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Sarah Jane Harrison
AUTEUR DE LA THÈSE / AUTHOR OF THESIS

M.Sc. (Biology)
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Department of Biology
FACULTÉ, ÉCOLE, DÉPARTEMENT / FACULTY, SCHOOL, DEPARTMENT

Relationships Between Land Use and Mercury Contamination in Twelve Tributaries of the Lake St. Francis Region of the St. Lawrence River near Cornwall, Ontario

TITRE DE LA THÈSE / TITLE OF THESIS

A. Poulain
DIRECTEUR (DIRECTRICE) DE LA THÈSE / THESIS SUPERVISOR

D. Fortin
CO-DIRECTEUR (CO-DIRECTRICE) DE LA THÈSE / THESIS CO-SUPERVISOR

Jeremy Kerr

Marc Amyot

Gary W. Slater
Le Doyen de la Faculté des études supérieures et postdoctorales / Dean of the Faculty of Graduate and Postdoctoral Studies

# Relationships Between Land Use and Mercury Contamination in Twelve Tributaries of the Lake St. Francis Region of the St. Lawrence River near Cornwall, Ontario

Sarah Harrison

Department of Biology

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395 Wellington Street
Ottawa ON K1A 0N4
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Direction du
Patrimoine de l'édition

395, rue Wellington
Ottawa ON K1A 0N4
Canada

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# Abstract

In the environment, oxidized mercury (Hg) can be converted to more toxic chemical species, such as methylmercury (MeHg), as a result of both abiotic and biotic reactions. Hg and MeHg are present in aquatic ecosystems that flow into the Lake St. Francis region of the St. Lawrence River, but their origin is still being debated. A study of mercury and methylmercury contamination in Lake St. Francis in cooperation with the Raisin Region Conservation Authority (RRCA) is ongoing, in collaboration with the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) and the Great Lakes Program. A recent report detailed the experimental results for one portion of the area of concern, the Raisin River. The goal of the present project is to update and expand upon the previous work in order to include other existing and new data for this river and several other watercourses feeding Lake St. Francis. Special attention was paid to the MeHg hotspots in an attempt to link methylation and subsequent mobilization to different types of land use and nutrient profiles compiled from new and existing data.

It was predicted that water draining off wetlands would have higher MeHg concentrations than water from catchments with other land use profiles. Total and methylmercury were expected to be correlated to the concentrations of nitrogen compounds, sulfate, phosphorus, dissolved inorganic carbon (DIC), and especially dissolved organic carbon (DOC). However, wetlands could not be correlated to MeHg as predicted but the area of crop land was correlated positively with the percentage of THg present as MeHg. Forest and impermeable areas were associated with a decrease in mercury. There was no difference in mercury during wet years compared to dry years when compared on an annual basis, but a significant seasonal difference exists between the two categories. MeHg was positively correlated to DOC, $NH_3$, and BOD. THg was positively correlated to BOD, TSS, *Escherichia coli*, and fecal coliforms. The percentage of THg present as MeHg (%MeHg) was positively correlated to phosphorus. There were also some statistically significant negative correlations. Forest and impermeable area were negatively correlated with the quantity of MeHg, and impermeable area was negatively correlated with %MeHg. Greater predictor strength and more numerous significant correlations are expected under more thorough sampling and more data.

# Résumé

Le mercure oxydé présent dans l'environnement peut être converti en méthyle mercure (MeHg) suite à des réactions biotiques et abiotiques. Le Hg et MeHg sont présents dans les écosystèmes aquatiques s'écoulant vers le lac St. Francis, mais leur origine demeure incertaine. Une étude de la contamination du mercure et du méthyle mercure dans Lac St. Francis, en coopération avec l'Autorité de Conservation de la Région Raisin (RRCA) et le Ministère de l'Agriculture, de l'Alimentation et des Affaires Rurales et le Programme des Grands Lacs, est maintenant en cours. Un rapport précédant a détaillé les résultats expérimentaux pour une partie de la rivière Raisin, mais le but principal de ce projet est de mettre à jour et d'augmenter le nombre de données pour cette rivière, ainsi que pour plusieurs autres tributaires du Lac St. Francis, afin de déterminer la contribution relative de THg et de MeHg dans les tributaires de la région de Lac St. Francis. Une attention toute particulière a été portée aux endroits hautement contaminés en MeHg, afin de déterminer le lien entre la méthylation et la mobilisation de MeHg et les différents types de profils nutritifs des échantillons déjà compilés et des nouvelles données.

L'hypothèse principale du projet prévoit que l'eau quittant les marécages aura une concentration plus élevée de MeHg que les autres sources d'eau. Le mercure total et méthylé devraient être corrélés avec les concentrations des composés azotés, de sulfate, de phosphore, de carbone inorganique dissout (CID), et particulièrement de carbone organique dissout (COD). Les résultats indiquent toutefois que les marécages ne sont pas corrélés avec le mercure. Cependant, le type de terrain, soit le secteur agricole, a été positivement corrélé avec le pourcentage de THg existant sous forme de MeHg. La forêt et les secteurs imperméables sont aussi des facteurs prédictifs d'une diminution de mercure. Il n'y a toutefois pas de différence entre les années humides et sèches, lorsqu'elles sont comparées sur une base annuelle, mais il y a une différence saisonnière significative qui existe entre les deux catégories. Le MeHg est corrélé avec le DOC, le $NH_3$ et la DBO. Le THg est corrélé avec la DBO, les solides totaux dissous, *Escherichia coli* et les coliformes fécaux. Le pourcentage de THg présent sous forme de MeHg (%MeHg) est aussi corrélé avec le phosphore. Il y a également quelques corrélations négatives statistiquement significatives. Les forêts et les zones imperméables sont négativement corrélées avec la quantité de MeHg. Les zones imperméables sont aussi négativement corrélées avec %MeHg. Une plus grande force du facteur prédictif et des corrélations significatives plus nombreuses devraient néanmoins améliorer les prédictions.

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# Table of Contents

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# Acronyms and Abbreviations

| | |
|---|---|
| ACS | American Chemical Society |
| ANOVA | Analysis of Variance |
| BOD | Biochemical Oxygen Demand |
| CVAFS | Cold Vapour Atomic Fluorescence Spectroscopy |
| DEM | Digital Elevation Model |
| DIC | Dissolved Inorganic Carbon |
| DO | Dissolved Oxygen |
| DOC | Dissolved Organic Carbon |
| DOM | Dissolved Organic Material |
| DV | Dependent Variable |
| EC | *Escherichia coli* |
| ESRI | Environmental Sciences Research Institute |
| FC | Fecal Coliform |
| Fe | Iron |
| GCMS | Gas Chromatograph with Mass Spectrometer |
| GCS | Geographic Coordinate System |
| GIS | Geographic Information Systems |
| Hg(II) | Divalent Mercury |
| $Hg^0$ | Elemental Mercury |
| HPOA | Hydrophobic Organic Acid |
| IBI | Index of Biotic Integrity |
| IHg | Inorganic Mercury |
| IV | Independent Variable |
| LCC | Lambert Conformal Conic |
| LOI | Loss on Ignition |
| MeHg | Methyl Mercury, $CH_3Hg$, monomethyl mercury |
| MNR | Ministry of Natural Resources |
| $NH_3$ | Ammonia |
| NHN | National Hydrological Network |
| $NO_3$ | Nitrate |
| OMAFRA | Ontario Ministry of Agriculture Farms and Rural Affairs |
| RR | Raisin River |
| RRCA | Raisin Region Conservation Authority |
| SBOD | Soluble Biochemical Oxygen Demand |
| SLR | St. Lawrence River |
| SLRIES | St. Lawrence River Institute of Environmental Sciences |
| $SO_4$ | Sulfate |
| SRB | Sulfate-reducing Bacteria |
| TDS | Total Dissolved Solids |
| THg | Total Mercury |
| TP | Total Phosphorus |
| TSS | Total Suspended Solids |

# Glossary

| | |
|---|---|
| Bioaccumulation | The buildup of a substance in the tissues of an organism. |
| Biomagnification | The non-linear increase in the amount of a bioaccumulating substance as the food chain is ascended. |
| Bog | Waterlogged ground or wetland with a peat substrate. |
| Catchment | The area over which water accumulates for a specific water body. |
| Conifer | Needle- or scale-leaved trees or shrubs that bear cones, eg. spruce and pine trees. |
| Deciduous | Describes trees that shed their foliage at the end of each growing season, eg. maple and birch trees. |
| Delineate | To determine the course of a line marking the limit of a geographic condition. For example, the shape of a catchment area. |
| Eutrophication | A body of water rich in organic nutrients, typically resulting in an over-abundance of algae to the detriment of other organisms. |
| Evapotranspiration | The loss of water from the Earth's surface and from vegetation through evaporative and reparative processes. |
| Extraction | Any procedure designed to separate the components of a mixture. |
| Fen | Similar to a bog, but less acidic and with an inflow and outflow instead of rain as the primary water source. |
| GeoBase | Online source of free Canadian geospatial data from federal, provincial, and territorial government sources. |
| GeoGratis | Online source of free geospatial data provided by Natural Resources Canada. |
| Hypopheric zone | Ground depth at which surface water and ground water may mix. |
| Land use | Categorisation of the function of different geographic units of area. |
| Lipophilic | Having an affinity for lipids. |
| Load | Contaminant quantity expressed as a function of area (mg/km$^2$). |
| Loam | A soil mixture typically containing silt, sand, clay, and decaying plant matter. |
| Methylation | The process of adding a methyl group to an element or molecule. |
| Oxidation | A loss of electrons and consequent increase in oxidation state. |
| Projection | The process of visualizing the spherical Earth in a two-dimensional representation. |
| Reduction | A gain of electrons and consequent decrease in oxidation state. |
| Spring freshet | The increased flow that results from the annual melting of accumulated snow. |
| Trophic level | The position of a species on the food chain. |
| Volatilization | The process of a substance evaporating. |
| Watershed | The outline of a catchment. |
| Wetland | Generic term for an area of land that has high soil moisture content, whether constant or seasonal. |
| Yield | The concentration of a contaminant expressed as a function of area and time, eg. x mg/km$^2$/day |

# 1 Introduction

## 1.1 *Background*

This study was conducted to expand on knowledge of mercury and methylmercury contamination in several tributaries of Lake St. Francis in the Cornwall, Ontario region. Specifically, the relationships between land use and MeHg formation and mobilization are examined.

### 1.1.1 Mercury, a global pollutant

Mercury is a known environmental contaminant and neurotoxin with varying degree of harmfulness depending on its form and the route of exposure (Ekstrom and Morel, 2008). Methylmercury (MeHg) is one of the most toxic forms of mercury. Organic mercury can be harmful to biota at a tenth of the concentration of inorganic mercury (Boening, 2000).

Deposition and volatilization cause important fluxes to take into consideration for creating catchment area mercury budgets. Inorganic mercury enters aquatic and terrestrial environments via atmospheric deposition and is methylated *in situ*. Plants are adversely affected by mercury in the water at 1mg/L Hg, and much lower concentrations for MeHg (Boening, 2000). Typically, lakes of the boreal shield in Canada exhibit Hg levels in the ng/L range. Long-term exposure to even low levels of methylmercury can have detrimental effects on biota due to accumulation within individual organisms, but humic material and sediments (i.e., clays) reduce the availability of mercury to aquatic plants via adsorption (Boening, 2000; Gabriel and Williamson, 2004). All forms of mercury exposure may have a wide range of sublethal effects. MeHg is readily bioaccumulated and biomagnified (DeForest et al., 2007; Fowlie et al., 2008), because it takes considerably longer for organisms to process and excrete MeHg than other mercury compounds. There is, however, hope for recovery. A 20-year study of four species of fish in the SLR showed that Hg levels have declined since 1975 (Goulet et al., 2008).

Atmospheric mercury is typically in the form $Hg^0$ (Selvendiran et al., 2008) (Figure 1 [1]). Oxidation reactions convert elemental mercury ($Hg^0$) to inorganic divalent mercury ($Hg^{2+}$), which is then readily deposited by precipitation or small airborne particles, called wet and dry deposition, respectively (Figure 1 [2]). The amount of $Hg^{2+}$ deposited at the surface of ecosystems from the atmosphere has increased five-fold since the industrial revolution, due in part to many factors including both anthropogenic and natural events (Streets et al., 2009). Human-induced increases are caused primarily by coal burning, metal processing, biomass burning, and gold mining, whereas natural sources of atmospheric mercury include volcanic eruptions, forest fires, localized ground deposits, and volatilization from lakes and oceans (Boening, 2000; Baeyens et al., 2003). The increasing concentrations of mercury in the air has led to greater deposition rates and consequently the potential for increased rates of MeHg production. Atmospheric transport of inorganic mercury occurs at a hemispheric scale (Streets et al., 2009), while overstory vegetation enhances direct deposition (Selvendiran et al., 2008). Mercury is a global problem because it can travel very far from its emission point. The presence of mercury in a wetland is therefore not necessarily an indication of a local pollution problem (Lean, 2000; Martinez-Cortizas, 1999; Schroeder and Munthe, 1998). Wet and dry deposition of MeHg is also possible, but in much smaller quantities (Morel et al., 1998). Wet deposition is usually in the form of Hg(II) and is considered a unidirectional process (Poissant et al., 2000).

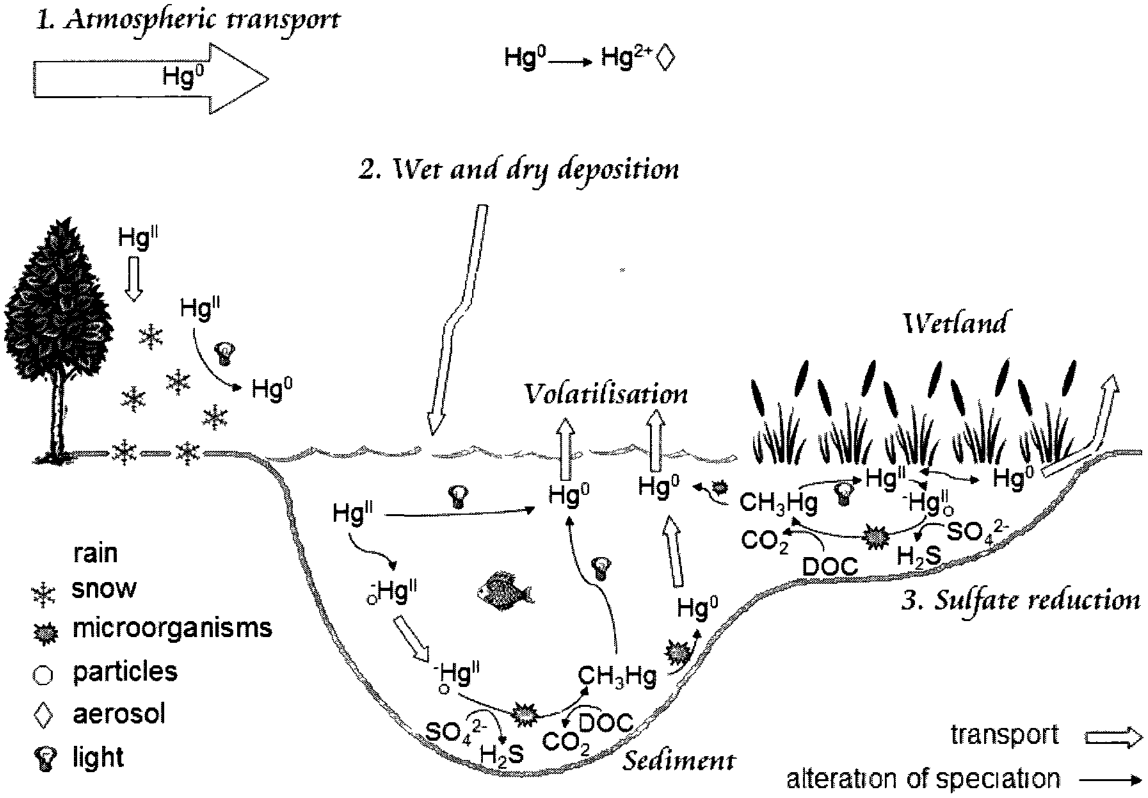


**Figure 1.** A schematic description of the mercury cycle.

Export of mercury from catchments lags behind atmospheric deposition and mercury levels may increase before they decline in response to decreased emissions (Mills et al., 2009). However, the size of a water catchment does not appear to affect the Hg export per unit area (Mills et al., 2009). Catchments are not in a steady state of Hg deposition and export. Mobilization of the MeHg is a function of the erosional properties of the soil as well as the volume of water flowing over/through the area. Easily eroded land cover types are more likely to have higher concentrations of DOC-bound contaminants, such as MeHg, in their runoff (Babiarz et al., 1998). Other studies have supported the hypothesis that methylation occurs near the surface of wetlands (Lean, 2000).

### 1.1.2 Biological significance of methylmercury

Methylmercury is of much greater biological concern than the inorganic forms. The methyl group makes MeHg much more readily accessible to living organisms than other forms of Hg, and it is therefore much more likely to bioaccumulate and biomagnify. Different MeHg complexes have different solubilities, and this affects where they are found in the water column as well as in the system as a whole (Gabriel and Williamson, 2004).

Methylmercury is the most biologically active species of mercury (Bemtssen, 2003). It is a known neurotoxin in fish, birds, and mammals that interferes with immune systems and impedes successful reproduction. Methylmercury has serious consequences for aquatic ecosystems since it easily accumulates along the food chain due to its persistence within organisms (Harris and Bodaly, 1998). Methylmercury can have bioaccumulation rates in the aquatic food chain by a factor of up to 10 million in piscivorous fish, which in turn increases exposure to other wildlife and humans (Driscoll et al., 2007). Organisms are almost certainly exposed to mixtures of metals, but little work has been done to establish the toxicity of MeHg in combination with other contaminants (Boening, 2000).

Toxicity is highly species-dependent, i.e., aquatic plants suffer at 800-1200 μg/L inorganic mercury, whereas fish die at 30 μg/L, and larvae are ten times more sensitive (Boening, 2000). In addition, fish are up to 100 times more sensitive in flow-through tests (Boening, 2000). Organic mercury is approximately ten times as toxic as inorganic mercury.

Methylmercury is known to biomagnify in terrestrial and marine ecosystems (Merritt and Amirbahman, 2008), but if point source contamination is stopped, water concentrations will decrease very quickly. Fish contamination takes much longer to decline, especially at higher levels of the food chain. Mercury gets into terrestrial food webs from aquatic ecosystems through birds eating insects (Cristol et al., 2008). Organisms that are higher in their food web have greater proportions of MeHg than inorganic Hg, the opposite of what is observed at the base of the food pyramid. Cristol et al. (2008) found that some terrestrial songbirds had more MeHg than fish-eating birds because of longer food chains when feeding on predatory invertebrates.

Rivers can have greater concentrations of DOC than lakes. In the plume of a river running into a lake, the DOC concentration declines as mixing occurs (Gorskie et al., 2008). The input of DOC from a river into a lake contributes to algal growth, which take up MeHg, introducing it to the food chain at the lowest level, and making it more bioavailable to other organisms in the lake (Gorskie et al., 2008). The tendency of MeHg to accumulate in the tissues of an organism is sometimes expressed as a bioconcentration factor, or BCF, as a value relative to the MeHg concentration in the water (L/kg).

#### 1.1.2.1 Relevance to human health

Dietary intake of biomagnified MeHg seafood is the primary route of exposure for humans. In Ontario, fish such as walleye, northern pike, large-mouth bass, and whitefish are commonly consumed (Kinghorn et al., 2007). These species contain varying amounts of MeHg depending on their geographic location and food web coordinates. The degree to which the current mercury levels in fish tissues present a hazard for humans is a hotly debated topic among physiologists. Consumed MeHg may promote heart disease, pass through the placental barrier, and is detrimental to neural development (Choi and Grandjean, 2008). It is excreted with urine and feces, and also in hair. Hair is often used to assess human exposure, but blood analysis is more reliable as excretion through hair is more variable between subjects (Canuel et al., 2006). For these reasons, there is currently much research activity with a view to setting fish consumption guidelines for humans.

Many studies focus on MeHg rather than analyzing other Hg species because MeHg accounts for greater than 95% of total mercury in the majority of fish tissue samples (Kinghorn et al., 2007). Setting consumption guidelines is challenging because the concentration of MeHg in water has to be related to tissue concentrations in a wide variety of species with vastly different feeding habits, environmental niches, and trophic levels (Hope et al., 2007). Understanding and characterizing the environmental fate and behaviour of MeHg is a crucial element of current efforts to preserve human health.

### 1.1.3 Mercury in aquatic ecosystems

The environmental fate and behaviour of mercury compounds in lakes and rivers has been described at length in the literature. Diel and seasonal patterns in volatilization of $Hg^0$ exist as a result of increasing sunlight and temperature and are dependent upon soil humidity in terrestrial systems. Volatilization of $Hg^0$ is generally greater during the day and under dry conditions. Though it was previously assumed to be zero in winter due to snow cover (Selvendiran et al., 2008), it has since been shown that $Hg^0$ volatilization from snow is occurring in the Canadian Arctic (Duval, 2009; Poulain et al., 2004). Volatilization from wet soil is slower than deposition, perhaps because the moisture slows down movement to the soil-air interface. Lower oxidation-reduction potential combined with high biological activity and saturated surfaces may contribute to higher volatilization from wetlands than from soil and lakes (Selvendiran et al., 2008).

Methylation is possible under both aerobic and anaerobic conditions (Amirbahman et al., 2002), though the rate of methylation may be different depending on other chemical, physical, or environmental influences. For example, lakes with more wetlands in their catchment area are likely to have higher concentrations of MeHg than lakes with fewer surrounding wetlands (St. Louis et al., 1996). Methylmercury is mobilized when it binds to DOC, which is abundant in all types of wetlands (Hall et al., 2008; Merritt and Amirbahman, 2007) (Figure 1). Near the ground-to-air interface, more MeHg is bound to DOC than the MeHg found at depth (Clarisse et al., 2009). The presence and transport of Hg has been associated with the availability of DOC (Grigal, 2002). In addition, the retention of organic matter in wetlands leads to high retention of Hg (Regnell and Hammar, 2004), but high-flow events are the primary means of export of MeHg; baseflow contributes comparatively much less (Balogh et al., 2004).

Methylmercury persists in anoxic wetlands where the methylation rate exceeds the demethylation rate (Goulet et al., 2007). Porewater studies have shown that sulfur chemistry and SRB activity are important for methylation of mercury (Goulet et al., 2007; Benoit et al., 1999). Methylmercury is known to be formed in wetlands, such as those in the Raisin Region near Cornwall, Ontario (Lean, 2000). There is elevated methylation of mercury in wetlands compared to other soil types. Previous work has shown that during high-flow periods, there is a higher ratio of MeHg to THg (Balogh et al., 2006). Increased concentrations of MeHg have also been associated with the higher levels of phosphorus and lower $O_2$ levels typical of anoxic environments (Balogh et al., 2006).

Peat bogs and marshy environments are ideal for microbial methylation of mercury because they are rich in organic matter and sulfates used by methylating bacteria (Newman and Unger 2003; Gustin et al., 2006; Babiarz et al., 1998; Lean, 2000; Martinez-Cortizas, 1999; Selvendiran et al., 2008; Shanley et al., 2008; Hall et al., 2008) (Figure 1 [3]). The presence and quantity of MeHg is related to many physical and chemical factors such as salinity, UV light, and nutrients present in the water. Both THg and MeHg are positively correlated to DOC and hydrophobic organic acid, also called HPOA (Hall et al., 2008), which are characteristic of wetlands. Peat bogs and other wetlands are potential long-term and short-term sources of mercury to downstream ecosystems.

Conditions conducive to methylation exist in the hyporheic zone in wetlands (Creswell et al., 2008). Reduced iron and sulfide accumulate during summer months as a result of microbial activity (Creswell et al., 2008), which also coincides with higher MeHg concentrations (Creswell et al., 2008). A study undertaken in Spain showed that THg is strongly correlated with TDS and chlorophyll-a (Nevado et al., 2009). The study supported other work with regards to the correlation between DOC and MeHg, and also found that Fe appeared to play a role in the methylation of mercury (Nevado et al., 2009), though to a lesser extent than SRB. Inhibition of SRB (82 to 96% inhibition of sulfate reduction) in a California study reduced the methylation by less than half (14 to 46%), therefore the role of Fe-reducing bacteria and other anaerobic organisms may have been previously underestimated (Fleming et al., 2006).

#### 1.1.3.1 Mercury and sulfate

The sulfur cycle in the surface peat also plays an important role as it may increase the availability of $SO_4$ to SRB. Sulfate can increase the methylation rate by acting as an electron acceptor for the SRB (Selvendiran et al., 2008; Compeau and Bartha, 1985; Gilmour et al., 1992), although the bacterial mechanisms are not yet well-understood. For example, Jeremiason et al. (2006) divided a wetland in half and added sulfate to the same half on four occasions and compared the MeHg in the outflow of the control and experimental halves. The MeHg concentration in the experimental half was three times that of the control half after the second application of sulfate (Jeremiason et al., 2006).

This implies a positive correlation between $SO_4$ and the rate of mercury methylation, which has been confirmed in other studies (Watras and Morrison, 2008). However, Han et al. (2010) found that methylation can also occur under sulfate-limited conditions by a different process.

Goulet et al. (2007) studied the Lake St. Francis Bay wetland, which is geographically proximate to the sites included in the present study. They found that the concentration of MeHg is positively correlated to the concentration of sulfate (Goulet et al., 2007). Another recent study found that adding organic carbon (glucose, acetate, and lactate) to a wetland does not result in an increased rate of methylation of inorganic mercury, but that adding $SO_4$ does cause an increase in methylation (Mitchell et al., 2008). In the St. Lawrence River, THg concentrations have been correlated to organic sulfur in solid samples (Canario et al., 2008). Availability of $SO_4^-$ is key to biotic methylation, but the role of DOC, though certainly important, is much less understood. The rate of methylation is correlated to the rate of sulfate reduction (King et al., 1999; 2001). Unlike the Hall et al., (2008) study, Mitchell et al. (2008) found that MeHg production was greatest when $SO_4$ and organic carbon were delivered concurrently, presumably through the activities of SRB. Other types of bacteria, such as iron-reducing bacteria, may also be important methylators in iron-rich freshwater sediments (Fleming et al., 2006). Effects of other environmental conditions are beginning to come to light. Two newly-identified limiting factors for bacterial methylation of mercury are cobalt and vitamin $B_{12}$ (Ekstrom and Morel, 2008).

### 1.1.4 Land use and environmental disturbance

Production, accumulation, and mobilization of MeHg depend on nutrient and oxygen levels, bacterial activity, and the rate of water flow through an environment, controlling the delivery of the inorganic Hg substrate for methylation. Factories and industry in the area have been vilified and blamed for the MeHg problem (Fowlie et al., 2008). However, it is not likely that industry is the main contributor. The appearance of MeHg in water samples is the result of a series of complex ecological interactions. There are many variables that affect mercury in the environment that are only very recently the subject of scientific study.

Previous work has shown that MeHg is associated with higher levels of DOC, and lower levels of dissolved oxygen (Balogh et al., 2005). A Minnesota study showed that land use had a greater effect on THg than on MeHg, and that the profiles of THg and MeHg are similar among catchments of different land use compositions (Balogh et al., 2005). In addition, drying peat can substantially increase leaching but, if the latter is stable, it does not release much mercury during regular aerobic and anaerobic cycling. Disturbed wetlands, on the other hand, produce more MeHg (Boening, 2000).

The Raisin River research area is unique because the terrain is comparatively flat. The land is often water-saturated because of the lack of downhill gradient. Water levels are lowered by tile drains and deep trenches created and maintained by landowners seeking to increase the area of their agriculturally viable land (Figure 2). Historically, wetlands such as the papyrus fields by the Nile River and the great tidal marsh of England were drained for farming hundreds of years ago. Precipitation causes re-saturation of the artificially dried upper layers, which drains very slowly. Re-wetting not only stimulates bacterial methylation, but can introduce more DOC to facilitate MeHg mobilization (Hall et al., 2008). MeHg hotspots are expected to be found near the upland-peatland interface because of DOC and $SO_4$ runoff from adjacent hill slopes (Mitchell et al., 2008).

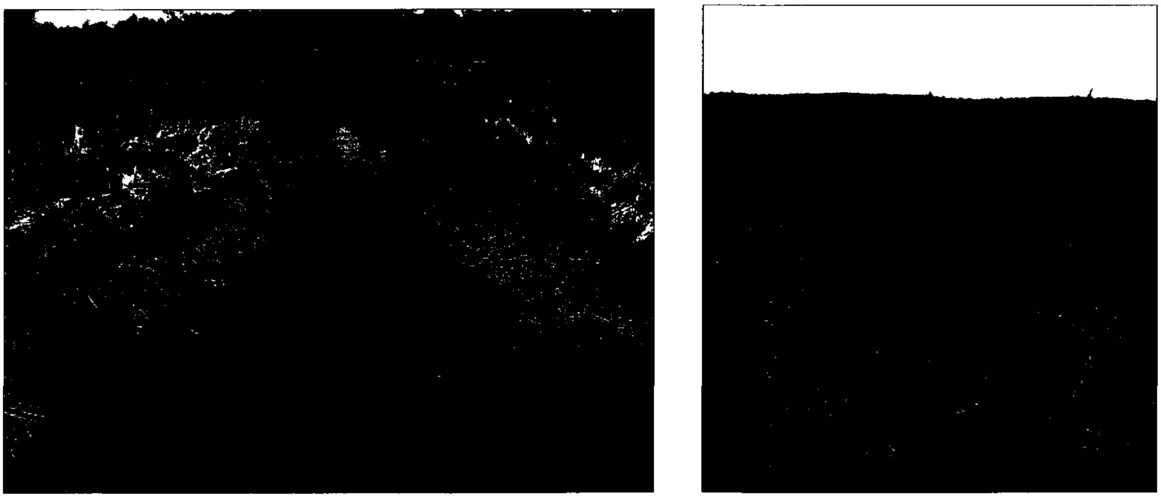


**Figure 2.** Examples of drainage measures in the Raisin Region.

## *1.2 Precipitation and runoff*

### 1.2.1 Runoff

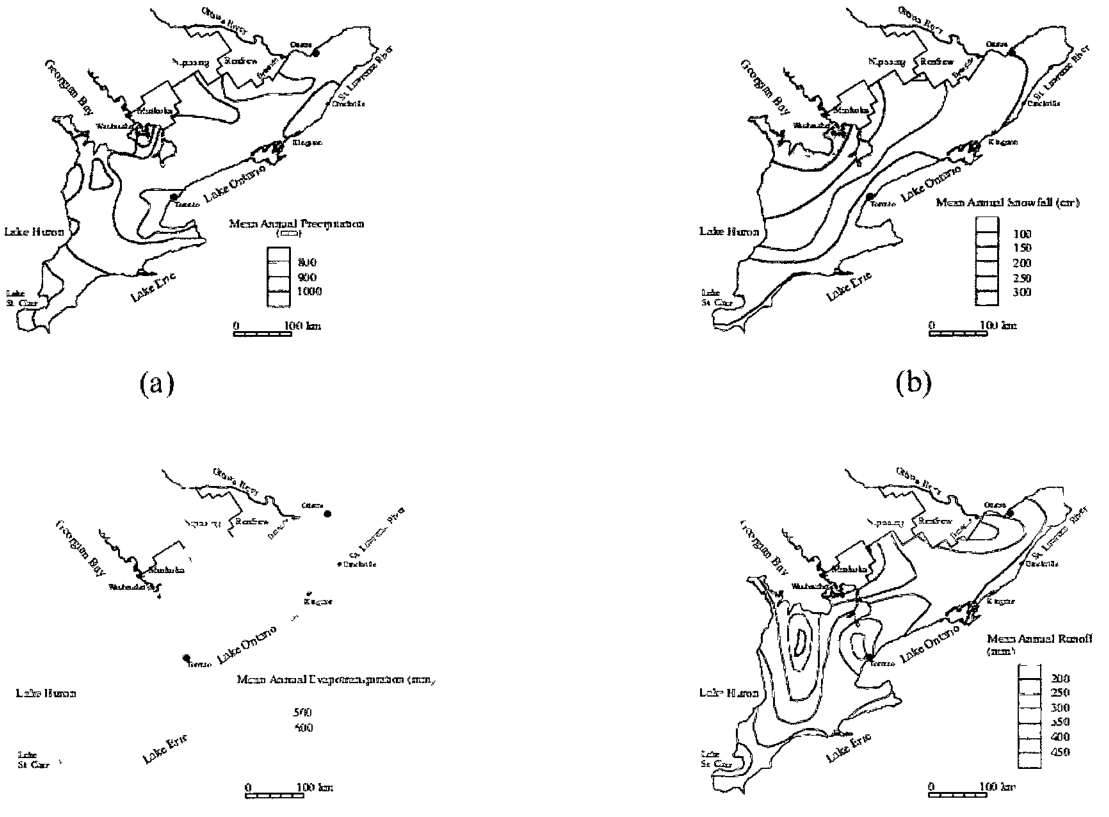
Runoff is a function of slope (topography), porosity, depth of topsoil layer, vegetation type and quantity, erosion potential, land use, and anthropogenic interruptions that cannot be determined by GIS images alone. Not only slope, but the shape of the slope must be taken into account. Over-reliance on GIS imagery may have negative consequences in conservation efforts, as the Earth's surface looks different from above. Visual assumptions may be made that prove untrue when a site is assessed at ground level. For example, a reflective rock surface may be erroneously classified as water by a computer program analyzing satellite images.

Urbanization may result in a nearly impervious surface layer, or it can allow a surprising amount of infiltration (Wiles and Sharp, 2008). Humans sometimes draw or pump water across watershed boundaries for a variety of reasons, such as to alter drainage or to irrigate agricultural areas. It is estimated that approximately 50% of annual rainfall in a Nordic mountainous area runs off (Engman, 1981). A large portion of it is during the spring runoff. Weather appears to be more important than the type of soil and land cover. Flow distance to stream channel may create greater chance for water to evaporate or to be absorbed, reducing the quantity of runoff (Monterith et al., 2006).

The estimation of runoff volume is quite complex. Intensity is the ratio of the amount of rain (mm) to the duration (h). The first drops are caught by leaves and stems of vegetation. This causes a portion of the total precipitation to never reach the ground, and eventually evaporate, in a process called interception storage. Runoff happens when the intensity exceeds the effect of interception storage combined with the infiltration capacity of the soil. Infiltration capacity is a function of soil density, composition, structure, pre-existing moisture content, slope, and slope length. The infiltration capacity decreases as a storm progresses because dry soil has greater water storage capacity than soil that is already partially wet, reducing to zero when the soil reaches saturation. Other runoff-influencing factors are the distribution of precipitation, ground porosity, disturbance, and the size of the raindrops. A ground seal can be formed when a burst of heavy rain compacts and saturates the top layer, drastically decreasing the expected infiltration rate.

Soils with higher proportions of clay or loam are especially prone to capping, but this effect is reduced by vegetation (Critchley and Siegert, 1991). Runoff is therefore highly catchment-specific.

There is little information on the proportion of precipitation that ends up as groundwater recharge, evapotranspiration, and runoff. Groundwater conditions over a few decades, however, are assumed to be relatively stable. In the Sun (2004) study, measured precipitation (n=87) in nine New Jersey catchments was not significantly different. The region of Ontario containing these tributaries is fairly uniform with respect to total precipitation and snowfall (Figure 3). Some amount of the recharge portion will eventually reach the stream, however not as directly or as fast as simple surface runoff.



(a) (b)

(c) (d)

**Figure 3.** Precipitation (a), snowfall (b), evapotranspiration (c), and runoff (d) in southern Ontario, modified with permission from Ontario MNR (1984).

Because there are so many influencing factors, estimates of runoff as a percentage of precipitation vary widely. However, it is possible to assign probable ranges to various catchments. Areas similar in climate and geography to the Raisin Region study site have runoff in the range of 25 to 55% of precipitation volume. Runoff in a north-central Minnesota study was 25.2 of 75.5 cm of precipitation, or 33%, at a latitude similar to that of the Raisin Region (Nichols et al., 2001). Their study site had similar latitude to the Raisin River, but was not as flat. The region surrounding Cornwall, Ontario, has a wide range of land use. There is little variation in the elevation and slope, and previous work from other areas has reported that base flow is not statistically different in rural and urban areas (Wiles and Sharp, 2008). Forest, however, creates a lag between precipitation and runoff compared to agricultural areas (Allan et al., 1997).

Rainfall type and intensity affects how much surface runoff there is. Rain quantity/quality is a big assumption. Radar can get much more accurate readings with a resolution of $1km^2$ and a temporal resolution of about 6 minutes. Although there is usually no appreciable increase in runoff from gentle rain, an intense rainfall will have a measurable result on runoff. Estimates of runoff vary depending on geographic location and environmental conditions. Published percentages range from 10% under normal circumstances to 95% during intense rain events (Wilcox et al., 1990). A somewhat accepted global average is 35%, but the range of values that determine this average is very large (Foster, 2010; Engman, 1981).

### 1.2.2 Intense rain events

High-intensity precipitation causes a parallel increase in THg and MeHg, suggesting a common source for both species (Shanley et al., 2008). However, there are studies that report the production is divergent, and others that report a decrease in the concentrations of THg and MeHg in streams after a major precipitation event (Balogh et al., 2004). Mercury budgets are difficult to establish since volatilization is hard to measure accurately (Grigal, 2002). The percentage of methylated mercury produced was inversely related to the slope of the catchment in the five lakes studied by Shanley et al. (2008). Adding water to dry soils has been shown to cause a release of $Hg^0$, possibly by physical displacement from the pores in the soil. Re-wetting may increase methylation because saturated environments favour reduction reactions. Also, the presence of dissolved oxidants may increase the potential of transforming $Hg^0$ to $Hg^{2+}$, which is then methylated by SRB.

Heavy precipitation results in an increase in MeHg in surface waters (Balogh et al., 2004). This increase is correlated with a decrease in dissolved oxygen and high DOC concentrations. Peaks in MeHg, $Hg^{2+}$, and DOC are seen in streams during summer runoff events (Balogh et al., 2008). Particulate Hg species, especially $Hg^{2+}$, are positively correlated to TSS (Balogh et al., 2008), but TSS was not significantly different between precipitation events and non-events (Balogh et al., 2008).

Precipitation is prerequisite to mobilize accumulated Hg on surfaces (Eckley et al., 2008). Mobilization is also dependent on spatial scale because a given input into a small-volume stream will have a much greater effect than the same quantity in a much larger body of water. In rural areas, leaves can act like buildings, creating a pulse of Hg the next time it rains (Eckley et al., 2008), and the magnitude of the pulse will be related to the number of dry days immediately preceding the rainfall. Soils are a longer-term sink than vegetation in some cases.

Upstream environmental characteristics clearly have an effect on conditions downstream. Land use upstream of a site explained 50% of the variance in the Index of Biotic Integrity (IBI), and 75% variance in habitat index (Allan et al., 1997). Due to the interconnected nature of chemistry, climatology, and biology within ecosystems, the variations in mercury profiles relative to upstream land uses is worth investigating.

The intensity of a rain event is a result of the physical properties of the environment (Houghton et al., 2001). The configuration of the environment affects the amount of vertical lift, condensation, and volume of atmospheric vapour (Bruce, 2007). A review of the literature reveals a variety of definitions for an intense/extreme rain event. For the purpose of the present study, an intense rain event is defined as 5% of the annual rainfall over a 24 hour period. This criterion may be lower than the majority of other studies. However, five percent of annual rainfall is a significant pulse of rain for the Raisin Region study system, especially considering the flatness of the area. The flat terrain can extend the residence time of the water in the soils compared with more sloped areas (Brady and Weil, 2002). The region may therefore stay wetter longer than climatically similar but more topographically varied landscapes.

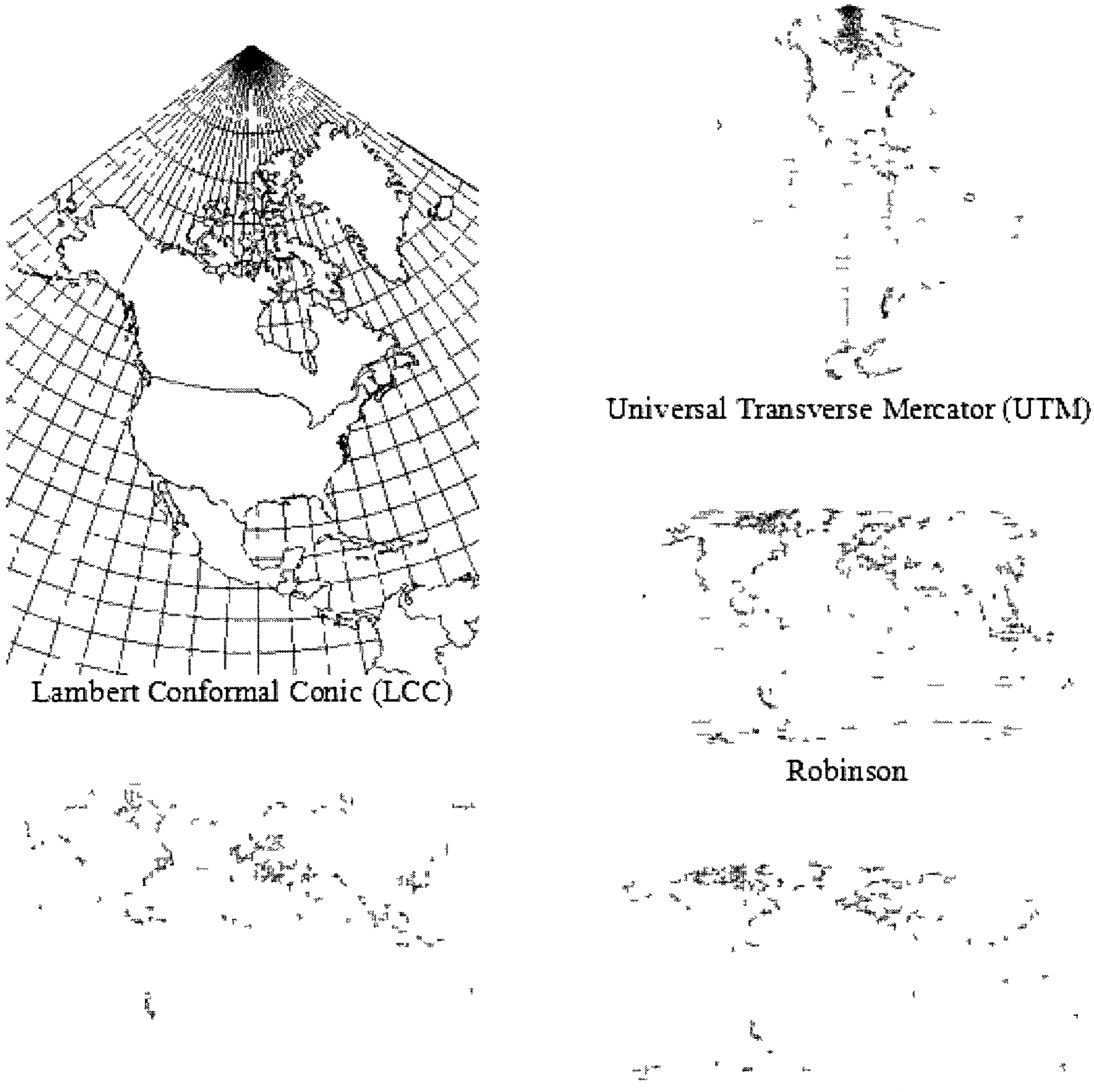
## *1.3 GIS applications for watershed management*

Geographic Information Systems (GIS) is a term that describes the tools which allow users to manipulate and interpret geospatial data. Pictures are most commonly used, but other types of information such as elevation, radar, infrared, and thermal data can also be collected. Watershed management and monitoring using GIS is an established practice (Tim and Mallavaram, 2003; Merwade, 2007; Wang and Yin, 1997; Jat et al., 2008; Chen et al., 2008).

Spatial analysis is ecologically important for many reasons. For example, different shapes may have the same surface area, but different edge-to-inside ratios. In a smaller sample, the microhabitats have greater influence on the results. To minimize the effects of these differences, large sample sizes are preferred. Larger sample areas provide a greater opportunity to explore a larger variety of flora and fauna. However, increasing the number of sites also increases the likelihood that some will fall outside the desired study area. This is especially important to consider in environments where spatial changes occur over relatively short distances.

### 1.3.1 Limitations of GIS

There are many potential problems when obtaining and manipulating satellite imagery. The first and most common problem is that of projection. Because the surface of the Earth is curved, the proportions of an image taken from a single point will be different depending on the angle at which the image is captured. There are infinite ways to display three-dimensional data in two dimensions. The myriad options are called projections (Figure 4). In order to compare different types of data for a single location, all data sets must be in the same projection. Some projections are particularly difficult to re-project into more useful forms. The user must depend on the creator of the data to define which projection was used, but that information may be inaccurate. Projection may be changed, for example, while neglecting to change the projection label associated with the data. This does not occur automatically, and it is a common source of error as the user often has little choice but to trust that the distributor is correct.


Universal Transverse Mercator (UTM)

Lambert Conformal Conic (LCC)

Robinson

Mercator

Geographic

**Figure 4.** Illustration of several projections of the Earth's surface. Modified with permission from Cozby (2003).

Another common challenge is that specialised satellite data are very expensive to custom-order. Basic imagery data are readily available for just about every location and at much smaller intervals than high-resolution data. However, these may be inadequate, especially within very small geographic areas. Specialised data for a specific location may be recorded only once per decade, which is especially true with regard to high-resolution data. This is especially frustrating when cloud cover obscures the area required, as it may be a very long period of time before the image is updated.

Users will sometimes make assumptions about their model to include details that are impossible to determine from satellite images. For example, two similar forests that are relatively close together may have very different types of soil. What appears to be a single forest from above could really be two or more distinct environments. Also, users frequently assume little temporal change: It is common to use a snapshot of one moment to represent longer periods of time. This is another argument for verifying remote sensing data in the field as much as is feasible.

Despite the challenges, the analysis of natural resources has become more accurate and much faster since the use of GIS. Data obtained from satellites is viewed and manipulated with special software. Perhaps the best known is the Arc suite of programs created by ESRI. Arc GIS software can be prohibitively expensive to buy, so many open-source options have been created. For more complex geographical models, Arc is often the best option. Add-on software for specialized operations is also available.

Over-reliance on GIS tools and data is not advisable, as errors do occur. In situ verification should always take place, especially when the outcome will influence conservation or environmental management decisions.

## *1.4 Objectives and hypotheses*

The present research is complementary to the M.Sc. thesis of Serena Maharaj-Briceño, which focused on characterization of mercury in the Raisin River. The purpose of the Raisin Region study is to determine the relationship between land use and MeHg formation and mobilization in twelve watercourses flowing into the Lake St. Francis region of the St. Lawrence River near Cornwall, Ontario.

### 1.4.1 Objectives

1. To quantify nutrients (TP, $NO_2$, $NH_3$, $SO_4$, DOC/DIC), MeHg, THg levels for twelve tributaries in the Cornwall, Ontario area;
2. To sample before, during, and after unusually heavy precipitation;

3. To use GIS software and publicly accessible GIS data to delineate watersheds and to characterize and quantify land uses upstream of each sample point;
4. To compare GIS data to lab analysis data in order to determine if land use, water chemistry, and mercury are correlated;
5. To estimate flow with limited information, such as catchment area, precipitation, and water depth;
6. To determine whether or not more mercury, especially MeHg, washes downstream during years with relatively greater precipitation; and
7. To determine if MeHg is associated with $SO_4$, $NH_3$, $NO_3$, DOC, DIC, TSS, $O_2$, BOD, SBOD, LOI, or TP in a statistically significant way.

### 1.4.2 Hypothesis and predictions

Previous studies have shown a relationship between MeHg and proximity to bog-like headwaters. The percentage of THg present as MeHg should therefore be higher near the headwaters of the Raisin River. Methylmercury levels are expected to be different in wet years compared to drier ones. Mercury is more mobile when bound to DOC, and will therefore show up downstream in greater concentrations after heavy precipitation. Methylmercury will also be associated to $SO_4$, $NH_3$, and TP levels.

# 2 Methods

## *2.1 Study location*

The purpose of the Raisin Region study is to determine the relationship between land use and MeHg formation and mobilization in twelve watercourses feeding Lake St. Francis in the Cornwall region (Figure 5) in cooperation with the Raisin Region Conservation Authority (RRCA) and the St. Lawrence River Institute of Environmental Sciences (SLRIES).

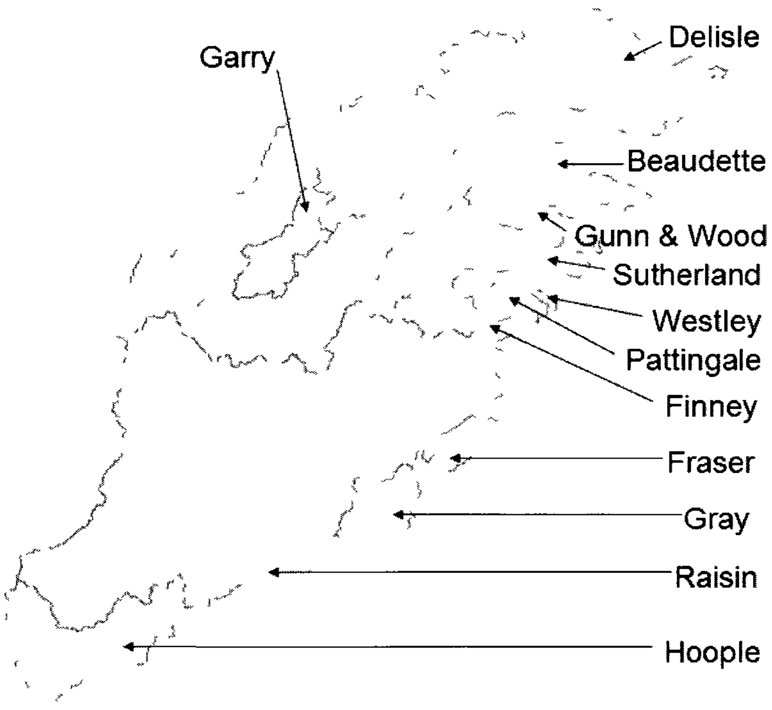


**Figure 5.** Catchment shapes and relative positions of the tributaries.

The area monitored during the present study is 1078 km$^2$ near Cornwall, Ontario (Figure 6). Twelve watercourses were examined with an emphasis on the largest, the Raisin River. The watercourses were selected based on previously collected data. Parts of this region are rich in peatlands. Farmers have dug trenches with the intention of drying the peat so that the land could be used for other purposes. These trenches are up to 3 meters deep and 6 meters wide, but many are smaller (Figure 2). Some are only 30 cm wide, but still more than a meter deep.

The areas of the catchments were calculated using ArcGIS software. The cell size was 25m$^2$, therefore the count presented was multiplied by 625 to get a value in m$^2$. Comparisons were conducted in terms of mass per square kilometer, therefore the cell count had to be multiplied by 625 and subsequently divided by 1,000,000. The area of each land use category within each watershed was also determined.

There is a variety of land use/land cover types in the region. Water samples were collected from seventeen sites in the Raisin River catchment area, and at the outflow of each of the other tributaries. Because the area covers a relatively small and uniform geographic range, deposition and volatilization of mercury were assumed to be constant across the entire study area.

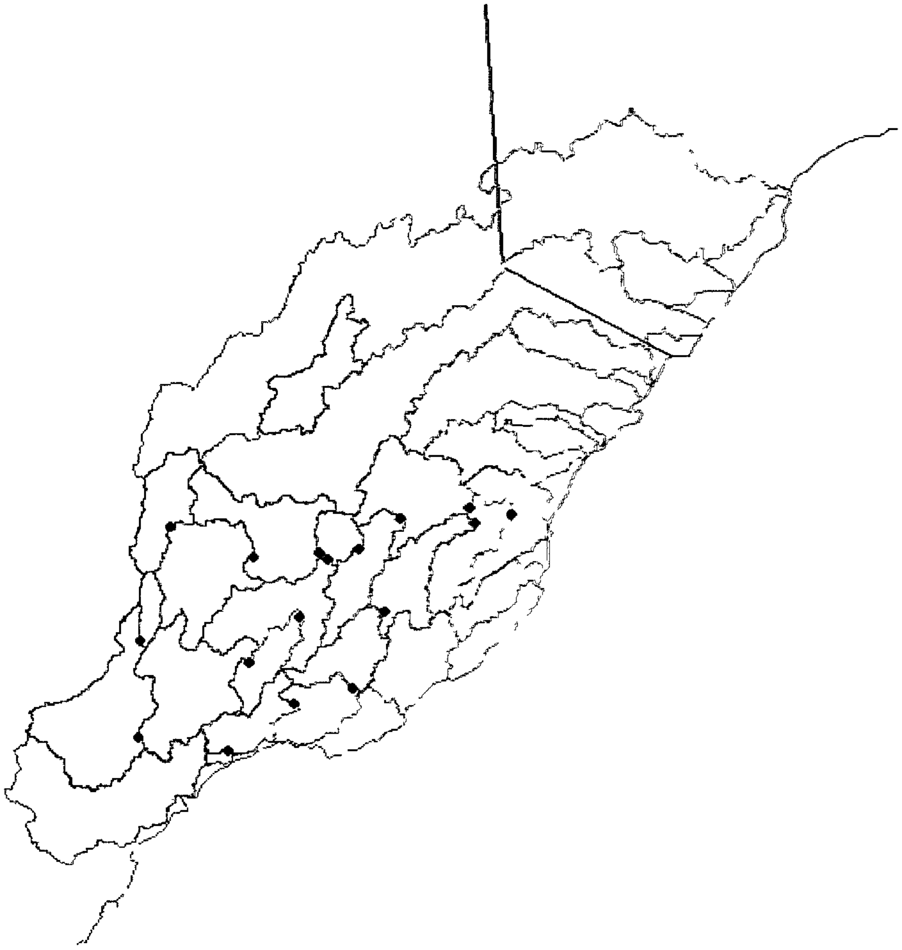


**Figure 6.** Catchment areas for several tributaries of the St. Lawrence River, including the sub-sample locations within the Raisin River's catchment area. The Ontario-Quebec provincial border is shown.

The largest tributary, the Raisin River, was the only one to be sampled at multiple locations (Figure 7). The Newington Bog site was considered part of the RR catchment area, since drainage strategies implemented by the landowner are likely drawing water from the Nation River catchment area to the north. The flow meter for the Raisin River near Williamstown (02MC001) is very close to sample location RR12 (Figure 8).

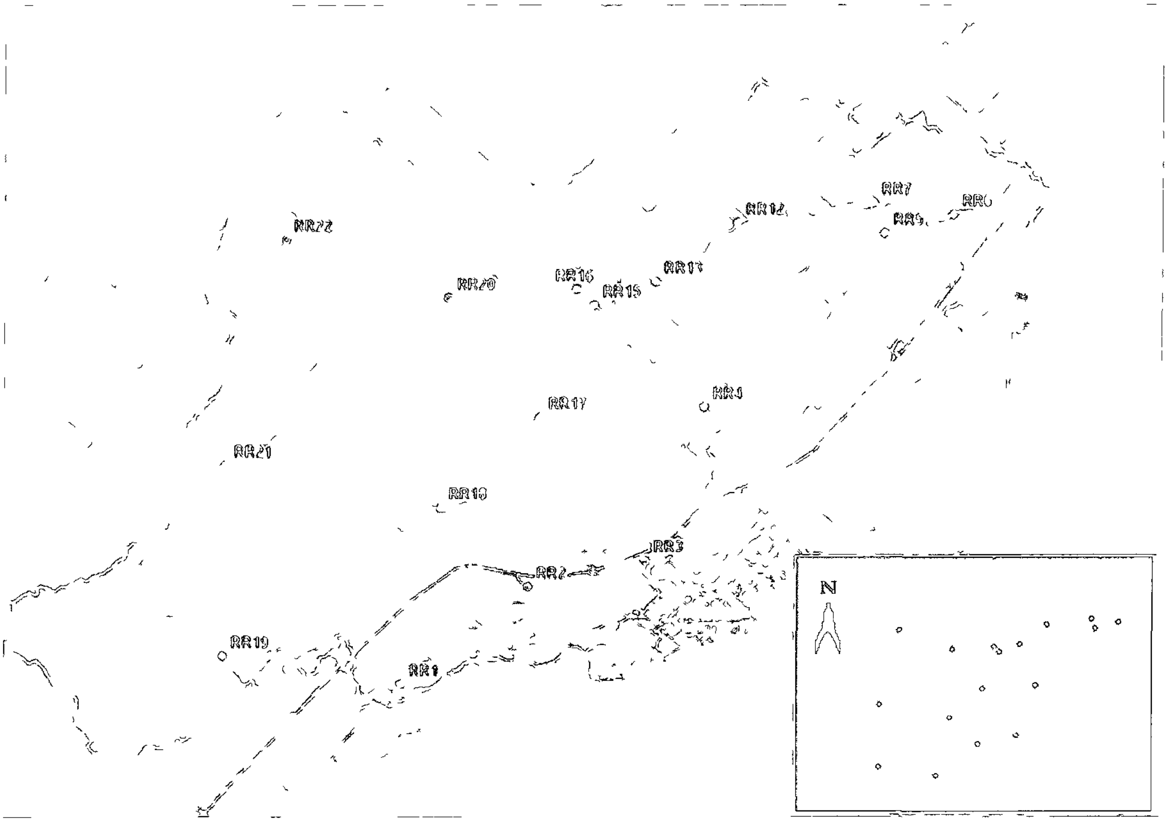


Figure 7. Position of the Raisin River catchment area relative to the city of Cornwall, Ontario, and the catchment areas of the sub-sampling sites of the Raisin River (inset). The yellow circle indicates the location of the Newington Bog sampling site.

Figure 8. Aerial photograph of Williamstown 02MC001 gauge site (bridge at far left) and sample location RR12 (green dot at far right). Google maps satellite view, Feb 5, 2010.

## 2.2 Sample collection and preservation

Water samples for all analyses were collected in 1L Nalgene HDPE bottles. All bottles were thoroughly washed with 10% HCl and rinsed five times with distilled water between uses and before the first use. Field sampling was conducted by various students and faculty of the biology department at the University of Ottawa, the Raisin Region Conservation Authority (RRCA) and by members of the St. Lawrence River Institute of Environmental Sciences (SLRIES). In most cases, specific conductivity was measured at the time of sampling with a YSI 85 dissolved oxygen, temperature, and conductivity meter. Water was collected near the sub-surface in most cases. Some technicians had access to a bottle holder on a long pole for sites where access to the water was more difficult. Bottles were handled with non-powdered gloves in the lab and in the field. Water samples for mercury analysis were collected in duplicate. Separate duplicate bottles were used to collect water for the nutrient analyses.

Upon return to the laboratory, a 50 mL subsample from each of the mercury bottles was transferred to clean polypropylene falcon tubes. These containers were tested and proven to not affect the results of mercury analyses. The subsamples were preserved with 400 µg of bromine chloride per 1L sample as described by Holmes (2005). Remainders of the original samples were used for MeHg analysis. These were preserved with 5 mL concentrated ACS-grade hydrochloric acid. Total mercury and MeHg samples were stored in coolers in a 4°C cold room until analysis.

From the nutrient water samples, ~200 mL was removed for total phosphorus analysis, and the remainder of the sample was filtered through a Whatman GF/F or GF/C fiberglass filter. The filter pore size used was determined by filter availability and sample turbidity. Some samples required a second filtration due to the loss of filter integrity or fouling. Filtration was completed within 24 hours of sample collection in most cases. The slight variations in procedure were the result of the number of laboratories and researchers contributing to the project. Filters with a larger pore size were required for some especially turbid samples. The filtrate was separated into falcon tubes and labeled for the type of analysis to be conducted. The total phosphorus (unfiltered) samples were preserved with 1 mL of concentrated sulfuric acid and stored in coolers in a 4°C fridge or cold room. Falcon tube samples destined for ammonia, nitrate, and sulfate analysis were stored in a freezer and thawed a day before analysis. Filtrate for ammonia and DOC/DIC analysis were stored in coolers in a 4°C fridge or cold room until analysis.

## *2.3 Data accumulation*

### 2.3.1 Existing data

Water samples were collected from many sites on all branches of the Raisin River as well as near the outlets of other tributaries. Several organizations have contributed to the sampling and analysis of these rivers, creeks, and streams. The main contributors of data were the Raisin Region Conservation Authority, St. Lawrence River Institute of Environmental Sciences, previous graduate students at the University of Ottawa, and the Environment Canada weather office. Many observations and analyses were performed, including but not limited to: temperature, pH, conductivity, MeHg, THg, TP, $SO_4$, DOC, DIC, $NH_3$, $NO_3$, $O_2$, TSS, EC, FC, LOI, and BOD. Some of these variables were not originally considered for the study, but their availability presents an opportunity to explore more possible predictors of mercury contamination. Samples were collected between 2004 and 2009 during all seasons, but with much greater frequency in spring and summer.

### 2.3.2 New data

Additional water samples were collected from selected sites during the spring freshet of 2009 and during a perceived heavy precipitation period in late June and early July, 2009. Recent samples were only collected for a few of the original sampling sites, such as Newington Bog (Figure 9).

**Figure 9.** Sample collection location in Newington Bog referred to as *Little Bridge*.

## 2.4 Analytical methods

Analyses were performed by several different researchers at different institutions. An effort was made to ensure that equivalent methods were used, but that could not be verified as many of the people involved in this research have since moved on.

### 2.4.1 Nutrients

Water samples were analysed for $NO_3$, $NH_3$, $O_2$, $SO_4$, DOC, DIC, and TP. The Lachat nutrient analyzer 8000 QuikChem was used for nitrate, ammonia, sulfate, and total phosphorus nutrient analysis. The Lachat QuickChem Method 10-107-04-1-C (Lachat Instruments, 2000a) was used to conduct nitrate analysis. The Lachat QuikChem Methods 10-107-06-1-J (Lachat Instruments, 2001) and 10-116-10-1-C (Lachat Instruments, 2003), were used for ammonia and sulfate analysis, respectively. Using the Lachat QuikChem Method 10-115-01-1-F (Lachat Instruments, 2000b) by flow injection, total phosphorus analysis was conducted. For each nutrient analysis sample, two readings were taken (pseudo-duplicate), except for total phosphorus analysis in which three subsamples were analyzed. Readings so obtained were averaged.

DOC and DIC analyses were conducted using the O-I-Analytical 1010 Total Organic Carbon Analyzer instrument. Triplicate readings were averaged and concentrations were obtained by comparison to calibrated standards.

### 2.4.2 Mercury

Two methods were used to quantify mercury in the water samples. Total mercury was determined with a Tekran 2600 following a modified version of EPA method 1631 as described by Holmes and Lean (2006). Methylmercury was measured with the solid-phase extraction process described in Cai et al. (1996). This method uses solid-phase extraction followed by capillary gas-chromatography-atomic fluorescence spectrometry. A 2:1 acidic $KBr/CuSO_4$ solution was used for solid-phase extraction, followed by liquid phase extraction using 300 μL of dichloromethane to obtain the organic layer of the solution. These sample extracts were analyzed using standard capillary gas chromatography paired with atomic fluorescence spectrometry (GC-AFS Analytical Mercury System Model PSA 10.723). Field blanks, laboratory blanks, and serial-dilution control samples were run concurrently as described in Holmes and Lean (2006) to ensure that there was no mercury contamination. During the process of MeHg determination, field and laboratory blanks were run to ensure that MeHg contamination was not present. Area peaks were integrated and concentrations were calculated.

Total mercury analysis was carried out using EPA method 1631 with the cold vapor atomic fluorescence spectroscopy (CVAFS). Samples were collected and transported in the same manner as the MeHg samples, and were subject to the same comparison to field and laboratory blanks and serial dilution control samples. Tekran 2600 and Tekran 2610 liquid handling modules and the Tekran 2620 autosampler instrumentation were used in conjunction with the spectroscope mentioned previously as described in Homes and Lean (2006). For total mercury, 100 μL of 30% hydroxylamine solution was added to each sample prior to analysis to prevent foaming and accidental sample loss. Concentrations were calculated based on a standard calibration curve with an $R^2$ value of 0.9 or higher.

## 2.5 *Geographic analyses*

### 2.5.1 Software

Arc GIS version 9.3 (ESRI, 2007) was used to create models of the study area. Additional software tools for watershed modeling were downloaded from the ESRI website. The help files available online were also instrumental in creating the geographic models. GIS data were cross-referenced with the analytical data to determine what types of environments are associated with higher concentrations of MeHg. Land uses upstream of each sampling location were compared to nutrient and mercury concentrations in the water using detailed GIS data. This complemented data previously collected by the RRCA and SLRIES.

### 2.5.2 GIS data sources

Delineation of the watersheds of the tributaries and the sub-catchments of the Raisin River was accomplished using a variety of GIS data (Table 1). It was assumed that the metadata attached to the files was accurate. Re-projections and alignment checks were conducted for each new data source.

**Table 1.** GIS data descriptions and sources.

| Data | Format | Projection | Cell size | Date | Source |
|---|---|---|---|---|---|
| Digital Elevation Model | Raster | UTM | 3 m | Dec. 2008 | Ontario MNR |
| Land uses | Raster | UTM | 25 m | 2000 | Ontario MNR |
| Rivers network | Polyline | Geo | N/A | 2008 | National Hydrological Database |
| Roads network | Polyline | Geo | N/A | Unknown. | Previous student |
| Base Map | Vector Digital Data | Geo | N/A | 2001 | National Topographic Data Base |
| LANDSAT 042-288 | GeoTIFF | UTM | 28.5 m | Oct. 2, 2000 | University of Maryland |
| LANDSAT 042-289 | GeoTIFF | UTM | 27 m | Sept. 3, 2001 | University of Maryland |

All data were re-projected to Lambert Conformal Conic (LCC) projection. The NHN data was used to ensure the other layers lined up. For example, the course of rivers should coincide with the lowest points on the DEM, and with the "water" classification on the land use layer. Some of the data were discontinuous over the provincial border. In these cases, the mosaic tool was used to splice them together. Alignment was verified by adding the NHN layer. The Watershed Delineations Toolbox was obtained from the ESRI website and installed within the ArcGIS software to facilitate catchment area definitions (Figure 10). Rounded shapes indicate GIS data and Boxes indicate actions. The data enclosed by the dotted line were obtained from outside sources (Table 1).

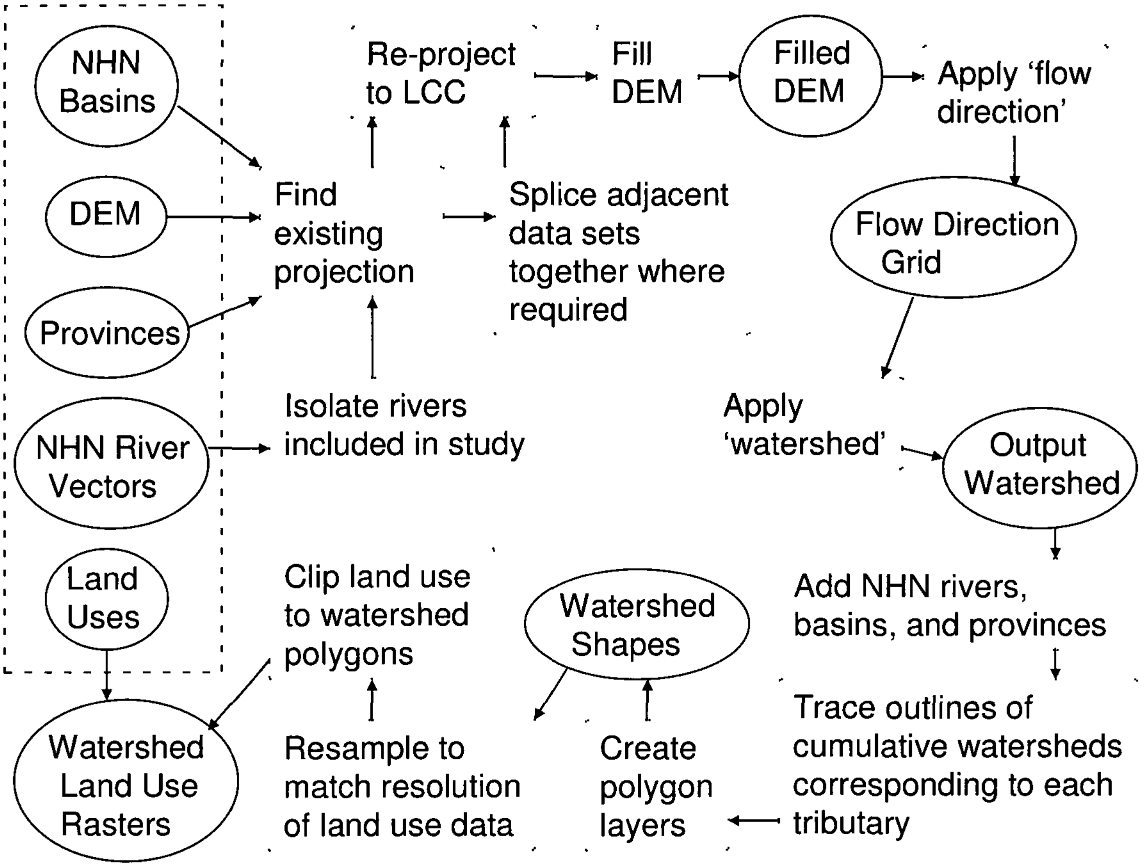


**Figure 10.** Methods applied to GIS data to obtain custom-shaped land use rasters for determining the land use profiles of each catchment area.

To fill a DEM data set means to auto-correct for depressions in the ground that do not clearly drain in any particular direction, called sinks. An example of a filled DEM and “Flow Direction” output raster is shown in Figure 11 a and b, respectively. In this particular case, the DEM was distributed as an Ontario dataset. As a result, the portion that falls in Quebec in the upper right corner has some unreliable results, and the American shore of the St. Lawrence River is not shown. Similarly, the flow direction output falsely projects the ends of two tributaries to the St. Lawrence when, in actuality, they extend into the province of Quebec before reaching the St. Lawrence River.

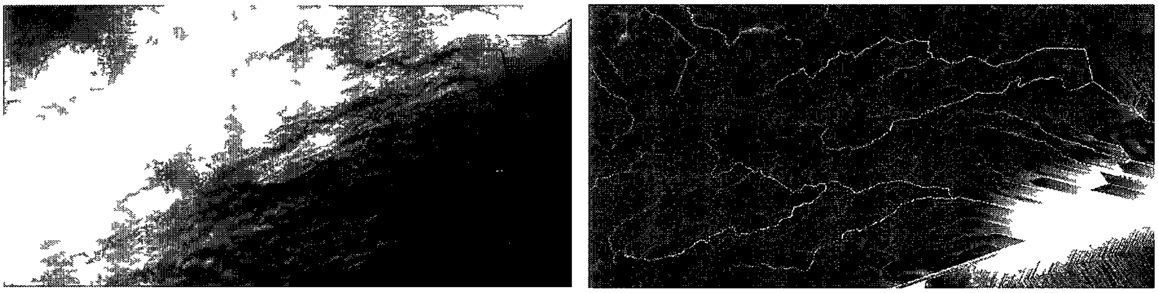

a) b)

**Figure 11.** Filled Digital Elevation Model (a) and Flow Direction Tool output raster (b) for a portion of the study area.

### 2.5.3 Land use classifications

The Land use data obtained from the Ontario MNR’s Ontario Land Cover Data Base (Ontario MNR, 2000) was re-projected to LCC and compared to the catchment area polygons. Out of a possible 28, there were 14 classes present in the study area (Appendix C). There were grouped into five broader categories wet, forest, impermeable, open, and crop (Table 2).

**Table 2.** Land uses within the study area and their re-classification into fewer categories.

| Provincial Class Number and Name | New Class |
|---|---|
| 1. Water | Wet |
| 5. Freshwater Coastal Marsh/Inland Marsh | Wet |
| 6. Deciduous Swamp | Wet |
| 7. Conifer Swamp | Wet |
| 8. Open Fen | Wet |
| 13. Dense Deciduous Forest | Forest |
| 14. Dense Coniferous Forest | Forest |
| 16. Mixed Forest, Mainly Deciduous | Forest |
| 17. Mixed Forest, Mainly Coniferous | Forest |
| 19. Sparse Deciduous Forest | Forest |
| 23. Mine Tailings, Quarries, and Bedrock Outcrops | Impermeable |
| 24. Settlement and Developed Land | Impermeable |
| 25. Pasture and Abandoned Fields | Open |
| 26. Cropland | Crop |

## 2.6 Calculation of contaminant yields

Runoff data are an essential component for the calculation of contaminant yield. Generally, yield (mg/month/$m^2$) is calculated as: concentration (mg/L)*flow (L/month)/area of individual site ($m^2$). However, flow data for all but one sample location were not available. Therefore, yield was calculated as a function of the expected volume of runoff based on precipitation data. Runoff was assumed to be uniformly 35% of precipitation based on literature values. The precipitation profile for the study period is presented in Figure 12.

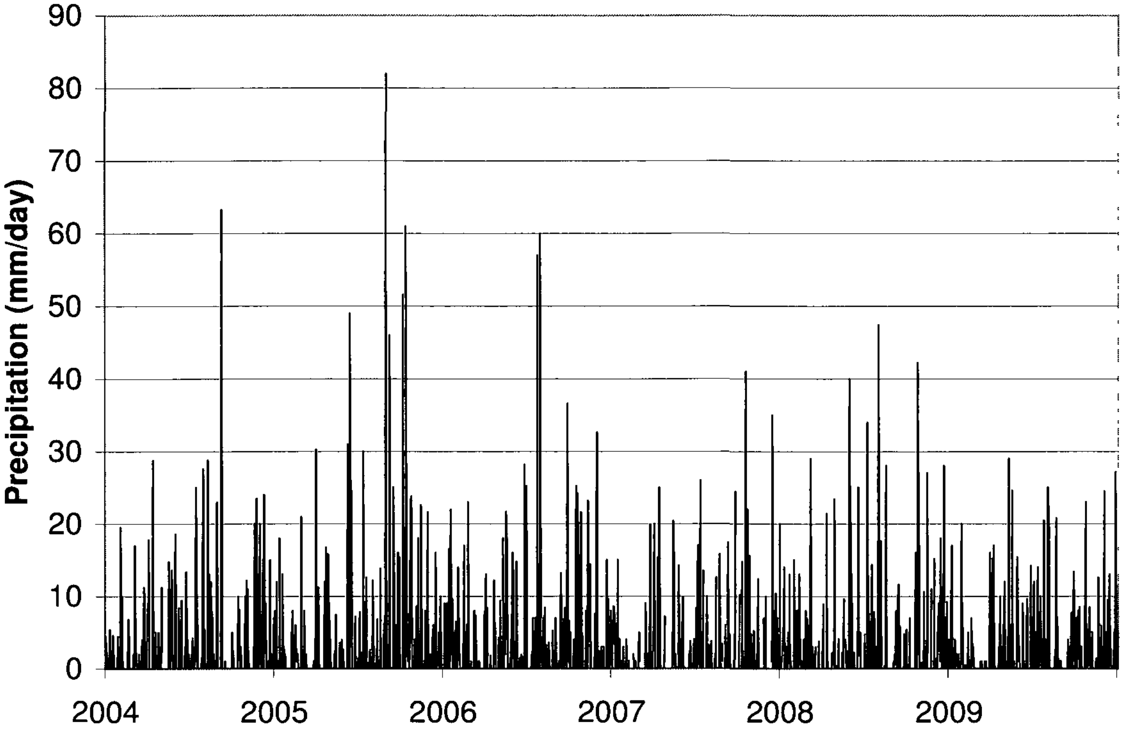


**Figure 12.** Precipitation profile for the city of Cornwall, Ontario, from 2004 to 2009.

Flow is necessary in order to calculate yield. Flow measurements were only recorded for one sampling site (Figure 13). Since precipitation was presumed to be equal in all parts of the catchment area, it would be ideal to establish a precipitation-flow relationship so that flow could be modeled for the other tributaries. Attempts to directly relate precipitation to volume failed. Delays of 1h, 1d, 3d, and 1 week were explored, but an equation could not be established. Flow is dependent on many variables such as slope, catchment size, soil porosity, pre-existing soil moisture, and vegetation type and density, among many others.

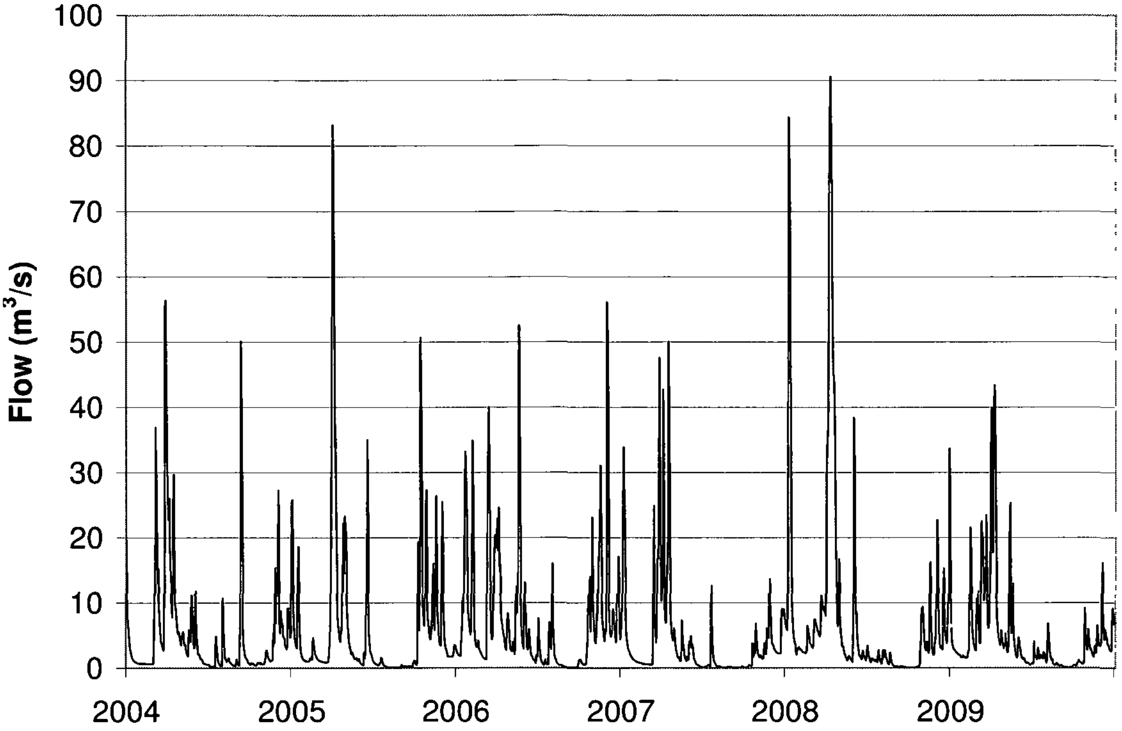


**Figure 13.** Flow profile for the Raisin River gauging station (02MC001) near Williamstown, Ontario from 2004 to 2009.

Several approximations and assumptions were made in order to perform the calculations. For concentration parameters, it is to be considered that even though sampling occurred from June 2005 to August 2009, some sites were sampled more frequently than others, and sampling did not occur in all months. For example, in a case where one measurement was obtained in a month, that value was considered the monthly average. Where several measurements were made, the monthly averages were used.

Direct measurable volumetric flow data for the Raisin River was available at one site only (Figure 13), very near sample site RR12. Water inputs to the river system include both rain and snow contributions. Rain precipitation readings, measured in millimeters, were collected daily at the climatological station located at the Water Filtration Plant by the City of Cornwall. Previous studies of Allan and Benke (2005) showed that for nine rivers within the St. Lawrence region 60% of precipitation is lost through evapotranspiration while 40% of precipitation becomes run-off, therefore such runoffs potentially may enter a body of water at the sub-surface level. However, this model does not allow for soil retention. It may be argued that absorbed water is most likely still headed toward the tributaries. These assumptions can be very misleading when depth-related density studies are not considered. Similarly, the average value for several lakes sampled in North America is that about 63% of precipitation is principally lost to the atmosphere via evapotranspiration mechanisms; also, there is about 84 cm annual precipitation and 31 cm (~37%) for runoff (Allan and Benke, 2005). Other investigators in North America have reported similar data, 67cm precipitation with 29 cm (~ 43%) runoff (Hornberger et al., 1998), and 76 cm precipitation and 34 cm (~46%) runoff (Shiklomanov, 1993).

The sample collection period includes the winter season for which snow is the predominant form of precipitation. Therefore, snowfall needs to be taken into account. Snow precipitation is generally recorded in centimeters of snow (Ridal, 2007). For a typical snowfall, Dubé (2003) demonstrated that the ratio of snow to water was 10:1, and this ratio was applied in the conversion of snow precipitation to water equivalence. For the yield calculations reported in this study, 35% of the total monthly precipitation, which comprises the sum of the rain and snow contributions, was used as the volumetric flow rate in the equation, based on the assumption that there are no gains or losses from groundwater or surrounding basins; this approach is consistent with that suggested by Allan and Benke (2005).

Estimates of the specific catchment areas upstream were obtained with the aid of a digital elevation map (Geobase, 2008). Geobase is a Canadian geographic information data base used for land management applications for terrain modeling, and can provide areas of selected land masses. In principle, Geobase is used in conjunction with ArcGIS software to calculate drainage basin shapes and sizes at sites of interest. The area, expressed in $m^2$ of the drainage basin, was determined and summarized in Table 3. Yields were assessed to determine relationships associated with land features at each site by comparing them to land use data. A land use GIS data set was obtained from the OMNR.

### 2.6.1 Statistical analyses

Statistical analyses were applied to the contaminant concentration data and the land use area data. These were in the form of nonparametric testing and conducted using SPSS computer-based statistical analyzer version 17. Data were divided into four temporal categories: winter (December to February), spring (March to May), summer (June to August), and autumn (September to November). Where more than one sample was analysed for one site in a month, an average value was used.

Correlations between nutrients and mercury were sought with a simple correlation and multiple regression analysis. Total mercury, MeHg, and the percent of THg present as MeHg (%MeHg) were compared to the areas of the different land uses with multiple regression analyses. A two-way ANOVA was used to determine if there is a difference in MeHg in wet years compared to dry years, and to determine if there is seasonal variation in THg, MeHg, and %MeHg.

# 3 Results and Discussion

## *3.1 Areas within watersheds*

The combined area of all twelve tributaries is predominantly agriculture, followed by forest. The area of open water, as visible by satellite, is a very small portion of the total area. The areas are presented in $km^2$ in Table 3. Sample location names and the abbreviations used in this section are described in Appendix A. Monthly averages of the raw data are presented in Appendix B. The resolution of the land use data was 25 $m^2$, which is larger than ideal given the relatively small study area.

**Table 3.** Catchment areas and land use composition in square kilometers (km$^2$) for twelve adjacent tributaries of the St. Lawrence River near Cornwall, Ontario.

| | Forest | Impermeable | Open | Wet | Crop | Total |
|---|---|---|---|---|---|---|
| Beaudette | 79.12 | 0.68 | 47.74 | 10.65 | 68.89 | 207.08 |
| Finney | 7.98 | 0.00 | 6.55 | 0.61 | 16.49 | 31.63 |
| Fraser | 7.93 | 0.00 | 3.89 | 2.81 | 3.91 | 18.53 |
| Gray | 9.58 | 3.50 | 8.20 | 3.32 | 8.84 | 33.45 |
| Gunn | 5.05 | 0.00 | 5.33 | 0.43 | 19.66 | 30.47 |
| Hoople | 33.20 | 0.14 | 20.90 | 8.83 | 20.74 | 83.80 |
| Pattingale | 2.58 | 0.00 | 2.24 | 0.14 | 8.69 | 13.65 |
| Sutherland | 17.93 | 0.00 | 16.33 | 0.88 | 41.57 | 76.72 |
| Westley | 1.11 | 0.00 | 1.58 | 0.06 | 7.14 | 9.89 |
| Raisin | 268.35 | 5.20 | 115.96 | 42.67 | 140.99 | 573.17 |
| RR1 | 0.54 | 0.62 | 0.24 | 0.03 | 0.45 | 1.89 |
| RR2 | 11.60 | 0.92 | 4.19 | 1.63 | 5.09 | 23.44 |
| RR3 | 19.07 | 4.05 | 8.19 | 3.73 | 12.91 | 47.95 |
| RR4 | 26.81 | 5.07 | 13.51 | 4.78 | 24.16 | 74.33 |
| RR5 | 38.38 | 5.07 | 20.78 | 6.07 | 35.14 | 105.45 |
| RR6 | 268.30 | 5.20 | 115.90 | 42.65 | 140.96 | 573.01 |
| RR7 | 206.60 | 0.13 | 85.76 | 30.22 | 86.10 | 408.81 |
| RR12 | 186.82 | 0.13 | 76.38 | 27.46 | 71.60 | 362.39 |
| RR13 | 178.42 | 0.00 | 70.29 | 26.50 | 59.86 | 335.06 |
| RR15 | 97.80 | 0.00 | 43.27 | 15.70 | 37.72 | 194.49 |
| RR16 | 77.28 | 0.00 | 24.33 | 10.05 | 17.15 | 128.80 |
| RR17 | 73.19 | 0.00 | 35.49 | 13.63 | 28.29 | 150.60 |
| RR18 | 64.09 | 0.00 | 31.72 | 12.11 | 24.18 | 132.09 |
| RR19 | 34.36 | 0.00 | 18.96 | 8.20 | 13.84 | 75.36 |
| RR20 | 49.16 | 0.00 | 14.92 | 6.95 | 9.09 | 80.11 |
| RR21 | 5.05 | 0.00 | 1.44 | 1.28 | 0.47 | 8.24 |
| RR22 | 16.54 | 0.00 | 5.59 | 3.61 | 3.39 | 29.13 |

Newington Bog, at the edge of the Raisin River's catchment area, was included in the study. It was later shown to be on the edge and perhaps just outside the watershed. However, the landowner had made attempts to improve drainage on his property by digging deep narrow trenches. These were so deep in places that their depth could not be measured while lying on the ground extending one's arm fully into the crevasse with a meter stick. The presumed area of the Raisin River's catchment area may therefore be misleading since land uses in the Nation River catchment area could be affecting conditions in Newington Bog. Flow rates in the trenches and ditches were often imperceptible. After many attempts on repeated visits to the site, it was determined that the flow is indeed southbound into the Raisin River. Aerial photographs showed that the dug trenches may be drawing water from the Nation River catchment area down toward the Raisin River (Figure 14). The Nation River flows to the Ottawa River and does not ordinarily relate to the Ontario portion of the St. Lawrence River. It seems that in an attempt to drain the bog into the Nation River, catchwater channels have inadvertently been created, allowing a flow diversion from the Nation River catchment to the Raisin River catchment.

**Figure 14.** Newington Bog sample location at the edge of the Raisin River catchment area. A man-made watercourse that drains into the Nation River is visible in the upper left corner of the image.

This man-made link may have serious ecological consequences. Most of the water in south-eastern Ontario flows north toward the Ottawa River. The Raisin River and the adjacent tributaries studied are distinct from the rest of the province in that they drain to the south. Without personal on-site assessment, this link would have been overlooked. It could be a very important detail, for example, when trying to trace the source of an unusual environmental contaminant. Since the flow in this small area defies reason to the extent that ArcGIS can determine conditions, one is reminded that verification of the accuracy of GIS data by onsite assessments is required.

## 3.2 Wet vs. dry years

The average annual rainfall at the Cornwall, Ontario measuring station from 2004 to 2009 was 996.35 mm/yr. A major precipitation event must therefore result in at least 49.8mm of rain in a single day to satisfy the 5% criterion. This occurred on several occasions during these years (Table 4). There were several other precipitation events that were very near the 5% criteria (Table 5).

**Table 4.** Precipitation events greater than 5% of the expected annual average, within a single day at the Cornwall, Ontario monitoring station.

| Month and Day | Year | Precipitation |
|---|---|---|
| September 9 | 2004 | 63 mm |
| August 31 | 2005 | 82 mm |
| October 10 | 2005 | 52 mm |
| July 24 | 2006 | 57 mm |
| July 30 | 2006 | 60 mm |

**Table 5.** Near-major precipitation events in the Cornwall, Ontario region between 2004 and 2009.

| Month and Day | Year | Precipitation |
|---|---|---|
| June 14 | 2005 | 49 mm |
| September 8 | 2005 | 46 mm |
| October 19 | 2007 | 41 mm |
| August 2 | 2008 | 47 mm |
| October 25 | 2008 | 42 mm |

In wet years, MeHg loads rise in the spring, and decrease in autumn and winter (Figure 15). The trend is reversed during dry years. It is surprising that MeHg is higher in the winter because bacterial activity should be slower during a Canadian winter. It may be that the decrease in demethylation may be of greater magnitude than the decrease in methylation rate, creating the relatively higher MeHg rates in the winter. In other words, the rates of methylation and demethylation might not decrease in proportion to one another.

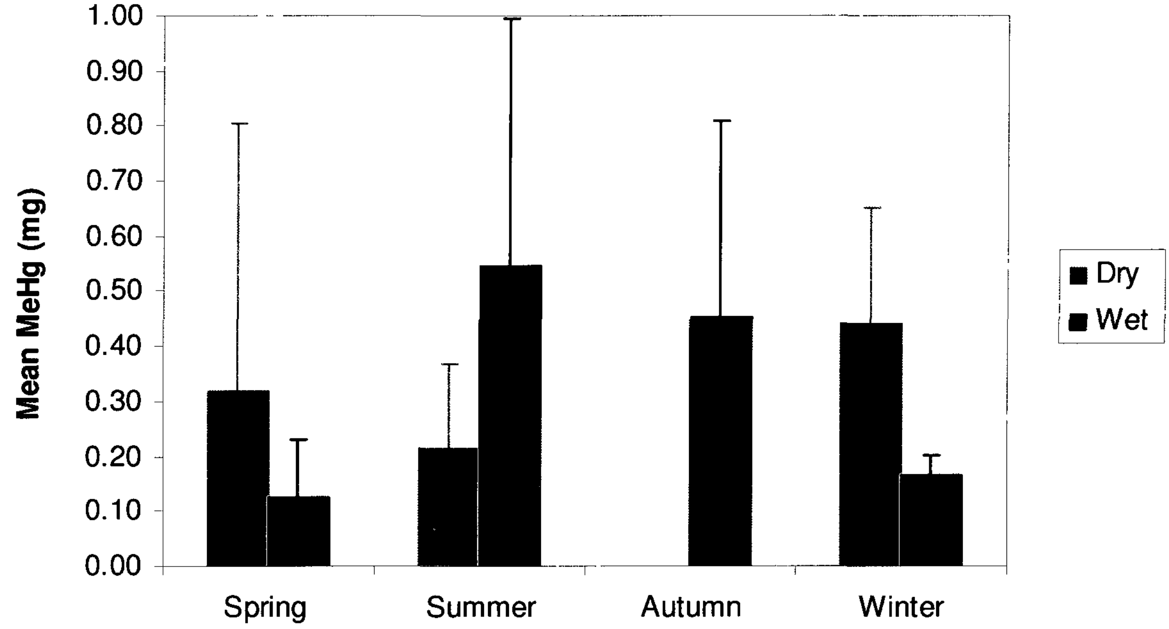


**Figure 15.** Estimated marginal means of MeHg by season during wet and dry years.

To explore the combinatory effects of the two categorical variables of year type (wet year/dry year) and season (spring, summer, autumn, and winter) upon the single continuous variable of MeHg load, a two-way ANOVA was performed (Table 6). The descriptive statistics are presented in Table 7. The overall ANOVA was significant, F(6, 223)=7.02, *p*<.001. The simple main effect of year type was not significant, F(1, 223)=0.22, not significant; while the simple main effect of season was significant, F(3, 223)=3.47, *p*<.05. However, both of these main effects were qualified by a significant year-by-season interaction, F(2, 223)=5.75, *p*<.01, indicating that the effects of season upon MeHg loads depends upon whether it is a wet year or dry year; necessitating further analyses to probe the interaction. For dry years, there was no significant difference in MeHg loads between seasons, F(2, 30)=0.42, not significant (Table 8).

**Table 6.** Two-way analysis of variance of MeHg load by season during wet and dry years.

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power |
|---|---|---|---|---|---|---|---|---|
| Corrected Model | 5.815E12 | 6 | 9.691E11 | 7.015 | <.001 | .159 | 42.091 | 1.000 |
| Intercept | 7.711E12 | 1 | 7.711E12 | 55.814 | <.001 | .200 | 55.814 | 1.000 |
| yearwetdry | 3.052E10 | 1 | 3.052E10 | .221 | .639 | .001 | .221 | .075 |
| season | 1.439E12 | 3 | 4.797E11 | 3.472 | .017 | .045 | 10.417 | .772 |
| yearwetdry * season | 1.589E12 | 2 | 7.945E11 | 5.751 | .004 | .049 | 11.502 | .864 |
| Error | 3.081E13 | 223 | 1.381E11 | | | | | |
| Total | 7.453E13 | 230 | | | | | | |
| Corrected Total | 3.662E13 | 229 | | | | | | |

a. R Squared = .159 (Adjusted R Squared = .136)

**Table 7.** Descriptive statistics of MeHg load by season during wet and dry years. The standard deviations (SD) and number of samples (n) are included.

| | Season | Mean (mg) | SD | n |
|---|---|---|---|---|
| Dry Year | Spring | 0.32 | 0.48 | 21 |
| | Summer | 0.21 | 0.16 | 9 |
| | Autumn | - | - | 0 |
| | Winter | 0.44 | 0.21 | 3 |
| | Total | 0.30 | 0.40 | 33 |
| Wet Year | Spring | 0.13 | 0.10 | 34 |
| | Summer | 0.55 | 0.45 | 91 |
| | Autumn | 0.45 | 0.35 | 60 |
| | Winter | 0.17 | 0.38 | 12 |
| | Total | 0.42 | 0.40 | 197 |
| Total | Spring | 0.2 | 0.32 | 55 |
| | Summer | 0.52 | 0.44 | 100 |
| | Autumn | 0.45 | 0.35 | 60 |
| | Winter | 0.22 | 0.14 | 15 |
| | Total | 0.41 | 0.40 | 230 |

*Dependent variable is miligrams of MeHg.*

**Table 8.** Interaction probing for dry year ANOVA of MeHg (ng).

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 1.384E11 | 2 | 6.918E10 | .416 | .663 |
| Within Groups | 4.985E12 | 30 | 1.662E11 | | |
| Total | 5.124E12 | 32 | | | |

For wet years, the overall ANOVA was significant, F(3, 193)=13.12, p<.001 (Table 9). To probe this significant finding, Dunnett's T3 post-hoc analyses were used, since Levene's test revealed a violation of the assumption of homogeneity of variances. Dunnett's T3 post hocs revealed the following significant group mean differences, for wet years: Spring ($\bar{x}$ = 0.13 mg, SD=0.10) had significantly lower MeHg loads than summer ($\bar{x}$ = 0.55 mg, SD=0.45), *p*<.001, spring had significantly lower MeHg loads than autumn ($\bar{x}$ =0.45 mg, SD=0.35), *p*<.001, summer had significantly higher MeHg loads than winter ($\bar{x}$ =0.17 mg, SD=0.04, *p*<.001), and autumn had significantly higher MeHg loads than winter, *p*<.001. No other comparisons were significantly different.

**Table 9.** Interaction probing for wet year ANOVA of MeHg (ng).

| | **Sum of Squares** | **df** | **Mean Square** | **F** | **Sig.** |
|---|---|---|---|---|---|
| Between Groups | 5.267E12 | 3 | 1.756E12 | 13.122 | <.001 |
| Within Groups | 2.582E13 | 193 | 1.338E11 | | |
| Total | 3.109E13 | 196 | | | |

Subsequently, each season was probed for differences between wet and dry years. In the spring, dry years ($\bar{x}$ =0.32 mg, SD=0.48) had marginally significantly higher MeHg loads than in wet years ($\bar{x}$ =0.13 mg, SD=0.10), t(21.14) = 1.82, *p*=.083, equal variances not assumed. For summer, wet years ($\bar{x}$ =0.55 mg, SD=0.45) had significantly higher MeHg loads than dry years ($\bar{x}$ =0.21 mg, SD=0.16), t(24.92)=4.78, *p*<.001, equal variances not assumed. No data were collected for dry year autumns, so no differences could be calculated. In the winter, no significant group mean differences were found between wet and dry years, t(2.03)=2.27, ns, equal variances not assumed.

Methylmercury loads do not differ between wet and dry years when looked at by year type alone. At the seasonal level, there are differences to be found. In the summer, wet years yielded higher mercury than dry year summers. In the spring, dry years showed a marginally significant trend toward having higher mercury loads than did wet springs. Autumn could not be determined since no data was collected during a dry year autumn, and no difference was found for winter.

Similarly, there is no significant difference in THg between wet and dry years according to a two-way ANOVA (Table 10). However, unlike MeHg, there is no seasonal variation, either . Descriptive statistics for THg are presented in Table 11.

There is no significant difference in THg loads over wet and dry years. There is an apparent spike in the spring of wet years, but it is not statistically significant because of the large error variance (Figure 16).

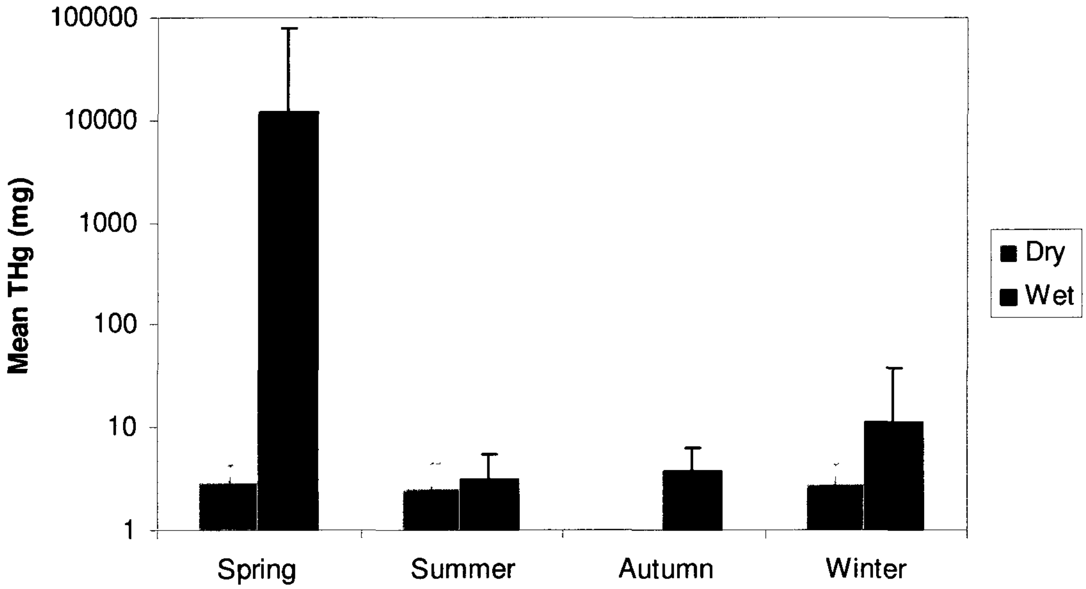


**Figure 16.** Seasonal variation of THg in wet and dry years.

To explore the combinatory effects of the two categorical variables of year type (wet year/dry year) and season (spring, summer, autumn, and winter) upon the single continuous variable of THg load, a two-way ANOVA was performed (Table 10). The overall ANOVA was not significant, F(6, 237)=1.07, ns. The simple main effect of year type was not significant, F(1, 237)=0.41, ns; nor was the simple main effect of season, (F(3, 237)=0.84, ns), nor the interaction, (F(2, 237)=0.91, ns), indicating that neither season, type of year, nor their interaction have any effect upon THg.

**Table 10.** Two-way analysis of variance for THg (ng) by season in wet and dry years.

| **Source** | **Type III Sum of Squares** | **df** | **Mean Square** | **F** | **Sig.** | **Partial Eta Squared** | **Noncent. Parameter** | **Observed Power**[b] |
|---|---|---|---|---|---|---|---|---|
| Corrected Model | 3.971E21 | 6 | 6.618E20 | 1.067 | .383 | .026 | 6.403 | .418 |
| Intercept | 1.351E20 | 1 | 1.351E20 | .218 | .641 | .001 | .218 | .075 |
| yearwetdry | 2.549E20 | 1 | 2.549E20 | .411 | .522 | .002 | .411 | .098 |
| season | 1.560E21 | 3 | 5.199E20 | .838 | .474 | .010 | 2.515 | .231 |
| yearwetdry * season | 1.124E21 | 2 | 5.618E20 | .906 | .406 | .008 | 1.812 | .205 |
| Error | 1.470E23 | 237 | 6.202E20 | | | | | |
| Total | 1.516E23 | 244 | | | | | | |
| Corrected Total | 1.510E23 | 243 | | | | | | |

a. R Squared = .026 (Adjusted R Squared = .002)

b. Computed using alpha = .05

**Table 11.** Descriptive statistics of THg load by season in wet and dry years.

| | Season | Mean | SD | n |
|---|---|---|---|---|
| Dry Year | Spring | 2.76 | 1.49 | 22 |
| | Summer | 2.49 | 1.98 | 23 |
| | Autumn | - | - | 0 |
| | Winter | 2.68 | 1.63 | 3 |
| | Total | 2.62 | 1.72 | 48 |
| Wet Year | Spring | 11799.75 | 67772.67 | 33 |
| | Summer | 3.16 | 2.41 | 92 |
| | Autumn | 3.76 | 2.60 | 59 |
| | Winter | 11.30 | 26.20 | 12 |
| | Total | 1990.00 | 27808.77 | 196 |
| Total | Spring | 7080.96 | 52496.44 | 55 |
| | Summer | 3.03 | 2.34 | 115 |
| | Autumn | 3.76 | 2.60 | 59 |
| | Winter | 9.57 | 23.51 | 15 |
| | Total | 1599.04 | 24923.85 | 244 |

*Dependent variable is miligrams of THg.*

There is no effect to be found when THg is the dependent variable. The marginal means suggest that there may be some effect to be found with a larger sample size, however a power analysis was not conducted. Spring and winter appear to be significantly higher than summer or fall, an interesting contrast to the MeHg analysis. This may be an effect of the small sample size. Total mercury loads do not differ between wet and dry years; and they don't differ between seasons.

The percentage of total mercury present as MeHg follows a similar seasonal trend in wet and dry years. In both cases, the %MeHg starts low in spring, increases during the summer, and tapers down throughout autumn and winter. The %MeHg is consistently higher in dry years than in wet years (Figure 17), but the difference is not statistically significant. This could be a function of biomass. It is possible that more plants thrive in wetter years, acting as a temporary carbon sink.

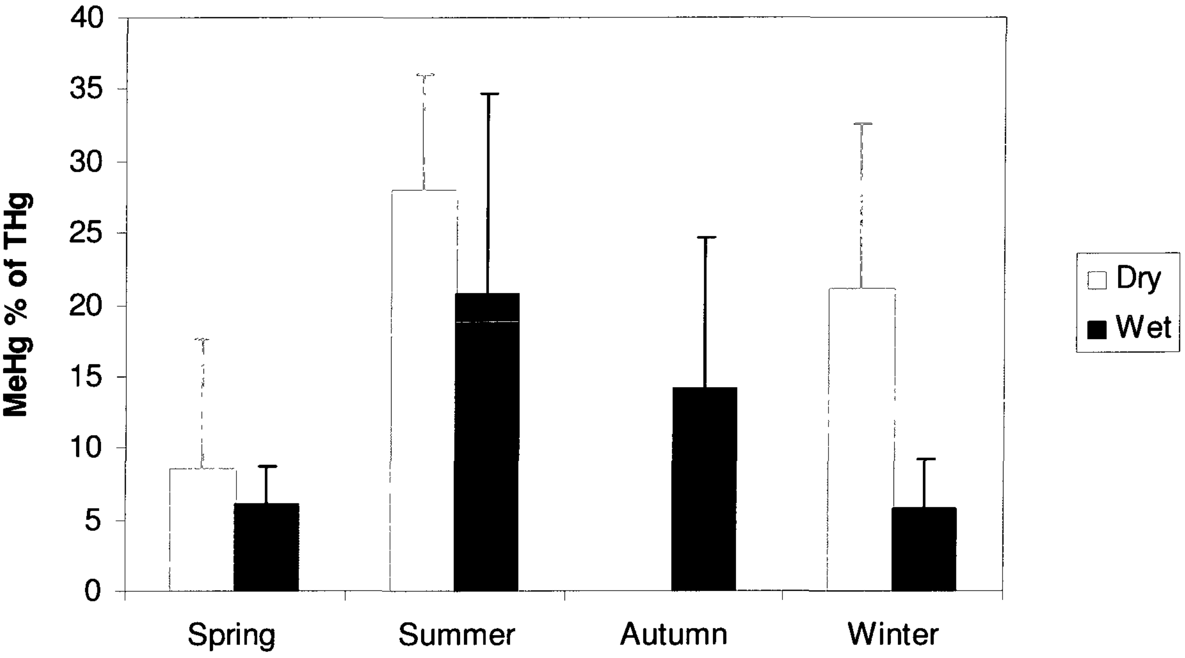


**Figure 17.** Seasonal variability of the percentage of mercury present in the form of MeHg during wet and dry years. There was no autumn data for dry years.

To explore the combinatory effects of the two categorical variables of year type (wet year/dry year) and season (spring, summer, autumn and winter) upon the single continuous variable of %MeHg, a two-way ANOVA was performed (Table 12). The overall ANOVA was significant, F(6, 214)=12.32, *p*<.001. The simple main effect of year type was also significant (F(1, 214)=8.20, *p*<.01), as was the simple main effect of season, (F(3, 214)=15.45, *p*<.001). However, the year-by-season interaction was not significant, (F(2, 223)=1.56, ns), indicating that the effects of season and year upon MeHg percent are independent of one another. Descriptive statistics are presented in Table 13.

**Table 12.** Two-way analysis of variance for %MeHg by season in wet and dry years.

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[b] |
|---|---|---|---|---|---|---|---|---|
| Corrected Model | 8913.377[a] | 6 | 1485.563 | 12.318 | <.001 | .257 | 73.906 | 1.000 |
| Intercept | 15949.354 | 1 | 15949.354 | 132.245 | <.001 | .382 | 132.245 | 1.000 |
| yearwetdry | 989.100 | 1 | 989.100 | 8.201 | .005 | .037 | 8.201 | .814 |
| season | 5589.806 | 3 | 1863.269 | 15.449 | <.001 | .178 | 46.348 | 1.000 |
| yearwetdry*season | 376.756 | 2 | 188.378 | 1.562 | .212 | .014 | 3.124 | .329 |
| Error | 25809.464 | 214 | 120.605 | | | | | |
| Total | 85906.439 | 221 | | | | | | |
| Corrected Total | 34722.841 | 220 | | | | | | |

a. R Squared = .257 (Adjusted R Squared = .236)

b. Computed using alpha = .05

**Table 13.** Descriptive statistics for %MeHg by season in wet and dry years.

| | Season | Mean | SD | n |
|---|---|---|---|---|
| Dry Year | Spring | 8.48 | 9.15 | 20 |
| | Summer | 28.06 | 7.92 | 8 |
| | Autumn | - | - | 0 |
| | Winter | 21.02 | 11.62 | 3 |
| | Total | 14.75 | 12.41 | 31 |
| Wet Year | Spring | 6.10 | 2.70 | 33 |
| | Summer | 20.75 | 13.97 | 88 |
| | Autumn | 14.22 | 10.49 | 57 |
| | Winter | 5.69 | 3.53 | 12 |
| | Total | 15.29 | 12.62 | 190 |
| Total | Spring | 7.00 | 6.04 | 53 |
| | Summer | 21.36 | 13.69 | 96 |
| | Autumn | 14.22 | 10.49 | 57 |
| | Winter | 8.75 | 8.33 | 15 |
| | Total | 15.22 | 12.56 | 221 |

*Dependent variable is percentage of THg present as MeHg.*

To probe this significant main effect of season, Dunnett's T3 post-hoc analyses were used, since Levene's test revealed a violation of the assumption of homogeneity of variances. Dunnett's T3 post hocs revealed the following significant group-mean differences in Hg%, for wet and dry years combined: Spring (7.00%) had significantly lower %MeHg levels than summer (21.36%, $p<.001$) and spring had significantly lower %MeHg levels than autumn (14.22%, $p<.001$), while summer had significantly higher %MeHg levels than autumn ($p<.01$) and summer had significantly higher %MeHg levels than winter (8.75%, $p<.001$). The higher summertime levels are consistent with results obtained by Creswell et al. (2008). No other comparisons were significantly different.

Although the ANOVA yielded a significant main effect of year type, upon probing the effect (basically comparing the mean percentage of 14.79% for dry years and 15.29% for wet years), it was determined that there is no statistically significant difference. This may be an effect of the small sample size. The percentage of total mercury present as MeHg does not differ between wet and dry years based on this limited data. In fact, they appear more dependent upon season. Summer and autumn have higher levels than winter and spring. The higher summer level could be a delayed effect of the spring freshet.

## 3.3 MeHg, THg, and %MeHg ranges

Several of the tributaries were sampled for mercury analysis only in 2008 and 2009. The sampling dates were July 30, August 20, October 6, and November 26 in 2008, and April 22 and June 1 in 2009. Minimum and maximum values for each sample location are shown in Table 14. These values are raw concentration values, not corrected for catchment area or modeled water volume.

**Table 14.** The range of measured MeHg, THg, and the %MeHg for several of the tributaries studied (n=6 unless stated).

| Site | MeHg (ng/L) | THg (ng/L) | %MeHg | Years |
|---|---|---|---|---|
| Newington | 0.21 - 1.67 | 2.60 - 7.11 | 2.95 - 29.17 | 2006, 2007, 2009 |
| RR6 (N=12) | 0.14 - 0.28 | 0.65 - 2.70 | 5.30 - 27.50 | 2005, 2006 |
| RR7 (N=10) | 0.1 - 0.43 | 0.76 - 3.08 | 4.50 - 33.30 | 2005, 2006 |
| Raisin+Bog | 0.07 - 0.26 | 0.23 - 1.40 | 9.56 - 28.17 | 2008, 2009 |
| Wood | 0.07 - 0.37 | 0.34 - 2.43 | 3.41 - 45.85 | 2008, 2009 |
| Westley (N=5) | 0.02 - 1.01 | 0.45 - 2.07 | 2.08 - 48.81 | 2008, 2009 |
| Sutherland | 0.04 - 3.30 | 0.68 - 3.44 | 3.54 - 96.10 | 2008, 2009 |
| Gunn | 0.05 - 0.37 | 0.33 - 1.34 | 4.03 - 36.94 | 2008, 2009 |
| Fraser | 0.10 - 0.57 | 0.41 - 2.24 | 5.43 - 40.69 | 2008, 2009 |
| Finney | 0.02 - 0.53 | 0.48 - 1.45 | 1.74 - 48.34 | 2008, 2009 |

The Raisin River catchment, which includes the Newington Bog, has the narrowest range of MeHg values of the seven tributaries measured in 2008 and 2009. This suggests that the Raisin may have a more constant source of MeHg than the others. Since the Raisin has little crop percentage compared to the others, it may be that crop areas yield MeHg seasonally, and wetlands are a more constant source. This is a rather large leap considering the small sample size, and it warrants an independent research project.

The MeHg range for Fraser, which has little crop area, is very similar to the MeHg ranges of Finney, Gunn, and Wood, which are each at least 50% crop area. Flow direction at the surface level is not necessarily a good representation of subsurface flow. Perhaps there is groundwater from the predominantly crop Westley and Pattingale area feeding into the Fraser. This is almost certainly not the case because it would have to pass under the Raisin River, which is quite wide and deep at that point, then resurface in the Fraser catchment to be observed in the samples. It is theoretically possible but extremely unlikely.

The THg ranges are similar, with Sutherland having the greatest minimum and maximum values, and also the widest range. The lower limits of THg are less variable than the minimum MeHg values. Wood, Westley, Sutherland, and Fraser have the highest upper limits.

The percentage of THg present as MeHg varies from 1.74 to 96.1%. The lowest reading in the Raisin River with Newington Bog is much higher than any of the lowest readings in the other tributaries. The bog data for the same sample dates was not available, but the lower limit of the %MeHg was much smaller than that of the entire Raisin catchment area, and the upper limit is nearly identical. The tributaries with an upper limit of %MeHg greater than 45% also have the highest percentage of crop area. The difference in the upper limits of THg between Gunn and Wood is surprising since they are so close together as to be almost indistinguishable.

## 3.4 Land use and MeHg, THg, and %MeHg

Multiple regressions were used to determine if land use can be used as a predictor of MeHg downstream. Total areas of each land use class were used to predict the variance in MeHg loads. A significant proportion, 6.3%, is predicted by these land use classifications. For every 1 km2 increase in forest, there is a 78.8 ng decrease in MeHg. Similarly, for every 1 km2 increase in impermeable surfaces, there is a decrease of 533.88 ng MeHg. No land use category predicts an increase in MeHg load (Table 15).

**Table 15.** Results of multiple regression for the relationship between MeHg (DV) and five land use categories (IV).

| Predictor | B | Std. Error | Std. Beta | t | p |
|---|---|---|---|---|---|
| (constant) | 406494.563 | 33624.484 | | 12.089 | <.001 |
| Forest | -78.796 | 39.882 | -1.758 | -1.976 | 0.050 |
| Impermeable | -533.878 | 206.388 | -0.279 | -2.587 | 0.010 |
| Open | 44.582 | 155.892 | 0.417 | 0.286 | 0.775 |
| Wet | 291.025 | 294.616 | 0.999 | 0.988 | 0.324 |
| Crop | 34.094 | 47.478 | 0.353 | 0.718 | 0.474 |

$R^2$=0.063; Adjusted $R^2$=0.039; F(5, 195)=26.2; $p<0.05$

The open, wet, and crop coefficients are positive, but they are not significant. Based on the available data, it appears that the larger the area of forest and rock/impermeable, the lower the mercury loads are.

The same analysis was repeated with THg as the dependent variable. The collective set of predictors was not able to predict a significant proportion of the variance in total mercury loads, only 2.3% (Table 16). No predictors were found to be significant. With the data available, we cannot conclude that land use has an impact on total mercury loads.

**Table 16.** Results of multiple regression for the relationship between THg (DV) and five land use categories (IV).

| Predictor | B | Std. Error | Std. Beta | t | p |
|---|---|---|---|---|---|
| (constant) | 334074403.750 | 2509162801.500 | | 0.130 | 0.894 |
| Forest | 1542243.270 | 2975312.220 | 0.480 | 0.520 | 0.605 |
| Impermeable | 2196806.440 | 15482571.460 | 0.020 | 0.140 | 0.887 |
| Open | 10077597.470 | 11571361.050 | 1.300 | 0.870 | 0.385 |
| Wet | -25683966.090 | 21683906.330 | -1.210 | -1.180 | 0.238 |
| Crop | -3493476.520 | 3505585.790 | -0.490 | -1.000 | 0.320 |

$R^2$=0.023; Adjusted $R^2$=0.000; F(5, 201)=0.93; not significant.

A third multiple regression was used to examine the effects of land use category on the percentage of THg present as MeHg. The collective set of predictors can predict a significant proportion of the variance in the percentage of THg present as MeHg, 13.2% ( Table 17). There is a negative relationship between impermeable area and %MeHg. For every 1 km$^2$ increase in impermeable area, there is a 0.016% decrease in %MeHg. This is consistent with Eckley et al. (2008), who found that mercury is more likely to accumulate in impermeable areas, making it less likely to show up in nearby watercourses in the absence of precipitation. Similarly, but conversely, there is a 0.006% increase in the %MeHg per 1 km$^2$ increase in crop area.

**Table 17.** Results of multiple regression for the relationship between the percentage of THg present as MeHg (DV) and five land use categories (IV) by total area.

| Predictor | B | Std. Error | Std. Beta | t | p |
|---|---|---|---|---|---|
| (constant) | 16.712 | 1.170 | | 14.285 | <.001 |
| Forest | 0.000 | 0.001 | -0.030 | -0.034 | 0.973 |
| Impermeable | -0.016 | 0.007 | -0.239 | -2.205 | 0.029 |
| Open | -0.007 | 0.005 | -1.782 | -1.241 | 0.216 |
| Wet | 0.001 | 0.010 | 0.131 | 0.133 | 0.895 |
| Crop | 0.006 | 0.002 | 1.706 | 3.428 | 0.001 |

$R^2$=0.132; Adjusted $R^2$=0.109; F(5, 185)=5.63; p<0.001

Similar results were obtained when the above analysis was repeated using land use percentages in place of areas. In this case, 13.0% of the variance in %MeHg was predicted (Table 18). The forest category was removed because it was significantly correlated with all other predictors, and it would therefore not be able to uniquely predict a significant proportion of the variance. The only significant result in this analysis was that the percentage of crop area can predict an increase in %MeHg. For every 1.0% increase in the area of crop land, the percentage of THg present of MeHg is expected to rise by 0.35% (Table 18). Therefore, we can conclude that the percent of an area that is crop is associated with a greater MeHg:THg ratio.

**Table 18.** Results of multiple regression for the relationship between the percentage of THg present as MeHg (DV) and five land use categories (IV) by percentage of total area.

| Predictor | B | Std. Error | Std. Beta | t | p |
|---|---|---|---|---|---|
| (constant) | 1.326 | 12.653 |  | 0.105 | 0.917 |
| Impermeable | 0.073 | 0.223 | 0.032 | 0.328 | 0.743 |
| Open | 0.070 | 0.449 | 0.014 | 0.157 | 0.875 |
| Wet | 0.438 | 0.454 | 0.146 | 0.965 | 0.336 |
| Crop | 0.345 | 0.108 | 0.481 | 3.179 | 0.002 |

$R^2$=0.130; Adjusted $R^2$=0.112; F(4, )=,

To conclude, forest and impermeable areas are associated with a decrease in MeHg concentration. Impermeable areas decrease the proportion of THg present as MeHg, and crop areas have the opposite effect on %MeHg. The percentage of the catchment area that is crop is also positively related to %MeHg.

## 3.5 MeHg and dissolved nutrients

### 3.5.1 Correlation analyses

Chemical and biological variables were examined by several contributing parties and the resulting data were combined. The tributaries for which there was mercury data were plotted with the other variables that they had in common (Figures 18 to 25), without taking area, precipitation, or flow into account. In this analysis, concentration was used and not net mass. It is assumed that the relationship between area, precipitation, and flow is uniform across the entire study area, and that the unaltered analytical concentrations should be directly comparable. The pH levels were similar in all cases and stable over time (Figure 18). Dissolved oxygen increases over the summer months, consistent with increasing seasonal primary productivity (Figure 19). Sutherland (~54% crop) has higher and less variable TSS values than the other tributaries (Figure 20). In most cases, MeHg decreased in the colder months. There was a dip in $NO_3$ in the summer of 2008, followed by an autumn increase and becoming stable for the winter (Figure 21). Total phosphorus tended to be higher in catchments with crop as their predominant land cover (Figure 22).

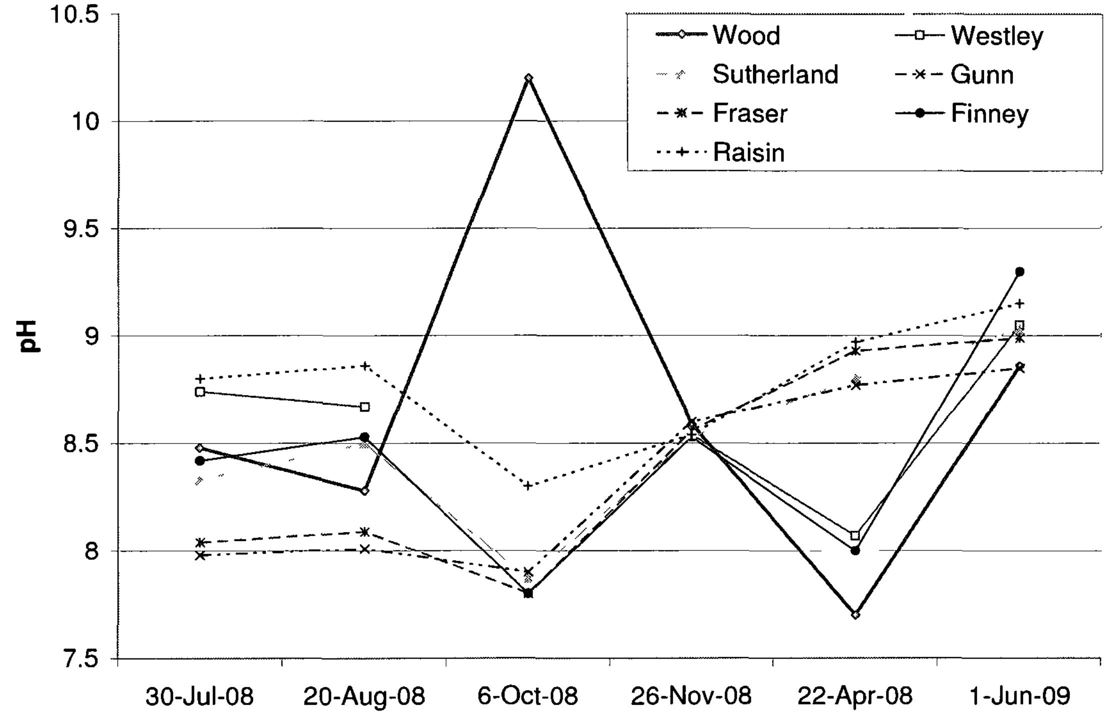


**Figure 18.** The pH of seven rivers sampled near their outflows into the St. Lawrence River near Cornwall, Ontario.

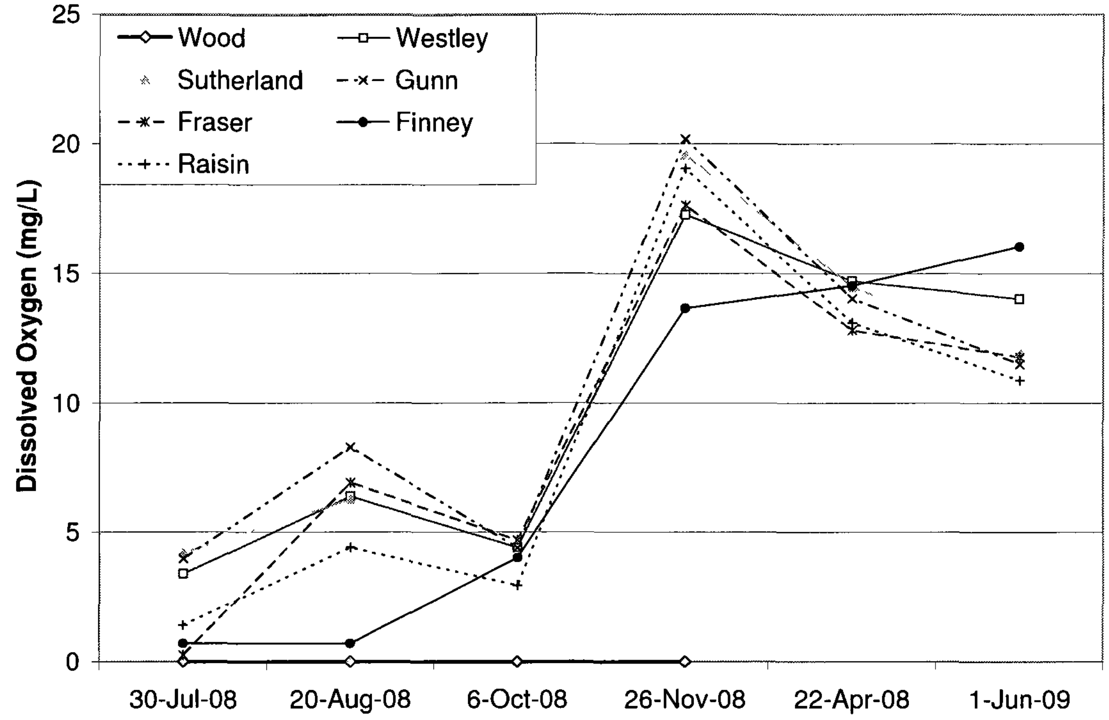


**Figure 19.** Dissolved oxygen (DO) concentration of several rivers sampled near their outflows into the St. Lawrence River near Cornwall, Ontario.

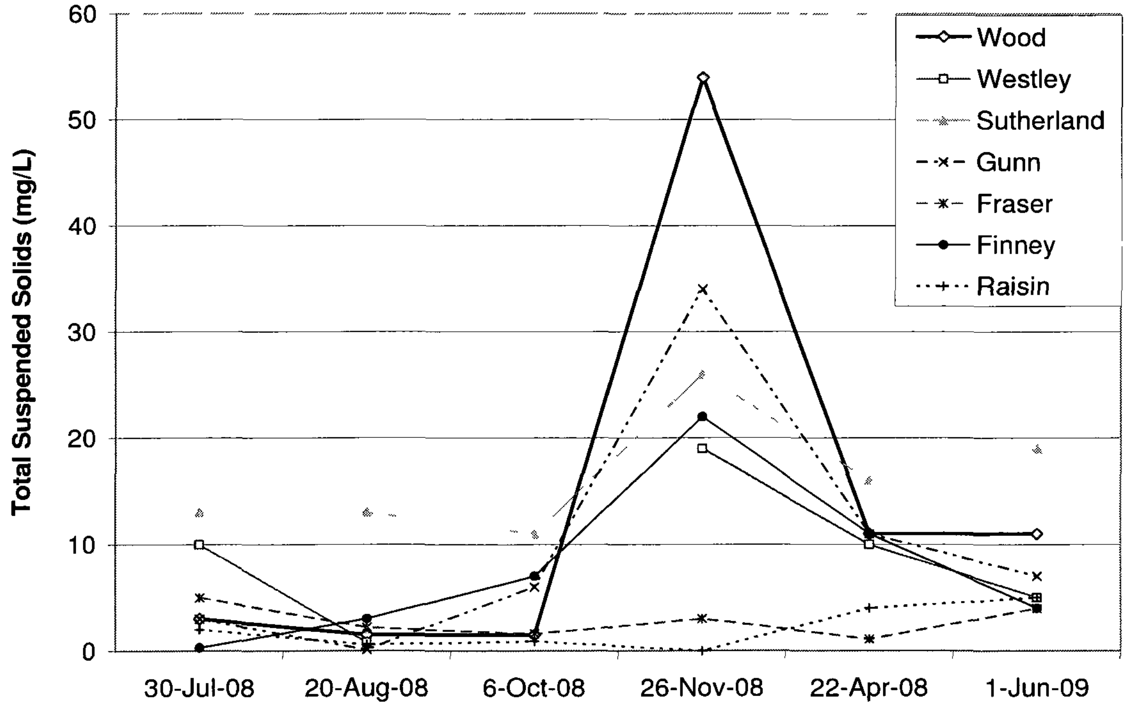


**Figure 20.** Concentration of total suspended solids (TSS) in several rivers sampled near their outflows into the St. Lawrence River near Cornwall, Ontario.

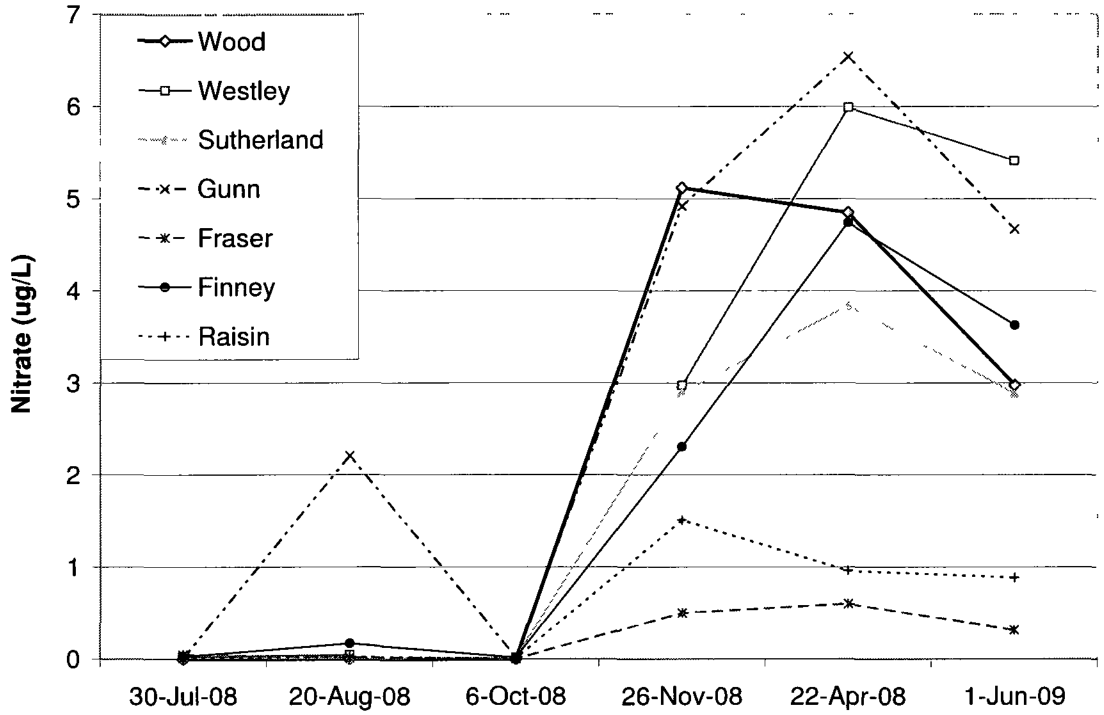


**Figure 21.** Nitrate ($NO_3$) concentrations of water samples from several rivers sampled near their outflows into the St. Lawrence River near Cornwall, Ontario.

Of the catchments represented in the figures above, Westley Creek has both the greatest percentage of crop area and the greatest amount of phosphorus (Figure 22). These are likely related because phosphorus is commonly a limiting factor in plant growth, and is therefore a key ingredient in fertilizers. A predominantly crop catchment is more likely to contain areas of fertilizer use.

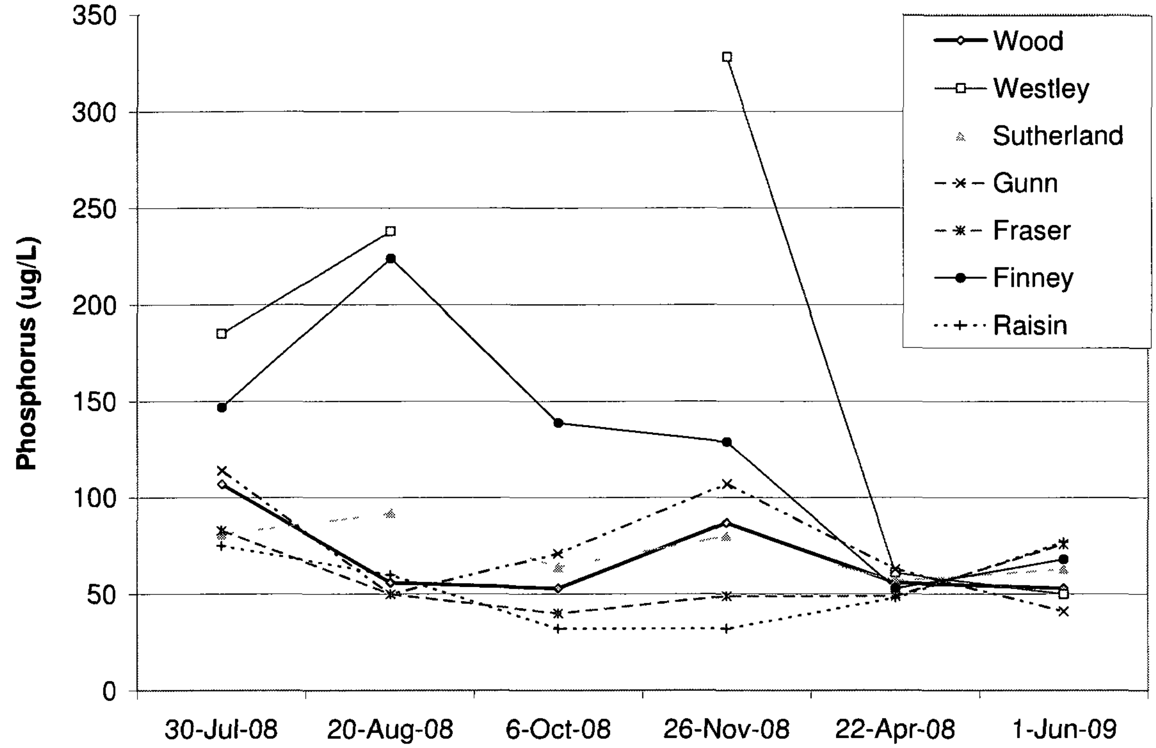


**Figure 22.** Total phosphorus (TP) in water samples of several rivers sampled near their outflows into the St. Lawrence River near Cornwall, Ontario.

Finney, Gunn, Sutherland, and Westley are adjacent to one another. Pattingale separates Finney and Westley, but Sutherland's catchment is adjacent to all the others (Figure 5). Of the tributaries presented in the figures above, these four are predominantly in crop use, and they also have the lowest MeHg values (Figure 23). It is interesting that the Raisin River has one of the lowest MeHg profiles, and that the MeHg and THg in the Raisin are more parallel than for any of the other tributaries' MeHg and THg profiles (Figures 23 to 25). The rivers are more similar with respect to THg concentrations (Figure 24) than MeHg. Balogh (2005) also found that MeHg was more variable between rivers than THg in the same rivers. The %MeHg is more consistent between sites than THg (Figure 25).

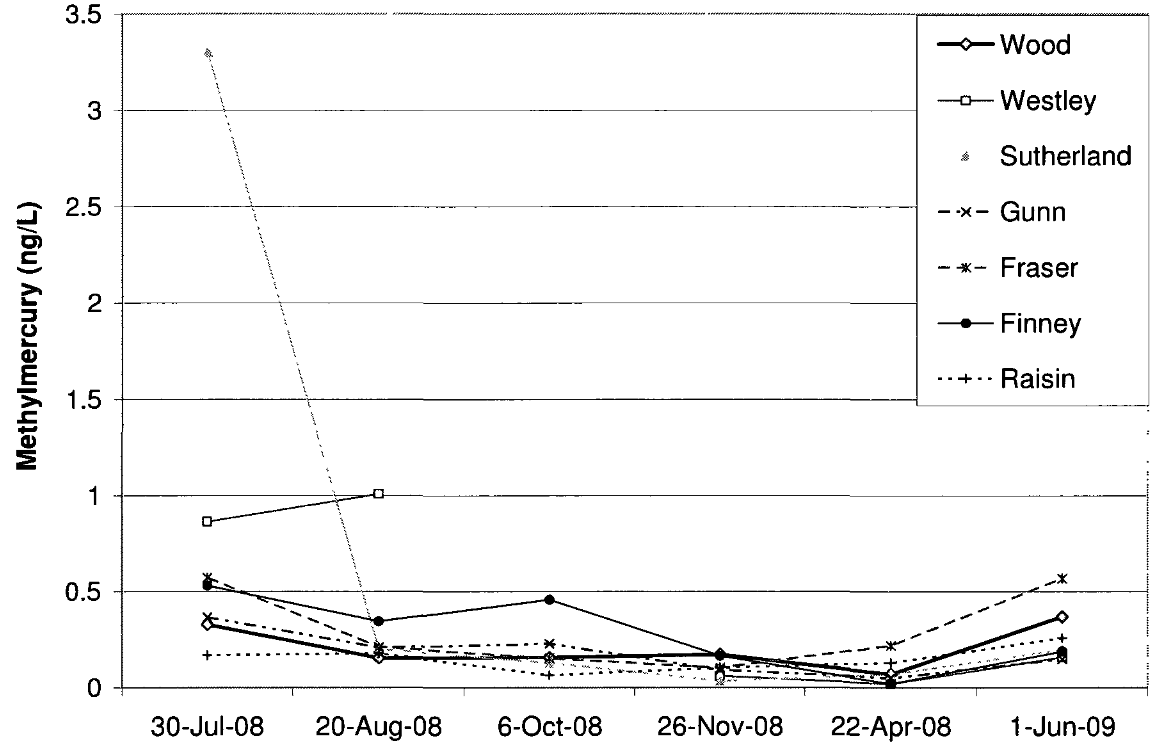


**Figure 23.** Concentration of methylmercury (MeHg) in several rivers sampled near their outflows into the St. Lawrence River near Cornwall, Ontario.

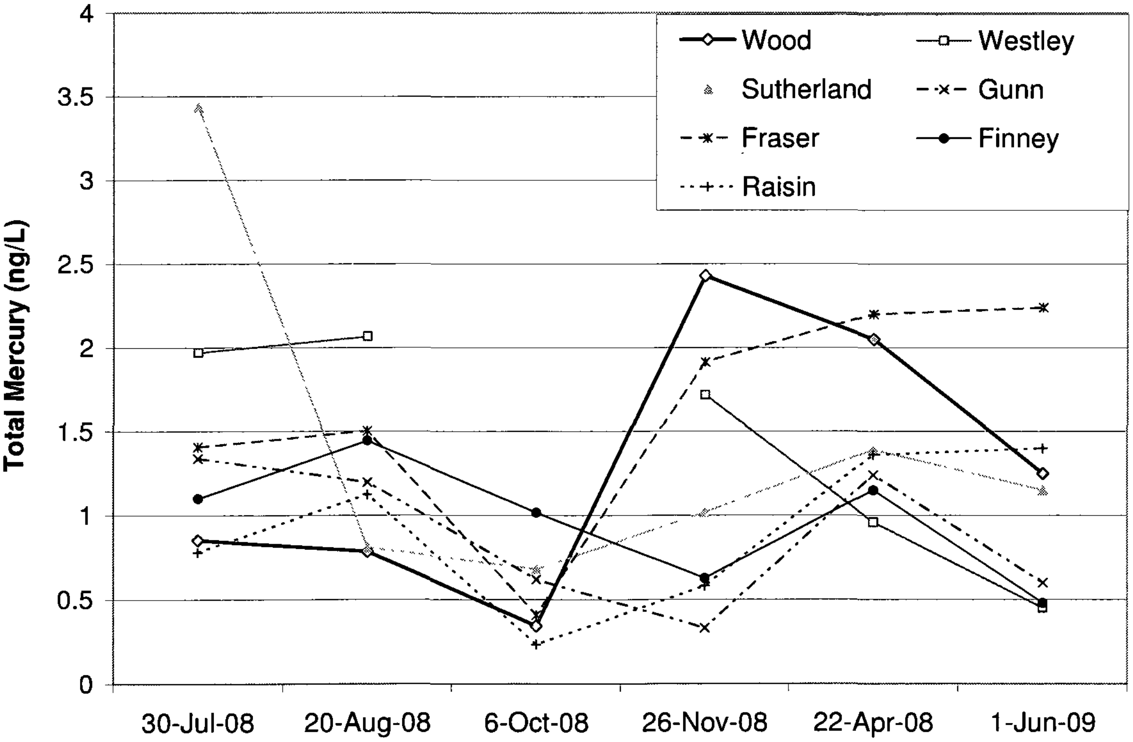


**Figure 24.** Total mercury (THg) concentrations of water samples collected near the outflows of several rivers into the St. Lawrence River near Cornwall, Ontario.

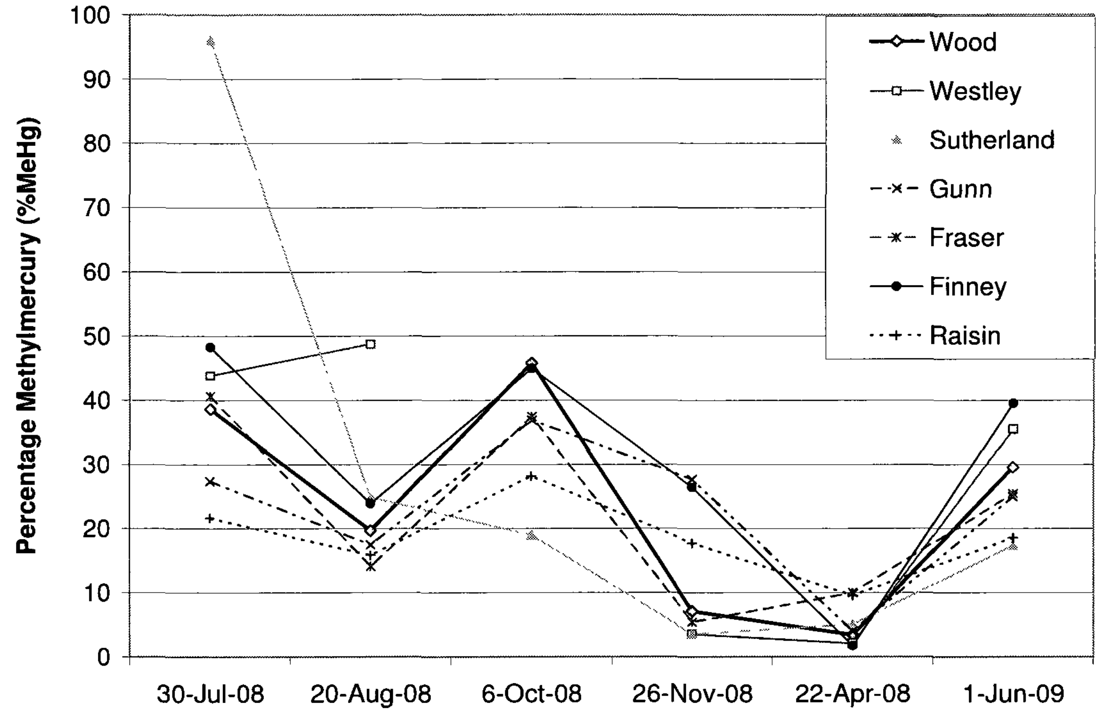


**Figure 25.** Percentage of total mercury present in the form of methylmercury (%MeHg) in seven rivers sampled near their outflows into the St. Lawrence River near Cornwall, Ontario.

Correlation analyses were preformed for MeHg, THg, and the percentage of MeHg to all the observed variables measured in mass/km$^2$. Correlations were considered significant where the p value was less than 0.05. Significant correlations are highlighted in Table 19.

**Table 19.** Results of descriptive correlation analysis of MeHg, THg, and the percentage of MeHg to all the observed chemical and biological variables, with statistically significant correlations highlighted.

| | MeHg | | THg | | %MeHg | |
|---|---|---|---|---|---|---|
| | r | p | r | p | r | p |
| DO | **-0.199** | 0.032 | -0.034 | 0.714 | **-0.416** | <.001 |
| DOC | **0.474** | <.001 | 0.125 | 0.163 | -0.053 | 0.566 |
| DIC | 0.022 | 0.807 | -0.096 | 0.283 | -0.085 | 0.361 |
| P | 0.124 | 0.111 | -0.065 | 0.407 | **0.155** | 0.047 |
| $SO_4$ | 0.056 | 0.529 | -0.094 | 0.292 | **-0.207** | 0.023 |
| $NO_3$ | 0.025 | 0.747 | -0.036 | 0.631 | **-0.29** | <.001 |
| $NH_3$ | **0.483** | <.001 | -0.054 | 0.574 | 0.09 | 0.381 |
| BOD | **0.589** | <.001 | **0.735** | <.001 | **-0.475** | 0.005 |
| SBOD | **0.542** | 0.001 | **0.795** | <.001 | **-0.435** | 0.011 |
| TSS | 0.157 | 0.149 | **0.527** | <.001 | **-0.245** | 0.029 |
| EC CFU | 0.123 | 0.49 | **0.585** | <.001 | **-0.396** | 0.022 |
| FC CFU | 0.158 | 0.373 | **0.606** | <.001 | **-0.365** | 0.037 |
| LOI % | **-0.396** | 0.022 | **-0.437** | 0.011 | **0.679** | <.001 |

Table 19 shows that MeHg is negatively correlated to the concentration of dissolved oxygen. This is consistent with the preferred conditions for methylating bacteria. Since anoxic conditions are required for SRB and other methylating microorganisms to function, the %MeHg is also associated with a decrease in DO. THg is not significantly correlated to DO because its presence is the result of atmospheric deposition regardless of the dissolved oxygen in an environment. The correlations between mercury and DO are consistent with other studies (Balogh et al., 2004; 2005; 2006; Compeau and Bartha, 1985; Fleming et al, 2006; Hall et al., 2008).

Conversely, MeHg is correlated positively to DOC, and there is no association between THg or %MeHg and DOC. MeHg is more likely to be bound to organic materials than other forms of mercury. Also, DOC may increase the methylation rate by acting as an energy source for SRB (Hall et al., 2008).

Methylmercury is also positively correlated positively to $NH_3$. This is consistent with limnological literature because nitrate declines in anoxic conditions, but ammonia increases. Therefore, anoxia creates conditions where MeHg can be created, and also favours the presence of nitrogen in the form of ammonia. The positive correlation between MeHg and $NH_3$ supports the hypotheses and is consistent with previous studies that link anoxia to methylation (Balogh et al., 2004; 2005; 2006; Compeau and Bartha, 1985; Fleming et al, 2006; Hall et al., 2008).

Phosphorus was positively correlated to %MeHg. Since erosion is a major source of phosphorus, it may be accidently elevated during sampling if the sediment is disturbed. In this case, sampling error is not likely the cause of increased phosphorus because the samples for MeHg and THg were collected at the same time in identical containers. Since phosphorus is commonly a limiting nutrient, this correlation may indicate a reduction in biological activity when the %MeHg is high. Alternatively, maybe the correlation is possibly the result of another factor such as new trenches being created in upstream wetlands. Such drainage could increase the rate of MeHg production, which in turn would increase the %MeHg assuming no change in THg, and the physical disturbance would loosen phosphorus-rich substrate which may then be washed downstream.

Methylmercury and THg were also positively correlated to BOD and SBOD. Wetlands that are periodically dried may be more productive than permanent ones because $O_2$ is sometimes able to penetrate deeper into the sediments. This would render the recycling of nutrients more efficient and increase the BOD and SBOD by improving the conditions required for growth. Such correlation could be from unexamined parallel consequences of artificial drainage.

The percentage of THg present as MeHg was negatively correlated with BOD and SBOD. It is possible that as the percentage of MeHg increases, the stress on the organism also increases since MeHg is the most biologically active form of mercury. This might explain the negative correlation, but not the positive correlations with MeHg and THg concentrations. Nitrate was not found to be correlated with MeHg nor THg, but it was negatively correlated to %MeHg. Possibly, the decreases in BOD and SBOD are an effect of the decreased nitrate concentration, and have no direct causal association with %MeHg. In addition, MeHg and THg were negatively correlated with LOI, and %MeHg was positively correlated to LOI.

There were positive correlations between THg and TSS, EC, and FC. It is possible that *E. coli* and fecal coliforms are related to mercury inputs from the digestive processes of animals. Fecal and urinary systems are significant pathways of mercury elimination in mammals (Canuel et al., 2006).

The %MeHg was negatively correlated to $SO_4$, $NO_3$, TSS, EC, FC, BOD, and SBOD. The negative correlation with $SO_4$ could be explained by the activity of SRB. When a greater proportion of the available mercury is being methylated, it is reasonable to assume that more $SO_4$ is being used by the methylators. However, Hall et al. (2008) found that MeHg was not related to $SO_4$. The same is true in the present study in terms of concentration, but there is a correlation between %MeHg and $SO_4$. This is an interesting contradiction to other research findings that sulfate is correlated to mercury methylation (Mitchell et al., 2008; Selvendiran et al., 2008). The degree to which methylation depends on the presence of $SO_4$ is partially determined by depth below the surface (Han et al., 2010). The relationship between %MeHg and $SO_4$ suggests that there is most likely also a correlation between MeHg and $SO_4$ that might be revealed with a larger sample size.

A decrease in $NO_3$ may be an indication of an increased rate of decomposition under anoxic conditions. Perhaps in the presence of a greater %MeHg, productivity is suppressed and the equilibrium between plant growth and decomposition is shifted. Also, inorganic N tends to accumulate in drier seasons, therefore a decrease may be a result of a wetter year (Austin et al., 2004). An inhibitory effect on growth is supported by the negative correlation between %MeHg and BOD and SBOD.

Nothing was found to be correlated to DIC, but all the other observed variables were correlated in some significant way to mercury.

### 3.5.2 Regression analyses exploring correlation results

To further examine the relationships between mercury and the observed, multiple regression was performed for each of MeHg, THg, and the %MeHg. Only the significant predictors highlighted in Table 14 were examined. Collectively, this set of predictors account for 86% of the variance in MeHg, which is significant at the $p<.001$ level. DOC and BOD each contribute a significant proportion of the variance in MeHg loads (Table 20). The cutoff for significance is usually 0.05, but 0.055 is so close that it should not be dismissed. For each mg increase in DOC and BOD, mercury loads will rise by 0.018 and 0.061 ng, respectively, above and beyond the contributions of all other predictors. The other variables are not significant because even though they are correlated with MeHg one-on-one, in regression analyses, one generally looks for unique contributions above and beyond all other variables. If two variables are highly correlated, one may not be able to contribute a meaningful amount of variance above and beyond what the other contributes. Therefore, we may conclude that while all six predictors are related to MeHg, DOC and BOD contribute the most unique variance.

**Table 20.** Results of multiple regression of MeHg to significantly correlated variables.

| Predictor | B | Std. Error | Std. Beta | t | p |
|---|---|---|---|---|---|
| (Constant) | -183911 | 92656.36 | | -1.985 | 0.058 |
| DO in mg | 0.009 | 0.013 | 0.078 | 0.7 | 0.49 |
| **DOC mg** | **0.018** | **0.003** | **0.708** | **6.403** | <.001 |
| $NH_3$ μg | 0 | 0 | -0.027 | -0.25 | 0.804 |
| **BOD in mg** | **0.061** | **0.03** | **0.373** | **2.012** | **0.055** |
| SBOD in mg | 0.008 | 0.023 | 0.051 | 0.33 | 0.744 |
| LOI % | 49923.2 | 103000.4 | 0.042 | 0.485 | 0.632 |

$R^2$=.860/Adj. $R^2$=.828, F(6, 26)=26.59, p<.001

Similar to the above, the collective set of predictors account for 71.7% of the variance in THg. No predictor contributes a significant and unique proportion of the variance above and beyond the others, but BOD and FC are each marginally significant (Table 21). For every one-unit increase in BOD, total mercury loads will rise 0.699 above and beyond the contributions of all other variables. For every one-unit increase in FC, THg will rise 0.002 above the contributions of all other variables.

**Table 21.** Multiple regression of THg and water chemistry laboratory values.

| Predictor | B | Std. Error | Std. Beta | t | p |
|---|---|---|---|---|---|
| (Constant) | 1173990 | 753061 | | 1.559 | 0.131 |
| **BOD in mg** | **0.699** | **0.383** | **0.557** | **1.823** | **0.08** |
| SBOD in mg | 0.406 | 0.336 | 0.355 | 1.207 | 0.238 |
| TSS in mg | -0.054 | 0.034 | -0.498 | -1.553 | 0.132 |
| EC CFU | -0.001 | 0.002 | -0.225 | -0.524 | 0.605 |
| **FC CFU** | **0.002** | **0.001** | **0.645** | **1.748** | **0.092** |
| LOI % | -1E+06 | 1033652 | -0.131 | -1.14 | 0.265 |

$R^2$=.717/Adj. $R^2$=.651, F(6, 26)=10.95, p<.001

The multiple regression defines the predictive model for THg as:

THg = 1173990+0.699(BOD)+0.406(SBOD)-0.054(TSS)-0.001(EC)+0.002FC-1E+06(LOI)

Finally, the collective set of predictors account for 58.7% of the variance in the percentage of THg present as MeHg, which is significant. Only the LOI predictor contributes a significant proportion of the variance above and beyond the others (Table 22). For every percent increase in LOI, the percentage of MeHg will rise by 21.87%. No other predictors were statistically significant, but, based on the small sample size, they should not be ruled out.

**Table 22.** Multiple regression of the percentage of THg present as MeHg (%MeHg) to calculated water chemistry values.

| Predictor | B | Std. Error | Std. Beta | t | p |
|---|---|---|---|---|---|
| (Constant) | 19.396 | 6.907 | | 2.808 | 0.01 |
| DO in mg | 0 | 0 | 0.234 | 0.908 | 0.374 |
| P µg | 0 | 0 | 0.36 | 0.905 | 0.375 |
| $SO_4$ mg | 0 | 0 | -0.457 | -1.165 | 0.257 |
| $NO_3$ µg | 0 | 0 | -0.164 | -0.745 | 0.464 |
| BOD in mg | 0 | 0 | -0.483 | -1.102 | 0.282 |
| SBOD in mg | 0 | 0 | 0.374 | 0.889 | 0.384 |
| TSS in mg | 0 | 0 | 0.227 | 0.467 | 0.645 |
| EC CFU | 0 | 0 | 0.044 | 0.056 | 0.956 |
| FC CFU | 0 | 0 | -0.617 | -0.827 | 0.417 |
| **LOI %** | **21.871** | **7.175** | **0.494** | **3.048** | **0.006** |

$R^2$=.587/Adj. $R^2$=.399, F(10, 22)=3.13, $p<.05$

# 4 General Conclusions

Mercury, and especially MeHg, has far-reaching biological consequences at every trophic level. Having a better understanding of the relationships between ecology and physiology will help predict which species used for human consumption are most likely to be highly contaminated.

Methylmercury production and mobilization is certainly correlated to land cover within a catchment. With further research, it is likely that a more predictive model can be created. Further research is required to investigate the movement of mercury compounds within specific types of environments. More variables such as the distance from distinctive land cover and disturbances should be considered. Real-time data would also yield a significant improvement.

The results of the present study are a starting point from which to engage in a more exhaustive analysis of the land cover of the region and the predictive value of land uses in determining mercury and MeHg contamination of rivers.

## 4.1 Wet vs. dry

Methylmercury loads did not differ between wet and dry years when examined by year type alone. However, at the seasonal level, there are differences to be found. The higher summer loads in wet years may be an indication of increased volume of spring runoff. This could also be due to the extremely small sample size of dry-year data collection in seasons other than spring. Cells less than ten are usually not reliable for performing analyses, and there were only nine for dry year summer, three for dry year winter, and none for dry year autumn. Similarly, the higher spring loads in dry years may be due to the lower dilution factor. Again, low sample size decreases the ability to detect meaningful differences. Autumn could not be determined since no data were collected during a dry year autumn, and no difference was found for the winter. It is very possible that the conclusions would be different if more data were included in future analyses. With the data at hand, however, the conclusions herein may be drawn.

## 4.2 Land use and mercury predictions

The study area is composed predominantly of forest and agriculture, followed by open area, wet area, and impermeable area. Forest and impermeable areas were associated with lower MeHg loads. Impermeable area may decrease the percentage of THg present as MeHg. Crop area may increase the percentage of THg present as MeHg, and crop percentage of total area may be positively correlated to the percentage of THg present as MeHg. There were no predictors for THg concentration, nor for an increase in MeHg load. Only crop use was a significant predictor of %MeHg.

The data suggests some trends that could be supported with more extensive sampling. Significant correlations, as expected, were found between MeHg and DOC, as expected. Methylmercury was not, however, associated with phosphorus or sulfate. The %MeHg was positively correlated to phosphorus. THg, like MeHg, load was positively correlated to BOD, while %MeHg was negatively correlated to BOD.

## 4.3 Challenges

It is challenging to determine how much of the area described in the GIS data as sparse forest is in actuality disturbed wetland area. Because of the drainage practices in place to enhance agricultural yield, land classified as crop area could physically and chemically be more consistent with the wetland category. The GIS data was obtained from reliable sources. However, some data layers were more recent than others. Ideally, all data would be from the same recent time period with high resolution. Even the most meticulous GIS data users are subject to errors, especially when using data from a single point in time to analyse a dynamic set of conditions. There is inherent doubt about the accuracy of any GIS information. Also, the average ecologist does not necessarily appreciate the complexity of GIS operations. The amateur user is at risk of significantly underestimating the time required to complete a GIS study.

Another spatial inconvenience is the presence of artificial limits. Political boundaries are often used to package units of spatial data. However, catchments are not bound by political jurisdictions. As a result of the tributaries that extended into the province of Québec, additional data sets had to be obtained, re-projected, and laboriously aligned with and spliced on to the Ontario data.

There were many individuals and organizations involved in the research and analyses included in this project. Since individual research interests vary, there inevitably was some inconsistent sampling. This inconsistency reflects a certain amount of "scope creep" in the early stages of the project. It would not be unusual that the many possible directions and questions that present themselves result in some incongruence in the objective. The main challenge of this research was the small sample size. There is little winter data, no autumn data for dry years, and there is no flow data for the tributaries. Statistical analyses may have shown stronger relationships and a greater number of statistically significant results had there been more samples included in the study. It would also have been meaningful to measure the effects of co-occurring toxic metals, and to collect water samples at different depths.

A significant limitation of the project is the absence of proper flow and yield calculations. A method was improvised that is not generally supported. It has many of the flaws that the previous modified yield model had, mainly in assuming linear relationships between the numerous environmental variables that affect precipitation, absorption, and runoff. Direction of groundwater flow, soil porosity, and depth of bedrock were not examined.

## 4.4 Concluding remarks

Balance must be reached between ecological, economic, and social values for sustainable watershed management (Foley et al., 2005; Allan et al., 1997). The challenge is that geographic boundaries are not aligned with political boundaries. This results in a diffusion of responsibility. Additional problems arise from a general reluctance to share data between organisations at both local and global levels. The analysis required to compare current conditions with historical values, when political boundaries have changed, would certainly be complex.

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## Appendix A. Sample collection location names and their abbreviations.

| Abbreviation | Description of Location |
|---|---|
| Beau | Beaudette River |
| Bridge | BRIDGE |
| Dix | Dixon Creek |
| Ferg | Ferguson/MacIntosh Creek |
| Finn | Finney Creek |
| Fras | Fraser Creek |
| Gray | Gray's Creek |
| Hoop | Hoople Creek |
| Hwy138 | Highway 138 |
| MD | M.D. |
| Monk | Monkland Drain |
| Moos | Moose Creek |
| Mud | Upstream Mud Road |
| New | Newington |
| NewA | Newington Bog A |
| NewB | Newington Bog B |
| NewC | Newington Bog C |
| NewD | Newington Bog D |
| NewE | Newington Bog E |
| Patt | Pattingale Creek |
| Raisin | Raisin River |
| RR1 | Long Sault - South Branch |
| RR11 | Lancaster Bridge |
| RR12 | MacGillivrays Bridge |
| RR13 | Downstream of Martintown |
| RR15 | Upstream of Martintown - Main Branch |
| RR16 | Upstream of Martintown - North Branch |
| RR17 | Downstream of St. Andrews |
| RR18 | Upstream of St. Andrews - Simon Fraser Farm |
| RR19 | North Lunenburg |
| RR2 | Upstream of Cornwall |
| RR20 | Mid-North Branch - Bingley Road |
| RR21 | Northfield - Newington Bog Outflow |
| RR22 | Monkland Drain - North Branch |
| RR3 | Downstream of Cornwall |
| RR4 | Mid South Branch |
| RR5 | Mouth of South Branch |
| RR6 | Finney's Bridge |
| RR7 | Downstream of Williamstown |
| RR8 | Downstream of Kraft |
| RR9 | Springhill Creek Upstream of Kraft |
| SC | Sutherland Creek |
| Stream | Stream |
| West | Westley's Creek |
| 174/175 | 174/175 |
| GW2 | Gunn & Wood |

# Appendix B. Raw data averaged by month.

| Station | Area km^2 | N | Month | Year | Vol. per km^2 (35% precip) | DO mg/ km$^2$ | BOD mg/ km$^2$ | SBOD mg/ km$^2$ | EC CFU/100 mL |
|---|---|---|---|---|---|---|---|---|---|
| Beau | 207 08 | 3 | August | 2004 | 1350322 75 | | | | |
| Beau | 207 08 | 3 | July | 2004 | 1302903 35 | | | | |
| Beau | 207 08 | 1 | June | 2004 | 721000 | | | | |
| Beau | 207 08 | 4 | August | 2005 | 1611129 1 | 12010967 | | | |
| Beau | 207 08 | 4 | July | 2005 | 821935 45 | 4952161 1 | | | |
| Beau | 207 08 | 2 | June | 2005 | 1633333 45 | 11139334 | | | |
| Beau | 207 08 | 3 | September | 2005 | 1667166 55 | 15310146 | | | |
| Beau | 207 08 | 2 | August | 2006 | 451613 05 | 3585807 6 | | | |
| Beau | 207 08 | 5 | July | 2006 | 1910322 75 | 10567905 | | | |
| Beau | 207 08 | 1 | June | 2006 | 1262333 45 | 9808330 9 | | | |
| Beau | 207 08 | 3 | August | 2007 | 758333 45 | 4105111 7 | | | |
| Beau | 207 08 | 4 | July | 2007 | 1551666 55 | 11082778 | | | |
| Beau | 207 08 | 3 | June | 2007 | 434999 95 | 3218999 6 | | | |
| Bridge | | 3 | August | 2009 | 939354 85 | | | | |
| Bridge | | 3 | July | 2009 | 1245322 75 | | | | |
| Bridge | | 2 | May | 2009 | 1186613 05 | | | | |
| Dix | | 1 | June | 2006 | 1262333 45 | 10098668 | | | |
| Ferg | | 3 | August | 2004 | 1350322 75 | | | | |
| Ferg | | 3 | July | 2004 | 1302903 35 | | | | |
| Ferg | | 1 | June | 2004 | 721000 | | | | |
| Ferg | | 4 | August | 2005 | 1611129 1 | 1949466 2 | | | |
| Ferg | | 4 | July | 2005 | 821935 45 | 4911064 3 | | | |
| Ferg | | 2 | June | 2005 | 1633333 45 | 14128334 | | | |
| Ferg | | 2 | August | 2006 | 451613 05 | 3712259 3 | | | |
| Ferg | | 5 | July | 2006 | 1910322 75 | 9345298 9 | | | |
| Ferg | | 1 | June | 2006 | 1262333 45 | 12863178 | | | |
| Ferg | | 3 | September | 2006 | 1109500 | 5425455 | | | |
| Ferg | | 3 | August | 2007 | 758333 45 | 2110694 8 | | | |
| Ferg | | 4 | July | 2007 | 1551666 55 | 12975812 | | | |
| Ferg | | 3 | June | 2007 | 434997 5 | 6912110 3 | | | |
| Finn | 31 629 | 3 | August | 2004 | 1350322 75 | 0 | | | |
| Finn | 31 629 | 3 | July | 2004 | 1302903 35 | 0 | | | |
| Finn | 31 629 | 1 | June | 2004 | 721000 | 0 | | | |
| Finn | 31 629 | 4 | August | 2005 | 1611129 1 | 3379343 3 | | | |
| Finn | 31 629 | 4 | July | 2005 | 821935 45 | 2889103 1 | | | |
| Finn | 31 629 | 2 | June | 2005 | 1633333 45 | 7921667 2 | | | |
| Finn | 31 629 | 2 | August | 2006 | 451613 05 | 3353226 9 | | | |
| Finn | 31 629 | 5 | July | 2006 | 1910322 75 | 16642732 | | | |
| Finn | 31 629 | 1 | June | 2006 | 1262333 45 | 12383491 | | | |
| Finn | 31 629 | 3 | September | 2006 | 1109500 | 8835318 3 | | | |
| Finn | 31 629 | 3 | August | 2007 | 758333 45 | 5540889 7 | | | |
| Finn | 31 629 | 4 | July | 2007 | 1551666 55 | 13084428 | | | |
| Finn | 31 629 | 3 | June | 2007 | 434997 5 | 4136826 2 | | | |
| Finn | 31 629 | 1 | August | 2008 | 1362499 95 | 6008624 8 | | | |
| Finn | 31 629 | 1 | July | 2008 | 959677 25 | 1353144 9 | | | |
| Finn | 31 629 | 1 | November | 2008 | 1085000 | 20669250 | | | |
| Finn | 31 629 | 1 | October | 2008 | 1482962 95 | 4359911 1 | | | |

| Station | Area km^2 | N | Month | Year | Vol. per km^2 (35% precip) | DO mg/ km$^2$ | BOD mg/ km$^2$ | SBOD mg/ km$^2$ | EC CFU/100 mL |
|---|---|---|---|---|---|---|---|---|---|
| Finn | 31.629 | 1 | April | 2009 | 1059333.45 | 15402708 | | | |
| Finn | 31.629 | 1 | June | 2009 | 616000 | 9880640 | | | |
| Fras | 18.529 | 3 | August | 2004 | 1350322.75 | | | | |
| Fras | 18.529 | 3 | July | 2004 | 1302903.35 | | | | |
| Fras | 18.529 | 1 | June | 2004 | 721000 | | | | |
| Fras | 18.529 | 4 | August | 2005 | 1611129.1 | 3105451.3 | | | |
| Fras | 18.529 | 4 | July | 2005 | 821935.45 | 2153470.9 | | | |
| Fras | 18.529 | 2 | June | 2005 | 1633333.45 | 1731333.5 | | | |
| Fras | 18.529 | 2 | August | 2006 | 451613.05 | 952903.54 | | | |
| Fras | 18.529 | 5 | July | 2006 | 1910322.75 | 8806587.9 | | | |
| Fras | 18.529 | 1 | June | 2006 | 1262333.45 | 11588221 | | | |
| Fras | 18.529 | 3 | September | 2006 | 1109500 | 3358086.7 | | | |
| Fras | 18.529 | 3 | August | 2007 | 758333.45 | 1835166.9 | | | |
| Fras | 18.529 | 4 | July | 2007 | 1551666.55 | 4352424.7 | | | |
| Fras | 18.529 | 3 | June | 2007 | 434997.5 | 2914483.3 | | | |
| Fras | 18.529 | 1 | August | 2008 | 1362499.95 | 953749.97 | | | |
| Fras | 18.529 | 1 | July | 2008 | 959677.25 | 671774.08 | | | |
| Fras | 18.529 | 1 | November | 2008 | 1085000 | 14821100 | | | |
| Fras | 18.529 | 1 | October | 2008 | 1482962.95 | 5961511.1 | | | |
| Fras | 18.529 | 1 | April | 2009 | 1059333.45 | 13580655 | | | |
| Fras | 18.529 | 1 | June | 2009 | 616000 | 7256480 | | | |
| Gray | 33.447 | 3 | August | 2004 | 1350322.75 | | | | |
| Gray | 33.447 | 3 | July | 2004 | 1302903.35 | | | | |
| Gray | 33.447 | 1 | June | 2004 | 721000 | | | | |
| Gray | 33.447 | 4 | August | 2005 | 1611129.1 | 11773326 | | | |
| Gray | 33.447 | 4 | July | 2005 | 821935.45 | 5582996.5 | | | |
| Gray | 33.447 | 2 | June | 2005 | 1633333.45 | 10861667 | | | |
| Gray | 33.447 | 2 | August | 2006 | 451613.05 | 3739356.1 | | | |
| Gray | 33.447 | 5 | July | 2006 | 1910322.75 | 12527897 | | | |
| Gray | 33.447 | 1 | June | 2006 | 1262333.45 | 11411494 | | | |
| Gray | 33.447 | 3 | September | 2006 | 1109500 | 11945617 | | | |
| Gray | 33.447 | 3 | August | 2007 | 758333.45 | 4772445.2 | | | |
| Gray | 33.447 | 4 | July | 2007 | 1551666.55 | 6276491.2 | | | |
| Gray | 33.447 | 3 | June | 2007 | 434997.5 | 4015026.9 | | | |
| Hoop | 83.801 | 5 | August | 2005 | 1611129.1 | 50448480 | | | |
| Hoop | 83.801 | 5 | July | 2005 | 821935.45 | 6417672 | 2843896.66 | 2104154.8 | 5700 |
| Hoop | 83.801 | 3 | June | 2005 | 1633333.45 | 13181001 | 4508000.32 | 3920000.3 | 1000 |
| Hoop | 83.801 | 1 | October | 2005 | 2494032.1 | | | | |
| Hoop | 83.801 | 2 | August | 2006 | 451613.05 | 4719356.4 | | | |
| Hoop | 83.801 | 5 | July | 2006 | 1910322.75 | 15160321 | | | |
| Hoop | 83.801 | 1 | June | 2006 | 1262333.45 | 11108534 | | | |
| Hoop | 83.801 | 3 | September | 2006 | 1109500 | 13517408 | | | |
| Hoop | 83.801 | 3 | August | 2007 | 758333.45 | 5401861.9 | | | |
| Hoop | 83.801 | 4 | July | 2007 | 1551666.55 | 15450720 | | | |
| Hoop | 83.801 | 3 | June | 2007 | 434997.5 | | | | |
| Hwy138 | | 1 | March | 2007 | 687930.95 | 7016895.7 | | | |
| MD | | 1 | June | 2006 | 1262333.45 | 6311667.3 | | | |
| Monk | | 2 | December | 2006 | 1070322.75 | | | | |
| Monk | | 2 | July | 2006 | 1910322.75 | 12035033 | | | |

| Station | Area km^2 | N | Month | Year | Vol. per km^2 (35% precip) | DO mg/ km$^2$ | BOD mg/ km$^2$ | SBOD mg/ km$^2$ | EC CFU/100 mL |
|---|---|---|---|---|---|---|---|---|---|
| Monk | | 2 | November | 2006 | 1264666.55 | 9801165.8 | | | |
| Monk | | 1 | October | 2006 | 1646129.1 | 9053710.1 | | | |
| Monk | | 2 | January | 2007 | 789193.65 | 8365452.7 | | | |
| Monk | | 2 | March | 2007 | 687930.95 | 8255171.4 | | | |
| Monk | | 2 | May | 2007 | 726551.7 | 4213999.9 | | | |
| Moos | | 1 | December | 2006 | 1070322.75 | | | | |
| Mud | | 1 | July | 2006 | 1910322.75 | 11652969 | | | |
| New | | 1 | April | 2009 | 1059333.45 | | | | |
| NewA | | 1 | December | 2006 | 1070322.75 | | | | |
| NewA | | 1 | June | 2006 | 1262333.45 | 5301800.5 | | | |
| NewA | | 1 | November | 2006 | 1264666.55 | 2402866.4 | | | |
| NewA | | 1 | October | 2006 | 1646129.1 | 4609161.5 | | | |
| NewA | | 1 | January | 2007 | 789193.65 | 5524355.6 | | | |
| NewA | | 1 | March | 2007 | 687930.95 | 7911205.9 | | | |
| NewA | | 1 | May | 2007 | 726551.7 | 2833551.6 | | | |
| NewA | | 2 | August | 2009 | 939354.85 | | | | |
| NewA | | 3 | July | 2009 | 1245322.75 | | | | |
| NewA | | 1 | May | 2009 | 1186613.05 | | | | |
| NewB | | 1 | December | 2006 | 1070322.75 | | | | |
| NewB | | 1 | June | 2006 | 1262333.45 | 4102583.7 | | | |
| NewB | | 1 | November | 2006 | 1264666.55 | 8473265.9 | | | |
| NewB | | 1 | October | 2006 | 1646129.1 | 6913742.2 | | | |
| NewB | | 1 | January | 2007 | 789193.65 | 8681130.2 | | | |
| NewB | | 1 | March | 2007 | 687930.95 | 7567240.5 | | | |
| NewB | | 1 | May | 2007 | 726551.7 | 5376482.6 | | | |
| NewC | | 1 | June | 2006 | 1262333.45 | 4544400.4 | | | |
| NewC | | 1 | August | 2009 | 939354.85 | | | | |
| NewD | | 1 | October | 2006 | 1646129.1 | 5926064.8 | | | |
| NewE | | 1 | December | 2006 | 1070322.75 | | | | |
| NewE | | 1 | November | 2006 | 1264666.55 | 5185132.9 | | | |
| Patt | 13.65 | 3 | August | 2004 | 1350322.75 | | | | |
| Patt | 13.65 | 3 | July | 2004 | 1302903.35 | | | | |
| Patt | 13.65 | 1 | June | 2004 | 721000 | | | | |
| Patt | 13.65 | 4 | August | 2005 | 1611129.1 | 8490650.4 | | | |
| Patt | 13.65 | 4 | July | 2005 | 821935.45 | 7417967.4 | | | |
| Patt | 13.65 | 2 | June | 2005 | 1633333.45 | 19943001 | | | |
| Patt | 13.65 | 2 | August | 2006 | 451613.05 | 2249033 | | | |
| Patt | 13.65 | 5 | July | 2006 | 1910322.75 | 11610942 | | | |
| Patt | 13.65 | 1 | June | 2006 | 1262333.45 | 13923538 | | | |
| Patt | 13.65 | 3 | September | 2006 | 1109500 | 2474185 | | | |
| Patt | 13.65 | 4 | July | 2007 | 1551666.55 | 6540274.5 | | | |
| Patt | 13.65 | 3 | June | 2007 | 434997.5 | 4967671.5 | | | |
| Patt | 13.65 | 1 | August | 2008 | 1362499.95 | 1049125 | | | |
| Patt | 13.65 | 1 | July | 2008 | 959677.25 | 3857902.5 | | | |
| Patt | 13.65 | 1 | November | 2008 | 1085000 | 18857300 | | | |
| Patt | 13.65 | 1 | April | 2009 | 1059333.45 | 15084908 | | | |
| Patt | 13.65 | 1 | June | 2009 | 616000 | 9584960 | | | |
| Raisin | 573.17 | 3 | August | 2004 | 1350322.75 | | | | |
| Raisin | 573.17 | 3 | July | 2004 | 1302903.35 | | | | |
| Raisin | 573.17 | 1 | June | 2004 | 721000 | | | | |
| Raisin | 573.17 | 4 | August | 2005 | 1611129.1 | 13187092 | | | |
| Raisin | 573.17 | 4 | July | 2005 | 821935.45 | 6367944.9 | | | |

| Station | Area km^2 | N | Month | Year | Vol. per km^2 (35% precip) | DO mg/ km$^2$ | BOD mg/ km$^2$ | SBOD mg/ km$^2$ | EC CFU/100 mL |
|---|---|---|---|---|---|---|---|---|---|
| Raisin | 573.17 | 2 | June | 2005 | 1633333.45 | 14014001 | | | |
| Raisin | 573.17 | 2 | August | 2006 | 451613.05 | 3161291.4 | | | |
| Raisin | 573.17 | 5 | July | 2006 | 1910322.75 | 12420919 | | | |
| Raisin | 573.17 | 1 | June | 2006 | 1262333.45 | 12093154 | | | |
| Raisin | 573.17 | 3 | September | 2006 | 1109500 | 11975203 | | | |
| Raisin | 573.17 | 6 | August | 2007 | 758333.45 | 3906681.2 | | | |
| Raisin | 573.17 | 4 | July | 2007 | 1551666.55 | 14504203 | | | |
| Raisin | 573.17 | 3 | June | 2007 | 434997.5 | 4510924.1 | | | |
| Raisin | 573.17 | 1 | August | 2008 | 1362499.95 | 9687374.6 | | | |
| Raisin | 573.17 | 1 | July | 2008 | 959677.25 | 4529676.6 | | | |
| Raisin | 573.17 | 1 | November | 2008 | 1085000 | 20050800 | | | |
| Raisin | 573.17 | 1 | October | 2008 | 1482962.95 | 11285348 | | | |
| Raisin | 573.17 | 1 | April | 2009 | 1059333.45 | 13877268 | | | |
| Raisin | 573.17 | 1 | June | 2009 | 616000 | 6702080 | | | |
| RR1 | 1.8863 | 2 | August | 2005 | 1611129.1 | | | | |
| RR1 | 1.8863 | 3 | July | 2005 | 821935.45 | 9205677 | 476722.56 | 98632.25 | |
| RR1 | 1.8863 | 1 | June | 2005 | 1633333.45 | 4671333.7 | 8820000.63 | 5128667 | 500 |
| RR1 | 1.8863 | 2 | October | 2005 | 2494032.1 | | | | |
| RR1 | 1.8863 | 1 | June | 2006 | 1262333.45 | | | | |
| RR1 | 1.8863 | 2 | May | 2006 | 1421451.5 | | | | |
| RR11 | | 1 | August | 2005 | 1611129.1 | | | | |
| RR11 | | 2 | July | 2005 | 821935.45 | 6838502.9 | 854812.87 | 443845.14 | |
| RR11 | | 2 | June | 2005 | 1633333.45 | 9979667.4 | 3413666.91 | 4573333.7 | 100 |
| RR12 | 362.39 | 1 | August | 2005 | 1611129.1 | | | | |
| RR12 | 362.39 | 1 | July | 2005 | 821935.45 | 4290503 | 2169909.59 | 1052077.4 | 380 |
| RR12 | 362.39 | 1 | June | 2005 | 1633333.45 | 10290001 | 4214000.3 | 4148667 | 1100 |
| RR12 | 362.39 | 1 | October | 2005 | 2494032.1 | | | | |
| RR12 | 362.39 | 1 | May | 2006 | 1421451.5 | | | | |
| RR12 | 362.39 | 7 | April | 2008 | 819999.95 | | | | |
| RR12 | 362.39 | 10 | May | 2008 | 971250 | | | | |
| RR12 | 362.39 | 3 | April | 2009 | 1059333.45 | | | | |
| RR12 | 362.39 | 2 | August | 2009 | 939354.85 | | | | |
| RR12 | 362.39 | 10 | July | 2009 | 1245322.75 | | | | |
| RR12 | 362.39 | 2 | July | 2009 | 1245322.75 | | | | |
| RR12 | 362.39 | 2 | June | 2009 | 616000 | | | | |
| RR12 | 362.39 | 4 | May | 2009 | 1186613.05 | | | | |
| RR13 | 335.06 | 1 | August | 2005 | 1611129.1 | | | | |
| RR13 | 335.06 | 1 | July | 2005 | 821935.45 | 4865857.9 | 3041161.17 | 1495922.5 | 220 |
| RR13 | 335.06 | 1 | June | 2005 | 1633333.45 | 10878001 | 4834667.01 | 4116000.3 | 700 |
| RR13 | 335.06 | 1 | June | 2005 | 1633333.45 | | | | |
| RR13 | 335.06 | 1 | October | 2005 | 2494032.1 | | | | |
| RR13 | 335.06 | 1 | May | 2006 | 1421451.5 | | | | |
| RR15 | 194.49 | 2 | August | 2005 | 1611129.1 | | | | |
| RR15 | 194.49 | 2 | July | 2005 | 821935.45 | 2893212.8 | 2367174.1 | 1265780.6 | 230 |
| RR15 | 194.49 | 1 | June | 2005 | 1633333.45 | 11155667 | 3985333.62 | 4606000.3 | 1000 |
| RR15 | 194.49 | 1 | November | 2005 | 1213333.45 | | | | |
| RR15 | 194.49 | 1 | October | 2005 | 2494032.1 | | | | |
| RR15 | 194.49 | 1 | September | 2005 | 1667166.55 | | | | |
| RR15 | 194.49 | 1 | April | 2006 | 772333.45 | | | | |

| Station | Area km^2 | N | Month | Year | Vol. per km^2 (35% precip) | DO mg/ km$^2$ | BOD mg/ km$^2$ | SBOD mg/ km$^2$ | EC CFU/100 mL |
|---|---|---|---|---|---|---|---|---|---|
| RR15 | 194.49 | 1 | August | 2006 | 451613.05 | | | | |
| RR15 | 194.49 | 1 | February | 2006 | 1006250 | | | | |
| RR15 | 194.49 | 1 | June | 2006 | 1262333.45 | | | | |
| RR15 | 194.49 | 2 | March | 2006 | 251774.25 | | | | |
| RR15 | 194.49 | 2 | May | 2006 | 1421451.5 | | | | |
| RR16 | 128.8 | 2 | August | 2005 | 1611129.1 | | | | |
| RR16 | 128.8 | 2 | July | 2005 | 821935.45 | 3945290.2 | 3205548.26 | 2005522.5 | 1200 |
| RR16 | 128.8 | 4 | June | 2005 | 1633333.45 | 10192001 | 3081555.78 | 2635111.3 | 600 |
| RR16 | 128.8 | 1 | November | 2005 | 1213333.45 | | | | |
| RR16 | 128.8 | 1 | October | 2005 | 2494032.1 | | | | |
| RR16 | 128.8 | 1 | September | 2005 | 1667166.55 | | | | |
| RR16 | 128.8 | 1 | April | 2006 | 772333.45 | | | | |
| RR16 | 128.8 | 1 | August | 2006 | 451613.05 | | | | |
| RR16 | 128.8 | 1 | February | 2006 | 1006250 | | | | |
| RR16 | 128.8 | 1 | June | 2006 | 1262333.45 | | | | |
| RR16 | 128.8 | 2 | March | 2006 | 251774.25 | | | | |
| RR16 | 128.8 | 1 | May | 2006 | 1421451.5 | | | | |
| RR17 | 150.6 | 1 | August | 2005 | 1611129.1 | | | | |
| RR17 | 150.6 | 1 | July | 2005 | 821935.45 | 6156296.5 | 2252103.13 | 1463045.1 | 390 |
| RR17 | 150.6 | 1 | June | 2005 | 1633333.45 | 12740001 | 3626000.26 | 3462666.9 | 800 |
| RR17 | 150.6 | 1 | October | 2005 | 2494032.1 | | | | |
| RR17 | 150.6 | 1 | May | 2006 | 1421451.5 | | | | |
| RR18 | 132.09 | 1 | August | 2005 | 1611129.1 | | | | |
| RR18 | 132.09 | 1 | July | 2005 | 821935.45 | 4841199.8 | 1906890.24 | 1841135.4 | 340 |
| RR18 | 132.09 | 1 | June | 2005 | 1633333.45 | 11106667 | 4475333.65 | 2580666.9 | 600 |
| RR18 | 132.09 | 1 | October | 2005 | 2494032.1 | | | | |
| RR18 | 132.09 | 1 | March | 2006 | 251774.25 | | | | |
| RR18 | 132.09 | 1 | May | 2006 | 1421451.5 | | | | |
| RR19 | 75.364 | 2 | August | 2005 | 1611129.1 | | | | |
| RR19 | 75.364 | 1 | July | 2005 | 821935.45 | 4964490.1 | 3271303.09 | 1874012.8 | 7000 |
| RR19 | 75.364 | 2 | June | 2005 | 1633333.45 | 9840834 | 3413666.91 | 3560666.9 | 450 |
| RR19 | 75.364 | 1 | June | 2005 | 1633333.45 | | | | |
| RR19 | 75.364 | 1 | October | 2005 | 2494032.1 | | | | |
| RR19 | 75.364 | 1 | June | 2006 | 1262333.45 | 10856068 | | | |
| RR19 | 75.364 | 1 | May | 2006 | 1421451.5 | | | | |
| RR2 | 23.436 | 3 | August | 2005 | 1611129.1 | | | | |
| RR2 | 23.436 | 2 | July | 2005 | 821935.45 | 9739935.1 | 591793.52 | 838374.16 | 200 |
| RR2 | 23.436 | 2 | June | 2005 | 1633333.45 | 7431667.2 | 3168666.89 | 4622333.7 | 10000 |
| RR2 | 23.436 | 1 | November | 2005 | 1213333.45 | | | | |
| RR2 | 23.436 | 2 | October | 2005 | 2494032.1 | | | | |
| RR2 | 23.436 | 1 | September | 2005 | 1667166.55 | | | | |
| RR2 | 23.436 | 1 | April | 2006 | 772333.45 | | | | |
| RR2 | 23.436 | 1 | August | 2006 | 451613.05 | | | | |
| RR2 | 23.436 | 2 | March | 2006 | 251774.25 | | | | |
| RR2 | 23.436 | 1 | May | 2006 | 1421451.5 | | | | |
| RR20 | 80.114 | 1 | August | 2005 | 1611129.1 | | | | |
| RR20 | 80.114 | 1 | July | 2005 | 821935.45 | 4890515.9 | 1084954.79 | 969883.83 | 1500 |
| RR20 | 80.114 | 1 | June | 2005 | 1633333.45 | 11139334 | 5716667.08 | 4573333.7 | 1200 |

| Station | Area km^2 | N | Month | Year | Vol. per km^2 (35% precip) | DO mg/ km$^2$ | BOD mg/ km$^2$ | SBOD mg/ km$^2$ | EC CFU/100 mL |
|---|---|---|---|---|---|---|---|---|---|
| RR20 | 80.114 | 1 | October | 2005 | 2494032.1 | | | | |
| RR20 | 80.114 | 1 | May | 2006 | 1421451.5 | | | | |
| RR21 | 8.2388 | 2 | August | 2005 | 1611129.1 | | | | |
| RR21 | 8.2388 | 2 | July | 2005 | 821935.45 | 5359019.1 | 1561677.36 | 1052077.4 | 900 |
| RR21 | 8.2388 | 3 | June | 2005 | 1633333.45 | 10535001 | 2531666.85 | 2695000.2 | 900 |
| RR21 | 8.2388 | 1 | November | 2005 | 1213333.45 | | | | |
| RR21 | 8.2388 | 1 | October | 2005 | 2494032.1 | | | | |
| RR21 | 8.2388 | 1 | September | 2005 | 1667166.55 | | | | |
| RR21 | 8.2388 | 1 | April | 2006 | 772333.45 | | | | |
| RR21 | 8.2388 | 1 | August | 2006 | 451613.05 | | | | |
| RR21 | 8.2388 | 1 | December | 2006 | 1070322.75 | | | | |
| RR21 | 8.2388 | 1 | February | 2006 | 1006250 | | | | |
| RR21 | 8.2388 | 2 | June | 2006 | 1262333.45 | 10477368 | | | |
| RR21 | 8.2388 | 2 | March | 2006 | 251774.25 | | | | |
| RR21 | 8.2388 | 1 | May | 2006 | 1421451.5 | | | | |
| RR21 | 8.2388 | 1 | November | 2006 | 1264666.55 | 8473265.9 | | | |
| RR21 | 8.2388 | 1 | October | 2006 | 1646129.1 | 10864452 | | | |
| RR21 | 8.2388 | 1 | March | 2007 | 687930.95 | 7704826.6 | | | |
| RR21 | 8.2388 | 7 | April | 2008 | 819999.95 | | | | |
| RR21 | 8.2388 | 8 | May | 2008 | 971250 | | | | |
| RR21 | 8.2388 | 5 | April | 2009 | 1059333.45 | | | | |
| RR21 | 8.2388 | 6 | August | 2009 | 939354.85 | | | | |
| RR21 | 8.2388 | 6 | July | 2009 | 1245322.75 | | | | |
| RR21 | 8.2388 | 3 | July | 2009 | 1245322.75 | | | | |
| RR21 | 8.2388 | 3 | June | 2009 | 616000 | | | | |
| RR21 | 8.2388 | 4 | May | 2009 | 1186613.05 | | | | |
| RR22 | 29.128 | 2 | August | 2005 | 1611129.1 | | | | |
| RR22 | 29.128 | 2 | July | 2005 | 821935.45 | 5309703 | 723303.2 | 2087716 | 700 |
| RR22 | 29.128 | 3 | June | 2005 | 1633333.45 | 13099334 | 2956333.54 | 3201333.6 | 400 |
| RR22 | 29.128 | 1 | November | 2005 | 1213333.45 | | | | |
| RR22 | 29.128 | 1 | October | 2005 | 2494032.1 | | | | |
| RR22 | 29.128 | 1 | September | 2005 | 1667166.55 | | | | |
| RR22 | 29.128 | 1 | April | 2006 | 772333.45 | | | | |
| RR22 | 29.128 | 1 | August | 2006 | 451613.05 | | | | |
| RR22 | 29.128 | 1 | February | 2006 | 1006250 | | | | |
| RR22 | 29.128 | 1 | July | 2006 | 1910322.75 | 15855679 | | | |
| RR22 | 29.128 | 1 | June | 2006 | 1262333.45 | | | | |
| RR22 | 29.128 | 2 | March | 2006 | 251774.25 | | | | |
| RR22 | 29.128 | 1 | May | 2006 | 1421451.5 | | | | |
| RR3 | 47.948 | 2 | August | 2005 | 1611129.1 | | | | |
| RR3 | 47.948 | 2 | July | 2005 | 821935.45 | 5893277.2 | 723303.2 | 854812.87 | 600 |
| RR3 | 47.948 | 1 | June | 2005 | 1633333.45 | 8575000.6 | 9342667.33 | 12315334 | 15000 |
| RR3 | 47.948 | 2 | October | 2005 | 2494032.1 | | | | |
| RR3 | 47.948 | 2 | May | 2006 | 1421451.5 | | | | |
| RR4 | 74.33 | 2 | August | 2005 | 1611129.1 | | | | |
| RR4 | 74.33 | 2 | July | 2005 | 821935.45 | 4520645 | 986322.54 | 410967.73 | 200 |
| RR4 | 74.33 | 1 | June | 2005 | 1633333.45 | 8901667.3 | 6010667.1 | 4573333.7 | 9000 |
| RR4 | 74.33 | 1 | November | 2005 | 1213333.45 | | | | |

| Station | Area km^2 | N | Month | Year | Vol. per km^2 (35% precip) | DO mg/km$^2$ | BOD mg/ km$^2$ | SBOD mg/ km$^2$ | EC CFU/100 mL |
|---|---|---|---|---|---|---|---|---|---|
| RR4 | 74.33 | 2 | October | 2005 | 2494032.1 | | | | |
| RR4 | 74.33 | 1 | May | 2006 | 1421451.5 | | | | |
| RR5 | 105.45 | 3 | August | 2005 | 1611129.1 | | | | |
| RR5 | 105.45 | 3 | July | 2005 | 821935.45 | 3904193.4 | 608232.23 | 591793.52 | 300 |
| RR5 | 105.45 | 2 | June | 2005 | 1633333.45 | 8199333.9 | 4246666.97 | 5161333.7 | 4200 |
| RR5 | 105.45 | 2 | November | 2005 | 1213333.45 | | | | |
| RR5 | 105.45 | 2 | October | 2005 | 2494032.1 | | | | |
| RR5 | 105.45 | 1 | September | 2005 | 1667166.55 | | | | |
| RR5 | 105.45 | 1 | April | 2006 | 772333.45 | | | | |
| RR5 | 105.45 | 1 | August | 2006 | 451613.05 | | | | |
| RR5 | 105.45 | 1 | February | 2006 | 1006250 | | | | |
| RR5 | 105.45 | 1 | June | 2006 | 1262333.45 | | | | |
| RR5 | 105.45 | 2 | March | 2006 | 251774.25 | | | | |
| RR5 | 105.45 | 1 | May | 2006 | 1421451.5 | | | | |
| RR6 | 573.01 | 3 | August | 2005 | 1611129.1 | | | | |
| RR6 | 573.01 | 2 | July | 2005 | 821935.45 | 5548064.3 | 1019199.96 | 82193.55 | 100 |
| RR6 | 573.01 | 1 | June | 2005 | 1633333.45 | 6533333.8 | 3724000.27 | 5684000.4 | 3900 |
| RR6 | 573.01 | 1 | November | 2005 | 1213333.45 | | | | |
| RR6 | 573.01 | 2 | October | 2005 | 2494032.1 | | | | |
| RR6 | 573.01 | 1 | September | 2005 | 1667166.55 | | | | |
| RR6 | 573.01 | 1 | June | 2006 | 1262333.45 | | | | |
| RR6 | 573.01 | 2 | March | 2006 | 251774.25 | | | | |
| RR6 | 573.01 | 2 | May | 2006 | 1421451.5 | | | | |
| RR7 | 408.81 | 3 | August | 2005 | 1611129.1 | | | | |
| RR7 | 408.81 | 2 | July | 2005 | 821935.45 | 5720670.7 | 493161.27 | 558916.11 | 100 |
| RR7 | 408.81 | 2 | June | 2005 | 1633333.45 | 11294501 | 3658666.93 | 2695000.2 | 4550 |
| RR7 | 408.81 | 1 | November | 2005 | 1213333.45 | | | | |
| RR7 | 408.81 | 2 | October | 2005 | 2494032.1 | | | | |
| RR7 | 408.81 | 1 | September | 2005 | 1667166.55 | | | | |
| RR7 | 408.81 | 1 | February | 2006 | 1006250 | | | | |
| RR7 | 408.81 | 1 | March | 2006 | 251774.25 | | | | |
| RR7 | 408.81 | 1 | May | 2006 | 1421451.5 | | | | |
| RR8 | | 3 | July | 2005 | 821935.45 | 4479548.2 | 3632954.69 | 2654851.5 | 4800 |
| RR8 | | 1 | June | 2005 | 1633333.45 | 8624000.6 | 3266666.9 | 2352000.2 | 800 |
| RR8 | | 5 | November | 2005 | 1213333.45 | | | | |
| RR9 | | 1 | August | 2005 | 1611129.1 | | | | |
| RR9 | | 1 | July | 2005 | 821935.45 | 3698709.5 | 986322.54 | 789058.03 | 500 |
| RR9 | | 1 | June | 2005 | 1633333.45 | 11025001 | 9179333.99 | 9473334 | 39000 |
| RR9 | | 1 | October | 2005 | 2494032.1 | | | | |
| SC | 76.718 | 3 | August | 2004 | 1350322.75 | | | | |
| SC | 76.718 | 3 | July | 2004 | 1302903.35 | | | | |
| SC | 76.718 | 2 | June | 2004 | 721000 | 8623160 | | | |
| SC | 76.718 | 5 | August | 2005 | 1611129.1 | 12349305 | | | |
| SC | 76.718 | 5 | July | 2005 | 821935.45 | 7200154.5 | 1183587.05 | 361651.6 | |
| SC | 76.718 | 2 | June | 2005 | 1633333.45 | 18032001 | | | |
| SC | 76.718 | 1 | October | 2005 | 2494032.1 | | | | |
| SC | 76.718 | 2 | August | 2006 | 451613.05 | 3253872 | | | |
| SC | 76.718 | 5 | July | 2006 | 1910322.75 | 13135379 | | | |
| SC | 76.718 | 1 | June | 2006 | 1262333.45 | 14062395 | | | |

| Station | Area km^2 | N | Month | Year | Vol. per km^2 (35% precip) | DO mg/ km$^2$ | BOD mg/ km$^2$ | SBOD mg/ km$^2$ | EC CFU/100 mL |
|---|---|---|---|---|---|---|---|---|---|
| SC | 76.718 | 3 | September | 2006 | 1109500 | 9094201.7 | | | |
| SC | 76.718 | 3 | August | 2007 | 758333.45 | 5022695.2 | | | |
| SC | 76.718 | 4 | July | 2007 | 1551666.55 | 11897403 | | | |
| SC | 76.718 | 3 | June | 2007 | 434997.5 | 2296786.8 | | | |
| SC | 76.718 | 1 | August | 2008 | 1362499.95 | 11295125 | | | |
| SC | 76.718 | 1 | July | 2008 | 959677.25 | 3819515.5 | | | |
| SC | 76.718 | 1 | November | 2008 | 1085000 | 21895300 | | | |
| SC | 76.718 | 1 | October | 2008 | 1482962.95 | 6525037 | | | |
| SC | 76.718 | 1 | April | 2009 | 1059333.45 | 15360335 | | | |
| Stream | | 2 | August | 2009 | 939354.85 | | | | |
| Stream | | 3 | July | 2009 | 1245322.75 | | | | |
| Stream | | 1 | May | 2009 | 1186613.05 | | | | |
| West | 9.8856 | 3 | August | 2004 | 1350322.75 | | | | |
| West | 9.8856 | 3 | July | 2004 | 1302903.35 | | | | |
| West | 9.8856 | 1 | June | 2004 | 721000 | | | | |
| West | 9.8856 | 4 | August | 2005 | 1611129.1 | 5139501.8 | | | |
| West | 9.8856 | 4 | July | 2005 | 821935.45 | 4002825.6 | | | |
| West | 9.8856 | 2 | June | 2005 | 1633333.45 | 6549667.1 | | | |
| West | 9.8856 | 2 | August | 2006 | 451613.05 | 2971613.9 | | | |
| West | 9.8856 | 5 | July | 2006 | 1910322.75 | 14533735 | | | |
| West | 9.8856 | 1 | June | 2006 | 1262333.45 | 14466341 | | | |
| West | 9.8856 | 3 | September | 2006 | 1109500 | 6712475 | | | |
| West | 9.8856 | 3 | August | 2007 | 758333.45 | 3867500.6 | | | |
| West | 9.8856 | 4 | July | 2007 | 1551666.55 | 11303891 | | | |
| West | 9.8856 | 3 | June | 2007 | 434997.5 | 3040632.5 | | | |
| West | 9.8856 | 1 | August | 2008 | 1362499.95 | 8542874.7 | | | |
| West | 9.8856 | 1 | July | 2008 | 959677.25 | 4030644.5 | | | |
| West | 9.8856 | 1 | November | 2008 | 1085000 | 21244300 | | | |
| West | 9.8856 | 1 | April | 2009 | 1059333.45 | 15593388 | | | |
| West | 9.8856 | 1 | June | 2009 | 616000 | 8636320 | | | |
| 174/175 | | 2 | April | 2009 | 1059333.45 | | | | |
| GW2 | 30.467 | 6 | August | 2004 | 1350322.75 | | | | |
| GW2 | 30.467 | 7 | July | 2004 | 1302903.35 | | | | |
| GW2 | 30.467 | 2 | June | 2004 | 721000 | | | | |
| GW2 | 30.467 | 8 | August | 2005 | 1611129.1 | 4976375 | | | |
| GW2 | 30.467 | 8 | July | 2005 | 821935.45 | 4025428.9 | | | |
| GW2 | 30.467 | 4 | June | 2005 | 1633333.45 | 11686501 | | | |
| GW2 | 30.467 | 4 | August | 2006 | 451613.05 | 1764678 | | | |
| GW2 | 30.467 | 10 | July | 2006 | 1910322.75 | 9093136.3 | | | |
| GW2 | 30.467 | 2 | June | 2006 | 1262333.45 | 12452919 | | | |
| GW2 | 30.467 | 6 | September | 2006 | 1109500 | 1941625 | | | |
| GW2 | 30.467 | 6 | August | 2007 | 758333.45 | 3200167.2 | | | |
| GW2 | 30.467 | 8 | July | 2007 | 1551666.55 | 8025995.2 | | | |
| GW2 | 30.467 | 6 | June | 2007 | 434997.5 | 2181512.5 | | | |
| GW2 | 30.467 | 2 | August | 2008 | 1362499.95 | 9067437.2 | | | |
| GW2 | 30.467 | 2 | July | 2008 | 959677.25 | 1746612.6 | | | |
| GW2 | 30.467 | 2 | November | 2008 | 1085000 | 18933250 | | | |
| GW2 | 30.467 | 2 | October | 2008 | 1482962.95 | 6747481.4 | | | |
| GW2 | 30.467 | 2 | April | 2009 | 1059333.45 | 15031942 | | | |
| GW2 | 30.467 | 2 | June | 2009 | 616000 | 6655880 | | | |

| Station | Area km^2 | N | Month | Year | EC CFU/km$^2$ | FC CFU/100 mL | FC CFU/km$^2$ | TSS mg/km$^2$ | LOI % |
|---|---|---|---|---|---|---|---|---|---|
| Beau | 207.08 | 3 | August | 2004 | | | | | |
| Beau | 207.08 | 3 | July | 2004 | | | | | |
| Beau | 207.08 | 1 | June | 2004 | | | | | |
| Beau | 207.08 | 4 | August | 2005 | | | | 5370430.3 | |
| Beau | 207.08 | 4 | July | 2005 | | | | 4931612.7 | |
| Beau | 207.08 | 2 | June | 2005 | | | | 22866668 | |
| Beau | 207.08 | 3 | September | 2005 | | | | 13337332 | |
| Beau | 207.08 | 2 | August | 2006 | | | | 4967743.6 | |
| Beau | 207.08 | 5 | July | 2006 | | | | 17957034 | |
| Beau | 207.08 | 1 | June | 2006 | | | | 17672668 | |
| Beau | 207.08 | 3 | August | 2007 | | | | 6066667.6 | |
| Beau | 207.08 | 4 | July | 2007 | | | | 20947498 | |
| Beau | 207.08 | 3 | June | 2007 | | | | 5654999.4 | |
| Bridge | | 3 | August | 2009 | | | | | |
| Bridge | | 3 | July | 2009 | | | | | |
| Bridge | | 2 | May | 2009 | | | | | |
| Dix | | 1 | June | 2006 | | | | | |
| Ferg | | 3 | August | 2004 | | | | | |
| Ferg | | 3 | July | 2004 | | | | | |
| Ferg | | 1 | June | 2004 | | | | | |
| Ferg | | 4 | August | 2005 | | | | 13291815 | |
| Ferg | | 4 | July | 2005 | | | | 7397419.1 | |
| Ferg | | 2 | June | 2005 | | | | 13066668 | |
| Ferg | | 2 | August | 2006 | | | | 2032258.7 | |
| Ferg | | 5 | July | 2006 | | | | 15282582 | |
| Ferg | | 1 | June | 2006 | | | | 10098668 | |
| Ferg | | 3 | September | 2006 | | | | 6102250 | |
| Ferg | | 3 | August | 2007 | | | | 6572223.2 | |
| Ferg | | 4 | July | 2007 | | | | 10085833 | |
| Ferg | | 3 | June | 2007 | | | | 3479980 | |
| Finn | 31.629 | 3 | August | 2004 | | | | | |
| Finn | 31.629 | 3 | July | 2004 | | | | | |
| Finn | 31.629 | 1 | June | 2004 | | | | | |
| Finn | 31.629 | 4 | August | 2005 | | | | 39875445 | |
| Finn | 31.629 | 4 | July | 2005 | | | | 9246773.8 | |
| Finn | 31.629 | 2 | June | 2005 | | | | 3266666.9 | |
| Finn | 31.629 | 2 | August | 2006 | | | | 1580645.7 | |
| Finn | 31.629 | 5 | July | 2006 | | | | 8914839.5 | |
| Finn | 31.629 | 1 | June | 2006 | | | | 7574000.7 | |
| Finn | 31.629 | 3 | September | 2006 | | | | 4992750 | |
| Finn | 31.629 | 3 | August | 2007 | | | | 3286111.6 | |
| Finn | 31.629 | 4 | July | 2007 | | | | 8534166 | |
| Finn | 31.629 | 3 | June | 2007 | | | | 4784972.5 | |
| Finn | 31.629 | 1 | August | 2008 | | | | 4087499.9 | |
| Finn | 31.629 | 1 | July | 2008 | | | | 287903.18 | |
| Finn | 31.629 | 1 | November | 2008 | | | | 23870000 | |
| Finn | 31.629 | 1 | October | 2008 | | | | 10380741 | |
| Finn | 31.629 | 1 | April | 2009 | | | | 11652668 | |
| Finn | 31.629 | 1 | June | 2009 | | | | 2464000 | |

| Station | Area<br>km^2 | N | Month | Year | EC<br>CFU/km$^2$ | FC<br>CFU/100 mL | FC<br>CFU/km$^2$ | TSS<br>mg/km$^2$ | LOI<br>% |
|---|---|---|---|---|---|---|---|---|---|
| Fras | 18.529 | 3 | August | 2004 | | | | | |
| Fras | 18.529 | 3 | July | 2004 | | | | | |
| Fras | 18.529 | 1 | June | 2004 | | | | | |
| Fras | 18.529 | 4 | August | 2005 | | | | 8861210.1 | |
| Fras | 18.529 | 4 | July | 2005 | | | | 4109677.3 | |
| Fras | 18.529 | 2 | June | 2005 | | | | | |
| Fras | 18.529 | 2 | August | 2006 | | | | | |
| Fras | 18.529 | 5 | July | 2006 | | | | 10506775 | |
| Fras | 18.529 | 1 | June | 2006 | | | | 9252904.2 | |
| Fras | 18.529 | 3 | September | 2006 | | | | | |
| Fras | 18.529 | 3 | August | 2007 | | | | 5561112 | |
| Fras | 18.529 | 4 | July | 2007 | | | | 12413332 | |
| Fras | 18.529 | 3 | June | 2007 | | | | 3044982.5 | |
| Fras | 18.529 | 1 | August | 2008 | | | | 2997499.9 | |
| Fras | 18.529 | 1 | July | 2008 | | | | 4798386.3 | |
| Fras | 18.529 | 1 | November | 2008 | | | | 3255000 | |
| Fras | 18.529 | 1 | October | 2008 | | | | 2372740.7 | |
| Fras | 18.529 | 1 | April | 2009 | | | | 1165266.8 | |
| Fras | 18.529 | 1 | June | 2009 | | | | 2464000 | |
| Gray | 33.447 | 3 | August | 2004 | | | | | |
| Gray | 33.447 | 3 | July | 2004 | | | | | |
| Gray | 33.447 | 1 | June | 2004 | | | | | |
| Gray | 33.447 | 4 | August | 2005 | | | | 13694597 | |
| Gray | 33.447 | 4 | July | 2005 | | | | 8835806.1 | |
| Gray | 33.447 | 2 | June | 2005 | | | | 26950002 | |
| Gray | 33.447 | 2 | August | 2006 | | | | 2709678.3 | |
| Gray | 33.447 | 5 | July | 2006 | | | | 18339098 | |
| Gray | 33.447 | 1 | June | 2006 | | | | 13885668 | |
| Gray | 33.447 | 3 | September | 2006 | | | | 3328500 | |
| Gray | 33.447 | 3 | August | 2007 | | | | 4550000.7 | |
| Gray | 33.447 | 4 | July | 2007 | | | | 16292499 | |
| Gray | 33.447 | 3 | June | 2007 | | | | 6524962.5 | |
| Hoop | 83.801 | 5 | August | 2005 | | | | | |
| Hoop | 83.801 | 5 | July | 2005 | 468503206.5 | 9800 | 805496741 | 6575483.6 | 0.1481 |
| Hoop | 83.801 | 3 | June | 2005 | 163333345 | 1500 | 245000018 | 40833336 | 0.1789 |
| Hoop | 83.801 | 1 | October | 2005 | | | | | |
| Hoop | 83.801 | 2 | August | 2006 | | | | | |
| Hoop | 83.801 | 5 | July | 2006 | | | | | |
| Hoop | 83.801 | 1 | June | 2006 | | | | | |
| Hoop | 83.801 | 3 | September | 2006 | | | | | |
| Hoop | 83.801 | 3 | August | 2007 | | | | | |
| Hoop | 83.801 | 4 | July | 2007 | | | | | |
| Hoop | 83.801 | 3 | June | 2007 | | | | | |
| Hwy138 | | 1 | March | 2007 | | | | | |
| MD | | 1 | June | 2006 | | | | | |
| Monk | | 2 | December | 2006 | | | | | |
| Monk | | 2 | July | 2006 | | | | | |
| Monk | | 2 | November | 2006 | | | | | |
| Monk | | 1 | October | 2006 | | | | | |

| Station | Area<br>km^2 | N | Month | Year | EC<br>CFU/km$^2$ | FC<br>CFU/100 mL | FC<br>CFU/km$^2$ | TSS<br>mg/km$^2$ | LOI<br>% |
|---|---|---|---|---|---|---|---|---|---|
| Monk | | 2 | January | 2007 | | | | | |
| Monk | | 2 | March | 2007 | | | | | |
| Monk | | 2 | May | 2007 | | | | | |
| Moos | | 1 | December | 2006 | | | | | |
| Mud | | 1 | July | 2006 | | | | | |
| New | | 1 | April | 2009 | | | | | |
| NewA | | 1 | December | 2006 | | | | | |
| NewA | | 1 | June | 2006 | | | | | |
| NewA | | 1 | November | 2006 | | | | | |
| NewA | | 1 | October | 2006 | | | | | |
| NewA | | 1 | January | 2007 | | | | | |
| NewA | | 1 | March | 2007 | | | | | |
| NewA | | 1 | May | 2007 | | | | | |
| NewA | | 2 | August | 2009 | | | | | |
| NewA | | 3 | July | 2009 | | | | | |
| NewA | | 1 | May | 2009 | | | | | |
| NewB | | 1 | December | 2006 | | | | | |
| NewB | | 1 | June | 2006 | | | | | |
| NewB | | 1 | November | 2006 | | | | | |
| NewB | | 1 | October | 2006 | | | | | |
| NewB | | 1 | January | 2007 | | | | | |
| NewB | | 1 | March | 2007 | | | | | |
| NewB | | 1 | May | 2007 | | | | | |
| NewC | | 1 | June | 2006 | | | | | |
| NewC | | 1 | August | 2009 | | | | | |
| NewD | | 1 | October | 2006 | | | | | |
| NewE | | 1 | December | 2006 | | | | | |
| NewE | | 1 | November | 2006 | | | | | |
| Patt | 13.65 | 3 | August | 2004 | | | | | |
| Patt | 13.65 | 3 | July | 2004 | | | | | |
| Patt | 13.65 | 1 | June | 2004 | | | | | |
| Patt | 13.65 | 4 | August | 2005 | | | | 7652863.2 | |
| Patt | 13.65 | 4 | July | 2005 | | | | 4520645 | |
| Patt | 13.65 | 2 | June | 2005 | | | | 4900000.4 | |
| Patt | 13.65 | 2 | August | 2006 | | | | 4741937 | |
| Patt | 13.65 | 5 | July | 2006 | | | | 79469426 | |
| Patt | 13.65 | 1 | June | 2006 | | | | 10098668 | |
| Patt | 13.65 | 3 | September | 2006 | | | | 19231333 | |
| Patt | 13.65 | 4 | July | 2007 | | | | 48489580 | |
| Patt | 13.65 | 3 | June | 2007 | | | | 10149942 | |
| Patt | 13.65 | 1 | August | 2008 | | | | 16349999 | |
| Patt | 13.65 | 1 | July | 2008 | | | | 63338699 | |
| Patt | 13.65 | 1 | November | 2008 | | | | 8680000 | |
| Patt | 13.65 | 1 | April | 2009 | | | | 8474667.6 | |
| Patt | 13.65 | 1 | June | 2009 | | | | 3080000 | |
| Raisin | 573.17 | 3 | August | 2004 | | | | | |
| Raisin | 573.17 | 3 | July | 2004 | | | | | |
| Raisin | 573.17 | 1 | June | 2004 | | | | | |
| Raisin | 573.17 | 4 | August | 2005 | | | | | |
| Raisin | 573.17 | 4 | July | 2005 | | | | 3287741.8 | |
| Raisin | 573.17 | 2 | June | 2005 | | | | 4900000.4 | |

| Station | Area km^2 | N | Month | Year | EC CFU/km$^2$ | FC CFU/100 mL | FC CFU/km$^2$ | TSS mg/km$^2$ | LOI % |
|---|---|---|---|---|---|---|---|---|---|
| Raisin | 573.17 | 2 | August | 2006 | | | | 2258065.3 | |
| Raisin | 573.17 | 5 | July | 2006 | | | | 7163710.3 | |
| Raisin | 573.17 | 1 | June | 2006 | | | | 10098668 | |
| Raisin | 573.17 | 3 | September | 2006 | | | | 2773750 | |
| Raisin | 573.17 | 6 | August | 2007 | | | | 18200003 | |
| Raisin | 573.17 | 4 | July | 2007 | | | | | |
| Raisin | 573.17 | 3 | June | 2007 | | | | 2827483.8 | |
| Raisin | 573.17 | 1 | August | 2008 | | | | 817499.97 | |
| Raisin | 573.17 | 1 | July | 2008 | | | | 1919354.5 | |
| Raisin | 573.17 | 1 | November | 2008 | | | | 0 | |
| Raisin | 573.17 | 1 | October | 2008 | | | | 1334666.7 | |
| Raisin | 573.17 | 1 | April | 2009 | | | | 4237333.8 | |
| Raisin | 573.17 | 1 | June | 2009 | | | | 3080000 | |
| RR1 | 1.8863 | 2 | August | 2005 | | | | | |
| RR1 | 1.8863 | 3 | July | 2005 | 0 | 100 | 8219354.5 | 1397290.3 | |
| RR1 | 1.8863 | 1 | June | 2005 | 81666672.5 | 200 | 32666669 | 63700005 | 0.2297 |
| RR1 | 1.8863 | 2 | October | 2005 | | | | | |
| RR1 | 1.8863 | 1 | June | 2006 | | | | | |
| RR1 | 1.8863 | 2 | May | 2006 | | | | | |
| RR11 | | 1 | August | 2005 | | | | | |
| RR11 | | 2 | July | 2005 | | | | 1602774.1 | 1.0000 |
| RR11 | | 2 | June | 2005 | 16333334.5 | 100 | 16333334.5 | 12440556 | 0.3553 |
| RR12 | 362.39 | 1 | August | 2005 | | | | 0 | |
| RR12 | 362.39 | 1 | July | 2005 | 31233547.1 | 410 | 33699353.5 | 11876967 | 0.3913 |
| RR12 | 362.39 | 1 | June | 2005 | 179666679.5 | 1600 | 261333352 | 18293335 | 0.2368 |
| RR12 | 362.39 | 1 | October | 2005 | | | | | |
| RR12 | 362.39 | 1 | May | 2006 | | | | | |
| RR12 | 362.39 | 7 | April | 2008 | | | | | |
| RR12 | 362.39 | 10 | May | 2008 | | | | | |
| RR12 | 362.39 | 3 | April | 2009 | | | | | |
| RR12 | 362.39 | 2 | August | 2009 | | | | | |
| RR12 | 362.39 | 10 | July | 2009 | | | | | |
| RR12 | 362.39 | 2 | July | 2009 | | | | | |
| RR12 | 362.39 | 2 | June | 2009 | | | | | |
| RR12 | 362.39 | 4 | May | 2009 | | | | | |
| RR13 | 335.06 | 1 | August | 2005 | | | | | |
| RR13 | 335.06 | 1 | July | 2005 | 18082579.9 | 280 | 23014192.6 | 31192450 | 0.3333 |
| RR13 | 335.06 | 1 | June | 2005 | 114333341.5 | 1400 | 228666683 | 16660001 | 0.0882 |
| RR13 | 335.06 | 1 | June | 2005 | | | | | |
| RR13 | 335.06 | 1 | October | 2005 | | | | | |
| RR13 | 335.06 | 1 | May | 2006 | | | | | |
| RR15 | 194.49 | 2 | August | 2005 | | | | | |
| RR15 | 194.49 | 2 | July | 2005 | 18904515.35 | 240 | 19726450.8 | 4890515.9 | 0.1395 |
| RR15 | 194.49 | 1 | June | 2005 | 163333345 | 1600 | 261333352 | 10943334 | 0.4500 |
| RR15 | 194.49 | 1 | November | 2005 | | | | | |
| RR15 | 194.49 | 1 | October | 2005 | | | | | |
| RR15 | 194.49 | 1 | September | 2005 | | | | | |
| RR15 | 194.49 | 1 | April | 2006 | | | | | |

| **Station** | **Area** km^2 | **N** | **Month** | **Year** | **EC** CFU/km$^2$ | **FC** CFU/100 mL | **FC** CFU/km$^2$ | **TSS** mg/km$^2$ | **LOI** % |
|---|---|---|---|---|---|---|---|---|---|
| RR15 | 194.49 | 1 | August | 2006 | | | | | |
| RR15 | 194.49 | 1 | February | 2006 | | | | | |
| RR15 | 194.49 | 1 | June | 2006 | | | | | |
| RR15 | 194.49 | 2 | March | 2006 | | | | | |
| RR15 | 194.49 | 2 | May | 2006 | | | | | |
| RR16 | 128.8 | 2 | August | 2005 | | | | | |
| RR16 | 128.8 | 2 | July | 2005 | 98632254 | 1200 | 98632254 | 10233096 | 0.7647 |
| RR16 | 128.8 | 4 | June | 2005 | 98000007 | 666.66667 | 108888897 | 17612779 | 0.2487 |
| RR16 | 128.8 | 1 | November | 2005 | | | | | |
| RR16 | 128.8 | 1 | October | 2005 | | | | | |
| RR16 | 128.8 | 1 | September | 2005 | | | | | |
| RR16 | 128.8 | 1 | April | 2006 | | | | | |
| RR16 | 128.8 | 1 | August | 2006 | | | | | |
| RR16 | 128.8 | 1 | February | 2006 | | | | | |
| RR16 | 128.8 | 1 | June | 2006 | | | | | |
| RR16 | 128.8 | 2 | March | 2006 | | | | | |
| RR16 | 128.8 | 1 | May | 2006 | | | | | |
| RR17 | 150.6 | 1 | August | 2005 | | | | | |
| RR17 | 150.6 | 1 | July | 2005 | 32055482.55 | 520 | 42740643.4 | 2630193.4 | 0.1379 |
| RR17 | 150.6 | 1 | June | 2005 | 130666676 | 1600 | 261333352 | 21151668 | 0.2222 |
| RR17 | 150.6 | 1 | October | 2005 | | | | | |
| RR17 | 150.6 | 1 | May | 2006 | | | | | |
| RR18 | 132.09 | 1 | August | 2005 | | | | | |
| RR18 | 132.09 | 1 | July | 2005 | 27945805.3 | 340 | 27945805.3 | 6123419.1 | 0.1176 |
| RR18 | 132.09 | 1 | June | 2005 | 98000007 | 1800 | 294000021 | 12168334 | 0.2174 |
| RR18 | 132.09 | 1 | October | 2005 | | | | | |
| RR18 | 132.09 | 1 | March | 2006 | | | | | |
| RR18 | 132.09 | 1 | May | 2006 | | | | | |
| RR19 | 75.364 | 2 | August | 2005 | | | | | |
| RR19 | 75.364 | 1 | July | 2005 | 575354815 | 10600 | 871251577 | 14753741 | 0.0003 |
| RR19 | 75.364 | 2 | June | 2005 | 73500005.25 | 950 | 155166678 | 14005834 | 0.3452 |
| RR19 | 75.364 | 1 | June | 2005 | | | | | |
| RR19 | 75.364 | 1 | October | 2005 | | | | | |
| RR19 | 75.364 | 1 | June | 2006 | | | | | |
| RR19 | 75.364 | 1 | May | 2006 | | | | | |
| RR2 | 23.436 | 3 | August | 2005 | | | | | |
| RR2 | 23.436 | 2 | July | 2005 | 16438709 | 200 | 16438709 | 2424709.6 | 1.0000 |
| RR2 | 23.436 | 2 | June | 2005 | 1633333450 | 19000 | 3103333555 | 66476671 | 0.1544 |
| RR2 | 23.436 | 1 | November | 2005 | | | | | |
| RR2 | 23.436 | 2 | October | 2005 | | | | | |
| RR2 | 23.436 | 1 | September | 2005 | | | | | |
| RR2 | 23.436 | 1 | April | 2006 | | | | | |
| RR2 | 23.436 | 1 | August | 2006 | | | | | |
| RR2 | 23.436 | 2 | March | 2006 | | | | | |
| RR2 | 23.436 | 1 | May | 2006 | | | | | |
| RR20 | 80.114 | 1 | August | 2005 | | | | | |
| RR20 | 80.114 | 1 | July | 2005 | 123290317.5 | 2400 | 197264508 | 6534386.8 | -0.0010 |
| RR20 | 80.114 | 1 | June | 2005 | 196000014 | 1200 | 196000014 | 19110001 | 0.0500 |

| Station | Area km^2 | N | Month | Year | EC CFU/km$^2$ | FC CFU/100 mL | FC CFU/km$^2$ | TSS mg/km$^2$ | LOI % |
|---|---|---|---|---|---|---|---|---|---|
| RR20 | 80.114 | 1 | October | 2005 | | | | | |
| RR20 | 80.114 | 1 | May | 2006 | | | | | |
| RR21 | 8.2388 | 2 | August | 2005 | | | | | |
| RR21 | 8.2388 | 2 | July | 2005 | 73974190.5 | 900 | 73974190.5 | 1602774.1 | 0.6000 |
| RR21 | 8.2388 | 3 | June | 2005 | 147000010.5 | 900 | 147000011 | 4001667 | 0.5625 |
| RR21 | 8.2388 | 1 | November | 2005 | | | | | |
| RR21 | 8.2388 | 1 | October | 2005 | | | | | |
| RR21 | 8.2388 | 1 | September | 2005 | | | | | |
| RR21 | 8.2388 | 1 | April | 2006 | | | | | |
| RR21 | 8.2388 | 1 | August | 2006 | | | | | |
| RR21 | 8.2388 | 1 | December | 2006 | | | | | |
| RR21 | 8.2388 | 1 | February | 2006 | | | | | |
| RR21 | 8.2388 | 2 | June | 2006 | | | | | |
| RR21 | 8.2388 | 2 | March | 2006 | | | | | |
| RR21 | 8.2388 | 1 | May | 2006 | | | | | |
| RR21 | 8.2388 | 1 | November | 2006 | | | | | |
| RR21 | 8.2388 | 1 | October | 2006 | | | | | |
| RR21 | 8.2388 | 1 | March | 2007 | | | | | |
| RR21 | 8.2388 | 7 | April | 2008 | | | | | |
| RR21 | 8.2388 | 8 | May | 2008 | | | | | |
| RR21 | 8.2388 | 5 | April | 2009 | | | | | |
| RR21 | 8.2388 | 6 | August | 2009 | | | | | |
| RR21 | 8.2388 | 6 | July | 2009 | | | | | |
| RR21 | 8.2388 | 3 | July | 2009 | | | | | |
| RR21 | 8.2388 | 3 | June | 2009 | | | | | |
| RR21 | 8.2388 | 4 | May | 2009 | | | | | |
| RR22 | 29.128 | 2 | August | 2005 | | | | | |
| RR22 | 29.128 | 2 | July | 2005 | 57535481.5 | 1300 | 106851609 | 3452128.9 | -0.0047 |
| RR22 | 29.128 | 3 | June | 2005 | 65333338 | 750 | 122500009 | 6043333.8 | 0.0417 |
| RR22 | 29.128 | 1 | November | 2005 | | | | | |
| RR22 | 29.128 | 1 | October | 2005 | | | | | |
| RR22 | 29.128 | 1 | September | 2005 | | | | | |
| RR22 | 29.128 | 1 | April | 2006 | | | | | |
| RR22 | 29.128 | 1 | August | 2006 | | | | | |
| RR22 | 29.128 | 1 | February | 2006 | | | | | |
| RR22 | 29.128 | 1 | July | 2006 | | | | | |
| RR22 | 29.128 | 1 | June | 2006 | | | | | |
| RR22 | 29.128 | 2 | March | 2006 | | | | | |
| RR22 | 29.128 | 1 | May | 2006 | | | | | |
| RR3 | 47.948 | 2 | August | 2005 | | | | | |
| RR3 | 47.948 | 2 | July | 2005 | 49316127 | 700 | 57535481.5 | 3246645 | 1.0000 |
| RR3 | 47.948 | 1 | June | 2005 | 2450000175 | 27000 | 4410000315 | 110032230 | 0.1815 |
| RR3 | 47.948 | 2 | October | 2005 | | | | | |
| RR3 | 47.948 | 2 | May | 2006 | | | | | |
| RR4 | 74.33 | 2 | August | 2005 | | | | | |
| RR4 | 74.33 | 2 | July | 2005 | 16438709 | 200 | 16438709 | 4890515.9 | 1.0000 |
| RR4 | 74.33 | 1 | June | 2005 | 1470000105 | 8000 | 1306666760 | 74235005 | 0.1829 |
| RR4 | 74.33 | 1 | November | 2005 | | | | | |

| Station | Area<br>km^2 | N | Month | Year | EC<br>CFU/km$^2$ | FC<br>CFU/100 mL | FC<br>CFU/km$^2$ | TSS<br>mg/km$^2$ | LOI<br>% |
|---|---|---|---|---|---|---|---|---|---|
| RR4 | 74.33 | 2 | October | 2005 | | | | | |
| RR4 | 74.33 | 1 | May | 2006 | | | | | |
| RR5 | 105.45 | 3 | August | 2005 | | | | | |
| RR5 | 105.45 | 3 | July | 2005 | 24658063.5 | 300 | 24658063.5 | 11466000 | 0.3265 |
| RR5 | 105.45 | 2 | June | 2005 | 686000049 | 2200 | 359333359 | 41704447 | 0.2347 |
| RR5 | 105.45 | 2 | November | 2005 | | | | | |
| RR5 | 105.45 | 2 | October | 2005 | | | | | |
| RR5 | 105.45 | 1 | September | 2005 | | | | | |
| RR5 | 105.45 | 1 | April | 2006 | | | | | |
| RR5 | 105.45 | 1 | August | 2006 | | | | | |
| RR5 | 105.45 | 1 | February | 2006 | | | | | |
| RR5 | 105.45 | 1 | June | 2006 | | | | | |
| RR5 | 105.45 | 2 | March | 2006 | | | | | |
| RR5 | 105.45 | 1 | May | 2006 | | | | | |
| RR6 | 573.01 | 3 | August | 2005 | | | | | |
| RR6 | 573.01 | 2 | July | 2005 | 8219354.5 | 200 | 16438709 | 7356322.3 | 0.8966 |
| RR6 | 573.01 | 1 | June | 2005 | 637000045.5 | 3300 | 539000039 | 9310000.7 | 0.4375 |
| RR6 | 573.01 | 1 | November | 2005 | | | | | |
| RR6 | 573.01 | 2 | October | 2005 | | | | | |
| RR6 | 573.01 | 1 | September | 2005 | | | | | |
| RR6 | 573.01 | 1 | June | 2006 | | | | | |
| RR6 | 573.01 | 2 | March | 2006 | | | | | |
| RR6 | 573.01 | 2 | May | 2006 | | | | | |
| RR7 | 408.81 | 3 | August | 2005 | | | | | |
| RR7 | 408.81 | 2 | July | 2005 | 8219354.5 | 200 | 16438709 | 5301483.7 | 0.4737 |
| RR7 | 408.81 | 2 | June | 2005 | 743166719.8 | 7050 | 1151500082 | 39935003 | 0.2625 |
| RR7 | 408.81 | 1 | November | 2005 | | | | | |
| RR7 | 408.81 | 2 | October | 2005 | | | | | |
| RR7 | 408.81 | 1 | September | 2005 | | | | | |
| RR7 | 408.81 | 1 | February | 2006 | | | | | |
| RR7 | 408.81 | 1 | March | 2006 | | | | | |
| RR7 | 408.81 | 1 | May | 2006 | | | | | |
| RR8 | | 3 | July | 2005 | 394529016 | 8300 | 682206424 | 100235028 | 0.2915 |
| RR8 | | 1 | June | 2005 | 130666676 | 1800 | 294000021 | 17476668 | 0.0278 |
| RR8 | | 5 | November | 2005 | | | | | |
| RR9 | | 1 | August | 2005 | | | | | |
| RR9 | | 1 | July | 2005 | 41096772.5 | 600 | 49316127 | 5917935.2 | 0.7727 |
| RR9 | | 1 | June | 2005 | 6370000455 | 40000 | 6533333800 | 280715576 | 0.3183 |
| RR9 | | 1 | October | 2005 | | | | | |
| SC | 76.718 | 3 | August | 2004 | | | | | |
| SC | 76.718 | 3 | July | 2004 | | | | | |
| SC | 76.718 | 2 | June | 2004 | | | | 13699000 | |
| SC | 76.718 | 5 | August | 2005 | | | | 7518602.5 | |
| SC | 76.718 | 5 | July | 2005 | | | | 8868683.5 | 0.3103 |
| SC | 76.718 | 2 | June | 2005 | | | | 32666669 | |
| SC | 76.718 | 1 | October | 2005 | | | | | |
| SC | 76.718 | 2 | August | 2006 | | | | 7903228.4 | |
| SC | 76.718 | 5 | July | 2006 | | | | 20631486 | |
| SC | 76.718 | 1 | June | 2006 | | | | 50493338 | |

| Station | Area<br>km^2 | N | Month | Year | EC<br>CFU/km$^2$ | FC<br>CFU/100 mL | FC<br>CFU/km$^2$ | TSS<br>mg/km$^2$ | LOI<br>% |
|---|---|---|---|---|---|---|---|---|---|
| SC | 76.718 | 3 | September | 2006 | | | | 20340833 | |
| SC | 76.718 | 3 | August | 2007 | | | | 11375002 | |
| SC | 76.718 | 4 | July | 2007 | | | | 29093748 | |
| SC | 76.718 | 3 | June | 2007 | | | | 13194924 | |
| SC | 76.718 | 1 | August | 2008 | | | | 17712499 | |
| SC | 76.718 | 1 | July | 2008 | | | | 12475804 | |
| SC | 76.718 | 1 | November | 2008 | | | | 28210000 | |
| SC | 76.718 | 1 | October | 2008 | | | | 16312592 | |
| SC | 76.718 | 1 | April | 2009 | | | | 16949335 | |
| Stream | | 2 | August | 2009 | | | | | |
| Stream | | 3 | July | 2009 | | | | | |
| Stream | | 1 | May | 2009 | | | | | |
| West | 9.8856 | 3 | August | 2004 | | | | | |
| West | 9.8856 | 3 | July | 2004 | | | | | |
| West | 9.8856 | 1 | June | 2004 | | | | | |
| West | 9.8856 | 4 | August | 2005 | | | | 6444516.4 | |
| West | 9.8856 | 4 | July | 2005 | | | | 7397419.1 | |
| West | 9.8856 | 2 | June | 2005 | | | | 13883334 | |
| West | 9.8856 | 2 | August | 2006 | | | | 3387097.9 | |
| West | 9.8856 | 5 | July | 2006 | | | | 11079872 | |
| West | 9.8856 | 1 | June | 2006 | | | | 10098668 | |
| West | 9.8856 | 3 | September | 2006 | | | | 6657000 | |
| West | 9.8856 | 3 | August | 2007 | | | | 9858334.9 | |
| West | 9.8856 | 4 | July | 2007 | | | | 21335415 | |
| West | 9.8856 | 3 | June | 2007 | | | | 14644916 | |
| West | 9.8856 | 1 | August | 2008 | | | | 1090000 | |
| West | 9.8856 | 1 | July | 2008 | | | | 9596772.5 | |
| West | 9.8856 | 1 | November | 2008 | | | | 20615000 | |
| West | 9.8856 | 1 | April | 2009 | | | | 10593335 | |
| West | 9.8856 | 1 | June | 2009 | | | | 3080000 | |
| 174/175 | | 2 | April | 2009 | | | | | |
| GW2 | 30.467 | 6 | August | 2004 | | | | | |
| GW2 | 30.467 | 7 | July | 2004 | | | | | |
| GW2 | 30.467 | 2 | June | 2004 | | | | | |
| GW2 | 30.467 | 8 | August | 2005 | | | | 8861210.1 | |
| GW2 | 30.467 | 8 | July | 2005 | | | | 4383655.7 | |
| GW2 | 30.467 | 4 | June | 2005 | | | | 19055557 | |
| GW2 | 30.467 | 4 | August | 2006 | | | | 1806452.2 | |
| GW2 | 30.467 | 10 | July | 2006 | | | | 13099356 | |
| GW2 | 30.467 | 2 | June | 2006 | | | | 13885668 | |
| GW2 | 30.467 | 6 | September | 2006 | | | | 7026833.3 | |
| GW2 | 30.467 | 6 | August | 2007 | | | | 14787502 | |
| GW2 | 30.467 | 8 | July | 2007 | | | | 40121664 | |
| GW2 | 30.467 | 6 | June | 2007 | | | | 16312406 | |
| GW2 | 30.467 | 2 | August | 2008 | | | | 1090000 | |
| GW2 | 30.467 | 2 | July | 2008 | | | | 2879031.8 | |
| GW2 | 30.467 | 2 | November | 2008 | | | | 47740000 | |
| GW2 | 30.467 | 2 | October | 2008 | | | | 5561111.1 | |
| GW2 | 30.467 | 2 | April | 2009 | | | | 11652668 | |
| GW2 | 30.467 | 2 | June | 2009 | | | | 5544000 | |

| Station | Area km^2 | N | Month | Year | NO3 ug/km$^2$ | NH3 ug/km$^2$ | DOC mg/km$^2$ | Sp Cond uS/cm | DIC mg/km$^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Beau | 207 08 | 3 | August | 2004 | | | | | |
| Beau | 207 08 | 3 | July | 2004 | | | | | |
| Beau | 207 08 | 1 | June | 2004 | | | | | |
| Beau | 207 08 | 4 | August | 2005 | | | | | |
| Beau | 207 08 | 4 | July | 2005 | | | | | |
| Beau | 207 08 | 2 | June | 2005 | | | | | |
| Beau | 207 08 | 3 | September | 2005 | | | | | |
| Beau | 207 08 | 2 | August | 2006 | | | | | |
| Beau | 207 08 | 5 | July | 2006 | | | | | |
| Beau | 207 08 | 1 | June | 2006 | | | | | |
| Beau | 207 08 | 3 | August | 2007 | | | | | |
| Beau | 207 08 | 4 | July | 2007 | | | | | |
| Beau | 207 08 | 3 | June | 2007 | | | | | |
| Bridge | | 3 | August | 2009 | 22266 58 | 371552 65 | | | |
| Bridge | | 3 | July | 2009 | 23429 97 | 1371948 7 | | | |
| Bridge | | 2 | May | 2009 | 36878 45 | 512686 85 | | | |
| Dix | | 1 | June | 2006 | 103511342 9 | 53018005 | 37870003 5 | | 29033669 35 |
| Ferg | | 3 | August | 2004 | | | | | |
| Ferg | | 3 | July | 2004 | | | | | |
| Ferg | | 1 | June | 2004 | | | | | |
| Ferg | | 4 | August | 2005 | | | | | |
| Ferg | | 4 | July | 2005 | | | | | |
| Ferg | | 2 | June | 2005 | | | | | |
| Ferg | | 2 | August | 2006 | | | | | |
| Ferg | | 5 | July | 2006 | | | | | |
| Ferg | | 1 | June | 2006 | | | | | |
| Ferg | | 3 | September | 2006 | | | | | |
| Ferg | | 3 | August | 2007 | | | | | |
| Ferg | | 4 | July | 2007 | | | | | |
| Ferg | | 3 | June | 2007 | | | | | |
| Finn | 31 629 | 3 | August | 2004 | | | | | |
| Finn | 31 629 | 3 | July | 2004 | | | | | |
| Finn | 31 629 | 1 | June | 2004 | | | | | |
| Finn | 31 629 | 4 | August | 2005 | | | | | |
| Finn | 31 629 | 4 | July | 2005 | | | | | |
| Finn | 31 629 | 2 | June | 2005 | | | | | |
| Finn | 31 629 | 2 | August | 2006 | | | | | |
| Finn | 31 629 | 5 | July | 2006 | | | | | |
| Finn | 31 629 | 1 | June | 2006 | | | | | |
| Finn | 31 629 | 3 | September | 2006 | | | | | |
| Finn | 31 629 | 3 | August | 2007 | | | | | |
| Finn | 31 629 | 4 | July | 2007 | | | | | |
| Finn | 31 629 | 3 | June | 2007 | | | | | |
| Finn | 31 629 | 1 | August | 2008 | 231624 99 | | | | |
| Finn | 31 629 | 1 | July | 2008 | 24951 61 | | | | |
| Finn | 31 629 | 1 | November | 2008 | 2506350 | | | | |
| Finn | 31 629 | 1 | October | 2008 | 20761 48 | | | | |
| Finn | 31 629 | 1 | April | 2009 | 5021240 55 | | | | |
| Finn | 31 629 | 1 | June | 2009 | 2236080 | | | | |

| Station | Area km^2 | N | Month | Year | NO3 ug/km$^2$ | NH3 ug/km$^2$ | DOC mg/km$^2$ | Sp Cond uS/cm | DIC mg/km$^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Fras | 18.529 | 3 | August | 2004 | | | | | |
| Fras | 18.529 | 3 | July | 2004 | | | | | |
| Fras | 18.529 | 1 | June | 2004 | | | | | |
| Fras | 18.529 | 4 | August | 2005 | | | | | |
| Fras | 18.529 | 4 | July | 2005 | | | | | |
| Fras | 18.529 | 2 | June | 2005 | | | | | |
| Fras | 18.529 | 2 | August | 2006 | | | | | |
| Fras | 18.529 | 5 | July | 2006 | | | | | |
| Fras | 18.529 | 1 | June | 2006 | | | | | |
| Fras | 18.529 | 3 | September | 2006 | | | | | |
| Fras | 18.529 | 3 | August | 2007 | | | | | |
| Fras | 18.529 | 4 | July | 2007 | | | | | |
| Fras | 18.529 | 3 | June | 2007 | | | | | |
| Fras | 18.529 | 1 | August | 2008 | 23162.5 | | | | |
| Fras | 18.529 | 1 | July | 2008 | 47024.19 | | | | |
| Fras | 18.529 | 1 | November | 2008 | 542500 | | | | |
| Fras | 18.529 | 1 | October | 2008 | 7414.81 | | | | |
| Fras | 18.529 | 1 | April | 2009 | 635600.07 | | | | |
| Fras | 18.529 | 1 | June | 2009 | 194040 | | | | |
| Gray | 33.447 | 3 | August | 2004 | | | | | |
| Gray | 33.447 | 3 | July | 2004 | | | | | |
| Gray | 33.447 | 1 | June | 2004 | | | | | |
| Gray | 33.447 | 4 | August | 2005 | | | | | |
| Gray | 33.447 | 4 | July | 2005 | | | | | |
| Gray | 33.447 | 2 | June | 2005 | | | | | |
| Gray | 33.447 | 2 | August | 2006 | | | | | |
| Gray | 33.447 | 5 | July | 2006 | | | | | |
| Gray | 33.447 | 1 | June | 2006 | | | | | |
| Gray | 33.447 | 3 | September | 2006 | | | | | |
| Gray | 33.447 | 3 | August | 2007 | | | | | |
| Gray | 33.447 | 4 | July | 2007 | | | | | |
| Gray | 33.447 | 3 | June | 2007 | | | | | |
| Hoop | 83.801 | 5 | August | 2005 | 6444516.4 | 21589130 | 33124814.3 | 526 | 82731479.29 |
| Hoop | 83.801 | 5 | July | 2005 | 397077015.9 | 33699353 | 24115586.1 | 537 | 37126824.28 |
| Hoop | 83.801 | 3 | June | 2005 | 735715452.6 | 67130005 | 45602669.9 | 476 | 64887437.97 |
| Hoop | 83.801 | 1 | October | 2005 | 3472964640 | | 47386609.9 | 440 | 92279187.7 |
| Hoop | 83.801 | 2 | August | 2006 | | | | | |
| Hoop | 83.801 | 5 | July | 2006 | | | | | |
| Hoop | 83.801 | 1 | June | 2006 | | | | | |
| Hoop | 83.801 | 3 | September | 2006 | | | | | |
| Hoop | 83.801 | 3 | August | 2007 | | | | | |
| Hoop | 83.801 | 4 | July | 2007 | | | | | |
| Hoop | 83.801 | 3 | June | 2007 | | | | | |
| Hwy138 | | 1 | March | 2007 | 318512029.9 | 59162062 | 9631033.3 | | 15134480.9 |
| MD | | 1 | June | 2006 | 10098667.6 | 61854339 | 30296002.8 | | 60592005.6 |
| Monk | | 2 | December | 2006 | 510008790.4 | 8562582 | 16590002.6 | | 33715166.63 |
| Monk | | 2 | July | 2006 | 42982261.88 | 30565164 | 54444198.4 | | 85009362.38 |
| Monk | | 2 | November | 2006 | 216890313.3 | 10749666 | 24660997.7 | | 45527995.8 |
| Monk | | 1 | October | 2006 | 4938387.3 | 121813553 | 42799356.6 | | 72429680.4 |

| Station | Area km^2 | N | Month | Year | NO3 ug/km$^2$ | NH3 ug/km$^2$ | DOC mg/km$^2$ | Sp Cond uS/cm | DIC mg/km$^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Monk | | 2 | January | 2007 | 79708558.65 | 62740895 | 11443307.9 | | 31567746 |
| Monk | | 2 | March | 2007 | 282739620.5 | 10318964 | 6879309.5 | | 16166377.33 |
| Monk | | 2 | May | 2007 | 11988103.05 | 23976206 | 14167758.2 | | 25429309.5 |
| Moos | | 1 | December | 2006 | 4602387825 | 50305169 | 12843873 | | 44953555.5 |
| Mud | | 1 | July | 2006 | 22923873 | 68771619 | 57309682.5 | | 64950973.5 |
| New | | 1 | April | 2009 | | | | | |
| NewA | | 1 | December | 2006 | 25687746 | 701061401 | 38531619 | | 1070322.75 |
| NewA | | 1 | June | 2006 | 0 | 103511343 | 69428339.8 | | 0 |
| NewA | | 1 | November | 2006 | 24028664.45 | 677861271 | 69556660.3 | | 2529333.1 |
| NewA | | 1 | October | 2006 | 0 | 694666480 | 100413875 | | 3292258.2 |
| NewA | | 1 | January | 2007 | 22097422.2 | 748155580 | 29200165.1 | | 3156774.6 |
| NewA | | 1 | March | 2007 | 36460340.35 | 209818940 | 15822411.9 | | 1375861.9 |
| NewA | | 1 | May | 2007 | 7992068.7 | 783949284 | 25429309.5 | | 2906206.8 |
| NewA | | 2 | August | 2009 | 9949.94 | 444941.98 | | | |
| NewA | | 3 | July | 2009 | 11107.19 | 1703214.6 | | | |
| NewA | | 1 | May | 2009 | 18059.36 | 470781.01 | | | |
| NewB | | 1 | December | 2006 | 218345841 | 47094201 | 37461296.3 | | 13914195.75 |
| NewB | | 1 | June | 2006 | 8836334.15 | 133807346 | 50493338 | | 29033669.35 |
| NewB | | 1 | November | 2006 | 111290656.4 | 34145997 | 56909994.8 | | 18969998.25 |
| NewB | | 1 | October | 2006 | 41153227.5 | 90537101 | 77368067.7 | | 32922582 |
| NewB | | 1 | January | 2007 | 82076139.6 | 94703238 | 23675809.5 | | 11048711.1 |
| NewB | | 1 | March | 2007 | 147905154.3 | 15134481 | 11694826.2 | | 8943102.35 |
| NewB | | 1 | May | 2007 | 10898275.5 | 19616896 | 23249654.4 | | 13804482.3 |
| NewC | | 1 | June | 2006 | 17672668.3 | 339567698 | 51755671.5 | | 27771335.9 |
| NewC | | 1 | August | 2009 | | 214908.42 | | | |
| NewD | | 1 | October | 2006 | 0 | 651867124 | 102060004 | | 4938387.3 |
| NewE | | 1 | December | 2006 | 65289687.75 | 465590396 | 39601941.8 | | 2140645.5 |
| NewE | | 1 | November | 2006 | 16440665.15 | 782828594 | 65762660.6 | | 3793999.65 |
| Patt | 13.65 | 3 | August | 2004 | | | | | |
| Patt | 13.65 | 3 | July | 2004 | | | | | |
| Patt | 13.65 | 1 | June | 2004 | | | | | |
| Patt | 13.65 | 4 | August | 2005 | | | | | |
| Patt | 13.65 | 4 | July | 2005 | | | | | |
| Patt | 13.65 | 2 | June | 2005 | | | | | |
| Patt | 13.65 | 2 | August | 2006 | | | | | |
| Patt | 13.65 | 5 | July | 2006 | | | | | |
| Patt | 13.65 | 1 | June | 2006 | | | | | |
| Patt | 13.65 | 3 | September | 2006 | | | | | |
| Patt | 13.65 | 4 | July | 2007 | | | | | |
| Patt | 13.65 | 3 | June | 2007 | | | | | |
| Patt | 13.65 | 1 | August | 2008 | 2043749.93 | | | | |
| Patt | 13.65 | 1 | July | 2008 | 38387.09 | | | | |
| Patt | 13.65 | 1 | November | 2008 | 4068750 | | | | |
| Patt | 13.65 | 1 | April | 2009 | 5964047.32 | | | | |
| Patt | 13.65 | 1 | June | 2009 | 2488640 | | | | |
| Raisin | 573.17 | 3 | August | 2004 | | | | | |
| Raisin | 573.17 | 3 | July | 2004 | | | | | |
| Raisin | 573.17 | 1 | June | 2004 | | | | | |
| Raisin | 573.17 | 4 | August | 2005 | | | | | |
| Raisin | 573.17 | 4 | July | 2005 | | | | | |
| Raisin | 573.17 | 2 | June | 2005 | | | | | |
| Raisin | 573.17 | 2 | August | 2006 | | | | | |

| Station | Area km^2 | N | Month | Year | NO3 ug/km$^2$ | NH3 ug/km$^2$ | DOC mg/km$^2$ | Sp Cond uS/cm | DIC mg/km$^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Raisin | 573.17 | 5 | July | 2006 | | | | | |
| Raisin | 573.17 | 1 | June | 2006 | | | | | |
| Raisin | 573.17 | 3 | September | 2006 | | | | | |
| Raisin | 573.17 | 6 | August | 2007 | | | | | |
| Raisin | 573.17 | 4 | July | 2007 | | | | | |
| Raisin | 573.17 | 3 | June | 2007 | | | | | |
| Raisin | 573.17 | 1 | August | 2008 | 31337.5 | | | | |
| Raisin | 573.17 | 1 | July | 2008 | 6717.74 | | | | |
| Raisin | 573.17 | 1 | November | 2008 | 1638350 | | | | |
| Raisin | 573.17 | 1 | October | 2008 | 5931.85 | | | | |
| Raisin | 573.17 | 1 | April | 2009 | 1016960.11 | | | | |
| Raisin | 573.17 | 1 | June | 2009 | 544544 | | | | |
| RR1 | 1.8863 | 2 | August | 2005 | 255041736.5 | 329798127 | 4124490.5 | 363 | 44322161.54 |
| RR1 | 1.8863 | 3 | July | 2005 | 72987867.96 | 8630322.2 | 2671290.21 | 349.5 | 21082644.29 |
| RR1 | 1.8863 | 1 | June | 2005 | 37823102.7 | 429403364 | 16338234.5 | 608 | 83055005.93 |
| RR1 | 1.8863 | 2 | October | 2005 | 965414885.6 | | 17458224.7 | 812 | 147147893.9 |
| RR1 | 1.8863 | 1 | June | 2006 | | | | | |
| RR1 | 1.8863 | 2 | May | 2006 | | | | | |
| RR11 | | 1 | August | 2005 | 16272403.91 | 23522485 | 14032934.5 | 385 | 50122226.3 |
| RR11 | | 2 | July | 2005 | 33740450.22 | 14753741 | 9546780.25 | 424.3 | 29992424.57 |
| RR11 | | 2 | June | 2005 | 390110261.2 | 101675007 | 21157384.8 | 483 | 61026237.69 |
| RR12 | 362.39 | 1 | August | 2005 | 9505661.69 | 11277904 | 32754254.6 | 469 | 74353607.97 |
| RR12 | 362.39 | 1 | July | 2005 | 16685289.64 | 35261031 | 16561999.3 | 483 | 39970720.93 |
| RR12 | 362.39 | 1 | June | 2005 | 1680172553 | 162680012 | 27996968.7 | 492 | 68379504.88 |
| RR12 | 362.39 | 1 | October | 2005 | 2675572697 | | 32422417.3 | 441 | 97267251.9 |
| RR12 | 362.39 | 1 | May | 2006 | | | | | |
| RR12 | 362.39 | 7 | April | 2008 | 480096.03 | 50668.53 | | | |
| RR12 | 362.39 | 10 | May | 2008 | 91295.80 | 57777.96 | | | |
| RR12 | 362.39 | 3 | April | 2009 | | | | | |
| RR12 | 362.39 | 2 | August | 2009 | 454614.40 | 46266.22 | | | |
| RR12 | 362.39 | 10 | July | 2009 | 951394.95 | 362465.85 | | | |
| RR12 | 362.39 | 2 | July | 2009 | | | | | |
| RR12 | 362.39 | 2 | June | 2009 | | 27790.532 | | | |
| RR12 | 362.39 | 4 | May | 2009 | | | | | |
| RR13 | 335.06 | 1 | August | 2005 | 15627952.27 | 42856034 | 36508185.4 | 480 | 74256940.22 |
| RR13 | 335.06 | 1 | July | 2005 | 2876774.08 | 5506967.5 | 16800360.6 | 488 | 38910424.2 |
| RR13 | 335.06 | 1 | June | 2005 | 1534253810 | 106003341 | 32145635.6 | 479 | 67628171.5 |
| RR13 | 335.06 | 1 | June | 2005 | | | | | |
| RR13 | 335.06 | 1 | October | 2005 | 2417639897 | | 34916449.4 | 432 | 97267251.9 |
| RR13 | 335.06 | 1 | May | 2006 | | | | | |
| RR15 | 194.49 | 2 | August | 2005 | 2013911.38 | 12083468 | 37579586.3 | 477.5 | 78735879.12 |
| RR15 | 194.49 | 2 | July | 2005 | 33987030.86 | 17055161 | 18662044.4 | 472.85 | 37948759.73 |
| RR15 | 194.49 | 1 | June | 2005 | 787573789.6 | 94406673 | 36622602.6 | 460 | 64844971.3 |
| RR15 | 194.49 | 1 | November | 2005 | 957295825.4 | | 12133334.5 | 398 | 43680004.2 |
| RR15 | 194.49 | 1 | October | 2005 | 2541593292 | | 34916449.4 | 425 | 94773219.8 |
| RR15 | 194.49 | 1 | September | 2005 | 819412359.3 | 17005099 | 27891696.4 | 543 | 79057037.8 |
| RR15 | 194.49 | 1 | April | 2006 | | | | | |
| RR15 | 194.49 | 1 | August | 2006 | | | | | |
| RR15 | 194.49 | 1 | February | 2006 | | | | | |

| Station | Area km^2 | N | Month | Year | NO3 ug/km$^2$ | NH3 ug/km$^2$ | DOC mg/km$^2$ | Sp Cond uS/cm | DIC mg/km$^2$ |
|---|---|---|---|---|---|---|---|---|---|
| RR15 | 194.49 | 1 | June | 2006 | | | | | |
| RR15 | 194.49 | 2 | March | 2006 | | | | | |
| RR15 | 194.49 | 2 | May | 2006 | | | | | |
| RR16 | 128.8 | 2 | August | 2005 | 46722743.9 | 33028147 | 26825299.5 | 484 | 90303786.06 |
| RR16 | 128.8 | 2 | July | 2005 | 56877933.14 | 27164967 | 14733192.9 | 537.5 | 45707830.37 |
| RR16 | 128.8 | 4 | June | 2005 | 350436591.7 | 62175560 | 32717302.3 | 477.8 | 70962893.96 |
| RR16 | 128.8 | 1 | November | 2005 | 706657534.6 | | 12133334.5 | 376 | 42466670.75 |
| RR16 | 128.8 | 1 | October | 2005 | 1224519880 | | 32422417.3 | 404 | 92279187.7 |
| RR16 | 128.8 | 1 | September | 2005 | 211730151.9 | 25340932 | 20506148.6 | 593 | 91927563.57 |
| RR16 | 128.8 | 1 | April | 2006 | | | | | |
| RR16 | 128.8 | 1 | August | 2006 | | | | | |
| RR16 | 128.8 | 1 | February | 2006 | | | | | |
| RR16 | 128.8 | 1 | June | 2006 | | | | | |
| RR16 | 128.8 | 2 | March | 2006 | | | | | |
| RR16 | 128.8 | 1 | May | 2006 | | | | | |
| RR17 | 150.6 | 1 | August | 2005 | 20461339.57 | 25133614 | 32802588.5 | 532 | 82425364.76 |
| RR17 | 150.6 | 1 | July | 2005 | 75371480.77 | 13397548 | 17145573.5 | 497 | 39313172.57 |
| RR17 | 150.6 | 1 | June | 2005 | 904690331.3 | 62720004 | 42567936.4 | 445 | 63154471.18 |
| RR17 | 150.6 | 1 | October | 2005 | 1414191022 | | 39904513.6 | 410 | 89785155.6 |
| RR17 | 150.6 | 1 | May | 2006 | | | | | |
| RR18 | 132.09 | 1 | August | 2005 | 51878357.02 | 36089292 | 35895956.3 | 505 | 83843158.36 |
| RR18 | 132.09 | 1 | July | 2005 | 122303995 | 20383999 | 17589418.6 | 491 | 39074811.29 |
| RR18 | 132.09 | 1 | June | 2005 | 415516763 | 88036673 | 45467103.2 | 435 | 62778804.48 |
| RR18 | 132.09 | 1 | October | 2005 | 1507866867 | | 42398545.7 | 376 | 82303059.3 |
| RR18 | 132.09 | 1 | March | 2006 | | | | | |
| RR18 | 132.09 | 1 | May | 2006 | | | | | |
| RR19 | 75.364 | 2 | August | 2005 | 26261404.33 | 43500486 | 50371951.3 | 394.55 | 73024426.46 |
| RR19 | 75.364 | 1 | July | 2005 | 127235607.7 | 17507225 | 24444360.3 | 403 | 32499327.69 |
| RR19 | 75.364 | 2 | June | 2005 | 412275412.8 | 101593341 | 57467204.1 | 383.8 | 54318137.21 |
| RR19 | 75.364 | 1 | June | 2005 | | | | | |
| RR19 | 75.364 | 1 | October | 2005 | 1653293879 | | 52374674.1 | 346 | 74820963 |
| RR19 | 75.364 | 1 | June | 2006 | 194399351.3 | 31558336 | 39132337 | | 45444004.2 |
| RR19 | 75.364 | 1 | May | 2006 | | | | | |
| RR2 | 23.436 | 3 | August | 2005 | 26503073.7 | 31417017 | 8248980.99 | 430.1 | 54069492.6 |
| RR2 | 23.436 | 2 | July | 2005 | 10931741.49 | 13561935 | 4652154.65 | 513 | 32729469.62 |
| RR2 | 23.436 | 2 | June | 2005 | 153775894.3 | 81013339 | 13918451 | 515 | 62172837.77 |
| RR2 | 23.436 | 1 | November | 2005 | 200297085.9 | | 7280000.7 | 479 | 48533338 |
| RR2 | 23.436 | 2 | October | 2005 | 312028356 | | 22446288.9 | 706 | 112231444.5 |
| RR2 | 23.436 | 1 | September | 2005 | 288586529.8 | 24007198 | 13470705.7 | 812 | 89643545.39 |
| RR2 | 23.436 | 1 | April | 2006 | | | | | |
| RR2 | 23.436 | 1 | August | 2006 | | | | | |
| RR2 | 23.436 | 2 | March | 2006 | | | | | |
| RR2 | 23.436 | 1 | May | 2006 | | | | | |
| RR20 | 80.114 | 1 | August | 2005 | 92801036.16 | 65089616 | 58580654.1 | 561 | 86888192.36 |
| RR20 | 80.114 | 1 | July | 2005 | 150578574.4 | 58603998 | 19496308.9 | 532 | 43315998.22 |
| RR20 | 80.114 | 1 | June | 2005 | 204901681.3 | 85913339 | 34741002.5 | 500 | 75858538.75 |
| RR20 | 80.114 | 1 | October | 2005 | 1562935096 | | 42398545.7 | 400 | 87291123.5 |
| RR20 | 80.114 | 1 | May | 2006 | | | | | |

| Station | Area km^2 | N | Month | Year | NO3 ug/km$^2$ | NH3 ug/km$^2$ | DOC mg/km$^2$ | Sp Cond uS/cm | DIC mg/km$^2$ |
|---|---|---|---|---|---|---|---|---|---|
| RR21 | 8.2388 | 2 | August | 2005 | 8780653.6 | 53006147 | 42936590.5 | 406.5 | 74554999.1 |
| RR21 | 8.2388 | 2 | July | 2005 | 33041805.09 | 38384386 | 23979966.8 | 312 | 25944392.48 |
| RR21 | 8.2388 | 3 | June | 2005 | 75374255.38 | 146428344 | 54051903.9 | 225.85 | 31162368.89 |
| RR21 | 8.2388 | 1 | November | 2005 | 308854029.7 |  | 29120002.8 | 181 | 16986668.3 |
| RR21 | 8.2388 | 1 | October | 2005 | 1188755460 |  | 79809027.2 | 195 | 39904513.6 |
| RR21 | 8.2388 | 1 | September | 2005 | 1042979394 | 117368525 | 54533017.9 | 290 | 43079583.65 |
| RR21 | 8.2388 | 1 | April | 2006 |  |  |  |  |  |
| RR21 | 8.2388 | 1 | August | 2006 |  |  |  |  |  |
| RR21 | 8.2388 | 1 | December | 2006 | 394949094.8 | 27828392 | 31039359.8 |  | 11773550.25 |
| RR21 | 8.2388 | 1 | February | 2006 |  |  |  |  |  |
| RR21 | 8.2388 | 2 | June | 2006 | 93412675.3 | 59329672 | 39132337 |  | 26509002.45 |
| RR21 | 8.2388 | 2 | March | 2006 |  |  |  |  |  |
| RR21 | 8.2388 | 1 | May | 2006 |  |  |  |  |  |
| RR21 | 8.2388 | 1 | November | 2006 | 701889935.3 | 29087331 | 41733996.2 |  | 18969998.25 |
| RR21 | 8.2388 | 1 | October | 2006 | 134982586.2 | 8230645.5 | 54322260.3 |  | 39507098.4 |
| RR21 | 8.2388 | 1 | March | 2007 | 443715462.8 | 12382757 | 10318964.3 |  | 8943102.35 |
| RR21 | 8.2388 | 7 | April | 2008 | 216784.72 | 28079.18 |  |  |  |
| RR21 | 8.2388 | 8 | May | 2008 | 35904.78 | 96146.47 |  |  |  |
| RR21 | 8.2388 | 5 | April | 2009 |  |  |  |  |  |
| RR21 | 8.2388 | 6 | August | 2009 | 83954.08 | 44196.65 |  |  |  |
| RR21 | 8.2388 | 6 | July | 2009 | 86282.5 | 187070.78 |  |  |  |
| RR21 | 8.2388 | 3 | July | 2009 | 37024.22 | 76462.82 |  |  |  |
| RR21 | 8.2388 | 3 | June | 2009 |  | 112643.25 |  |  |  |
| RR21 | 8.2388 | 4 | May | 2009 |  |  |  |  |  |
| RR22 | 29.128 | 2 | August | 2005 | 59370107.34 | 110523456 | 54697832.9 | 838 | 92825203.1 |
| RR22 | 29.128 | 2 | July | 2005 | 7274128.73 | 18534644 | 25245747.3 | 701 | 41996791.82 |
| RR22 | 29.128 | 3 | June | 2005 | 102600290.7 | 86485006 | 46231503.3 | 494 | 65073637.98 |
| RR22 | 29.128 | 1 | November | 2005 | 1018277965 |  | 18200001.8 | 329 | 33973336.6 |
| RR22 | 29.128 | 1 | October | 2005 | 2041639617 |  | 52374674.1 | 370 | 72326930.9 |
| RR22 | 29.128 | 1 | September | 2005 | 19505848.64 | 13003899 | 37161142.4 | 1066 | 90227053.69 |
| RR22 | 29.128 | 1 | April | 2006 |  |  |  |  |  |
| RR22 | 29.128 | 1 | August | 2006 |  |  |  |  |  |
| RR22 | 29.128 | 1 | February | 2006 |  |  |  |  |  |
| RR22 | 29.128 | 1 | July | 2006 | 30565164 | 17192905 | 64950973.5 |  | 76412910 |
| RR22 | 29.128 | 1 | June | 2006 |  |  |  |  |  |
| RR22 | 29.128 | 2 | March | 2006 |  |  |  |  |  |
| RR22 | 29.128 | 1 | May | 2006 |  |  |  |  |  |
| RR3 | 47.948 | 2 | August | 2005 | 166912974.8 | 55906180 | 7991200.34 | 560 | 67006859.27 |
| RR3 | 47.948 | 2 | July | 2005 | 8712515.77 | 18082580 | 4709690.13 | 583 | 35532269.5 |
| RR3 | 47.948 | 1 | June | 2005 | 733342219 | 81830006 | 16931134.5 | 454 | 44106536.48 |
| RR3 | 47.948 | 2 | October | 2005 | 945188285.3 |  | 19952256.8 | 579 | 112231444.5 |
| RR3 | 47.948 | 2 | May | 2006 |  |  |  |  |  |
| RR4 | 74.33 | 2 | August | 2005 | 37539308.03 | 78300874 | 9070656.83 | 668 | 73338596.63 |
| RR4 | 74.33 | 2 | July | 2005 | 130030188.2 | 36165160 | 4438451.43 | 690 | 37718617.8 |
| RR4 | 74.33 | 1 | June | 2005 | 4205221134 | 279136687 | 14332501 | 591 | 62378637.79 |
| RR4 | 74.33 | 1 | November | 2005 | 1054629435 |  | 7280000.7 | 523 | 44893337.65 |
| RR4 | 74.33 | 2 | October | 2005 | 3113549674 |  | 14964192.6 | 502 | 112231444.5 |
| RR4 | 74.33 | 1 | May | 2006 |  |  |  |  |  |

| Station | Area km^2 | N | Month | Year | NO3 ug/km$^2$ | NH3 ug/km$^2$ | DOC mg/km$^2$ | Sp Cond uS/cm | DIC mg/km$^2$ |
|---|---|---|---|---|---|---|---|---|---|
| RR5 | 105 45 | 3 | August | 2005 | 9022322 96 | 17722420 | 10625396 4 | 601 | 74055549 08 |
| RR5 | 105 45 | 3 | July | 2005 | 7438515 82 | 13561935 | 6065883 62 | 632 5 | 37266553 3 |
| RR5 | 105 45 | 2 | June | 2005 | 490784851 7 | 138016677 | 14985834 4 | 603 5 | 68108371 53 |
| RR5 | 105 45 | 2 | November | 2005 | 2129485138 |  | 6066667 25 | 517 | 49140004 73 |
| RR5 | 105 45 | 2 | October | 2005 | 2202130583 |  | 19952256 8 | 583 | 117219508 7 |
| RR5 | 105 45 | 1 | September | 2005 | 1132672954 | 43179614 | 10903269 2 | 706 | 87092780 57 |
| RR5 | 105 45 | 1 | April | 2006 |  |  |  |  |  |
| RR5 | 105 45 | 1 | August | 2006 |  |  |  |  |  |
| RR5 | 105 45 | 1 | February | 2006 |  |  |  |  |  |
| RR5 | 105 45 | 1 | June | 2006 |  |  |  |  |  |
| RR5 | 105 45 | 2 | March | 2006 |  |  |  |  |  |
| RR5 | 105 45 | 1 | May | 2006 |  |  |  |  |  |
| RR6 | 573 01 | 3 | August | 2005 | 36572630 57 | 35042058 | 22249692 9 | 506 | 73161372 43 |
| RR6 | 573 01 | 2 | July | 2005 | 17589418 63 | 27288257 | 12945483 3 | 521 | 39148785 48 |
| RR6 | 573 01 | 1 | June | 2005 | 355205925 4 | 159903345 | 22246001 6 | 518 | 66911138 11 |
| RR6 | 573 01 | 1 | November | 2005 | 1299783458 |  | 10920001 1 | 470 | 47320004 55 |
| RR6 | 573 01 | 2 | October | 2005 | 2105237436 |  | 37410481 5 | 543 | 109737412 4 |
| RR6 | 573 01 | 1 | September | 2005 | 748557781 | 112200309 | 23190286 7 | 579 | 77239826 26 |
| RR6 | 573 01 | 1 | June | 2006 |  |  |  |  |  |
| RR6 | 573 01 | 2 | March | 2006 |  |  |  |  |  |
| RR6 | 573 01 | 2 | May | 2006 |  |  |  |  |  |
| RR7 | 408 81 | 3 | August | 2005 | 10391782 7 | 16755743 | 26196959 2 | 470 25 | 77640311 33 |
| RR7 | 408 81 | 2 | July | 2005 | 55727223 51 | 23507354 | 15772941 3 | 484 | 39666604 82 |
| RR7 | 408 81 | 2 | June | 2005 | 287656970 5 | 73173339 | 27853235 3 | 480 25 | 67257404 8 |
| RR7 | 408 81 | 1 | November | 2005 | 796371409 9 |  | 10920001 1 | 433 | 46106671 1 |
| RR7 | 408 81 | 2 | October | 2005 | 397124731 3 |  | 39904513 6 | 593 | 104749348 2 |
| RR7 | 408 81 | 1 | September | 2005 | 343936459 3 | 33676764 | 21173015 2 | 502 | 75539316 38 |
| RR7 | 408 81 | 1 | February | 2006 |  |  |  |  |  |
| RR7 | 408 81 | 1 | March | 2006 |  |  |  |  |  |
| RR7 | 408 81 | 1 | May | 2006 |  |  |  |  |  |
| RR8 |  | 3 | July | 2005 | 170400643 7 | 57782062 | 15998699 6 | 513 66667 | 33516335 82 |
| RR8 |  | 1 | June | 2005 | 597310042 7 | 99470007 | 37566669 4 | 471 | 99633340 45 |
| RR8 |  | 5 | November | 2005 | 1411366456 | 49504005 | 19789468 6 | 600 | 59822192 42 |
| RR9 |  | 1 | August | 2005 | 207030089 4 | 121801360 | 25359172 | 521 | 85228729 39 |
| RR9 |  | 1 | July | 2005 | 60247868 49 | 64439739 | 19742889 5 | 494 | 38129585 53 |
| RR9 |  | 1 | June | 2005 | 5779542246 | 533446705 | 18097334 6 | 334 | 23977335 05 |
| RR9 |  | 1 | October | 2005 | 1452998161 |  | 49880642 | 1066 | 74820963 |
| SC | 76 718 | 3 | August | 2004 |  |  |  |  |  |
| SC | 76 718 | 3 | July | 2004 |  |  |  |  |  |
| SC | 76 718 | 2 | June | 2004 | 2083690 |  |  |  |  |
| SC | 76 718 | 5 | August | 2005 | 16755742 64 | 24005824 | 10665674 6 | 468 | 54778389 4 |
| SC | 76 718 | 5 | July | 2005 | 8301548 05 | 76193416 | 5605599 77 | 520 | 37685740 38 |
| SC | 76 718 | 2 | June | 2005 |  |  |  |  |  |
| SC | 76 718 | 1 | October | 2005 | 929625525 |  | 12470160 5 | 662 | 134677733 4 |
| SC | 76 718 | 2 | August | 2006 |  |  |  |  |  |
| SC | 76 718 | 5 | July | 2006 |  |  |  |  |  |
| SC | 76 718 | 1 | June | 2006 |  |  |  |  |  |
| SC | 76 718 | 3 | September | 2006 |  |  |  |  |  |
| SC | 76 718 | 3 | August | 2007 |  |  |  |  |  |

| Station | Area km^2 | N | Month | Year | NO3 ug/km$^2$ | NH3 ug/km$^2$ | DOC mg/km$^2$ | Sp Cond uS/cm | DIC mg/km$^2$ |
|---|---|---|---|---|---|---|---|---|---|
| SC | 76 718 | 4 | July | 2007 | | | | | |
| SC | 76 718 | 3 | June | 2007 | | | | | |
| SC | 76 718 | 1 | August | 2008 | 8175 | | | | |
| SC | 76 718 | 1 | July | 2008 | 11516 13 | | | | |
| SC | 76 718 | 1 | November | 2008 | 3146500 | | | | |
| SC | 76 718 | 1 | October | 2008 | 20761 48 | | | | |
| SC | 76 718 | 1 | April | 2009 | 4067840 45 | | | | |
| Stream | | 2 | August | 2009 | 11104 60 | 312246 07 | | | |
| Stream | | 3 | July | 2009 | 9216 63 | 1405175 8 | | | |
| Stream | | 1 | May | 2009 | 40754 82 | 478115 17 | | | |
| West | 9 8856 | 3 | August | 2004 | | | | | |
| West | 9 8856 | 3 | July | 2004 | | | | | |
| West | 9 8856 | 1 | June | 2004 | | | | | |
| West | 9 8856 | 4 | August | 2005 | | | | | |
| West | 9 8856 | 4 | July | 2005 | | | | | |
| West | 9 8856 | 2 | June | 2005 | | | | | |
| West | 9 8856 | 2 | August | 2006 | | | | | |
| West | 9 8856 | 5 | July | 2006 | | | | | |
| West | 9 8856 | 1 | June | 2006 | | | | | |
| West | 9 8856 | 3 | September | 2006 | | | | | |
| West | 9 8856 | 3 | August | 2007 | | | | | |
| West | 9 8856 | 4 | July | 2007 | | | | | |
| West | 9 8856 | 3 | June | 2007 | | | | | |
| West | 9 8856 | 1 | August | 2008 | 61312 5 | | | | |
| West | 9 8856 | 1 | July | 2008 | 23032 25 | | | | |
| West | 9 8856 | 1 | November | 2008 | 3233300 | | | | |
| West | 9 8856 | 1 | April | 2009 | 6345407 37 | | | | |
| West | 9 8856 | 1 | June | 2009 | 3332560 | | | | |
| 174/175 | | 2 | April | 2009 | 24845 21 | 332501 23 | | | |
| GW2 | 30 467 | 6 | August | 2004 | | | | | 115677648 9 |
| GW2 | 30 467 | 7 | July | 2004 | | | | | 263744863 9 |
| GW2 | 30 467 | 2 | June | 2004 | | | | | 80752000 |
| GW2 | 30 467 | 8 | August | 2005 | | | 735 75 | | 159501780 9 |
| GW2 | 30 467 | 8 | July | 2005 | | | 556 25 | | 102433705 5 |
| GW2 | 30 467 | 4 | June | 2005 | | | 557 5 | | 75950005 43 |
| GW2 | 30 467 | 4 | August | 2006 | | | 574 25 | | 33870978 75 |
| GW2 | 30 467 | 10 | July | 2006 | | | 623 5 | | 199055630 6 |
| GW2 | 30 467 | 2 | June | 2006 | | | 631 | | 42288170 58 |
| GW2 | 30 467 | 6 | September | 2006 | | | 587 67 | | 123339416 7 |
| GW2 | 30 467 | 6 | August | 2007 | | | 533 33 | | 86955568 93 |
| GW2 | 30 467 | 8 | July | 2007 | | | 499 25 | | 282597270 4 |
| GW2 | 30 467 | 6 | June | 2007 | | | 523 5 | | 62857138 75 |
| GW2 | 30 467 | 2 | August | 2008 | 3011124 89 | | 964 5 | | 72212497 35 |
| GW2 | 30 467 | 2 | July | 2008 | 7677 42 | | 1409 5 | | 106044336 1 |
| GW2 | 30 467 | 2 | November | 2008 | 5446700 | | 610 | | 105245000 |
| GW2 | 30 467 | 2 | October | 2008 | 32625 18 | | 774 5 | | 91943702 9 |
| GW2 | 30 467 | 2 | April | 2009 | 6032904 | | 491 | | 63030340 28 |
| GW2 | 30 467 | 2 | June | 2009 | 2356200 | | 484 5 | | 28952000 |

| Station | Area km^2 | N | Month | Year | P ug/km$^2$ | SO4 mg/km$^2$ | MeHg ng/km$^2$ | THg ng/km$^2$ | % MeHg % |
|---|---|---|---|---|---|---|---|---|---|
| Beau | 207 08 | 3 | August | 2004 | 113427111 | | | | |
| Beau | 207 08 | 3 | July | 2004 | 279689919 1 | | | | |
| Beau | 207 08 | 1 | June | 2004 | 33887000 | | | | |
| Beau | 207 08 | 4 | August | 2005 | 163126821 4 | | | | |
| Beau | 207 08 | 4 | July | 2005 | 75823545 26 | | | | |
| Beau | 207 08 | 2 | June | 2005 | 106983341 | | | | |
| Beau | 207 08 | 3 | September | 2005 | 135596212 7 | | | | |
| Beau | 207 08 | 2 | August | 2006 | 44483885 43 | | | | |
| Beau | 207 08 | 5 | July | 2006 | 166580143 8 | | | | |
| Beau | 207 08 | 1 | June | 2006 | 66903672 85 | | | | |
| Beau | 207 08 | 3 | August | 2007 | 71788899 93 | | | | |
| Beau | 207 08 | 4 | July | 2007 | 179993319 8 | | | | |
| Beau | 207 08 | 3 | June | 2007 | 35089995 97 | | | | |
| Bridge | | 3 | August | 2009 | | | | 2712387 1 | |
| Bridge | | 3 | July | 2009 | | | | 4440111 1 | |
| Bridge | | 2 | May | 2009 | | | | | |
| Dix | | 1 | June | 2006 | 15148001 4 | 18935002 | 744776 74 | 4481283 7 | 16 62 |
| Ferg | | 3 | August | 2004 | 208399811 1 | | | | |
| Ferg | | 3 | July | 2004 | 420837782 1 | | | | |
| Ferg | | 1 | June | 2004 | 401597000 | | | | |
| Ferg | | 4 | August | 2005 | 714938538 1 | | | | |
| Ferg | | 4 | July | 2005 | 350144501 7 | | | | |
| Ferg | | 2 | June | 2005 | 129033342 6 | | | | |
| Ferg | | 2 | August | 2006 | 109967777 7 | | | | |
| Ferg | | 5 | July | 2006 | 740441097 9 | | | | |
| Ferg | | 1 | June | 2006 | 41657003 85 | | | | |
| Ferg | | 3 | September | 2006 | 367244500 | | | | |
| Ferg | | 3 | August | 2007 | 266427818 8 | | | | |
| Ferg | | 4 | July | 2007 | 438345800 4 | | | | |
| Ferg | | 3 | June | 2007 | 69889598 33 | | | | |
| Finn | 31 629 | 3 | August | 2004 | 108475927 6 | | | | |
| Finn | 31 629 | 3 | July | 2004 | 200647115 9 | | | | |
| Finn | 31 629 | 1 | June | 2004 | 38213000 | | | | |
| Finn | 31 629 | 4 | August | 2005 | 1135846016 | | | | |
| Finn | 31 629 | 4 | July | 2005 | 566929976 6 | | | | |
| Finn | 31 629 | 2 | June | 2005 | 285833353 8 | | | | |
| Finn | 31 629 | 2 | August | 2006 | 64129053 1 | | | | |
| Finn | 31 629 | 5 | July | 2006 | 217012664 4 | | | | |
| Finn | 31 629 | 1 | June | 2006 | 69428339 75 | | | | |
| Finn | 31 629 | 3 | September | 2006 | 90609166 67 | | | | |
| Finn | 31 629 | 3 | August | 2007 | 70019455 22 | | | | |
| Finn | 31 629 | 4 | July | 2007 | 241672065 2 | | | | |
| Finn | 31 629 | 3 | June | 2007 | 47124729 17 | | | | |
| Finn | 31 629 | 1 | August | 2008 | 305199988 8 | | 470743 73 | 1969493 7 | 23 90 |
| Finn | 31 629 | 1 | July | 2008 | 141072555 8 | | 510548 3 | 1056124 8 | 48 34 |
| Finn | 31 629 | 1 | November | 2008 | 139965000 | | 180110 | 680295 | 26 48 |
| Finn | 31 629 | 1 | October | 2008 | 206131850 1 | | 679197 03 | 1508914 8 | 45 01 |
| Finn | 31 629 | 1 | April | 2009 | 56144672 85 | | 21186 7 | 1218233 5 | 1 74 |
| Finn | 31 629 | 1 | June | 2009 | 41888000 | | 117040 | 295680 | 39 58 |

| Station | Area km^2 | N | Month | Year | P ug/km$^2$ | SO4 mg/km$^2$ | MeHg ng/km$^2$ | THg ng/km$^2$ | % MeHg % |
|---|---|---|---|---|---|---|---|---|---|
| Fras | 18.529 | 3 | August | 2004 | 95872915.25 | | | | |
| Fras | 18.529 | 3 | July | 2004 | 401728532.9 | | | | |
| Fras | 18.529 | 1 | June | 2004 | 69937000 | | | | |
| Fras | 18.529 | 4 | August | 2005 | 125668069.8 | | | | |
| Fras | 18.529 | 4 | July | 2005 | 77672900.03 | | | | |
| Fras | 18.529 | 2 | June | 2005 | 151900010.9 | | | | |
| Fras | 18.529 | 2 | August | 2006 | 20774200.3 | | | | |
| Fras | 18.529 | 5 | July | 2006 | 87110717.4 | | | | |
| Fras | 18.529 | 1 | June | 2006 | 69428339.75 | | | | |
| Fras | 18.529 | 3 | September | 2006 | 53256000 | | | | |
| Fras | 18.529 | 3 | August | 2007 | 66733343.6 | | | | |
| Fras | 18.529 | 4 | July | 2007 | 87281243.44 | | | | |
| Fras | 18.529 | 3 | June | 2007 | 32044815.83 | | | | |
| Fras | 18.529 | 1 | August | 2008 | 68124997.5 | | 289531.24 | 2049199.9 | 14.13 |
| Fras | 18.529 | 1 | July | 2008 | 79653211.75 | | 549415.23 | 1350265.9 | 40.69 |
| Fras | 18.529 | 1 | November | 2008 | 53165000 | | 112840 | 2077775 | 5.43 |
| Fras | 18.529 | 1 | October | 2008 | 59318518 | | 226893.33 | 605048.88 | 37.50 |
| Fras | 18.529 | 1 | April | 2009 | 51907339.05 | | 233053.36 | 2330533.6 | 10.00 |
| Fras | 18.529 | 1 | June | 2009 | 46816000 | | 351120 | 1379840 | 25.45 |
| Gray | 33.447 | 3 | August | 2004 | 59864308.58 | | | | |
| Gray | 33.447 | 3 | July | 2004 | 74265490.95 | | | | |
| Gray | 33.447 | 1 | June | 2004 | 36771000 | | | | |
| Gray | 33.447 | 4 | August | 2005 | 115598512.9 | | | | |
| Gray | 33.447 | 4 | July | 2005 | 72535803.46 | | | | |
| Gray | 33.447 | 2 | June | 2005 | 103716674.1 | | | | |
| Gray | 33.447 | 2 | August | 2006 | 26645169.95 | | | | |
| Gray | 33.447 | 5 | July | 2006 | 150151368.2 | | | | |
| Gray | 33.447 | 1 | June | 2006 | 64379005.95 | | | | |
| Gray | 33.447 | 3 | September | 2006 | 29956500 | | | | |
| Gray | 33.447 | 3 | August | 2007 | 55611119.67 | | | | |
| Gray | 33.447 | 4 | July | 2007 | 134219156.6 | | | | |
| Gray | 33.447 | 3 | June | 2007 | 50314710.83 | | | | |
| Hoop | 83.801 | 5 | August | 2005 | 319293565 | 33511485 | | | |
| Hoop | 83.801 | 5 | July | 2005 | 122616330.4 | 17425032 | | | |
| Hoop | 83.801 | 3 | June | 2005 | 358897803.4 | 33156669 | | | |
| Hoop | 83.801 | 1 | October | 2005 | 62350802.5 | 48134820 | | | |
| Hoop | 83.801 | 2 | August | 2006 | 80387122.9 | | | | |
| Hoop | 83.801 | 5 | July | 2006 | 409573197.6 | | | | |
| Hoop | 83.801 | 1 | June | 2006 | 328206697 | | | | |
| Hoop | 83.801 | 3 | September | 2006 | 183437333.3 | | | | |
| Hoop | 83.801 | 3 | August | 2007 | 144588911.1 | | | | |
| Hoop | 83.801 | 4 | July | 2007 | 411191635.8 | | | | |
| Hoop | 83.801 | 3 | June | 2007 | 65249625 | | | | |
| Hwy138 | | 1 | March | 2007 | 22013790.4 | 6879309.5 | 130706.88 | 5297068.3 | 2.47 |
| MD | | 1 | June | 2006 | 41657003.85 | 10098668 | 517556.72 | 2802380.3 | 18.47 |
| Monk | | 2 | December | 2006 | 17125164 | 7492259.3 | 133790.34 | 94120329 | 0.14 |
| Monk | | 2 | July | 2006 | 55399359.75 | 20058389 | 830990.4 | 6485545.7 | 12.81 |
| Monk | | 2 | November | 2006 | 23396331.18 | 18969998 | 202346.65 | 2247249.2 | 9.00 |
| Monk | | 1 | October | 2006 | 65845164 | 13169033 | 510300.02 | 1563822.6 | 32.63 |

| Station | Area km^2 | N | Month | Year | P ug/km$^2$ | SO4 mg/km$^2$ | MeHg ng/km$^2$ | THg ng/km$^2$ | % MeHg % |
|---|---|---|---|---|---|---|---|---|---|
| Monk | | 2 | January | 2007 | 0 | 5524355 6 | 276217 78 | 848383 17 | 32 56 |
| Monk | | 2 | March | 2007 | 9974998 78 | 5159482 1 | 158224 12 | 2731085 9 | 5 79 |
| Monk | | 2 | May | 2007 | 4359310 2 | 6902241 2 | 312417 23 | 1311425 8 | 23 82 |
| Moos | | 1 | December | 2006 | 48164523 75 | | 117735 50 | 3099333 6 | 3 80 |
| Mud | | 1 | July | 2006 | 38206455 | 22923873 | 420271 01 | 6189445 7 | 6 79 |
| New | | 1 | April | 2009 | | | | 5620355 1 | |
| NewA | | 1 | December | 2006 | 0 | 17125164 | 214064 55 | 8407920 4 | 2 55 |
| NewA | | 1 | June | 2006 | 17672668 3 | 11361001 | 1426436 8 | 10464744 | 13 63 |
| NewA | | 1 | November | 2006 | 20234664 8 | 21499331 | 1011733 24 | 7179891 4 | 14 09 |
| NewA | | 1 | October | 2006 | 74075809 5 | 14815162 | 1744896 85 | 5646222 8 | 30 90 |
| NewA | | 1 | January | 2007 | 2367580 95 | 13416292 | 678706 54 | 3204126 2 | 21 18 |
| NewA | | 1 | March | 2007 | 4815516 65 | 10318964 | 178862 05 | 3584120 2 | 4 99 |
| NewA | | 1 | May | 2007 | 9445172 1 | 13804482 | 1663803 39 | 4272124 | 38 95 |
| NewA | | 2 | August | 2009 | | | | 6513016 9 | |
| NewA | | 3 | July | 2009 | | | | 6452688 | |
| NewA | | 1 | May | 2009 | | | | | |
| NewB | | 1 | December | 2006 | 0 | 16054841 | 224767 78 | 8040585 6 | 2 80 |
| NewB | | 1 | June | 2006 | 20197335 2 | 21459669 | 1401190 13 | 6551510 6 | 21 39 |
| NewB | | 1 | November | 2006 | 1264666 55 | 22763998 | 278226 64 | 11866872 | 2 34 |
| NewB | | 1 | October | 2006 | 9876774 6 | 29630324 | 1086445 21 | 6205906 7 | 17 51 |
| NewB | | 1 | January | 2007 | 0 | 11048711 | 370921 02 | 3977536 | 9 33 |
| NewB | | 1 | March | 2007 | 1375861 9 | 6879309 5 | 137586 19 | 3769861 6 | 3 65 |
| NewB | | 1 | May | 2007 | 726551 7 | 13804482 | 755613 77 | 3894317 1 | 19 40 |
| NewC | | 1 | June | 2006 | 25246669 | 22722002 | 1136100 11 | 6299043 9 | 18 04 |
| NewC | | 1 | August | 2009 | | | | | |
| NewD | | 1 | October | 2006 | 80660325 9 | 14815162 | 1580283 94 | 6222368 | 25 40 |
| NewE | | 1 | December | 2006 | 5351613 75 | 18195487 | 224767 78 | 6394001 1 | 3 52 |
| NewE | | 1 | November | 2006 | 18969998 25 | 21499331 | 733506 6 | 6461687 3 | 11 35 |
| Patt | 13 65 | 3 | August | 2004 | 516273398 1 | | | | |
| Patt | 13 65 | 3 | July | 2004 | 2036003635 | | | | |
| Patt | 13 65 | 1 | June | 2004 | 208369000 | | | | |
| Patt | 13 65 | 4 | August | 2005 | 299670012 6 | | | | |
| Patt | 13 65 | 4 | July | 2005 | 86097738 39 | | | | |
| Patt | 13 65 | 2 | June | 2005 | 340550024 3 | | | | |
| Patt | 13 65 | 2 | August | 2006 | 110645197 3 | | | | |
| Patt | 13 65 | 5 | July | 2006 | 992221636 4 | | | | |
| Patt | 13 65 | 1 | June | 2006 | 41657003 85 | | | | |
| Patt | 13 65 | 3 | September | 2006 | 384256833 3 | | | | |
| Patt | 13 65 | 4 | July | 2007 | 597391621 8 | | | | |
| Patt | 13 65 | 3 | June | 2007 | 95699450 | | | | |
| Patt | 13 65 | 1 | August | 2008 | 235712491 4 | | 354931 24 | 2074406 2 | 17 11 |
| Patt | 13 65 | 1 | July | 2008 | 422257990 | | 936645 | 2605043 9 | 35 96 |
| Patt | 13 65 | 1 | November | 2008 | 132370000 | | 40145 | 2746135 | 1 46 |
| Patt | 13 65 | 1 | April | 2009 | 190680021 | | 95340 01 | 1673746 9 | 5 70 |
| Patt | 13 65 | 1 | June | 2009 | 73920000 | | 154000 | 462000 | 33 33 |
| Raisin | 573 17 | 3 | August | 2004 | 133231844 7 | | | | |
| Raisin | 573 17 | 3 | July | 2004 | 75568394 3 | | | | |
| Raisin | 573 17 | 1 | June | 2004 | 20909000 | | | | |
| Raisin | 573 17 | 4 | August | 2005 | 106334520 6 | | | | |
| Raisin | 573 17 | 4 | July | 2005 | 81988061 14 | | | | |
| Raisin | 573 17 | 2 | June | 2005 | 78400005 6 | | | | |
| Raisin | 573 17 | 2 | August | 2006 | 19870974 2 | | | | |

| Station | Area<br>km^2 | N | Month | Year | P<br>ug/km$^2$ | SO4<br>mg/km$^2$ | MeHg<br>ng/km$^2$ | THg<br>ng/km$^2$ | % MeHg<br>% |
|---|---|---|---|---|---|---|---|---|---|
| Raisin | 573 17 | 5 | July | 2006 | 127609559 7 | | | | |
| Raisin | 573 17 | 1 | June | 2006 | 64379005 95 | | | | |
| Raisin | 573 17 | 3 | September | 2006 | 32915166 67 | | | | |
| Raisin | 573 17 | 6 | August | 2007 | 185918084 2 | | | | |
| Raisin | 573 17 | 4 | July | 2007 | 84565826 98 | | | | |
| Raisin | 573 17 | 3 | June | 2007 | 21894874 17 | | | | |
| Raisin | 573 17 | 1 | August | 2008 | 81749997 | | 243206 24 | 1532812 4 | 15 87 |
| Raisin | 573 17 | 1 | July | 2008 | 71975793 75 | | 162185 46 | 748548 26 | 21 67 |
| Raisin | 573 17 | 1 | November | 2008 | 34720000 | | 111755 | 630385 | 17 73 |
| Raisin | 573 17 | 1 | October | 2008 | 47454814 4 | | 97134 07 | 344788 89 | 28 17 |
| Raisin | 573 17 | 1 | April | 2009 | 50848005 6 | | 137713 35 | 1440693 5 | 9 56 |
| Raisin | 573 17 | 1 | June | 2009 | 47432000 | | 160160 | 862400 | 18 57 |
| RR1 | 1 8863 | 2 | August | 2005 | 257619543 1 | 32222582 | 273891 95 | 10746231 | 2 55 |
| RR1 | 1 8863 | 3 | July | 2005 | 10931741 49 | 14959225 | 90412 9 | | |
| RR1 | 1 8863 | 1 | June | 2005 | 264862985 6 | 34626669 | 784000 06 | 2793000 2 | 28 07 |
| RR1 | 1 8863 | 2 | October | 2005 | 32173014 09 | 51875868 | 673388 67 | 3541525 6 | 19 01 |
| RR1 | 1 8863 | 1 | June | 2006 | | | 227220 02 | 2310070 2 | 9 84 |
| RR1 | 1 8863 | 2 | May | 2006 | | | 99501 61 | 1066088 6 | 9 33 |
| RR11 | | 1 | August | 2005 | 78461987 17 | 29805888 | | | |
| RR11 | | 2 | July | 2005 | 49316127 | 14424967 | | | |
| RR11 | | 2 | June | 2005 | 82498855 89 | 29808335 | | | |
| RR12 | 362 39 | 1 | August | 2005 | 104562278 6 | 24005824 | | 2626140 4 | |
| RR12 | 362 39 | 1 | July | 2005 | 46685933 56 | 13561935 | 172606 45 | 2038399 9 | 8 47 |
| RR12 | 362 39 | 1 | June | 2005 | 114669808 2 | 30706669 | 800333 39 | 5324667 | 15 03 |
| RR12 | 362 39 | 1 | October | 2005 | 104250541 8 | 52873481 | 548687 06 | 6634125 4 | 8 27 |
| RR12 | 362 39 | 1 | May | 2006 | | | 213217 73 | 2672328 8 | 7 98 |
| RR12 | 362 39 | 7 | April | 2008 | | 8396290 6 | 71454 8 | 3 893E+11 | 0 00 |
| RR12 | 362 39 | 10 | May | 2008 | | 16152627 | 232468 45 | 2775465 3 | 8 38 |
| RR12 | 362 39 | 3 | April | 2009 | | | 126028 90 | 3330487 2 | 3 78 |
| RR12 | 362 39 | 2 | August | 2009 | | | | 2550818 1 | |
| RR12 | 362 39 | 10 | July | 2009 | | | | 2167639 5 | |
| RR12 | 362 39 | 2 | July | 2009 | | | | 2668726 7 | |
| RR12 | 362 39 | 2 | June | 2009 | | | | 1434659 7 | |
| RR12 | 362 39 | 4 | May | 2009 | | | 284015 54 | 2722497 8 | 10 43 |
| RR13 | 335 06 | 1 | August | 2005 | 94251052 35 | 26422517 | | 2658363 | |
| RR13 | 335 06 | 1 | July | 2005 | 46768127 11 | 13726322 | 263019 34 | 2876774 1 | 9 14 |
| RR13 | 335 06 | 1 | June | 2005 | 108780007 8 | 29073335 | 718666 72 | 5945333 8 | 12 09 |
| RR13 | 335 06 | 1 | June | 2005 | | | 718666 72 | 5945333 8 | 12 09 |
| RR13 | 335 06 | 1 | October | 2005 | 110236218 8 | 53122884 | 498806 42 | 6758827 | 7 38 |
| RR13 | 335 06 | 1 | May | 2006 | | | 199003 21 | 2587041 7 | 7 69 |
| RR15 | 194 49 | 2 | August | 2005 | 36733743 48 | 26825300 | 314170 18 | 2698641 2 | 11 64 |
| RR15 | 194 49 | 2 | July | 2005 | 27329353 71 | 12164645 | 316445 15 | 1290438 7 | 24 52 |
| RR15 | 194 49 | 1 | June | 2005 | 87902739 61 | 32176669 | 947333 40 | 8003333 9 | 11 84 |
| RR15 | 194 49 | 1 | November | 2005 | 36642670 19 | 19777335 | 315466 7 | 2851333 6 | 11 06 |
| RR15 | 194 49 | 1 | October | 2005 | 80557236 83 | 53122884 | 498806 42 | 5711333 5 | 8 73 |
| RR15 | 194 49 | 1 | September | 2005 | 187889670 2 | 31176014 | 316761 65 | 2634123 1 | 12 03 |
| RR15 | 194 49 | 1 | April | 2006 | | | 131296 69 | 1490603 6 | 8 81 |
| RR15 | 194 49 | 1 | August | 2006 | | | 266451 7 | 2063871 6 | 12 91 |
| RR15 | 194 49 | 1 | February | 2006 | | | 150937 5 | 2072875 | 7 28 |

| Station | Area km^2 | N | Month | Year | P ug/km$^2$ | SO4 mg/km$^2$ | MeHg ng/km$^2$ | THg ng/km$^2$ | % MeHg % |
|---|---|---|---|---|---|---|---|---|---|
| RR15 | 194.49 | 1 | June | 2006 | | | 391323.37 | 3332560.3 | 11.74 |
| RR15 | 194.49 | 2 | March | 2006 | | | 37766.14 | 703709.03 | 5.37 |
| RR15 | 194.49 | 2 | May | 2006 | | | 170574.18 | 3205373.1 | 5.32 |
| RR16 | 128.8 | 2 | August | 2005 | 38586541.95 | 24811388 | 378615.34 | 2142801.7 | 17.67 |
| RR16 | 128.8 | 2 | July | 2005 | 30370514.88 | 10808451 | 341103.21 | 1672638.6 | 20.39 |
| RR16 | 128.8 | 4 | June | 2005 | 91025455.39 | 27548891 | 775833.39 | 4720333.7 | 16.44587227 |
| RR16 | 128.8 | 1 | November | 2005 | 24024002.31 | 21233335 | 339733.37 | 2535866.9 | 13.40 |
| RR16 | 128.8 | 1 | October | 2005 | 41400932.86 | 29678982 | 498806.42 | 5387109.3 | 9.26 |
| RR16 | 128.8 | 1 | September | 2005 | 15337932.26 | 17171815 | 133373.32 | 2133973.2 | 6.25 |
| RR16 | 128.8 | 1 | April | 2006 | | | 92680.01 | 1444263.6 | 6.42 |
| RR16 | 128.8 | 1 | August | 2006 | | | 275483.96 | 1169677.8 | 23.55 |
| RR16 | 128.8 | 1 | February | 2006 | | | 150937.5 | 1630125 | 9.26 |
| RR16 | 128.8 | 1 | June | 2006 | | | 302960.03 | 3395677 | 8.92 |
| RR16 | 128.8 | 2 | March | 2006 | | | 31471.78 | 521172.7 | 6.04 |
| RR16 | 128.8 | 1 | May | 2006 | | | 71072.58 | 2388038.5 | 2.98 |
| RR17 | 150.6 | 1 | August | 2005 | 57839534.69 | 30450340 | 386671 | 2674474.3 | 14.46 |
| RR17 | 150.6 | 1 | July | 2005 | 18329160.54 | 11835870 | 172606.45 | 2161690.2 | 7.98 |
| RR17 | 150.6 | 1 | June | 2005 | 82217759.21 | 28420002 | 816666.73 | 5814667.1 | 14.04 |
| RR17 | 150.6 | 1 | October | 2005 | 180567924 | 53122884 | 623508.03 | 6484483.5 | 9.62 |
| RR17 | 150.6 | 1 | May | 2006 | | | 326933.85 | 3681559.4 | 8.88 |
| RR18 | 132.09 | 1 | August | 2005 | 39633775.86 | 33511485 | 306114.53 | 2448916.2 | 12.50 |
| RR18 | 132.09 | 1 | July | 2005 | 16027741.28 | 16849677 | 213703.22 | 1947987 | 10.97 |
| RR18 | 132.09 | 1 | June | 2005 | 82570232.56 | 32666669 | 1339333.43 | 6304667.1 | 21.24 |
| RR18 | 132.09 | 1 | October | 2005 | 93526203.75 | 26935547 | 648448.35 | 6534364.1 | 9.92 |
| RR18 | 132.09 | 1 | March | 2006 | | | 40283.88 | 856032.45 | 4.71 |
| RR18 | 132.09 | 1 | May | 2006 | | | 241646.76 | 3553628.8 | 6.80 |
| RR19 | 75.364 | 2 | August | 2005 | 83698156.75 | 25858622 | 467227.44 | 3351148.5 | 13.94 |
| RR19 | 75.364 | 1 | July | 2005 | 64110965.1 | 13890709 | 312335.47 | 4323380.5 | 7.22 |
| RR19 | 75.364 | 2 | June | 2005 | 66151148.06 | 32013336 | 1290333.43 | 6517000.5 | 19.80 |
| RR19 | 75.364 | 1 | June | 2005 | | | 1192333.42 | 6092333.8 | 19.57 |
| RR19 | 75.364 | 1 | October | 2005 | 49381835.58 | 41400933 | 648448.35 | 7182812.4 | 9.03 |
| RR19 | 75.364 | 1 | June | 2006 | 42919337.3 | 17672668 | 1022490.09 | 4910477.1 | 20.82 |
| RR19 | 75.364 | 1 | May | 2006 | | | 497508.03 | 4235925.5 | 11.74 |
| RR2 | 23.436 | 3 | August | 2005 | 44144937.34 | 16755743 | 233613.72 | 1063345.2 | 21.97 |
| RR2 | 23.436 | 2 | July | 2005 | 15698967.1 | 9205677 | 106851.61 | 172606.44 | 61.90 |
| RR2 | 23.436 | 2 | June | 2005 | 108383107.7 | 16660001 | 392000.03 | 4075167 | 9.62 |
| RR2 | 23.436 | 1 | November | 2005 | 13468001.3 | 16016002 | 303333.36 | 1735066.8 | 17.48 |
| RR2 | 23.436 | 2 | October | 2005 | 40902126.44 | 51626464 | 473866.1 | 4289735.2 | 11.05 |
| RR2 | 23.436 | 1 | September | 2005 | 46513946.75 | 10503149 | 183388.32 | 2334033.2 | 7.86 |
| RR2 | 23.436 | 1 | April | 2006 | | | 54063.34 | 617866.76 | 8.75 |
| RR2 | 23.436 | 1 | August | 2006 | | | 298064.61 | 1020645.5 | 29.20 |
| RR2 | 23.436 | 2 | March | 2006 | | | 26436.3 | 253033.12 | 10.45 |
| RR2 | 23.436 | 1 | May | 2006 | | | 56858.06 | 1279306.4 | 4.44 |
| RR20 | 80.114 | 1 | August | 2005 | 143712715.7 | 24005824 | 531672.60 | 3818376 | 13.92 |
| RR20 | 80.114 | 1 | July | 2005 | 32384256.73 | 15123612 | 394529.02 | 1989083.8 | 19.83 |
| RR20 | 80.114 | 1 | June | 2005 | 82221842.54 | 29890002 | 1127000.08 | 4720333.7 | 23.88 |
| RR20 | 80.114 | 1 | October | 2005 | 33918836.56 | 31674208 | 748209.63 | 5611572.2 | 13.33 |
| RR20 | 80.114 | 1 | May | 2006 | | | 71072.58 | 3112978.8 | 2.28 |

| Station | Area<br>km^2 | N | Month | Year | P<br>ug/km$^2$ | SO4<br>mg/km$^2$ | MeHg<br>ng/km$^2$ | THg<br>ng/km$^2$ | % MeHg<br>% |
|---|---|---|---|---|---|---|---|---|---|
| RR21 | 8.2388 | 2 | August | 2005 | 42936590.52 | 24247493 | 894176.65 | 3045034 | 29.37 |
| RR21 | 8.2388 | 2 | July | 2005 | 7027548.1 | 13726322 | 558916.11 | 2030180.6 | 27.53 |
| RR21 | 8.2388 | 3 | June | 2005 | 58556065.85 | 30053335 | 778555.61 | 5243000.4 | 14.87 |
| RR21 | 8.2388 | 1 | November | 2005 | -7158667.36 | 19777335 | 291200.03 | 4513600.4 | 6.45 |
| RR21 | 8.2388 | 1 | October | 2005 | -2244628.89 | 43396159 | 598567.70 | 9776605.8 | 6.12 |
| RR21 | 8.2388 | 1 | September | 2005 | 17671965.43 | 33343331 | 533493.3 | 3417691.4 | 15.61 |
| RR21 | 8.2388 | 1 | April | 2006 |  |  | 100403.35 | 2131640.3 | 4.71 |
| RR21 | 8.2388 | 1 | August | 2006 |  |  | 216774.26 | 1431613.4 | 15.14 |
| RR21 | 8.2388 | 1 | December | 2006 | 46023878.25 | 11773550 | 139141.96 | 4177897.8 | 3.33 |
| RR21 | 8.2388 | 1 | February | 2006 |  |  | 161000 | 2757125 | 5.84 |
| RR21 | 8.2388 | 2 | June | 2006 | 12623334.5 | 18935002 | 372388.37 | 5308112.2 | 7.09 |
| RR21 | 8.2388 | 2 | March | 2006 |  |  | 47837.11 | 813230.83 | 5.88 |
| RR21 | 8.2388 | 1 | May | 2006 |  |  | 184788.7 |  |  |
| RR21 | 8.2388 | 1 | November | 2006 | 10117332.4 | 17705332 | 177053.32 | 4238656.4 | 4.18 |
| RR21 | 8.2388 | 1 | October | 2006 | 29630323.8 | 24691937 | 724296.80 | 3374564.7 | 21.46 |
| RR21 | 8.2388 | 1 | March | 2007 | 1375861.9 | 6879309.5 | 178862.05 | 3322706.5 | 5.38 |
| RR21 | 8.2388 | 7 | April | 2008 |  | 8668005.9 | 86518.19 | 3397383.7 | 2.55 |
| RR21 | 8.2388 | 8 | May | 2008 |  | 14859554 | 214394.94 | 3203239.5 | 6.69 |
| RR21 | 8.2388 | 5 | April | 2009 |  |  | 111668.36 | 4468495.5 | 2.50 |
| RR21 | 8.2388 | 6 | August | 2009 |  |  |  | 3678513.6 |  |
| RR21 | 8.2388 | 6 | July | 2009 |  |  |  | 4104362.1 |  |
| RR21 | 8.2388 | 3 | July | 2009 |  |  |  | 4409687.9 |  |
| RR21 | 8.2388 | 3 | June | 2009 |  |  |  | 2281394.2 |  |
| RR21 | 8.2388 | 4 | May | 2009 |  |  | 261934.45 | 3767024.8 | 6.95 |
| RR22 | 29.128 | 2 | August | 2005 | 93203818.44 | 19091880 | 692785.51 | 3383371.1 | 20.48 |
| RR22 | 29.128 | 2 | July | 2005 | 17342838 | 10274193 | 616451.59 | 2137032.2 | 28.85 |
| RR22 | 29.128 | 3 | June | 2005 | 57538254.11 | 26296669 | 849333.39 | 4453555.9 | 19.08 |
| RR22 | 29.128 | 1 | November | 2005 | 7765334.08 | 21112002 | 388266.70 |  |  |
| RR22 | 29.128 | 1 | October | 2005 | 26935546.68 | 52624077 | 623508.03 | 7457156 | 8.36 |
| RR22 | 29.128 | 1 | September | 2005 | 12003599.16 | 24173915 | 500149.97 | 2684138.1 | 18.63 |
| RR22 | 29.128 | 1 | April | 2006 |  |  | 139020.02 | 1876770.3 | 7.41 |
| RR22 | 29.128 | 1 | August | 2006 |  |  | 325161.4 | 1734194.1 | 18.75 |
| RR22 | 29.128 | 1 | February | 2006 |  |  | 191187.5 | 2334500 | 8.19 |
| RR22 | 29.128 | 1 | July | 2006 | 47758068.75 | 26744519 | 553993.6 | 6151239.3 | 9.01 |
| RR22 | 29.128 | 1 | June | 2006 |  |  | 366076.70 | 5352293.8 | 6.84 |
| RR22 | 29.128 | 2 | March | 2006 |  |  |  |  |  |
| RR22 | 29.128 | 1 | May | 2006 |  |  | 71072.58 | 3468341.7 | 2.05 |
| RR3 | 47.948 | 2 | August | 2005 | 37055969.3 | 11116791 | 273891.95 | 1192235.5 | 22.97 |
| RR3 | 47.948 | 2 | July | 2005 | 9698838.31 | 8712515.8 | 98632.25 | 213703.22 | 46.15 |
| RR3 | 47.948 | 1 | June | 2005 | 217088145.5 | 24336668 | 882000.06 | 12364334 | 7.13 |
| RR3 | 47.948 | 2 | October | 2005 | 33669433.35 | 52873481 | 299283.85 | 5112765.8 | 5.85 |
| RR3 | 47.948 | 2 | May | 2006 |  |  | 142145.15 | 3894777.1 | 3.65 |
| RR4 | 74.33 | 2 | August | 2005 | 75884180.61 | 6122290.6 | 290003.24 | 1627240.4 | 17.82 |
| RR4 | 74.33 | 2 | July | 2005 | 38877546.79 | 14301677 | 90412.9 | 172606.44 | 52.38 |
| RR4 | 74.33 | 1 | June | 2005 | 182386179.7 | 33646669 | 424666.7 | 6255667.1 | 6.79 |
| RR4 | 74.33 | 1 | November | 2005 | 70130673.41 | 13832001 | 254800.03 | 3567200.3 | 7.14 |
| RR4 | 74.33 | 2 | October | 2005 | 69832898.8 | 38906901 | 349164.49 | 7132931.8 | 4.90 |
| RR4 | 74.33 | 1 | May | 2006 |  |  | 42643.55 | 767583.81 | 5.56 |

| Station | Area km^2 | N | Month | Year | P ug/km$^2$ | SO4 mg/km$^2$ | MeHg ng/km$^2$ | THg ng/km$^2$ | % MeHg % |
|---|---|---|---|---|---|---|---|---|---|
| RR5 | 105.45 | 3 | August | 2005 | 57114526.6 | 23200259 | 193335.49 | 1538628.3 | 12.57 |
| RR5 | 105.45 | 3 | July | 2005 | 25890966.68 | 13808516 | 110961.29 | 308225.79 | 36.00 |
| RR5 | 105.45 | 2 | June | 2005 | 121009755.3 | 34381669 | 375666.69 | 2548000.2 | 15.9 |
| RR5 | 105.45 | 2 | November | 2005 | 47502004.57 | 14924001 | 327600.03 | 4295200.4 | 7.63 |
| RR5 | 105.45 | 2 | October | 2005 | 117967718.3 | 52624077 | 448925.78 | 5287348.1 | 8.49 |
| RR5 | 105.45 | 1 | September | 2005 | 25174214.91 | 10836583 | 216731.65 | 1717181.5 | 12.62 |
| RR5 | 105.45 | 1 | April | 2006 |  |  | 54063.34 | 818673.46 | 6.60 |
| RR5 | 105.45 | 1 | August | 2006 |  |  | 248387.18 | 1336774.6 | 18.58 |
| RR5 | 105.45 | 1 | February | 2006 |  |  | 140875 | 1388625 | 10.14 |
| RR5 | 105.45 | 1 | June | 2006 |  |  | 214596.69 | 2108096.9 | 10.18 |
| RR5 | 105.45 | 2 | March | 2006 |  |  |  |  |  |
| RR5 | 105.45 | 1 | May | 2006 |  |  | 42643.55 | 2160606.3 | 1.97 |
| RR6 | 573.01 | 3 | August | 2005 | 171263023.3 | 27228082 | 306114.53 | 1425849.3 | 21.47 |
| RR6 | 573.01 | 2 | July | 2005 | 111783221.2 | 14877032 | 180825.8 | 657548.36 | 27.50 |
| RR6 | 573.01 | 1 | June | 2005 | 120067975.2 | 32830002 | 457333.37 | 2058000.1 | 22.22 |
| RR6 | 573.01 | 1 | November | 2005 | 33973336.6 | 17350668 | 254800.03 | 2899866.9 | 8.79 |
| RR6 | 573.01 | 2 | October | 2005 | 41151529.65 | 38158691 | 523746.74 | 4938183.6 | 10.61 |
| RR6 | 573.01 | 1 | September | 2005 | 40845580.48 | 33676764 | 300089.98 | 1817211.5 | 16.51 |
| RR6 | 573.01 | 1 | June | 2006 |  |  | 252466.69 | 2549913.6 | 9.90 |
| RR6 | 573.01 | 2 | March | 2006 |  |  | 36507.27 | 521172.7 | 7.00 |
| RR6 | 573.01 | 2 | May | 2006 |  |  | 277183.04 | 2935297.3 | 9.44 |
| RR7 | 408.81 | 3 | August | 2005 | 40600453.32 | 25616953 | 177224.20 | 1506405.7 | 11.76 |
| RR7 | 408.81 | 2 | July | 2005 | 48083223.83 | 13561935 | 263019.34 | 789058.03 | 33.33 |
| RR7 | 408.81 | 2 | June | 2005 | 91326124.86 | 29481669 | 612500.04 | 4271167 | 14.34 |
| RR7 | 408.81 | 1 | November | 2005 | 33609336.57 | 24752002 | 279066.69 | 2960533.6 | 9.43 |
| RR7 | 408.81 | 2 | October | 2005 | 26686143.47 | 42149142 | 523746.74 | 6908468.9 | 7.58 |
| RR7 | 408.81 | 1 | September | 2005 | 25340931.56 | 35510648 | 216731.65 | 2850854.8 | 7.60 |
| RR7 | 408.81 | 1 | February | 2006 |  |  | 130812.5 | 1147125 | 11.40 |
| RR7 | 408.81 | 1 | March | 2006 |  |  | 35248.4 | 775464.69 | 4.55 |
| RR7 | 408.81 | 1 | May | 2006 |  |  | 156359.67 | 2288536.9 | 6.83 |
| RR8 |  | 3 | July | 2005 | 137330892.8 | 15151010 |  |  |  |
| RR8 |  | 1 | June | 2005 | 188114280.1 | 30380002 |  |  |  |
| RR8 |  | 5 | November | 2005 | 144241080.5 | 22398135 |  |  |  |
| RR9 |  | 1 | August | 2005 | 236674864.8 | 28516985 |  |  |  |
| RR9 |  | 1 | July | 2005 | 105454318.2 | 16603096 |  |  |  |
| RR9 |  | 1 | June | 2005 | 286636953.8 | 28093335 |  |  |  |
| RR9 |  | 1 | October | 2005 | 32671820.51 | 52873481 |  |  |  |
| SC | 76.718 | 3 | August | 2004 | 54012910 |  |  |  |  |
| SC | 76.718 | 3 | July | 2004 | 69488178.67 |  |  |  |  |
| SC | 76.718 | 2 | June | 2004 | 44341500 |  | 144200 | 829150 | 17.39 |
| SC | 76.718 | 5 | August | 2005 | 87000971.4 | 34317050 |  |  |  |
| SC | 76.718 | 5 | July | 2005 | 52160023.66 | 17425032 |  |  |  |
| SC | 76.718 | 2 | June | 2005 | 80033339.05 |  |  |  |  |
| SC | 76.718 | 1 | October | 2005 | 62101399.29 | 23693305 |  |  |  |
| SC | 76.718 | 2 | August | 2006 | 24612911.23 |  |  |  |  |
| SC | 76.718 | 5 | July | 2006 | 130284011.6 |  |  |  |  |
| SC | 76.718 | 1 | June | 2006 | 83314007.7 |  |  |  |  |
| SC | 76.718 | 3 | September | 2006 | 102813666.7 |  |  |  |  |
| SC | 76.718 | 3 | August | 2007 | 60919453.82 |  |  |  |  |

| Station | Area<br>km^2 | N | Month | Year | P<br>ug/km$^2$ | SO4<br>mg/km$^2$ | MeHg<br>ng/km$^2$ | THg<br>ng/km$^2$ | % MeHg<br>% |
|---|---|---|---|---|---|---|---|---|---|
| SC | 76.718 | 4 | July | 2007 | 109004575.1 | | | | |
| SC | 76.718 | 3 | June | 2007 | 35959793.33 | | | | |
| SC | 76.718 | 1 | August | 2008 | 125349995.4 | | 275224.99 | 1106350 | 24.88 |
| SC | 76.718 | 1 | July | 2008 | 77733857.25 | | 3168854.28 | 3297451 | 96.10 |
| SC | 76.718 | 1 | November | 2008 | 86800000 | | 39060 | 1104530 | 3.54 |
| SC | 76.718 | 1 | October | 2008 | 94909628.8 | | 192043.70 | 1009897.8 | 19.02 |
| SC | 76.718 | 1 | April | 2009 | 60382006.65 | | 74153.34 | 1472473.5 | 5.04 |
| Stream | | 2 | August | 2009 | | | | 3536431.5 | |
| Stream | | 3 | July | 2009 | | | | 5031443.9 | |
| Stream | | 1 | May | 2009 | | | | | |
| West | 9.8856 | 3 | August | 2004 | 332179396.5 | | | | |
| West | 9.8856 | 3 | July | 2004 | 399991328.5 | | | | |
| West | 9.8856 | 1 | June | 2004 | 89404000 | | | | |
| West | 9.8856 | 4 | August | 2005 | 445879978.4 | | | | |
| West | 9.8856 | 4 | July | 2005 | 176305154 | | | | |
| West | 9.8856 | 2 | June | 2005 | 78400005.6 | | | | |
| West | 9.8856 | 2 | August | 2006 | 81741962.05 | | | | |
| West | 9.8856 | 5 | July | 2006 | 318259770.2 | | | | |
| West | 9.8856 | 1 | June | 2006 | 40394670.4 | | | | |
| West | 9.8856 | 3 | September | 2006 | 264061000 | | | | |
| West | 9.8856 | 3 | August | 2007 | 166327803.4 | | | | |
| West | 9.8856 | 4 | July | 2007 | 285118728.6 | | | | |
| West | 9.8856 | 3 | June | 2007 | 63654634.17 | | | | |
| West | 9.8856 | 1 | August | 2008 | 324274988.1 | | 1374762.45 | 2816287.4 | 48.81 |
| West | 9.8856 | 1 | July | 2008 | 177540291.3 | | 829640.98 | 1891044 | 43.87 |
| West | 9.8856 | 1 | November | 2008 | 355880000 | | 66185 | 1864030 | 3.55 |
| West | 9.8856 | 1 | April | 2009 | 64619340.45 | | 21186.67 | 1016960.1 | 2.08 |
| West | 9.8856 | 1 | June | 2009 | 30800000 | | 98560 | 277200 | 35.56 |
| 174/175 | | 2 | April | 2009 | | | | | |
| GW2 | 30.467 | 6 | August | 2004 | | | | | |
| GW2 | 30.467 | 7 | July | 2004 | | | | | |
| GW2 | 30.467 | 2 | June | 2004 | | | | | |
| GW2 | 30.467 | 8 | August | 2005 | | | | | |
| GW2 | 30.467 | 8 | July | 2005 | | | | | |
| GW2 | 30.467 | 4 | June | 2005 | | | | | |
| GW2 | 30.467 | 4 | August | 2006 | | | | | |
| GW2 | 30.467 | 10 | July | 2006 | | | | | |
| GW2 | 30.467 | 2 | June | 2006 | | | | | |
| GW2 | 30.467 | 6 | September | 2006 | | | | | |
| GW2 | 30.467 | 6 | August | 2007 | | | | | |
| GW2 | 30.467 | 8 | July | 2007 | | | | | |
| GW2 | 30.467 | 6 | June | 2007 | | | | | |
| GW2 | 30.467 | 2 | August | 2008 | | 248315.62 | 1351940.58 | 18.367347 | |
| GW2 | 30.467 | 2 | July | 2008 | | 334447.52 | 1052046.19 | 31.79 | |
| GW2 | 30.467 | 2 | November | 2008 | | 143762.5 | 1497842.5 | 9.6 | |
| GW2 | 30.467 | 2 | October | 2008 | | 286582.59 | 714417.40 | 40.11 | |
| GW2 | 30.467 | 2 | April | 2009 | | 63560.01 | 1742603.53 | 3.65 | |
| GW2 | 30.467 | 2 | June | 2009 | | 160160 | 569800 | 28.11 | |

## Appendix C. Classifications of land uses present in Ontario MNR land use GIS data set.

| Provincial class number | Provincial class name and definition |
|---|---|
| 1 | WATER: All waterbodies, both deep/clear and shallow/sedimented. |
| 2 | COASTAL MUDFLATS: Unvegetated coastal areas of the Hudson Bay-James Bay Lowlands, partly submerged at high tide. |
| 3 | INTERTIDAL MARSH: Coastal marshes of the Hudson Bay-James Bay Lowlands lying between the coastal mudflats and the supertidal zone. |
| 4 | SUPERTIDAL MARSH: Coastal marshes of the Hudson Bay-James Bay Lowlands lying inland of both the coastal mudflats and intertidal marshes, and subject to only exceptionally high tides. |
| 5 | FRESHWATER COASTAL MARSH/INLAND MARSH: Coastal marshes of the Hudson Bay-James Bay Lowlands lying beyond the area of saltwater influence; marshes occurring along lakeshores; Southern Ontario inland marshes characterized by a range of moisture conditions, including the following: seasonal marshes, flooded in spring but often dry by fall, which may appear flooded more deeply than other types of inland marsh; cattail marshes, which appear generally drier than the flooded seasonal marshes; and grassy meadow marshes, which appear generally drier than either the seasonal marshes or cattail marshes. |
| 6 | DECIDUOUS SWAMP: Hardwood swamps of Southern Ontario occurring along rivers and in old lake beds and other low-lying areas. |
| 7 | CONIFER SWAMP: Swamps with dense conifer tree or shrub cover occurring mainly in Southern Ontario. |
| 8 | OPEN FEN: Non-treed, grassy fens; fens with open pools occurring most extensively in the Hudson Bay-James Bay Lowlands; bogs of the Hudson Bay-James Bay Lowlands that have a high proportion of open water surface (termed "string bogs"). |
| 9 | TREED FEN: Fens with dense shrub cover and tamarack tree cover occurring generally in the province but most extensively in the Hudson Bay-James Bay Lowlands. |
| 10 | OPEN BOG: Non-treed bog that may have a partial cover of stunted trees occurring generally in the province but most extensively in the Hudson Bay-James Bay Lowlands, where it also includes lichen-rich peat plateau. |
| 11 | TREED BOG: Bog with a low to high density of tree cover. These is expected to be some degree of overlap between densely treed bog and sparse conifer forest in more northerly parts of the province and especially in the Hudson Bay-James Bay Lowlands. |
| 12 | TUNDRA HEATH: Areas of dense, ericaceous vegetation occurring on better-drained areas only in the Hudson Bay coastal zone. |
| 13 | DENSE DECIDUOUS FOREST: Largely continuous forest canopy composed at least 80 percent of deciduous species; includes deciduous shrub cover on old burns and alder thick swamps in the Hudson Bay-James Bay Lowlands. |
| 14 | DENSE CONIFEROUS FOREST: Largely continuous forest canopy composed at least 80 percent of coniferous species; includes dense conifer swamp in the Hudson Bay-James Bay Lowlands. |
| 15 | CONIFEROUS PLANTATION: Mature coniferous plantations, mostly pine, occurring in evenly spaced rows, mainly in Southern Ontario. This class does not include artificially regenerated cutovers or burns in Northern Ontario. |
| 16 | MIXED FOREST, MAINLY DECIDUOUS: Largely continuous forest canopy composed of coniferous and deciduous species, with deciduous species dominant (i.e., comprising more than 50 percent of the canopy). |
| 17 | MIXED FOREST, MAINLY CONIFEROUS: Largely continuous forest canopy composed of coniferous and deciduous species, with coniferous species dominant (i.e., comprising more than 50 percent of the canopy). |

| | |
|---|---|
| 18 | SPARSE CONIFEROUS FOREST: Patchy or sparse forest canopy (i.e., approximately 30 to 40 percent canopy closure) composed approximately 80 percent of coniferous species. |
| 19 | SPARSE DECIDUOUS FOREST: Patchy or sparse forest canopy (i.e., approximately 30 to 40 percent canopy closure) composed approximately 80 percent of deciduous species. |
| 20 | RECENT CUTOVERS: Forest clear-cuts estimated at less than 10 years of age. |
| 21 | RECENT BURNS: Forest burns estimated at less than 10 years of age. |
| 22 | OLD CUTS AND BURNS: Forest clear-cuts and burns estimated at more than 10 years of age. |
| 23 | MINE TAILINGS, QUARRIES, AND BEDROCK OUTCROPS: Clearings for mining activity scattered in all parts of the province; aggregate quarries occurring mainly in Southern Ontario; bedrock outcrops. |
| 24 | SETTLEMENT AND DEVELOPED LAND: Clearings for human settlement and economic activity; major transportation routes. |
| 25 | PASTURE AND ABANDONED FIELDS: Open grassland with sparse shrubs mapped in agricultural areas of Southern Ontario; includes orchard lands. |
| 26 | CROPLAND: Row crops mapped in Southern Ontario; may or open soil in areas of agricultural land use. |
| 27 | ALVAR: Homogeneous areas of dry grassland growing on thin soils over a limestone substrate, mapped only where they occur in clusters in the central and eastern portions of Southern Ontario. |
| 28 | UNCLASSIFIED: Small, local areas where no classification data could be generated, because clouds and their shadows obscured the land surface on the satellite image data. |