Ecosystem recovery of Tampa bay following the 2021 release of phosphate mine wastewater from the Piney Point facility

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## Abstract (150-250 words)

Mining activities can support local and global economies, yet also impose significant consequences for the natural environment. Phosphate mining in central Florida has been ongoing for decades and many facilities present risks to freshwater and coastal aquatic environments in the state. In 2021, a breach in the liner of a wastewater holding pond at Piney Point, a legacy phosphate processing facility, resulted in the emergency discharge of ~815 million liters of highly acidic and nutrient-laden (nitrogen, phosphorus) process water into Tampa Bay. A multi-agency, event-response monitoring program resulted, which documented ecosystem impacts within several months. Short-term declines in water quality were observed, with a notable harmful algal bloom and substantial fish kills occurring three months after the initial wastewater release. Acute spills like the 2021 event threaten past successes, while efforts to mitigate and prevent these negative outcomes in the future are ongoing. This chapter will present the historical context and management of Piney Point as a precursor to the events of 2021, while providing quantitative examples of the bay’s response for interpretation relative to the long-term recovery of the bay. The role of the Tampa Bay Estuary Program as a non-regulatory institution that works to build public and private partnerships for bay management will also be explored, with emphasis on its role coordinating monitoring efforts and disseminating open science communication products.

## 1 Introduction (500-1500 words)

Provide background for the instructor that helps integrate the case study into disciplinary material and, if possible, relate the case study to ABET General Criteria (Student Outcomes 1-7), Program Criteria for Civil Engineering and Environmental Engineering, and general definitions and statements (e.g., ABET’s Statement on Implementing DEI Concepts into Program Criteria). The references in this section should focus on pedagogical aspects of the case study. As Section Editor, I can assist with the latter.

ABET General Criteria Student Outcomes:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. an ability to communicate effectively with a range of audiences.
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Regarding DEI. The ABET information can be found here <https://www.abet.org/about-abet/idea-inclusion-diversity-equity-accessibility/> Social justice issues relevant to the spill could be addressed.

This case study provides an example of the roles and responsibilities of public institutions and private organizations and how they can work together to address environmental problems (Environmental Engineering Program Criterion e)

My notes:

This is about bay management as the engineering challenge - strength of partnerships, key players, and how they work together to manage the bay. What are the threats and challenges to bay management? How has it been effective in the past? What is the role of TBEP and, more generally, research/volunteerism/regulation? This is the engineering problem.

Managing the bay and protecting water quality is the design process, constraints to this are economic, political, and social forces that are at odds with environmental protection

Role of data/monitoring to support bay management - make this a key concept that relates to Piney Point.

Introduce mining as an economic driver in Central Florida, highlight past environmental issues with mining in the region (earlier Piney Point spills, Mosaic/Alafia), also chronic issues with port facilities and fertilizer losses

What is it about fertilizer mining that creates problems? A waste-intensive process… many facilities located near critical infrastructure to support transport (ports)

Introduce Piney Point and events of 2021

In February 1974, a news segment airing on Sixty Minutes drew national attention on the effects of unchecked growth in the Tampa Bay region. Noxious macroalgal blooms, loss of seagrass, and a decline in fisheries were evidence of the effects of this growth as water quality resources were stressed by an increasing human population. The discharge of untreated wastewater into Tampa Bay was a culprit for many of these maladies. Several decades later, external nutrient loads to the bay have been reduced by 2/3 and seagrasses recovered to an all-time high (since recorded) of 41,656 acres in 2016, exceeding the management goal by several thousand acres. Effective management of the natural environment requires dedicated public and private efforts to balance competing interests for how human activities affect natural resources. The contemporary history of Tampa Bay, Florida is an exemplary model for how collaborative efforts can successfully recover a degraded aquatic environment.

The events leading up to the recovery of Tampa Bay are the product of multiple factors, some of which were opportune while others were more intentional. In the 1960s, a growing nationwide environmental movement influenced public sentiment on how unchecked economic growth and development can severely harm the environment. Notable events such as the Cuyahoga River catching on fire and widely read texts like “Silent Spring” were influential factors that motivated change in a national environmental ethic. These sentiments trickled down to Tampa Bay communities as local environmental disasters combined with unfettered growth lead to public calls for regulatory reform and environmental restoration. No longer was it considered acceptable to discharge untreated sewage directly to the bay, as legislation was ultimately passed that required all wastewater treatment plants to upgrade to advanced treatment technologies, in addition to tighter controls on stormwater pollution. These efforts were reinforced at the federal level with enactment of the Clean Water Act in the same year. Gradually and over several decades, water quality in the bay improved and the seagrasses returned.

Local public and private environmental groups continue to be key players in coalescing public support to improve water quality in Tampa Bay. The Tampa Bay Estuary Program (TBEP), in particular, has been a consistent voice over the last three decades that has worked to build partnerships to restore and protect Tampa Bay. This work is implemented through a scientifically sound, community-based management plan. The TBEP is part of a broader National Estuary Program consisting of 28 similar programs around the country that have been established at Congressionally recognized “estuaries of national significance”, each with their own locally-specific mission. Since 1991, the TBEP has worked to engage local communities, private businesses, and local/state government to work towards the common good of a healthy Tampa Bay. The TBEP also manages the Tampa Bay Nitrogen Management Consortium that has worked to reduce nitrogen loads as a key pollutant to the Bay, with a primary source being wastewater and stormwater. The management approach is simple; reduced nitrogen loads will lower algal growth, promoting a light environment in the water that is supportive of seagrass growth. The TBNMC has quantified and allocated sources of nitrogen among public entities that directly or indirectly discharge to the bay, with totals not to exceed based on the capacity of the Bay to assimilate these nutrients. The Florida Department of Environmental Protection (FDEP) maintains regulatory oversight.

Despite the nationally recognized success story of Tampa Bay, current challenges have emerged that threaten past successes and bring into question the effectiveness of existing management paradigms. From 2016 to 2022, seagrasses declined baywide by over 11,000 acres, falling well below the management target of 40,000 acres. These declines were notable because water quality goals were met in successive years of seagrass decline, suggesting that additional factors were driving this loss. Recent interest has shifted towards climate change as a potential culprit as extreme temperatures and changes in precipitation may be stressing seagrasses beyond their optimal tolerance ranges. These additional stressors mean that further improvements in water quality may be needed to account for external climate factors that are difficult, if not impossible, to control at the local scale. Resilience of the bay to assimilate nutrient inputs has likely been reduced as shifting baselines as a result of climate change cause regional managers to reconsider the effectiveness of past targets and thresholds.

Reduced resilience of Tampa Bay to respond to management efforts threatens to undo the years of collaborative efforts in restoring seagrasses. Unanticipated events may push the bay beyond a tipping point to a condition similar to those in the past as the bay may no longer have the capacity to process excess nutrient inputs. The events of March 2021 were a substantial test for the management of Tampa Bay that provided an unintentional system-wide experiment for the bay’s resources respond to acute nutrient inputs. The Piney Point facility is located on the southwest edge of Tampa Bay and is a remnant phosphorus fertilizer processing facility that has been inactive for over twenty years. Central Florida has had a long and complicated history with fertilizer mining that provides a source of economic growth while also having unintended consequence for the natural environment. Piney Point embodies this relationship, as thousands of tons of phosphorus fertilizer has been exported from Port Manatee but unintentional wastewater releases from the facility have harmed the bay’s resources.

In April 2021, a tear in the plastic liner of the southeastern holding pond (NGS-S) at Piney Point was detected and the release of wastewater into Tampa Bay was authorized by FDEP to prevent catastrophic failure of the pond walls. The decision to discharge millions of gallons of wastewater into Tampa Bay from Piney Point was intentional to safeguard property and human life near Piney Point, despite the anticipated environmental consequences. Over 215 millions gallons of wastewater was released, introducing 205 tons of nutrients to lower Tampa over a ten day period, exceeding the amount that is typically introduced in a year. The TBEP, in collaboration with multiple local, regional, and state entities, coordinated a response-based monitoring effort to document the effects of this release on the bay’s resources. Several dramatic effects were observed over the months following the initial release, the most notable being a massive bloom of the red-tide organism *Karenia brevis* that was likely fueled by the nutrient-rich wastewater. Red tide blooms produce a potent neurotoxin that is fatal for wildlife exposed to it for sustained periods. As a result, over 1600 metric tons of dead fish were recovered from Tampa Bay in July 2021.

This chapter will provide an overview of the history of the Piney Point facility and the effects on the bay during and after the wastewater release, including past incidents prior to 2021. This information is presented in the context of the long-term recovery of Tampa Bay, the effects on seagrass resources, and how the history of local partnerships were important for the response-based effort. The reader should have an understanding of how past events influenced the decision to release wastewater to Tampa Bay and what actions can be taken in the future to prevent similar events from occurring. The role of TBEP as a facilitator for bay management will be emphasized and the reader should reflect on how the past activities of the program were important for responding to the Piney Point event, in addition to future challenges for managing bay resources in light of the details presented here.

## 2 Background (1000-2000 words)

Provide background information for the study that relates to the events, design process, etc. Make sure to include sufficient information (including pictures, figures, graphs, etc.) so that a novice (i.e., student) can understand the case study. Include references to the events that allow for the reader to investigate further.

My notes:

History of Piney Point - emphasis on facility management, oversight (or lack of), multiple owners.

Why was there an emergency discharge?

What was the response - monitoring effort and environmental (short-term, red tide, present), legal outcomes

What did TBEP do? updates, facilitate monitoring, dashboard, media requests

long-term closure plan for piney point, other facilities in the region - deep well injection, disposal of phosphogypum via road construction? Piney Point well may be precedent for future activities, but still a lot of unknowns, related to groundwater/drinking water?

Figures:

* map
* water quality
* red tide
* seagrass/macro?
* fisheries (we now have good nekton data to report)

## 3 Student Activities (500-1000 words)

### 3.1 Classroom discussion questions

Include at least 3 discussion questions based on the case study that can be used in a classroom situation.

My notes:

Something about communication/transparency of information

Something about history of past partnerships, why were they so important

Something about reactive v proactive, i.e., Piney Point was a disaster waiting to happen, but somethign was only done once it happened. What are the forces at play that prevent proactive action?

### 3.2 Individual student responses

Include at least 3 questions/prompts based on the case study that can be used in a homework assignment or on an exam. These could include further reading (be sure to provide references to readily available materials) or personal reflections.

My notes:

Something about interpretation of the figures/tables in this chapter

## 4 Conclusion (500-1000 words)

Include a discussion of key take-aways.

My notes:

Bring everybody to the table (highlight Mosaic’s role in the TBNMC)

Something about resiliency and the bay’s ability to recover from this event

## References