STOVER CREEK WATERSHED

Restoration and Management Plan

Tip of the Mitt Watershed Council
2015

Made possible with support from the Charlevoix County Community Foundation
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Project Summary
Cumulative impacts from a combination of sources have resulted in the continuous degradation of Stover Creek. These sources include 1) concentration of development and impervious surfaces within groundwater recharge areas, 2) poorly designed road/stream crossings, often with undersized culverts, 3) poor riparian management along various stream segments, and 4) natural features such as erodible soils and steep topography. Many of these factors have been acknowledged for decades; however, little has been done to mitigate their impacts. Due to the diverse nature of Stover Creek's problems, a multi-faceted approach must be undertaken in order to restore or improve the Creek's health. This approach involves many corrections that together will ultimately yield benefits to the stream.

The Stover Creek Watershed Restoration and Management Plan project includes a comprehensive assessment of resources for purposes of identifying, with some specificity, nonpoint source pollution contributions and other stream impacts that are degrading the overall health of Stover Creek. The Plan includes watershed management plan recommendations that, if implemented, would improve the overall health of Stover Creek, as well as improve the water quality of its receiving water body, Lake Charlevoix.

The following inventories were completed as part of the project:

- Road/Stream Crossing (RSX) Inventory: 11 RSXings were inventoried. Many were found to be perched, undersized, and poorly aligned with the stream channel. Several had erosion immediately around the structure and/or road runoff was causing the road bed to erode into the stream. Some structures were in poor condition.

- Streambank Erosion Inventory: 34 erosion sites were documented between the golf course and stream mouth with the following categories: Very Minor (1), Minor (9), Minor to Moderate (2), Moderate (10), Moderate to Severe (3) and Severe (9). The majority of the erosion is occurring below the M-66 crossing, although several severe sites were also noted at the golf course.

- Stormwater Assessment: 15 distinct stormwater basins were delineated including: 4 areas with conduits that transport stormwater (e.g., pipe, ditch) into the creek; 3 areas of diffuse stormwater flow over the landscape and into the creek; and 8 areas where stormwater infiltrates into the ground directly or via infrastructure. Estimates from the empirical model indicate that runoff from the seven drainage areas that flow into the creek collectively contribute large quantities of pollutants on an annual basis (e.g. >90 lbs. of phosphorus and nearly 19,000 lbs. of sediments). However, drainage areas where runoff infiltrates into the ground naturally or via BMPs prevent nearly equal quantities of pollutants from entering the creek (e.g. nearly 80 lbs. of phosphorus and nearly 17,000 lbs. of sediments).

- Stream Habitat Survey: Habitat mapping was conducted between the golf course and mouth. Bedform (Pool, glide, run, riffle and cascade), large woody debris (LWD), riparian vegetation, and sand composition were documented. The habitat survey indicated the following:
• Bedform results show the stream to have an average of 1:33.9 pool/riffle ratio (reference condition studies indicate a 1:1 ratio is ideal for Brook Trout).
• The average LWD content for all bedform units is 210 pieces per mile. Upper Midwestern streams have, on average, 525 pieces of LWD per mile. While some sections do meet this reference condition, in general, it much of the stream is lacking in large woody debris. Several areas stand out as being devoid of LWD, including the Belvedere Golf Course, Brookside Cemetery, and developed areas near the mouth of the Creek.
• The survey results indicate that large areas in and around the Golf Course, Brookside Cemetery, and stream mouth have only turf grass as riparian vegetation.
• Vegetative canopy cover is lacking in developed reaches of the stream.
• Typically, riffles in the Creek have a higher proportion of gravel and cobble substrate, while pools and glides have a higher proportion of sand, silt, and organic substrate. Riffles within the lower channel (below M66) had, on average, 20% more sand than riffles in the upper channel.

• Water Quality Monitoring: Water quality monitoring was conducted at four sites: near the mouth at Irish Boat Shop; upstream of Highway M-66 at the Brookside Cemetery; and at two sites at a convergence in the Belvedere Golf Course of the Main (south) Branch and a small tributary referred to as the West Branch. Note that flow ceases in the West Branch site during dry periods and stagnation can cause large shifts (generally increases) in pollutant concentrations. The following parameters were monitored during 2013 and 2014:

• Dissolved Oxygen: Of the 37 measurements taken at these sites in the spring, summer, and fall, dissolved oxygen concentrations were above 8 mg/L except for one occasion. A low dissolved oxygen concentration of 4.21 mg/L was recorded at the west branch site during August of 2013 when the related discharge measurement was zero. The stagnant conditions contributed to the low readings. Overall, data show that Stover Creek is attaining water quality standards for dissolved oxygen.
• Chloride and Conductivity: Research shows that both chloride and conductivity levels in surface waters are good indicators of human disturbance in a watershed, particularly from urban landuse. Chloride levels were highest in the West Branch (average of 23.4 mg/L) and at the mouth (average of 18.8 mg/L). The average chloride concentration in Stover Creek (16.5 mg/L) was similar to the average for lakes and rivers monitored throughout Michigan’s Northern Lower Peninsula in 2013 through the Watershed Council’s 2013 Comprehensive Water Quality Monitoring Program, which was 12.8 mg/L. Conductivity levels were highest at the west branch site (average of 491 µS) and at the mouth (average of 454 µS). Conductivity levels in Stover Creek fall within a typical range for Northern Michigan surface waters. The conductivity and chloride levels documented in Stover Creek do not pose a risk to aquatic organisms.
Nutrients: Nutrients, including Phosphorus and Nitrogen, are chemicals needed by organisms to live, grow, and reproduce. However, excess nutrients from sources such as fertilizers, faulty septic systems, and stormwater runoff lead to nutrient pollution, which can have negative impacts on the surface waters of the Stover Creek Watershed. Phosphorus concentrations exceeded the USEPA reference condition 50% of the time. The highest concentrations were found in the west branch, some of which are considered atypically and alarmingly high for streams in the Northern Lower Peninsula. As previously noted, sluggish flows and stagnation influence water quality in the west branch. However, total phosphorus was high in the west branch during most sample events regardless of flow, which indicates that nutrient pollution is occurring in that tributary. The USEPA total nitrogen reference condition of 440 ppb was exceeded in 100% of samples from Stover Creek. The abnormally high levels of nitrogen likely result from the same sources described in the conductivity and chloride section. Agriculture in the upper watershed, the golf course in the middle watershed and urban development in the lower watershed, are all suspected of contributing nitrogen to Stover Creek.

Bacteria: Bacteria in surface waters are regulated by the State of Michigan for partial-body contact: “All waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1000 E. coli per 100 milliliters.” Bacteriological monitoring results ranged from 12 E. coli bacteria per 100 milliliters to over 2419 E. coli, which is the maximum that can be counted using the Health Department’s methods. The highest bacteria concentrations occurred at the cemetery and west branch sites, while lowest average concentrations were documented at the creek mouth. The maximum allowable concentration of 1000 E. coli/100mL was exceeded in 38% of samples that were analyzed. The high concentrations all occurred during the same sample event and at all sites but the mouth. However, concentrations at the mouth were above the State’s standard of 300 E. coli/100mL for surface waters protected for full body contact, which includes Lake Charlevoix.

Biological Monitoring: Stover Creek was put on the impaired water body list by DEQ following poor macroinvertebrate community scores from the 1998 survey data. Following the 2003 data that showed Stover Creek was meeting standards, DEQ removed the creek from the impaired water body list. In spite of apparent improvements in macroinvertebrate diversity between 1998 and 2003, Volunteer Stream Monitoring (VSM) program data indicate that the creek remains impaired in the lower section. Monitoring results from the VSM program for Stover Creek show aquatic macroinvertebrate diversity to be moderate at the cemetery site and low at the mouth site. In fact, not one sensitive macroinvertebrate family has been encountered at the mouth (adjacent to Irish Boat Shop) during seven years of monitoring. The low biological diversity at the mouth of Stover Creek is thought to be the result of urbanization. The averaged sensitive taxa score of 0.3, the lowest of over 40 sites monitored in the VSM program, pointedly indicates that the stream is degraded near the mouth. Localized
conditions are suspected of contributing to the low taxa scores at the creek mouth. Urbanization in this lower section (City of Charlevoix) invariably affects Stover Creek due to stormwater runoff inputs laden with sediments, nutrients, metals and other pollutants commonly found in urban areas. Thermal pollution as a result of stormwater runoff flowing across pavement and other impervious surfaces may also have negative impacts on the water quality and aquatic macroinvertebrate populations in the creek’s lower sections. Habitat degradation due to channelization and riparian vegetation removal near the creek mouth are also factors that potentially contribute to poor diversity in the aquatic macroinvertebrate community.

- Land Use Assessment: The land use assessment was conducted by reviewing changes in land use between 1985 and 2010 using data from the NOAA Coastal Change Analysis. The watershed was divided into upper and lower units with the boundary being the Belvedere Golf Course. The upper watershed has remained fairly static in its land cover, with only a small decline in agriculture (from 43.16% to 42.53%) and an equally small increase in urban or developed land (from 3.87% to 3.96%). By contrast, the Lower Watershed has significantly changed, with agriculture increasing over 2% from 6.13% to 8.29%, and urban or developed land increasing over 8% from 63.99% to 72.4%. Several land cover categories decreased in area, including forest (from 10.26% to 9.27%), grassland (from 12.74% to 2.63%), scrub/shrub (from .78% to 1.42%), and wetlands (from 6.09% to 5.99%).

The major conclusions drawn from the assessment include:

- Development within important groundwater recharge areas in the lower watershed has contributed to significant hydrologic interruptions.
- Undersized culverts and otherwise improperly designed and installed RSX have resulted in stream channel alterations.
- Poor riparian management, particularly in the lower watershed, has destabilized the streambanks and is contributing to stream channel alterations.
- Stormwater outfalls discharging directly to the stream are affecting water quality.
Introduction to Stover Creek and its Watershed

Stover Creek is an important cold water tributary within the Lake Charlevoix Watershed. It flows directly into Lake Charlevoix’s western basin, near the City of Charlevoix. The main channel of Stover Creek is 8-miles and the land area of its watershed encompasses 4,220 acres (Figure 1 and Figure 2).

For decades, locals and resource agencies have had cause for concern given both the stream’s water quality measurements and anecdotal observations of the stream. In 2012, the Lake Charlevoix Watershed Management Plan, approved by both the Michigan Department of Environmental Quality and the Environmental Protection Agency, designated the Stover Creek Watershed as one of 16 acute critical areas. Acute critical areas are the priority locations where attention is needed first and foremost. Impacts to the Watershed, as described in the Lake Charlevoix Watershed Management Plan, follow:

- **Stover Creek Watershed (urban and agricultural stormwater, road-stream crossings):** Stover Creek is impacted by expanding urban land cover in its lower section and by agricultural activity (a mix of row crop, dairy, orchards, and livestock-sheep) in the upper Watershed. Sediments, nutrients, pesticides, and bacteria are the primary pollutants. There are also several problematic road-stream crossings in the Watershed, as well as a minor impoundment and fish passage barrier at the stream mouth.

Given these concerns, Tip of the Mitt Watershed Council (TOMWC), with support from the Charlevoix County Community Foundation, set out to examine the stream and its watershed to try to determine the leading causes of degradation.

During 2013-2014, TOMWC conducted a comprehensive suite of resource inventories, including the land use, in-stream habitat, streambank erosion, road/stream crossings, stormwater, and water quality monitoring. Results of these inventories begin on page 12.
FIGURE 1: STOVER CREEK WATERSHED
FIGURE 2: STOVER CREEK WATERSHED TOPOGRAPHY
Resource Inventories

A suite of field and desktop resource inventories were conducted to collect data and document existing conditions of the stream and its Watershed. Inventories include road/stream crossings (RSX), streambank erosion, stormwater, land use, and in-stream habitat. In addition, water quality monitoring was conducted at four locations on Stover Creek included standard parameters including temperature, Total Phosphorus, Total Nitrogen, Nitrate-Nitrite, Dissolved Organic Carbon, Chloride, Total Suspended Solids, biological and bacteriological.

Land Use

Studies have shown a direct correlation between stream health and its watershed’s land cover. Specifically, in watersheds where impervious surfaces have replaced pervious land cover types such as forests, wetlands, and grasslands, stream health degrades as impervious surface cover increases. These increases generally result in an increase in the speed and amount of water flowing to streams. This change, combined with pollutants, such as sediment, nutrients, and other contaminants, are linked to changes in stream 1) hydrology, including the amount, movement, and distribution of water, and 2) physical habitat, the actual structure of the stream that is home for organisms, such as invertebrates and fish, and 3) chemistry.

In most cases, when impervious cover is less than 10% of a watershed, streams remain healthy. Above 10% impervious cover, common signs of stream degradation include:

- Excessive stream channel erosion (bed and bank)
- Reduced groundwater recharge
- Increased size and frequency of 1-2 year floods
- Decreased movement of groundwater to surface water
- Loss of streambank tree cover
- Increased contaminants in water
- Increased fine sediment in stream bed
- Overall degradation of the aquatic habitat

The major land cover categories throughout the Watershed include agriculture, wetlands and urban classifications. Agriculture is the dominant category with nearly 40% of the Watershed dedicated to agricultural practices. Wetlands comprise the second-most dominant land cover with most concentrated along the riparian corridor. The third-most dominant land cover is urban, or developed, land and is concentrated within the lower section of the Watershed. This concentration likely plays the most significant role in the health of Stover Creek and has contributed largely, of not solely, to earning Stover Creek the distinction of being one of the most “urban streams” in Northern Michigan.

For purposes of this assessment, the Watershed was divided into upper and lower watersheds. The boundary between the upper and lower watersheds was delineated immediately above the Belvedere
Golf Course as land cover and uses markedly change at this location. Land cover changes for the upper and lower watersheds were compared using data from the NOAA Coastal Change Analysis Program.

The Upper Watershed has remained fairly static in its land cover, with only a small decline in agriculture (from 43.16% to 42.53%) and an equally small increase in urban or developed land (from 3.87% to 3.96%) (Table 1).

**TABLE 1: UPPER WATERSHED LAND COVER CHANGE (1985-2010)**

<table>
<thead>
<tr>
<th>Upper Watershed Land Cover</th>
<th>1985</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Cover Class</td>
<td>Acreage</td>
<td>Percentage</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1658.26</td>
<td>43.16%</td>
</tr>
<tr>
<td>Barren</td>
<td>11.38</td>
<td>0.30%</td>
</tr>
<tr>
<td>Forest</td>
<td>906.24</td>
<td>23.59%</td>
</tr>
<tr>
<td>Grassland</td>
<td>247.18</td>
<td>6.43%</td>
</tr>
<tr>
<td>Scrub/Shrub</td>
<td>98.00</td>
<td>2.55%</td>
</tr>
<tr>
<td>Urban</td>
<td>148.64</td>
<td>3.87%</td>
</tr>
<tr>
<td>Water</td>
<td>0.54</td>
<td>0.01%</td>
</tr>
<tr>
<td>Wetlands</td>
<td>772.15</td>
<td>20.10%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3842.40</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>

By contrast, the Lower Watershed has significantly changed, with agriculture increasing over 2% from 6.13% to 8.29%, and urban or developed land increasing over 8% from 63.99% to 72.4%. Several land cover categories decreased in area, including forest (from 10.26% to 9.27%), grassland (from 12.74% to 2.63%), scrub/shrub (from .78% to 1.42%), and wetlands (from 6.09% to 5.99%) (Table 2).

Figure 3 and Figure 4 illustrate these changes.

**TABLE 2: LOWER WATERSHED LAND COVER CHANGE (1985-2010)**

<table>
<thead>
<tr>
<th>Lower Watershed Land Cover</th>
<th>1985</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Cover Class</td>
<td>Acreage</td>
<td>Percentage</td>
</tr>
<tr>
<td>Agriculture</td>
<td>25.88</td>
<td>6.13%</td>
</tr>
<tr>
<td>Barren</td>
<td>0.00</td>
<td>0.00%</td>
</tr>
<tr>
<td>Forest</td>
<td>43.29</td>
<td>10.26%</td>
</tr>
<tr>
<td>Grassland</td>
<td>53.75</td>
<td>12.74%</td>
</tr>
<tr>
<td>Scrub/Shrub</td>
<td>3.31</td>
<td>0.78%</td>
</tr>
<tr>
<td>Urban</td>
<td>270.09</td>
<td>63.99%</td>
</tr>
<tr>
<td>Water</td>
<td>0.06</td>
<td>0.01%</td>
</tr>
<tr>
<td>Wetlands</td>
<td>25.70</td>
<td>6.09%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>422.07</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>
FIGURE 3: STOVER CREEK WATERSHED LAND COVER 1985
**Stover Creek Watershed Restoration and Management Plan**

**Figure 4:** Stover Creek Watershed Land Cover 2010

<table>
<thead>
<tr>
<th>Land Cover Type</th>
<th>Acres</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>1669.31</td>
<td>39.14</td>
</tr>
<tr>
<td>Barren</td>
<td>10.26</td>
<td>0.24</td>
</tr>
<tr>
<td>Forested</td>
<td>941.56</td>
<td>22.08</td>
</tr>
<tr>
<td>Grassland</td>
<td>256.62</td>
<td>6.02</td>
</tr>
<tr>
<td>Scrub/Shrub</td>
<td>125.67</td>
<td>2.95</td>
</tr>
<tr>
<td>Urban</td>
<td>457.63</td>
<td>10.73</td>
</tr>
<tr>
<td>Water</td>
<td>0.60</td>
<td>0.01</td>
</tr>
<tr>
<td>Wetland</td>
<td>802.82</td>
<td>18.83</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>4264.47</td>
<td>100.00</td>
</tr>
</tbody>
</table>

*Data Sources:*
Habitat Survey
A habitat survey was conducted for the lower reaches of Stover Creek. Tip of the Mitt staff surveyed in an upstream direction, beginning at the stream’s mouth at Lake Charlevoix, and finishing just past the Belvedere Golf Course. The survey methods were based on the work “Basin Wide Estimation of Habitat and Fish Populations in Streams” (Dollos, et al. 1993), with some modifications to accommodate the use of a Geographic Information System (GIS) and investigation of water quality.

Bedform
The framework of the survey was created by identifying stream bedform units (Figure 5) as the surveyor moved upstream. Bedform units are determined by stream channel characteristics related to the slope of the stream bed. The different types of bedform units used in this survey are run, riffle, glide, pool, and cascade. The most obvious to the observer are water velocity, depth, amount of turbulence, and substrate type. Cascades exhibit the most vertical drop, with water becoming airborne, and some type of solid substrate (boulders or bedrock) maintaining the steep slope. Riffles are generally more common than cascades, and occur where stream gradient is moderately steep. The classic “white water” turbulence that occurs in streams is often a telltale sign of a riffle, and is usually accompanied by hard substrate (gravel, cobble, or boulders). Runs are areas of the stream channel where water flows with moderate speed, but without high gradient slopes or a great degree of turbulence. Slower yet are glides, where the channel has a minimal, usually imperceptible, slope. These bedform units generally contain a finer substrate (sand, silt, or organics) and do not vary greatly in depth relative to runs. Pools are areas of a stream where water slows, and depths greatly increase. Finer particulate settles here, and there is little to no turbulence.

Each bedform unit was paired with a unique number to distinguish it from other units of the same type. A handheld Trimble Juno GPS was used while walking upstream to make a line feature for each bedform unit for integration with GIS. Width, bankfull width, average depth, and maximum depth were measured and recorded for each bedform unit.

The least occurring type was cascade, which was only documented at the weir near the mouth of the creek. Considering that Stover Creek has no natural cascades, this bedform unit will be left out of the discussion. The second-most limited bedform unit was pool, comprising only 0.84% of all bedform unit types. This small amount of pool habitat falls far below the reference condition provided in the US Fish and Wildlife Service report: Habitat Suitability Index Models: Brook Trout. According to this document, optimal brook trout riverine habitat is characterized by a 1:1 pool-riffle ratio. Stover creek was found to have a pool-riffle ratio of 1:33.9, which indicates that this could be a limiting factor on the current resident trout population.
FIGURE 5: STOVER CREEK DOMINANT BEDFORMS
**Substrate**

Stream substrate is a product of water velocity and how it moves the stream’s sediment load down the channel. The sediment load of a channel is determined by the parent material of the stream bed, and also through external inputs such as bank erosion and stormwater. In a stream with stable banks and few sediment inputs, fine particulate is trapped in depositional areas of slow current, and transported away in areas of fast current. This process generates variability in substrate, which is generally desirable and encourages stream biodiversity. Gravel is necessary (as mentioned above) for trout spawning and sensitive macroinvertebrate populations. Depositional areas of organic material provide habitat for burrowing fauna and provide substrate for aquatic vegetation. When this balance is disrupted, biodiversity suffers.

Substrate was quantitatively evaluated by assigning a percentage makeup of each possible particle type to every bedform unit, totaling 100%. Particle types included organics, clay, silt, sand, gravel, cobble, boulder, and bedrock. Stover Creek was found to contain a range of substrate types, largely typical of area streams. On average, riffles contained more gravel and cobble, where pools and glides had more sand, silt, and organics. Riffles within the lower channel (below M66) had, however, 20% more sand than riffles in the upper channel (Figure 6). This is likely caused by the accumulation of sediments in the stream bed from sandy eroding banks, stormwater inputs, and erosion at road-stream crossings. Considering that the lower-most reaches of Stover Creek also exhibit the highest channel gradient (Figure 7), it is likely unnaturally sandy. In most high-gradient streams, faster flows transport sand downstream. In the case of Stover Creek, altered hydrology is likely preventing this. It is possible that this sediment load is covering up ecologically valuable gravel, and filling in pools. Many studies, including a 1974 study by the Forest Service, have found that in riffle areas, the presence of fines (sand, silt, and organics) reduces the production of macroinvertebrate fauna. Trout also require clean gravel for reproduction. Thus, large amounts of sand within the lower reaches of Stover Creek could be negatively impacting overall biodiversity and the base of the food chain.
FIGURE 6: STOVER CREEK SAND COMPOSITION
FIGURE 7: STOVER CREEK STREAM GRADIENT

Legend
- Roads
- Highways
- Streams
- Watershed
- Townships

Stream Gradient (ft/mi)
- 0 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- 61 - 70

Data Sources:
Stream gradient & watershed data from Tip of the Mitt Watershed Council using USGS NED data. Aerial from Charlevoix County GIS. All other data layers acquired from the Michigan Geographic Data Library (MGDL) at http://www.mngi.state.mi.us/mgdl.

Map Made By: Michigan Watershed Council
May 20, 2014

Stover Creek Watershed Restoration and Management Plan
**Riparian Vegetation**
The vegetation growing around a stream widely influences conditions within. Allochthonous inputs (material originating outside of the stream) such as sticks and leaves supplement water with nutrients as they decay. Large allochthonous inputs are considered LWD (covered above), and offer the stream many benefits. Vegetation above the steam provides shade, intercepting the warming energy of direct sunlight. Roots from vegetation prevent erosion to stream banks by holding the soil in place, and can even aid in the formation of undercut banks. Animals that use the stream for water and food benefit from the cover.

Dominant riparian vegetation (Figure 8) was also categorized and evaluated at each bedform unit. Inner zone vegetation (growth found within a few feet of the stream channel) was categorized into size classes (grass/sedge, shrub, sapling, or tree) and type (grass/sedge, alder, conifer, aspen, or hardwood). Outer zone vegetation (growth within the stream basin) was also categorized into the same size and type classes as above. Canopy cover over the stream was categorized into five different cover classes (partial shrub canopy, partial tree canopy, closed shrub canopy, closed tree canopy, and open canopy).

Vegetative canopy cover was found to be lacking in developed reaches of Stover Creek. Approximately 50% - 75% mid-day shading has been identified as optimal for cold water fish populations in streams. This reference condition is captured in survey categories of partial and closed canopies. Open canopy does not provide enough shade to ensure temperatures mid-summer stay within the survival limits of brook trout (<68°F). Temperatures exceeded these guidelines regularly during the summer months of the study period on the west branch of Stover Creek at monitoring site WQ 3. It is likely that a lack of vegetation in this area is contributing to this condition.
FIGURE 8: STOVER CREEK RIPARIAN HABITAT
Large Woody Debris
Large woody debris (Figure 9) were counted and categorized into three different size classes (woody debris longer than ½ the bankfull width of the bedform unit in which they are found and greater than six inches in diameter; woody debris longer than ½ the bankfull width of the bedform unit in which they are found and four to six inches in diameter; and woody debris shorter than ½ the bankfull width of the bedform unit in which they are found and greater than six inches in diameter).

Large Woody Debris (LWD) abundance in Stover Creek was found to range from zero in multiple areas to over 2000 pieces per mile just downstream from Marion Center Road. The average LWD content for all bedform units of Stover Creek units was 210 pieces per mile. Upper Midwestern streams (Northern MI and MN) have, on average, 525 pieces of LWD per mile (Identified by a 2006 study published in River Research and Applications). While some limited sections of Stover Creek do meet this reference condition, it is indicated that much of Stover Creek is lacking in large woody debris. Several areas stand out as being devoid of LWD, including the Belvedere Golf Course, the cemetery, and developed areas near the mouth.

Numerous studies have shown the importance of LWD in stream systems for both macroinvertebrates and fish. A 2007 study by the MI DNR confirmed a positive relationship between the abundance of age class 0 – 2 brown and brook trout and the amount of LWD found within different reaches of the Au Sable River. Studies of smaller, higher gradient streams in the pacific northwest have also shown the importance of LWD inputs related to sustainable logging practices and their influence on salmonid populations.

LWD provides surface area within the stream channel for macro invertebrates to live on, cling to, and even build cases and nets on (in the case of the caddisfly). Macro invertebrates belonging to the scraper-shredder functional feeding group often rely on LWD for sustenance, not by eating the wood directly, but by eating the biofilm that forms on LWD. Through additional nutrients resulting from log decomposition and formation of biofilm, the base of the stream food chain is sustained. Macroinvertebrate abundance is a product of this, and is an important food source for fish populations.

LWD in a stream not only acts to augment the food chain, but plays an important role in the morphology of a stream channel. Dave Rosgen, in his 1996 book Applied River Morphology, identified that at the watershed scale, streams are shaped by geology, water flow, and sediment deposition. On a local scale of stream morphology, the channel is shaped by slope, bed and bank material, riparian vegetation, and local hydrology. LWD plays a role in these factors as bed and bank material, altering flow patterns of water to create plunge pools, meanders, zones of deposition, and other small-scale channel variations. By altering stream flow, LWD actually increases the amount of time water spends in a given portion of stream, and prevents high water velocities from scouring away banks and bottom substrates.
FIGURE 9: STOVER CREEK WOODY DEBRIS

Stover Creek Watershed Restoration and Management Plan
**Water Quality**

There is a considerable amount of water quality data available for Stover Creek, particularly considering its diminutive nature (8-mile main channel and 4220-acre watershed). Water quality data sources for Stover Creek include the Michigan Department of Environmental Quality (DEQ) and Tip of the Mitt Watershed Council (TOMWC). Although the earliest known data were collected in 1977, the majority of water quality information dates from 1998 to present. More attention has been given to Stover Creek in recent decades by the DEQ, and more so by TOMWC due to evidence of water quality degradation.

Stover Creek was put on the State of Michigan’s 303d list of impaired water bodies due to poor aquatic macroinvertebrate diversity documented during a 1998 survey by DEQ. Following a second survey by DEQ in 2003, which showed improved conditions, Stover Creek was removed from the 303d list. However, water quality monitoring carried out by TOMWC staff and volunteers from 2004 to present indicate that problems in Stover Creek persist, particularly in the lower stream reaches.

**Dissolved Oxygen**

Dissolved oxygen is one of the most important parameters monitored for assessing a stream’s water quality. Oxygen is required by almost all organisms, including those that live in the water. Oxygen dissolves into the water from the atmosphere and through photosynthesis of aquatic plants and algae. State law requires that a minimum of five to seven milligrams per liter (mg/L) be maintained depending on the lake type. Due to Stover Creek’s designation as a cold-water fishery, the minimum concentration of dissolved oxygen required by the State of Michigan is 7 milligrams per liter (mg/L).

Dissolved oxygen levels in DEQ Legacy data from 1977 and 1978 were well above the State standard, ranging from 8.0 to 13.2 mg/L during nine monitoring events in all seasons of the year. Monitoring performed in 2013 and 2014 as part of this project, as well as the Lake Charlevoix Tributary Monitoring Project (funded by DEQ), also found high dissolved oxygen concentrations. Monitoring for these projects occurred at four sites: near the mouth at Irish Boat Shop (WQ 1); upstream of Highway M-66 at the Brookside Cemetery (WQ 2); and at two sites at a convergence in the Belvedere Golf Course of and a small tributary referred to as the west branch (WQ 3) and the main (south) branch (WQ 4) (Figure 10). Of the 37 measurements taken at these sites in the spring, summer, and fall, dissolved oxygen concentrations were above 8 mg/L except for one occasion. A low dissolved oxygen concentration of 4.21 mg/L was recorded at WQ 3 site during August of 2013 when the related discharge measurement was zero. The stagnant conditions contributed to the low readings. Overall, data show that Stover Creek is attaining water quality standards for dissolved oxygen.
**Figure 10: Stover Creek Monitoring Sites**
Conductivity and Chloride

Conductivity is a measure of the ability of water to conduct an electric current, which is dependent upon the concentration of charged particles (ions) dissolved in the water. Chloride, a component of salt, is a negatively charged particle that contributes to the conductivity of water. Chloride is a “mobile ion,” meaning it is not removed by chemical or biological processes in soil or water. Many products associated with human activities contain chloride (e.g., de-icers, water softeners, fertilizers, and bleach).

Conductivity and chloride levels in lakes and streams tend to increase as population and human activity in a watershed increase. Research shows that both conductivity and chloride levels in surface waters are good indicators of human disturbance in a watershed, particularly from urban landuse (Jones and Clark 1987, Lenat and Crawford 1992, Herlihy et al. 1988).

Water quality data collected by TOMWC in 2013 and 2014 from Stover Creek show a range in specific conductivity of 355 microsiemens (µS) at WQ 4 to 562 µS at WQ 1, with an average of 442 µS among all sites. The MDEQ specific conductance measurement of 481 µS during their 1998 survey at WQ 2 was within this range. Conductivity levels were highest at the WQ 3 (average of 491 µS) and at WQ 1 (average of 454 µS). Conductivity levels in Stover Creek fall within a typical range for Northern Michigan surface waters. Conductivity measurements taken in 2013 for lakes and rivers in TOMWC’s Comprehensive Water Quality Monitoring Program (CWQM) ranged from 69 µS (Thayer Lake) to 826 µS (Spring Lake) with an average of 305 µS.

Chloride concentrations in Stover Creek ranged from 5.7 mg/L to 34.8 mg/L, both measurements from the South Branch site, with an average of 16.5 mg/L among all sites. The MDEQ specific conductance measurement of 9 mg/L during their 1998 survey at Marion Center Road was within this range. Chloride levels were highest in the west branch (average of 23.4 mg/L) and at the mouth (average of 18.8 mg/L). The average chloride concentration in Stover Creek was similar to the average for lakes and rivers in the CWQM Program during 2013, which was 12.8 mg/L.

Factors influencing the higher conductivity and chloride levels at WQ 3 and WQ 1 include land use and flow. WQ 3 is located on the west branch, a small tributary that originates near the intersection of Heise and Barnard Roads. It converges with the main branch of Stover Creek after flowing through and receiving runoff from a golf course. This branch flows sluggishly or becomes stagnant during dry times of the year, allowing mobile ions like chloride to accumulate in the system. Polluted runoff from nearby commercial and residential areas contribute to the higher chloride and conductivity levels documented at the creek mouth.

The conductivity and chloride levels (Figure 11 and Figure 12) documented in Stover Creek do not pose a risk to aquatic organisms. Conductivity levels were mostly within the range of 150-500 µS/cm, which studies of inland freshwater streams have found to support good mixed fisheries (USEPA, 1997). Studies show that chloride levels do not affect aquatic insects until well over 1,000 PPM (Crowther and Hynes 1977, Blasius and Merritt 2002). However, increases in conductivity and chloride can be indicative of more harmful pollutants that are associated with human activity contaminating a watershed’s surface waters (e.g., automotive fluids and metals from roads, nutrients and bacteria from septic systems).
**Figure 11: Conductivity Levels in Stover Creek, 2013-2014.**

**Figure 12: Chloride Concentrations in Stover Creek, 2013-2014.**

*mg/l = milligrams/liter = parts per million.*
Nutrients
Nutrients are chemicals needed by organisms to live, grow, and reproduce. Nutrients occur naturally and can be found in soils, water, air, plants, and animals. Phosphorus and nitrogen are essential nutrients for plant growth and important for maintaining healthy, vibrant aquatic ecosystems. However, excess nutrients from sources such as fertilizers, faulty septic systems, and stormwater runoff lead to nutrient pollution, which can have negative impacts on the surface waters of the Lake Charlevoix Watershed.

DEQ Part 4 Water Quality Standards do not include a numerical standard for nutrient concentration limits for surface waters. Regulation for surface waters is limited to the following narrative standard from Rule 60 (323.1060): “nutrients shall be limited to the extent necessary to prevent stimulation of growth of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the waters of the state.” A total phosphorus concentration of 12 µg/L or less and total nitrogen concentration of 440 µg/L or less for streams in the Northern Michigan ecoregion is considered the reference condition by the United States Environmental Protection Agency (USEPA) “because it is likely associated with minimally impacted conditions, will be protective of designated uses, and provides management flexibility” (USEPA, 2001).

Phosphorus
Phosphorus is the most important nutrient for plant productivity in Northern Michigan lakes because it is usually in shortest supply relative to nitrogen and carbon. A water body is considered phosphorus limited if the ratio of nitrogen to phosphorus is greater than 15:1. Based on data collected by Tip of the Mitt Watershed Council, most lakes monitored in the Northern Lower Peninsula, including Lake Charlevoix, are found to be phosphorus limited (TOWMC, 2010). Data from the Lake Charlevoix Tributary Monitoring Project conducted in 2013 and 2014 found that tributary streams flowing into Lake Charlevoix, including Stover Creek, are also consistently phosphorus limited.

It has been estimated that one pound of phosphorus could stimulate 500 or more pounds of algae growth. Therefore, heavy phosphorus inputs into Stover Creek and thereby, into Lake Charlevoix, could result in nuisance algae and plant growth, which could, in turn, degrade water quality and alter the natural lake ecosystem. Because of the negative impacts that phosphorus can have on surface waters, legislation was first passed in Michigan to ban phosphorus in soaps and detergents and more recently, phosphorus use in fertilizers has been regulated.

Legacy data from DEQ show a range of 3 µg/L to 15 µg/L total phosphorus in 1977 and 1978 and an average of 9 µg/L, which is below the USPEA reference condition. Total phosphorus concentrations in Stover Creek from 2013 and 2014 monitoring data ranged from 4.6 µg/L to 74.1 µg/L, with an overall average of 20.0 µg/L (Figure 13). Concentrations exceeded the USEPA reference condition 50% of the time. The highest concentrations were found in west branch, some of which are considered atypically and alarmingly high for streams in the Northern Lower Peninsula. As previously noted, sluggish flows
and stagnation influence water quality in the west branch. However, total phosphorus was high in the west branch during most sample events, regardless of flow, which indicates that nutrient pollution is occurring in that tributary.

**Figure 13: Total Phosphorus in Stover Creek 2013-2014.**

*ug/l = micrograms/liter = parts per billion.

**Nitrogen**

Nitrogen is a very abundant element throughout the earth’s surface and is a major component of all plant and animal matter. Nitrogen is also generally abundant in our lakes and streams and needed for plant and algae growth. Interestingly, algae have adapted to a wide variety of nitrogen situations in the aquatic environment, some fixating nitrogen directly from the atmosphere to compete in low-nitrogen environments (blue-green algae), while others thrive in nitrogen-rich environments (certain diatoms).

Total nitrogen is a measure of all nitrogen types, organic and inorganic, in a water sample. The USEPA total nitrogen reference condition of 440 ppb was exceeded in 100% of samples from Stover Creek. Averaged total nitrogen concentrations were lowest at the WQ 4 (991 µg/L) and highest at WQ 1 (1312 µg/L)(Figure 14). Excluding the west branch site, total nitrogen increased consistently in a downstream direction, generally increasing most between the cemetery and mouth.

The abnormally high levels of nitrogen likely result from the same sources described in the conductivity and chloride section. Agriculture in the upper watershed, the golf course mid-watershed and urban development in the lower watershed, are all suspected of contributing nitrogen to Stover Creek. Although not the limiting nutrient, excessive nitrogen in the ecosystem could cause shifts in the aquatic food web, beginning with changes in algal communities. The high nitrogen concentrations indicate that Stover Creek is becoming or poised to become more eutrophic. Although there are no nutrient data...
from areas upstream of the golf course, nitrogen pollution is likely ameliorated in the upper watershed through uptake, settling, and denitrification in the large wetland complexes buffering both sides of the creek. Unfortunately, lower stream sections are not afforded these same protections as there are little to no riparian wetlands in the lower watershed.

*ug/l = micrograms/liter = parts per billion.

**Figure 14:** Total nitrogen in Stover Creek 2013-2014.

Discharge
Discharge was also monitored as part of TOMWC’s Lake Charlevoix Tributary study, a project supported by the Michigan Department of Environmental Quality Clean Michigan Initiative and conducted concurrently with the Stover Creek project. Results show that data plotted from four study stream watersheds representing different areas of the greater Lake Charlevoix Watershed (north, south, east, and west) show moderate to strong relationships between precipitation and discharge in three of the four areas. Stover Creek, however, shows a weak relationship (Figure 15), which could indicate that it is a flashy stream, but could also be due to errors in the precipitation model or timing of discharge measurements. Discharge measured at the beginning or end of the hydrograph, as opposed to the peak, would result in a weaker relationship between precipitation and discharge.
Bacteriological Monitoring

Fecal contamination of surface waters in Michigan, due to human and animal sources, is typically accessed by measuring the number of *Escherichia coli* (*E. coli*) colonies in a given volume of sample water. *E. coli* bacteria usually do not pose a direct danger, but are rather indicators of the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that originate in human and animal digestive systems. Thus, their presence in surface waters indicates that pathogenic microorganisms might also be found and that there may be health risks associated with full body contact.

Bacteria in surface waters are regulated by the State of Michigan per Rule 62 (R 323.1062) of DEQ Part 4 Water Quality Standards. There is a provision in Rule 62 for surface waters, such as Stover Creek that are designated to be protected for partial-body contact. The Rule states that: “All waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1000 *E. coli* per 100 milliliters.”

Bacteriological monitoring data for Stover Creek is only available for 2013 and 2014 when samples were collected during two of the six sample events. Water samples were analyzed in the Health Department of Northwest Michigan’s laboratory in Gaylord to determine the number of *E. coli* bacteria per 100 milliliters. Results ranged from 12 *E. coli* bacteria per 100 milliliters to over 2419 *E. coli*, which is the maximum that can be counted using the Health Department’s methods (Table 3). The highest bacteria
concentrations occurred at the cemetery and west branch sites, while lowest average concentrations were documented at the creek mouth.

The maximum allowable concentration of 1000 E. coli/100mL was exceeded in 38% of samples that were analyzed. The high concentrations all occurred during the same sample event and at all sites but the mouth. However, concentrations at the mouth were above the State's standard of 300 E. coli/100mL for surface waters protected for full body contact, which includes Lake Charlevoix.

**TABLE 3: BACTERIOLOGICAL MONITORING RESULTS FROM STOVER CREEK, 2013–2014**

<table>
<thead>
<tr>
<th>Sample Date</th>
<th>South Branch (E. Coli/100ml)</th>
<th>West Branch (E. Coli/100ml)</th>
<th>Cemetery (E. Coli/100ml)</th>
<th>Mouth (E. Coli/100ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/7/2013</td>
<td>1413.6</td>
<td>2419.6</td>
<td>2419.6</td>
<td>469.5</td>
</tr>
<tr>
<td>7/7/2014</td>
<td>195.6</td>
<td>149.7</td>
<td>12.4</td>
<td>460.6</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>804.6</td>
<td>1284.7</td>
<td>1216.0</td>
<td>465.1</td>
</tr>
</tbody>
</table>

**Biological Monitoring**

Biological monitoring data for Stover Creek are available from DEQ and TOMWC. DEQ biologist assessed aquatic macroinvertebrate community at Marion Center Road in 1998 and 2003. Volunteers, trained by TOMWC staff, have monitored three sites as part of the Tip of the Mitt Volunteer Stream Monitoring (VSM) program: Ferry Road, the Brookside Cemetery, and the mouth. TOMWC have monitored the cemetery and mouth sites consistently two times per year, spring and fall, from 2005 to present. The Ferry Road site was also monitored twice per year from 2004 to 2008. MDEQ biologists perform taxonomic identification to the family level in the field. Specimens collected by TOMWC volunteers are preserved in ethanol and identified to the family level by experienced aquatic macroinvertebrate taxonomist at a later date.

Stover Creek was put on the impaired water body list by DEQ following poor macroinvertebrate community scores from the 1998 survey data. Following the 2003 data showing that Stover Creek was meeting standards, DEQ removed the creek from the impaired water body list. In spite of apparent improvements in macroinvertebrate diversity between 1998 and 2003, VSM program data indicate that the creek remains impaired in the lower section.

TOMWC’s VSM program utilizes three metrics to assess aquatic macroinvertebrate data and make comparisons. These metrics include: 1) total taxa = the total number of macroinvertebrate families found at a site; 2) EPT taxa = the number of families belonging to three insect orders that are largely intolerant of pollution (mayflies, stoneflies, and caddisflies); and 3) sensitive taxa = the number of macroinvertebrate families that are the most intolerant of pollution (those that rate 0, 1, or 2 in PhD William Hilsenhoff’s family-level system for rating sensitivity to nonpoint source pollution). Total taxa numbers can be useful for assessing stream ecosystem health, but EPT and sensitive taxa numbers are the most telling.
Monitoring results from the VSM program for Stover Creek show aquatic macroinvertebrate diversity to be moderate at the cemetery site and low at the mouth site. Despite monitoring sites being less than a mile apart, averaged numbers for all three indices show considerably more diversity at the cemetery as compared to the mouth (Table 4 and Figure 16). The averaged sensitive taxa score of 0.3, the lowest of over 40 sites monitored in the VSM program, indicates that the stream is degraded near the mouth.

Localized conditions are suspected of contributing to the low taxa scores at the creek mouth. Urbanization in this lower section invariably affects Stover Creek due to stormwater runoff inputs laden with sediments, nutrients, metals and other pollutants commonly found in urban areas. Thermal pollution as a result of stormwater runoff flowing across impervious surfaces may also have negative impacts on the water quality and aquatic macroinvertebrate populations in the creek’s lower sections. Habitat degradation due to channelization and riparian vegetation removal near the creek mouth are also factors that potentially contribute to poor diversity in the aquatic macroinvertebrate community.

### Table 4: VSM Macroinvertebrate Diversity Data from Stover Creek.

<table>
<thead>
<tr>
<th>Date</th>
<th>Total Taxa* (Cemetery)</th>
<th>Total Taxa* (Mouth)</th>
<th>EPT Taxa† (Cemetery)</th>
<th>EPT Taxa† (Mouth)</th>
<th>Sensitive Taxa £ (Cemetery)</th>
<th>Sensitive Taxa £ (Mouth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept 2005</td>
<td>18</td>
<td>14</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>May 2005</td>
<td>18</td>
<td>15</td>
<td>8</td>
<td>3</td>
<td>3</td>
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<tr>
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<td>15</td>
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<td>5</td>
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<td>3</td>
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<td>11</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Sept 2008</td>
<td>18</td>
<td>13</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>May 2008</td>
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<td>No data</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
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<tr>
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<td>7</td>
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<td>2</td>
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<td>18</td>
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<td>3</td>
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<tr>
<td>Sept 2011</td>
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<td>6</td>
<td>2</td>
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<td>6</td>
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<td>Sept 2012</td>
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<td>May 2013</td>
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<td>10</td>
<td>7</td>
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<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Sept 2014</td>
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<td>11</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>17.9</td>
<td>13.4</td>
<td>6.6</td>
<td>2.6</td>
<td>3.1</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*Total taxa: the total number of macroinvertebrate families found at a site.
†EPT taxa: the number of families in pollution-sensitive mayfly, stonefly and caddisfly orders.
£Sensitive taxa: the number of macroinvertebrate families that are the most intolerant of pollution.
**Figure 16: Aquatic Macroinvertebrate Diversity in Stover Creek**

*Total taxa = the total number of macroinvertebrate families found at a site; EPT taxa = the number of families in three insect orders known to be intolerant of pollution (mayflies, stoneflies, and caddisflies); and sensitive taxa = the number of macroinvertebrate families that are the most intolerant of pollution.*
Stormwater
When stormwater runoff flows over roads, sidewalks, lawns, and gardens, it picks up substances like dirt, fertilizers, oil, salt, and bacteria. Additional pollution comes from nutrients used in fertilizers applied to lawns and gardens, as well as pet waste, and sediments from soil particles that are washed away from bare spots in lawns and gardens, roadways, and other areas of exposed soils. Stormwater can also contain other pollutants such as toxins and heavy metals. Most stormwater runoff washes into nearby water bodies, carrying these pollutants from the places where we live and work into lakes, streams, and wetlands. The polluted runoff negatively impacts aquatic ecosystems, causing water quality impairment and habitat degradation in nearby surface waters.

Sediments, nutrients, and bacteria are among the most widespread pollutants associated with urban runoff. These pollutants should be monitored to determine impacts because they have been shown to be a problem in urban runoff monitoring projects implemented by TOMWC in other Northern Michigan watersheds. Pollutants associated with cars and roads, including metals, chlorides, and Polycyclic Aromatic Hydrocarbons (PAHs), are also commonly found in urban stormwater and warrant monitoring. The USEPA lists metals and salts as pollutants associated with urban runoff that “can harm fish and wildlife populations, kill native vegetation, foul drinking water, and make recreational areas unsafe and unpleasant.” PAHs are not water soluble and persist in the environment for long periods, although they can breakdown from UV light exposure. According to a study conducted by the University of Wisconsin, “95% of the samples from storm sewer discharges violate the human cancer criteria for PAHs” (Johnson & Juengst, 1997).

Stormwater from urban areas has been identified as a primary source of nonpoint source pollution to surface waters in the Lake Charlevoix Watershed Management Plan (2012). Stormwater drainage areas were mapped and pollutant loadings estimated for the City of Charlevoix, which includes a portion of the lower Stover Creek Watershed. To determine the full extent of stormwater impacts, drainage areas were mapped and pollutant loads estimated for the entire lower Stover Creek Watershed. The land area considered to contribute the majority of urban runoff to Stover Creek is located in the lower watershed, downstream roughly from a line between the intersection of Clark and Marion Center Roads to the intersection of Barnard Road and US31. Development within this 390-acre area includes a golf course, old city dump (now used for yard wastes), airport, cemetery, single-family homes, multiple family condominium complexes, individual businesses, commercial strip malls, and industrial complexes.

TOMWC conducted a stormwater assessment in the lower Stover Creek Watershed during the spring of 2014. TOMWC staff reviewed stormwater information gathered during development of the Lake Charlevoix Watershed Management Plan, and then met with staff from the City of Charlevoix Department of Public Works, who provided information about storm sewer infrastructure and drainage patterns. TOMWC utilized the information provided by the City, along with aerial imagery and topographic maps to perform field reconnaissance and locate storm sewer outfalls, identify stormwater best management practices (e.g., detention basins), and delineate stormwater drainage areas. All information was used to develop a GIS data layer that represents storm drainage areas in the lower
watershed. In addition, another map layer for impervious surfaces, such as buildings, roads, and sidewalks was developed in a GIS using 2010 orthophotographs obtained from the Charlevoix County GIS Department.

A simple, empirical method developed by the Washington Metropolitan Water Resource Planning board in 1987 was used to estimate pollutant loadings for four important pollutants: sediment, phosphorus, copper, and zinc (Appendix A). The empirical methods utilizes stormwater drainage area and impervious surface data to estimate pollutant exports. Although very general in nature, this method is considered precise enough to make to make reasonable and reliable nonpoint source pollution management decisions at the site-planning level.

The Stover Creek stormwater assessment identified 15 distinct drainage areas: 4 areas with conduits that transport stormwater (e.g., pipe, ditch) into the creek; 3 areas of diffuse stormwater flow over the landscape and into the creek; and 8 areas where stormwater infiltrates into the ground directly or via BMPs (Figure 17).
FIGURE 17: LOWER STOVER CREEK STORMWATER
Estimates from the empirical model indicate that runoff from the seven drainage areas that flow into the creek collectively contribute large quantities of pollutants on an annual basis (e.g. >90 lbs. of phosphorus and nearly 19,000 lbs. of sediments (Table 5 and Table 6). However, drainage areas where runoff infiltrates into the ground naturally or via BMPs prevent nearly equal quantities of pollutants from entering the creek (e.g. nearly 80 lbs. of phosphorus and nearly 17,000 lbs. of sediments (Table 7).

**Table 5: Pollutant Load Estimates from Drainage Areas with Conduits to Creek**

<table>
<thead>
<tr>
<th>Stormwater Drainage Area</th>
<th>Basin 1: Marion Center Rd</th>
<th>Basin 2: M66 North</th>
<th>Basin 3: M66 South</th>
<th>Basin 4: USPS</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin area (acres)</td>
<td>14.60</td>
<td>43.82</td>
<td>19.66</td>
<td>1.88</td>
<td>79.96</td>
</tr>
<tr>
<td>Impervious surface area (acres)</td>
<td>2.41</td>
<td>24.15</td>
<td>8.56</td>
<td>1.16</td>
<td>36.28</td>
</tr>
<tr>
<td>Impervious cover (%)</td>
<td>16.51</td>
<td>55.11</td>
<td>43.54</td>
<td>61.70</td>
<td>NA</td>
</tr>
<tr>
<td>Phosphorus (lbs/year)</td>
<td>4.92</td>
<td>40.61</td>
<td>14.74</td>
<td>1.93</td>
<td>62.20</td>
</tr>
<tr>
<td>Nitrogen (lbs/year)</td>
<td>11.25</td>
<td>312.37</td>
<td>113.42</td>
<td>14.86</td>
<td>451.90</td>
</tr>
<tr>
<td>Sediment (lbs/year)</td>
<td>1,031.54</td>
<td>8,512.04</td>
<td>3,090.61</td>
<td>404.86</td>
<td>13,039.05</td>
</tr>
<tr>
<td>Zinc (lbs/year)</td>
<td>2.44</td>
<td>20.15</td>
<td>7.32</td>
<td>0.96</td>
<td>30.87</td>
</tr>
<tr>
<td>Lead (lbs/year)</td>
<td>0.96</td>
<td>7.92</td>
<td>2.88</td>
<td>0.38</td>
<td>12.14</td>
</tr>
<tr>
<td>Copper (lbs/year)</td>
<td>0.21</td>
<td>1.73</td>
<td>0.63</td>
<td>0.01</td>
<td>2.58</td>
</tr>
</tbody>
</table>

**Table 6: Pollutant Load Estimates from Drainage Areas with Overland Flow to Creek**

<table>
<thead>
<tr>
<th>Stormwater Drainage Area</th>
<th>Basin 13 (Belvedere Golf Course)</th>
<th>Basin 14 (Golf Course to M66)</th>
<th>Basin 15 (M66 to mouth)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin area (acres)</td>
<td>74.02</td>
<td>82.74</td>
<td>33.96</td>
<td>190.72</td>
</tr>
<tr>
<td>Impervious surface area (acres)</td>
<td>1.39</td>
<td>6.28</td>
<td>5.41</td>
<td>13.08</td>
</tr>
<tr>
<td>Impervious cover (%)</td>
<td>1.88</td>
<td>7.59</td>
<td>15.93</td>
<td>NA</td>
</tr>
<tr>
<td>Phosphorus (lbs/year)</td>
<td>0.10</td>
<td>16.61</td>
<td>11.15</td>
<td>27.86</td>
</tr>
<tr>
<td>Nitrogen (lbs/year)</td>
<td>0.79</td>
<td>127.80</td>
<td>85.74</td>
<td>214.33</td>
</tr>
<tr>
<td>Sediment (lbs/year)</td>
<td>21.40</td>
<td>3,482.68</td>
<td>2,336.33</td>
<td>5,840.41</td>
</tr>
<tr>
<td>Zinc (lbs/year)</td>
<td>0.05</td>
<td>8.24</td>
<td>5.53</td>
<td>13.82</td>
</tr>
<tr>
<td>Lead (lbs/year)</td>
<td>0.02</td>
<td>3.24</td>
<td>2.17</td>
<td>5.43</td>
</tr>
<tr>
<td>Copper (lbs/year)</td>
<td>0.00</td>
<td>0.71</td>
<td>0.48</td>
<td>1.19</td>
</tr>
</tbody>
</table>

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TABLE 7: POLLUTANT LOAD ESTIMATES FOR DRAINAGE AREAS OF INFILTRATION INTO THE GROUND

<table>
<thead>
<tr>
<th>Stormwater Drainage Area</th>
<th>Basin 5</th>
<th>Basin 6</th>
<th>Basin 7</th>
<th>Basin 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin area (acres)</td>
<td>39.04</td>
<td>34.38</td>
<td>25.46</td>
<td>1.16</td>
</tr>
<tr>
<td>Impervious surface area (acres)</td>
<td>5.12</td>
<td>9.88</td>
<td>20.71</td>
<td>0.87</td>
</tr>
<tr>
<td>Impervious cover (%)</td>
<td>13.11</td>
<td>28.74</td>
<td>81.34</td>
<td>75.00</td>
</tr>
<tr>
<td>Phosphorus (lbs/year)</td>
<td>11.16</td>
<td>18.01</td>
<td>33.79</td>
<td>1.43</td>
</tr>
<tr>
<td>Nitrogen (lbs/year)</td>
<td>85.81</td>
<td>138.51</td>
<td>259.96</td>
<td>10.98</td>
</tr>
<tr>
<td>Sediment (lbs/year)</td>
<td>2,338.30</td>
<td>3,774.30</td>
<td>7,083.94</td>
<td>299.21</td>
</tr>
<tr>
<td>Zinc (lbs/year)</td>
<td>5.53</td>
<td>8.93</td>
<td>16.77</td>
<td>0.71</td>
</tr>
<tr>
<td>Lead (lbs/year)</td>
<td>2.18</td>
<td>3.51</td>
<td>6.59</td>
<td>0.28</td>
</tr>
<tr>
<td>Copper (lbs/year)</td>
<td>0.48</td>
<td>0.77</td>
<td>1.44</td>
<td>0.06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stormwater Drainage Area</th>
<th>Basin 9</th>
<th>Basin 10</th>
<th>Basin 11</th>
<th>Basin 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin area (acres)</td>
<td>2.28</td>
<td>7.76</td>
<td>0.77</td>
<td>0.90</td>
</tr>
<tr>
<td>Impervious surface area (acres)</td>
<td>1.56</td>
<td>6.95</td>
<td>0.62</td>
<td>0.31</td>
</tr>
<tr>
<td>Impervious cover (%)</td>
<td>68.42</td>
<td>89.56</td>
<td>80.52</td>
<td>34.44</td>
</tr>
<tr>
<td>Phosphorus (lbs/year)</td>
<td>2.58</td>
<td>11.27</td>
<td>1.01</td>
<td>0.55</td>
</tr>
<tr>
<td>Nitrogen (lbs/year)</td>
<td>19.82</td>
<td>86.73</td>
<td>7.79</td>
<td>4.23</td>
</tr>
<tr>
<td>Sediment (lbs/year)</td>
<td>540.06</td>
<td>2,363.37</td>
<td>212.20</td>
<td>115.26</td>
</tr>
<tr>
<td>Zinc (lbs/year)</td>
<td>1.28</td>
<td>5.59</td>
<td>0.50</td>
<td>0.27</td>
</tr>
<tr>
<td>Lead (lbs/year)</td>
<td>0.50</td>
<td>2.20</td>
<td>0.20</td>
<td>0.11</td>
</tr>
<tr>
<td>Copper (lbs/year)</td>
<td>0.11</td>
<td>0.48</td>
<td>0.04</td>
<td>0.02</td>
</tr>
</tbody>
</table>

In addition to nutrient and sediment loading of the stream, stormwater is contributing to thermal pollution. As water flows across the land’s surface it is naturally warmed. Once the overland flow reaches the stream, the base temperature of the stream is raised. In addition, in areas where riparian vegetation has been removed and the stream channel is no long shaded, sunlight penetration elevates the water temperature, especially where current is slow or sluggish. Golf course likely contributes higher level of pollutants than model indicates and elevates water temperatures.
Streambank Erosion

A stable stream is one that can transport its water and sediment inputs without changing its dimensions (width, depth, cross-sectional area, and slope). Conversely, stream instability will result in physical changes, most oftentimes observed as streambank erosion. Streambank erosion can range from minor to severe and occur at the toe of base of the streambank, or a combination of both. It is important to note, that although streambank and bed mobility is a natural phenomenon, and stable streams differ from unstable streams primarily in the rate of bank and bed mobility. Unnaturally high rates of bank and bed mobility can have multiple causes, ranging from small-scale, local causes like unrestricted livestock access or all-terrain vehicle traffic, to large-scale, regional causes like a watershed-wide increase in impervious pavement.

Channel and bank instability, which leads to the physical degradation of streams, stems from the increased flooding that follows development. The signs of instability, however, may not become evident for several years following urbanization. Signs of instability include channel widening by bank erosion or a deepening of the channel through down cutting. With the former, channel beds may become covered in sediment; with the latter, beds are subject to frequent scours.

Additional physical characteristics indicative of channel instability include the following:

- Unvegetated mid-channel bars or side bars, or braided channels often indicate excessive sedimentation (aggradation), although they can also be caused by local flow restrictions, like undersized or blocked culverts. Mid-channel bars due to excessive sediment loads are often accompanied by locally over-wide channels.
- Leaning trees on both sides of the channel in straight reaches can indicate channel widening or incision.
- Observations of arching vs. straight tree trunks can provide insight into the speed of channel widening; trees can compensate for slow channel widening by arching back towards the bank.
- Tree trunks in the middle of the channel can be caused by excessive sedimentation, or other causes of channel widening.
- Headcuts, or nickpoints, are points of channel incision where the channel bed elevation rapidly adjusts to a natural or human-induced disturbance. Headcuts range from over-steep riffles to small waterfalls, and can rapidly migrate upstream, destabilizing channels far from the original disturbance. If observed at or near the mouth of a small tributary, another headcut has already migrated upstream in the larger stream.
- Exposed tree roots on both sides of the bank indicate channel widening.
- Accelerated recruitment of large woody debris (abundance of downed trees)

All of the above conditions can be found within the Stover Creek corridor. While the severity of the conditions vary, the most pronounced occurrences are found within the lower section of the stream. To document these occurrences, a streambank erosion inventory was completed for the lower section, from the Belvedere Golf Course to its mouth at Lake Charlevoix. TOMWC surveyed the stream by
walking the channel and recording streambank erosion. Each site was documented using the Streambank Erosion and Alterations Assessment Form (Appendix B). In addition to taking GPS coordinates, field measurements, photos, and site sketches, field reviewers note erosion severity for each site. In total, 34 erosion sites were noted with the following severity ratings applying:

- 1 Very Minor
- 9 Minor
- 2 Minor to Moderate
- 10 Moderate
- 3 Moderate to Severe
- 9 Severe

Figure 18 shows the distribution of the erosion sites throughout the surveyed stream channel. Severe streambank erosion sites tend to be located where one of more of the following conditions are present:

1. Poor riparian management, particularly where native vegetation has been replaced with maintained turf grass, most notably at the Belvedere golf course. Figure 19 and Figure 19 shows severe streambank erosion located where native vegetation has been replaced with turf grass. The lack of deep, fibrous roots has made the streambank vulnerable to erosion, thereby destabilizing the toe of the slope and resulting in the turf grass overhanging (and breaking into) the stream.

2. Concentrated stormwater inputs, such as runoff from road surfaces

3. In-stream obstruction such as downed trees, remnants of walls or other structures. Figure 21 shows concrete wall remnants influencing the stream channel immediately below M-66. Figure 22 shows streambank erosion conditions likely influenced by the fallen tree that is directing flow against the opposing steep, sandy streambank. Also shown is a random shopping cart as an example of the litter that accumulates within the corridor.

In addition, in 2003, Tip of the Mitt Watershed Council coordinated a streambank erosion inventory between M--66 and the south end of the cemetery. Results from the survey showed there were 11 erosion sites characterized by steep sandy soils where the stream had undercut the base (or toe) of the bluff, causing soils and trees to fall into the stream. Such a large number of severe sites within a short stretch of stream suggested an accelerated erosion problem associated with human activities. The inventory completed as part of this project identified only three erosion sites within this stretch. The reduced number of erosion sites is most likely due to the higher stream flows during which the field reviewers completed the inventory as the higher water levels may have obscured evidence of erosion.
FIGURE 18: STOVER CREEK STREAMBANK EROSION
FIGURE 19: SEVERE STREAMBANK EROSION AT BELVEDERE GOLF COURSE (STV-034)

FIGURE 20: REMNANT STRUCTURE WITH ERODING STREAMBANK IMMEDIATELY UPSTREAM
FIGURE 21: STREAMBANK EROSION (STV-019)

FIGURE 22: STREAMBANK EROSION
Road/stream Crossings
TOMWC inventoried all of the RSX within the Stover Creek Watershed. Field review included utilizing the Great Lakes Road/Stream Crossing protocol and corresponding field form (Appendix C). Additional information collected includes photographs of the site, a site sketch, whether it is considered a priority site, whether a future visit is recommended, and if any invasive species were observed at the site. All data collected during the inventory was then entered into the Great Lakes Road Stream Crossing Inventory Access database. The database includes formulas built into each record as a means to rank each site with respect to the erosion and fish passage, and calculates a severity rating (minor, moderate, and severe). Of the 11 RSX inventoried, seven were ranked as severe, three as moderate, and one as minor (Figure 23).

Road/stream crossings (RSX) that are improperly designed or installed, structurally failing, or no longer accommodate current stream conditions affect stream health. They can affect stream hydrology, prevent fish and other aquatic organisms from reaching up-and downstream reaches, increase water temperatures, and are sources of nutrients, sediments, bacteria, heavy metals, and other nonpoint source pollutants. In Northern Michigan, sediments pose the greatest threat to rivers and streams. Sedimentation can adversely impact fish and aquatic organisms by degrading their habitat and reducing water quality.

Common problems associated with RSX include improper design, sizing, and installation of the structure; concentrated use from angler, paddlers and other seeking access Figure 24); and careless road maintenance practices. Furthermore, RSXs can impede fish and other aquatic organisms’ passage due to either a “perched”, a velocity barrier, or both. Another common issue noted was the “perched” culvert (Figure 25 and Figure 26). Perched culverts occur when the bottom of the culvert is elevated above the streambed. Typically, this applies to the downstream end of the culvert and is the result of either improper setting of the culvert or the stream has eroded away the streambed immediately below the culvert. Perched culverts pose nearly impossible obstacles to aquatic organism passage, particularly macroinvertebrates and smaller fish. Upstream and downstream passage is critical to fish and other organisms so they can access habitat resources, as well as other genetic populations of the same species. Lack of access to stream reaches beyond the RSX isolates populations and causes habitat fragmentation. When a stream is constricted at a crossing, stream hydrology is affected. Stream velocity increases through the crossing thereby creating a velocity barrier as fish and other organisms cannot overcome the powerful flows. RSXs can also slow and impound waters upstream, thereby, causing warmer water temperatures and flooding, as well as “starve” a stream of sediment below the crossing and accumulate sediment above as it can no longer transport sediment without interruption (Figure 27).
Figure 23: Stover Creek Road/Stream Crossings

Legend

Road/Stream Crossings

▲ Minor
▲ Moderate
▲ Severe

Roads
Highways
Streams
Watershed

Data Sources:
Watershed and RSQ data from Tip of the Mitt Watershed Council. Aerial from Charlevoix County GIS. All other data from the Michigan Geographic Data Library (MGDL) at http://www.mngis.state.mi.us/mgdl.

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Figure 24: Stream Crossing At Railroad Grade/Trail Upstream Of Marion Center Road (SC-007)

Figure 25: Stream Crossing At M-66 (SC-009)
FIGURE 26: OUTLET AT FERRY ROAD (EAST) CROSSING (SC-004)

FIGURE 27: STREAM CROSSING AT PATHWAY OFF FERRY ROAD (SC-010)
Hydrology
Although no formal stage/discharge/precipitation relationships are known to have been developed for the stream, first-hand observations of the stream indicate that at least the lower portion has lower base-flows and higher flood-stages than similar nearby streams with less urbanized watersheds. This is also evidenced by watermarks on surrounding vegetation and structures, and extensive un-vegetated alluvial deposits that are not inundated most of the time. It is presumed that the concentrated development within the lower watershed, which corresponds with the watershed’s groundwater recharge areas, is affecting base flow. Because groundwater provides the stream with a constant base flow during dry periods, it is not unusual to observe an almost entirely dry streambed in the lowermost reaches during dry periods (Figure 28). Conversely, during a rain event of most any magnitude, the stream overtops its banks (over bankfull) in a relatively short amount of time (Figure 29). This is most likely a result of combination of factors including a large volume of runoff flowing at a fast rate off impervious surfaces directly into the stream. Further evidence of the lower base flow includes an excessive sand bedload in portions of the channel (Figure 30). If the base flow was more constant the stream would be able to transport the sand rather than deposit it throughout the channel.

Figure 28: Dry Creek Bed (August 2012)
Figure 29: Stover Creek Over Bankfull

Figure 30: Excess Bedload of Deposited Sand
In-stream Structures
Remnants of old in-stream and streamside structures, most originating from mills and other commercial enterprises, can be found in Stover Creek, particularly in its lower stretches. Although their individual impacts are most likely not contributing to Stover Creek’s degradation, their cumulative impacts may be posing more of a threat. These structures can: increase stream velocity; cause streambank erosion and streambed scour; prevent passage of aquatic organisms and fish; cut off the stream’s floodplain connectivity; and change the stream gradient through aggradation (above the structure) and degradation (below the structure).

![Image of stream crossing at Irish boat shop near mouth of Stover Creek](image)

**FIGURE 31: STREAM CROSSING AT IRISH BOAT SHOP NEAR MOUTH OF STOVER CREEK**
Figure 32: Remnants of Structure at Outlet (SC-01)
Priority Parcel Analysis

One of the most effective tools for long-term water quality protection is permanent protection of land, particularly sensitive lands such as those containing wetlands. In order to protect sensitive areas, a system is needed to assess land parcels in terms of ecological values. To that end, Tip of the Mitt Watershed Council collaborated with the Little Traverse Conservancy (LTC) and Grand Traverse Regional Land Conservancy (GTRLC) to conduct a “Priority Parcel Analysis”: a GIS process that evaluates individual land parcels based on multiple ecological criteria and ranks parcels accordingly. The final product provides a tool to land conservancies, governmental entities, and others to assist in prioritizing land protection efforts in a manner that provides the greatest benefit to local ecosystems while also complementing existing land protection efforts. Descriptions of selection criteria and the scoring system used to determine priority parcels are described below:

Parcel Size: Larger blocks of contiguous land typically have higher ecological value due to their potential to harbor a greater diversity of habitat types and species. Larger parcels are also more time and cost effective to protect than smaller parcels. The selection threshold for parcel size criteria during this process was 10 acres. The larger the parcel, the more points it received.

Groundwater Recharge Potential: As previously discussed, groundwater plays an important role in water quality protection. Predominant soil type and associated permeability were determined for each parcel using the physical properties found in county soil surveys. Parcels were scored based on acreage containing soils with high groundwater recharge potential, the minimum threshold set at one acre.

Presence of Wetlands: As noted earlier, wetlands are a critical to protecting water quality. Digital GIS data layers containing results of the National Wetlands Inventory (NWI) were used to determine the presence of wetlands on individual parcels. Parcels were scored based on wetland acreage identified in the NWI, any parcel with wetlands scoring at least one point.

Lake Shoreline/Riparian Ecosystems: Protecting the land/water interface, the riparian area, is essential to good water quality. The length of lake shoreline was determined for individual properties using hydrography GIS data layers from the State of Michigan. Scores were based on the total shoreline distance contained within the parcel, with a minimum threshold of 100 feet.

Stream Shoreline/Riparian Ecosystems: The length of streambank was determined for individual properties using hydrography GIS data layers from the State of Michigan. Scores were based on the total streambank distance contained within the parcel, with a minimum threshold of 200 feet.

Steep Slopes: Land parcels with steep slopes should be permanently protected. GIS data from the State of Michigan was used to determine the highest percent slope on a parcel and scored accordingly. Properties with slopes greater than 20% received points.
**Protected Land Adjacency:** Properties adjacent to protected lands such as State Forests or conservancy lands have a high ecological value because they provide a buffer to pre-existing protected lands and increase the contiguous protected area, which essentially expands the biological corridor for species migration and interaction. Protected lands include properties owned by the federal government, tribal governments, State of Michigan, local governments, universities, land conservancies, and private owners (conservation easements). Properties bordering protected lands were scored based on the number of adjacent protected land parcels.

**Presence of State or Federally Listed Threatened or Endangered Species:** Threatened and endangered species represent an important aspect of biodiversity. The Michigan Natural Features Inventory developed a probability model and rarity index based on existing threatened and endangered species information. Properties within or touching upon the model’s grid cells that had a high probability of threatened and endangered species occurrence scored points; receiving a higher score as the rarity index number increased.

All 595 land parcels in the Stover Creek Watershed were analyzed and scored using the eight listed criteria. The scores for each criterion were summed to produce a total “priority” score for each land parcel. Seven parcels received a total score of 15 or greater and grouped into the high priority tier as they are considered to be the most vital for water resource protection. 110 parcels were grouped into a second tier of medium priority, with total scores ranging from 5 to 14. The remaining 455 parcels received a score of less than five and are considered low priority. Figure 33 illustrates the results of the prioritization process.
**FIGURE 33: PRIORITY PARCELS FOR PRIORITY LAND PROTECTION**

**Legend**
- Highways
- Lakes
- Streams
- Watershed boundary
- Protected lands

**Priority Ranking**
- High (15 - 31)
- Medium (5 - 14)
- Low (0 - 4)

**Conservation drivers used to prioritize parcels:**
1. Parcel size
2. Wetland acreage
3. Lake shoreline
4. Stream length
5. Groundwater recharge
6. Steep slopes
7. Protected land adjacency
8. Threatened/endangered species

**Data Sources:**
- Priority parcel data layer developed by Tip of the Mitt Watershed Council with equalization data provided by Charlevoix County, as well as preserve and easement information from the Little Traverse Conservancy.
- All other data from the Michigan Geographic Data Library at [http://www.megi.state.mi.us/mgdl/](http://www.megi.state.mi.us/mgdl/)

<table>
<thead>
<tr>
<th>Number of Properties</th>
<th>High Priority</th>
<th>Medium Priority</th>
<th>Low Priority</th>
<th>Currently Protected</th>
<th>Total for Watershed</th>
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<tbody>
<tr>
<td>7</td>
<td>110</td>
<td>455</td>
<td>23</td>
<td></td>
<td>595</td>
</tr>
</tbody>
</table>

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Recommendations:
Stover Creek is impacted by a range of land uses, development patterns, management strategies, and stream channel modifications. Although some causes appear to influence the stream’s health more than others, it will most likely require implementing many different types of watershed management practices in order to improve water quality, habitat, and hydrology. The following recommendations are not listed in any particular order of priority.

Land Use
Many of the recommendations fall under “land use” and one or more of the below categories. Recommendations for the upper watershed, however, are mostly land use-based.

- Agriculture is the dominant land use with the upper watershed. Accordingly, outreach and education efforts should extend to all agricultural producer and hobby farms, but with a focus on the largest agricultural operations. Specifically, these producers could volunteer to be verified through the Michigan Agricultural Environmental Assurance Program, which is a comprehensive, voluntary, proactive program designed to reduce farmers’ legal and environmental risks through a three-phase process: 1) education; 2) farm-specific risk assessment and practice implementation; and 3) on-farm verification that ensure the farmer has implemented environmentally sound practices. The program’s four systems-Farmstead, Cropping, Livestock and the newly developed Forest, Wetlands and Habitats System-each examine different aspects of the farm.
- Although corn, hay and soybeans are reported as comprising the majority of the croplands in the upper watershed, a more thorough assessment of agricultural lands may yield more information regarding the connection to Stover Creek’s water quality.

Streambank Protection and Restoration
Riparian Management:
- Enhanced riparian management is needed throughout the stream corridor. The lower section of Stover Creek, in particular, should be a priority for improved riparian management. Several critical areas where the need is greatest include the Belvedere Golf Course, Brookside Cemetery, and Irish Boat Shop. Riparian management includes how the vegetation is maintained along the streambank. For greater water quality benefits and streambank stability, native, existing vegetation should be maintained. In areas where vegetation has been partially or fully removed, native shrubs, trees, grasses, and other plant types should be installed. Deep-rooting, native plant species are strongly preferred. Areas where maintained turf grass is managed along the streambank, should be, at a minimum, allowed to revert to “no mow” conditions. In other words, mowing should cease within a ten foot minimum buffer on both sides of the stream.
- Restore severe erosion sites using bioengineering methods, which include deep-rooting native plant species, and flexible, biodegradable stabilization materials (coir logs, soil lifts, etc.)
In-stream Management:
- Large woody debris (LWD) should be monitored between the stream mouth and the cemetery to assess trends in recruitment as an unstable stream will experience a high rate of tree fall.
- As part of the above monitoring, trees that are creating stream obstructions (log jams) should be removed/repositioned to reduce erosive forces directed at the streambanks and to improve flow. Management of LWD, however, must be balanced as to not remove critical LWD.
- LWD should be added to stream reaches where it is lacking, including the Brookside Cemetery and the Belvedere golf course.

Monitoring:
- Streambank erosion surveys should be performed every five years, particularly between the stream mouth to just above the golf course. Future survey results should be compared with previous data to assess any erosion trends and to determine priority sites for restoration.
- Substrate monitoring should also be incorporated with the erosion surveys to assess trends in substrate changes.

Stormwater
Stormwater is likely the greatest contributor to the degradation of Stover Creek. Opportunities to mitigate stormwater impacts include both managerial and physical.

Policy (Managerial):
- Stormwater ordinances would serve to regulate future stormwater impacts. In particular, limiting impervious surfaces as it applies to future development and re-development would help address any further stormwater impacts to the stream.
- Adoption of stormwater best management practices (BMPs) for commercial and residential properties should be incentivized via discounts or lower fees associated with utility services, or other cost-savings programs.

Best Management Practices (Physical):
Physical best management practices (BMPs) include both small- and large-scale options, from residential rain gardens (bioretention) to impervious paver parking lots. Installation of new BMPs, as well as maintenance of existing BMPs, should be promoted throughout the lower watershed via education and outreach efforts. In particular, the following recommendations apply to the discrete stormwater basins:

- Install bioretention areas (rain gardens) throughout all basins, particularly in basins 2, 3, and 4
- Regularly maintain car wash detention pond in basin 11
- In basin 12, revise Post Office detention pond (raise elevation of outlet to allow for detention)
- In conjunction with above, incorporate pervious surfaces within basin 12 to increase infiltration and reduce stormwater volume received by detention pond.
- In basin 4, revise roadside ditches to include more infiltration opportunities, including deep-rooting native plants, a broad swale-like profile, and a gradient that allows drainage, yet is gradual enough to encourage infiltration
- Increase riparian buffer width in basin 14

**Monitoring:**
Monitor water quality of stormwater at outfalls in basins 2, 3, and 4. Testing for a variety of toxins including heavy metals, polycyclic aromatic hydrocarbons, and pesticides should be performed during wet weather events and also include discharge. Measuring discharge at these locations will assist in determining the volume of water that is potentially being diverted from groundwater recharge. It is also recommended that an analytical laboratory or research institution be first consulted to assist in determining the specific parameters, as there are hundreds, if not thousands, of options and analysis is very costly. Furthermore, water quality should be monitored immediately downstream of the outfalls and in conjunction with the stormwater monitoring. Results would indicate whether or not the stormwater is having a measurable impact on the stream’s water quality.

**Road/Stream Crossings**
The majority of the road/stream crossings, particularly in the lower watershed, are contributing to stream degradation due to being both improperly designed and/or installed.

**Monitoring:**
- Re-inventory severe and moderate RSX every 5 years to determine if priorities are the same, and to document newly installed BMPs or improvements
- Re-inventory minor RSX every 10 years in conjunction with 5 year cycle of severe and moderate sites

**RSX Improvements:**
A stream crossing structure, whether it is a bridge, culvert, or other type of structure should span the entire width of the stream channel, and if not, it should be as wide as possible.

Clear-span structures, such as a timber bridge, would provide the greatest benefit to the stream at these locations. In lieu of these costly structures, larger culverts that match the stream channel width are recommended. Ideal culverts should be bottomless, such as concrete box culverts. If non-bottomless culverts are used, then their bottoms must be buried well into the streambed. Culverts must also be installed at the proper elevation to prevent creating fish passage barriers and stream gradient interruptions. Grade control structures should also be integrated in areas where necessary in order to prevent headcutting of the streambed.

- Develop engineering plans for priority RSXs in the lower watershed: Marion Center Rd. (SC009), M-66 (SC008), and the railroad grade/trail crossing upstream of Marion Center Rd. (SC007)
- Replace priority RSX (above) with channel-spanning structures

**In-Stream Structures**
The dam at the mouth near Irish Boat Shop, despite being only a remnant of the original dam, is likely impacting the stream. Upstream of the partial dam, the remnants of the mill structure are also impacting the stream hydrology.
• Engineering studies should be conducted to forecast the changes to the stream upon removal of these structures. Results of the studies should recommend a future approach to addressing these structures whether it be to remove them entirely or partially, and how to restore the stream channel in these sections in order to protect both water quality and nearby infrastructure.

**Hydrology**

• Consult with a hydrologist and subsequently conduct a comprehensive hydrologic analysis to confirm and quantify the conclusions drawn in this report. Specifically, an assessment of the stream’s flashiness should be performed. A hydrologic analysis will also provide a foundation on which to build, with greater specificity, further recommendations, such as location, type, design, and size of structural BMPs. The analysis should also evaluate whether the groundwater watershed extends beyond the surface watershed at the Kmart plaza on the south side of the stream. It is possible that the plaza, which has its own stormwater detention basin, is diverting groundwater away from the stream.

**Land Protection**

• Protect high priority parcels, as determined through the prioritization process. A variety of mechanisms, including conservation easement and purchase of development rights (PDR), could be applied to achieve protection of any or all of the seven high priority parcels. Results of the prioritization process will be shared with Little Traverse Conservancy in an effort to connect the organization with the high priority parcels’ land owners.

**Water Quality Monitoring**

• An ongoing water quality monitoring program should be initiated to assess water quality trends over time and should include the same parameters as this study. In addition, a 5th and 6th site should be added to the original four. The added sites should be located immediately upstream of the golf course and at Ferry Road.
Appendix A: Stormwater Pollutant Estimation Method

Simple, empirical method developed by the Washington Metropolitan Water Resource Planning board in 1987. Stormwater export for an area can be estimated by using the following equation:

\[ L = \frac{(P)(P_j)(R_v)}{12}(C)(A)(2.72) \]

Where:

- \( L \) = Pollutant export in pounds.
- \( P \) = Rainfall amount in inches over the desired time interval. 31.25 was used for this study, which has been determined to be the average annual rainfall at Pellston, Michigan.
- \( P_j \) = A factor that corrects \( P \) for storms that produce no runoff. A value of 0.90, determined from a study in the metropolitan Washington D.C area, was used for this study.
- \( R_v \) = A runoff coefficient that expresses the fraction of rainfall that is converted to runoff, based on percent watershed imperviousness. This was determined from a figure depicting the relationship between watershed imperviousness and the runoff coefficient developed during a nationwide urban runoff study in the 1980's.
- \( C \) = Flow-weighted mean concentration of the selected pollutant in urban runoff. Values for total phosphorus (0.46 mg/l), zinc (0.176 mg/l) and copper (0.047 mg/l) were taken from nation-wide averages determined during the aforementioned nationwide urban runoff study. Values for suspended sediment were taken from water testing results of storm sewers conducted in Harbor Springs by Tip of the Mitt Watershed Council in 1987-88.
- \( A \) = Area of the study site in acres. Area determinations were determined using a geographic information system.
- 12 and 2.27 are unit conversion factors.
Appendix B: Streambank Erosion and Alterations Assessment Form

STREAMBANK EROSION AND ALTERATIONS ASSESSMENT FORM  Site ID: ____________________

Stream Name: ____________________  Date: ______________  Severity: ______________
Recorders Name(s): ____________________  Picture #: ____________________

SITE INFORMATION:
Bank as designated while looking downstream (circle one)  RIGHT  LEFT  (Mark the appropriate side of the site on the map)
Is the site accessible by road? (circle one)  YES  NO  UNSURE  Nearest RSX: ____________________
Other location information: ____________________

CONDITION OF THE BANK (circle A, B, or C):
A. Toe is undercutting  B. Toe is stable; upper bank eroding  C. Toe and upper bank are eroding
D. The percent of vegetative cover on the bank is (circle one): 0-10%  11-50%  51-100%
E. Problem trend (circle one): INCREASING  DECREASING  COMBINATION  STABLE
F. Other (describe): ____________________

APPARENT CAUSE OF BANK EROSION (circle all that apply):
A. Obstruction in river  B. Bank seepage  C. Gullying of bank from side channels
D. Bend in river  E. Road/stream crossing runoff  F. Access traffic (type): ____________________
Other: ____________________

AMOUNT OF EROSION AND SLOPE RATIO:
A. Length of eroded bank (estimated or measured): ________ feet
B. Average height of eroded bank: ________ feet
C. Slope of bank-vertical (circle one): 1:1  2:1  3:1  4:1 or flatter

RIVER CONDITIONS:
A. Approximate width of river where erosion occurs (feet): ____________________
B. Approximate depth of river: ________ at ________ feet from the bank. (Preferably get estimate 4' from the bank)
C. Current (circle one): FAST  MODERATE  SLOW
D. Soil Texture (circle all that apply): SAND  CLAY  LOAM  GRAVEL  STRATIFIED  SAND OVER CLAY
Other Textures: ____________________

STREAMBANK STRUCTURES (circle all that apply):
A. Hardened seawall (describe): ____________________  B. Dock  C. Launch/ramp
D. Stairway  E. Riprap  F. Other: ____________________

RIPARIAN VEGETATION: Has native vegetation been removed? YES  NO
Linear footage of disturbance: ________  Average depth of disturbance (feet): ________
Has native vegetation been replaced with other vegetation? YES  NO  IF YES: TURF  OTHER
Remaining vegetation types (circle all that apply): TREES  SHRUBS  HERBACEOUS  NONE

TYPE OF TREATMENT RECOMMENDED (circle): A. Rock Riprap  B. Obstruction Removal  D. Bank Regrading
E. Dedicated Access  F. Bank Planting  G. Fencing  I. Other (explain): ____________________

USE BACK OF FIELD FORM TO SKETCH SITE
### Appendix C: Stream Habitat Inventory Data Sheet

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Unit Type</th>
<th>Unit Number</th>
<th>Distance (ft)</th>
<th>Max Depth (0.1 ft)</th>
<th>Avg Depth (0.1 ft)</th>
<th>Substrate %</th>
<th>Substrate</th>
<th>SC</th>
<th>OR</th>
<th>COB</th>
<th>BOU</th>
<th>BED</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SET Width (0.5 ft)</th>
<th>Actual Width (0.5 ft)</th>
<th>Set BF width (0.5 ft)</th>
<th>Actual BF width (0.5 ft)</th>
<th>Large Woody Material</th>
<th>Comment Riparian Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<th>Size</th>
<th>Type</th>
<th>Size</th>
<th>Type</th>
<th>Size</th>
<th>Type</th>
<th>Comments</th>
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</tr>
</tbody>
</table>

- **SC**: Substrate Class
- **OR**: Organic Matter
- **COB**: Cobble
- **BOU**: Boulder
- **BED**: Bedrock

---

*Flow Conditions:*
- Air
- Water

*Flow Conditions:*

- **Canopy:**
  - PS: Partial canopy
  - OC: Open canopy

*Vegetation Types:*
- **Riparian Vegetation:**
  - PS: Partial canopy
  - OC: Open canopy
  - SC: Substrate Class
  - OR: Organic Matter
  - COB: Cobble
  - BOU: Boulder
  - BED: Bedrock
## Appendix D: Great Lakes Road/Stream Crossing Inventory Data Sheet

### Stream Crossing Data Sheet

**General Information**
- **Stream Name:**
- **Road Name:**
- **Name of Observer(s):**
- **Date:**
- **GPS Waypoint:**
- **GPS Lat/Long:**
- **County:**
- **Township:**
- **Range:**
- **Sec.:**
- **Adjacent Landowner Information:**
- **Additional Comments:**

**Crossing Information**
- **Crossing Type:**
  - Culvert(s) no.: [ ]
  - Bridge [ ]
  - Ford [ ]
  - Dam [ ]
  - Other [ ]
- **Structure Shape:**
  - Round [ ]
  - Square/Rectangle [ ]
  - Open Bottom Square/Rectangle [ ]
  - Pipe Arch [ ]
  - Open Bottom Arch [ ]
  - Ellipse [ ]
- **Inlets Type:**
  - Projecting [ ]
  - Mitered [ ]
  - Measwood [ ]
  - Apron [ ]
  - Wingwall 10-50° [ ]
  - 50-79° [ ]
  - Drain Rock [ ]
  - Other [ ]
- **Outlet Type:**
  - At Stream Grade [ ]
  - Cascade over Ripp[ ]
  - Freetfall into Pool [ ]
  - Freetfall onto Ripp[ ]
  - Outlet Apron [ ]
  - Other [ ]
- **Structure Material:**
  - Metal [ ]
  - Concrete [ ]
  - Plastic [ ]
  - Wood [ ]
- **Substrate in Structure:**
  - None [ ]
  - Sand [ ]
  - Gravel [ ]
  - Rock [ ]
  - Mixture [ ]
- **General Condition:**
  - New [ ]
  - Good [ ]
  - Fair [ ]
  - Poor [ ]
- **Plugged:** %
- **Crushed:** %
- **Rusted Through:**
  - Yes [ ]
  - No [ ]
  - Structure Interior:
  - Smooth [ ]
  - Corrugated [ ]
- **Structure Length (ft):** [ ]
- **Structure Width (ft):** [ ]
- **Structure Height (ft):** [ ]
- **Structure Water Depth (ft):** [ ]
  - Inlet [ ]
  - Outlet [ ]
- **Perch Height (ft):** [ ]
- **Embedded Depth of Structure (ft):** [ ]
  - Inlet [ ]
  - Outlet [ ]
- **Structure Water Velocity (ft/sec):** [ ]
  - Inlet [ ]
  - Outlet [ ]
- **Structure Water Velocity Measured:** At Surface [ ]
  - Ft Below Surface [ ]
  - Measured With: Meter [ ]
  - or Float Test [ ]

### Multiple Culverts/Spans

<table>
<thead>
<tr>
<th>Culvert/Span #</th>
<th>Width (ft)</th>
<th>Length (ft)</th>
<th>Height (ft)</th>
<th>Material</th>
</tr>
</thead>
</table>

**Stream Information**
- **Stream Flow:**
  - None [ ]
  - < ¼ Bankfull [ ]
  - < Bankfull [ ]
  - = Bankfull [ ]
  - > Bankfull [ ]
- **Scour Pool (if present):**
  - Length [ ]
  - Width [ ]
  - Depth [ ]
- **Upstream Pond (if present):**
  - Length [ ]
  - Width [ ]

**Riffle Information**

**Water Depth (ft):** [ ]
- **Bankfull Width (ft):** [ ]
- **Wetted Width (ft):** [ ]
- **Water Velocity (ft/sec):** [ ]

**Dominant Substrate:**
- Cobble [ ]
- Gravel [ ]
- Sand [ ]
- Organics [ ]
- Clay [ ]
- Bedrock [ ]
- Silt [ ]
  - Measured With: Meter [ ]
  - or Float Test [ ]

### Road Information

**Type:**
- Federal [ ]
- State [ ]
- County [ ]
- Town [ ]
- Trib [ ]
- Private [ ]
- Other [ ]

**Condition:**
- Good [ ]
- Fair [ ]
- Poor [ ]

**Road Surface:**
- Paved [ ]
- Gravel [ ]
- Sand [ ]
- Native Surface [ ]

**Location of Low Point:**
- At Stream [ ]
- Other [ ]
- Runoff Path:
  - Roadway [ ]
  - Ditch [ ]

**Embankment:**
- Upstream Fill Depth (ft): [ ]
- Downstream Fill Depth (ft): [ ]

**Slope:**
- Vertical [ ]
- 1:1 [ ]
- 1:2 [ ]

**Left Approach:**
- Length (ft): [ ]
- Slope: [ ]

**Right Approach:**
- Length (ft): [ ]
- Slope: [ ]

---

Form Date: February 28, 2011

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Stover Creek Watershed Restoration and Management Plan 65
Appendix D: Great Lakes Road/Stream Crossing Inventory Data Sheet-Continued

### Erosion Information

Use a new row for each distinct gully/erosion location. Note prominent streambank erosion within 50 feet of crossing.

<table>
<thead>
<tr>
<th>Location of Erosion</th>
<th>Erosion Dimensions (ft)</th>
<th>Eroded Material Reaching Stream?</th>
<th>Material Eroded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ditch, approach, or streambank</td>
<td>Length</td>
<td>Width</td>
<td>Depth</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
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<td>Yes</td>
<td>No</td>
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</tr>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

If there is erosion occurring, can corrective actions, such as road drainage measures, be installed to address the problem?  Y  N

Extent of Erosion:  Minor  Moderate  Severe  Stabilized

Erosion Notes:

Photos – enter photo number in blank corresponding to location

- Site ID
- Upstream Conditions
- Downstream Conditions
- Inlet
- Outlet
- Road Approach – Left
- Road Approach – Right

Summary Information

Would you consider this a priority site?  Fish Passage  Erosion  Why?

Would you recommend a future visit to this site?  Yes  No  Why?

Were any non-native invasive species observed at the site?  Yes  No  If yes, what species were observed?

Site Sketch

Draw an overhead sketch of crossing. Be sure to mark North on the map and to indicate the direction of flow. Include major features documented on form, such as erosion sites, multiple culverts, scour pool, impounded water, etc.

Form Date: February 28, 2011