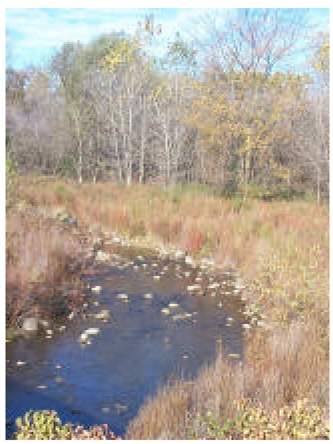
Imperviousness Reduction and Mitigation in Tributaries of the Huron River:

A Stormwater Management Study of
Ann Arbor, Scio and Superior Townships



A Project of the Washtenaw County Drain Commissioner
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PROJECT OVERVIEW:
A parking lot can generate 16 times the runoff of an undisturbed meadow (Schueler, 1994a). Asphalt and other surfaces – parking lots, roads, and rooftops – prevent water filtration into the ground, thereby generating higher runoff volumes than would occur prior to development. Lawn runoff can be also problematic if the soil is sufficiently compacted or over-watered (Schueler, 1995a). Storm sewers and storage ponds offer an alternate path for stormwater; however, this route bypasses the vegetation and soil that would naturally slow, filter and treat stormwater.

Altering the natural flow of water over the land introduces a host of surface pollutants – lawn chemicals, sediments, and trace metals from automobiles – that are washed downstream into lakes, streams and wetlands. This "*nonpoint source pollution*" is one of the leading causes of declining water quality nationwide (USEPA, 1997). Research has shown that watercourses tend to become degraded when their watersheds – the land area draining into waterways – reach 10% - 15% imperviousness. After 25-30%, stream degradation becomes absolute (Schueler, 1994).

To determine if it is possible to prevent seemingly inevitable stream quality decline that accompanies rapid, intense urbanization, the office of the Washtenaw County Drain Commissioner undertook a one-year study of imperviousness management within the Honey and Fleming Creeksheds – tributaries to the Huron River that lie within Ann Arbor, Scio and Superior Townships. The Michigan Department of Environmental Quality, Great Lakes Protection Fund, funded the project. The Huron River Watershed Council provided technical assistance. This report details project findings and methodology for the benefit of the townships within the project area, as well as other communities considering implementation of project recommendations.

GOALS:
The goals of the project were to work with the Townships to:

1. Minimize the future imperviousness of Honey and Fleming Creeksheds, and;
2. Limit water quality impairment of Honey and Fleming Creeks caused by stormwater runoff

RESULTS:
Conducting a buildout analysis of current zoning district maps and land use regulations in the Townships, future imperviousness was found to rise to the following levels:

Table 1
Current and Future Imperviousness

Location	Current Imperviousness	Future Imperviousness
Honey Creekshed in Scio Township	12%	22%
Fleming Creekshed in Superior Township	8%	12%
Fleming Creekshed in Ann Arbor Township	9.5%	20%

For comparison, an alternative buildout analysis was performed that assumed lower imperviousness levels for future development. The assumptions behind these lower levels were the result of recommended changes to zoning and development standards allowing narrower private roads, flexibility in off-street parking requirements, and open space development that promotes clustering and reduces paved surfaces. This alternative analysis forecast future imperviousness of the following levels:

Table 2
Current and Future Imperviousness
with Reductions for Amended Development Standards

Location	Future Imperviousness	Future Imperviousness Reduced
Honey Creekshed in Scio	22%	19%
Fleming Creekshed in Superior	12%	10%
Fleming Creekshed in Ann Arbor	20%	17%

This analysis shows that changing development standards and ordinances would reduce total buildout imperviousness as much as 15% (from 20% to 17% for Fleming Creek in Ann Arbor Township, for example). However, because the total imperviousness at buildout is still significant, imperviousness reduction alone will not be sufficient to protect the integrity and water quality of Honey and Fleming Creeks.

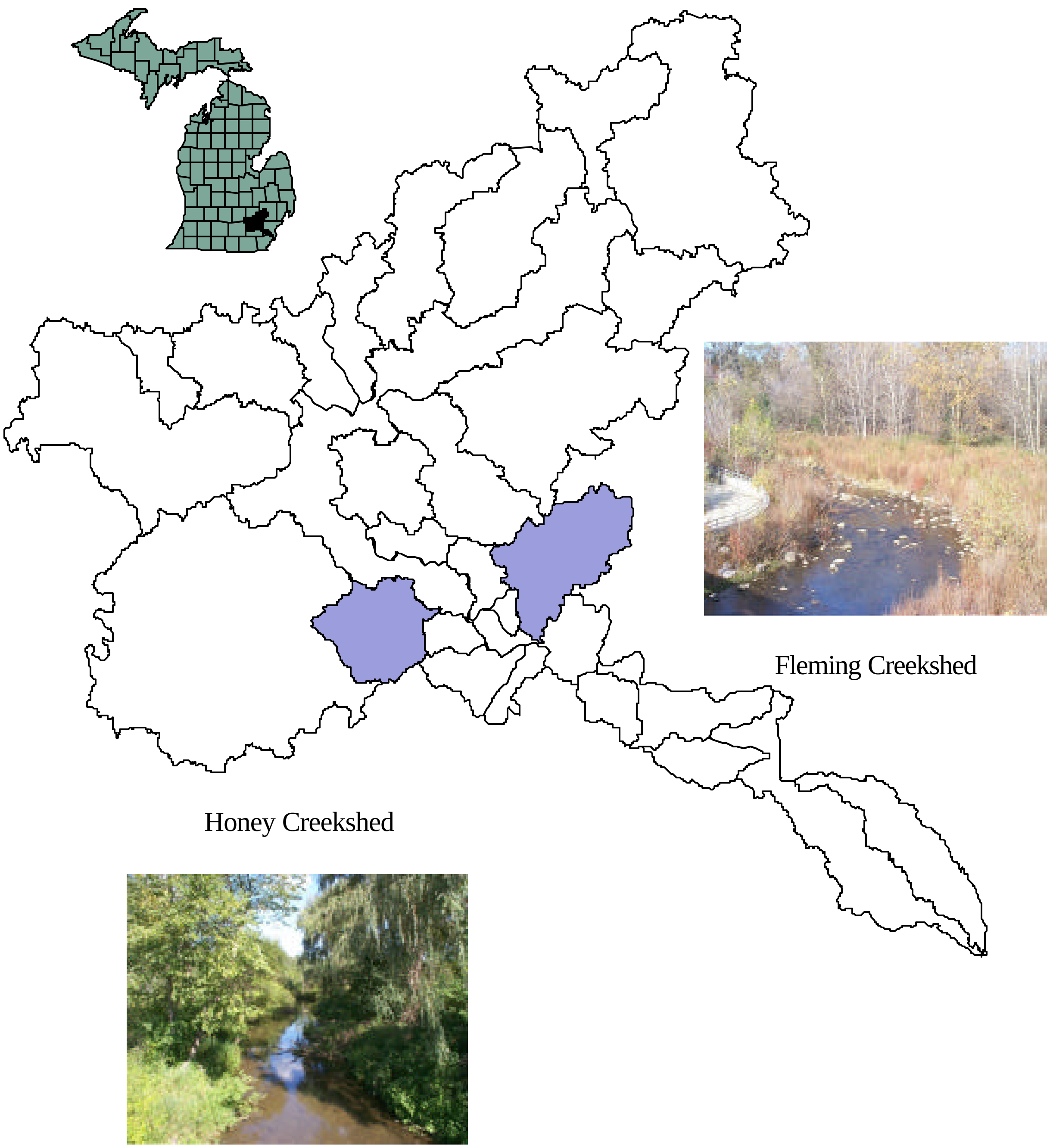
While efforts to limit imperviousness certainly reduce stormwater runoff, long-term improved management and treatment of the remaining stormwater is also necessary if water quality is to be preserved. The second task of the project was to examine existing and potential management practices such as stormwater ponds, swales, and landscape practices, for their effectiveness in treating stormwater pollution, and to develop a viable regulatory tool that ensures application of these practices in new development.

As excess phosphorus is the primary water quality concern in the middle Huron River tributaries, phosphorus removal became the priority criterion for evaluating treatment effectiveness. A performance standard limiting phosphorus export was drafted based on analysis results. Although no performance standards were established for other common stormwater pollutants, they will be indirectly regulated through application of this ordinance.

LESSONS LEARNED:

Changing development standards to managing impervious cover is not sufficient to preserve water quality the rapidly urbanizing Townships of Ann Arbor, Scio and Superior. Limiting impervious cover needs to be coupled with improved stormwater management that goes beyond current end-of-the-pipe treatment provided by stormwater ponds. To protect Honey and Fleming Creeks from nonpoint source phosphorus – the primary water quality impairment in the middle Huron River basin – integrated stormwater best management practices (BMPs) are necessary. In addition to limiting impervious cover, these BMPs include vegetation management, overland conveyance, stormwater infiltration and improved water quality treatment efficiency of storage ponds.

PROJECT LOCATION MAP



INTRODUCTION

PROBLEM STATEMENT:
Converting agricultural land and natural areas to commercial and residential development replaces open space with buildings, roads and parking lots that impede infiltration of rainwater into the soil. This *impervious cover* alters the *hydrology* of the *watershed,* often generating tremendous increase in stormwater runoff. The cumulative effect of increased development can pose a significant threat to the quality of lakes, rivers and streams. Minimizing impervious cover throughout the watershed is one way of minimizing runoff. Water quality protection becomes much more effective if impervious management is combined with improved stormwater practices that moderate the influence of runoff. The following report details the results of a one-year study to reduce impervious cover and manage stormwater runoff in three rapidly developing townships in southeast Michigan.

Imperviousness and its Consequences
A typical acre of undeveloped land in the Midwest absorbs as much as 90% of the annual rain and snowfall it receives (Figure 1). With natural vegetative cover, a large fraction -- perhaps 50 % -- of the water infiltrates into the soil. Much of this water may flow under the surface, often recharging into lakes or streams. Other infiltrated water descends to a deeper level, perhaps recharging an underground aquifer used for drinking water. A significant share of precipitation is taken up by plant roots, or evaporates into the atmosphere. Only a small amount of the water – the remaining 10% – typically remains on the surface of undeveloped land to run off into lakes, streams and wetlands (Aponte-Clark et. al., 1999).

Figure 1
Typical pre-development land cover.

The hydrology, or water cycle, of a developed acre is very different (Figure 2). As much as 95% of the water falling on roads, rooftops and other impervious surfaces flows off the land. This added volume of stormwater runoff, running off of impervious surfaces at an accelerated rate, threatens downstream property with potential flooding, erosion and sedimentation. It also threatens water quality. Total imperviousness is a good indicator of water quality.

Figure 2
Typical post-development land cover.

As stormwater runoff travels over the surface of the land, it carries with it a wide range of contaminants that impair quality of receiving waters. Examples of common stormwater pollutants are listed in Table 3 below. These contaminants, collectively called "*nonpoint source pollution*" because of their diffuse nature, are the leading cause of water quality impairment nationwide (USEPA, 1997). The most significant nonpoint source pollutant in the middle Huron basin is phosphorus (Brenner and Rentschler, 1996). Phosphorus pollution comes from a variety of sources, including lawn fertilizers, pet and animal waste, and erosion of topsoil and stream banks resulting from rapid fluctuations in the rate of stormwater flow.

The three townships that are the focus of this Impervious Surface Reduction and Stormwater Management Project lie within the middle Huron River basin, which is under a mandate from the State Department of Environmental Quality to cut phosphorus loading in half (Brenner and Rentschler, 1996). All three communities are signatories to the Middle Huron Initiative, to reduce nonpoint source phosphorus loading from their jurisdictions. Phosphorus reduction should be a priority component in future stormwater permits that all three communities will be required to attain.

Table 3
Common Sources and Examples of Nonpoint Source Pollutants

Sources	Examples
cars, rooftops	zinc, cadmium, copper, chromium, arsenic, lead, oil, gasoline, grease, hydrocarbons
lawn, septic, household and aerial deposition	nitrogen, phosphorus, pesticides, oil, gasoline, grease, hydrocarbons, leaves, human, and animal waste
pet and animal waste	viruses, bacteria, protozoa
topsoil and bank erosion	sand, soil, and silt
road salts	sodium chloride

(Aponte-Clark et. al., 1999 and Schueler, 1995b)

With increasing development pressure, phosphorus and other nonpoint source pollutants threaten not only the Huron River and its tributary waters, but it also threaten the public health, economic vitality and character of the surrounding communities (Aponte-Clark et. al., 1999).

IMPACT MITIGATION:

Figure 3
Stormwater Pond.

Development can drastically change the hydrology of a watershed, impeding groundwater recharge, degrading wetlands, and transforming water that would have infiltrated into the soil into stormwater runoff. Recent regulations require that stormwater pond*s* be incorporated into site design, to capture runoff generated from impervious surfaces that would have infiltrated into the ground under pre-development conditions. Depending on the specific design, ponds either completely retain, or slowly meter out stormwater over a period of at least 24 hours (Figure 3). At best, stormwater ponds are and end-of-the-pipe solution. Their detention and slow release rate affords significant downstream protection from flooding, and some water quality improvement. However, detention alone does not adequately mitigate stormwater impacts.

Preserving water quality of local waterways requires a more integrated and comprehensive approach to stormwater management. This approach certainly begins with source controls, such as reduction of impervious cover. Research has shown that watercourses tend to show diminished water quality, habitat, and channel stability when the watershed reaches 10-15% imperviousness. After 25-30%, stream degradation becomes absolute (Schueler, 1994a). Imperviousness reduction, however, is just a starting point beyond which improved management of stormwater is needed.

Research indicates that the pollution removal through stormwater *best management practices* (BMPs) – overland conveyance using swales, vegetated filter strips and improved stormwater ponds – can effectively reduce sediment and phosphorus generated by remaining impervious surfaces. Use of integrated BMPs can slow, filter and treat stormwater onsite, preserving the integrity of downstream watercourses.

PROJECT OBJECTIVES:

Objective #1-- Imperviousness Reduction

> ***To develop amendments to existing regulations and ordinances that will reduce the imperviousness of future development.***

In 1995, Olympia, Washington conducted a nationally noted alternative planning analysis to examine ways to limit future imperviousness. The City found that it could reduce by 20% the imperviousness of the study area by instituting policy, regulatory and management changes to its Land Use Plan (City of Olympia, 1995). This Great Lakes Protection Fund project sought to conduct similar imperviousness reduction analysis by examination of local ordinances in three urbanizing township surrounding Ann Arbor, Michigan to identify opportunities to reduce total imperviousness within the Honey and Fleming Creeksheds.

With the aid of a project advisory committee made up of Township representatives, ordinances regulating parking ratios, parking lot stall dimensions, private road widths, setbacks, clustering provisions and ground floor ratios were analyzed and where appropriate, ordinance amendments were drafted to minimize imperviousness. The effects of these reductions were then projected using geographic information systems (GIS) to forecast buildout imperviousness for each creekshed.

Objective #2 -- Imperviousness Mitigation through Best Management Practices

> ***To evaluate the effectiveness of existing and potential BMPs in mitigating the effects of imperviousness, and to offer recommendations that can be used by Townships to slow, infiltrate and treat stormwater runoff, thereby preserving water quality of Honey and Fleming Creeksheds.***

Impervious surfaces increased the volume, rate and pollutant load of stormwater runoff (Aponte-Clark et. al., 1999). Consequences to the community and to downstream water quality include:

- Flooding and Property Damage
- Streambank and Streambed Erosion
- Siltation and Sedimentation
- Increased Water Temperature
- Harm to Aquatic Life
- Aesthetic Losses

Impervious reductions achieved under Objective #1, by themselves, will not be sufficient to ensure stream quality in the rapidly developing Fleming and Honey Creeksheds. Therefore, to mitigate the water quantity and quality effects of stormwater runoff, an ordinance requiring a performance standard for phosphorus reduction was drafted for the communities.

ANALYSIS OF IMPERVIOUS COVER

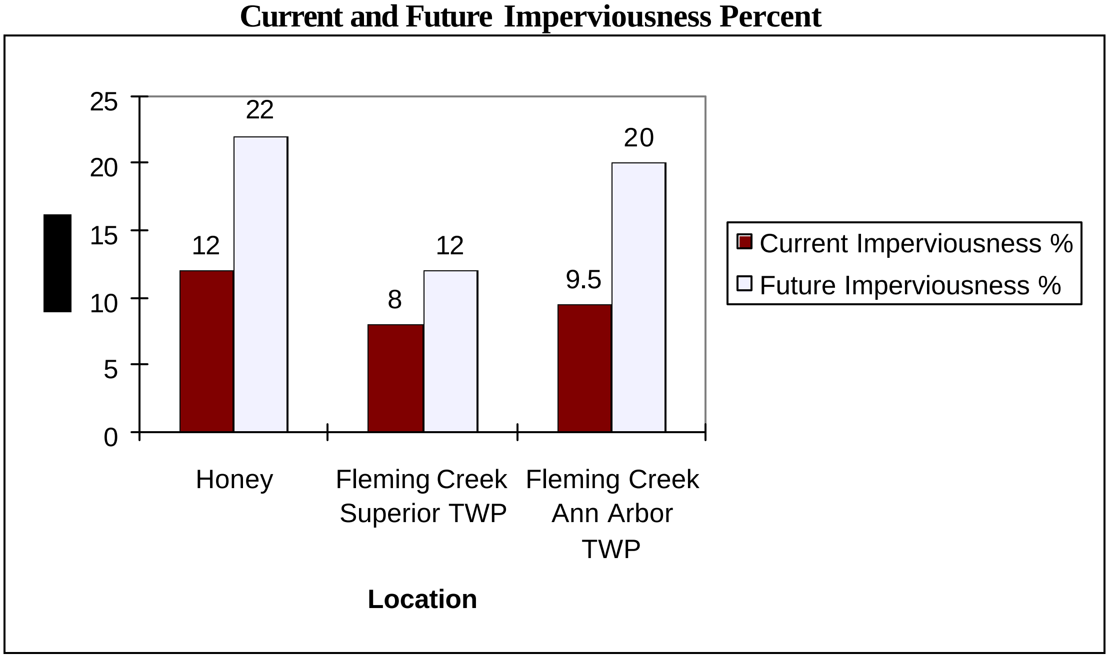
1. CURRENT AND FUTURE IMPERVIOUSNESS

Current Imperviousness:
Current imperviousness was quantified by assigning land-use-specific values for existing imperviousness to MDNR's Michigan Resource Inventory System (MIRIS) land use coverage for Ann Arbor, Scio and Superior Townships. Land use categories, associated imperviousness values and Geographic Information System method are described Appendix 1.

Future Imperviousness:
Much of the land within the three-township project area is currently in agricultural use or is developed at densities below what is allowed by current zoning. To project into the future, imperviousness values were assigned consistent with the allowable "buildout" densities of each zoning district. For example, if the R-3 zoning district prescribed a maximum density of one unit per acre, that district was assigned an imperviousness value consistent with that density (19%, in this example). The zoning densities and associated imperviousness values are also provided in Appendix 1.

Figure 4

Current and Future Imperviousness Percent



RESULTS:
The current and future levels of imperviousness of Honey and Fleming Creeksheds within the project area are shown in Figure 4. Honey Creek in Scio Township is currently 12% impervious; projected imperviousness at buildout would be 22%. Similarly, imperviousness within Fleming Creek would rise from below 8% to 12% in Superior Township, and from 9.5% to 20% in Ann Arbor Township.

2. OPPORTUNITIES TO REDUCE FUTURE IMPERVIOUS COVER

RECOMMENDED ORDINANCE AMENDMENTS:
The same analysis of future imperviousness was performed again with imperviousness reductions projected by adoption of ordinance amendments recommended by this study (Appendix 2; sample for Scio Township). Imperviousness reductions were as follows:

- Reduction in residential road widths to 22 feet by amending private road standards (ASCE, 1990).
- Open space development (clustering) resulting in 20% less imperviousness than conventional design (Schueler, 1994b).
- Parking lot reduction resulting in 20% less imperviousness than conventional site development. This could be achieved with smaller stalls (9 x 18), compact car parking, reduced aisle widths, and lower parking ratios per square foot of floor area (Schueler, 1995b).

ADDITIONAL OPPORTUNITIES:
There are other means of amending zoning ordinances and development standards to reduce future imperviousness. This project looked at the following standards for such opportunities:

- Front and Side Yard Setbacks
- Sidewalk Standards
- Ground Floor Ratios (GFR) and Floor Area Ratios (FAR)

Front and Side Yard Setbacks
Front and side yard setback requirements can be manipulated to lessen required imperviousness without compromising traffic safety, marketability of homes or parking availability (Arendt, 1994). For instance, a house set back 50 feet from the right-of-way will usually have a longer driveway than one set back 35 feet. Similarly, lengthier side yard setbacks increase the linear distance of road necessary to access the area. This technique can reduce linear road and driveway distances by 7% to 58% depending on lot size (Schueler, 1998a).

This technique, however, often has the unintended consequence of increasing the number of buildable lots. For instance, a 10-acre parcel in an area not served by sewers may only have 8 buildable lots. As is often the case in the project area, the remaining lots may be unbuildable due to wetlands, steep slopes or clay soils that are not suitable for septic systems. Altering geometric requirements of front and side setbacks may decrease the road and driveway lengths per unit, but it also may result in 2 additional buildable lots; adding 2 more driveways, 2 more rooftops and perhaps 150 feet of additional road length.

Without a provision limiting density to that originally allowed in conventional design, this approach has the potential to add imperviousness to the site rather that lowering it. Manipulating setbacks, therefore, is best left to the discretion of the planning commissions via Planned Unit Development provisions, or in the case of Scio Township, its clustering provision.

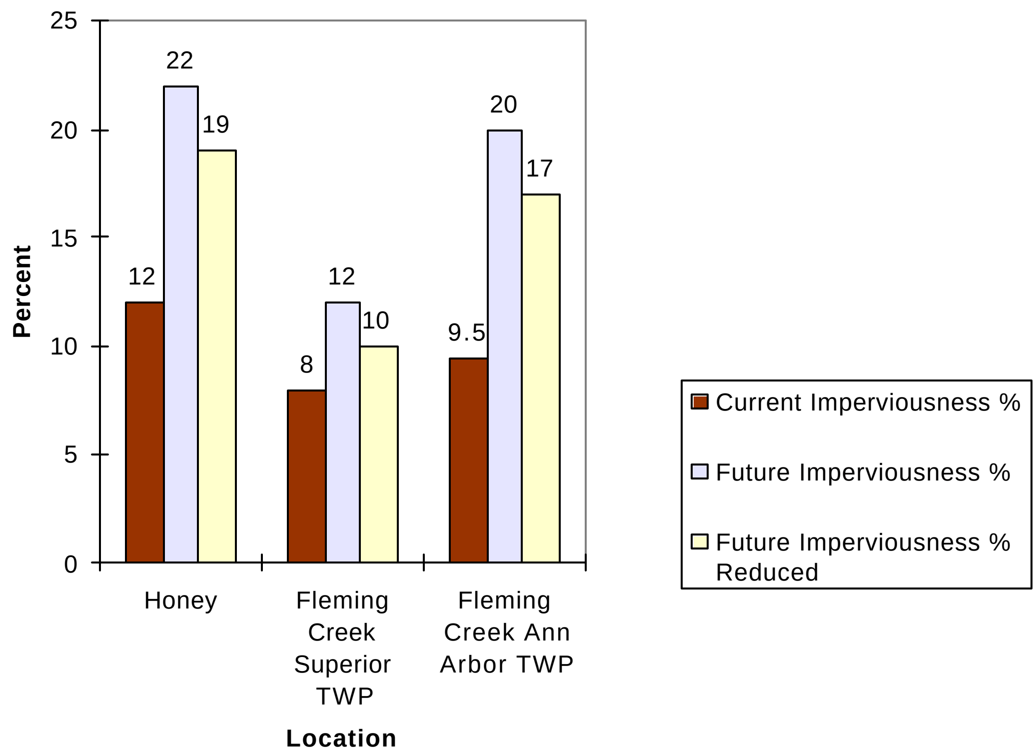
Sidewalk Standards
Sidewalks account for less than 1% of total watershed imperviousness. Sidewalk imperviousness can be reduced in two ways. They can be restricted to one side of the street, and they can be restricted to 4 feet in width.

Within the project area, much of the future development is planned will occur in low-density zoning districts that do not necessarily require sidewalks. When required, the minimum width is set at 4-5 feet. The analysis concluded that restricting sidewalks to a maximum of 4 feet, one side of the street only, would have a negligible effect on total watershed imperviousness. Rather than offering amendments to sidewalk standards, this study recommends that, where required, sidewalks be constructed to drain away from the street to more pervious surfaces such as lawns, thereby reducing runoff.

Ground Floor Ratios (GFR) and Floor Area Ratios (FAR)
From the standpoint of limiting imperviousness, a 5% GFR or 10% FAR limit would no doubt reduce stormwater runoff. In fact, water resources would be even better protected if there were a total imperviousness limit for each lot within the watershed. However, current stormwater management literature also warns against using imperviousness as the sole foundation for zoning and regulatory actions to protect water quality (Schueler, 1994a). Instead, a more comprehensive stormwater management approach is favored – one that views imperviousness minimization as one of the many stormwater best management practices available (Schueler, 1998b). For this reasons, GFR and FAR limitations were not recommended by this project.

RESULTS:
The results of these three analyses are given in Figure 5, below. By reducing private road widths and off-street parking standards, and by allowing open space development, imperviousness reduction of the Creeksheds could be reduced by an average of 14%. Honey Creek in Scio Township is currently 12% impervious; projected imperviousness at buildout would be reduced from 22% to 19%. Similarly, imperviousness within Fleming Creek would be reduced from 12%, and 20% for Superior and Ann Arbor Townships, to 10% and 17%, respectively.

Figure 5
Current and Future Imperviousness Percent with Reductions for Reduced Parking, Reduced Private Road Widths and Open Space Zoning



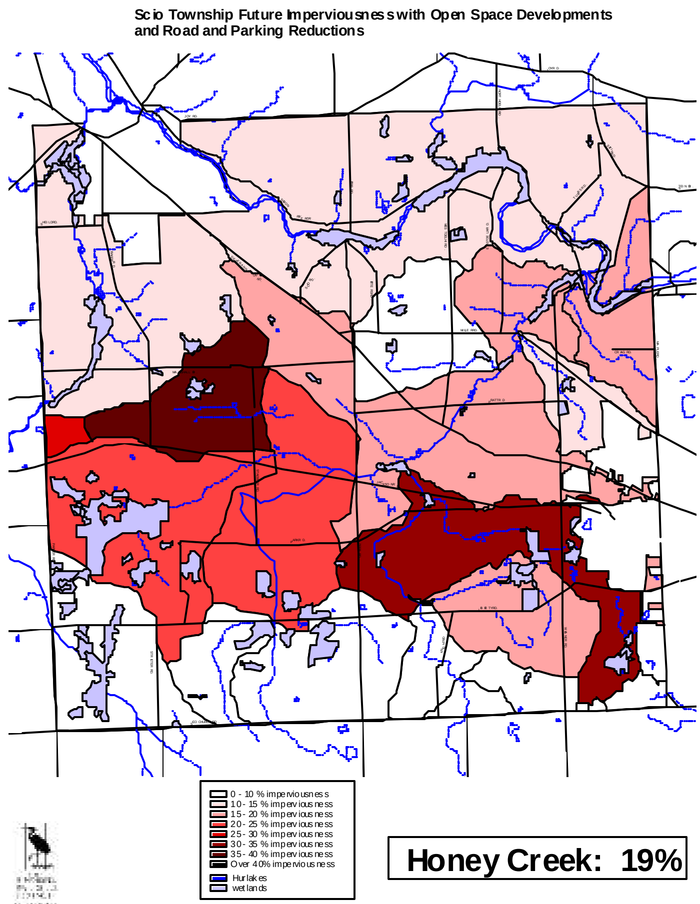
3. CONCLUSIONS

The current imperviousness of Honey and Fleming Creeksheds is 12% and 9%, respectively. The original assumption of this study was that, by amending development standards to minimize the future impervious cover, this figure could be kept below 15% as the townships grow. Additionally, by delineating the creeksheds into smaller units, or sub-basins, appropriate impervious limits could be set for each sub-basin, and a more targeted approach to stormwater best management practices could be applied to highly-affected areas (Figure 6, Honey Creek).

It was assumed that amending development standards would substantially reduce total imperviousness, and the sub-basin analysis would insure that imperviousness was not concentrated within a small area of the creekshed without proper mitigation. These assumptions proved optimistic.

The study concluded that amending development standards could reduce imperviousness, but savings were not as high as expected. The Olympia, Washington study concluded that reductions of 20% were possible in that particular study area. This local study found that potential reductions were closer to 14% reduction. The different conclusions were largely due to reduction opportunities available in urban settings that were not attainable locally.

Figure 6
Buildout Imperviousness by Sub-Creekshed in Honey Creek Basin



The Fleming Creek segment in Superior Township was the only area among the three that could be maintained below 15%. However, this area of Superior Township is zoned at such low-densities that total imperviousness would be below this level regardless of ordinance changes recommended by this study.

Ordinance amendments alone will not achieve a 15% limit in Honey Creekshed and in the Fleming Creek segment within Ann Arbor Township. Because most development is inherently more that 15% impervious, this level could only be achieved by rezoning to lower densities (Table 4). This is not a realistic long-term strategy in the study area.

At this point, imperviousness reduction must also be viewed in the larger context. If further impervious reductions require lower density development, and the demand for land remains constant, then such an approach will push development further out to the next creekshed or township. Several important questions then emerge. Does it serve the townships involved to incorporate lower density zoning just a few miles from a metropolitan area, and in districts serviced by sewer and water? What contribution will zoning based solely on imperviousness have on sprawl? Are very low-density lots marketable or exclusionary? What are the alternatives? From a watershed protection standpoint, is it any better to plan for highly impervious development affecting only a small area; or spread it out, affecting a wider region?

Table 4
Imperviousness Values by Density

Land Use	Density (Homes /ac)	Impervious (%)
Low Density Res.	0.1	2.4
	0.5	12
	1	20
Medium Density Res.	2	25
	4	38
High Density Res.	5-7	50
Mobile Homes		60
Multi-family Townhouse	>7	65
Industrial		72
Commercial/Office		56

Fortunately, there are other, more appropriate tools to manage stormwater runoff and protect water quality that do not perpetuate inefficient use of land. The same literature that documents water resource degradation at 10% - 15% imperviousness cautions against zoning based solely on impervious cover (Schueler, 1994a). Instead experts favor a more comprehensive approach to watershed protection that incorporates stormwater BMPs to mitigate the *effects* of runoff generated by impervious cover. The following section discusses this approach in more detail.

LESSONS LEARNED:
Although ordinance amendments did not yield imperviousness reductions below the 15% limit, it is important to appreciate the significance of the savings that can be achieved. For Honey Creekshed to be built out to 19% rather than 22% imperviousness translates to 535 acres less pavement. The average annual precipitation in Honey Creekshed is 31 inches. Of these 31 inches of precipitation, 29 inches would run off an impervious site, as opposed to only 6 inches from open space (assuming Rv .95 and .2 respectively). Though 535 acres of additional open space alone would not preserve water quality within Honey Creek, it is a significant positive step. This reduction in runoff, coupled with the mitigation strategies discussed in the next section of this report, represents a more comprehensive approach to stream protection that will prove far more effective than current land development patterns.

STORMWATER BEST MANAGEMENT PRACTICES

INTRODUCTION:
While efforts to limit imperviousness in new development certainly reduce stormwater runoff, long-term improved management and treatment of the remaining stormwater is also necessary if water quality is to be preserved. The second task of the project was to examine existing and potential management practices such as stormwater ponds, swales, and landscape practices, for their effectiveness in treating stormwater pollution, and to develop a viable regulatory tool that ensures application of these practices in new development.

The hydrologic effect of impervious cover is complex. Because ground infiltration is bypassed, runoff is different from natural water flow in many ways, including:

- Increased Volume and Velocity
- Longer and Higher Peak Flows Downstream
- Increased Temperature and Contamination

As previously discussed, imperviousness reduction is one site design element that counters these effects. Storage ponds also play a critical flood control and pollution abatement role by moderating stormwater discharge offsite and allow pollutants to settle out (Figure 7).

Figure 7
Stormwater Ponds Detain Runoff and Allow Pollutants to Settle

But while effective in reducing flooding and providing limited water quality treatment, ponds are at best an end-of-the-pipe solution. Combining additional BMPs – overland conveyance, vegetation management and onsite retention – with impervious cover reduction and improved stormwater ponds provides a more comprehensive approach to addressing the full range of water quality concerns inherent in stormwater runoff (Horner et. al., 1994).

This “treatment train” approach more effectively utilizes stormwater as an onsite resource, protecting downstream water and property by preserving hydrology and emulating the pre-development flow of water over the land. While this approach is simple in theory, this is a difficult concept to prescribe in a one-size-fits-all regulation suitable for all new development. However, it is reasonable to prescribe a performance standard addressing specific stormwater quality concerns resulting from all development. A performance standard would insure consistent application of stormwater treatment measures; yet allow site-specific conditions to determine how the standard is met. This project offers the participating Townships a Stormwater Management and Treatment Ordinance prescribing such a performance standard (Appendix 3). The specific elements of this ordinance are detailed below.

STORMWATER MANAGEMENT AND TREATMENT ORDINANCE:
The MDEQ has identified excess phosphorus as the principal water quality concern in the middle Huron and its tributaries – mandating 50% reduction. Several years of study by the Huron River Watershed Council's Middle Huron Initiative demonstrates that nearly half of this target must be achieved through improved stormwater management to treat nonpoint source phosphorus (Brenner, A., and Rentschler, P. 1996). Therefore, in developing a stormwater treatment ordinance for the Townships, total phosphorus became the primary criterion for evaluating the effectiveness of BMPs.

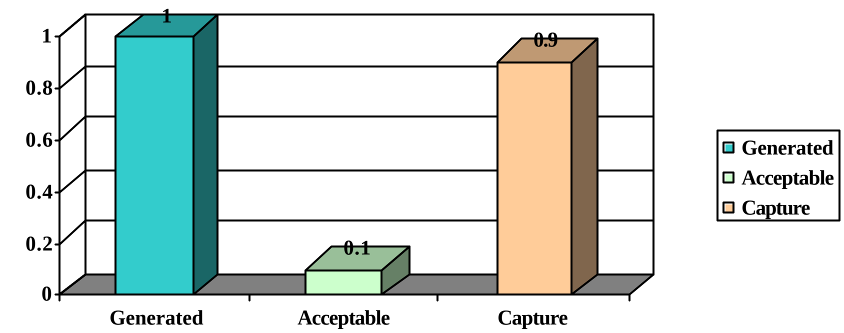
All impervious surfaces – parking lots, roads, and rooftops – generate a higher volume of runoff than would occur naturally on the land. Even lawn runoff can be problematic if the soil is sufficiently compacted or over-watered (Schueler, 1995a). This added volume of runoff carries a certain concentration of phosphorus and other pollutants depending the proportion of the site occupied (Schueler, 1999; USGS, 1999 and Schueler, 1994c). Phosphorus concentrations from rooftops, pavement and lawns add up to seasonal loads of ¼, ½ and 1.5 pounds per acre, respectively (Figure 8; see Ordinance material, Appendix 3, calculations).

Figure 8
Phosphorus Export by Land Cover and Treatment values

The ordinance requires that newly proposed development limit phosphorus runoff to one-tenth of a pound per acre (0.10 lb/acre). This is a level comparable to background phosphorus level that would be expected to runoff from the land before developed (Horner et. al., 1994; Reckhow et. al., 1980; Schueler, 1995b). (**NOTE: Since nonpoint source loading is dependent on rainfall and runoff, phosphorus loading is quantified for the months of May – October. Mandated reductions prescribed by the ordinance are based on the period as well.)

For instance, if an acre of residential development would generate 1 pound of phosphorus each season, and the performance standard is .1 lbs, then a development's stormwater treatment system would have to remove 0.9 pounds of phosphorus (Figure 9).

Figure 9
Phosphorus Performance Standard
(lbs/ac/yr)



On average, dry detention ponds can be counted on to remove 20% of the phosphorus entering them. Wet detention ponds can reduce phosphorus by 55%. Retention ponds provide full treatment, as water does not leave the site as runoff.

Other important elements of site design can improve water quality before runoff goes to a stormwater pond. Routing stormwater through a properly designed, vegetated swale can remove 35% of phosphorus. Compared to storm sewers, overland flow offers longer contact time with the soil and allows settling of pollutants, nutrient uptake by vegetation and complete infiltration of smaller rain events.

Rooftop drainage can also be directed to sheet flow onto vegetation, which will slow, filter and provide some infiltration of runoff. Natural landscaping can reduce runoff volume and pollutant load. Vegetated filters are another element of site design that remove 40% of the phosphorus concentration in runoff. The treatment efficiencies assigned to specific BMPs in the Ordinance are given in Table 5.

Table 5
BMP Efficiencies

Stormwater Best Management Practice (BMP)	BMP Efficiencies
Permanent Retention	1.0
Extended Detention Pond	.20
Wet Detention Pond	.55
Two-stage Pond and Wetland	.55
Disconnected Impervious Surfaces	.20
Water Quality Swales	.35
Filter Strips	.40
Sand Filter	.50
Infiltration Trench	.70
Offsite Stormwater Mitigation	Variable
On-site Treatment of Upland Runoff	Variable

(Brown and Schueler, 1997; Doll, 1996; Field et. al., 1993; Horner et. al., 1994; Schueler, 1997; US EPA, 1993)

Combining BMPs creates the so-called treatment train, where stormwater is being cleansed each step of the way. In Figure 10, parking lot runoff flows along the surface to a treatment swale, before going to the stormwater pond not shown in the photo. There is no point where the stormwater is conveyed below ground.

Figure 10
Above Ground Treatment

Although the ordinance mandates only phosphorus reduction, the same BMPs described above will also reduce suspended sediment in stormwater runoff by 60 -- 80%, hydrocarbons by 80 – 90%, and trace metals 40 – 80% (Schueler, 1997).

In addition to the performance standard there are other requirements of the ordinance aimed at reducing runoff including:

- Requiring aeration of compacted soils prior to finalizing zoning compliance
- Requiring rain sensors – a $40 instrument that shuts off automated watering systems when the soil is saturated. The photo of an active automated watering system was taken on a day when 2 inches of rain had fallen.

- Restricting drainage of natural depressions when more sensible solutions exist (Figure 11).

- And a provision for maintenance agreements, binding current and future users of the stormwater system to provide for regular upkeep.

Figure 11
Bioretention Using Natural Depressions

To provide guidance to site designers in meeting the standard, and to local governments in reviewing developments, treatment levels provided by ponds and other stormwater BMPs were thoroughly researched and a guidebook, Performance Standards and Design Criteria for Stormwater Best Management Practices, accompanies the ordinance. (A portion of this document, detailing the calculations required to determine phosphorus load and treatment sufficiency, is provided in Appendix 3. Copies of the full guidebook are available from the Washtenaw County Drain Commissioner's Office.) These criteria are taken from a variety of references including, the Rules of the Washtenaw County Drain Commissioner and the MDNR Guidebook of BMPs for Michigan Watersheds.

SUPPLEMENTAL MODEL ORDINANCES

The specific recommendations to reduce off-street parking and private road widths, and the complete stormwater ordinance and design guidebook have been submitted to the Townships for consideration. In addition there are several other model ordinances provided by this project that would supplement these efforts and further enhance water quality protection. They are as follows:

- Wetlands
- Natural Features
- Native Landscaping
- Open Space

Copies of these ordinances can be obtained from the Washtenaw County Drain Commissioner's Office.

CONCLUSIONS

The most instructive aspect of this study was the realization of the limited potential to restrict future impervious cover through ordinance amendments. The actual zoning districts within the individual townships are the overwhelming determinant of total watershed imperviousness. Without a substantial component of agricultural, open space or exceptionally low level development, the impervious percentage of even rural townships is likely to exceed stream protection thresholds. Without the use of more comprehensive stormwater best management practices, the effect on water quality and aquatic resources within the creeksheds will be detrimental.

With future implementation of BMPs recommended in this study, however, the threat posed by increased stormwater runoff can be effectively mitigated so that imperviousness levels in excess of 10 – 15% need not render water quality within Honey and Fleming Creeksheds "impaired" as defined by the Michigan Department of Environmental Quality.

Implementation of the recommendations provided in this study will enhance the Townships' ability to manage their stormwater, help protect Honey and Fleming Creeks, and contribute to phosphorus reduction prescribed by both the Middle Huron Initiative and likely requirements of future stormwater permits.

DEFINITIONS

Best Management Practice (BMP) is a practice or combination of practices that is determined by a state to be the most effective means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.

The **Hydrologic Cycle** is the movement of water. Water is constantly in motion between the land – including subsurface water tables, lakes, streams and wetlands – the air and the sea.

An **Impervious Surface** is anything that prevents the movement of water into the soil. Examples include, asphalt, rooftops and concrete.

Nonpoint Source Pollution is water pollution that cannot be traced to its specific origin or starting point.

A **Watershed** (or basin) is the area of surrounding land that drains into a stream, lake or wetland.

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< http://www.epa.gov/OWOW/NPS/MMGI/Chapter4/ch4-2a.html#Effectiveness >

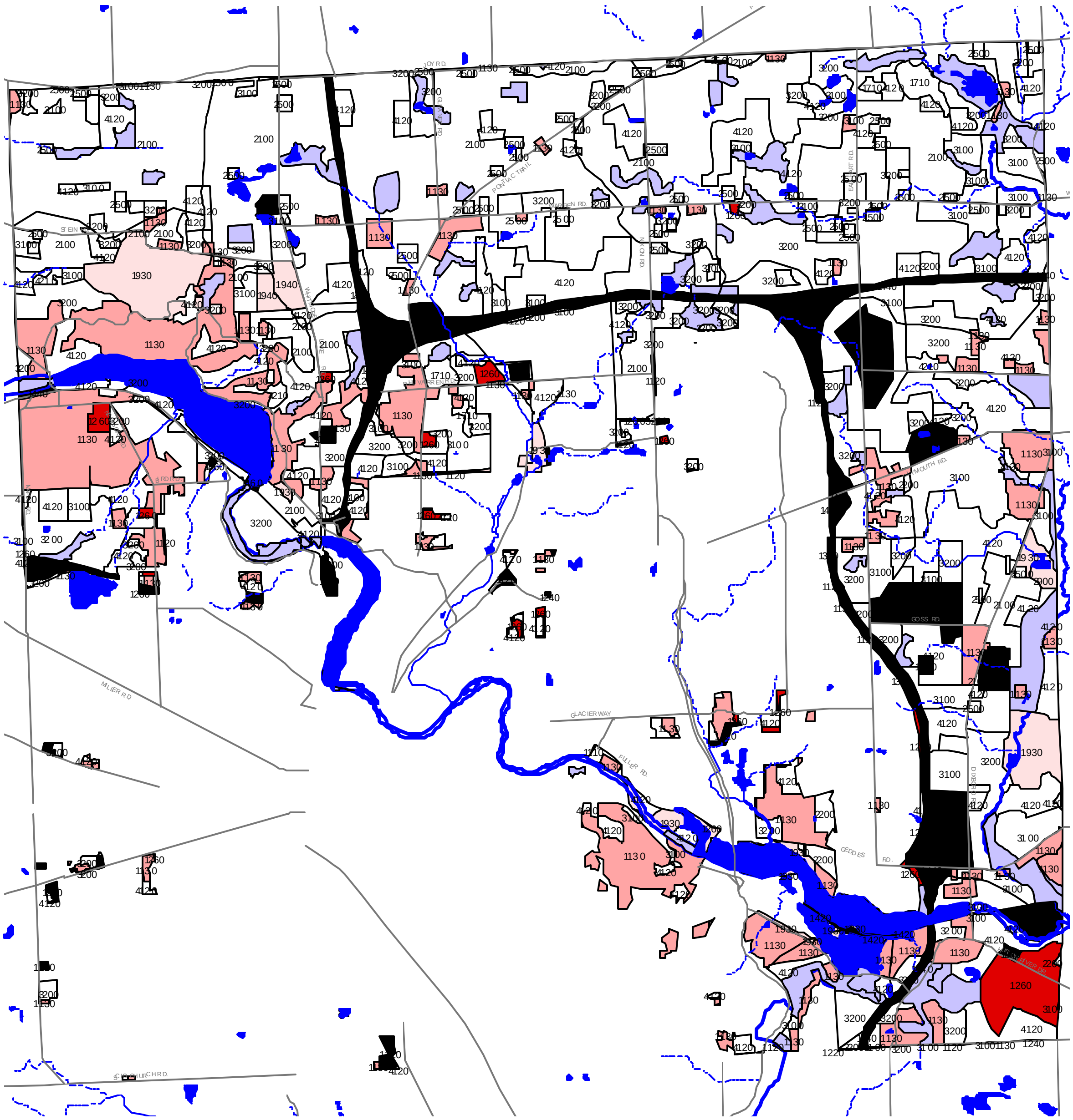
APPENDIX 1
GIS METHOD

Method for Determining Current Imperviousness
The Michigan Department of Natural Resource's Michigan Resource Inventory System (MIRIS) coverage provided an existing photo interpretation of development within the project area and was the foundation for determining current imperviousness. Imperviousness values were assigned using the values of the National Wet Weather Demonstration Project's Rouge Program Office and the Natural Resource Conservation Service impervious values (RPO, 1994 & Schueler, 1998b). Honey and Fleming Creekshed boundaries were then superimposed on the MIRIS land use coverage to determine current imperviousness.

Table 1
MIRIS Land Use and Associated Imperviousness Values

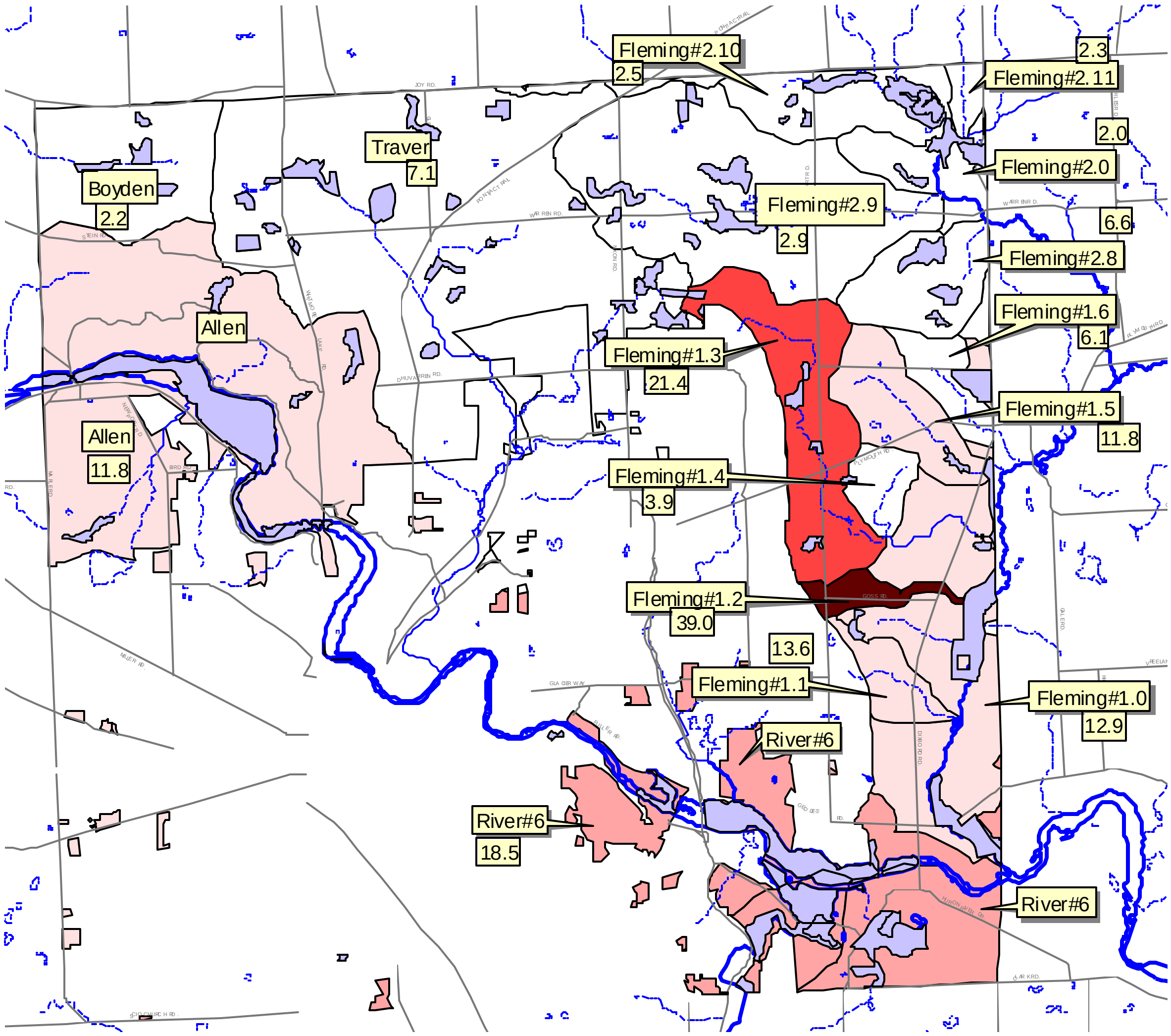
MIRIS Land Use	MIRIS Code	Imperviousness Value Assigned
Multi Family, Low Rise	1120	38
Single Family	1130	19
Mobile Home Park	1150	60
Strip Commercial	1240	56
Institutional	1260	28
Industrial	1310	72
Road	1440	53
Communications	1450	53
Utilities	1460	66
Open Pit	1710	10
Recreation	1930	11
Cemetery	1940	13
Cropland	**2100**	**2**
Orchard	**2200**	**2**
Farm House	**2500**	**2**
Rural Residential	**2900**	**11**
Non-forested Herbaceous	**3100**	**2**
Shrub	**3200**	**2**
Central Hardwood	**4120**	**2**
Pine	**4210**	**2**

A2 Township Imperviousness by Land Use



- 0 - 10 % imperviousness
- 10 - 15 % imperviousness
- 15 - 20 % imperviousness
- 20 - 25 % imperviousness
- 25 - 30 % imperviousness
- 30 - 35 % imperviousness
- 35 - 40 % imperviousness
- Over 40% imperviousness

Ann Arbor Township 1995 Imperviousness



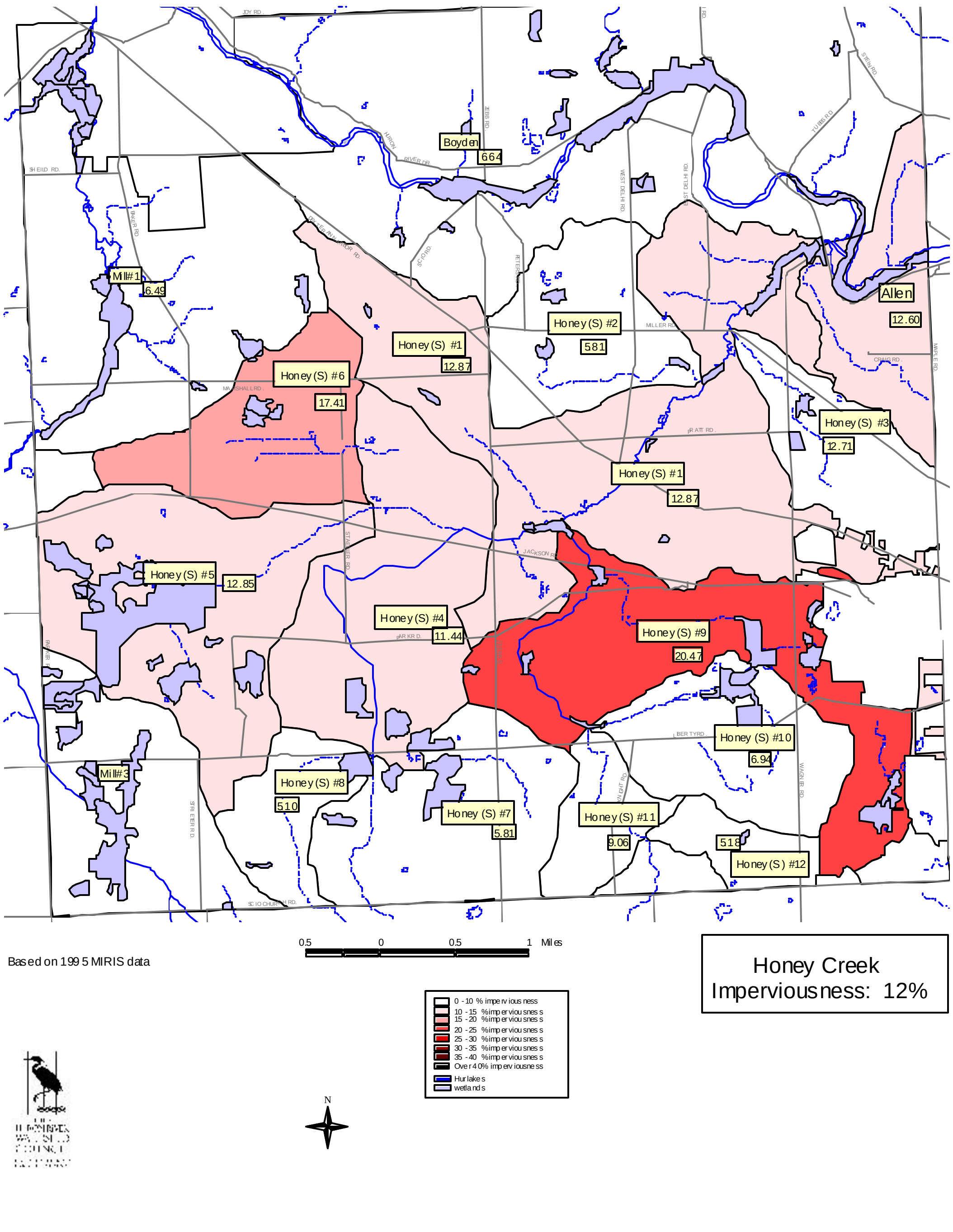
Based on 1995 MIRIS data

0.5 0 0.5 1 Miles

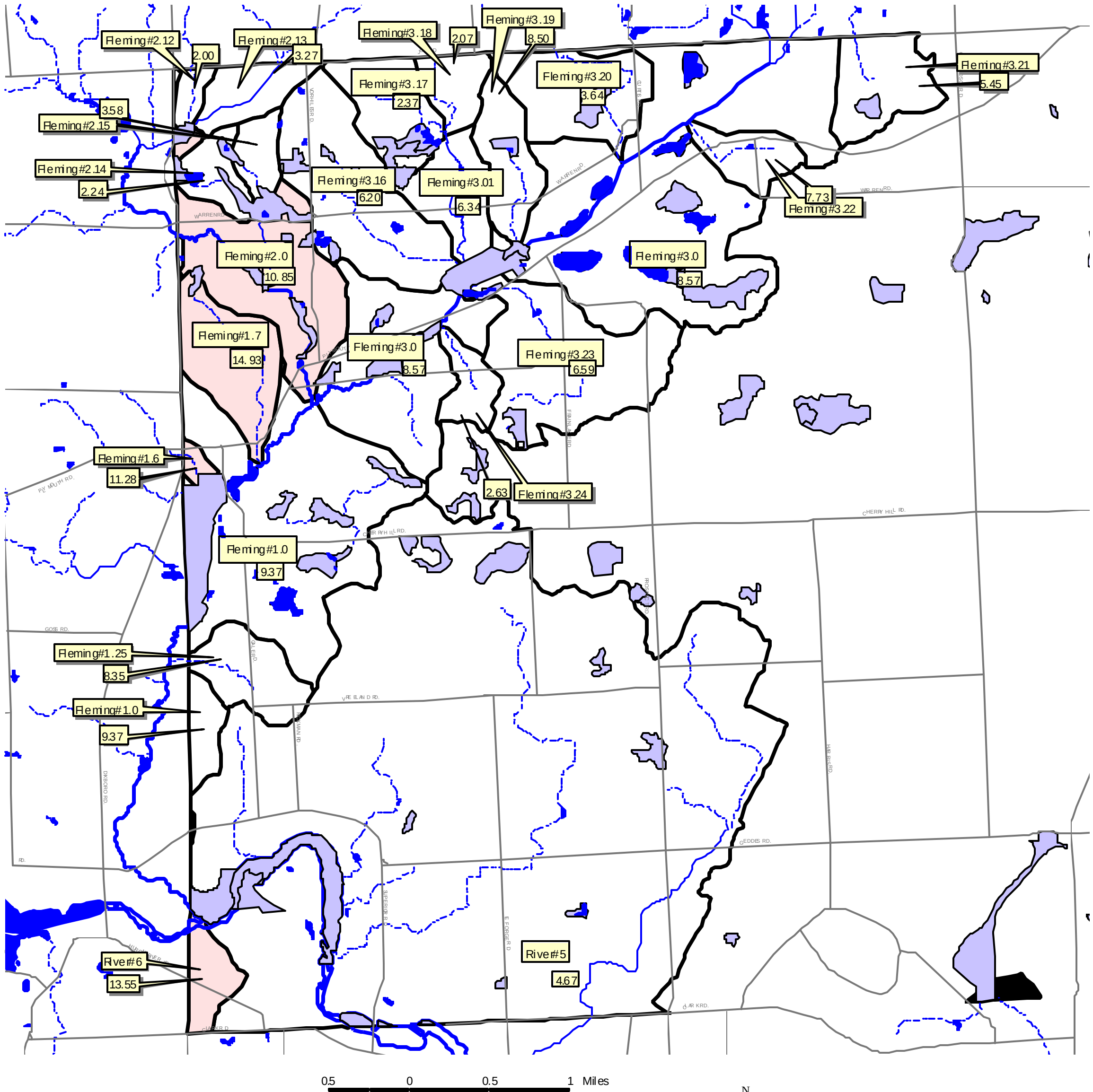
- 0- 10 % imperviousness
- 10 - 15 % imperviousness
- 15 - 20 % imperviousness
- 20 - 25 % imperviousness
- 25 - 30 % imperviousness
- 30 - 35 % imperviousness
- 35 - 40 % imperviousness
- Over 40% imperviousness
- Hurlakes
- wetlands

Upper Fleming: 3.2%
Lower Fleming: 15.0%

Scio Township 1995 Imperviousness



SuperiorTownship 1995 Imperviousness



Based on 1995 MIRIS data

- 0 - 10 % imperviousness
- 10 - 15 % imperviousness
- 15 - 20 % imperviousness
- 20 - 25 % imperviousness
- 25 - 30 % imperviousness
- 30 - 35 % imperviousness
- 35 - 40 % imperviousness
- Over 40% imperviousness
- Lakes
- wetlands

Imperviousness for:
Fleming #1: 10%
Fleming #2: 7%
Fleming #3: 7%
Fleming Total: 8%

Method for Determining Future Imperviousness

To determine future imperviousness the townships were divided into two coverages:

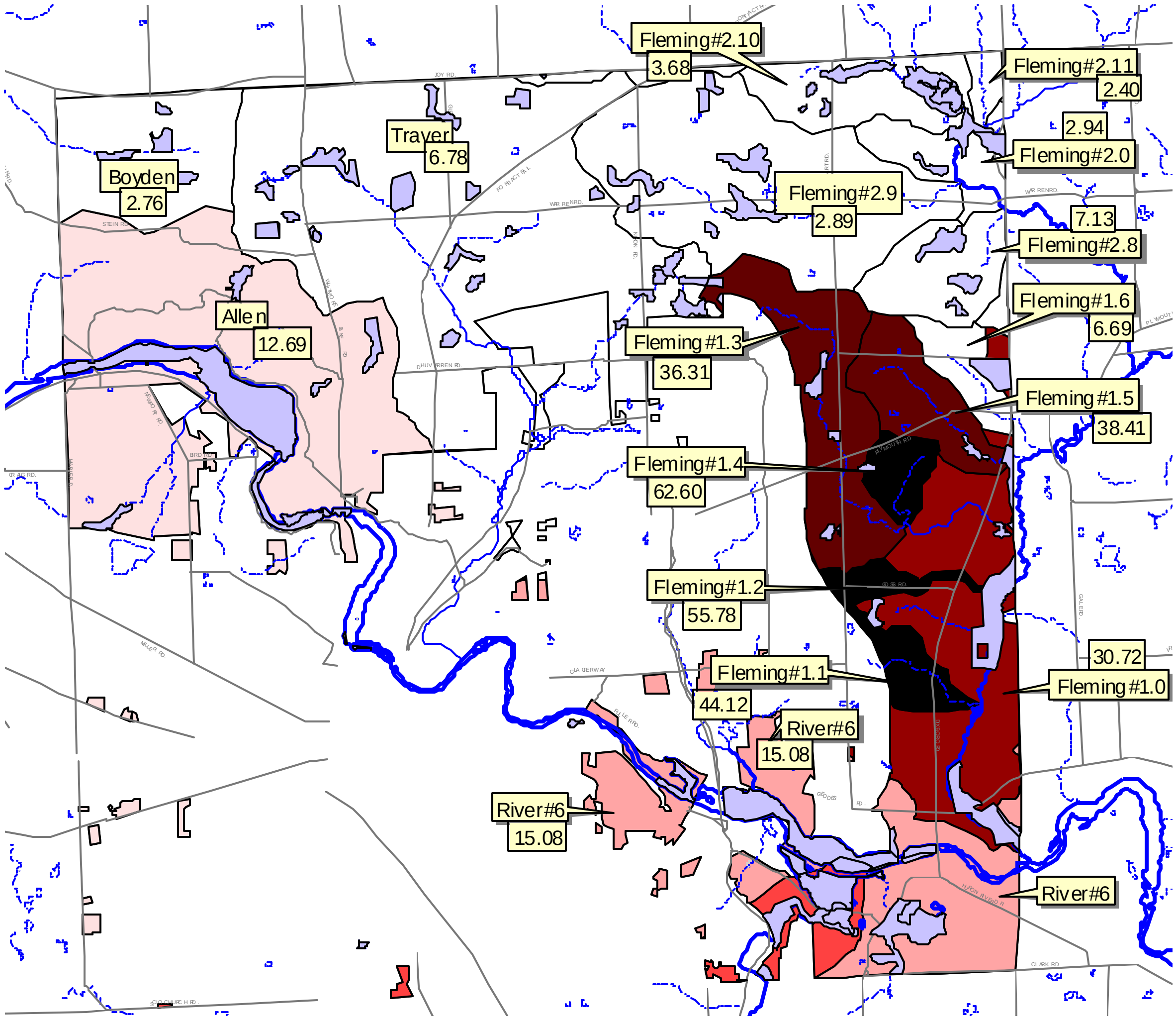
- Currently developed land (MIRIS Codes: 1120-1940)
- Buildable lots (MIRIS Codes: 2100-4210)

The imperviousness of currently developed land remained consistent with the values of the previous section throughout the analysis. Buildable lots were then assigning appropriate imperviousness values compatible with existing zoning. The values assigned are listed in the table 2. Assigning theses values to undeveloped and underdeveloped land yielded future imperviousness at buildout depicted following maps for all three townships.

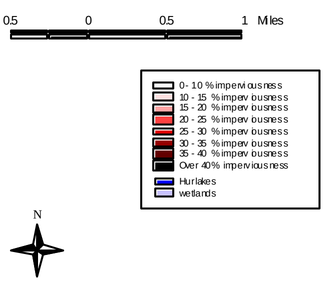
Table 2
Future Imperviousness Values by Zoning

Land Use per Zoning	Density (d.u. / acre)	Imperviousness Value
Low Density Res.	0.1	2.4
	0.2	4.8
	0.33	8.0
	0.4	9.6
	0.5	12
	1	20
Medium Density Res.	2	25
	3	30
	4	38
High Density Res.	5-7	50
Mobile Homes		60
Multi-family Townhouse	>7	65
Industrial		72
Commercial/Office		56

Ann Arbor Township Future Imperviousness

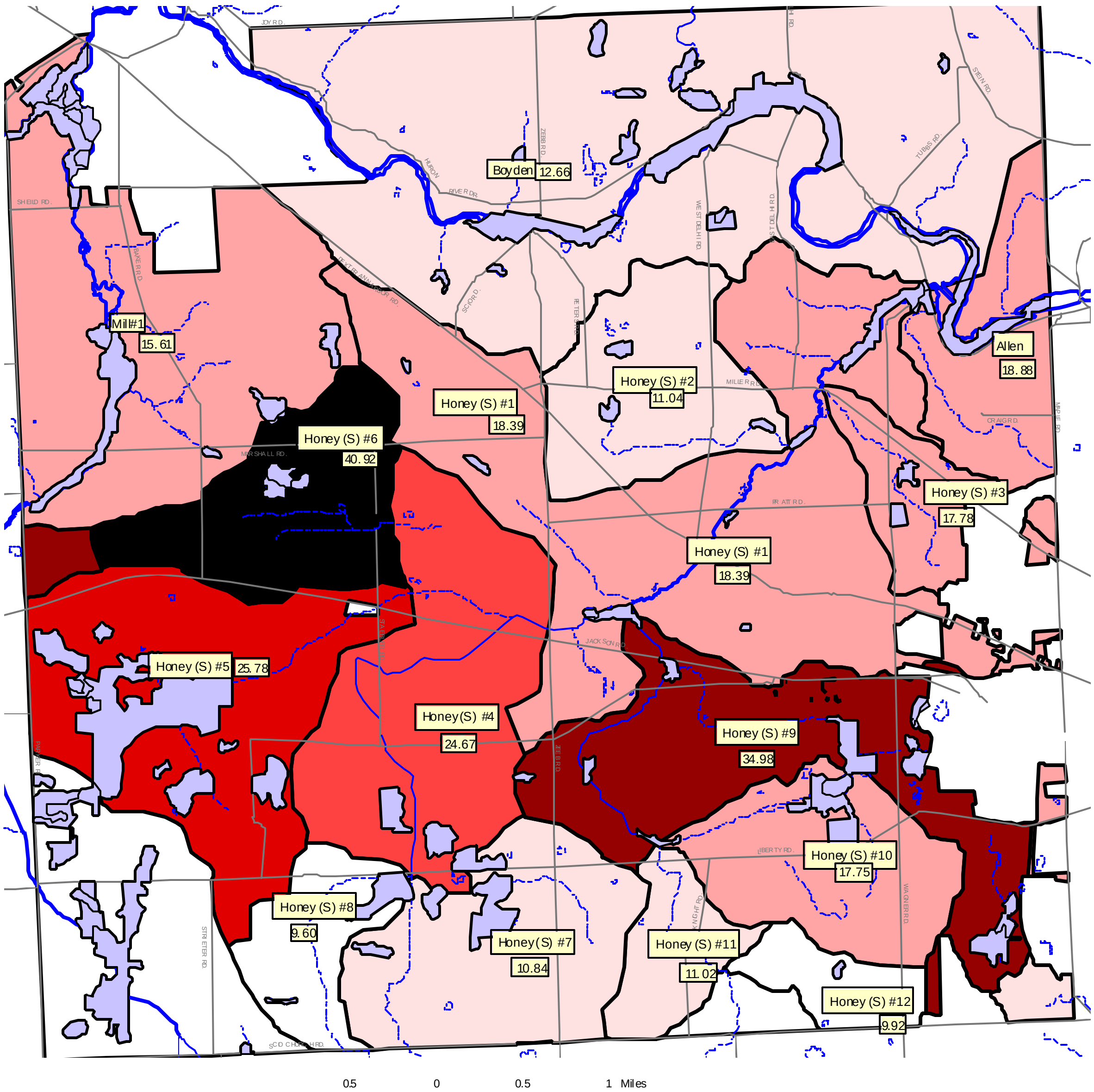


Based on Ann Arbor Township zoning map

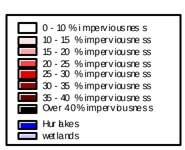


Upper Fleming: 3.6%
Lower Fleming: 34.9%

Scio Township Future Imperviousness from Zoning

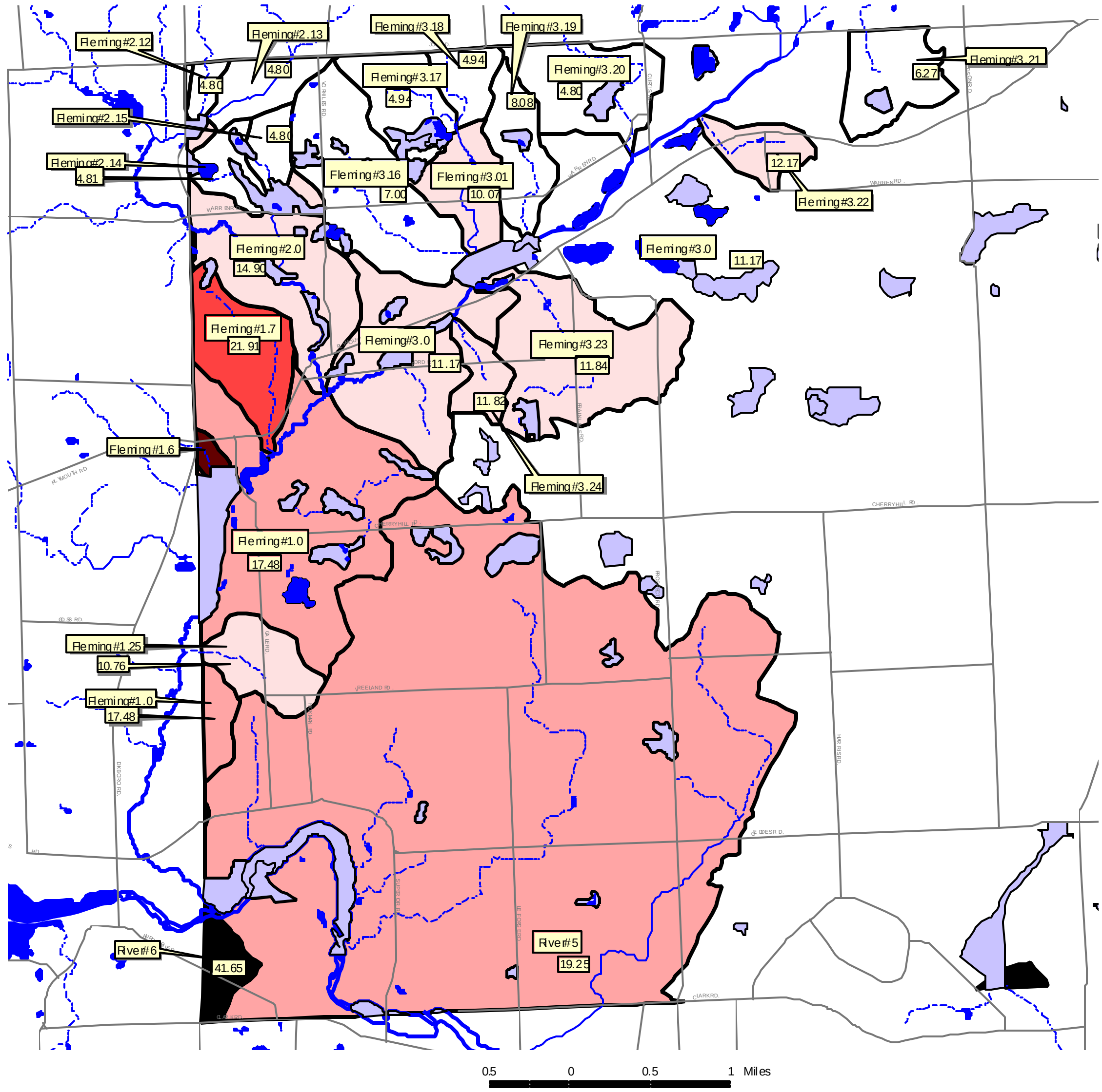


Based on Scio Township zoning map



Honey Creek
Imperviousness: 22%

Superior Township Imperviousness from Zoning Build Out



Based on SuperiorTownship zoning map

	0 - 10 % imperviousness
	10 - 15 % imperviousness
	15 - 20 % imperviousness
	20 - 25 % imperviousness
	25 - 30 % imperviousness
	30 - 35 % imperviousness
	35 - 40 % imperviousness
	Over 40% imperviousness
	lakes
	wetlands

Imperviousness for:
Fleming #1: 17.8%
Fleming #2: 11%
Fleming #3: 10%
Fleming Total: 12%

N

Method for Determining Imperviousness Reductions
From the "Impervious Values" associated with land uses (Table 2, above), imperviousness was broken down into the individual components (Table 3):

- Streets
- Sidewalks
- Parking and Driveway
- Building Footprint

These ratios were extrapolated from the Olympia, Washington study (City of Olympia, 1995).

Table 3
Breakdown of Impervious Cover

Land Use	Density (du / acre)	Impervious %	Ratio			
			Streets	Sidewalk	Parking Driveway	Roofs
Low Density Res.	0.1	2.4	0.400	0.075	0.150	0.375
	0.2	4.8	0.400	0.075	0.150	0.375
	0.33	8.0	0.400	0.075	0.150	0.375
	0.4	9.6	0.400	0.075	0.150	0.375
	0.5	12	0.400	0.075	0.150	0.375
	1	20	0.400	0.075	0.150	0.375
Medium Density Res.	2	25	0.400	0.075	0.150	0.375
	3	30	0.400	0.075	0.150	0.375
	4	38	0.400	0.075	0.150	0.375
High Density Res.	5-7	50	0.400	0.075	0.150	0.375
Mobile Homes		60	0.229	0.104	0.313	0.354
Multi-family Townhouse	>7	65	0.229	0.104	0.313	0.354
Industrial		72	0.035	0.047	0.616	0.302
Commercial		56	0.035	0.047	0.616	0.302

Next, imperviousness reductions were assigned to Streets and Parking/Driveways (Table 4; italics) based on:

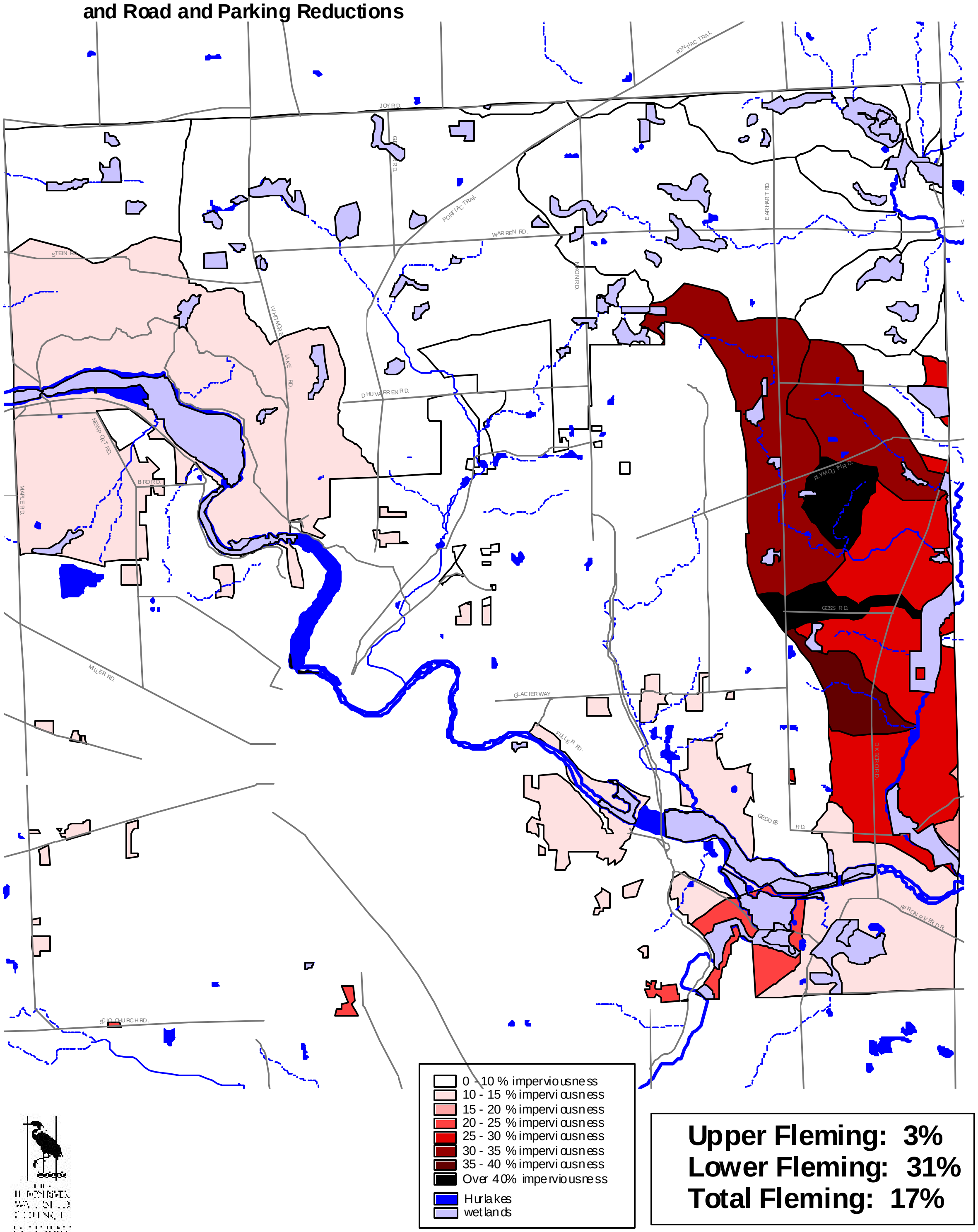
- Open space development (clustering) resulting in 20% less imperviousness attributed to reduced road and driveway lengths compared to conventional design (Schueler, 1994b).
- Reduction in residential road widths to 22 feet by amending private road standards (ASCE, 1990).
- Parking lot reduction resulting in 20% less imperviousness than conventional site development. This could be achieved with smaller stalls (9 x 18), compact car parking, reduced aisle widths, and lower parking ratios per square foot of floor area (Schueler, 1995b).

Table 4
Starting and Ending Imperviousness Cover
Based on Reductions Through Ordinance Amendments

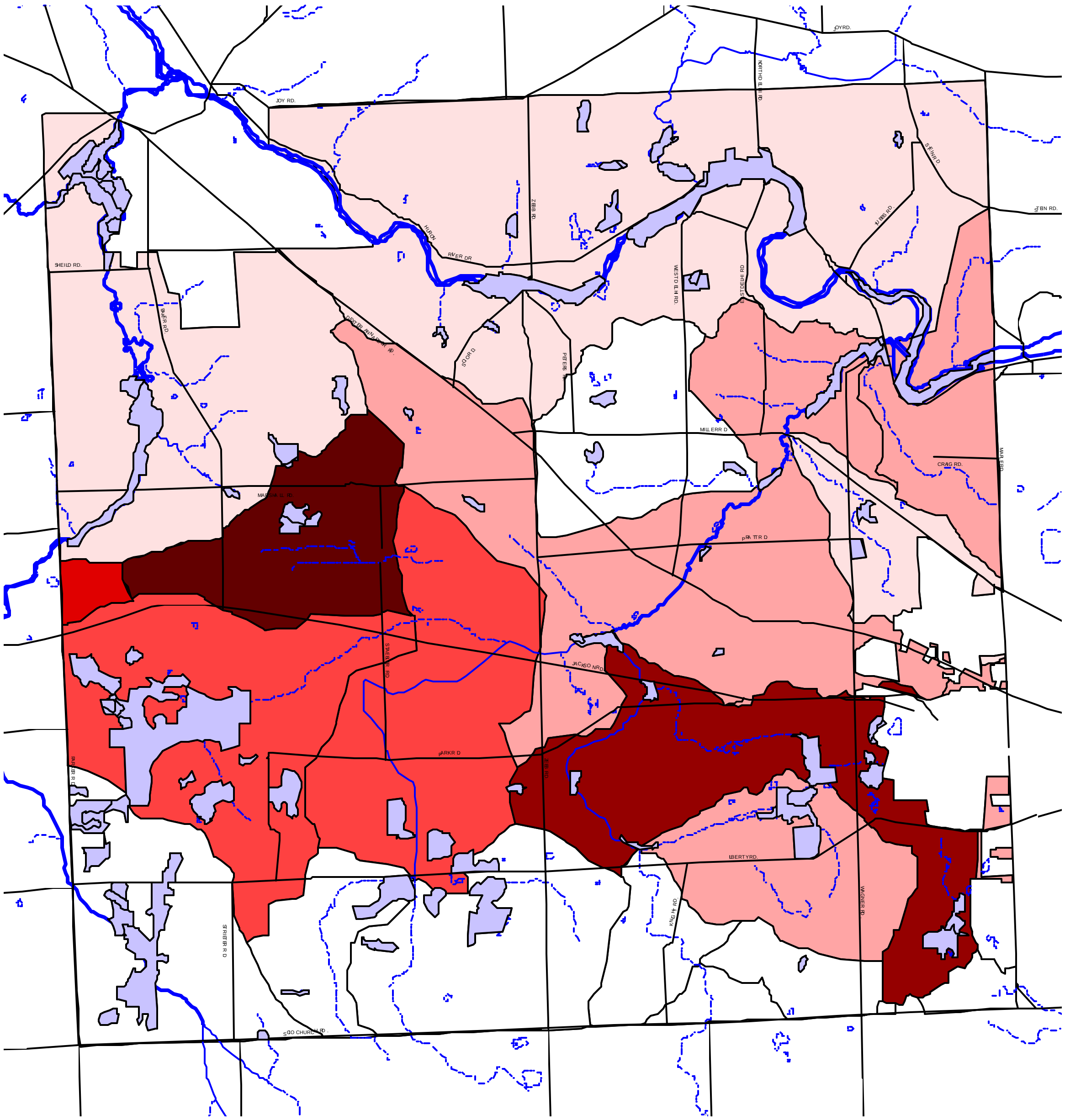
Land Use	Density (du / acre)	**Start (%)**	Streets	Sidewalk	Parking & Driveway	Roofs	**End (%)**
Low Density Res.	0.1	***1.9***	*0.58*	0.14	0.29	0.72	1.73
	0.2	***3.8***	*1.15*	0.29	0.58	1.44	3.46
	0.33	***6.4***	*1.92*	0.48	0.96	2.40	5.76
	0.4	***7.7***	*2.30*	0.58	1.15	2.88	6.91
	0.5	***9.6***	*2.88*	0.72	1.44	3.60	8.64
	1	***16***	*4.80*	1.20	2.40	6.00	14.40
Medium Density Res.	2	***20***	*6.00*	1.50	3.00	7.50	18.00
	3	***24***	*7.20*	1.80	3.60	9.00	21.60
	4	**38**	*11.40*	2.85	5.70	14.25	34.20
High Density Res.	5-7	**50**	*15.00*	3.75	7.50	18.75	45.00
Mobile Homes		**60**	13.74	6.24	*15.02*	21.24	56.24
Multi-family Townhouse	>7	**65**	14.89	6.76	*16.28*	23.01	60.93
Industrial		**72**	2.52	3.38	*35.48*	21.74	63.13
Commercial		**56**	1.96	2.63	*27.60*	16.91	49.10

The resulting imperviousness reductions are given in the final column "End (%)" in Table 4. The final imperviousness – based on reductions in street widths, flexible parking standards, and open space development – were then used to create an alternative buildout analysis. These analyses are depicted as follows:

Ann Arbor Township Future Imperviousness with Open Space Developments and Road and Parking Reductions



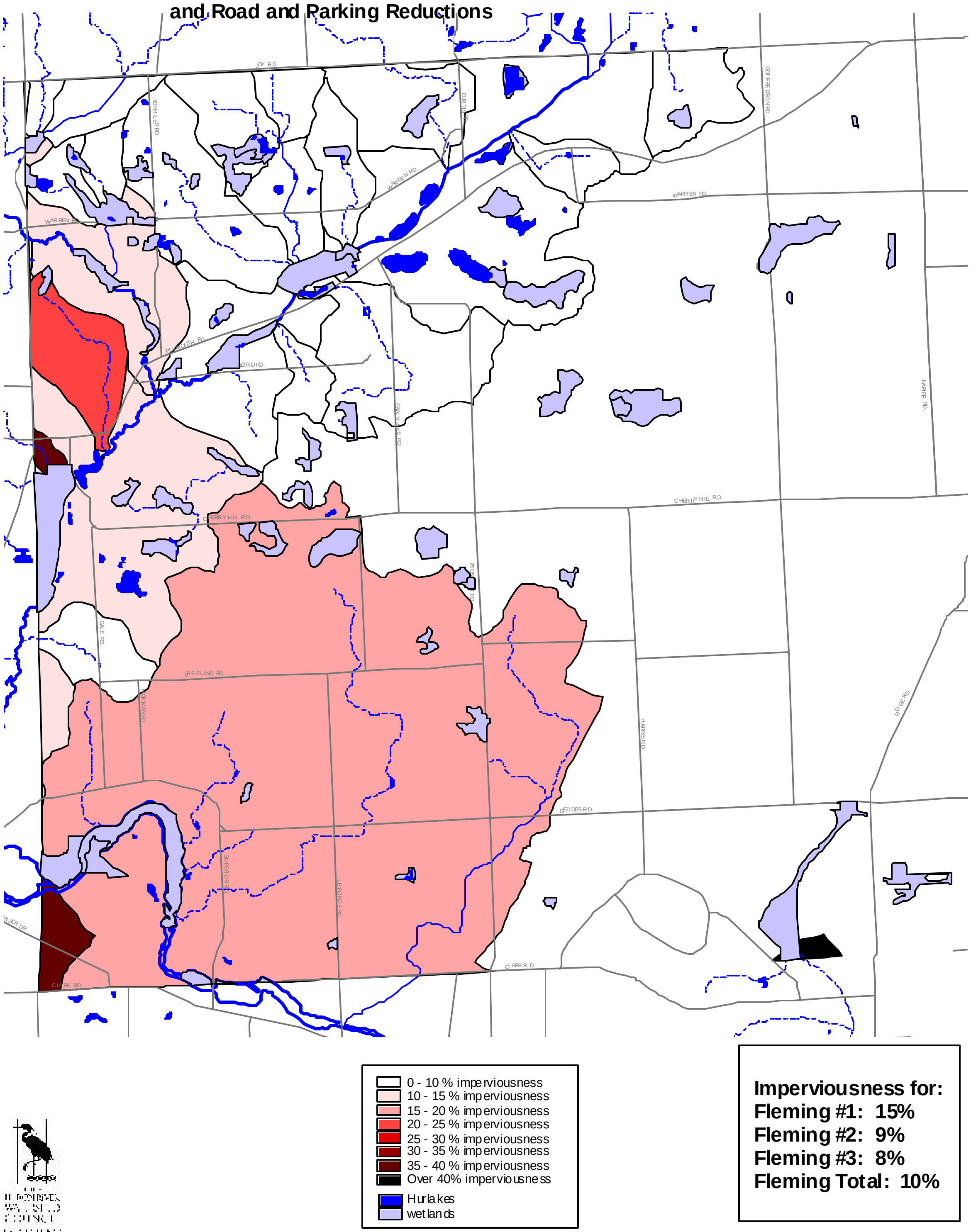
Scio Township Future Imperviousness with Open Space Developments and Road and Parking Reductions



- 0 - 10 % imperviousness
- 10 - 15 % imperviousness
- 15 - 20 % imperviousness
- 20 - 25 % imperviousness
- 25 - 30 % imperviousness
- 30 - 35 % imperviousness
- 35 - 40 % imperviousness
- Over 40% imperviousness
- Hurlakes
- wetlands

Honey Creek: 19%

Superior Township Future Imperviousness with Open Space Developments and Road and Parking Reductions



A summary table of current, future and future reduced imperviousness provides the breakdown of sub-basin imperviousness for Scio Township (Table 5).

Table 5
Current, Future and Future Reduced Imperviousness Values

Sub-basin	Acreage	Current Imperviousness	Imperviousness from zoning	Imperviousness from zoning with reductions
Honey (S) #1	2867.83	12.87	18.39	16.29
Honey (S) #10	841.28	6.94	17.75	15.53
Honey (S) #11	346.56	9.06	11.02	9.21
Honey (S) #12	258.30	5.18	9.92	7.63
Honey (S) #13	125.72	3.86	9.60	7.20
Honey (S) #2	818.10	5.81	11.04	8.92
Honey (S) #3	405.39	12.71	17.78	14.84
Honey (S) #4	1469.87	11.44	24.67	21.45
Honey (S) #5	1690.78	12.85	25.78	23.04
Honey (S) #6	866.64	17.41	40.92	36.74
Honey (S) #7	1079.50	5.81	10.84	8.73
Honey (S) #8	438.86	5.10	9.60	7.44
Honey (S) #9	1503.41	20.47	34.98	31.08
Total Honey	**12712.24**	**12**	**22**	**19.00**
* Based on zoning map, with all remaining buildable open space converted to one acre lots				

Detailed GIS Method

The following Memo Outlines the Huron River Watershed Council's step-by-step method for performing GIS analysis of current and future imperviousness outlined in this appendix:

> *Note: This memo includes instructions for additional buildout analyses not reported in this document but were performed to provide supplemental information to the Townships:*

From: **Kris Olsson**
To: **Washtenaw County Drain Commissioner's Office**
Subject: **GIS method for Great Lakes Protection Fund Imperviousness Analysis**
Date: **November 1, 1999**

Imperviousness Buildout Procedures:

Make *twp*zoning.dbf tables for each township. These are look up tables to associate zoning type with imperviousness. To do this, sum the zoning.dbf from the shape file on the zoning field. Add impervious, new impervious, and open space imervious, fields. Or any fields you want to associate to zoning type.

"look up tables" I created:	from shape file:
A2twpzon.dbf	a2twpzon-w
A2twpzonfancy.dbf	the above table, with 20% imp for Ag/rural land
A2twpflum.dbf	a2twpmasterplan
A2twpflumfancy.dbf	the above table, with 20% imp for Ag/rural land
Sciozoning.dbf	scio_zoning-w
Sciotwpzonfancy.dbf	the above table, with 20% imp for Ag/rural land
Scioflumlut.dbe	scioflum
Sciotwpflumfancy.dbf	the above table, with 20% imp for Ag/rural land
Supzoning.dbf	supzoning-w
Suptwpzonfancy.dbf	the above table, with 20% imp for Ag/rural land
Supflumlut.dbf	supflum
Suptwpflumfancy.dbf	the above table, with 20% imp for Ag/rural land

Fields I created in each table:
Hrwc_imp – impervious percentages we determined for each zoning type
New_imp – imperviousness as a result of parking lot reductions in commercial/industrial/multi-family, or road reductions in residential
Opsp_imp – imperviousness as a result of conservation design in residential subdivisions
Op+p_imp - imperviousness as a result of conservation design and parking/road reductions

Current imperviousness from MIRIS:
Imperviousness by polygon:

Take water out of land use coverage ("town95" or *twpname*95) by using theme properties to select MIRIS land codes not equal to 5000 - 6999. Then convert that to a shape file (*theme*95-w). Add table that shows impervious figures for each MIRIS land code. By showing the impervious figure in the theme, you can show imperviousness by polygon.

Imperviousness by watershed:
INTERSECT **theme95-w** on **subsheds.** When the computer asks what fields you'd like in the resulting them, take the "hrwc_imp" field from **theme95-w**, and take the subsubsheds and subsheds fields from **subsheds.** You get a new **themex**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*hrwc_imp/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over merge_shape, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twp95subimp** or something like that.

<u>Future imperviousness from zoning:</u>
Imperviousness by polygon:
Take water out of the zoning map. CLIP the **__twp** boundary coverage on a **water& wetland** land use coverage to create **__twp w&w** only. ERASE **__twp zoning** with **__twp w&w**. Do THEME PROPERTIES on the resulting theme to find zoning <> “” (all the water will have blank for zoning). Then CONVERT this to a shapefile - **__twp zoning-w**.

JOIN __*twpzoning.dbf* look up table to **__twp zoning-w.** You now have imp% per polygon

<u>Coverages created:</u>
A2zon-w
Scio_zoning-w
Supzoning-w

Imperviousness by watershed:
INTERSECT **__twp zoning-w** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take the hrwc_imp field from **zoning-w**, and take the subsubsheds field from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*hrwc_imp/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over merge_shape, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpfutsubimp** or something like that.

Coverages created:
A2bo
Sciobuildout
Superbuildout

Future imperviousness from zoning, but with reductions from roads and parking.

JOIN __*twpzoning.dbf look up table* to **_twpbuiltzon-w**, and to **_twpunbuiltzon-w.** ADD FIELD on to the tables of those coverages called *imp_to_use*. In the **_twpbuiltzon-w** table, calculate *imp_to_use* = *Hrwc_imp*. In the **_twpunbuiltzon-w** table, calculate *imp_to_use* = *new_imp*.

MERGE **__twpbuiltzon-w** and **__twpunbuiltzon-w.** Name this new coverage **__twpreducedimp** or something. *Imp_to_use* is the imp% of each polygon.

Coverages created:
A2zonroads
Sciozonroads
superzonroads

Future imperviousness build out with road and parking reductions, by watershed:
INTERSECT **__the above coverage** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, the imp_to_use field from **the above coverage**, and take the subsubsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*imp_to_use/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpfutroadssubimp** or something like that.

Coverages created:
A2boroads
Scioboroads
Superbuildoutroads

Future imperviousness from zoning, but with reductions from open space developments.
JOIN __*twpzoning.dbf look up table* to **_twpbuiltzon-w**, and to **_twpunbuiltzon-w.** You may have already done this above. ADD FIELD on to the tables of those coverages called *imp_to_use*. (You may have already done this for imp_to_use for roads/setback reductions. You can recalculate it). In the **_twpbuiltzon-w** table, calculate *imp_to_use* = *Hrwc_imp*. In the **_twpunbuiltzon-w** table, calculate *imp_to_use* = *opsp_imp*.

MERGE **__twpbuiltzon-w** and **__twpunbuiltzon-w.** Name this new coverage **__twpopenspaceimp** or something.

Coverages created:
A2zonopensp
Superzonopensp
Sciozonopensp

Future imperviousness build out with open space reductions, by watershed:
INTERSECT **__the above coverage** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take the imp_to_use field from **the above coverage**, and take the subsubsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*imp_to_use/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpfutopenspacesubimp** or something like that.

Coverages created:
A2opensp
Superopensp
scioopensp

Future imperviousness from zoning, but with reductions from open space developments and parking.
JOIN __*twpzoning.dbf look up table* to **_twpbuiltzon-w**, and to **_twpunbuiltzon-w.** You may have already done this above. ADD FIELD on to the tables of those coverages called *imp_to_use*. (You may have already done this for imp_to_use for roads/setback reductions. You can recalculate it). In the **_twpbuiltzon-w** table, calculate *imp_to_use* = *Hrwc_imp*. In the **_twpunbuiltzon-w** table, calculate *imp_to_use* = *op+p_imp*.

MERGE **__twpbuiltzon-w** and **__twpunbuiltzon-w.** Name this new coverage **__twpopsp&pkgimp** or something.

Coverages created:
A2zonopsp_p
Sciozonopsp+p
Superzonopsp+p

Future imperviousness build out with open space & pkg. reductions, by watershed:
INTERSECT **__the above coverage** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take the imp_to_use field from **the above coverage**, and take the

subsubsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*imp_to_use/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpfutopsp+pkgsubimp** or something like that.

Coverages created:
A2opsp+p
Scioopsp+p
Superopsp+p

Future imperviousness from zoning, with all Agriculture converted to one acre lots:

Imperviousness by polygon:
JOIN *__twpzonfancy.dbf* look up table to **__twp zoning-w.** But first, remove the join with the *__twpzoning.dbf*, or use a different copy of **__twpzoning-w.** You now have imp% per polygon

Coverages created:
A2zon-w
Scio-zoning-w
Supzoning-w

Imperviousness by watershed:
INTERSECT **__twp zoning-w** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take hrwc_imp from **zoning-w**, and take the subsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*hrwc_imp/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpfutsubimp** or something like that.

Coverages created:
A2fancybuildout
Sciofancybuildout
Superfancybuildout

Future imperviousness from zoning, with Agriculture=20%, but with reductions from roads and parking.

JOIN __*twpzonfancy.dbf look up table* to **_twpbuiltzon-w**, and to **_twpunbuiltzon-w.** Remember to remove any previous joins, or use a new copy of those themes. CALCULATE *imp_to_use*. In the **_twpbuiltzon-w** table, calculate *imp_to_use* = *Hrwc_imp*. In the **_twpunbuiltzon-w** table, calculate *imp_to_use* = *new_imp*.

MERGE **__twpbuiltzon-w** and **__twpunbuiltzon-w.** Name this new coverage **__twpfancyreducedimp** or something.

Coverages created:
A2zonfancyrds
sciozonfancyrds
superzonfancyrds

Future imperviousness build out(Ag. = 20%) with road and parking reductions, by watershed: INTERSECT **__the above coverage** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take imp_to_use from **zoning-w**, and take the subsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area* imp_to_use/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpfancyfutroadssubimp** or something like that.

Coverages created:
A2fancyroadsbo
sciofancyroadsbo
superfancyroadsbo

Future imperviousness from zoning, with Agriculture=20%, but with reductions from open space developments.

JOIN __*twpzonfancy.dbf look up table* to **_twpbuiltzon-w**, and to **_twpunbuiltzon-w.** Remember to remove any previous joins, or use a new copy of those themes. CALCULATE *imp_to_use*. In the **_twpbuiltzon-w** table, calculate *imp_to_use* = *Hrwc_imp*. In the **_twpunbuiltzon-w** table, calculate *imp_to_use* = *opsp_imp*.

MERGE **__twpbuiltzon-w** and **__twpunbuiltzon-w.** Name this new coverage **__twpfancyopenspaceimp** or something.

Coverages created:

A2fancyzonopenspace sciofancyzonopsp superfancyzonopsp

Future imperviousness build out(Ag. = 20%) with open space reductions, by watershed:
INTERSECT **__the above coverage** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take Imp_to_use from **__the above coverage**, and take the subsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area* imp_to_use/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpfancyfutopenspacesubimp** or something like that.

Coverages created: A2fancyopenspbo sciofancyopsp superfancyopsp

Future imperviousness from zoning, with Agriculture=20%, but with reductions from open space developments and parking/road widths

JOIN *__twpzonfancy.dbf look up table* to **_twpbuiltzon-w**, and to **_twpunbuiltzon-w.** Remember to remove any previous joins, or use a new copy of those themes. CALCULATE *imp_to_use*. In the **_twpbuiltzon-w** table, calculate *imp_to_use = Hrwc_imp*. In the **_twpunbuiltzon-w** table, calculate *imp_to_use = opsp+p_imp*.

MERGE **__twpbuiltzon-w** and **__twpunbuiltzon-w.** Name this new coverage **__twpfancyopenspace+pimp** or something.

Coverages created: A2fancyzonopsp+p Sciofancyzonopsp+p Superfancyzonopsp+p

Future imperviousness build out(Ag. = 20%) with open space &pkg/rd reductions, by watershed:
INTERSECT **__the above coverage** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take imp_to_use from **the above coverage**, and take the subsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area* imp_to_use/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpfancyfutopenspace+psubimp** or something like that.

Coverages created:
A2fancyopsp+p
Sciofancyopsp+p
Superfancyopsp+p

Future imperviousness from FLUM:

Imperviousness by polygon:

Take water out of the FLUM map. UPDATE **__twp flum** with **__twp w&w**. Do THEME PROPERTIES on the resulting theme to find zoning <> "" (all the water will have blank for zoning). Then CONVERT this to a shapefile - **__twp flum-w**.

JOIN *__twpflum.dbf* look up table to **__twp flum-w.** You now have imp% per polygon

Coverages created:
A2twpflum-w
Scioflum-w

Imperviousness by watershed:

INTERSECT **__twp flum-w** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take hrwc_imp from **flum-w**, and take the subsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*hrwc_imp/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpflumfutsubimp** or something like that.

Coverages created:
A2flumbo
scioflumbo

Future imperviousness from flum, but with reductions from roads and parking.

REMOVE JOINS from **_twpbuiltzon-w**, and **_twpunbuiltzon-w**. CLIP **__twp flum-w** with **_twpbuiltzon-w**, and **_twpunbuiltzon-w** to create **__twpbuiltflum-w** and **__twpunbuiltflum-w.** JOIN *__twpflum.dbf look up table* to **_twpbuiltflum-w**, and to **_twpunbuiltflum-w.** ADD FIELD on to the tables of those coverages called *imp_to_use*. In the **_twpbuiltzon-w** table, calculate *imp_to_use* = *Hrwc_imp*. In the **_twpunbuiltzon-w** table, calculate *imp_to_use* = *new_imp*.

MERGE **__twpbuiltflum-w** and **__twpunbuiltflum-w.** Name this new coverage **__twpflumreducedimp** or something.

Coverages created:
A2flumroads

Future imperviousness build out with road and parking reductions, by watershed:
INTERSECT **__the above coverage** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take the imp_to_use field from **zoning-w**, and take the subsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*imp_to_use/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpflumroadssubimp** or something like that.

Coverages created:
A2flumroadsbo

Future imperviousness from flum, but with reductions from open space developments.
JOIN *__twpflum.dbf look up table* to **_twpbuiltflum-w**, and to **_twpunbuiltflum-w.** You may have already done this above. CALCULATE FIELD on to the tables of those coverages called *imp_to_use*. (This used to be imp_to_use for roads/setback reductions. You can recalculate it). In the **_twpbuiltflum-w** table, calculate *imp_to_use* = *Hrwc_imp*. In the **_twpunbuiltflum-w** table, calculate *imp_to_use* = *opsp_imp*.

MERGE **__twpbuiltflum-w** and **__twpunbuiltflum-w.** Name this new coverage **__twpflumopenspaceimp** or something.

Coverages created:
A2flumopensp

Future imperviousness flum build out with open space reductions, by watershed:

INTERSECT **__the above coverage** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take the imp_to_use field from **zoning-w**, and take the subsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*hrwc_imp/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpfutopenspacesubimp** or something like that.

Coverages created:
A2twpflumopenspbo

Future imperviousness from flum, with all Agriculture converted to one acre lots:

Imperviousness by polygon:
JOIN *__twpflumfancy.dbf* look up table to **__twpflum-w.** But first, remove the join with the *__twpzoning.dbf*, or use a different copy of **__twpflum-w.** You now have imp% per polygon

Coverages created:
A2twpflum-w

Imperviousness by watershed:
INTERSECT **__twp flum-w** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take zoning & all the imperviousness fields from **flum-w**, and take the subsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*imp_to_use/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpflumfancysubimp** or something like that.

Coverages created:
A2twpflumfancybo

Future imperviousness from flum, with Agriculture=20%, but with reductions from roads and parking.

JOIN *__twpflumfancy.dbf look up table* to **_twpbuiltflum-w**, and to **_twpunbuiltflum-w.** Remember to remove any previous joins, or use a new copy of those themes. CALCULATE

FIELD *imp_to_use*. In the **_twpbuiltflum-w** table, calculate *imp_to_use = Hrwc_imp*. In the **_twpunbuiltflum-w** table, calculate *imp_to_use = new_imp*.

MERGE **__twpbuiltflum-w** and **__twpunbuiltflum-w.** Name this new coverage **__twpfancyflumreducedimp** or something.

Coverages created:
A2twpfancyflumroads

Future imperviousness build out(Ag. = 20%) with road and parking reductions, by watershed:
INTERSECT **__the above coverage** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take the imp_to_use field from **zoning-w**, and take the subsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*imp_to_use/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpfancyflumroadssubimp** or something like that.

Coverages created:
A2twpfancyflumroadsbo

<u>Future imperviousness from flum, with Agriculture=20%, but with reductions from open space developments.</u>

JOIN *__twpflumfancy.dbf look up table* to **_twpbuiltflum-w**, and to **_twpunbuiltflum-w.** Remember to remove any previous joins, or use a new copy of those themes. CALCULATE FIELD called *imp_to_use*. In the **_twpbuiltflum-w** table, calculate *imp_to_use = Hrwc_imp*. In the **_twpunbuiltflum-w** table, calculate *imp_to_use = opsp_imp*.

MERGE **__twpbuiltflum-w** and **__twpunbuiltflum-w.** Name this new coverage **__twpfancyflumopenspaceimp** or something.

Coverages created:
A2twpfancyflumopensp

Future imperviousness build out(Ag. = 20%) with open space reductions, by watershed:
INTERSECT **__the above coverage** on **subsheds.** When the computer asks what fields you'd like in the resulting theme, take the imp_to_use field from **zoning-w**, and take the subsheds from **subsheds.** You get a new **theme#x**. Don't bother naming this. Open **theme#x's** table. ADD FIELD *imp_area* (=area*imp_to_use/100).

Now SUM this table on *subsheds* or *subsubsheds*. In the dialogue box, bring over shape_merge, sum_area, and sum_imp_area. You get a **sum#x.**

Open **sum#x's** table. ADD FIELD *imp%* = imp_area/area *100. You should now have a table that shows imp% for each subshed. CONVERT this **sumx** to a theme - **__twpfancyflumopenspacesubimp** or something like that.

Coverages created: A2twpfancyflumopenspbo

APPENDIX 2
PRIVATE ROAD AND OFF-STREET PARKING RECOMMENDATIONS FOR SCIO TOWNSHIP

(NOTE: See Hamberg Township, MI, for comprehensive model Private Road Ordinance)

AMENDMENTS TO ORDINANCE NO. 93-4

PRIVATE ROAD ORDINANCE

SCIO TOWNSHIP, MICHIGAN

SECTION 1

SECTION 2 DEFINITIONS

A.
B.
C.
D.
E.
F. Private Road. An area of land which is privately owned, has not been dedicated to public use other than access by emergency and public safety vehicles, is maintained by its private owners, and provides vehicular access to more than one parcel. (Amended 3/9/94 and 9/17/96)

G. ~~Public Street or Right-of-way. A public or dedicated right-of-way, which affords the principal means of vehicular access to abutting property, and which is under public ownership or control.~~ Private Driveway: An area of land which is privately owned, has not been dedicated to public use other than access by emergency and public safety vehicles, is maintained by its private owners, and provides vehicular traffic servicing up to two parcels.

H. ~~Township Board. The Board of Scio Township.~~ Public Street or Right-of-way. A public or dedicated right-of-way, which affords the principal means of vehicular access to abutting property, and which is under public ownership or control.

I. ~~Township Clerk. The Clerk of Scio Township.~~ Township Board. The Board of Scio Township.

J. ~~Township Engineer. An engineer appointed by the Township Board to the position of Township Engineer or any other person authorized by the Township Board to perform the~~

~~duties of Township Engineer as set forth in this Ordinance.~~ Township Clerk. The Clerk of Scio Township.

K. Township Engineer. An engineer appointed by the Township Board to the position of Township Engineer or any other person authorized by the Township Board to perform the duties of Township Engineer as set forth in this Ordinance.

SECTION 3 GENERAL ACCESS AND PERMIT REQUIREMENTS

A. For the purposes of this Ordinance, private roads shall be further defined and classified as follows:

1) Class A private roads meet one or more of the following criteria:

a. Serves ten (10) or more single-family residential lots, or has a reasonably foreseeable potential to be extended in the future to serve a total of ten (10) or more single-family residential lots. The potential shall be based upon the amount of acreage serviced and the potential buildable parcels.

b. Connects with, or has a reasonably foreseeable potential to be extended at a future time to connect with another public or private road.

~~c. Has a reasonable probability of dedication as a public road at a future time.~~ Has a length of more than one thousand (1,000) feet, measured on the roadway centerline from the right-of-way of the public road it intersects to either another intersecting roadway or center of a cul-de-sac.

~~d. Has a length of more than one thousand (1,000) feet, measured on the roadway centerline from the right-of-way of the public road it intersects to either another intersecting roadway or center of a cul-de-sac.~~ Serves one or more non-residential uses, not including farm uses and farm buildings.

~~e. Serves one or more non-residential uses, not including farm uses and farm buildings.~~

2) Class B private roads are those which do not meet the criteria for Class A roads as defined above, but which do exceed the criteria for Class C roads as defined below.

3) Class C private roads are those which will serve no more than four (4) lots or parcels provided:

a) Said lots are no less than two and one-half (2 ½) acres in size;

b) The lots or parcels are located no greater distance than one thousand (1,000) feet from the centerline of a public street.

4) Private Driveways may serve up to two (2) parcels and shall not be considered a private road. If two (2) lots are to be served by one (1) private driveway, both lots must have the required frontage on an improved public or private road. Approval of the approach to a public road is required from the Washtenaw County Road Commission. If at any time more than two (2) parcels are to have access using the existing private driveway, it shall be brought into compliance with the standards contained in this Ordinance.

B.

C.

D.

E.

SECTION 4 APPLICATION FOR PERMIT: REQUIREMENTS

Application for Permits shall be delivered to the Township Zoning Administrator and filed with the Clerk and shall consist of the following information:

A. Class A or B Private Road – Each <u>private road</u> application for a Class A or B road shall be accompanied by completed plans prepared and sealed by a civil engineer or land surveyor registered in the State of Michigan, which include the information contained herein. Where the required information is incorporated in the overall site plan of a development, separate road plans shall not be required.

The application and plans for a Class A or B road shall include the following information:

1.
2.
3.
4.
5.
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7.
8.

B. Class C Private Road. Each <u>private road</u> application for a Class C Road shall be accompanied by completed plans prepared and sealed by civil engineer or land surveyor registered in the State of Michigan, which include the information contained herein. Where the required information is incorporated in the overall site plan of a development, separate road plans shall not be required.

The application and plans for a Class C Road shall include the following information:

1.
2.
3.
4.
5.
6.
7.

SECTION 5 DESIGN STANDARDS

A.

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3.
4. The private road easement and road shall be adequately drained so as to prevent flooding or erosion of the roadway. Open swale/ditch drainage systems will be preferred to enclosed storm sewers where applicable governmental standards and site conditions permit. Open swales/ditches shall be located within the private road easement. Stormwater conveyance will comply with the Washtenaw County Drain Commissioner's Rules and Design (See Appendix A). Road drainage shall be constructed so that runoff water shall be conveyed to existing watercourses or water bodies. The discharged water shall not be discharged upon the land of another property owner unless the water is following an established watercourse. The discharged water onto adjoining properties shall also not exceed the normal agricultural rate. Stormwater management shall comply with the current Washtenaw County Drain Commissioner Rules and Design (See Appendix B.) Connection to county drains shall be approved by the Washtenaw County Drain Commissioner prior to the issuance of permit. Connection to roadside ditches within public road rights-of-way shall be approved by the County Road Commission prior to the issuance of a permit.
5.
6.
7.

B. The following Schedule of Minimum Requirements and Specifications for Private Streets and Roads shall apply:

SECTION 5.B
MINIMUM REQUIREMENTS AND SPECIFICATIONS
FOR PRIVATE STREETS AND ROADS

	Class A Private Streets and Roads	Class B Private Streets and Roads	Class C Private Streets and Roads
Easement Width*	66 feet	66 feet	66 feet for 3-4 parcels, 33 feet for 2 parcels
Sub-base	Depth will vary depending upon native soil types. Spread to a minimum width sufficient to extend to the front slope of the roadside ditch.	Same as Class A.	Same as Class A.
Base			
For gravel Surfaces	6 inches of crushed limestone; slag or processed road gravel (MDOT 21A) in two equal courses, each compacted ~~32 feet wide~~ 20 feet wide (22 feet for 20 parcels or more)	~~Same as Class A, except 22A or 23A processed road gravel shall be used in lieu of 21A and width shall be 22 feet wide.~~ 6 inches of crushed limestone; slag or processed road gravel (MDOT 22A or 23A) in two equal courses, each compacted 18 feet wide	Same as Class B except 16 feet wide.
For paved surfaces	Same as for gravel surface, plus 2 inches more of base, compacted	Not applicable	Not applicable
Pavement	2 ½ inches bituminous aggregate, #1100 mix, ~~24 feet wide~~ 20 feet wide (22 feet for 20 parcels or more).	Not applicable	Not applicable

* In cases where utility easements are located away the road corridor, roadway easement widths may be lowered. This provision is subject to Township approval.

	Class A	Class B	Class C
Turnaround area			
Cul-de-sac	~~75 foot radius right-of-way, 50 foot radius roadway surface.~~ 60 foot radius right-of-way, cul-de-sac 40-foot radius with landscape island, 33-foot radius without	**Same as Class A**	Same as Class A
T-Type	Not Permitted	~~May be substituted for cul-de-sac if applicant can shiw that it will function as well as the required turning circle.~~ 20' x 60' turnaround may substitute	~~Same as Class B.~~ 20' x 60' turnaround may substitute
Ditches			
Minimum Grade 0.5%-4.0%, Grades 4.1% and steeper, Grades Fron/back slopes Check dams	Sod or otherwise stabilized Rip-rap 1 on 4 Channels greater than 50 feet in length shall be equipped with check dams in accordance with the MDNR's "Guidebook of Best Management Practices for Michigan Watersheds." (attach)	Same as Class A	~~Ditches shall be of sufficient width, depth, and grades to provide for adequate and positive drainage.~~ Same as Class A
Roadway Grades			
Minimum	0.5%	0.5%	0.5%
Maximum	6.0%	6.0%	6.0%
Roadway Curves			
Horizontal-minimum	~~230 foot radius~~ 100 foot radius	Same as Class A	Same as Class A
Vertical-minimum	100 foot long for	Same as Class A	Same as Class A

	changes in gradient of 2% or more		
Curb and Gutter	----------	-------------	------------
May be required by Township Engineer in consideration of narrow lot width, and road grade.			

SECTION 6

A.

B.

C.

D.

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F.

SECTION 7 INSPECTION

All required improvements shall be inspected by the Township and Road Commission Engineer at various stages of construction. The Township Engineer and the Washtenaw County Road Commission shall make a final inspection upon completion of construction and shall report the results of the final inspection to the Township Board in writing. The applicant's engineer shall certify to the Township Engineer, before the final inspection and report thereon are made, that the required improvements were made in accordance with this Ordinance and all approved plans. A letter of completion by the Township Engineer shall be delivered to the Township Clerk, and the applicant. The costs of inspection, including compensation of the Township Engineer, shall be paid by the applicant prior to the issuance of the certificate of completion. The Township Board shall establish and determine the costs of inspection. If the applicant does not directly pay the costs of inspection, the same shall be paid from the deposit established by the Township Board and held by the Township Clerk, and the balance, if any, shall be returned to the applicant.

SECTION 8

SECTION 9

SECTION 10

SECTION 11

SECTION 12

SECTION 13

Recommended Amendments to Scio Township Ordinance:

ARTICLE 8

OFF-STREET PARKING AND LOADING

(Amendment No. 178, 4-21-92)

SECTION 8.1

SECTION 8.2

8.2.1

8.2.2

8.2.3 Location of Parking

A.

B.

C. Churches. The number of off-street parking spaces required for churches may be reduced ~~by fifty (50) percent~~ in accordance with Section 8.3.3 of this Article where churches are located ~~in non-residential districts and within three-hundred (300) feet~~ within six hundred (600) feet of existing usable public or private off-street spaces. The Zoning Inspector shall determine if such public or private spaces qualify under this section.

8.2.4

8.2.5

SECTION 8.3 OFF-STREET PARKING REQUIREMENTS

8.3.1

8.3.2

8.3.3 Collective provisions. Nothing in this Section shall be construed to prevent collective provisions of off-street parking facilities for two or more buildings or uses. ~~provided such~~

~~facilities collectively shall no be less than the sum of the requirements for the various individual uses computed separately in accordance with Section 8.3.5 of this Article.~~ The number of parking spaces required for land or buildings used for two or more purposes shall be the sum of the requirements for the various uses determined in accordance with this Ordinance. Parking facilities for one use shall not be considered as providing the required parking facilities for any other use, except as provided below:

A. Shared Parking – Combined land uses may result in a demand for parking space that is less than the demand generated by separate freestanding developments of a similar size and nature. Cumulative parking requirements for mixed-use occupancies may be reduced where it can be determined that the peak requirements of the several occupancies occur at different times (either daily or seasonally). The applicant shall have the burden of proof for a reduction in the total number of required parking spaces, and documentation shall be submitted substantiating the reasons for this requested parking reduction. Shared parking shall be approved if:

   a. A sufficient number of spaces are provided to meet the greater parking demand of the participating uses.

   b. Satisfactory evidence has been submitted by the parties operating the shared parking facility, describing the nature of the uses and times when the uses operate so as to demonstrate the lack of conflict between them.

   c. Additional documents, covenants, deed restrictions, or other agreements as may be deemed necessary by the Township are executed to assure that the required parking spaces provided are maintained, and that uses with similar hours and parking requirements as those uses sharing the parking remain for the life of the building.

B. Captive Market – Parking requirements for retail, office, restaurant, and hotel, convention and conference uses may be reduced where it can be shown that some portion of the patronage of these businesses comes from other uses (i.e., employees of area offices patronizing restaurants).

8.3.4 Flexibility in Application. The Township recognizes that, due to the specific requirements of any given development, inflexible application of the parking standards set forth in section 8.3.5 may result in development with inadequate parking or parking far in excess of that which is needed. The former situation may lead to traffic congestion or unauthorized parking on adjacent streets or neighboring sites. The latter situation may result in excessive paving and stormwater runoff and a waste of space which could be left as open space.

The Planning Commission may permit deviations from the requirements of Section 8.3.5 and may require more or allow less parking based upon a finding that such deviations are more likely to provide a sufficient number of parking spaces to accommodate the specific characteristics of the use in question.

The Planning Commission may attach conditions to the approval of a deviation from the requirement of Section 12.04 that bind such approval to the specific use in question. Where deviations result in a reduction of parking, the Planning Commission may further impose conditions which ensure that adequate reserve area is set aside for future parking, if needed. Where area is set aside for reserve parking, it shall be easily developed, not devoted to a use other than open space, and shall be designed to accommodate attendant facilities such as maneuvering lanes and drainage.

The Planning Commission may, prior to granting reserved parking, require a covenant executed to guarantee that the owner will provide the additional spaces if, upon investigation of the actual utilization of parking spaces at the building or use, the Township determines that the approved reduction be modified or revoked.

The Planning Commission may require a demand analysis, prepared by a qualified parking or traffic consultant, prior to granting exceptions to Section 12.04.

8.3.5 Schedule of Off-Street Parking Requirements

Use	**Required No. of Parking Spaces Per Each Unit of Measure as Follows:**	
A. Residential Uses.		
1)		
2) Multiple-Family Dwelling	~~2~~	~~Per each dwelling unit~~
	~~1~~	~~Per each ten (10) dwelling units~~
	1.25	**Per each studio dwelling unit**
	1.5	Per each one bedroom dwelling unit
	2	Per each dwelling unit of two or more bedrooms
3) Senior Citizen Housing	~~1.5~~ 0.5	Per each dwelling unit
B. Institutional Uses		
1)		
2)		
3)		
4)		
5) High Schools, Trade Schools, Colleges, & Universities	~~8~~ 5	Per each classroom

6) Elementary & Junior High Schools	~~5~~ 3	Per each classroom
7) Child Care Center, Day Nurseries, or Nursery Schools	1	Per each ~~five (5)~~ ten (10)students plus
	1	Per each employee
8)		
9)		

C. General Commercial Uses

1) Retail Stores, except as otherwise specified herein	1	Per ~~100~~ 300 sq. ft. of floor area
2) Supermarkets, drugstores, and other self-serve retail establishments	1	Per ~~150~~ 250 sq. ft. of floor area
3) Convenience Stores	1	**Per ~~100~~ 250 sq. ft. of floor area**
4)		
5) Service Retail, Furniture, Appliance, Hardware & Household Equipment Sales	1	Per ~~300~~ 400 sq. ft. of floor area **plus**
	1	Per each 666 sq. ft. of interior storage and exterior display / storage space
6)		
7)		
8)		
9)		
10)		
11)		
12)		

D. Automotive Uses

1)		
2)		
3)		
4) Gasoline Stations with Convenience Store	1	Per pump unit, plus
	3	Per each service stall, plus
	1	Per each ~~100~~ 250 sq. ft. of floor area devoted to retail sales and customer service.
5)		
6)		
7)		

E. Office and Service Uses

1)
2) Business & Professional Offices 1 Per each ~~200~~ 275 sq. ft. of floor area
3)
4)

F. Recreational Use

1)
2)
3)

G. Industrial Use

1) Industrial, Manufacturing or Research Establishments ~~1~~ ~~Per each 500 sq. ft. of floor area~~

a) Heavy manufacturing, including tool and dye, lumber yards, steel fabrication and welding 1 **Per each 1500 sq. ft. of floor area**

b) Limited Manufacturing, Research and Development 1 **Per each 600 sq. ft. of floor area**

2) Warehouse or Storage Buildings 1 Per each ~~1500~~ 2000 sq. ft. of floor area
3)

SECTION 8.4 OFF-STREET PARKING DESIGN AND CONSTRUCTION

8.4.1

8.4.2

8.4.3

8.4.4

8.5.5

8.4.6 Plans for the layout of automobile off-street parking facilities shall be in accordance with the following minimum table. The Planning Commission, may allow up to 20% of the total parking be designated for "small car parking." Small car parking shall meet the length and width dimensions as specified in the following table:

	Maneuvering Lane Width		Parking Space Dimensions*			
			Regular Car		Small Car	
Parking Pattern	One-Way	Two-Way	Parking Space Width	Parking Space Length	Parking Space Width	Parking Space Length
0° Parallel	11’	20’	9’	~~24’~~ 20’	n/a	n/a
30° - 53°	12’	~~20’~~ One way only	9’	18’	8’	16’
54° - 74°	15’	~~22’~~ One way only	9’	18’	8’	16’
75° - 90°	20	22’	9’	18’	8’	16’

* Curbed stalls which allow for vehicle overhang can be reduced in depth by if the overhang area is not used for parking and does not encroach upon the uses set forth in Section 8.5.5. The depth reduction can be up to one and one-half (1 ½) feet for diagonal parking, two (2) feet for 90 degree parking.

a. The planning commission, may allow regular car stall width to be reduced to eight feet two inches (8’ 2”) for spaces serving low turnover parking (e.g. employee, commuter, residential.)
b. The width of a parking space shall be measured on a line perpendicular to both sidelines of the space.
c. Aisles for access to all parking spaces on two-way aisles shall be designed and clearly marked for two-way traffic flow. Aisles for angle parking spaces shall have one-way movement only and shall be clearly marked for one-way movement.

8.4.7

8.4.8

APPENDIX 3
STORMWATER MANAGEMENT AND TREATMENT ORDINANCE

STATE OF MICHIGAN

COUNTY OF WASHTENAW

TOWNSHIP OF ____________

STORMWATER MANAGEMENT AND TREATMENT

AN ORDINANCE OF THE TOWNSHIP OF ___________ ESTABLISHINGS PROVISIONS FOR APPROVAL FOR THE MANAGEMENT AND TREATMENT OF STORMWATER.

IT IS ORDAINED BY THE TOWNSHIP BOARD OF THE TOWNSHIP OF____________, MICHIGAN, as follows:

Section 1. There is hereby added/amended to the Township Code of Ordinances an article numbered (#) entitled "Stormwater Management and Treatment Ordinance" to read as follows:

A. DEFINITIONS

Agricultural activities – All activities associated with the primary use of the property for bona fide pasturing of livestock, or for planting, growing, cultivating, and harvesting crops for human or animal consumption. Also where the primary use of the property is for bona fide horticulture and silviculture including plowing, irrigation, irrigation ditching, seeding, cultivating, minor drainage, harvesting for the production of food, fiber or forest products.

Best Management Practices (BMPs) – A structural, vegetative or managerial practice used to treat **Nonpoint Source Pollution** and to prevent or reduce to the maximum extent practicable, the discharge of **Nonpoint Source Pollution** directly or indirectly to stormwater, **stormwater** conveyance systems, or **receiving water**s. **BMPs** must comply with other regulations as well as **Stormwater** regulations; **BMPs** must be compatible with the areas land use, character, facilities, and activities; and **BMPs** must be technically feasible (considering area soil, geography, water resources, and other resources available). Those practices, including but not limited to those described in the accompanying *Performance Standards and Design Criteria for Stormwater Best Management Practices*, that prevent or control **nonpoint source pollution**. Innovative **BMPs**, those practices designed by the applicant's engineer to meet or exceed these performance standards.

Development – All land modification activity, including the preparation for and construction of buildings, roads, paved storage areas, parking lots, and lawns. "**Development**" includes redevelopment of land, and also includes any land disturbing construction activities or human-made change of the land surface, including clearing of vegetative cover, excavating, dredging and filling, grading, contouring; mining and the deposit of refuse, waste, or fill. **Agricultural activities** are excluded from this definition.

Erosion **--** The detachment and movement of soil, sediment or rock fragments, by wind, water, ice, or gravity.

Impervious Cover – An artificial structure, improvement or covering, that creates a barrier to the percolation of stormwater into the soil (e.g. asphalt, building or gravel surface). Also, impervious surface and imperviousness.

Irrigation system – A device or combination of devices having a hose, pipe, or other conduit installed in the landscape which transmits water, through which device or combination of devices water or a mixture of water and chemicals is drawn and applied to residential or commercial lawns, landscapes or green space.

Nonpoint Source Pollution – Pollution that is caused by or attributable to diffuse sources. Typically, NPS pollution results from contaminated **stormwater** runoff, **erosion** and sedimentation, precipitation, atmospheric deposition.

Rain sensor – means a device that measures rainfall and will override the irrigation cycle of an **irrigation system**, thus turning it off, when a predetermined amount of rain has fallen.

Receiving water – A natural or man-made stream, creek, river, reservoir, lake, lagoon, wetland or estuary.

Sedimentation -- Pollution resulting from the deposit of detached soil particles.

Stormwater. Surface runoff and drainage associated with storm events and snowmelt.

Well-vegetated – Ground that is ninety percent covered by vegetation at least 6 inches in height, and/or 90% covered by a forest or wooded canopy.

B. FINDINGS AND INTENT

The Township Board makes the following findings, which, in part, are the basis for the adoption of this ordinance:

1. An increasing number of federal, state and local governmental actions are aimed at improving watershed conditions in order to increase water quality, improve hydrologic flows to reduce flooding and **erosion** and maintain stream flows to support healthy living conditions for human, fish, insect, and animal life; and

2. Degradation of water quality via polluted **stormwater** runoff is a threat to the public health, safety and welfare; and

3. Site design is important to water resource protection and standards are desired that result in less **impervious cover**, more "green" and open space areas, and retention and water quality treatment of precipitation on site to the extent reasonably possible; and

4. Degradation of water quality can occur in watersheds that are as little ten percent (10%) **impervious**; and

5. Watersheds within the township are soon to be or already do exceed ten percent (10%) imperviousness; and

6. Effective **stormwater** management techniques that incorporate **best management practices** have been shown to protect water quality by mitigating the effects of **development** including **stormwater** runoff and **nonpoint source pollution** emanating from **impervious surfaces**.

Consistent with such findings, it is the intent of the Township in adopting this section to:

1. Protect public health, safety and welfare by requiring **stormwater** management whenever new, expanded or modified developments are proposed.

2. Reduce the risk to persons and damage to property as a result of flood conditions in the Township.

3. Prevent soil **erosion** and sedimentation.

4. Protect surface water quality and quantity.

5. Assure that **stormwater** runoff from **development** is controlled so that water quality is protected and that **sedimentation** and pollution are minimized.

6. Attain and maintain federal and state water quality standards.

7. Provide for cost-effective and functionally-effective **stormwater** management, and to reduce the need for future remedial projects.

8. Establish regulations to prevent harmful effects of changes in the quality of discharge into **receiving waters** as a result of **development** within or partly within the Township.

C. APPLICABILITY AND REQUIREMENT FOR APPROVAL

All of the following proposals for development shall require approval under this section, with such approval to be made at the time and by the body or official specified below:

1. Land **development** proposals subject to site plan review. Review and approval shall be undertaken by the Planning Commission at the time of site plan review.

2. Subdivision plat proposals. Review and approval shall be undertaken by the Township Board at the time of final plat approval.

3. Site condominium proposals. Review and approval shall be undertaken by the Planning Commission at the time of final review of the proposed site condominium development.

4. Golf courses and driving ranges. Review and approval shall be undertaken by the Planning Commission at the time of final review and approval of the project.

5. Any **development** on property divided by land division in connection with which one or more public or private roads are created or extended, and/or in connection with which more than three parcels of less than one acre are created. Review and approval shall be undertaken prior to approval of any site development on the property.

6. **Development** of facilities by federal, state and local agencies and school districts. Review and approval shall be undertaken by the Township engineer, or his/her appointed designee, prior to the approval of any site development on the property.

D. EXEMPTIONS – The following activities are not subject to the requirements of this Section:

1. **Agricultural activities**, where the primary use of the property for bona fide pasturing of livestock, or for planting, growing, cultivating, and harvesting crops for human or animal consumption. Also where the primary use of the property is for bona fide horticulture and silviculture including plowing, irrigation, irrigation ditching, seeding, cultivating, minor drainage, harvesting for the production of food, fiber or forest products.

2. Routine single family residential landscaping and/or gardening that do not violate the provisions of an existing **stormwater** drainage system.

3. **Development** on one single family lot, parcel or condominium unit where the Township engineer, or his/her appointed designee, determines that, due to the size of the site, or due to other circumstances, the quantity, quality and or rate of **stormwater** leaving the site will not be meaningfully altered.

E. MANAGEMENT DESIGN CRITERIA – **Development** subject to this Section shall adequately provide for **stormwater** management and shall comply with the current

Washtenaw County Drain Commissioner Rules and Design Criteria for **Stormwater** Management Systems (see accompanying *Performance Standards and Design Criteria for Stormwater Best Management Practices*, Attachment B).

F. WATER QUALITY TREATMENT OF **STORMWATER – Stormwater** runoff from **development** subject to this article shall be pre-treated by **stormwater best management practices** to remove nonpoint source pollution so as not to impair or further impair water quality of **receiving water**s. The criteria set forth in the accompanying "*Performance Standards and Design Criteria for Stormwater Best Management Practices*" shall be used to determine adequacy of treatment. No **development** or preparation for **development** on a site shall occur unless and until site plans have been reviewed by the township engineer, or his/her appointed designee, and found to be in compliance with this Section. Mitigation sufficiency shall be documented at the concept plan stage. A Zoning Compliance Certificate shall not be granted unless and until mitigation sufficiency is verified.

Stormwater best management technologies are rapidly developing and improving. Alternative stormwater treatment BMPs not listed in the accompanying "*Performance Standards and Design Criteria for Stormwater Best Management Practices,*" may be submitted for review and approval to the Township engineer, or his/her appointed designee. The Township engineer, or his/her appointed designee, may find the proposed alternative to be a practicable stormwater management solution that meets or exceeds the treatment efficiency set forth in the "*Performance Standards and Design Criteria for Stormwater Best Management Practices.*" Such alternatives shall be considered on a case-by-case basis and may require stormwater monitoring. The following must be documented and submitted by the proposer to the Township prior to consideration and approval of alternative BMPs:

- Mechanism(s) by which phosphorus will be treated and rate and volume will be managed with supporting documentation;
- Key design specifications or considerations;
- Specific installation and maintenance requirements necessary to insure maximum long-term efficiency of BMP performance.

G. DISCHARGE OF **STORMWATER** RUNOFF TO WETLANDS –

1. Wetlands will be protected from damaging modification and adverse changes in runoff quality and quantity associated with land developments. Before final approval of **stormwater** management systems, all necessary wetland permits from the **MDEQ** and the Township will be in place.

2. Direct discharge of untreated **stormwater** to a natural wetland, lake or stream is prohibited. All runoff from the **development** will be pre-treated to remove sediment and other pollutants, as set forth in the accompanying "*Performance Standards and Design Criteria for Stormwater Best Management Practices,*" prior to discharge to a wetland. Such treatment facilities will be constructed as a first element of property grading.

3. Site drainage patterns will not be altered in any way that will modify existing water levels in protected wetlands without proof that all applicable permits from the **MDEQ** and the Township have been obtained, and proof that easements have been obtained from the owners of all other properties on which any portion of the impacted wetland is situated.

4. Wetlands will be protected during **development** by appropriate soil **erosion** and sediment control measures.

H. LAWN DRAINAGE – Landscape areas compacted during site preparation shall be core aerated to facilitate infiltration and reduce runoff. Core aeration shall occur following the completion of all other activities requiring the use of heavy equipment in such areas.

Contiguous slopes averaging 20% or greater for more than 1000 square feet shall be well-vegetated with tall-grass or other such stabilizing vegetative cover to slow, filter and promote infiltration of **stormwater** runoff. Any re-vegetation required shall be in accordance with MDNR's Guidebook of Best Management Practices for Michigan Watersheds (*Performance Standards and Design Criteria for Stormwater Best Management Practices*, Attachment I).

Where practical and feasible, natural depressions shall be maintained for bio-retention and to promote infiltration. Landscaping at these locations shall use appropriate vegetative cover adapted for extended soil saturation. Storm drain facilities in place solely for the purpose of draining and maintaining turf, lawn or sod cover in natural depressions are not permitted unless infiltration and bio-retention are found to be impractical or unfeasible.

I. AUTOMATED WATERING SYSTEMS – Over-saturation of managed turf landscapes can limit soil infiltration, increase runoff volume and contribute to **nonpoint source pollution**. Automated watering systems shall be equipped with **rain sensor**s that can disable watering systems following rainstorms.

1) Required installation.

(a) New installation. **Rain sensor**s shall be required on all automatic **irrigation systems**.
(b) Existing systems. Rain sensors shall be installed on all existing automatic **irrigation systems** at the time of sale of property.
(c) The requirements of this provision shall be incorporated into all master deed restrictions, homeowner association rules and prevailing maintenance agreements.

2) Required maintenance.

All **rain sensor**s shall be adjusted and set so that they automatically shut off the **irrigation system** after not more than one-fourth (1/4) inch of rainfall has occurred. All **rain sensor**s shall be installed according to manufacturer's instructions in a location that will provide full exposure to rainfall such that accuracy of operation is assured, and shall be maintained in good working condition. No person shall, with the intent of circumventing the purpose of this section, adjust either the **rain sensor** or **irrigation system** so that the **rain sensor** is not able to override and turn off the **irrigation system** after one-fourth (1/4) inch of rain has fallen.

J. STORMWATER BMP MAINTENANCE – A legally binding maintenance agreement shall be executed and approved by the Township Board prior to final approval of the project. In the event that there are multiple users, a county drainage district shall be established. A maintenance agreement shall be binding on all subsequent owners of land served by the stormwater management and facilities, and shall be recorded in the office of the Washtenaw County Register of Deeds prior to approval by the Township Board. It shall contain a plan, schedule and budget for routine, emergency and long-term maintenance of all elements of the stormwater management system and mitigation Stormwater BMPs, shall identify the party responsible for maintenance and the source of funding. The Township Board shall approve maintenance agreements prior to issuance of a Zoning Compliance Certificate.

Maintenance plans shall be submitted with all construction plans and included in the by-laws of all subdivisions, site condominiums, homeowner association rules, private road agreements or other pertinent documents.

Performance Standards and Design Criteria for Stormwater Best Management Practices

Table of Contents

Part One

I Definitions

In addition to the definitions established in the Stormwater Management and Treatment Ordinance, are the following:

MDEQ **–** Michigan Department of Environmental Quality

Native Landscaping Area – A maintained or restored area vegetated with species that flourished in southeastern Michigan prior to its occupation by settlers from eastern North America and Europe that is not regularly mowed or cleared of vegetative cover during the growing season.

Naturally Vegetated Area – Permanently vegetated land undisturbed by construction activities or human-made change of the land surface, including mowing or clearing of vegetative cover, excavating, dredging and filling, grading, contouring; mining and the deposit of refuse, waste, or fill.

Permitted Phosphorus Export (PPE) – One-tenth (.10) pound per acre from May - October; the maximum allowable amount of total phosphorus (TP) to be exported from each acre of land subject to this article.

Total Maximum Daily Load (TMDL) – A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

Undeveloped – Land not falling under the above definition of development. Also, surfaces **well-vegetated** with **native landscaping** concurrent with development.

II Introduction

Phosphorus has been identified by the **MDEQ** as the leading cause of water quality impairment within the middle Huron River basin. As phosphorus runoff is highly dependent on rainfall and amount of runoff, a monthly **TMDL** has been established for the months of May through October. Background phosphorus loading from undeveloped land is estimated to be 0.10 lbs/acre/yr. Therefore, water quality shall be considered sufficiently protected, if annual phosphorus export, as a result of a development, does not exceed **Permitted Phosphorus Export** of 0.10 lb/acre during the months of May – October.

Suspended sediment, hydrocarbons, and trace metals are also common nonpoint source pollutants emanating from developed land. The BMPs required to mitigating phosphorus to the above standard will also reduce these other pollutants, on average, by the following levels:

Sediment	60 – 80%
Hydrocarbons	80 – 90%
Trace Metals	40 – 80%

Part Two

I. Phosphorus Loading Values by Land Coverage (L-values)

Total annual phosphorus generated by each acre of development (L-value) shall be determined by the following equation. Values by land cover are summarized in Table 1:

$$L = Cf * P * PC * A * 0.226639$$

Where:

Cf = C-Factor given in Table 1

P = Average Precipitation for Washtenaw County between the months of May through October, or 16.74 inches.

PC = Average Total Phosphorus Concentration for a given surface coverage (Table 1).

A = One acre (43,560 Sq. Ft.)

0.226639 = Conversion factor from (in) (mg/l) (ft^2) to lbs/acre

Table 1
Per Acre Export Load for Various Land Uses

Cover	**C-Factor**	**May-Oct Precip. (in)**	**Phosphorus Concentration (mg/l)**	**Export Load or L-value (lbs/acre)**
All Roofs	0.95	16.74	0.07	0.25
Asphalt or Concrete Pavements	0.95	16.74	0.14	0.50
Gravel/Brick Surfaces	0.8	16.74	0.14	0.42
Lawns	0.25	16.74	1.56	1.48
Undeveloped	0.1	--	--	0.10

II. Stormwater BMPs efficiency (T-values)

A. Stormwater Best Management Practices and their effectiveness in reducing total phosphorus are listed in Table 2.

Table 2
Treatment Ratios

	Stormwater Best Management Practice (BMP)	BMP T- Value
A*	**Permanent Retention**	1.0
B*	**Extended Detention Pond**	.20
C*	**Wet Detention Pond**	.55
D*	**Wetland Detention Basins**	
	1. Shallow Marsh	.42
	2. Extended Detention Wetland	.28
	3. Two-stage Pond and Wetland	.55
E	**Disconnected Impervious Surfaces**	.20
F	**Water Quality Swales**	.35
G	**Filter Strips**	.40
H	**Sand Filter**	.50
I	**Infiltration Trench**	.70
J	**Offsite Stormwater Mitigation**	See (j)
K	**On-site Treatment of Upland Runoff**	See (k)

**** Stormwater Pond Requirement*** -- *At least one type of stormwater pond (BMPs A-D) is required unless it can be shown that detention and discharge rate requirements of current Washtenaw County Drain Commissioner Rules and Design Criteria for Stormwater Management Systems are otherwise met (Attachment B).*

B. Combining BMPs – The use of multiple BMPs into an integrated stormwater management system is permissible and encouraged. Credit shall be granted for use of multiple BMPs to account for the cumulative effect of integrated treatment. Use of any two BMPs shall be credited an additional 0 .1 in calculating the T-value. Any three BMPs, shall be credited an additional 0.2, etc.

Example: A stormwater system that employs a wet pond and water quality swale shall have an effectiveness ratio of .55 for the wet pond + .35 for the water quality swale + .1 for use of multiple BMPs, for a cumulative T-value of 1.0.

A weighted average shall be calculated for BMPs that partially serve any given area. The cumulative T-Value shall never exceed 1.0.

Part Three

I. Adequacy of Treatment BMPs

A. Determine Permitted Phosphorus Export (PPE)

Permitted phosphorus export is 0.10 lbs/acre:

$$\mathbf{PPE = A * 0.10\ lbs/ac}$$

Where:

A = Total acreage of the project

B. Determining Phosphorus Export from Site (P_X)

Take the phosphorus load generated (L_{SUM}) and subtract the phosphorus load treated (T_{SUM}) via BMPs:

$$\mathbf{P_X = L_{SUM} - T_{SUM}}$$

1) Phosphorus load generated (L_{SUM})

Take the sum of the phosphorus load exported from each cover type multiplied by acres:

$$\mathbf{L_{SUM} = (A_R * L_R) + (A_P * L_P) + (A_G * L_G) + (A_L * L_L) + (A_U * L_U)}$$

Where:

A_R, A_P, A_G, A_L, A_U = Acreage of roof tops, pavement, gravel, lawn, **undeveloped** areas

L_R, L_P, L_G, L_L, L_U = Loading from rooftops, pavement, gravel, lawn, **undeveloped** areas. (See Part Two, Table 1)

2) Phosphorus load treated (T_{SUM})

Take the L-values and multiply by the treatment value (T-values) for each cover type to determine phosphorus removal:

$$\mathbf{T_{SUM} = (A_R * L_R * T_R) + (A_P * L_P * T_P) + (A_G * L_G * T_G) + (A_L * L_L * T_L) + (A_U * L_U * T_U)}$$

Where:

A_R, A_P, A_G, A_L, A_U = Acreage of roof tops, pavement, gravel, lawn, **undeveloped** areas

L_R, L_P, L_G, L_L, L_U = Loading from roof tops, pavement, gravel, lawn, **undeveloped** areas (See Part Two, Table 1)

T_{R}, T_{P}, T_{G}, T_{L}, T_{U} = Treatment efficiency of BMPs serving rooftops, pavement, gravel, lawn, **undeveloped** areas. (See Part Two, Table II, and the design criteria that follow)

C. Adequate water quality treatment of stormwater runoff is attained when phosphorus exported from the site is less than or equal to permitted phosphorus export:

PPE 3 **Px**

Where:

PPE = permitted phosphorus export

$P_{X} = L_{SUM} - T_{SUM}$ = (phosphorus export from site)

Part Four

I. BMP Design Criteria -- BMPs shall be designed and constructed in accordance to the following Design Criteria.

a) **Permanent Retention –** Washtenaw County Drain Commissioner Rules and Design Criteria for Stormwater Management Systems (WCDC, Attachment B).

b) **Extended Detention Basin –** Washtenaw County Drain Commissioner Rules and Design Criteria for Stormwater Management Systems (Attachment B).

c) **Wet Detention Basin –** Washtenaw County Drain Commissioner Rules and Design Criteria for Stormwater Management Systems (Attachment B).

d) **Stormwater Wetland Systems –** Washtenaw County Drain Commissioner Rules and Design Criteria for Stormwater Management Systems (Attachment B). For additional guidance, refer to Constructed Wetland Conservation Practice Standard, NRCS (Appendix C), and Terrene Institute Publication (Attachment D). Where criteria conflict, the Washtenaw County Drain Commissioner Rules shall apply.

e) **Disconnected Impervious Surfaces –** Directing impervious cover to drain as sheet flow onto a lawn, **Native Landscaping Areas**, or **Naturally Vegetated Areas** will slow, filter and infiltrate runoff. Impervious areas are considered disconnected if they do not connect to a storm drain system or other impervious areas through direct or shallow concentrated flow.

1) Disconnection must ensure no basement seepage to basements or other structures.
2) Runoff cannot come from a facility that stores "Toxic, Hazardous or polluting substances" as defined by the Washtenaw County Pollution Prevention Regulation (Attachment E).
3) Receiving area shall be on an average slope of 5% or less.
4) The length of the "disconnection" must be equal to or greater than the contributing length.
5) Roof drains must be at least 10 feet away from the nearest impervious surface to discourage reconnection.
6) Only drainage from an impervious surface can be disconnected. Drainage from green space such as lawns and undeveloped land cannot be included in this credit.
7) For disconnected impervious surfaces draining to **Native Landscaping Areas** or **Naturally Vegetated Areas**, only the disconnected impervious surfaces credit or the Filter Strip credit can be used, not both.

f) **Water Quality Swales –** A water quality swale is an artificial, **well-vegetated** watercourse designed to accommodate concentrated flows without erosion. Vegetated waterways reduce runoff velocity, filter sediment and absorbed chemicals from sheet erosion, and deliver intermittent flows to stormwater ponds.

1) Permissible velocity < 6 fps.
2) Minimum depth 0.8 feet.
3) Minimum bottom width shall be 2 feet.
4) Minimum flow slope shall be 1.5%.
5) Bank slope shall be at least 3:1.
6) Vegetative cover shall be established to a minimum height of six inches and 90% ground cover.
7) Check dams are required for swales greater than 75' in length and shall be spaced in accordance with MDNR's Guidebook of Best Management Practices for Michigan Watersheds (Attachment F).
8) To limit excessive nutrient contamination, swales shall not receive direct or shallow concentrated flow from managed turf, lawn or sod and shall have a 15' buffer strip between the two.
9) Swales shall be designed and constructed in accordance with MDNR's Guidebook of Best Management Practices for Michigan Watersheds (Attachment G). For additional guidance refer to Terrene Institute Publication (Attachment H). Where criteria conflict, the MDNR's Guidebook of Best Management Practices for Michigan Watersheds shall apply.
10) Seeding, mulching and sod application shall comply with MDNR's Guidebook of Best Management Practices for Michigan Watersheds (Attachment I).

g) Filter Strips – A filter strip is a **naturally vegetated area** or n**ative landscaping area** used to filter sediment, organic matter, and other pollutants from surface water runoff. Mown turf or non-native grass species shall not be used as filter strips. Filter strips may be used as a water quality treatment measure throughout the site, but are most beneficial when adjacent to watercourses (including swales), wetlands, or any other area that could be detrimentally affected by sediment loading, organic matter, nutrients or pesticides.

1) **Naturally vegetated areas** that are intended for use as a mitigation BMP shall be identified and protected before any development occurs on the site
2) Runoff cannot come from a facility that stores "Toxic, Hazardous or polluting substances" as defined by the Washtenaw County Pollution Prevention Regulation (Attachment E).
3) Runoff must enter and leave filter strip as sheet flow. Direct or shallow concentrated flow shall pass through a level spreader.
4) If vegetated with native landscaping, the developer will provide for the monitoring of filter strip plantings and replacement as needed for a two year period after construction
5) Filter strip width shall be designed in accordance with MDNR's Guidebook of Best Management Practices for Michigan Watersheds (Attachment J). For additional guidance refer to Terrene Institute Publication (Attachment H). Where criteria conflict, the MDNR's Guidebook of Best Management Practices for Michigan Watersheds shall apply.

h) Sand Filter – Washtenaw County Drain Commissioner Rules and Design Criteria for Stormwater Management Systems (Attachment B).

i) Infiltration Trench – Washtenaw County Drain Commissioner Rules and Design Criteria for Stormwater Management Systems (Attachment B).

j) Offsite Stormwater Mitigation – The use of offsite stormwater BMPs to treat runoff emanating from development within any portion of the watershed may be proposed. Proposals must not be in conflict with existing stormwater management systems. Offsite stormwater management facilities shall be designed to comply with all standards provided by this section that are applicable to on-site facilities

1) Offsite stormwater management areas may be shared with other landowners, provided that a county drainage district is established for future maintenance.
2) Adequate provision and agreements providing for inspection and maintenance of stormwater management facilities and the financing there of, shall be made by recorded instrument approved by the Township. The proprietor shall establish an easement on the affected property granting access to the Township and, where applicable, the Washtenaw County Drain Commissioner, for inspection and maintenance of the offsite stormwater system.
3) Accelerated soil erosion shall be managed offsite as well as on-site.
4) BMP efficiency shall be determined by acres served and BMP utilized in accordance with Table 2 of this section.
5) Offsite mitigation shall not affect on-site compliance requirements of the current Washtenaw County Drain Commissioner Rules and Design Criteria for Stormwater Management Systems as set forth in Paragraph E of this Section.

k) Onsite Treatment of Upland Runoff – Normally, drainage from offsite is not passed through on-site stormwater storage facilities. To supplement onsite stormwater mitigation, however, stormwater runoff emanating from offsite may be directed through on-site stormwater ponds and appurtenant BMPs that are designed and constructed to detain/retain the additional volume and will discharge the added volume at the same rate required of on-site runoff.

1) Only that upland runoff generated by developed parcels shall serve as mitigation. Upland land use and runoff calculations shall be included with required stormwater management design.
2) All standards applicable to on-site facilities apply.
3) BMP efficiency shall be determined in the identical manner as onsite BMPs in accordance with Table 2 of this Section.

Attachment A

Examples

I. Example 1 -- The following 40-acre commercial development is proposed:

Surface Cover	Acres
Rooftop	10
Pavement	10
Lawns	20
Undeveloped	0
Total	40

A. Determining Permitted Phosphorus Export (PPE):

$PPE = A * 0.10$ lbs/ac

$= 40 * 0.10$ lbs/ac

= 4 lbs

B. Determining phosphorus export from site (P_X):

$P_X = L_{SUM} - T_{SUM}$

The stormwater BMPs consists of a wet pond and water quality swales treating the entire site:

T-Values*

Surface Cover	WQ Swale (.35)	Wet Pond (.55)	Multiple BMPs (0.10) For Each Pair	T-Value
Roof	.35	.55	.10	1.0
Pavement	.35	.55	.10	1.0
Lawn	.35	.55	.10	1.0

* From Part II, Table 2

L_{-SUM} and T_{-SUM}

Cover	Acres	L-value*	L_{SUM}	T-value	T_{-SUM}
Roofs	10	0.25	2.5	1	2.5
Pavements	10	0.50	5.0	1	5.0
Lawn	20	1.48	29.6	1	29.6
			37.1		**37.1**

* From Part II, Table 1

C. Adequate water quality treatment of stormwater runoff is attained when phosphorus exported from the site is less than or equal to permitted phosphorus export:

$$PPE \geq Px$$

Where: $P_X = L_{SUM} - T_{SUM}$

$P_X = 37.1 – 37.1$

$P_X = 0$ Therefore: $\mathbf{4\ ^{3}\ 0}$, BMPs are sufficient to reduce actual phosphorus export below the permitted phosphorus export.

I. Example 2

The following 100-acre residential development is proposed:

Surface Cover	Acres
Rooftop	15
Pavement	25
Lawns	40
Undeveloped	20
Total	100

A. Determining Permitted Phosphorus Export (PPE):

$PPE = A * 0.10$ lbs/ac

$= 100 * 0.10$ lbs/ac

= **10 lbs**

B. Determining phosphorus export from site (P_X):

$$P_X = L_{SUM} - T_{SUM}$$

The stormwater BMPs consists of wet ponds, disconnection of rooftop runoff, water quality swales employed as follows:

- Water quality swale
- Wet extended detention pond
- Dry extended detention pond
- Disconnected impervious surface

T-values

Surface Cover	Acres	WQ Swale (.35)	Wet Pond (.55)	Dry Pond (.20)	Disconnect Imp. Surface (.20)	Multiple BMPs (0.10) / pair	T-values*	
Roof	10	.35	.55			.10	1.0	Wt. Avg. .98
	5	.35		.20	.20	.20	.95	
Pavement	25	.35	.55			.10	1.0	
Lawn	30	.35	.55			.10	1.0	Wt. Avg. .91
	10	.35		.20		.10	.65	
Undeveloped	20			.20			.20	

*T-value cannot exceed 1.0

L-values

Cover	Acres	L-value	L_{SUM}	T-value	T_{-SUM}
Roofs	15	0.25	3.75	.98	3.68
Asphalt or Concrete Pavements	25	0.50	12.50	1.00	12.50
Lawn	40	1.48	59.20	.91	53.87
Undeveloped	20	0.10	2.00	.20	0.40
Total			**77.45**		**70.45**

Adequate water quality treatment of stormwater runoff is attained when phosphorus exported from the site is less than or equal to permitted phosphorus export:

$$PPE \geq Px$$

Where: $P_X = L_{SUM} - T_{SUM}$

$P_X = 77.45 - 70.45$

$P_X = 7.00$

Therefore: $10 \geq 7.00$, BMPs are sufficient