Investigation of Septic Leachate to the Shoreline Area of Whitefish Lake, Montana

RRG-11-1474

Final Report

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1 March 2012

EXECUTIVE SUMMARY

The Whitefish Lake Institute conducted this investigation for the Whitefish County Water District under the Department of Natural Resources Renewable Resource Grant & Loan program to determine the spatial and temporal extent of septic leachate to the shoreline area of Whitefish Lake. The study also provides a scientific basis for identifying ecological threats to the lake, economic threats to the community of Whitefish, and potential public health risks resulting from decreased water quality. Synoptic sampling of 20 sites—including one midlake reference site—occurred on 9 sample dates starting in May 2011 and concluding in October 2011. The results of this investigation are intended as actionable information for resource decision makers and Whitefish citizens concerning septic system usage around Whitefish Lake. Whitefish Lake is located in northwestern Montana in the larger Flathead Watershed which is part of the Columbia River Basin.

Septic "leachate" is the liquid that remains after wastewater drains though septic solids. The liquid contains elevated concentrations of bacteria and organic compounds from waste, detergents, and other household materials. When properly placed, functioning, and maintained, septic systems are designed to collect wastewater to neutralize these contaminants before they enter ground or surface water systems. Decomposition of waste begins in the septic tank and ends in a leachfield after undergoing a series of treatments whereby wastewater is chemically, physically, and biologically processed to remove contaminants. Modern septic systems are considered cost-effective for wastewater treatment, however issues such as improper initial system design, impermeability of soil, improper soil drainage class, improper vertical distance between the absorption field and the water table, improper slope, or improper maintenance may lead to system failure. Even when properly installed and maintained, septic systems have a finite life expectancy.

In addition to basic cleaning components, 97% laundry detergents in the U.S. contain Optical Brightening Agents (OBAs). OBAs are added to laundry soaps, detergents, and other cleaning agents because they adsorb to fabrics and materials during the washing and cleaning processes making clothes appear brighter. Laundry wastewater is the largest contributor of OBAs to wastewater systems. The presence of OBAs in wastewater with laundry effluent as a component is therefore considered an excellent indicator of septic or sewage system failure. Because the specific light spectrum emitted from OBAs found in cleaning products is easily measurable, it is one of the key data parameters used in tracking ineffective sewage treatment from septic systems.

Numerous studies have shown that septic leachate is transported by groundwater flow through lake-bottom sediments into lake water, elevating nutrient concentrations (Kerfoot and Brainard 1978; Belanger *et al*. 1985; Jourdonnais and Stanford 1985 *in* Jourdonnais *et al*. 1986). Previous studies specific to Whitefish Lake have indicated septic system failures, and confirmed the presence of OBAs from household cleaning products commonly found in septic leachate. This investigation was designed to build on the techniques and results of prior studies, but employ newer data collection techniques along with bacterial source tracking methodologies. Because septic leachates are known to

contain elevated concentrations of both organic and inorganic compounds, the study employed a toolbox of techniques, including; fluorometry, dissolved organic carbon (DOC), fluorometry/DOC ratio (F/DOC), *E. coli* enumeration, human DNA biomarkers, conductivity, total dissolved solids (TDS), and GIS methodologies and tools. In addition to data collection and analysis, a historical record for the study area was established.

In total, we identified three confirmed areas of septic leachate contamination, including Site 3: City Beach Bay, Site 5: Viking Creek, and Site 13: Lazy Bay. We identified two areas of high potential for septic leachate contamination, including Site 12: Lazy Channel and Site 18: Dog Bay State Park Seep. Four areas were identified as having medium potential for septic leachate contamination, including Site 2: City Beach Seep, Site 4: SE Monk's Bay, Site 11: Brush Bay, and the East Lakeshore from Gaines Point south to north Monk's Bay, including Site 8: Carver Bay and Site 7: SE Houston Pt. The remaining 10 shoreline sites are considered to have a low potential for contamination by septic leachate (Figure 24). A study conducted in 1985 reported signs of chronic contamination from shoreline developments at Sites 2: City Beach Seep, 18: Dog Bay State Park Seep, 5: Viking Creek, and the approximate location of Site 14: Central Beaver Bay, correlating directly with results of this study.

Our results suggest that the three confirmed sites, along with the two sites with high potential and four sites with medium potential have also shown contamination in prior studies, and represent locations where action should be considered. The study concluded with the development of a *Septic Leachate Contamination & Risk Assessment Map* (Figure 24) which identifies confirmed sites of septic leachate contamination as well as areas of low, medium, and high potential for future contamination.

General and site specific recommendations included herein, largely based on examples from other wastewater management programs, are provided as examples of actions that can be taken to support the common goal of protecting Whitefish Lake water quality. They include Education & Outreach and Regulatory programs.

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In maps 24 through 29, we employed available GIS data to create the most robust depiction of septic systems and septic system density possible. However, our maps are only a representation of the best data available at the time. We are therefore not responsible for any errors or omissions in this data or misrepresentations of actual septic system status. We recommend the reader use the maps to consider trends for various neighborhoods rather than looking at specific designations for individual lots.

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ACKNOWLEDGEMENTS

Josh Gubits, Environmental Scientist: Whitefish Lake Institute for assistance in field data collection and content reviews; Leif Castren, 2011 College Intern: Whitefish Lake Institute for field support; Jon Cuthbertson, Director: Montana Environmental Laboratory for procedural and laboratory support; Chuck Gailey, OTB DesignWorks for 3-D bathymetry; Eric Hintze, Support Team: Number Cruncher Statistical System (NCSS) for support with NCSS; Nathan Holm, GISP: Flathead County GIS Department for cartography and data files; Wendee Jacobs, Flathead County Sanitarian/Environmental Health Service: Flathead City-County Health Department for historical septic system data; Mauricio Larenas, Source Molecular Corporation for microbial source tracking; Bill Leonard, posthumously for championing the grant process for this study; Matthew Middendorf, Service Technician: Hach Company for field equipment audit and site support; Peter Petri, GIS Analyst & Cartographer: Mobile LoGIStics Mapping for database reconciliation and cartography; Mark Reller, Constellation Services for bathymetry; Joe Russell, County Public Health Officer: Flathead County for documentation and verification; Adele Scholl, Gravityshots.com for aerial images; Peter Stanley, Lion Mountain Homeowners Association for showing us the communal septic system; Steve Thompson, Executive Director: Cinnabar Foundation for spatial content; Heidi Van Everen, Program Director: Whitefish Legacy Partners for Whitefish Trails information; Marilyn Williams, Flathead County Health Department for County GIS data, Lawrence Younan, Applications Scientist: Turner Designs for fluorometry calibration and usage techniques; Rita Hanson, Director of the Whitefish County Water District; the members of the Whitefish County Water District Board of Directors: Carl Denny, Bambi Goodman, Jim Kibbe, and Jan Metzmaker; and the members of WLI's Board of Directors: Greg Lane, President; Karen Reeves, Vice President; Charlie Abell, Secretary/Treasurer; Susan Fletcher, Greg Gunderson, Sharon Morrison, John Muhlfeld, Nancy Svennungsen, Dan Weinberg, and City Council Board Representative Frank Sweeney.

We dedicate this report to the memory of Betty Koopal (1934-2011) whose gentle persuasion and constant encouragement imparted the values of patience and perseverance, requisite traits to complete a project of this nature.

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Cite:
Curtis, L. and Koopal, M. (2012). Investigation of Septic Leachate to the Shoreline Area of Whitefish Lake, Montana. Prepared for the Whitefish County Water District, DNRC RRG-11-1474. Whitefish Lake Institute, Whitefish, MT.

1.0 INTRODUCTION

1.1 Purpose

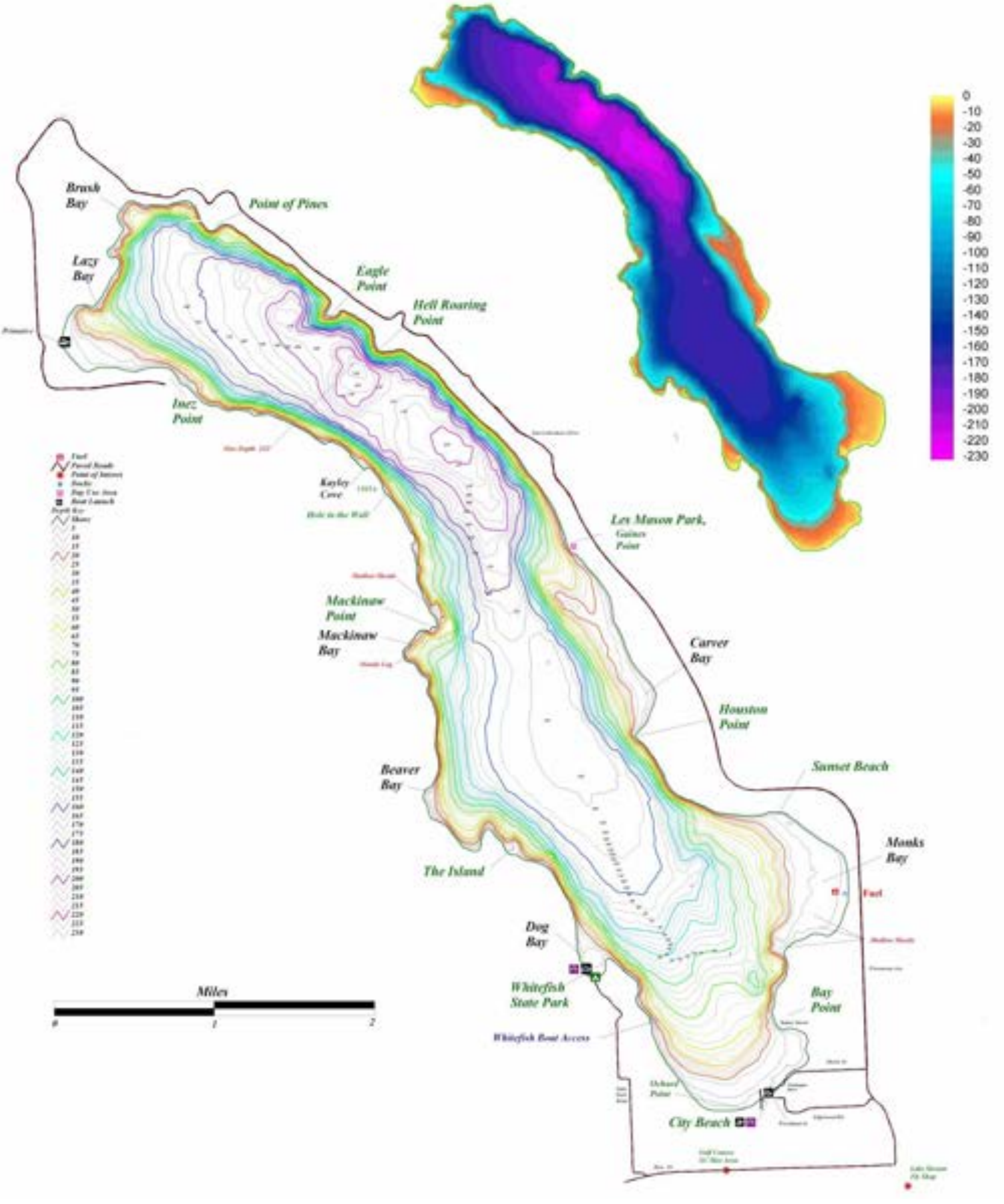
The purpose of this investigation is to identify the spatial and temporal extent of septic leachate to the shoreline area of Whitefish Lake. Septic "leachate" is the liquid that remains after wastewater drains though septic solids. The remaining liquid contains elevated concentrations of bacteria and organic compounds from waste, detergents, and other household materials. This study was designed to accomplish two goals. First, it will help determine the potential extent of septic contamination to the lake. Second, it will provide a scientific basis for identifying ecological threats to the lake such as eutrophication, and economic threats to the community of Whitefish resulting from decreased water quality, as well as potential public health risks such as pathogenic viruses and bacteria. The results of this investigation will provide information to resource decision makers regarding septic systems and wastewater conveyance issues, and create public awareness of concerns relating to septic system usage around the lake.

Numerous studies have shown that septic leachates are transported by groundwater through lake-bottom sediments into lake water, elevating nutrient concentrations (Kerfoot & Brainard, 1978; Belanger *et al*, 1985; Jourdonnais & Stanford, 1985; Jourdonnais *et al*, 1986). The Jourdonnais *et al* study *Investigation of Septic Contaminated Groundwater Seepage as a Nutrient Source to Whitefish Lake, Montana* (1986) indicated contamination of Whitefish Lake from cultural influences, with one site—Dog Bay Seep—confirming the presence of chemical whiteners from household cleaning products commonly found in septic leachate. The survey also identified septic-related groundwater nutrients entering the lake at several specific points. This current study builds on the results of the 1986 Jourdonnais study by using some similar data collection techniques, but employing newer technology and additional methodologies.

1.2 Study Area

Whitefish Lake (48.4536°N, 114.3796°W) is located in northwestern Montana at an elevation of 914m (2998.5 ft) above sea level. It is 9.3 km (5.7 miles) long and 2.2 km (1.4 miles) wide with 25.5 km (15.85 miles) of shoreline. The lake is approximately 70.7 m (232 ft) at its deepest point (Constellation Services, 2006) (Figure 1). Whitefish Lake is classified by the Montana Department of Environmental Quality (MDEQ) as an A-1 water body meaning it is "suitable for drinking, culinary, and food processing purposes after conventional treatment for removal of naturally present impurities. Under this classification, water quality must be suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life; waterfowl and furbearers; and agricultural and industrial water supply" (MDEQ, 2011). Whitefish Lake has been identified as fully supporting aquatic life, however categorized as "Threatened" with siltation/sediment, PCBs, and mercury as the source of impairment.

Figure 1. Whitefish Lake Bathymetric Map (courtesy Constellation Services)



In addition to being a source for drinking water, Whitefish Lake is a popular recreational lake. In 2005, WLI conducted a survey of 461 Whitefish school students in grades 4, 8, and 11 to determine their contact with Whitefish Lake water. The survey, which had a response rate of almost 90%, showed that 85 to 90% of respondents recreated at the lake—specifically swimming—with 25-30% swimming more than 20 days (Koopal, 2006). Water contact recreation at Whitefish Lake is considered high, influenced by the convenience of City Beach, Whitefish State Park, and Les Mason Park. For this reason, understanding the extent of bacteria in the lake—human and non-human—in addition to other pollutants is particularly important.

The lake basin is the result of Pleistocene Epoch glaciation, with morainal deposits of glacial till at its southern and eastern shores. The till is a heterogenous mixture composed of unsorted gravels in a silt-clay matrix, suggesting widely varying hydraulic conductivities as well as varied seepage rates. The mix includes lacustrine silt, clay, gravel, and glacial drift. The glacial till of the area was mostly deposited beneath extensive ice sheets, leaving a dense core. Further toward the surface, the till is less dense having been exposed to progressive weathering. Esker deposits of sand, gravel, and cobbles also occur along the shoreline of Whitefish Lake. (Montgomery *et al*, 2006; Jourdonnais *et al*, 1986; USDA, 1960).

The Whitefish and Stryker Faults run northwest to southeast along the east and west sides, respectively, of the lake. Outcroppings of Precambrian dolomitic limestone occur parallel to and along the lake's west shore, dipping perpendicularly into the lake at approximately a 30-degree angle. In general, limited groundwater seepage occurs along this west section of shoreline because flows are limited to fractures and joints in confined bedding planes. Hydrolyzed illite and chlorite clays cover these formations, sometimes further restricting groundwater movement. The highest seepage rates are found in the alluvial deposits along the north shore of the lake near Swift Creek where deposits are composed of stratified, well sorted gravels that yield high hydraulic conductivities. Aside from these areas, the glacial soils around the lake are typically non-porous or poorly drained. (City of Whitefish, 2006; Johns *et al*, 1963; Jourdonnais *et al*, 1986).

The lake is fed by six perennial tributaries including Swift Creek, Lazy Creek, Hellroaring Creek, Beaver Creek, Smith Creek, and Viking Creek. Swift Creek is the largest tributary to the lake, draining 63% of the total watershed along the Whitefish Range (Craft *et al*, 2003). Lazy Creek is a meandering lowland second order stream draining 13% of the total watershed. Lazy Creek runs parallel to Swift Creek in the northern valley, also draining into the north end of the lake (Craft *et al*, 2003). Fine silts and clays high in organic matter contribute reduced hydraulic conductivities and low groundwater inflows near Lazy Creek (Jourdonnais *et al*, 1986). The remaining 24% of the Whitefish Lake Watershed is drained by several smaller tributaries and groundwater seeps. The largest of the small tributaries is Hellroaring Creek which originates on Big Mountain draining about 2.5% of the watershed.

A 2008 summary of two USDA soil surveys reported 63 specific soil types in the Whitefish area (City of Whitefish, 2008). According to the City of Whitefish (1997), the

Soil Conservation Service (1970), and the Whitefish County Water and Sewer District (1984), the majority of the soil types occurring along all the developed shorelines of Whitefish Lake have characteristics such as low soil permeability rate, stoniness, low depth to bedrock, and shallow groundwater that limit adequate treatment of septic effluents. In addition to functional restrictions to septic systems, there may also be issues regarding slope stability and the placement of septic tanks and leachfields associated with these landtypes. Slope failures and landslides pose a threat to Whitefish Lake water quality because of the potential for heavy sediment pollutant contributions. In addition, septic system placement in a steep slope environment could lead to system failure potentially allowing wastewater to reach the lake. Pre-installation evaluation is conducted by engineers to determine site-specific soil characteristics and proper septic system type and placement.

Unlike any other large lake in the State of Montana, Whitefish Lake is located entirely within the boundaries of a municipality, having been annexed by the City of Whitefish in 2005. The community of Whitefish is located primarily south of the lake on a glacial outwash plain dissected by the Whitefish River and several smaller streams. Glacial features include morainal deposits (lateral, recessional, and terminal), lacustrine sediments, the occasional kettle (pothole), and small pockets of stratified drift.

The City of Whitefish, a popular resort community, has a population of approximately 6,357 people (Whitefish Chamber of Commerce, 2011). U.S. Census Bureau data show that the population of Whitefish increased 36% since 1980, and 20% since 1990 (U.S. Census Bureau, 2011). Recent demographic reports show Whitefish remains one of the fastest growing communities in the state of Montana, with a 26.3% population growth between 2000 and 2010 (Montana Department of Labor and Industry, 2011). Land ownership around Whitefish Lake is mostly private, with some DNRC State Trust land at the north end of the lake and the Beaver Lake area. There are two state parks—Les Mason on the east shore and Whitefish Lake State Park on the lower west shore that are managed by Montana Fish Wildlife & Parks. Small parcels of U.S. Forest Service lands are found north and northwest of Whitefish Lake. (Figure 2)

Based on information from a Whitefish Weather Station (WRCC, 2012), average temperatures in the Whitefish Lake area (1948-2005) ranged from an average -9.16°C (15.5°F) in January/February to 27.2°C (80.9°F) in July/August. July also had the warmest monthly average max for Whitefish (PBS&J, 2006). The Watershed receives an average 60-66 cm (22-26 inches) of precipitation annually (NOAA, 2011).

Whitefish Lake supports a native fish assemblage including bull trout, westslope cutthroat trout, mountain whitefish, pygmy whitefish, long-nosed sucker, large-scale sucker, northern pikeminnow, peamouth chub, redside shiner, and 3 species of sculpin (Koopal, 2011; Deleray, 2012; Deleray & Knotek, 1999). Bull trout and westslope cutthroat trout have persisted in the Whitefish Lake Watershed for

Figure 2: Whitefish Lake Land Ownership

approximately 10,000 to 12,000 years through droughts, flooding, fires, and human development. They are considered important indicator species for environmental disturbance because of their specific spawning and rearing requirement for clean, sediment-free rivers and streams, and for their sensitivity throughout their life histories (Curtis, 2010; Muhlfeld, 2010). Bull trout have been listed as “threatened” since 1998 under the Endangered Species Act (ESA). Several introduced fish species also have been historically documented in Whitefish Lake, including lake whitefish, lake trout, yellow perch, brook trout, northern pike, and Kokanee salmon (now extirpated) (Koopal, 2011; Deleray, 2012; Deleray & Knotek, 1999).

1.3 Septic & Sewer Systems

Septic Systems

The French are credited with having developed underground septic tank systems in the 1870s. By the mid 1880s, two-chamber, automatic siphoning septic tank systems, not unlike those used today, were being installed in the United States. Now, more than a century later, septic tank systems continue to be a major residential wastewater treatment option. Almost one in four households in the U.S. uses individual or small community septic systems to treat wastewater (U.S. Environmental Protection Agency, 2011a). Septic systems are designed to collect household waste in a tank and then filter wastewater and pollutants through leach fields. Functioning leach fields break down and neutralize contaminants before they enter ground or surface water systems.

Decomposition of waste begins in the septic tank where wastewater separates into layers. The solids that settle to the bottom of the tank are digested by naturally occurring bacteria that transform up to 50% of the solids into liquids and gasses. Once the wastewater leaves the tank and enters the drainfield, further digestion of organic matter occurs. Wastewater is processed chemically, physically, and biologically. Chemical treatment occurs when wastewater comes into contact with soil. Nutrients adsorb to soil particles preventing them from moving into groundwater. Physical treatment occurs as wastewater moves through pores in the soil which act as a filter removing particulate contaminants (solids). Finally, biological treatment occurs as microorganisms feed on the wastewater. Every square inch of soil contains millions of naturally occurring beneficial microscopic organisms which complete the wastewater treatment process by killing disease-causing organisms in the sewage and by removing excess nutrients (Hart et al, 2006).

Modern septic systems can be cost-effective options for wastewater treatment; however poor septic performance or even system failure can arise from a number of scenarios, including improper initial system design, impermeability of soil, improper soil drainage class, improper vertical distance between the absorption field and the water table, and improper slope. For instance, an absorption field must be located below the frost line, within a biologically active zone, and above the seasonal water table. Low permeability of soil may force effluent toward the surface. Shallow or coarse soils may be too permeable, allowing effluent to move laterally or downward too quickly for sufficient decomposition, potentially transporting untreated or improperly treated effluent into groundwater, tributaries, or the lake.

After septic systems are in place and operating, they require periodic maintenance. If maintenance is ignored or done improperly, system failures can occur. Even when properly installed and maintained, septic systems have a finite life expectancy (U.S. Environmental Protection Agency, 2011a). Flathead County reported that the effective lifespan of septic systems varies according to a number of factors, including system type, overall soil suitability, installation, maintenance, and usage. Prior to advancements in septic system technology starting in 1990, septic systems generally lasted 15 to 20 years. Given optimal conditions, the average lifespan of post 1990 systems is approximately 30 years, after which time systems may fail and nutrients may leach into groundwater (Flathead County Health Department, 2012). In 1998, the Flathead County Health Department estimated that more than 50% of the individual septic systems in Flathead County were over 20 years old (Flathead Lakers, 2002).

There are several constituents of concern to human health from wastewater, including biological contaminants (bacteria & viruses); synthetic organic contaminants (algaecides, pesticides, and herbicides); and inorganic contaminants such as phosphorus, nitrogen, metals (lead, tin, zinc, copper, iron, cadmium, and arsenic), sodium, chlorides, potassium, calcium, magnesium, and sulfates (U.S. Environmental Protection Agency, 1984). Pathogenic viruses are a major concern because they can enter groundwater from numerous sources, the most common being livestock waste, landfill effluent, and septic systems. Infective viruses have been shown to move 50 m (164 ft) in depth from septic tanks to drinking wells, and controlled studies have shown horizontal movement of up to 1.6 km (just under one mile) (Dodds, 2002). Deborde *et al* (1999) demonstrated that the poliovirus moved approximately 20 m (65.6 ft) in a course cobble aquifer resulting in a virus mortality rate of less than 1%. Soil properties, temperature, organic matter, microbial activity, and virus survival times all potentially influence the spread of viruses through groundwater.

Another set of health concerns emanating from groundwater contamination come from nitrates. High nitrate concentrations in drinking water have been linked in studies to Methemoglobinemia and “blue baby” syndrome (Avery, 1999), hypertension (Malberg *et al*, 1978), central nervous system birth defects (Dorsch *et al*, 1984), certain cancers (Hill *et al*, 1972) non-Hodgkin’s lymphoma (Ward *et al*, 1996 & Weisenberger, 1991), and diabetes (Parslow *et al*, 1997). Additional research is needed to further understand these linkages, but concern for nitrate related health risks from sewage outfall remains high. Some high nitrate readings have been recorded in the west Flathead Valley.

In addition to creating general human health hazards, one of the other main concerns regarding septic systems is the potential for long-term chronic nutrient, pollutant and bacterial loading to lakes. Bacteria, degradable organic compounds, synthetic detergents, and chlorides can enter and contaminate water and can increase *eutrophication* of lakes. The eutrophication process in lakes is natural. Typically as lakes age, nutrients, sediment, and plant material accumulates, slowly filling a lake’s basin.

The basin eventually—over centuries—becomes inhabited by terrestrial vegetation. The timing is highly variable, depending on the climate and characteristics of the basin and its watershed. However, by altering nutrient and sediment inputs, humans have greatly increased the rate at which eutrophication takes place. Depending on the lake and degree of human impact on it, this *cultural eutrophication* can take place in a much shorter timeframe.

Cultural eutrophication occurs when the addition of nitrates, phosphates, and sediment above natural background levels promotes excessive plant growth and decay, showing preference to algae and plankton over other aquatic plants. Enhanced growth of algae and phytoplankton can lead to a partial lack of available dissolved oxygen (*hypoxia*) or a total lack of available dissolved oxygen (*anoxia*) needed by fish and other aquatic life forms to survive, thereby disrupting normal ecosystem functioning. Algae normally produce oxygen through photosynthesis, but under eutrophic conditions, water clarity is reduced, as is underwater light needed by algae to produce oxygen. When algae lose the ability to produce oxygen, they begin to consume it, quickly reducing available dissolved oxygen for other aquatic life forms.

Further complications also arise as algae blooms die and precipitate to the lake bottom where bacterial and microbial decomposers further deplete available dissolved oxygen. Eutrophication can rapidly turn a lake into an anoxic and lethal environment. In addition to impacting fisheries, eutrophication also decreases the value of lakes for swimming, boating, fishing, and aesthetic enjoyment which can have significant economic impacts.

Household detergents contribute cultural eutrophication. There are two basic components found in most household detergents—*surfactants* and *builders*. The surfactants (surface-acting agents) are the main cleaning components. Builders are water softeners that function by sequestering calcium ions. The most commonly used builder is sodium triosphate. In the 1950s and 1960s, sodium phosphate was the most commonly used builder in household detergents, leading to major eutrophication problems in water bodies around the globe. In the 1960s, governments, detergent manufacturers and consumers worked to reduce the use of phosphates in detergents, while wastewater treatment facilities began removing phosphorus from treated water. Phosphorus concentrations in water bodies have subsequently been reduced. Today, laundry and dishwashing detergents containing phosphates are banned in the state of Montana and 15 other states in the U.S.

In addition to surfactants and builders, 97% of laundry detergent products in the U.S. contain Optical Brightening Agents (OBAs) to make clothes appear cleaner (Hartel *et al*, 2007 & Hagedorn *et al*, 2005). Also known as Fluorescent Whitening Agents, OBAs have replaced "bluing" which was previously used for the same reason. OBAs are added to products such as laundry soaps, detergents, and other cleaning agents because they adsorb to fabrics and materials during the washing and cleaning processes. They are also used in paper production and cosmetic manufacturing (Khan & Ansarni, 2005).

Laundry wastewater is the largest contributor of OBAs to wastewater systems. Although the total volume of whiteners in most laundry detergents is less than 0.5%, up to 80% of its concentration can remain as dissolved compounds in ineffectively treated wastewater.

The presence of OBAs in human wastewater that includes laundry effluent as a component is therefore an excellent indicator of septic or sewage system failure (Hagedorn *et al*, 2005; Hartel *et al*, 2008; Hartel *et al*, 2007; Tavares, *et al*, 2008; Turner Designs, 2011). Because the specific light spectrum emitted from OBAs found in cleaning products is easily measurable, it is one of the key data parameters used in tracking ineffective human sewage treatment from septic systems and sewer infrastructure.

Sewer Systems

The earliest covered sewer systems were discovered by archaeologists in the early planned cities of the Indus Valley Civilization (3300–1300 BCE) in the northwest region of the Indian subcontinent. Community wastewater and sewer systems were later designed to prevent flooding in large cities like London and Paris. The stormwater and sewer system infrastructure in London dates back to the 13th century but it was not until the early 1800s that they were used for wastewater. The municipal sewer system in Paris was built in the 16th century but fewer than five percent of the households had connected to it as late as the turn of the 20th century. In the U.S., it was not until the early 1700s that a drainage system was built in Boston, Massachusetts (Schladweiler, 2005).

Today, the City of Whitefish sewer system includes about 46 miles of conventional gravity sewer mains, 17 lift stations, 13 duplex grinder pump stations which each serve 1020 residences, and two septic tank pump systems on the east shore of Whitefish Lake. The wastewater treatment plant is located on 40 acres south of town alongside the Whitefish River and has a capacity of 1.8 million gallons per day. The system collects wastewater, delivers it to the main sewage liftstation then to an aerated lagoon treatment system for the removal of phosphorus, finally discharging the water to the Whitefish River.

Liftstation installation dates range from 1960 to 2003, with the main liftstation having undergone a rehabilitation effort in 2003. The lagoons were built in 1979. An alum based phosphorus removal process was added and improvements to the main lift station were made in 1986. The lagoons were upgraded in 2002 with sludge removal and new aeration filters. In 2009, an automated 5mm bar screen was installed to replace the 2” bar screen that required manual cleaning. A second clarifier was also brought online. In 2012, the State is mandating disinfection before effluent enters the Whitefish River. (Cassidy *et al*, 2008). The City has continued to contract with engineers to identify wastewater system weaknesses and make improvements to the system including the 2011 project to rehabilitate 11,400 linear feet of sewer mains.

The bulk of the sewer system includes conventional gravity sewers, augmented by lift stations where required by terrain (Figure 3). Lift stations located in close proximity to the lake include Mountain Park, Boat House, Birch Point, City Beach, Viking, Monk’s Bay, and Houston Point. According to an engineering report prepared for the City of Whitefish (Anderson-Montgomery, 2005), the City’s gravity sewers have performed satisfactorily with the exceptions of typical root intrusions, cracked pipe sections, and occasional joint separations in older vitrified clay pipe sections. Manholes have been upgraded or replaced as needed due to structural deterioration. Hydraulic performance of the existing gravity system is good and the capacity of the treatment plant is sufficient to serve current customers and growth through the year 2020 (City of Whitefish, 2012b).

Figure 3: Whitefish City Sewer System

1.4 History

From 1911
Local historical anecdotal accounts refer to methods of sewage disposal along the shoreline of Whitefish Lake involving the use of outhouses, cess pools, dry wells and direct deposit of effluent into the lake (Engelter & Schafer, 1973). The City of Whitefish began collecting sanitary wastewater around 1911 (Anderson & Montgomery, 2005). The City passed Ordinance 82, 12-7-1911 which led to the construction of one sewer system for storm runoff and one for sanitary sewage. According to the City, the 8" diameter clay tile pipe was designed to "…collect wastewater from area residents and convey it to several large septic tanks located throughout town (Anderson & Montgomery, 2005)." Use of the sewer was broadened to attempt to lower the groundwater table either by creating gaps between pipe lengths, or omitting gasket materials. It was thought that the additional clear water would enhance solids flushing velocity. Septic tanks were discharged to drainfields along the banks of the Whitefish River that were likely hydrologically connected to the river (Anderson & Montgomery, 2005).

1960s
In 1962, the City of Whitefish constructed its first centralized treatment system located at the current wastewater treatment plant site. It also constructed a 12" diameter interceptor pipe along the northeast bank of the Whitefish River to collect wastewater from various systems in town. Septic tanks and drainfields were abandoned in place. In 1973, the city abandoned the use of clay pipes and opted for PVC pipe for extensions to the sanitary system. However, virtually all of the original vitrified clay pipe system remains in use today (Anderson & Montgomery, 2005).

1970s
Flathead County started requiring septic permits in 1970, even though the permitting process was voluntary for the first two years. As a result, it is not possible to determine septic system density pre-1970 (Flathead County, 2006).

After a 1977 study on the trophic status of Whitefish Lake, (U.S. Environmental Protection Agency National Eutrophication Survey), the lake was classified as *oligotrophic* at that time, but the EPA warned that any significant increased nutrient loading to Whitefish Lake could result in degradation of water quality, and they urged that "every effort be made to limit phosphorus inputs to the lake" (U.S. Environmental Protection Agency, 1977). An oligotrophic lake has low nutrient content, therefore low primary productivity, low algal production, and clear, high-quality, drinkable water that also supports numerous fish species.

1980s
Dye tests conducted by the Flathead County Sanitarian in 1981 confirmed that septic tank effluent was entering Whitefish Lake from a number of sites along the east lakeshore. In addition, the Sanitarian determined that septic systems were failing in a number of areas other than along the lakeshore (Whitefish County Water and Sewer District, 1984). In September of 1984, the U.S. Environmental Protection Agency's Region 8 Water

Division requested laboratory analysis of color infrared aerial photographs of Whitefish, including the developed sections of the Whitefish Lake shoreline. The photos were stereoscopically examined for indications of malfunctioning septic systems. In October of 1984, several suspected failing septic systems were inspected.

The ground observations provided an added level of detail that identified and isolated issues other than septic failure—such as Fairyring fungus, natural grass species patterns, and old filled-in drainage channels—so that actual septic system failures were correctly identified. Results of the study showed 85 possible failed septic systems of the 147 investigated, 55 with high confidence (U.S. Environmental Protection Agency, 1985). These historical results corroborate our current findings at sites where older septic systems remain in operation.

A limnological study of Whitefish Lake in the early 1980s by the Flathead Lake Biological Station indicated that the lake was in a transitory phase toward eutrophication (Golnar & Stanford, 1984). They reported that most metrics measured at that time (primary productivity, phytoplankton structure and density, total organic carbon, and total nitrogen) were within the typical ranges of an oligotrophic water body. However, oxygen depletion in the *hypolimnion* (the dense bottom layer of water—below the *metalimnion* (the transition layer between surface and deep water)—in a thermally stratified lake) during late summer, combined with high total phosphorus concentrations in the *epilimnion* (the top-most layer in a stratified lake) were associated with *mesotrophic* lakes (lakes with intermediate productivity, generally clear with submerged plant life and a medium level of nutrients).

A study sponsored by the Whitefish County Water and Sewer District and conducted by the Flathead Lake Biological Station investigated septic contaminated groundwater seepage as a nutrient source to Whitefish Lake (Jourdonnais *et al*. 1986). That study found evidence of septic contaminated groundwater and surface water along shoreline locations around the lake. Figure 4 shows the locations with the highest elevated conductivity (>170 µmhos/cm) and fluorometry (>1,000 RFVs) readings compared to mid-lake reference values of conductivity (150 µmhos/cm) and fluorometry (400 RFVs). The Jourdonnais *et al* report (1986) was instrumental in providing baseline data for comparison in this study. The study was also used to support a grant application to extend the sewer system along a portion of the east shore of Whitefish Lake. This work was completed in the late 1980s.

The Flathead Lake Biological Station returned to Whitefish Lake to gather data in 1986, 1987, and 1993, and select data were later reported in their Whitefish Lake Water Quality Report (Craft *et al*, 2003). The Montana Department of Natural Resources and Conservation (DNRC) has, since 1976, measured total phosphorus, nitrates, and nitrogen entering Whitefish Lake from Swift Creek. Prior studies on Whitefish Lake have been generally limited in duration and/or scope.

Figure 4. Locations of Highest Fluorometry & Conductivity (Jourdonnais *et al*, 1986)

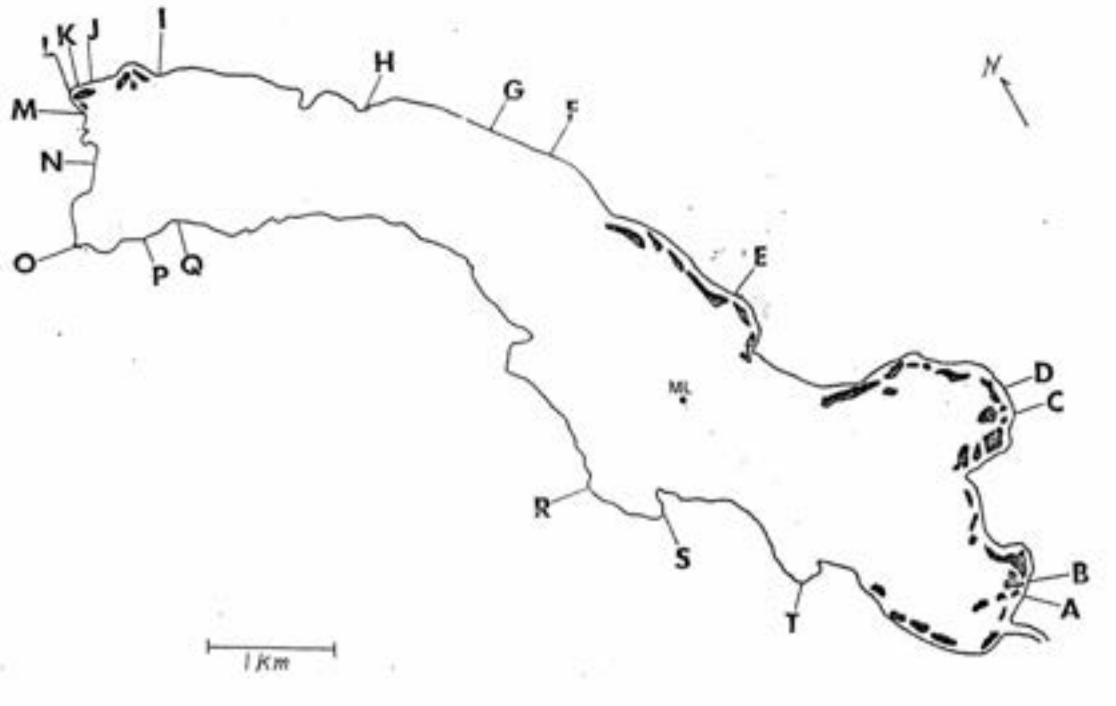


Figure 4. Locations (A-T, Table 3) on Whitefish Lake where in situ measurements of fluorometry and/or conductivity were significantly higher than values taken at mid-lake.

1990s

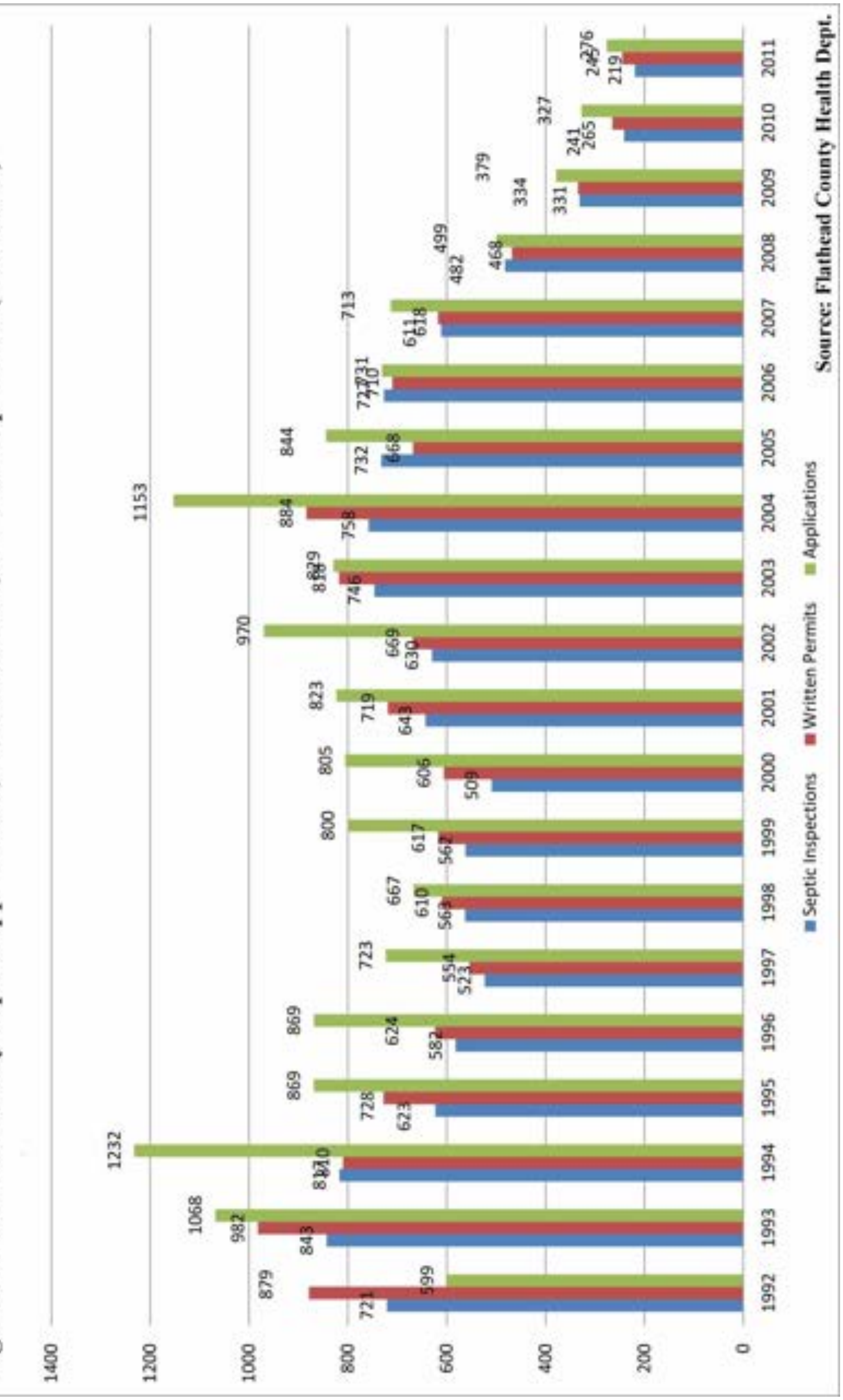
A 1997 Wastewater Facilities Plan for Whitefish Montana (Peccia & Associates) allowed the City to proceed with implementing a capital improvement program for wastewater collection and treatment systems for a 24-year period. Included in the findings and recommendations were growth projections; recommendations for problematic collection systems, interceptors, lift station improvements, and treatment upgrades; and funding allocation and rate increase plans to fund the work.

2000s

Data from the Flathead County Department of Environmental Services reported there was a 44% increase in septic system installations from 2000-2005. There were 668 permits issued for new septic systems in 2005. After an increase to 727 new permits in 2006, issued permits declined continuously from 611 in 2007 down to 245 in 2011 (Flathead County, 2012) (Figure 5).

WLI formed in 2005 with the objective of implementing a long-term Whitefish Lake Water Quality Monitoring Program. The goal of the program is to provide a comprehensive understanding of the lake resource by consistently gathering physical, chemical, and biological data for the lake and its tributaries over time and to gain an

Figure 5. Flathead County Septic Applications, Permits Issued, & Final Inspections (1991-2010)



Source: Flathead County Health Dept.

understanding of Whitefish Lake watershed processes. While the program takes into account past studies, it offers a higher level of consistency and coordination, a baseline data set, and an integrated long-term analysis of the lake. WLI monitors two sites on Whitefish Lake along with five tributaries (Hellroaring Creek, Lazy Creek, Smith Creek, Swift Creek, and Viking Creek) (Figure 6) and two sites on the Whitefish River. Monitoring of Swift Creek is done in partnership with DNRC. Chemical sampling includes total organic carbon (TOC), total phosphorus (TP), total persulfate/nitrogen (TPN), total suspended solids (TSS), soluble reactive phosphorus (SRP), and a standard Hydrolab profile using a DS5 Sonde. This profile includes sample date, time, temperature (°F), water depth (m), conductivity (aeS/CM), resistivity (ke-cm), salinity (ppt), total dissolved solids (TDS), pH, oxygen reduction potential (ORP), luminescent dissolved oxygen (LDO) (% sat), and LDO (mg/l). Tributary sampling also includes measuring stream flow and developing stage discharge relationships. Atmospheric bulk loading data (wet and dry) is collected from the Weather Station WLI installed and maintains near Lazy Creek. Data collected includes ammonia (NH_3), nitrates (NO_3), nitrites (NO_2), and total phosphorus (TP).

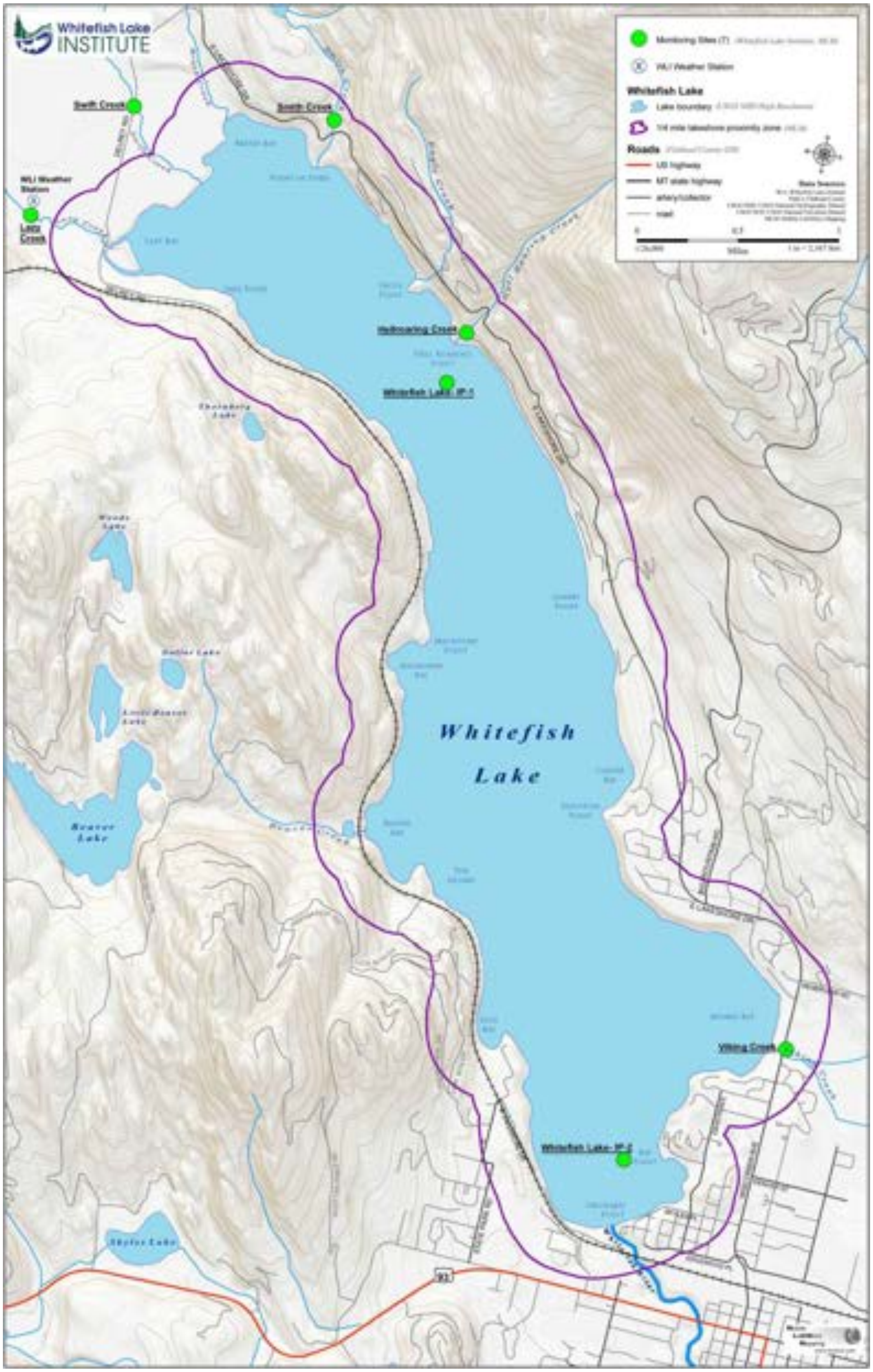
Also in 2005, sewer outflows overwhelmed the pumps at the Viking Liftstation during spring snowmelt and rain events on 2 or 3 occasions. Large amounts of stormwater runoff and groundwater entered the collection system upstream from the lift station. Entry points included leaking pipes and manholes in the Crestwood subdivision area, one poorly installed manhole at the Iron Horse subdivision, and roof drains from one of the newer lodges on Big Mountain that were improperly connected to the sanitary sewer. The City of Whitefish was fined by the Department of Environmental Quality. Inflow problems have since been corrected and the pumping system and forcemain were upgraded to accommodate seasonal peak flows and future growth (City of Whitefish, 2012b).

In 2006, the City of Whitefish completed the groundwork for planning for the future of the City’s stormwater system. The resulting report (Anderson Montgomery, 2006) included; an evaluation of growth trends and projected land use, identification of deficiencies in the existing system, definition of regulatory impacts, description of improvements to protect water resources, evaluation of lands of critical concern with regard to stormwater infrastructure, evaluation of stormwater management and design standards, development of a capital improvements plan, development of operations and maintenance requirements, and provision of a financial plan to ensure the City’s stormwater management goals.

The report concentrated on stormwater challenges in areas of increased development pressure, including State Park Road Area, Monegan-Voerman Area, Karrow Avenue Area, Armory Area, and Northeast Whitefish Area. Recommended improvements were prioritized by a set of criteria, including: protection of public health and environmental quality, regulatory compliance, system reliability and redundancy, operator safety, operational flexibility, and coordination and compatibility with other capital programs.

Also in 2006, the City of Whitefish enacted Urgency Ordinance 06-08 which prohibited certain types of development that did not comply with critical stormwater conveyance restrictions, critical area protection provisions, and groundwater monitoring requirements. The ordinance was superseded by the Critical Areas Ordinance which has been rewritten, renamed, and formally adopted by the Council on February 6, 2011 as Ordinance No. 12-04 Water Quality Protection Ordinance.

Figure 6. WLI Monitoring Sites on Whitefish Lake & Tributaries



In 2008, the Flathead County Health Department conducted a study on wastewater systems in the county (Cassidy *et al*, 2008). The resulting report discussed the risks and benefits that current sewage treatment and disposal systems pose to water resources in the county. The report also addressed the challenges resulting from population growth and the anticipated stricter controls on water quality that could arise from the Flathead Lake Total Maximum Daily Load (TMDL) plan. The report reviewed the county's three municipal wastewater treatment plants in Kalispell, Whitefish, and Columbia Falls, and the three Wastewater Treatment District facilities, two of which treat their own wastewater (Bigfork and the combined Lakeside/Somers County Water & Sewer). Evergreen County Water & Sewer District is contracted with the City of Kalispell for treatment (Cassidy *et al*, 2008).

The county's septic system permit database was updated in 2011 to capture previously unavailable information, and the county Geographic Information System (GIS) Septic System Permit Map was updated with this information. Although there remain numerous unknowns about septic system age and placement around Whitefish Lake, this updated information is the most current data available from Flathead County on relative density and age of septic systems around the lake. For this study, our GIS analyst researched and analyzed all other septic system databases and combined them to provide the most comprehensive view of septic system density around Whitefish Lake.

Since the earliest on-site wastewater regulations in Flathead County in 1969, regulations for septic systems have been continuously revised based on new science and technology. Each revision has represented improvements in construction standards and technologies with an emphasis on treatment, and has resulted in a tightening of regulations. Until 2005, most systems consisted of a tank and gravity flow drainfield. Currently, all systems use uniform pressure distribution in the drainfields requiring the use of a pump or siphon to pressurize the system. Since 2002, in compliance with the state Water Quality Act, an analysis on the impacts of water from nitrates and phosphorus is done prior to the issuance of any septic permit (Cassidy *et al*, 2008).

Flathead County Sewage Treatment Regulations define Level 2 treatment as "a subsurface wastewater treatment system that, a) removes at least 60% of total nitrogen as measured from the raw sewage load to the system; or b) discharges a total nitrogen effluent concentration of 24 mg/l or less" (Cassidy *et al*, 2008). Level 2 treatment systems are becoming more common particularly in areas with limited space for drainfields. In addition to a higher standard of water treatment than a conventional system, the drainfield area for a Level 2 system can be reduced by 50%. This is directly applicable in certain areas around Whitefish Lake.

This Investigation of Septic Leachate to the Shoreline Area of Whitefish Lake, Montana looks at one of the more serious, yet most actionable threats to the lake, the inflow of septic leachate from faulty or failing septic or sewer systems. *In situ* field fluorometry and the fluorometric/dissolved organic carbon ratio, combined with *E. coli* enumeration, DNA biomarking, conductivity, TDS, and GIS analysis provided a multi-tiered process to identify contamination from septic leachates and a framework for a shoreline risk assessment.

2.0 METHODOLOGY

2.1 Sampling Frequency, Locations and Techniques

Synoptic sampling occurred on 9 sample dates starting in May 2011 and concluding in October 2011. Samples were collected as early in spring as possible when near shore areas of the lake were most influenced by seeps and seepage. A combination of a late spring ice off and equipment failures prevented sampling in April. On 7 of the 9 sample dates, standardized sampling occurred at 20 predetermined sites, (Figure 7) 10 of which were based on high septic densities or highly developed areas and/or high fluorometry and conductivity values previously reported by Jourdonnais *et al* (1986). Nine sites were randomly selected to cover developed areas of the shoreline, and one was the reference site at midlake in the *pelagic* zone. The remaining 2 sample dates included 10 of the 20 predetermined sites plus 10 additional random sites (Figure 8).

Viking Creek, City Beach Seep and the Dog Bay Seep were sampled due to high septic densities or highly developed areas that are part of the sewer system, and high values reported in the Jourdonnais *et al* study (1986). Swift Creek and Hellroaring Creek were not sampled since there are very few septic systems and no sewer systems in their drainage basins. Lazy Creek also does not have a sewer system, but the dredged Lazy Creek Bay residential area which has many septic systems was sampled.

Septic leachates are known to contain elevated concentrations of both organic and inorganic compounds (Canter and Knox, 1985). Study area water samples were therefore analyzed using a combination of techniques, including; fluorometry, dissolved organic carbon (DOC), fluorometry/DOC ratio (F/DOC), *E. coli* enumeration, human DNA biomarkers, conductivity, and total dissolved solids (TDS). The location and density of the wastewater systems also influences the functionality of those systems. GIS methodologies and tools were consequently employed to analyze those data sets in the study area. See Section 2.2 for additional information on techniques and analytes.

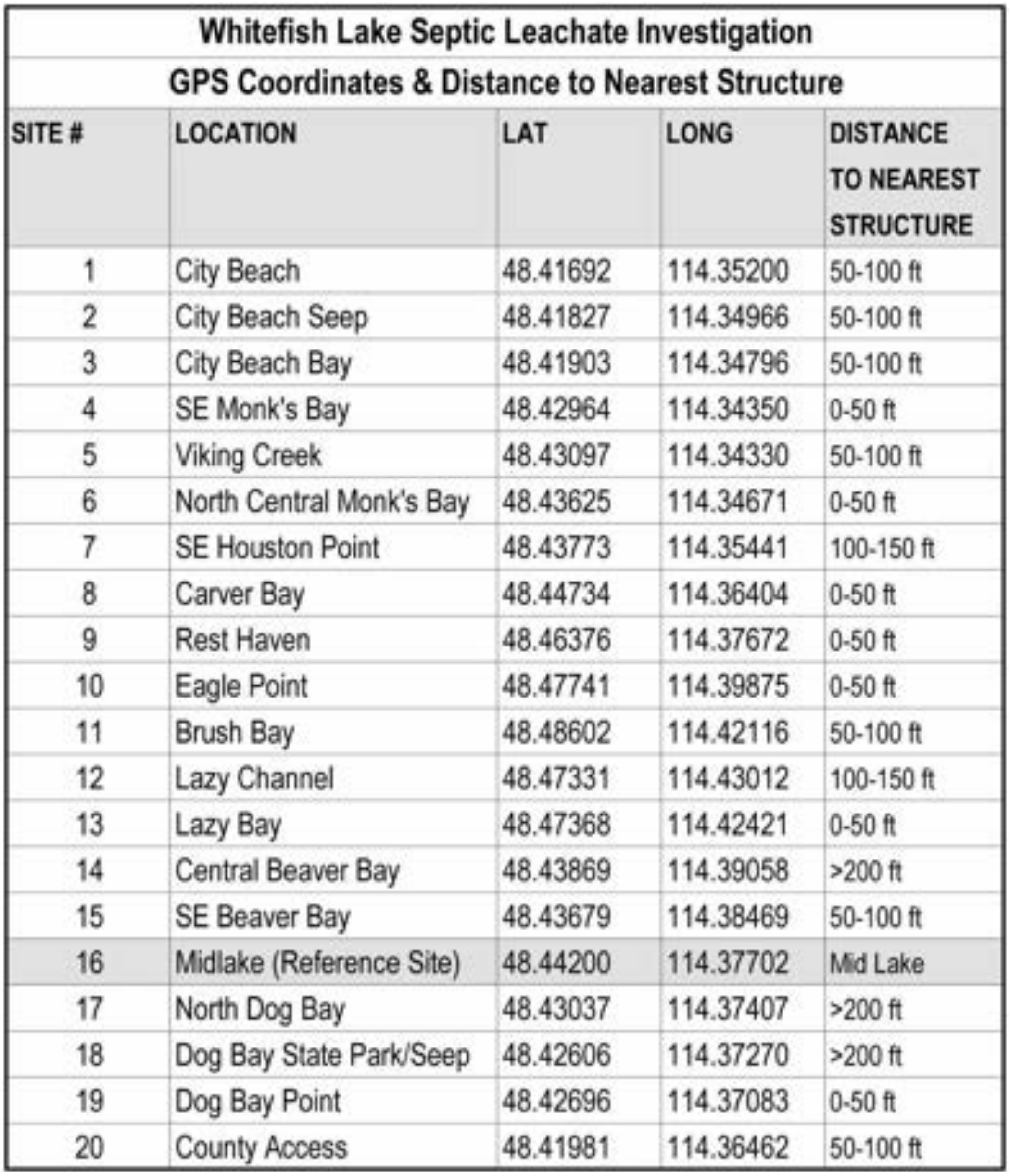
Photo 2. Hydrolab® DS5 Sonde

All study location latitudes and longitudes were documented via GPS and the distance from each sample site to the nearest structure was estimated and recorded (Table 1). Standard water body parameters such as sample times, water depth, temperature (°F), conductivity (aeS/CM), resistivity (ke-cm), salinity (ppt), total dissolved solids (TDS), pH, oxygen reduction potential (ORP), luminescent dissolved oxygen (LDO) (% sat), and LDO (mg/l) were all taken using a Hydrolab® DS5 Sonde and recorded on WLI project field data forms (Addendum 7.1).

Figure 7. Whitefish Lake Septic Leachate Investigation Sample Sites

Figure 8. Septic Leachate Investigation: Random Sites

Table 1. GPS Coordinates & Distances to Nearest Structure



Whitefish Lake Septic Leachate Investigation

GPS Coordinates & Distance to Nearest Structure

SITE #	LOCATION	LAT	LONG	DISTANCE TO NEAREST STRUCTURE
1	City Beach	48.41692	114.35200	50-100 ft
2	City Beach Seep	48.41827	114.34966	50-100 ft
3	City Beach Bay	48.41903	114.34796	50-100 ft
4	SE Monk's Bay	48.42964	114.34350	0-50 ft
5	Viking Creek	48.43097	114.34330	50-100 ft
6	North Central Monk's Bay	48.43625	114.34671	0-50 ft
7	SE Houston Point	48.43773	114.35441	100-150 ft
8	Carver Bay	48.44734	114.36404	0-50 ft
9	Rest Haven	48.46376	114.37672	0-50 ft
10	Eagle Point	48.47741	114.39875	0-50 ft
11	Brush Bay	48.48602	114.42116	50-100 ft
12	Lazy Channel	48.47331	114.43012	100-150 ft
13	Lazy Bay	48.47368	114.42421	0-50 ft
14	Central Beaver Bay	48.43869	114.39058	>200 ft
15	SE Beaver Bay	48.43679	114.38469	50-100 ft
16	Midlake (Reference Site)	48.44200	114.37702	Mid Lake
17	North Dog Bay	48.43037	114.37407	>200 ft
18	Dog Bay State Park/Seep	48.42606	114.37270	>200 ft
19	Dog Bay Point	48.42696	114.37083	0-50 ft
20	County Access	48.41981	114.36462	50-100 ft

For streams and seeps, “grab” samples were obtained when flow permitted. When grab samples were taken, a 500 ml graduated cylinder was rinsed with 10% HCL solution and then rinsed three times with sample site water prior to sampling. If the seep discharge was too low, sampling occurred at the immediate confluence of the seep and the lake. Littoral areas of the lake were sampled using an opaque horizontal Van Dorn style self closing sampler which was rinsed with 10% HCL solution prior to each sampling trip and rinsed once with sample site water at each sample site. All sample bottles with the exception of sealed laboratory supplied bottles with preservative were rinsed three times with sample site water prior to filling.

Since groundwater has been shown in numerous studies to transport septic leachate through lake-bottom sediments into overlying waters (Kerfoot and Brainard 1978; Belanger *et al*. 1985; Jourdonnais *et al*. 1986) samples were collected at a maximum of one foot above the lake sediments.

Fluorometric values were analyzed at each site with a *Aqua*fluor™ portable Fluorometer. 3.5 ml cuvettes were filled using a bulb syringe dipped into a single water sample. Disposable cuvettes and syringes were used one time at each sample site. Conductivity was measured *in-situ* with a Hydrolab® DS5 Sonde. DOC samples were filtered using a .45µ filter into 40 ml bottles, iced after collection, and delivered same day to Montana Environmental (ME) Labs of Kalispell for analysis. *E. coli* water samples were collected in 100 ml vials with sodium thiosulphate preservative, iced after collection, and also delivered same day to ME Labs of Kalispell. A subset of water sample duplicates were collected at two sites during all nine sample dates and provided to ME Labs for quality assurance and quality control (QA/QC) purposes.

Water samples for human *Enterococcus and Bacteroidetes* DNA biomarker sampling were collected in 300 ml amber bottles that were rinsed three times in sample site water, and iced overnight until *E. coli* samples were processed. Human *Enterococcus and Bacteroidetes* DNA biomarker presence/absence testing was triggered either when an *E. coli* test result from a sample site exceeded 10 mpn/100ml and/or a high fluorometric value was displayed. Site samples that met these parameters were also sent the next morning via overnight morning delivery service for analysis by Source Molecular Corporation in Miami, Florida. All laboratory reports are included in Addendum 7.2.

Geographical Information Science (GIS) methodologies and tools were used to analyze and present relevant cartographic and statistical data about the study area. Presented herein are maps that include data sets from several sources in order to communicate the most complete information regarding septic system density and sewer infrastructure around the lake as well as maps provided by the Natural Resources Conservation Service (NRCS) soil survey including the geologic structure, land types, soil types, taxonomic particles, soil drainage class, and percent of slope. Also included is the Soils SSURGO – STAF DC Septic Tank Absorption Fields Suitability layer. This map takes into account all constituents of land structure and soil that affect suitability for septic tank leach fields and ranks the area according to well-documented and commonly used aggregated variables.

2.2 Purpose of Analytes

The purpose of the study was to substantiate the presence or absence of septic leachate and quantify the data when available. As a result, a toolbox method—utilizing more than one scientific investigation tool—was implemented to meet the request. After numerous candidate analytes were reviewed for their applicability and fiscal sensibility to the project, the methodologies listed in Table 2 were selected.

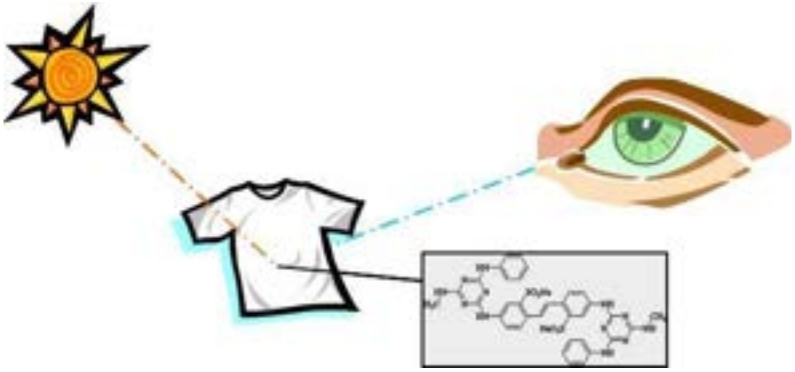
Table 2. Analytes & Tools: Rationale for Study Inclusion

Analyte/ Technique	Background Information / Rationale
Chemical Whiteners: Compounds normally associated with humans: Fluorometry Fluorometric/DOC ratio	Used on Flathead Lake (Jourdonnais & Stanford, 1985) and Whitefish Lake (Jourdonnais *et al*., 1986). F/DOC ratio established as benchmark for anthropogenic effluent. Data can be used for trend analysis.
Fecal contamination: *E. coli*	Excellent secondary indicator that has been used in the past in many studies. Testing, however, does not differentiate between human and other animal fecal coliform.
Human fecal contamination: DNA analysis of Human *Enterococcus faecium*	*Enterococci* are a subgroup of Fecal *Streptococci*. Detection of the *Enterococcus faecium* human gene biomarker by PCR DNA analytical technology. Excellent tool to determine human sources. To be used in conjunction with Human *Bacteroidetes* testing.
Human fecal contamination: DNA analysis of Human Bacteroidetes	Fecal *Bacteroidetes* are anaerobes and indicative of recent fecal contamination. *Bacteroidetes* do not proliferate in soil like *Enterococci.* Excellent tool to determine human sources. To be used in conjunction with *Enterococci* testing.
General septic contamination: Conductivity measurement	Elevated conductivity is an indicator of potential septic or sewage effluent because of its presence of inorganic dissolved solids such as chloride and phosphate. It is used as a secondary tool in conjunction with Fluorometry & F/DOC.
General septic contamination: TDS measurement	Elevated TDS is an indicator of the presence of potential septic leachate and other chemical contaminants. It is used as a secondary tool in conjunction with Fluorometry & F/DOC.
Septic system density & Soil suitability GIS analysis	Abundant septic system density can contribute to overloading of wastewater to leachfields and groundwater. Soil and land suitability variables contribute to the functionality or failure of septic systems. GIS analysis identifies potential stresses to wastewater systems and their performance.

Fluorometry (Relative Fluorescent Values)

In situ fluorometry was conducted using an *Aqua*flor handheld fluorometer (Turner Designs, Sunnyvale, California) set by the manufacturer to detect the specific light spectrum emitted from long wavelength Optical Brightener Agents (OBAs) found in domestic cleaning products.

Figure 9. Optical brighteners emit blue light to compensate for yellowing (Hartel, 2011)



These compounds are activated by near-ultraviolet (UV) range (360 to 365 nm) wavelengths and then emit light in the blue range (400 to 445 nm) (Hagedorn *et al*, 2005, Hartel *et al*, 2007). In fluorescent molecules, electrons are excited into a higher energy state by light adsorption, and then emit a small amount of heat and fluorescence as they return to their ground state (Figure 9). Studies have shown that wastewater effluent contains near-UV fluorescent organics from OBAs (Kerfoot and Brainard, 1978, Kerfoot & Skinner, 1981, Hagedorn et al, 2005, Hartel et al, 2007).

Fluorometric calibration was conducted using a solution of 1% household detergent containing a known whitener compound (Tide, Procter and Gamble, Cincinnati, Ohio), and a DI water base. Fluorometer results are reported in Relative Fluorescent Values (RFVs).

While fluorometric readings alone may indicate the presence of OBAs, they can also indicate the presence of naturally occurring dissolved organic carbon (DOC) from humic and fulvic compounds. The major organic components of soil (humus) are made up of substances produced by the biodegradation of organic matter. These humic compounds educe fluorescence, but generally at much lower RFVs than OBAs. The lower fluorescent value is a result of the concentration of materials being lower in humic compounds than in OBAs (Thurman and Malcolm, 1981; Stanford *et al*, 1985).

The *Aqua*flor Handheld Fluorometer (Photo 3) is pre-set with a filter to detect UV445 (+/- 7.5) giving an optimal reading range of 437.5 to 452.50. By restricting the emission filter to this wavelength range, the resolution to detect optical brighteners from background fluorescence is optimized (Hartel *et al, 2007*). Human fecal contamination studies conducted in 2007 showed that adding a 436 nm filter to a non-filtered fluorometer, resulted in reducing background fluorescence from natural organic compounds by >50% (Hartel *et al*, 2007).

Photo 3: *Aqua*flor Handheld Fluorometer

Photo courtesy Turner Industries, Inc.

Dissolved Organic Carbon (DOC)

DOC describes dissolved material found in water from organic matter such as decomposed plant matter. DOC is known to emit a similar, though generally far lower magnitude light spectrum as whitener compounds detected by fluorometry, and therefore was collected and measured separately to describe dissolved material. In the Jourdonnais and Stanford (1985) septic leachate study on Flathead Lake, it was determined that DOC generally emits a fluorometric signal approximately two magnitudes lower than OBAs. However, DOC in streams, seeps, and areas with heavy influences of organic matter can fluoresce in the higher output ranges. DOC results were therefore also used as a component in developing a ratio of fluorometric-to-dissolved organic carbon. DOC is measured in mg/l.

Fluorometric to Dissolved Organic Carbon Ratio (F/DOC)

This technique involves using a similar fluorometric-to-dissolved organic carbon ratio as developed by Jourdonnais & Stanford (1985). The F/DOC ratio was developed in an effort to distinguish Optical Brightener-emitted fluorescent compounds from fluorescent compounds naturally present in uncontaminated water measured as DOC. Using this F/DOC ratio method, the background fluorescence from DOC can be reduced from the final F/DOC values. In the 1985 septic leachate study on Flathead Lake, researchers reported that high fluorometric readings due to the presence of whiteners elicited little effect on DOC values, further supporting the usefulness of the F/DOC ratio (Jourdonnais & Stanford,1985). F/DOC is therefore a more robust measurement than fluorometry alone, particularly in streams and seeps where DOC is typically elevated.

The 1985 study noted that a F/DOC ratio in excess of 380 indicated septic leachate. The equipment used in that study is now obsolete and the 380 ratio could not be reliably duplicated on the newer equipment. Further, RFVs differ greatly depending on fluorometric data gathering equipment and on numerical values set at the time of calibration. Based on the values of the newer fluorometer used in this study and its calibration to a neutral sample and various concentrations of OBA samples, an F/DOC ratio in excess of 22.7 was determined to indicate septic leachate.

Conductivity

Conductivity is a measure of the ability of water to pass an electrical current, and it is affected by the presence of inorganic dissolved solids. Conductivity in seeps, streams, and rivers is influenced primarily by the bedrock geology and mineral composition of the sediments through which the water flows. Water that flows through more inert materials that do not dissolve into ionic components will have a lower conductivity. Water that flows through soils with compounds that are ionized, have a higher conductivity. Septic or sewage effluent would raise the conductivity of the water because of the presence of chloride, phosphate, and nitrate it contributes to the water. Conductivity is used in this study as a secondary tool in support of fluorometry, DOC, and F/DOC. Conductivity is measured in micromhos per centimeter (µmhos/cm or aeS/CM) and reported as (*ms*) in Hydrolab files.

Escherichia coli (E. coli) Enumeration

E. coli are bacteria found in human and animal feces. Because *E. coli* are generally not found growing and reproducing in the environment, they are considered to be the best species of coliform bacteria to indicate warm-blooded fecal pollution and the possible presence of pathogenic (disease-causing) bacteria and viruses. The U. S. Environmental

Protection Agency recommends *E. coli* as the best indicator of health risk from sewage contamination in recreational waters (1986). Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis, and hepatitis A. *E. coli* is measured using a table of *most probable numbers* to estimate the coliform content of the sample and reported in mpn/100ml. The laboratory methods used for this test are Standard Methods 9223B Enzyme Substrate Test, using the Multi-Well procedure (Standard Methods, 1998).

DNA analysis of Human *Enterococcus faecium*

Enterococci are a subgroup of Fecal Streptococci and are characterized by their ability to grow in 6.5% sodium chloride, at temperatures as low as 10^{o}C (50^{o}F) and elevated temperatures as high as 45^{o}C (113^{o}F), as well as elevated pH (9.5). These microorganisms have been used as indicators of fecal pollution for many years and have been especially valuable in aquatic environments and recreational waters as indicators of potential health risks such as swimming-related gastroenteritis.

Enterococci are benign bacteria when they reside in their normal habitat such as the gastrointestinal tracts of human or animals. Outside of their normal habitat, Enterococci are pathogenic causing urinary tract and wound infections, and life-threatening diseases such as bacteraemia, endocarditis, and meningitis. Enterococci easily colonize open wounds and skin ulcers.

> **Human Enterococcus Explanation** (Source Molecular, 2011)
> Compounding their pathogenesis, Enterococci are also some of the most antibiotic resistant bacteria, particularly from human sources. Studies have shown that certain strains of Enterococci are resistant to expensive and potent antibiotics such as vancomycin. This is particularly worrisome for the medical community since these antibiotics are given as a last resort to fight severe bacterial infections. Several intrinsic features of the *Enterococcus* genus allow it to survive for extended periods of time, leading to its extended survivability and diffusion. For example, *Enterococci* have been shown to survive for 30 minutes at 60°C (140°F) and persist in the presence of detergents. As such, the inherent ruggedness of *Enterococcus* confers it a strong tolerance to many classes of antibiotics.
>
> The Human Enterococcus IDTM service is designed around the principle that certain strains of the *Enterococcus* genus are specific to humans. These *Enterococci* can be used as indicators of human fecal contamination. Strains of *Enterococcus faecium*, *Enterococcus faecalis* and yellow-pigmented *Enterococci* have been shown to be from human sources. Within these *Enterococcus spp.* are genes associated with *Enterococci* that are specific to humans. The Human Enterococcus IDTM service targets the human gene biomarker in *Enterococcus faecium*. One of the advantages of the Human Enterococcus IDTM service is that the entire cultured population of *Enterococci* of the selected portion of the water sample is screened. This method avoids the randomness effect of selecting isolates. This is a particular advantage for highly contaminated water systems with multiple sources of fecal contamination.

DNA analysis of Human *Bacteroidetes*

Fecal Bacteroidetes are considered for several reasons to be an interesting alternative to more traditional indicator organisms such as *E. coli* and *Enterococci*. Since they are strict anaerobes, they are indicative of *recent* fecal contamination when found in water systems. This is a particularly strong reference point when trying to determine recent outbreaks in fecal pollution. They are also more abundant in feces of warm-blooded animals than *E. coli* and *Enterococci*. Furthermore, these latter two organisms are facultative anaerobes and as such they can be problematic for monitoring purposes since it has been shown that they are able to proliferate in soil, sand and sediments.

Human Bacteroidetes Explanation (Source Molecular, 2011)
The phylum *Bacteroidetes* is composed of three large groups of bacteria with the best-known category being *Bacteroidaceae*. This family of gram-negative bacteria is found primarily in the intestinal tracts and mucous membranes of warm-blooded animals and is sometimes considered pathogenic. Comprising *Bacteroidaceae* are the genus *Bacteroides* and *Prevotella*. The latter genus was originally classified within the former (i.e. *Bacteroides*), but since the 1990’s it has been classified in a separate genus. *Bacteroides* and *Prevotella* are gram-negative, anaerobic, rod-shaped bacteria that inhabitant of the oral, respiratory, intestinal, and urogenital cavities of humans, animals, and insects. They are sometimes pathogenic.

The Human Bacteroidetes IDTM service is designed around the principle that fecal *Bacteroidetes* are found in large quantities in feces of warm-blooded animals. Furthermore, certain categories of *Bacteroidetes* have been shown to be predominately found in humans. Within these *Bacteroidetes*, certain strains of the *Bacteroides* and *Prevotella* genus have been found to be specific to humans. As such, these bacterial strains can be used as indicators of human fecal contamination.

An advantage of the Human Bacteroidetes IDTM service is that the entire portion of water sampled is filtered for *Bacteroidetes*. As such, this method avoids the randomness effect of culturing and selecting bacterial isolates. This is an advantage for highly contaminated water systems with potential multiple sources of fecal contamination. Each submitted water sample was filtered through 0.45 micron membrane filters. Each filter was placed in a separate, sterile 5ml disposable tube containing a unique mix of beads and lysis buffer. It was then bead beated for 5min. DNA extraction was prepared using the MoBio Power Water DNA Isolation kit (MoBio, Carlsbad, CA), as per manufacturer's protocol. Amplifications were run on an Applied Biosystems StepOne real-time thermal cycler (Applied Biosystems, Foster City, CA) in a final reaction volume of 20ul containing the sample extract, forward primer, reverse primer, probe and an optimized buffer. The following thermal cycling parameters were used: 50°C for 2 min, 95°C for 10 min and 40 cycles of 95°C for 15 s and 60°C for 1 min. All assays were run in duplicate.

Total Dissolved Solids (TDS)

TDS measures the combined dissolved content of all organic and inorganic substances in freshwater systems. While it was not a first-order sampling parameter and is not considered a primary pollutant, it is an indicator of the presence of chemical contaminants including septic leachate. TDS was used in this study as a secondary indicator to support fluorometric value and was measured in grams/liter.

GIS

Presented herein are maps including data sets from several databases in order to communicate the most complete information regarding septic system density and sewer infrastructure around the lake. Additionally, the geologic structure, land types, soil types, taxonomic particles, soil drainage class, and percent of slope are provided by the Natural Resources Conservation Service (NRCS) soil survey. Also included is the NRCS Soils SSURGO – STAF DC Septic Tank Absorption Fields Suitability layer. This map takes into account all constituents of land structure and soil that affect suitability for septic tank leach fields and ranks the area according to well-documented and commonly used aggregated variables.

The final GIS products in this report were developed using a multi-phased process. Using the property boundaries (parcels) and land ownership information from the Montana Cadastral Mapping Project (http://svc.mt.gov/msl/mtcadastral/), our GIS analyst queried the Computer Assisted Mass Appraisal (CAMA) database to develop two characteristics for each property in the study area. The first was to determine if the property's utility codes included a septic description and the second was to identify the development status of the property. The WLI Study Location map (Figure 7) shows the combinations of these derived values.

The first step was to determine for each property if any of the utility code fields contained a value indicating septic systems. There are three fields in the CAMA data that store information about the property's utilities. If any of the three fields returned true, then the property was coded with the value of 1 (new SepCode field) to indicate that the property was listed in the database as having a septic system.

The second step was to determine the development status for each property. Using the Property Type field in the CAMA data, the GIS analyst created a lookup table that defined the development status for each property type. This analysis is similar to an approach taken by Flathead County GIS to represent the Development Status of properties. The resulting table identifies the development code (0=undeveloped or unknown, 1=developed) for each property type.

The map symbology renders the property boundaries (parcels) based on the combination of the SepCode and DevCode values. Such that a parcel denoted as *Septic, Developed* is one that has a value of 1 for both the SepCode and DevCode fields. *Septic, Undeveloped* indicates SepCode=1 and DevCode=0. The challenge with depicting a parcel with a color indicating its status is that in some cases the parcel is large in area, others like many of the lakeshore lots, are small. The size of the parcel is therefore in no way indicative of the extent of the status. The reason for determining these combinations is that properties that have been classified as developed and using a septic system are of interest to this study. In particular those properties that meet these conditions and which are located either adjacent to or within the lakeshore proximity zone present a potentially measurable risk of septic system effluent leaching into groundwater. The Septic Leachate Contamination and Risk Assessment layer (Figure 23) is coded to reflect these risk values. The shape of the risk border is defined by a .40 km (¼ mile) lakeshore proximity zone to clearly identify properties most likely to influence the Whitefish Lake shoreline.

The *Address on File* layer shown in the various maps is derived from the *Parcel* layer using the codes described above. The Flathead County GIS address file stores a point location for each address that is registered on file at the County. These points fall within the property boundary and in many cases are positioned within the property boundary such that the point represents the location of the dwelling or major structure. In various cases, an address is created on file yet there is no developed structure at the site. The goal was to limit the addresses to those that fell within the properties where SepCode = 1 and DevCode =1. This subset of points is used to represent the *Address on File* layer.

The Address layer provides a visual indication of development density. The points do not differentiate the size or type of structure, such that an old lakeshore cottage and a new, large house are both represented as the same size and color point, or dot. The idea is to convey the distribution and density of structures (typically residential dwellings) in the lakeshore area.

The Septic Permit data is provided by the Flathead County Department of Health and FlatCo GIS. Each point represents a record of a septic permit on file with the County. There is limited information in this data and therefore each point is represented equally in terms of its color, shape, and size. There is no differentiation based on the size of the drainage field, the capacity of the system, the age of the system, or the number of rooms/people that the permit is intended to serve. In some cases individual septic system information is omitted, in other cases it is either inaccurate, not current, or both. By comparing the septic permit data to the number of addresses that are listed as being supported by septic systems, the map reader can clearly see discrepancies between the *Address on File* layer and the utility code in some areas. What the reader cannot see is the variation in the age, size, capacities, and conditions of those permitted systems.

Summary of Analytes

The data on all of these parameters were considered independently and in concert for the purposes of this investigation. Various combinations of analytical techniques in this study have been used in a number of other studies, particularly in estuarine environments (Cioffi & Goblick, 1999; Hagedorn *et al*, 2005; Hagedorn *et al*, 2003; Hartel *et al*, 2008; Hartel *et al*, 2007; Mallin *et al*, 2006; Spivey *et al*, n.d.; Tavares, *et al*, 2008). Most of the research has been done at universities via microbial source tracking studies and marine ecology exploration. While none of the individual analytes used herein offer an exact science, they each offer verifiable evidence regarding contamination from human wastewater. Taken together, they provide a significant confirmation of both the presence and absence of septic leachate in the study area.

Table 3. Summary Description of Sampling and Reporting Methods/Techniques.

Technique	Sample Collection Instrumentation	Laboratory Method	Reporting
Fluorometry	Turner Designs handheld fluorometer	Field measurement	Fluorometric units (RFVs)
DOC	Van Dorn sampler	EPA 415.2/SM 5310 C	mg/l
F/DOC Ratio	Turner Designs handheld fluorometer & Van Dorn sampler	Field measurement & EPA 415.2/SM 5310 C	Fluorometric units (RFVs) & mg/l
Conductivity	Hydrolab DS5 multiprobe	Field measurement	µmhos/cm
E. coli	Van Dorn sampler	mpn/100ml	mpn/100ml
DNA analysis of Human *Enterococcus*	Van Dorn sampler	PCR DNA analytical technology	Presence/ Absence of DNA biomarker.
DNA analysis of Human *Bacteroidetes*	Van Dorn sampler	PCR DNA analytical technology	Presence/ Absence of DNA biomarker.
Conductivity	Hydrolab DS5 multiprobe	Field measurement	aeS/CM (µmhos/cm)
TDS	Hydrolab DS5 multiprobe	Field measurement	g/l
GIS	Data files	Analysis & cartography	Map layers

2.3 QA/QC

Sampling and Laboratory Protocols

WLI follows the Montana Department of Environmental Quality (MDEQ) Flathead Basin Program Quality Assurance Project Plan (QAPP) protocols (2005). This includes protocols for collecting and handling water samples in the field, packaging samples, maintenance of sample temperatures, and analytical methods. In addition to following general protocols, appropriate documentation was maintained throughout the study, including field forms for recording data, Chain-of-Custody forms for sample transferal, laboratory records of analysis, and quarterly project reports as required by the project sponsor.

Samples were analyzed by ME Laboratories in Kalispell, Montana and Source Molecular Corporation in Miami, Florida. ME Laboratories conducted all processing and analysis of DOC and *E. coli* samples, and Source Molecular Corporation conducted all processing and analysis of microbial source tracking. Both laboratories reviewed the Chain-of-Custody forms for completeness and for clarity of instructions; inspected the coolers to make sure the samples were kept at the proper temperature; and inspected the samples for leakage or breakage, and to confirm that sample labels were consistent with the Chain-of-

Custody forms. The samples were then logged in, and stored in accordance with the laboratory's procedures.

ME Laboratory Control

ME Laboratory follows a QA/QC procedure for all chemical assays so collection of DOC field quality control replicates were important for this parameter. Four replicate samples for each of two sites were collected on each study date and analyzed as part of ME Lab's standard QA/QC policy. Field quality control samples were packaged, labeled and submitted to the analytical laboratory in the same manner as the natural samples to ensure that they were treated and analyzed by the lab in a similar fashion. Results of these quality control measures are included in Addendum 7.3. Biological assays such as *E. coli* do not require batch-level QA/QC; however collections vials are tested for sterility, and performance evaluations are conducted three times annually on the laboratory's biological processing equipment.

Source Molecular Corporation Laboratory Control

Accuracy of the results is possible because the method uses quantitative PCR (qPCR) DNA technology. qPCR allows DNA to be amplified into large number of small copies of DNA sequences. This is accomplished with small pieces of DNA called primers that are complementary and specific to the genomes to be detected. Through a heating process called thermal cycling, the double stranded DNA is denatured and inserted with complementary primers to create exact copies of the DNA fragment desired. This process is repeated many times ensuring an exponential progression in the number of copied DNA. If the primers are successful in finding a site on the DNA fragment that is specific to the genome to be studied, then billions of copies of the DNA fragment will be detected in real-time. The accumulation of DNA product is plotted as an amplification curve. The absence of an amplification curve indicates that the Human gene biomarker is not present. To strengthen the validity of the results, the service should be combined with other DNA analytical services such as the Human Bacteroidetes service.

For quality control purposes, a positive control consisting of appropriate genomic DNA and a negative control consisting of PCR-grade water were run alongside the sample(s) to ensure a properly functioning reaction and to reveal any false negatives or false positives. The accumulation of PCR product is detected and graphed in an amplification plot. If the fecal indicator organism is absent in the sample, this accumulation is not detected and the sample is considered negative. If accumulation of PCR product is detected, the sample is considered positive.

3.0 RESULTS

3.1 Key Parameter Results

Key parameters in this study include fluorometry, dissolved organic carbon (DOC), the ratio of fluorometry to dissolved organic carbon (F/DOC), *E. coli* enumeration, conductivity, total dissolved solids (TDS), and Geographical Information Science (GIS). Figures 10-15 presenting data displayed as box plots include results from all 9 sample dates.

Fluorometric Values

Fluorometric values were recorded *in situ* providing immediate results. The highest single fluorometric reading of the study—recorded in Relative Fluorometric Value (RFV)—was 164.10 and occurred at Site 12: Lazy Channel during the first sample date of the study, May 4th, 2011. The next highest RFV of 128.70 occurred at Site 5: Viking Creek on the same sample date. The next two highest values of 93.42 and 82.87 were recorded at the Dog Bay State Park Seep in August and October respectively. Taking into account all fluorometric values recorded over the duration of the study, the three highest median fluorometric values were recorded at Site 18: Dog Bay State Park Seep, 5: Viking Creek, and 12: Lazy Channel (Figure 10 and Table 4). The highest data values across all sample periods were also recorded at these three sites. The highest RFV at the reference Site 16: Midlake was 22.49, which was used to set the top of the low range of values. The reference site highest value was doubled to 44.98 and used to set the top of the medium range. RFV results of 44.99 and above were therefore considered in the high range.

Figure 10. Fluorometry Results per Site

Box plot shows the full range of results from all 9 sample dates. Whiskers extend to the highest and lowest values recorded, and the median for each data set is represented by the horizontal center black line.

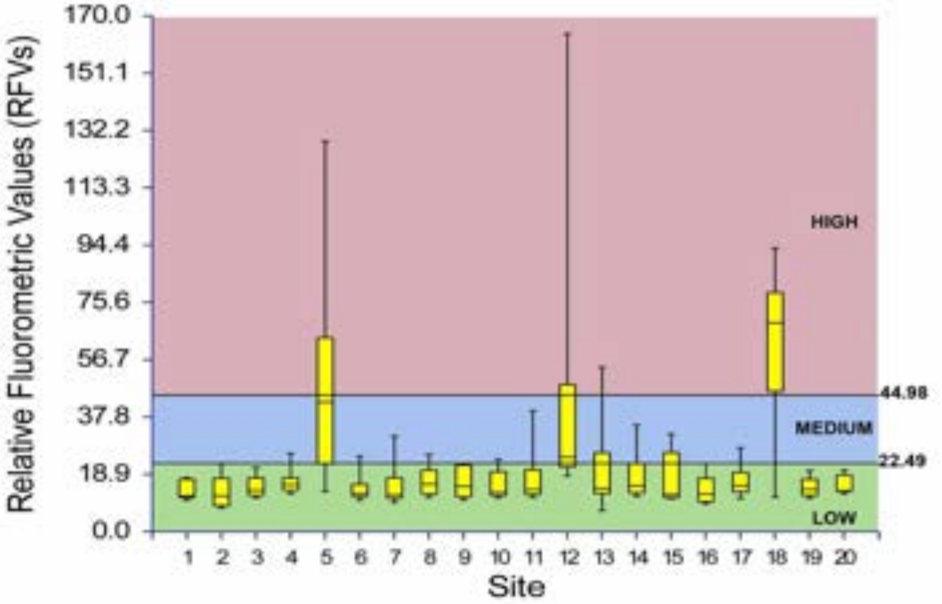


Table 4. Fluorometry Values (RFVs) Based on Low, Medium, and High Ranking

SITE	4-May	6-Jun	6-Jul	10-Aug	17-Aug	30-Aug	13-Sep	27-Sep	26-Oct
1	17.36	17.20	17.71	12.24	11.98	11.79	10.36	10.77	14.99
2	12.23	22.35	21.36	8.40	9.83	13.80	7.80	8.74	12.54
3	19.11	21.08	16.32	12.58	11.31	14.07	11.11	13.91	15.27
4	18.69	25.78	16.45	14.34	15.92	15.75	12.43	13.14	16.63
5	128.70	76.77	16.85	13.23	51.02	27.94	44.75	28.43	43.18
6	11.46	24.89	16.25	13.48	12.49	X	13.56	12.32	10.39
7	18.41	31.49	13.29	11.20	12.29	9.62	11.08	12.48	17.14
8	19.86	20.37	25.41	11.29	12.42	X	15.58	12.68	16.57
9	21.93	22.03	15.73	15.02	11.84	X	10.47	11.45	21.89
10	23.83	20.15	12.89	13.13	13.65	X	11.18	11.57	18.49
11	39.82	21.00	13.23	12.65	15.38	X	11.29	12.26	18.46
12	164.10	60.93	18.86	18.35	28.95	25.00	23.94	24.91	35.94
13	33.63	54.20	14.66	14.01	12.95	12.36	6.89	14.71	18.30
14	35.12	22.84	14.53	16.51	14.10	X	11.64	12.45	21.37
15	32.18	27.01	11.78	11.12	11.85	X	10.89	13.64	22.94
16	16.88	22.49	15.62	11.60	10.24	9.14	9.58	12.78	18.34
17	20.40	27.65	14.47	15.91	15.21	X	10.96	12.79	16.69
18	71.15	39.83	52.77	93.42	74.71	69.27	66.50	11.42	82.87
19	17.56	20.10	14.16	13.59	11.40	X	11.05	14.47	16.31
20	16.67	20.25	13.34	13.88	19.17	X	12.48	14.04	13.43

LOW 0-22.49
MED 22.50-44.98
HIGH 44.99 +
NOT COLLECTED

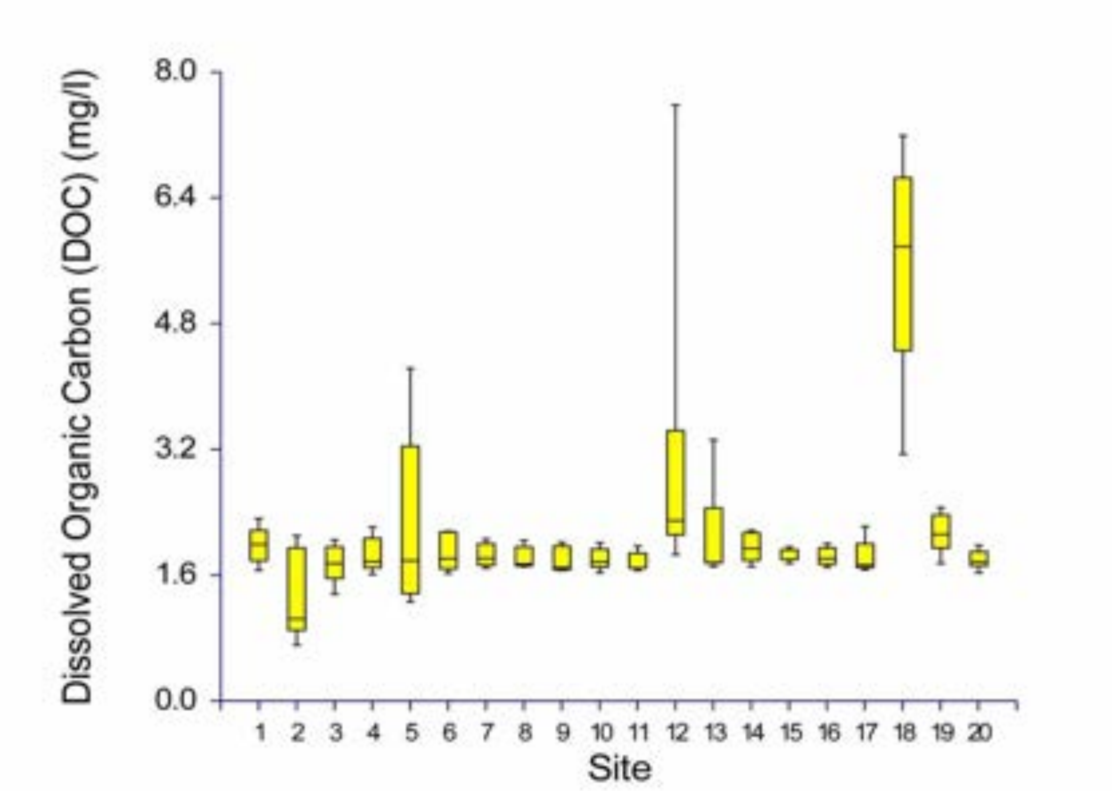
Because fluorescence decreases over time with exposure to sunlight (Jourdonnais and Stanford, 1985), the best determination of septic leachate through fluorometry would occur in an area where leachate inputs are continuous. Given the sporadic nature of home inhabitation around the lake, septic system usage—and therefore wastewater movement and septic leachate inputs—are inconsistent. This inconsistency, along with the effects of photo-oxidation on leachate fluorescence, suggest that the fluorometry study results, and therefore the F/DOC results, may underestimate the presence of septic leachate in Whitefish Lake.

Dissolved Organic Carbon

DOC samples collected at all sites on all sample dates for this study were analyzed and reported by ME Labs in Kalispell. The highest readings were reported consistently at Site 18:Dog Bay State Park Seep. The highest DOC readings recorded were 7.58 at Site 12: Lazy Channel on May 4, 7.19 at Site 18: Dog Bay State Park Seep on August 30, 7.11 at Site 18: Dog Bay State Park on August 10, and 4.23 at Site 5: Viking Creek on May 4. Taking into account all DOC values recorded over the duration of the study, the three highest median DOC values were recorded at Site 18: Dog Bay State Park (5.51), Site 12: Lazy Channel (3.07), and Site 19: Dog Bay Pt. (2.23) (Figure 11). The highest values recorded across all sample periods were recorded at Site 12: Lazy Channel, Site 18: Dog Bay State Park, and Site 5: Viking Creek.

We noted that high fluorometric values were generally accompanied by high DOC values as previously reported on Whitefish Lake by Jourdonnais *et al* (1986). The high DOC values in the current study were obtained in streams and seeps where DOC readings are typically high resulting from the continuous natural augmentation and transport of allochthonous (imported material and nutrients) organic matter prior to dilution in the lake environment.

Figure 11. Dissolved Organic Carbon Results by Site
Box plot shows the full range of results from all 9 sample dates. Whiskers extend to the highest and lowest values recorded, and the median for each data set is represented by the

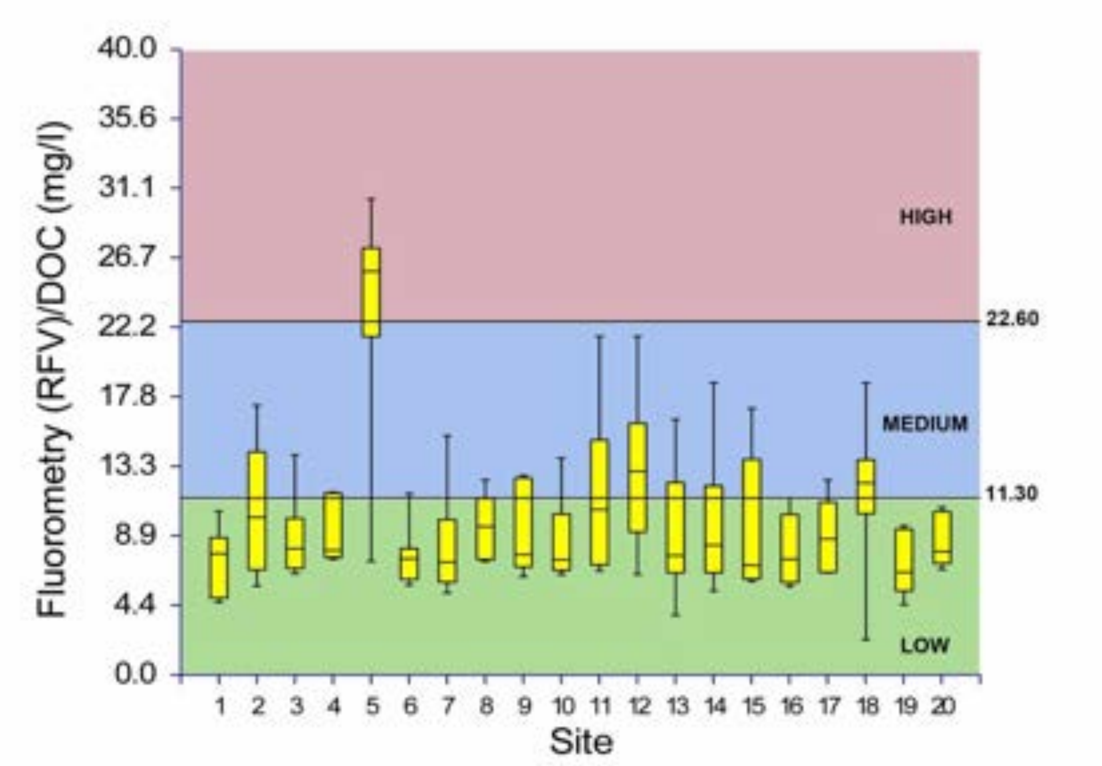


F/DOC

A Fluorometric to Dissolved Organic Carbon ratio (F/DOC) was calculated using in-situ fluorometric values in RFVs along with DOC results provided by ME Laboratories in Kalispell. The five highest overall F/DOC (mg/l) values (30.43, 27.29, 27.16, 25.90, & 22.56)—the first four considered conclusive for OBAs—occurred at Site 5: Viking Creek in spring, summer and fall, which also reported three medium values and only once dropped into the low range. Site 11: Brush Bay and 12: Lazy Channel each had values just below the high range in the spring (21.64 & 21.65 respectively), followed by 14: Central Beaver Bay (18.68), 18: Dog Bay State Park Seep (18.67), 2: City Beach Seep

(17.23), and 15: SE Beaver Bay (17.03) all with medium values, also occurring in the spring timeframe (Figure 12 and Table 5). Taking into account all F/DOC values recorded over the duration of the study, the three highest median F/DOC values were recorded at Site 5 (23.18), Site 12 (13.14), and Site 18 (11.77). The highest values across all sample periods were recorded at Site 5, Site 12, and Site 11.

Figure 12. F/DOC Results by Site
Box plot shows the full range of results from all 9 sample dates. Whiskers extend to the highest and lowest values recorded, and the median for each data set is represented by the horizontal center black line.



The highest F/DOC value of the study at the reference Site (16: Midlake) was 11.30, which was used to set the top of the low range of F/DOC values. As with RFVs, the reference site highest F/DOC value was doubled (22.60) to set the top of the medium range. F/DOC ratios ranging from 0 to 11.30 were considered low, 11.31 to 22.60 medium, 22.61 and above equated to a high/conclusive reading of OBAs in sampled water. F/DOC ratios in this study were generally elevated in seeps and creeks as compared to the reference site. Based on F/DOC values, it is concluded that Site 5: Viking Creek shows conclusive signs of wastewater contamination.

As a comparison, an F/DOC value above the threshold set in the 1985 study was reported at Site 18: Dog Bay State Park Seep (417), and elevated F/DOC values—not far below the threshold—were reported at Site 2: City Beach Seep (340) and Site 5: Viking Creek (286) (Jourdonnais *et al*). Although the fluorometric equipment differed from the earlier study to this study, the results suggest that F/DOC values of this study remain high in areas with previously high readings, and that values at several additional sites have increased.

Table 5. F/DOC Values based on Low, Medium, and High Ranking

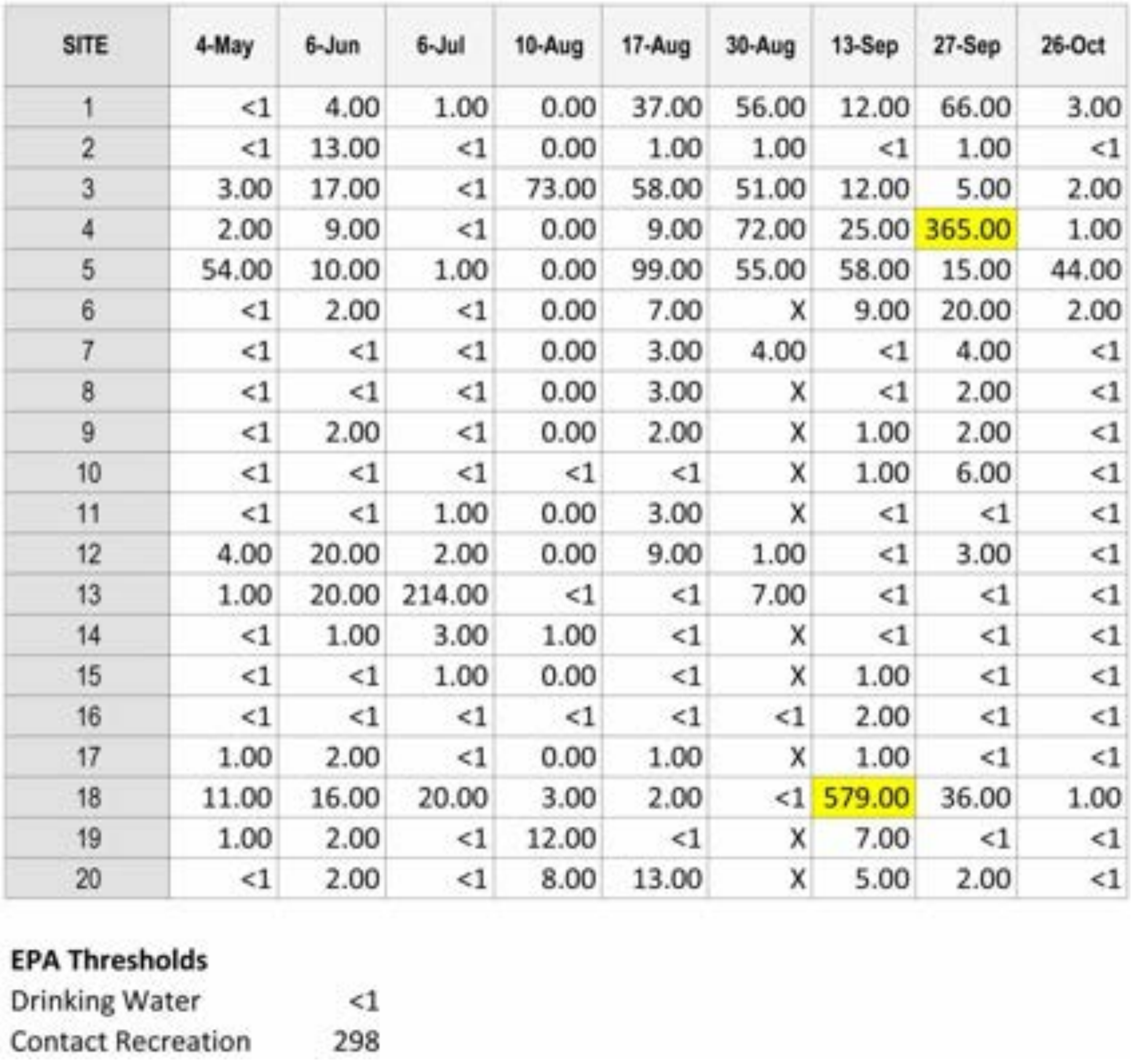
SITE	4-May	6-Jun	6-Jul	10-Aug	17-Aug	30-Aug	13-Sep	27-Sep	26-Oct
1	10.46	7.85	8.77	X	5.99	6.34	4.91	4.64	8.52
2	17.23	11.06	10.17	X	5.68	14.53	6.72	9.01	14.25
3	14.05	10.49	7.96	6.59	6.46	7.95	7.46	8.53	8.39
4	11.61	11.67	8.06	X	7.65	8.56	7.40	7.51	9.56
5	30.43	21.63	7.26	X	25.90	21.66	27.29	22.56	27.16
6	5.73	11.58	7.52	X	6.83	X	8.07	7.60	6.11
7	10.06	15.29	6.58	X	7.23	5.23	5.71	7.38	9.47
8	11.28	10.39	12.46	X	7.26	X	8.85	7.37	9.58
9	12.75	11.18	7.79	X	6.92	X	6.27	6.90	12.58
10	13.85	10.33	6.41	7.02	7.80	X	6.58	7.10	10.10
11	21.64	10.66	7.04	X	9.05	X	6.64	15.01	10.80
12	21.65	16.25	8.77	X	15.56	11.90	10.23	6.42	14.32
13	12.89	16.33	6.37	7.87	7.57	6.98	3.81	7.03	10.52
14	18.68	10.82	7.12	8.78	8.01	X	5.36	6.34	12.50
15	17.03	13.78	6.14	X	6.77	X	5.98	7.10	12.74
16	9.22	11.30	7.81	6.11	5.85	4.99	5.64	7.19	10.60
17	11.03	12.45	7.24	X	8.79	X	6.56	6.53	9.82
18	18.67	12.68	9.92	13.14	12.05	9.63	11.47	2.24	13.95
19	9.29	9.53	6.65	5.59	5.30	X	4.49	6.67	9.32
20	10.23	10.49	6.74	7.71	10.71	X	6.97	8.26	7.59

LOW	0-11.30
MED	11.31-22.60
HIGH	22.61 +
NOT COLLECTED	

E. coli Enumeration

Fecal coliform bacteria water samples were collected at all sites, analyzed and reported by ME Labs in Kalispell, MT. Fecal coliforms, particularly *E. coli*, indicate that there are feces in the water from warm blooded animals. *E. coli* results in this study ranged from <1 mpn to a high of 579 mpn on September 13 (Table 6 & Figure 13). The health and safety threshold established by the Montana Department of Environmental Quality for Montana is 298 mpn/100ml for contact. Because there is no acceptable level of *E. coli* for drinking water, there is concern for any result that is above <1 mpn/100 ml. Fecal coliform counts were high at least once at all sites during the study, even though many of these samples did not test positive for Human DNA biomarkers. Although this number of samples does not rule out human contamination at these specific sites, it does suggest possible contamination by wildlife or domestic pets.

Table 6. *Escherichia coli* Result Compared to Impairment Thresholds



SITE	4-May	6-Jun	6-Jul	10-Aug	17-Aug	30-Aug	13-Sep	27-Sep	26-Oct
1	<1	4.00	1.00	0.00	37.00	56.00	12.00	66.00	3.00
2	<1	13.00	<1	0.00	1.00	1.00	<1	1.00	<1
3	3.00	17.00	<1	73.00	58.00	51.00	12.00	5.00	2.00
4	2.00	9.00	<1	0.00	9.00	72.00	25.00	365.00	1.00
5	54.00	10.00	1.00	0.00	99.00	55.00	58.00	15.00	44.00
6	<1	2.00	<1	0.00	7.00	X	9.00	20.00	2.00
7	<1	<1	<1	0.00	3.00	4.00	<1	4.00	<1
8	<1	<1	<1	0.00	3.00	X	<1	2.00	<1
9	<1	2.00	<1	0.00	2.00	X	1.00	2.00	<1
10	<1	<1	<1	<1	<1	X	1.00	6.00	<1
11	<1	<1	1.00	0.00	3.00	X	<1	<1	<1
12	4.00	20.00	2.00	0.00	9.00	1.00	<1	3.00	<1
13	1.00	20.00	214.00	<1	<1	7.00	<1	<1	<1
14	<1	1.00	3.00	1.00	<1	X	<1	<1	<1
15	<1	<1	1.00	0.00	<1	X	1.00	<1	<1
16	<1	<1	<1	<1	<1	<1	2.00	<1	<1
17	1.00	2.00	<1	0.00	1.00	X	1.00	<1	<1
18	11.00	16.00	20.00	3.00	2.00	<1	579.00	36.00	1.00
19	1.00	2.00	<1	12.00	<1	X	7.00	<1	<1
20	<1	2.00	<1	8.00	13.00	X	5.00	2.00	<1

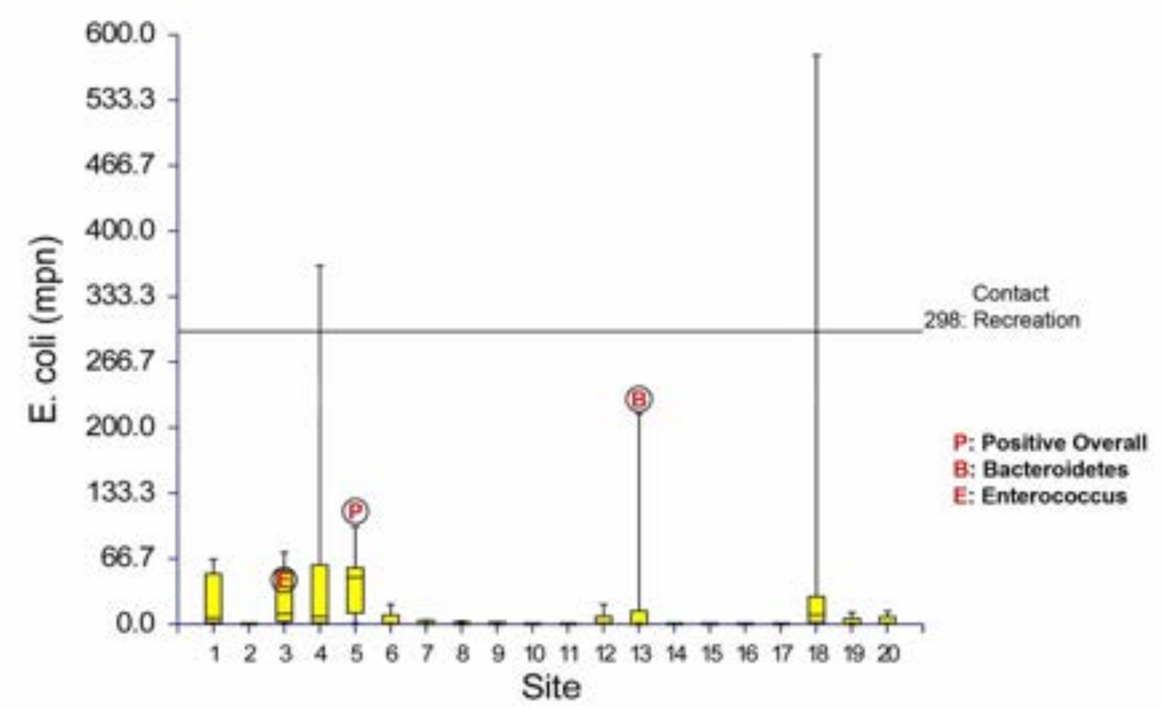
EPA Thresholds	
Drinking Water	<1
Contact Recreation	298

Two exceedingly high *E. coli* counts that did not test positive for human DNA biomarkers were noted at Site 4: SE Monk's Bay (365 mpn/100ml) on September 27 and Site 18: Dog Bay State Park Seep (579 mpn/100ml) on September 13. These levels far exceed the EPA limit for contact recreation (298 mpn/100 ml). A threshold of 10 mpn/100ml was established for this study to potentially trigger DNA testing. Two to five samples each study date with results above this threshold were sent to Source Molecular Laboratory to be analyzed for human DNA biomarkers.

Human DNA Biomarkers

Water samples were analyzed and reported by Source Molecular Laboratories in Florida. Of the samples analyzed throughout the study, there were three affirmative human DNA biomarker results, providing conclusive evidence of contamination resulting from anthropogenic influences (Figure 13). One result was *positive* for both human DNA biomarkers, and two had *traces* of human DNA biomarkers. The *positive* result was found on August 17 at Site 5: Viking Creek. In order for a result to be considered *positive* overall, it must show positive results in both *Enterococcus* and *Bacteroidetes* tests. This *positive* finding suggests a definitive and recent presence of human feces.

Figure 13. ***Escherichia coli*** **Results and Human DNA Biomarker by Site**
Box plot shows the full range of results from all 9 sample dates. Whiskers extend to the highest and lowest values recorded, and the median for each data set is represented by the horizontal center black line.



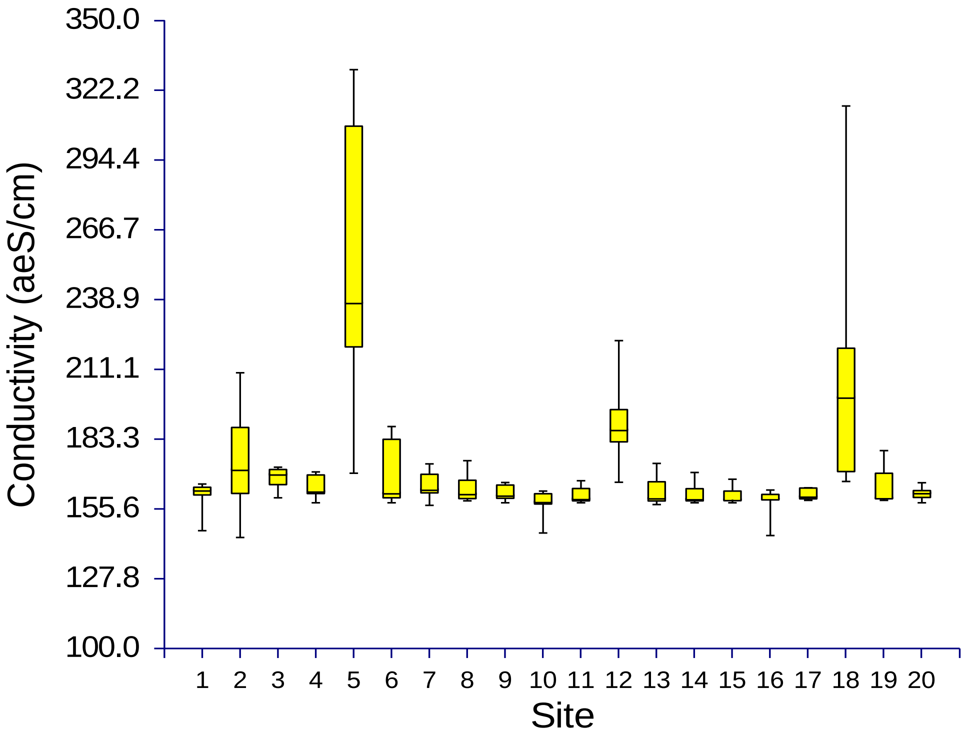
A *trace* result means the biomarker was found in low quantifies, but above the detection limit. One *trace* finding for *Bacteroidete*s was reported on July 6 at Site 13: Lazy Bay. Trace *Bacteroidetes*, even with a negative *Enterococcus* is considered significant and also suggests certain fecal pollution. One trace finding for *Enterococcus* was reported on August 17 at Site 3: City Beach Bay. Trace *Enterococcus* with a negative *Bacteroidetes* suggests possible re-growth of bacteria.

Conductivity

Conductivity was measured *in-situ* with immediate results. Values were generally stable across all sites throughout the study, with noticeably elevated values as expected in seeps and streams. Similarly to DOC, these high values are typically the result of the continuous natural augmentation and transport of allochthonous organic matter prior to dilution in the lake environment. The highest recorded value (594.2) was at Site 18: Dog Bay State Park Seep. Values at this site included 316.0 on August 10, 221.0 on May 4, 215.3 on July 6, 205.9 on August 30, 194.7 on Sep 27, and 170.0 on October 16. The second highest value (408.4) was recorded at Site 5:Viking Creek on July 6. Values at this site included 330.5 on September 13, 308.0 on May 5, 248.7 on June 6, 238.0 on October 26, 236.5 on August 30, 220.1 on September 27, and the lowest reading 169.8 on

August 17 (Figure 14). Taking into account all conductivity values recorded over the duration of the study, the three highest median conductivity values were recorded at Site 5: Viking Creek (270.0), Site 18: Dog By State Park Seep (207.7), and Site 12: Lazy Channel (189.6). The highest values across all sample periods were also recorded at these three sites.

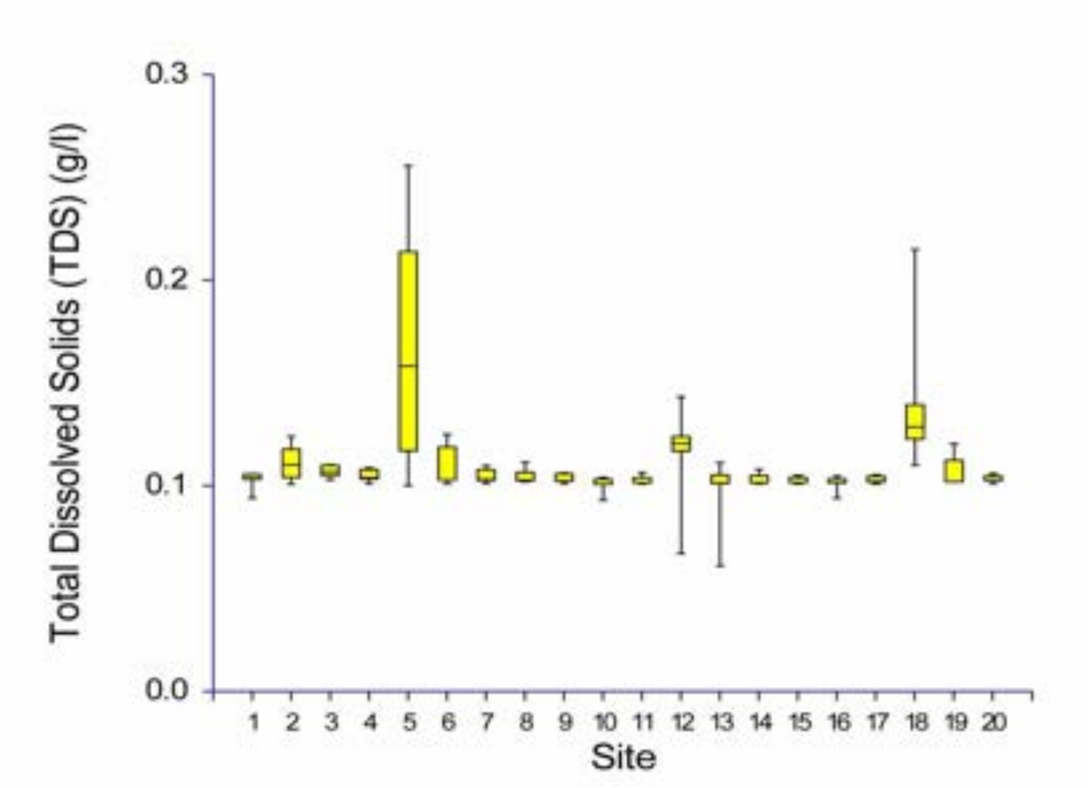
Figure 14. Conductivity Results by Site
Box plot shows the full range of results from all 9 sample dates. Whiskers extend to the highest and lowest values recorded, and the median for each data set is represented by the horizontal center black line.



Total Dissolved Solids (TDS)

TDS was measured *in situ* providing immediate results. The highest TDS results .2557 and .2241 g/l were recorded at Site 5: Viking Creek, followed by the third highest .2150 at Site 18: Dog bay State Park Seep. Taking into account all conductivity values recorded over the duration of the study, the three highest median TDS values were recorded at Site 5: Viking Creek (.166), Site 18: Dog Bay State Park Seep (.138), and Site 12: Lazy Channel (.116). While these values are consistent with the natural environment in seeps and creeks, the presence of contaminants cannot be ruled out. The highest values across all sample periods were also recorded at these three sites.

Figure 15. Total Dissolved Solids by Site
Box plot shows the full range of results from all 9 sample dates. Whiskers extend to the highest and lowest values recorded, and the median for each data set is represented by the horizontal center black line.



GIS

GIS was used to analyze and present relevant cartographic and statistical data about the study area. GIS analysis resulted in several key findings. First, septic system densities are much greater than previously thought because information is lacking in certain databases regarding actual current septic system permits and use (Mobile LoGIStics Mapping, 2011).

Second, incorrect information about dwelling units also skews the understanding of overall septic density, particularly in areas where numerous small homes have been replaced by higher end, large home developments. For example, septic system permits—regardless of home size—appear as the same size point on the Whitefish Area Septic Permits map (Flathead County GIS, 2011).

GIS analysis also resulted in information that helped us identify the geological properties that limit or enhance wastewater treatment and movement into groundwater. The rate of transportation of pollutants can be influenced by many environmental factors, including temperature, rainfall, soil moisture, pH, and the availability of organic matter. Bacteria, however, are most significantly removed through straining and absorption as water percolates through soil. This is influenced by flow rate, clay composition, soluble organic concentrations, and the general composition of soil. Soil, therefore, plays an integral part in both filtering and transporting of wastewater. Soil properties such as texture, porosity, specific yield, permeability, and attenuation affect the function of septic leach fields and the possibility for septic leachate to move from its source—through groundwater—to the lake. Soils can range from fine clay to silt and to coarse sand. Wastewater movement around Whitefish Lake is affected not only by the current soil unit (Figure 16), but also by geological structure (Figure 17), land type (Figure 18), taxonomic particle size (Figure 19), soil drainage class (Figure 20), percent of slope (Figure 21), and sediment hazard rating (Figure 22).

The Natural Resources Conservation Service (NRCS) conducts soil surveys which take into account all of the significant variables of soil and land structure suitability for septic field functionality. The resulting Septic Tank Absorption Fields Suitability map of Whitefish Lake (Figure 23) shows the limitations for septic fields in the study area overlain with known septic system placements. Although there are a few areas around the lake that have not been rated, most of the shoreline and extended area is defined as "Very Limited" by NRCS for septic tank absorption field suitability. This supports the findings reported by the Whitefish County Water and Sewer District (1984) and the Soil Conservation Service (1970) that the majority of soil types along the developed shoreline of Whitefish Lake have characteristics that limit adequate treatment of septic effluents.

> Explanation of Septic Tank Absorption Fields Suitability (NRCS)
> Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 60 inches is evaluated. The ratings are based on the soil properties that affect absorption of the effluent, construction and maintenance of the system, and public health. Saturated hydraulic conductivity (Ksat), depth to a water table, ponding, depth to bedrock or a cemented pan, and flooding affect absorption of the effluent. Stones and boulders, ice, and bedrock or a cemented pan interfere with installation. Subsidence interferes with installation and maintenance. Excessive slope may cause lateral seepage and surfacing of the effluent in downslope areas.
>
> Some soils are underlain by loose sand and gravel or fractured bedrock at a depth of less than 4 feet below the distribution lines. In these soils the absorption field may not adequately filter the effluent, particularly when the system is new. As a result, the groundwater may become contaminated.
>
> Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation,

special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Figure 16. Soil Unit

Figure 17. Geologic Structure

Figure 18. Land Type

Figure 19. Taxonomic Particle Size

Figure 20. Soil Drainage Class

Figure 21. Percent of Slope

Figure 22. Sediment Hazard Rating

Figure 23. Septic Tank Absorption Fields Suitability

Random Sampling Results

On two of the nine sample dates, August 10 and August 30, the study included 10 random site investigations, totaling 20 random samplings. The purpose of the random sampling was to evaluate areas outside the standard sample set. The sites were identified by letters of the alphabet (A through J on August 10, and K through T on August 30) to distinguish them from the standard numbered sites. All Hydrolab DS5 Sonde parameters were recorded at these sites, and water samples were collected in the same manner as for all other standard sampling sites.

Of the random sampling results, only two sites produced values of interest. A fluorometric value in the high range (50.35) was reported on August 10 at Site L on the west shore near Site 14: Lazy Bay. This was accompanied by a high DOC of 5.44 and high conductivity at 406.0. Although *E. coli* results were low at this site, based on other values, the sample was sent to Source Molecular Corporation for DNA biomarker analysis. The analysis was negative for human DNA biomarkers. The calculated F/DOC value for this sample registered in the low range at 9.26.

Although all Hydrolab parameters were within the expected ranges on August 30 at Site T north of Site 5, the *E. coli* results were high (49). This sample was therefore sent to Source Molecular Corporation for human DNA biomarker analysis. The results were negative, suggesting that this site was uninfluenced by septic leachate on that sample date. Study analyte thresholds and indicators are noted in Table 7.

Table 7. Study Analyte Thresholds vs. Results

	Reporting	**Threshold level**	**Results**
Fluorometry	Fluorometric units (RFVs)	44.99+	Highest 164.10 13 Sites above threshold
DOC	mg/l	Relative indicator	Highest 7.58
F/DOC Ratio		22.70+	Highest 30.43 4 Sites above threshold
E. coli	mpn/100ml	Drinking water: 235 mpn/100ml. Contact: 298 mpn/100ml 10 mpn /100ml used as benchmark to trigger DNA testing	Highest: 579
DNA Overall Positive	Presence/ Absence of DNA biomarkers	Positive human DNA biomarkers identified	1 Positive overall
DNA analysis of Human *Enterococcus*	Presence/ Absence of DNA biomarker	Positive human DNA biomarker identified	1 Positive Trace
DNA analysis of Human *Bacteroidetes*	Presence/ Absence of DNA biomarker.	Positive human DNA biomarker identified	1 Positive Trace
Conductivity	µmhos/cm	Relative indicator	Highest 594.2
TDS	g/l	Relative indicator	Highest 0.2557
GIS	Cartography	Data set specific	Data set specific

3.2 Summary: Contamination & Risk Assessment

All of the test parameter results—Fluorometry, F/DOC, *E. coli*, Human DNA biomarkers, Conductivity, TDS, and septic density—were evaluated individually and in concert, to provide a complete analysis of septic leachate contamination to the shoreline area of Whitefish Lake, as well as a risk assessment for current and future contamination. A Septic Leachate Contamination & Risk Assessment was developed showing confirmed areas of septic leachate contamination as well as areas of low, medium, and high potential for future septic leachate contamination (Figure 24, Table 8).

In total, we identified three confirmed areas of contamination including 3: City Beach Bay, 5: Viking Creek, and 13: Lazy Bay. We identified two areas of high potential for septic leachate contamination, including Site 12: Lazy Channel and Site 18: Dog Bay State Park Seep. Four areas were identified as having medium potential, including Site 2: City Beach Seep, Site 4: SE Monk's Bay, Site 11: Brush Bay, and the East Lakeshore from Gaines Point south to north Monk's Bay, including Site 8: Carver Bay and Site 7: SE Houston Pt. The remaining 10 shoreline sites are considered to have a low potential for contamination by septic leachate.

The study conducted in 1985 reported signs of chronic contamination from shoreline developments at Sites 2: City Beach Seep, 18: Dog Bay State Park Seep, 5: Viking Creek, and the approximate area of Site 14: Central Beaver Bay (Jourdonnais *et al*, 1986), correlating directly with results of this study. Our results suggest that the three confirmed sites, along with the two sites with high potential and four sites with medium potential represent areas where action should be considered.

Table 8. Table of Confirmed Contamination & Risk Assessment

CONFIRMED CONTAMINATION	**HIGH RISK OF CONTAMINATION**	**MEDIUM RISK OF CONTAMINATION**
Site 3: City Beach Bay	Site 12: Lazy Channel	Site 2: City Beach Seep
Site 5: Viking Creek	Site 18: Dog Bay State Park Seep	Site 4: SE Monk's Bay
Site 13: Lazy Bay		Site 11: Brush Bay
		Site: East Lakeshore

Figure 24. Septic Leachate Contamination & Risk Assessment

4.0 DISCUSSION

4.1 Data Results and Ranking

Data Results

A review of Fluorometry, F/DOC, Conductivity, and TDS results show consistently high mean values at sites 5: Viking Creek, 12: Lazy Channel, and 18: Dog Bay State Park Seep for all study analytes. Examined individually, conductivity and TDS are typically high in seeps and streams. However, when examined in concert with Fluorometry and F/DOC, the values of these combined analytes demonstrate evidence of contamination. The significance of the high mean values is also strengthened by their highest recorded values, and provide strong support for the conclusions of this study.

Ranking

We developed a ranking system for all of the parameters of this study in order to provide an overall view of the effects of septic leachate on the lake. Where developing ranking values such as fluorometry and F/DOC, we tended toward mathematically conservative low, medium, and high ranges. Using the Jourdonnais *et al* study (1986) as a reference point, the results suggest that over the past 26 years, F/DOC values have remained high in areas with previously high readings, and that values at additional sites have increased since that study.

4.2 Limitations of Study

Sampling Frequency & Occupancy Variability

Because lakes are open and dynamic, we need to look at a number of parameters over time and in concert with one another to fully interpret our findings. It was not possible—within the financial constraints and research parameters defined in this study—to sample more sites or to sample the 20 study sites with greater frequency.

Many Whitefish Lake shoreline and hillside properties are inconsistently inhabited during several months of the year, with peak usage during the summer months and holidays. Therefore, a study with multiple sample dates in early-, mid-, and late-spring, summer, and fall would provide a more detailed picture of the changes that occur as residential usage ramps up, reaches its peak, and ramps down. Variable habitation and sampling constraints, combined with the photo-oxidation potential to ONAs over time, suggest that these study results may underestimate the presence of septic leachate in Whitefish Lake.

Natural and Cultural Influences

The study of an aquatic ecosystem requires understanding the physical, biological, and chemical interactions that define that system. It also necessitates comprehending the human uses of—and influences on—the ecosystem. Previous studies of Whitefish Lake have identified reasonable concern over the impacts of groundwater contamination from septic leachate and movement of contamination into the littoral zones of the lake. Chemistry data in those studies from shoreline creeks, seeps and groundwater show signs of chronic contamination from near shore development (Jourdonnais *et al*, 1986) and aerial infrared photographic analysis identified numerous failing septic systems around the lake (Hoppus, 1985). This study focused on a specific set of variables to define an interaction between humans and the aquatic ecosystem of Whitefish Lake. Here, we have attempted to add data to the cumulative knowledge base regarding human wastewater systems and their effects on Whitefish Lake.

Studies have shown that development and land disturbance around Whitefish Lake have long contributed to the nutrient loading to the lake (Jourdonnais & Stanford, 1985; Jourdonnais *et al*, 1986). These external inputs are influenced by the complex variability and interactions of the lake's ecosystem. Physically, lakes vary in terms of geologic dimensions, temperature, light, and currents. Biologically, lakes vary in terms of structure, function, and species composition, richness, and population growth rates. Chemically, lakes vary in terms of nutrients and contaminants. Whitefish Lake has a great potential for temporal and spatial *heterogeneity* (non uniformity), making its study challenging. Physically, the lake is influenced by vertical and horizontal mixing effects.

Horizontal lake currents—resulting from inflow and outflow of water, wind events, and changes in water density—could have influenced the study results at specific sites. The *bathymetry* (underwater topography) of the lake could also help to channel those currents across the lake. At the tributaries where water flows into Whitefish Lake and where the lake empties into the Whitefish River, there are natural currents. Depending on flow rates of the tributaries and temperature differences between stream and lake temperatures, these currents can be strong, extending far into the lake. Wind blowing over the lake pulls water along with it also producing currents and small waves. Those currents can continue long after the wind dissipates, and may influence vertical mixing depending on lake temperatures.

Lastly, changes in temperature and density influence the movement of the lake's water, resulting in a vertical effect. Rising warm water and sinking cold water drive currents in the lake, particularly in spring and fall. Most dense at 4°C (39.2°F), water becomes less dense at both higher and lower temperatures. This temperature-density relationship can cause lakes to mix and stratify, or separate into distinct layers. The *epilimnion* is the uppermost and warmest layer of water. The *hypolimnion* is the lowest, coldest and densest layer of water. Between those two layers is the *metalimnion* where water temperature decreases rapidly with depth. Whitefish Lake is a *dimictic* lake, meaning it mixes from top to bottom annually in spring and late fall. It is important to acknowledge that these interactions related to currents can influence water sampling.

Behavior of Bacteria

Although *E. coli* unrelated to septic leachate is not a concern of this study, it is important to consider in the overall health of the lake. High *E. coli* results at several sites in this study that did not result in identifying human DNA biomarkers may still represent a threat to humans because the feces of non-human warm-blooded animals can also carry microorganisms that are pathogenic to humans. Recent research has confirmed the findings of multiple prior studies that stormwater runoff can flush accumulated feces of wildlife and domestic animals from the ground into water bodies, raising *E. coli* concentrations (Sejkora *et al*, 2011).

E. coli can also re-grow, making it more difficult to determine the initial source. A recent study (Bucci *et al*, 2011), building on previous research, showed that *E. coli* can re-grow at low nutrient concentrations typical of surface water. Although water samples for this study were taken from approximately one foot above the lake bottom at each site (with the exception of seeps and streams), it is important to recognize the possibility of re-growth. The EPA estimates that 13% of streams, 3% of lakes, and 11% of estuaries in the U.S. are impaired by pathogens (EPA, 2009). *E. coli* is therefore considered an important indicator of public health risk associated with general fecal pollution.

Human DNA Biomarkers as Indicators

The *Bacteroidetes* and *Enterococcus* biomarkers serve as an indicator of the targeted fecal pollution, but the absence of the biomarker does not preclude the sample site from having human fecal pollution. Based on lake volume, dynamics, and mixing regimes, the potential for detecting bacteria is reduced. Only with repeated location-specific sampling events are researchers able to draw more definitive conclusions.

Residence Time & Dispersal Rates

Given that this study was conducted in a dynamic aquatic environment, we concerned ourselves with the residence time and dispersal rates of bacteria as it relates to our sampling. *Bacteroidetes* are *anaerobic* and have a broad range in which they can persist, depending on variances in light, temperature, and oxygen content in the water. Most research suggests they can typically persist for 2-7 days. *Enterococcus* are *aerobic* and can last up to several weeks. They can also re-grow, though this is uncommon. They are also considered the most antibiotic resistant bacteria. Most importantly, the dispersal rate of bacteria is highly dependent on the physics of the water system and turbulence at the sample sites (Source Molecular, 2011). Point collection is therefore limited by the vulnerability of bacteria to environmental change.

Railroad Propagated Vibration

This study did not investigate the vibration impact to septic systems from trains that travel along the west shore of the lake. It would be good to evaluate whether railroad propagated vibration and its potential impact on soil stability to sewer and septic systems is being studied elsewhere, and if there is any potential concern for the lakeshore area.

Stormwater Conveyance

Where there is human development, there are pollutants that can make their way into stormwater runoff. Contributions of pollutants by stormwater was not one of the concerns of this study, however stormwater conveyances may—during certain times of year, and certain years—contribute both sediment and pollutants to creeks. The City of Whitefish stormwater system consists of a complex mix of detention ponds, swales, roadside ditches, pipes, manholes, catch basins, and treatment systems that convey and treat storm runoff from the City of Whitefish and the surrounding area prior to discharge to Whitefish Lake, the Whitefish River, and Cow Creek.

The stormwater system currently consists of fifteen outfalls to the Whitefish River, three outfalls to Whitefish Lake and six outfalls to Cow Creek. There are approximately 500 catch basins, 300 manholes, 8,100 lineal feet of 8-inch pipe, 25,000 lineal feet of 12-inch pipe, 2,100 lineal feet of 15-inch pipe, 12,000 lineal feet of 18-inch pipe, 1,900 lineal feet of 21-inch pipe, 7,580 lineal feet of 24-inch pipe, 800 lineal feet of 36-inch pipe and 140 lineal feet of 42-inch pipe in the system (Montgomery *et al*, 2006). Stormwater conveyance to creeks around Whitefish Lake generally takes place in well vegetated areas, resulting in the trapping of sediment and filtering of nutrients. However, contamination from stormwater cannot be ruled out as a possible contributor. (Addendum 7.4).

GIS Databases

A more robust county database of septic and sewer systems, more frequent data collection and maintenance, and enhanced data integration using multiple data sources are three actions that could improve not only the quality of the existing data, but also the ability of those charged with monitoring and enforcing water quality for Whitefish Lake. Improvements to the data have recently been made, but a more thorough update and an ongoing review process would be beneficial. In some cases older permits were issued for single "dwelling units." One dwelling unit is equal to a three bedroom house. As properties changed hands, the same permit and septic system were sometimes used where new, much larger homes were built. In such instances, small septic systems—designed to treat the waste of a small household—may be inefficient for treating the waste of numerous occupants. This heavier demand can lead to premature system breakdowns and wastewater making its way into groundwater and to the lake. Septic system type, functionality, and density around the lake may also be misrepresented. Septic systems are identified as dots on a map. However three six-bedroom homes, noted as three dots on a septic density map, could contribute twice the wastewater effluent as three three-bredroom homes, also noted as three dots on the density map.

4.3 Developments in Areas with Confirmed Contamination, and High or Medium Risk of Contamination

Three confirmed sites of contamination include Site 3: City Beach Bay, Site 5: Viking Creek, and Site 13: Lazy Bay. The two sites with high contamination potential include Site 12: Lazy Channel and Site 18: Dog Bay State Park. The four sites with medium contamination potential are 2: City Beach Seep, 4: SE Monk's Bay, 11: Brush Bay, and the East Lakeshore from Gaines Point south to north Monk's Bay, including Site 8: Carver Bay and Site 7: SE Houston Pt. This information, combined with GIS led to the development of breakout maps of general areas of concern. The development in those areas is described below, along with the most probable scenario of contamination.

Area Including Site 2: City Beach Seep and Site 3: City Beach Bay

City Beach Seep and City Beach Bay are located in an area with homes built mostly from the mid-1930s and on, including numerous subdivisions. Although many homes were built prior to the development of the City sewer system, almost all homes in this area are now connected to that system. In 2010, the City abandoned and removed the sewer line located in front of City Beach. The confirmed human DNA biomarker in this area is therefore troublesome in that it may indicate leakage from an old, abandoned and improperly terminated septic system, or a sewer system breach.

It is possible that water chemistry results at the two sites may have been influenced by lake currents and/or perhaps boat-wash. Boat-wash is the movement of water produced by a vessel as it travels through the water. With an active dock at City Beach, it is difficult to know if water samples taken at sites affected by boat wash contain samples of water only from that site. Given that the homes at and near City Beach, and the public restroom, are all connected to the City sewer system, lake currents or boat-wash could explain the medium F/DOC values at both sites and the positive *Enterococcus* biomarker result at Site 3. The positive result could be a consequence of lake water contaminated with excrement being transported from City Beach via natural or boat-wash currents to the sample site. However, a technical problem with the sewer system should not be ruled out.

Most Probable scenario: Human excrement from swimmers at City Beach was dispersed via natural or boat-wash currents to the sample site.

Photo 4. City Beach, Whitefish Lake (WLI stock photo)

Area Including Site 4: SE Monk's Bay & Site 5: Viking Creek

Groundwater at Site 4: SE Monk's Bay, south of Viking Creek is influenced by Wildwood Condominiums and several private homes. The area is fully available for connection to the City sewer system, though there are a few septic systems shown in the county database in close proximity to this site. Groundwater near Site 5: Viking Creek is influenced by development on Wisconsin Avenue, all of which is connected to the City sewer system. Viking Creek passes beneath Wisconsin Avenue to its outfall in Whitefish Lake. The Viking Creek liftstation and associated equipment was upgraded after pumps were overwhelmed in 2005. According to the 2006 Wastewater Utility Plan, the Viking lift station is in good condition and will operate reliably with projected growth until 2025 (Montgomery *et al*). However, a sewer system leak cannot be ruled out.

Figure 25. SE. Monk's Bay & Viking Creek

The City of Whitefish Wastewater Utility Plan noted some stormwater issues in this area. First, the main stormwater conveyance culvert that moves water from the Murdock Nature Conservancy area is often clogged with debris causing water to back up in the Conservancy area. The Montana Department of Transportation maintains this culvert. East of Murdoch Lane is the main culvert that transports drainage from Suncrest and Mountain Harbor Subdivisions across East Lakeshore Drive to the lake. Some of the flow at this section actually drains under the culvert rather than through it. The Crestwood Subdivision, which once included some wetlands, has high groundwater and an inadequate drainage system (Montgomery *et al*, 2006).

Further complicating issues in this area is the potential impact of Wisconsin Avenue structures on groundwater flow migration. Flows may have been obstructed and/or rerouted as a result of building footprints. Also potentially influencing these sites are the septic systems and stormwater flows in the upper Viking Creek drainage. According to the City of Whitefish (2011), there are three types of storm water treatment facilities in the Viking Creek/Lodge at Whitefish Lake area: 1) Hydrodynamic stormceptors are used as part of the underground piped system in the parking lot of the Lodge adjacent to the lake; 2) Bioswales within the parking lot and a stormwater management filter that employs filter media to treat pollutants are both used in the newer parking area by the Viking Creek Lodge. This is a very robust system that is costly to deploy and maintain. The first system of this type in the state was installed on Bay Point Drive several years ago; and 3) The private undeveloped 17-lot Viking Creek Development just north of Crestwood has both bioswales along the road and a bioretention pond for treatment.

28.82 acres of the undeveloped land was gifted to WLI for conservation, wetland restoration, and public education (Photo 5). The wetland has a perched water table on silty to lean clay soils with low vertical hydraulic conductivity, however horizontal transmissivity is likely pronounced as a result.

Photo 5. WLI's Viking Creek Wetland Preserve

Considering the buffering capabilities of the Viking Creek wetland complex that WLI owns and manages, along with the Murdock Nature Conservancy to the north and east, it is reasonable to assume that any wastewater or stormwater issues from the upper Viking Creek drainage would be mitigated (treated) prior to conveyance to Viking Creek.

The Viking Creek Lodge project required a plan that minimized impact to the wetland, and where impacted, a mitigation strategy to replace impacted wetland area at a 10:1 ratio. The wetland performs tasks such as groundwater retention, discharge and recharge, and sediment and pollutant filtration, functioning as a kidney to Whitefish Lake. It is of concern that contamination is reaching the lake via Viking Creek, even with the wetland buffering capacity.

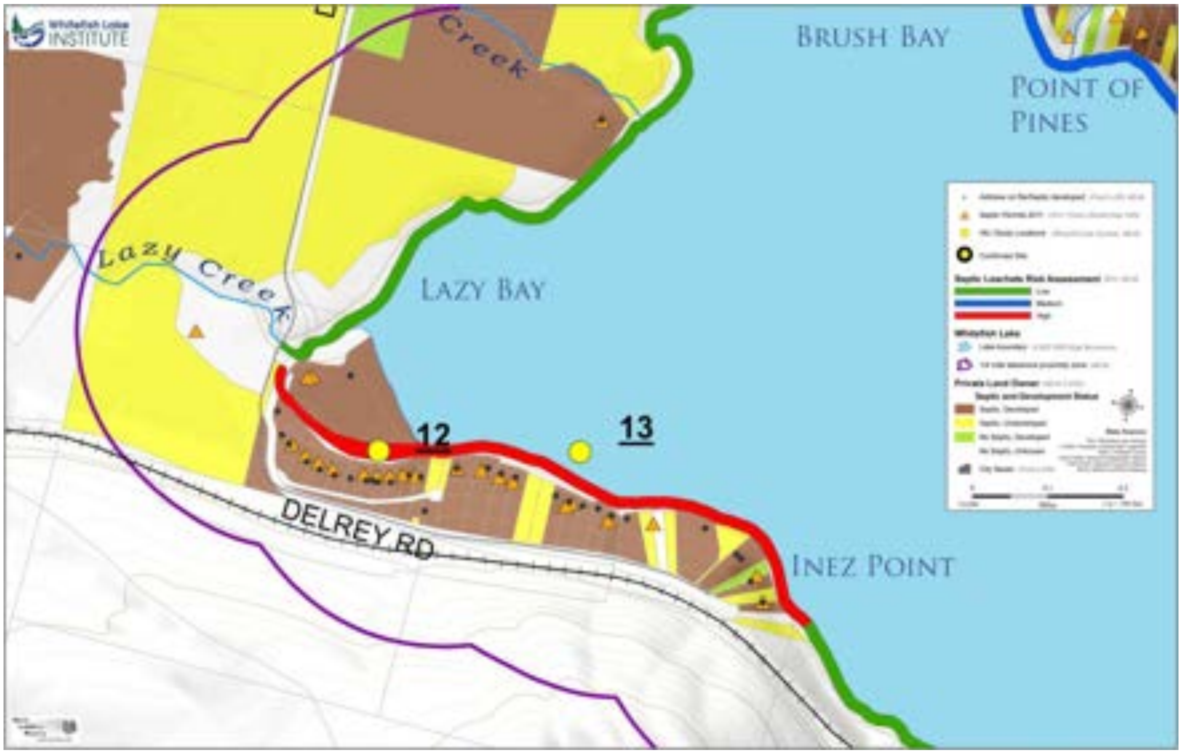
Most probable scenario: Chronic contamination at this site is likely the result of a localized sewer system infrastructure failure.

Photo 6. Viking Creek Outfall Fronting The Lodge at Whitefish Lake (WLI stock photo)

Area Including Site 12: Lazy Channel and Site 13: Lazy Bay

Groundwater at Site 12: Lazy Channel and Site 13: Lazy Bay is influenced by the subdivisions adjacent to the bay. The Lazy Bay and Inez Point subdivisions—on the north end of the lake has a high density of septic systems in an area of limited soil suitability for septic systems, and in close proximity to the lake. There is no access to the City sewer infrastructure in this area. There are only 2 homes situated on Lazy Creek. Lot slope in this area varies from 11% to 50%. This area has a mix of homes built since the first subdivision approval in 1976 suggesting that—unless since replaced—there are septic systems up to 36 years old. Site 13: Lazy Bay had generally low to medium fluorometric and F/DOC values, but had a positive result for the human DNA biomarker *Bacteroidetes*. Site 12: Lazy Channel had the single highest fluorometric reading (164.10) and F:DOC values from medium to just below the high range.

Figure 26. Lazy Bay & Vicinity



Lazy Creek flows naturally into the lake on the north side of the island, but is diverted by a culvert to the channel. Lazy Channel has low input flows resulting from the angled culvert on the input side and is influenced by lake inundation effect on the output side.

Lazy Bay is also home to a small, little known, county owned public access/park listed in county records as Lake Park Addition Park when it was created. The park became county property in 2009, also the year that a county planner submitted to the county park board a proposal for improvements such as public parking, handicap-accessible parking, trails, and a vault toilet to replace the pit toilet.

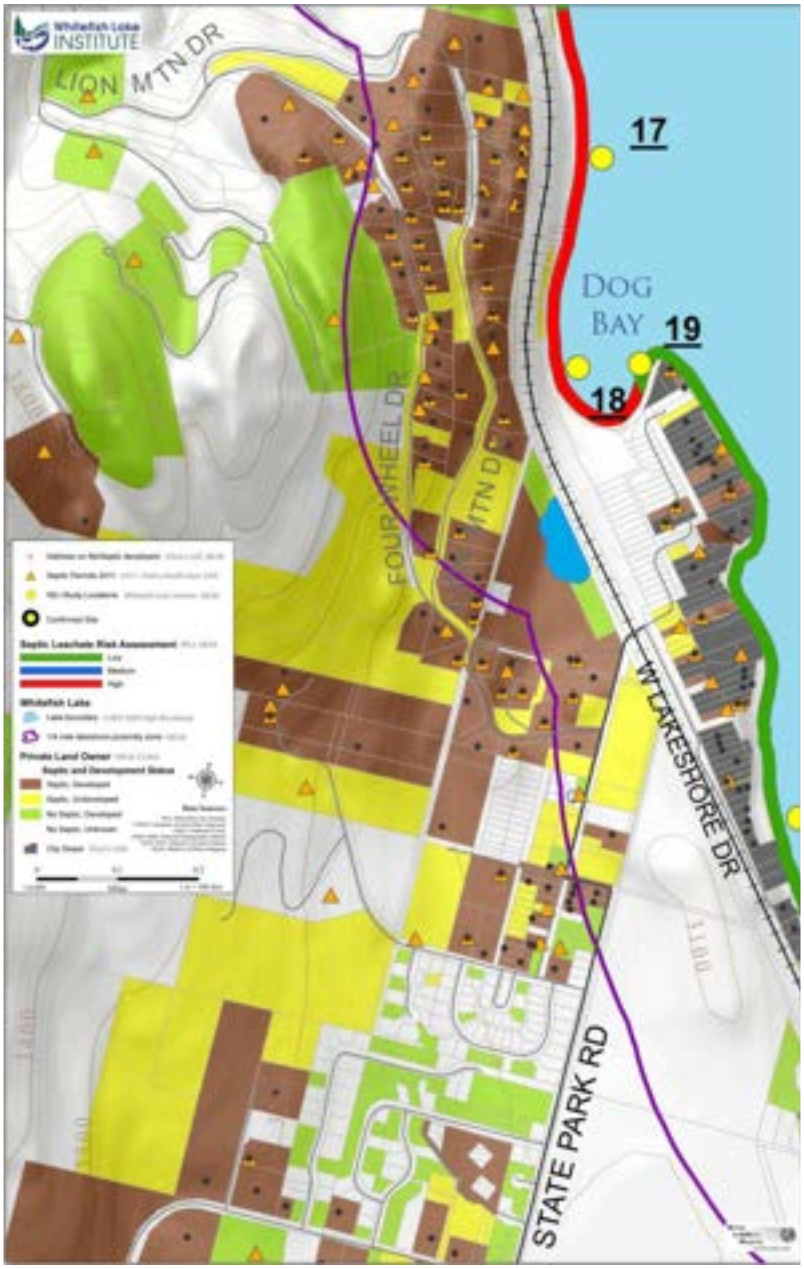
Photo 7. Lazy Bay & Lazy Channel (courtesy gravityshots.com)

Most probable scenario: Aging septic systems have begun failing and are contributing septic leachate to groundwater and the lake.

Area Including Site 18: Dog Bay State Park

Site 18: Dog Bay State Park groundwater is influenced primarily by the multi-phased Lion Mountain Subdivision. The subdivision was initially developed in 1973. It is located on the western edge of the City of Whitefish, and consists of 123 lots ranging from one-half acre to over twenty acres, of which 17 lots are connected to the city sewer system. Of those 17 lots, 11 homes have been built and tied into the system. The remaining 106 lots have conventional septic systems ranging in age from 7 to 38 years. The terrain is considered forest mountainous with ranges in elevation. Septic system suitability is very limited. There are about nine miles of private paved roads throughout the nearly 800 acres of the development.

Figure 27. Dog Bay



There are six subdivisions within the development. Phase 1 and 2 were developed in 1973, phase 3 in 1974, phase 4 in 1976, and phase 5 in 1977.

Individual septic systems in the first five phases of the subdivision are 34 to 38 years old and were installed prior to advancements in septic treatment systems.

Development in the most recent subdivision (6) began in 1997 and uses a more modern communal septic system. Wastewater from 18 lots goes from individual on-site septic tanks—some with effluent pump systems—to two 2,000 gallon tanks, each with effluent filters, then to a duplex siphon tank, then on to a 2-zone sand filter, then a 4-zone subsurface drainfield.

Photo 8. Dog Bay (WLI stock photo)

A new development—Underwoods— is located north of Lion Mountain on a small jetty of lakeshore land. It has a small number of lots on the east side of the Burlington Northern Railroad tracks. Newly installed septic systems service properties in the development.

Most probable scenario: Aging septic systems from one or more of the first five phases of development have begun failing and contributing septic leachate to groundwater.

Area Including Site 11: Brush Bay

Site 11 is influenced by numerous septic systems off East Lakeshore Drive located in close proximity to the lake. Most of the developed shoreline area situated between Brush Creek and the area south of Point of Pines is on a 21-50% slope below a glacial terrace. F/DOC values are just below the high range, and a high density of older septic systems, make this an area of concern. The Point of Pines Subdivision was first platted in 1934. Other homes in the Brush Bay area were generally built in the mid-1980s and later. Based on slope, property size, and less stringent regulations, older septic drainfields were typically installed near the lakeshore.

Most probable scenario: Aging septic systems have begun failing and contributing septic leachate to groundwater. Note: The Point of Pines Subdivision has designed and installed a very robust modern communal septic system that will begin operating in the spring of 2012. The system is designed to handle waste from all current and future homes in the subdivision.

Figure 28. Brush Bay & Point of Pines

Area Including East Lakeshore from Gaines Point south to north Monk's Bay, including Site 8: Carver Bay and Site 7: SE Houston Pt.

Based on analysis of GIS data, this area on the east shore of the lake is influenced by a high density of individual septic systems in close proximity to the lake. Homes range in age from the earliest built in 1934, to recently built homes. Included in the area are Whitefish Lake Summer Homes, and Carver Bay and Houston Point subdivisions. Homes in this area vary in size from small single family homes to several thousand square foot homes for multiple occupants. Several homes in the area are serviced by the City sewer system, but many remain on individual septic systems.

Most probable scenario: Aging septic systems have or will likely begin failing and contributing septic leachate to groundwater.

Figure 29. East Shore

5.0 RECOMMENDATIONS & PUBLIC BENEFIT

5.1 Beneficial Value

Whitefish Lake offers many values and provides beneficial functions that resource managers and citizens generally agree warrant protecting. Some of the more recognizable values associated with the lake are aesthetic enjoyment, recreational opportunities, and increased property values. The lake is also functionally important for maintaining our unique ecosystem with its inimitable assemblage of flora and fauna. Whitefish Lake additionally provides water quality control functions for downstream waterways and water users. The lake is also a significant cultural and economic aspect of the community of Whitefish, and a principal contributor to the larger Flathead County Basin community.

Provided herein are some recommendations, largely based on examples from other wastewater management programs, that may support the common goal of protecting Whitefish Lake water quality. These recommendations are intended to serve as talking points should the jurisdictional body determine action is required.

5.2 Community Wastewater Management Program

Note: At the time of this report, jurisdiction of some portions of the area around Whitefish Lake remains undefined pending resolution between the City of Whitefish and Flathead County. Therefore, all recommendations are made to the “jurisdictional body” as appropriate.

As a measure to protect the lake from trending further toward eutrophication from wastewater inputs, and to protect human health, we propose for consideration the following broad spectrum of programmatic activity under the umbrella of a Community Wastewater Management Program. Programs are presented as follows:

Community Wastewater Management Program

- Education & Outreach
    - Septic Systems 101 or “Take the Septic Plunge”
    - Septic Systems Community Tour
- Regulatory
    - Septic System Inspection & Upgrade Cooperative Program
        - *Criteria Setting, Prioritization & Testing*
        - *Individual On-Site Septic System Upgrade*
        - *Upgrade to Communal Septic Systems*
        - *Septic to Sewer Upgrade*
        - *Property Conveyance Septic to Sewer or Communal Septic Upgrade*
    - Stormwater Outfall Management Plan
- Area Specific Recommendations

By bringing together community agencies and the citizens they represent, and combining programmatic recommendations with funding possibilities, the jurisdictional body could implement this program for Whitefish Lake. The jurisdictional body would need to decide how best to administer and manage the program. Critical to the success of the program will be community support and participation, funding, and enforcement. Following the recommendations are a number of funding options that may be applicable and available to advance these programs.

The Community Wastewater Management Program would have two key elements, Education & Outreach programs, and Regulatory programs. The Education & Outreach programs would focus on improving community awareness about wastewater management around Whitefish Lake. The Regulatory programs would focus on a comprehensive community strategy for ensuring properly installed, operated, and maintained septic and sewer systems around the lake. The most effective regulatory programs would be those that are incentive-based, providing funding options to ease or eliminate financial and other hardships of community members. Regulatory programs would have 2 levels of implementation; policy development and enforcement. Program suggestions include:

Education & Outreach Programs

Septic Systems 101 or “Take the Septic Plunge”

Property owners, as well as septic system engineers, fabricators, and installers, are subject to rules and regulations set forth by the U.S. EPA and MDEQ. New systems are required to meet specific rules including, for site-specific conditions, the reduction of total nitrogen in wastewater by 60%. Newer septic systems are designed to meet and exceed these standards. Some newer properties and developments around Whitefish Lake have employed the most current wastewater treatment technologies and products. By doing so, they are helping to protect the water quality of the lake.

However, many older properties on Whitefish Lake have wastewater treatment systems that do not meet today’s more stringent standards which were developed and implemented long after their homes were built. One step in the process of safeguarding the water quality of the lake is to upgrade aging or inadequate systems, or, where offered, connect those homes to the city sewer system. It is important to provide information to homeowners about the wastewater treatment systems used on their properties, current wastewater treatment options, and the consequences of their wastewater treatment choices.

Several local septic system engineers have agreed to give seminars at no charge to property owners to help them understand how wastewater treatment systems work, and how individual property variables influence the type, location, and maintenance of those systems. We propose a series of seminars—free to homeowners—at which valuable information about septic systems and connecting to the City sewer infrastructure would be shared with attendees. Some of the material to be covered would include: How septic systems work; How failing septic systems can be a significant source of health risk to people and to Whitefish Lake; How a properly designed, installed and maintained septic system treats wastewater; What causes septic systems to fail; How to properly maintain septic systems; and Why some properties should connect to the City sewer system.

Also available at these seminars would be an expert who could talk about implementation costs, financial incentives, and funding programs available for upgrading their wastewater treatment systems. In order to entice homeowners to attend, we recommend partnering with local restaurants and businesses to offer incentives to those who attend the seminar. A "Water Quality Coupon Book" could be developed whereby Whitefish businesses could contribute by offering free or discount coupons for meals and products. In addition to the coupon book, each attendee would leave with information about septic systems, an understanding of the wastewater treatment options for their specific property, and a list of programs to help them accomplish program goals. The EPA already produces educational literature such as *A Homeowner's Guide to Septic Systems* (2005) which could also be used for the program. In addition to septic system specific literature, there are a number of organizations and programs that provide resources and materials which could be useful in the Education & Outreach Program (Flathead Lakers, 2012).

Septic Systems Community Tour

Through this education & outreach program, community members would have an opportunity to visit local companies that design, build, install and maintain septic systems. They would be introduced, by experts in the field, to various types of tanks, pumps, filtration systems and other related equipment used for septic system deployment and operations. The connectivity of the system components would be described and the physical, chemical, and biological interworkings of the systems would be explained. A septic system repair and maintenance expert would be onsite to describe typical maintenance and cleaning procedures, as well as describing what kinds of problems can be repaired and how those repairs are made. As part of the tour, community members would be taken to see local communal septic system installations and learn how they function.

Regulatory Program

The multi-part regulatory program would be designed to set policy and encourage participation. Such participation may be accomplished on a volunteer basis or implemented as regulatory requirements. Policy would be developed to describe and enact the regulations, and enforcement would be handled through programmatic activities. While volunteer programs are more likely to be met with community acceptance, they are less likely to achieve human health and water quality goals.

Septic System Inspection & Upgrade Cooperative Program

Using the results of this study and the Septic Leachate Contamination & Risk Assessment Map, a *Septic System Inspection & Upgrade Cooperative Program* could be developed to address water quality concerns relating to wastewater. A timeline for implementation would need to be developed, but with human and ecological health in mind, we recommend a five-year program limit. This timing would be further defined by the funding sources available. For instance, a DNRC Renewal Resource Grant and Loan program (RRGL) might be available during the first year of the program, and other local, state, or federal funds might take affect during additional years.

The Massachusetts Department of Environmental Protection designed and implemented a comprehensive program that could be used for plan design ideas and implementation procedures (Shephard, 1996). Although this was an extensive state-wide, multi-agency initiative, there are a number of water quality and human health goals common to those of the Whitefish Lake jurisdictional bodies and the community that could be applied to this program. The effort also included the review of numerous case studies of other municipalities' programs in several states and in Canada which may prove useful to the local jurisdictional body. This regulatory umbrella program would include 4 individual programmatic segments that could be implemented individually, in concert, or in select combinations.

1. ***Criteria Setting, Prioritization & Testing***
   A set of criteria to meet policy standards would drive implementation of water quality goals. The program would first prioritize septic and sewer system upgrade goals in order of those areas already contaminated with septic leachate and those with high and medium degrees of potential contamination. After prioritization, a procedure and schedule could be developed for system inspections. Inspections of septic systems could include dye testing and physical examination. Dye testing is a non-invasive, relatively low cost method for testing of onsite sewage treatment systems. While it does not provide a complete assessment of the system or its future performance, and may not always detect a system failure, it does identify current performance issues. It is minimally disruptive to the homeowners and causes no damage to the system. In order to get the truest results, the system must not have been pumped or altered in any way in the 30 days prior to the test.

   A physical septic system examination would generally include looking at household waste plumbing and discharges; inspection of visually available components of the sewage treatment system; looking for evidence of sewage backup in basements or low level rooms; checking storm water discharge to the sewage treatment system; observing drainage pipes that may influence or be influenced by the system; flushing the lowest level toilet and checking for wastewater backups; visual confirmation of the location of the septic tank, pump, and leachfield, checking for visible evidence of problems (odor, saturated soil, lush vegetation), and observing pump operations. After the dye test, the tank should be pumped and visually inspected for cracks or other problems. All testing would be communicated in a written report to the jurisdictional body and the property owner, noting any system problems and a proposed timeline for taking corrective action.

   The City of Whitefish conducts sewer inspections to determine the condition of the wastewater infrastructure and to identify maintenance and rehabilitation needs. An extensive review of the system and recommendations for repairs and upgrades was made in 2006 (Anderson-Montgomery). For this program, sewer systems at sites of concern would be re-investigated to evaluate specific components of the system, and to identify any problems that might be contributing to sewer leachate entering groundwater and the lake.

Following inspections, there would be scheduling and funding of upgrade projects including a plan for following the projects through to completion. As with any type of utility upgrade to protect human health and water quality, funding must be part of the program. All properties with septic systems would be inspected and the information recorded for future reference. Systems that fail inspection would be listed for one of three possible actions, 1) individual on-site septic system upgrade, 2) upgrade to a communal septic system, or 3) connection to the existing or an extended sewer system infrastructure.

2. ***Individual On-Site Septic System Upgrade***
   Old systems that are designated by inspection as not performing fully or not meeting current standards would be either repaired and brought back to functionality where feasible, or properly cleaned and terminated. If the property is not in an area that allows connection to the City sewer system or would not benefit from connection to a communal septic system, then a new residential on-site septic system would be scheduled for installation. All new systems would need to meet current standards for wastewater treatment as well as (if known) new standards to be implemented within the next two years, and abide by local rules and ordinances. Some property configurations will require Level 2 treatment to meet current standards.

3. ***Upgrade to Communal Septic Systems***
   Where it is not economically, spatially, or environmentally feasible for the City to extend the sewer line, and where Communal Septic Systems are—or may become—available, older or problematic septic systems might be improved by upgrading to inclusion in a common leachfield. Communal septic systems are useful when soils or slopes are not suitable for some or all homes in a development to have individual septic systems, or when less land area use is desired or required. In some cases a communal septic system makes otherwise unbuildable properties (pertaining to wastewater management) available for development. According to local septic system engineers, an excellent example of an upgrade to a community wastewater system that benefits homeowners and the lake can be found in the new communal septic system at the Point of Pines subdivision. It is also an example of collaboration between property owners, agencies and engineers to find a solution to water quality issues and make it work.

   The Point of Pines subdivision at the head of Whitefish Lake was originally platted in 1934. Located on a strip of land between the lake and State School Trust land, there are 21 homes in the subdivision—some older smaller homes and some newer, larger homes. With a lack of land to construct drainfields that would conform to today’s regulations, the older drainfields were placed next to the lake. Led by a long-time lakeshore property owner, a group of homeowners formed the

Point of Pines Neighborhood Association with the purpose of funding the design and construction of a wastewater treatment system and purchasing an easement on which to locate the system. The system was designed and installed to serve 25 "dwelling units" (a dwelling unit is equal to one 3 bedroom home), including all of the lots in the subdivision. Individual hook-ups to the system will be done in the spring of 2012.

The new system consists of a force main that runs along East Shore Drive, and two ancillary force mains. Each home site is equipped with an effluent pump with a 2000 gallon tank split into a 1500 gallon compartment and a 500 gallon compartment where the pump is housed. The final treatment system is located on state land, through a Right-of-Way project with the Montana DNRC located in the south half of the southwest quarter of Section 32, and the southwest quarter of the southwest quarter of Section 33, in Township 32 north, Range 22 west, and along the East Lakeshore Road approximately 5 miles northwest of Whitefish. The School Trust received $82,000 for the mostly underground easement and retains ownership of the land.

Treatment is handled by an AdvanTex Treatment System (from Orenco Systems) which uses a recirculating filter configured similarly to a recirculating sand filter, but using a lightweight, large-surface area, multi-pass textile treatment. The 15,000 gallon recirculation tank takes all the effluent from the entire system from all homes to filter pods which recirculates back through the system (depending on loading) through a duplex siphon, then to a 2-zone drainfield. In addition to leasing the land, the Point of Pines Neighborhood Association obtained a discharge permit through Montana DEQ. According to the engineer that installed the system, the soil there is reasonably good, partially gravely, some silty/sandy, but very gravelly around the treatment system. The new system has the potential to reduce septic leachate issues for the lake now and long into the future. However, connection to the new system is not mandatory, and some homeowners have said they are not connecting to the system at the time of initial hook-up.

4. Septic to Sewer Upgrade

In this program, the City could focus on areas where sewer services exist, but not all homes are hooked up, and where wholly surrounded properties could be easily annexed. The City could encourage hooking up to the City sewer system through a rebate program in which they refund back to the property owners a portion of the increased revenue generated by the new hook-ups, along with other funding possibilities including; grants and a nutrient trading program.

5. Property Conveyance Septic to Sewer or Communal Septic Upgrade Program

A Property Conveyance Septic Upgrade program that takes place at the sale of any property in the defined area would be most successful if the jurisdictional body obtained funding to offer a waiver of connection fees or discounted connection fees for residents to connect to existing or new sewer lines. This program would continue until all properties with pre-1990 septic systems were updated. Homeowners might be given a “certificate of upgrade” as evidence of their participation in the program, and to satisfy potential buyers and lenders of their wastewater treatment status.

Funding for the program would eventually sunset, perhaps encouraging homeowners to take advantage of the program even if they have no current plans to place their property on the market. The more people who use the program, the fewer opportunities will remain for septic system failure.

In the absence of financial incentives, the cost of an upgrade would need to be assigned to the seller, the buyer, or a combination of both. At the time of sale of any property the responsible party(ies) would bear the cost to connect to the city sewer system. In addition to the new connection, the termination of the existing septic system would require a final pumping and cleaning of the septic tank, inspection of the tank and leachfield, and submittal of determination of proper closure. Currently, some lending institutions will deny loans if homes have more bedrooms than the number approved under a septic permit. It would be good to look into the banking regulations regarding septic system capacity.

It is possible that over time, septic-to-sewer upgrades would be considered similarly as roofing to home-owners. Home buyers typically don’t want to deal with problem roofs, so sellers are compelled to repair or replace roofs—or provide financial incentive for the work—prior to listing their homes. Given the potential for further contamination of the lake, it would be very beneficial to fund this program.

Stormwater Outfall Management Plan

In addition to the programs described above, it is recommended that the City of Whitefish consider developing a Stormwater Outfall Operation and Maintenance Plan to monitor the outfalls suspected to be contributing pollutants to Whitefish Lake and the Whitefish River, and developing a mitigation strategy to address techniques to improve water quality.

5.3 Area Specific Recommendations

Area Including Site 2: City Beach Seep & Site 3: City Beach Bay

Since all the homes in this area are connected to the City sewer system, it would be beneficial to check sewer lines to rule out leaks or other system disturbances. Site 3 had a positive result for the human DNA *Enterococcus* biomarker, however our interpretation suggests that the results in this area point to possible drift of human waste from City Beach as the most likely contributing factor.

Area Including Site 4: SE Monk’s Bay & Site 5: Viking Creek

Because the SE Monk’s Bay site is surrounded mostly by properties connected to the City sewer system, it is important to inspect the properties that remain on pre-1990 septic systems for functionality. There may be homes that could benefit from connecting to the

City sewer system or to upgrade to a modern individual system, if a City sewer connection is not possible. SE Monk's Bay is the site of the second highest (365 mpn/100ml) of two exceedingly high fecal coliform counts that did not test positive for human DNA biomarkers. This area could also benefit from monitoring of fecal coliform throughout the year to determine safety levels for recreationists.

With the five highest overall F/DOC values (four considered conclusive for OBAs) and the positive DNA result for a human biomarker, Viking Creek is an area of concern. The closest proximity properties to the Viking Creek site have long been connected to the City sewer system, yet the area shows signs of chronic contamination. It is therefore important to check the integrity of the City sewer system and Viking Liftstation in the greater Viking Creek area to identify system failures that may be contributing septic leachate to groundwater. A dye test may also contribute to isolating any existing issues. An investigation of the age and condition of septic systems in private homes in the upper Viking Creek drainage is also important, as they could be contributing pollutants to groundwater.

To rule out septic leachate from the headwaters of Viking Creek, a synoptic sampling is recommended for the two stormwater channels, Viking Creek above the Wisconsin Avenue culvert, and the north and south fork of Viking Creek on the WLI wetlands. WLI would be willing to cost share by donating the labor and equipment to do the sampling. The Whitefish County Water District or the City (or both) could cost share to send water samples with positive *E. coli* and/or high fluorometric values to Source Molecular for Human DNA biomarker testing.

Area Including Site 12: Lazy Channel & Site 13: Lazy Bay

Because Site 13: Lazy Bay is the site of the positive result for the human DNA *Bacteroidetes* biomarker, and given the age of some septic systems in the area, it is particularly important to investigate these systems. Properties in the Lazy Bay area may benefit from upgrading to a new communal septic system.

Discussions regarding the possibility of a section of the Whitefish Trail crossing the Lazy Creek area between Beaver Lake and the Swift Creek drainage include a proposal for a trail crossing which would involve a Right-of-Way over the Burlington Northern Santa Fe (BNSF) Railroad. Such a Right-of-Way could also provide a possible location for a conveyance pipe through which to move septic effluent to a communal drainfield on BNSF property. This circumstance could provide an opportunity for BNSF to participate in protecting water quality on Whitefish Lake and the health of community citizens much in the same way as DNRC has done in the Point of Pines subdivision. There is also some private land in the area that might be suitable for a communal drainfield.

Area Including Site 18: Dog Bay State Park Seep

With generally high *E. coli* readings, consistently medium F/DOC values, and a high density of aging septic systems, this is an area of concern. It is important to investigate the septic systems in the first five phases of the Lion Mountain subdivision as they include systems up to 36 years old. Older properties in this area may benefit from upgrading to a modern communal septic system, similar to the one installed in Phase 6 of the subdivision, or connection to an extended City sewer service infrastructure.

Area Including Site 11: Brush Bay

The new Point of Pines communal septic system is recognized as a very positive effort to protect water quality on Whitefish Lake. The concern here is that connection to the new system is not mandatory, and not all homeowners are planning to connect at the time of initial hook-up. This area should be included in the program for encouraging or incentivizing property owners to take advantage of the new system. With F/DOC values just below the high range and numerous older septic systems in very close proximity to the lake, widespread participation in the new system is important for keeping septic leachate from entering groundwater and reaching the lake.

Area Including East Lakeshore from Gaines Point south to north Monk’s Bay, including Site 8: Carver Bay and Site 7: SE Houston Pt.

This area on the east shore of the lake has a high density of older septic systems in close proximity to the lake. While some properties are serviced by the City sewer system, many remain on individual septic systems. This area may benefit from connecting to the City sewer or upgrading to one or more communal septic systems.

Finally, we suggest it would be prudent to repeat this or a similar lake-wide investigation in about ten years, to describe the effectiveness of any mitigation programs or to comprehend trends in water quality if no action is taken.

5.4 Funding Options

The options listed herein include funding that could be implemented or sponsored by the Whitefish County Water District, the City of Whitefish, or another appropriate jurisdictional body. Tax Increment Financing (TIF) funds, as well as a number of Federal and State funding programs are included. The Water, Wastewater and Solid Waste Action Coordinating Team (W^{2}ASACT) and the EPA researched and summarized a number of programs which are described follow. There are no intended or implied guarantees that any of the programs are fully applicable for septic and sewer upgrade projects or that they will be available at the time implementation is considered. However, the W^{2}ASACT *Financial Assistance Programs Available to Fund Water, Wastewater and Solid Waste Projects in Montana* and the *Federal Funding Sources for Watershed Protection* from the EPA offer excellent sources for potential project funding.

Tax Increment Financing (TIF)

TIF funds are used for improvements within a tax district, and technically could be used for water and sewer upgrades. There are a very small number of Whitefish Lake properties that are located within the City of Whitefish Tax District. For those properties that are included in the District—and possibly those that are within a short distance of the District—TIF funds may be an option for the City. The City of Whitefish could also consider extending the district to include more of the shoreline areas of concern. This will give the City an opportunity to expand its efforts for water quality. Given the specificity of eligible projects for this funding as identified by the 1987 Urban Renewal Plan, and the increasing demand on the funds, it is not the most likely source of funding for the projects discussed in this report. However, it should not be dismissed.

Nutrient Trading

The State of Montana has drafted a policy for nutrient trading which will provide numeric criteria for nutrients (nitrogen and phosphorus) in an effort to reduce nutrient loading and meet wastewater facility compliance criteria. There will be options for wastewater facility compliance including point to non-point source pollution credit exchanges. A nutrient trading program could allow the City to obtain compliance credits for financially enabling homeowners with aging or failing septic systems to hook up to the City sewer system where available. Where the sewer is unavailable, it could allow the City to provide financial incentives to homeowners to join a communal septic system, or upgrade to current individual on-site septic system technology.

The economic and natural resource benefits of nutrient trading appear to be very promising for the community. By participating in a nutrient trading program, the City would directly reduce the amount of expenditure required to meet nutrient loading criteria for its wastewater facility plant-while also providing a vehicle to cover part of the cost for an individual to hook up to the sewer system. Participation in this program would reduce nutrient loading to Whitefish Lake and the Whitefish River from non-point source pollution, and will protect the water quality and beneficial uses of Whitefish Lake.

WLI strongly recommends that the City explore the concept of nutrient trading as a tool for net economic benefit to the community and to protect and improve water quality. As a first step, the City should consider pursuing a grant to develop a pilot nutrient trading program which could also serve as an example to other Flathead Valley communities.

W^{2}ASACT Programs

W^{2}ASACT is a group of federal, state, and non-profit organizations and agencies that finance, regulate, or provide technical assistance for community water and wastewater systems. The group developed the *Financial Assistance Programs Available to Fund Water, Wastewater and Solid Waste Projects in Montana*, (2011) (http://dnrc.mt.gov/cardd/ResourceDevelopment/wasact/Docs/SummaryOfFinancialOptions.pdf) (Table 8). This table incorporates all known financial assistance programs, discusses project eligibility, applicant eligibility, funding cycles, applicant requirements, and program contacts. In addition to the programs currently available, additional funding options may become available if a Total Maximum Daily Load (TMDL) is developed for Whitefish Lake. The group in Montana includes:

Federal Agencies

- Bureau of Reclamation (Department of Interior)
- U.S. Department of Housing and Urban Development- HUD Montana Field Office Helena Economic Development Administration (Department of Commerce)
- Environmental Protection Agency Rural Development, Rural Utilities Services (Department of Agriculture)

Private Associations or Non Profit Organizations
- Midwest Assistance Program
- Montana Association of County Water and Sewer Systems
- Montana Association of Counties
- Montana League of Cities and Towns
- Montana Rural Development Partners
- Montana Rural Water Systems, Inc.

State Agencies and Programs
- Community Development Block Grant Program (Department of Commerce)
- Community Technical Assistance Program (Department of Commerce)
- Public Water Supply Section (Department of Environmental Quality)
- INTERCAP Program (Board of Investments)
- Local Government Center (Montana State University)
- Local Government Services Bureau (Department of Commerce)
- Governor’s Office of Indian Affairs
- Montana Coal Board (Montana Department of Commerce)
- Montana Water Center (Montana State University)
- Municipal Wastewater Assistance Program (Department of Environmental Quality)
- Renewable Resources Grant and Loan Program (Department of Natural Resources and Conservation)
- State Drinking Water Revolving Fund (Department of Environmental Quality and Department of Natural Resources and Conservation)
- State Wastewater Revolving Fund (Department of Environmental Quality and Department of Natural Resources and Conservation)
- Treasure State Endowment Program (Department of Commerce)
- Technical and Financial Assistance Bureau (Department of Environmental Quality)

W^{2}ASACT group members put together a common preliminary engineering report format that is acceptable to all of the agencies that fund water, wastewater, and solid waste projects in Montana. Its success led to the development of the Uniform Application for Montana Public Facility Projects (2011), a publication that includes a commonly accepted application form, environmental checklist, and preliminary engineering report guidelines. While each of the funding programs has some unique program requirements and varied application deadlines, the publication simplifies the process. Because some programs offer time-sensitive grants that have near-term expiration dates, program grant cycles should be reviewed immediately and often. The main funding programs include:

- Montana Board of Investments/INTERCAP Program
- Montana Department of Commerce/Community Development Block Grant (CDBG)
- Montana Department of Commerce/Treasure State Endowment Program (TSEP)
- Montana Department of Environmental Quality/State Revolving Fund (SRF) Loan Programs
- Montana Department of Natural Resources and Conservation/Renewable Resource Grant and Loan (RRGL) Program and State Revolving Fund (SRF) Loan Programs

- U.S. Department of Agriculture/Rural Development Programs

Details about the individual programs and applicability of projects are described in the publication.

EPA Programs

The US Environmental Protection Agency (EPA) also catalogues Federal Funding Sources for Watershed Protection (2011) through which a number of drinking water, wastewater, and source water protection programs are included. Some of the programs overlap with those listed by W^2ASACT, but a number of programs offer funding for applicable projects (Table 9). In addition to the federal funding source catalogue, several grant programs are listed, including:

- Clean Water State Revolving Fund
- Drinking Water State Revolving Fund
- Performance Partnership Grants
- Section 106 Water Pollution Control Grants
- Safe Drinking Water Act
- Targeted Watersheds Grants Programs
- National Tribal Water Council Funding
- Wetlands Program Development Grants
- Environmental Education Grants Programs
- Regional Grant Opportunities

The Clean Water State Revolving Fund has been used successfully to fund cluster septic systems in which multiple residences are served by a communal septic system.

Table 9. Summary of Federal Funding Options

Draft FINANCIAL ASSISTANCE PROGRAMS AVAILABLE TO FUND WATER, WASTEWATER AND SOLID WASTE PROJECTS IN MONTANA

FEDERAL AGENCIES ACCEPTING UNIFORM APPLICATION

Program Name	Eligible Applicants	Eligible Projects	Local Match Required	Planning Costs Covered?	Amount of Funds Available Per Project	Loan Repayment Period	Ranking Criteria	Funding Cycle (Deadline)	Special Requirements and Additional Information	Program Contact

STATE AGENCIES ACCEPTING UNIFORM APPLICATION

Program Name	Eligible Applicants	Eligible Projects	Local Match Required	Planning Costs Covered?	Amount of Funds Available Per Project	Loan Repayment Period	Ranking Criteria	Funding Cycle (Deadline)	Special Requirements and Additional Information	Program Contact

ADDITIONAL FEDERAL FUNDING PROGRAMS

Program Name	Eligible Applicants	Eligible Projects	Local Match Required	Planning Costs Covered?	Amount of Funds Available Per Project	Loan Repayment Period	Ranking Criteria	Funding Cycle (Deadline)	Special Requirements and Additional Information	Program Contact

Draft FINANCIAL ASSISTANCE PROGRAMS AVAILABLE TO FUND WATER, WASTEWATER AND SOLID WASTE PROJECTS IN MONTANA

ADDITIONAL STATE FUNDING PROGRAMS

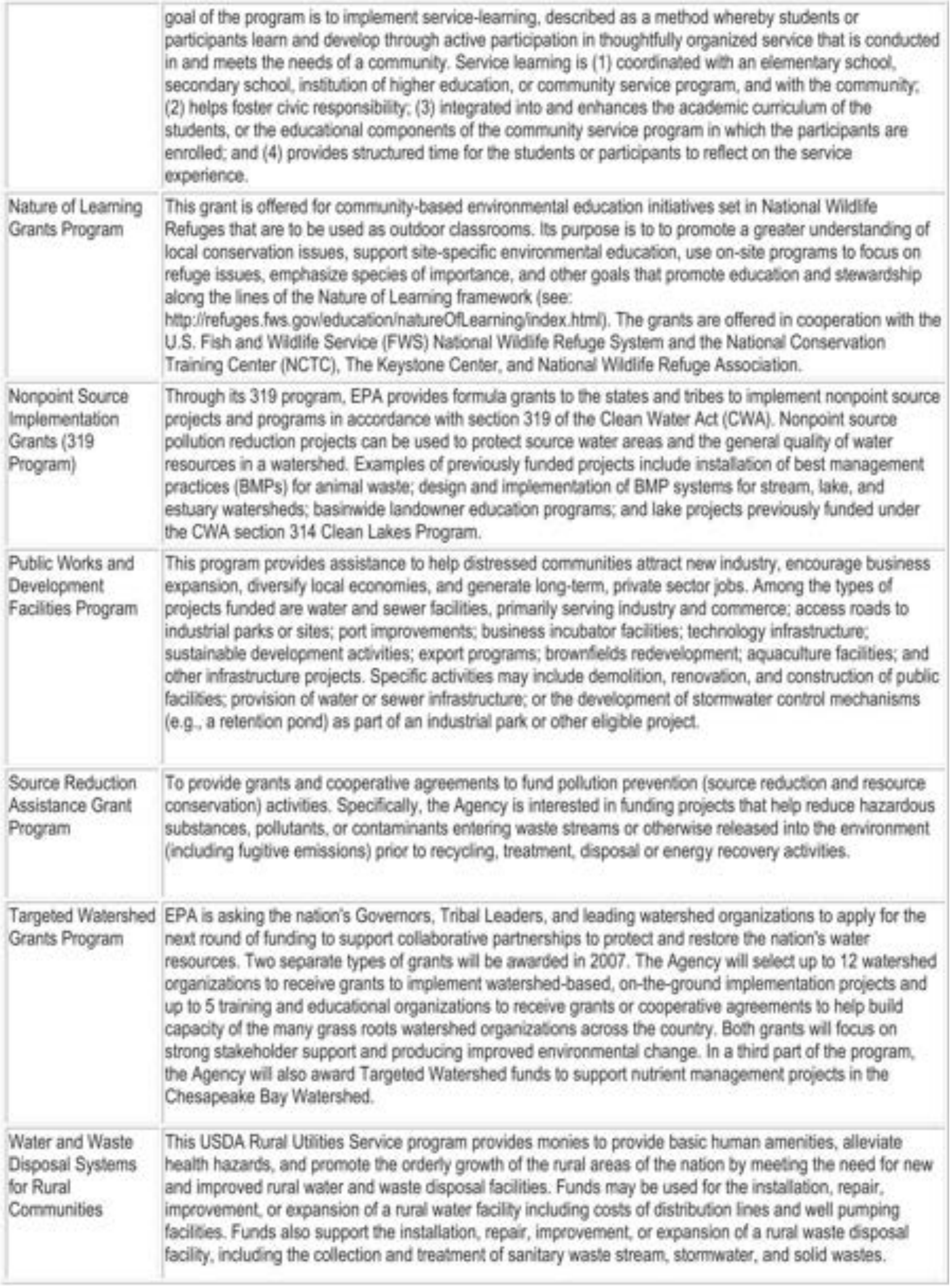
Program Name	Eligible Applicants	Eligible Projects	Local Match Required	Planning Costs Covered?	Amount of Funds Available Per Project	Loan Repayment Period	Ranking Criteria	Funding Cycle (Deadline)	Special Requirements and Additional Information	Program Contact
DNRC - **Reclamation & Development Grants Program (RDGP)** **a. RDGP Project Grants** **b. RDGP Project Planning Grants**	Governmental Agencies (includes Indian Tribes)	a. & b. Reclamation of land, water or other resources affected by mining and exploration, mitigation of damage to public resources caused by mining, investigation and remediation of hazardous waste sites	a. & b. No	a. No b. Yes	a. up to $300,000 b. up to $50,000	a. Not Applicable b. Not Applicable				a. & b. [illegible] 1625 11th avenue PO BOX 201601 Helena, MT 59620-1601 (406) 444-[illegible]
DOC – a. **Montana Coal Board Grant Program** b. **Quality Schools Program** 1. Project Grants 2. Planning Grants 3. Emergency Grants **Grant** (State)	a. Counties & Municipalities, Local Governmental Units, State Agencies, Special Districts, Water/Sewer Districts, Federally recognized Indian Tribes b. Updates pending	a. Water, Wastewater, and Solid Waste Systems b. Updates pending	a. Yes b. Updates pending	a. Yes b. Updates pending	a. No limitations, but typically no more than $200,000. Project cost estimates will be reviewed by Board. b. Updates pending	a. Not Applicable b. Updates pending	a. Five ranking criteria: Planning, Need, Severity of impact, Availability of funds, and Degree of local effort b. Updates pending	a. Continuous cycle, applications due prior to quarterly meetings b. Updates pending	a. Must represent areas experiencing impacts from coal development or decline. Planning grants are also provided. b. Updates pending	a. [illegible] - Montana Coal Board 301 S Park Avenue PO Box 200523 Helena, MT 59620-0523 (406) 841-[illegible] b. Updates pending
DOJ - **Natural Resource Damage Program** **Grant** (State)	General Public, Private Organizations, Governmental Agencies. Projects located in the Upper Clark Fork River Basin	Restoration Projects, Project planning, Monitoring and research Projects and Education Projects	No	No	Requests over or under $25,000	Not Applicable	-General Legal Criteria -General Policy Criteria -General Policy Criteria -General Policy Criteria	Projects over $25,000: Applications are due by April [illegible] Projects under $25,000: open cycle	Pre-Applications	[illegible], Program Specialist DOJ Natural Resource Damage Program 1301 East Lockey P.O. Box 201425 Helena, MT 59620-1425 (406) 444-[illegible]

PROGRAMS SPECIFICALLY FOR FUNDING TRIBAL PROJECTS

Program Name	Eligible Applicants	Eligible Projects	Local Match Required	Planning Costs Covered?	Amount of Funds Available Per Project	Loan Repayment Period	Ranking Criteria	Funding Cycle (Deadline)	Special Requirements and Additional Information	Program Contact
HUD - **Indian Community Development Block Grants** **Grants** (Federal)	Federally recognized Indian Tribes	Community Facilities, Economic Development, Housing Rehab, Water & Sewer Systems.	No, but up to 10 points are awarded for leveraged resources.	Yes, if not incurred before the grant.	[illegible]	Not Applicable	Five ranking criteria: Capacity of the applicant, Need/extent of the problem, Soundness of approach, Leveraged resources, and Comprehensiveness and coordination.	Annual competition, but deadline varies each year.	At least [illegible] of the beneficiaries of a project must be low or moderate income. Applications are normally due [illegible] days after publication of HUD's SuperNOFA, which is generally published in February or March.	Michael E. [illegible] HUD Northern Plains Office of Native American Programs 1670 Broadway Denver, CO 80202 (303) [illegible]
IHS – **Sanitation Facilities Construction Program** **Grants** (Federal)	Federally recognized Indian Tribes	Water and sewer facilities for new non-HUD funded housing. Funding to correct sanitation deficiencies.	No, but points are added for contributions to project	Planning is provided by IHS engineers.	No limit per project. $[illegible] to $40,000 limit per home, depending on situation.	Not Applicable	Deficiency level, O&M capability, Tribal Priority, Capital Cost, Health Impact, Previous Service from Federal Agencies, and other considerations.	May 1 of each year		[illegible], Commander U.S. Public Health Service Director Sanitation Facilities Construction Billings Area Indian Health Service PO Box [illegible] Billings, MT [illegible] (406) 247-[illegible]
EPA – **Clean Water Act (CWA) and Safe Drinking Water Act (SDWA) Indian Set Aside** **Grants** (Federal)	Federally recognized Indian Tribes	Water and sewer facilities for all Indian homes served by community facilities or that could be consolidated into community facilities.	No	Yes	No limit, but typically less than $150,000	Not Applicable	CWA - IHS Sanitation Deficiency System (SDS) is used. SDWA - Improvements to public health, public safety, ability to comply, environment, adequacy and efficiency, and utility capacity.	Usually around end of March each year.	Tribes may choose a direct grant from EPA or enter into an agreement with EPA and IHS to transfer funds to IHS, who then administers the project.	[illegible] U.S. EPA [illegible] 999 18th Street, Suite 500 Denver, CO 80202 (303) 312-[illegible]
EPA - **Interagency Tribal Solid Waste Management Assistance Project** **Grants and Loans** (Federal)	Federally recognized Indian Tribes and Intertribal Consortia	Characterizing/assessing open dumps, developing integrated solid waste management plans, developing alternative solid waste management activities/facilities and clean-up, closure and post-closure of open dumps.	No	Yes	Not specified. Since 1999, about $[illegible] million has been awarded for over 170 projects.	Not applicable unless awarding agency requires a loan as a component of the project.	Varies with project type; emphasis on sites posing threat to human health and the environment, evidence of solid waste management plans in place and implemented. Tribal in-kind commitment is [illegible].	Annually, usually in January or February.	A tribe may submit more than one proposal; final approval for assistance subject to awarding agency requirements. Technical assistance provided. Funded by EPA, BIA, IHS, USDA RD, and DoD	Stephanie [illegible] EPA Montana Office 10 W. 15th Street, Suite 3200 Helena, MT 59626 (406) 457-[illegible]
EPA – **General Assistance Program (GAP) Grants** **Grants** (Federal)	Federally recognized Indian Tribes	Program development and solid waste management	No	Yes	$175,000 max.	Not applicable	Grants are non-competitive.	Annually in January	Grants are for capacity development, not program implementation. However, solid waste implementation is allowable.	[illegible] EPA Montana Office 10 W. 15th St., Suite 3200 Helena, MT 59626 (406) [illegible]

Table 10. U.S. EPA Federal Funding Sources

Clean Water Act Indian Set-Aside Grant Program	The EPA's Clean Water Act Indian Set-Aside Grant Program provides assistance to Indian tribes for the planning, design, and construction of wastewater treatment systems. This program uses the Indian Health Service's (IHS) Sanitation Deficiency System (SDS) to identify priority wastewater projects for EPA grant funding. Eligible projects include interceptor sewers, wastewater treatment facilities, infiltration/inflow correction, collector sewers, major sewer system rehabilitation, and correction of combined sewer overflows
Clean Water State Revolving Fund	EPA awards grants to states to capitalize their Clean Water State Revolving Funds (CWSRFs). The states, through the CWSRF, make loans for high-priority water quality activities. As loan recipients make payments back into the fund, money is available for new loans to be issued to other recipients. Eligible projects include point source, nonpoint source and estuary protection projects. Point source projects typically include building wastewater treatment facilities; combined sewer overflow and sanitary sewer overflow correction; urban stormwater control; and water quality aspects of landfill projects. Nonpoint source projects include agricultural, silviculture, rural, and some urban runoff control; on-site wastewater disposal systems (septic tanks); land conservation and riparian buffers; leaking underground storage tank remediation, etc. Estuary protection projects include all of the above point and nonpoint source projects, as well as habitat restoration and other unique estuary projects.
Drinking Water State Revolving Fund	EPA awards grants to states to capitalize their Drinking Water State Revolving Fund (DWSRF) programs. States use a portion of their capitalization grants to set up a revolving fund from which loans are provided to eligible public water utilities (publicly- and privately-owned) to finance the costs of infrastructure projects. States rank projects and offer loans to utilities based on a priority ranking system. Priority is given to eligible projects that: (1) address the most serious risk to human health; (2) are necessary to ensure compliance with the requirements of the Safe Drinking Water Act; and, (3) assist systems most in need, on a per household basis, according to state-determined affordability criteria. States may also use up to 31 percent of their capitalization grants to fund set-aside activities that help to prevent contamination problems of surface and ground water drinking water supplies, as well as enhance water system management through source water protection, capacity development, and operator certification programs.
Environmental Education Grants	This program provides funding for the following educational priorities: (1) Capacity Building: Increasing capacity to develop and deliver coordinated environmental education programs across a state or across multiple states. Steps include developing effective leaders and organizations which create strategic plans to implement and link environmental education programs to promote long term programs and to decrease fragmentation of effort and duplication across programs; (2) Education Reform: Utilizing environmental education as a catalyst to advance state, local, or tribal education reform goals; (3) Community Issues: Designing and implementing model projects to educate the public about environmental issues and/or health issues in their communities through community-based organizations or through print, film, broadcast, or other media; (4) Health: Educating teachers, students, parents, community leaders, or the public about human-health threats from environmental pollution, especially as it affects children, and how to minimize human exposure to preserve good health; (5) Teaching Skills: Educating teachers, faculty, or non-formal educators about environmental issues to improve their environmental education teaching skills, e.g., through workshops; or (6) Career Development: Educating students in formal or non-formal settings about environmental issues to encourage environmental careers.
Five-Star Restoration Program	The EPA supports the Five-Star Restoration Program by providing funds to the National Fish and Wildlife Foundation and its partners, the National Association of Counties, NOAA's Community-based Restoration Program and the Wildlife Habitat Council. These groups then make subgrants to support community-based wetland and riparian restoration projects. Competitive projects will have a strong on-the-ground habitat restoration component that provides long-term ecological, educational, and/or socioeconomic benefits to the people and their community. Preference will be given to projects that are part of a larger watershed or community stewardship effort and include a description of long-term management activities. Projects must involve contributions from multiple and diverse partners, including citizen volunteer organizations, corporations, private landowners, local conservation organizations, youth groups, charitable foundations, and other federal, state, and tribal agencies and local governments. Each project would ideally involve at least five partners who are expected to contribute funding, land, technical assistance, workforce support, or other in-kind services that are equivalent to the federal contribution.
Learn and Serve America Program	Learn and Serve America provides students and youth with opportunities to serve America by connecting community service with academic learning, personal growth, and civic responsibility. Typical projects address local needs in the areas of education, public safety, the environment, and other human needs. The



	goal of the program is to implement service-learning, described as a method whereby students or participants learn and develop through active participation in thoughtfully organized service that is conducted in and meets the needs of a community. Service learning is (1) coordinated with an elementary school, secondary school, institution of higher education, or community service program, and with the community; (2) helps foster civic responsibility; (3) integrated into and enhances the academic curriculum of the students, or the educational components of the community service program in which the participants are enrolled; and (4) provides structured time for the students or participants to reflect on the service experience.
Nature of Learning Grants Program	This grant is offered for community-based environmental education initiatives set in National Wildlife Refuges that are to be used as outdoor classrooms. Its purpose is to to promote a greater understanding of local conservation issues, support site-specific environmental education, use on-site programs to focus on refuge issues, emphasize species of importance, and other goals that promote education and stewardship along the lines of the Nature of Learning framework (see: http://refuges.fws.gov/education/natureOfLearning/index.html). The grants are offered in cooperation with the U.S. Fish and Wildlife Service (FWS) National Wildlife Refuge System and the National Conservation Training Center (NCTC), The Keystone Center, and National Wildlife Refuge Association.
Nonpoint Source Implementation Grants (319 Program)	Through its 319 program, EPA provides formula grants to the states and tribes to implement nonpoint source projects and programs in accordance with section 319 of the Clean Water Act (CWA). Nonpoint source pollution reduction projects can be used to protect source water areas and the general quality of water resources in a watershed. Examples of previously funded projects include installation of best management practices (BMPs) for animal waste; design and implementation of BMP systems for stream, lake, and estuary watersheds; basinwide landowner education programs; and lake projects previously funded under the CWA section 314 Clean Lakes Program.
Public Works and Development Facilities Program	This program provides assistance to help distressed communities attract new industry, encourage business expansion, diversify local economies, and generate long-term, private sector jobs. Among the types of projects funded are water and sewer facilities, primarily serving industry and commerce; access roads to industrial parks or sites; port improvements; business incubator facilities; technology infrastructure; sustainable development activities; export programs; brownfields redevelopment; aquaculture facilities; and other infrastructure projects. Specific activities may include demolition, renovation, and construction of public facilities; provision of water or sewer infrastructure; or the development of stormwater control mechanisms (e.g., a retention pond) as part of an industrial park or other eligible project.
Source Reduction Assistance Grant Program	To provide grants and cooperative agreements to fund pollution prevention (source reduction and resource conservation) activities. Specifically, the Agency is interested in funding projects that help reduce hazardous substances, pollutants, or contaminants entering waste streams or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, disposal or energy recovery activities.
Targeted Watershed Grants Program	EPA is asking the nation's Governors, Tribal Leaders, and leading watershed organizations to apply for the next round of funding to support collaborative partnerships to protect and restore the nation's water resources. Two separate types of grants will be awarded in 2007. The Agency will select up to 12 watershed organizations to receive grants to implement watershed-based, on-the-ground implementation projects and up to 5 training and educational organizations to receive grants or cooperative agreements to help build capacity of the many grass roots watershed organizations across the country. Both grants will focus on strong stakeholder support and producing improved environmental change. In a third part of the program, the Agency will also award Targeted Watershed funds to support nutrient management projects in the Chesapeake Bay Watershed.
Water and Waste Disposal Systems for Rural Communities	This USDA Rural Utilities Service program provides monies to provide basic human amenities, alleviate health hazards, and promote the orderly growth of the rural areas of the nation by meeting the need for new and improved rural water and waste disposal facilities. Funds may be used for the installation, repair, improvement, or expansion of a rural water facility including costs of distribution lines and well pumping facilities. Funds also support the installation, repair, improvement, or expansion of a rural waste disposal facility, including the collection and treatment of sanitary waste stream, stormwater, and solid wastes.

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ADDENDA

ADDENDUM 7.1
Project Field Data

ADDENDUM 7.2
Laboratory Reports

ADDENDUM 7.3
QA/QC Results

ADDENDUM 7.4
Stormwater Conveyance map

ADDENDUM 7.5
Grant Project Costs

ADDENDUM 7.6
Certificate of Compliance