**San Diego Water Resources**

*Monitoring Coastal Water Quality After Storm-induced Runoff to Improve Pollution Monitoring Efforts*

**Project Team**

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**Project Overview**

***Project Synopsis:***

The San Diego Water Resources project aims to better inform partners’ water quality management efforts by providing maps and metrics for stormwater, wastewater, and mixed plumes in the San Diego Bay. Utilizing NASA Earth observations, the team produced turbidity thresholds to map plume extent and averaged values of area, CDOM, turbidity, and Chlorophyll-a across all plume types. In-situ data was used to develop regression models with remotely sensed data to evaluate its accuracy. These end products help determine the feasibility of using NASA Earth observations to monitor pollution and provides useful metrics to quantify plumes in the San Diego Bay.

***Abstract:***

Stormwater and wastewater runoff are a large source of pollutant discharge along the southern California coast and are a major concern to the health of local communities and ecosystems. In partnership with the Tijuana River National Estuarine Research Reserve and the California Department of Environmental Quality, the NASA DEVELOP team utilized satellite imagery to visualize and analyze the water quality of the Tijuana Estuary and southern California coast after major storm and wastewater events. Using Landsat 8 Operational Land Imager (OLI) and Sentinel-2 Multispectral Instrument (MSI), the team estimated the extent and severity of plumes released from the Tijuana River Estuary. The team used remotely sensed turbidity to map the extent of plumes, and used remotely sensed turbidity, Chlorophyll-a (chl-a), and colored dissolved organic matter (CDOM) to quantify and visualize stormwater, wastewater, and mixedplumes from 2013 to 2022. Furthermore, remotely sensed CDOM, turbidity, and chl-a were validated with in-situ data from NOAA and the San Diego Public Utilities in the San Diego coastal area to evaluate the accuracy of water quality data derived from satellite imagery. End products of this project include maps of stormwater, wastewater, and mixed plumes, tables illustrating the average area, CDOM, turbidity, and chl-a of each plume type, and validation graphs between satellite and in-situ data sources. These end products informed the environmental management of the Tijuana River National Estuarine Research Reserve and the public beaches in San Diego.

***Key Terms:***

plume, remote sensing, water quality, CDOM, turbidity, chlorophyll-a, Tijuana River Watershed, San Diego Bay

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

***Study Location:*** San Diego Bay & Tijuana River Watershed, CA

***Study Period:*** March 2013 to November 2022

***Community Concerns:***

* Water quality on the coast of San Diego has been impaired by urban runoff from the Tijuana River to levels that endanger human health and the local ecosystem.
* Beach closures have been enacted due to the toxic levels of pollution that occur along the coast after storm events. These beach closures negatively impact the local tourism and recreation economy.
* Storm events bring toxic pollutants, such as trace metals and microplastics, into the Tijuana River National Estuarine Research Reserve (TRNERR), harming the ecosystem’s aquatic wildlife.

***Project Objectives:***

* Create maps of stormwater, wastewater, and mixed plumes using satellite imagery of CDOM, turbidity, and chl-a, to determine the spatial patterns of pollution plumes.
* Create a tool that can delineate pollution plumes from satellite imagery in Google Earth Engine
* Validate remotely sensed water quality data with in-situ data to determine the accuracy of remote sensing for analyzing pollution plumes in the Southern California region

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Tijuana River National Estuarine Research Reserve** | Dr. Jeff Crooks, Research Coordinator; Kellie Uyeda, Research Scientist | End User |
| **Waterkeeper Alliance** | Margarita Diaz, Tijuanna Waterkeeper | End User |
| **San Diego Regional Water Quality Control Board** | David Gibson, Executive Officer;  Vicente Rodriguez, Water Resource Control Engineer; Brandi Outwin-Beals, Senior Water Resource Control Engineer | End User |
| **City of San Diego** | Dr. Ryan M. Kempster, Senior Marine Biologist & Ocean Monitoring Program Manager;  Ami Latker, Marine Biologist and Project Manager | End User |
| **City of Imperial Beach** | Chris Helmer, Environmental and Natural Resources Director | End User |

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

The primary focus of TRNERR is to track short-term variability and long-term change in and around the Tijuana River Estuary. TRNERR works with the NOAA NERR System-Wide Monitoring Program (SWMP) to study water quality parameters in the estuary with the goal of preserving and protecting the area. The TRNERR’s research program tracks short-term variability and long-term changes in water quality to assist management decisions in protecting the estuary’s ecosystem. The TRNERR carries out this research in partnership with the NOAA NERR system, San Diego State University’s Pacific Estuarine Research Laboratory, and the California State Coastal Conservancy. TRNERR and NOAA are working together to understand the physical processes that create hypoxic conditions in low-inflow estuaries, identifying at risk areas, and studying its ecological consequences. Waterkeeper Alliance is a nonprofit organization whose efforts lie in preserving and protecting water by connecting and mobilizing more than 300 local Waterkeeper groups around the world. Waterkeeper Alliance addresses critical issues related to clean water and environmental issues. They use position statements to inform their public policy agenda, priorities, advocacy, communications, and all levels of work. The San Diego Regional Water Quality Control Board’s mission is to develop and enforce water quality objectives, as well as implement plans that will best protect the area's waters while recognizing our local differences in factors like climate, topography, geology and hydrology.

The City of San Diego produces annual Drinking Water Quality Reports, which are also known as the Consumer Confidence Report, and it is a state-mandated document that provides information on the drinking water that is delivered to citizens daily and how it compares to the standards of the state.

The City of Imperial Beach participates in the development and implementation of the San Diego Bay Water Quality Improvement Plan. The purpose of the Water Quality Improvement Plan (WQIP) is to guide local Storm Water Management Programs to address specific priorities within the watershed management area.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Surface reflectance, Colored Dissolved Organic Matter (CDOM), turbidity, chlorophyll-a | These data will be used to analyze changes in water quality parameters from 2013- 2022 to determine storm-induced runoff events and monitor seasonal and annual trends. |
| **Sentinel-2 MSI** | Surface reflectance, CDOM, turbidity, chlorophyll-a | These data will be used to analyze changes in water quality parameters over the last 6 years to determine storm-induced runoff events and monitor seasonal and annual trends. |

***Ancillary Datasets:***

* NOAA's National Estuarine Research Reserve System (NERRS) System-wide Monitoring Program (SWMP) – Turbidity data from water quality sensors within TRNERR can be used for comparison to remotely-sensed data.
* NOAA National Center for Environmental Information (NCEI) Record of Climatological Observations (RCO) – Meteorological data can be used to determine the dates of large precipitation events which preface stormwater and mixed plume events.
* International Boundary and Water Commission (IBWC) River Gage Data – River discharge data from the TRNERR Oneonta Slough station can be used to determine when significant runoff events occur for pollution plume analysis.
* City of San Diego Public Utilities Department's Ocean Monitoring Program (OMP) – near-daily water quality samples and wastewater plume data can be used for comparison to remotely-sensed data

***Software & Scripting:***

* Esri ArcGIS Pro 2.8.0 – Raster manipulation and map product generation
* Google Earth Engine Application Programming Interface (API) – Acquisition of remotely-sensed data and application of ocean color detection algorithms
* Optical Reef and Coastal Area Assessment Tool (ORCAA) – Calculates water quality indexes based off an input region and date range

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit and Use** | **Software Release Category** |
| **Maps of Pollution Plumes along the Coastline of the Tijuana River Estuary.** | Landsat 8 OLI  Sentinel-2 MSI | This product will allow the partners to identify areas that have historically experienced storm-induced runoff and may require special monitoring because of their position near protected habitats or public beaches. | N/A |
| **Plume Area and Severity Table** | Landsat 8 OLI  Sentinel-2 MSI | Table of average area, turbidity, chl-a, and CDOM can be used to compare plume extent and severity for stormwater, wastewater, and mixed plume types. | N/A |
| **ORCAA and Plume Delineation Tutorial** | Landsat 8 OLI  Sentinel-2 MSI | This tutorial shows partners how to use ORCAA in order to conduct future research along with how to replicate the plume delineation code. | N/A |
| **Regression Plots for Water Quality Parameters** | Landsat 8 OLI  Sentinel-2 MSI | Regression plots allow partners to evaluate the accuracy of using remotely sensed data for measuring CDOM, chlorophyl-a, and turbidity in the study area. | N/A |  |

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

The end products of this project will enhance the partners’ understanding of water quality in San Diego Bay and the Tijuana River estuary while also informing their stormwater and wastewater management and water quality improvement efforts. The results of our research illustrate the extent and severity of various types of pollution plumes. Maps of plumes will help end users better understand and visualize plume extent and the scale of the affected areas. This work will contribute to long term efforts of predicting pollution plume formation, life cycle, and spatial and temporal distribution. Similarly, data validation and regression models between satellite and in-situ data will allow end product users to better evaluate the use of remote sensing to analyze water quality. The results of this project will provide policy makers with better understanding of the scale and severity of plumes along the southern California coast induced by stormwater and wastewater events. The end products will help to inform future policies pertaining to management and mitigation strategies.

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