KAWKAWLIN RIVER WATERSHED

IMPERVIOUS SURFACE CAPACITY AT BUILD-OUT ANALYSIS

PREPARED FOR:

KAWKAWLIN RIVER WATERSHED PARTNERSHIP

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PROJECT NO. G04322

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LIST OF ACRONYMS

C-CAP	Coastal Change Analysis Program
CGI	Michigan Center for Geographic Information
CT	Connecticut
DOQQ	Digital Orthophoto Quarter Quadrangle
DR	Drain
ESRI	Environmental Systems Research Institute
FTC&H	Fishbeck, Thompson, Carr & Huber, Inc.
GIS	Geographic Information System
ISAT	Impervious Surface Analysis Tool
LFC	Little Forks Conservancy
MDEQ	Michigan Department of Environmental Quality
NLCD	National Land Cover Dataset
NOAA	National Oceanic and Atmospheric Administration
PA 116	Public Act 116
SBCARL	Saginaw Bay Conservation and Recreation Lands
TCF	The Conservation Fund
TWP	Township
US	United States
USGS	United States Geological Survey

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INTRODUCTION

The conversion of pervious surfaces, such as farmland, forests, wetlands, and meadows into impervious surfaces, mainly rooftops, roads, and parking lots, increases surface runoff during storm events. This increase in runoff affects the hydrology, morphology, water quality, and ecology of surface waters in a watershed. Past studies have resulted in a current understanding of how the level of imperviousness in a watershed can be linked to stream degradation. As little as 10% watershed impervious cover has been linked to stream degradation in many regions of the county (Schueler and Holland, 2000).*

Current impervious cover, estimated from satellite imagery, can be contrasted with projected levels of imperviousness derived from a zoning-based build-out analysis. The build-out analysis allows township and municipal officials to visualize a possible future of their community, not in the conventional terms of populations or buildings, but in terms of impervious cover, and by inference, the health of local water resources.

The Kawkawlin River Watershed project used Environmental Systems Research Institute (ESRI) ArcView 8.3, ESRI Spatial Analyst 8.3, and National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center Impervious Surface Tool (ISAT) software to analyze existing and potential impervious surfaces within the watershed. ISAT is an extension for ArcView and is available for ArcView versions 3.x and 8.x.

NOAA states that ISAT was developed to help managers and planners determine the impact of impervious surface coverage on local water quality. ISAT applies impervious surface coefficients to a remotely sensed land cover data grid to calculate the total and the percentage of impervious surface within a given area. In the Kawkawlin River Watershed, this tool was also used to determine the effects of impending land cover change on the imperviousness of five selected subwatersheds. The tool is available free of charge from the NOAA Coastal Services website, http://www.csc.noaa.gov/crs/cwq/isat.html.

*Schueler, Tom and Holland, Heather. 2000. *The Practice of Watershed Protection.* Center for Watershed Protection.

PART I - DATA COLLECTION

1. BASE MAP AND WATERSHED DELINEATION

The Kawkawlin River Watershed drains nearly 250 square miles and encompasses areas in Bay, Gladwin, Midland, and Saginaw Counties. Base map and watershed delineation files were collected for the entire watershed. The Michigan Center for Geographic Information (CGI) Framework was selected for base mapping of roads, surface water, county and municipal boundaries. This data is provided in ArcView shape file format and is available for download at the Michigan Geographic Library web site http://www.michigan.gov/cgi.

Watershed delineations for the Saginaw Bay Watershed as provided by the Michigan Department of Environmental Quality (MDEQ) are also available from the CGI. The base map and the Kawkawlin River Watershed "MDEQ DELINEATION" are shown in Figure 1.

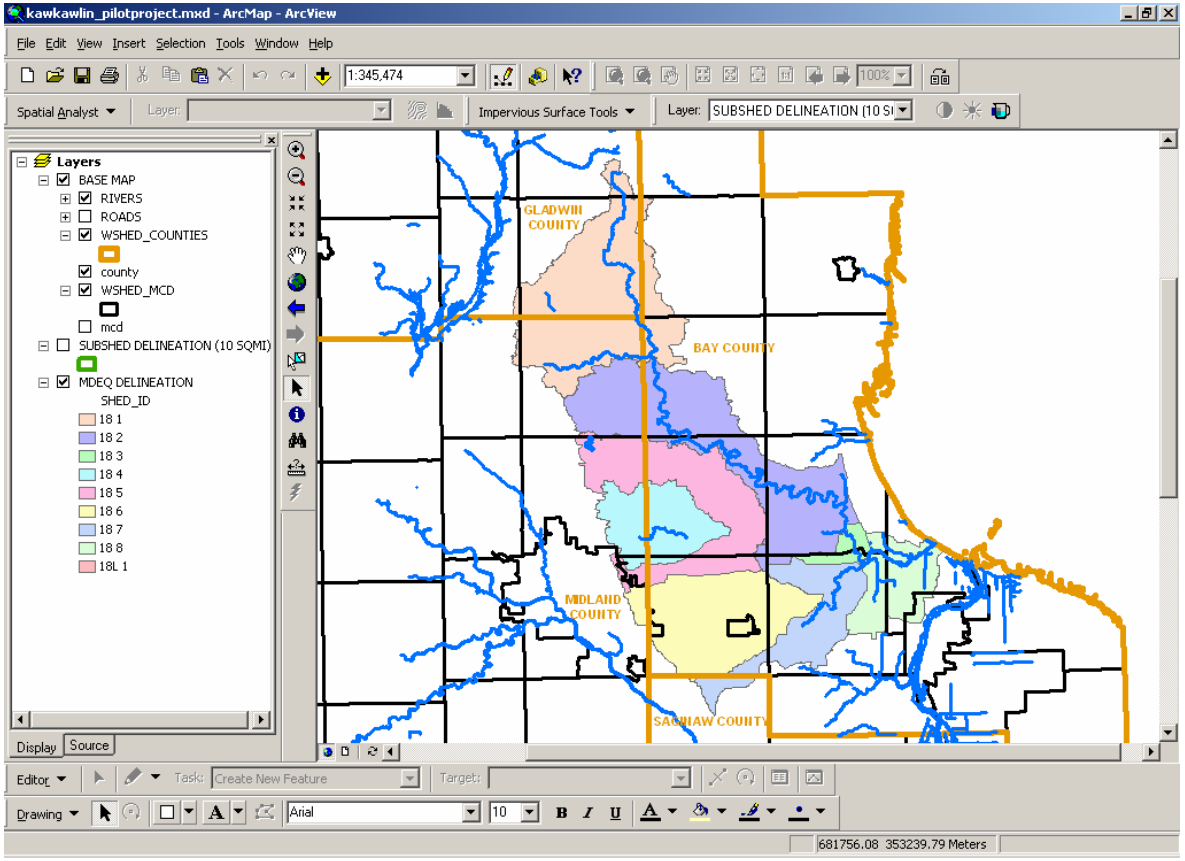

Figure 1: Watershed Base Map

The Little Forks Conservancy (LFC) requested MDEQ to further delineate the sub basin boundaries to areas of approximately 10 square miles or less. The resulting ArcView shape file available specifically for this project is referred to as “SUBSHED DELINEATION (10 SQMI)” as shown in Figure 2.

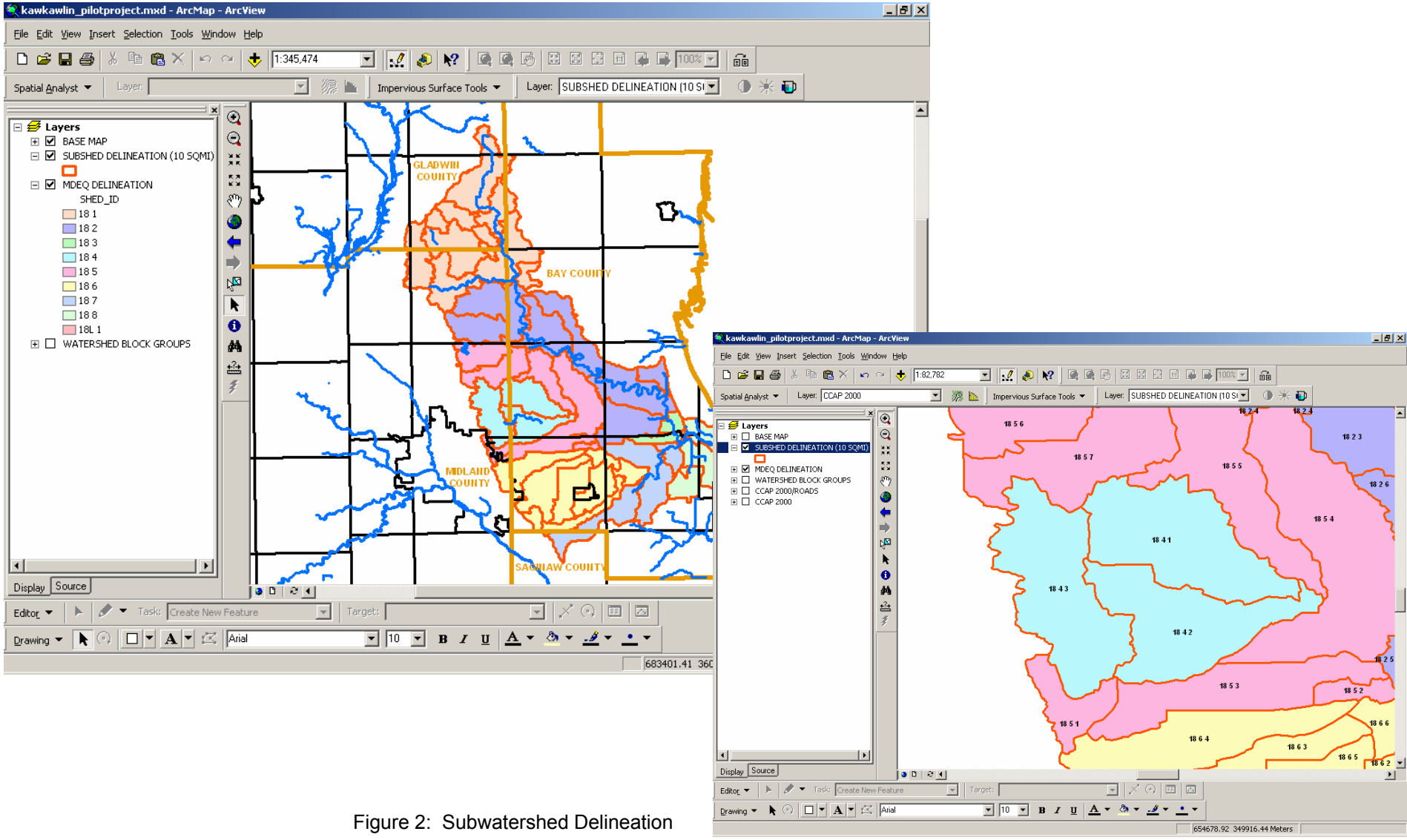

Figure 2: Subwatershed Delineation

2. EXISTING LAND COVER

The 2000 Great Lakes Coastal Change Analysis Program (C-CAP) data was provided by LFC for use in this project. The program uses the U.S. Geological Survey's (USGS) National Land Cover Dataset (NLCD) to represent existing land cover.

NLCD data specifications:

- Derived from Landsat satellite imagery
- 30 meter pixel resolution
- Target 85% overall classification accuracy
- 22 land cover classes (19 of which are found within the Kawkawlin River Watershed)

This data is also available for download at the NOAA Coastal Service Center Coastal Water Quality website: http://www.csc.noaa.gov/crs/lca/ccap.html .

A close up view of the NLCD for the year 2000, "CCAP 2000," is shown in Figure 3.

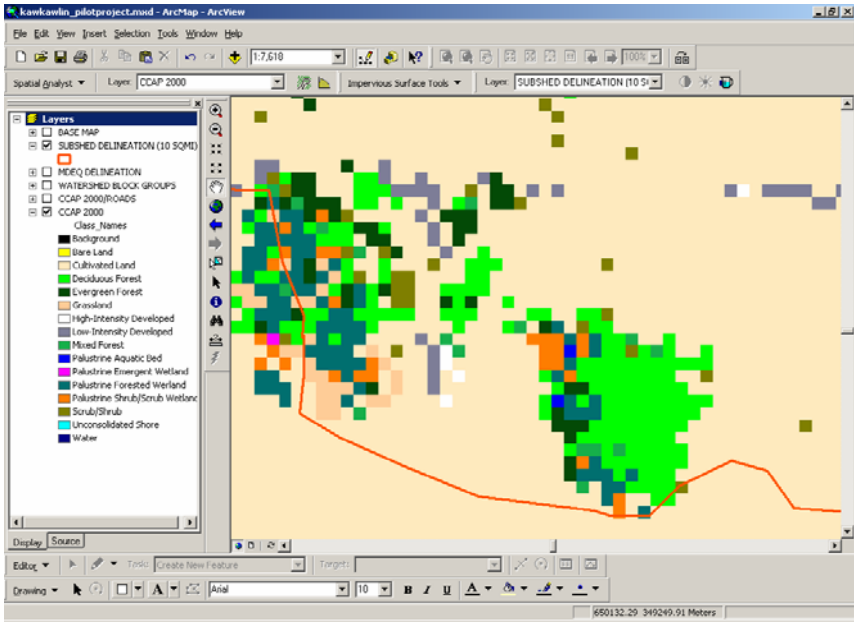

Figure 3: NLCD

Upon initial review of the existing land cover files, it was determined that the NLCD data provided did not adequately capture the local road surfaces throughout the watershed. Many of the roads in agricultural areas were not significantly represented due to their width being less than the 30 meter pixel size being sampled. LFC used the Spatial Analyst program to burn in the Framework road network vector data at a 10-meter pixel sample size and assign the pixels a low intensity developed land class code. This resulted in a modified existing land cover grid file which accounts for impervious runoff contributed from the local road surfaces. The modified land cover "CCAP 2000/ROADS" was added in Figure 4.

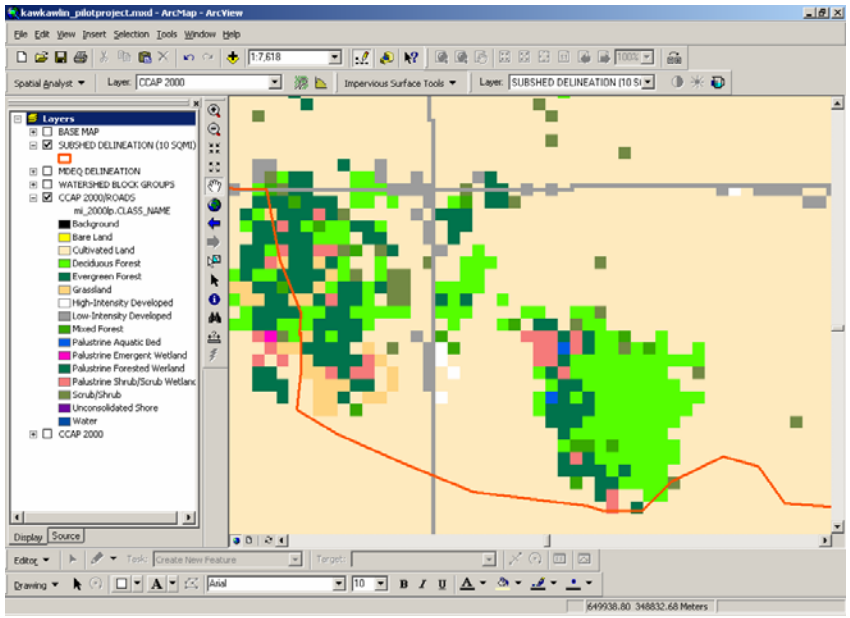

Figure 4: NLCD with Framework Roads

3. U.S. CENSUS POPULATION DATA

ISAT calculates the percentage of impervious surface area of selected geographic areas. These selected geographic areas could represent watersheds, subwatersheds, municipalities, subdivisions, census blocks, or any user defined area boundary. Initial ISAT runs for the Kawkawlin River Watershed showed that even at the subwatershed level, significant differences in land cover and population density were averaged out over large areas. Thus, the results were not specific to the individual communities or development areas within each community.

U.S. Census Block Group polygon files are available for use from CGI Geographic Data Library. These files are consistent with the Michigan Framework base map which was chosen for this project. The "Census Data for Geographic Framework" application program allows users to select and download census data to a summary file that is readily imported into ArcView. The summary file contains the total population of each block group. It was linked to the Michigan Framework block group files which include area of each block group. From the data, population density of persons per square mile was calculated and added as an attribute "POPDNS2000."

The layer representing the census block groups including population density is "2000_KAWKAWLIN_WATERSHED_CENSUS_BLOCK_GROUPS." This layer was intersected with the subwatersheds to generate a layer representing subwatersheds and their subsequent block group boundaries. "WATERSHED BLOCK GROUPS". Population density was mapped in 3 classes:

- 0-250 persons per square mile
- 250-2000 persons per square mile
- Greater than 2000 persons per square mile

These class breaks were selected upon review of the natural population class breaks of communities within the Watershed. They are used to select impervious surface coefficients based on population density. Figure 5 illustrates population density within the watershed. "WATERSHED BLOCK GROUPS" is the analysis layer for ISAT.

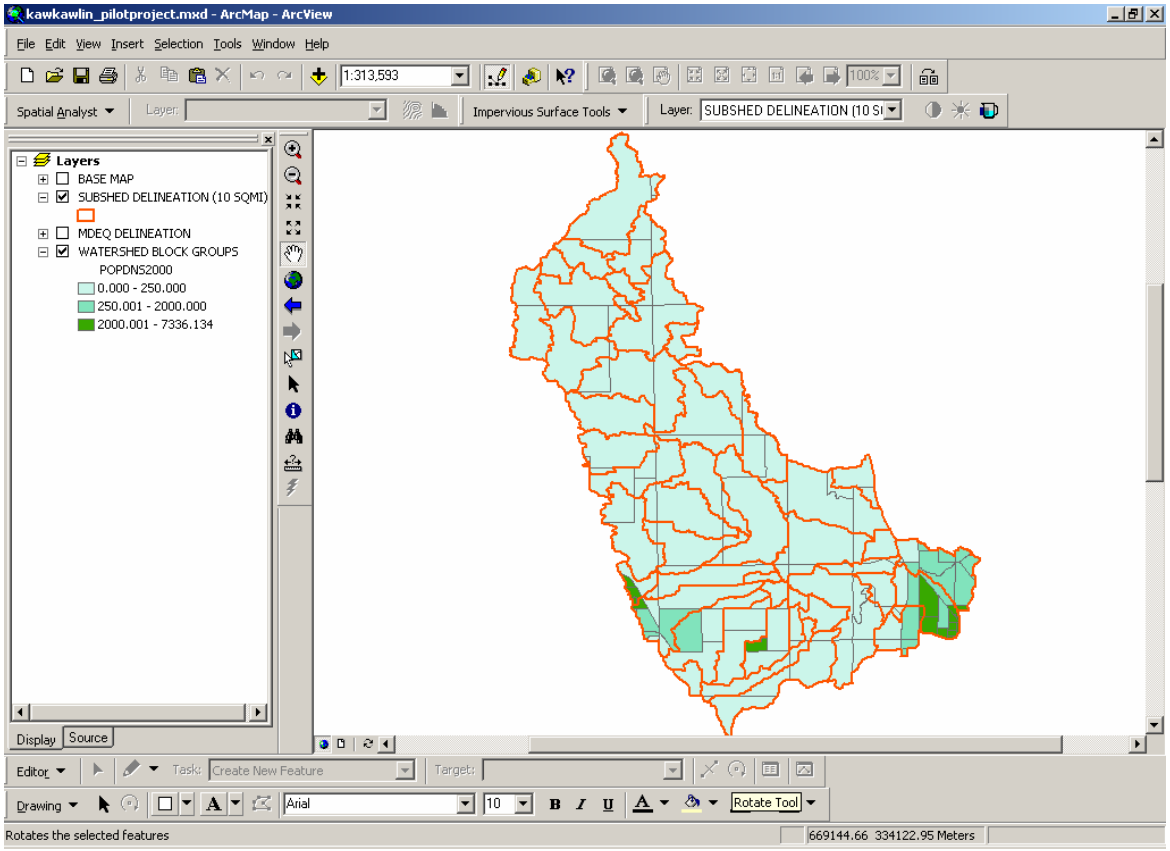

Figure 5: Population Density

The analysis layer contains an analysis field for which percentage imperviousness was calculated. The field "NAME2" represents a unique value to identify each block group/subwatershed combination. Figure 6.

Attributes of WATERSHED BLOCK GROUPS

SQMILES	P001001	POPDNS2000	name	NAME2
11.729	897	76.477	Bradford Creek at Mouth 0101002	0
11.729	897	76.477	Culver Creek at Union Road 0101002	1
14.16	2033	143.573	Culver Creek at Union Road 2856004	2
14.16	2033	143.573	Hoppler Creek Above Labozinski Drain 2856004	3
14.16	2033	143.573	Phillips Drain at Mouth 2856004	4
14.16	2033	143.573	Bradford Creek at Mouth 2856004	5
5.398	1116	206.743	Bradford Creek at Mouth 2856003	6
7.123	1108	155.552	Phillips Drain at Mouth 2855003	7
0.89	1057	1187.640	Mill Pond Drain at Wilder Road, south side 2855001	8
14.16	2033	143.573	Hoppler Creek at Mouth 2856004	9
0.499	1191	2386.774	Dell Creek at Hoppler Creek 2856005	10
7.123	1108	155.552	Pine Drain at Mouth 2855003	11
7.123	1108	155.552	Bradford Creek at Mouth 2855003	12
7.123	1108	155.552	Culver Creek at Union Road 2855003	13
5.532	1171	211.678	Kawkawlin River Wheeler Road 2855002	14
7.123	1108	155.552	Kawkawlin River Wheeler Road 2855003	15
5.532	1171	211.678	Mill Pond Drain at Wilder Road, south side 2855002	16
0.375	559	1490.667	Mill Pond Drain at Wilder Road, south side 2855004	17
5.398	1116	206.743	Pine Drain at Mouth 2856003	18

Record: 1 Show: All Selected Records (0 out of 197 Selected.) Options

Figure 6: Census Block Groups

PART II - WATERSHED EXISTING LAND COVER IMPERVIOUS ANALYSIS

The watershed delineations, existing land cover, and population block group data were the parameters collected to run ISAT. The process was begun by choosing impervious surface coefficients for the project. From the **Impervious Surface Tools**, **Change Coefficients** displays the **Change Coefficients** dialog box.

ISAT comes with a set of coefficients provided by the University of Connecticut based on impervious surface data for that state. Information on this source is included in the ISAT support documentation. The NOAA Coastal Services Center is currently working in cooperation with the Great Lakes Commission to develop an Integrated Coastal Management Tool for analyzing the impacts of various management decisions on the Lake St. Clair coastal habitat. This process uses ISAT and includes a plan to study the impervious surface coefficients based on Michigan, and more specifically eastern Michigan, land cover conditions. Although this information was not developed in time for use in the Kawkawlin River Watershed pilot projects, it may become available in the near future. In the meantime, the values included with the ISAT tools were used in lieu of Michigan specific data.

The **Change Coefficients** dialog box was used to create a new coefficient set modeled after the preset coefficient set provided with the tool (CCAP_CT).

The following classes were deleted from the given set:

20 Estuarine Aquatic Bed
21 Tundra
22 Snow/Ice

The following class was added to the new coefficient set:

0 unknown, 0, 0, 0

The deleted classes were not found within the Kawkawlin River Watershed land cover data set and would cause errors in ISAT if they were included in the coefficient set. Likewise, if a background value was found within the dataset, it must have coefficients included, even though those are zero. The coefficient set was saved as “kawkawlin_ccap” as shown in Figure 7.

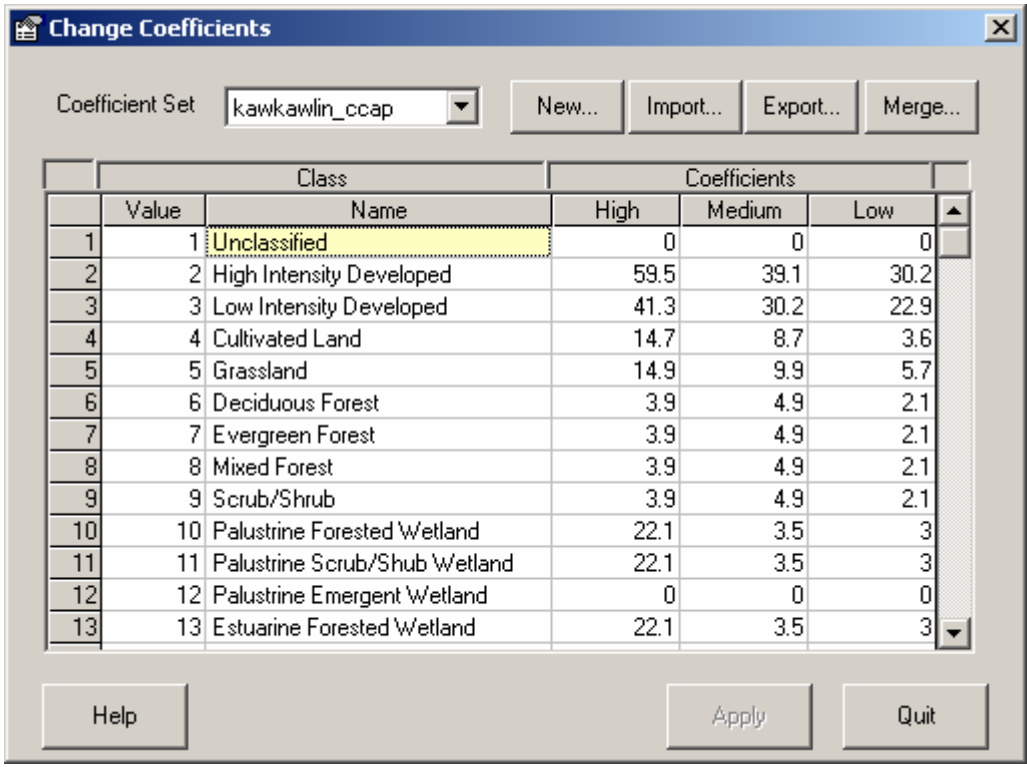

Figure 7: Runoff Coefficients

From ISAT, **Run Impervious Surface Analysis** opens the tool dialog box. Data input is shown in Figure 8.

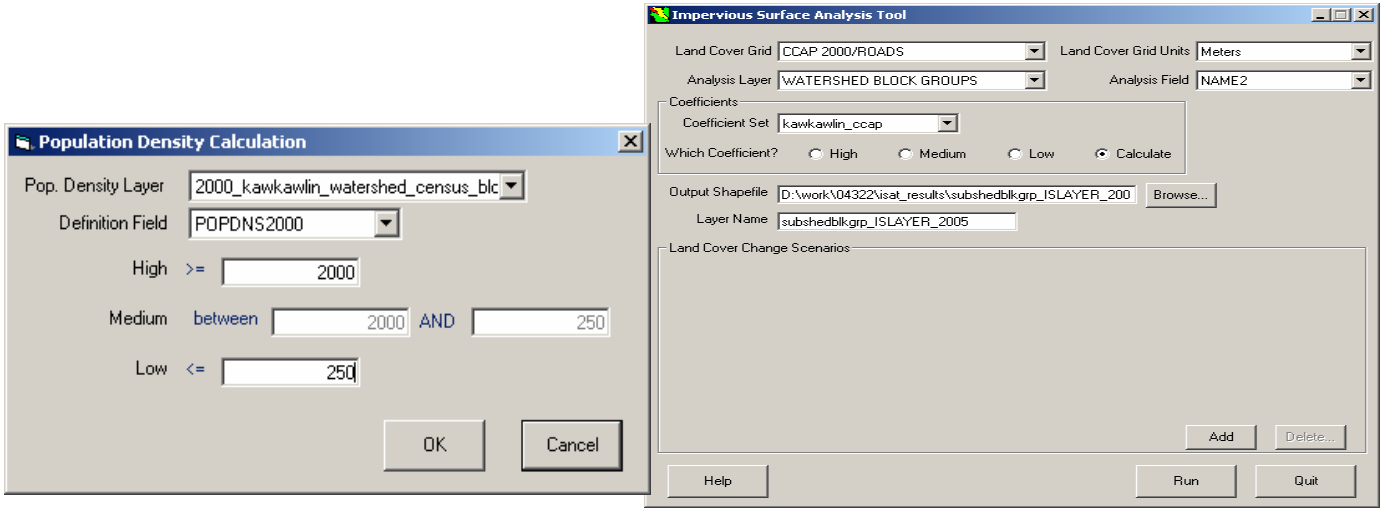

Figure 8: ISAT Parameters

The results were stored as an ESRI shape file and associated layer file and were automatically added to the ArcView project as seen in Figure 9.

The layer was stored as "subshedblkgrp_ISLAYER_2005" representing an impervious surface analysis based on subwatershed delineations divided by census block group for existing land cover conditions. The default legend applied to the new layer indicates the potential impact to water quality based on the estimated percentage of imperviousness within each analysis field.

- **PROTECTED:** Green areas are labeled <10%, which corresponds to <10% impervious surface area. These areas generally have stable channels, excellent biodiversity, and excellent water quality.
- **DEGRADED:** Yellow areas are labeled 10%-25%, which corresponds to 10%-25% impervious surface area. These areas have channel that are becoming unstable, declining habitat, and fair to good water quality.
- **IMPACTED:** Red areas are labeled >25%, which corresponds to >25% impervious surface area. The areas often have unstable channels, a lack of biodiversity, and poor water quality.

The results of the analysis run on existing conditions identified small areas in the cities of Midland, Auburn, and Bay City that are currently surpassing impacted threshold levels and may be experiencing adverse water quality effects.

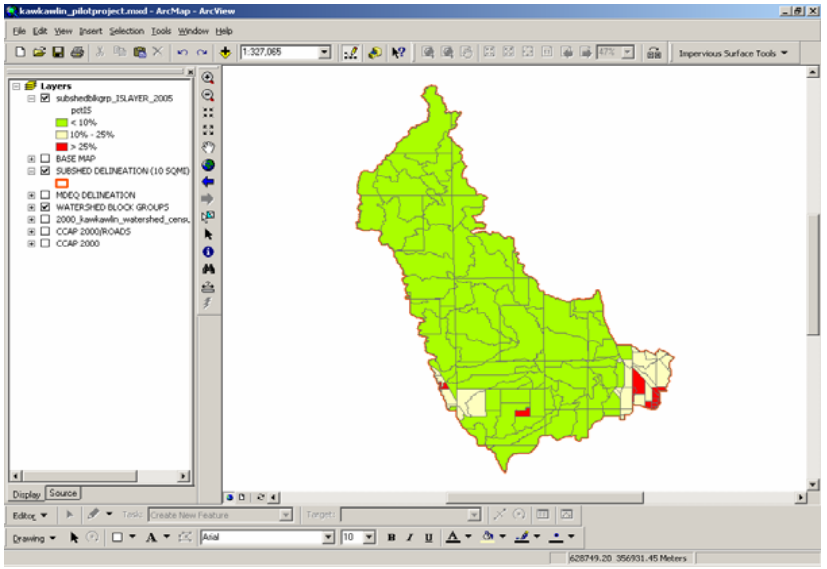

Figure 9: Existing Land Cover ISAT Results

The layer's attribute table displays the results in tabular form, Figure 10. The field "NAME2" was chosen as the analysis field and represents an unique value to identify each block group/subwatershed combination. The attribute table contains four columns for each Analysis Field (Name2): TotHects, TotISHec, pctIS, and Complete. TotHects is the total area within each analysis field. TotISHec is the total impervious surface area within each analysis field, and pctIS is the percentage of impervious surface within each analysis field. ISAT checks for polygons in the analysis layer that overlap NO DATA cells in the land cover grid. The Complete attribute indicates Y for yes, that a full calculation was made because there are no NO DATA cells, or N for no, that area calculations for these polygons exclude area where NO DATA cells were found. The land cover grid data provided was projected to Michigan Georef (meters), the same system used for the Michigan Framework base map and the ArcView project. Therefore, the results are in hectares because the initial data input was in meters.

Attributes of subshedblkgrp_ISLAYER_2005

FID	Dissolve_	NAME2	TotHects	TotISHec	pctIS	Complete
8	Polygon	8	22.59	3.76917	16.69	Y
9	Polygon	9	665.86	40.35502	6.06	Y
10	Polygon	10	5.51	1.83437	33.29	Y
11	Polygon	11	39.77	1.85767	4.67	Y
12	Polygon	12	128.55	8.26868	6.43	Y
13	Polygon	13	826.78	44.54605	5.39	Y
14	Polygon	14	266	20.28665	7.63	Y
15	Polygon	15	469.96	28.54726	6.07	Y
16	Polygon	16	142.95	13.92046	9.74	Y
17	Polygon	17	79.39	17.72576	22.33	Y
18	Polygon	18	0.26	0.05954	22.9	Y
19	Polygon	19	124.01	38.72873	31.23	Y
20	Polygon	20	7.82	2.97586	38.05	Y
21	Polygon	21	4.29	1.51903	35.41	Y
22	Polygon	22	31.88	2.31712	7.27	Y
23	Polygon	23	96.47	11.7393	12.17	Y
24	Polygon	24	37.52	7.24979	19.32	Y
25	Polygon	25	29.39	11.04225	37.57	Y
26	Polygon	26	821.56	54.76447	6.67	Y

Record: 1 Show: All Selected Records (0 out of 197 Selected.) Options

Figure 10: Existing Land Cover ISAT Results Table

A closer view of the results, labeled with the percentage impervious surface values, is shown in Figure 11. The ISAT parameters that created this layer were stored in a separate file. To view the file, choose **View ISAT Parameters** from the ISAT menu. If the naming convention will not allow ISAT to view the file, it can be opened as a text file from the same directory as the shape file but with a ".prm" extension. ISAT parameter reports for this project can be found in the Appendix.

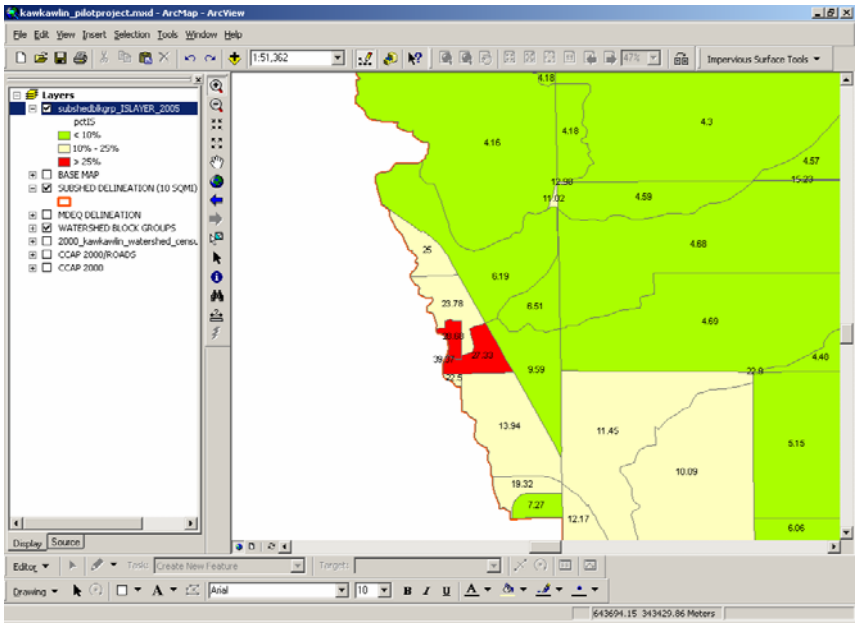

Figure 11: Existing Land Cover Percentage Impervious Surface

PART III - APPLICATIONS AT THE LOCAL LEVEL

A build-out analysis is a feasible and cost-effective indicator of water pollution that can provide a solid foundation for a community's plan of action. Impervious coverage is a readily identified, measurable aspect of the landscape, facilitating its use in both planning and regulatory applications. The establishment of consistent and defendable measures of imperviousness enables the development of strategies for community and watershed planning, site planning, and local regulations. The ability to project future land use and its associated imperviousness can give the land use planner a link between development and water quality.

Impervious cover has been documented to have a strong influence on water quality. Land use planners can use this information to critically analyze the degree and location of future development that is expected to happen in a watershed. Land use planning ranks as perhaps the single most important watershed protection tool. A goal of a land use planner should be to plan for development toward subwatersheds that can support a particular type of land use and/or density (Schueler and Holland, 2000 Article 27).* The basic goal of a watershed management plan is to apply land use planning techniques to redirect development, preserve sensitive areas, and maintain or reduce the impervious cover within a given subwatershed. Many of the subwatersheds In the Kawkawlin River Watershed are entirely contained within the same political jurisdiction, which helps to establish a clear and direct regulatory authority. This study was conducted on a subwatershed scale to provide management units that can be mapped at a resolution that is meaningful to the planners and the public. These subwatersheds are also small enough in which to perform monitoring and evaluation to assess the effectiveness and success of a project.

Stream Protection Goals

The classification of the subwatersheds of protected, degraded, and impacted can assist the communities in developing goals and criteria for development. With these goals and criteria in place, developers and consultants can refer to the subwatershed can determine applicable site requirements for that particular subwatershed (Schueler and Holland, 2000 - Article 29).*

Protected subwatersheds, with 0 to 10% impervious cover, should have a goal of maintaining predevelopment hydrology and biodiversity and set limits on site development impervious cover. To protect the streams, wide buffers are recommended, through land acquisition or conservation easements.

Degraded subwatersheds, with 10% to 25% impervious cover, should have a goal of limiting degradation of stream habitat and quality through setting an upper limit for the watershed imperviousness. Implementation practices should focus on pollutant removal and channel protection measures.

Impacted subwatersheds, with over 25% impervious cover, should have a goal of minimizing downstream pollutant loads by preventing flooding and creating preservation areas to reduce the effects of flooding.Creating a plan based on these goals can protect rivers, lakes, and streams from the cumulative effects of development in a watershed. This method of classifying and managing urbanizing watersheds, based on current or projected impervious cover, can improve the effectiveness of practices implemented by limiting the amount of new impervious cover that can be created.

Conservation and Preservation Techniques to Meet Goals - Working with local land conservancies, a variety of conservation options are available to preserve existing natural areas within the Kawkawlin River Watershed. A land conservancy is a non-profit 501(c)3 community based land conservation organization working to protect land. In the Kawkawlin watershed, The Little Forks Conservancy and the Saginaw Basin Land Conservancy work with landowners who voluntarily choose to protect their lands. The following conservation options can used to assist landowners.

- Conservation easements - A conservation easement is a legal agreement between landowner and a qualified conservation organization, such as the Little Forks Conservancy, that permanently protects the land while it remains as private property. For example, conservation easements can limit future subdivision, commercial or industrial activity, clear cutting of woodlots, and mining of sand and gravel on the property. The limitations set forth in a conservation easement are tailored to suit goals and objectives of the landowner

- Remainder Interests and Reserved Life Estates - It is possible for landowners to donate land to a conservancy and continue to live on the property for the balance of their life and/or the lifetime of certain named individuals. This is a reserved life estate. When the landowner or others named by the landowner die, the life interest is released and the conservancy receives full title and control over the property. An income tax deduction is possible, based on the difference between the full market value at the time of the contribution and expected value of the reserved life estate.

- Bequest - If a landowner wishes to maintain full control over the land during his or her lifetime, but assure that it is protected after their death, a property can be bequeathed to a conservancy by will.

- Bargain Sale of Land or Conservation Easement - If a landowner does not desire to donate property outright, it is possible to conduct a bargain sale of the property. A conservancy can purchase the property or conservation easement at below full market value. The difference between the sale price and full market value of the property or conservation easement can be used as a tax deduction and to offset capital gains taxes triggered by the sale.

Purchase of Land or Conservation easement-In special situations the protection of a property is important enough for a conservancy to purchase property at its full market value. This may occur when a landowner will only give up control of the property through a sale.

*Schueler, Tom and Holland, Heather. 2000. *The Practice of Watershed Protection.* Center for Watershed Protection.

PART IV - SUBWATERSHED EXISTING AND FUTURE LAND COVER IMPERVIOUS ANALYSIS

The impervious surface capacity analysis was performed on five subwatersheds. These subwatersheds were selected by criteria developed through discussions with the advisory committee, residents, local officials, and other agencies and organizations to identify areas that are rapidly developing or slated to be developed in the near future. The criteria included:

- Subwatershed area of less than 10 square miles
- Percent imperviousness borderline between two classifications
- Natural features present
- Land use
- Proximity to urban or developing area
- Location in Kawkawlin River Watershed
- Condition of stream or designated drain

The following subwatersheds were selected, based on the criteria.

Subwatershed 18 2 1 - Torey, Drain, Mills Township
- Mills Township, Midland County
- Located entirely in a single Township
- Existing Agricultural lands
- Large percentage of preservation lands
- Located in headwaters of the watershed

Subwatershed 18 6 2 - Phillips Drain, Auburn
- City of Auburn/Williams Township/Monitor Township, Bay County
- Developing from high intensity urban core
- Located in center of watershed

Subwatershed 18 6 5 - Dell Creek, Auburn
- City of Auburn/Williams Township, Bay County
- Developing from high intensity urban core
- Located in center of watershed

Subwatershed 18 8 3 - Mill Pond Drain, Monitor Township
- Monitor Township/Bangor Township, Bay County
- Highly developed area
- Located near mouth of the Kawkawlin River

Subwatershed 18 4 3 - Waldo Drain, Larkin Township
- Larkin Township/Midland Township, Midland County
- Beaver Township, Bay County
- Encompasses several jurisdictions
- Located in center of watershed
- Developing from City of Midland urban area

The capacity analysis illustrates the effects of development if existing zoning and preservation ordinances continue. The influence on impervious cover on hydrology, water quality, and biodiversity is most strongly felt at the subwatershed scale. By concentrating on a subwatershed level, existing land cover conditions can be more closely examined and the Landsat satellite imagery interpretation of land cover can be modified as necessary. Therefore, ISAT was run again for each subwatershed's existing land cover to account for field modifications. This also allowed for a one-on-one comparison of existing conditions and capacity analysis on a subwatershed basis. Table 1.

Data availability and application vary across the watershed. A matrix was developed to track applicable data for land cover change scenarios in each pilot subwatershed. Each pilot area may have a slightly different set of parameters to consider. The pilot areas were selected to provide a variety of land cover change scenarios that are possible throughout the watershed. A detailed description of data sets for each pilot area is located in the Appendix.

TABLE 1: IMPERVIOUS SURFACE CAPACITY ANALYSIS PROCEDURE

			18 2 1	18 6 2	18 6 5	18 8 3	18 4 3
			TOREY DRAIN MILLS TWP	PHILLIPS DRAIN AUBURN	DELL CREEK AUBURN	MILL POND DRAIN MONITOR TWP	WALDO DRAIN LARKIN TWP
			MIDLAND COUNTY	BAY COUNTY	BAY COUNTY	BAY COUNTY	MIDLAND COUNTY
	STEP	**DATA**					
1	**Select subwatershed for analysis**	MDEQ Subwatershed Delineation	✓	✓	✓	✓	✓
2	**Intersect block groups to subwatershed**	Watershed Census Block Groups	✓	✓	✓	✓	✓
3	**Field review existing land cover**	Existing Land Cover	✓	✓	✓	✓	✓
4	**Run ISAT for existing land cover**	2005 Impervious Surface Layer	✓	✓	✓	✓	✓
5	**Import future land cover layer**	Zoning/Future Land Use	✓	✓	✓	✓	✓
6	**Export low/high-intensity development layers**	Land Use Selection	✓	✓	✓	✓	✓
7	**Remove PA 116 Lands**	Saginaw Bay PA 116 Lands	✗	✗	✓	✓	✓
8	**Remove Recreation Lands**	Conservation and Recreation Lands	✗	✓	✓	✓	✓
9	**Remove Private Conservation Lands**	Conservation and Recreation Lands	✗	✗	✓	✓	✓
10	**Remove Green Infrastructure Lands**	Green Infrastructure Models	✓	✗	✗	✗	✓
11	**Run ISAT for future land cover**	2025 Impervious Surface Layer	✓	✓	✓	✓	✓

Subwatershed 18 2 1 - Torey Drain, Mills Township

STEP 1 - Select subwatershed for analysis.

Select subwatershed 18 2 1 from the SUBSHED DELINEATION (10 SQMI) layer. Data export to its own layer, 18_2_1SUBSHED.

STEP 2 - Intersect block groups to subwatershed.

Use the ArcView Geoprocessing Wizard to intersect the WATERSHED BLOCK GROUPS layer with the 18_2_1SUBSHED layer. Result is 18_2_1BLKGRP. There is only one census block group located within this subwatershed. Figures 12 and 13.

STEP 3 - Field review existing land cover.

There are no documented changes to the 2000 NLCD data set based on field inspection for this subwatershed.

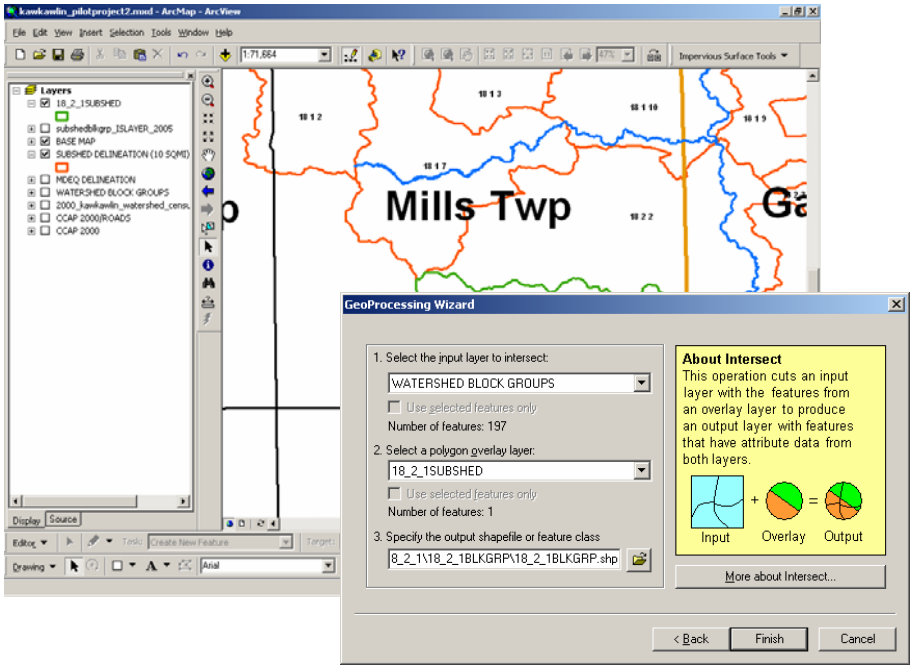

Figure 12: Torey Drain Block Group Intersection Input

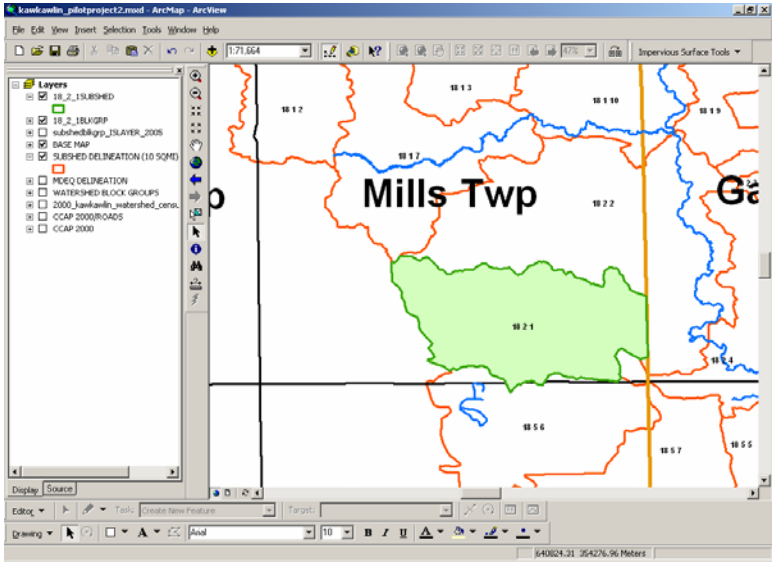

Figure 13: Torey Drain Block Group Intersection Result

STEP 4 - Run ISAT for existing land cover.

Run ISAT for existing land cover on subwatershed census block groups. Figure 14.

ISAT adds results to the project as layer 18_2_1ISLAYER_2005. Open the attribute table to see that the impervious surface area covers 3.05% of the subwatershed. Figure 15.

View and confirm ISAT parameters for this scenario in 18_2_1ISLAYER_2005.prm. (Appendix)

STEP 5 - Import future land cover layer.

Import Mills Township Zoning layer, MILLS_ZONING, and clip to the subwatershed boundary, 18_2_1ZONING. Figure 16.

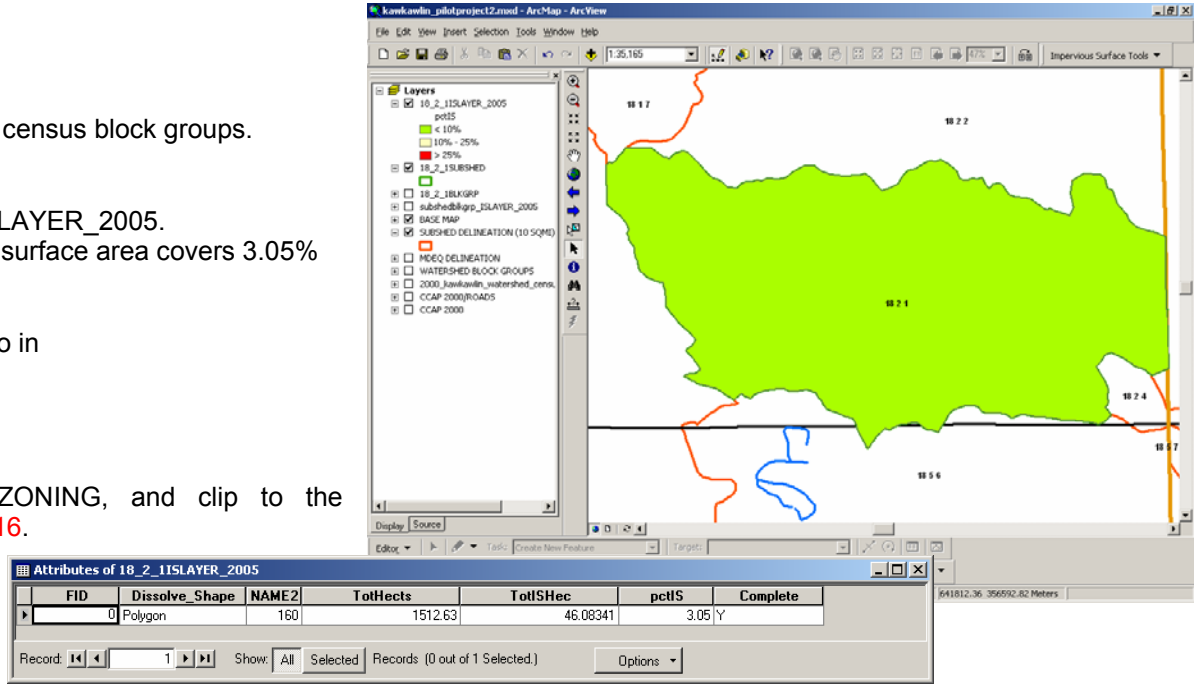

Figure 15: Torey Drain Existing Land Cover ISAT Results

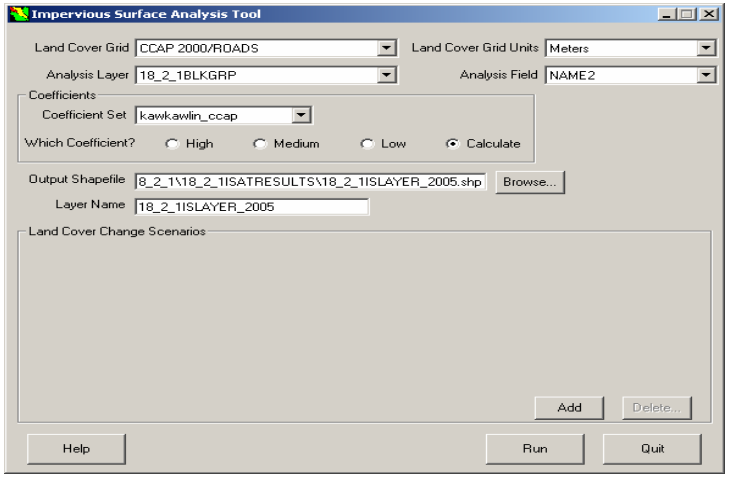

Figure 14: Torey Drain Existing Land Cover ISAT Input

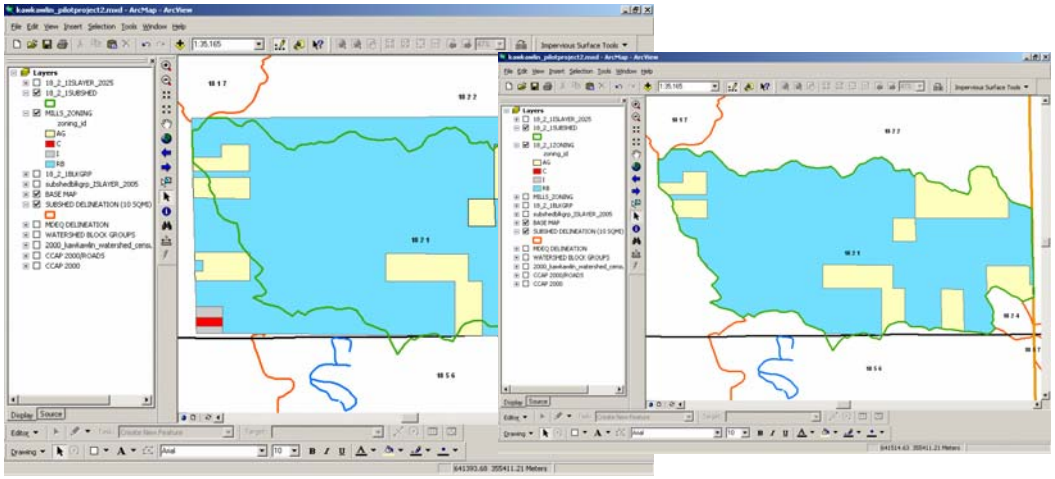

Figure 16: Torey Drain Future Land Use

STEP 6 - Export low/high intensity development layers.

Based on zoning classes, select and export zoning features which represent low intensity development and high intensity development to their own layers. In Mills Township, zone Residential (B) represents low density and rural residential uses. This description falls into class 3, Low Intensity Developed. Features in the Residential (B) zone are exported to 18_2_1ZONLOW. There are no zoning classes in this subwatershed which qualify as high intensity developed. Figure 17.

A complete description the NLCD Classification Scheme can be found on the NOAA Coastal Service Center website http://csc.noaa.gov/crs/lca/oldscheme.html. Assuming that existing developed lands will not revert to undeveloped lands in the future, only Low Intensity Developed and High Intensity Developed land classes will be added for future land change scenarios.

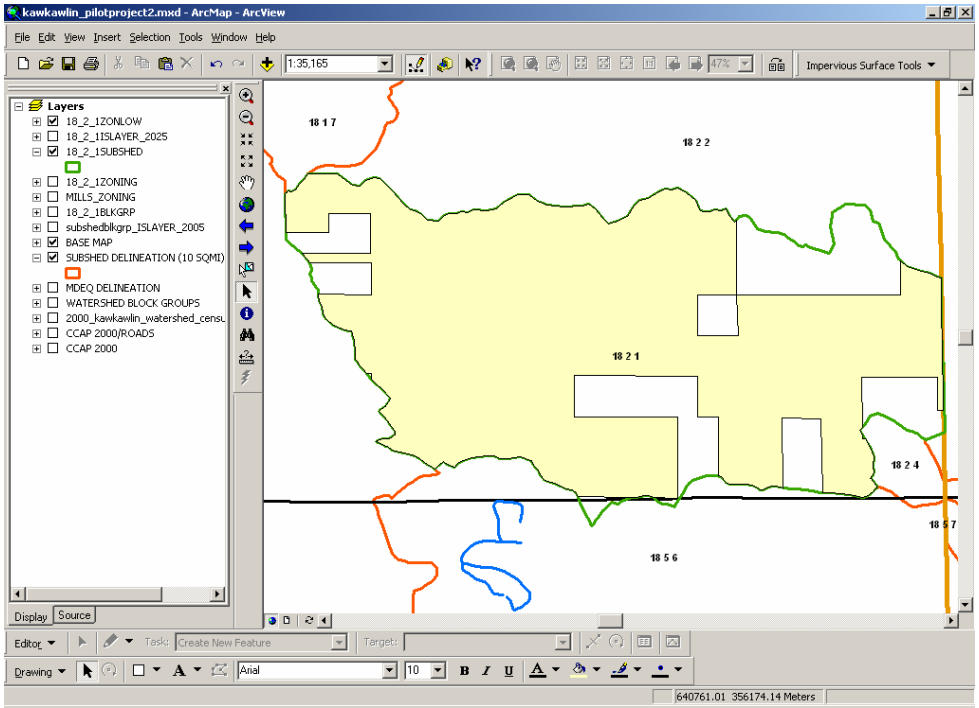

Figure 17:
Torey Drain
Development Layers

NLCD Classification Scheme:

2 High Intensity Developed – Contains little or no vegetation. This subclass includes heavily built-up urban centers as well as large constructed surfaces in suburban and rural areas. Large buildings (such as multiple family housing, hangars, and large barns), interstate highways, and runways typically fall into this subclass.

"High Intensity, Developed Land includes heavily built-up urban centers and large constructed surfaces in suburban and rural areas with a variety of different land uses. The High Intensity category contains areas in which a significant land area is covered by concrete and asphalt or other constructed materials. ***Vegetation, if present, occupies < 20 percent of the landscape****. Examples of such areas include apartment buildings, skyscrapers, shopping centers, factories, industrial complexes, large barns, airport runways, and interstate highways."*

3 Low Intensity Developed – Contains substantial amounts of constructed surface mixed with substantial amounts of vegetated surface. Small buildings (such as single family housing, farm outbuildings, and sheds), streets, roads, and cemeteries with associated grasses and trees typically fall into this subclass.

"Low Intensity, Developed Land includes areas with a mixture of constructed materials (e.g., roofing, metal, concrete, asphalt) and vegetation or other cover. ***Constructed materials account for 50 to 79 percent of total area.*** *These areas commonly include single-family housing areas, especially in suburban neighborhoods, but may include scattered surfaces associated with all types of land use. As the percentage of constructed material cover decreases, this category grades into Cultivated, Grassland, Woody, and other land cover classes. A large building surrounded by several acres of grass, for example, might appear as one or more pixels of High Intensity Developed Land, one or more pixels of Low Intensity Developed Land and many pixels of Grassland."*

STEP 7 - Remove PA 116 Lands.

No PA 116 lands are located in this subwatershed.

STEP 8 - Remove Recreation Lands.

No recreation lands are located in this subwatershed.

STEP 9 - Remove Private Conservation Lands.

No private conservation lands are located in this subwatershed.

STEP 10 - Remove Green Infrastructure Lands.

Green Infrastructure Lands are represented in layer GREENPLAN_REGIONAL_CONS_NETWORK. The Green Infrastructure Shape file was developed using priority conservation lands identified by the Saginaw Bay Greenways Collaborative through GIS modeling, meetings with major stakeholders and municipal officials, and community design sessions. This layer includes areas which are to be preserved from future development, even if the local zoning map or future land use map indicates potential development. Therefore, this area should be removed from the future low intensity and high intensity development area.

Use the ArcView Geoprocessing Wizard to union the 18_2_1ZONLOW layer with the GREENPLAN_REGIONAL_CONS_NETWORK layer. Delete polygons within the Green Infrastructure Lands. The result is 18_2_1ZONLOW2. Figure 18.

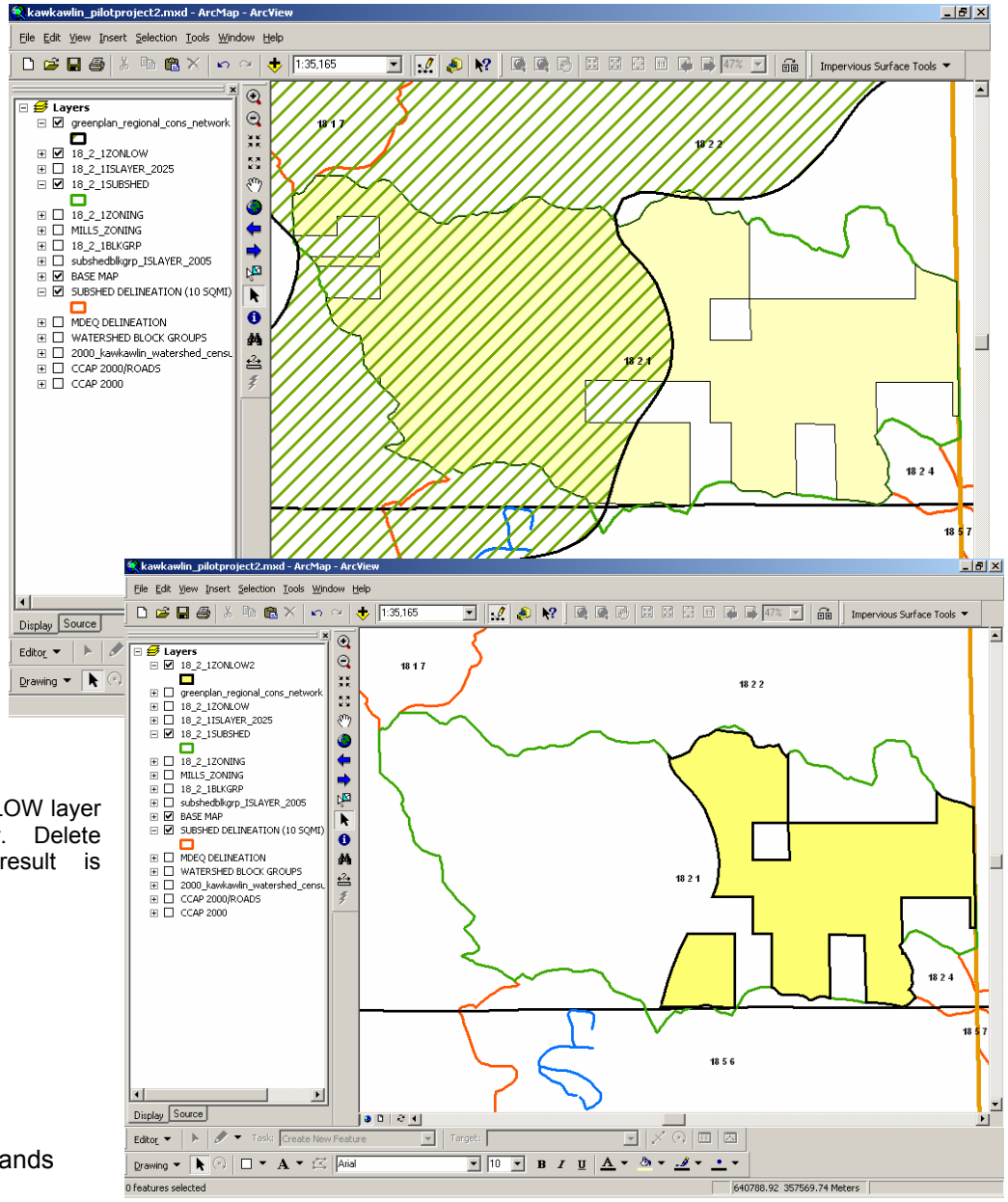

Figure 18:
Torey Drain
Greenways Lands

STEP 11 - Run ISAT for future land cover.

Run ISAT introducing the land cover change scenario developed for future low intensity development. The layer generated is saved as 18_2_1ISLAYER_2025 indicating zoning or future land use plan land cover changes over the next 20 years. Figure 19.

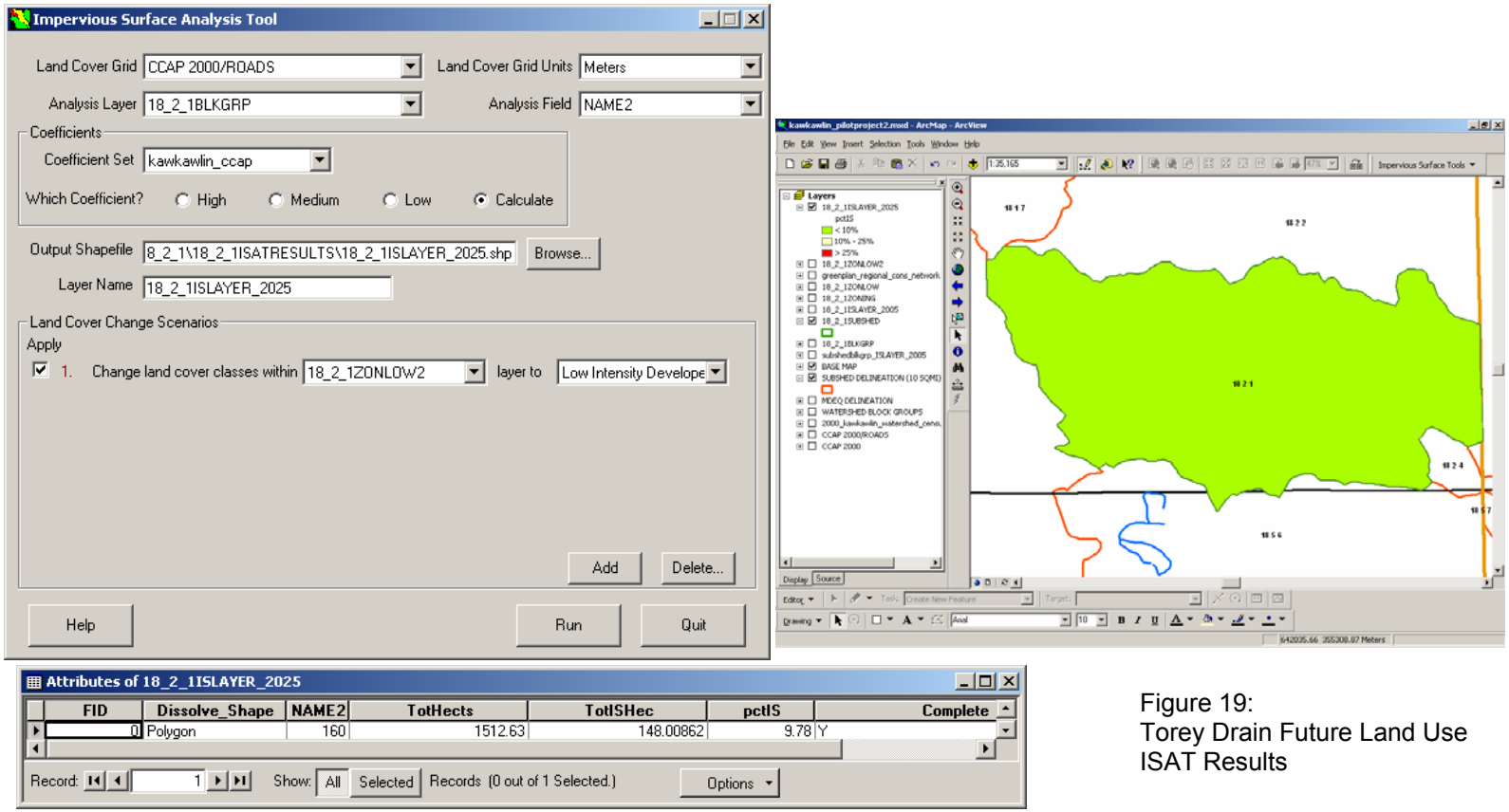

Figure 19:
Torey Drain Future Land Use
ISAT Results

Both existing and future ISAT runs yielded results in the <10% impervious surface area, or **Protected Stream Quality** category. Closer inspection of the numerical attributes reveals that the percent impervious surface area **increased from 3.05% to 9.78%.** Although it remains within the **Protected Stream Quality** category, it very closely approaches the **Degraded Stream Quality** category.

Subwatershed 18 6 2 - Phillips Drain, Auburn

STEP 1 - Select subwatershed for analysis.

Select subwatershed 18 6 2 from the SUBSHED DELINEATION (10 SQMI) layer. Data export to its own layer, 18_6_2SUBSHED.

STEP 2 - Intersect block groups to subwatershed.

Use the ArcView Geoprocessing Wizard to intersect the WATERSHED BLOCK GROUPS layer with the 18_6_2SUBSHED layer. Result is 18_6_2BLKGRP. Figures 20 and 21.

STEP 3 - Field review existing land cover.

There are no documented changes to the 2000 NLCD data set based on field inspection for this subwatershed.

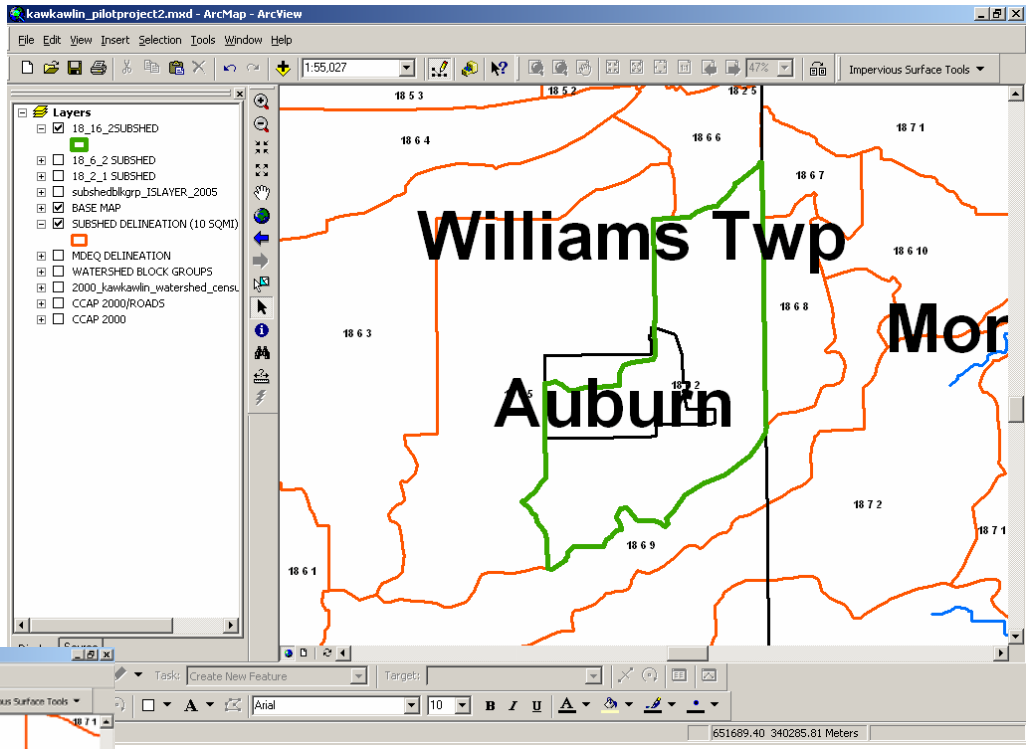

Figure 20: Phillips Drain Block Group Intersection Input

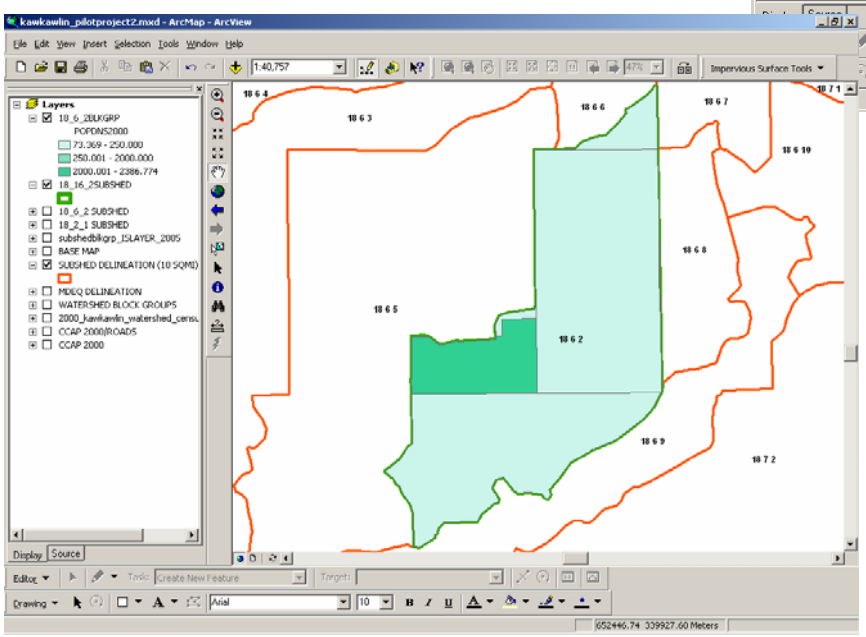

Figure 21: Phillips Drain Block Group Intersection Result

STEP 4 - Run ISAT on existing land cover.

Run ISAT for existing land cover on subwatershed census block groups. Figure 22. Results are added to project as layer 18_6_2ISLAYER_2005.

Open the attribute table to view the percent impervious surface values. Label the layer based on pctIS to add these values to the map. Percent impervious surface per block group within the subwatershed is shown in Figure 23. View and confirm ISAT parameters for this scenario in 18_6_2ISLAYER_2005.prm. (Appendix)

STEP 5 - Import future land cover layer.

Bay County GIS provided a regional zoning layer for Bay County, "common_zoning_2000_new.shp". This layer is a composite of local unit zoning maps. The following abstract was provided by the Bay County GIS Department.

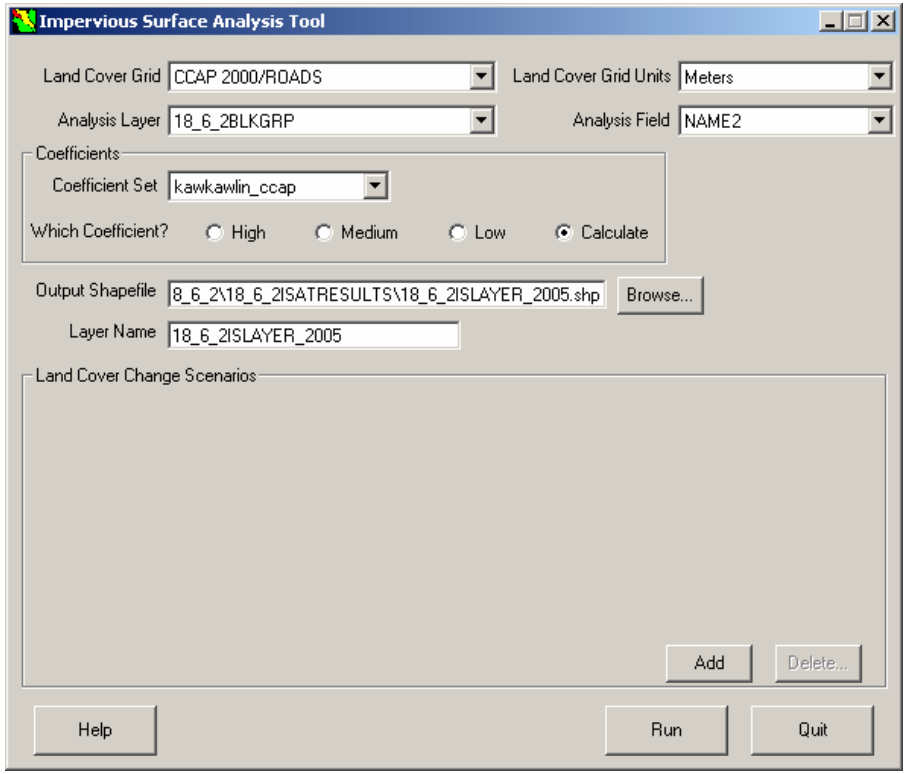

Figure 22: Phillips Drain Existing Land Cover ISAT Input

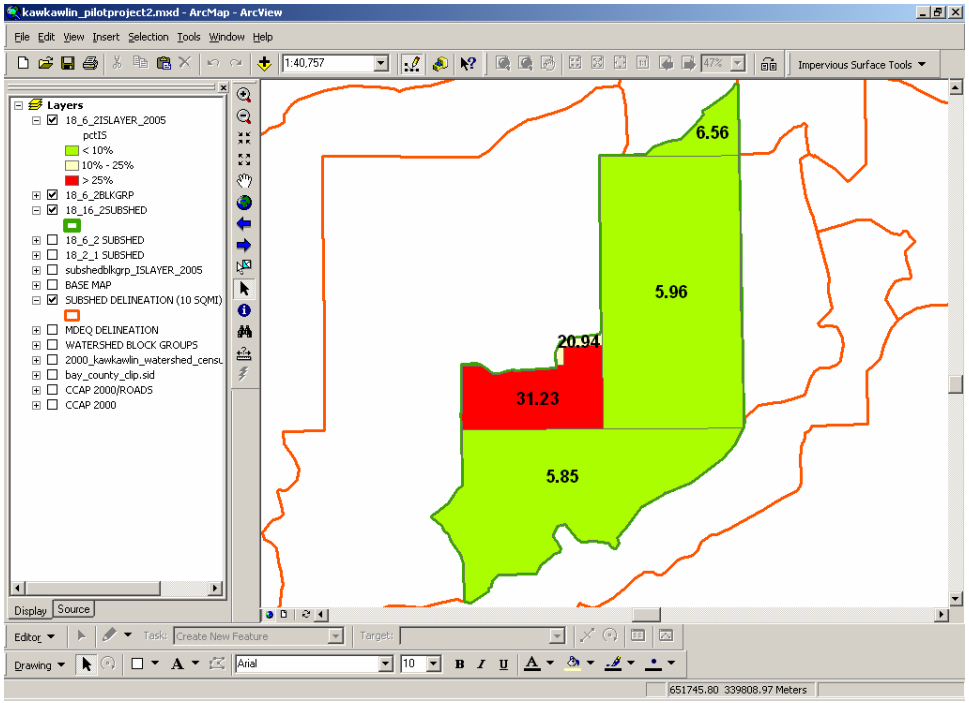

Figure 23: Phillips Drain Existing Land Cover ISAT Results

Developing a Common Land Use Code

Municipal zoning and land use plan codes are unique for each community. Developing a common coding system through which the zoning and land use codes of all Bay County township and municipalities could be easily compared and evaluated was necessary. The common land use code key is shown in Table 2.

Table 2
Common Land Use Coding Key

Code	Map Color	Development Type	Dwelling Units Per Acre
1	Light Brown	Residential Rural	1 or Less
2	Yellow	Residential Urban (Low Density)	2 - 3
3	Orange	Residential Urban (Moderate Density)	4 - 6
4	Dark Brown	Residential Urban (High Density)	7 or Greater
5	Red	Commercial/Office	(None)
6	Purple	Industrial	(None)
7	Grey	Transportation/Transitional	(None)
8	Green	Recreation/Institutional	(None)
9	Blue	Water	(None)

The classification of agricultural zones and categories was a special concern in the development of this common code system. Although the primary intention of these land use types is to permit farm-related activities, residential development is usually also allowed. Most zoning ordinances and land use plans simply specify minimum lot areas and other directions as criteria for these residential uses while failing to place restrictions on how much residential development can occur. In effect, the agricultural designation becomes a form of residential land use regulation. Therefore, agricultural zones/categories have been coded with the rural residential designation. For this assessment, the number of allowable housing units assigned to property parcels having this code was based on the density regulations of either the local zoning ordinance or the Michigan Land Division Act (PA 591 of 1996), whichever placed the greater restrictions.

Import “common_zoning_2000_new.shp” and clip to the subwatershed boundary, 18_6_2ZONING. Figure 24.

STEP 6 - Export low/high-intensity layers.

Based on zoning classes, select and export zoning features which represent low intensity development and high intensity development to their own layers. In Bay County, the attribute “New_Cmn_Cd” for common zoning code was the basis for selection.

Low-Intensity Development includes:

- Code 2 (Residential Urban (Low Density)

These features were exported to 18_6_2ZONLOW.

High-Intensity Development includes:

- Code 3 Residential Urban (Moderate Density)
- Code 4 Residential Urban (High Density)
- Code 5 Commercial/Office
- Code 6 Industrial
- Code 7 Transportation

These features were exported to 18_6_2ZONLOW. Figure 25.

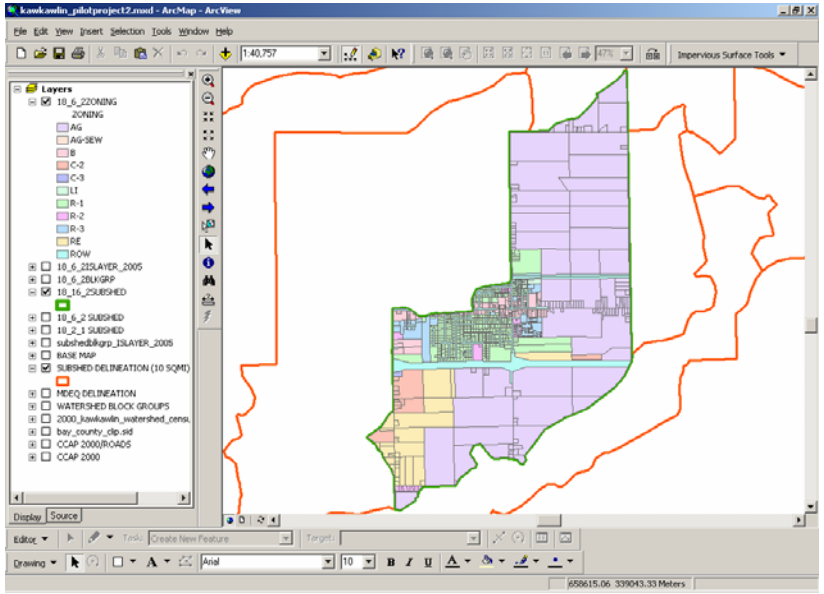

Figure 24: Phillips Drain Future Land Use

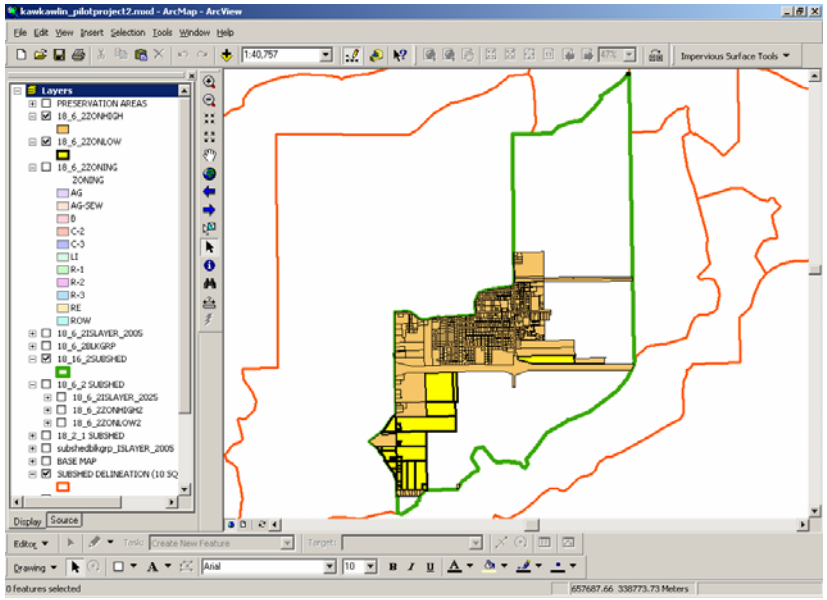

Figure 25:
Phillips Drain
Development Layers

STEP 7 - Remove PA 116 lands.

No PA 116 lands are in this subwatershed.

STEP 8 - Remove Recreation Lands.

Public recreation lands are represented in layer SBCARL_FORDISTR_VER2. The Saginaw Bay Conservation and Recreation Lands layer was created by the Great Lakes/Atlantic Regional Office of Ducks Unlimited using a variety of regional and local sources. This layer includes areas which are to be preserved from future development, even if the local zoning map or future land use map indicates potential development. Therefore, this area should be removed from the future low intensity and high intensity development area. Delete these areas within public recreation lands from 18_6_2ZONLOW. The result is 18_6_2ZONLOW2. Repeat the process for18_6_2ZONHIGH. The result is 18_6_2HIGH2. Figure 26.

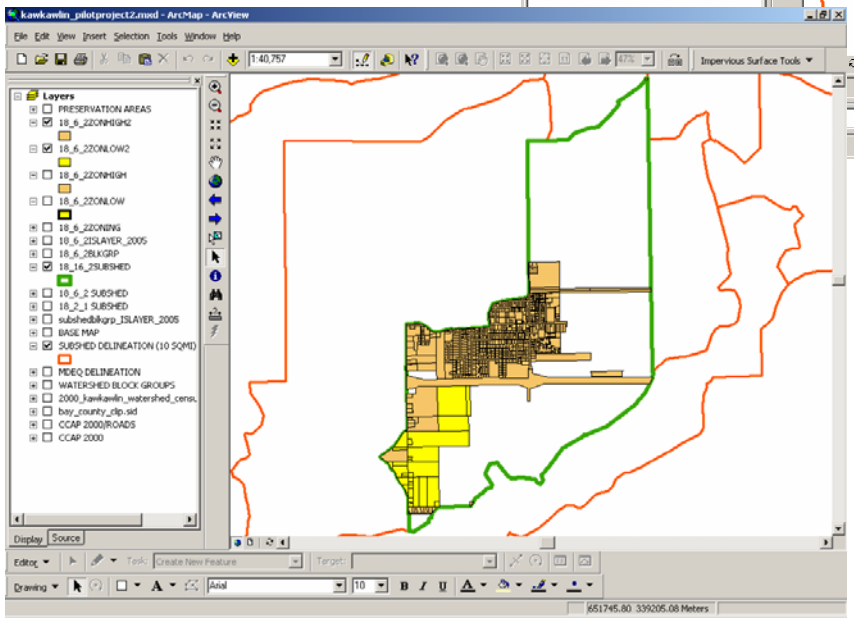

Figure 26: Phillips Drain Recreation Lands

STEP 9 - Remove private conservation lands.

No private conservation lands are in this subwatershed.

STEP 10 - Remove Green Infrastructure Lands.

No Green Infrastructure Lands are in this subwatershed.

STEP 11 - Run ISAT for future land cover.

Run ISAT introducing the land cover change scenario developed for future low and high intensity development. The layer generated was saved as 18_2_1ISLAYER_2025 indicating zoning or future land use plan land cover changes over the next 20 years. Figure 27.

Results are added to project as layer 18_6_2ISLAYER_2025. Open the attribute table to view the percent impervious surface values. Label the layer based on pctIS to add these values to the map. Percent impervious surface per block group within the subwatershed is shown in Figure 28.

Compare existing and future land use ISAT runs. For example, in subwatershed block group NAME2=4 the percent impervious surface area **increased from 5.85% to 12.09%.** Applying the land use change scenario increases the impervious surface percentage of this block group within the subwatershed from **Protected Stream Quality** category to **Degraded Stream Quality** category.

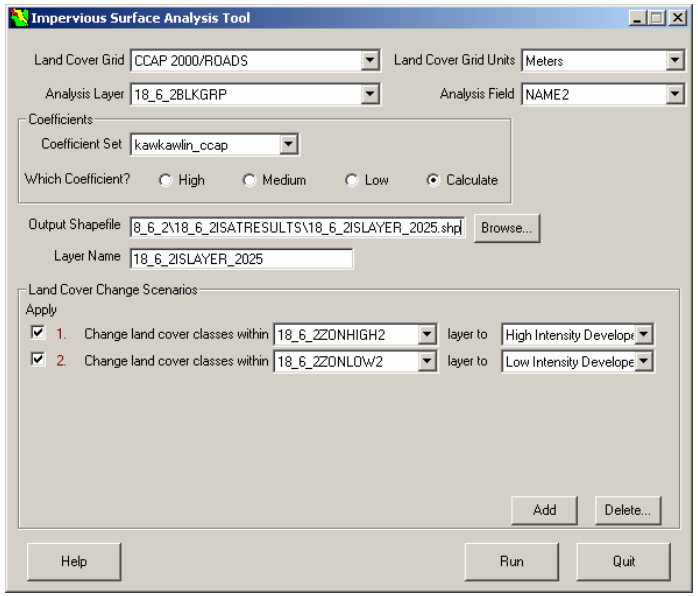

Figure 27: Phillips Drain Future Land Use ISAT Input

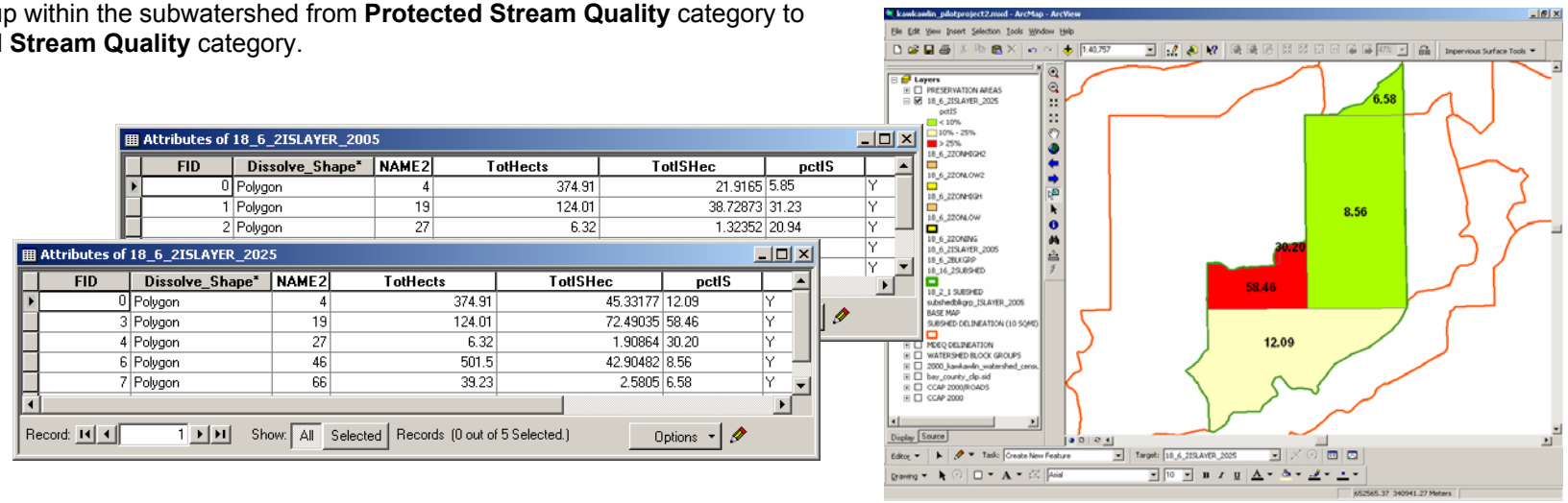

Figure 28: Phillips Drain Future Land Use ISAT Results

Subwatershed 18 6 5 - Dell Creek, Auburn

STEP 1 - Select subwatershed for analysis.

Select subwatershed 18 6 5 from the SUBSHED DELINEATION (10 SQMI) layer. Export data to its own layer: 18_6_5SUBSHED.

STEP 2 - Intersect block groups to subwatershed.

Use the ArcView Geoprocessing Wizard to intersect the WATERSHED BLOCK GROUPS layer with the 18_6_5SUBSHED layer. Result is 18_6_5BLKGRP. Figure 29.

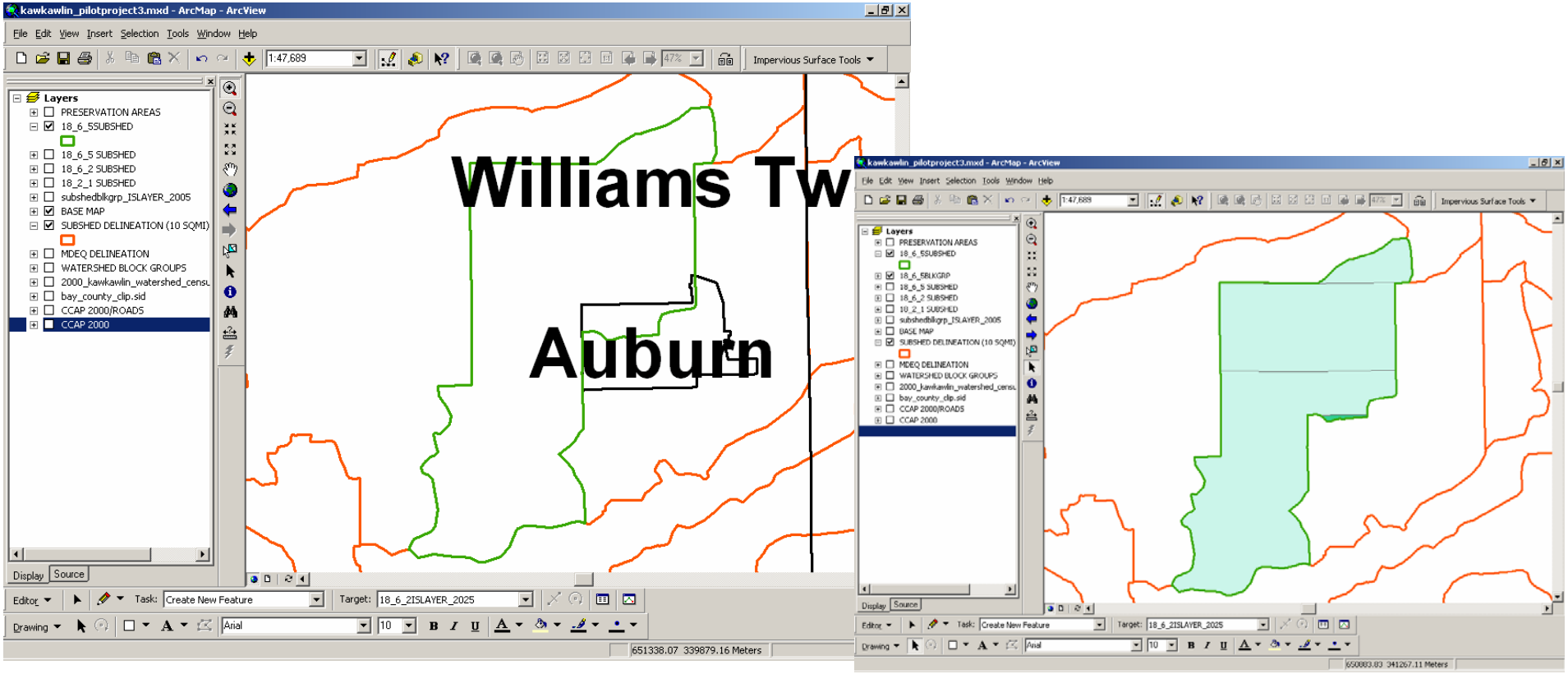

Figure 29: Dell Creek Block Group Intersection

STEP 3 - Field review existing land cover.

Field investigation was performed to compare the 2000 NLCD imagery with existing conditions. Areas of recent development that were not captured in the 2000 NLCD imagery were of particular interest. The USGS 1998 DOQQ digital ortho photography was used to document this task simply because those photos were easier to read, follow, and mark up in the field. Figure 30.

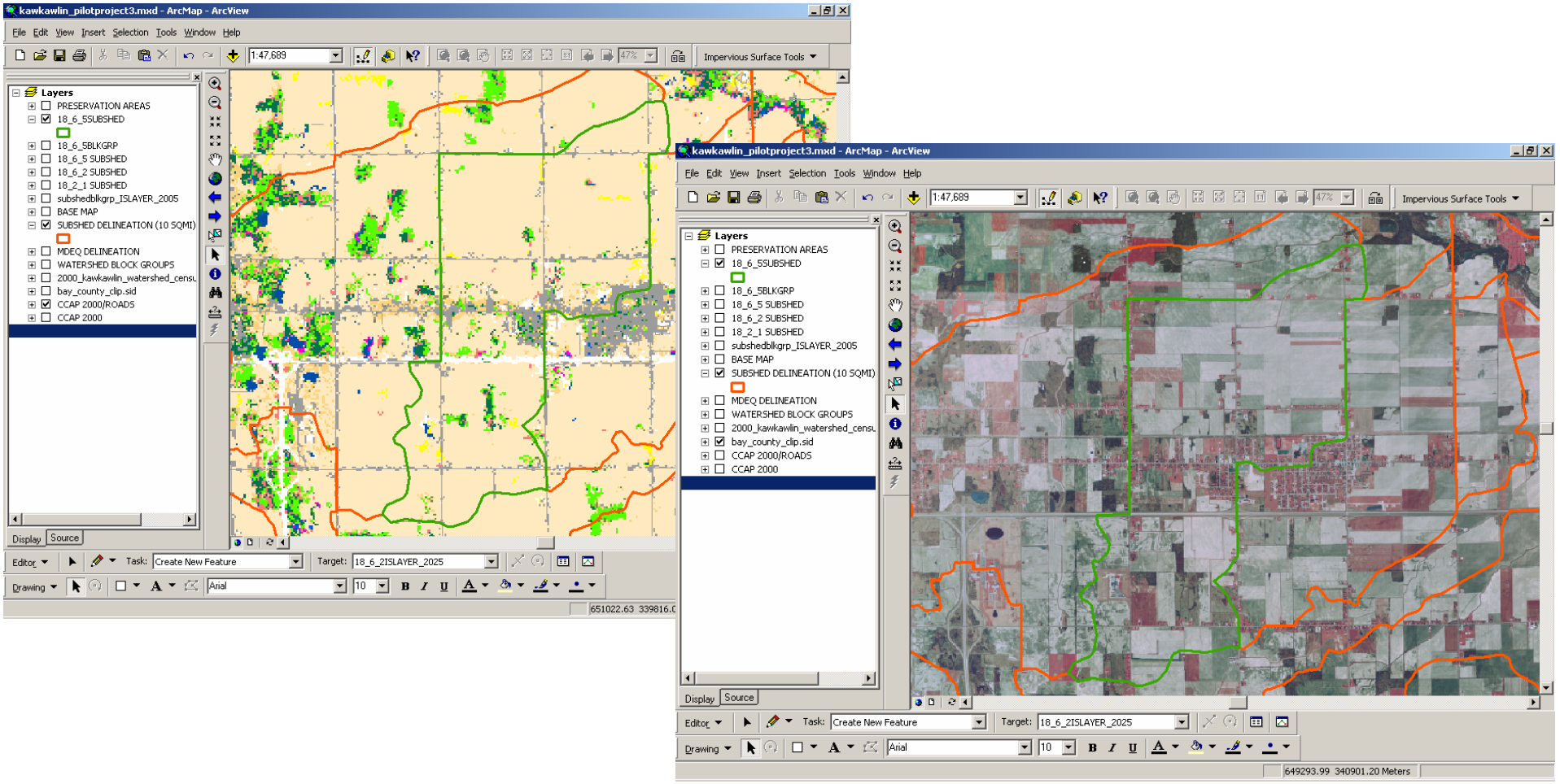

Figure 30: Dell Creek Existing Land Cover Review

From the field notes, polygons were digitized to represent areas of significant development and saved to appropriate layers. In this subwatershed, one area was documented as new low density residential development land cover. This area was digitized based on the 1998 DOQQ photo and saved as layer 18_6_5LC2005LOW. Figure 31.

Run ISAT for existing land cover on subwatershed census block groups. This time, for existing 2005 land cover, add a land cover change scenario for recent development. Figure 32. Results are added to project as layer 18_6_5ISLAYER_2005.

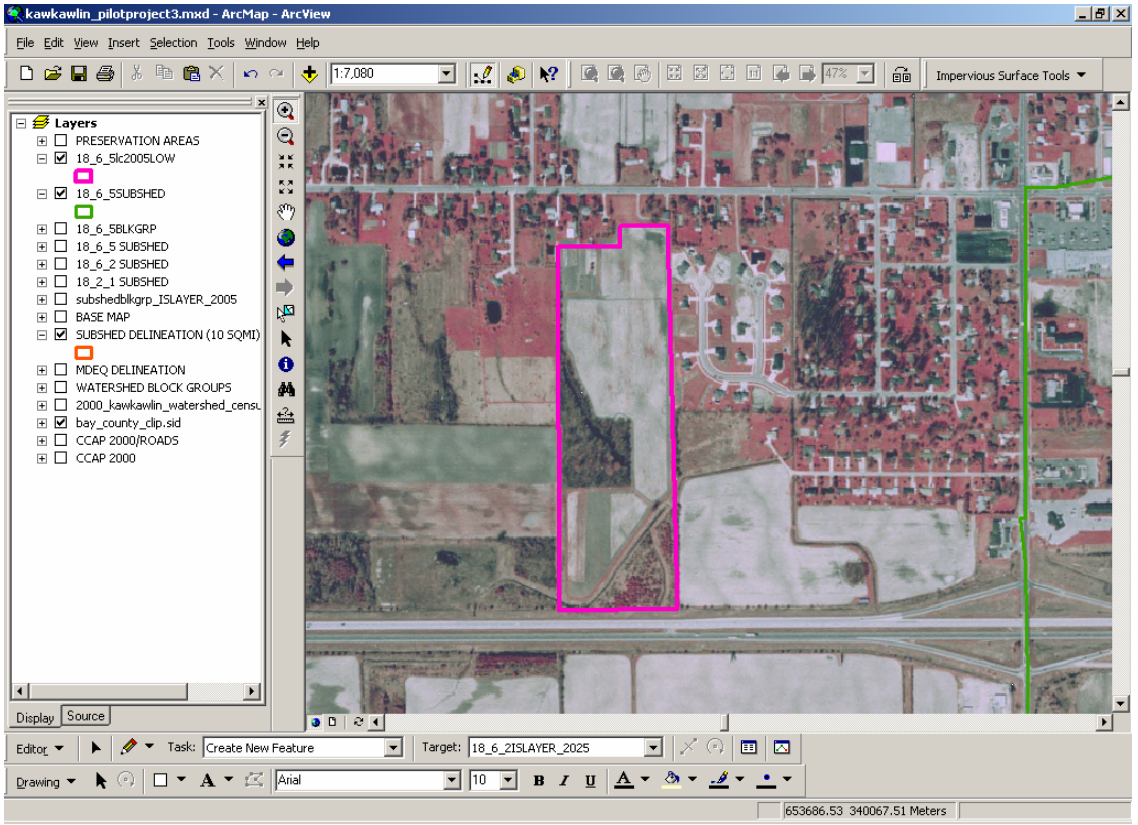

Figure 31: Dell Creek Existing Land Cover Revision

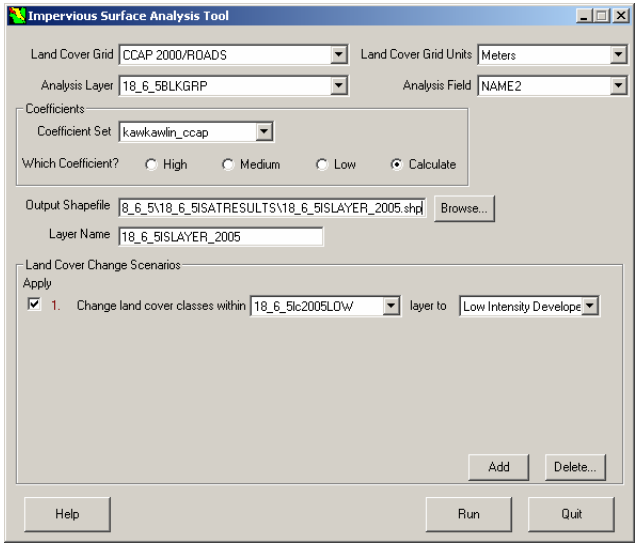

Figure 32: Dell Creek Existing Land Cover ISAT Input

STEP 4 - Run ISAT on existing land cover.

Open the attribute table to view the percent impervious surface values. Label the layer based on pctIS to add these values to the map. Percent impervious surface per block group within the subwatershed is shown in Figure 33. View and confirm ISAT parameters for this scenario in 18_6_5ISLAYER_2005.prm. (Appendix.)

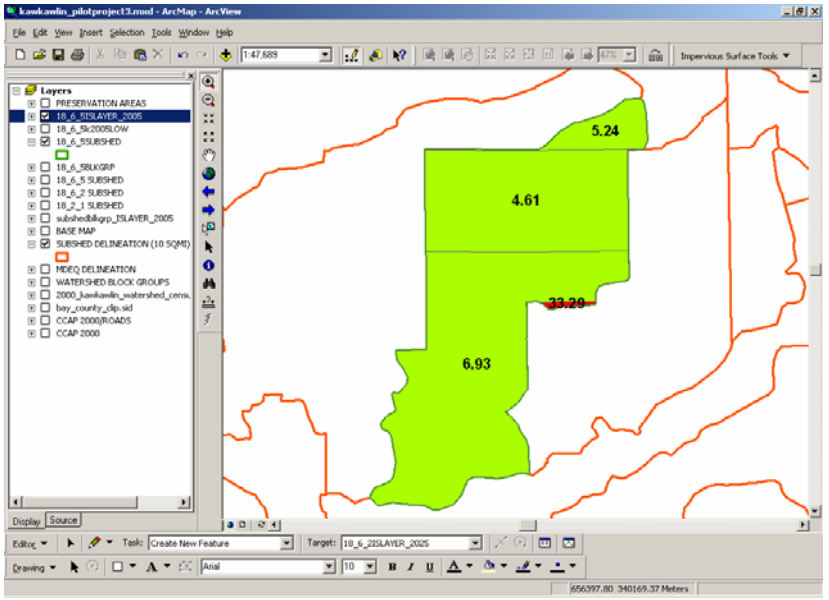

Figure 33:
Dell Creek
Existing Land Cover
ISAT Results

STEP 5 - Import future land cover layer.

Using the Bay County GIS regional zoning layer for the County, clip the zoning to the subwatershed boundary, 18_6_5ZONING. Figure 34.

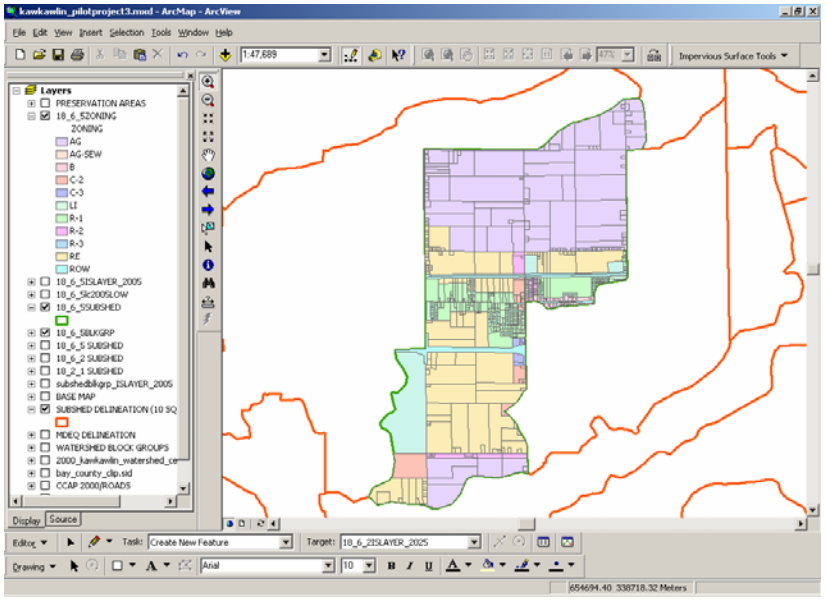

Figure 34:
Dell Creek
Future Land Use

STEP 6 - Export low/high-intensity layers.

Based on zoning classes, select and export zoning features which represent low intensity development and high intensity development to their own layers. Use the Bay County zoning common code as described for subwatershed 18 6 2. These features are exported to 18_6_5ZONLOW and 18_6_5HIGH. Figure 35.

STEP 7 - Remove PA 116 lands.

The Farmland and Open Space Preservation Act, Public Act 116 (PA116) of 1974 was established to slow development of agricultural lands. PA116 allows farmers to exchange development rights on lands used primarily for agriculture for property tax credit. Parcels are enrolled for a minimum of 10 years up to a maximum of 99 years. The layer SAGBAY_PA116 includes PA116 lands for the entire Saginaw Bay Watershed. These areas should be removed from the future low intensity and high intensity development area. Delete PA116 areas from 18_6_5ZONLOW and 18_6_5HIGH. The result is 18_6_5ZONLOW2 and 18_6_5ZONHIGH2. Repeat the process for 18_6_2ZONHIGH. The result is 18_6_2HIGH2. Figure 36.

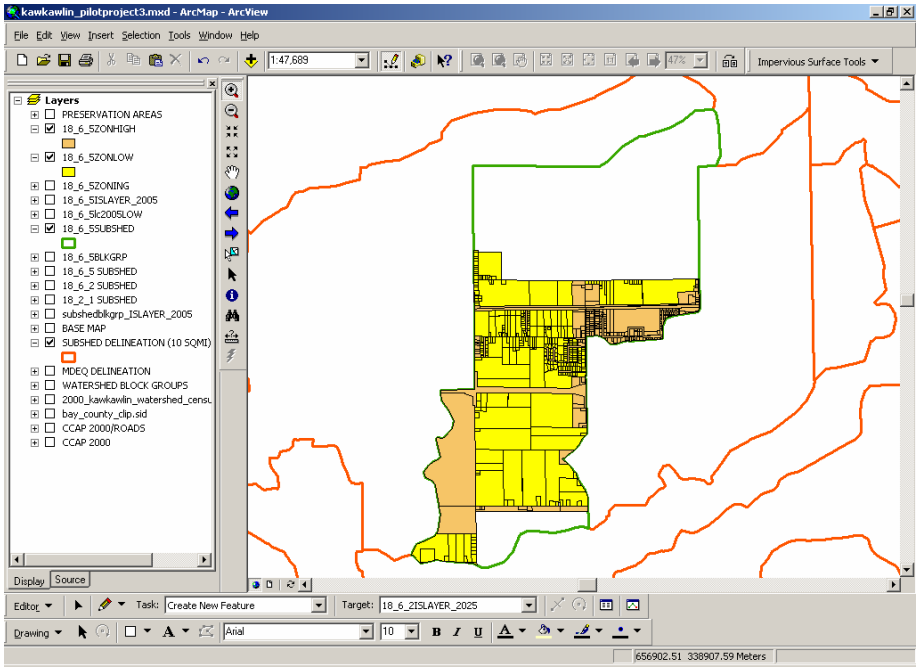

Figure 35: Dell Creek Development Layers

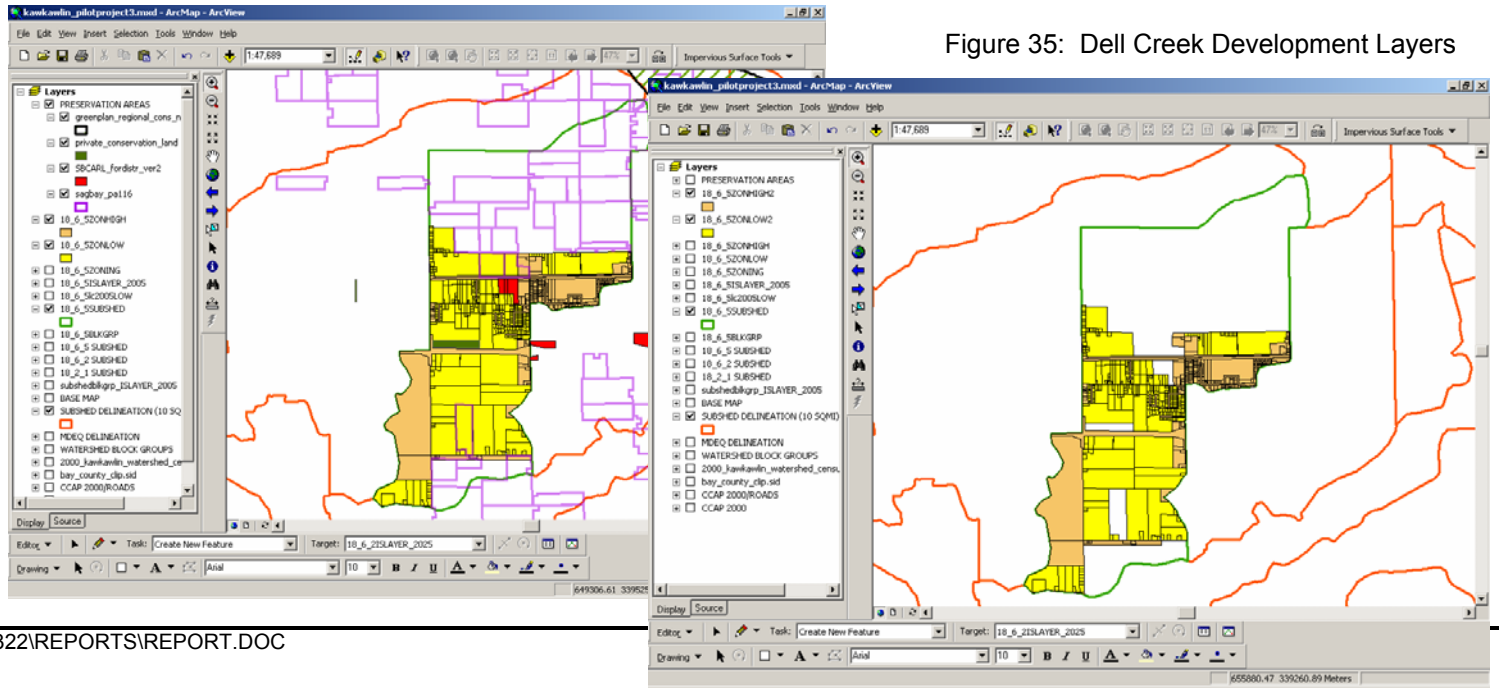

Figure 36:
Dell Creek
Preservation Lands

STEP 8 -Remove Recreation Lands.

Public recreation lands are represented in layer SBCARL_FORDISTR_VER2. The Saginaw Bay Conservation and Recreation Lands layer was created by the Great Lakes/Atlantic Regional Office of Ducks Unlimited using a variety of regional and local sources. This layer includes areas which are to be preserved from future development, even if the local zoning map or future land use map indicates potential development. Therefore, this area should be removed from the future low intensity and high intensity development area. Delete these areas within recreation lands from 18_6_5ZONLOW. The result is 18_6_5ZONLOW2. Repeat the process for 18_6_5ZONHIGH. The result is 18_6_5HIGH2. Figure 36.

STEP 9 -Remove private conservation lands.

Private conservation lands are represented in layer PRIVATE_CONSERVATION_LAND. The Saginaw Bay Conservation and Recreation Lands layer was created by the Great Lakes/Atlantic Regional Office of Ducks Unlimited using a variety of regional and local sources. This layer includes areas which are to be preserved from future development, even if the local zoning map or future land use map indicates potential development. Therefore, this area should be removed from the future low intensity and high intensity development area.

Delete these areas within private conservation lands from 18_6_5ZONLOW.
The result is 18_6_5ZONLOW2.
Repeat the process for 18_6_5ZONHIGH.
The result is 18_6_2HIGH5.
Figure 36.

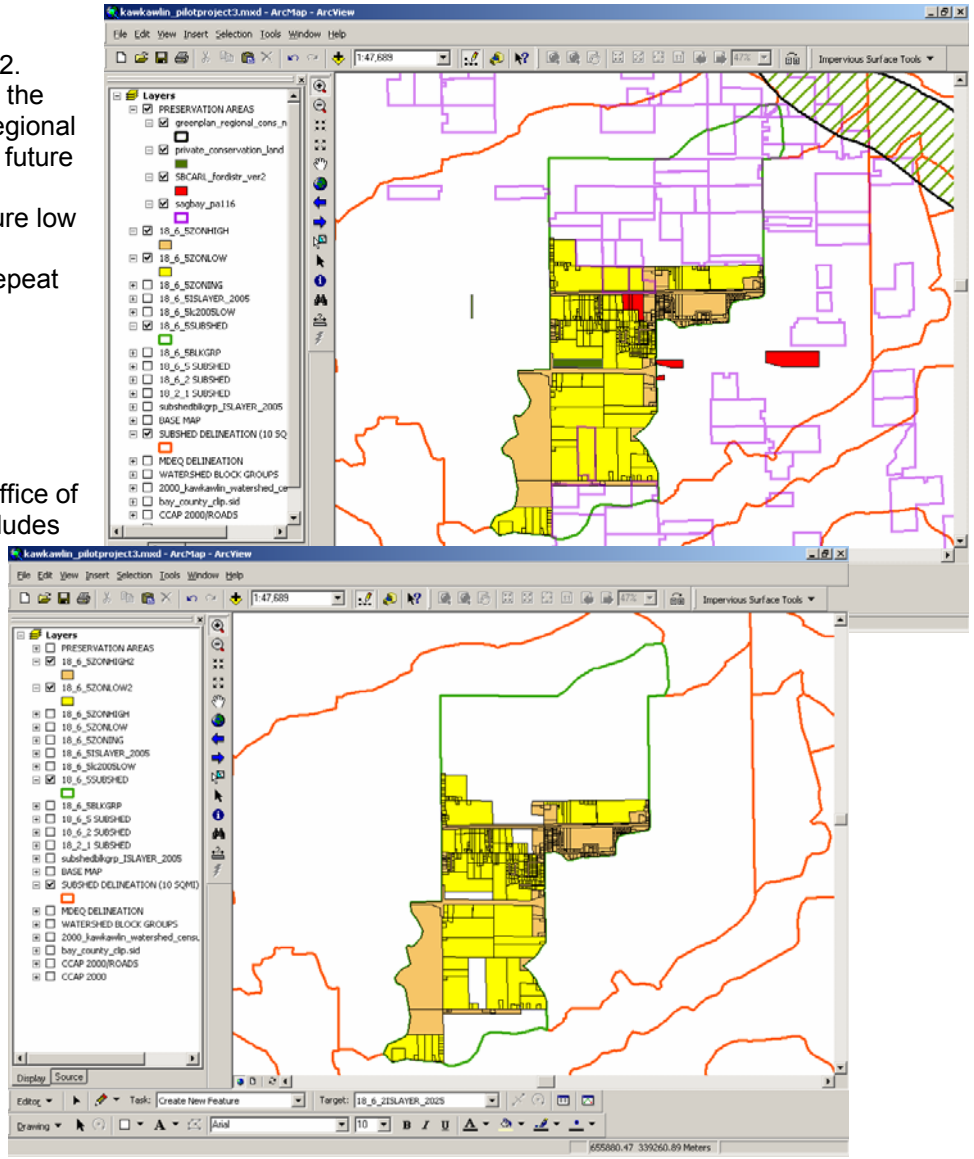

Figure 36:
Dell Creek
Preservation Lands

STEP 10 - Remove Green Infrastructure Lands.

No Green Infrastructure Lands are in this watershed.

STEP 11 - Run ISAT for future land cover.

Run ISAT introducing the land cover change scenario developed for future low and high intensity development. The layer generated will be saved as 18_6_5ISLAYER_2025 indicating zoning or future land use plan land cover changes over the last 5 years and the next 20 years. Figure 37. Results are added to project as layer 18_6_5ISLAYER_2025.

Open the attribute table to view the percent impervious surface values. Label the layer based on pctIS to add these values to the map. Percent impervious surface per block group within the subwatershed is shown in Figure 38.

Compare existing and future land use ISAT runs. For example, in subwatershed block group NAME2=26 the percent impervious surface area **increased from 6.93% to 22.03%.** Applying the land use change scenario increases the impervious surface percentage of this block group within the subwatershed from **Protected Stream Quality** category to **Degraded Stream Quality** category, approaching the **Impacted Stream Quality** category.

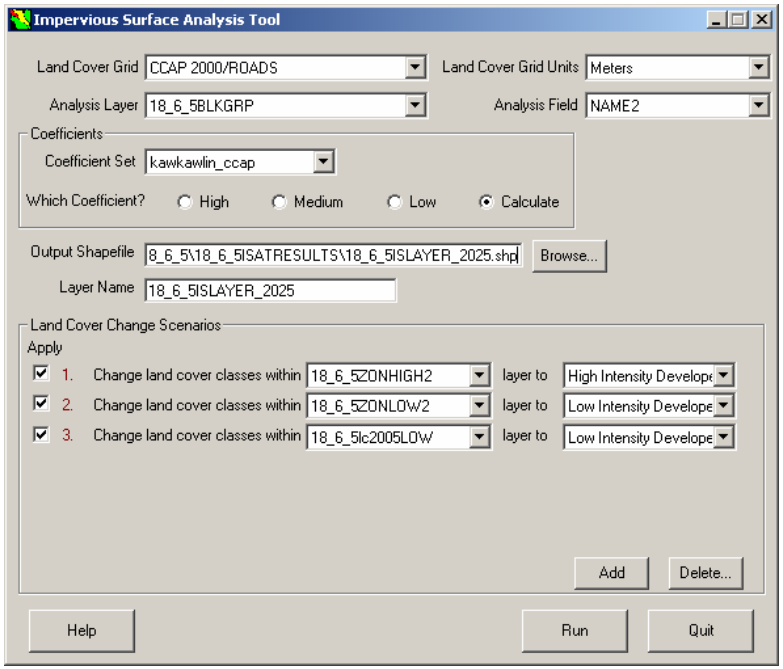

Figure 37: Dell Creek Future Land Use ISAT Input

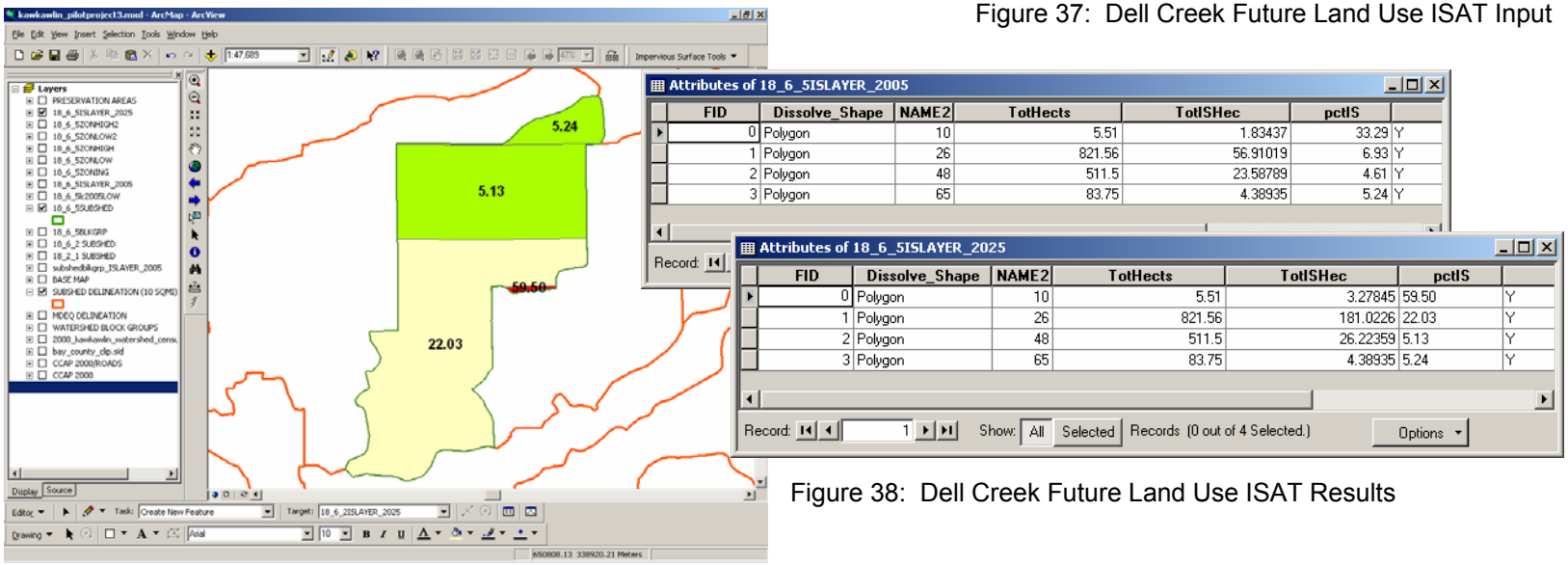

Figure 38: Dell Creek Future Land Use ISAT Results

Subwatershed 18 8 3 - Mill Pond Drain, Monitor Township

STEP 1 - Select subwatershed for analysis.

Select subwatershed 18 8 3 from the SUBSHED DELINEATION (10 SQMI) layer. Export data to its own layer: 18_8_3SUBSHED.

STEP 2 - Intersect block groups to subwatershed.

Use the ArcView Geoprocessing Wizard to intersect the WATERSHED BLOCK GROUPS layer with the 18_8_3SUBSHED layer. Result is 18_8_3BLKGRP. Figure 39.

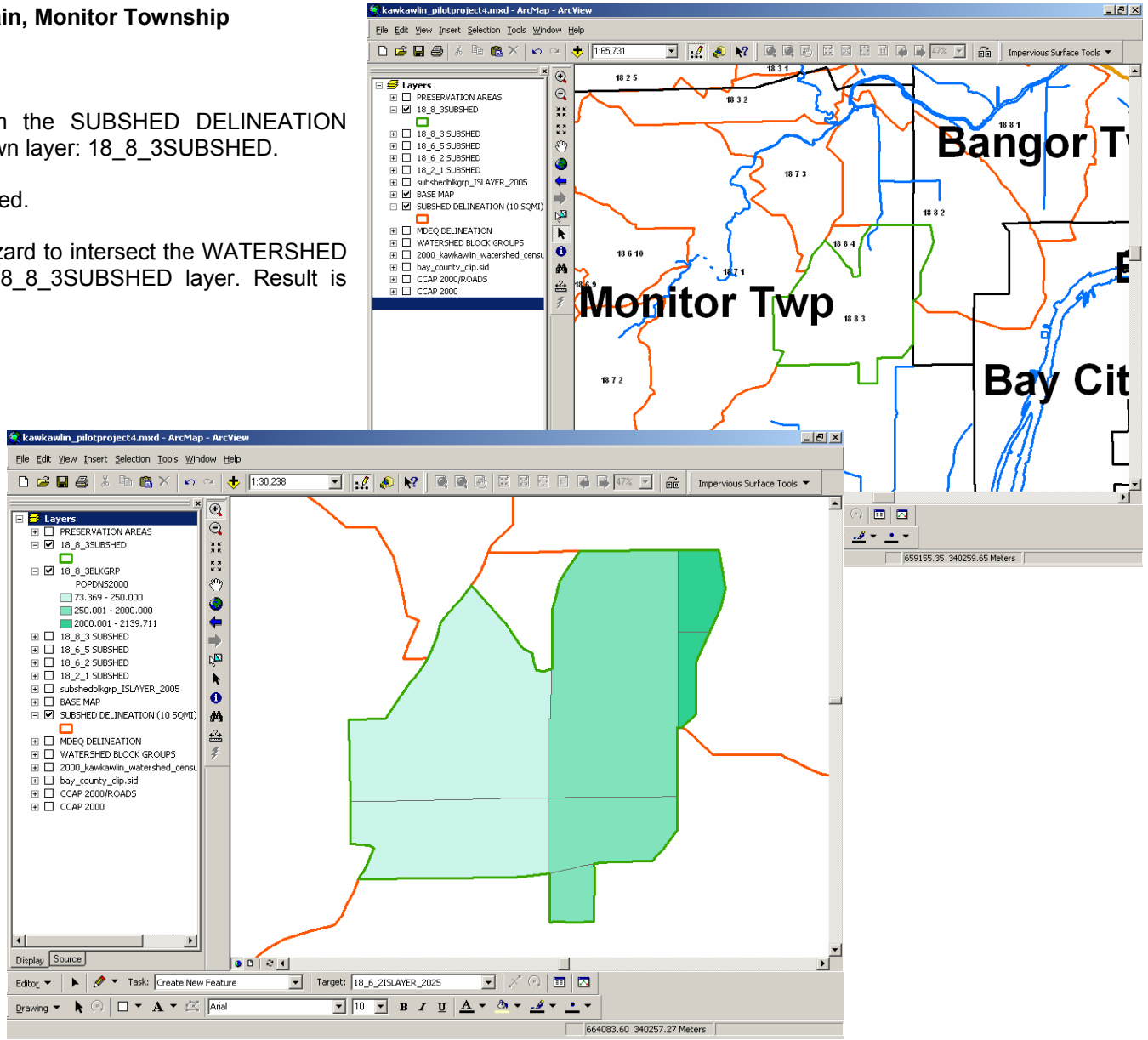

Figure 39: Mill Pond Drain
Block Group Intersection

STEP 3 - Field review existing land cover.

Field investigation was performed to compare the 2000 NLCD imagery with existing conditions. Areas of recent development that were not captured in the 2000 NLCD imagery were of particular interest. The USGS 1998 DOQQ digital ortho photography was used to document this task simply because those photos were easier to read, follow, and mark up in the field. Figure 40.

From the field notes, polygons were digitized to represent areas of significant development and saved to appropriate layers. In this subwatershed, several areas were documented as new high density residential development land cover. These areas were digitized based on the 1998 DOQQ photo and saved as layer 18_8_3LC2005HIGH. Figure 41.

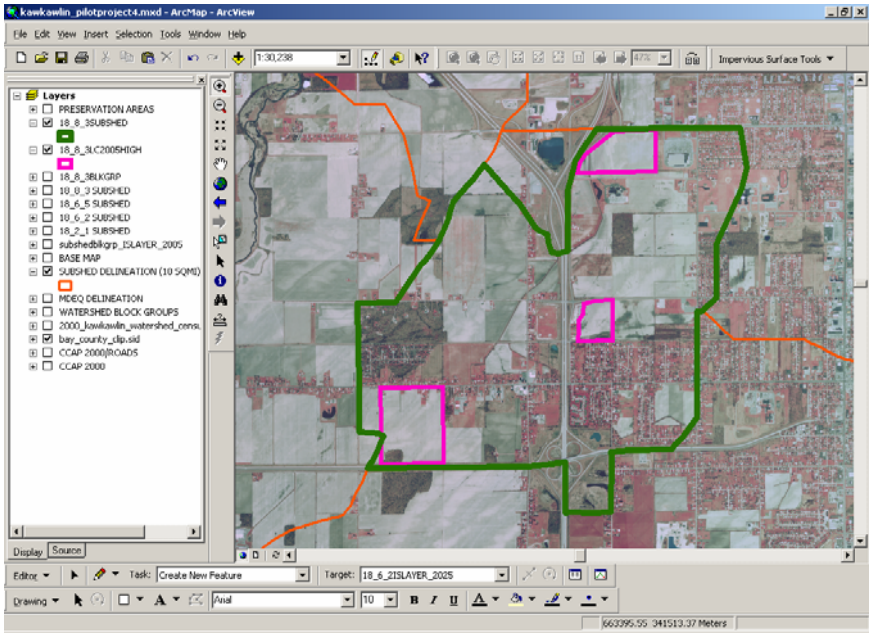

Figure 41: Mill Pond Drain Existing Land Cover Revision

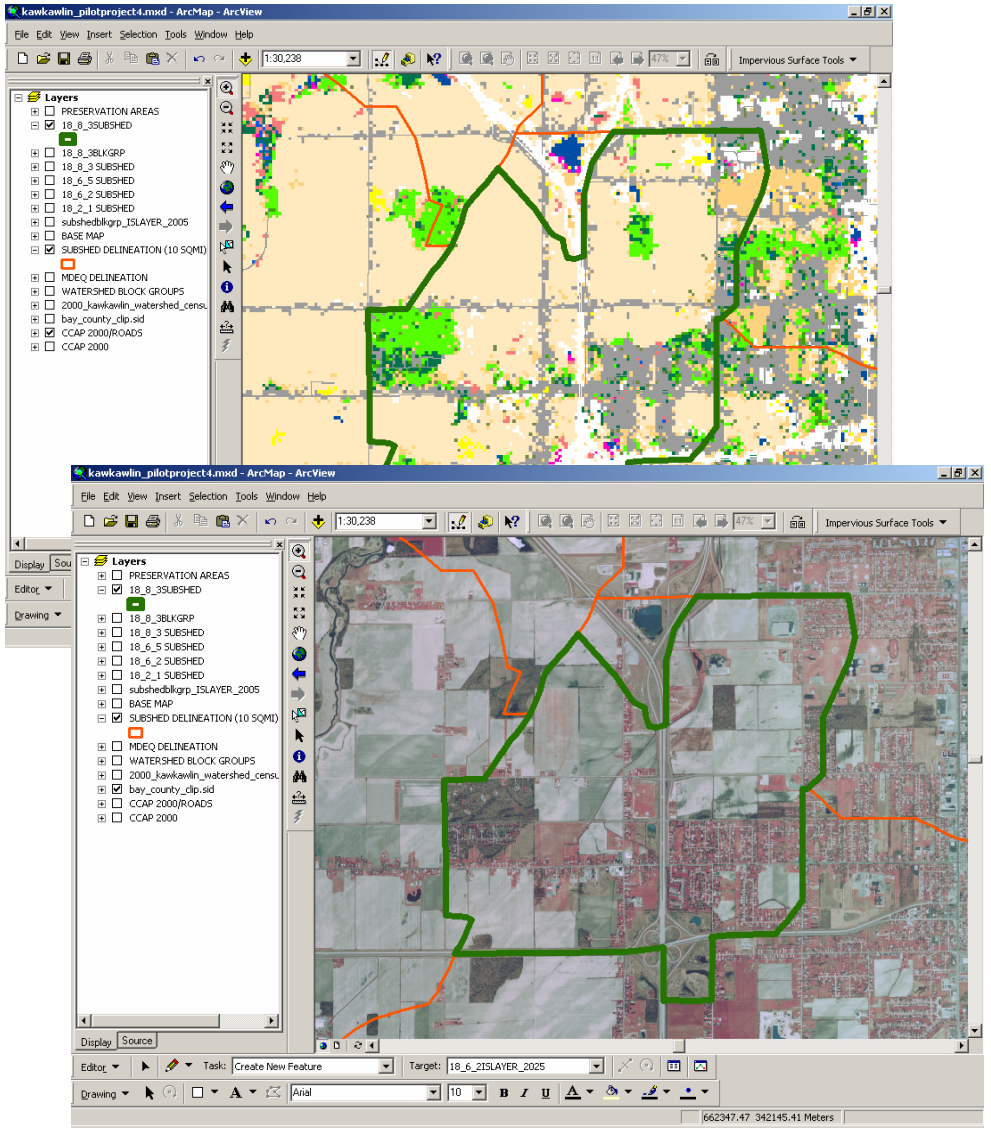

Figure 40: Mill Pond Drain Existing Land Cover Review

STEP 4 - Run ISAT on existing land cover.

Run ISAT for existing land cover on subwatershed census block groups. For existing 2005 land cover, add a land cover change scenario for recent development. Figure 42. Results were added to project as layer 18_8_3ISLAYER_2005. Open the attribute table to view the percent impervious surface values.

Label the layer based on pctIS to add these values to the map. Percent impervious surface per block group within the subwatershed is shown in Figure 43. View and confirm ISAT parameters for this scenario in 18_8_3ISLAYER_2005.prm. (Appendix.)

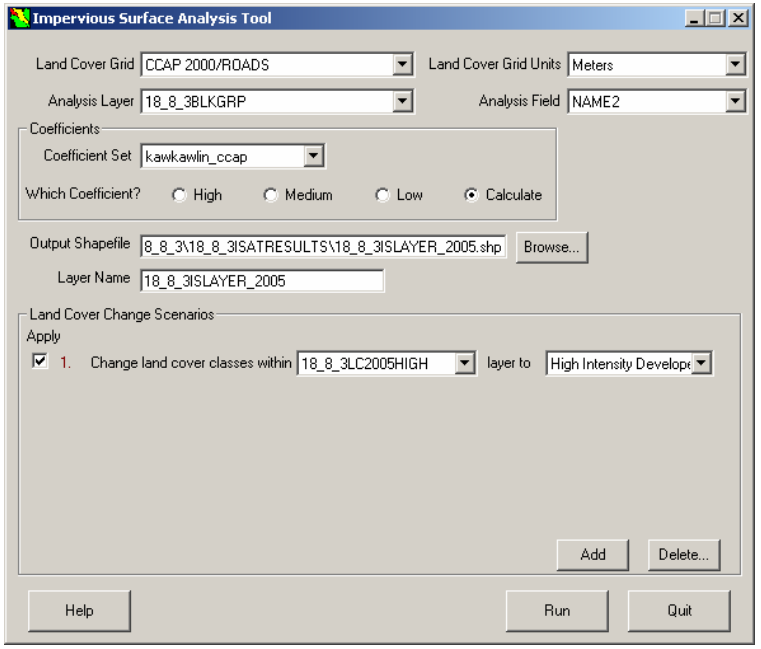

Figure 42: Mill Pond Drain
Existing Land Cover ISAT Input

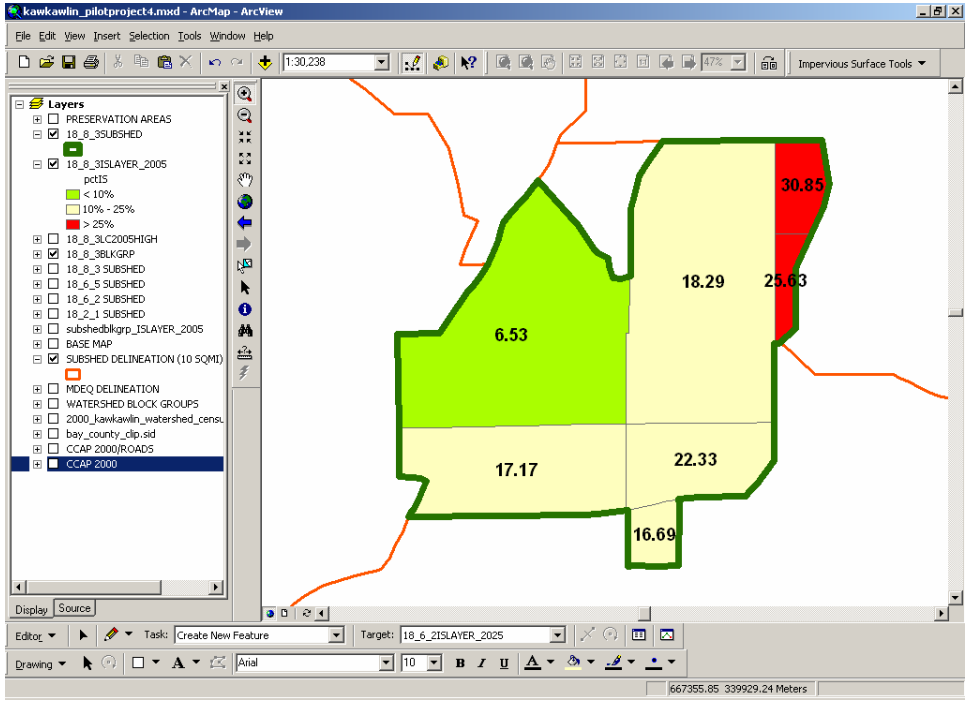

Figure 43: Mill Pond Drain Existing Land Cover ISAT Results

STEP 5 - Import future land cover layer.

Using the Bay County GIS regional zoning layer for the County, clip the zoning to the subwatershed boundary, 18_8_3ZONING. Figure 44.

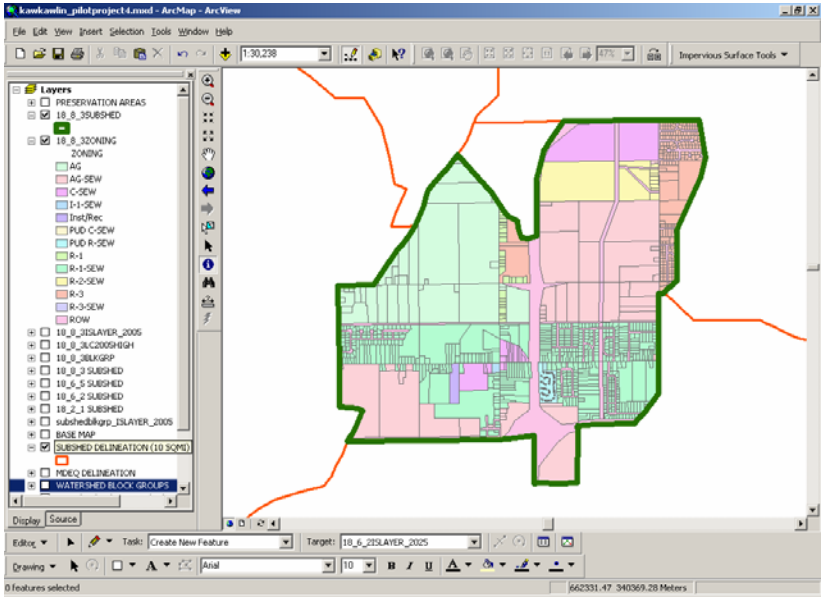

Figure 44:
Mill Pond Drain
Future Land Use

STEP 6 - Export low/high-intensity layers.

Based on zoning classes, select and export zoning features which represent low intensity development and high intensity development to their own layers. Use the Bay County zoning common code as described for subwatershed 18 8 3. These features were exported to 18_8_3ZONLOW and 18_8_3HIGH. Figure 45.

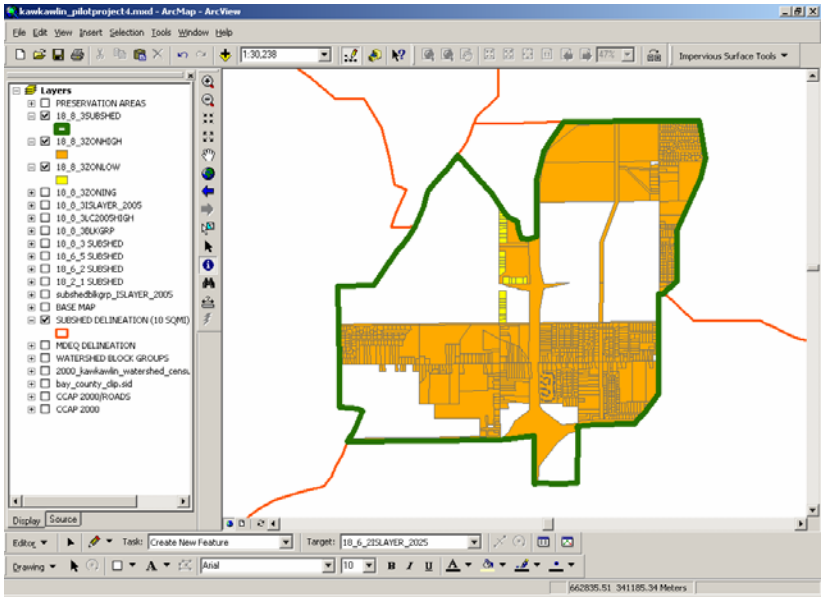

Figure 45:
Mill Pond Drain
Development Layers

STEP 7 - Remove PA 116 lands.

The Farmland and Open Space Preservation Act, Public Act 116 (PA116) of 1974 was established to slow development of agricultural lands. PA116 allows farmers to exchange development rights on lands used primarily for agriculture for property tax credit. Parcels are enrolled for a minimum of 10 years up to a maximum of 99 years. The layer SAGBAY_PA116 includes PA116 lands for the entire Saginaw Bay Watershed. These areas should be removed from the future low intensity and high intensity development area. Delete PA116 areas from 18_8_3ZONLOW and 18_8_3HIGH. The result is 18_8_3ZONLOW2 and 18_8_3ZONHIGH2. Repeat the process for 18_8_3ZONHIGH. The result is 18_8_3HIGH2. Figure 46.

STEP 8 - Remove Recreation Lands.

Public recreation lands are represented in layer SBCARL_FORDISTR_VER2. The Saginaw Bay Conservation and Recreation Lands layer was created by the Great Lakes/Atlantic Regional Office of Ducks Unlimited using a variety of regional and local sources. This layer includes areas which are to be preserved from future development, even if the local zoning map or future land use map indicates potential development. Therefore, this area should be removed from the future low intensity and high intensity development area. Delete these areas within recreation lands from 18_8_3ZONLOW. The result is 18_8_3ZONLOW2. Repeat the process for 18_8_3ZONHIGH. The result is 18_8_3HIGH2. Figure 46.

STEP 9 - Remove private conservation lands.

Private conservation lands are represented in layer PRIVATE_CONSERVATION_LAND . The Saginaw Bay Conservation and Recreation Lands layer was created by the Great Lakes/Atlantic Regional Office of Ducks Unlimited using a variety of regional and local sources. This layer includes areas which are to be preserved from future development, even if the local zoning map or future land use map indicates potential development. Therefore, this area should be removed from the future low intensity and high intensity development area. Delete these areas within private conservation lands from 18_8_3ZONLOW. The result is 18_6_5ZONLOW2. Repeat the process for 18_8_3ZONHIGH. The result is 18_6_2HIGH5. Figure 46.

STEP 10 - Remove Green Infrastructure Lands

No Green Infrastructure Lands are in this watershed.

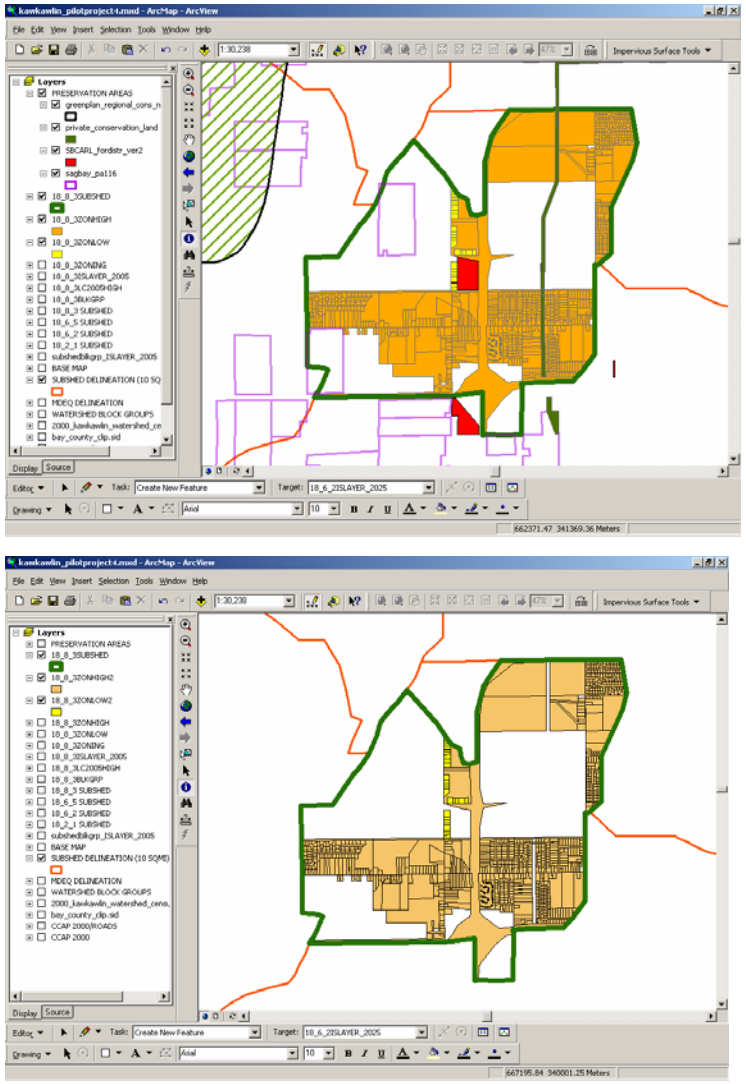

Figure 46: Mill Pond Drain Preservation Lands

STEP 11 - Run ISAT for future land cover.

Run ISAT introducing the land cover change scenario developed for future low and high intensity development. The layer generated was saved as 18_8_3ISLAYER_2025 indicating zoning or future land use plan land cover changes over the last 5 years and the next 20 years. Figure 47.

Results were added to project as layer 18_8_3ISLAYER_2025. Open the attribute table to view the percent impervious surface values. Label the layer based on pctIS to add these values to the map. Percent impervious surface per block group within the subwatershed is shown in Figure 48. Compare existing and future land use ISAT runs. For example, in subwatershed block group NAME2=17 the percent impervious surface area **increased from 22.33% to 36.74%.** Applying the land use change scenario increases the impervious surface percentage of this block group within the subwatershed from **Degraded Stream Quality** category to **Impacted Stream Quality** category.

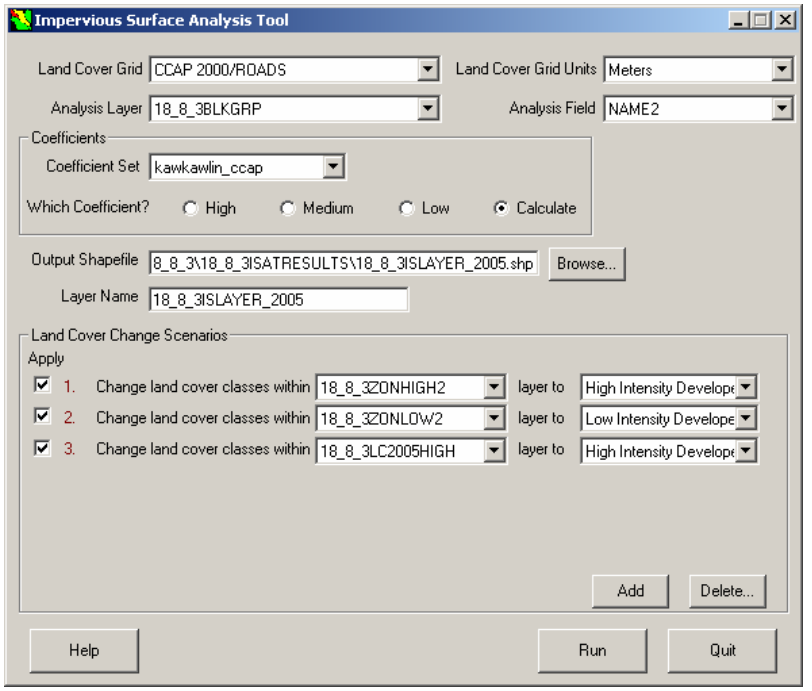

Figure 47: Mill Pond Drain Future Land Use ISAT Input

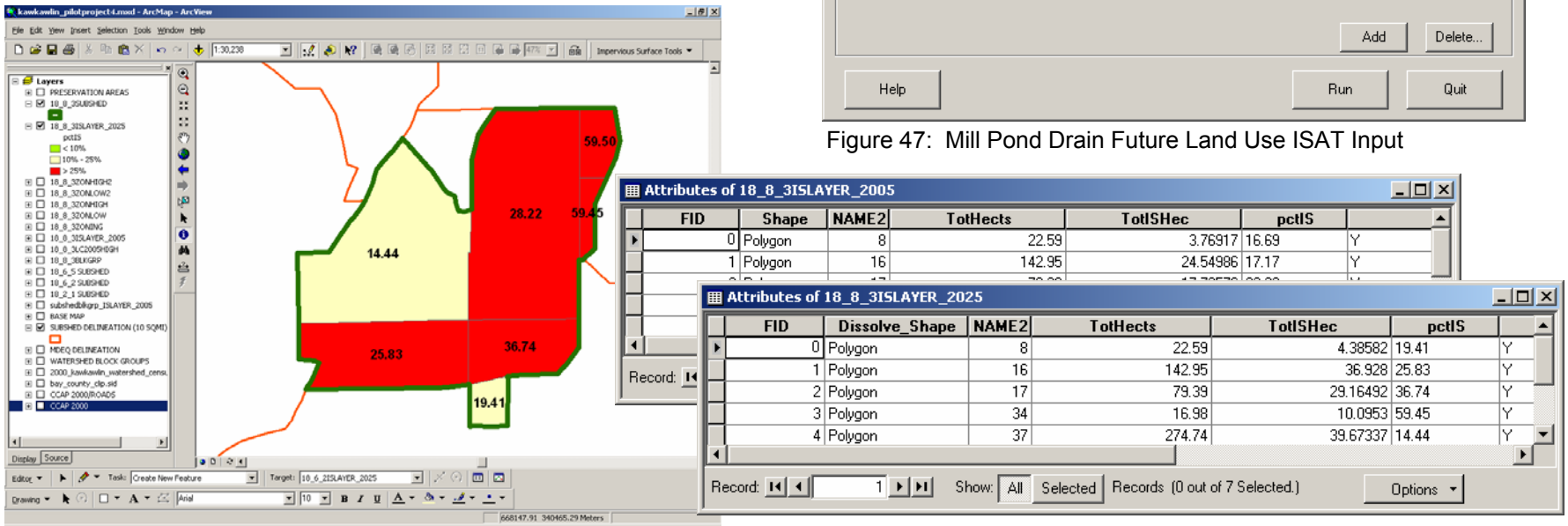

Figure 48: Mill Pond Drain Future Land Use ISAT Results

Subwatershed 18 4 3 - Waldo Drain, Larkin Township

STEP 1 - Select subwatershed for analysis.

Select subwatershed 18 4 3 from the SUBSHED DELINEATION (10 SQMI) layer. Export data to its own layer: 18_4_3SUBSHED.

STEP 2 - Intersect block groups to subwatershed.

Use the ArcView Geoprocessing Wizard to intersect the WATERSHED BLOCK GROUPS layer with the 18_4_3SUBSHED layer. Result is 18_4_3BLKGRP. Figure 49.

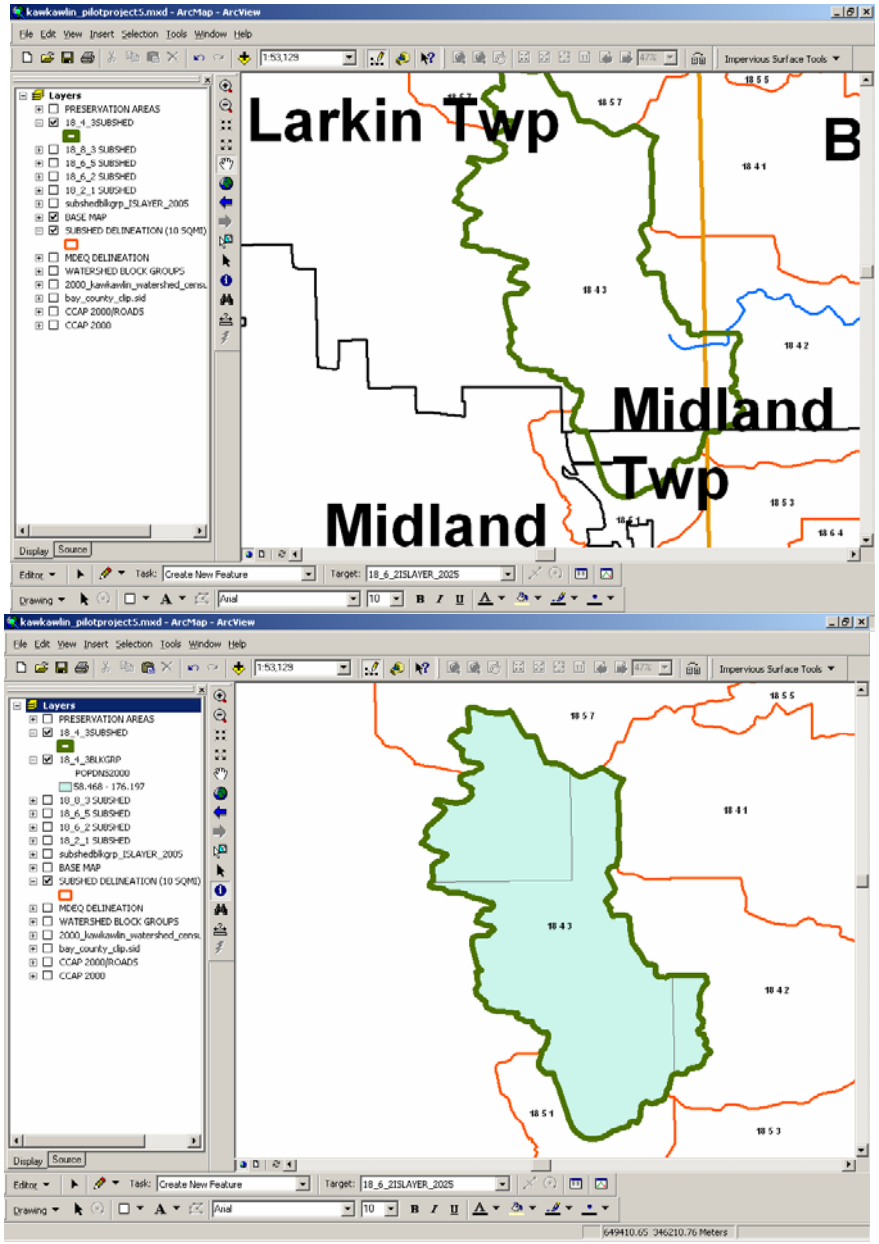

Figure 49: Waldo Drain
Block Group Intersection

STEP 3 - Field review existing land cover.

Field investigation was performed to compare the 2000 NLCD imagery with existing conditions. Areas of recent development that were not captured in the 2000 NLCD imagery were of particular interest. The USGS 1998 DOQQ digital ortho photography was used to document this task simply because those photos were easier to read, follow, and mark up in the field. Figure 50.

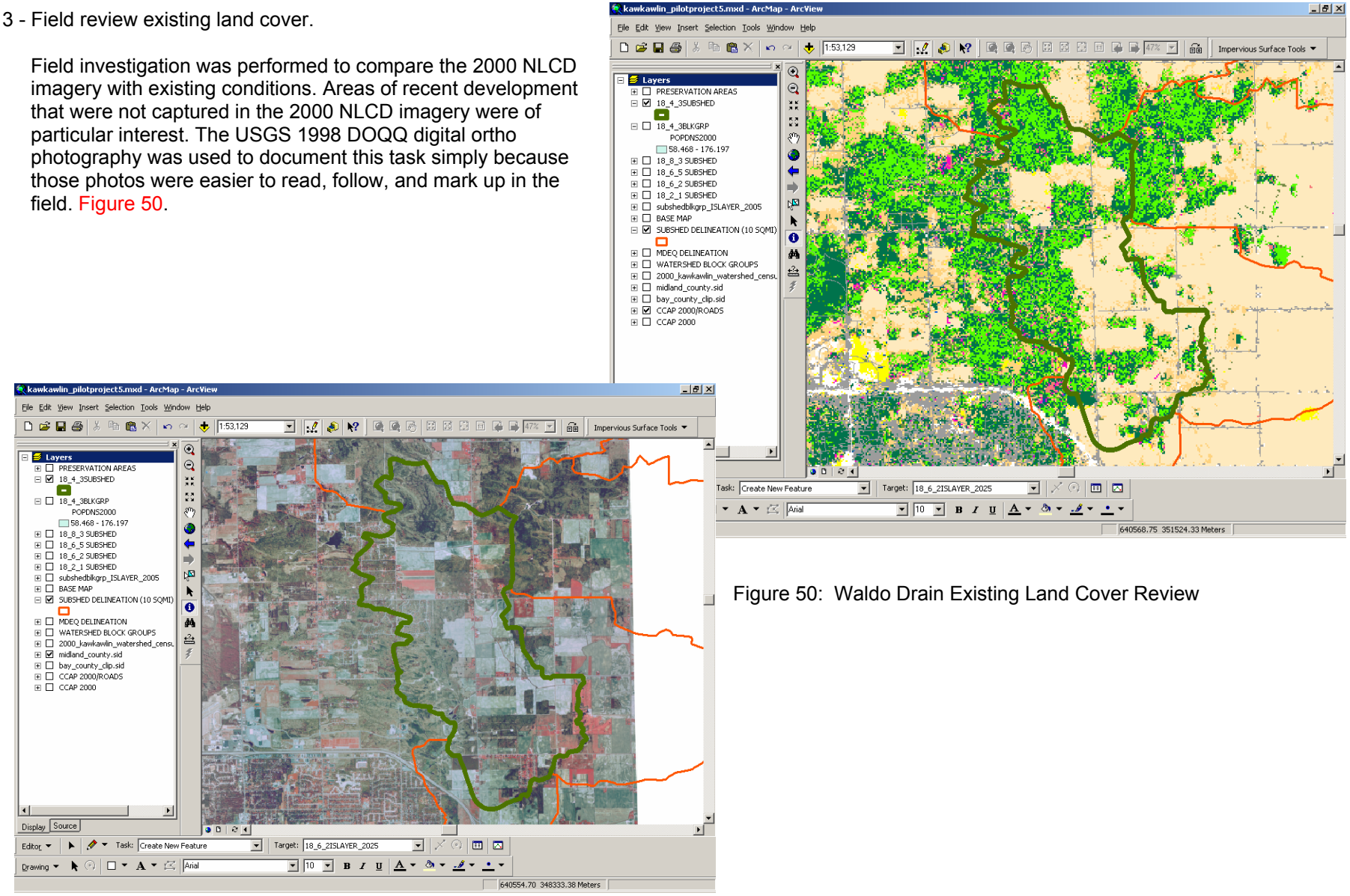

Figure 50: Waldo Drain Existing Land Cover Review

From the field notes, polygons were digitized to represent areas of significant development and saved to appropriate layers. In this subwatershed, several areas were documented as new high density residential development land cover. These areas were digitized based on the 1998 DOQQ photo and saved as layer 18_4_3LC2005HIGH. Figure 51.

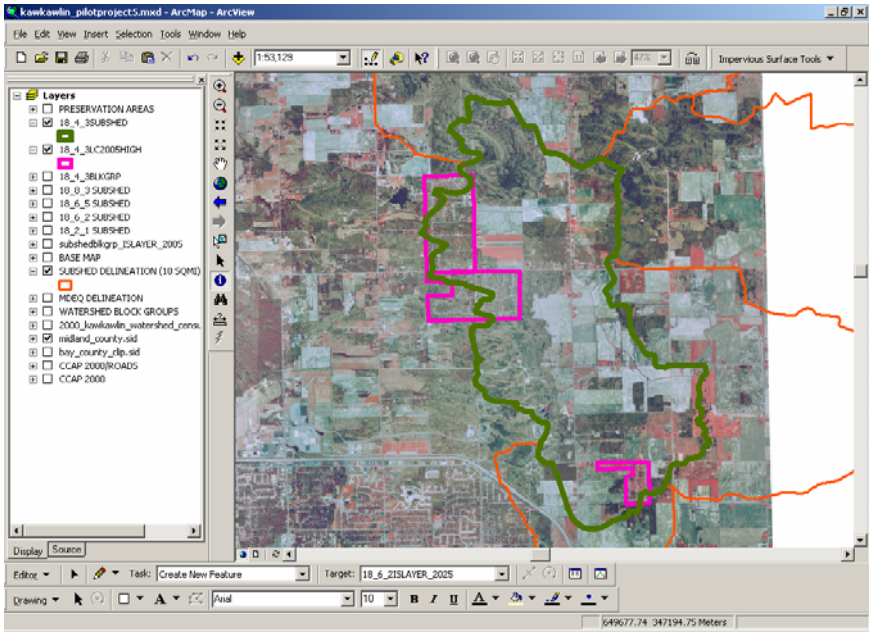

Figure 51: Waldo Drain
Existing Land Cover Revision

STEP 4 - Run ISAT on existing land cover.

Run ISAT for existing land cover on subwatershed census block groups. For existing 2005 land cover, add a land cover change scenario for recent development. Figure 52. Results were added to project as layer 18_4_3ISLAYER_2005.

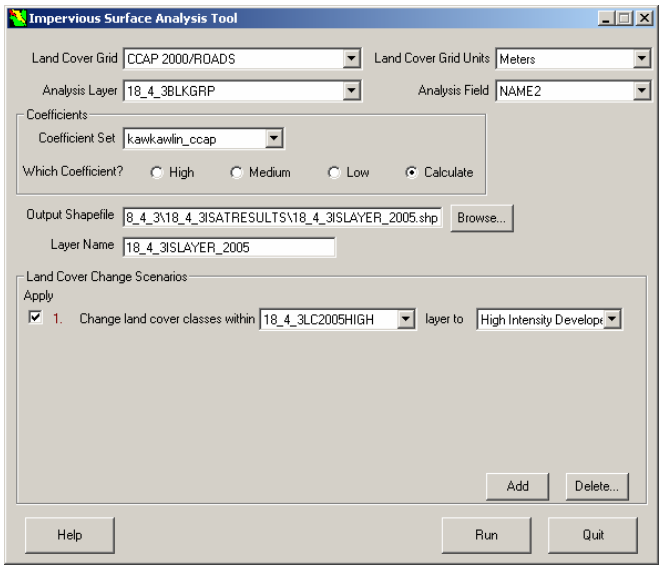

Figure 52: Waldo Drain
Existing Land Cover ISAT Input

Open the attribute table to view the percent impervious surface values. Label the layer based on pctIS to add these values to the map. Percent impervious surface per block group within the subwatershed is shown in Figure 53. View and confirm ISAT parameters for this scenario in 18_4_3ISLAYER_2005.prm. (Appendix.)

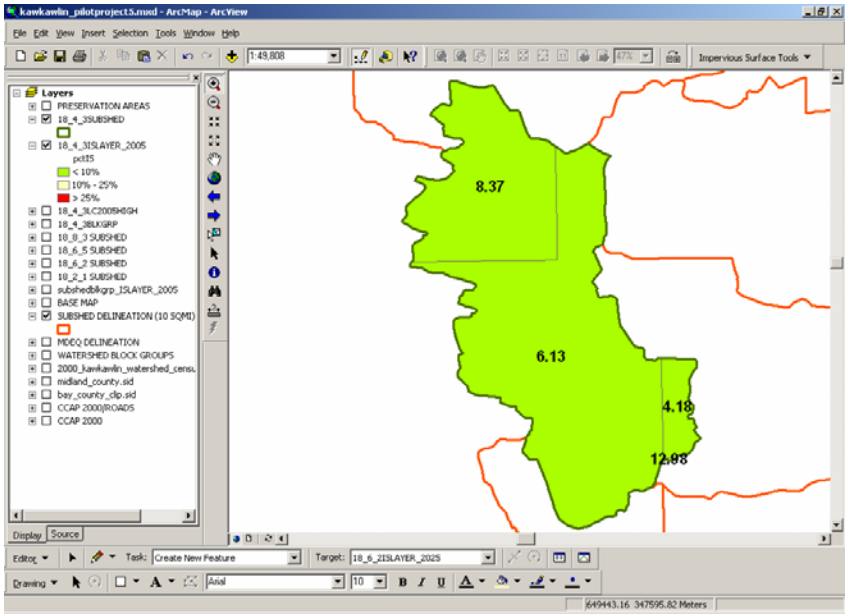

Figure 53: Waldo Drain
Existing Land Cover
ISAT Results

STEP 5 - Import future land cover layer.

This subwatershed includes lands from three townships in two counties. The Larkin Township Future Land Use Map, Midland Township Zoning Map, and the Bay County GIS regional zoning layer for Beaver Township were merged and clipped to the subwatershed boundary, 18_8_3ZONING. Figure 54.

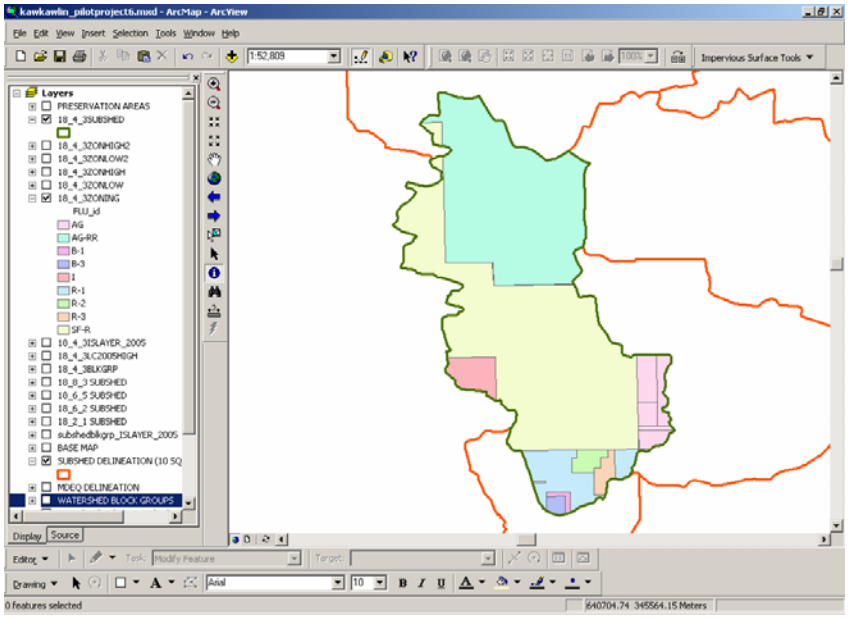

Figure 54: Waldo Drain
Future Land Use

STEP 6 - Export low/high-intensity layers.

Based on zoning and future land use classes, select and export zoning features which represent low intensity development and high intensity development to their own layers.

In Beaver Township, use the Bay County zoning common code as described for subwatershed 18 8 3. These features are exported to 18_4_3ZONLOW and 18_4_3HIGH. Figure 55.

In Larkin Township, Low Intensity Developed includes Agricultural/Rural Residential land use. High Intensity Developed includes Single Family Residential and Industrial Land use.

In Midland Township, Low Intensity Developed includes R-1 Residential Zone. High Intensity Developed includes R-2 Residential, R-3 Residential, B-1 Office Service, and B-3 Business Zones.

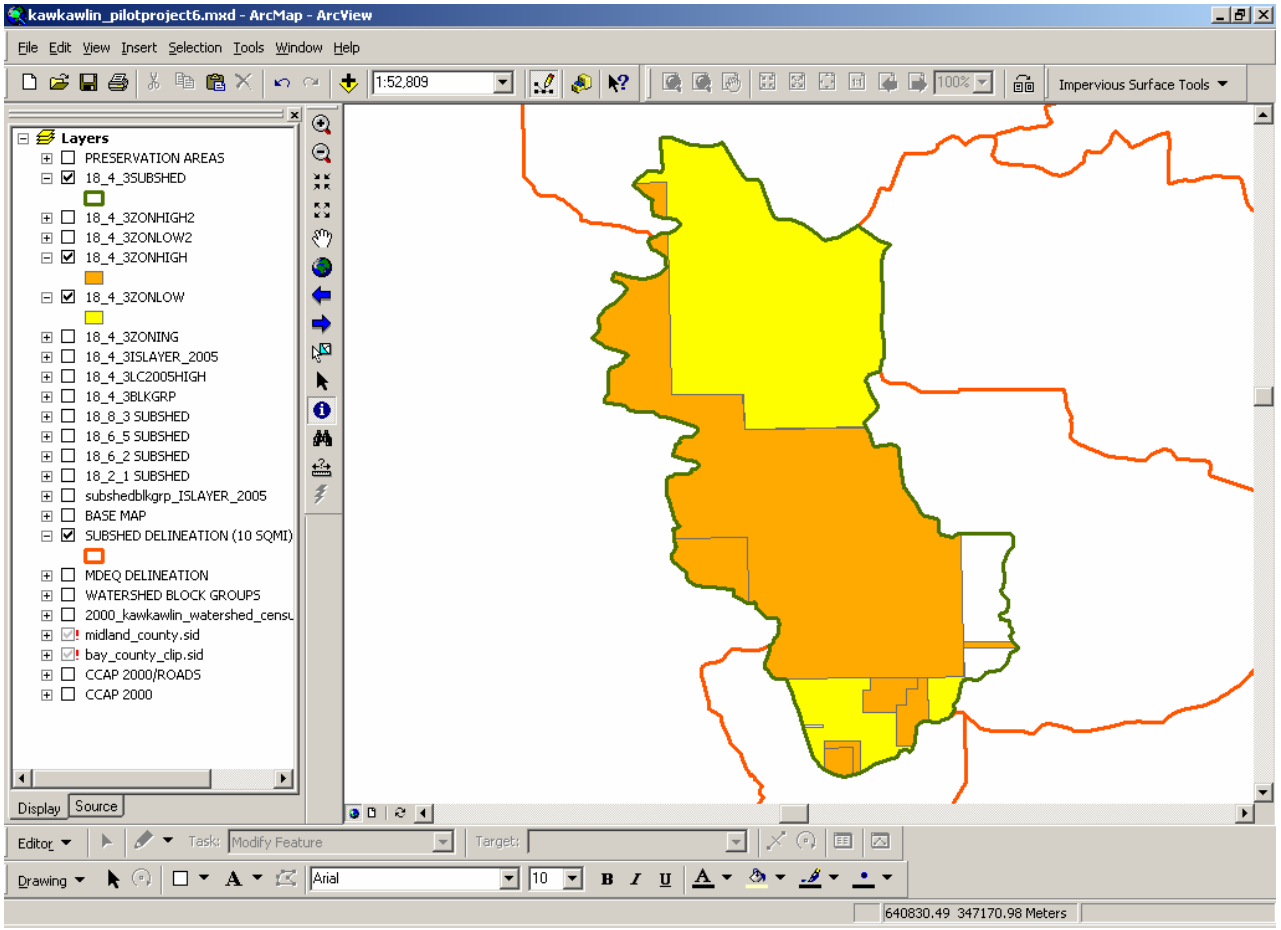

Figure 55: Waldo Drain Development Layers

STEP 7 - Remove PA 116 lands.

The Farmland and Open Space Preservation Act, Public Act 116 (PA116) of 1974 was established to slow development of agricultural lands. PA116 allows farmers to exchange development rights on lands used primarily for agriculture for property tax credit. Parcels are enrolled for a minimum of 10 years up to a maximum of 99 years. The layer SAGBAY_PA116 includes PA116 lands for the entire Saginaw Bay Watershed. These areas should be removed from the future low intensity and high intensity development area. Delete PA116 areas from 18_4_3ZONLOW and 18_4_3HIGH. The result is 18_4_3ZONLOW2 and 18_4_3ZONHIGH2. Repeat the process for 18_4_3ZONHIGH. The result is 18_4_3HIGH2. Figure 56.

STEP 8 - Remove Recreation Lands.

Public recreation lands are represented in layer SBCARL_FORDISTR_VER2. The Saginaw Bay Conservation and Recreation Lands layer was created by the Great Lakes/Atlantic Regional Office of Ducks Unlimited using a variety of regional and local sources. This layer includes areas which are to be preserved from future development, even if the local zoning map or future land use map indicates potential development. Therefore, this area should be removed from the future low intensity and high intensity development area. Delete these areas within recreation lands from 18_4_3ZONLOW. The result is 18_4_3ZONLOW2. Repeat the process for 18_4_3ZONHIGH. he result is 18_4_3HIGH2. Figure 56.

STEP 9 - Remove private conservation lands.

Private conservation lands are represented in layer PRIVATE_CONSERVATION_LAND . The Saginaw Bay Conservation and Recreation Lands layer was created by the Great Lakes/Atlantic Regional Office of Ducks Unlimited using a variety of regional and local sources. This layer includes areas which are to be preserved from future development, even if the local zoning map or future land use map indicates potential development. Therefore, this area should be removed from the future low intensity and high intensity development area. Delete these areas within private conservation lands from 18_4_3ZONLOW. The result is 18_4_3ZONLOW2. Repeat the process for 18_4_3ZONHIGH. The result is 18_4_3HIGH2. Figure 56.

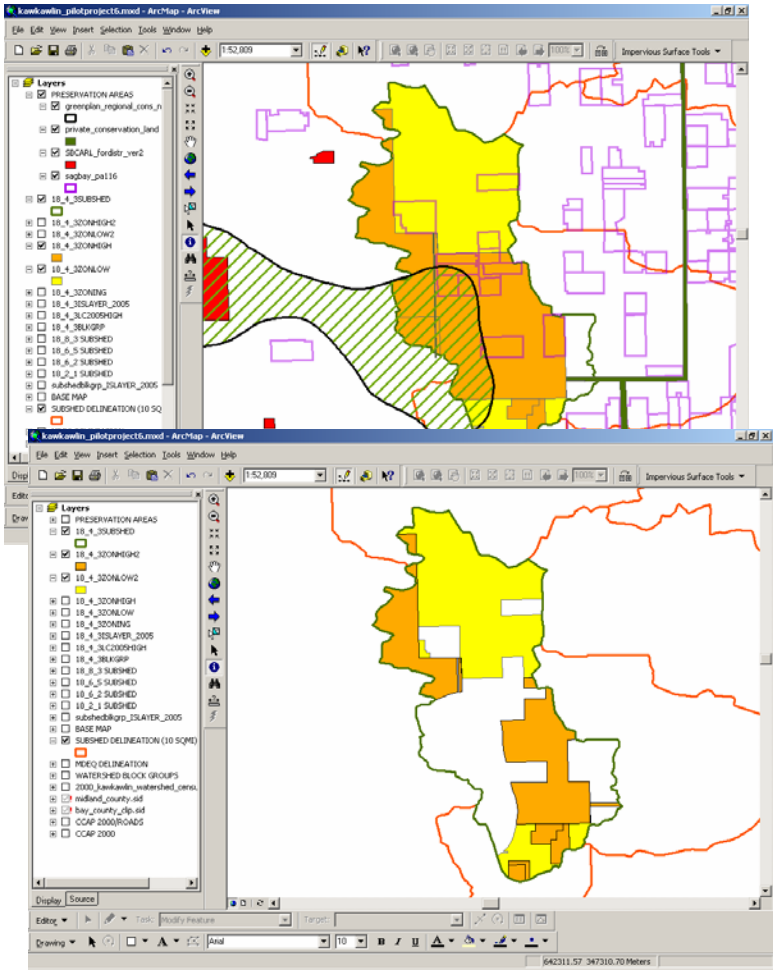

Figure 56: Waldo Drain Preservation Lands

STEP 10 - Remove Green Infrastructure Lands.

Green Infrastructure Lands are represented in layer GREENPLAN_REGIONAL_CONS_NETWORK. The Green Infrastructure Shape file was developed using priority conservation lands identified by the Saginaw Bay Greenways Collaborative through GIS modeling, meetings with major stakeholders and municipal officials, and community design sessions. This layer includes areas which are to be preserved from future development, even if the local zoning map or future land use map indicates potential development. Therefore, this area should be removed from the future low intensity and high intensity development area.

Use the ArcView Geoprocessing Wizard to union the 18_4_3ZONLOW layer with the GREENPLAN_REGIONAL_CONS_NETWORK layer. Delete polygons within the Green Infrastructure Lands. The result is 18_4_3ZONLOW2. Figure 56.

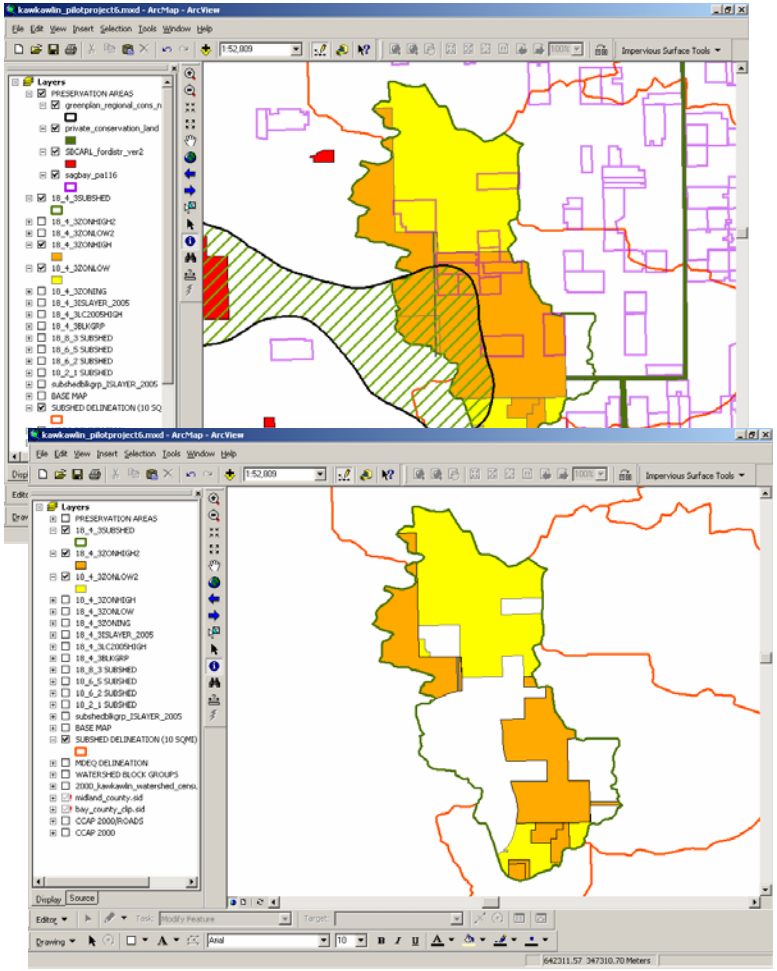

Figure 56: Waldo Drain Preservation Lands

STEP 11 - Run ISAT for future land cover.

Run ISAT introducing the land cover change scenario developed for future low and high intensity development. The layer generated was saved as 18_4_3ISLAYER_2025 indicating zoning or future land use plan land cover changes over the last 5 years and the next 20 years. Figure 57.

Results were added to project as layer 18_4_3ISLAYER_2025. Open the attribute table to view the percent impervious surface values. Label the layer based on pctIS to add these values to the map. Percent impervious surface per block group within the subwatershed is shown in Figure 58. Compare existing and future land use ISAT runs. For example, in subwatershed block group NAME2=132 the percent impervious surface area **increased from 8.37% to 27.29%.** Applying the land use change scenario increases the impervious surface percentage of this block group within the subwatershed from **Protected Stream Quality** category to **Impacted Stream Quality** category.

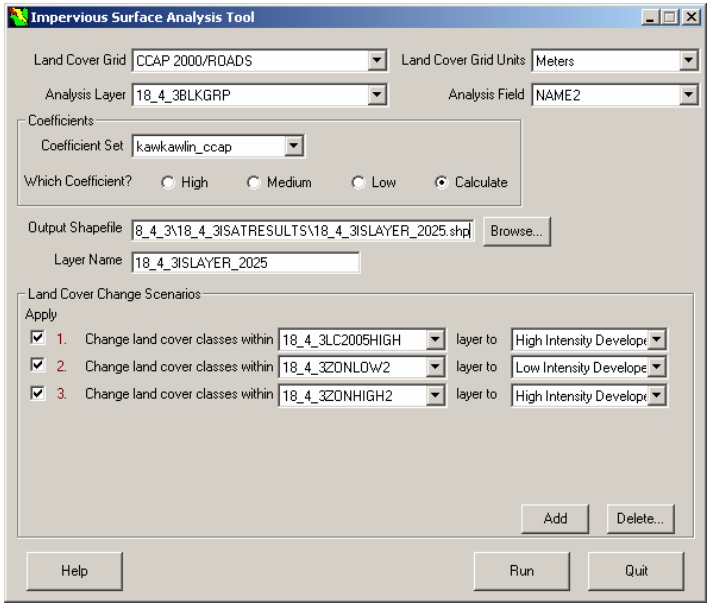

Figure 57: Waldo Drain Future Land Use ISAT Input

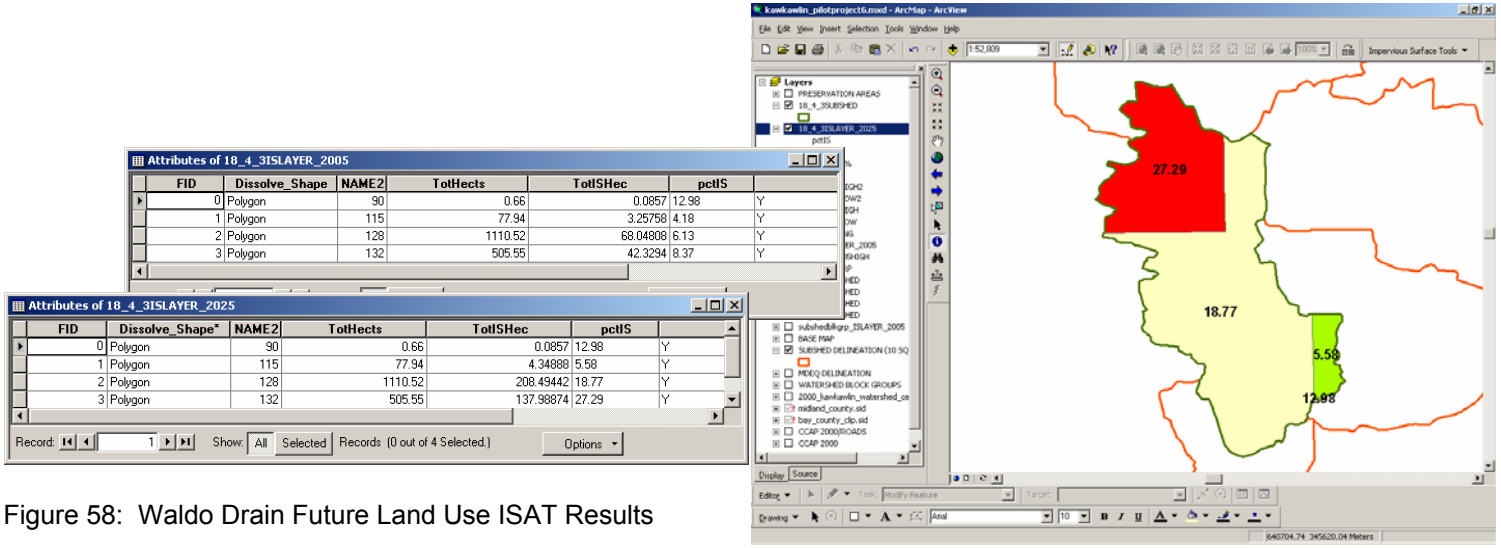

Figure 58: Waldo Drain Future Land Use ISAT Results