**Kankakee Water Resources**

*Monitoring Temperature and Vegetation to Detect River Flow Impediments at Energy Intake Structures*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:***

In July 2022, a grassing event along the Kankakee River near Joliet, IL, disrupted energy operations at the Constellation Nuclear Dresden Generating Station after large mats of aquatic grasses clogged their water intake structures. To support Constellation Nuclear’s decision-making, this project compared imagery from various satellites, including Landsat 8 OLI, Landsat 9 OLI-2, Sentinel-2 MSI, DOVE PlanetScope, and WorldView-3, to test the feasibility of visualizing and detecting mats of floating vegetation that lead to major grassing events. Additionally, GPM IMERG, Terra MODIS, and measurements from USGS water gage data were utilized to pair vegetation detections from Earth observations with several environmental metrics within the watershed, aiming to understand the origins and factors influencing these grassing events.

***Abstract:***

In recent years, unpredictable grassing events have occurred at the Dresden Generating Station, located on the Kankakee River in northern Illinois. Grassing events are characterized by large mats of aquatic vegetation that accumulate downstream, resulting in the clogging of water intake structures and leading to major disruptions in power generation. Currently, employees at the Dresden Generating Station are responsible for reactively responding to each grassing event individually. This project, in partnership with Constellation Nuclear and the United States Geological Survey (USGS), assessed the feasibility of using Earth observations (Landsat 9 OLI-2, Landsat 8 OLI, Sentinel-2 MSI, DOVE PlanetScope, WorldView-3, and GPM IMERG) to detect floating aquatic vegetation within the Kankakee River and identify predictive factors that trigger grassing events, as doing so will provide the Dresden Generating Station the ability to anticipate future grassing events and enhance general hydrologic modeling efforts held by the USGS. The results of this study illustrated that, while aquatic vegetation can be detected by satellites with up to moderate spatial resolution (30 m), temporal resolution is a major limiting factor for tracking movements in floating aquatic vegetation and identifying predictive measures for these events. In addition, correlation results suggest a possible negative relationship between grassing events and river discharge (-0.875 correlation coefficient). In the future, pairing these results with ground control surveys and sensors with higher temporal capabilities would allow our project partners to predict and proactively address future grassing events, ensuring the reliable operation of the Dresden Generating Station.

***Key Terms:*** Landsat, Sentinel, PlanetScope, WorldView, floating aquatic vegetation, environmental trend analysis.

***National Application Area Addressed:*** Water Resources

***Study Location:*** Kankakee River, IL

***Study Period:*** May 1st, 2022 - September 30th, 2022

***Community Concerns:***

* Grassing events in the Kankakee River pose a critical problem by clogging the Dresden Generating Station’s water-cooling intake and therefore disrupting energy operations.
* Dresden Generating Station generates enough energy to power the equivalent of 1.4 million homes and is a source of income for over 600 people. The reliable and consistent operation of the station is paramount to the local community.
* Without the ability to predict grassing events, employees at the Dresden Generating Station are unable to be proactive in monitoring the station’s intake when it is at risk of clogging.

***Project Objectives:***

* Detect floating aquatic vegetation in the Kankakee River using Earth observations
* Predict future grassing events by pairing Earth observation measurements with the following environmental metrics: precipitation, cloud cover, water temperature, and discharge rate
* Develop a reproducible workflow for future partner use through an ArcGIS Pro tutorial

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organizations** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Constellation Nuclear** | Beckie Maddox, Senior Environmental Specialist | End User |
| **USGS Central Midwest Water Science Center** | Allison Atkinson, Civil Engineer | Collaborator |

***Decision-Making Practices & Policies:***

Constellation Nuclear’s main interest in this project is developing predictive capabilities to anticipate grassing events that clog the intake at the Dresden Generating Station. Prior to the project, Constellation Nuclear was reactively responding to grassing events, with operators manually assessing floating vegetation, and removing it on a case-by-case basis. As of summer 2023, they began employing contractors who specialize in Unmanned Aerial Vehicles (UAVs) to assist in vegetation detection and removal in the Kankakee River near the intake. However, imagery from UAVs to this date has solely consisted of aerial imagery. Additionally, field surveys have been employed to characterize the macrophyte species present within the Kankakee River. Constellation Nuclear is also collaborating with the USGS Central Midwest Water Science Center to understand the cause of wide scale macrophyte growth and release in the water body.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 9 OLI-2** | Surface reflectance | Surface reflectance was used to delineate the river boundary and calculate vegetation indices that identify aquatic vegetation. |
| **Landsat 8 OLI** | Surface reflectance | Surface reflectance was used to delineate the river boundary and calculate vegetation indices that identify aquatic vegetation. |
| **Sentinel-2 MSI** | Surface reflectance | Surface reflectance was used to delineate the river boundary and calculate vegetation indices that identify aquatic vegetation. |
| **PlanetScope** | Surface reflectance | Surface reflectance was used to delineate the river boundary and calculate vegetation indices that identify aquatic vegetation. |
| **WorldView-3** | Surface reflectance | Surface reflectance imagery was used to visually inspect patches of aquatic vegetation to compare with other Earth observations. |
| **GPM IMERG** | Precipitation | Precipitation data was used to examine temporal trends that correlate with aquatic vegetation detection. |
| **Terra MODIS** | Cloud Fraction | Cloud fraction data was used to examine temporal trends that correlate with aquatic vegetation detection. |

***Ancillary Datasets:***

* USGS Water Gage Data within the Kankakee River Near Wilmington, IL – discharge, gage height, and water temperature measurements (daily means)
* USGS Water Gage Data within Kankakee River at Inflow of Power Plant NR Lorenzo, IL – gage height and water temperature measurements (daily means)

***Software & Scripting:***

* ArcGIS Pro 3.1.2 – Used in the case-study analysis for comparing resolved patches of aquatic vegetation within each EO and final tutorial generation
* Python 3.10 – Used for generating a land mask for the study area, calculating vegetation indices for all scenes in the analysis, and for assessing environmental trends with vegetation detection

***End Products:***

|  |  |  |
| --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** |
| **Case Study Analysis** | Landsat 8 OLI  Landsat 9 OLI-2  Sentinel-2 MSI  PlanetScope  WorldView-3 | The case study analysis of the Summer 2022 grassing event will inform the partners of the benefits and drawbacks of using each Earth observation and index in detecting aquatic vegetation. These results will provide a starting point that partners can use to further incorporate remote sensing into continuous monitoring of aquatic vegetation. The case study analysis will help our partners make informed decisions with regards to the monitoring and removal of aquatic grasses to ensure optimal power generation for the surrounding community. |
| **Environmental Trends Monitoring** | Landsat 8 OLI  Landsat 9 OLI-2  GPM IMERG  Terra MODIS | The identified environmental correlations corresponding to aquatic vegetation detection will help the partners begin to understand potential mechanisms that trigger grassing events so that they can better predicts when to increase monitoring efforts around the water intake at the Dresden Generating Station. |
| **Tutorial** | Landsat 8 OLI  Landsat 9 OLI-2  GPM IMERG  Terra MODIS | A tutorial document (GIS) will demonstrate to the partners how to further investigate environmental triggers for grassing events using Earth observations. |

***Product Benefit to End User:***

By utilizing remote sensing technologies paired with environmental trends analysis, this project enables the accurate and timely detection of floating vegetation in the Kankakee River. This information can be leveraged by Constellation Nuclear and the USGS Central Midwest Water Science Center to enhance their reaction to grassing events that threaten energy operations at the Dresden Generating Station. With continuous detection of vegetation presence and growth patterns, they can be prepared when they observe similar environmental conditions and take mitigation and preventive measures, ensuring optimal power generation and serving the community without disruption to their power supply. Moreover, our project will establish a baseline workflow for partners to investigate these events in further detail by incorporating Earth observations into their current modeling efforts.

**References:**

Al-lami, A. K., Abbood, R. A., Al Maliki, A. A., & Al-Ansari, N. (2021). Using vegetation indices for monitoring the spread of Nile Rose plant in the Tigris River within Wasit province, Iraq. *Remote Sensing Applications: Society and Environment, 22*, 100471. <https://doi.org/10.1016/j.rsase.2021.100471>

Dogliotti, A. I., Gossn, J. I., Vanhellemont, Q., & Ruddick, K. G. (2018). Detecting and quantifying a massive invasion of floating aquatic plants in the Río de la Plata turbid waters using high spatial resolution ocean color imagery. *Remote Sensing, 10(7)*, 1140. <https://doi.org/10.3390/rs10071140>

Constellation. (2023). Dresden Generating Station [Fact sheet]. <https://www.constellationenergy.com/content/dam/constellationenergy/images/location-sites/nuclear/Dresden%20Generating%20Station_Fact%20Sheet.pdf>

Tan, W., Xing, J., Yang, S., Yu, G., Sun, P., & Jiang, Y. (2020). Long term aquatic vegetation dynamics in Longgan Lake using Landsat time series and their responses to water level fluctuation. *Water, 12(8)*, 2178. <https://doi.org/10.3390/w12082178>