

Glacier National Park
2019 Physical Science Program Annual Report

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NPS Fixed air quality monitoring station located near the park horse barn, West Glacier, Glacier National Park (supported by Glacier National Park as well as the NPS Intermountain Regional and Washington Area Offices).



NPS mobile E-BAM mobile particulate monitoring station, Glacier National Park (Funded by Glacier National Park Conservancy).

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ABSTRACT

Air and water quality in Glacier National Park have been monitored in individual research projects involving park partner's such as the USGS, researcher's affiliated with Montana's university system, by other external researcher's, by Regional and Washington Office NPS staff, as well as by Glacier National Park physical science staff. Some of these programs are long-running national trend network programs, and by virtue of its undeveloped nature and low local population density, Glacier plays an important role in these networks. Across these national networks and studies, air and water quality in the park generally remains very good. Some areas of concerns exist, including trends in nitrogen and ammonium deposition, as well as the transport and deposition of airborne contaminants from outside the park. Climate warming poses a continued threat as changes in air and/or water temperature drive many ecological and physical processes within the park.

INTRODUCTION

AIR QUALITY

Glacier National Park (GNP), along with other national parks greater than 6,000 acres and Wilderness areas greater than 5,000 acres in size, are classified as Class 1 airsheds under the Clean Air Act (Act). This designation affords the highest level of air quality protection provided under the Act and sets limits on how much pollution can be emitted by facilities within the Class 1 airsheds. In addition, the federal land managers of Class 1 areas are required to have the opportunity to review air pollution permit applications submitted to state agencies prior to the issuance of any permits that will result in degradation to the air quality in a Class 1 area, including visibility.

Clean air, dramatic visual vistas, and clean water are some of the many natural qualities of the park that draw visitors from all over the world. The air in the park affects all other aspects of the visitor experience, from obvious tangible qualities such as visibility, to less obvious impacts such as water quality, forest composition and ecosystem function. Airborne transport of pollution often originates from outside the park upwind and generally from the west (Landers et al. 2008). Sources generally includes industry, agriculture, fires, and transportation (Landers et al. 2008). These pollutants can harm the natural and scenic resources visitors' value and the National Park Service (NPS) is charged with protecting. Air Quality has been monitored at GNP in some fashion since 1980. At that time, a permanent monitoring site was established near the horse corals between the park headquarters and Apgar. This site has developed over the years, and now includes multiple devices and networks to measure different atmospheric components. In addition to the stationary site near Apgar, during the 2019 season a mobile particulate sampler was added to the capabilities of the air quality program. This new tool will provide insights into more specific sources of particulate throughout the park.

The National Atmospheric Deposition Program (NADP) monitors precipitation chemistry at 381 sites across the United States. It is a cooperative effort between many differing groups including federal, state, tribal and local government agencies, educational institutions, private companies and non-governmental agencies. Glacier National Park plays a role in this network as a National Trends Networks (NTN) site, of which there are 263 nationwide; and a Mercury Deposition Network (MDN) site, of which there are 197 sites nationwide. Deposition measurements of nitrogen and sulfur in GNP are made to monitor possible harmful effects of acidification. These processes can alter water chemistry, and as a result the connected ecosystems may be affected as well. Some waters have low buffering capacity due to low dissolved mineral levels while others more directly associated with the park's glaciers have higher buffering capacity. Watersheds that receive glacial runoff are less sensitive to acid deposition due to buffering minerals like calcium in the runoff (Ellis et al. 1992; Clow et al. 2002; Nanus et al. 2009; Peterson et al. 1998; Sullivan et al. 2011a; Sullivan et al. 2011b).

Nitrogen also effects forest ecosystems, and can lead to nutrient enrichment, which can alter the natural nutrient cycling in the plant community. The ecosystem can buffer a certain amount of additional nitrogen, but eventually a "Critical Load" is achieved, and additional pollution will most likely have a harmful effect on the sensitive portions of the ecosystem. (Porter 2005). Lichens can be particularly sensitive to increased nitrogen deposition. These impacts vary among climate types, with increasing nitrogen deposition negatively correlated with species richness in temperate forests and grasslands (Han et al. 2019). The NPS has assessed the risk of elevated nitrogen deposition on Glacier's vegetative types and in some cases, these levels warrant concern (NPS 2019). The investigators present a range of values for each vegetative type because there is often variability in how each vegetative type responds. For some groups, currently modeled nitrogen deposition loads in Glacier exceed the lower-most threshold where impacts to vegetation could begin.

Ozone (O₃) is another atmospheric component that is monitored by the NPS and can be related to EPA national standards. High levels of ozone can cause human health problems and negatively affect forest ecosystems by physically damaging plants, negatively impacting photosynthesis, and leading to increased vulnerability to disease and pests (USEPA – Ground Level Ozone Impacts, accessed online on 03/31/2020@ 1200 hrs). Ozone also impacts visibility as it is a major component of “smog”. Volatile organic compounds (VOCs) and nitrogen oxides (NO_x) (byproducts of fossil fuel combustion from cars, industrial and power plant emissions, etc.) interact with sunlight and heat to form ground level ozone (EPA, 2007). Levels at GNP are relatively low and have not exceeded the 2015 revised national standard (Federal Register 2015).

Visibility is an important quality of Glacier National Park and is affected by particulates from many sources aside from ground level ozone. Many of the same pollutants that ultimately fall out of the atmosphere as nitrogen and sulfur deposition contribute to haze that can reduce visibility substantially. Organic compounds, smoke, and dust play a role in reducing visibility as well. (National Park Service 2019) The Interagency Monitoring of Protected Visual Environments (IMPROVE) network provides the primary method for visibility monitoring at Class I areas throughout the United States. Monitoring is conducted by collecting PM_{2.5} and PM₁₀ samples every third day at over 150 sites nationwide, with PM_{2.5} samples being analyzed for chemical composition. Using these data, light extinction is reconstructed by the IMPROVE program. Reconstructed extinction values are then used to calculate haze levels and estimate visibility. In addition to calculated light extinction from IMPROVE, the National Park Service directly measures light scattering at a subset of IMPROVE sites using Optec NGN-2 integrating nephelometers (including at GNP). The optical measurements serve as a quality assurance check for IMPROVE, in that measured scattering from the nephelometers and reconstructed scattering from the IMPROVE equation should be equivalent. Nephelometer data also are particularly useful when high time resolution measurements are needed.

Although mercury naturally occurs in the environment, investigations of lake sediments (Swain et al. 1992), glacial cores (Schuster et al. 2002), and preserved animal tissues (Dietz et al. 2009) have revealed large increases since the onset of the Industrial Revolution. The primary source of elevated mercury levels in most areas is increased atmospheric deposition, particularly in remote headwater settings such as GNP (Fitzgerald et al. 1998). Currently, coal burning is the largest source of mercury to the atmosphere followed by artisanal gold mining (Streets et al. 2011). Globally, it is estimated that the mercury flux from the atmosphere has tripled since the Industrial Revolution (Lindberg et al. 2007). Regionally, glacial cores from the Wind River Range, Wyoming (700 km SE of GNP) suggest that in the 20th century about 70% of the mercury deposited aerally was from human sources (Schuster et al. 2002). Locally, sediment cores from four GNP lakes show that modern fluxes of mercury (post-1985) averaged 3.2 times higher than pre-industrial fluxes (pre-1875) (Mast et al. 2010).

Given the importance of the atmosphere in delivering mercury, regional concentrations in precipitation and the associated mercury deposition rates are relevant when evaluating mercury hazards. The Mercury Deposition Network (MDN) of the National Atmospheric Deposition Program (NADP; Madison, WI; for details see <http://nadp.slh.wisc.edu/MDN/>) regularly collects precipitation samples from sites throughout most of the US, including GNP, which are analyzed for total mercury. The extent to which these deposition patterns present an ecological or human health hazard is influenced by the speciation of mercury in the environment.

Although atmospheric deposition is dominated by inorganic mercury, methylmercury is typically the form of greatest ecotoxicological concern. Methylmercury primarily is produced in lakes and their watersheds by sulfate reducing bacteria (Gilmour and Henry 1991), although some is deposited aerally (Fitzgerald et al. 1991). Methylmercury biomagnifies in aquatic food chains and generally comprises a larger fraction of the total mercury burden with increasing trophic level (Mason and Sullivan 1997). These food chain dynamics together

with the high toxicity of methylmercury create toxicological concerns, particularly for high level consumers such as humans and piscivorous wildlife (Stafford et al. 2016). The MDN network monitors both wet and dry inorganic mercury deposition at the fixed monitoring site in GNP.

WATER QUALITY

Similarly, Glacier's waters receive the highest level of protection under the Clean Water Act (CWA). The Environmental Protection Agency (EPA) delegates much of the implementation of the CWA to the State of Montana (as it does with most other states), and the Montana Department of Environmental Quality oversees implementation of these responsibilities. The State of Montana sets the water quality standards for each water classification level (A-C). Most of the park's waters are classified by the state as A-1, which is essentially a non-degradation standard with specific limits on contaminants such as *Escherichia coli* and strictly limits human induced changes to parameters like dissolved oxygen, pH, turbidity, and water temperature. Water quality must be maintained in these waters to support each of the beneficial uses the state designated for them including drinking (with basic water treatment), salmonid fish growth and survival, bathing, recreation, and others. GNP and its partners monitor a variety of water quality parameters across the park each year. The USGS monitors water quality and quantity on the North Fork Flathead River at the Canadian border. In addition, in partnership with GNP, the USGS monitors water quality and quantity on Swiftcurrent Creek as part of the National Hydrologic Benchmark Network (HBN). HBN data are housed in USGS and national databases and do not reside with the park. Water quality is also one of the park's benchmark monitoring initiatives under the NPS Vital Signs Monitoring Network. These efforts focus exclusively on park-wide stream water quality, stream habitat, and the biotic health of stream and river systems. Fine sediment is also collected and analyzed for contaminants at some sites under the Vital Signs program. Under the Vital Signs program, field sampling is conducted by GNP staff under the direction of the NPS Rocky Mountain Inventory and Monitoring network (network) in Ft. Collins, Colorado. These data are housed at the network and do not reside at the park.

GNP also independently monitors water clarity, water quality, and temperature on the park's larger lakes. The park also monitors water temperature on park streams and periodically conducts site-specific water quality evaluations as specific water quality questions or concerns arise. For example, in 2018, the park initiated a re-evaluation of water quality on Lake McDonald in partnership with the University of Montana Flathead Lake Biological Station (FLBS) and USEPA. This project is ongoing and while we have received all of the raw data, we are awaiting interpretation of some of the data from our project partners.

METHODS

AIR QUALITY

The stationary air quality site in GNP is near the horse corral in West Glacier/Apgar area. Six different programs and stations outlined below exist at the site. Weekly site visits by GNP physical science staff maintain the processes and equipment that analyze the air at the site. Filter changes and calibrations are completed according to manufacture procedures. Each station and program measurements and procedures are outlined below.

Additionally, in the 2019 summer season a mobile particulate sampler was added to the park air quality capabilities. The Environmental Beta Attenuation Monitor (E-BAM) is mounted to a trailer and can be moved to sample at key locations throughout the park. The primary focus of the device is to measure particulates at 10 or

2.5 microns and below (PM₁₀ or PM_{2.5} respectively). This site is maintained weekly by GNP physical science staff to ensure quality data collection and tend to any issues that may arise. The addition of a portable E-BAM to GNP adds more versatility to the air quality program.

National Trends Network – NTN

The National Trends Network is considered the primary source for gathering wet deposition data. Samples are collected continuously in a wet deposition collector. A sensor opens a sampling bucket to the atmosphere during precipitation, the bucket collects this precipitation and is then automatically closed as soon as the precipitation stops. Every Tuesday, the site operator replaces the collection bucket with a new one that has been specifically cleaned for the next sample. The sample is then weighed and transferred to a shipping bottle to be sent to the lab at the University of Wisconsin, Madison for analysis. The site is also equipped with a weighing-bucket rain gauge that provides a continuous record of rainfall amounts, recorded to the nearest 0.01 inches. The rain gauge also monitors the wet deposition collector, recording whether the collector was properly open during wet periods and closed during dry periods (National Atmospheric Deposition Program, n.d. -d).

The Central Analytical Laboratory (CAL) processes the samples, measuring the concentrations of the constituents of interest. These measurements include acidity (measured as pH), sulfate, nitrate, ammonium, chloride (Cl⁻), sodium (Na⁺) and the base cations including magnesium (Mg²⁺), calcium (Ca²⁺), and potassium (K⁺). Base cations in the soil occur naturally from the parental bedrock weathering and provide essential nutrients for plant growth. Nitric and sulfuric acid, upon contact with the soil, release their hydrogen ions, and bind to the base cations present. These compounds move into the soil water solution, acidifying the remaining soil and can lead to stream acidification as they flow toward water bodies. A reduced availability of base cations reduces the capacity of soils to recover from acidic deposition (US Forest Service, 2020). A stringent data verification process is employed to make sure that the data meets the completeness and accuracy standards. After data verification, the sample record is entered into the NADP database (National Atmospheric Deposition Program, n.d. -e).

Mercury Deposition Network – MDN

The MDN is the only network providing a long-term record of total mercury (Hg) concentration and deposition in precipitation in the United States and Canada. All MDN sites follow standard procedures and have uniform precipitation chemistry collectors and gauges. The automated collector has the same basic design as the NTN collector but is modified to preserve mercury. Modifications include a glass funnel, connecting tube, bottle for collecting samples, and an insulated enclosure to house the sampling train. The funnel and connecting tube reduce sample exposure to the open atmosphere and limit loss of dissolved mercury. As an additional sample preservation measure, the collection bottle is charged with 20 mL of a one percent hydrochloric acid solution (National Atmospheric Deposition Program, n.d. -b).

Each weekly MDN sample is sent to the Mercury Analytical Laboratory (HAL) at the Wisconsin State Laboratory of Hygiene in Madison, Wisconsin for analysis and the entire sampling train is replaced with a clean one from (HAL). Rigorous cleaning ensures that each sampling train component is essentially mercury-free. The HAL supplies the collection bottles already charged with the hydrochloric-acid preservative. By following those procedures and stringent sampling protocols, the MDN can report mercury concentrations below 1 part per trillion (<1 nanogram/liter). HAL analyzes all forms of mercury in a single measurement and reports this as a total mercury concentration. The HAL reviews field and laboratory data for completeness and accuracy, and flags samples that were mishandled, compromised by precipitation collector failures, or grossly contaminated. The HAL delivers all data and information to the NADP Program Office for final checks and resolution of

remaining discrepancies. Data then are made available on the NADP Web site (National Atmospheric Deposition Program, n.d.-c).

Nephelometer

Visibility is monitored using a nephelometer which uses light scatter to measure the size and concentration of particles in the air. The Nephelometer at GNP, Model NGN-2, uses an integrated open-air design to measure the atmospheric scattering coefficient of the ambient air. This is accomplished through a complicated, yet simple measurement sequence. Essentially, a halogen light source is shined through a glass diffuser to reduce the wavelengths; then a chopper modulates the light at 10 Hz. This is measured in line with the light source by a photodiode detector. Compared to this in-line measure is the light absorbed by a second silicon photodiode that uses lenses to target a small 6 mm x 260 mm diameter volume of air that is 90 degrees to the light source. The second measurement of light is proportional to light scattered by the air sample plus light reflecting in the optical chamber. This relationship can be used to calculate the scattering coefficient, reported at GNP as inverse megameters (Optec, Inc, 1998). The optical measurements taken by the nephelometer serve as a quality assurance check for IMPROVE, in that measured scattering from the nephelometers and reconstructed scattering from the IMPROVE equation should be equivalent. Nephelometer data also are particularly useful when detailed time resolution measurements are needed.

Weekly, a calibration sequence is performed to ensure accurate monitoring and correction for any instrument gain and zero intercept drifts due to temperature changes and/or dirt accumulating on the measurement chamber optics. A checklist is followed for physical machine checks, and then a calibration program runs automatically with span gas to calibrate. Temperature and humidity sensors are also monitored as air moisture must be accounted in the QA/QC process for data using this instrument (Optec, Inc, 1998).

Ozone

Ozone is analyzed continuously with a Thermo Scientific Analyzer, Model 49i. The analyzer operates on the principle that ozone absorbs UV light with a wavelength of 254 nm. The sampling inlet is at the top of the tower at the site, and sampled air travels through tubing to the analyzer. Here, the flow is split into parallel streams. One gas stream flow through an ozone scrubber and then to the reference solenoid valve, whereas the other stream flows directly to the solenoid valve. The solenoids then alternate flows for reference or sample gas every 10 seconds to both cells A and B. The UV light intensities of each cell are measured by detector A and B respectively. As flow switches occur, measurements are delay several seconds so that cells A and B can be flushed with the sample or reference before data is recorded (Thermo Scientific, 2011).

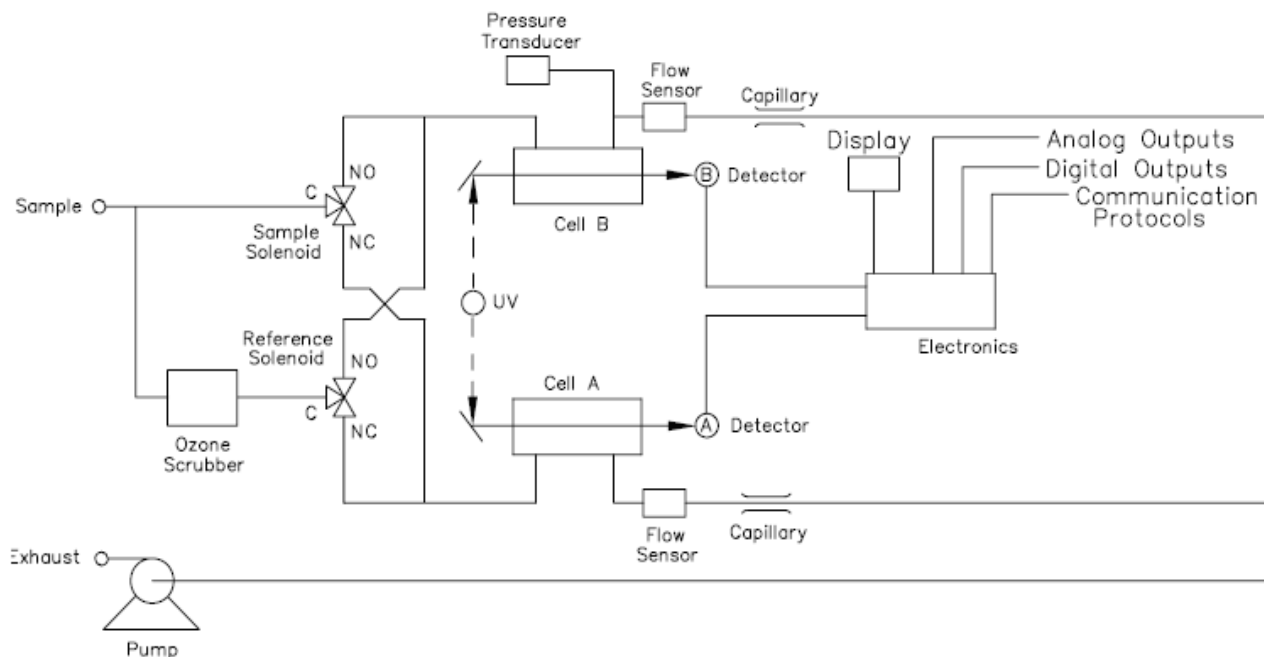


Figure 1. Ozone Model 49i Air Flow Schematic.

Site visit procedures involve bi-weekly inlet filter changes and subsequent calibration. The inlet filter removes particulates that would interfere with analyzer functioning. During heavy particulate environmental conditions, such as wildfire smoke or heavy pollen, the filters and calibrations are performed weekly.

Interagency Monitoring of Protected Visual Environments – IMPROVE

The Interagency Monitoring of Protected Visual Environments (IMPROVE) network provides the primary method for visibility monitoring at Class I areas throughout the United States. Monitoring is conducted by collecting $PM_{2.5}$ and PM_{10} samples every third day at over 150 sites nationwide, with $PM_{2.5}$ samples being analyzed for chemical composition. Using these data, light extinction is reconstructed using the second IMPROVE equation. Reconstructed extinction values are then used to calculate haze levels and estimate visibility.

The IMPROVE particle monitor consists of four independent sampling modules. Three modules (A, B, and C) collect only fine particles ($PM_{2.5}$), while the fourth (module D) collects both fine and coarse particles (PM_{10}). Data from all the modules are used to calculate visibility metrics. Module A is equipped with a Teflon filter that is analyzed for $PM_{2.5}$ gravimetric fine mass, elemental concentration, and light absorption. Module B is fitted with a Nylasorb (nylon) filter and analyzed for the anions sulfate, nitrate, nitrite, and chloride using ion chromatography. Module C utilizes a quartz fiber filter that is analyzed by thermal optical reflectance (TOR) for organic and elemental carbon (EC). Module D is fitted with a PM_{10} inlet and utilizes a Teflon filter to determine PM_{10} aerosol mass concentrations gravimetrically (Interagency Monitoring of Protected Visual Environments, n.d.). The measured constituents contribute to regional haze, which adversely impacts visibility.

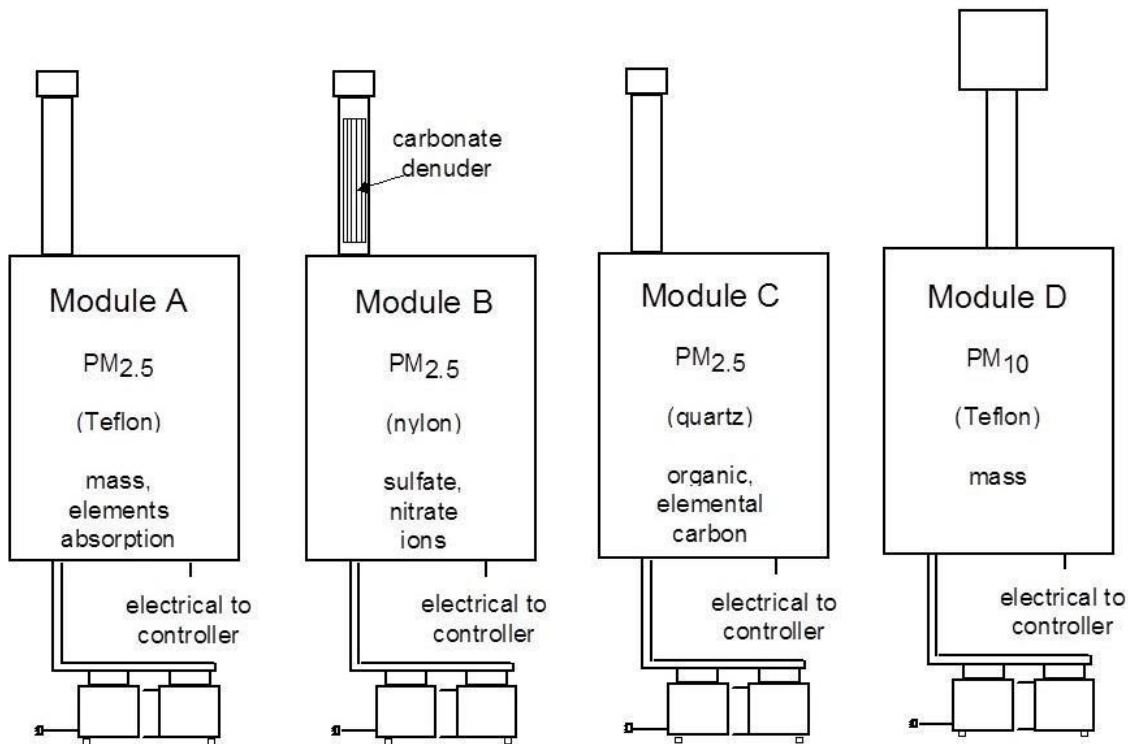


Figure 2. Schematic view of the IMPROVE sampler showing the four modules with separate inlets and pumps. The substrates and analyses performed for each module are also shown.

Clean Air Status and Trends Network – CASTNET

There are 97 Clean Air Status and Trends Network (CASTNET) sites throughout the United States, which are managed and operated by the US Environmental Protection Agency and the National Park Service. The inlet of the system has a filter pack located on top of a 10-meter tower. Analysis of the filter pack provides weekly ambient concentrations of gaseous pollutants and particulates including nitric acid (HNO_3), sulfur dioxide (SO_2), nitrate (NO_3^-), ammonium (NH_4^+), and sulfate (SO_4^{2-}), as well as the base cations magnesium (Mg^{2+}), calcium (Ca^{2+}), and potassium (K^+). Sodium (Na^+) and chloride (Cl^-) are also measured along with hourly O_3 concentrations. Measurements complement the NADP's National Trends Network. Nearly all CASTNET sites are co-located with or near an NTN site. Together, these two monitoring programs provide data necessary to estimate long-term temporal and spatial trends in total deposition (dry via CASTNET and wet via NTN) as well as ecosystem health (United States Environmental Protection Agency, 2018). The CASTNET filter is changed weekly at the air quality site, packaged, and sent to Wood Environment and Infrastructures Solutions, Inc. in Florida for lab analysis.

Environmental Beta Attenuation Monitor - E-BAM

The E-BAM system monitors the quantities of particulate in the air. The E-BAM-9800 model can sample for PM₁₀ and PM_{2.5}; particulate matter less than 10 micrometers and less than 2.5 micrometers respectively. GNP was initially interested in PM₁₀ quantities in the atmosphere adjacent to the North Fork Flathead River and measured at this level for the 2019 season. The E-BAM system was mounted onto a trailer and used a solar array

and deep cycle batteries to power it for remote deployment. The station was deployed at two sites at varying distances from the North Fork Flathead River, between the Camas Road junction with the North Fork Road and Kintla Creek. Site 1 was located between the Camas Road and Anaconda Creek and approximately 1,650 meters from the river (1,700 meters from the North Fork Road) and Site 2 was located between Bowman and Kintla creeks and 30 meters from the river (800 meters from the North Fork Road).

Sampling is completed by a process known as beta attenuation. A known quantity of air is pumped through a filter tape every minute. Upstream of this tape is a carbon 14 element, which emits a constant source of high-energy particles known as beta particles. Downstream of the tape is a highly sensitive scintillation detector. As air flows past the filter tape dust is deposited on the tape. Beta particles are attracted to this dust, regardless of type, and adhere to the dust accumulating on the tape at a known rate. The detector on the downstream side of the tape then measures how many beta particles get through, and with the known volume of air that passed during that interval, calculates the quantity of dust suspended in the air.

The park sampled at two measurement cycles, 1 hour and 30-minute averages. The hourly concentration measurements are the most accurate and are based on two four-minute-long beta counts. The hourly measurement takes a four-minute count at the beginning and end of every hour and compares these beta counts to measure the particulate mass deposited on the filter tape over the course of the hour. Calculations result in an hourly particulate concentration. This is the most accurate measurement because it is taken over a longer sampling interval of four minutes.

The 30 minute “real-time” sampling average is determined by an average of thirty-one-minute measurements leading up to the 30-minute mark. There is more beta detection variation in measuring for a single minute, so despite the 30-minute average, this measurement cycle is slightly less accurate than the four-minute interval used for the hourly concentrations (Met One Instruments, Inc., 2008).

WATER QUALITY

Methods of data collection for USGS stream gauging and water quality sites monitored in the park can be found at: <https://pubs.er.usgs.gov/publication/tm3A8>, <https://pubs.er.usgs.gov/publication/ofr94455>, and <https://pubs.usgs.gov/circ/circ1173/Methods.htm>. These sites include the HBN network site on Swiftcurrent Creek and the stream gauging station on the North Fork Flathead River at the Canadian border. Methods for data collection for NPS Vital Signs monitoring on wadeable and non-wadeable streams followed those of Schweiger et al. (2016). GNP monitors water transparency or clarity using a Secchi disk. Secchi disks are a common measurement tool in lake monitoring. A Secchi disk is an 20cm diameter black and white disk that is lowered into the water until it is no longer visible. The depth at which it disappears from view is known as the Secchi depth. This depth measurement over time can be used as an indicator of changing water quality. Declining Secchi disk measurements over time can indicate increases in turbidity from suspended solids or increased algal productivity resulting from nutrient pollution. In addition, GNP uses temperature loggers to measure water temperature each year in multiple streams and lakes.

In 2018 and 2019, GNP collected water samples from a number of waters in the Flathead River drainage to evaluate *Escherichia coli* (*E. coli*) levels. This was done in response to public concerns over potential septic contamination and/or improper human waste disposal along the North and the Middle Forks of the Flathead River adjacent to the park. In addition, Lake McDonald was also sampled in 2019 for similar reasons. *E. coli* is found in the gut of warm-blooded animals and is often used as an indicator of human waste contamination. Some strains of *E. coli* are harmless while others can make humans very sick. It is important to periodically monitor park waters for *E. coli* to protect human and aquatic health. Sterile 100mL sample bottles were

provided by the testing laboratory (Montana Environmental Laboratory (MEL)). The sample bottles were buffered with sodium thiosulphate in the event chlorine was present in the water. Water samples were collected in rivers by wading out into knee-deep well-mixed water, opening the sample bottle, and dipping it into the stream until it was approximately 90% full. The approach was similar in lakes except the samples were collected from a boat. Nitrile gloves were used when collecting samples to avoid any potential sample contamination. Samples were kept on ice and transported to MEL the same day they were collected. Samples were processed using EPA method SM9223B and results reported as “most probable number/100mL” (MPN) which is analogous to “colony forming units” (CFU’s).

RESULTS AND DISCUSSION

AIR QUALITY

National Trends Network – NTN

NTN network data from the Apgar stationary air quality site (MT05) show some contrasting patterns over time (Figures 3-13), as measured in wet deposition as kilograms per hectare. The trendline is a moving three consecutive year average and is only displayed where there is sufficient valid data. Data is validated along three criteria: 1. Valid samples for 75% of the time period. 2. Valid samples for 90% of the precipitation amount. 3. Precipitation amounts for 75% of the time period. Invalid data are included to show that samples were taken that year but are not used in establishing the moving average trendlines. In general, the lower the quantity of any substance found in the sample, the less there is of that element in the atmosphere.

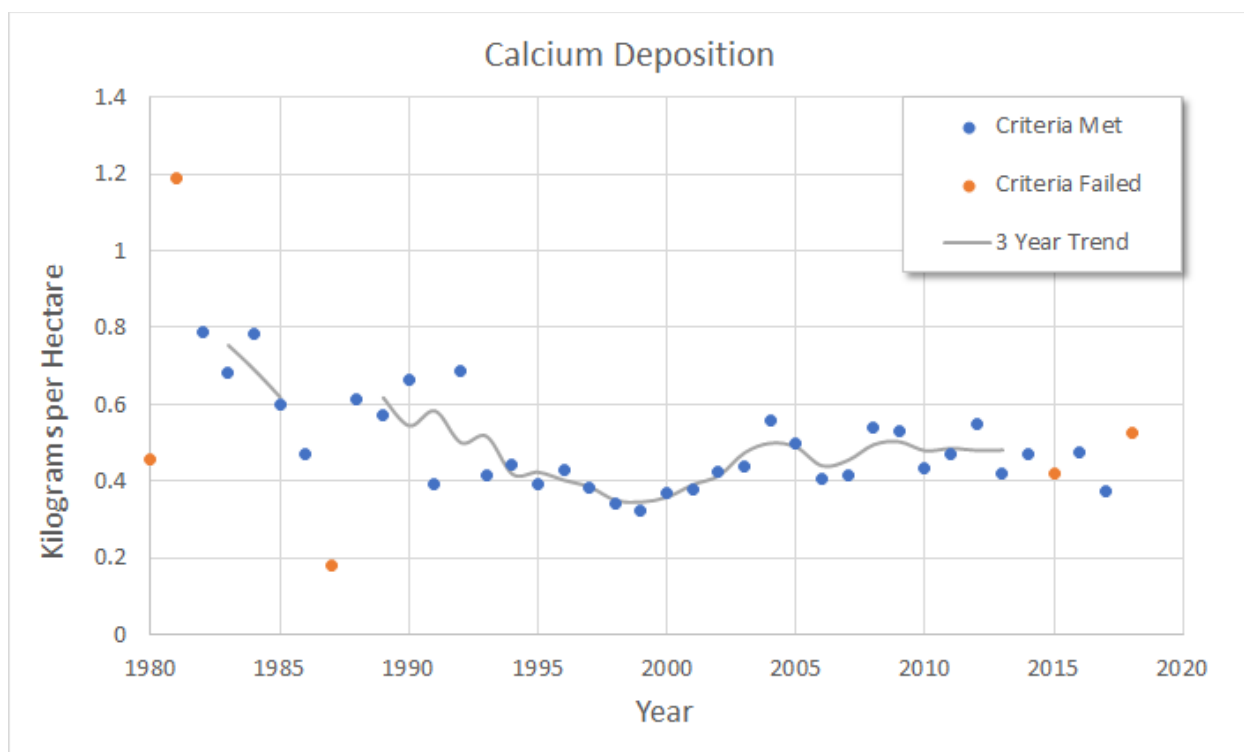


Figure 3. Calcium deposition at the fixed air quality monitoring site in Glacier National Park measured as part of the National Trends Network.

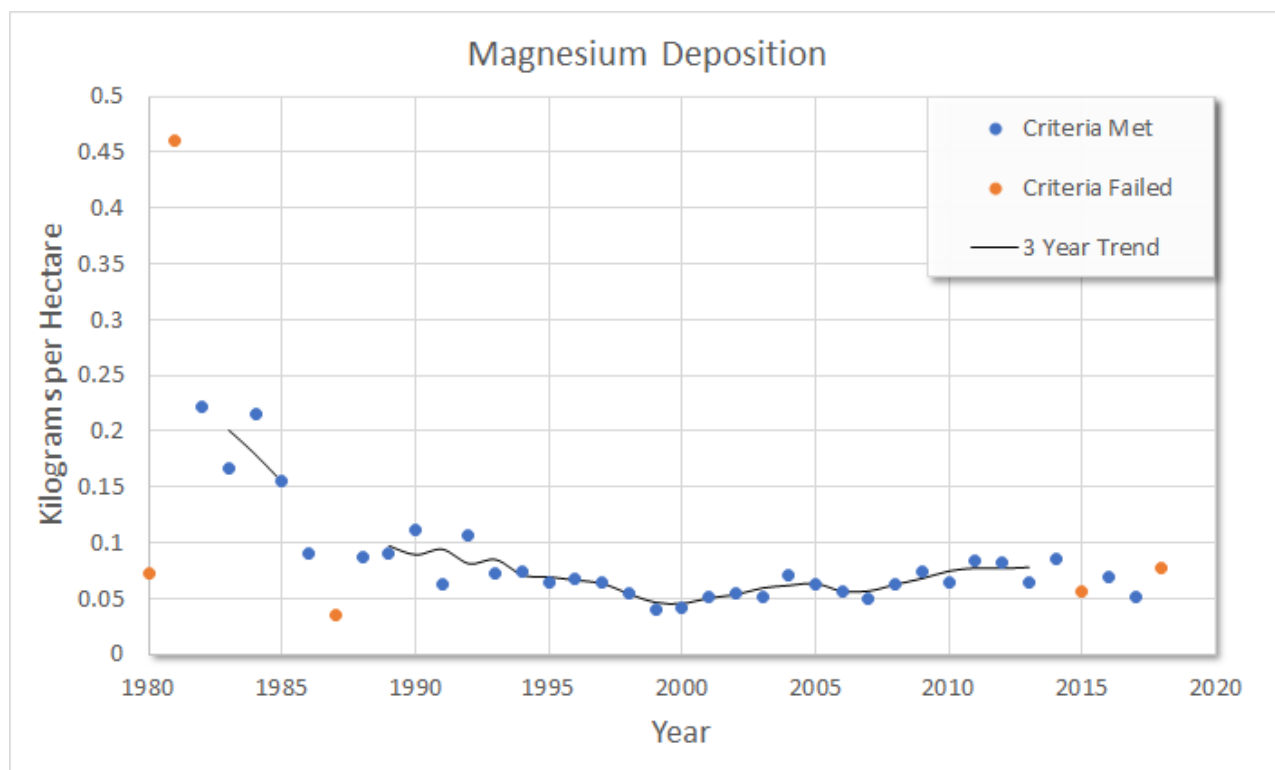


Figure 4. Magnesium deposition measured at the fixed air quality monitoring site in Glacier National Park.

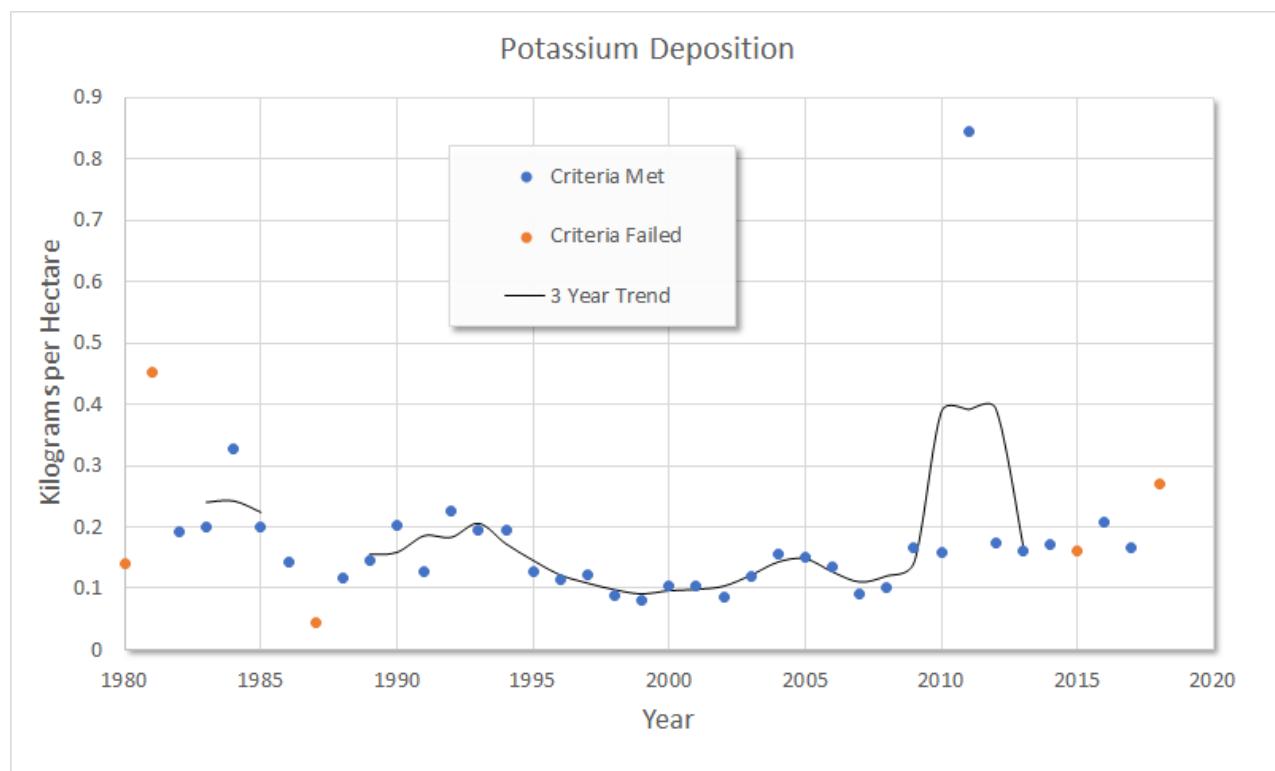


Figure 5. Potassium deposition measured at the fixed air quality monitoring site in Glacier National Park.

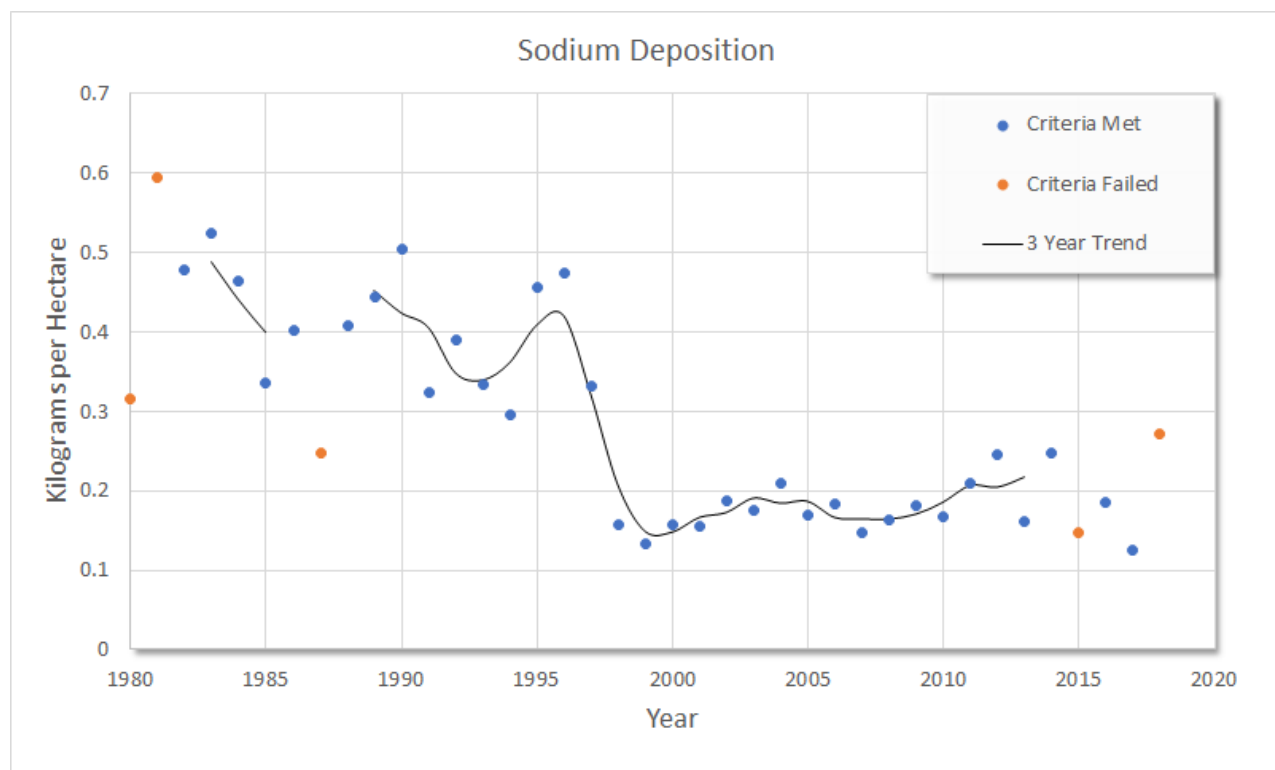


Figure 6. Sodium deposition measured at the fixed air quality monitoring site in Glacier National Park.

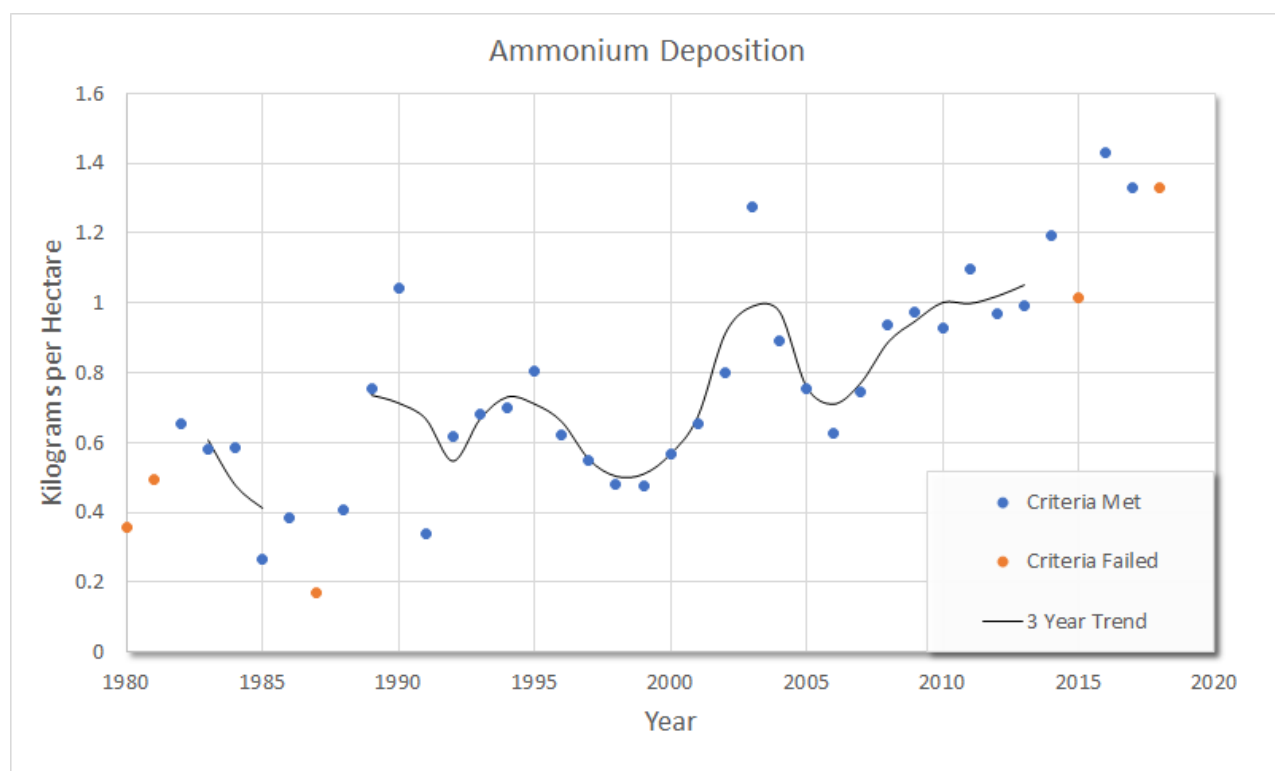


Figure 7. Ammonium deposition measured at the fixed air quality monitoring site in Glacier National Park.

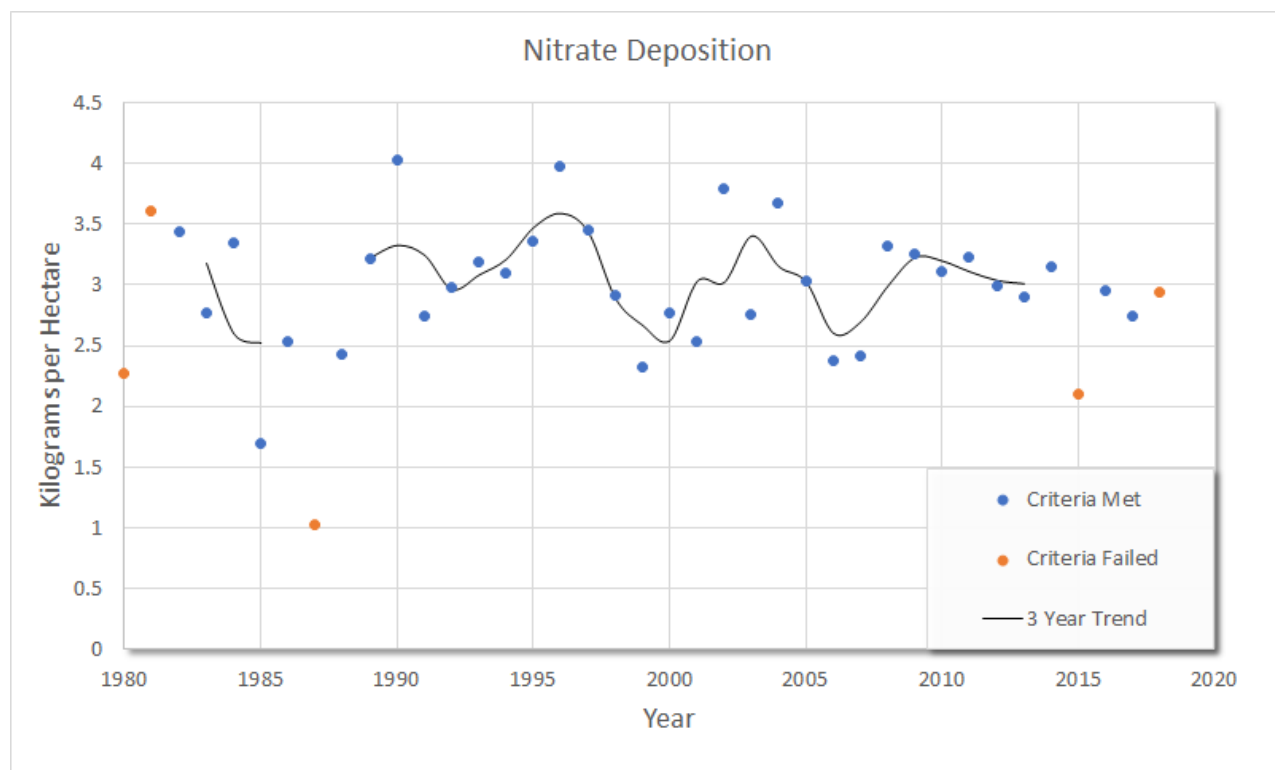


Figure 8. Nitrate deposition measured at the fixed air quality monitoring site in Glacier National Park.

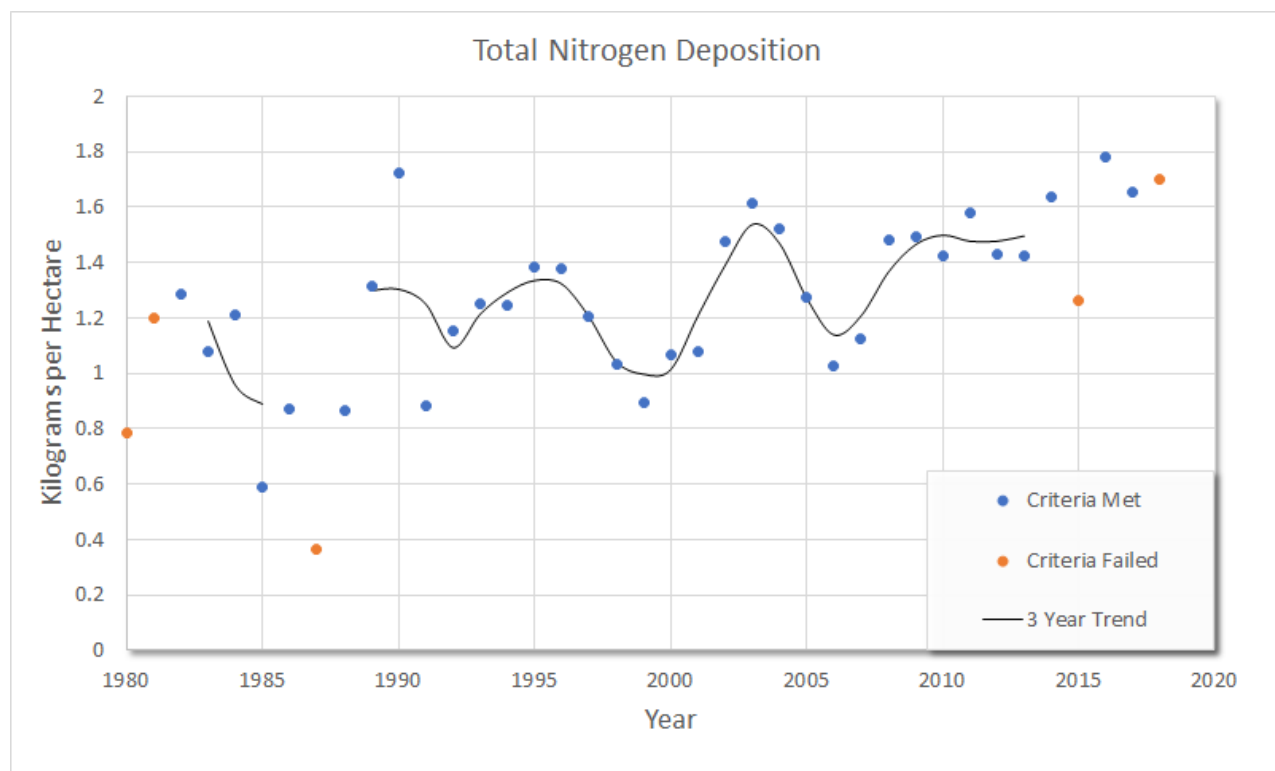


Figure 9. Total Nitrogen deposition measured at the fixed air quality monitoring site in Glacier National Park.

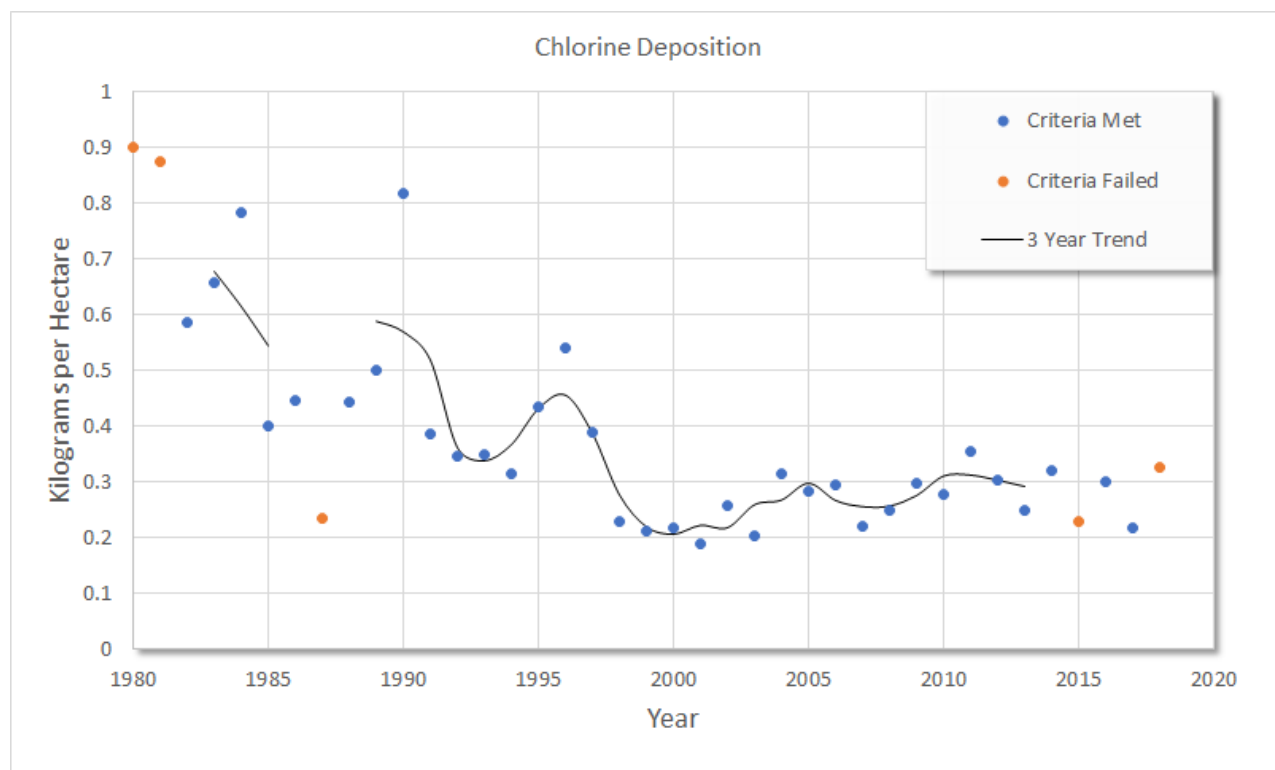


Figure 10. Chlorine deposition measured at the fixed air quality monitoring site in Glacier National Park.

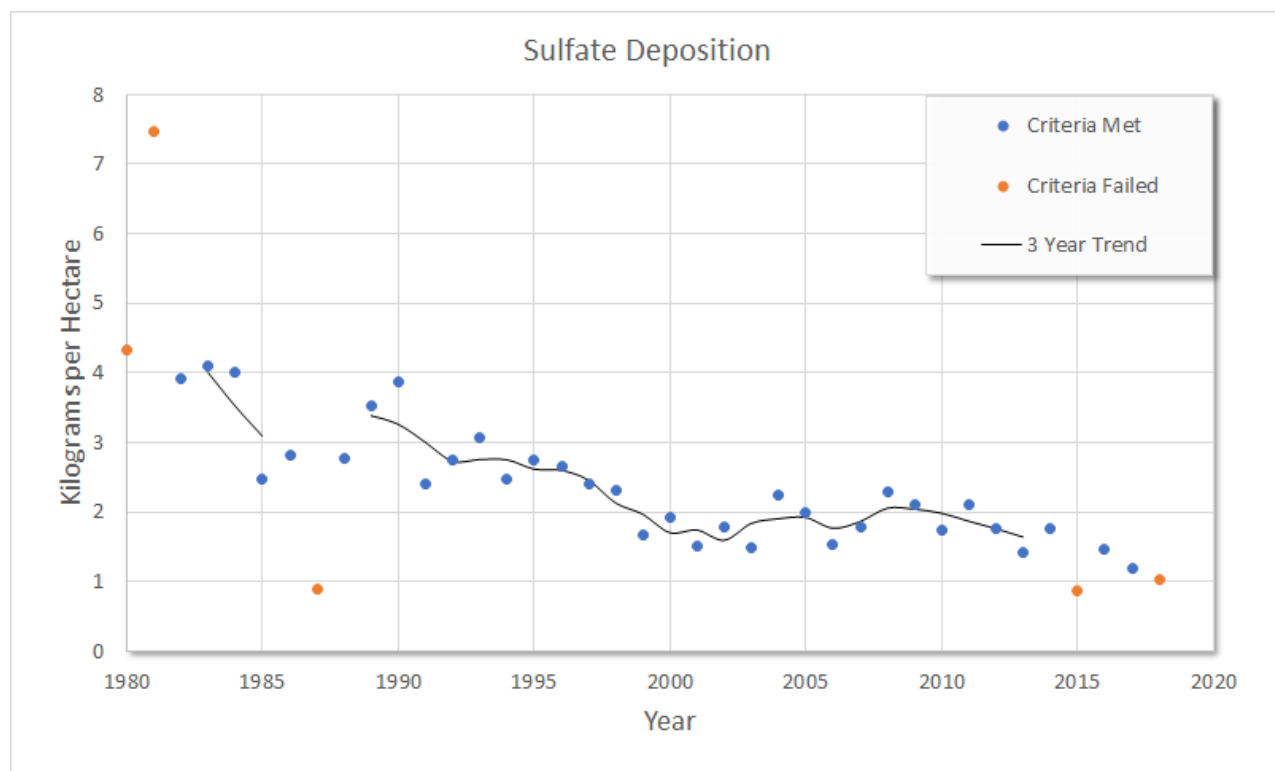


Figure 11. Sulfate deposition measured at the fixed air quality monitoring site in Glacier National Park.

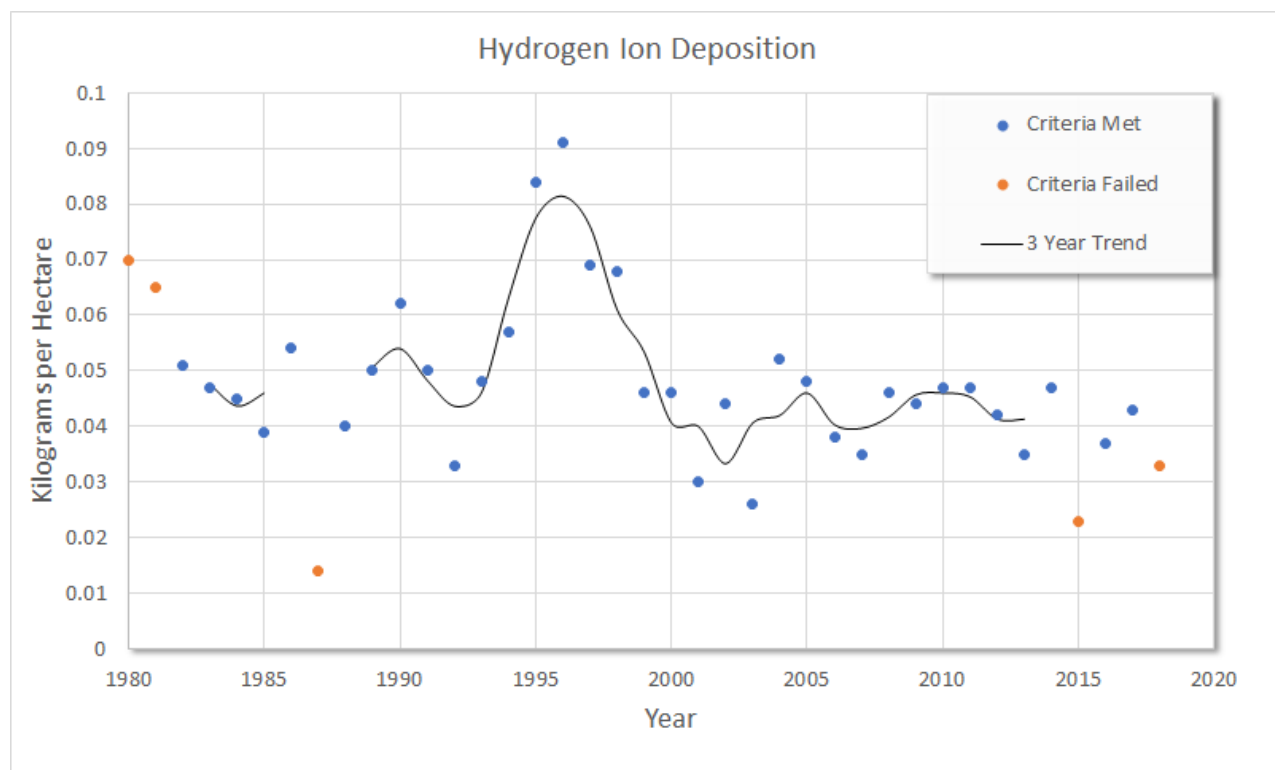


Figure 12. Hydrogen ion deposition measured at the fixed air quality monitoring site in Glacier National Park.

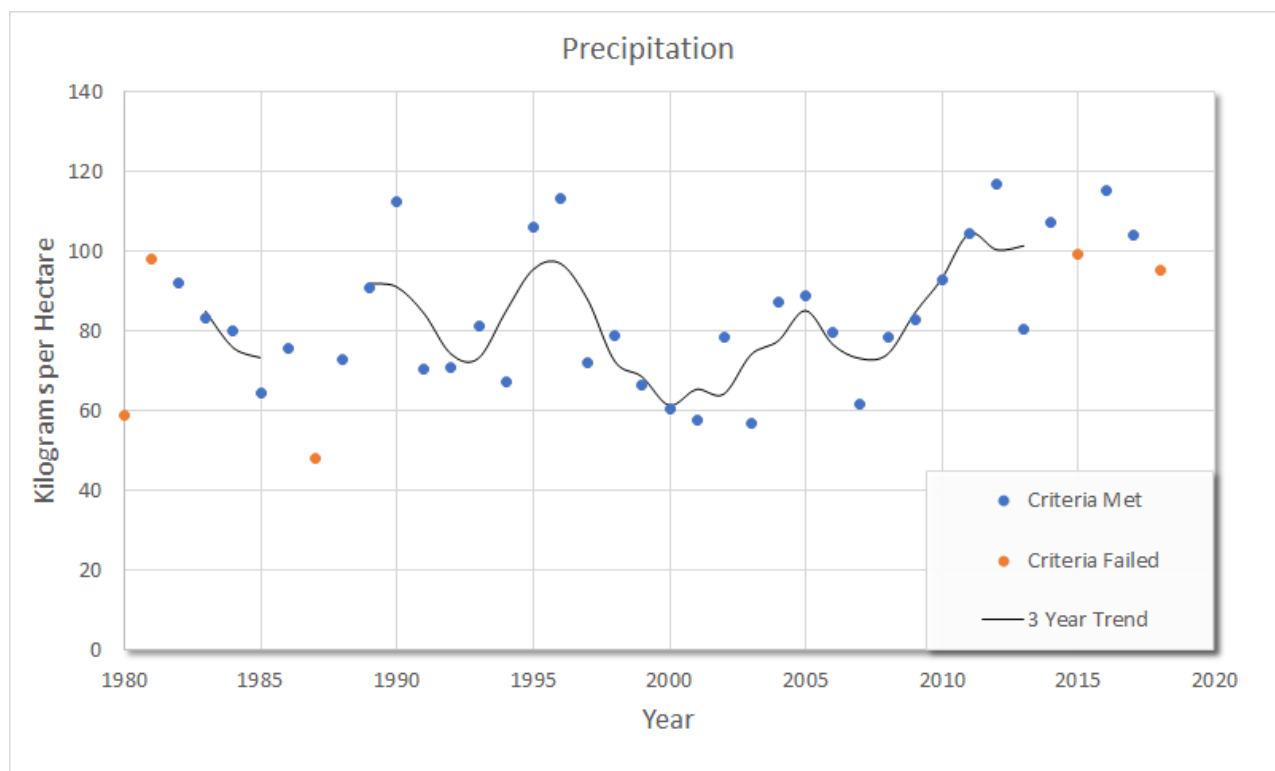


Figure 13. Total precipitation measured at the fixed air quality monitoring site in Glacier National Park.

Elements monitored in the NTN program can impact the productivity, composition, and health of forest and aquatic communities. Some are important system nutrients at appropriate levels including nitrogen, calcium, potassium, and magnesium (Holmes and Likens 2016). Others are pollutants produced by human use of fossil fuels and impact the pH balance of soils and water via “acid rain”, such as sulfate and nitrate. Acid precipitation can also directly harm plants by injuring leaves and reducing soil nutrition, both of which can stress plants and make them more vulnerable to disease and forest pests, particularly at higher elevations. In addition to being plant nutrients, calcium and magnesium also can buffer the effects of acid precipitation. Hydrogen ions are measured as an indicator of pH (National Atmospheric Deposition Program, 2020).

Long-term sodium measurements at the park demonstrate the strong influence of sodium fluoride (NaF), an air pollutant historically emitted in large quantities by the nearby, but now defunct, Columbia Falls Aluminum Company (Figure 6). The emissions were the subject of a lawsuit between the Federal government and the company that resulted in the installation of new pollution control measures which significantly reduced the NaF pollution. The success of the pollution mitigation measures is readily apparent in the long-term deposition data (Figure 6). Calcium, magnesium and sulfate have decreased consistently over time, and show the least inter-annual variation. Ammonium (NH_3) and nitrogen (N) deposition appear to be increasing over time.

Elevated ammonium levels are often associated with pollution from livestock operations or are derived from agricultural operations using nitrogen-based fertilizers. The ammonium becomes volatilized and enters the atmosphere where it is transported and deposited in other areas of the country or the world. Volatilization increases with increasing air temperatures and climate warming may be playing a role in increased ammonium levels observed in the park. Increasing ammonium levels can be harmful to native vegetation by direct harm to leaves or through favoring some species over others. It follows that nitrogen would increase along with ammonium as nitrogen is a component in ammonium. In addition, nitrogen is emitted by fossil fuel combustion. Increased visitation to GNP and the larger Flathead Valley could also be contributing factors to this trend. Increases in annual precipitation over the past 15-20 years could also play a direct role in the observed increases in total NH_3 and N wet deposition over the same timeframe even if the atmospheric concentrations remained constant. Hydrogen ion (H^+) deposition, a measure of acidification in precipitation, has been fairly steady to declining over time which suggests we are not seeing changes in the pH of precipitation in GNP. Increased deposition of H^+ would suggest increased acidification of precipitation. This is likely the result of increasingly more stringent emission control requirements for the power generation and automobile industries. Apart from N and NH_3 , air quality as described by the NTN network data appears to be good and potentially improving.

Mercury Deposition Network – MDN

Mercury deposition at the Apgar stationary site (MT05) is measured as both a concentration and a total deposition value. The graphs below display the differences portrayed in viewing the data from these two perspectives for the measurement time periods of 2004 to 2018.

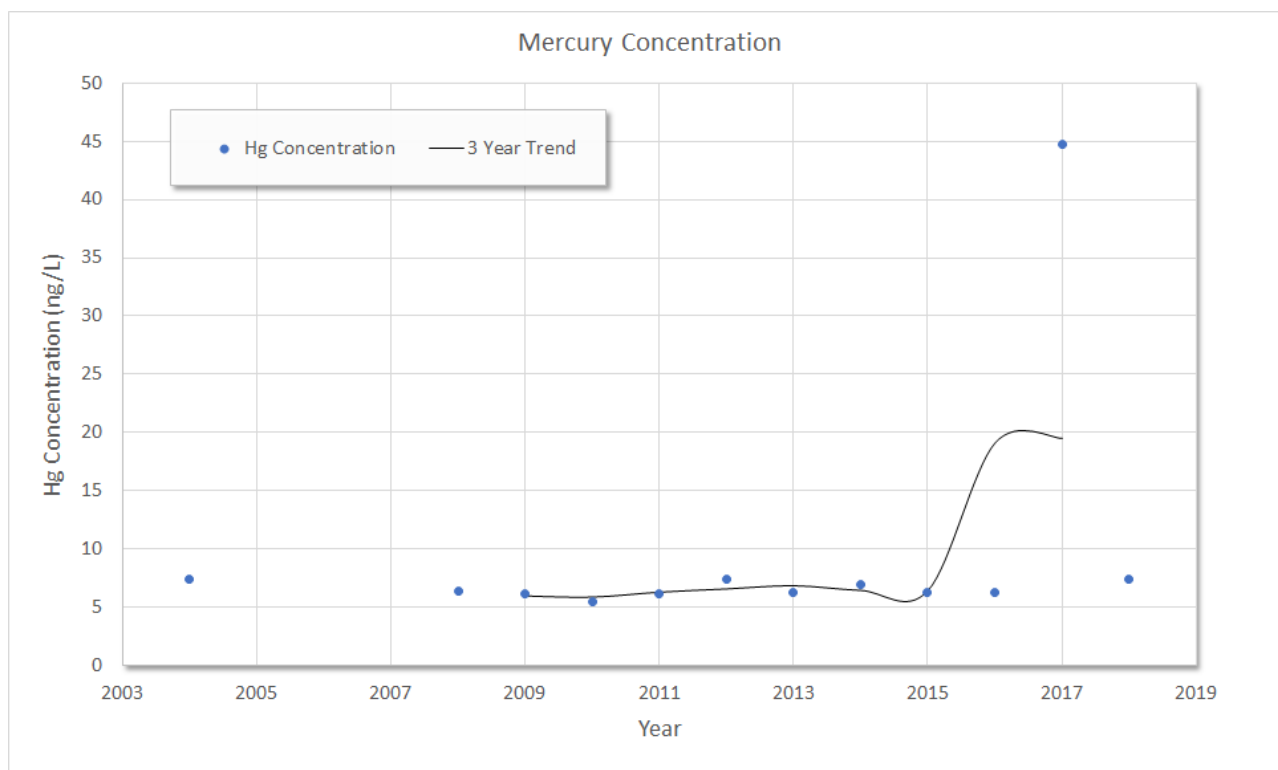


Figure 14. Mean mercury concentration (ng/L) in precipitation measured at the fixed air quality monitoring site in Glacier National Park.

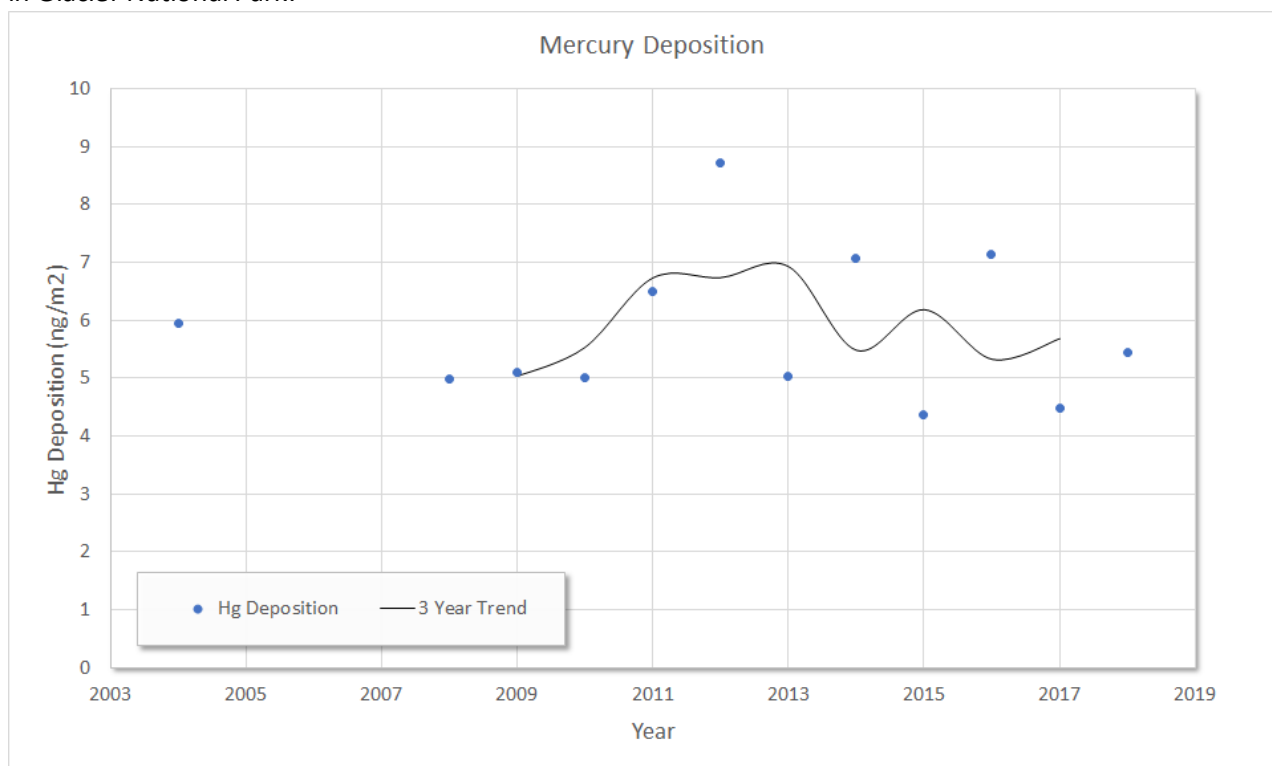


Figure 15. Total Mercury deposition (ng/m²) measured at the fixed air quality monitoring site in Glacier National Park.

Mercury concentration has remained relatively stable in the rainwater collected throughout the years, with the exception of 2017. In 2017, the average mercury concentration was approximately 4 times as much as the other years measured. Mercury is also released naturally from volcano's and forest fires (Stafford et al. 2016), and in 2017 GNP experienced a large fire (Sprague Fire) along the southeast shore of Lake McDonald, about 9 km from the air quality monitoring site. Winds were often pushing the fire downslope towards the lake and the air quality site, likely delivery not only smoke and ash, but also elevated levels of mercury to the site. Interestingly, the NADP maps generated from these data show that mercury concentrations are higher in the western than eastern U.S., while total deposition (which integrates mercury concentration and precipitation amount) is greatest in the Southeast and high elevation mountains of the West (Figure 16).

Elemental mercury deposition measurements are informative to gauge emissions, transport, and deposition, but only when methylation occurs in the environment that mercury becomes readily available to the biological communities. Studies have shown elevated levels of mercury in Glacier's fish and as a result, human consumption guidance has been provided to the public by the NPS (Stafford et al. 2016). Methylmercury concentrates in the tissues of larger, older, predatory fishes and glacier's wildlife have limited opportunity to consume highly contaminated fishes, so the risk of adverse ecosystem impacts from current levels appears limited (Stafford et al. 2016).

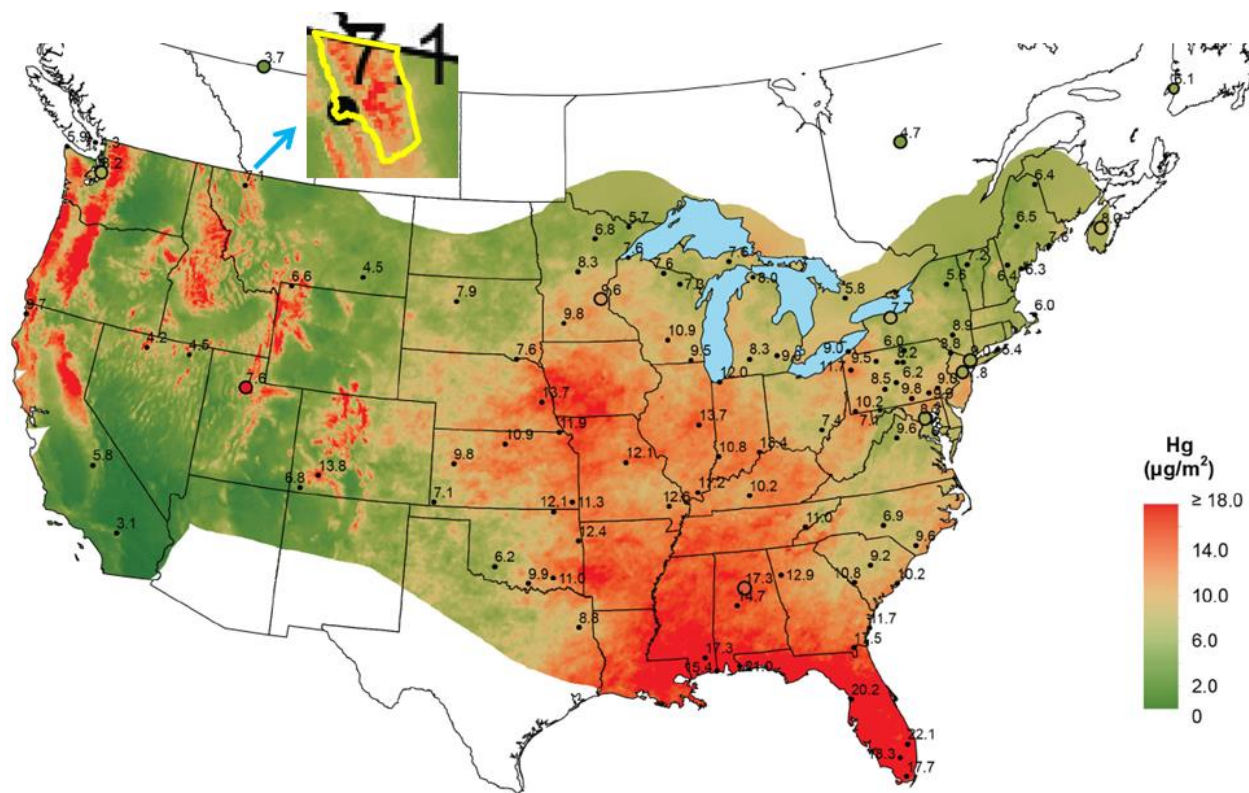


Figure 16. Annual amount of total mercury deposited by precipitation per unit area ($\mu\text{g}/\text{m}^2$) in the US and parts of southern Canada for 2014. Black dots are denoted with the observed data at each monitoring station, while colors represent values based on a modeled, spatial interpolation. The inset denoted with the blue arrow is an enlargement of the Glacier National Park area, including the West Glacier precipitation monitoring station and the park boundary (yellow). All data and the associated map are from the Mercury Deposition Network of the National Atmospheric Deposition Program (NADP; Madison, WI; for details see <http://nadp.slh.wisc.edu/MDN/>), and we have modified their map with the inset and cropping.

Nephelometer

The nephelometer measurements taken at the Apgar stationary air quality site (GLAC1) are used to calculate a light scattering coefficient, which relates to the visibility observed in the ambient air. The greater the coefficient, the more scattered the light is by particles in the air and results in reduced visibility. The upper peaks represent poor visibility days, while the majority of the data shows that visibility is relatively good for vast portions of the year. Variation in visibility is quite high on an annual basis (Figures 17-23) and is affected by factors such as forest fires, regional haze, and wood smoke and inversions in winter months from wood burning stoves. A higher value means poorer visibility.

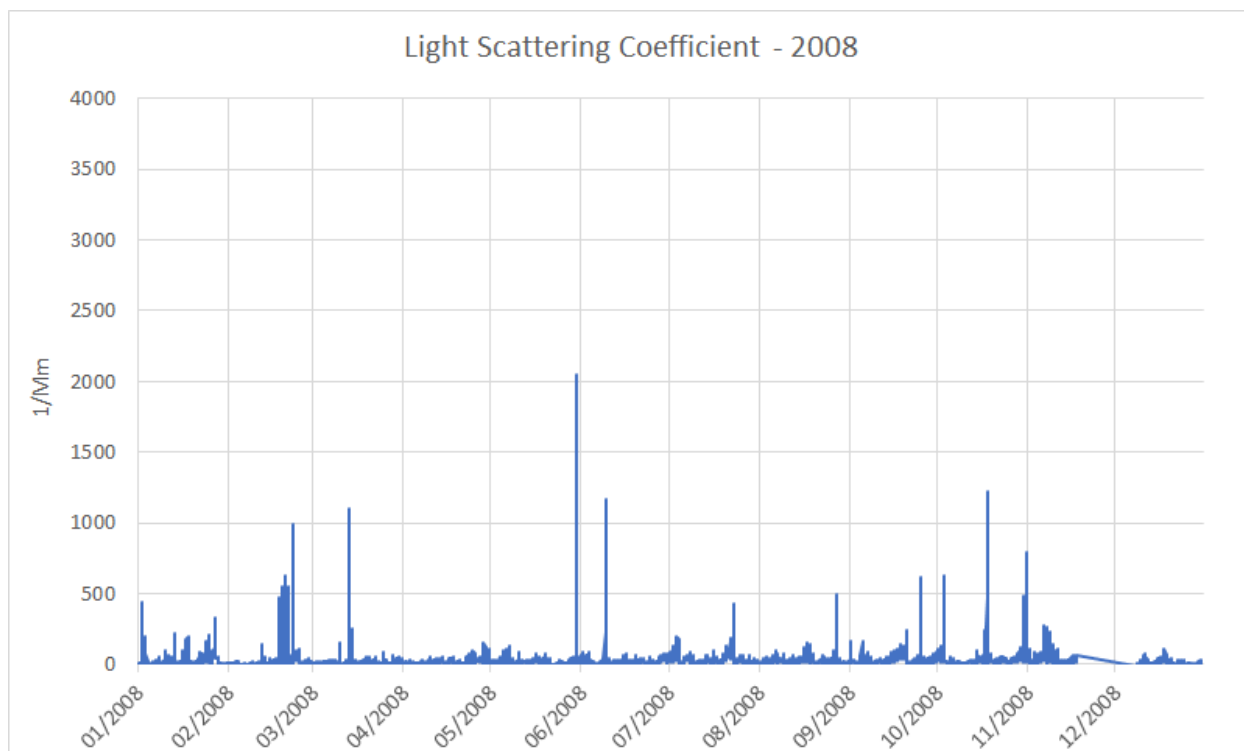


Figure 17. Nephelometer measurements taken at the fixed-site air quality station in 2008 in Glacier National Park.

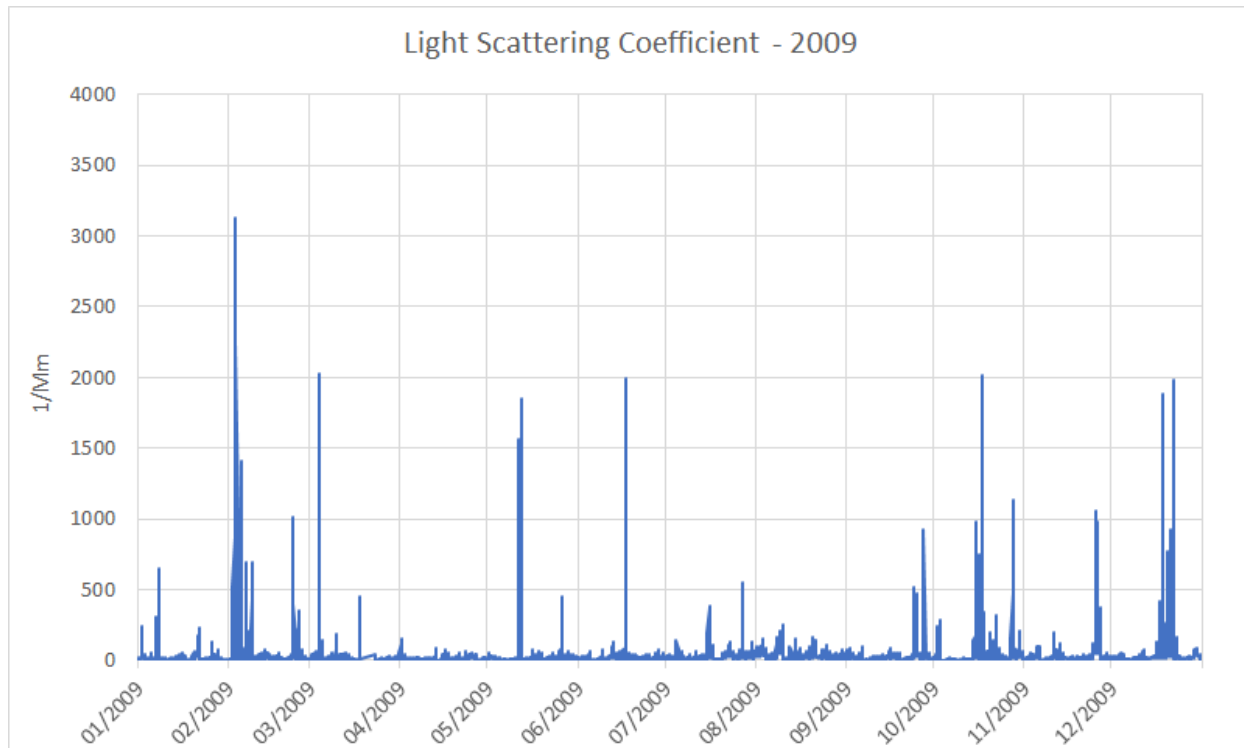


Figure 18. Nephelometer measurements taken at the fixed-site air quality station in 2009 in Glacier National Park.

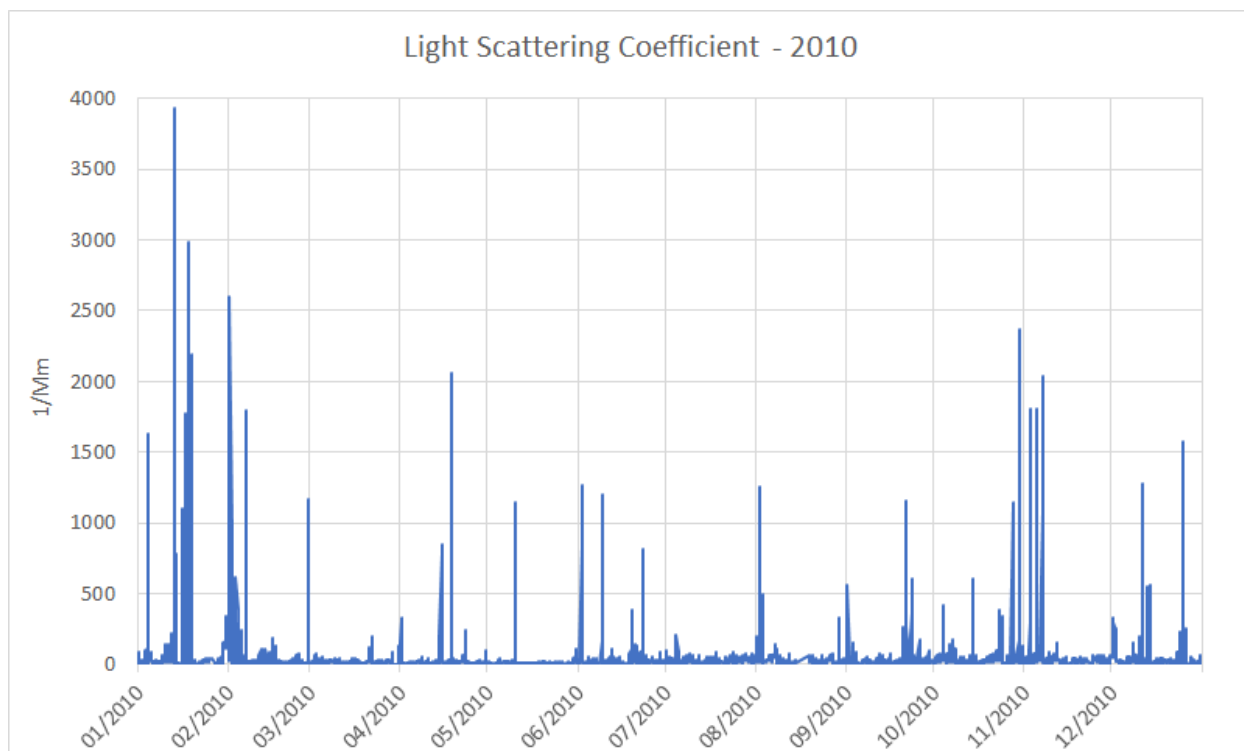


Figure 19. Nephelometer measurements taken at the fixed-site air quality station in 2010 in Glacier National Park.

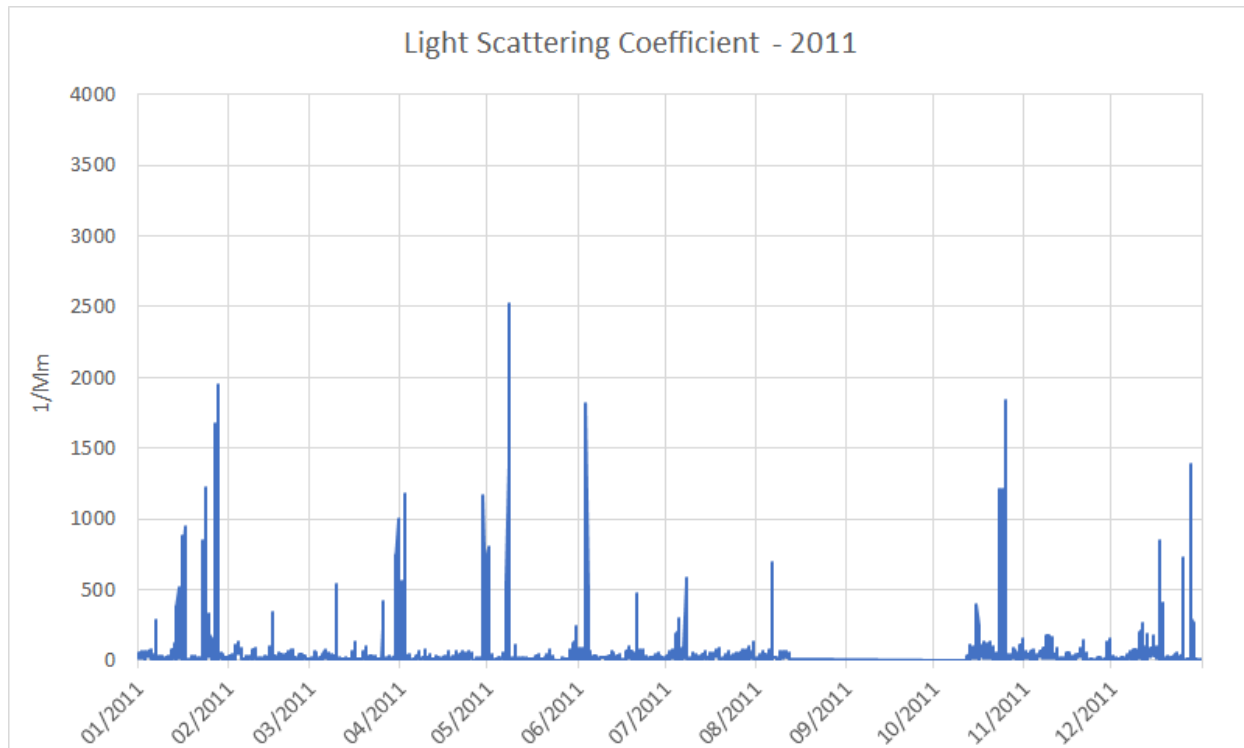


Figure 20. Nephelometer measurements taken at the fixed-site air quality station in 2011 in Glacier National Park.

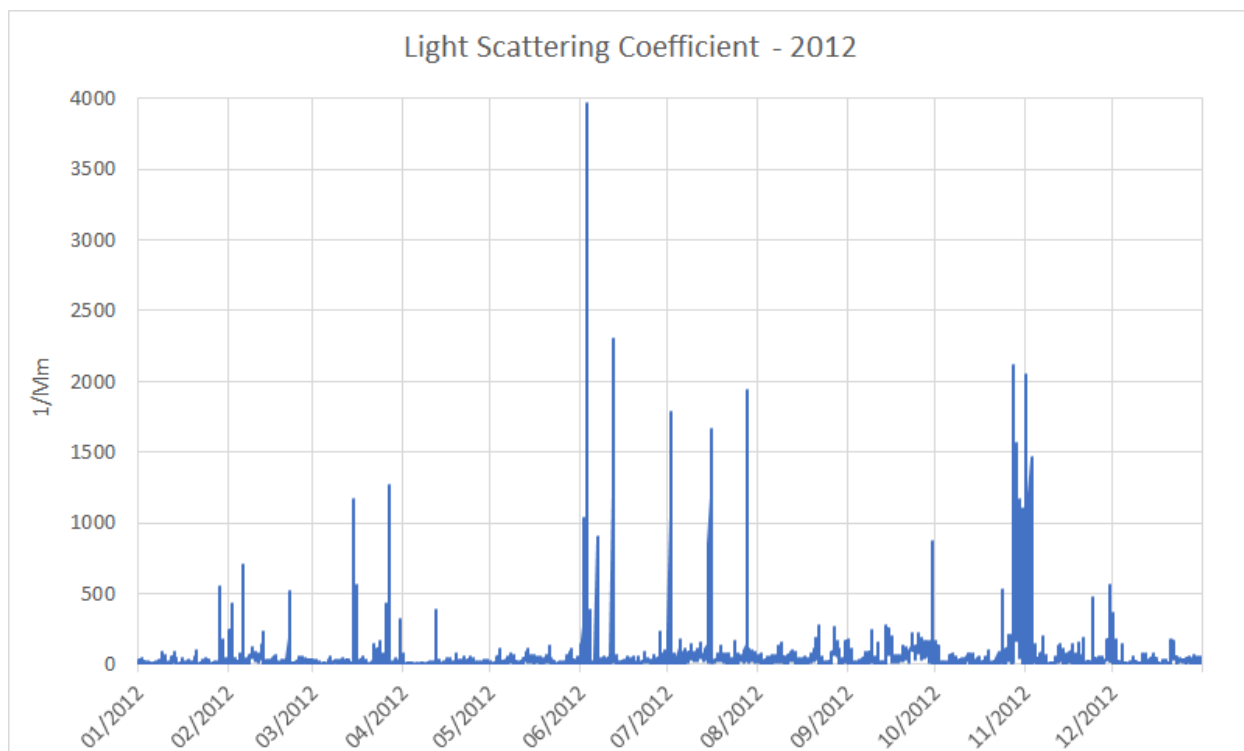


Figure 21. Nephelometer measurements taken at the fixed-site air quality station in 2012 in Glacier National Park.

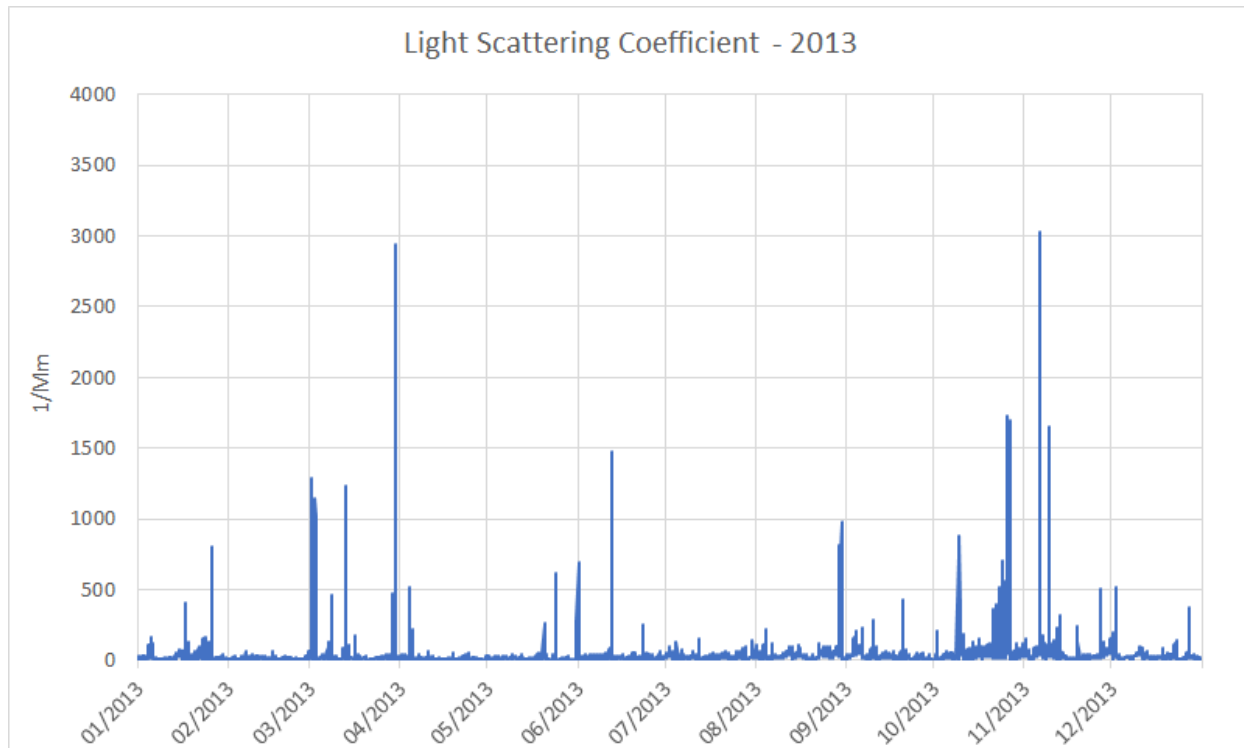


Figure 22. Nephelometer measurements taken at the fixed-site air quality station in 2013 in Glacier National Park.

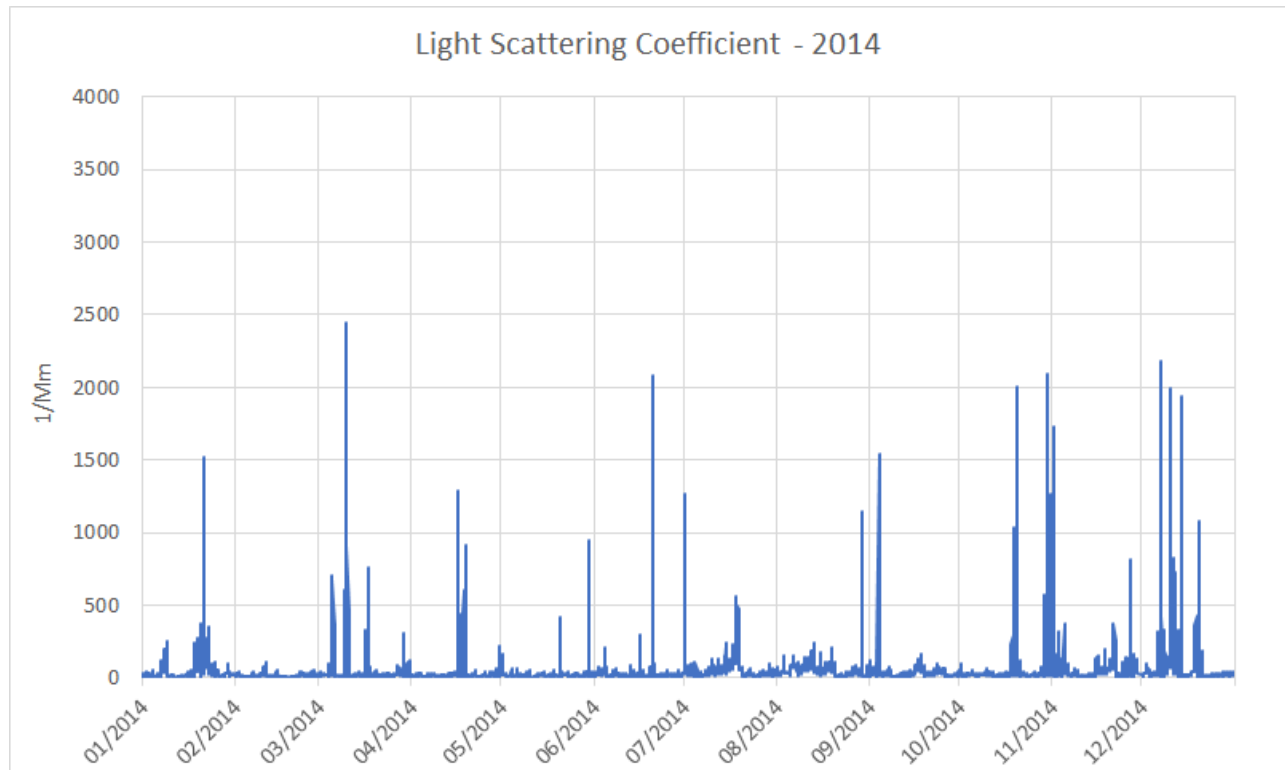


Figure 23. Nephelometer measurements taken at the fixed-site air quality station in 2014 in Glacier National Park.

Ozone

Elevated ground-level ozone can reduce lung function and impact those with pre-existing respiratory conditions. It can also directly harm plants and reduce visibility. However, ozone (O_3) has remained below the human health standard over the course of monitoring at GNP (1990 to 2019). In accordance with the 2015 EPA standards, ozone measurements from the 4th highest daily maximum based on an 8-hour ozone concentration average, averaged over 3 years is what is assessed against the EPA standards (Federal Register 2015). Ozone levels have remained below the national standard of 0.07 ppm since monitoring at GNP began (Figure 24).

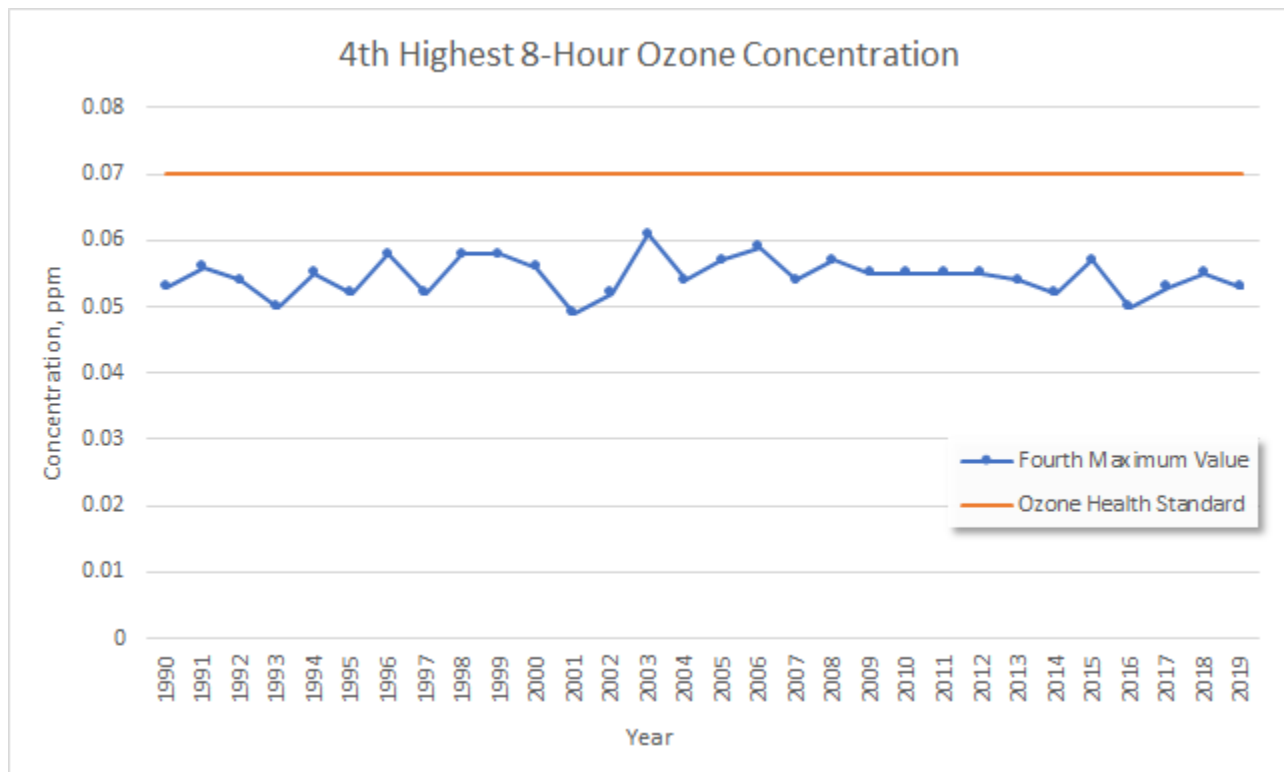


Figure 24. Fourth Highest 8-Hour average ozone concentration measured at the fixed-site air quality monitoring station in Glacier National Park.

Interagency Monitoring of Protected Visual Environments – IMPROVE

The data gathered from the IMPROVE filters at the Apgar stationary site (GLAC1) span from 1989 to 2018 and are shown as a light extinction measure (Figure 25) and as haze index (Figure 26). The light extinction is measured as the amount of light scattered and absorbed as it travels over one million meters. The haze index is in a measure known as a deciview (dv) which is analogous for the sound measure of decibels. Deciview is designed so that incremental changes in the haze index correspond to uniform incremental changes in visual perception, across the entire range of conditions from pristine to highly impaired. A 1.0 dv change is defined as approximately a 10 percent change in the light extinction coefficient, which corresponds to a 2 to 5 percent change in contrast of a “black target” against a clear sky, at the most optically sensitive distance from an observer. The highest year for both measuring techniques is 2003 (Figures 25 and 26) indicating the two assessment approaches are consistent with one another. 2003 was the most significant fire season in the history of the park, with 136,000 acres burned (National Park Service, 2020). Wildfire smoke was the driver of the visibility impacts in 2003. Although the general assumption by the visiting public that GNP has pristine air quality, the haze index indicates there are times of the year when visibility is impacted by regional haze.

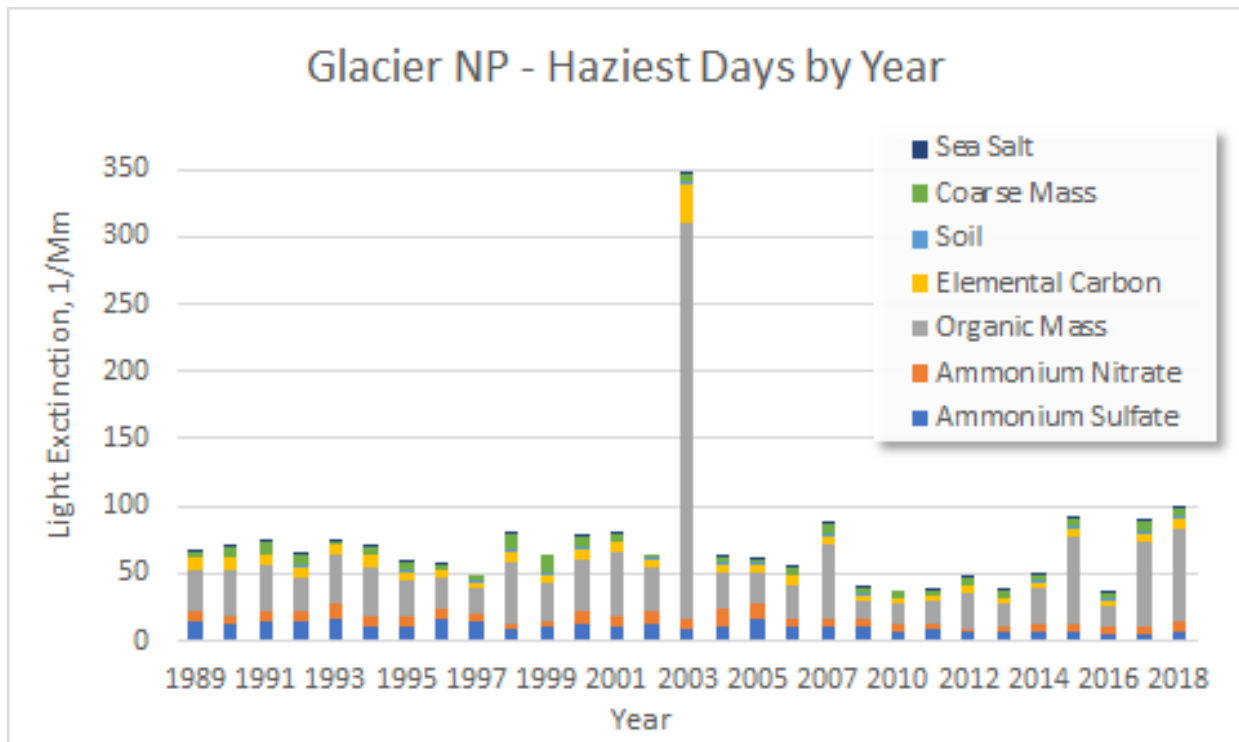


Figure 25. Light extinction on the haziest day by year and contributing pollutants measured at the fixed-site air quality monitoring station in Glacier National Park.

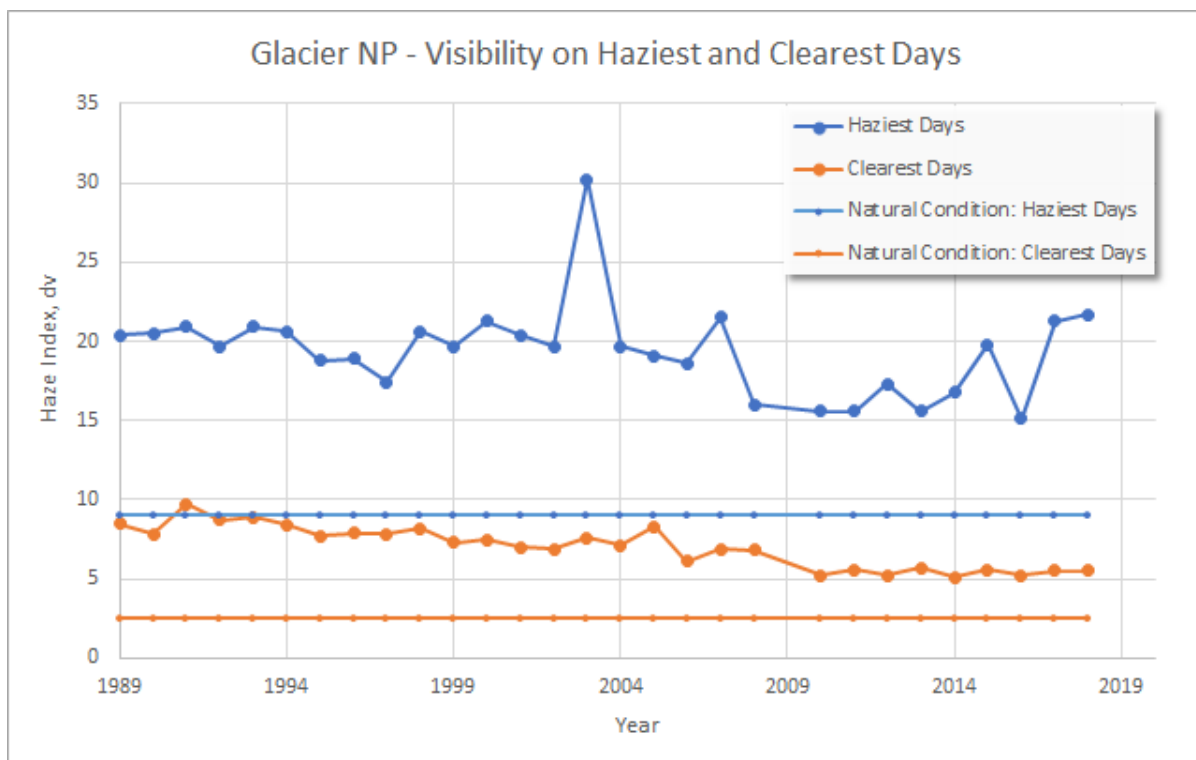


Figure 26. Visibility on the haziest and clearest days measured at the fixed-site air quality monitoring station in Glacier National Park.

Clean Air Status and Trends Network – CASTNET

CASTNET filter analysis from the stationary Apgar air quality site (GLR468) produces data for wet and dry deposition of sulfur, nitrogen, and base cations magnesium (Mg^{2+}), calcium (Ca^{2+}), and potassium (K^+) (Figures 27-30). Base cations are important plant nutrients and help buffer soil acidification. Dry deposition of sulfur and nitrogen appears to be stable to decreasing for both constituents, which suggests improving air quality and reduced risk of acid precipitation. However, wet deposition of nitrogen appears to have increased over the past 20 years. Roughly 1/3 of all sulfur reaching the atmosphere, including 90% of the SO_2 , comes from human sources. These emissions, along with nitrogen emissions, contribute the formation of acid precipitation (Environmental Literacy Council, 2020). Excess deposition of nitrogen can increase eutrophication of lakes and reduce water quality. It can also result in changes in the plant species community, particularly for sensitive components such as lichens with deposition levels exceeding 3-5kg/ha/year (USDA Forest Service, 2020). Total nitrogen deposition is generally less than this, but in some years exceeds this threshold (Figure 28). Although base cation measurements have fluctuated, no trend is apparent in the data (Figure 30).

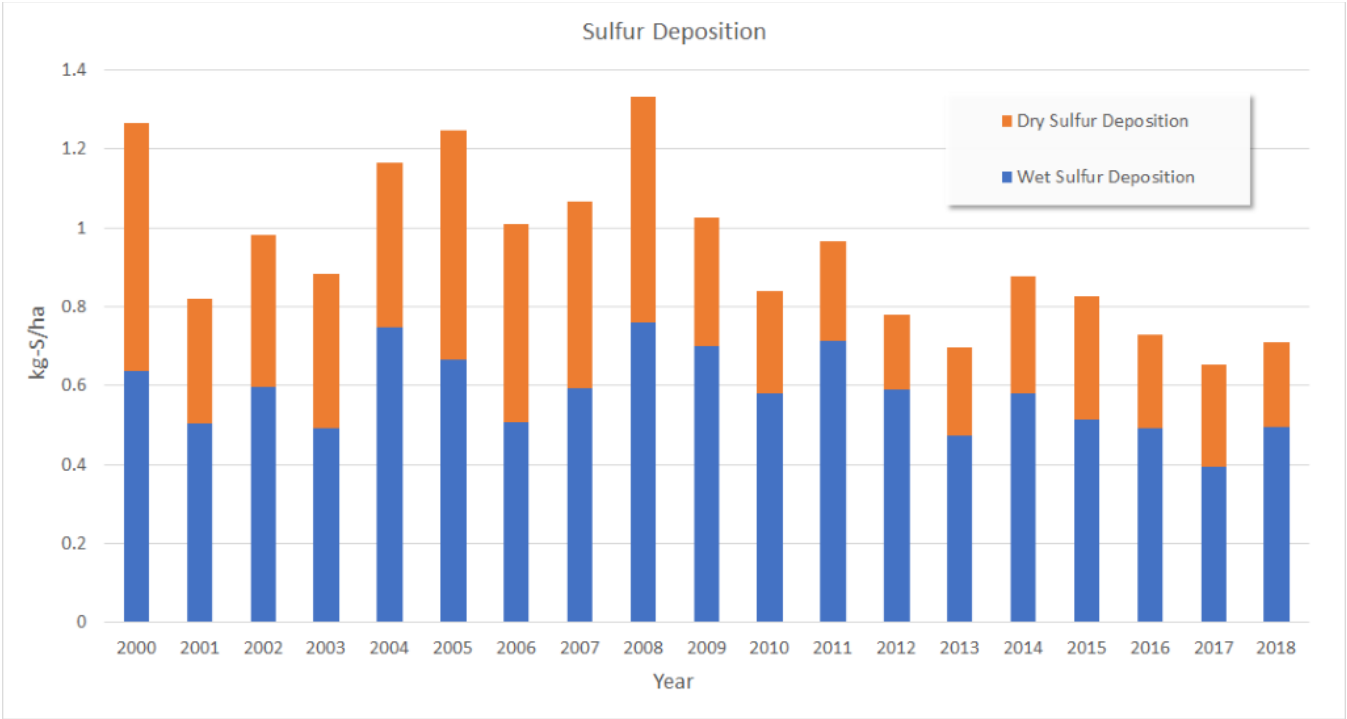


Figure 27. Sulfur deposition measured at the fixed-site air quality monitoring station in Glacier National Park.

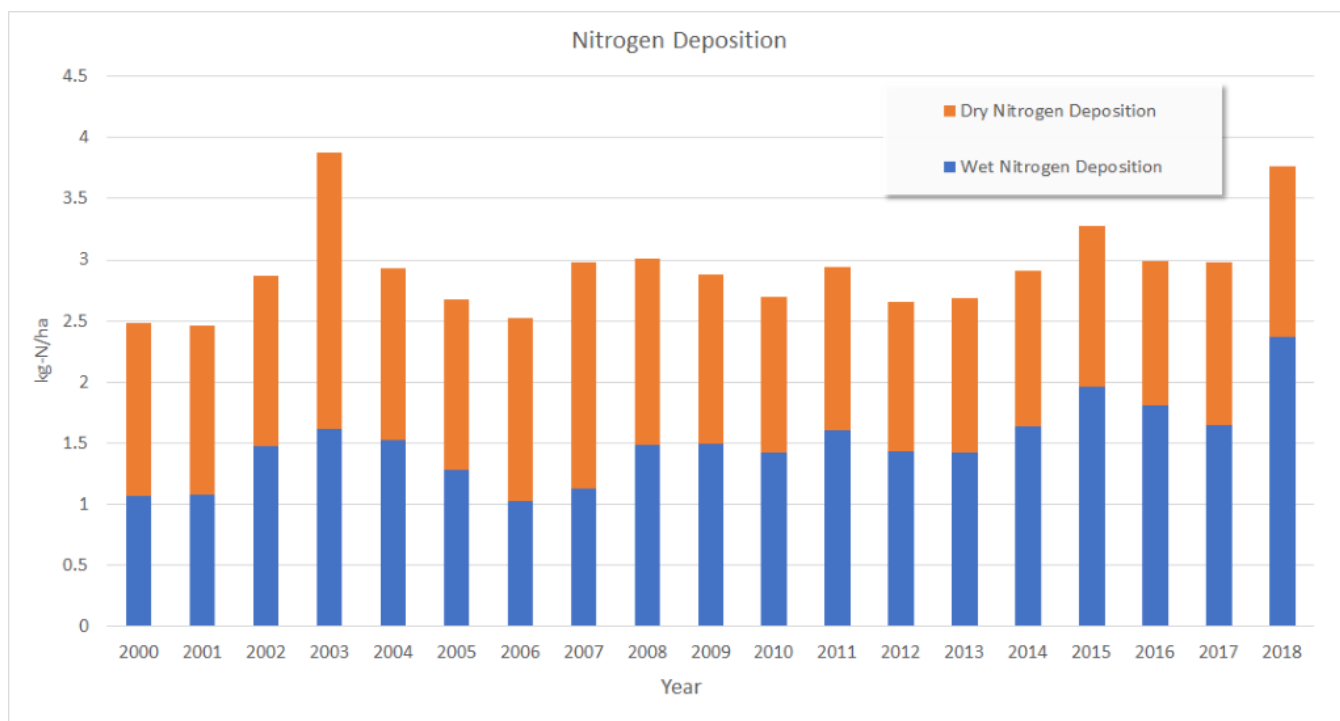


Figure 28. Nitrogen deposition measured at the fixed-site air quality monitoring station in Glacier National Park.

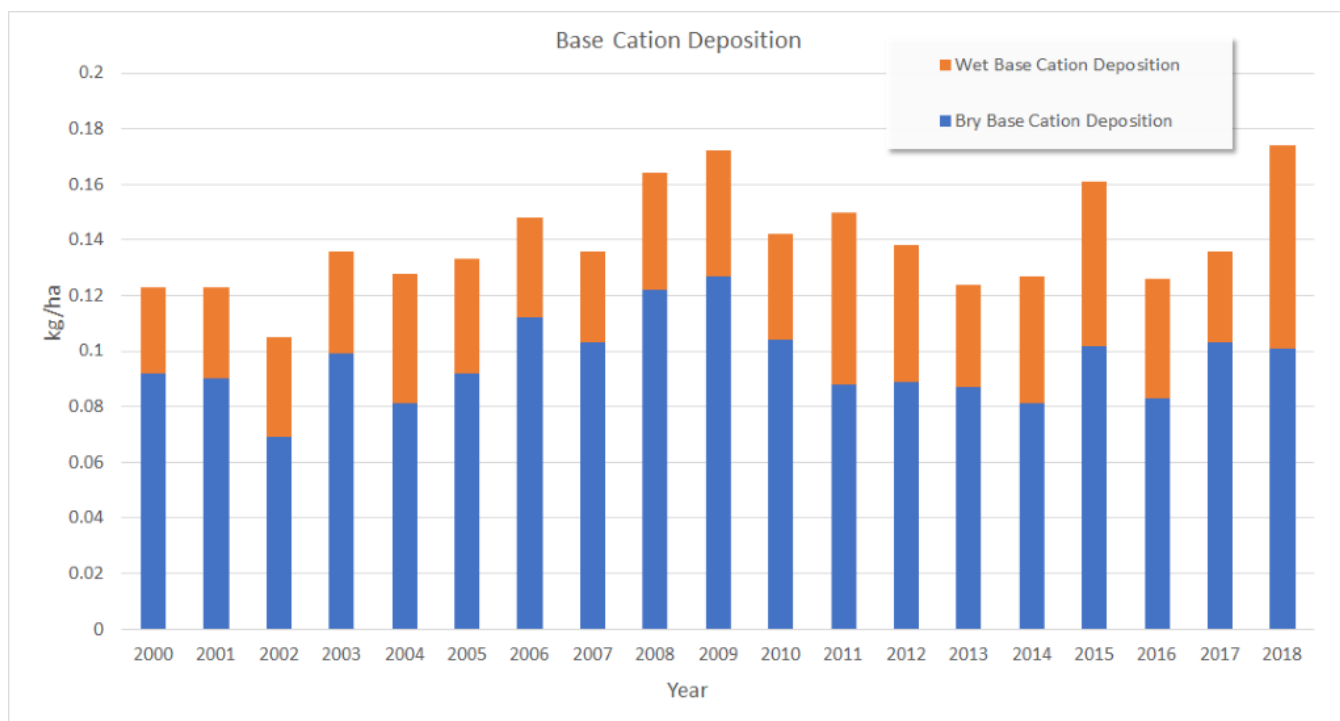


Figure 29. Base cation deposition measured at the fixed-site air quality monitoring station in Glacier National Park.

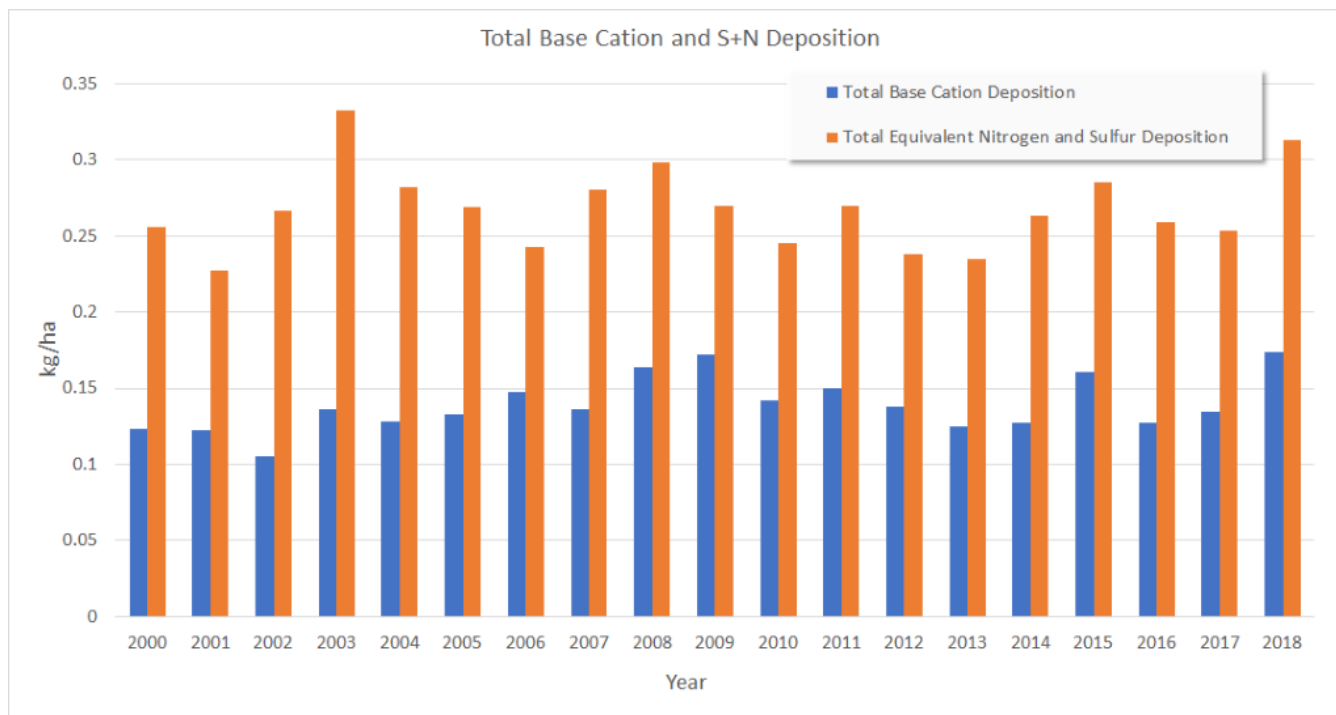


Figure 30. Total base cation deposition and total equivalent Nitrogen and Sulfur deposition.

Environmental Beta Attenuation Monitor - E-BAM

The national standard for human health for particulate 10 microns and less (PM_{10}) is stated as not to exceed a 24-hour average of 150 $\mu g/m^3$ more than once per year on average over a three-year period (USEPA 2020). At both sites' GNP experienced particulate concentrations nearly an order of magnitude below this national human health standard (Figures 31 and 32). At these locations, PM_{10} concentrations do not pose a risk to human health. Future sampling will include site locations downstream of the Camas Road to get a more complete picture of PM_{10} relative to other locations and distances from the North Fork Road.

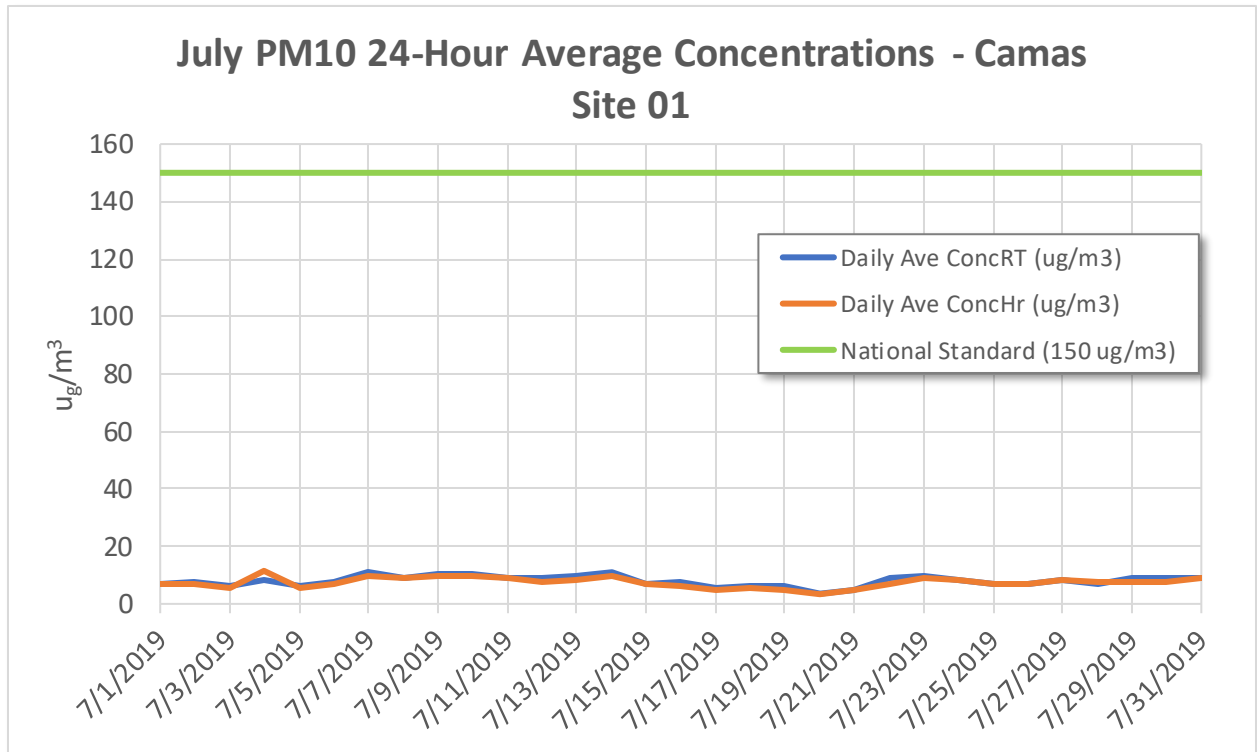


Figure 31. Average PM10 measurements recorded by the E-BAM at the Camas Road monitoring site.

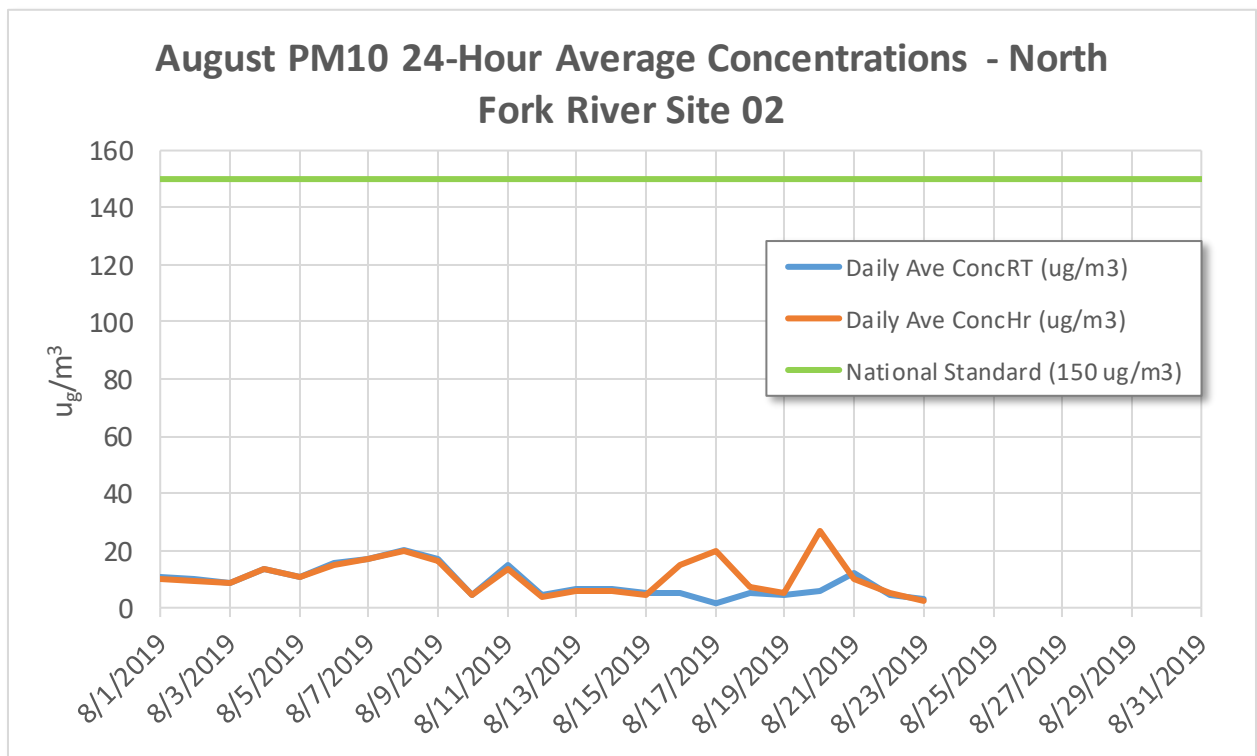


Figure 32. Average PM10 measurements recorded by the E-BAM at the upper monitoring site.

WATER QUALITY

North and Middle Forks of the Flathead River

Summer air and water temperatures are positively correlated in Flathead River Basin (Muhlfeld et al. 2014). Hotter, drier summers result in warmer summer water temperatures, as is evident in the water temperature data for the North Fork Flathead River at the Canadian border (NPS, unpublished data) (Figure 33). Water temperatures at the NPS monitoring site at the border have been slowly increasing over the past decade (NPS, unpublished data), but currently remain within the thermal tolerance of both westslope cutthroat and bull trout. Westslope cutthroat trout have a thermal preference for 15°C (McMahon et al. 2008) while bull trout have a thermal preference of about 12°C (Selong et al. 2001). Peak summer water temperatures exceeding 18°C have been observed at the Canadian border in recent years (NPS, unpublished data). Warming summer water temperatures threaten the year-around habitat suitability of the mainstem North Fork Flathead River for bull trout. The USFWS has classified the mainstem North Fork Flathead in Montana as “critical” feeding and migration habitat, but not spawning and rearing habitat. It is likely that during peak summer water temperatures, bull trout seek areas of cold-water influence such as tributary mouths or in tributaries themselves (Muhlfeld and Marotz 2005).

Montana DEQ instantaneous dissolved oxygen (d.o.) standard for class A-1 rivers is 8 mg/L (Mills et al. 2012), with 3.0 mg/L being the acute lethal limit for salmonids (EPA 1986). Mills et al. (2012) documented d.o. levels in excess of 9.5mg/L in the North Fork Flathead for water the water year 2007-2008. These standards are generally protective of the broader cold-water aquatic community as well.

Similarly, pH, a measure of acid-base equilibrium, is important as it effects a broad array of chemical and biological processes in water (EPA 2006). The MTDEQ standard for pH in class A-1 waters is a non-numerical, non-degradation standard, whereas EPA criteria for aquatic life indicate an acceptable pH level ranging from 6.5-9. Mills et al. (2012) documented pH range of 7.8-8.4 in the North Fork of the Flathead River. NPS alkalinity data (a measure of acid buffering capacity) suggests the river has adequate capacity to buffer any currently occurring acid inputs (e.g. from precipitation or other human sources). Alkalinity levels have been relatively stable for the past decade, suggesting little change in acid inputs (Figure 34). Under Montana law, with few exceptions, human-caused changes in the water quality in either the North or Middle Forks of the Flathead River (classified as A-1) are not permitted.

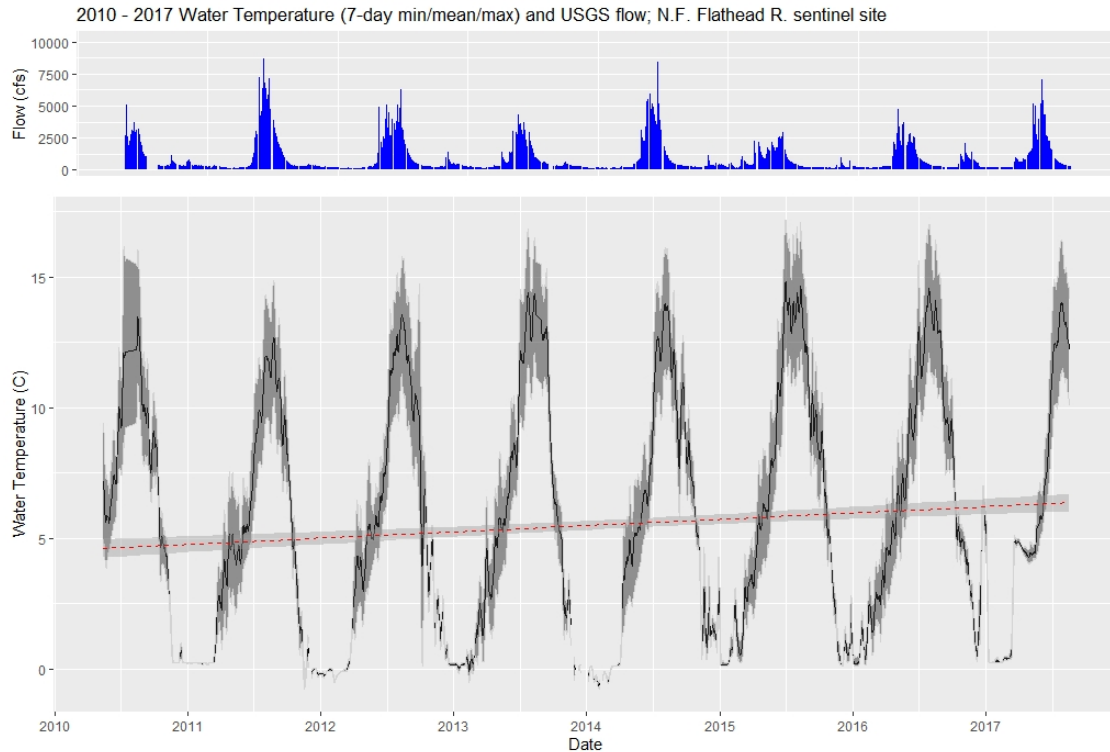


Figure 33. Stream flow and water temperature recorded at the USGS and NPS border monitoring site on the North Fork of the Flathead River (B. Schweiger, NPS, unpublished data).

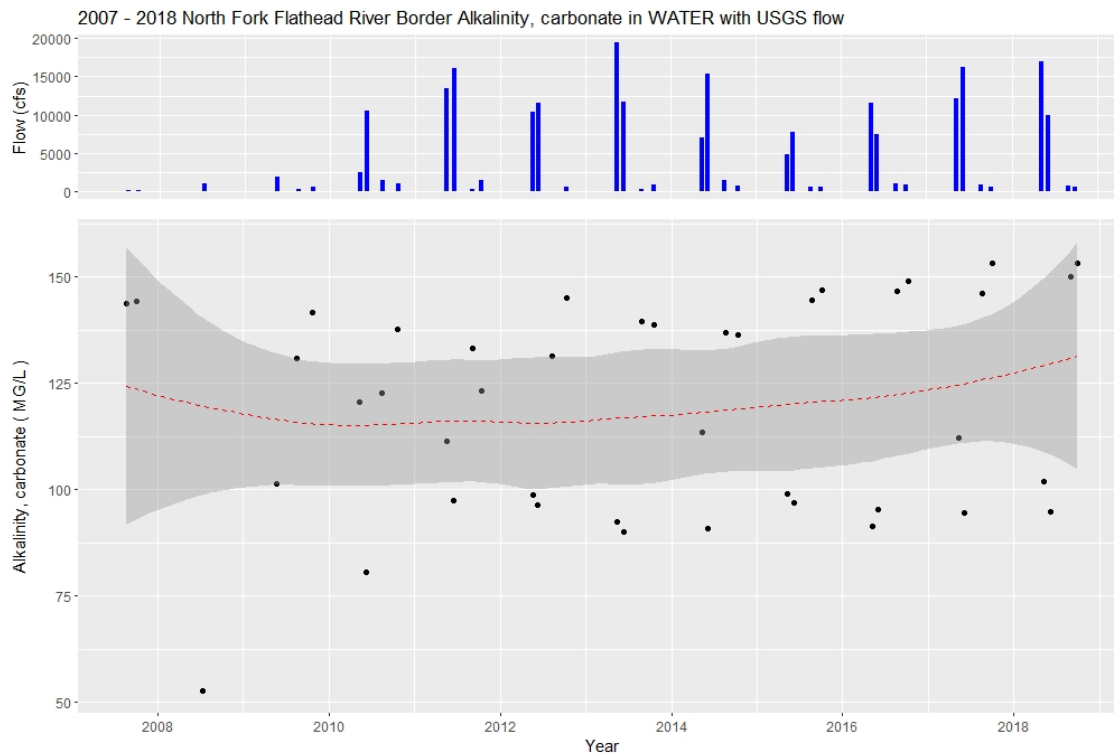


Figure 34. Alkalinity (mg/L) and river discharge recorded on the day of the alkalinity measurement was taken at the USGS and NPS border monitoring site on the North Fork of the Flathead River (B. Schweiger, NPS, unp. data).

Mills et al. (2012) evaluated water quality and water quality trends for the North Fork Flathead River for the period of record (generally starting in the mid-1970's) for a variety of water properties and constituents (e.g. suspended sediment, phosphorus) in addition to water temperature, dissolved oxygen, and pH. They found no meaningful trends of either improving or declining water quality over time. The authors also tested for trace elements including arsenic, cadmium, chromium, copper, lead, nickel, and zinc. The only water quality exceedance was for peak lead levels associated with spring runoff (likely tied to the pulse of sediment/organics that come with spring runoff). The chronic lead level limit for aquatic health (MTDEQ 2017), adjusted for the appropriate local water hardness, would be about 2.2 ug/L. Peak lead exceedances observed in May of 2018 by Mills et al. (2012) were 0.24ug/L for the border site and 2.06ug/L for the Columbia Falls site. Single exceedances in this situation aren't likely to be biologically relevant as evidenced by the season-long median lead values of 0.14 and 0.5 for the border and Columbia Falls sites (Mills et al. 2012).

Changes in the aquatic invertebrate community are often associated with reduced water quality. The North Fork of the Flathead River maintains a healthy and diverse aquatic insect community, dominated by pollution sensitive taxa of the orders Plecoptera, Ephemeroptera, and Tricoptera (Hauer and Sexton 2012). The authors documented higher algal species diversity in the North Fork Flathead River drainage as compared to the nearby Elk River drainage which has been heavily impacted by mining. The authors also pointed out that the North Fork Flathead is co-limited in algal production by nitrogen and phosphorus and the low levels of these nutrients reflect the high-water quality of the basin due to its largely undeveloped nature.

In 2018 and 2019, in response to public concern over potential leaking septic systems and other improper human waste disposal issues along the North and Middle Forks of the Flathead River, GNP began testing the rivers for the presence of *E. coli*. *E. coli* is found in the gut of warm-blooded animals and is often used as an indicator of human waste contamination. Some strains of *E. coli* are harmless while others can make humans very sick. It is important to periodically monitor park waters for *E. coli* to protect human and aquatic health. We collected 6 water samples from three sites on the North Fork of the Flathead River and four samples from two sites on the Middle Fork of the Flathead River in 2018. We collected samples from the same sites in 2019, with the addition of a new sample site on the North Fork Flathead at Blankenship Bridge and a new sample site at Walton on the Middle Fork Flathead River (Figures 35 and 36). Across both years and sites on the rivers, *E. coli* levels were well below human health standards and indicative of very clean water (Tables 1 and 2).

Lake McDonald

Similar concerns also prompted bacteria testing of Lake McDonald in 2019. Consistent with the data for the river samples, samples from Lake McDonald did not show elevated levels of *E. coli* (Table 3, Figure 37). Based on these data, we did not detect any evidence of leaking septic tanks or improper waste disposal in Lake McDonald.

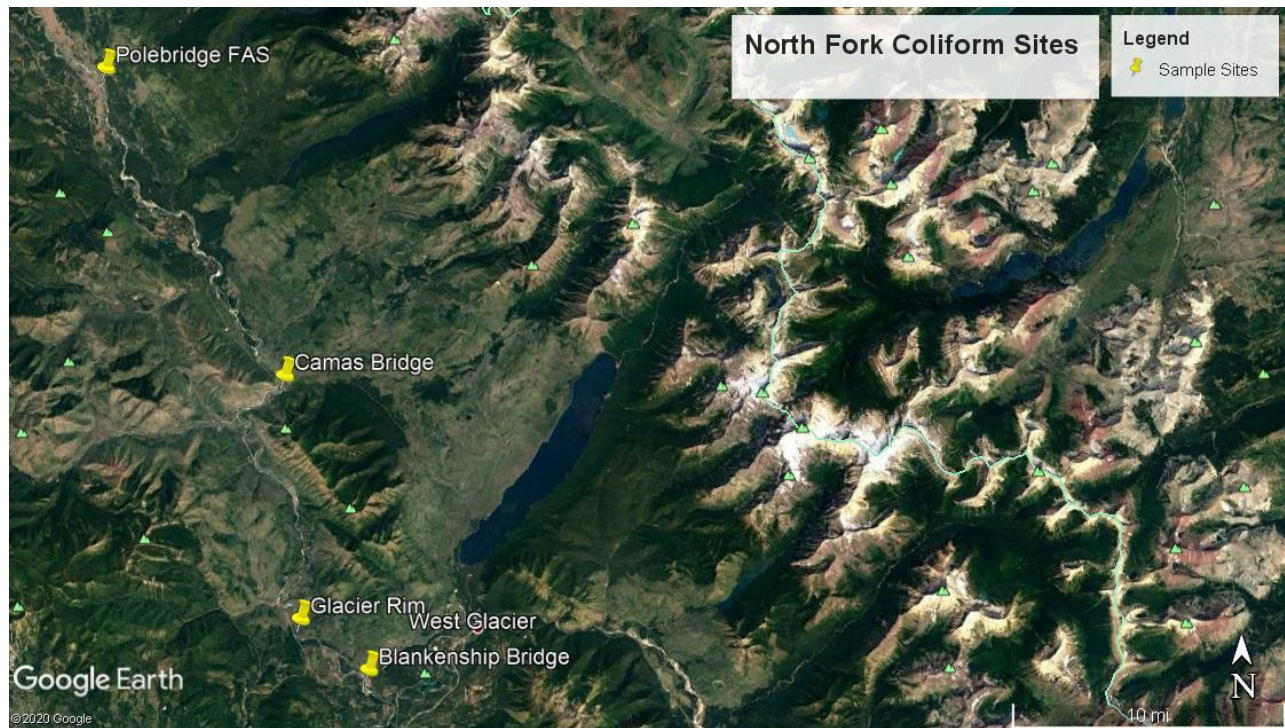


Figure 35. 2018 and 2019 North Fork Flathead River NPS coliform bacteria samplings sites.



Figure 36. 2018 and 2019 Middle Fork Flathead River NPS coliform bacteria samplings sites.

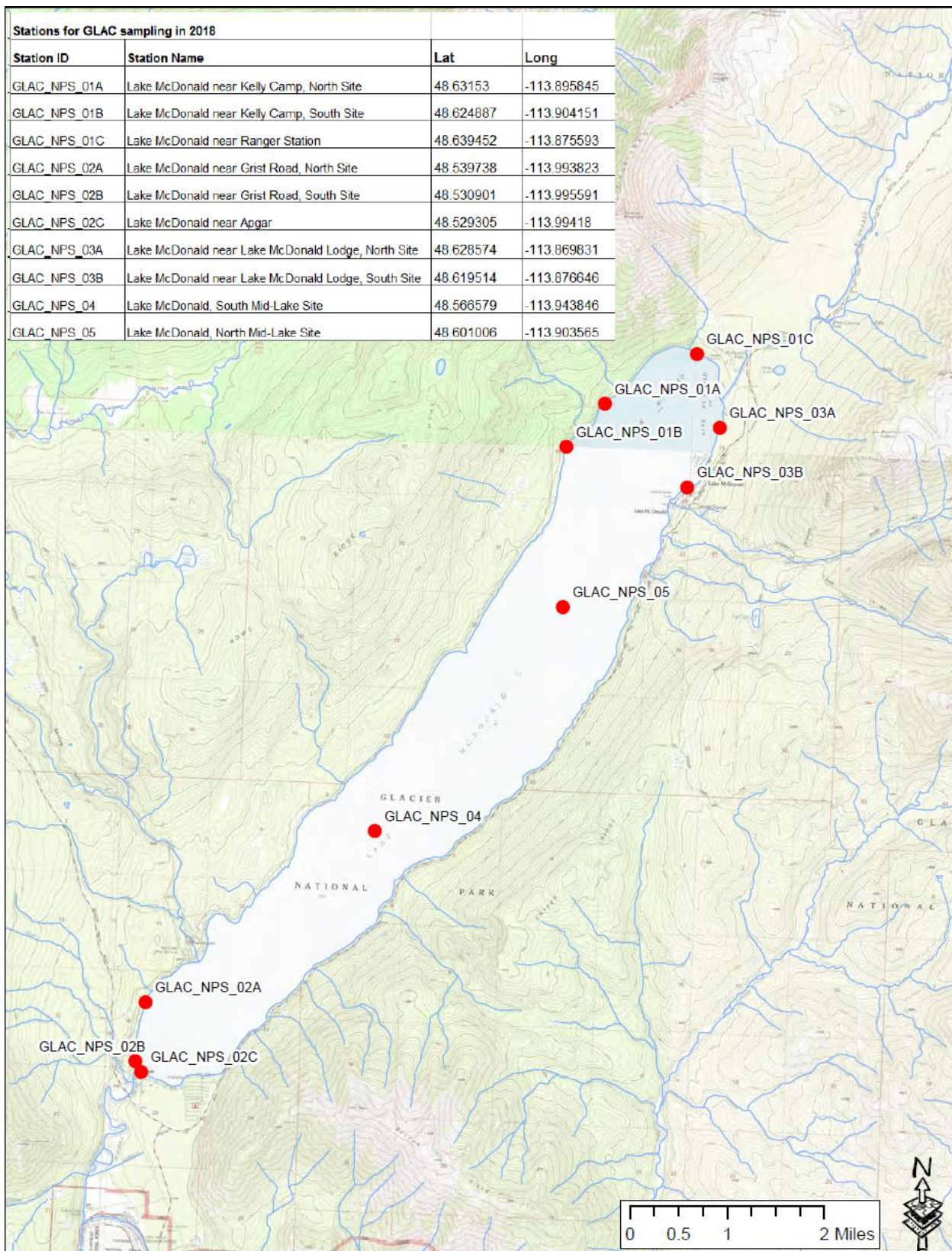


Figure 37. Lake McDonald water quality monitoring sites used to collect coliform bacteria samples in 2019. Sites 6 and 7 (not pictured) were located near the outlet of Lake McDonald.

Table 1. Coliform bacteria sampling results for the North and Middle Forks of the Flathead River, 2018.

Drainage	Site	Sample Date	E. coli (mpn/100ml)	Total coli. (mpn/100ml)
North Fork Flathead	Polebridge FAS	8/28/18	<1	167
North Fork Flathead	Polebridge FAS	8/28/18	2	173
North Fork Flathead	Camas Bridge	8/28/18	3	148
North Fork Flathead	Camas Bridge	8/28/18	5	166
North Fork Flathead	Glacier Rim FAS	8/28/18	2	201
North Fork Flathead	Glacier Rim FAS	8/28/18	9	140
Middle Fork Flathead	Cascadia FAS	8/28/18	3	99
Middle Fork Flathead	Cascadia FAS	8/28/18	4	133
Middle Fork Flathead	Golf Course FAS	8/28/18	5	179
Middle Fork Flathead	Golf Course FAS	8/28/18	5	201

Table 2. Coliform bacteria sampling results for the North and Middle Forks of the Flathead River, 2019.

Drainage	Site	Sample Date	E. coli. (mpn/100ml)	Total coli. (mpn/100ml)
North Fork Flathead	Polebridge FAS	7/1/19	2	27
North Fork Flathead	Polebridge FAS	7/1/19	1	38
North Fork Flathead	Camas Bridge	7/1/19	<1	214
North Fork Flathead	Camas Bridge	7/1/19	<1	157
North Fork Flathead	Glacier Rim FAS	7/1/19	1	65
North Fork Flathead	Glacier Rim FAS	7/1/19	<1	57
North Fork Flathead	Blankenship Bridge	7/1/19	<1	35
Middle Fork Flathead	Walton FAS	7/30/19	<1	20
Middle Fork Flathead	Walton FAS	7/30/19	<1	64
Middle Fork Flathead	Cascadilla FAS	7/30/19	<1	33
Middle Fork Flathead	Cascadilla FAS	7/30/19	1	39
Middle Fork Flathead	Golf Course FAS	7/30/19	1	50
Middle Fork Flathead	Golf Course FAS	7/30/19	<1	47

Table 3. Coliform bacteria sampling results for Lake McDonald, 2019.

Site	Sample Date	E. coli. (mpn/100ml)	Total coli. (mpn/100ml)
01a	8/5/19	<1	<1
01b	8/5/19	<1	<1
01c	8/5/19	<1	2
02a	8/5/19	<1	<1
02b	8/5/19	<1	14
02c	8/5/19	<1	<1
03a	8/5/19	<1	<1
03b	8/5/19	<1	<1
04	8/5/19	<1	<1
05	8/5/19	<1	1
06	8/5/19	<1	1
07	8/5/19	<1	25

That said, recent studies undertaken by GNP in partnership with Environmental Protection Agency (EPA) have documented the presence of personal care products and medicines, metabolites of tobacco exposure, caffeine, and insect repellent in Lake McDonald water (National Park Service, unpublished data). Some of these could come from direct contact of people with Lake McDonald, like insect repellent (DEET) or methylparaben (a preservative found in sunscreen, cosmetics, and other personal care products), but other substances are more likely to be excreted from the human body (e.g. – cotinine, a metabolite of nicotine; caffeine; acetaminophen). These substances don't have established EPA or MTDEQ water quality standards, but most were detected at very low concentrations (with the exception of some detections of DEET) and don't likely pose an environmental or human health risk. Although we did not find evidence of septic leachate entering lake McDonald by looking for *E. coli.*, it is still possible it is occurring at some low level due to the presence of other contaminants found in the EPA project. These results are not necessarily unexpected, as previous water quality studies in GNP documented the presence of a variety of airborne contaminants being transported to park and being deposited as wet and dry deposition on park lands (Landers et al. 2008).

We collected secchi depth measurements from seven park lakes between 2011-2019 (Figure 38). Secchi depth is a measure of water transparency (how deep an observer can see the disk in the water). Reduced transparency can be a result of increased productivity (nutrient enrichment/pollution) stimulating algal growth. Most of the parks lakes are oligotrophic in nature, meaning they are naturally low in productivity (nutrients) and have very high-water quality (Ellis et al. 1992). Overall, Glacier's waters have among the highest water quality in the Flathead River Basin as evidenced by Secchi depth comparisons to other high-quality waters at similar times of the year (late July-early August) including Flathead Lake (36'), Ashley Lake (36'), and Swan Lake (41').

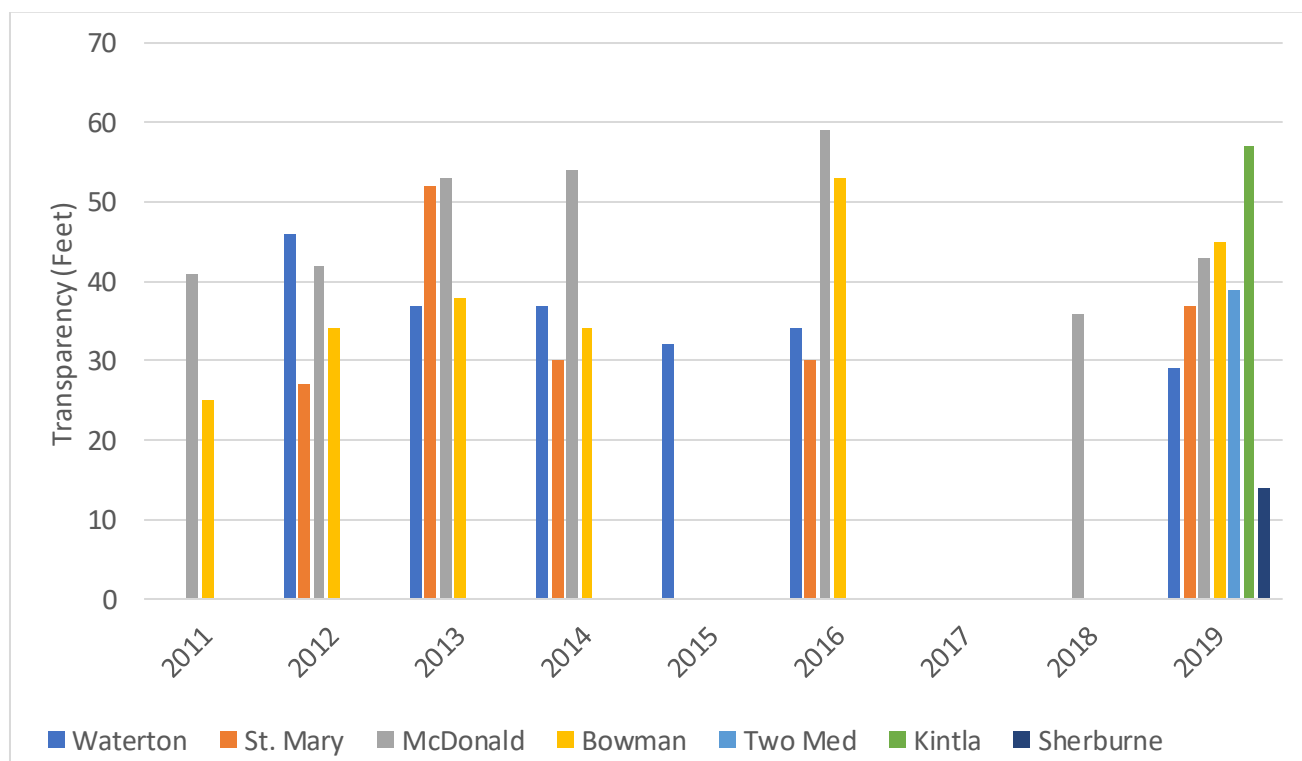


Figure 38. Secchi disk water transparency measurements collected during the summer in various Glacier National Park waters.

Swiftcurrent Creek

GNP works with the USGS to monitor water quality at the Swiftcurrent Creek stream gaging station as part of the national Hydrologic Benchmark Network. Discharge and water temperature are recorded at the site and water samples are collected to characterize water quality over time. The Swiftcurrent drainage is snowmelt driven with peak flows associated with spring runoff (Figure 39). The highest instantaneous discharge observed from 2003-2020 is about 700 cubic feet/second (cfs) and has an observed recurrence interval of between 4-7 years. The average annual peak discharge is about 400 cfs. No trends in peak discharge are evident.

Annual water temperature was monitored from 2012-2019 (Figure 40). Peak water temperatures varied from about 15.5°C to 18°C. 2012 and 2013 had lower peak water temperatures than 2014-2019. These data are consistent with other authors (Giersch et al. 2014) findings that have documented an increase in peak air temperature in the Many Glacier Valley from 1960-2012 of between 0.67 and 1.28°C. On a broader scale, northern latitude and/or high elevation areas, such as Glacier National Park, are warming much faster than other areas of the U.S. (Muhlfeld et al. 2014, Gonzalez et al. 2018). Gonzalez et al. (2018) demonstrated climate warming as having a disproportionate impact on natural resources of the U.S. National Park system.

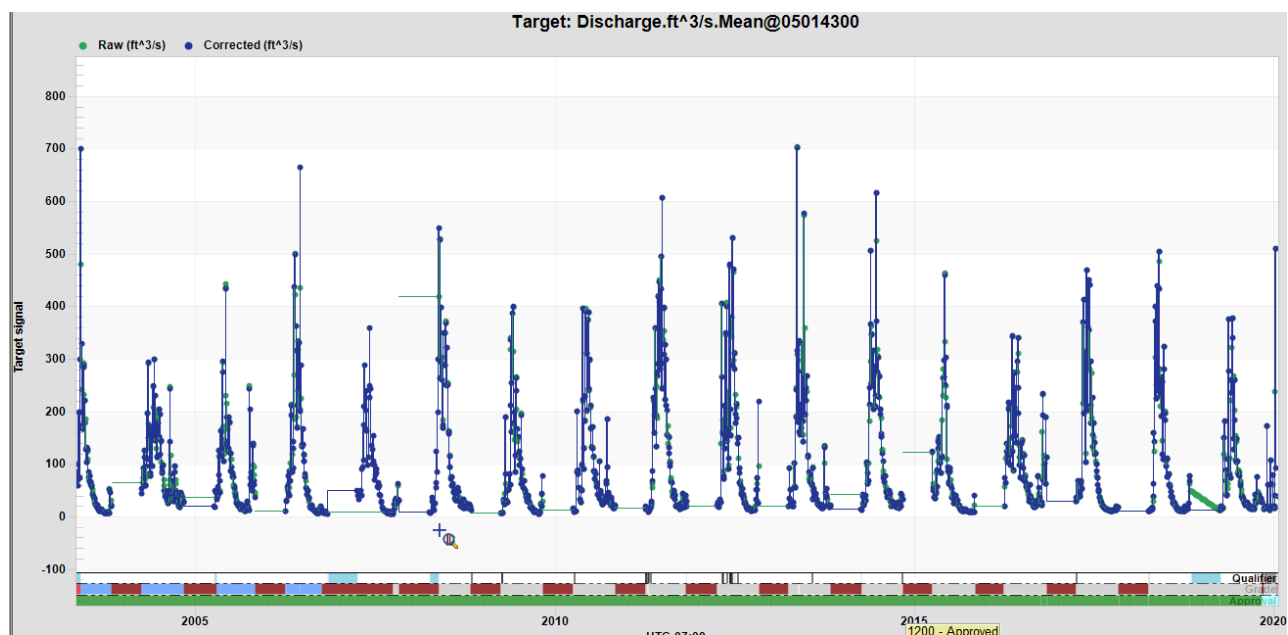


Figure 39. Swiftcurrent Creek Discharge measured at the USGS gaging station.

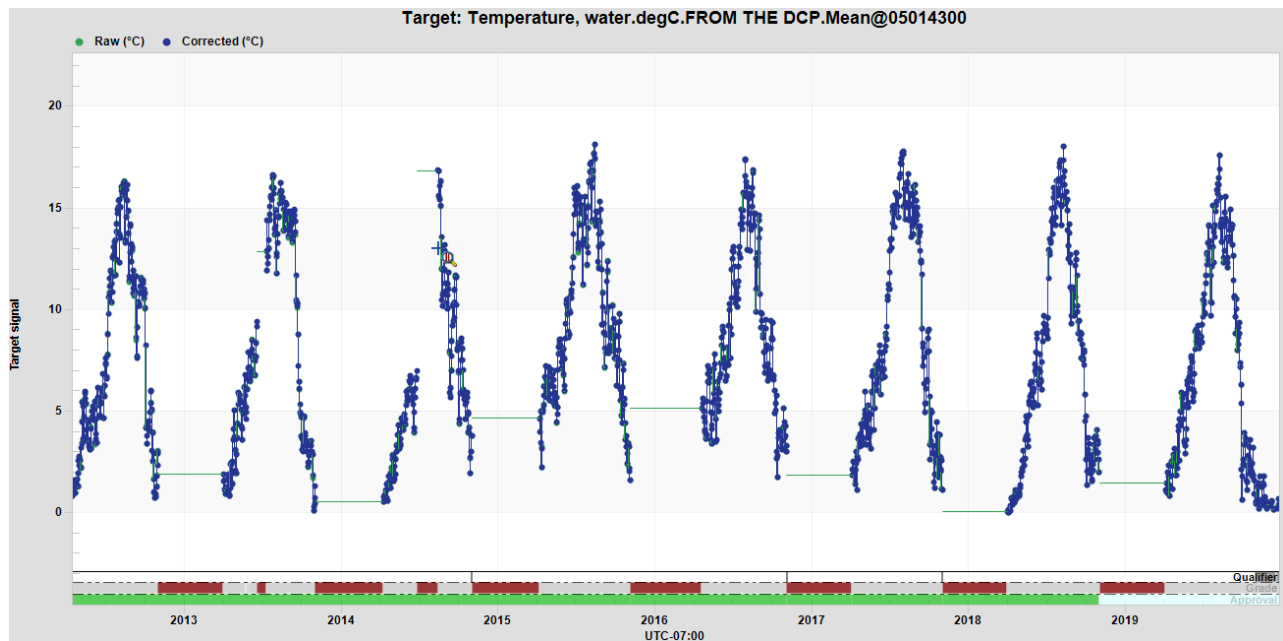


Figure 40. Swiftcurrent Creek water temperature (Celsius) measured at the USGS gaging station.

Swiftcurrent Creek pH has remained fairly stable over the period of record (Figure 41). In 2012, the HBN network switched to using a different lab and the apparent slight increase in pH values seen after this date may be due to changing processing labs (Abbey Kieth, USGS, personal communication).

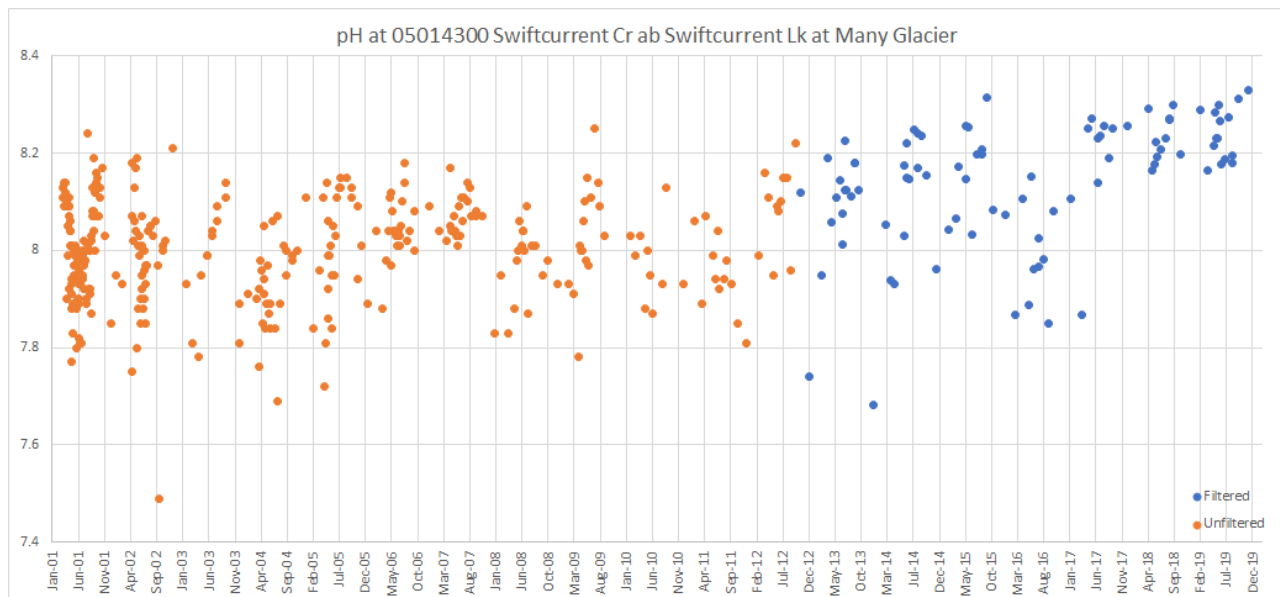


Figure 41. Swiftcurrent Creek pH measured at the USGS gauging station.

Swiftcurrent Hydrocarbon Seep

In early August, 2019 a park visitor reported “oil” coming out of a shallow area of streambed on Swiftcurrent Creek when the streambed was disturbed. The site was assessed by GLAC fisheries staff shortly thereafter. The site is located along the north edge of the creek between sites 87 and 88 in the Many Glacier Campground. NPS staff observed a hydrocarbon product bubbling to the surface when the streambed was disturbed and the substance created an oily sheen that extended for several meters downstream each time the streambed was disturbed. The release point appeared quite localized as the substance did not emanate from other nearby areas of streambed when they were disturbed.

After consultation with park staff and with Montana Environmental Labs (MEL) in Kalispell, Montana, a sample of the substance was collected by GLAC and delivered to MEL. MEL sent the sample to Energy Labs in Billings, a lab that specializes in fractionating hydrocarbon samples. Results were shared with GLAC staff along with many others in an attempt to ascertain the source and determine if it is a natural oil seep or a release from an unknown underground source related to the parks nearby infrastructure (Table 4). Unfortunately, the question still remains as the sample and analysis did not provide conclusive evidence one way or the other. Some experts pointed to the early exploration for hydrocarbons in the Many Glacier Valley and the potential it is a natural source.

There is mention of oil seeps in GLAC in a couple of older USGS reports. From USGS Bulletin 600, The Glacier National Park - A popular Guide to Its Geology and Scenery, Marius R. Campbell, 1914, that specifically addresses seeps in the Swiftcurrent Valley:

Mining.—The zone of fracture mentioned in the descriptions of the valleys lying farther south crosses Swiftcurrent Valley, passing through Allen Mountain, the point of Grinnell Mountain, Mount Wilbur, and Ahern Pass. At all these places prospects have been opened and some copper ore has been found, but nowhere has it been mined in sufficient quantity to pay for operation. There also has been considerable excitement regarding oil in this valley, and a number of wells have been sunk in the vicinity of the Sherburne Lakes, but though gas has been obtained in very small quantities nothing has been found that would justify the expense of drilling.

Further historical accounts of hydrocarbon exploration in the Many Glacier Valley can be found at:

https://www.nps.gov/parkhistory/online_books/glac/chap1.htm

Excerpt: “The biggest oil boom in the park area, oddly enough, occurred in the same valley as did the largest mining boom—Swiftcurrent Valley. Credit for the discovery of oil in this valley seems to go to Sam Somes who ran the hotel at the town of Altyn. Sam evidently had some claims in the lower valley, near the site of the present Sherburne Dam, and one day in 1901, while he was doing assessment work in his tunnel following a dynamite charge, he discovered small pools of oil on the floor of the tunnel. As he worked on into the tunnel he continued to find traces of this oil seepage. This interested him and he collected some samples of the oil and headed for Great Falls where he talked to some friends about it. As a result, the Montana Swiftcurrent Oil Company was organized, with Somes as general manager, and was capitalized at \$1,500,000.00

Equipment and men were soon organized and moved to the drilling site. Drilling operations were started and continued through the spring and summer of 1903, at which time Somes, to create more interest in the

venture, took a bottle of oil to Great Falls and persisted in pouring it on the floors and desks in the banks and offices around town. The result of this little performance was the formation of several oil companies and the resultant grabbing up of practically all the land on the floor of Swiftcurrent Valley, along with some in adjacent valleys, for "oil-placer" claims.

Somes' well never did produce either gas or oil, although a few of the others produced gas in varying quantities and some even showed traces of oil, none of it in commercial quantities. The only claim this company has to fame is the fact that it was the discovery well and the first oil well drilled on the eastern side of the park.

By the fall of 1903, most of the miners were gone from the valley, and many of the oil-placer claims were abandoned, but during the summer Mike Cassidy, one of the prospectors, had observed bubbles arising from the waters of a small creek emptying into Sherburne Lake. This, coupled with Somes' discovery in 1901 made him suspicious of the possibility of oil there. He immediately got busy and before long another oil company, one that was to make its mark on the history of the valley, sprang into existence. The Cassidy Swiftcurrent Oil Company, under manager and driller Matt Dunn, started drilling on what was known as St. Louis Placer No. 1. In 1905 and 1906 gas was struck; drilling continued intermittently until 1909, when tools were lost in the hole. Cassidy spent the next three summers in an unsuccessful attempt to retrieve them. No oil was struck in this well although gas was found on three levels. In 1907, Cassidy piped the gas from the well to his house and used it until 1914 for heating and lighting.

When plans were made to construct the Sherburne Reservoir, condemnation proceedings were directed against the portion of this claim that was below the flowage level of the proposed reservoir. On August 28, 1920, this claim was settled with the Federal Government paying Cassidy the sum of \$7,675.00 for that part of the claim below the flow line, which included the gas well. Later Cassidy exchanged the remaining acreage for lands outside the park.

The largest and probably the most controversial of all the oil companies to arise at this time was the Swift Current Oil Land and Power Company, incorporated on April 30, 1904. The original incorporators were J. H. Sherburne of Browning, Dave Greenwood Altyn, for whom the town of Altyn had been named, F. M. Stevenson who had a cabin and a claim nearby, A. J. Gibson of Missoula, Otto J. Hartwig of Chicago and Sherburne Morse of Browning. Many of the claim-holders up and down the valley soon assigned their claims to the new company in return for shares; and through this the company acquired twenty-nine claims totaling approximately four thousand acres of land, and was capitalized at two million shares.

A professional driller was imported from West Virginia and paid \$80 per month and board. Drilling was intermittent and slow, and continued until 1907, after which the machinery was loaned to another company and all work on the well ceased. Two wells were drilled by the company, only one of which produced any oil, and that in very small quantities. This well went down to a depth of 1,500 feet and cost, in cash, \$19,900, plus what was paid out in shares.

The most interesting thing about this well was the fact that in 1905 a diploma was awarded to the Swift Current Oil Land and Power Company, reading in part: "Awarded to Swift Current Oil Land and Power Company for the first producing oil well in the State of Montana, and the best display of crude and refined oil from the Swift Current District, Teton County, Montana, at the State Fair, Helena, Montana, 1905." As very little oil was ever produced from this well, there persisted the ever-present rumor that the company imported barrels of crude oil and poured them into the well to "grease" the investors, while others maintained that the well was an actual, bonafide producer. In any event, it received the fame and the certificate, and must have produced some oil in order to have done so.

The oil boom died out almost completely after 1907, except for a few oil men, like the few remaining miners, who could not give up the idea of finding a million dollars that all the others had overlooked. A few more holes were drilled, but nothing except a trace here and there was ever found. Frank Stevenson, who remained to make his home in the valley, gradually came into possession of some of the more promising claims,

including some that he had staked himself; he built his home on nine of them, where he lived for many years, spending some time as a park ranger when the area was first included in Glacier National Park. Galbraith's map of June 1923, shows that the entire valley floor from the vicinity of the Sherburne Dam to Swiftcurrent Falls was taken up at one time by these oil placer claims. In all, between eight and ten wells were drilled in the valley, mostly near the valley floor and within two miles of the present Sherburne Dam. The waters of the Sherburne Reservoir now cover most of the old well sites."

Based on the fractionation results and the lack of some constituents often associated with crude oil (Appendix A), others felt it looked like "weathered" diesel or heating oil. Examination of the park's archives identified a gas pump at the Swiftcurrent Motor Inn at some point in the 1950's (no longer present) and there were buildings in the area that were historically heated with heating oil. We have not been able to find a map that shows the locations of any underground storage tanks (UST's) near the site in question or a map of where above ground heating tanks were used in the area. There are records of two leaking UST's that was once in the Many Glacier developed area but we do not have locations beyond they were in "Many Glacier". Several UST's were removed from the Many Glacier Hotel area in the late 1990's (S. Byrd, NPS, personal communication), but because these tank locations are about a half-mile downstream of the site in question, they are likely not related to the source of hydrocarbons in question.

We continue to communicate with the Montana Department of Environmental Quality (DEQ) about assistance in determining the source of the seep. We plan to meet with DEQ staff on-site in 2020 to continue investigations. Recommendations from the experts consulted included getting a better sample of the undiluted product as there will be a better chance of identifying it if it is concentrated and not just collected as water surface sheen. Others suggested implementing a more systematic sample of the shoreline to see if it is localized or widespread. We will pursue these suggestions during the 2020 field season.



Figure 42. Hydrocarbon seep area relative to the Swiftcurrent Motor Inn and local NPS facilities including the ranger station, NPS housing area, and campground.



Figure 43. Hydrocarbon sheen produced when shallow stream gravels were disturbed adjacent to the NPS campground on Swiftcurrent Creek.

Table 4. Contacts involved in identification and assessment of hydrocarbon sheen on Swiftcurrent Creek

Name	Affiliation	Date of initial contact
Rebecca Merritt	NPS – CLAC-VRP	8/12/2019
Mary Wysong	NPS – GLAC-Concessions	8/12/2019
Mark Biel	NPS – GLAC-SRM	8/12/2019
Chris Downs	NPS – GLAC-SRM	8/12/2019
Phil Wilson	NPS – GLAC-SRM	8/12/2019
Montana Environmental Lab	N/A – private business	8/14/2019
Energy Labs	N/A -private business	8/14/2019
David Smith	NPS – GLAC-VRP	9/18/2019
Billy Schweiger	NPS – IMR Vital Signs	9/18/2019
John Lucke	NPS – GLAC-Facilities	9/18/2019
Jim Foster	NPS – GLAC-Facilities	9/18/2019
Christina Staten	MT DEQ	9/18/2019
Laura Alvey	MT DEQ	9/19/2019
David Anderson	NPS – Spill Response	9/19/2019
Paul Torcoletti	NPS - IMR	9/9/2019
Steven Rice	NPS – WRD - Hydrology	9/19/2019
Jeremiah Kimbell	NPS – GRD – Petroleum eng.	9/20/2019
Jean Tabbert	NPS – GLAC - Archives	9/24/2019
Mary Riddle	NPS – GLAC-Env. compliance	9/27/2019
Steven Byrd	NPS - Concessions	10/8/2019
Kerensa King	NPS-WRD-Contaminants	10/15/2019
Greg Powell	EPA	10/16/2019
Amy Steinmetz	MT DEQ	11/20/2019
Dean Kinney	MT DEQ	11/20/2019

CONCLUSION

Assessing and understanding air and water quality is a highly complex process and as a result, many different components and measuring techniques are used gauge the state of air and water quality in Glacier National Park. The Apgar stationary air quality site along with the mobile E-BAM give insights into the state of the air quality in the park, which as a whole appears very good. However, there are some signs of potentially increasing total nitrogen and ammonium deposition in the park that could result in nitrogen nutrient enrichment and soil acidification throughout the system, resulting in direct and indirect harm to native plant communities. Continued monitoring and investigation will be necessary to understand the cause(s) if the trend continues. Acid precipitation does not appear to be a concern at this time as evidenced by stable precipitation and stream pH levels as well as stable or decreasing trends in wet and dry deposition of acid-forming compounds such as nitrate and sulfate/sulfur.

Visibility is a basic metric of overall air quality. Long-term data for ozone monitoring as well as the long-term “haze index” either show stable or improving conditions. These data support the overall conclusion that air quality in GNP in general remains very good. Wildland fire and winter wood stove use and atmospheric

inversions drive periodic declines in air quality in GNP and if the park continues to experience hotter, drier late summer conditions, the frequency of poor air quality from fire and the resulting smoke will likely increase.

The E-BAM failed to document the transport of meaningful levels of road dust (PM₁₀) from the North Fork Road to the park. Although severe dust conditions can occur on the road itself during dry summer months in the absence of dust-reducing surface treatments, road dust at the locations monitored in the park does not appear to be a concern at this time. It should be noted that the road has been treated with dust abatement chemicals in recent years. Cruezer et al. (2015) studied wetlands and associated water quality impacts from dust generated by heavy truck traffic on gravel roads in the Bakken and concluded that dust levels declined rapidly with distance from the road (from 300+ % increase in dust within 10m of the road declining to 46% increase at 40m from the road in the heavily impacted sites). The authors further concluded that the dust had little impact on wetland function or water quality. Models of fugitive dust transport from unpaved roads created at The Pennsylvania State University showed similar rapid declines in dust concentration moving away from the unpaved road itself (Cuscino et al.). Therefore, it is not surprising we did not find significant dust impacts where we monitored since much of the North Fork Road north of the Camas Road is more than 100m from the river (and the park). Much of the road distance in this area is considerably further than 100m from the river (and the park). There are approximately 16 km of unpaved road downstream of the Camas Road that in places comes very close to the river. Moving the monitoring system to a location downstream of the Camas Road in 2020 will allow the park to evaluate potential dust transport in areas where the road is closer to the river.

Due to its geography and rugged mountain terrain, GNP receives more dry and wet mercury deposition than much of the rest of the U.S. Mercury cycling is complex and global in nature. According to EPA estimates, only about 17% of the mercury deposited in the U.S. comes from the U.S. (NADP, 2020). The east coast of the U.S. does receive mercury from mid-western US coal-fired power plants, but most of what is being deposited in GNP on the west coast of the U.S. is international in nature. Mercury is transformed into the bio-available form methylmercury in the park's watersheds. It then enters the food web where it bioconcentrates and bioaccumulates. This is the reason that large, old, fish-eating fish like lake trout have high levels of mercury. As a result, GNP has issued advisories for human consumption of these types of fishes. Fortunately, the fish consumed by wildlife are smaller, younger individuals with reduced mercury levels. These levels do not appear to pose a consumption risk to fish-eating wildlife (Stafford et al. 2016).

Water quality in the waters assessed remains very good. Water clarity in park lakes is among the highest in the Flathead River Basin and no obvious trends appear in the data. Similarly, our evaluation of E. coli. bacteria levels (and indicator of human waste contamination) in Lake McDonald and on the Middle and North forks of the Flathead River suggests these waters remain very clean. Other investigators have documented diverse, healthy aquatic insect communities inhabiting the North Fork of the Flathead River (Hauer and Sexton 2012), which is also a reflection of excellent water quality. However, water temperature and timing of precipitation and spring runoff will continue to be an area of concern across the park. Current water temperatures are sufficient to protect the cold-water ecological systems and processes that rely on them, but continued climate warming will eventually threaten even delicate headwater aquatic communities (Giersch et al. 2015). Similarly, transport and deposition of airborne contaminants, of which we know little about in terms of human or ecological health impacts, is a continuing threat to water quality of GNP (Landers et al. 2008). Continued periodic monitoring will be required to understand patterns of deposition and potential impacts to the natural systems of GNP. Further investigation of the hydrocarbon seep on Swiftcurrent Creek is needed to determine if it is a natural occurrence that warrants interpretation or a legacy source of environmental contamination that should be remediated.

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Appendix A – Fractionation results for hydrocarbon sample collected from Swiftcurrent Creek, GNP, in early August 2019



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ANALYTICAL SUMMARY REPORT

September 11, 2019

Montana Environmental Lab
PO Box 8900
Kalispell, MT 59904-8900

Work Order: B19081987

Project Name: Glacier National Park

Energy Laboratories Inc Billings MT received the following 2 samples for Montana Environmental Lab on 8/20/2019 for analysis.

Lab ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
B19081987-001	MEL 8652, Swiftcurrent Creek-Many Glacier	08/15/19 10:50	08/20/19	Aqueous	EPH-Liquid-Liquid Extraction SW3520C EPH Fractionation Hydrocarbons, Aliphatic Extractable Petroleum Hydrocarbons, Aromatic Extractable Petroleum Hydrocarbons, Extractable Petroleum Screen Volatile Petroleum Hydrocarbons Separatory Funnel SW3510C Liquid-Liquid Ext. Low Level PAH
B19081987-002	Trip Blank Lot071119 B-JLB SHP0274	08/15/19 0:00	08/20/19	Trip Blank	Volatile Petroleum Hydrocarbons

The analyses presented in this report were performed by Energy Laboratories, Inc., 1120 S 27th St., Billings, MT 59101, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative. Any issues encountered during sample receipt are documented in the Work Order Receipt Checklist.

The results as reported relate only to the item(s) submitted for testing. This report shall be used or copied only in its entirety. Energy Laboratories, Inc. is not responsible for the consequences arising from the use of a partial report.

If you have any questions regarding these test results, please contact your Project Manager.

Report Approved By:

William T Brown
President

Digitally signed by
Bill Brown

Date: 2019.09.11 13:25:49 -06:00



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LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Montana Environmental Lab
Project: Glacier National Park
Lab ID: B19081987-001
Client Sample ID: MEL 8652, Swiftcurrent Creek-Many Glacier

Report Date: 09/11/19
Collection Date: 08/15/19 10:50
Date Received: 08/20/19
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PETROLEUM HYDROCARBONS-VOLATILE (VPH)							
Methyl tert-butyl ether (MTBE)	ND	ug/L	D	2.0	30	MA-VPH	08/23/19 12:46 / jpb
Benzene	ND	ug/L	D	1.0	5	MA-VPH	08/23/19 12:46 / jpb
Toluene	ND	ug/L	D	1.0	1000	MA-VPH	08/23/19 12:46 / jpb
Ethylbenzene	ND	ug/L	D	1.0	700	MA-VPH	08/23/19 12:46 / jpb
m+p-Xylenes	ND	ug/L	D	1.0		MA-VPH	08/23/19 12:46 / jpb
o-Xylene	ND	ug/L	D	1.0		MA-VPH	08/23/19 12:46 / jpb
Xylenes, Total	ND	ug/L	D	1.0	10000	MA-VPH	08/23/19 12:46 / jpb
Naphthalene	ND	ug/L	D	2.0	100	MA-VPH	08/23/19 12:46 / jpb
C9 to C10 Aromatics	ND	ug/L	D	40	1100	MA-VPH	08/23/19 12:46 / jpb
C5 to C8 Aliphatics	ND	ug/L	D	40	650	MA-VPH	08/23/19 12:46 / jpb
C9 to C12 Aliphatics	ND	ug/L	D	40	1400	MA-VPH	08/23/19 12:46 / jpb
Total Purgeable Hydrocarbons	61	ug/L		40		MA-VPH	08/23/19 12:46 / jpb
Surr: VPH Aromatics Surrogate	93.0	%REC		70-130		MA-VPH	08/23/19 12:46 / jpb
Surr: VPH Aliphatics Surrogate	87.0	%REC		70-130		MA-VPH	08/23/19 12:46 / jpb
- Note 1: The C5 to C8 Aliphatics value is corrected for aromatic constituents Benzene and Toluene. - Note 2: The C9 to C12 Aliphatics value is corrected for aromatic constituents Ethylbenzene, m+p-Xylenes, o-Xylene and C9 to C10 Aromatics.							
EXTRACTABLE PETROLEUM HYDROCARBONS-SCREEN							
Total Extractable Hydrocarbons	6230	ug/L	*	300	1000	SW8015M	08/28/19 12:15 / amn
Surr: o-Terphenyl	78.0	%REC		40-140		SW8015M	08/28/19 12:15 / amn
- Note: Total Extractable Hydrocarbons are defined as the total hydrocarbon responses regardless of elution time.							
EXTRACTABLE PETROLEUM HYDROCARBONS (EPH)							
C9 to C18 Aliphatics	1780	ug/L	*	300	1400	MA-EPH	09/07/19 22:22 / kjr
C19 to C36 Aliphatics	2560	ug/L	*	300	1000	MA-EPH	09/07/19 22:22 / kjr
Surr: 1-Chloro-octadecane	90.0	%REC		40-140		MA-EPH	09/07/19 22:22 / kjr
C11 to C22 Aromatics	1440	ug/L	*	300	1100	MA-EPH	09/07/19 23:05 / kjr
Total Extractable Hydrocarbons	6420	ug/L	*	300	1000	MA-EPH	09/07/19 23:05 / kjr
Surr: 2-Bromonaphthalene	109	%REC		40-140		MA-EPH	09/07/19 23:05 / kjr
Surr: 2-Fluorobiphenyl	95.0	%REC		40-140		MA-EPH	09/07/19 23:05 / kjr
Surr: o-Terphenyl	91.0	%REC		40-140		MA-EPH	09/07/19 23:05 / kjr
- Note: Total Extractable Hydrocarbons are defined as the total hydrocarbon responses regardless of elution time.							
SEMI-VOLATILE ORGANIC COMPOUNDS (LOW LEVEL)							
1-Methylnaphthalene	ND	ug/L		0.20	11	SW8270C	09/10/19 23:44 / jph
2-Methylnaphthalene	ND	ug/L		0.20	36	SW8270C	09/10/19 23:44 / jph
Acenaphthene	ND	ug/L		0.20	670	SW8270C	09/10/19 23:44 / jph
Acenaphthylene	ND	ug/L		0.20		SW8270C	09/10/19 23:44 / jph
Anthracene	ND	ug/L		0.20	2100	SW8270C	09/10/19 23:44 / jph
Benzo(a)anthracene	ND	ug/L		0.20	0.5	SW8270C	09/10/19 23:44 / jph
Benzo(a)pyrene	ND	ug/L		0.20	0.05	SW8270C	09/10/19 23:44 / jph
Benzo(b)fluoranthene	ND	ug/L		0.20	0.5	SW8270C	09/10/19 23:44 / jph
Benzo(g,h,i)perylene	ND	ug/L		0.20		SW8270C	09/10/19 23:44 / jph

Report Definitions: RL - Analyte reporting limit.
QCL - Quality control limit.
* - The result exceeds the MCL.

MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
D - RL increased due to sample matrix.



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LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Montana Environmental Lab
Project: Glacier National Park
Lab ID: B19081987-001
Client Sample ID: MEL 8652, Swiftcurrent Creek-Many Glacier

Report Date: 09/11/19
Collection Date: 08/15/19 10:50
Date Received: 08/20/19
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
SEMI-VOLATILE ORGANIC COMPOUNDS (LOW LEVEL)							
Benzo(k)fluoranthene	ND	ug/L		0.20	5	SW8270C	09/10/19 23:44 / jph
Chrysene	ND	ug/L		0.20	50	SW8270C	09/10/19 23:44 / jph
Dibenzo(a,h)anthracene	ND	ug/L		0.20	0.05	SW8270C	09/10/19 23:44 / jph
Fluoranthene	ND	ug/L		0.20	130	SW8270C	09/10/19 23:44 / jph
Fluorene	ND	ug/L		0.20	1100	SW8270C	09/10/19 23:44 / jph
Indeno(1,2,3-cd)pyrene	ND	ug/L		0.20	0.5	SW8270C	09/10/19 23:44 / jph
Naphthalene	ND	ug/L		0.20	100	SW8270C	09/10/19 23:44 / jph
Phenanthrene	0.27	ug/L	B	0.20		SW8270C	09/10/19 23:44 / jph
Pyrene	ND	ug/L		0.20	830	SW8270C	09/10/19 23:44 / jph
Surr: 2-Fluorobiphenyl	61.0	%REC		25-94		SW8270C	09/11/19 00:17 / jph
Surr: o-Terphenyl	72.0	%REC		40-140		SW8270C	09/11/19 00:17 / jph

Report Definitions: RL - Analyte reporting limit. MCL - Maximum contaminant level.
QCL - Quality control limit. ND - Not detected at the reporting limit.
B - The analyte was detected in the method blank.



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LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Montana Environmental Lab
Project: Glacier National Park
Lab ID: B19081987-002
Client Sample ID: Trip Blank Lot071119 B-JLB SHP0274

Report Date: 09/11/19
Collection Date: 08/15/19
Date Received: 08/20/19
Matrix: Trip Blank

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PETROLEUM HYDROCARBONS-VOLATILE (VPH)							
Methyl tert-butyl ether (MTBE)	ND	ug/L		1.0	30	MA-VPH	08/21/19 16:43 / jlb
Benzene	ND	ug/L		0.50	5	MA-VPH	08/21/19 16:43 / jlb
Toluene	ND	ug/L		0.50	1000	MA-VPH	08/21/19 16:43 / jlb
Ethylbenzene	ND	ug/L		0.50	700	MA-VPH	08/21/19 16:43 / jlb
m+p-Xylenes	ND	ug/L		0.50		MA-VPH	08/21/19 16:43 / jlb
o-Xylene	ND	ug/L		0.50		MA-VPH	08/21/19 16:43 / jlb
Xylenes, Total	ND	ug/L		0.50	10000	MA-VPH	08/21/19 16:43 / jlb
Naphthalene	ND	ug/L		1.0	100	MA-VPH	08/21/19 16:43 / jlb
C9 to C10 Aromatics	ND	ug/L		20	1100	MA-VPH	08/21/19 16:43 / jlb
C5 to C8 Aliphatics	ND	ug/L		20	650	MA-VPH	08/21/19 16:43 / jlb
C9 to C12 Aliphatics	ND	ug/L		20	1400	MA-VPH	08/21/19 16:43 / jlb
Total Purgeable Hydrocarbons	ND	ug/L		20		MA-VPH	08/21/19 16:43 / jlb
Surr: VPH Aromatics Surrogate	105	%REC		70-130		MA-VPH	08/21/19 16:43 / jlb
Surr: VPH Aliphatics Surrogate	98.0	%REC		70-130		MA-VPH	08/21/19 16:43 / jlb

- Note 1: The C5 to C8 Aliphatics value is corrected for aromatic constituents Benzene and Toluene.

- Note 2: The C9 to C12 Aliphatics value is corrected for aromatic constituents Ethylbenzene, m+p-Xylenes, o-Xylene and C9 to C10 Aromatics.

Report Definitions: RL - Analyte reporting limit.
QCL - Quality control limit.

MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.



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QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Montana Environmental Lab

Work Order: B19081987

Report Date: 09/11/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MA-VPH							Analytical Run: R326298		
Lab ID: CCV_0821VA205r-W							Continuing Calibration Verification Standard		
							08/21/19 13:56		
1,2,4-Trime-thylbenzene	26.2	ug/L	1.0	105	75	125			
2,2,4-Trime-thylpentane	26.1	ug/L	1.0	104	75	125			
2-Methylpentane	27.9	ug/L	1.0	112	75	125			
n-Butylcyclohexane	24.6	ug/L	1.0	98	75	125			
n-Decane	25.0	ug/L	1.0	100	75	125			
Methyl tert-butyl ether (MTBE)	28.9	ug/L	1.0	116	75	125			
Benzene	28.2	ug/L	0.50	113	75	125			
Toluene	28.0	ug/L	0.50	112	75	125			
Ethylbenzene	27.4	ug/L	0.50	110	75	125			
m-p-Xylenes	50.0	ug/L	0.50	100	75	125			
o-Xylene	26.1	ug/L	0.50	105	75	125			
Naphthalene	25.9	ug/L	1.0	104	75	125			
n-Pentane	29.5	ug/L	1.0	118	75	125			
Surr: VPH Aromatics Surrogate			1.0	106	75	125			
Surr: VPH Aliphatics Surrogate			1.0	95	75	125			
Lab ID: CCV_0821VA248r-W							Continuing Calibration Verification Standard		
							08/22/19 15:28		
1,2,4-Trime-thylbenzene	21.7	ug/L	1.0	87	75	125			
2,2,4-Trime-thylpentane	24.7	ug/L	1.0	99	75	125			
2-Methylpentane	27.0	ug/L	1.0	108	75	125			
n-Butylcyclohexane	26.8	ug/L	1.0	107	75	125			
n-Decane	29.4	ug/L	1.0	118	75	125			
Methyl tert-butyl ether (MTBE)	23.7	ug/L	1.0	95	75	125			
Benzene	21.7	ug/L	0.50	87	75	125			
Toluene	22.6	ug/L	0.50	90	75	125			
Ethylbenzene	21.7	ug/L	0.50	87	75	125			
m-p-Xylenes	41.0	ug/L	0.50	82	75	125			
o-Xylene	22.0	ug/L	0.50	88	75	125			
Naphthalene	23.2	ug/L	1.0	93	75	125			
n-Pentane	28.4	ug/L	1.0	113	75	125			
Surr: VPH Aromatics Surrogate			1.0	97	75	125			
Surr: VPH Aliphatics Surrogate			1.0	95	75	125			
Method: MA-VPH							Batch: R326298		
Lab ID: LCS_0821VA206r							Laboratory Control Sample		
							Run: VARIAN2_190821A		
							08/21/19 14:29		
1,2,4-Trime-thylbenzene	23.4	ug/L	1.0	94	70	130			
2,2,4-Trime-thylpentane	24.1	ug/L	1.0	97	70	130			
2-Methylpentane	23.6	ug/L	1.0	94	70	130			
n-Butylcyclohexane	24.7	ug/L	1.0	99	70	130			
n-Decane	25.2	ug/L	1.0	101	70	130			
Methyl tert-butyl ether (MTBE)	25.1	ug/L	1.0	100	70	130			
Benzene	24.3	ug/L	0.50	97	70	130			
Toluene	24.4	ug/L	0.50	98	70	130			
Ethylbenzene	23.7	ug/L	0.50	95	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.



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QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Montana Environmental Lab

Work Order: B19081987

Report Date: 09/11/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MA-VPH							Batch: R326298		
Lab ID: LCS_0821VA206r	Laboratory Control Sample		Run: VARIAN2_190821A				08/21/19 14:29		
m+p-Xylenes	44.7	ug/L	0.50	89	70	130			
o-Xylene	24.5	ug/L	0.50	98	70	130			
Naphthalene	23.8	ug/L	1.0	95	70	130			
Total Purgeable Hydrocarbons	361	ug/L	20	96	70	130			
n-Pentane	21.9	ug/L	1.0	88	70	130			
Surr: VPH Aromatics Surrogate			1.0	99	70	130			
Surr: VPH Aliphatics Surrogate			1.0	94	70	130			
Lab ID: MBLK_0821VA209r	Method Blank		Run: VARIAN2_190821A				08/21/19 16:10		
Methyl tert-butyl ether (MTBE)	ND	ug/L	1.0						
Benzene	ND	ug/L	0.50						
Toluene	ND	ug/L	0.50						
Ethylbenzene	ND	ug/L	0.50						
m+p-Xylenes	ND	ug/L	0.50						
o-Xylene	ND	ug/L	0.50						
Xylenes, Total	ND	ug/L	0.50						
Naphthalene	ND	ug/L	1.0						
C9 to C10 Aromatics	ND	ug/L	20						
C5 to C8 Aliphatics	ND	ug/L	20						
C9 to C12 Aliphatics	ND	ug/L	20						
Total Purgeable Hydrocarbons	ND	ug/L	20						
Surr: VPH Aromatics Surrogate			1.0	99	70	130			
Surr: VPH Aliphatics Surrogate			1.0	94	70	130			
Lab ID: B19081714-001BMS	Sample Matrix Spike		Run: VARIAN2_190821A				08/22/19 14:21		
Methyl tert-butyl ether (MTBE)	22.4	ug/L	1.0	90	70	130			
Benzene	22.7	ug/L	0.50	91	70	130			
Toluene	23.0	ug/L	0.50	92	70	130			
Ethylbenzene	22.5	ug/L	0.50	90	70	130			
m+p-Xylenes	43.1	ug/L	0.50	86	70	130			
o-Xylene	22.3	ug/L	0.50	89	70	130			
Naphthalene	23.0	ug/L	1.0	92	70	130			
Total Purgeable Hydrocarbons	347	ug/L	20	93	70	130			
Surr: VPH Aromatics Surrogate			1.0	92	70	130			
Surr: VPH Aliphatics Surrogate			1.0	92	70	130			
- The sample was received in the laboratory with a pH > 2. The pH was 7.									
Lab ID: B19081714-001BMSD	Sample Matrix Spike Duplicate		Run: VARIAN2_190821A				08/22/19 14:55		
Methyl tert-butyl ether (MTBE)	23.2	ug/L	1.0	93	70	130	3.1	20	
Benzene	21.8	ug/L	0.50	87	70	130	4.1	20	
Toluene	22.4	ug/L	0.50	90	70	130	2.5	20	
Ethylbenzene	21.7	ug/L	0.50	87	70	130	3.5	20	
m+p-Xylenes	41.3	ug/L	0.50	83	70	130	4.2	20	
o-Xylene	21.7	ug/L	0.50	87	70	130	2.7	20	
Naphthalene	23.2	ug/L	1.0	93	70	130	0.9	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.



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QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Montana Environmental Lab

Work Order: B19081987

Report Date: 09/11/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MA-VPH							Batch: R326298		
Lab ID: B19081714-001BMSD	Sample Matrix Spike Duplicate		Run: VARIAN2_190821A				08/22/19 14:55		
Total Purgeable Hydrocarbons	359	ug/L	20	96	70	130	3.2	20	
Surr: VPH Aromatics Surrogate			1.0	95	70	130			
Surr: VPH Aliphatics Surrogate			1.0	94	70	130			
- The sample was received in the laboratory with a pH > 2. The pH was 7.									
Lab ID: LCS_0821VA249r	Laboratory Control Sample		Run: VARIAN2_190821A				08/22/19 16:02		
1,2,4-Trimeethylbenzene	21.0	ug/L	1.0	84	70	130			
2,2,4-Trimeethylpentane	22.9	ug/L	1.0	91	70	130			
2-Methylpentane	22.9	ug/L	1.0	91	70	130			
n-Butylcyclohexane	25.7	ug/L	1.0	103	70	130			
n-Decane	25.5	ug/L	1.0	106	70	130			
Methyl tert-butyl ether (MTBE)	22.9	ug/L	1.0	92	70	130			
Benzene	20.9	ug/L	0.50	83	70	130			
Toluene	21.9	ug/L	0.50	88	70	130			
Ethylbenzene	21.2	ug/L	0.50	85	70	130			
m-p-Xylenes	40.4	ug/L	0.50	81	70	130			
o-Xylene	21.5	ug/L	0.50	86	70	130			
Naphthalene	23.2	ug/L	1.0	93	70	130			
Total Purgeable Hydrocarbons	366	ug/L	20	98	70	130			
n-Pentane	20.9	ug/L	1.0	84	70	130			
Surr: VPH Aromatics Surrogate			1.0	96	70	130			
Surr: VPH Aliphatics Surrogate			1.0	95	70	130			
Lab ID: MBLK_0821VA252r	Method Blank		Run: VARIAN2_190821A				08/22/19 17:43		
Methyl tert-butyl ether (MTBE)	ND	ug/L	1.0						
Benzene	ND	ug/L	0.50						
Toluene	ND	ug/L	0.50						
Ethylbenzene	ND	ug/L	0.50						
m-p-Xylenes	ND	ug/L	0.50						
o-Xylene	ND	ug/L	0.50						
Xylenes, Total	ND	ug/L	0.50						
Naphthalene	ND	ug/L	1.0						
C9 to C10 Aromatics	ND	ug/L	20						
C5 to C8 Aliphatics	ND	ug/L	20						
C9 to C12 Aliphatics	ND	ug/L	20						
Total Purgeable Hydrocarbons	ND	ug/L	20						
Surr: VPH Aromatics Surrogate			1.0	92	70	130			
Surr: VPH Aliphatics Surrogate			1.0	92	70	130			
Lab ID: B19081994-014CMS	Sample Matrix Spike		Run: VARIAN2_190821A				08/23/19 14:59		
Methyl tert-butyl ether (MTBE)	163	ug/L	5.0	130	70	130			
Benzene	135	ug/L	2.5	71	70	130			
Toluene	109	ug/L	2.5	87	70	130			
Ethylbenzene	173	ug/L	2.5	60	70	130			S
m-p-Xylenes	189	ug/L	2.5	76	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

S - Spike recovery outside of advisory limits.



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QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Montana Environmental Lab

Work Order: B19081987

Report Date: 09/11/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MA-VPH							Batch: R326298		
Lab ID: B19081994-014CMS	Sample Matrix Spike		Run: VARIAN2_190821A				08/23/19 14:59		
o-Xylene	107	ug/L	2.5	85	70	130			
Naphthalene	93.1	ug/L	5.0	74	70	130			
Total Purgeable Hydrocarbons	4130	ug/L	100	83	70	130			
Surr: VPH Aromatics Surrogate			5.0	124	70	130			
Surr: VPH Aliphatics Surrogate			5.0	112	70	130			
Lab ID: B19081994-014CMSD	Sample Matrix Spike Duplicate		Run: VARIAN2_190821A				08/23/19 15:33		
Methyl tert-butyl ether (MTBE)	152	ug/L	5.0	122	70	130	6.8	20	
Benzene	125	ug/L	2.5	63	70	130	7.8	20	S
Toluene	103	ug/L	2.5	82	70	130	6.0	20	
Ethylbenzene	163	ug/L	2.5	52	70	130	5.9	20	S
m,p-Xylenes	180	ug/L	2.5	72	70	130	5.2	20	
o-Xylene	102	ug/L	2.5	82	70	130	4.1	20	
Naphthalene	90.3	ug/L	5.0	72	70	130	3.1	20	
Total Purgeable Hydrocarbons	4210	ug/L	100	88	70	130	1.9	20	
Surr: VPH Aromatics Surrogate			5.0	123	70	130			
Surr: VPH Aliphatics Surrogate			5.0	114	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

S - Spike recovery outside of advisory limits.

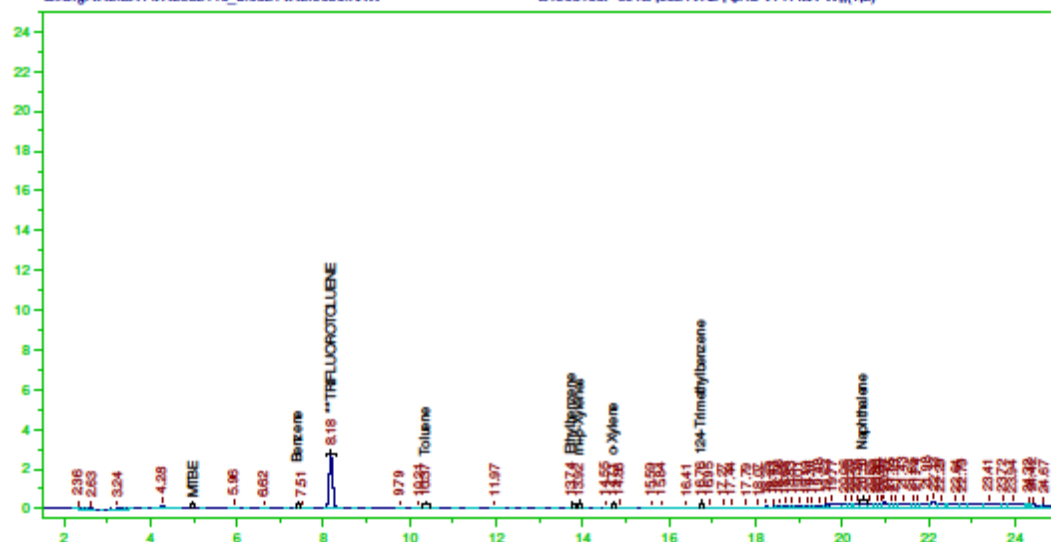


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MEL 8652, Swiftcurrent Creek-Many Glacier
G:\Org\VA2\DATA\VA2082119_b\0821VA2.0086.RAW

B19081987-001B;0821VA2, \$HC-VPH-MA-W,,(1,2)



VPH AROMATICS PHOTOIONIZATION DETECTOR CHROMATOGRAM REPORT

Sample Name: B19081987-001B ;0821VA2, \$HC-VPH-MA-W,,(1,2)
Raw File: G:\Org\VA2\DATA\VA2082119_b\0821VA2.0086.RAW
Date & Time Acquired: 8/23/2019 12:46:50 PM
Method File: G:\Org\VA2\Methods\190823V19871\MET
Calibration File: G:\Org\VA2\Cals\190823_190510VPH.CAL
Sample Weight: 5 Dilution: 2 S.A.: 2

Mean RF for C9 to C10 Aromatic Hydrocarbons: 408.4298

Rt range for C9 to C10 Aromatics: 14.77 to 20.39

Aromatic Hydrocarbon Range Area and Quantitation:

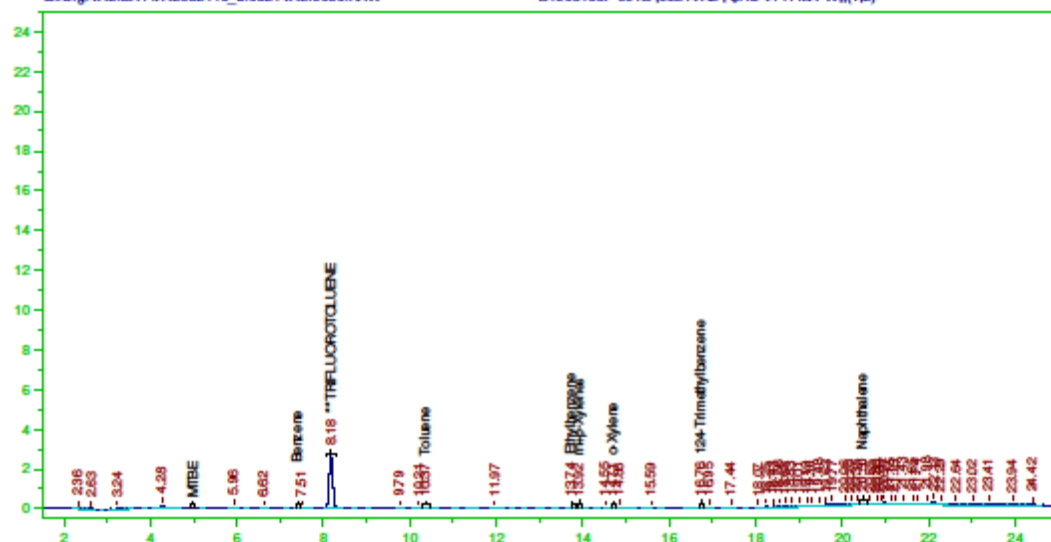
C9-C10 Aromatics Area:21414.82 C9-C10 Aromatics Amount: 20.97283

TARGET ANALYTES	RT	CAL RRT	RRT	AREA	AMOUNT	FLAG
MTBE					2.	U
Benzene					1.	U
Toluene	10.369	10.369	10.369	70	1.	U
Ethylbenzene	13.742	13.742	13.742	155	1.	U
m+p-Xylenes	13.921	13.921	13.921	183	1.	U
o-Xylene	14.708	14.708	14.708	100	1.	U
124-Trimethylbenzene	16.764	16.764	16.764	495	1.	U
Naphthalene	20.496	-12.3	-12.318	2541	~~1.000~~	± No JJB 8/27/19

SURROGATE COMPOUND	RT	ACTUAL	MEASURED	%REC	QC LIMITS
**TRIFLUOROTOLUENE	8.178	50.	46.523	93.05	70-130

MEL 8652, Swiftcurrent Creek-Many Glacier
— G:\Ordn\VA2\DAT\VA2082119 B\0821\VA2.0086.FAW

B19081987-001B :0821VA2 , \$HC-VPH-MA-W..(1,2)



VPH AROMATICS PHOTOIONIZATION DETECTOR CHROMATOGRAM REPORT

Sample Name: B19081987-001B ; 0821VA2 , \$HC-VPH-MA-W,, (1, 2)

Raw File: G:\Org\VA2\DAT\VA2082119_b\0821VA2.0086.RAW

Date & Time Acquired: 8/23/2019 12:46:50 PM

Method File: G:\Org\VA2\Methods\190823V19071AN\MET

Calibration File: G:\Org\VA2\Cals\190823_190510VPH.CAL

Sample Weight: 5 Dilution: 2 S.A.: 2

Mean RF for C9 to C10 Aromatic Hydrocarbons: 408.4298

Rt range for C9 to C10 Aromatics: 14.77 to 20.39

Aromatic Hydrocarbon Range Area and Quantitation:

C9-C10 Aromatics Area:6002.521 C9-C10 Aromatics Amount: 5.878632

TARGET ANALYTES	RT	CAL RRT	RRT	AREA	AMOUNT	FLAG
MTBE	-	-	-	-	2.	U
Benzene	-	-	-	-	1.	U
Toluene	10.269	10.269	10.269	70	1.	U
Ethylbenzene	13.743	13.743	13.743	155	1.	U
m,p-Xylene	13.921	13.921	13.921	182	1.	U
o-Xylene	14.700	14.700	14.700	100	1.	U
1,2,4-Trimethylbenzene	16.764	16.764	16.764	373	1.	U
Naphthalene	20.496	20.496	20.496	292	2.	U JJB 8/27/11

SURROGATE COMPOUND	RT	ACTUAL	MEASURED	%REC	QC LIMITS
**TRIFLUOROTOLUENE	8.178	50.	46.523	93.05	70-130

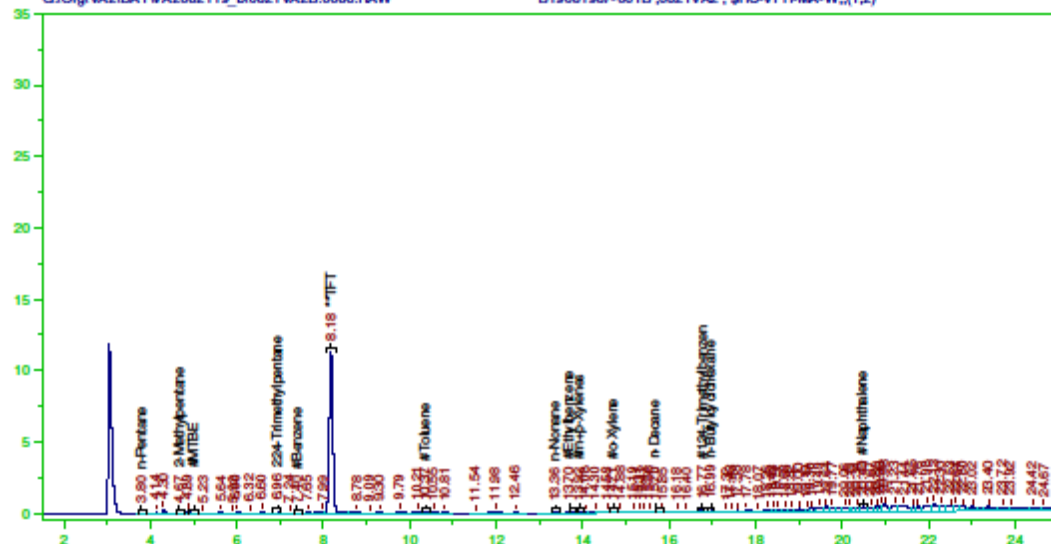


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MEL 8652, Swiftcurrent Creek-Many Glacier
G:\Org\VA2\DAT\VA2082119_b\0821VA2B.0086.RAW

B19081987-001B;0821VA2, \$HC-VPH-MA-W,,(1,2)



VPH ALIPHATICS FLAME IONIZATION DETECTOR CHROMATOGRAM REPORT

Sample Name: B19081987-001B ;0821VA2, \$HC-VPH-MA-W,,(1,2)
Raw File: G:\Org\VA2\DAT\VA2082119_b\0821VA2B.0086.RAW
Date & Time Acquired: 8/23/2019 12:46:50 PM
Method File: G:\Org\VA2\Methods\190823VPHB.MET
Calibration File: G:\Org\VA2\Cals\190823_190510VPHB.CAL
Sample Weight: 5 Dilution: 2 S.A.: 2

Mean RF for C5 to C8 Aliphatic Hydrocarbons: 606.8051
Mean RF for C9 to C12 Aliphatic Hydrocarbons: 529.0131
Mean RF for all calibrated compounds: 766.8345
Rt range for Gasoline Range Organics: 4.59 to 15.87
Rt range for C5 to C8 Aliphatic Hydrocarbons: 3.72 to 13.28
Rt range for C9 to C12 Aliphatic Hydrocarbons: 13.33 to 20.39

SURROGATE COMPOUND	RT	ACTUAL	MEASURED	%REC
**TPT	8.18	50.	43.365	86.73

GRO Area:16172.73 GRO Amount: 8.436102
TPH Area:116196.6 TPH Amount: 60.61103

Aliphatic Hydrocarbon Areas and Quantitations uncorrected for Aromatics:
C5-C8 Area:12520.77 C5-C8 Amount: 8.253572
C9-C12 Area:34883.23 C9-C12 Amount: 26.37608

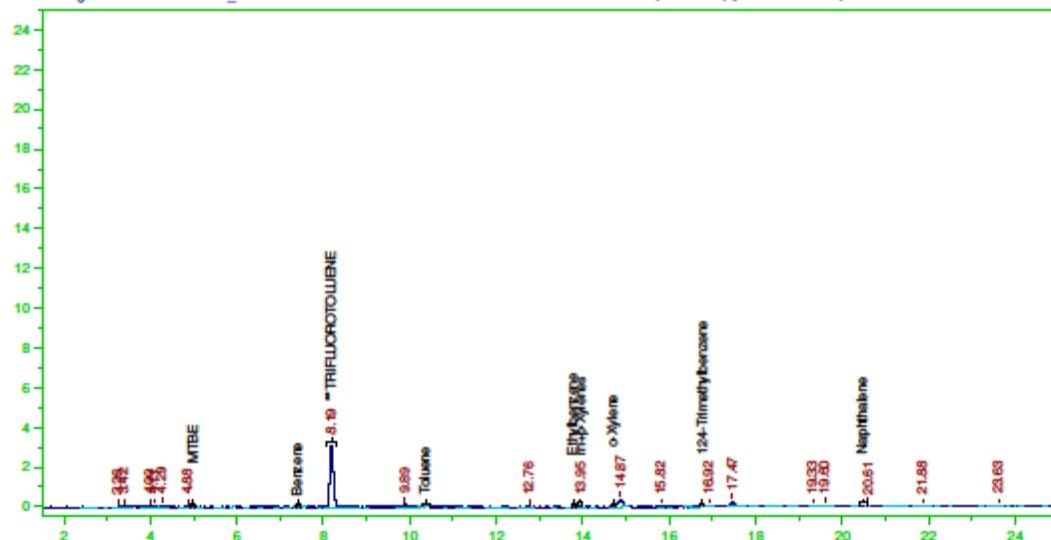


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Trip Blank Lot071119 B-JLB SHP0274
G:\Org\VA2\DATA\VA2082119_b\0821VA2.0010.RAW

B19081987-002A ;0821VA2 , \$HC-VPH-MA-W,



VPH AROMATICS PHOTOIONIZATION DETECTOR CHROMATOGRAM REPORT

Sample Name: B19081987-002A ;0821VA2 , \$HC-VPH-MA-W,
Raw File: G:\Org\VA2\DATA\VA2082119_b\0821VA2.0010.RAW
Date & Time Acquired: 8/21/2019 4:43:59 PM
Method File: G:\Org\VA2\Methods\190823VPH.MET
Calibration File: G:\Org\VA2\Cals\190823_190510VPH.CAL
Sample Weight: 5 Dilution: 1 S.A.: 1

Mean RF for C9 to C10 Aromatic Hydrocarbons: 408.4298

Rt range for C9 to C10 Aromatics: 14.77 to 20.39

Aromatic Hydrocarbon Range Area and Quantitation:

C9-C10 Aromatics Area:5921.915 C9-C10 Aromatics Amount: 2.899844

TARGET ANALYTES	RT	CAL RRT	RRT	AREA	AMOUNT	FLAG
MTBE	.	.	.	.	1.	U
Benzene	.	.	.	.	.5	U
Toluene	.	.	.	.	.5	U
Ethylbenzene	.	.	.	.	.5	U
m+p-Xylenes	13.949	13.949	13.949	105	.5	U
o-Xylene	.	.	.	.	.5	U
124-Trimethylbenzene	.	.	.	.	.5	U
Naphthalene	.	.	.	.	1.	U

SURROGATE COMPOUND	RT	ACTUAL	MEASURED	%REC	QC LIMITS
**TRIFLUOROTOLUENE	8.195	25.	26.375	105.5	70-130

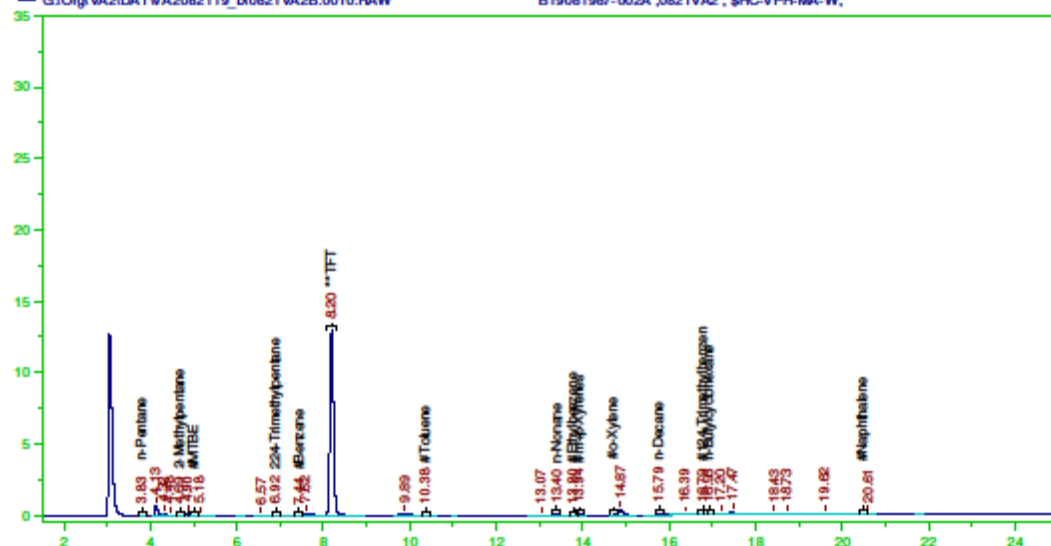


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Trip Blank Lot071119 B-JLB SHP0274
G:\Org\VA2\DAT\VA2082119_b\0821VA2B.0010.RAW

B19081987-002A ;0821VA2 , \$HC-VPH-MA-W,



VPH ALIPHATICS FLAME IONIZATION DETECTOR CHROMATOGRAM REPORT

Sample Name: B19081987-002A ;0821VA2 , \$HC-VPH-MA-W,
Raw File: G:\Org\VA2\DAT\VA2082119_b\0821VA2B.0010.RAW
Date & Time Acquired: 8/21/2019 4:43:59 PM
Method File: G:\Org\VA2\Methods\190823VPHB\$.MET
Calibration File: G:\Org\VA2\Cals\190823_190510VPHB.CAL
Sample Weight: 5 Dilution: 1 S.A.: 1

Mean RF for C5 to C8 Aliphatic Hydrocarbons: 606.8051
Mean RF for C9 to C12 Aliphatic Hydrocarbons: 529.0131
Mean RF for all calibrated compounds: 766.8345
Rt range for Gasoline Range Organics: 4.59 to 15.87
Rt range for C5 to C8 Aliphatic Hydrocarbons: 3.72 to 13.28
Rt range for C9 to C12 Aliphatic Hydrocarbons: 13.33 to 20.39

SURROGATE COMPOUND	RT	ACTUAL	MEASURED	%REC
**TPT	8.197	25.	24.479	97.92

GRO Area:9140.07 GRO Amount: 2.383844
TPH Area:19011.75 TPH Amount: 4.958502

Aliphatic Hydrocarbon Areas and Quantitations uncorrected for Aromatics:
C5-C8 Area:9141.633 C5-C8 Amount: 3.013038
C9-C12 Area:9424.302 C9-C12 Amount: 3.562975



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QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Montana Environmental Lab

Work Order: B19081987

Report Date: 09/11/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8015M Batch: 136496									
Lab ID: LCS-136496	Laboratory Control Sample				Run: GCFID-HP3-B_190827B		08/28/19 10:48		
Total Extractable Hydrocarbons	5900	ug/L	300	92	60	140			
Surr: o-Terphenyl			2.0	85	40	140			
Lab ID: MB-136496	Method Blank				Run: GCFID-HP3-B_190827B		08/28/19 11:32		
Total Extractable Hydrocarbons	ND	ug/L	300						
Surr: o-Terphenyl			2.0	81	40	140			
Lab ID: B19081987-001AMS	Sample Matrix Spike				Run: GCFID-HP3-B_190827B		08/28/19 12:59		
Total Extractable Hydrocarbons	32700	ug/L	560	224	60	140			S
Surr: o-Terphenyl			3.7	83	40	140			
Lab ID: B19081987-001AMSD	Sample Matrix Spike Duplicate				Run: GCFID-HP3-B_190827B		08/28/19 13:43		
Total Extractable Hydrocarbons	38700	ug/L	560	274	60	140	17	20	S
Surr: o-Terphenyl			3.7	82	40	140			
S - Second bottle that was used had light coating of tar-like substance near the top 1" of the bottle that was not present in the parent. The higher than normal recoveries are due to the difference between the parent sample and the sample used for the MS/MSD analysis.									
Method: SW8015M Analytical Run: R326486									
Lab ID: CCV_0827HP316r-W	Continuing Calibration Verification Standard				08/28/19 03:07				
n-Nonane	205	ug/L		103	75	125			
n-Decane	210	ug/L		105	75	125			
n-Dodecane	215	ug/L		107	75	125			
n-Tetradecane	210	ug/L		105	75	125			
n-Hexadecane	212	ug/L		106	75	125			
n-Octadecane	212	ug/L		106	75	125			
n-Nonadecane	215	ug/L		107	75	125			
n-Eicosane	215	ug/L		107	75	125			
n-Docosane	215	ug/L		107	75	125			
n-Tetracosane	216	ug/L		108	75	125			
n-Hexacosane	217	ug/L		109	75	125			
n-Octacosane	217	ug/L		109	75	125			
n-Triacontane	215	ug/L		107	75	125			
n-Hexatriacontane	218	ug/L		109	75	125			
Surr: o-Terphenyl			2.0	99	75	125			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

S - Spike recovery outside of advisory limits.

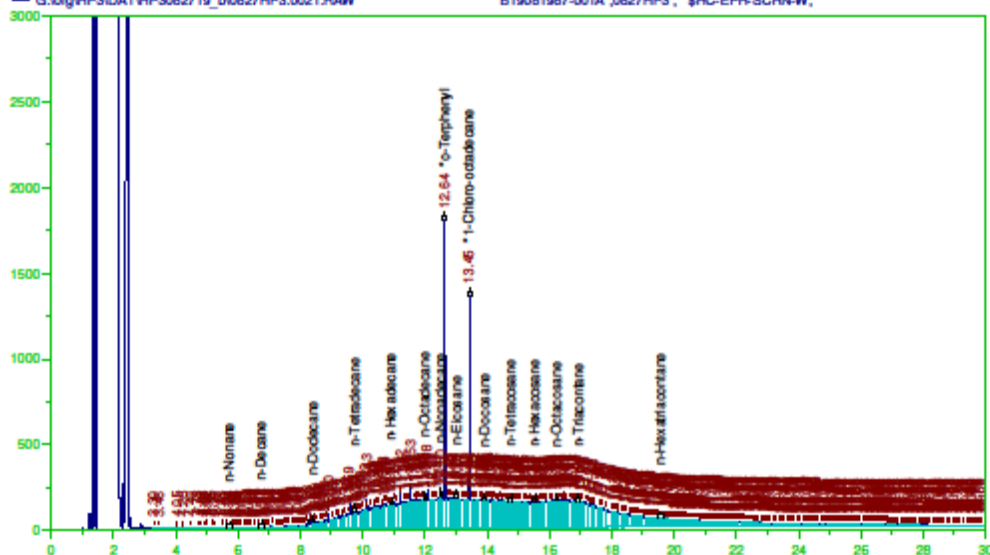


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MEL 8652, Swiftcurrent Creek-Many Glacier
G:\org\HP3\DAT\HP3082719_b\0827HP3.0021.RAW

Batch ID: 136496
B19081987-001A, 0827HP3, \$HC-EPH-SCRN-W,



EXTRACTABLE PETROLEUM HYDROCARBONS (EPH) SCREENING ANALYSIS CHROMATOGRAM

Sample Name: B19081987-001A ; 0827HP3, \$HC-EPH-SCRN-W,
Raw File: G:\org\HP3\DAT\HP3082719_b\0827HP3.0021.RAW
Date & Time Acquired: 8/28/2019 12:15:55 PM
Method File: g:\org\HP3\Methods\SR_SCN-082721-UL-L\met
Calibration File: G:\Org\HP3\Cals\MA-EPH_SC190129UL.CAL
Sample Weight: 1 Dilution: 2 S.A.: 1

Mean RF for C9 to C18 Hydrocarbons: 28956.04
Mean RF for C19 to C36 Hydrocarbons: 28683.01
Mean RF for Total Extractable Hydrocarbons: 28819.53
Rt range for Diesel Range Organics: 6.65 to 16.96
Rt range for C9 to C18 Hydrocarbons: 5.65 to 12.56
Rt range for C19 to C36 Hydrocarbons: 12.595 to 19.66

SURROGATE COMPOUND	RT	AREA	ACTUAL	MEASURED	%REC	
*o-Terphenyl	12.64	3989785	200.	230.803	115.4	-
*1-Chloro-octadecane	13.445	3215475	200.	252.661	126.33	-

DRO Area: 6.722792E+07 DRO Amount: 4665.442
TEH Area: 8.971294E+07 TEH Amount: 6225.844
C9-C18 Area: 2.940193E+07 C9-C18 Amount: 2030.798
C19-C36 Area: 5.152539E+07 C19-C36 Amount: 3592.746

G:\org\HP3\dat\HP3082719_b\Review\021_B19081987-001A_SR_SCN-082721-UL-L\xls



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QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Montana Environmental Lab

Work Order: B19081987

Report Date: 09/11/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MA-EPH							Batch: 136803		
Lab ID: LCS-136803-136496	Laboratory Control Sample		Run: GCFID-HP3-B_190906B				09/06/19 17:05		
C9 to C18 Aliphatics	809	ug/L	300	67	40	140			
C19 to C36 Aliphatics	1530	ug/L	300	95	40	140			
n-Nonane	73.6	ug/L	5.0	37	30	140			
n-Decane	105	ug/L	5.0	52	40	140			
n-Dodecane	125	ug/L	5.0	62	40	140			
n-Tetradecane	146	ug/L	5.0	73	40	140			
n-Hexadecane	161	ug/L	5.0	80	40	140			
n-Octadecane	180	ug/L	5.0	90	40	140			
n-Nonadecane	184	ug/L	5.0	92	40	140			
n-Eicosane	187	ug/L	5.0	94	40	140			
n-Docosane	191	ug/L	5.0	95	40	140			
n-Tetracosane	194	ug/L	5.0	97	40	140			
n-Hexacosane	193	ug/L	5.0	97	40	140			
n-Octacosane	191	ug/L	5.0	95	40	140			
n-Triacontane	187	ug/L	5.0	94	40	140			
n-Hexatriacontane	190	ug/L	5.0	95	40	140			
Surr: 1-Chloro-octadecane			2.0	90	40	140			
Lab ID: MB-136803-136496	Method Blank		Run: GCFID-HP3-B_190906B				09/06/19 18:31		
C9 to C18 Aliphatics	ND	ug/L	300						
C19 to C36 Aliphatics	ND	ug/L	300						
Surr: 1-Chloro-octadecane			2.0	90	40	140			
Lab ID: B19081987-001AMS	Sample Duplicate		Run: GCFID-HP3-B_190906B				09/08/19 00:30		
C9 to C18 Aliphatics	7610	ug/L	560				88	20	R
C19 to C36 Aliphatics	11100	ug/L	560				91	20	R
- Because the sample amount was significantly higher than the spike amount, the MS and MSD spike samples are calculated as Duplicate samples based on the spike amount added plus the original sample concentration. - Second bottle that was used had light coating of tar-like substance near the top 1" of the bottle that was not present in the parent. The higher than normal RPDs are due to the difference between the parent sample and the sample used for the MS/MSD analysis.									
Lab ID: B19081987-001AMS	Sample Matrix Spike		Run: GCFID-HP3-B_190906B				09/08/19 00:30		
n-Nonane	129	ug/L	5.0	35	30	140			
n-Decane	180	ug/L	5.0	49	40	140			
n-Dodecane	235	ug/L	5.0	63	40	140			
n-Tetradecane	294	ug/L	5.0	79	40	140			
n-Hexadecane	313	ug/L	5.0	85	40	140			
n-Octadecane	343	ug/L	5.0	93	40	140			
n-Nonadecane	354	ug/L	5.0	95	40	140			
n-Eicosane	351	ug/L	5.0	95	40	140			
n-Docosane	355	ug/L	5.0	96	40	140			
n-Tetracosane	366	ug/L	5.0	99	40	140			
n-Hexacosane	365	ug/L	5.0	98	40	140			
n-Octacosane	362	ug/L	5.0	97	40	140			
n-Triacontane	350	ug/L	5.0	94	40	140			
n-Hexatriacontane	362	ug/L	5.0	98	40	140			

Qualifiers:

RL - Analyte reporting limit.

R - RPD exceeds advisory limit.

ND - Not detected at the reporting limit.



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QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Montana Environmental Lab

Work Order: B19081987

Report Date: 09/11/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MA-EPH									
Batch: 136803									
Lab ID: B19081987-001AMS	Sample Matrix Spike		Run: GCFID-HP3-B_190906B				09/08/19 00:30		
Surr: 1-Chloro-octadecane			3.7	90	40	140			
Lab ID: B19081987-001AMSD	Sample Duplicate		Run: GCFID-HP3-B_190906B				09/08/19 02:38		
C9 to C18 Aliphatics	9700	ug/L	560				110	20	R
C19 to C36 Aliphatics	13200	ug/L	560				100	20	R
- Because the sample amount was significantly higher than the spike amount, the MS and MSD spike samples are calculated as Duplicate samples based on the spike amount added plus the original sample concentration.									
- Second bottle that was used had light coating of tar-like substance near the top 1" of the bottle that was not present in the parent. The higher than normal RPDs are due to the difference between the parent sample and the sample used for the MS/MSD analysis.									
Lab ID: B19081987-001AMSD	Sample Matrix Spike Duplicate		Run: GCFID-HP3-B_190906B				09/08/19 02:38		
n-Nonane	130	ug/L	5.0	35	30	140	0.3	30	
n-Decane	195	ug/L	5.0	53	40	140	7.9	20	
n-Dodecane	271	ug/L	5.0	73	40	140	14	20	
n-Tetradecane	339	ug/L	5.0	92	40	140	14	20	
n-Hexadecane	351	ug/L	5.0	95	40	140	11	20	
n-Octadecane	370	ug/L	5.0	100	40	140	7.5	20	
n-Nonadecane	379	ug/L	5.0	101	40	140	6.7	20	
n-Eicosane	372	ug/L	5.0	101	40	140	5.8	20	
n-Docosane	374	ug/L	5.0	101	40	140	5.3	20	
n-Tetracosane	385	ug/L	5.0	104	40	140	5.0	20	
n-Hexacosane	386	ug/L	5.0	104	40	140	5.4	20	
n-Octacosane	384	ug/L	5.0	103	40	140	5.9	20	
n-Triacontane	368	ug/L	5.0	99	40	140	5.2	20	
n-Hexatriacontane	381	ug/L	5.0	103	40	140	5.2	20	
Surr: 1-Chloro-octadecane			3.7	91	40	140			
Lab ID: LCS-136803-136496	Laboratory Control Sample		Run: GCFID-HP3-B_190906B				09/06/19 17:48		
C11 to C22 Aromatics	3310	ug/L	300	92	40	140			
Total Extractable Hydrocarbons	5670	ug/L	300	89	40	140			
Naphthalene	102	ug/L	5.0	51	40	140			
2-Methylnaphthalene	119	ug/L	5.0	59	40	140			
Acenaphthylene	145	ug/L	5.0	73	40	140			
Acenaphthene	147	ug/L	5.0	73	40	140			
Fluorene	166	ug/L	5.0	83	40	140			
Phenanthrene	194	ug/L	5.0	97	40	140			
Anthracene	201	ug/L	5.0	100	40	140			
Fluoranthene	203	ug/L	5.0	101	40	140			
Pyrene	205	ug/L	5.0	103	40	140			
Benzo(a)Anthracene	205	ug/L	5.0	103	40	140			
Chrysene	219	ug/L	5.0	110	40	140			
Benzo(b)Fluoranthene/Benzo(k)Fluoranthene	428	ug/L	5.0	107	40	140			
Benzo(a)Pyrene	201	ug/L	5.0	100	40	140			
Dibenz(a,h)anthracene/Indeno(1,2,3-cd)pyrene	419	ug/L	5.0	105	40	140			
Benzo(g,h,i)perylene	200	ug/L	5.0	100	40	140			
Surr: 2-Bromonaphthalene			2.0	99	40	140			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

R - RPD exceeds advisory limit.



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QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Montana Environmental Lab

Work Order: B19081987

Report Date: 09/11/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MA-EPH							Batch: 136803		
Lab ID: LCS-136803-136496	Laboratory Control Sample		Run: GCFID-HP3-B_190906B				09/06/19 17:48		
Surr: 2-Fluorobiphenyl			2.0	89	40	140			
Surr: o-Terphenyl			2.0	92	40	140			
Lab ID: MB-136803-136496	Method Blank		Run: GCFID-HP3-B_190906B				09/06/19 19:14		
C11 to C22 Aromatics	ND	ug/L	300						
Total Extractable Hydrocarbons	ND	ug/L	300						
Naphthalene	ND	ug/L	5.0						
2-Methylnaphthalene	ND	ug/L	5.0						
Acenaphthylene	ND	ug/L	5.0						
Acenaphthene	ND	ug/L	5.0						
Fluorene	ND	ug/L	5.0						
Phenanthrene	ND	ug/L	5.0						
Anthracene	ND	ug/L	5.0						
Fluoranthene	ND	ug/L	5.0						
Pyrene	ND	ug/L	5.0						
Benzo(a)Anthracene	ND	ug/L	5.0						
Chrysene	ND	ug/L	5.0						
Benzo(b)Fluoranthene/Benzo(k)Fluoran	ND	ug/L	5.0						
Benzo(a)Pyrene	ND	ug/L	5.0						
Dibenz(a,h)anthracene/Indeno(1,2,3-cd	ND	ug/L	5.0						
Benzo(g,h,i)perylene	ND	ug/L	5.0						
Surr: 2-Bromonaphthalene			2.0	103	40	140			
Surr: 2-Fluorobiphenyl			2.0	93	40	140			
Surr: o-Terphenyl			2.0	85	40	140			
Lab ID: B19081987-001AMS	Sample Duplicate		Run: GCFID-HP3-B_190906B				09/08/19 01:13		
Total Extractable Hydrocarbons	32000	ug/L	560				86	20	R
- Because the sample amount was significantly higher than the spike amount, the MS and MSD spike samples are calculated as Duplicate samples based on the spike amount added plus the original sample concentration.									
- Second bottle that was used had light coating of tar-like substance near the top 1" of the bottle that was not present in the parent. The higher than normal RPDs are due to the difference between the parent sample and the sample used for the MS/MSD analysis.									
Lab ID: B19081987-001AMS	Sample Matrix Spike		Run: GCFID-HP3-B_190906B				09/08/19 01:13		
C11 to C22 Aromatics	11400	ug/L	560	150	40	140			S
Naphthalene	212	ug/L	9.3	57	40	140			
2-Methylnaphthalene	259	ug/L	9.3	70	40	140			
Acenaphthylene	318	ug/L	9.3	86	40	140			
Acenaphthene	317	ug/L	9.3	86	40	140			
Fluorene	352	ug/L	9.3	95	40	140			
Phenanthrene	392	ug/L	9.3	106	40	140			
Anthracene	390	ug/L	9.3	105	40	140			
Fluoranthene	399	ug/L	9.3	108	40	140			
Pyrene	400	ug/L	9.3	108	40	140			
Benzo(a)Anthracene	404	ug/L	9.3	109	40	140			
Chrysene	421	ug/L	9.3	114	40	140			
Benzo(b)Fluoranthene/Benzo(k)Fluoran	639	ug/L	9.3	113	40	140			

Qualifiers:

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QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Montana Environmental Lab

Work Order: B19081987

Report Date: 09/11/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MA-EPH							Batch: 136803		
Lab ID: B19081987-001AMS	Sample Matrix Spike		Run: GCFID-HP3-B_190906B				09/08/19 01:13		
Benzo(a)Pyrene	394	ug/L	9.3	106	40	140			
Dibenz(a,h)anthracene/Indeno(1,2,3-cd)	819	ug/L	9.3	111	40	140			
Benzo(g,h,i)perylene	390	ug/L	9.3	105	40	140			
Surr: 2-Bromonaphthalene			3.7	108	40	140			
Surr: 2-Fluorobiphenyl			3.7	102	40	140			
Surr: o-Terphenyl			3.7	96	40	140			
Lab ID: B19081987-001AMS	Sample Duplicate		Run: GCFID-HP3-B_190906B				09/08/19 03:20		
Total Extractable Hydrocarbons	38000	ug/L	560				99	20	R
- Because the sample amount was significantly higher than the spike amount, the MS and MSD spike samples are calculated as Duplicate samples based on the spike amount added plus the original sample concentration. - Second bottle that was used had light coating of tar-like substance near the top 1" of the bottle that was not present in the parent. The higher than normal RPDs are due to the difference between the parent sample and the sample used for the MS/MSD analysis.									
Lab ID: B19081987-001AMS	Sample Matrix Spike Duplicate		Run: GCFID-HP3-B_190906B				09/08/19 03:20		
C11 to C22 Aromatics	12900	ug/L	560	172	40	140	12	20	S
Naphthalene	217	ug/L	9.3	58	40	140	2.0	20	
2-Methylnaphthalene	270	ug/L	9.3	73	40	140	4.3	20	
Acenaphthylene	332	ug/L	9.3	90	40	140	4.5	20	
Acenaphthene	335	ug/L	9.3	90	40	140	5.4	20	
Fluorene	373	ug/L	9.3	101	40	140	5.8	20	
Phenanthrene	407	ug/L	9.3	110	40	140	3.8	20	
Anthracene	403	ug/L	9.3	109	40	140	3.5	20	
Fluoranthene	410	ug/L	9.3	111	40	140	2.8	20	
Pyrene	410	ug/L	9.3	111	40	140	2.6	20	
Benzo(a)Anthracene	412	ug/L	9.3	111	40	140	2.0	20	
Chrysene	436	ug/L	9.3	118	40	140	3.5	20	
Benzo(b)Fluoranthene/Benzo(k)Fluoran	858	ug/L	9.3	116	40	140	2.2	20	
Benzo(a)Pyrene	411	ug/L	9.3	111	40	140	4.2	20	
Dibenz(a,h)anthracene/Indeno(1,2,3-cd)	841	ug/L	9.3	113	40	140	2.6	20	
Benzo(g,h,i)perylene	402	ug/L	9.3	108	40	140	3.0	20	
Surr: 2-Bromonaphthalene			3.7	113	40	140			
Surr: 2-Fluorobiphenyl			3.7	103	40	140			
Surr: o-Terphenyl			3.7	94	40	140			

Qualifiers:

RL - Analyte reporting limit.

R - RPD exceeds advisory limit.

ND - Not detected at the reporting limit.

S - Spike recovery outside of advisory limits.



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QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Montana Environmental Lab

Work Order: B19081987

Report Date: 09/11/19

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MA-EPH							Batch: 136803		
Lab ID: B19081987-001AMS	Sample Matrix Spike		Run: GCFID-HP3-B_190906B				09/08/19 01:13		
Benzo(a)Pyrene	394	ug/L	9.3	106	40	140			
Dibenz(a,h)anthracene/Indeno(1,2,3-cd)	819	ug/L	9.3	111	40	140			
Benzo(g,h,i)perylene	390	ug/L	9.3	105	40	140			
Surr: 2-Bromonaphthalene			3.7	108	40	140			
Surr: 2-Fluorobiphenyl			3.7	102	40	140			
Surr: o-Terphenyl			3.7	96	40	140			
Lab ID: B19081987-001AMS	Sample Duplicate		Run: GCFID-HP3-B_190906B				09/08/19 03:20		
Total Extractable Hydrocarbons	38000	ug/L	560				99	20	R
- Because the sample amount was significantly higher than the spike amount, the MS and MSD spike samples are calculated as Duplicate samples based on the spike amount added plus the original sample concentration. - Second bottle that was used had light coating of tar-like substance near the top 1" of the bottle that was not present in the parent. The higher than normal RPDs are due to the difference between the parent sample and the sample used for the MS/MSD analysis.									
Lab ID: B19081987-001AMS	Sample Matrix Spike Duplicate		Run: GCFID-HP3-B_190906B				09/08/19 03:20		
C11 to C22 Aromatics	12900	ug/L	560	172	40	140	12	20	S
Naphthalene	217	ug/L	9.3	58	40	140	2.0	20	
2-Methylnaphthalene	270	ug/L	9.3	73	40	140	4.3	20	
Acenaphthylene	332	ug/L	9.3	90	40	140	4.5	20	
Acenaphthene	335	ug/L	9.3	90	40	140	5.4	20	
Fluorene	373	ug/L	9.3	101	40	140	5.8	20	
Phenanthrene	407	ug/L	9.3	110	40	140	3.8	20	
Anthracene	403	ug/L	9.3	109	40	140	3.5	20	
Fluoranthene	410	ug/L	9.3	111	40	140	2.8	20	
Pyrene	410	ug/L	9.3	111	40	140	2.6	20	
Benzo(a)Anthracene	412	ug/L	9.3	111	40	140	2.0	20	
Chrysene	436	ug/L	9.3	118	40	140	3.5	20	
Benzo(b)Fluoranthene/Benzo(k)Fluoran	858	ug/L	9.3	116	40	140	2.2	20	
Benzo(a)Pyrene	411	ug/L	9.3	111	40	140	4.2	20	
Dibenz(a,h)anthracene/Indeno(1,2,3-cd)	841	ug/L	9.3	113	40	140	2.6	20	
Benzo(g,h,i)perylene	402	ug/L	9.3	108	40	140	3.0	20	
Surr: 2-Bromonaphthalene			3.7	113	40	140			
Surr: 2-Fluorobiphenyl			3.7	103	40	140			
Surr: o-Terphenyl			3.7	94	40	140			

Qualifiers:

RL - Analyte reporting limit.

R - RPD exceeds advisory limit.

ND - Not detected at the reporting limit.

S - Spike recovery outside of advisory limits.

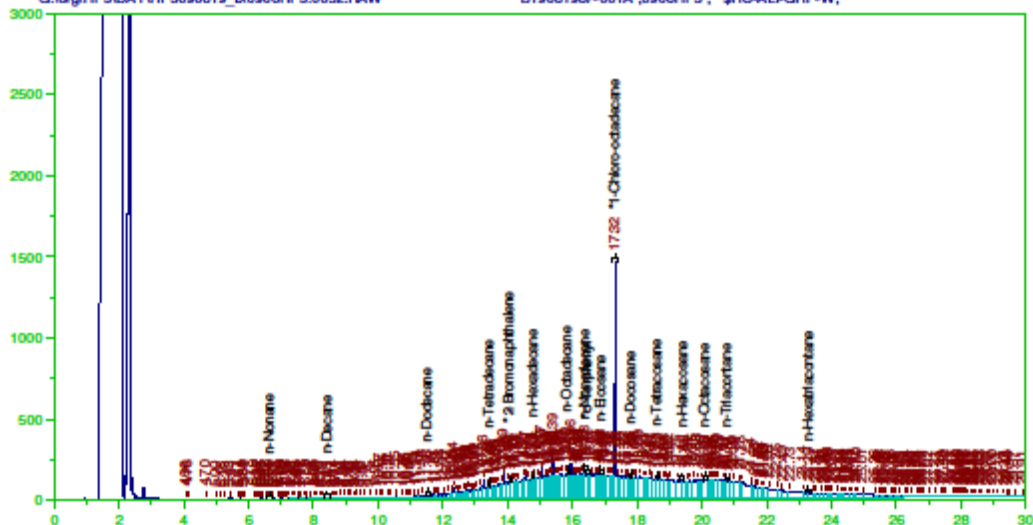


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MEL 8652, Swiftcurrent Creek-Many Glacier
G:\org\HP3\DAT\HP3090619_b\0906HP3.0052.RAW

Batch ID: 136803
B19081987-001A ;0906HP3, \$HC-ALI-GRP-W,



EPH ALIPHATICS (FID) ANALYSIS REPORT

Sample Name: B19081987-001A ;0906HP3, \$HC-ALI-GRP-W,
Raw File: G:\org\HP3\DAT\HP3090619_b\0906HP3.0052.RAW
Date & Time Acquired: 9/7/2019 10:22:50 PM
Method File: g:\org\HP3\Methods\LR_EPH-090652-SS-L\met
Calibration File: G:\Org\HP3\Cals\MA-EPH_AL190123SS.CAL
Sample Weight: 1 Dilution: 2 S.A.: 1

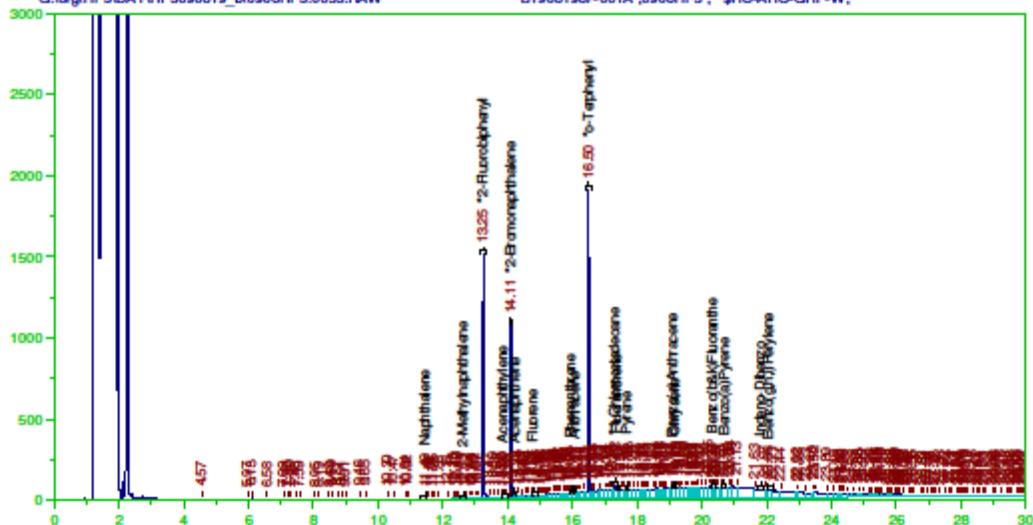
Mean RF for C9 to C18 Aliphatic Hydrocarbons: 29585.69
Mean RF for C19 to C36 Aliphatic Hydrocarbons: 29817.4
Mean RF for Total Extractable Hydrocarbons: 29718.1
Rt range for Diesel Range Organics: 8.36 to 20.16
Rt range for C9 to C18 Aliphatic Hydrocarbons: 6.57 to 16.36
Rt range for C19 to C36 Aliphatic Hydrocarbons: 16.385 to 23.4

SURROGATE COMPOUND	RT	ACTUAL	MEASURED	%REC	
*1-Chloro-octadecane	17.323	200.	248.527	124.26	-

DRO Area: 5.149566E+07 DRO Amount: 3465.609
TEH Area: 6.871158E+07 TEH Amount: 4624.225

Aliphatic Hydrocarbon Areas and Amounts:
C9-C18 Area: 2.628454E+07 C9-C18 Amount: 1776.841
C19-C36 Area: 3.809424E+07 C19-C36 Amount: 2555.168

Batch ID: 136803
B19081987-001A :0906HP3. \$HC-ARO-GRP-W.



EPH AROMATICS RANGE VALUES (FID) ANALYSIS REPORT

Sample Name: B19081987-001A ; 0906HP3 , \$HC-ARO-GRP-W,
Raw File: G:\Org\HP3\DAT\HP3090619_b\0906HP3.0053.RAW
Date & Time Acquired: 9/7/2019 11:05:27 PM
Method File: g:\Org\HP3\Methods\RR_EPH-090653-SS-L4.met
Calibration File: G:\Org\HP3\Cals\MA-EPH_AR190123SS.CAL
Sample Weight: 1 Dilution: 2 S.A.: 1

Mean RF EPH Aromatics: 30680.28

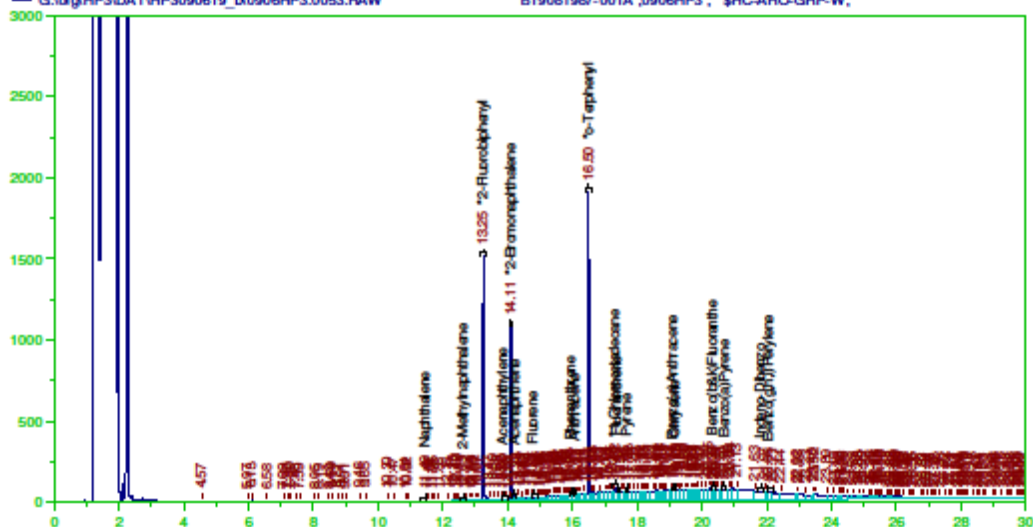
Rt range for EPH C11 to C22 Aromatics: 11.3 to 22.21

SURROGATE COMPOUND	RT	ACTUAL	MEASURED	%REC	
*2-Fluorobiphenyl	13.247	200.	191.928	95.96	-
*2-Bromonaphthalene	14.106	200.	220.162	110.08	-
*o-Terphenyl	16.505	200.	200.977	100.49	-
*1-Chlorooctadecane	17.322	200.	27.268	13.63	-

C11-C22 Aromatics Area: 2.201568E+07 C11-C22 Aromatics Amount: 1435.169
EPH Aromatics total Area: 2.757579E+07 EPH Aromatics Total Amount: 1797.623

MEL 8652, Swiftcurrent Creek-Many Glacier
— G:\ord\HP3\DATA\HP3090619 b.0906HP3.0053.RAW

Batch ID: 136803
B19081987-001A :0906HP3. \$HC-ARO-GRP-W.



EPH AROMATICS RANGE VALUES (FID) ANALYSIS REPORT

Sample Name: B19081987-001A ; 0906HP3 , \$HC-ARO-GRP-W,
Raw File: G:\Org\HP3\DAT\HP3090619.b\0906HP3.0053.RAW
Date & Time Acquired: 9/7/2019 11:05:27 PM
Method File: g:\org\HP3\Methods\RR_EPH-090653-SS-L4.met
Calibration File: G:\Org\HP3\Cals\MA-EPH_AR190123SS.CAL
Sample Weight: 1 Dilution: 2 S.A.: 1

Mean RF EPH Aromatics: 30680.28

Rt range for EPH C11 to C22 Aromatics: 11.3 to 22.21

SURROGATE COMPOUND	RT	ACTUAL	MEASURED	%REC	
*2-Fluorobiphenyl	13.247	200.	191.928	95.96	-
*2-Bromonaphthalene	14.106	200.	220.162	110.08	-
*o-Terphenyl	16.505	200.	200.977	100.49	-
*1-Chlorooctadecane	17.322	200.	27.268	13.63	-

C11-C22 Aromatics Area:2.201568E+07 C11-C22 Aromatics Amount: 1435.169
EPH Aromatics total Area:2.757579E+07 EPH Aromatics Total Amount: 1797.623



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Work Order Receipt Checklist

Montana Environmental Lab

B19081987

Login completed by: Briana G. Sangiuliano

Date Received: 8/20/2019

Reviewed by: BL2000/gmccartney

Received by: keh

Reviewed Date: 8/21/2019

Carrier name: Return-UPS Ground N/C

Shipping container/cooler in good condition?	Yes ☒	No ☐	Not Present ☐
Custody seals intact on all shipping container(s)/cooler(s)?	Yes ☒	No ☐	Not Present ☐
Custody seals intact on all sample bottles?	Yes ☐	No ☐	Not Present ☒
Chain of custody present?	Yes ☒	No ☐	
Chain of custody signed when relinquished and received?	Yes ☒	No ☐	
Chain of custody agrees with sample labels?	Yes ☒	No ☐	
Samples in proper container/bottle?	Yes ☒	No ☐	
Sample containers intact?	Yes ☒	No ☐	
Sufficient sample volume for indicated test?	Yes ☒	No ☐	
All samples received within holding time? (Exclude analytes that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☒	No ☐	
Temp Blank received in all shipping container(s)/cooler(s)?	Yes ☒	No ☐	Not Applicable ☐
Container/Temp Blank temperature:	°C Blue Ice		
Water - VOA vials have zero headspace?	Yes ☒	No ☐	No VOA vials submitted ☐
Water - pH acceptable upon receipt?	Yes ☒	No ☐	Not Applicable ☐

Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as -dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Contact and Corrective Action Comments:

The temperature of the sample(s) for shipping container 1 was 4.6°C and shipping container 2 was 8.4°C.



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Chain of Custody & Analytical Request Record

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Page 1 of 1

Account Information (Billing information)

Company/Name	
Contact	
Phone	
Mailing Address	
City, State, Zip	
Email	
Receive Invoice ☐ Hard Copy ☐ Email ☐	Receive Report ☐ Hard Copy ☐ Email ☐
Purchase Order	
Quote	
Bottle Order	

Report Information (if different than Account Information)

Company/Name	
Contact	
Phone	
Mailing Address	
City, State, Zip	
Email	
Receives Report ☐ Hard Copy ☐ Email ☐	Special Report/Format
☐ LEVEL IV ☐ NELAC ☐ EDD/EDT (contact laboratory) ☐ Other	

Comments

Creek Water - oil spill suspected

Project Information

Project Name, PWSID, Permit, etc	
Sampler Name	
Sample Origin State	
EPA/State Compliance ☐ Yes ☒ No	
MIXING CLIENTS, please indicate sample type	
If one has been processed or refined call before sending	
☐ Byproduct 11 (e)2 material ☐ Unprocessed ore (NOT ground or refined)*	

Matrix Codes

A - Air
W - Water
S - Solids
V - Vegetation
B - Bacteria
O - Other
DW - Drinking Water

Analysis Requested

VPH	EPH Screen	See Attached
-----	------------	--------------

All turnaround times are standard unless marked as RUSH
Energy Laboratories MUST be contacted prior to RUSH sample submittal for changes and scheduling - See Instructions Page

Sample Identification (Name, Location, Interval, etc)	Collection		Matrix (See Codes Above)	Number of Containers	Date	Time	Signature	Date/Time	Signature	Date/Time	Signature	Amount	Receipt Number (cashcheck only)
	Date	Time											
1 Swiftcurrent Creek -	8-15-19	10:50	5	W									
2 MARY GLACIER													
3 TRIP BLANK - HULLA B-TUB SHPOUT			1										
4													
5													
6													
7													
8													
9													
10													

EU/LAB ID
RUSH
TAT
814081987

Custody	Relinquished by (print)	Signature	Date/Time	Received by (print)	Signature	Date/Time	Amount	Receipt Number (cashcheck only)
Record MUST be signed	Nicole	Signature	8/19/19 16:00	Relinquished by (print)	Signature	8/19/19 16:30		
Shipped By	Cooler D(s)	Custody Seals	Intact	Receipt Temp	Temp Blank	On Ice	Payment Type	
		Y N C B	Y N	°C	Y N	Y N	Cash Check	

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested. This serves as notice of this possibility. All subcontracted data will be clearly notated on your analytical report.

EU-COC-12/16 v 1