

Appendix B

Clinton Main Riparian Analysis

*Analysis conducted by:
Oakland County Planning & Economic Development Services Environmental Stewardship Group*

Introduction: What is a Riparian Ecosystem?

The area of land that exists between low, aquatic areas in a landscape such as rivers, streams, lakes and wetlands, and higher, dry upland areas such as forests, fields, cities and suburbs are known as riparian landscapes. Because these lands travel along the paths of flowing water, they are more aptly called riparian corridors.

Riparian lands are sensitive, critical components of the landscape, providing ecological and cultural value to the communities and landscapes through which they travel. The function of riparian landscapes is governed by their dual roles as transition zones between aquatic and terrestrial environments and as corridors. They often have steep or moderate slopes, sensitive vegetation and soils, provide critical wildlife habitat, and protect the water quality of streams, rivers, lakes and wetlands. When these lands are altered or developed, unique opportunities and challenges arise.

Each riparian corridor provides unique values to local communities which are ecological, cultural, and economic in nature. In landscapes affected by human activity, unique challenges to these values can be addressed through stewardship opportunities tailored to the specific needs of a river corridor. Table B.1 below provides a sampling of typical riparian values and their associated challenges and stewardship opportunities, described in terms of whether they are ecological, cultural, and/or economic in nature.

Table B.1 Riparian Assets, Challenges and Values

Riparian Asset	Potential Challenges	Stewardship Opportunities	Ecological Value	Cultural Value	Economic Value
Generate biodiversity	Habitat destruction and fragmentation, exotic invasive species	Protection and restoration of habitat, exotic management	X		
Provide wildlife corridors	Vegetation destruction and fragmentation	Protection and restoration of land along riparian corridor	X		X
Filter surface runoff pollutants	Direct piping of stormwater to river; inadequate riparian vegetation	Protection and restoration of riparian buffers, innovative stormwater management	X	X	X
Provide recreational opportunities	Lack of public access to river, lack of available land, flooding, poor water quality	Acquisition and development of public access and park land, flood control, water quality improvement		X	X
Provide drinking water	Water quality quantity degradation, alteration of natural hydrologic	Best practices to improve water quality and hydrologic regime			X

Riparian Asset	Potential Challenges	Stewardship Opportunities	Ecological Value	Cultural Value	Economic Value
	regime				
Water supply to wetlands/lakes	Alteration of natural hydrologic regime	Best practices to improve hydrologic regime	X		X
Stormwater detention and treatment	Alteration of natural hydrologic regime	Best practices to improve hydrologic regime	X		X
Provide fisheries/waterfowl habitat	Destruction and fragmentation of natural vegetation, alteration of natural hydrologic regime, invasion by exotic invasive species	Best practices to improve hydrologic regime, protection and restoration of habitat	X	X	X
Provide floral diversity and wildlife habitat	Destruction and fragmentation of natural vegetation, invasion by exotic invasive species	Protection and restoration of habitat, management of exotic invasive species	X	X	X
Protect shoreline and streambank from erosion	Alteration of natural hydrologic regime, hardening of natural shorelines, removal of riparian buffer, development too close to water's edge, filling of riparian wetlands and floodplains	Best practices to improve hydrologic regime, protection and restoration of natural shoreline and riparian buffers,	X		X
Recharge groundwater aquifers	Alteration of natural hydrologic regime	Best practices to improve hydrologic regime, protection of recharge areas	X		X
Provide unique geological resources, topography and scenic vistas	Grading, development too close to water's edge, erosion	Protection of unique areas, interpretation of geological origins of river valley		X	X
Provide historical resources	Destruction or neglect of historic resources	Protection and interpretation of historic resources of river valley		X	X

Riparian Mapping Methodology

In order to facilitate best practices for riparian management, it is useful to map riparian areas. This provides communities with an idea of where riparian resources are located. Some methods of mapping simply delineate riparian vegetation, others map a defined "buffer distance" from water's edge. These methods are not ideal. Simply mapping riparian vegetation will discount many unvegetated but important riparian areas. Simply applying a buffer distance may discount some riparian areas outside of the buffer while including others within.

Riparian resources are defined by the geomorphology of the landscape. The entire river valley needs consideration. In addition, unique riparian features should be delineated. This type of geomorphologic mapping is possible using a Geographic Information System with high-resolution digital topography and complementary layers including aerial photography.

The following features within the Clinton Main were delineated using a geomorphologic mapping process, as shown in Figure B.1:

Upland features:

The following three features are usually found in association with one another, below headwaters areas but above the lower sections where rivers reach the lake plain. They reflect the action of pro-glacial river systems exerting great force as they incised their river valleys and adjusted for the episodically receding base levels of the glacial lake stages, in a process called base-level adjustment.

- ❖ Valley walls- are steeply sloped lands which enclose the entire river valley. Valley walls are often steeper than may be explained by the size of the modern river, providing evidence of much larger pro-glacial systems that did most of the work carving out the valley.
- ❖ Ravines- are steep-sided tributary channels often found in association with valley walls.
- ❖ Terraces- are abandoned floodplains reflecting a former (higher) river base elevation during a historical lake stage.

Lowland features:

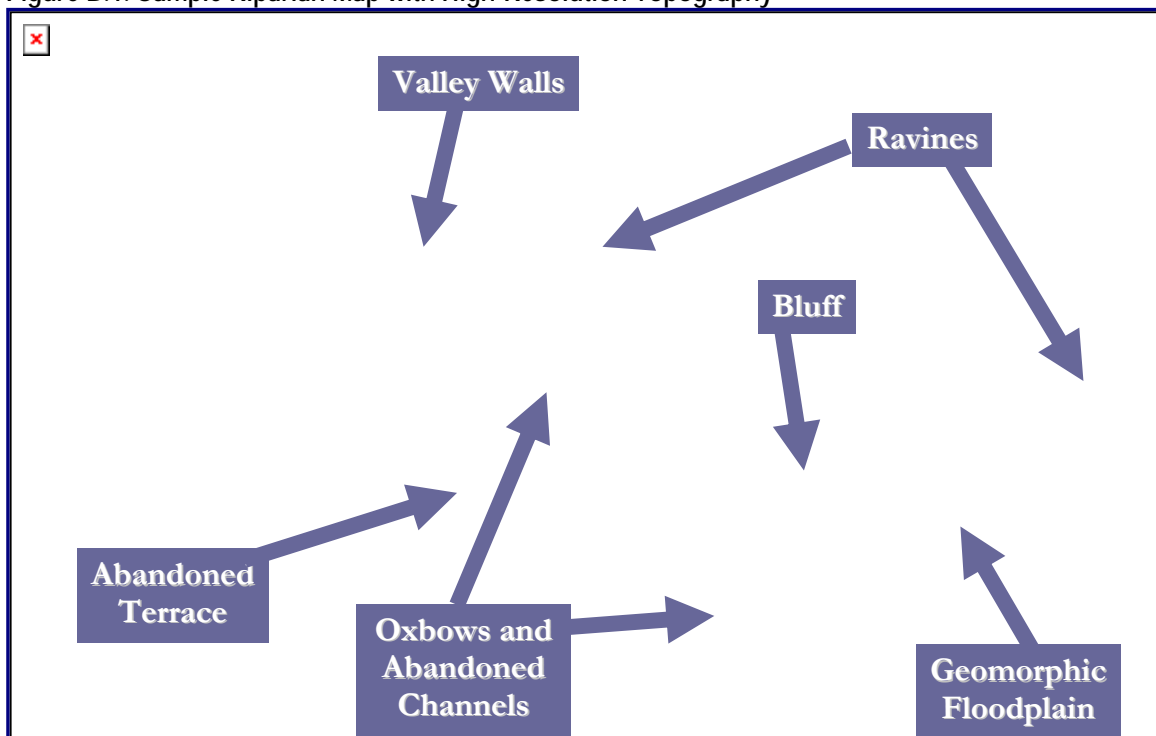
Lowland features are very diverse; some are confined to specific areas within a particular landscape ecosystem types while others may be found in all three.

- ❖ Abandoned channels- are old channels within the floodplain that have been abandoned as the river has migrated and is hydrologically connected to the modern river only minimally or not at all.
- ❖ Oxbows- are old channels that were abandoned as the river migrated that are still hydrologically connected with the modern river and may be inundated during wet seasons or flood events.
- ❖ Confluence areas- are areas where two streams coalesce to flow together as one. They may represent the joining of two small stream systems, or larger subwatershed drainage systems.
- ❖ Deltas- are depositional areas formed as pro-glacial streams or rivers slowed in velocity as they formed confluences with other tributaries or flowed into glacial lakes or estuaries.
- ❖ Lakes Areas- are primarily a feature of the Jackson Interlobate area where lakes were formed in pitted outwash plains and glacial depressions. Kettle lakes, also referred to as "ice-block depressions" were formed as ice-chunks broke away from the receding glaciers and were buried in sand and gravel. Other lakes are formed in old glacial drainages, while still others were formed by beavers.
- ❖ Wetlands Areas- may exist in any of the landscape types. Many types of wetlands may exist depending on local conditions.

In addition to these naturally occurring features, many features occur within riparian corridors that have been significantly altered by human encroachment, development, or management. These features can occur in any of the landscape ecosystems described.

- ❖ Altered riparian areas- are areas in which the topography has been so extensively altered that it is impossible to tell what underlying riparian physical features may exist.
- ❖ Enclosed channels- are channels that have been encased in metal or concrete and diverted through an underground path.
- ❖ Straightened channels- are river channels that have been straightened to accommodate development or facilitate drainage.

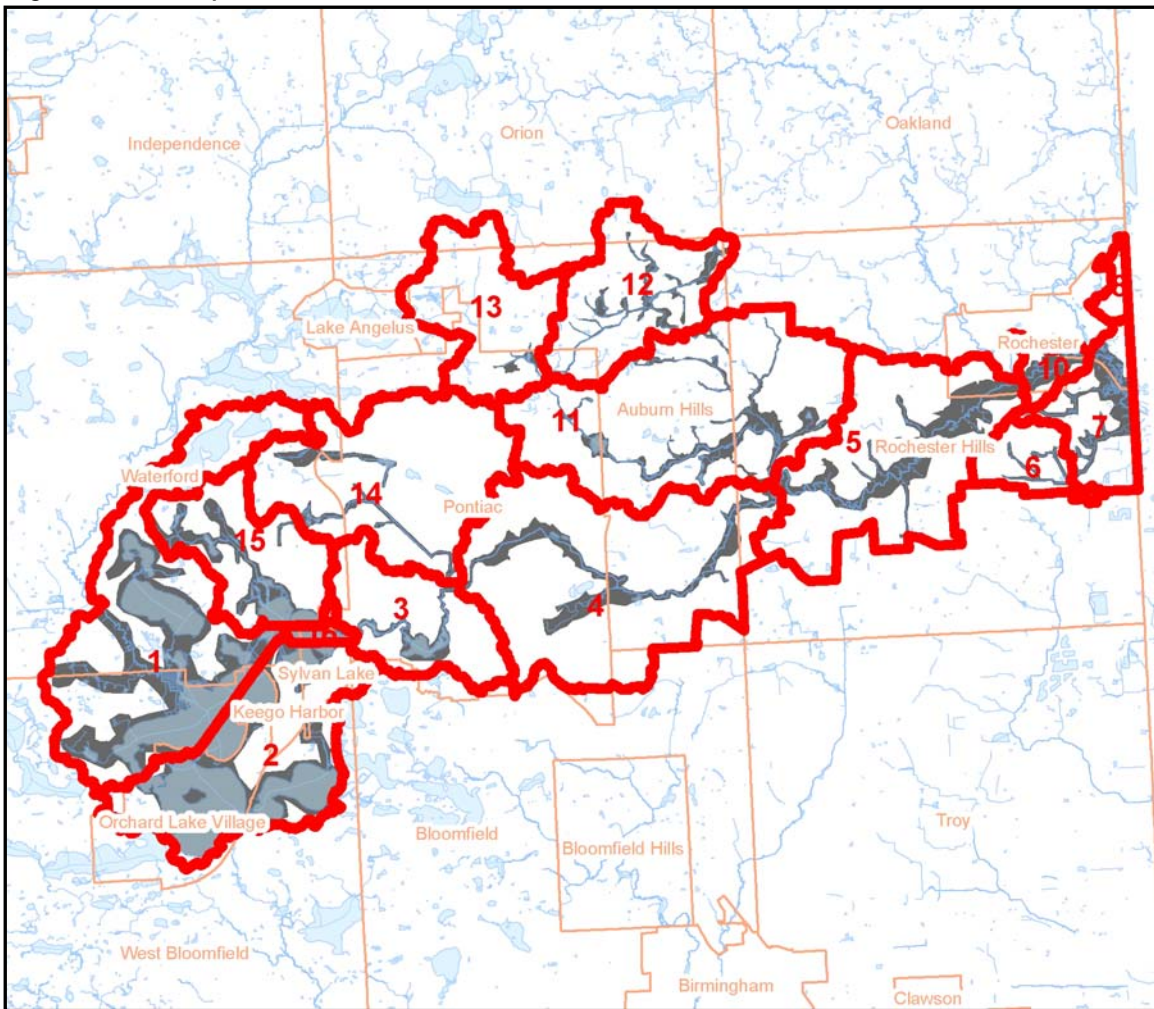
Figure B.1. Sample Riparian Map with High-Resolution Topography



The Clinton Main Riparian Corridor

The Clinton Main Corridor occupies the heart of the Clinton River Watershed, transitioning from a small stream upland lake and wetland- dominated areas through to the confluence of major tributaries (Stony and Paint Creek), emerging as a significantly sized river. The riparian corridor itself is heavily altered in many places, particularly in the smaller tributaries within the watershed. A major stretch of the main branch is enclosed within the City of Pontiac. Figure B.2 highlights the riparian corridor of the Clinton Main subwatershed.

Figure B.2. The Riparian Area of the Clinton Main Subwatershed



Riparian Area and Features

Map 31 illustrates the riparian area and features within the Clinton Main subwatershed. The riparian area is defined by the lakes in the upper part of the subwatershed, the broad outwash channel along the main river corridor, and several steep and narrow tributaries (Pontiac and Galloway Creeks). Natural features of interest include the lakes areas in the upper part of the subwatershed, several oxbows, ravines, and bluffs along the main stem in the lower part of the subwatershed, and a few wetlands areas in Pontiac, Auburn Hills and Rochester Hills. The riparian corridor is heavily altered in many places. A major stretch of the main branch is enclosed within the City of Pontiac. Many stretches have been channelized; most notably a significant stretch of Pontiac Creek along the railroad tracks near the Oakland County Service Center. Large areas within the City of Rochester Hills have been graded and developed, obscuring the original riparian features. Table B.2 summarizes the area of each feature type within each subbasin.

Table B.2. Composition of Riparian Features by Subbasin

Subbasin	Feature Type	Total Area (Acres)
1	Lakes Area	3053.1
2	Lakes Area	2625.6
3	Enclosed Channel	15.7
4	Altered Riparian Area	235.4
	Channelized Section	307.5
	Enclosed Channel	22.4
	Marshy Section	328.7
5	Altered Riparian Area	871.1
	Bluff	32.0
	Channelized Section	136.7
	Oxbow	1.9
	Ravine	39.8
	Terrace	5.1
6	Channelized Section	99.5
7	Altered Riparian Area	338.9
	Channelized Section	197.1
10	Altered Riparian Area	233.8
11	Oxbow	1.6
	Altered Riparian Area	16.0
	Channelized Section	290.9
	Marshy Section	154.8
	Valley Floor	268.0
12	Altered Riparian Area	44.5
	Channelized Section	126.5
	Marshy Section	194.1
13	Channelized Section	6.4
	Marshy Section	49.5
14	Channelized Section	104.7
	Enclosed Channel	33.7
	Lakes Area	211.0
15	Channelized Section	18.4
	Lakes Area	736.4
16	Lakes Area	143.7

Riparian Surface Geologic Landforms

The surficial geology of Oakland County was mapped in 2002 through a partnership initiative between Oakland County Planning & Economic Development Services and the Cranbrook Institute of Science. A combination of data sets including the existing Michigan Surficial Geology data layer and high-resolution digital topography was used to delineate the following landform features and sediment types:

- Outwash Plain, Glacial Channel, Recent Alluvium
- End Moraine: Till
- Ground Moraine: Till
- Water-Lain Moraine: Till
- Glacial Lake Plain: Sand, Silt, and Clay

Kame: Stratified Sand, Gravel, and Debris Flow Deposits
 Esker: Stratified Sand and Gravel

In addition, published data was used to map the areas encompassing the elevations of former glacial lake shorelines:

- Lake Maumee Shoreline (790' - 765')
- Lake Arkona Shoreline (710' - 694')
- Lake Whittlesey Shoreline (740' - 735')
- Lake Wayne Shoreline (665' - 660')
- Lake Warren Shoreline (685' - 680')

Map 32 illustrates the geological composition of the corridor. The upper part of the corridor resides in an outwash plain characterized by large lakes. The main branch mainly occupies a large outwash channel that bisects the large end moraines that comprise the river valley. Tributaries following narrow outwash channels also bisect these end and ground moraines as they flow to the river. As the river flows through the City of Rochester, outwash areas broaden as the river arrives at its confluence with Stony and Paint Creeks. Small tributaries in southeast Rochester Hills flow through lake plain topography, crossing old glacial lake ridges. The main corridor descends from the higher ground of the moraine area into the glacial lake plain.

Table B.3 describes the areal geologic composition of the riparian area within each subbasin by percentage. Surficial geology largely controls the permeability of soils. Outwash is the most permeable landform type, followed by end moraine and then ground moraine. Glacial lake plain is generally the least permeable type.

Table B.3. Composition of Riparian Surface Geology and Landforms by Subbasin

Subbasin	% Riparian Area	Geologic Landform Type
1	64	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel
	27	Ground Moraine: Till
	8	End Moraine: Till
2	97	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel
	3	End Moraine: Till
3	99	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel
	1	Ground Moraine: Till
4	69	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel
	31	End Moraine: Till
5	32	End Moraine: Till
	2	Ground Moraine: Till
	66	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel
6	53	Glacial Lake Plain: Sand, Silt and Clay
	32	Lake Maumee Shoreline (790' - 765')
	15	Lake Whittlesey Shoreline (740' - 735')
7		

51 Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and

Subbasin	% Riparian Area	Geologic Landform Type
		Gravel
	40	Glacial Lake Plain: Sand, Silt and Clay
	5	Lake Maumee Shoreline (790' - 765')
	4	Lake Whittlesey Shoreline (740' - 735')
10	89	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel
	7	End Moraine: Till
	2	Glacial Lake Plain: Sand, Silt and Clay
	2	Lake Maumee Shoreline (790' - 765')
11	60	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel
	35	End Moraine: Till
	4	Ground Moraine: Till
12	73	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel
	20	End Moraine: Till
	3	Ground Moraine: Till
	3	Kame: Stratified Sand, Gravel and Debris Flow Deposits
13	97	Ground Moraine: Till
	3	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel
14	53	Ground Moraine: Till
	47	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel
15	70	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel
	20	End Moraine: Till
	9	Ground Moraine: Till
16	100	Outwash Plain, Glacial Channel, Recent Alluvium: Stratified Sand and Gravel

Riparian Topography

Map 33 illustrates the topographic composition of the corridor. The corridor has a significant gradient, ranging from 1098 and 666 feet in elevation. The upper part of the corridor, dominated by lakes, is relatively high and flat, ranging from between 1098 and 912 feet. The lower part of the subwatershed has a much steeper gradient as the river transitions from the high outwash plains of the headwaters to the lake plain, descending almost 300 feet through auburn Hills, Rochester Hills and the city of Rochester. Table B.4 reports the elevation ranges within the riparian area of each subbasin.

Several viewsheds are significant within the riparian area. Subbasins 10, 11, 12, and 5 contain the greatest elevation ranges and consequently, the greatest viewsheds.

Table B.4. Elevation of Riparian Areas by Subbasin

Subbasin	Minimum Elevation (feet)	Maximum Elevation (feet)	Range of Elevation (feet)
1	925.8	978.0	52.2
2	926.2	978.4	52.3
3	914.2	948.2	34.1
4	811.9	942.2	130.3
5	708.4	864.4	156.1
6	734.1	820.3	86.3
7	666.0	819.1	153.1
10	691.4	807.9	116.5
11	811.9	1003.6	191.7
12	917.1	1098.9	181.9
13	915.4	952.0	36.6
14	912.4	1002.4	90.0
15	926.2	976.6	50.5
16	926.5	952.8	26.4

Riparian Slope

Map 34 and Table B.5 illustrate the slopes in and around the corridor. Because the corridor is a large outwash channel surrounded by moraines and has a significant gradient, there are significant slopes along its length. The greatest slopes can be found in subbasin 10 in the City of Rochester, between the confluences with Paint and Stony Creeks. The lakes-dominated basins (15 and 16) have the lowest slopes. Subbasins 11, 4, and 5, located in the center of the subwatershed, also have significant slopes.

Table B.5. Slope of Riparian Areas by Subbasin

Subbasin	Maximum Percent Slope
1	19
2	16
3	10
4	22
5	29
6	6
7	28
10	39
11	21
12	24
13	6
14	19
15	13
16	9

Riparian Michigan Natural Features Inventory Lands

The Michigan Natural Features Inventory lands are shown in Map 35. The map is the result of an analysis of aerial photos conducted by experienced landscape ecologists with the Michigan Natural Features Inventory for Oakland County. More information about this project and the ranking criteria for natural area priority can be found at the following website:

http://www.oakgov.com/peds/program_service/es_prgm/natural_areas.html.

The majority of MNFI sites contained within the riparian area include priority three Natural Areas. A significant priority one natural area is contained within the riparian areas of subbasins 7 and 10. A small priority one area is contained within the riparian area of subbasin 1. A total of 1802.7 acres exist within the riparian area, with only 22% (393.9 acres) under some form of protection as a public recreation land or other form of committed open space.

Table B.6. MNFI Acreage and Protection Status by Subbasin Riparian Area

Subbasin	Riparian MNFI Protection Status (Acres)		Total MNFI Acres
	<i>NO</i>	<i>YES</i>	
1	291.2	18.1	309.3
2	38.4	0	38.4
3	8.7	18	26.7
4	196.9	33.8	230.7
5	201.7	74.6	276.3
7	156.2	85.1	241.3
10	34.4	79.6	114.0
11	211.8	11.9	223.7
12	105.7	19.4	125.1
13	18.5	0	18.5
14	26.9	34.8	61.7
15	118.3	18.6	136.9
<i>Grand Total</i>	<i>1408.8</i>	<i>393.9</i>	<i>1802.7</i>

Riparian Land Use

Map 36 illustrates the Land Use within each parcel area, derived from Oakland County Parcel data and tax information. Table B.7 summarizes the acres and overall percentages for each land use type corridor-wide, while the appendix summarizes land use for the riparian corridor within each subbasin. Table B.7 removed water from the land use analysis while the appendix includes water. The majority of land use in the corridor is residential (33%). Vacant land accounts for 19% of land and 20% is in a recreation/conservation use.

Table B.7. Land Use in the Clinton Main Riparian Corridor

Land Use	Total	Percent
Commercial/Office	240.53	3%
Industrial	367.43	5%
Mobile Home Park	84.54	1%
Multiple Family	267.66	4%
Public/Institutional	582.61	8%
Railroad ROW	16.96	0%
Recreation/Conservation	1412.86	20%

Land Use	Total	Percent
Road ROW	716.17	10%
S.F. More than one unit per parcel	62.83	1%
Single Family, 1 to 2.5 Acres	341.56	5%
Single Family, 14,000 to 43,559 sq. ft.	648.54	9%
Single Family, 2.5 to 5 acres	175.50	2%
Single Family, 5 to 10 acres	136.75	2%
Single Family, 8,000 to 13,999 sq. ft.	432.33	6%
Single Family, Greater than 10 acres	60.39	1%
Single Family, Less than 8,000 sq. ft.	147.25	2%
Transportation/Utility/Communication	121.90	2%
Vacant	1348.95	19%
Grand Total	7164.77	

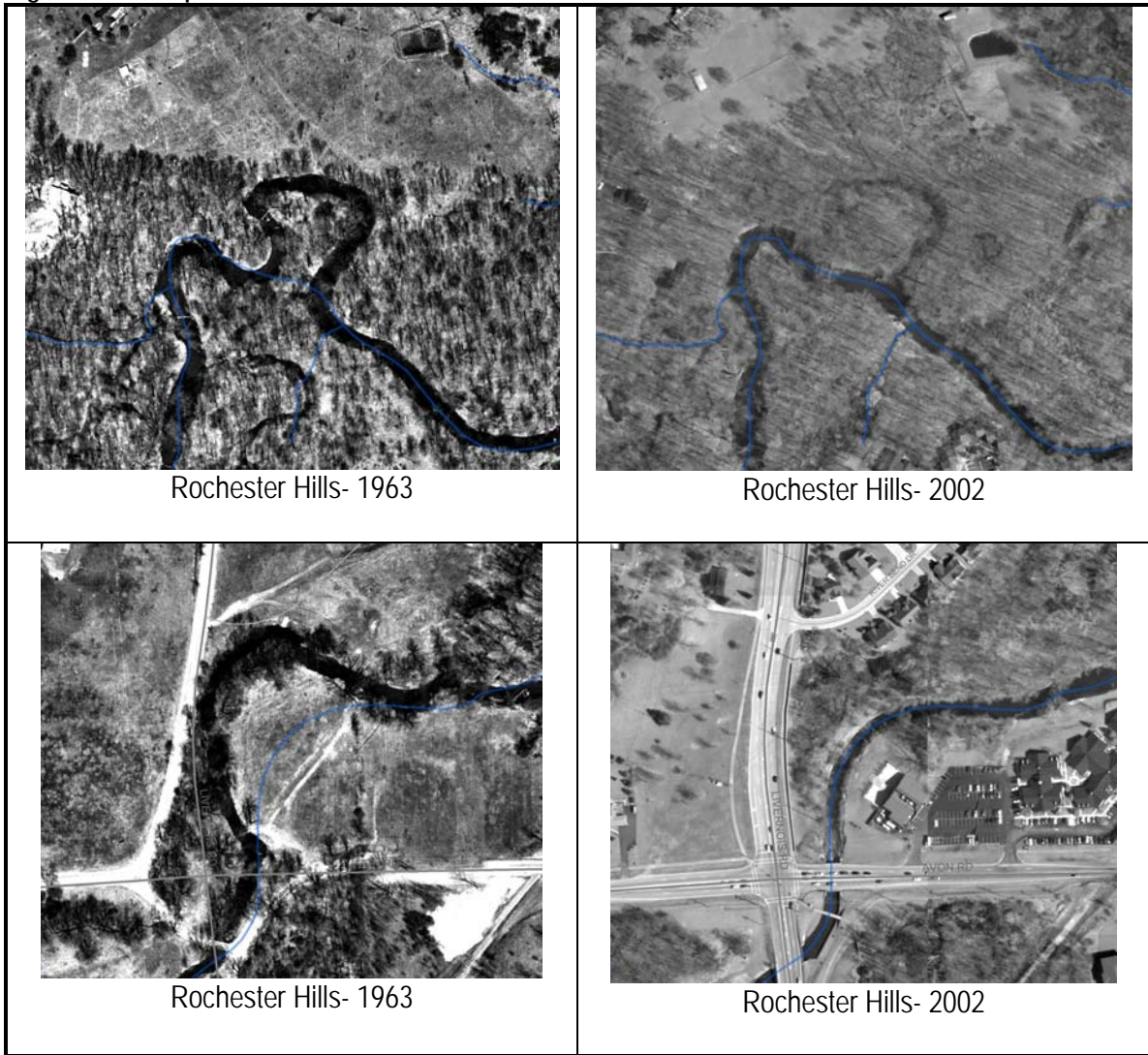
Overview of Riparian Historical Channel Migration

The path of a river naturally migrates over time as a river adjusts to the amount of water and sediment in its load. Changes in landscape composition and hydrology (development, impervious surfaces, additional stormwater discharge), as well as changes to the river channel and banks (channelization, bank armoring) can cause additional instability in a river system and speed the migration of the river system. Changes in a river's path can threaten property that has been developed too close to a river (Figure B.3). Examples of channel migration can be seen along the stretch of the Clinton River, particularly in Rochester Hills and the City of Rochester (Figure B.3). The images in Figure B.4 compare a 1963 aerial photo with the stream centerline in 2002.



Figure B.3. Erosion due to channel migration is threatening this property in the City of Rochester Hills (photo taken in 2002).



Figure B.4. Comparison of Clinton River meanders between 1963 and 2002



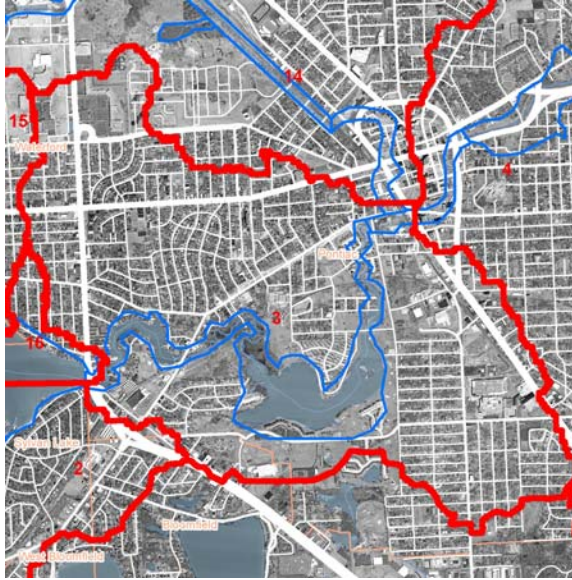
Subbasin Analysis: Riparian Character, Issues & Opportunities

Analyses conducted for subbasins with significant riparian resources. Similar areas geographically connected were considered together. Also see Table B.8 Riparian Land Use Summaries by Subbasin.

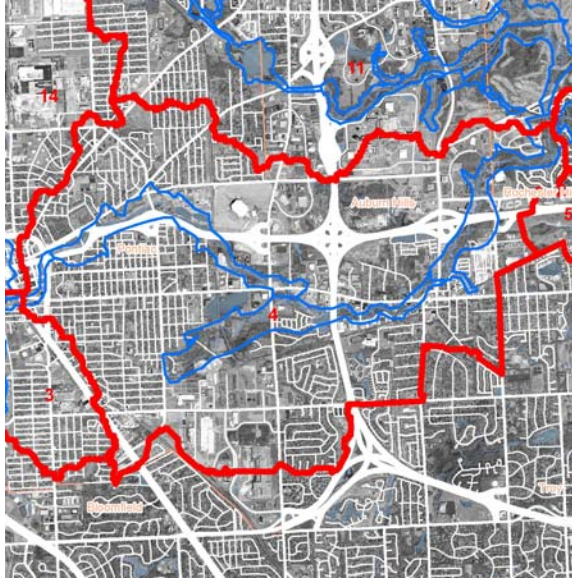
Subbasins 1 and 2

<p>Character</p> <p>The riparian area of Subbasins 1 and 2 is entirely a lakes area, is characterized by an outwash plain. The riparian area is dominated by single family residential land uses, as well as recreation/conservation land. The gradient is shallow, with a range of elevation of only 52 feet in subbasins 1 and 2, a maximum slope of 19% in subbasin 1 and 16% in subbasin 2. The riparian area of subbasin 1 contains 309.3 MNFI acres, only 18.1 of which are protected. The riparian area of subbasin 2 contains 38.4 MNFI acres, none of which are protected.</p>	
<p>Issues</p> <ul style="list-style-type: none">❖ Erosion and runoff due to heavy shoreline development❖ Storm water discharge to lakes and wetlands from commercial areas❖ Significant amount of unprotected MNFI area	
<p>Opportunities</p> <ul style="list-style-type: none">❖ Residential shoreline education and management❖ Storm water management in commercial areas❖ Evaluate ways to protect additional MNFI areas	

Subbasin 3

<p>Character</p> <p>The riparian area of Subbasin 3 is varied, including a lake area and an enclosed channel, and is characterized by an outwash plain and ground moraine. The riparian area is 19% recreation/conservation, 10% vacant and 38% water, with significant areas of commercial office and high-density residential. The gradient is very shallow, with a range of elevation of only 34 feet, and maximum slope of 10%. The riparian area contains 26.7 MNFI acres; 18 of which are protected.</p>	
<p>Issues</p> <ul style="list-style-type: none">❖ Multiple land uses require different approaches for BMPs	
<p>Opportunities</p> <ul style="list-style-type: none">❖ Use public recreation land as demonstration for best practices.❖ Daylighting of enclosed channel	

Subbasin 4

<p>Character</p> <p>The riparian area of Subbasin 4 includes a wetlands area, altered riparian area, enclosed channel, and channelized section, and is characterized by an outwash plain and ground moraine. The riparian area is 6% water, 27% vacant, 16% road right of way, and 12% recreation/conservation, with significant areas of commercial/office, industrial, and mobile home park. The gradient is steep, with a range of elevation of 130, and maximum slope of 22%. The riparian area contains 230.7 MNFI acres; only 33.8 of which are protected.</p>	 An aerial photograph of a city area with a red boundary line outlining a specific subbasin. Blue lines represent stream channels and waterways within the subbasin. The map shows a dense urban grid, roads, and various land uses. The subbasin boundary is irregular, following the course of the streams and surrounding urban areas.
<p>Issues</p> <ul style="list-style-type: none">❖ Multiple land uses require different approaches for BMP❖ High density of road runoff	
<p>Opportunities</p> <ul style="list-style-type: none">❖ Large MNFI area in a vacant parcel, primarily wetland, could be preserved❖ Utilize BMPs to mitigate impacts of road runoff❖ Daylighting of enclosed channel	

Subbasin 5

Character

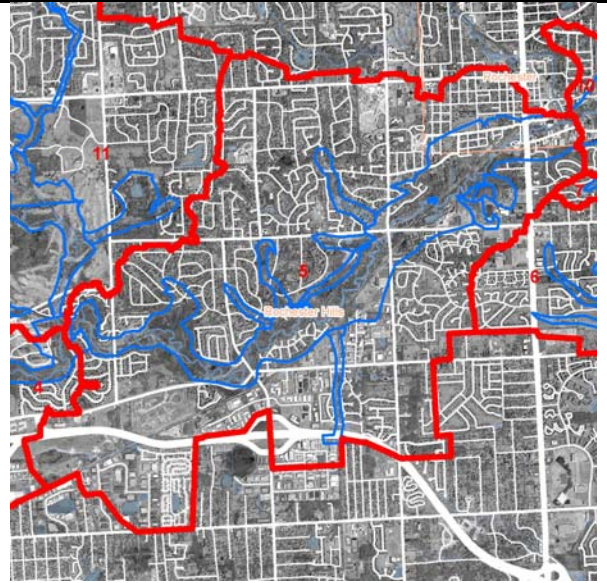
The riparian area of Subbasin 5 is highly varied, including altered riparian areas, bluffs, ravines, terraces, a channelized section and altered riparian area, and is characterized by an outwash plain, end moraine and ground moraine. The riparian area is 13% vacant, 18% recreation and conservation, with significant areas of multiple family, public institutional, and single family residential land uses. The gradient is steep, with a range of elevation of 156, and maximum slope of 29%. The riparian area contains 276 MNFI acres; only 74.6 of which are protected within the public domain.

Issues

- ❖ Multiple intense land uses require different approaches for BMP
- ❖ Varied riparian features sensitive to erosion/sedimentation
- ❖ Steep slopes encourage bank erosion

Opportunities

- ❖ Significant amounts of MNFI area worthy of protection
- ❖ Scenic resources including bluffs, terraces, and ravines are worthy of protection
- ❖ Measures to mitigate bank erosion and manage development close to steep slopes



Subbasin 6

Character

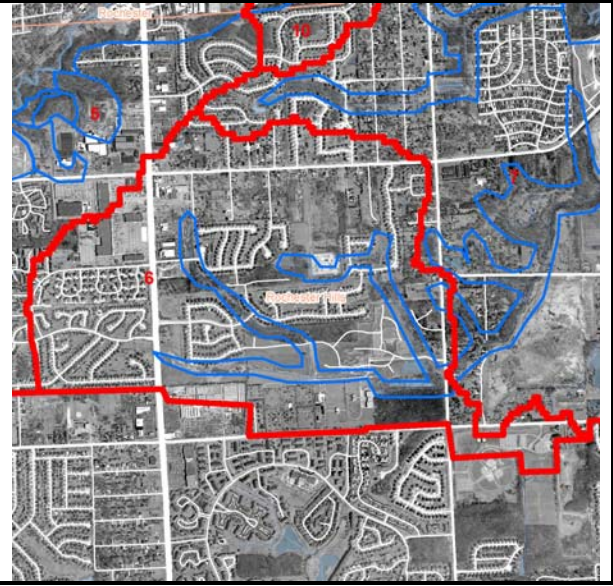
The riparian area of Subbasin 6 is entirely channelized and characterized by end moraine and glacial lake shoreline. The riparian area is 31% recreation and conservation, and 23% public institutional, with significant single family residential. The gradient is shallow, with a range of elevation of 86 feet, and maximum slope of 6%. The riparian area contains no MNFI area.

Issues

- ❖ Riparian area is highly disturbed

Opportunities

- ❖ Restoration and buffering of disturbed sections, particularly in recreation & conservation land use areas



Subbasin 7

Character

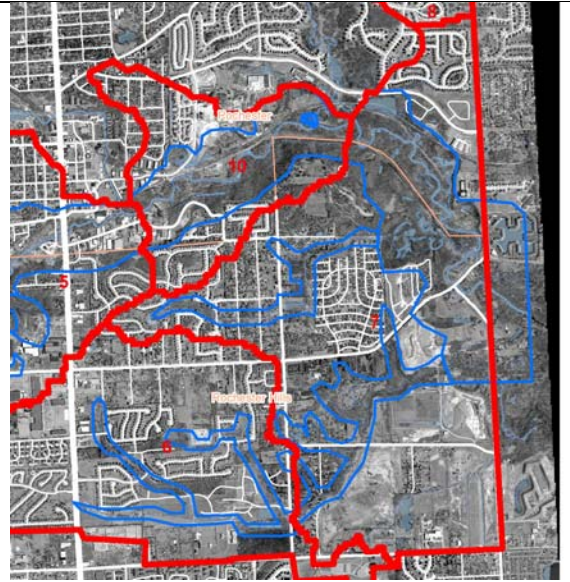
The riparian area of Subbasin 7 includes a large extent of somewhat altered but largely natural river corridor and channelized sections and is characterized by outwash, lake plain, and glacial lake shoreline. The riparian area is 45% vacant and 18% recreation and conservation, and 23% public institutional, with significant single family residential and a mobile home park. The gradient is relatively steep, with a range of elevation of 153 feet, and maximum slope of 28%. The riparian area contains 241.3 acres of MNFI area, 85.1 of which are protected.

Issues

- ❖ Habitat damage in channelized areas
- ❖ Large priority one MNFI natural area in need of permanent protection
- ❖ Steep gradient increases risk of erosion

Opportunities

- ❖ Habitat restoration and land protection
- ❖ BMPs for shoreline stabilization
- ❖ Measures to mitigate bank erosion and manage development close to steep slopes



Subbasin 10

Character

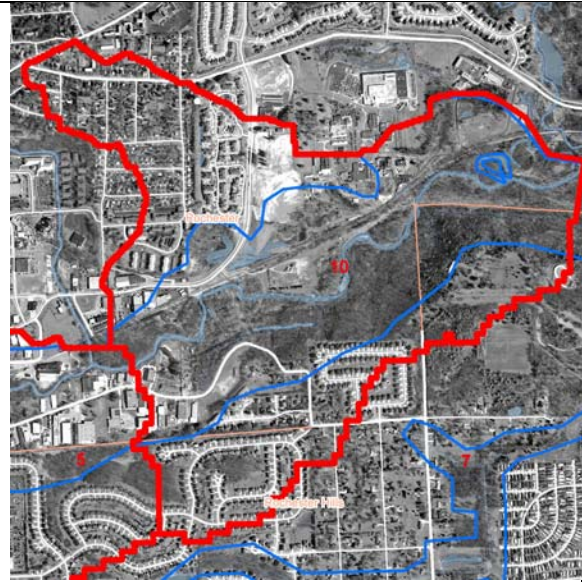
The riparian area of Subbasin 10 includes a large extent of somewhat altered but largely natural river corridor characterized by a varied geology including outwash, end moraine, lake plain, and glacial lake shoreline. The riparian area is 16% vacant and 44% recreation and conservation, and 24% industrial. The gradient is relatively steep, with a range of elevation of 116.5 feet, and maximum slope of 39%. The riparian area contains 114 acres of priority one MNFI area, 79.6 of which are protected.

Issues

- ❖ Large priority one MNFI natural area in need of permanent protection
- ❖ Steep gradient increases risk of bank erosion
- ❖ Runoff from industrial areas

Opportunities

- ❖ Habitat restoration and land protection
- ❖ BMP's for shoreline stabilization and industrial stormwater management
- ❖ Measures to mitigate bank erosion and manage development close to steep slopes



Subbasin 11 & 12

Character

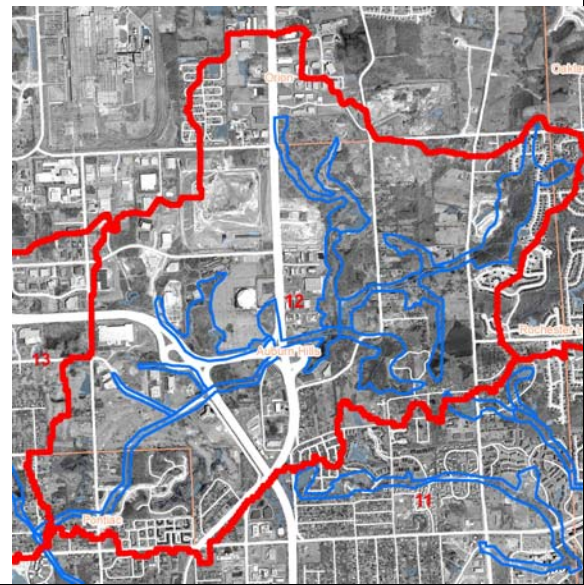
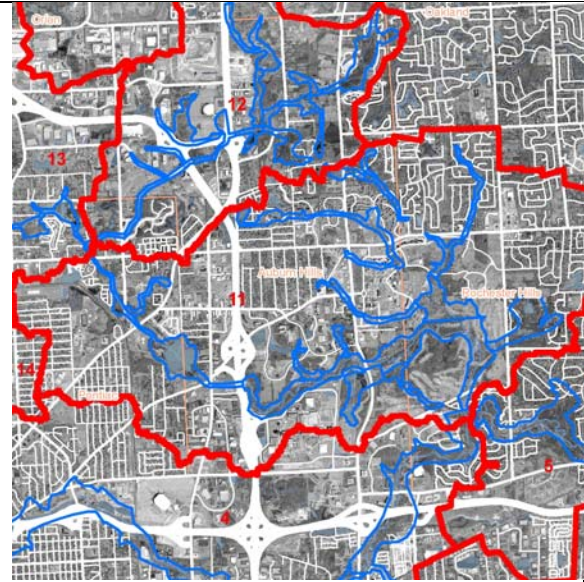
The riparian area of Subbasins 11 and 12 include Galloway Creek and contain an oxbow, altered riparian area, channelized section, wetlands area, and valley floor. It also has a varied geology including outwash, end moraine, and ground moraine. The riparian area of subbasin 11 is 13% vacant and 26% recreation and conservation, 24% public/institutional, and 8% Road Right-of-way. The riparian area of subbasin 12 is 24% vacant and 21% recreation and conservation, and 24% public/institutional, and 7% Road Right-of-way with significant commercial/office and industrial land uses. The gradient is relatively steep, with a range of elevation of 191.7 and 181.7 feet, and maximum slope of 21% and 24%. The riparian area of subbasin 11 contains 223.7 acres of priority one MNFI area, only 11.9 of which are protected, and subbasin 12 contains 125.1 acres, only 19.1 of which are protected.

Issues

- ❖ Significant areas of unprotected MNFI area within riparian corridor
- ❖ Steep gradient increases risk for shoreline
- ❖ Road runoff

Opportunities

- ❖ Land protection
- ❖ BMP's for shoreline stabilization and industrial stormwater management
- ❖ Mitigation of road runoff



Subbasin 14

<p>Character</p> <p>The riparian area of Subbasin 14 includes a small lake area, extensive channelized section and enclosed channel and is characterized by outwash and ground moraine. The riparian area is 18% vacant, 18% recreation and conservation, and 26% public/institutional. The gradient is relatively moderate, with a range of elevation of 90 feet, and maximum slope of 19%. The riparian area contains 61.7 acres of MNFI area, 34.8 of which are protected.</p>	
<p>Issues</p> <ul style="list-style-type: none"> ❖ Habitat degradation in channelized areas ❖ Runoff from public institutional areas 	
<p>Opportunities</p> <ul style="list-style-type: none"> ❖ Buffering and habitat restoration in channelized areas ❖ Stormwater BMP's in public institutional areas 	

Subbasin 15

<p>Character</p> <p>The riparian area of Subbasin 15 includes a lake area and small channelized and is characterized by outwash, end moraine and ground moraine. The riparian area is 12% vacant, 5% recreation and conservation, and primarily in single-family residential land use. The gradient is relatively shallow, with a range of elevation of 50.5 feet, and maximum slope of 13%. The riparian area contains 136.9 acres of MNFI area, 18.6 of which are protected.</p>	
<p>Issues</p> <ul style="list-style-type: none"> ❖ Residential runoff 	
<p>Opportunities</p> <ul style="list-style-type: none"> ❖ Education of residents on use of residential BMP's 	

Table B.8. Riparian Land Use Summaries by Subbasin

Subbasin	Land Use	Total Acres	% Riparian Area
Subbasin 1	Commercial/Office	14.70	0%
	Multiple Family	36.83	1%
	Public/Institutional	25.91	1%
	Recreation/Conservation	316.04	10%
	Road ROW	201.91	7%
	S.F. More than one unit per parcel	19.10	1%

Subbasin	Land Use	Total Acres	% Riparian Area
	Single Family, 1 to 2.5 Acres	78.66	3%
	Single Family, 14,000 to 43,559 sq. ft.	243.20	8%
	Single Family, 2.5 to 5 acres	49.03	2%
	Single Family, 5 to 10 acres	58.88	2%
	Single Family, 8,000 to 13,999 sq. ft.	235.68	8%
	Single Family, Greater than 10 acres	22.88	1%
	Single Family, Less than 8,000 sq. ft.	71.18	2%
	Transportation/Utility/Communication	0.71	0%
	Vacant	252.38	8%
	Water	1411.89	46%
	(blank)	14.07	0%
Subbasin 1 Total		3053.05	
Subbasin 2	Commercial/Office	1.34	0%
	Industrial	4.51	0%
	Mobile Home Park	2.05	0%
	Multiple Family	21.06	1%
	Public/Institutional	11.16	0%
	Recreation/Conservation	104.82	4%
	Road ROW	91.62	3%
	S.F. More than one unit per parcel	8.36	0%
	Single Family, 1 to 2.5 Acres	108.22	4%
	Single Family, 14,000 to 43,559 sq. ft.	166.18	6%
	Single Family, 2.5 to 5 acres	17.11	1%
	Single Family, 5 to 10 acres	7.24	0%
	Single Family, 8,000 to 13,999 sq. ft.	74.00	3%
	Single Family, Less than 8,000 sq. ft.	26.25	1%
	Transportation/Utility/Communication	4.02	0%
	Vacant	48.06	2%
	Water	1922.23	73%
	(blank)	7.50	0%
Subbasin 2 Total		2625.71	
Subbasin 3	Commercial/Office	10.82	5%
	Industrial	2.69	1%
	Mobile Home Park	2.21	1%
	Multiple Family	4.55	2%
	Public/Institutional	8.00	4%
	Railroad ROW	1.05	1%
	Recreation/Conservation	40.56	19%
	Road ROW	16.87	8%
	Single Family, 1 to 2.5 Acres	1.59	1%
	Single Family, 14,000 to 43,559 sq. ft.	2.98	1%
	Single Family, 8,000 to 13,999 sq. ft.	4.61	2%
	Single Family, Less than 8,000 sq. ft.	6.00	3%

Subbasin	Land Use	Total Acres	% Riparian Area
	Transportation/Utility/Communication	3.78	2%
	Vacant	21.93	10%
	Water	80.45	38%
	(blank)	0.88	0%
Subbasin 3 Total		208.99	
Subbasin 4	Commercial/Office	55.86	6%
	Industrial	77.30	9%
	Mobile Home Park	49.85	6%
	Multiple Family	13.36	1%
	Public/Institutional	20.74	2%
	Railroad ROW	1.24	0%
	Recreation/Conservation	111.41	12%
	Road ROW	139.51	16%
	Single Family, 1 to 2.5 Acres	6.02	1%
	Single Family, 14,000 to 43,559 sq. ft.	19.82	2%
	Single Family, 5 to 10 acres	7.10	1%
	Single Family, 8,000 to 13,999 sq. ft.	8.98	1%
	Single Family, Less than 8,000 sq. ft.	11.02	1%
	Transportation/Utility/Communication	82.25	9%
	Vacant	237.44	27%
	Water	50.73	6%
	(blank)	1.32	0%
Subbasin 4 Total		893.94	
Subbasin 5	Commercial/Office	24.88	2%
	Industrial	113.61	10%
	Multiple Family	115.06	11%
	Public/Institutional	113.71	10%
	Recreation/Conservation	199.38	18%
	Road ROW	80.04	7%
	S.F. More than one unit per parcel	1.79	0%
	Single Family, 1 to 2.5 Acres	71.02	7%
	Single Family, 14,000 to 43,559 sq. ft.	63.94	6%
	Single Family, 2.5 to 5 acres	24.41	2%
	Single Family, 5 to 10 acres	25.56	2%
	Single Family, 8,000 to 13,999 sq. ft.	39.86	4%
	Single Family, Less than 8,000 sq. ft.	19.33	2%
	Transportation/Utility/Communication	3.87	0%
	Vacant	137.38	13%
	Water	48.63	4%
	(blank)	1.37	0%
Subbasin 5 Total		1083.84	
Subbasin 6	Commercial/Office	5.38	5%

Subbasin	Land Use	Total Acres	% Riparian Area
	Public/Institutional	22.48	23%
	Recreation/Conservation	30.87	31%
	Road ROW	5.61	6%
	Single Family, 1 to 2.5 Acres	0.76	1%
	Single Family, 14,000 to 43,559 sq. ft.	3.34	3%
	Single Family, 2.5 to 5 acres	0.72	1%
	Single Family, 8,000 to 13,999 sq. ft.	12.38	12%
	Single Family, Greater than 10 acres	5.41	5%
	Single Family, Less than 8,000 sq. ft.	0.36	0%
	Transportation/Utility/Communication	7.74	8%
	Vacant	2.26	2%
	Water	2.22	2%
Subbasin 6 Total		99.50	
Subbasin 7	Commercial/Office	5.11	1%
	Industrial	3.09	1%
	Mobile Home Park	18.66	3%
	Recreation/Conservation	95.57	18%
	Road ROW	21.60	4%
	Single Family, 1 to 2.5 Acres	23.81	4%
	Single Family, 14,000 to 43,559 sq. ft.	20.84	4%
	Single Family, 2.5 to 5 acres	25.01	5%
	Single Family, 5 to 10 acres	7.21	1%
	Single Family, 8,000 to 13,999 sq. ft.	4.65	1%
	Single Family, Greater than 10 acres	31.21	6%
	Single Family, Less than 8,000 sq. ft.	0.01	0%
	Transportation/Utility/Communication	0.47	0%
	Vacant	241.96	45%
	Water	36.55	7%
Subbasin 7 Total		535.74	
Subbasin 10	Industrial	57.13	24%
	Multiple Family	6.44	3%
	Public/Institutional	0.87	0%
	Recreation/Conservation	102.92	44%
	Road ROW	6.21	3%
	Single Family, 1 to 2.5 Acres	1.19	1%
	Single Family, 14,000 to 43,559 sq. ft.	1.35	1%
	Single Family, 2.5 to 5 acres	4.47	2%
	Single Family, 8,000 to 13,999 sq. ft.	1.69	1%
	Single Family, Less than 8,000 sq. ft.	0.89	0%
	Transportation/Utility/Communication	0.10	0%
	Vacant	37.15	16%
	Water	13.42	6%
Subbasin 10		233.82	

Subbasin	Land Use	Total Acres	% Riparian Area
Total			
Subbasin 11	Commercial/Office	10.12	1%
	Industrial	77.39	9%
	Mobile Home Park	9.68	1%
	Multiple Family	40.44	5%
	Public/Institutional	200.48	24%
	Recreation/Conservation	219.78	26%
	Road ROW	36.73	4%
	S.F. More than one unit per parcel	5.36	1%
	Single Family, 1 to 2.5 Acres	11.08	1%
	Single Family, 14,000 to 43,559 sq. ft.	23.56	3%
	Single Family, 2.5 to 5 acres	8.14	1%
	Single Family, 5 to 10 acres	1.86	0%
	Single Family, 8,000 to 13,999 sq. ft.	8.71	1%
	Transportation/Utility/Communication	0.09	0%
	Vacant	110.34	13%
	Water	80.26	10%
	(blank)	0.14	0%
Subbasin 11 Total		844.17	
Subbasin 12	Commercial/Office	24.57	7%
	Industrial	24.71	7%
	Public/Institutional	32.91	9%
	Recreation/Conservation	76.83	21%
	Road ROW	29.15	8%
	S.F. More than one unit per parcel	24.60	7%
	Single Family, 1 to 2.5 Acres	5.06	1%
	Single Family, 14,000 to 43,559 sq. ft.	5.47	1%
	Single Family, 2.5 to 5 acres	21.80	6%
	Single Family, 5 to 10 acres	9.65	3%
	Single Family, 8,000 to 13,999 sq. ft.	5.34	1%
	Single Family, Greater than 10 acres	0.89	0%
	Single Family, Less than 8,000 sq. ft.	0.29	0%
	Vacant	88.78	24%
	Water	15.09	4%
	(blank)	0.09	0%
Subbasin 12 Total		365.22	
Subbasin 13	Recreation/Conservation	8.92	16%
	Road ROW	4.18	7%
	Single Family, 1 to 2.5 Acres	8.76	16%
	Single Family, 14,000 to 43,559 sq. ft.	5.28	9%
	Single Family, 2.5 to 5 acres	4.60	8%
	Single Family, 5 to 10 acres	1.94	3%
	Single Family, 8,000 to 13,999 sq. ft.	1.35	2%

Subbasin	Land Use	Total Acres	% Riparian Area
	Single Family, Less than 8,000 sq. ft.	0.22	0%
	Transportation/Utility/Communication	1.00	2%
	Vacant	13.07	23%
	Water	6.39	11%
	(blank)	0.27	0%
Subbasin 13 Total		55.98	
Subbasin 14	Commercial/Office	23.84	7%
	Industrial	3.80	1%
	Multiple Family	6.83	2%
	Public/Institutional	92.00	26%
	Railroad ROW	14.67	4%
	Recreation/Conservation	65.86	18%
	Road ROW	31.05	9%
	Single Family, 14,000 to 43,559 sq. ft.	0.38	0%
	Single Family, 2.5 to 5 acres	0.21	0%
	Single Family, 8,000 to 13,999 sq. ft.	1.77	0%
	Single Family, Less than 8,000 sq. ft.	3.25	1%
	Transportation/Utility/Communication	14.16	4%
	Vacant	64.60	18%
	Water	37.25	10%
	(blank)	0.29	0%
Subbasin 14 Total		359.97	
Subbasin 15	Commercial/Office	63.84	8%
	Industrial	3.20	0%
	Mobile Home Park	0.01	0%
	Multiple Family	23.09	3%
	Public/Institutional	54.35	7%
	Recreation/Conservation	39.46	5%
	Road ROW	46.68	6%
	S.F. More than one unit per parcel	3.62	0%
	Single Family, 1 to 2.5 Acres	25.39	3%
	Single Family, 14,000 to 43,559 sq. ft.	86.31	11%
	Single Family, 2.5 to 5 acres	20.00	3%
	Single Family, 5 to 10 acres	17.31	2%
	Single Family, 8,000 to 13,999 sq. ft.	27.06	4%
	Single Family, Less than 8,000 sq. ft.	6.28	1%
	Transportation/Utility/Communication	3.72	0%
	Vacant	91.48	12%
	Water	243.03	32%
Subbasin 15 Total		754.83	
Subbasin 16	Commercial/Office	0.08	0%
	Mobile Home Park	2.09	1%

Subbasin	Land Use	Total Acres	% Riparian Area
	Recreation/Conservation	0.44	0%
	Road ROW	5.02	3%
	Single Family, 14,000 to 43,559 sq. ft.	5.88	4%
	Single Family, 8,000 to 13,999 sq. ft.	6.27	4%
	Single Family, Less than 8,000 sq. ft.	2.16	1%
	Vacant	2.13	1%
	Water	123.37	84%
	(blank)	0.14	0%
Subbasin 16 Total		147.57	
Grand Total		11262.34	