BROWN CREEK EROSION POTENTIAL ANALYSIS

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Introduction

This document summarizes the digital analysis methods and procedures for identifying locations on the landscape that predict erosion potential. The main goal of the analysis is to identify potentially sensitive sites to target and focus Best Management Practices (BMPs) and ecological land stewardship. This analysis does not eliminate the need for field assessments; however, it can reduce the amount of time spent in the field and increase efficiency to prioritize critical source areas.

Overview

The procedure requires the use of ESRI's ArcGIS (v10.7.1) computer software with the Spatial Analysis extension installed. The input Digital Elevation Model (DEM) used for the analysis is an output of the 0.5m resolution OMAFRA LiDAR Digital Terrain Model (DTM) from the period of 2016-2018. The terrain analysis process involves combining primary terrain sources to form secondary terrain products. The primary terrain analysis tools used in ArcGIS were executed, to generate indicative values of high erosion potential. The tools used for analysis included Flow Direction, Flow Accumulation, and the Slope tool. These tools were used to compute two derivative indices to identify areas with potential high erosion: Stream Power Index (SPI) and Topographic Wetness Index (TWI).

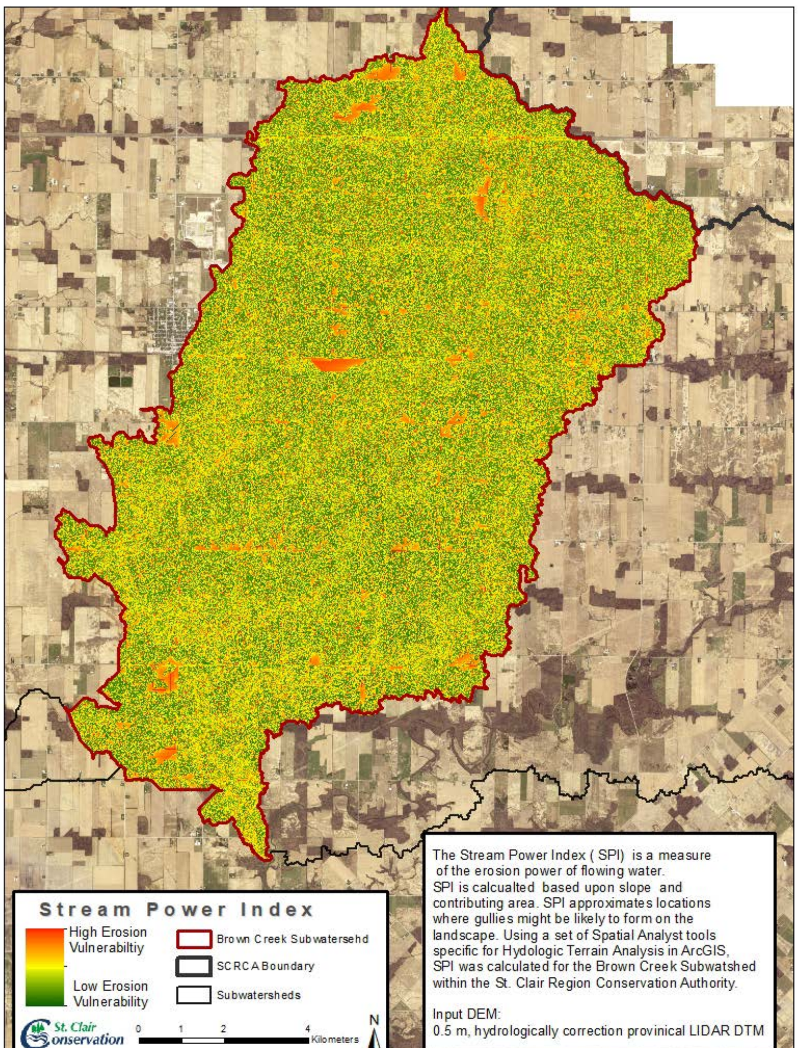


Figure 1: Stream Power Index results for Brown Creek subwatershed

High SPI values represent areas on the landscape where flow can concentrate with erosive potential. When the proper thresholds have been established, SPI can be used to locate and prioritize sites prone to gully formation. For this reason, SPI is very useful for determining locations to target Best Management Practices (BMP) and implementation planning.

TWI was also calculated. It is also known as the Compound Topographic Index (CTI) is the quotient of both slope and flow accumulation. This calculation will show areas on a landscape which are prone to ponding and holding water. The TWI can be used to predict the location of wetness-saturated surface areas and wetlands.

STUDY AREA

The study area for this project is the Brown Creek Subwatershed, one of the 14 subwatersheds within the St. Clair Region Watershed. Past GIS analysis in Brown Creek involved identifying areas deficient in Riparian Vegetation. Combining the results of both these studies will be an asset for identifying priority stewardship project areas.

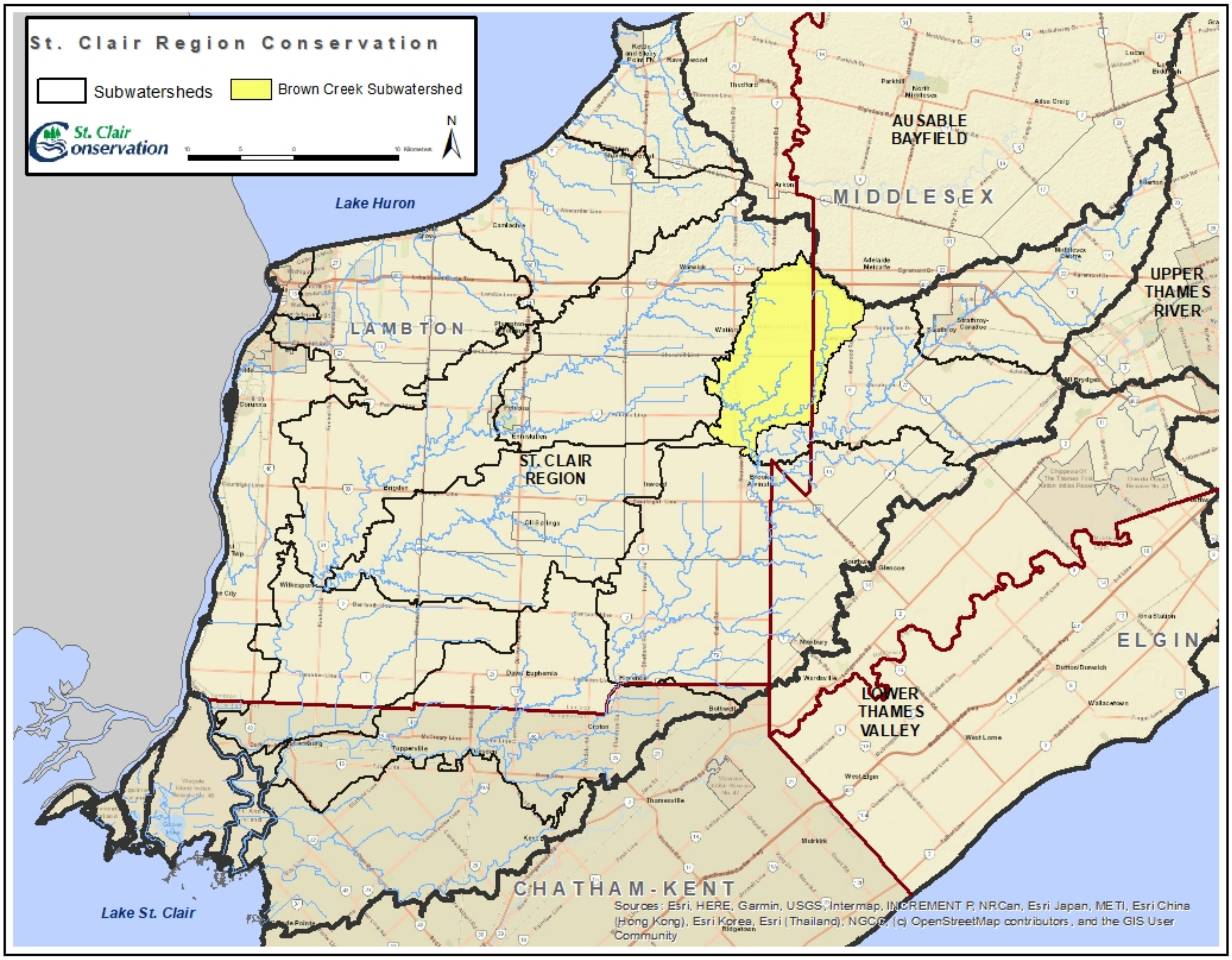


Figure 1: SCRCA Watershed Boundary with Brown Creek Study Area

ARCGIS ANALYSIS METHODS

DATA ACQUISITION

The Provincial LiDAR-derived Digital Elevation Model (DEM) was used as the base terrain for the analysis. The LiDAR DEM is a high-resolution spatial image which contains highly accurate elevation characteristics. It is open data, available for download at the link below:
https://geohub.lio.gov.on.ca/

SURFACE WATERCOURSES

The SCRCA has updated the surface watercourse data to the 2015 orthoimagery. Watercourse data is necessary to determine hydrological connections when creating a hydrologically conditioned DEM.

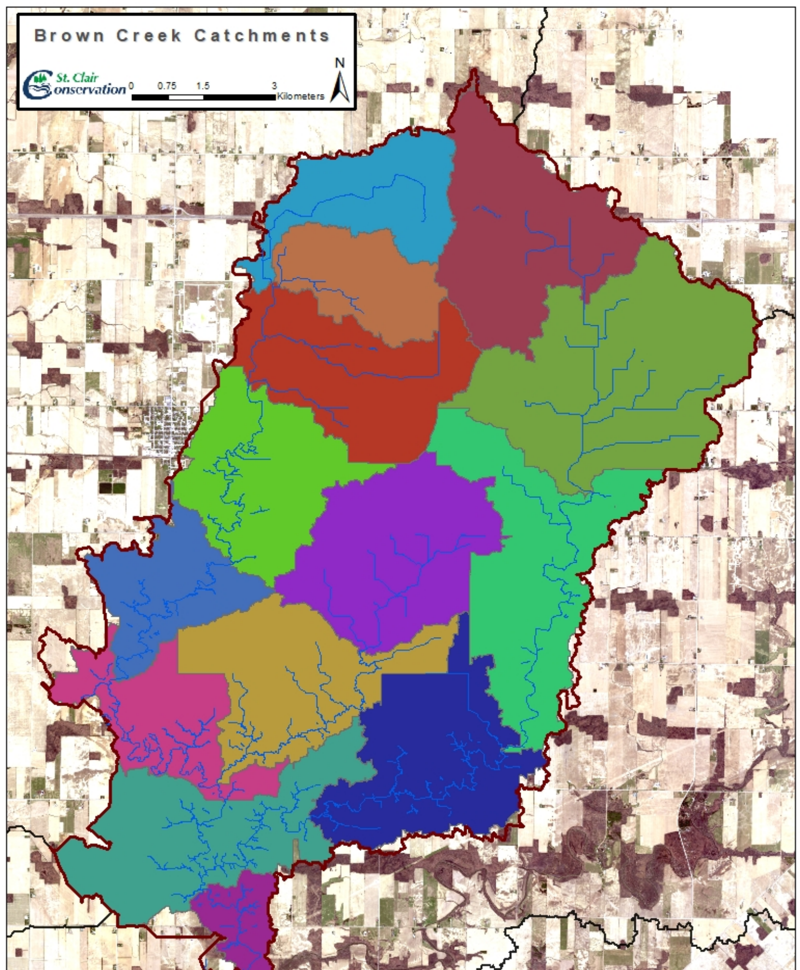


Figure 2: Brown Creek Catchment Areas

WATERSHED CATCHMENTS

Fourteen catchment areas were created within the Brown Creek Subwatershed. The watershed catchments are convenient for use as an extent when creating mapping products, as the extents allow management of file size by clipping raster datasets.

AERIAL PHOTOGRAPHY

The SCRCA is using the most recent aerial photography, obtained from the 2015 Southwestern Ontario Ortho-Photograph (SWOOP). This aerial photography is required for hydro-conditioning the DEM, as well as evaluating the final product outputs: Stream Power Index (SPI) and Total Wetness Index (TWI).

PRE-PROCESSING THE DEM

Hydrological Conditioning is the process of modifying a DEM to correct flow routing and drainage. **Two** methods of Hydro Conditioning were used:

1. Pit Filling: the process of filling all the sinks in the DEM, that would otherwise fill with hypothetical water, and to force flow in a downstream direction. For this study, pit filling raises the elevation of pits to the point where they overflow and "force" the flow downstream. Pit filling is about improving flow direction by removing erroneous or anomalous cells which form depressions. This process provides an improved terrain analysis, as it creates a more accurate flow.

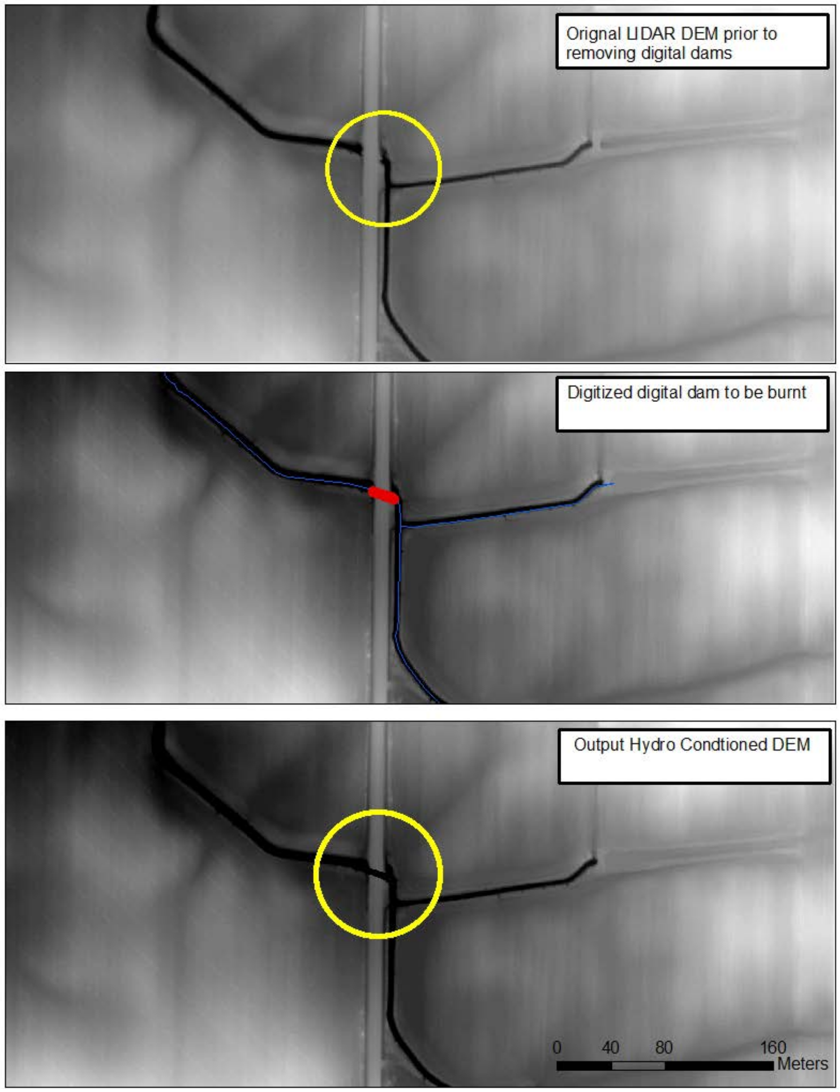


Figure 4 : Hydro Conditioning and Digital Dam Removal

2. Digital Dams: the practice of removing "digital dams" (i.e., bridges, roads, and culverts which interrupt the flow of water, is the second technique used to Hydrologically condition the DEM. The process modifies the elevation of these artificial impediments to simulate how man – made drainage structures such as culverts or bridges allow continuous downslope flow. The method of removing digital dams is to "burn" or lower the obstruction so the DEM represents the actual flow downstream.

Ideally all DEM's used for SPI creations should be hydrologically conditioned. Using both these processes combined creates a more accurate terrain analysis and generates a better representation of the SPI signatures.

ARCGIS TERRAIN ANALYSIS

The pre-processed Hydrologically Conditioned DEM was used to develop several intermediate raster datasets. These include Flow Direction, Flow Accumulation, and Slope**.** The Flow Direction grid is the simplest tool and represents the direction of hydrological flow over the terrain. This raster represents the direction of flow from each cell to its steepest downslope neighbor. The resulting Flow Direction raster was used as the input for the Flow Accumulation analysis.

Flow Accumulation calculates accumulated flow as cells flow downslope. Otherwise known as *contributing area*, this grid represents the cells' own contribution plus the contribution from all the upslope neighbors that drain into it.

Finally, slope is calculated using the maximum rate of change in elevation from one cell to its neighbors/calculated as a percent rise. Slope and Flow Accumulation are used directly in the calculation of SPI and TWI.

With the use of the raster calculator, SPI raster dataset was calculated with the following equation:

*SPI = LN (([FlowAccum_Raster] + 0.001) * (([Slope_Raster]/100) + 0.001))*

Also using the raster calculator, the TWI raster dataset was calculated as:

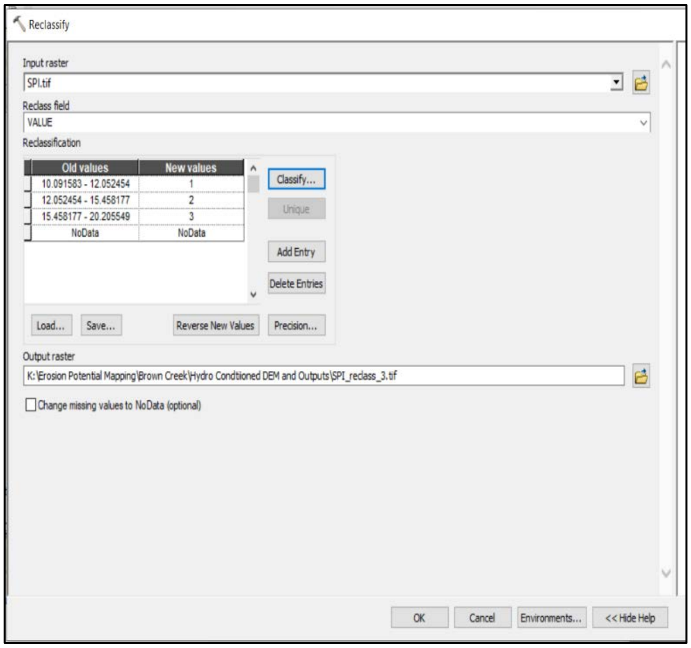
*LN (([FlowAccum_Raster] *900)/Tan ([Slope_Raster]))*

To make the results interpretable, it is necessary to normalize the SPI and TWI results. Normalizing and standardizing follows a process of scaling a set of values to a small, more interpretable range. In the case of the SPI and TWI, it is the highest range of values that indicate areas more likely (higher probability) to predict potential erosion.

The process of normalizing the data was accomplished through a combination of image interpretation using the 2015 SWOOP and comparing the histogram to the range of values. The SPI threshold was determined to begin at 10. SPI values at or above the 10-percentile threshold value display a close correlation to runoff areas observed on the imagery. The data was reclassified to a raster with all values over the threshold value of 10 into three classes according to the following:

SPI result values	Reclassified Raster value	Mapping Legend
10.09-12.05	1	Low Erosion Potential
12.05-15.46	2	Medium Erosion Potential
15.46-20.21	3	High Erosion Potential

Figure 5 -Reclassification of SPI results into 3 classes



SPI RECLASSIFICATION

Reclassification of the SPI results into three classes: ranging from low erosion potential, medium erosion potential and high erosion potential. These values create a mapping symbology which enhances the overall mapping visualization and highlight areas with the highest erosion potential.

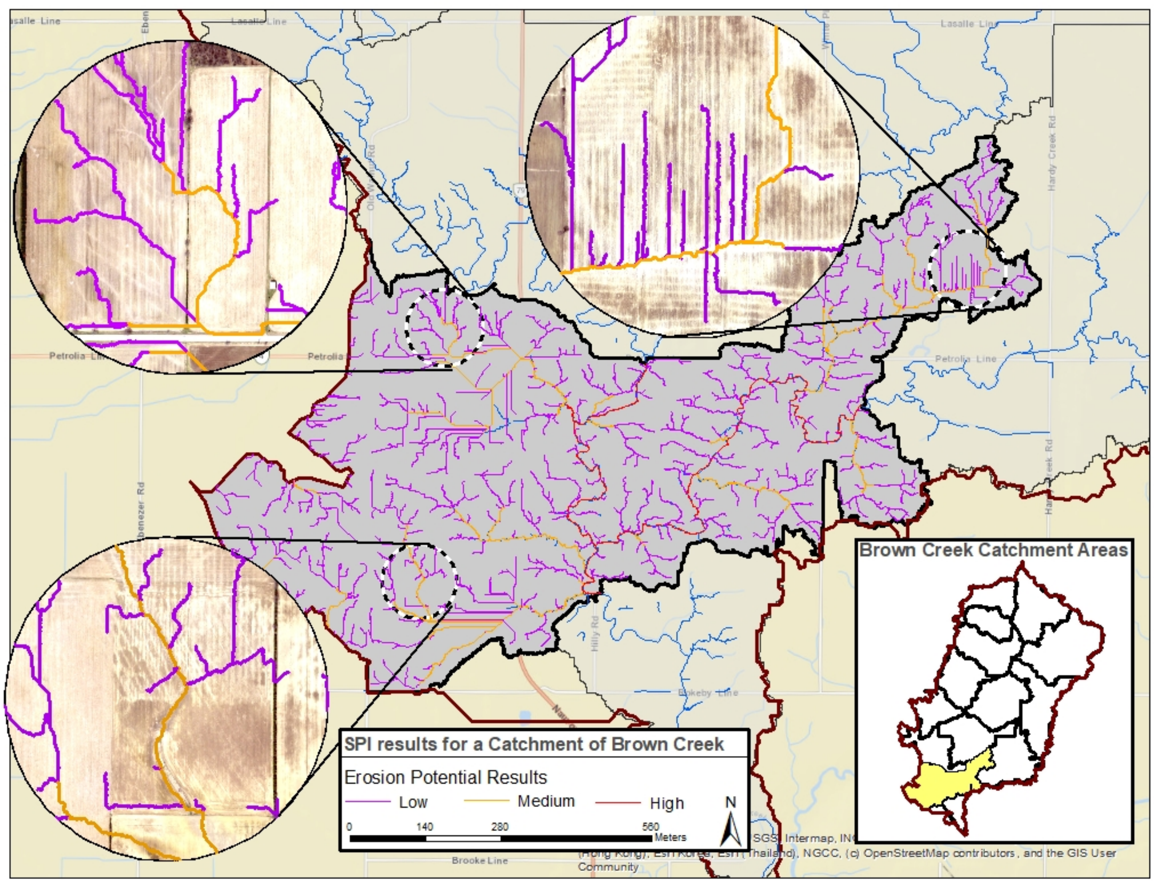


Figure 6: SPI Results reclassified to all values over 10 and three classes: low, medium, and high