USGS Stations to be Modeled



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Mass Load Equation – The total of Arsenic Mass Loads

∑ TAL = YNP + PSL + GW + Trib + RO

∑ TAL - Total Arsenic Load of a sampling location, based on flow rate and concentration at a specific time

YNP - Geothermal arsenic load from the Yellowstone Caldera, @ the park boundary, **∑ TAL = YNP**

PSL – Point source arsenic load, permitted discharge operations

GW – Groundwater arsenic load contribution

Trib – Surface water discharge into the main stems from the major tributaries

RO – Surface water runoff

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Modeling ∑ TAL

LOADEST, USGS Model, and **LOADRUNNER** (Utility), Yale School of Forestry and Environmental Science

- Program that finds a best fit data model for flux as a function of discharge, then extrapolates these relationships to estimate flux from daily flow data.
- Inputs
  - Flow Data
  - Water Quality Data – TRC Arsenic
- Outputs
  - Daily Load (kg/Day) and Concentration (ug/L) estimates for the time period modeled
  - Calibration and modeling statistics for each site

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Assumptions

- A minimum of twelve concentration data points is needed to calibrate.
- Modeling stations are existing USGS stations with years of daily hydrologic data
- Only Total Recoverable Arsenic is modeled
- The modeling results estimate a total arsenic load and concentration for a station. This result includes both anthropogenic and non-anthropogenic arsenic
- Anthropogenic arsenic inputs must be estimated separately and subtracted from the final results of the model

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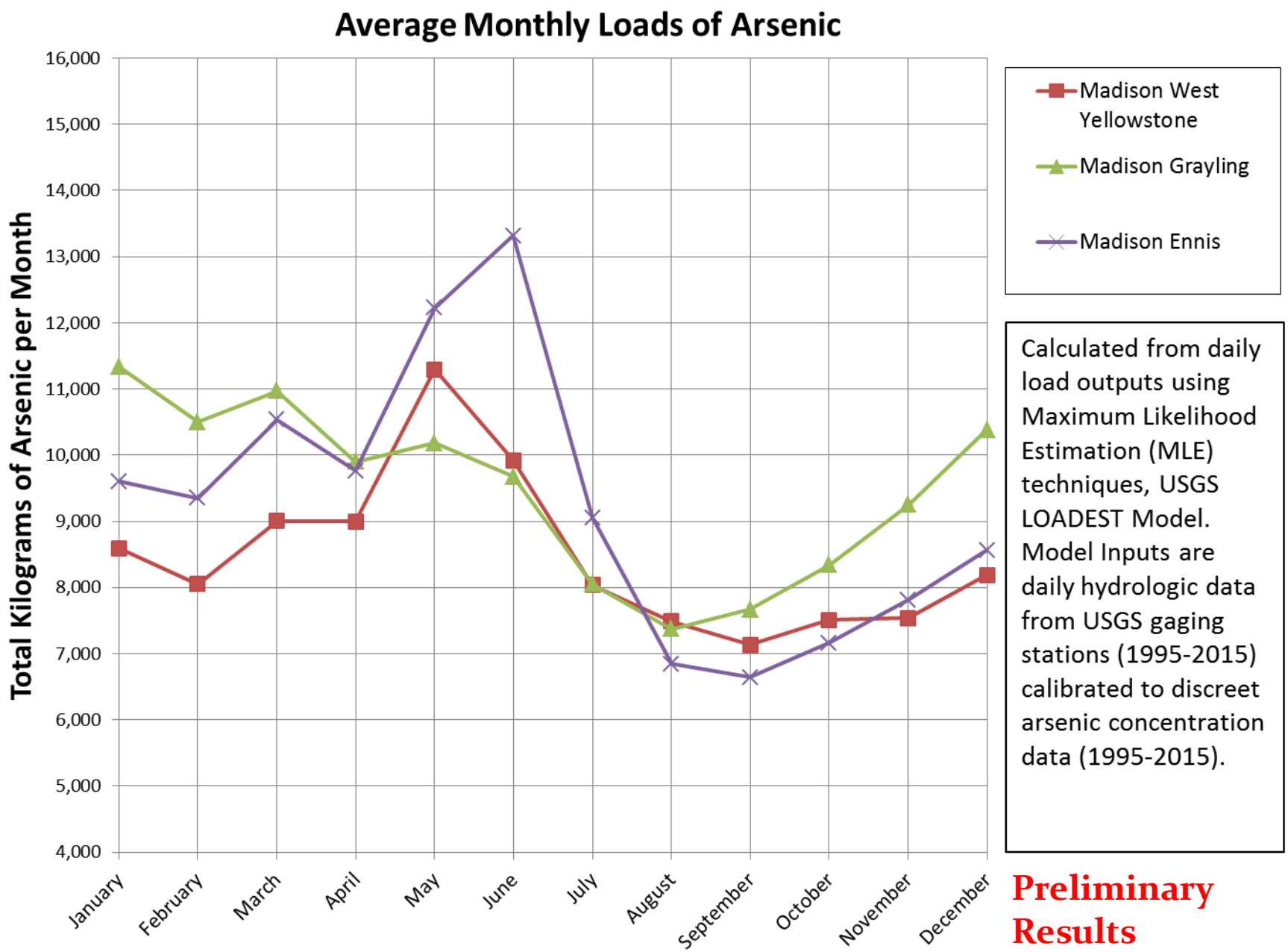
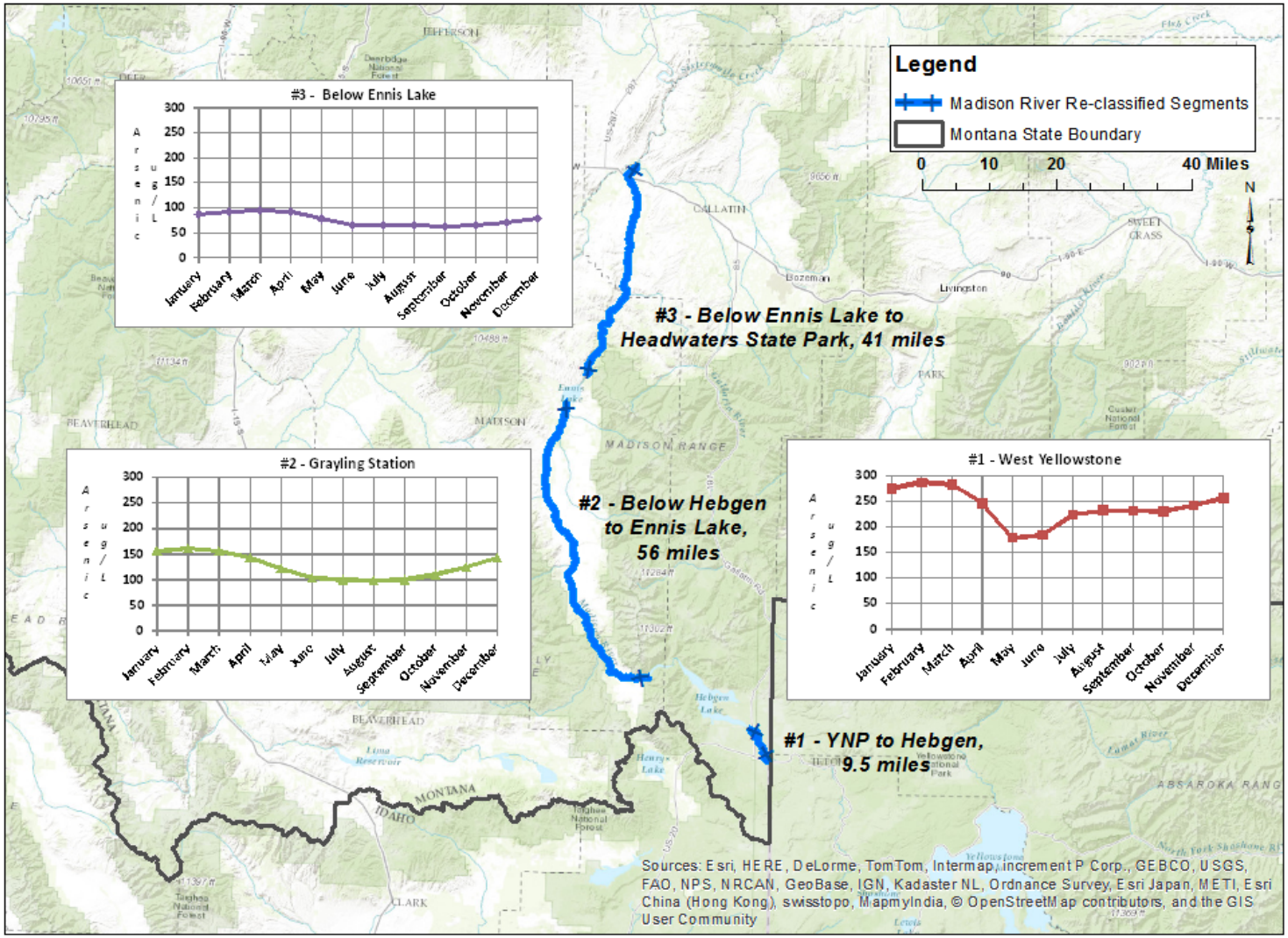


Calculated from daily load outputs using Maximum Likelihood Estimation (MLE) techniques, USGS LOADEST Model. Model Inputs are daily hydrologic data from USGS gaging stations (1995-2015) calibrated to discreet arsenic concentration data (1995-2015).

Preliminary Results

Proposed Re-Classified Segments for Madison River

With Average Monthly Concentrations from Daily Modeled Estimates (1995 - 2015)



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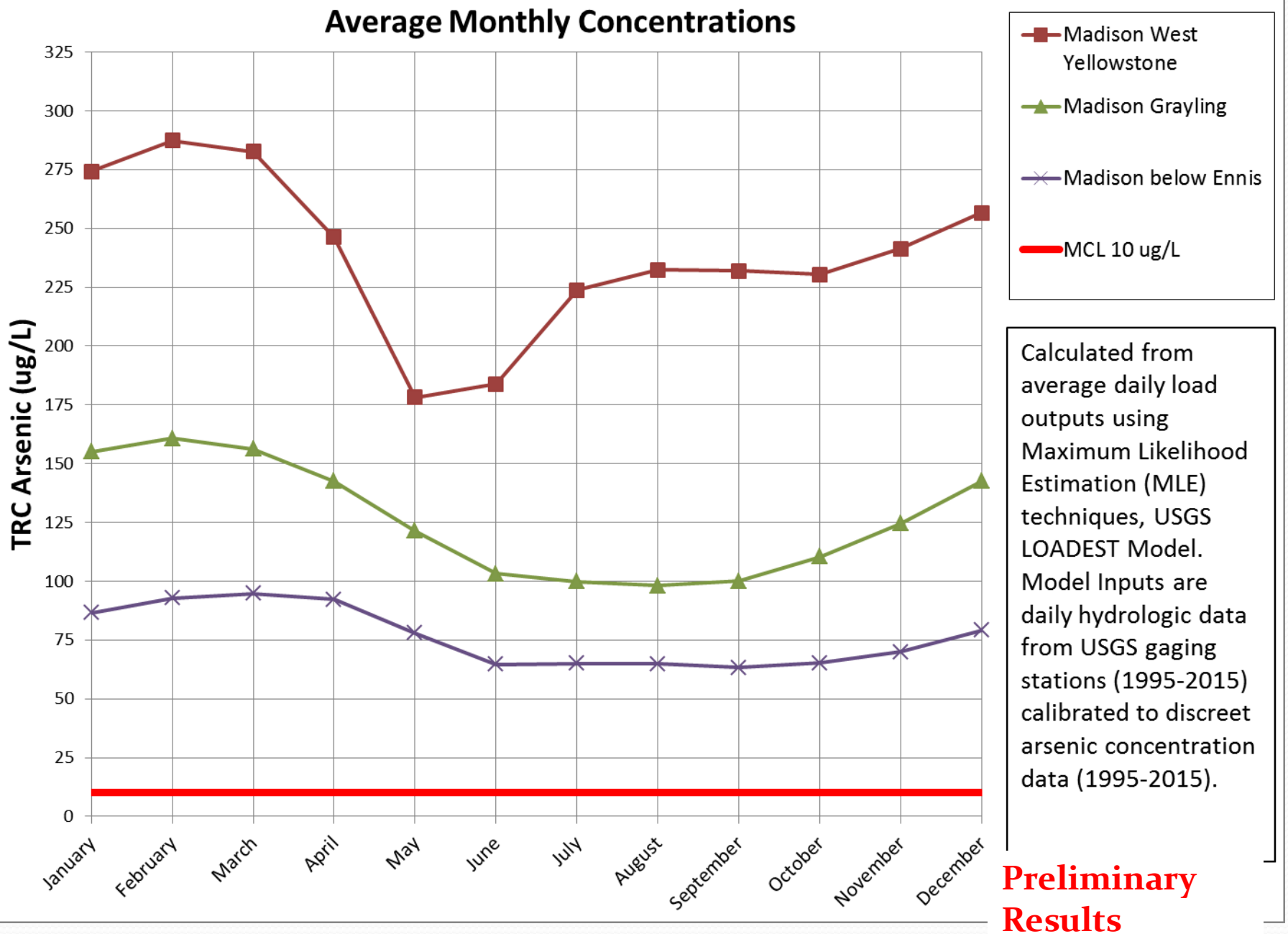

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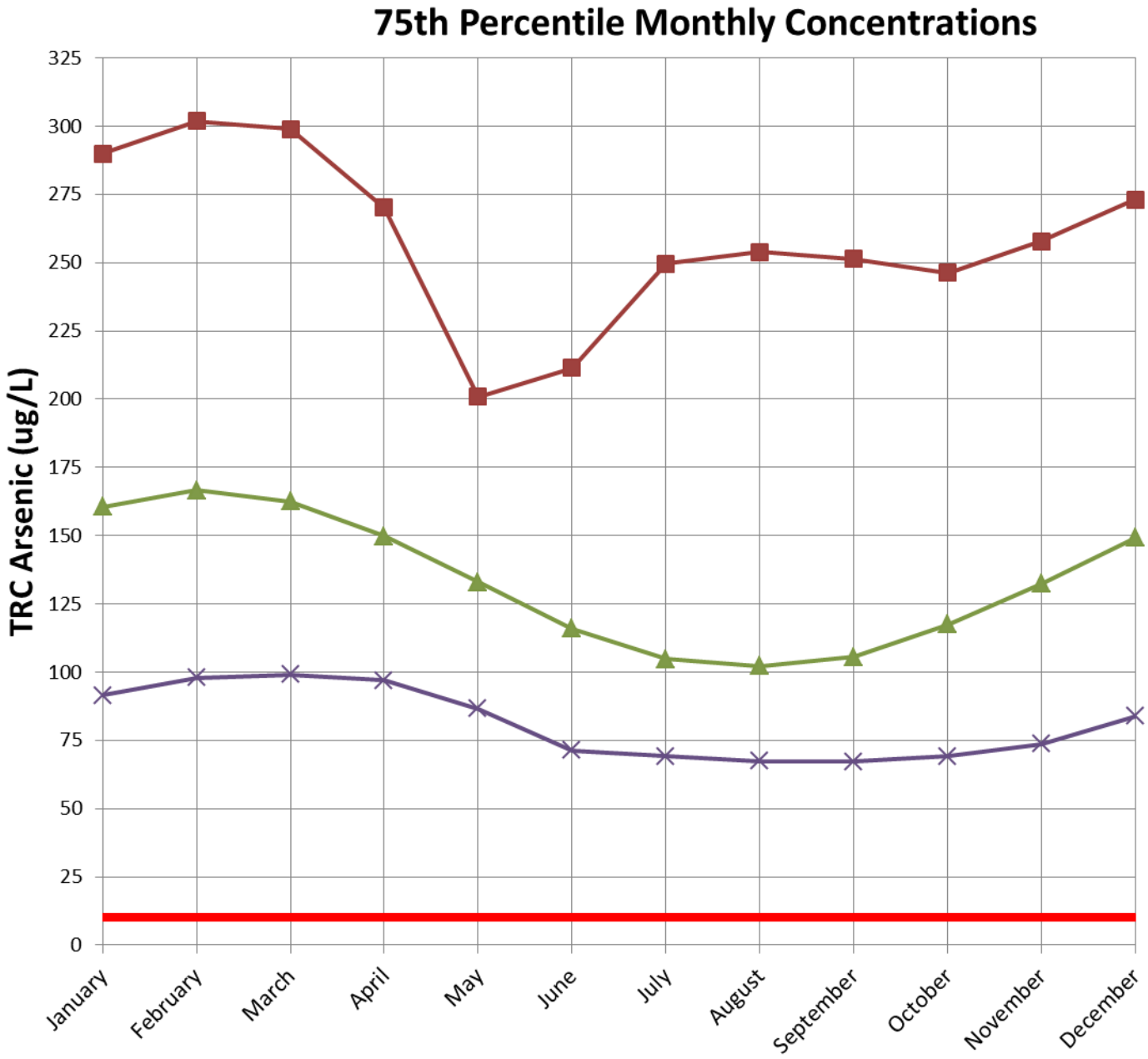
Preliminary Results



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Preliminary Results

Teasing out the Anthropogenic Load Using the Mass Load Equation

∑ TAL = YNP + PSL + GW + Trib + RO

∑ TAL - Total Arsenic Load of a sampling location, based on flow rate and concentration at a specific time

YNP - Geothermal arsenic load from the Yellowstone Caldera, @ the park boundary, **∑ TAL = YNP**

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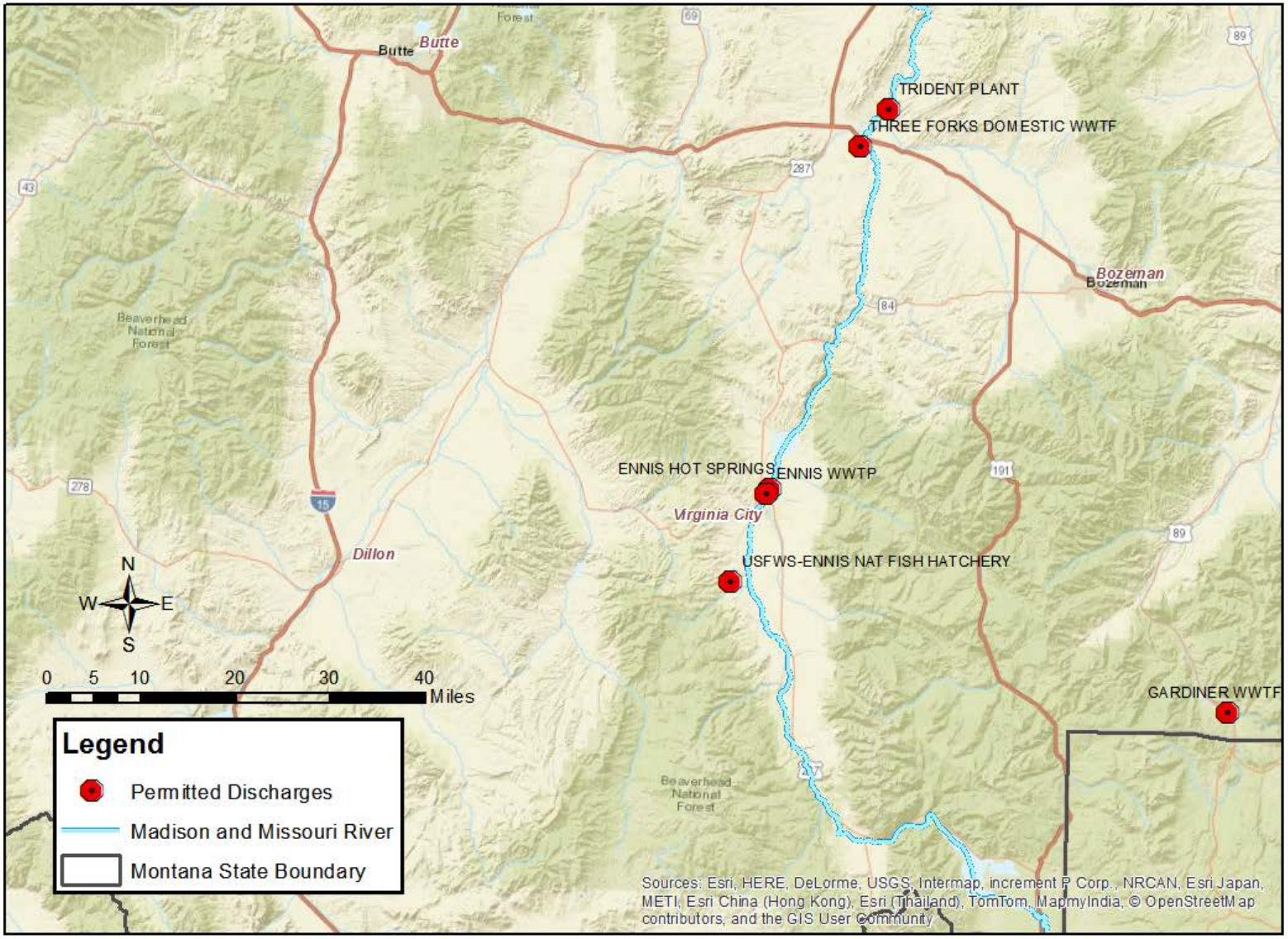
Point Source Discharge Locations



An example of Anthropogenic Load: Point Source Dischargers

Facility Monitoring for Arsenic	Discharge Body	Facility Load (Kg/Day)	River Load at Facility (Kg/Day)	Facility/ River Load (%)	Facility Load (Kg/Day)	River Load at Facility (Kg/Day)	Facility/ River Load (%)
		June			**December**		
USGS-Ennis Fish Hatchery	Blaine Spring Creek	ND	43	**ND**	ND	28	**ND**
Ennis WWTP	Madison River	0.006	563	**0.001%**	0.005	272	**0.002%**
Ennis Hot Springs	Moore Creek	0.006	43	**0.014%**	0.005	28	**0.018%**
Three Forks WWTP	Madison River	0.042	351	**0.012%**	0.015	347	**0.004%**
Total Point Source Loads at Three Forks		0.054	351	**0.027%**	0.025	347	**0.024%**

*Madison River loads are modeled medians. Blaine Spring Creek and Moore Creek River are actual measured values.
ND = No Data
Loads based on Total Recoverable Concentrations

Preliminary Results

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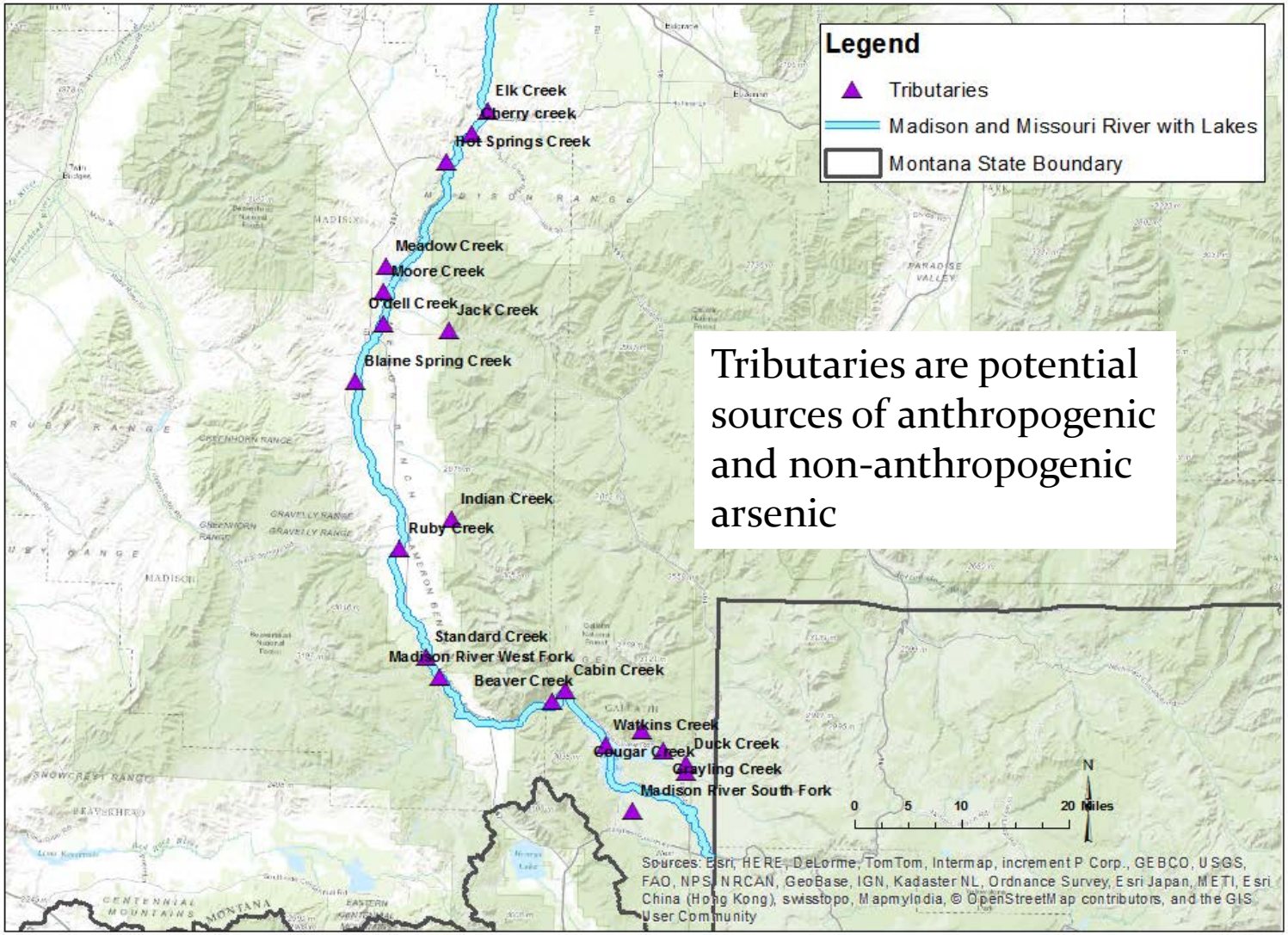
Madison River Tributaries



Tributaries are potential sources of anthropogenic and non-anthropogenic arsenic

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Questions?

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