City of St. Joseph, Missouri

Facilities Plan

Technical Memorandum No. TM-CSO-6

Identification and Prioritization of Green Solutions Opportunities

By

BLACK & VEATCH
Building a **world** of difference.

Work Order No. 09-001
B&V Project 163509

September 2, 2009

Table of Contents

Tables

Appendices

Identification and Prioritization of Green Solutions Opportunities

1.0   Executive Summary

A ranked green infrastructure locator model was developed that considers a natural resources suitability index for stormwater Best Management Practices (BMPs) otherwise known as green solutions. Detailed urban hydrology, parcel data, and remote sensing data were utilized to identify and rank green solutions opportunities at a City-wide scale. One application of this model is to identify public and semi-public green solutions opportunities for further study and refinement that will assist the St. Joseph combined sewer overflow (CSO) program. The green solutions identification was also extended to the areas of the City served by the separate sanitary sewer system as this information can be useful for future planning and utilized as part of a holistic stormwater management effort. Public and semi-public green solutions opportunities include City-owned and semi-public owned schools, golf courses (public and private), parks, cemeteries (public and private), and boulevards with available open space and appropriate drainage and environmental characteristics to retain/detain stormwater runoff prior to entering the sewer system. The identified open space locations suitable for these purposes could be retrofitted with a number of green solution technologies which may:

1. Provide a factor of safety for the CSO Long Term Control Plan,

2. Mitigate hard infrastructure facilities and/or reduce hard infrastructure facility costs, and/or

3. Improve water quality.

In addition to the benefits mentioned above, implementation of the green solutions can create neighborhood amenities and enhance wildlife habitat and will serve to improve public awareness and learning opportunities of CSO control technologies.

The modeling process identified 366 City-owned and semi-public sites totaling 3,846 acres that could be considered for public green infrastructure within the combined sewer system (CSS) and separate sanitary sewer areas. The identified City-owned and semi-public sites range in size from less than 1 acre to 156 acres. Locations of the green

solution opportunities are displayed on Plates 5, 6, and 7 which are included in Appendix B. In addition, the ranked green infrastructure locator and BMP suitability index results presented herein may be useful for future stormwater, transportation, parks and recreation, planning, and development projects that are not directly associated with the CSO program.

2.0   Purpose of Technical Memorandum

The purpose of this technical memorandum (TM) is to:

- Document the green solutions modeling (i.e., identification) process.

- Present green solutions opportunities for public, semi-public, vacant, and right-of-way areas.

- Set the stage for an upcoming technical memorandum that will discuss specific green solution concepts, costs, and design criteria that could be used at the various suitable locations identified herein.

3.0   Introduction

A ranked green infrastructure locator model was developed that considers a natural resources suitability index for stormwater BMPs otherwise known as green solutions. Detailed urban hydrology, parcel data, and remote sensing data were utilized to identify and rank green solutions opportunities at a City-wide scale. One application of this model is to identify public and semi-public green solutions opportunities for further study and refinement that will assist the St. Joseph CSO program. The green solutions identification was also extended to the areas of the City served by the separate sanitary sewer system as this information can be useful for future planning and utilized as part of a holistic stormwater management effort. Public and semi-public green solutions opportunities include City-owned and semi-public owned schools, golf courses (public and private), parks, cemeteries (public and private), and boulevards with available open space and appropriate drainage and environmental characteristics to retain/detain stormwater runoff prior to entering the sewer system. The identified open space locations suitable for these purposes could be retrofitted with a number of green solutions technologies which may:

1.   Provide a factor of safety for the CSO Long Term Control Plan,

2.   Mitigate hard infrastructure facilities and/or reduce hard infrastructure facility costs, and/or

3.   Improve water quality.

In addition to the benefits mentioned above, implementation of the green solutions can create neighborhood amenities and enhance wildlife habitat and will serve to improve public awareness and learning opportunities of CSO control technologies.

The following sections briefly describe the green solutions locator and prioritization process as well as the results of the modeling efforts. The description of the process, site selection criteria, and assumptions will help the City in future work efforts to evaluate the specific feasibility of the identified opportunities. Additional supporting maps/plates are included in Appendix B.

4.0   Tasks and Results

The green solutions modeling process used a raster-based analysis to classify natural resources and identify green solutions opportunities and constraints.   The rasterization process converts spatial data into pixels rather than polygons or linear features as performed with vector analyses. Raster analyses are more appropriate for the green solutions modeling process because much of the base information (such as the digital elevation model and aerial imagery data described in later sections of this TM) is already in raster format. In addition, raster data can be more easily composited and incorporated into statistical models to generate useful outputs. All raster output from the modeling work summarized herein, with the exception of the Landsat data, is provided in 5 foot resolution. The Landsat data is provided at 1 acre resolution (30 meters (m)).

Figure 1 included in Appendix A provides a graphical representation of the ranked green infrastructure locator model used for St. Joseph. The following sections describe each task and the results of those tasks in greater detail.

4.1   Task 1 – Composite Digital Elevation Model

The modeling team first built a 5 foot grid cell digital elevation model (DEM) for the entire city of St. Joseph from 2 foot contours provided by the City and from the United States Geological Survey (USGS). Three datasets were used to create the DEM, being ranked with priority in the modeling as follows: 1) 2003 2 foot contours, 2) 1996 2 foot contours, and 3) 2008 30 meter USGS DEM. The composite DEM was the basis for subsequent evaluation of urban hydrology and catchments, slopes, hillshade, and existing depressional storage areas. The DEM indicates a range in elevation from 979 to 1,151 feet within the study area. Slopes ranged from 0 to 47 percent, with the most relief located in western St. Joseph along the Missouri River bluffs and along the east-west oriented alluvial valleys. Once out of the Missouri River flood plain and the steep east west valleys of the local tributaries flowing to the Missouri River, much of St. Joseph is composed of moderately rolling hills within the glaciated till plain physiographic province. The study area is urbanized in the flood plain and alluvial valleys, and much of the terrain indicates the pattern of a grid-based city. Plate 1, located in Appendix B, displays the DEM of St. Joseph, Missouri.

4.2   Task 2 – Landsat Cover Classification

In lieu of local natural resources mapping, the modeling team used 2 meter surface cover analysis based on the United States Department of Agriculture (USDA) National Aerial Imagery Program (NAIP). Multispec image processing software (Biehl, 2006; Purdue Research Foundation, 2006) and ArcGIS were used to classify the cover types. The NAIP imagery was classified to identify interior forest, closed canopy, open canopy/grass, grass/open field, open field/agriculture, dirt/roof, and roof/paved. The cover types were classified within Multispec utilizing statistical breakpoints of the 2008 NAIP 2 meter Red (R), Green (G), and Blue (B) spectrum composite image. Computer delineated classifications were field verified on two field visits applying a random sampling technique (Brown, June and July 2009).

Plate 2, located in Appendix B, displays the results of the St. Joseph Surface Cover Analysis. The output was used in Tasks 3 and 4 discussed in the following sections. In addition, the cover classification may be useful for planning-level activities

such as City-wide comprehensive planning, natural resource assessments, City-wide engineering tasks (impervious surface estimates), and transportation and infrastructure corridor studies.

4.3   Task 3 – BMP Suitability Index

Next, the modeling team developed a BMP suitability index using available natural resources data and the surface cover analysis. The modeling team used GIS data collected from USGS; the Missouri Spatial Data Information Service (MSDIS); the Missouri Department of Natural Resources (MDNR); the City of St. Joseph, Missouri; and the United States Fish & Wildlife Service (USF&WS) to map and identify natural resources, physiography, and cover type such as urban streams, wetlands, vegetative cover types, flood plains and valleys with alluvial soils, imperious surface, and geology. The natural resources were ranked for their suitability for stormwater BMP installations. The modeling process and weighting factors are illustrated in Figure 2, located in Appendix A.

Factor and weight are two variables in the BMP suitability index that control the overall suitability of a natural resource layer. Factor is a value of 100, 200, or 300 that represents the quality of individual resources. For example, in the vegetation layer low quality woodland would be assigned a factor of 100, medium quality woodlands receive a factor of 200, and high quality woodlands would be assigned a factor of 300. Factors can be further subdivided if more categories are needed (i.e., 100, 150, 200, etc.).

The weight variable is an assigned multiplier that is used to rank resources against each other such as the overall importance of soil characteristics versus vegetation or hydrology characteristics. For example, a site with alluvial soils would make a better BMP than one with steep slopes, therefore the characteristic of "alluvial soil" has a higher weighted value than "slope". The weight value is determined using past experience of the modeling team and consultation with the client based upon their needs for the analysis.

Factor and weight are multiplied and the product is taken to derive a BMP suitability value for each raster (McHarg, 1992; Hopkins, 1977; Steiner, 2000; Steinitz, 1968). The modeling team further refined the inputs and weighting factors based on

experience and after reviewing preliminary modeling results for sensitivity and overall clarity. Plate 3, located in Appendix B, displays the results of the BMP suitability index.

Areas identified with high quality natural resources, such as mature forest or wetlands, may be better candidates for non-structural BMPs such as preservation or protection rather than engineered, structural BMPs (Dunne and Leopold, 1978; Forman, 1986 and 1995). These sensitive resources therefore have a lower factor and weight in the BMP suitability index as they are less suitable for a structural BMP retrofit, which was the focus of this evaluation. However, it may be acceptable to replace lower quality or immature vegetation with a structural BMP. Wetlands and Federal Emergency Management Agency (FEMA) 100 year (1 percent) flood plain should also not be used for structural BMPs for both regulatory and practical reasons and were removed from consideration in the BMP suitability index. Streams without mapped FEMA flood plains may be subject to similar practical limitations (i.e. frequent inundation), but do not have the same regulatory protections. These areas may be suitable for some BMPs such as filter strips or infiltration practices and were therefore given a high factor and weighting. However, it may be preferable to set these resources aside in a stream buffer for non-structural BMP preservation. Non-structural BMPs include stream or wetland buffers, permanent open space protection, and habitat restoration, and could be implemented in conjunction with conservation development or other low-impact development approaches.

4.4   Task 4 – Urban Drainage Analysis

The modeling team developed an urban hydrology and parcel analysis to identify parcels that currently intercept and/or are adjacent to detailed overland flow paths. The ArcGIS ARChydro extension was applied to the composite 2 meter DEM to create a detailed flow line network, which was overlaid on the City's parcel mapping to identify properties that intersect or are adjacent to surface flow lines. A 15 foot buffer was applied to the flow line to identify adjacent rights-of-way or roadways that could be used to capture runoff along a flow line. Parcels that intersect the surface flow lines were extracted for further consideration under Task 5. Plate 4, located in Appendix B, displays the results of the urban drainage analysis (UDA).

4.5 Task 5 – Ranked Green Infrastructure Analysis

To complete the modeling effort, the value of the BMP suitability index was joined to the unfiltered parcels intersecting the UDA to create a ranked green infrastructure analysis. Parcels were then screened to develop results based on several tiers of ownership, including Tier 1 – City-owned and semi-public (Plate 5), Tier 2 – Vacant (Plate 6), and Tier 3 – Boulevards/Rights-of-way (Plate 7). Table 1 indicates the City land use types within each tier. Plates 5, 6, and 7 are located in Appendix B.

The St. Joseph BMP locator identified 366 parcels totaling 3,846 acres within Tier 1, 1,525 parcels totaling 3,822 acres within Tier 2, and 16 parcels totaling 300 acres within Tier 3. Table 2 presents the quantitative results from the BMP locator by number of identified parcels, total acres, and size.

Table 1
Parcel Selection Criteria Tier Breakdown by City Land Use Code

Tier 1 – City-Owned and Semi-Public	Tier 2 – Vacant	Tier 3 – Boulevard and Highway Right-of-Way
229 - Schools	110 - Vacant Residential	900 - Boulevard
551 - City-Owned	220 - Vacant Commercial	901 - Highway Right-of-Way
555 - School-Owned	270 - Vacant in a TIF	
910 - Parks/Parkway	440 - Vacant Agricultural	
920 - Public	550 - Vacant Tax Exempt	
930 - Quasi-Public	570 - Vacant in a TIF and Tax Exempt	

Table 2
Summary of Green Solutions Opportunities

Screening Criteria	No. of Properties Identified	Total Acres	No. of Properties Identified by Size		
			Less than 1 Acre	Between 1 and 10 Acres	Greater than 10 Acres
Tier 1	366	3,846	132	149	85
Tier 2	1,525	3,822	1,118	327	80
Tier 3	16	300	4	6	6
Total	1,907	7,968	1,254	482	171

5.0 Summary and Conclusions

The information presented in Plates 5, 6, and 7 can be used to identify locations for demonstration projects, future City acquisition and creation of public green solutions,

opportunities for private green solutions, prioritization of tax increment financing (TIF) projects, neighborhood redevelopment, corridor and streetscape redevelopment, trails and parks master planning, area plans, or redistribution of land-use and zoning categories. The information presented in this technical memorandum will be reviewed by the City and upon review, a selection of Tier 1, 2, and 3 sites will be identified to develop more specific and detailed green solutions concepts that will be discussed in TM-CSO-7 – Green Solutions Evaluation and Recommendations.

6.0   Deliverables

The modeling team developed the following deliverables as a result of the evaluation required for this TM:

1.   This TM documenting the modeling process and results.

2.   A hard copy map of the environmental sensitivity analysis results and a high resolution PDF.

3.   Hard copy maps of public green solutions opportunities in the CSO study area and high resolution PDFs.

4.   GIS data of all data layers and results from this evaluation.

7.0   References

1.   Biehl, Larry. 2006. "Multispec Image Classification Exercises 1-6." Purdue Research Foundation. October 15, 2006. Online Address: http://cobweb.ecn.purdue.edu/~biehl/MultiSpec/tutorials/MultiSpec_Exercise_4.pdf.

2.   Brown, Laurie. Field visits to St. Joseph. June and July 2009.

3.   Dunne, Thomas, Leopold, Luna G. 1978. *Water in Environmental Planning.* W. H. Freemand and Company, New York.

4.   Forman, Richard T.T. 1995. Land Mosaics, *The Ecology of Landscapes and Regions.* Cambridge University Press, UK.

5.   Forman, Richard T.T, Godron, Michel. 1986. *Landscape Ecology.* John Wiley and Sons, New York.

6. Hopkins, Lewis D. 1977. "Methods for Generating Land Suitability Maps: A Comparative Evaluation". AIP Journal.

7. McHarg, Ian. 1992 reissue. *Design With Nature.* John Wiley and Sons, Jr, New York.

8. Purdue Research Foundation. 1994-2008. *Multispec: A Freeware Multispectral Image Data Analysis System, Version 5.3.01.* http://cobweb.ecn.purdue.edu/~biehl/MultiSpec/.

9. Steiner, Frederick. 2000. *The Living Landscape.* McGraw-Hill, Inc, New York, NY.

10. Steinitz, Carl. 1968. *A Systems Analysis Model of Urbanization and Change; An Experiment in Interdisciplinary Education.* Harvard Graduate School of Design, Boston, Massachusetts.

Appendix A

Figures
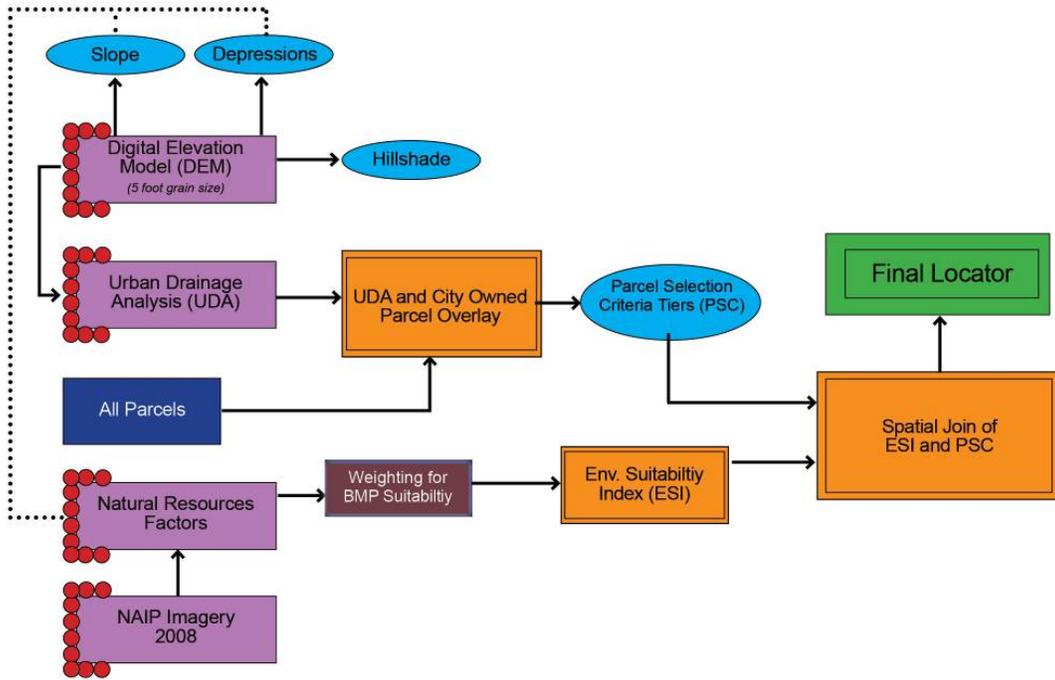
Figure 1 – Green Solutions Model Overview

St. Joseph Environmental Suitability Index (ESI) - Weighted for BMPs

FACTOR **WEIGHTING**

STREAMS
200 - 3rd Order (~20 Ac. Trib)
167 - 4th Order
134 - 5th Order
101 - 6th Order
68 - 7th Order
35 - 8th Order (Missouri Riv)

(6)

Hydric Soils
200 - B
150 - B/D
100 - C
50 - C/D
25 - D

(2)

DEPRESSIONS
200 - Present
1 - Not Present

(5)

WETLANDS
200 - Water Body
100 - 100-Foot Buffer
1 - Not Present

(5)

SLOPE
200 - Less Than 3%
150 - 3-8.33%
50 - 8.33-15%
1 - 15%+

(3)

SURFACE COVER
200 - Grass/Open
150 - Open Field
100 - Ag. Open
1 - Paved
-100 - Forest/Forest Edge

(8)

GEOLOGY
200 - Glacial Drift (report)
100 - Alluvium
1 - Not Present

(4)

Wells
-100 - 200-Foot Buffer
1 - Not Present

(4)

Weighted Overlay → FINAL EVI

Figure 2 – BMP Suitability Index

Appendix B

Plates

Plate 1 – Digital Elevation Model (DEM)
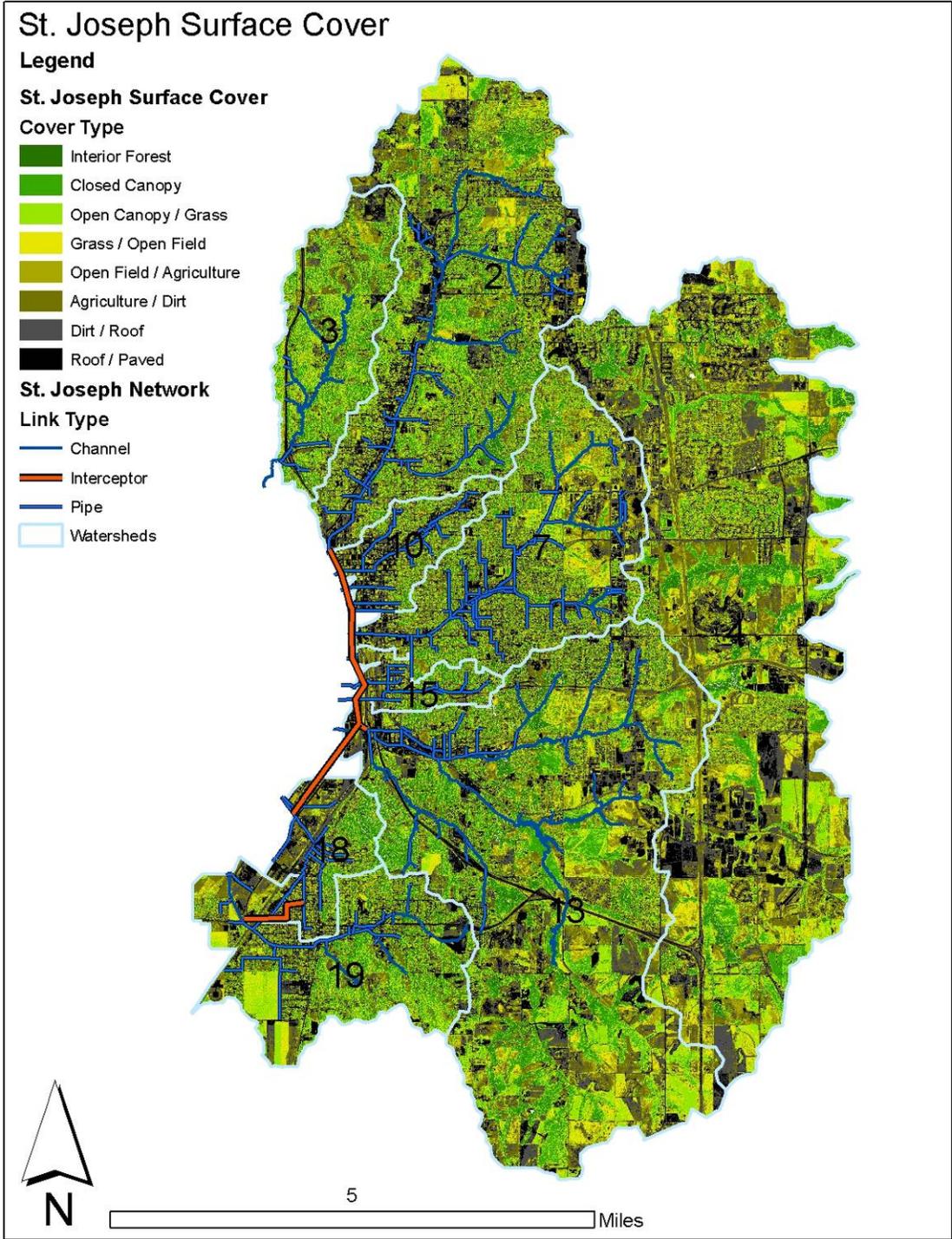
Plate 2 – Surface Cover Analysis

St. Joseph BMP Suitability Index

Legend

BMP Suitability Index
Suitability for BMP

Highly Suitable: 77

Not Ideal: 6

St. Joseph Network
Link Type

— Channel
— Interceptor
— Pipe
☐ Watersheds

3 Miles
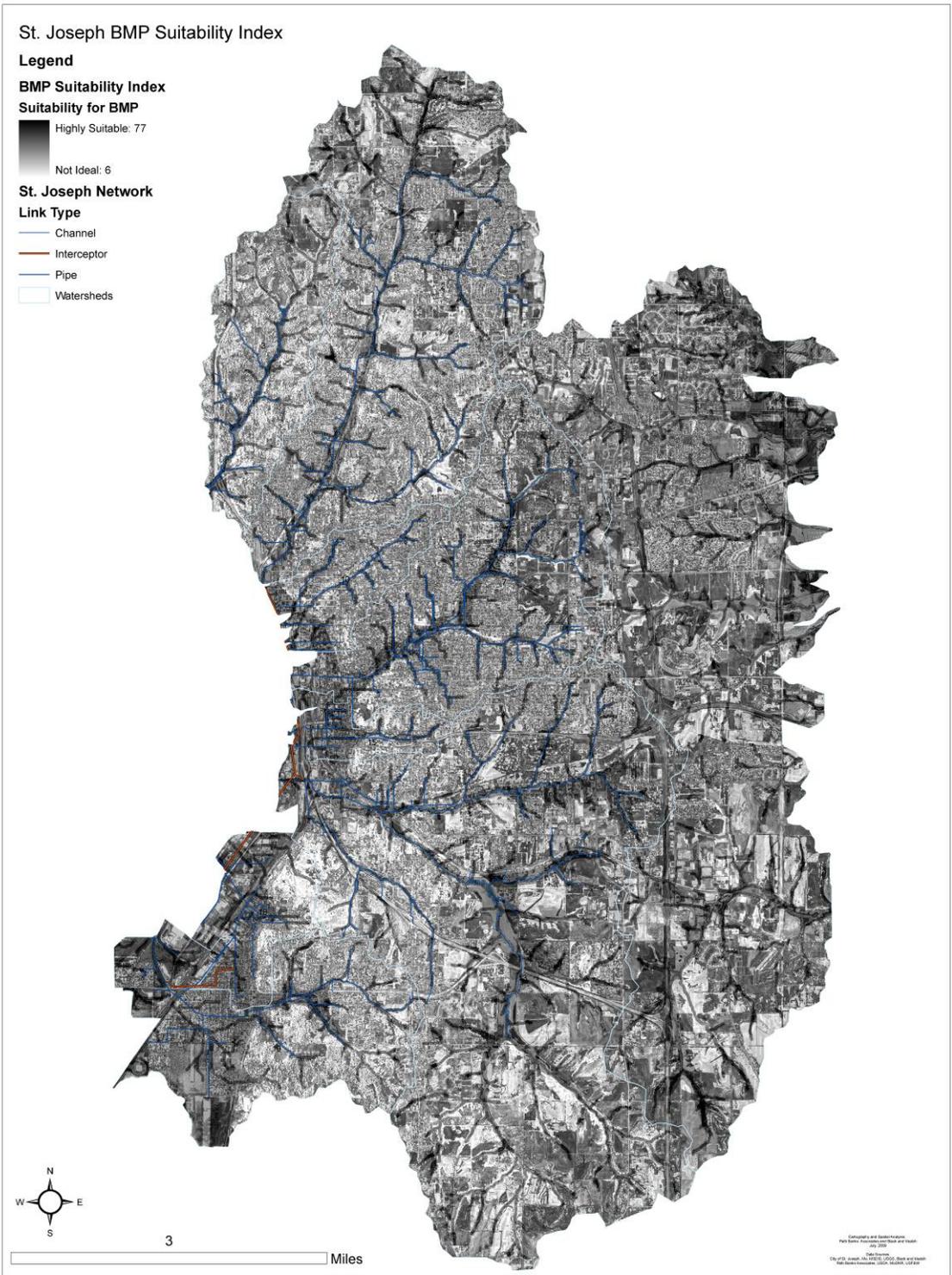
Plate 3 – BMP Suitability Index

St. Joseph Urban Drainage Analysis

Legend

Urban Drainage Analysis

LAND_USE
- 110 - Vacant Residential
- 220 - Vacant Commercial
- 229 - Schools
- 270 - TIF Vacant
- 440 - Vacant Ag
- 550 - Vacant Tax Exempt
- 551 - City Owned
- 554 - Church Owned
- 555 - School Owned
- 558 - Cemetery
- 559 - Private Common Area
- 570 - TIF Vacant Exempt
- 900 - Boulevard
- 910 - Parks/Pkwy
- 920 - Public
- 930 - Quasi Public

St. Joseph Network

Link Type
- Channel
- Interceptor
- Pipe
- Watersheds
- Detailed Hydrology from 5-Foot DEM

Composite 5-Foot DEM
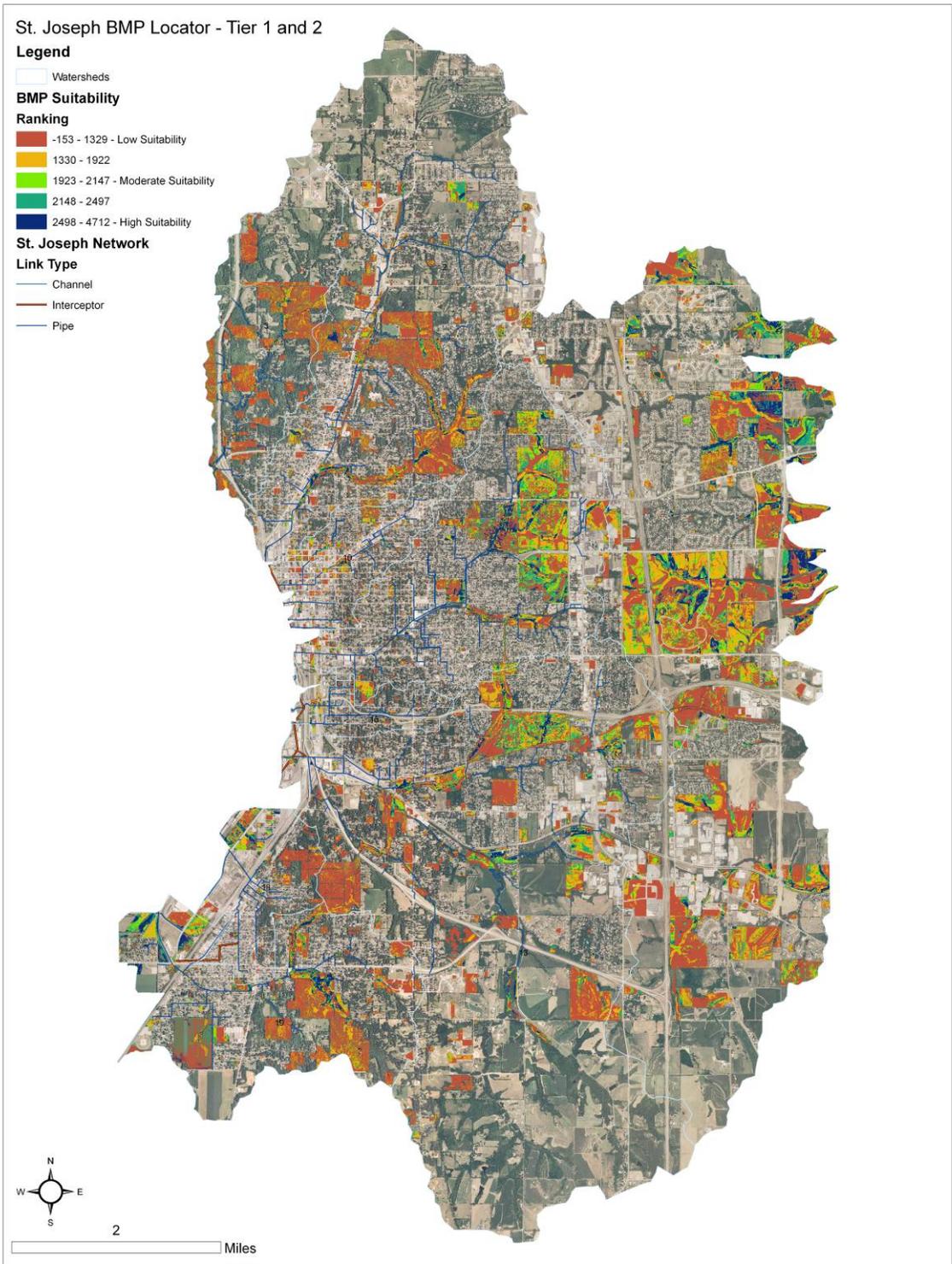
Value in Feet
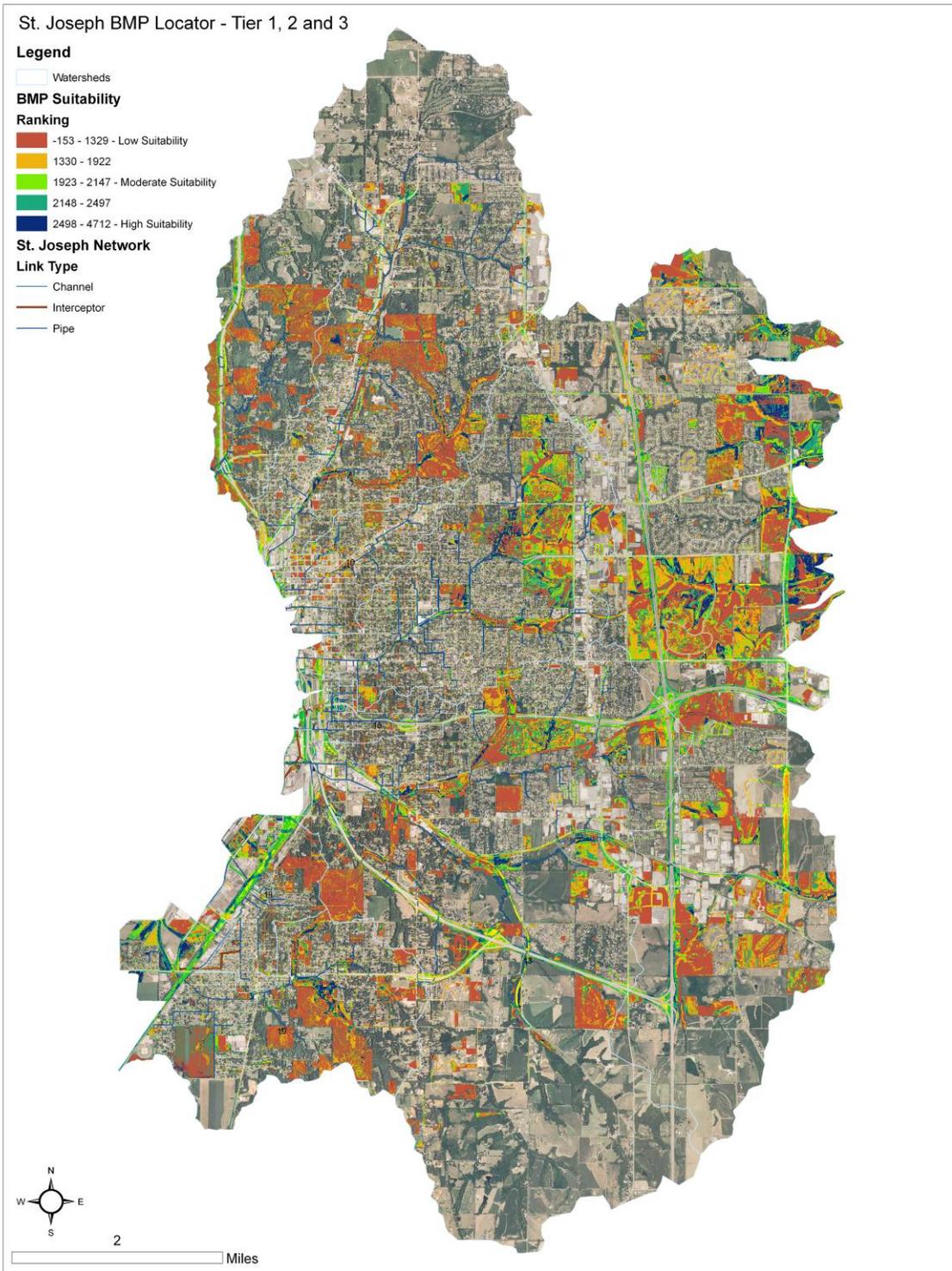- High : 1151
- Low : 797
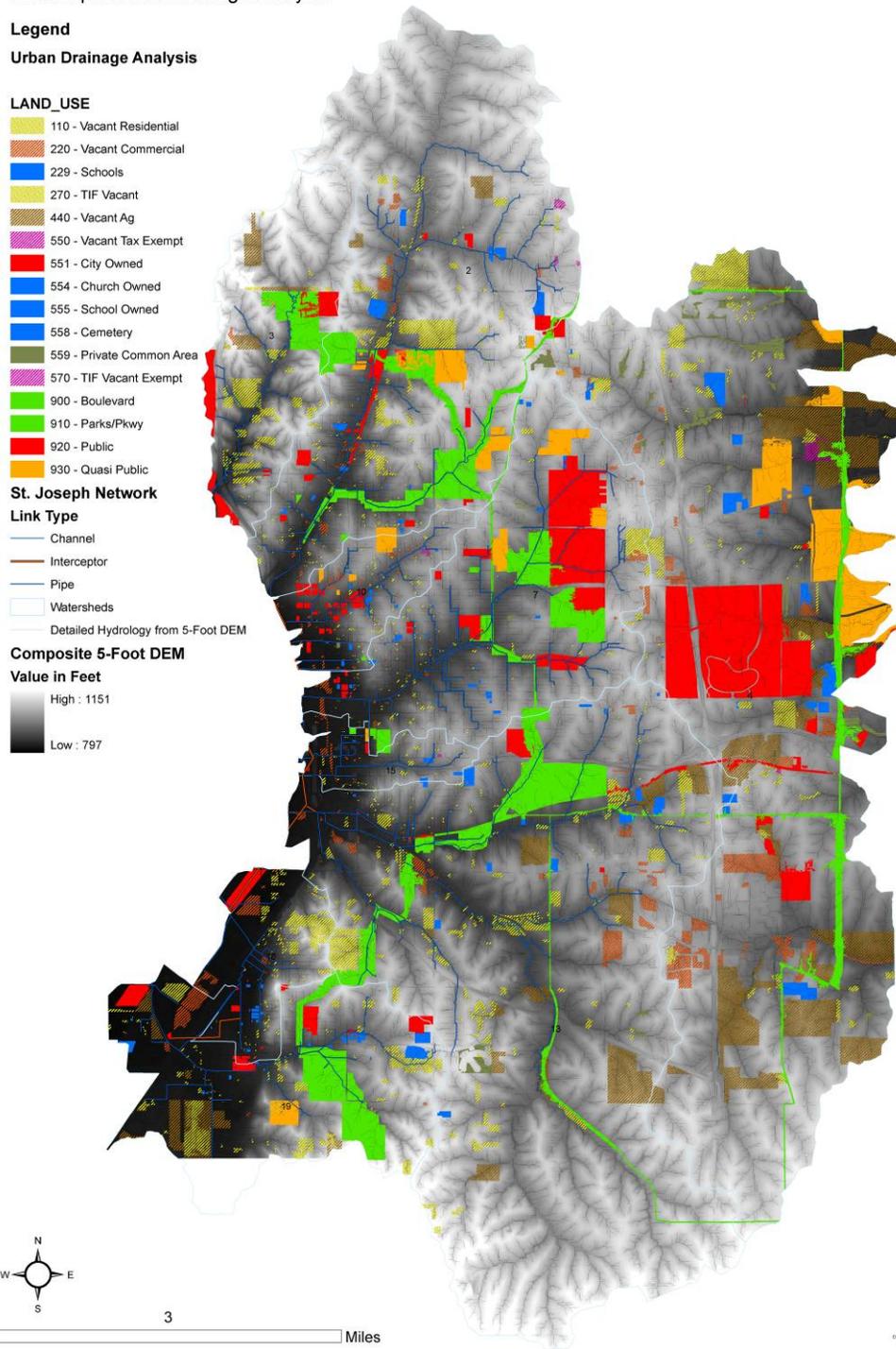
Plate 4 – Urban Drainage Analysis
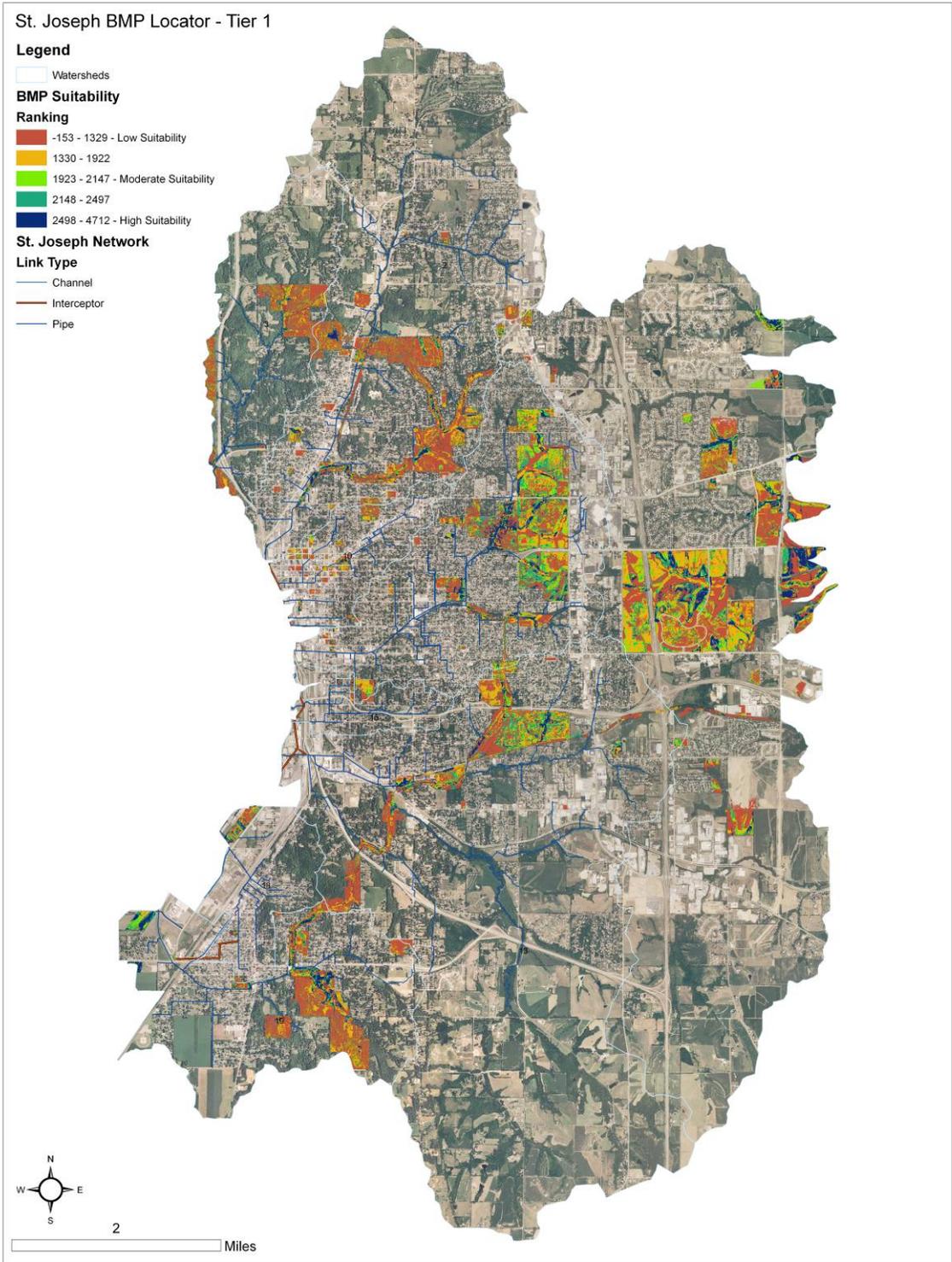
Plate 5 – Tier 1 BMP Locator
(City-Owned, Semi-Public)

Plate 6 – Tier 1 and Tier 2 BMP Locator

(City-Owned, Semi-Public, and Vacant Open Spaces)

Plate 7 – Tier 1, Tier 2, and Tier 3 BMP Locator

(City-Owned, Semi-Public, Vacant Open Spaces, Boulevards, and Rights-of-Way)