ENHANCED SATELLITE IMAGERY OF BLUE-GREEN ALGAE BLOOMS IN THE LAKE OF THE WOODS

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PCI GEOMATICS

PURPOSE

Blue-green algae, also known as cyanobacteria, are microscopic organisms that occur naturally in shallow, slow moving and warm bodies of water. Populations of algae can grow rapidly to a large mass called a bloom that are harmful to humans and animals because they can produce cyanotoxins, a natural poison (Government of Canada, 2024). The purpose of this project is focus on refining a Landsat 8 satellite image to visualize blue-green algae blooms in Lake of the Woods following an outbreak. To achieve this, various image processing tools and techniques were applied in Catalyst Focus to create a visually distinct image that enabling easy identification of the bloom within the lake.

STUDY AREA

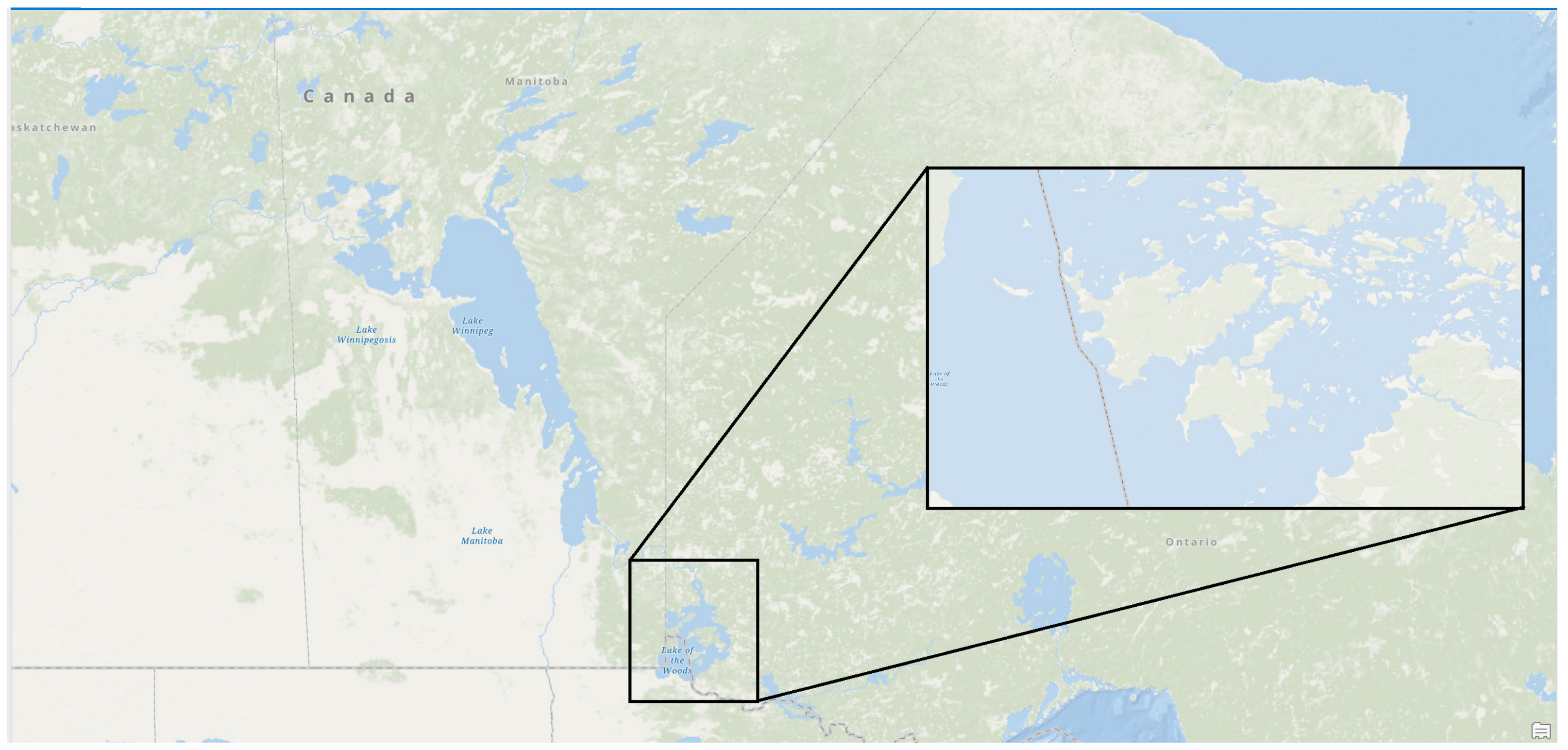

Figure 1. Map of Location and extent of Study Area

Lake of the Woods is a large, ecologically diverse lake located along the borders of Ontario, Manitoba and Minnesota. Covering an area of 4350 km^2, it drains into the Winnipeg River and has an extensive shoreline with over 14,000 islands (The Encyclopedia of Canada, 2014). In particular the extent of the study area was between 94° 58'21.73"W, 49°19'27.66"N and 94°11'01.44"W, 48°56'43.56" (Figure 1). The surrounding area includes multiple human settlements and First Nation reserves offering fishing and tourist opportunities. The lake's location makes it susceptible to environmental issues such as algae blooms. These blooms can significantly impact water quality, wildlife, and nearby communities.

PREPARATION

The analysis began by locating a suitable satellite image using the *United States Geological Survey (USGS) Earth Explorer Site*. A Landsat 8 image from the Level 1 Collection 2, capture on September 28, 2024, with a Cloud Cover parameter between 0% and 15% was selected and downloaded for its spatial resolution, which captured the detailed features of Lake of the Woods. The image was then imported into Catalyst Focus, where the clipping function was used to isolate a section that preserved the integrity of key features needed for analysis.

Figure 2. Standard Enhancement of 754 composite

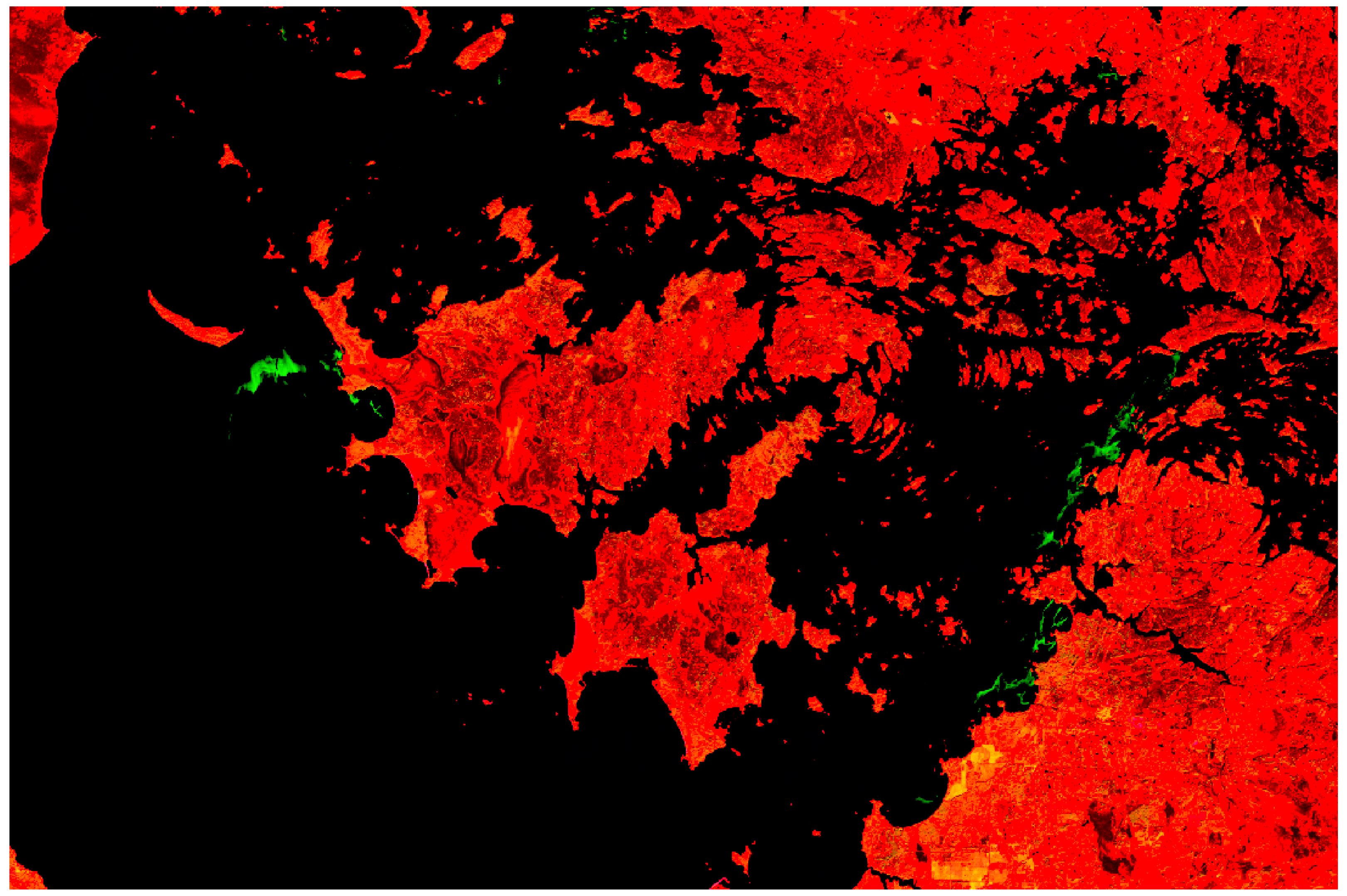

Figure 3. Custom Enhancement of 754 composite

SPECTRAL BANDS

Choice of Spectral Bands: The spectral bands selected for this project were short-wave infrared 2 **(SWIR2)**, near infrared **(NIR)** and Red because they effectively distinguish vegetation from water and sediment.

The combination was selected based on spectral plots (Figure 4) in natural color which showed that all features have similar reflectance in visible light however algae has a significant reflectance spike in the shortwave infrared, while sediment exhibits a decrease in reflectance at these wavelengths. Vegetation also exhibits a similar spike to algae.

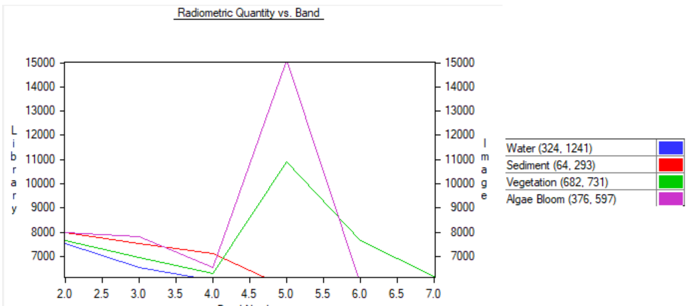

Figure 4. Spectral Plot of Various Features

ENHANCEMENT CHOICES

Standard Enhancement: An **adaptive** enhancement to the 7,5,4 composite band image was applied in order to better distinguish between the various features in the lake. In particular it combined the equalization and linear options for a more natural display while compensating for outliers (PCI Geomatics Enterprises, 2024). However the contrast between the features in the lake were were still limited hence the need for further enhancement.

Custom Enhancement: A bitmap layer covering some of the algae was added to the map in order to determined the appropriate range of digital number (DN) values to stretch for adjustment using a histogram (Figure 5). Using the bitmap as a mark the **SWIR-2** band was enhanced using a DN range between 5136 and 6319. Furthermore a **squared stretch** was apply to this band in order to enhance the extent of the shoreline and islands. Similarly, the **NIR** band in green was enhanced using a DN range between 11341 and 25532 and also applying a **root stretch** in order to brighten the algae spots more clearly against the darker features. Lastly the **red band** in blue was enhanced using a DN range between 6456 and 7081 and a **square stretch** was applied.This resulted in the water and all other features within, except for the algae, being masked.

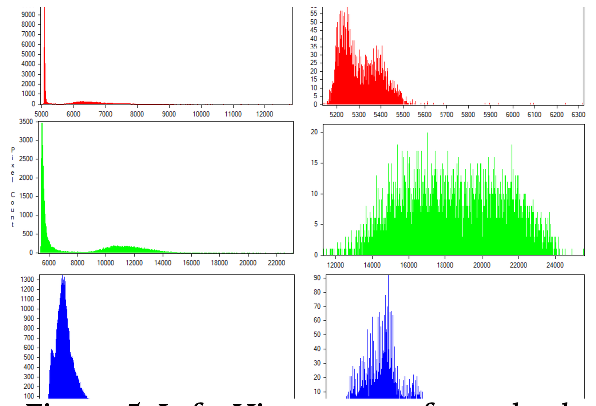

Figure 5. Left: Histograms of standard enhancement. Right: Histograms of custom enhancements.

DISCUSSION

In the standard enhancement (Figure 2), water appears black due to complete absorption across wavelengths, while sediment near the shoreline shows as a vibrant, darker blue, reflecting the impact of water on its brightness. Chlorophyll-rich organisms appear bright green allowing for easy differentiation between sediment and photosynthetic organisms in the lake.

In the custom enhancement (Figure 3), specific band combinations and a **root stretch** produce distinct colors. Water stays black with low reflectance, while algae blooms appear bright green due to strong infrared reflection, enhanced by compressed brightness range, bringing out detail in darker water. A bitmap layer further isolates algae, defining DN values for direct color adjustments. This technique emphasizes algae as green without affecting red-toned land vegetation, enhancing interpretability. Seasonal changes and spectral band selection may be necessary to differentiate vegetation from algae when reflectance values are similar, as these factors can affect reflectivity and clarity.

RESOURCES & DATA SOURCES

Government of Canada (2024, June 13). *Health*. Retrieved from https://www.canada.ca/en/health-canada/services/environment/recreational-water/cyanobacteria-toxins.html

The Canadian Encyclopedia (2014, October 28). *Lake of the Woods*. Retrieved from https://www.thecanadianencyclopedia.ca/en/article/lake-of-the-woods
Focus User Guide by 2024 PCI Geomatics Enterprises

Image source: United States Geological Survey Landset 8
Scene ID LC80290262024272LGN00
Path 029, Row 026 Data Acquired 2024-09-28
Projection: UTM 15, Datum: WGS84

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