

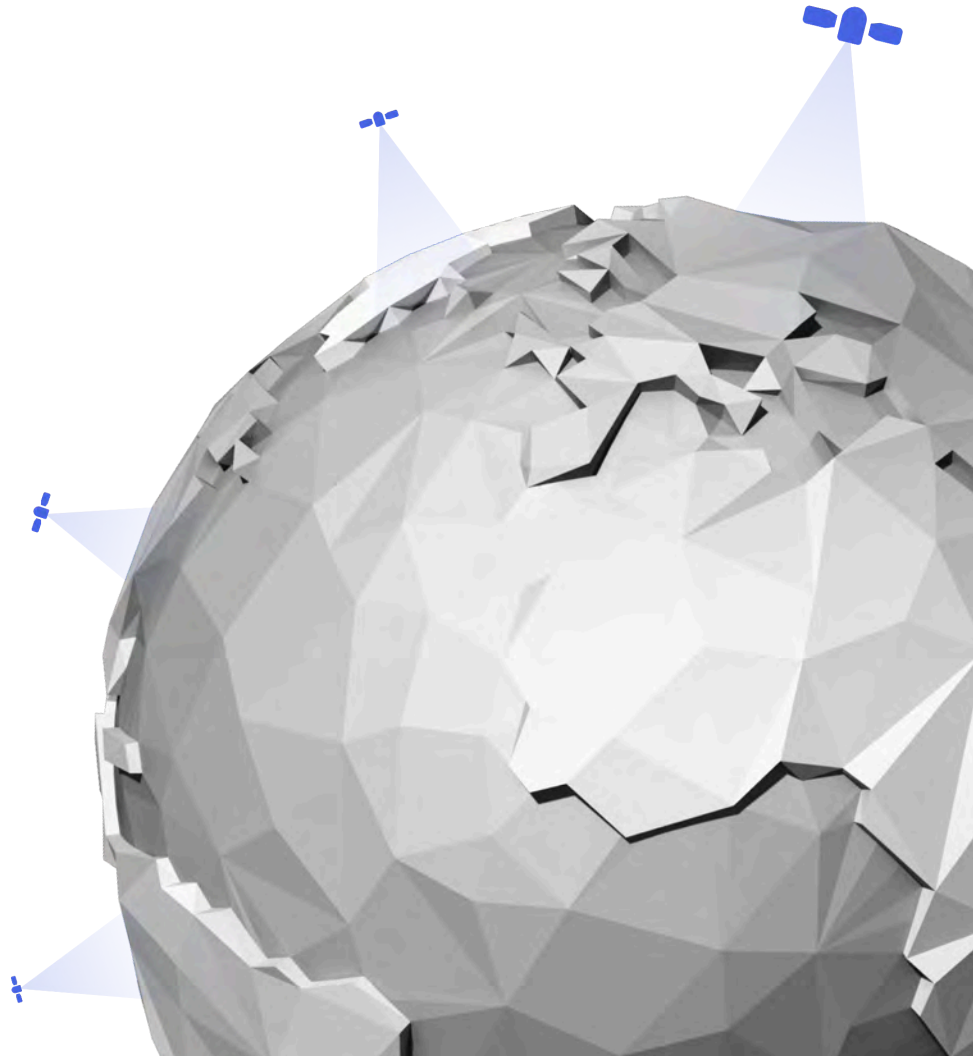
Delivery report

# Change Detection Analysis

Saginaw Malleable Site vol.3

January 01, 2023 – January 01, 2024

Translating Earth data into  
actionable intelligence





# Saginaw Malleable Site

## Introduction



<b>Area of Interest (AOI)</b>	Saginaw Malleable Site [0.54 mi <sup>2</sup> (1.39 km <sup>2</sup> )]
<b>Change Period</b>	January 01, 2023 – January 01, 2024
<b>Change Detection Scope</b>	Changes in buildings / structures / roadways / trails Erosion Stressed or dead vegetation Excavation / disturbed soil
<b>Delivery Report Date</b>	January 31, 2024

<b>Table of Contents</b>	<b>Methodology and Analyst Commentary</b>	<b>3</b>
	<b>Vegetation Indices Explained</b>	<b>5</b>
	<b>Inventory of Images</b>	<b>6</b>
	<b>Imagery and Imagery Analysis</b>	<b>11</b>
	<b>Area of Interest (AOI) Map</b>	<b>12</b>
	<b>Change Detection Summary</b>	<b>13</b>
	<b>No Change Indication Summary</b>	<b>22</b>
	<b>Additional Observation Summary</b>	<b>23</b>



# Methodology and Analyst Commentary

## Analyst Commentary

Examining the available High-resolution imagery we detected no major changes.

Analyzing the long-term time series of vegetation indices, we have been able to compare this year's development of the vegetation cover with the development during previous years. Generally, the growth of the vegetation was comparable to that of previous years, with very small differences. There were some local increases and decreases that you can find described in respective chapters but in overall summary, it seems that this area is being overtaken by vegetation.

No changes in structures, roadways, trails, excavation, or soil erosion have been captured.

Additional Observations regarding the Wetland and Pond AOI Sectors are included, with vegetation indices values being generally comparable to the development in previous years.

SAR Low resolution Sentinel S-1 satellite imagery was inspected, however, it showed no relevant data and thus it was not involved in the Delivery Report.

Within this Delivery Report, three types of conclusions are presented.

- **Change Detections** concern exclusively the changes defined within Change Detection Scope.
- **No Change Indication** presents data that support the conclusion that no change of the phenomena defined within Change Detection Scope has been detected.
- **Additional Observation** refers to areas where relevant and/or interesting phenomena have been observed beyond the Change Detection Scope.

## Methodology

1. **AOI Sector Creation.** AOI Sectors are created within the AOI while considering the type of surface which is being monitored, in order to be able to carry out long term analyses.
2. **Index Image Analysis.** Index values are calculated and evaluated for each AOI Sector.
3. **Visual Inspection.** Each AOI Sector is assessed over available optical Low, Medium and High resolution satellite imagery.
4. **Assess SAR Imagery.** Low resolution SAR satellite imagery (Sentinel S-1) is analyzed whether it detects additional findings. If useful, it is included into the Delivery Report.
5. **Create Delivery Report.** Outcomes of all prior steps are analyzed and findings described in the Delivery Report.



## Imagery Resolution

Following types of imagery are used in this Delivery Report.

- **High resolution (0.75 - 0.80 m/pixel)**
  - SkySat (SS) from Planet Labs
- **Medium resolution (3 - 4 m/pixel)**
  - PSScene4Band (PS) from Planet Labs
- **Low resolution (10 - 60 m/pixel)**
  - Sentinel-2-SR-Harmonized (S2) from ESA-COPERNICUS



# Vegetation Indices Explained

In order to assess specific features of observed surfaces, all remote sensing indices are calculated using a combination of the visible electromagnetic spectrum wavelength bands - Red, Blue, as well as the Near InfraRed (NIR) band.

In this Change Detection Analysis we use two standard Vegetation indices.

## NDVI

Normalized Difference Vegetation Index (NDVI) is the fundamental index used for vegetation health assessment. It uses differences in NIR and Red bands to indicate the condition of greenery. Higher values indicate healthy vegetation with a higher content of chlorophyll and/or more dense vegetation cover. Lower values indicate vegetation that is less healthy, or which populates the ground sparsely.

## MSAVI2

Modified Soil-Adjusted Vegetation Index 2 (MSAVI2) is a soil adjusted vegetation index that addresses the NDVI limitations when applied to areas with a high degree of exposed soil surface. It introduces a soil brightness correction factor into its equation and it is best applied for areas such as fields and meadows, where lower vegetation such as grasses occur in combination with bare soil.

## How to interpret NDVI and MSAVI2 values

### Max = 1

Healthy and abundant vegetation, high content of chlorophyll

### Min = 0

No vegetation present, dead vegetation, out of season detection

When interpreting vegetation indices values, it is important to assess them in the context of the previous years development, for this purpose, we use Sentinel 2 SR Harmonized satellite imagery with available data from the beginning of 2019 these data are compensated for the impact of atmosphere conditions (like weather and haze).



# Inventory of Images

## Imagery and Imagery Analysis

Imagery Provider	Date	Quantity	Type	Resolution Category	Resolution (m/pixel)	SpaceKnow Guardian*
[SS] Planet Labs - SkySat	Dec-21-2022- Dec-25-2023	2	Optical	High	0.75-0.8	<a href="#">View images</a>
[PS] Planet Labs - PSScene4Band	Dec-4-2022- Dec-13-2023	18	Optical	Medium	3 - 4	<a href="#">View images</a>
[S2] ESA-COPERNICUS - Sentinel-2-SR-Harmonized	Nov-25-2022- Nov-18-2023	32	Optical	Low	10 - 60	<a href="#">View images</a>

\* SpaceKnow Guardian provides access to imagery as well as Artificial Intelligence-based analysis of Change activity.



# High Resolution Imagery Time Series

## Imagery and Imagery Analysis



**FIRST IMAGE** of the Change period •  
December 21, 2022 • Planet Labs - SkySat



**LAST IMAGE** of the Change period •  
December 25, 2023 • Planet Labs - SkySat



# High Resolution Imagery Time Series

## Imagery and Imagery Analysis



ENLARGED FIRST IMAGE of the Change period • December 21, 2022 • Planet Labs - SkySat



# High Resolution Imagery Time Series

## Imagery and Imagery Analysis



ENLARGED LAST IMAGE of the Change period • December 25, 2023 • Planet Labs - SkySat



# Medium Resolution Imagery Time Series

## Imagery and Imagery Analysis



**FIRST IMAGE** of the Change period •  
December 04, 2022 • Planet Labs - PSScene4Band

**LAST IMAGE** of the Change period •  
December 13, 2023 • Planet Labs - PSScene4Band



# Low Resolution Imagery Time Series

## Imagery and Imagery Analysis



**FIRST IMAGE** of the Change period •  
November 25, 2022 • COPENICUS - Sentinel-2B

**LAST IMAGE** of the Change period •  
November 18, 2023 • COPENICUS - Sentinel-2B



# Area of Interest (AOI) Map

The AOI is divided into AOI Sectors, which are created based on their specific characteristics, primarily in relation to the defined Change Detection Scope.

This approach enables us to consistently monitor the state of each AOI Sector and compare its features, most importantly the condition of the vegetation, with the development in previous years, and account for seasonality.





# Change Detection Summary



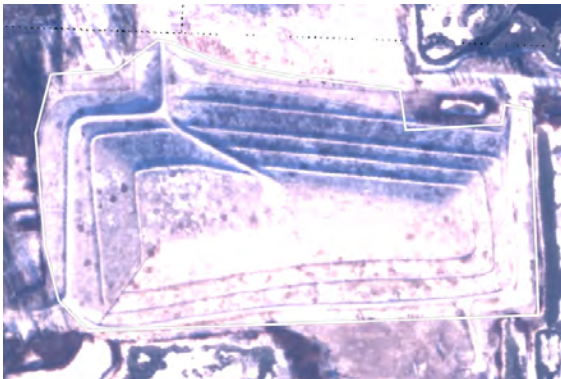
AOI Sector	Change Detection Scope	Item (pages)	Commentary
9 - S Former Landfill	Stressed or dead vegetation	#1 14	We observed a slightly earlier increase in vegetation growth compared to other years and higher vegetation density during September also the vegetation seems to last longer than in other parts of the site.
1 - N Vegetation		#2 17	Vegetation development with a small drop during June, and slightly higher values in August/September compared to previous years.
3 - Intake Channel		#3 18	Vegetation in this area seems to follow the trend from previous years with a little higher values at the beginning of the growth season.
5 - E Former Landfill		#4 19	Vegetation development with a bigger drop during June, the rest of the year seems to correspond with the trend from previous years.
6 - W Former Landfill		#5 20	Vegetation development shows lower growth of vegetation compared to 2022, however, it's very similar to the other years.
8 - W Vegetation		#6 21	Vegetation development shows an ongoing trend of vegetation growth.



## Change Detection Detail

### Change Detection Item #1 - High Resolution Imagery

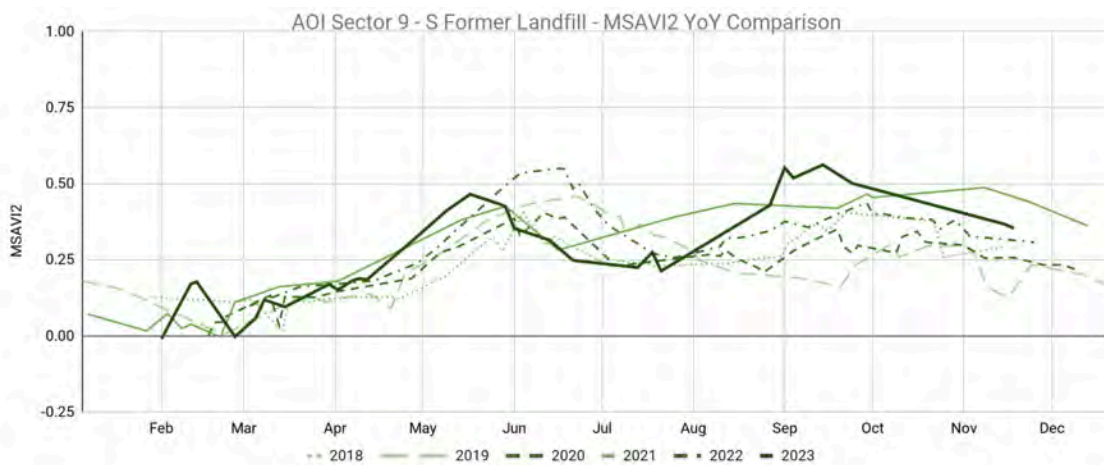
Change Detection Scope	AOI Sector	Commentary
Stressed or dead vegetation	9 - S Former Landfill	We observed a little bit earlier increase in vegetation growth compared to other years and higher vegetation density during September also the vegetation seems to last longer than in other parts of the site.



**Image 1** December 21, 2022, SS (High-res)



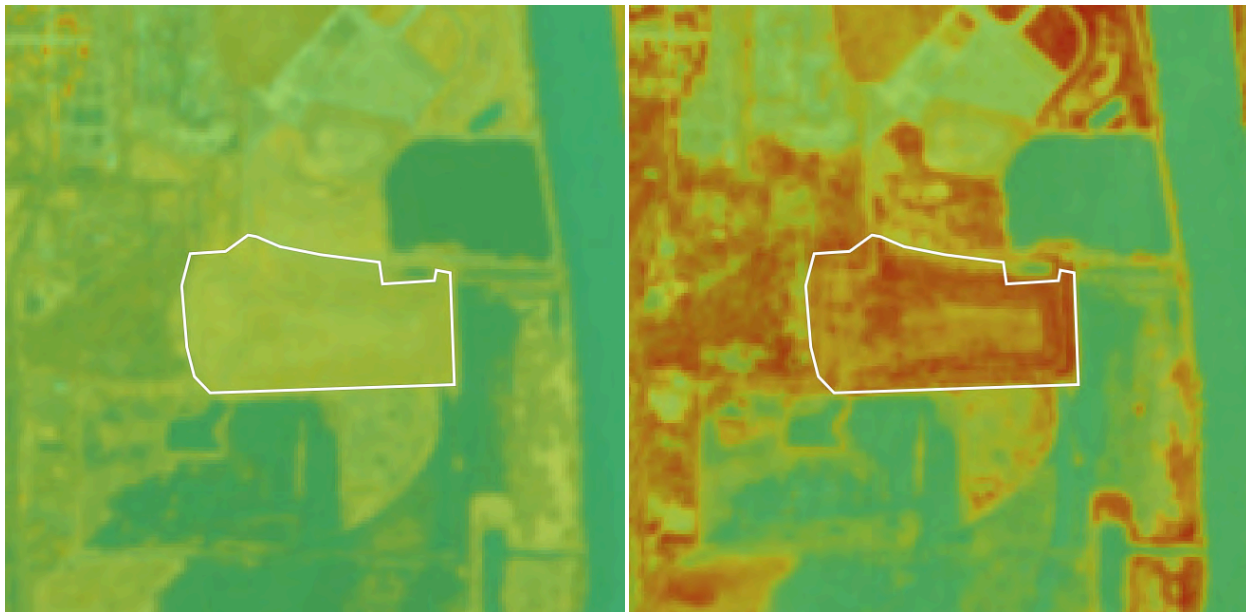
**Image 2** December 25, 2023, SS (High-res)



Analysis of MSAVI2 (Modified Soil-Adjusted Vegetation Index 2 - defined on pg. 4) vegetation index time series shows a slightly earlier growth of vegetation compared to previous years, the biggest difference can be seen in September.

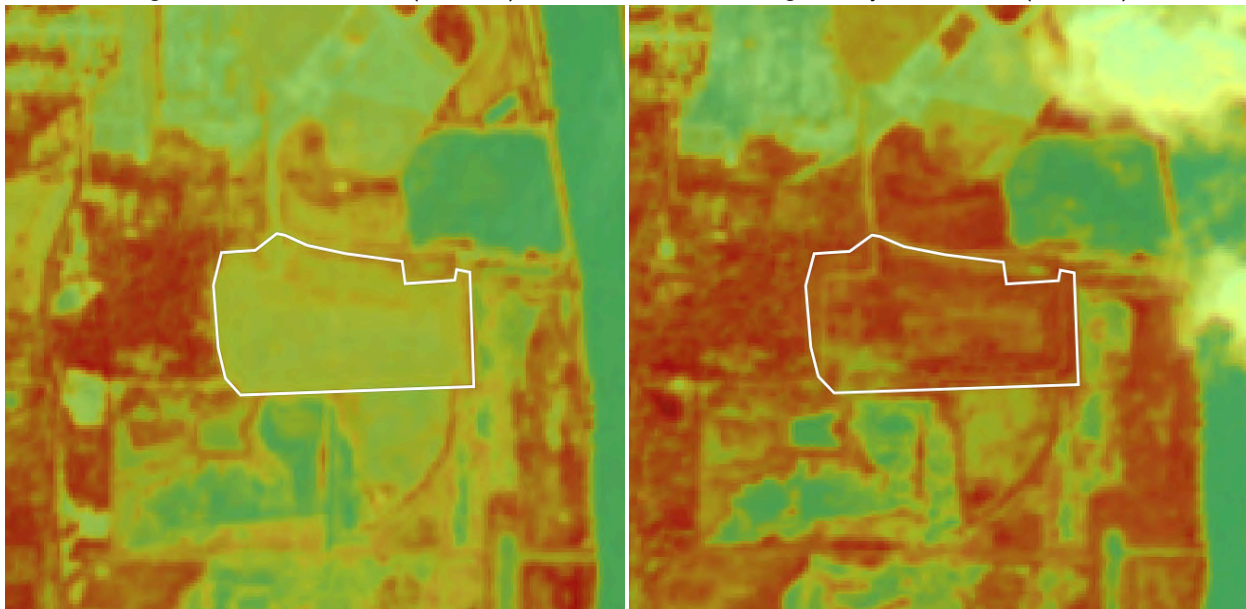


## Change Detection Item #1 - Time series



**Image 1** March 30, 2023, S2 (Low-res)

**Image 2** May 17, 2023, S2 (Low-res)



**Image 3** June 21, 2023, S2 (Low-res)

**Image 3** September 1, 2023, S2 (Low-res)

**Images 1 - 4** show development of vegetation over the former landfill using the visualization of MSAVI2 index. We can observe the higher vegetation density in May and September however we can see a large decrease in June compared to other areas.



## Change Detection Item #1 - Medium Resolution Imagery



**Image 1** April 02, 2023, PS (Mid-res)



**Image 2** May 09, 2023, PS (Mid-res)



**Image 3** June 07, 2023, PS (Mid-res)



**Image 4** September 24, 2023, PS (Mid-res)



**Image 4** November 14, 2023, PS (Mid-res)

**Images 1 - 5** Medium resolution imageries confirm the same vegetation behavior as we saw on MSAVI2 chart and that is growth in May, decrease during summer and increase at the beginning of autumn also the vegetation seems to last longer on the landfill than in other areas of the site.



## Change Detection Detail

### Change Item #2 - High Resolution Imagery

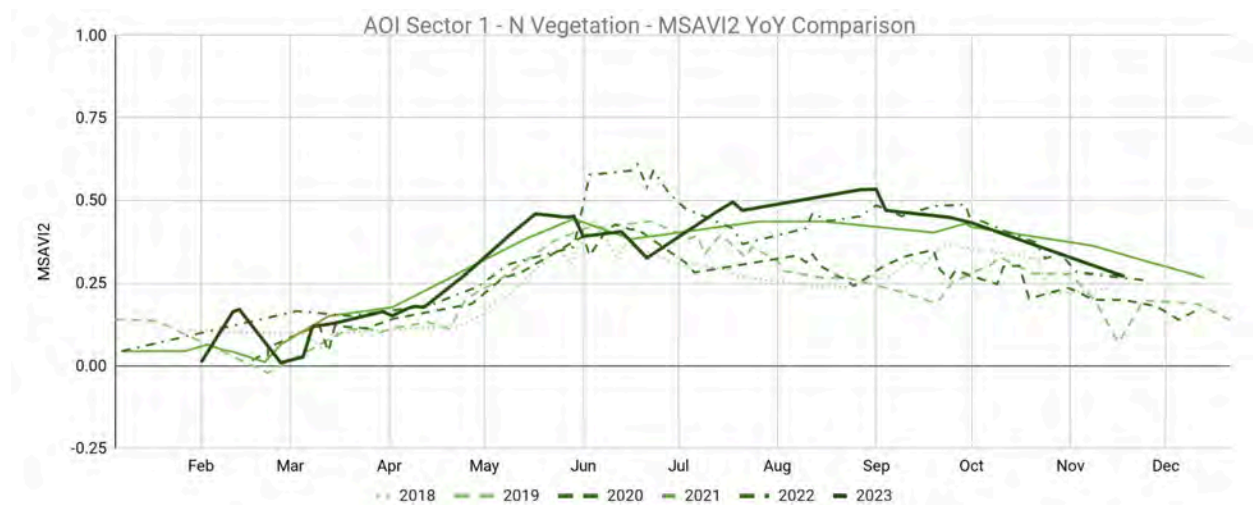
Change Detection Scope	AOI Sector	Commentary
Stressed or dead vegetation	1 - N Vegetation	Vegetation development with a small drop during June and slightly higher values in August/September compared to previous years.



**Image 1** December 21, 2022, SS (High-res)



**Image 2** December 25, 2023, SS (High-res)



Analysis of MSAVI2 (Modified Soil-Adjusted Vegetation Index 2 - defined on pg. 4) vegetation index time series shows a drop during June/July but slightly higher vegetation density in August/September compared to the previous year.



# Change Detection Detail

## Change Item #3 - High Resolution Imagery

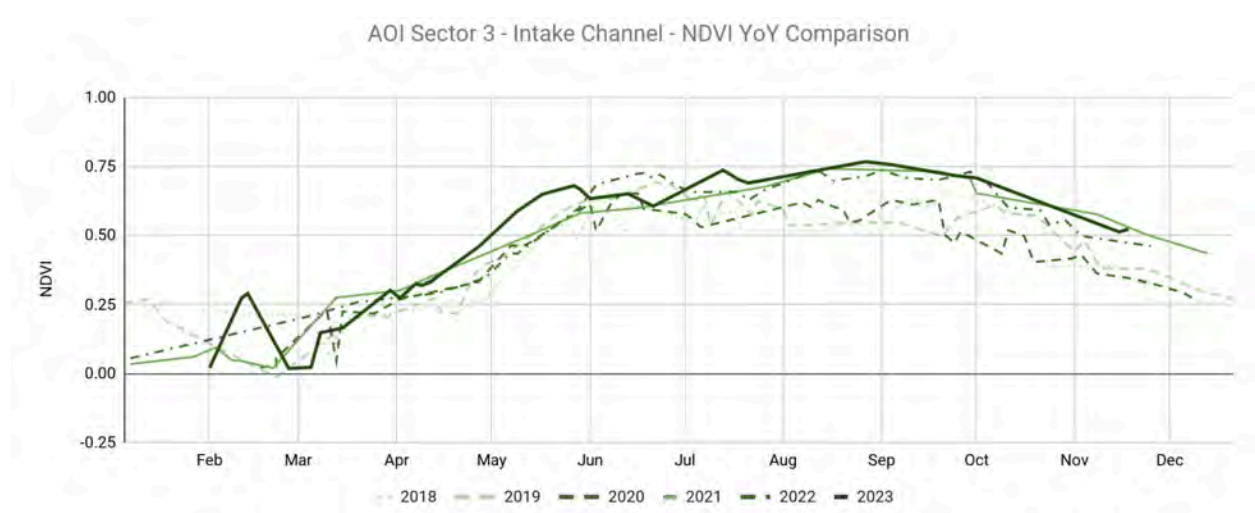
Change Detection Scope	AOI Sector	Commentary
Stressed or dead vegetation	3 - Intake Channel	Vegetation in this area seems to follow the trend from previous years with a little higher values at the beginning of the growth season.



**Image 1** December 21, 2022, SS (High-res)



**Image 2** December 25, 2023, SS (High-res)



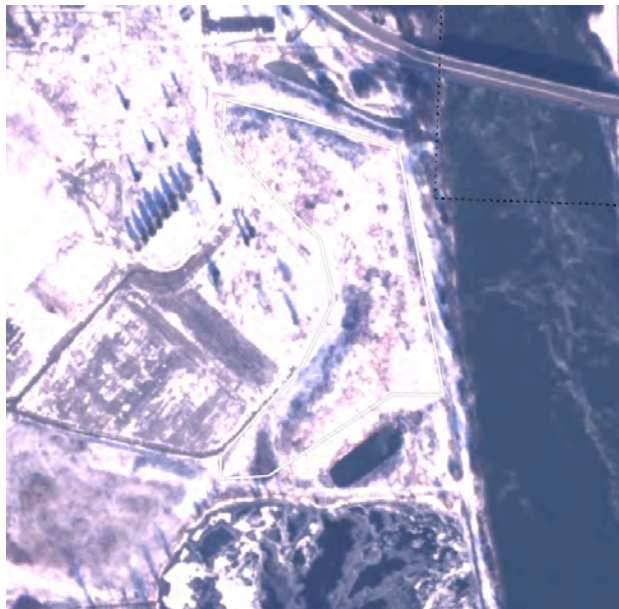
Analysis of NDVI (Normalized Difference Vegetation Index - defined on pg. 4) vegetation index time series shows stable values over the previous years with slightly higher values in the middle of May which might be caused by the earlier start of the season.



# Change Detection Detail

## Change Item #4 - High Resolution Imagery

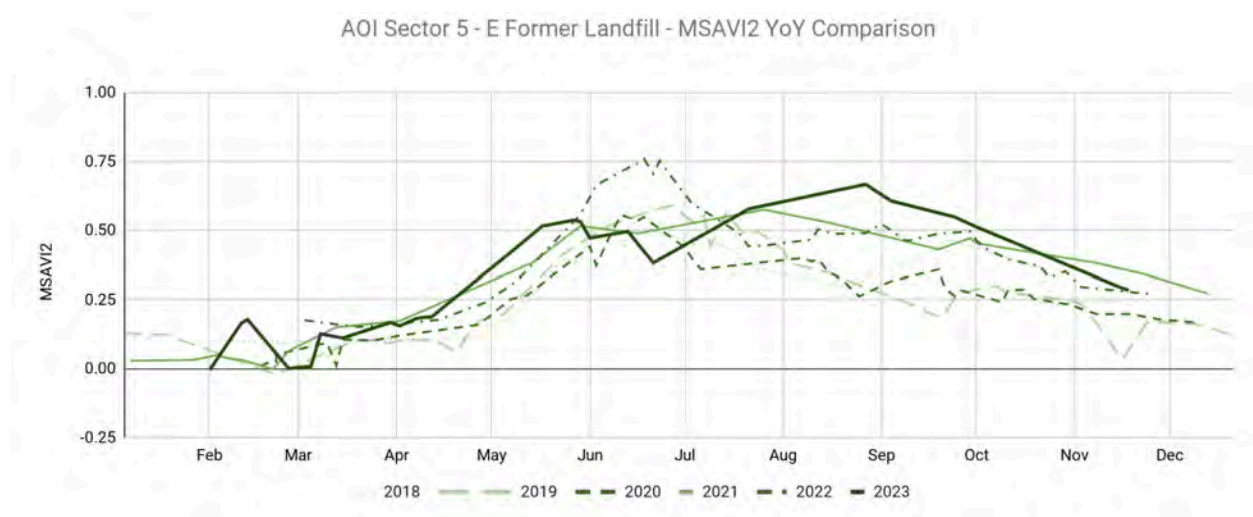
Change Detection Scope	AOI Sector	Commentary
Stressed or dead vegetation	5 - E Former Landfill	Vegetation development with a bigger drop during June, the rest of the year seems to correspond with the trend from previous years.



**Image 1** December 21, 2022, SS (High-res)



**Image 2** December 25, 2023, SS (High-res)



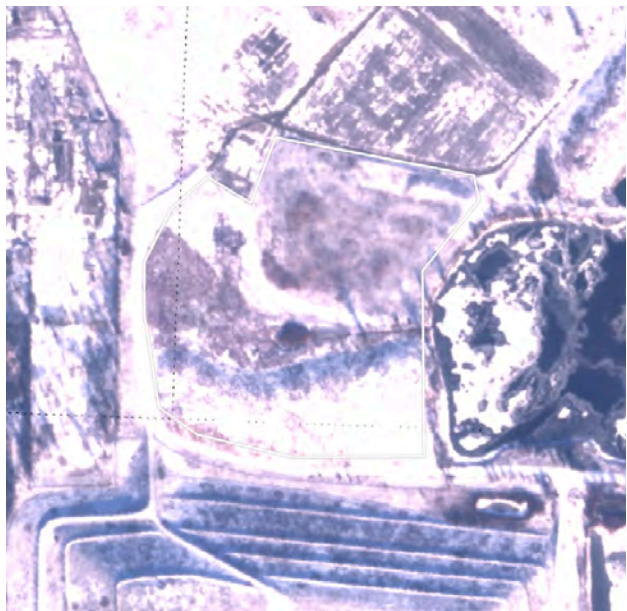
Analysis of MSAVI2 vegetation index time series shows similar development as in previous years but with one drop in June which might be caused by this season's weather.



# Change Detection Detail

## Change Item #5 - High Resolution Imagery

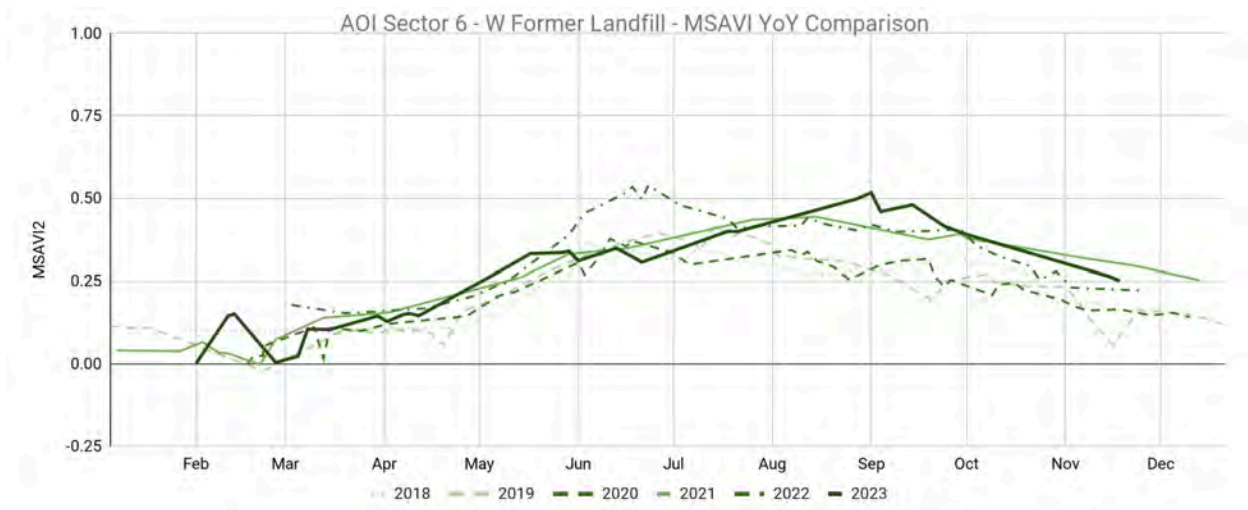
Change Detection Scope	AOI Sector	Commentary
Stressed or dead vegetation	6 - W Former Landfill	Vegetation development shows lower growth of vegetation compared to 2022, however, it's very similar to the other years.



**Image 1** December 21, 2022, SS (High-res)



**Image 2** December 25, 2023, SS (High-res)



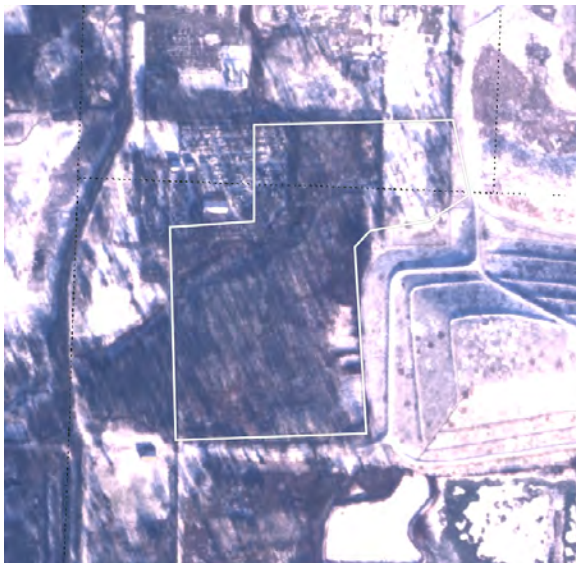
Analysis of MSAVI2 vegetation index time series shows lower - growth of vegetation compared to 2022, however, it's very similar to the other years.



# Change Detection Detail

## Change Item #6 - High Resolution Imagery

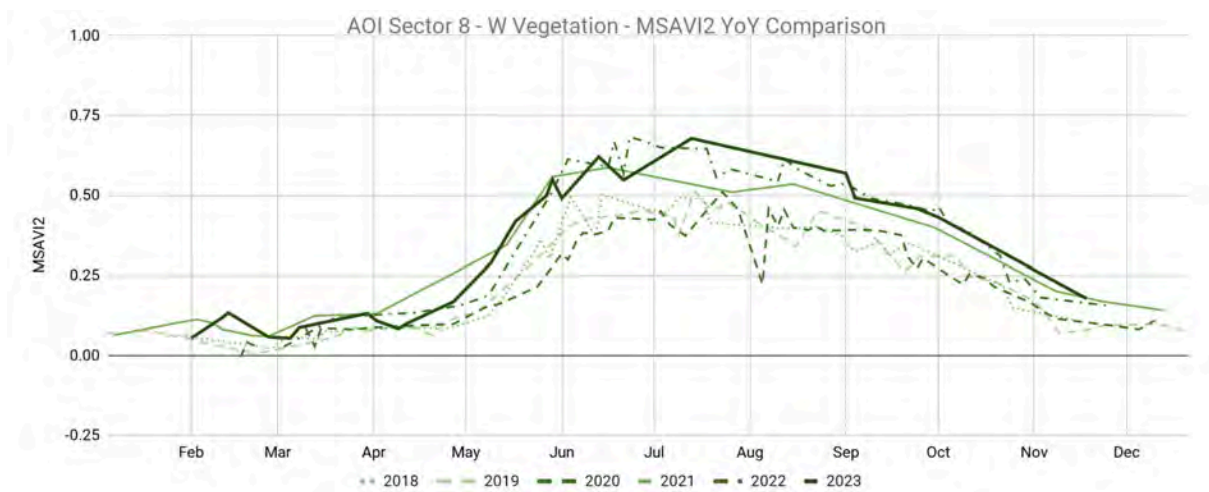
Change Detection Scope	AOI Sector	Commentary
Stressed or dead vegetation	8 - W Vegetation	Vegetation development shows an ongoing trend of vegetation growth.



**Image 1** December 21, 2022, SS (High-res)



**Image 2** December 25, 2023, SS (High-res)



Analysis of MSAVI2 vegetation index time series shows ongoing trend of vegetation growth.



## No Change Indication Summary

AOI Sector	Change Detection Scope	Commentary
All	Changes in buildings/structures/roadways /trails	No apparent changes in buildings or structures have been detected.
All	Excavation / disturbed soil	No apparent excavation has been detected.
All	Erosion	No apparent erosion has been detected.



# Additional Observation Summary



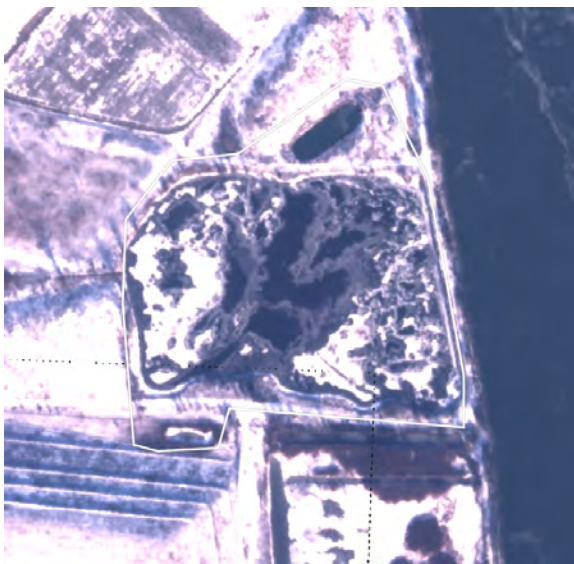
AOI Sector	Observation	Observation - pages	Commentary
7 - Settling Pond	Pond algae development	A 24-25	Development of vegetation over a wetland area. The growth of algae which has been observed corresponds with the development in previous years with a very slight decrease compared to last year.
10 - W Mitigation Wetland	Wetland restoration	B 26-27	Development of vegetation over wetland area. The growth of algae that has been observed corresponds to previous years.
11 - E Mitigation Wetland	Wetland restoration	C 28-30	Development of vegetation over a wetland area. The growth of algae that has been observed corresponds to previous years.



## Additional Observation Detail

### Observation A - High Resolution Imagery

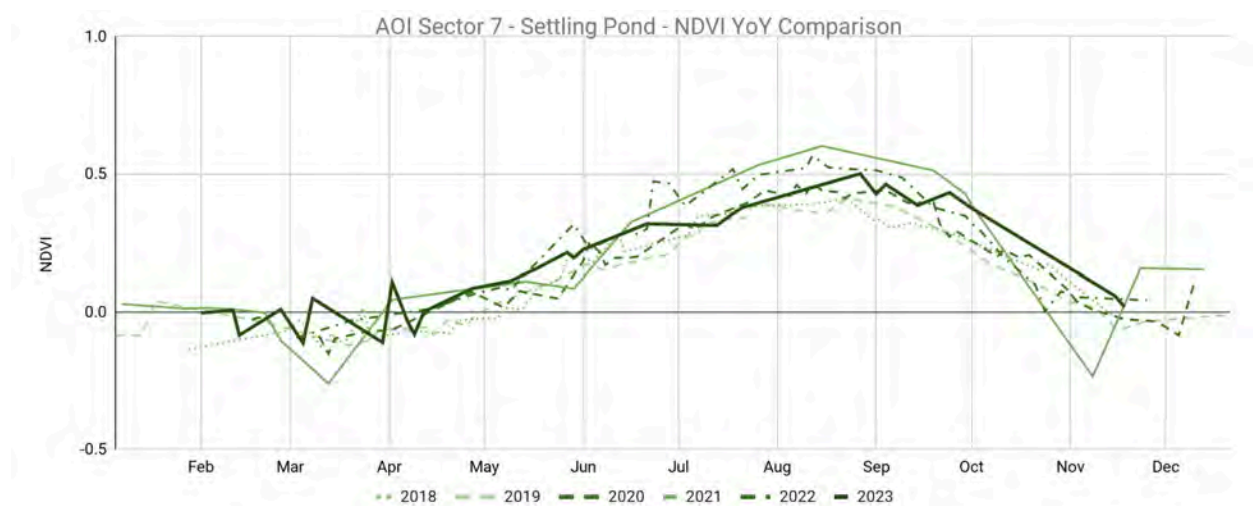
Observation	AOI Sector	Commentary
Pond algae development	7 - Settling Pond	Development of vegetation over a wetland area. The growth of algae which has been observed corresponds with the development in previous years with a very slight decrease compared to last year.



**Image 1** December 21, 2022, SS (High-res)



**Image 2** December 25, 2023, SS (High-res)



NDVI time series shows that the observed Change period development of pond algae corresponds to previous years with a slight decrease compared to 2022.



## Additional Observation Detail

### Observation A - Medium Resolution Imagery



**Image 1** April 02, 2023, PS (Mid-res)



**Image 2** July 30, 2023, PS (Mid-res)



**Image 3** September 24, 2023, PS (Mid-res)



**Image 4** November 14, 2023, PS (Mid-res)

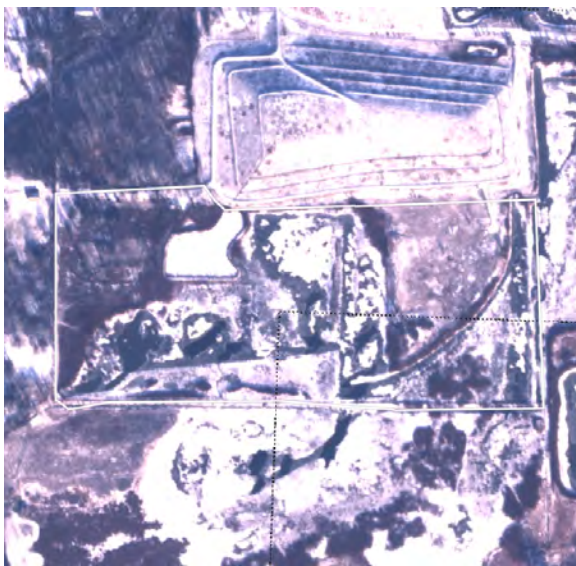
**Images 1 - 4** show development of vegetation over the pond. Growth of algae can be observed from spring till autumn with higher density during July-August.



## Additional Observation Detail

### Observation B - High Resolution Imagery

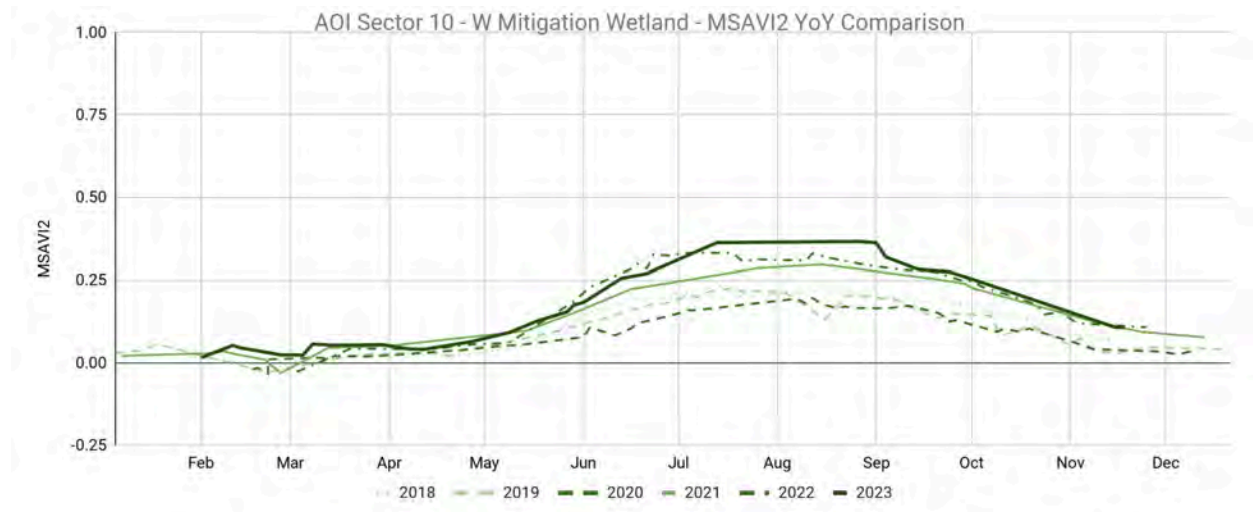
Observation	AOI Sector	Commentary
Wetland restoration	10 - W Mitigation Wetland	Development of vegetation over a wetland area. The growth of algae that has been observed corresponds to previous years.



**Image 1** December 21, 2022, SS (High-res)



**Image 2** December 25, 2023, SS (High-res)



Examination of MSAVI2 time series shows vegetation development cycle with very similar values compared to previous years.



## Additional Observation Detail

### Observation B - Medium Resolution Imagery



**Image 1** April 2, 2023, PS (Mid-res)



**Image 2** June 1, 2023, PS (Mid-res)



**Image 3** July 30, 2023, PS (Mid-res)



**Image 4** September 24, 2023, PS (Mid-res)



**Image 5** November 24, 2023, PS (Mid-res)

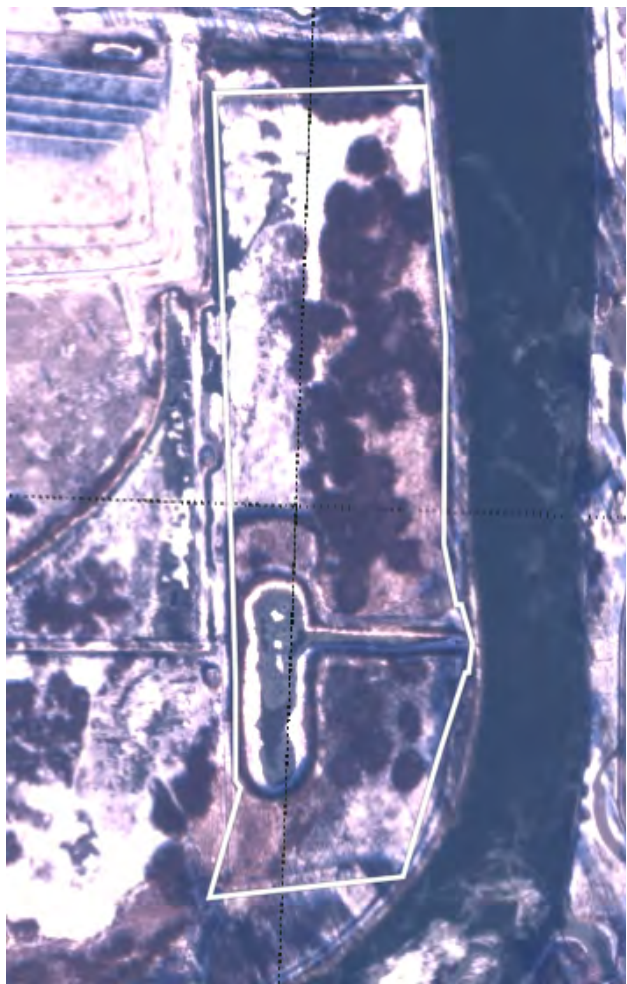
**Images 1 - 5** show development of vegetation over the wetland area. Growth of algae can be observed from spring till autumn with higher density during summer.



## Additional Observation Detail

### Observation C - High Resolution Imagery

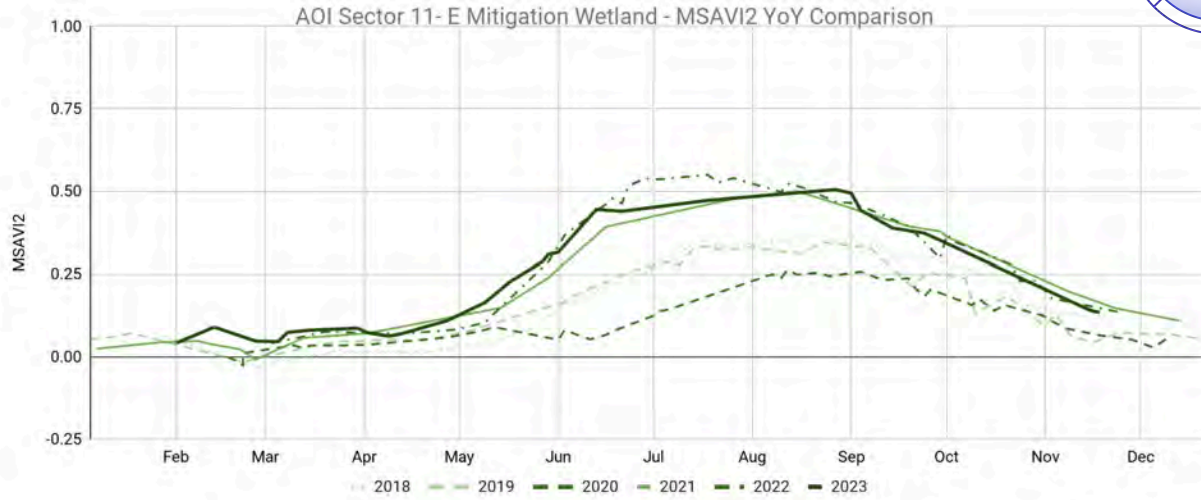
Observation	AOI Sector	Commentary
Wetland restoration	11 - E Mitigation Wetland	Development of vegetation over wetland area. The growth of algae which has been observed corresponds to previous years.



**Image 1** December 21, 2022, SS (High-res)



**Image 2** December 25, 2023, SS (High-res)



Examination of MSAVI2 time series shows a vegetation development cycle that copies pattern and values from the previous two years.

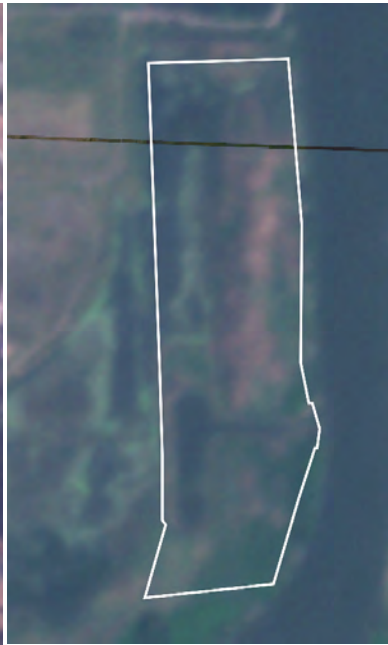


## Additional Observation Detail

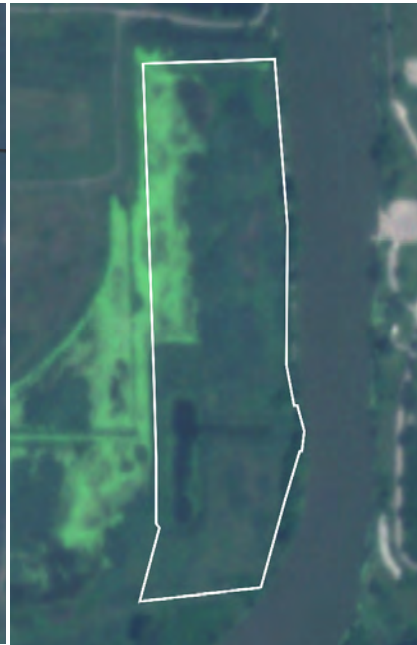
### Observation C - Medium Resolution Imagery



**Image 1** April 2, 2023, PS (Mid-res)



**Image 2** June 1, 2023, PS (Mid-res)



**Image 3** July 30, 2023, PS (Mid-res)



**Image 4** September 24, 2023, PS (Mid-res)



**Image 5** September 08, 2022, PS (Mid-res)

**Images 1 - 5** show development of vegetation over the wetland area. Growth of algae can be observed from spring till autumn with higher density during summer.