Piney Point Phosphate Plant: An Environmental Analysis

BY
Carl Henderson

University Honors Program
University of South Florida
St Petersburg, Florida

CERTIFICATE OF APPROVAL

Honors Thesis

This is to certify that the Honors Thesis of

Carl Henderson

has been approved by the Examining Committee
on August 9, 2004
as a satisfactory for the thesis requirement
for the University Honors Program

Examining Committee:

Thesis Director: Melanie Riedinger-Whitmore, Ph.D.
Professor, College of Arts and Sciences

Thesis Committee Member: Raymond Arsenault, Ph.D.
Professor, College of Arts and Sciences

Thesis Committee Member: Peter Swarzenski, Ph.D.
Geochemist, United States Geological Survey

Piney Point Phosphate Plant:
An Environmental Analysis

By

Carl S. Henderson

A thesis submitted in partial fulfillment
of the requirements of the
University Honors Program
University of South Florida, St Petersburg

July 27, 2004

Thesis Director: Melanie Riedinger-Whitmore, Ph.D.
Professor, College of Arts and Sciences

Acknowledgments

I would like to thank Dr. Melanie Riedinger-Whitmore, Dr. Peter Swarzenski, Dr. Raymond Arsenault, and Dr. Andrew Price-Smith for their editing of and assistance with this project. I would further like to thank George and Lynn Carol Henderson for their support and love. I would also like to acknowledge Lisa Fish for her huge contribution to the structural integrity of this work, as well as for her near saintly patience.

Table of Contents

Illustrations

Tables

Introduction

The Piney Point Phosphate Facility declared bankruptcy in late 2000, and in doing so left the state with the "gravest environmental threat ever" in the words of Assistant Director of the Department of Environmental Protection Alan Bidwell.[1] The company that owned Piney Point, Mulberry Phosphate Inc., formed in 1993 with investor capital and management formed from several long term industry executives and phosphate investors. The new conglomerate pledged to run the plant with environmental awareness at all times, in compliance with local and national laws. Mulberry Phosphates Inc. purchased both Piney Point and a still operational mining plant at Mulberry, Florida (the Mulberry Facility).[2,3] Within three years of its new ownership, the facility in Mulberry experienced a dike failure at a wastewater containment pond and 55 million gallons of highly acidified wastewater flowed into the Alafia River.[4] In four hours, this industrial process water contaminated several miles of the Alafia., According to the Department of Environmental Protection, nearly all fish and aquatic vegetation within this zone were killed. The company was assessed several million dollars for natural resource damages, and warned that litigation would follow if plant operations and oversight were not improved. What to this day remains unclear is how a company already under public and governmental scrutiny was able to only sporadically operate, make no substantive public improvements to their facilities, and within five years, declare bankruptcy and abandon the plants. Among the consequences was a towering lagoon of wastewater threatening to overflow its earthen berm after a strong rain, and discharge as much as one billion gallons

nutrient and metal rich acidic wastewater into Bishop's Harbor and Greater Tampa Bay.[5,6] This was in 2002.

Now in 2004, the Piney Point Phosphate Plant remains in bankruptcy proceedings and seems unlikely to be taken out of bankruptcy or sold any time in the near future.[7,8] By the end of 2004, according to a Florida Department of Environmental Protection estimate, the agency will spend 150 million dollars maintaining and disposing of Piney Point's phosphogypsum wastewater through 2009.[9] Continued decommissioning of the plant is a practical necessity, but the immediate risk that Piney Point posed to the health of the Tampa Bay region in 2001-2003 has greatly diminished. Yet the controversies and contentious policy decisions that plagued the DEP from day one are both precedent-setting and likely to have mixed long-term results.[10, 11]

The highly acidic wastewater in question is a by-product from processing phosphate rich deposits of limestone and silica bedrock. After chemical extractions using sulfuric acid are performed on these rocks, the wastewater becomes more acidic and gains high levels of heavy metals, including arsenic, cadmium, lead, and an assortment of short and long lived radioisotopes such as Uranium 238, Radium 226, 224, and Bismuth - 214, previously held in the rock.[12] Due to the possible threat to human and environmental health if Piney Point's wastewater structures should collapse, the EPA approved an emergency permit in 2003 to dump up to 375 million gallons of partially-treated wastewater into the Gulf of Mexico.[13] This unprecedented action to allow dumping despite international treaties protecting international waters created several legislative and international hurdles.[14] While these obstacles were ultimately overcome, the project's permits continue to evoke criticisms from citizens and stakeholders and raise further

questions about the viability of global environmental legislation and ongoing international projects.[15,16]

The Florida phosphate industry responded to the bankruptcy and potential for environmental disaster at Piney Point by promoting a contingency plan using an environmental trustfund created to restore damaged mining lands.[17] This trust's funding originates from phosphate severance taxes; in fact, the recent scrutiny on phosphate mining operations has resulted in industry acceptance of several measures, including tax increases, which they had opposed throughout the 1990s.[18] In regard to Piney Point, other operators are openly distancing themselves from the bankrupt plant and emphasizing that Piney Point is an isolated incident. However, as a way to help reduce the wastewater containment issues at Piney Point, other phosphate companies such as Cargill have accepted small wastewater shipments.[19]

The environmental concerns that the Piney Point Bankruptcy created were never an immediate concern because in previous instances where phosphate mining and chemical companies entered into bankruptcy proceedings, they were repeatedly bought out by other companies in the area. This practice has been part of the longstanding "boom and bust" for Florida mining, but as environmental regulations have become tighter and foreign competition in Northwest Africa and the former Soviet Union has increased, the Florida industry contains very few phosphate corporations.[20, 21] Even these remaining conglomerates may soon be restructured. One prominent analyst working for the state of Florida, Pamela Peterson, found that among the top five (and primary) phosphate companies with operations in Florida, three failed to meet corporate health criteria determined by the state investigative team, with the other two questionably stable over

the long term.[22] Despite the industry's denials of these findings, both the public and private sectors remain unconvinced, and seem to desire an economy based more on tourism, natural beauty, and agricultural profitability instead of phosphate.[23] This bodes ill for the expansion that the phosphate industry is seeking on permits in Hardee, DeSoto, and other South Florida counties.[24, 25]

Historically, development issues were less contentious. The industry was once largely unregulated. Before air conditioning and the popularity of Disney World, phosphate mining and chemical processing operated throughout rural central Florida, with most major mining and rendering taking place within the limits of Polk, Hillsborough, and Manatee Counties.[26] Political agreements and tax reduction packages regularly were used to encourage expansion, since phosphate mining was so lucrative.

The Piney Point Facility, situated just inside the borders of Manatee County and adjacent to Bishop Harbor and the Tierra Ciea Aquatic Preserve, was solely devoted to fertilizer production. Cost savings were anticipated by the location, which was placed closer to Tampa Bay and high-density population centers than the other facilities.[27] In the 1950s and 1960s, members of the fertilizer industry speculated that operational expenses might be lowered by locating fertilizer rendering plants (ore to fertilizer) nearer to the ports on Tampa Bay. While this scenario has never demonstrated cost savings, it has left a legacy of Superfund sites (areas where federal sponsorship has paid for toxic cleanup due to active public health risk) across Hillsborough and Manatee County.[28]

Another facility of recent interest has been the Coronet Plant in Hillsborough County. Because of ongoing litigation alleging fluorine water contamination within local supply lines and wells, Coronet further sensitizes the public to development risks. The

cattle and citrus producers of the 1950s were the first to demand regulations of air emissions and water discharges, due to incidents of citrus chlorinosis and cattle deaths from fluoridosis. However, the government was loathe to give itself more stringent regulatory capabilities up until the environmental movements of the 1960s and 70s. After the 1972 Federal Water Pollution Control Act, enforcement actions were taken with expanded regulatory authority and additional monitoring budgets that increased later in the decade.[29]

The failure and environmental risks presented by the Piney Point bankruptcy and closure has unnerved long-term residents, and perhaps more importantly, shocked many of the newer more urban residents of Hillsborough and Pinellas Counties with the extent of phosphate development and its proximity to their lives and immediate environment.[30] Phosphate producers work hard to promote themselves as environmentally friendly and economically important, but Piney Point's closure has led several groups to call for the industry to phase out of Florida entirely, regardless of its economic impact. Leaving Florida is actually the long-term industry-developed plan due to greater profit potential in Tunisia and other areas of North Africa.[31] Before this can take place, the industry must resolve issues such as transport and market share. Analysts anticipate that the transition will take place between 2010 and 2025.

Another event unnerving to residents was a string of highly visible Red Tide outbreaks along Tampa Bay and the Gulf Coast in the summer of 2003. Large fish kills and respiratory irritation are common in *Karina Brevis* outbreaks, resulting in huge short-term economic losses for the tourism and service industry.[32] At the time, the EPA had recently approved its permitting for nutrient-rich water disposal into the Gulf.[33] Smaller-

scale studies on nutrient enriched wastewater have correlated nutrient influx with an increased growth factor of dinoflagellates (Red Tide) and harmful macroalgae blooms.[34] It should be noted, however, that these events occurred before nitrogen and phosphorus rich wastewater from Piney Point were actually dumped into the Gulf, and that the wastewater discharges occurred after the Red Tide events.

In the past, large-scale controversies, involving Central Florida's third largest industry (after tourism and citrus), were largely overlooked due to its profitability. However, as population changes occur and water resources become increasingly managed, the phosphate industry will most likely incur greater scrutiny and criticism. Now that the imminent wastewater and bankruptcy crisis has been abated for another year, we have time to reflect and assess the damage created by this scandal. What created the Piney Point bankruptcy? Did we as citizens and policymakers have indicators that mismanagement was occurring? What is Piney Point's history? Did this history provide us any clues that so much expense and possible damage was in the offing from a medium-sized agribusiness factory on US 41, just south of Hillsborough County? This paper will outline the state's environmental response, before and after Piney Point's bankruptcy, and address the status and future of the Piney Point plant, as well as the Florida phosphate industry.

[1] Craig Pittman, Julie Hauserman, and Candice Rondeaux, "Bending the Rules at Piney Point: A $140 Million Mess," St. Petersburg Times, 6 July 2003, sec. A1.

[2] Tom Palmer, "Shuttered Property: More Than Two Years After Shutdown, Mulberry Phosphates Sits In Bankruptcy, Land in Limbo," Lakeland Ledger, 10 March 2002, sec. A.

[3] "Phosphate Fiascoes: Hillsborough Plant's Problems Show Need for Comprehensive Study," Sarasota Herald Tribune, 4 August 2003, sec. A8.

[4] Environmental Protection Commission of Hillsborough County, Florida Department of Environmental Protection, National Oceanic and Atmospheric Administration, Polk County Natural Resources, and U. S. Fish and Wildlife Service, Final Damage Assessment and Restoration Plan and Environmental Assessment for the December 7, 1997 Alafia River Spill, 21 July 2000.

[5] "Phosphate Dangers Pile Up," Sarasota Herald Tribune, 19 July 2003, sec. A.

[6] Victoria Parsons and Mary Kelley Hoppe. "Piney Point: back from the brink?" Tampa Bay Soundings, summer 2002, 1, 6-7.

[7] Florida Department of Environmental Protection, "Piney Point status update." Memo, 8 June 2004.

[8] Florida Department of Environmental Protection, "Piney Point status update." Memo, 11 May 2004.

[9] Florida Department of Environmental Protection, "Piney Point status update." Memo, 25 April 2003.

[10] Scott Carroll and Victor Hull, "Piney Point Controversy, Wastewater Still Flowing: Toxin's Effect On Gulf Unknown," Sarasota Herald Tribune, 4 July 2003, sec. B.

[11] Scott Carroll, "Rain Re-Elevates Waste Problems At Piney Point," Sarasota Herald Tribune, 12 August 2003, Metro 3.

[12] Florida Department of Environmental Protection. Piney Point status update. Memo, 7 May 2002.

[13] Steven Isbitts, "No Harm Evident As Waste Dumping Continues In Gulf," Tampa Tribune, 7 July 2003, sec. B.

[14] WMNF, Interview with…., on 1:00 Call-In Show, (date)

[15] James Connelly and Graham Smith, Politics and the Environment: From Theory to Practice (New York: Routledge, 1999), 160.

[16] Walter A. Rosenbaum, Politics and the Environment: Politics and Policy, 5th ed (Washington, D.C.: CQ Press, 2002), 345, 347-53.

[17] Charlie Hunsicker, <charlie.hunsicker@co.manatee.fl.us> "Draft letter for congressional appropriations (edited)," 16 April 2002, personal email to Melissa Klein <mel.klein@fpl.com> (14 June 2004).

[18] David Wasson, "Phosphate Makers Moving Closer to Tax Increase," Tampa Tribune, 25 October 2003, sec. B.

[19] Power point presentation on cd.

[20] Andrew Meadows, "Searching for New Digs," Tampa Tribune, 4 Nov 2002, sec. D.

[21] Michael Sasso, "Phosphate Faces Challenges; Experts Say Competition Abroad and Public Opposition Plagues the Industry," Lakeland Ledger, 19 October 2003, sec. E.

[22] Craig Pittman, "Phosphate Companies Don't Measure Up," St. Petersburg Times, 20 Sep 2003, sec. B.

[23] Michael Sasso, "Phosphate Faces Challenges; Experts Say Competition Abroad and Public Opposition Plagues the Industry," Lakeland Ledger, 19 October 2003, sec. E.

[24] Kevin Bouffard, "IMC Phosphate Requests Delay of Florida Mine Review," Lakeland Ledger, 29 July 2003.

[25] Kevin Bouffard, "Official Says Florida Phosphate-Mining Industry's Future in Doubt," Lakeland Ledger, 18 October 2002.

[26] Scott Dewey, Don't Breathe the Air: Air Pollution and U.S. Environmental Politics, 1945-1970 (College Station: Texas A&M Press, 2000).

[27] Robert Trigaux, "Executives Turn their Backs on the Piney Point Disaster," St. Petersburg Times, 18 August 2003, sec. E.

[28] EPA website, PIRG

[29] Jacqueline Vaughn Switzer, Environmental Politics: Domestic and Global Dimensions, 3rd ed. (Boston: Bedford/St. Martin's Press, 2001), 177.

[30] Rick Barry, "The Spoonfuls of Wastewater are Adding Up," Tampa Tribune, 31 August 2003, sec B.

[31] Guerry H. McClellan and James L. Eades, "The Economic and Industrial Minerals of Florida," in The Geology of Florida, eds. Anthony Randazzo and Douglas S. Jones (Gainsville, FL: University of Florida Press, 1995).

[32] Karen A. Steidinger, "Basic Factors Influencing Red Tides." First International Conference on Toxic Dinoflagellate Blooms. (Boston: Massachusetts Science and Technology Foundation, 1975), 153-162.

[33] Florida Department of Environmental Protection. Request for emergency permit under the Marine Protection, Research and Sanctuaries Act (Tallahassee, FL: Feb 2003).

[34] Karen A. Steidinger, "Implications of Dinoflagellate Life Cycles on Initiation of Gymnodinium breve Red Tides." Environmental Letters 9, no. 2 (1975): 129-139.

Chapter 1. The Geochemical Production of Florida Phosphate

The geology of Florida and the ways that biological organisms use phosphate shaped the availability and high concentration of phosphoric rock within the state of Florida and created the industrial impetus for commercial fertilizer production. Carbonate formations make up the bulk of Florida's bedrock.[1] These comprise Karst formations and other manifestations of limestone deposition.[2] Limestone is highly prevalent as Florida bedrock and tends to give alkalinity to Florida waters. However, dispersed sands, quartzes, dolostones, and clays are interspersed through Florida's predominantly carbonate sediments.[3] Phosphates are found within these rock types.[4] Igneous rocks may be found below the sediments but since igneous deposition occurred more than 400 million years ago, this rock type is not found with most igneous rocks.[5] In contrast, the highly concentrated phosphate deposits throughout central Florida were formed by a series of tectonic upheaval and nearshore oceanic changes in the Cenezoic period (last 65 million years), and more specifically the Neogene era.[6]

One key feature of the development of phosphoric rock has been the variability in local sea level over the last 65 million years. Several dramatic sea level fluctuations resulted in vastly different shapes and sizes for prehistoric Florida.[7] At one point, Florida was completely underwater, and it later extended more than 100 miles further into the gulf. These types of changes, and the geomorphological alterations that go along with sea level change, governed limestone formation and contributed to nutrient availability on land and in the ocean.[8]

Before the beginning of the Holocene (approximately 11,500 BP) and alternating throughout geological history, the portions of Florida that were underwater supported abundant marine flora and fauna.[9] These organisms were eventually deposited as sediments or were transported by currents to deeper portions of the Gulf of Mexico. Carbonate life forms such as corals, foraminifera, and coquinas generated sediments rich in organic phosphates,[10] because these organisms sequestered phosphorus from the ocean for use in cellular processes. Because these micro-organisms accumulate phosphates, (PO_4^{-3} or $P_2O_5^{-4}$), when they die their reserves of chemical bound phosphate remain in their calcium carbonate ($CaCO_3$) skeletons. These skeletons, washed into the deeper portions of the Gulf of Mexico or the Atlantic Ocean and dissolved under pressure and heat, release the phosphates.[11] During the Neogene era of the Cenozoic Period, erosion and tectonic activity contributed large quantities of siliclastic sediments from the Appalachian Highlands into the Gulf of Mexico.[12, 13] At this time, a change in currents due to a warming trend created deep-water upwelling in the Gulf of Mexico. This nutrient-rich water spurred high planktonic growth in shallower waters, leading to anoxic conditions along the coast of Florida. Plankton die-offs and the presence of anoxia in saltwater environments changed the oxidation state for many types of heavy metals being deposited from the erosion of the Appalachians.[14, 15] These metals became cationically associated with the soluble phosphates and iron.[16] Minerals released by the planktonic die-offs, in hypoxic or anoxic water, underwent reformation with Silica (clay), suspended fluorides, and other heavy metals coming from inland.[17] It is from an assortment of chemical reactions among these different molecules and elements that Calcium Fluoroapatite (apatite) was formed. Loosely bound apatite found within larger sediment

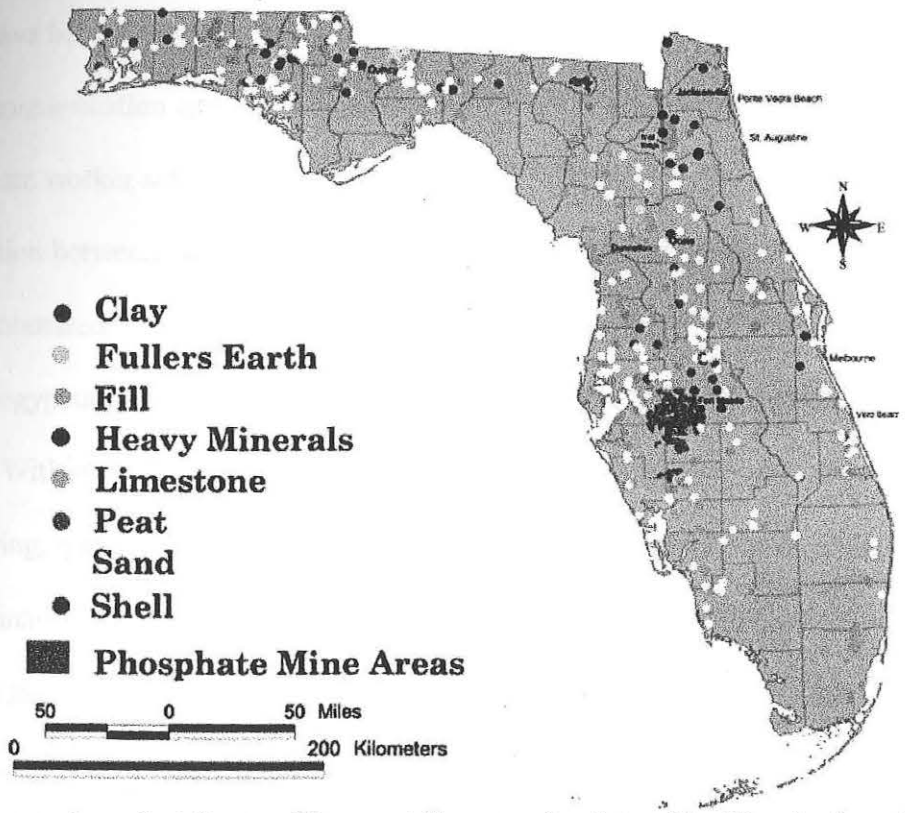
deposits represents the bulk of commercially valuable phosphates.[18] Apatite's chemical formula of $Ca_3 \cdot (F \cdot Cl) \cdot (PO_4)_3$ indicates the binding of Ca, P, Fl, and Cl, in a mineralized matrix.[19] When there are high concentrations of Magnesium, sometimes found with sedimentary flux, or when silica is lacking, dolostone ($CaMg(C0_3)_2$) or limestone ($CaC0_3$) may form instead of apatite.[20] The high concentrations of silica needed for apatite occur only rarely without a nearby source of mountainous erosion, which is why the bulk of Florida's sediments do not contain high quantities of phosphate.[21]

Other than small, high-density regions in eastern North Carolina, Florida has the greatest density of phosphoric rock in North America.[22] There are large-scale but poor concentration deposits spread across eastern Canada, and more recently western US deposits in Idaho and Wyoming have become commercially available. With most of the Canadian and northern deposits, there are vastly different geological histories contributing to phosphate formation.[23]

The world's largest deposits are found in North Africa, and they too were formed by a similar process as in Florida and North Carolina. During the Neogene, what is now the Mediteranean marked the edges of a large sea separating Eurasia from Africa, the Tethys Sea. Upwelling currents moving in a Westerly direction flowed against the North African region where erosion from the Morroccan and Spanish Highlands was already taking place.[24] Similar to Florida, the creation of a diagenic ooze comprised of shales, dolostone, and limestone eventually formed thick deposits in what is now Mauritania, Tunisia, and Morrocco, though like much of the Southern United States, lower grade deposits exist elsewhere along the North African Coastline and in Saudi Arabia.

Phosphoric rocks found in Florida are predominantly sedimentary rocks but some deeper deposits undergo significant metamorphoric reworking. Phosphoric rocks are often contained within larger deposits of sand, clay or quartz, and very often are accreted or otherwise held in a sedimentary matrix.[25] Near surface deposits of apatite, metamorphically compressed and concentrated, are especially prevalent in and along central Florida's riverbeds and wetlands, where erosional processes expose areas where

Fig. 1. Map of Florida extractive industries. Source: FDEP.



apatite was deposited from gulf current flows coalescing with silicaclastic sediments.[26]

Another environmentally relevant aspect to central Florida phosphate deposits is their high concentrations of naturally occurring Uranium and heavy metals. Although phosphate was deposited throughout the Neogene era, a high productivity period is found in the Hawthorn group sediments.[27] Hawthorn group sediments contain very high natural uranium concentrations from Appalachian erosion and a period of pronounced Gulf

upwelling. These, along with Bone Valley deposits, named for high fossil concentrations associated with phosphate, have been mined extensively in Polk, Hillsborough, and Hardee County.[28] While Uranium levels are not a problem when mining, concentrating and chemically altering the concentrated phosphoric rock creates commercially unusable phosphogysum bi-product with low level radioactivity.[29] This radioactivity comprises Ur 238, 235 and associated daughter isotopes. Radium 226 and Rn 222 tend to present the largest management issues and be of greatest concern to human health.[30] Specifically there have been concerns that this radioactivity poses a health hazard through potential water contamination and to phosphate workers.[31, 32] Many of these concerns about phosphate worker safety concerns have never been scientifically proven, though the correlation between long term exposure of sulfuric acid and various forms of cancer can be corroborated.[33] Phosphate companies and their lobbyists have attempted to reclassify phosphogypsum as non-hazardous, but so far legislative changes are not forthcoming.[34]

Within the combined processes of phosphate mining, commercial concentration and drying, and chemical alteration by sulfuric acid, land, air and groundwater contamination are possible.[35] Early mining techniques and production lacked many of modern mining's risks, although risks to workers were high.

In the late 1800s early efforts to mine central Florida led to various mining techniques for different types of apatite deposits. Hard-rock mining was one widely used method. In hard-rock mining, large amounts of surface overlay are removed, and concentrated phosphate deposits, often in the form of thin underground veins, are extracted. River-rock mining uses barges to remove pebble to boulder sized chunks of apatite which are exposed by a river or tributary. Similarly, "land pebble" mining

operates like river rock mining except it uses rock that has been exposed on land. All of these techniques originally utilized shovels, pickaxes, and a great deal of manual labor.[36, 37] Modern day matrix mining is a combination of "land pebble" mining and hard rock mining, where lower-grade deposits of many types are extracted together with massive draglines, and then separated at a nearby factory.

Fig. 2. A photograph of a site rich in land pebbles (white). Source: Florida Geological Survey

From the earth-moving operations of the modern dragline, raw ore is normally piped as a water slurry to a beneficiation plant. At this beneficiation plant the phosphoric rock is separated from shales, sands and clays by several methods, depending on what grade of product is needed..[38] Sometimes called washing stations, all beneficiation plants operate using one or more filter systems to separate out the larger stones and pebbles of phosphoric origin and secondary techniques to recover the smaller particles. Mechanical and electric vibrating screens, centrifugation, sand traps in the slurry line, and hydraulic classification are some of the major methods used in separation.[39]

Hydraulic classification and floatation systems have created what are often known as "slime ponds" and have been one of the phosphate industry's most obvious

environmental impacts for the last 80 years. Slime ponds became more prevalent after the 1920s, when it was discovered that small phosphate particles could be separated from even smaller clay particles by controlling settling rates in artificially created ponds.[40, 41] This allows recovery of phosphoric rock smaller than 0.033 inches across, but leaves a long-term legacy of clay wastewater ponds, which may take several years to dry up or drain.[42]

Fig. 3. Washing station, Polk County. Source: Florida Geological Survey.

At this point in the industrial process, fertilizer grade phosphate is extracted from the concentrated ore at a separate chemical processing plant, such as the Piney Point Facility. After the ore has been piped or otherwise brought into the fertilizer plant, sulfuric acid or sometimes nitric acid is used to saturate the ore and convert it into phosphoric acid.[43] Nitric acid is rarely used in the United States and never in Florida because it is more expensive. Heat could also be used, but creating temperatures high enough to form phosphoric acid from apatite would be very costly. For these reasons, sulfuric acid is used almost exclusively at phosphate agri-chemical plants in the US.[44]

The ore must be converted to phosphoric acid to release the bound fluoride in the apatite, allowing the phosphate to become bioavailable. At this point, superphosphate (in bold) is formed.

$$Ca_3(PO_4)_2 + 2H_2SO_4 + H_2O \rightarrow 2CaSO_4 + \mathbf{CaH_4(PO_4)_2 \cdot (H_20)}$$

This is a mono calcium bound phosphate with approximately 15% bioavailability. "Triple super," the most common fertilizer-grade phosphate formulation, is produced in the next stage.

$$Ca_3(P0_4)_2 + 4H_3P0_4 + 3H_20 \rightarrow \mathbf{3CaH_4(PO_4)_2 \cdot H_20}$$

Triple superphosphate takes the previously reacted superphosphate, and adds additional phosphoric acid to un-reacted phosphate rock. This yields triple super phosphate (in bold), with approximately 45% bioavailable phosphate.[45] However, if some of the lesser constituents of apatite, such as fluorine, are made available this stage allows phosphoric acid to react with calcium fluoride, forming gaseous fluorine, which is highly reactive and hazardous.[46]

For many chemical processing plants, such as Piney Point, Diammonium Phosphate (NH4H2PO4) is the desirable end product because it is more stable and the most biologically useful.[47] It can be formed with the addition of anhydrous ammonia to "triple super" but neccessitates the use of scrubbers to limit ammonia emissions.

These reactions leave one major wasteproduct, gypsum ($CaSO_4\ H_20$) with loosely associated phosphates, creating phosphogypsum ($CaSO_4\ H_20$) $\cdot$ ($P0_4$). Fluorine gas and radioisotopes must also be managed through scrubber technology and particle extraction. This does not reduce the radioisotope load fully and the gypsum produced from these reactions must be stored onsite because of its mild radioactivity. Standard landfills cannot accept the waste, and it cannot be totally reclaimed because of elevated radon levels and other Uranium progeny.[48] For these reasons, agrichemical plants stack phosphogypsum in large mounds next to the facility. These waste mounds are called "gypstacks" and may reach thirty meters high and several hundred meters long.

These gypstacks create a huge management problem, but part of their usefulness has been in conserving water for the agrichemical plant. They collect rain water which the plant may use at a later date. Like other phosphate chemical plants, Piney Point normally consumes more water than it collects.[49] Without a way to conserve and collect water used in the conversion to diammonium phosphate, our modern method of phosphate extraction would be prohibitively expensive. In this respect gypstacks serve a dual purpose. They allow companies to minimize water usage, and gypstacks are mandated by law because of their potential toxicity. However gypstacks require maintenance and active phosphate processing. This way the gypstack wastewater does not overflow the stack structure, and release several hundred million gallons of highly acidified water. This was the risk that Piney Point presented to Tampa Bay.[50]

[1] William Burnett and Alan Elzerman, "Nuclide Migration and Environmental Radiochemistry of Florida Phosphogypsum," Journal of Environmental Radioactivity 54 (2001): 27-51.

[2] Arch Fredric Blakey, The Florida Phosphate Industry: A History of the Development and Use of a Vital Mineral (Cambridge: Harvard University Press, 1973), 25-30.

[3] P. M. Rutherford, M. J. Dudas, and R.A. Samek, "Environmental Impacts of Phosphogypsum," Science of the Total Environment 149 no. 1-2 (1994): 1-38.

[4] Anthony Randazzo, "The Sedimentary Platform of Florida," in The Geology of Florida, eds. Anthony Randazzo and Douglas S. Jones (Gainsville, FL: University of Florida Press, 1995), 39-56.

[5] Kurt Andrew Grimm, "Phosphorites Feed People: Finite Fertilizer Ores Impact Canadian and Global Food Security," Dr. Kurt A. Grimm personal website <http://www.eos.ubc.ca/personal/grimm/phosphorites.html> (1 July 2004), Phosphorites Feed People.

[6] Ed Lane, ed, "Special Publication No. 35: Florida's Geological History and Geological Resources," Florida Geological Survey, 1994, <http://www.clas.ufl.edu/users/guerry/GLY4155/sp35/Fgs35.HTM> (26 June 2004)

[7] Thomas M. Scott, et al. "Geologic Map of the State of Florida," South Florida Information Access, Florida Geological Survey, 2001, <http://sflwww.er.usgs.gov/publications/maps/florida_geology/> (2 July 2004).

[8] Tom Garrison, Oceanography: An Introduction to Marine Science, 4th ed. (Pacific Grove, CA: Wadsworth/Thomson Learning, 2002).

[9] "Florida's Geologic History," Florida Department of Environmental Protection, 2004, <http://www.dep.state.fl.us/geology/geologictopics/geohist.htm > (1 July 2004).

[10] John P. Smol, Pollution of Lakes and Rivers: A Paleoenvironmental Perspective. Key Issues in Environmental Change, vol. 5 (New York: Oxford University Press, 2002).

[11] P. J. Cook and J. H. Shergold, eds., Phosphate Deposits of the World: Proterozoic and Cambrian Phosphorites, vol 1 (Cambridge: Cambridge University Press, 1986).

[12] Ed Lane, ed, "Special Publication No. 35: Florida's Geological History and Geological Resources," Florida Geological Survey, 1994, <http://www.clas.ufl.edu/users/guerry/GLY4155/sp35/Fgs35.HTM> (26 June 2004).

[13] J. Michael, "Redistribution of Uranium and Thorium Series Isotopes during Isovolumetric Weathering of Granite," Geochimica Cosmochimica Acta 48 (1984): 1249-1255.

[14] Peter W. Swarzenski, et al, "The Behavior of U- and Th-series Nuclides in the Estuarine Environment," in Uranium-Series Geochemistry, eds. B. Bourdon et al, Reviews in Mineralogy and Geochemistry, (Washington, D. C.: Mineralogical Society of America, 2004).

[15] B. Bourdon, et al, "Introduction to U-Series Geochemistry," Reviews in Mineral Geochemistry 52 (2003): 1-21.

[16] Jacob Kalff, Limnology: Inland Water Ecosystems (Upper Saddle River, NJ: Prentice-Hall, Inc., 2002).

[17] S. P. Singh, L. Ma, and W. G. Harris. "Heavy Metal Interactions with Phosphoric Clay: Sorption and Desorption Behavior," Journal of Environmental Quality 30, no 6 (2001).

[18] A. N. Sharpley, "Soil Phosphorus Dynamics: Agronomic and Environmental Impacts," Ecological Engineering 5 (1995): 2-3.

[19] C. D. Hull and W. C. Burnett, "Radiochemistry of Florida Phosphogypsum," Journal of Environmental Radioactivity 32, no. 2 (1996): 213-238.

[20] P. Mislevy and W. G. Blue. "Reclamation of Quartz Sand Tailings From Phosphate Mining," Journal of Environmental Quality 10 no. 4 (1981): 449-453.

[21] C. D. Hull and W. C. Burnett, "Radiochemistry of Florida Phosphogypsum," Journal of Environmental Radioactivity 32, no. 2 (1996): 213-238.

[22] Blakey, The Florida Phosphate Industry.

[23] P. J. Cook and J. H. Shergold, eds., Phosphate Deposits of the World: Proterozoic and Cambrian Phosphorites, vol 1 (Cambridge: Cambridge University Press, 1986).

[24] "Diammonium Phosphate (DAP) Production from Saudi Arabian Phosphate Deposits,"Azom.com: The Premier Online Materials Information Site, 2004, <http://www.azom.com/details.asp?ArticleID=2083#_Origins_of_Phosphate> (10 March 2004).

[25] Guerry H. McClellan and James L. Eades, "The Economic and Industrial Minerals of Florida," in The Geology of Florida, eds. Anthony Randazzo and Douglas S. Jones, 139-154.

[26] Florida Institute of Phosphate Research, "How Was Phosphate Desposited in Florida?" FIPR Website, 2001 <http://www.fipr.state.fl.us/southa_why_do_we_mine_phosphate.htm> (3 July 2004): FAQ.

[27] Thomas Scott, "Miocene to Holocene: History of Florida," in The Geology of Florida, eds. Anthony Randazzo and Douglas S. Jones (Gainsville, FL: University of Florida Press, 1995), 60-61.

[28] Sam B. Upchurch and Anthony Randazzo, "Environmental Geology of Florida," in The Geology of Florida, eds. Anthony Randazzo and Douglas S. Jones, 240-241.

[29] C. D. Hull and W. C. Burnett, "Radiochemistry of Florida Phosphogypsum," Journal of Environmental Radioactivity 32, no. 2 (1996): 213-238.

[30] Curtiss Travis, et al, "Cancer Risk Management: A Review of 132 Federal Regulatory Decisions," Environmental Science and Technology 21 (1987): 415-420.

[31] H. Checkoway, N. J. Heyer, and P. A. Demers, "An Updated Mortality Follow-up Study of Florida Phosphate Industry Workers," American Journal of Industrial Medicine 30 no. 4 (1996): 452-460.

[32] G. J. McNabb, J. A. Kirk, and J. L. Thompson, "Radionuclides from Phosphate Ore-Processing Plants: Environmental Impact after 30 Years of Operation," Health Physics 37 no. 4 (1979).

[33] Nalini Sathiakumar, et al, "Epidemiological Evidence on the Relationship between Mists Containing Sulfuric Acid and Respiratory Tract Cancer," Critical Reviews in Toxicology 27 no. 3 (1997): 233-251.

[34] D. Martin, P. Dorris, and D. Sumpter, "Environmental Impacts of Phosphoypsum vs. Borrow Pits in Roadfill Construction," Journal of Environmental Science and Health: Toxic/Hazardous Substances & Environmental Engineering 36 no. 10 (2001).

[35] Scott H. Dewey, "The Fickle Finger of Phosphate: Central Florida Air Pollution and the Failure of Environmental Policy, 1957-1970" The Journal of Southern History 3 (1999): 565-603.

[36] Garnault Agassiz, "Florida in Tomorrow's Sun," Suniland 3, no. 2 (1925): 37-45, 88-94, 113-133.

[37] Blakey, The Florida Phosphate Industry.

[38] Florida Institute of Phosphate Research, "How Was Phosphate Desposited in Florida?" FIPR Website, 2001 <http://www.fipr.state.fl.us/southa_why_do_we_mine_phosphate.htm> (3 July 2004): FAQ.

[39] IMC Global, "Phosphate Production Techniques," IMC Global Website, 2001 < http://www.imcglobal.com/general/education_corner/phosphates/techniques.htm> (4 July 2004): Education Corner.

[40] Glenn Compton, Bradenton Sun Herald, 21 October 2003, Letter to the Editor.

[41] Michael Connet, "The Phosphate Fertilizer Industry," Fluoride Action Network Website, May 2003 <http://www.fluoridealert.org/phosphate/overview.htm> (3 July 2004).

[42] Blakey, The Florida Phosphate Industry.

[43] "Phosphate Rock Processing," Mineral Products Industry, United States Environmental Protection Agency, January 1995, <http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s21.pdf> (19 June 2004).

[44] "Ammonium Phosphate," Inorganic Chemical Industry, United States Environmental Protection Agency, January 1995, <http://www.epa.gov/ttn/chief/ap42/ch08/final/c08s05-3.pdf> (19 June 2004).

[45] "Phosphate Rock Processing," Mineral Products Industry, United States Environmental Protection Agency, January 1995, <http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s21.pdf> (19 June 2004).

[46] Blakey, The Florida Phosphate Industry.

[47] "Diammonium Phosphate (DAP) Production from Saudi Arabian Phosphate Deposits,"Azom.com: The Premier Online Materials Information Site, 2004, <http://www.azom.com/ details.asp?ArticleID=2083#_Origins_of_Phosphate> (10 March 2004).

[48] Sam B. Upchurch and Anthony Randazzo, "Environmental Geology of Florida," in The Geology of Florida, eds. Anthony Randazzo and Douglas S. Jones, 240-241.

[49] Cargill Saving Taxpayer's Money

[50] Craig Pittman, Julie Hauserman, and Candice Rondeaux, "Bending the Rules at Piney Point: A $140 Million Mess," St. Petersburg Times, 6 July 2003, sec. A.

Chapter 2. A Social History of the Florida Phosphate Industry

Throughout the first half of the Nineteenth Century, European chemists began utilizing acid-base chemistry to extract phosphate, nitrites, and elemental metals from fossils and rock deposits.[1] All high-grade fertilizers use phosphate, nitrogen, and potash. Of these major ingredients, phosphate is the hardest to locate. Early chemical engineering firms were located predominantly in England and Scotland. As they grew larger and more prosperous, they outgrew domestic suppliers and required imported ores. Canadian mining operations initially met this demand, until in 1867 high yield ores were found and mined in South Carolina.[2, 3] Small patches of accreted phosphoric sand, similar in consistency to cement, were broken with shovels, picks and earthmovers and shipped to England. In 1905, phosphate mining companies began using machinery, further increasing the amount of profit to be made in mining and export of phosphate rock.[4]

The initial South Carolina boom spurred aspiring entrepreneurs to identify regions with large fossil reserves. Geological knowledge was still quite rudimentary at the time, but from anecdotal observations it was thought that where large fossils were found, near-surface phosphate deposits might also be found.[5] The Bone Valley Region of Florida became a logical choice for mining explorations. In 1883, Dr. C.A. Simmons mined the sands and clays of Florida's Alachua County. Although the project was based on preliminary soil findings, the project failed due to lack of capital within the first year.[6] Four years later, the Peace River Phosphate Company initiated a phosphate-mining boom that developed into a full fledged industry within ten years. A national depression in the 1890s stifled further phosphate mining growth. In 1895, 400 companies operated along the Peace River using a variety of methods. But, by 1900 only fifty of the larger, better capitalized mining operations remained in business.[7, 8]

In 1894, Florida surpassed South Carolina as the leading U.S. producer of phosphate ore, and in the early 1900s, the phosphate industry developed greater financial returns by becoming more technologically advanced and by shifting from hard rock mining to mining "land pebble" deposits in Florida's phosphate district.[9] This district includes stretches of land adjacent to small rivers and their tributaries in Polk, Hillsborough, Hardee and Manatee Counties.[10] Bone Valley and Hawthorn Group sediments are widely dispersed throughout these counties, and eroded areas near the rivers were where easily accessed boulders (land pebble) and veins of solid apatite (hard rock) could quickly be loaded by barge and shipped out of the Port of Tampa.[11, 12]

The state government in Tallahassee gave these operations little oversight, concerning itself primarily with tax revenue from these operations. One prominent aspect they overlooked or tacitly supported was the industry's use of unregulated and often forced labor.[13] Florida's Jim Crow Laws created a labor pool of African-American convicts, who were then used by phosphate companies to load and unload ore and heavy machinery.[14] Deplorable safety conditions and long hours made for high worker mortality and injury.[15]

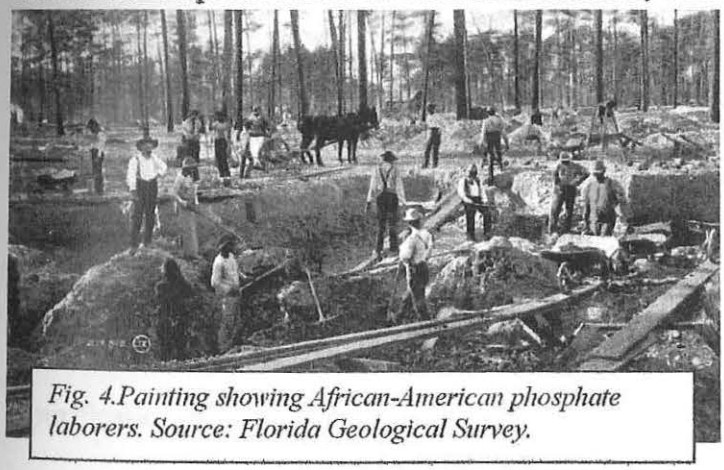


Fig. 4.Painting showing African-American phosphate laborers. Source: Florida Geological Survey.

Working conditions for wage earners in the early phosphate industry were often little better than those for chain gang laborers. These conditions and the lack of any benefits for the workers led to several worker strikes. Most notably, the 1919 strike marked large-scale but ultimately unsuccessful attempts by workers to negotiate favorable working conditions and contracts.[16, 17]

From 1914 to 1918, employee scarcity generated increased wages and better working conditions for phosphate miners. Yet after the war, industry managers rolled back these gains to

forestall long term change and to increase profits.[18] In Central Florida, this resulted in a highly protracted and violent strike. The use of strike busters from Georgia and armed "security forces" resulted in several deaths and serious injuries on both sides of the conflict. The governor at the time, Sidney Catts, called out local National Guard units to restore order.[19] The Prairie Agricultural Corporation sued successfully in court to have the officers and members of the International Union of Mine, Mill, and Smelter Workers declared trespassers in the mining areas of Prairie, Bartow, and other locales across Polk County.[20] This injunction, enforced by private detective agencies in the hire of the local mining companies, broke the strike and established a pattern that would dominate the Florida phosphate industry for the remainder of the 20th century.[21] Repeated strikes between 1920 and 1980 failed or were only marginally successful. Rioting and more violence erupted in the large-scale 1954 strike. This strike gained so much negative publicity for the industry that mining companies acquiesced to some worker demands. Yet even the changes made amounted to little substantive difference to the industry's overall business practices.[22]

After World War I , companies increasingly used automation for extraction and production of fertilizers.[23] The technological advancements paralleled the increasing population of Florida, though most of Florida's population growth occurred in coastal areas. At this time, new types of industrial factories were being built near the mines to wet process the raw ore. Changing techniques for purification resulted in a stronger fertilizer for American farmers and a better yield from given deposits.[24] The improved methods increased profitability, which was necessary to recover from the drastic reduction in market size due to World War I.[25]

YEARS	TYPE OF EXCAVATION	COST PER CUBIC YARD
1890-1905	Pick and shovel	15-25 ¢
1890-1905	Mules and scrapers	12-15
1905-1920	Hydraulics	12
1920-1940	Draglines	1.6

Table 1. The Long-term Profit Increase Due To Mechanization.[26]

In the 1920s, an increase in fertilizer demand spurred factory mechanization and vertical integration in local shipping. These changes allowed fertilizer companies to increase profits and their marketshare in a rigorously competitive industry. Mechanization and integration also meant greater industrial development across Hillsborough and Polk Counties; the Port of Tampa practically doubled in transported tonnage. Expanded corporate size by previously larger mining companies resulted in farmers buying fertilizers manufactured for the first time in the U. S. A.[27]

British companies that had previously processed raw ore began to scale back their operations and re-invest in Florida-based corporate entities or in Tunisia's domestic mining interests.[28] Since only the consolidated companies with the greatest financial reserves could succeed in this business environment, international firms became the norm rather than the exception.[29] This widespread transformation gave phosphate extraction and shipping an array of new environmental side effects. It also developed new technical and legal demands which generated employment for high-skill, high-wage labor. The 1920s also witnessed the successful maturation of phosphate conglomerates as an influential lobby in the state and national legislature. The newly engineered fertilizer rendering plants began to attract higher paying jobs in several fields to work in and around the factories in Central Florida.[30] The changing face of the employees gave the industry a more legitimate mainstream reputation among outsiders.

Regardless of the phosphate industry's marketing, it has always been subject to farm demand for commercial grade fertilizer. During times when crops do well, fertilizer use remains constant. When the agricultural sector shrinks, fertilizer use goes down, and the industry suffers.[31] One side effect of America's highly productive 1920s farms was that the price of agricultural products dropped sharply due to overabundance. One out of every four American farms declared bankruptcy in the 1920s.[32] Meanwhile the phosphate ore and fertilizer companies continued to increase production, and very often operated on a system of credit with farmers and local distributors. This

resulted in profit losses for the companies along with the farmers. As the 1920s ended, reduced demand and continued expansion prolonged low prices, and throughout the 1930s the price of phosphate ore decreased. In 1938, the per ton price of phosphate was less than in 1918.[33]

Economic depression during the 1930s affected profits, but caused few company bankruptcies, since the industry maintained relevant markets, even if international exports were used to make up some of the shortfall in domestic demand. In these years, the French began to also explore phosphate production in Tunisia and Morocco.[34] This area contains phosphate deposits similar to Florida, but did not receive much interest from investors at the turn of the century. The more comprehensive mining explorations of the 1930s drew European and Asian investors, who were now searching for a realizable source of phosphate more local to Eurasia which could compete with American production. Morrocan and Tunisian mined fertilizer was a great success, and is still the main competitor of Florida-produced phosphate.

In Florida, fertilizer development factories sprung up quickly or were expanded in the pro-business environment post World War II. Within this industry's industrial expansion, it is important to appreciate that only rudimentary environmental laws had been established, such as the U.S Law of Nuisance, which prohibited some downstream effluents.[35] However until the 1960s, even if a state had environmental laws in place, it lacked enforcement capabilities.

A series of new re-organizations in the 1950s and buyouts by several of the international conglomerates consolidated the industry to under 15 companies. Vertical integration of mining and fertilizer processing by the same corporation become standard practice across Florida and the world.[36] By 1960, fewer than twelve companies remained in operation at any one given time.[37]

Huge draglines were used to mine the apatite deposits and railroad and barges took this ore to the adjacent fertilizer facility. Blending of the ore with sulfuric acid to create super diammonium phosphate or triple superphosphate (also known as "wet process") came next.[38] Shipment down

natural and dredged portions of the Withlacchochee River, Hillsborough River, Peace River, and associated tributaries to the Port of Tampa and then elsewhere had changed very little since the end of the 1880s.

Mining has always created pits and problems with siltation and groundwater contamination. Most of this early pollution was benign in comparison with the new generation of environmental alteration and destruction.[39] The new processing plants of the 1940s and 1950s generated air, land and water pollution on a large scale.[40] Acidic wastewater ponds, gypsum stacks and miscellaneous airborne toxic emissions became an accepted part of the business. Cattle deaths, well contaminations, and citrus blight caused by fluorine poisoning galvanized a consortium of business leaders to seek amends from the state legislature. Very few concrete changes occurred for a variety of reasons. Regulatory investigators were highly sympathetic to the phosphate operatives, the injured parties had very little "smoking gun" type evidence for damage correlations, and the laws at the time were not designed to legally regulate heavy industry, or to enforce regulatory decisions.[41] The short-term outcome of this outrage included voluntary agreements by phosphate rendering and processing facilities to end well contamination and limit fluorine emissions. Since facilities built after this timeframe have been directly linked to groundwater contamination and fluorine emissions, it would appear that these agreements did not have their desired effect. Additionally, in keeping with the environmental laws of the late 1950s,

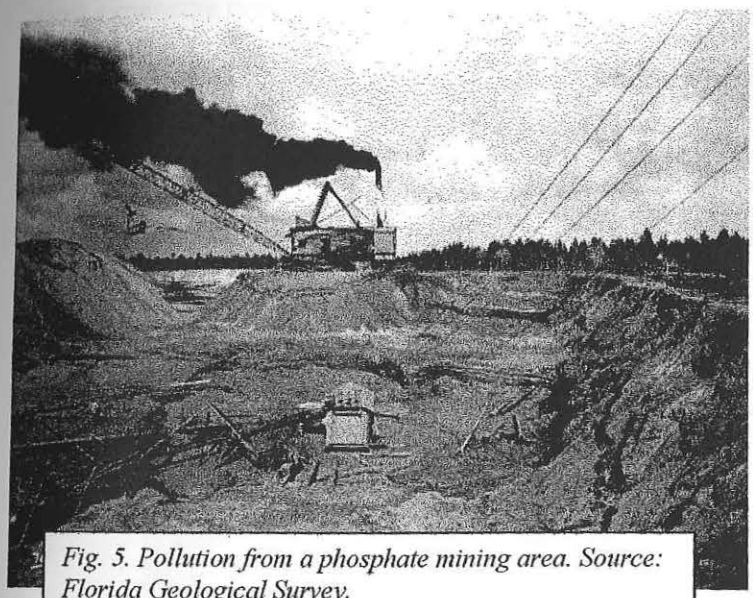


Fig. 5. Pollution from a phosphate mining area. Source: Florida Geological Survey.

state regulators agreed to bi-yearly inspections of the facilities, and passed legislation with non-specified fee structures for polluting extractor technology and equipment.[42]

The chemical extractions and large construction equipment needed to maintain these chemical facilities were similar to those used in the coal and oil industry. For this reason, in the mid-1960s Mobil, Phillips, Sinclair Petrochemicals, and other oil companies bought new mining leases, as well as existing facilities, in Hillsborough, Manatee, Polk, Hamilton, and Desoto Counties. The most expensive new investment was a $60 million complex built by Occidental Chemical Corporation, and in the middle price range, Borden Chemicals built a $15 million phosphate processing plant near Port Manatee called the Piney Point Fertilizer Facility Inc.[43, 44] Fertilizer profits and world demand increased practically every year through the end of the 1960s. It is within this climate of growth, both in profits and pollution, that Piney Point Phosphate Facility opened its doors in 1966.

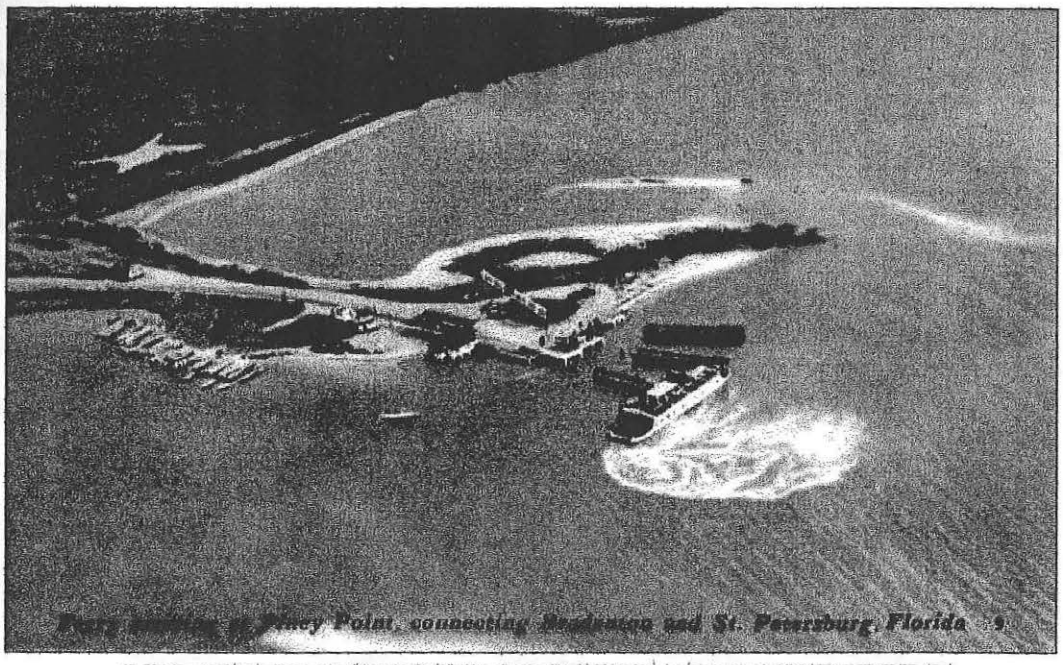


Fig. 6. Aerial view of Piney Point. Source: Florida Geological Survey.

[1] Blakey, The Florida Phosphate Industry, 2-4.

[2] Ibid., 7-12.

[3] Files of the American Chemical Company, cited by ibid, 9.

[4] Gene M. Burnett, Florida's Past: People and Events that Shaped the State, vol. 3 (Sarasota, FL: Pineapple Press, 1991), 35.

[5] Canter Brown, Jr. Florida's Peace River Frontier (Gainesville: University Press of Florida, 1991), 312-3.

[6] Blakey, 18-19.

[7] Brown, Florida's Peace River Frontier,, 312-4.

[8] Mark Derr, Some Kind of Paradise: A Chronicle of Man and the Land In Florida (Gainesville, FL: University Press of Florida, 1998), 122.

[9] Burnett, Florida's Past: People and Events that Shaped the State, 135.

[10] Guerry H. McClellan and James L. Eades, "The Economic and Industrial Minerals of Florida," in The Geology of Florida, eds. Anthony Randazzo and Douglas S. Jones (Gainsville, FL: University of Florida Press, 1995), 41.

[11] Sam B. Upchurch and Anthony Randazzo, "Environmental Geology of Florida," in ibid., 240-241.

[12] Iris Tracy Comfort, Florida's Geological Treasures (Baldwin Park, CA: Gem Guides Book Co, 1998).

[13] Millar, Florida Phosphates, 109-110, cited by Arch Fredric Blakey, The Florida Phosphate Industry: A History of the Development and Use of a Vital Mineral (Cambridge: Harvard University Press, 1973), 77.

[14] Brown, Florida's Peace River Frontier, 315.

[15] Florida Department of Corrections, "Florida Corrections: Centuries of Progress, 1877-1895," Florida Department of Corrections Website, Myflorida.com, 2004, <http://www.dc.state.fl.us/ oth/timeline/1877-1895.html> (3 June 2004): Facts, Fallicies, and FAQs.

[16] Blakey, The Florida Phosphate Industry.

[17] Burnett, Florida's Past: People and Events that Shaped the State.

[18] Ibid.

[19] Blakey, The Florida Phosphate Industry.

[20] Ibid.

[21] Ibid.

[22] Ibid.

[23] W. E. Pittman. "Technology and Environmentalism in the Florida Phosphate Industry." Papers of the American Chemical Society 187 (1984).

[24] Florida Institute of Phosphate Research, FIPR Website, 15 December 2003, <http://www.fipr.state.fl.us/ > (25 June 2004)

[25] Blakey, The Florida Phosphate Industry.

[26] Blakey, The Florida Phosphate Industry.

[27] Burnett, Florida's Past: People and Events that Shaped the State, 35.

[28] Mineral Resources of the United States for 1919, as found in Blakey, The Florida Phosphate Industry.

[29] George Henderson, Florida Fish and Wildlife Conservation Commission, personal communication, 15 January 2004.

[30] Derr, Some Kind of Paradise: A Chronicle of Man and the Land In Florida, 123.

[31] P. Clifford, M. Lloyd, and P. Zhang, "Technology Research Improves Phosphate Economics," Mining Engineering 50 (1998).

[32] Blakey, The Florida Phosphate Industry.

[33] Ibid.

[34] The Ministry of Communication, "A Focus on the 21st Century," The Kingdom of Morocco, Moroccan Government, 2004, <http://www.mincom.gov.ma/english/invest/Business/economic %20overview.htm> (10 March 2004).

[35] R. Gottlieb, ed. Reducing Toxics: A New Approach to Policy and Industrial Decision-making (Washington DC: Island Press, 1995).

[36] Scott H. Dewey, "The Fickle Finger of Phosphate: Central Florida Air Pollution and the Failure of Environmental Policy, 1957-1970" The Journal of Southern History 3 (1999): 565-603.

[37] Blakey, The Florida Phosphate Industry.

[38] "Ammonium Phosphate," Inorganic Chemical Industry, United States Environmental Protection Agency, January 1995, <http://www.epa.gov/ttn/chief/ap42/ch08/final/c08s05-3.pdf> (19 June 2004).

[39] Dewey, "The Fickle Finger of Phosphate: Central Florida Air Pollution and the Failure of Environmental Policy, 1957-1970," 565-603.

[40] Derr, Some Kind of Paradise: A Chronicle of Man and the Land In Florida, 106, 366.

[41] Scott H. Dewey, Don't Breathe the Air: Air Pollution and U. S. Environmental Politics 1945-1970 (College Station, TX: Texas A&M University Press, 2000).

[42] Dewey, "The Fickle Finger of Phosphate: Central Florida Air Pollution and the Failure of Environmental Policy, 1957-1970," 565-603.

[43] Blakey, The Florida Phosphate Industry.

[44] Don Moore, "Commissioners Negotiate: Bordens' Water Use May Double," Tampa Tribune, 4 February 1966, sec. 2-B.

Chapter 3. The Buildup to Bankruptcy

Borden Chemicals started processing ore at the Piney Point facility in September 1965, and began shipping phosphate out of Port Manatee soon after.[1] Before the plant became operational, there were several public and private meetings among nearby landowners, interested citizens, Borden representatives, and health inspectors.[2] These meetings allowed citizens to express a variety of viewpoints, though officials gave more time, energy and legitimacy to pro-development factions.

The Manatee County Board of Commissioners did not acknowledge several groups, both environmental and agricultural, that opposed the plant. In many ways Manatee County "courted" Borden Chemicals, encouraging development in return for its own goals.[3] For example Borden Chemicals built Manatee County a public reservoir, as well as funding extensive improvements for Port Manatee from 1964-1968.[4] At the same time, the Piney Point facility became the largest single contributor to Manatee County's tax base. These improvements came at the risk of environmental degradation, not to mention Borden's expectations that its daily water use could exceed 10 million gallons for the first two years.[5] Its daily use for the first two years totaled approximately 7.9 million gallons, and while it practically built Port Manatee, it also became its primary user. Other considerations for Piney Point's development, which many agriculturalists felt were ignored by the county commission, included effluent water contamination to Tampa Bay, groundwater contamination from industrial solvents, and air pollution, most importantly hydrofluoric acid and sulfur dioxide.[6,7] Over the years each of these problems

has occurred. All have required mitigation and very often resulted in legal settlements to the effected parties.

Frank Cross Jr., Manatee County's Environmental Inspector, took part in numerous plant inspections before Borden's $15 million plant became operational. Enthusiasm for the anticipated facility's cleanliness and technologically advanced processing was generated by Borden engineers, who along with Cross concluded that the facility should only produce 0.167 pounds of fluoride per ton of emissions, or approximately 0.275 parts per billion. The fluoride emissions were anticipated to be so minimal that gladiolis, among the most fluoride sensitive plants, would not wilt or die. The Borden facility also publicized an anticipated 155 parts per billion of sulfur dioxide emissions during full operational capacity.[8] Accepting these expectations, when permitting was completed but production was not, the Manatee County Port Authority and the Florida Committee of 100 (a longstanding development organization) stated that Piney Point was "the cleanest plant of its kind in the nation."[9]

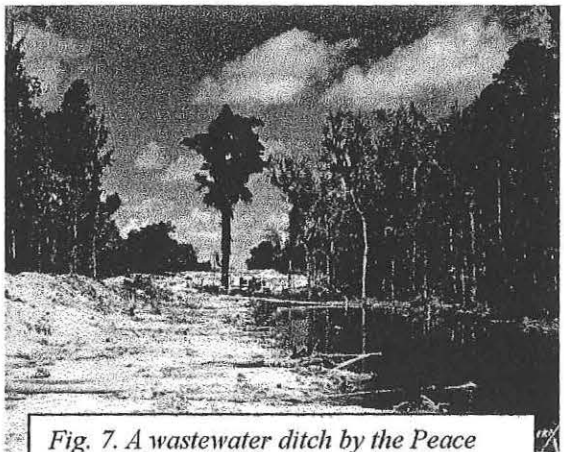


Fig. 7. A wastewater ditch by the Peace River. Source: Florida Geological Survey.

Immediately after going operational, reports of blighted oranges and gladioli flowed in from irate landowners.[10] After three months of operations, the Manatee County Department of Environmental Management sampled the emissions from the smokestacks at Piney Point and found 40 parts per million fluoride concentration.[11] At this same time Borden Chemicals unveiled a plan to build a ditchline

from the facility to Tampa Bay.[12] The plant intended to use this ditchline to dump excess uncontaminated cooling water in the event of more than 6 inches of rain over a 24 hour period. This plan received county permits, but it stipulated that any water entering Tampa Bay and Bishop's Harbor would be uncontaminated.[13] In November 1966, several water quality samples taken from the ditchline indicated that recent effluent from Piney Point was contaminated phosphoric wastewater.[14] This in turn led to more studies. Borden Chemicals denied knowledge of these discharges and found fault with the laboratory findings of excessive fluoride. Consequently, over the next year Borden became hostile to Manatee County Environmental regulators sampling their ditch or smokestack emissions. By 1967, against the direction of many Manatee County officials,. Cross admitted to the public at large that while his office had the capacity to sample the Piney Point Facility, they had no legislated regulatory capabilities for forcing Borden Chemicals to comply with pollution control measures.[15] Since Borden Chemicals generated more revenue for Manatee County than any other source both the public and the local government about what steps to take with Piney Point, and legal action (an option still open to the county) was largely not taken. [16, 17] However, this did not stop several private interests from taking legal action.[18]

From 1967 to 1972 Bishop's Harbor experienced repeated algal blooms and sea grass losses.[19] Borden Chemicals denied many of the spills, or attributed them to other causes, disregarding repeated scientific studies demonstrating that the plant was the greatest point source of nitrogen enrichment in Manatee County.[20] Legal suits by farmers often could not be substantiated, but through the 1970s, Borden repeatedly settled private environmental damage claims out of court.[21, 22] In 1980, Borden Chemicals sold the plant

to AMAX. AMAX ran the plant from 1980 to 1987. At the end of the 1980s, CMI or Consolidated Minerals Inc. bought out the AMAX operators, and then sold the plant to Royster in early 1989.[23] Under Royster and AMAX, the state of Florida fined Piney Point for several violations, including a 23,000 gallon leak of sulfuric acid (1989), which forced the evacuatation of hundreds of people at Port Manatee and the surrounding areas. In 1991, also under Royster's ownership, the plant accidentally discharged a cloud of sulfur dioxide and trioxide, and in 1994 groundwater contamination led the Department of Environmental Protection to fine Mulberry Phosphate $135,000. Royster, who sold Piney Point in 1993 after declaring bankruptcy, settled repeated environmental violations at both its other facilities after its reorganization in 1996. While it was the proprietor at Piney Point, the plant did not operate regularly.[24] [25]

Mulberry Phosphate came into ownership of Piney Point facility in 1993, along with large mining leases and a beneficiation facility and sulfuric acid factory in Mulberry, Florida,. The Mulberry facility is still operational, but at Piney Point the company neglected to fully inspect or consider the physical soundness of the site.[26],[27] Mulberry Phosphate was made up of investors, European and American, and run by a French CEO, Philip Rinaldi.[28] Some Manatee County and DEP environmental regulators felt that an ineffective management team and little experience with business ownership in the state of Florida precipitated Mulberry Phosphate's 2001 bankruptcy.[29]

Regardless of this hypothesis, when Mulberry Phosphate assumed responsibility for the Piney Point facility, it was not prepared to pay for the huge amount of renovations nor to undergo the lengthy permitting process for upgrades at Piney Point. This led to a total shutdown of diammonium phosphate production from 1994-1996.[30] During these

years, the Mulberry Plant generated revenue and was fully operational. Some of the needed upgrades to the Piney Point Facility were made in 1996, but in 1997 one of the dam outflows from the Mulberry agri-chemical plant broke, spilling 54 million gallons of phosphoric wastewater into the Alafia River.[31] This resulted in an immediate fishkill and the death of most aquatic plants for five miles downriver. The legal aftermath, fees, and public scrutiny of Mulberry Phosphate reduced the amount of money and effort the company put into maintaining and running the Piney Point plant. Mulberry Phosphate continued regular maintenance of Piney Point but ignored the increasing amount of rainwater held in the gypsum stacks. The years between 1997 and 1999 were uneventful, except that the facility was increasing its wastewater volume. Mulberry Phosphate ultimately invested over $30 million in renovations to Piney Point between 1994-1999, partly because they believed that an increase in phosphate demand was just on the horizon.[32] When this growth did not occur, Piney Point spent 1999 and 2000 with minimal supervision and no water circulation pumps at its gypstack complex. During this time, very little oversight or mandates came from FDEP.

The Florida Department of Environmental Protection is divided into different divisions and bureaus based on function and location. These different sections normally operate different missions of the agency. The scientific assessments and remediation projects and regulatory guidelines normally fall to scientists and engineers. However the chiefs of different sections, especially as they relate to permitting, are often appointees who are chosen more for their bureaucratic abilities than their scientific expertise.

While Piney Point was still owned by Mulberry Phosphate the state legislature never passed legislation allowing the FDEP to mandate risk prevention steps, such as

reducing the gypsum stacks' water volume.[33] If Piney Point was being regularly maintained by a viable company, but no processing was done, then the FDEP had nothing to regulate. State governments and the national government seek to promote industry, and the EPA and state environmental regulators receive a mandate to limit pollution from these same industries. However, in an effort to limit the invasive nature of government, there have been few laws, and none at the national level, that require a polluting industry to demonstrate financial soundness. Environmental regulators may step in after a company has declared bankruptcy, and also if active pollution is ongoing. However, Piney Point presented something of a loophole.[34] The plant was not being upgraded, or producing phosphate, nor were the owners bankrupt. Piney Point remained in regulatory limbo from 1998 to 2001, and by the time Mulberry Phosphate filed for bankruptcy and gave FDEP official notice, their phosphogypsum stacks were an imminent threat to homeowners and Tampa Bay.[35]

[1] Clyde Burnett, "Grower Files Air Pollution Suit in Court in Tampa," Sarasota Herald-Tribune, 8 October 1965, sec. 2.

[2] "Pollution Control Ordinance Skirted," Sarasota Herald-Tribune, 1 October 1965, p. 21.

[3] "Manatee Unit Advises Against Air Pollution Control District," Sarasota Herald-Tribune, 23 November 1965.

[4] Robert Brown, personal communication, 21 July 2004

[5] Don Moore, "Commissioners Negotiate: Bordens' Water Use May Double," Tampa Tribune, 4 February 1966, sec. 2-B.

[6] "Plant Pollution Level Seen as OK," Sarasota Herald-Tribune, 30 March 1966, sec. 2.

[7] Tom Todd, "Pollution Safeguards Planned by Borden Co. at New Manatee Plant," Tampa Tribune, 9 April 1966.

[8] Plant Pollution Level Seen as OK," Sarasota Herald-Tribune, 30 March 1966, sec. 2.

[9] "First Charts of Pollution in Manatee," Sarasota Herald-Tribune, 27 March 1966, sec. 2.

[10] Norma Bergmann, "Air Sampling Stands Guard Over Pollution," Tampa Tribune, 6 August 1966.

[11] "First Charts of Pollution in Manatee," Sarasota Herald-Tribune, 27 March 1966, sec. 2.

[12] Tom Todd, "Pollution Safeguards Planned by Borden Co. at New Manatee Plant," Tampa Tribune, 9 April 1966.

[13] "Borden Plant Will Discharge Water on a Regular Basis," Sarasota Herald-Tribune, 9 April 1966.

[14] Roger Ross, "Two Experts Differ on Effect of Effluent Discharge," Sarasota Herald-Tribune, 29 April 1966, sec. A.

[15] Editorial, "At Last They Admit It," Bradenton Herald, 20 June 1966, 4-A.

[16] "Borden Official Cites Plant Impact," Sarasota Herald-Tribune, 14 April 1967.

[17] Myrtle B. Faithful, "Borden Plant Target in Pollution Hearing," Bradenton Herald, 11 Jan 1967, sec. 1-B.

[18] Norma Bergmann, "Air Sampling Stands Guard Over Pollution," Tampa Tribune, 6 August 1966.

[19] Roger Ross, "Potential Chemical Hazard Cleared Up," Sarasota Herald-Tribune, 22 March 1967, sec. 2.

[20] Roger Ross, "Borden Plant Water Pollution Test Set: Samples Now Being Collected," Sarasota Herald-Tribune, 1 August 1966, sec. 2.

[21] Roger Ross, "Potential Chemical Hazard Cleared Up," Sarasota Herald-Tribune, 22 March 1967, sec. 2.

[22] "Pollution Samples Taken," St Petersburg Times, 14 July 1967.

[23] Sam Zumani, Florida Department of Environmental Protection, Bureau of Mines, "Piney Point," 15 June 2004, personal e-mail (15 June 2004).

[24] Scott Harper, "Chesapeake Fertilizer Company Fined For Pollution," Virginian Pilot. 3 August 2002, sec. A.

[25]

[26] Rob Brown, Manatee County Environmental Office, chief, interview by author, 22 July 2004

[27] Craig Pittman, Julie Hauserman, and Candice Rondeaux, "A $140-Million Mess," St Petersburg Times, 6 July 2003.

[28] Howard M. Unger, "Failed Phosphate Plant Is Tough Sell," Sarasota Herald-Tribune, 17 February 2002, sec. B.

[29] Rob Brown, Florida Department of Environmental Protection, interview by author, 22 July 2004.

[30] Howard M. Unger, "Failed Phosphate Plant Is Tough Sell," Sarasota Herald-Tribune, 17 February 2002, sec. B.

[31] Environmental Protection Commission of Hillsborough County, "Final Damage Assessment And Restoration Plan and Environmental Assessment For The December 7, 1997 Alafia River Spill," U.S. Fish and Wildlife Service, 2000.

[32] P. Clifford, M. Lloyd, and P. Zhang, "Technology Research Improves Phosphate Economics," Mining Engineering 50 (1998).

[33] Florida Senate, Phosphate mining: Senate staff analysis and economic impact statement. Bill CS/SB 18-E, 22 Oct 2003.

[34] Walter A. Rosenbaum, "Risk Assessment and the Limits of Science," Environmental Politics and Policy, 5th ed. (Washington DC: CQ Press, 2002).

[35] Florida Senate, Phosphate mining: Senate staff analysis and economic impact statement. Bill CS/SB 18-E, 22 Oct 2003.

Chapter 4. The State of Florida Contains an Environmental Emergency

When Mulberry Phosphate Corporation declared bankruptcy in February 2001, the corporation gave the Florida Department of Environmental Protection (FDEP) approximately 48 hours notice that Piney Point's gypsum containment stacks were in need of continuous maintenance and that the corporation would be unable to provide any of the funding.[1] Total water volume contained in the four onsite gypstacks was approximately 1.2 billion gallons when Mulberry Phosphate Inc. declared bankruptcy.[2] Since each inch of rain that falls on the facility has been calculated to add approximately 12.5 million gallons of standing water to the gypstacks, a series of reasonably strong rain events adding 12 to 15 inches, or a 50 or 100 year storm, could overflow part of the berm and collapse the entire structure.[3] This would release several million gallons of free process water and some portion of the pore waters as a clay slurry (toxic mudslide). Over 60 homeowners in the immediate area were in imminent danger from the spill. The state took immediate action. After assessing the critical situation of phosphogypsum holding ponds, it moved to assume receivership in bankruptcy proceedings. This ensured that the plant did not remain inactive while creditors were notified and compensated. The state authorized Louis Timchak, an attorney in Lutz Fl, as receiver to protect the environment. He, on behalf of the state, employed Ardaman and Associates to do geotechnical analysis and site recommendations.[4] Additional consultants, such as Janicki Environmental, Inc, have been retained for maintenance, decommissioning, and monitoring.

One of the most characteristic behaviors of FDEP site management has been self-application and internal approval for permit alterations to the gypstacks and the nearshore

environment primarily through emergency orders.[5] When the state assumed receivership, one of its first actions was to authorize itself to permit the building of higher berm walls, as only 1.5 feet of space remained at the top of the phosphogypsum stack. The state also immediately discharged 50 million gallons of wastewater after single lime treatment into Bishop's Harbor.[6] Bishop's Harbor lies in close proximity to the Piney Point site and for the last 34 years has had a ditchline connecting it to the gypstack containment structures.[7] Several types of discharge have gone into Bishop's Harbor over the years of Piney Point's operation, and the discharges releases in February 2001 were neither the worse, historically, nor the best from a pollution standpoint.

The stacks at Piney Point are denoted as North, South, East, and West. In February 2001, the four gypstacks held nearly 650 million gallons of process water and another 600 million of pore water.[8] Process water is standing water within the stack, commonly thought of as the "pond," while pore water is interspersed with the gypsum and makes up the bottom layer in the mining waste piles.[9]

Both process and pore water have similar chemical compositions. The untreated waste water has a pH of 3.11 and contains 503 mg/L of ammonia nitrogen, 1233 mg/L total phosphate (contained as ortho-phosphate), greater than 100 mg/L of Magnesium and Chloride, and 63 mg/L of Fluoride. Additionally, metals such as Radium, Arsenic, Nickel and Zinc are present in quantities which violate EPA effluent regulations.[10] Single lime treatment raises the pH of the wastewater to 4.5 (an acidity reduction of 50 times) and removes most of the metals, but does not remove enough of the phosphorus or nitrogen to meet state or federal water quality standards or to be discharged on even a limited basis to surface waters such as the poorly flushed Bishop's Harbor, under normal

circumstances.[11] To reduce this nitrogen problem, later single and double limed discharges also included aeration and assorted dispersal techniques.

After initially raising the dikes, water volume reduction was the decommissioning project's priority concern.[12] This was done by discharging millions of gallons per day of process water into Bishop's Harbor. Single lime treated discharges cost the least per thousand gallon, but have been used only when the water volume in the stacks became critical due to their elevated levels of phosphorus and nitrogen.[13] Past environmental exposures and laboratory tests have confirmed that these substances added to a water body the size of Bishop's Harbor could induce a massive die-off of flora and fauna, eutrophication, and hypoxia (low water oxygen content).[14]

Double lime discharges and reverse osmosis have been more widely used for the Piney Point dewatering project. These cost more per ton of treated water, but contain less Nitrogen in the effluent. Reverse osmosis water is by far the most expensive processing, but it presents almost no environmental risks. Bottled water plants often use this purification technology, and the process water after R.O. is nearly potable. Because Manatee County's Wastewater Treatment Facility is less than one mile from the Piney Point factory, it accepted a few million gallons of double limed process water, which can be treated along with Manatee County's regular wastewater, if the quantities shipped are moderate.[15]

Another important management issue from Mulberry Phosphate's bankruptcy involved the still operational sulfuric acid fertilizer factory in Mulberry, Florida.[16] The state became responsible for decommissioning and maintenance of that site from the bankruptcy as well. For several months, the state was the caretaker of both, but since May

2002 Cargill Inc., which owned an adjacent facility to Mulberry Phosphates's defunct plant in Mulberry, agreed to manage and shut the plant down at a cost of up to $25 million. The state estimated that closing the Mulberry Plant themselves would cost between $25-50 million, so having Cargill take on that responsibility at a lower cost was a great benefit (financially) to FDEP. To decommission the plant, Cargill actively runs the site, but does not replenish many materials, such as water. The closure of the gypsum stacks at Mulberry will be complete in 2008, but under the terms of the state agreement, Cargill will continue long-term care for up to 50 years.[17] Cargill also agreed to take several million gallons of wastewater from Piney Point and dispose of it at their facility in Polk County.[18]

The most cost-efficient manner of reducing the water volume at a phosphate agrichemical plant is to run the plant.[19] Additional gypsum will be created, but producing phosphate with sulfuric and phosphoric acid has a negative water balance.[20] Under normal operating conditions a phosphate plant will occasionally pipe water into the facility rather than attempt to reduce the gypstack volume. If the plant remained operational, then another phosphate contractor could come in, if paid by the state to run the gypstacks down. Years of neglect and outdated machinery prevented this from being an option.

The FDEP used trucks to haul the water from Piney Point to Cargill's Polk county plant in 2002-2004. The FDEP worked out a plan where the Hillsborough Wastewater Treatment facility would accept and dispose of the process water.[21] Virtually any major wastewater treatment facility could adequately dispose of this phosphoric wastewater, as long as the quantity did not overwhelm their purification system. Concerned that their

wastewater systems with phosphoric additives might not pass code, some cities, such as St. Petersburg, declined to take significant wastewater at their sewage treatment plants.[22]

Many different plans for how to deal with the wastewater at Piney Point were proposed by consultants and FDEP personnel. Some plans such as using R.O. water for local farms or as reclaimed water for the public did not pass because local farmers would not agree, nor would municipalities.[23] Farmers wanted assurances that if they took the water the state would assume liability if their crop yields were small, and most municipalities refused to take on the added hassle of processing more wastewater. Also water taken to wastewater treatment plants, except for the adjacent Manatee County plant, require trucking away from Piney Point. Trucking becomes very expensive when you consider that a truck can only load up to 50 thousand gallons at one time, and the Piney Point stacks need to be reduced by at least 600 million before the stacks are totally under control.[24] Since Piney Point has so much water, and since it had to must be reduced rapidly, plans requiring long time periods for design or implementation were rejected.[25]

By the end of summer in 2001, there were still fewer than 250 million gallons that could safely be accepted to the gypstacks, meaning twenty inches of rain could be accepted before the stacks overflowed.[26] The FDEP faced criticism over the single lime discharges, but the large scale development of reverse osmosis and double lime treated wastewater was still underway. However, the FDEP felt the potential risk of not having additional gypstack capacity for the remainder of the hurricane season outweighed the risks of eutrophication and metal contamination.[27] They increased discharges, primarily of double limed water, and stepped up a policy to get municipal wastewater treatment facilities to accept trucked-in water. The discharges were seemingly justified when on

September 15 tropical storm Gabrielle hit the area and added more than 12 inches of rain to the gypstack structures.[28] The gypstacks remained intact, but safe water levels were exceeded. Directly after Gabrielle, approximately three inches of water (37.5 million gallons) separated the upper lip of the berm from the contained process water. This prompted the immediate additional discharge of several million gallons of single lime process water to Bishop's Harbor.[29] In many ways, the most critical risk period for the Tampa Bay area's health was in this first year. Simply running the plant could not build up the capacity needed for the gypstacks to accept large amounts of rainfall common to Florida summers and because each step in the decommissioning process must be studied and funded first, a framework strategy for onsite construction and timeframe goals was not complete.[30]

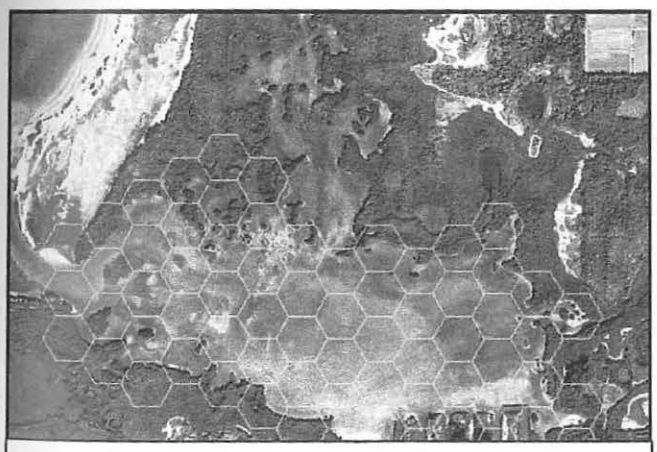


Fig. 8. Sampling Strata of Bishop's Harbor. Source: United States Geological Survey.

Some water quality repercussions occurred because of the repeated discharges, but Bishop's Harbor had been receiving some contaminated water in smaller amounts for several years. The state determined that 11 acres of sea grass beds were killed in discharge related incidents in the years 1998 and 1999; however, a detailed evaluation of sea grass destruction from the years 2001-2004 has not been completed.[31] Bishop's Harbor experienced some macro algae blooms during spring 2004 which FDEP collected and disposed of to limit nutrient recycling and further blooms. As yet, (November 2004) red tide has not been correlated with any of the dumping practices.

Fig. 9. Bishop Harbor monitoring sites. Source: FDEP.

Repeatedly through the decommissioning process, rainfall exceeded the National Weather Service's estimates. In the spring of 2002, Manatee County exceeded the national weather service estimates by several inches over a four month period, but the over the summer, moderate rainfall occurred.[32] Double lime discharges, trucked out or spread out over Bishop's Harbor, increased the storage capacity to over 200 million gallons by October 2002. Though the state discharged more than a million gallons daily at this time, they could not keep up with the amount of rainfall. However, the state anticipated that gradually, and with more, agencies accepting water, this methodology could work.[33, 34]

The FDEP considered applying for emergency permits to barge the double lime treated process water into the Gulf of Mexico, and spray it into the Gulf. This plan became the official policy after a series of heavy rains in late November and early December 2002 and the addition of 6.5 inches of rain on December 31st.[35] This storm with others added 16.5 inches of rainwater through December (which

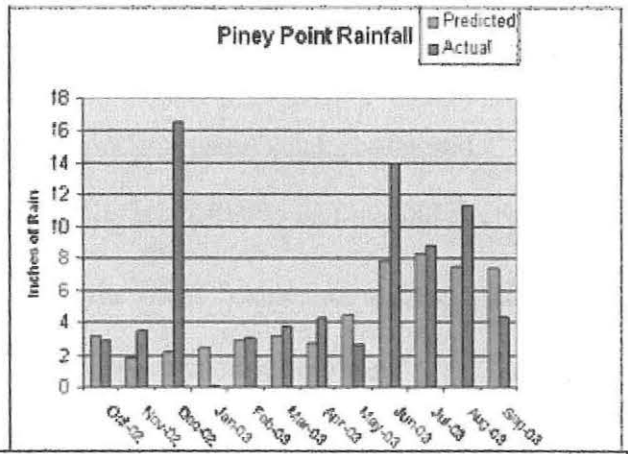


Table 2. Note the heavy rain in December. Source: FDEP

constituted a five hundred year storm event) and the winter weather disrupted reverse osmosis proceeding. These factors reduced storage capacity to 33 million gallons (roughly 2.7 inches of additional rainfall). Additional single lime discharges were authorized, as well as double lime discharges and R.O. water. The discharge levels into Bishop's Harbor, for the double limed water, were increased to two million gallons per day.[36]

Unfortunately, with such low storage capacity, and the near catastrophic incidents of the last two years, DEP felt that another year taking such risks was unacceptable. Scientists speculated that 2003 would have El Nino weather patterns, (which in Florida means above average rain) compounding the problem.[37] For these reasons, FDEP filed a request with the EPA in February 2003 for emergency dumping permits not to exceed 484 million gallons into the Gulf of Mexico.[38] This would be double lime treated and would be in compliance with all water quality criteria except ammonia (nitrogen levels). The DEP filed the request under the Marine Protection, Research, and Sanctuaries Act for its dumping violations and based its argument on preserving the health of Tampa Bay, but also on preserving the health and property of more than 60 individuals who would be directly impacted, possibly killed if Piney Point's gypsum stacks collapsed.[39] Stipulations for this dumping fall under the Ocean Dumping Act of 1972 and require (1) "there has been demonstrated to be an emergency"; (2) the waste "causes an unacceptable risk relating to human health" and (3) there is "no other feasible solution."

EPA investigated the problem thoroughly, and returned the approval for permitting in April 2003.[40] The permits were set to expire in November 2003, but many local stakeholders wanted to block the discharges. Local groups, such as sponge divers,

and a newly formed Fisherman's coalition felt that even if the discharges were necessary, 35 miles for offshore dumping (as the permit dictated) of water with elevated nitrogen levels came too close to Tampa Bay and near shore fishing areas.

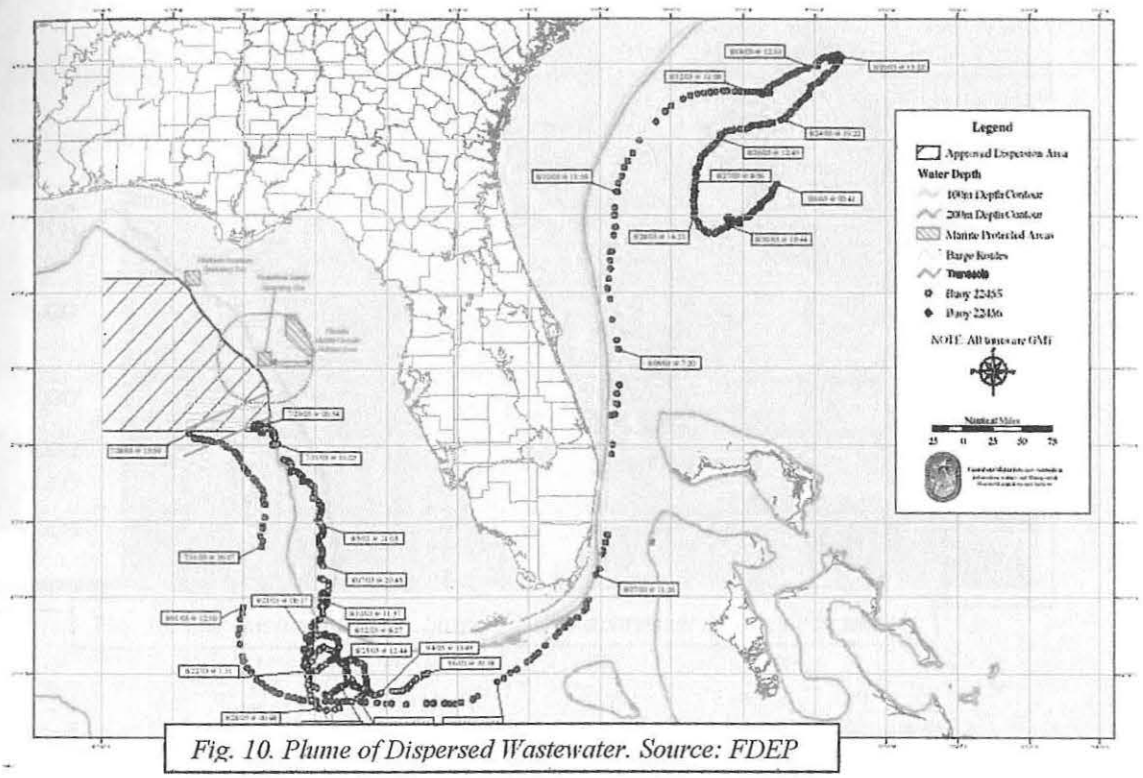


Fig. 10. Plume of Dispersed Wastewater. Source: FDEP

Ultimately these groups, and the efforts of U.S. Representative Bilarakis, made FDEP discharge the wastewater further out in the Gulf of Mexico at a distance of greater than 120 miles.[41]

Multiple buoy markers and detailed satellite imagery followed the plume of dispersed wastewater which FDEP discharged between May and November 2003.[42, 43] These images, such as the examples on the previous page, indicate that the plume missed Florida entirely and in retrospect, the total volume of nitrogen was drastically lower than

weekly influx of nitrogen from the Mississippi River.[44]

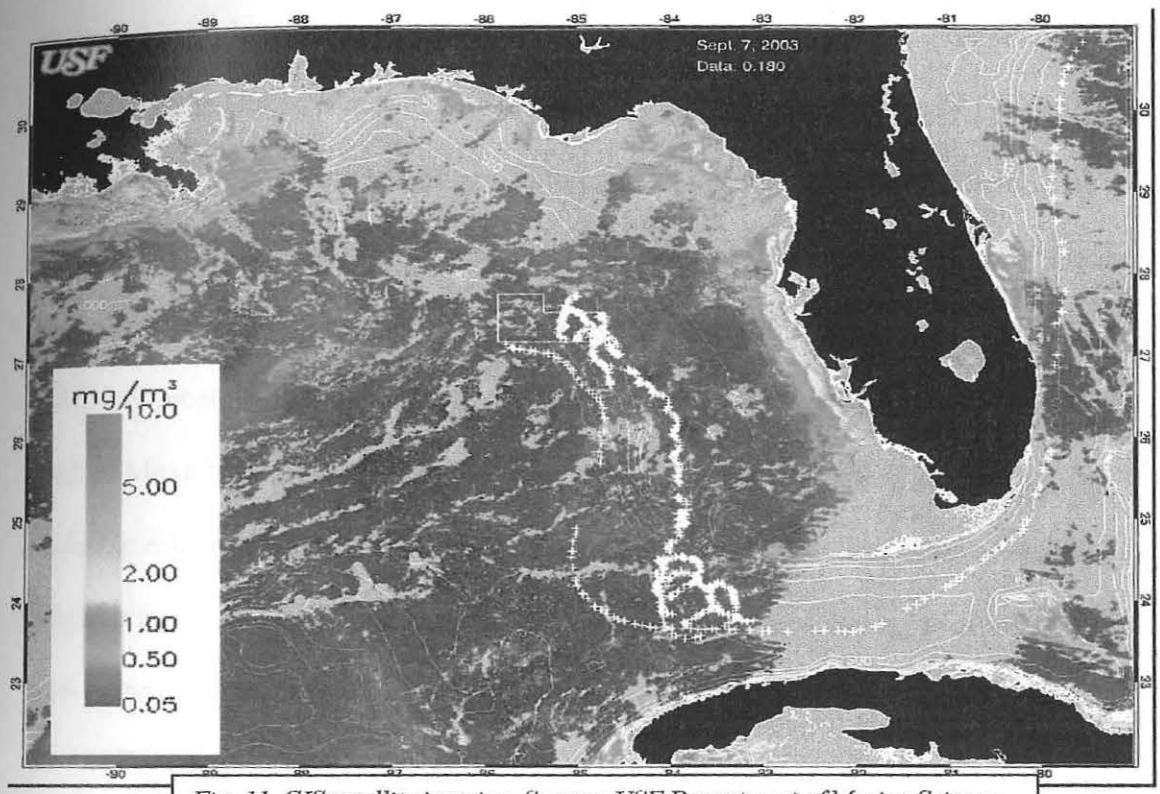


Fig. 11. GIS satellite imaging. Source: USF Department of Marine Science.

Another factor that should not be understated is the prohibition enacted by the United Nations on offshore dumping by any nation. The prohibitive treaty, called the United Nations International Law of the Sea (UNCLOS), declares that the oceans are held in the common trust.[45] EPA and the FDEP actually went to the UN and asked for formal permission to discharge Piney Point's treated wastewater and received approval. However, by receiving approval for an exception a joint agreement, the treaty becomes weaker.[46] Originally started as a way to regulate international toxic waste dumping and ocean mineral rights, UNCLOS is one of the most important and comprehensive environmental treaties.

UN treaties are normally backed up by good faith agreements. Non-compliance can result in diplomatic repercussions, but very few UN treaties are backed up by force or fines.[47] For the United States to violate a worldwide environmental treaty for any incident calls into question the whole nature of international treaties and their relevancy. By setting such a precedent, the U.S. demonstrates that mandates not backed up by force or methods of economic coercion can be selectively followed. Making an exception to Piney Point will most likely not cause Mexico or Guatemala to dump hazardous wastes into the Gulf of Mexico, because so many of their domestic programs depend on funding and amicable relations with the U.S. The potential ramifications are more pertinent for neighboring under-developed nations that wish to use ocean dumping to alleviate their own environmental problems.[48]

For a variety of factors, monetary and logistically, only 374 gallons of wastewater were sprayed into the Gulf.[49] At the same time, DEP reduced the gypstack water volume by more than two million gallons per day thanks to several industrial donors and R.O. and double lime discharges into Bishop's Harbor. When FDEP attempted to renew their Gulf discharge permits, EPA gave formal notice on November 25 that no additional would be given. The El Nino weather patterns turned out to mild, and between the additional discharges and

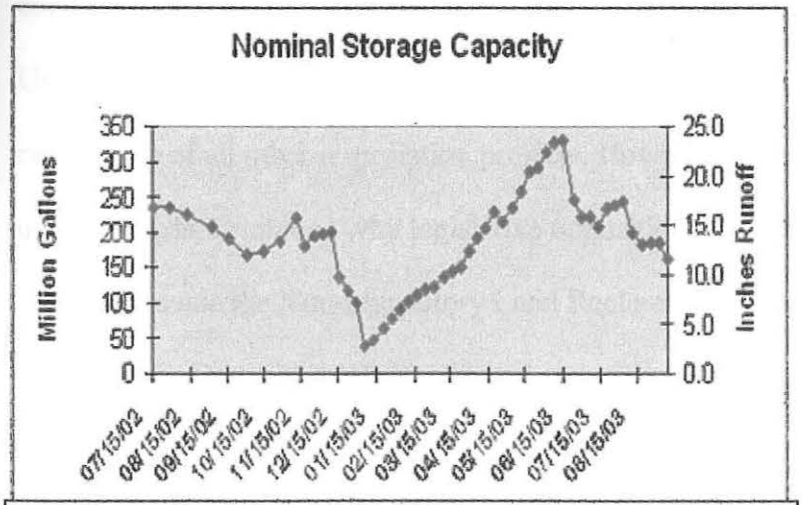


Table 3. Results of FDEP's efforts. Source: FDEP.

Gulf dumping, EPA felt that DEP already contained the emergency to the point where emergency permits in violation of national legislation were unnecessary.[50]

By summer 2004, one of the four gypsum stacks was permanently shut down. An ongoing issue of critical importance for completion of the decommissioning process will be finding adequate funding. When the FDEP received an emergency budget proposal for Piney Point in 2001, they were allowed $4,000,000 for immediate use.[51] The Non-Mandatory Land Reclamation Trust Fund, used for the reclamation and remediation of abandoned areas mined before 1975, was raided for the decommissioning funds. The legislature parceled the funds into large chunks and then allowed FDEP to distribute these funds as needed until later legislative appropriations. In February 2002, FDEP received $16,000,000 to work with and since this time, additional appropriations have been added.[52] Most of the funding goes to onsite construction, maintenance and reducing the water volume of the gypsum stacks.

This trust fund, financed by the Florida Phosphate Severance Tax, originally contained $104 million, but by summer 2004 it was reduced to $54 million.[53] This fund comprises the only legislative allocation for remediation of previously mined lands. Using this fund so extensively on Piney Point's closure increases the timeframe for completion of all other remediation projects. However the necessity for quick allocation of large funds, combined with legislative opposition to reducing the budgets of other programs, made the Non-Mandatory Land Reclamation Trust Fund the best choice. The project of dealing with Mulberry Phosphate's financial assets will mostly likely cost upwards of $140 million dollars.[54] Since much of this money has not been allocated, it remains unclear which programs will have funding re-directed to pay for this time-

consuming and costly bankruptcy. To prevent other companies from putting the state at similar risk, legislation was added in fiscal year 2003 to deal with phosphate corporations and financial accountability, as well as bonds taken out against the possibility of bankruptcy and state management of gypsum stacks.[55] At this time, there are 25 gypsum stack complexes. Twelve are active, ten inactive, and three have already been shut down. Piney Point's wastes are by no means the largest.[56] The second Mulberry Phosphate investment, which Cargill agreed to manage, contained 2.4 billion gallons of water in February of 2001.[57]

The safety of homeowners and the economic impacts an acidic spill would have on Tampa Bay lent considerable impetus to FDEP requests for state funding, and for the FDEP application to the EPA for emergency dumping permits. The Sierra Club, Ocean Conservancy, and other groups took an official stand against any Gulf discharges, advocating certain alternative plans that FDEP did not consider economically feasible.[58, 59] The decommissioning process will continue until 2008, but unless the state stops its efforts midway, Piney Point no longer presents an imminent threat.

[1] Florida Department of Environmental Protection. Bankruptcy proceedings. Official receiver authorization, case no. 01-1650. Jan 2001.

[2] Victoria Parsons and Mary Kelley Hoppe. "Piney Point: back from the brink?" Tampa Bay Soundings, (Summer 2002), 1, 6-7.

[3] Agency on Bay Management, Tampa Bay Regional Planning Council. November Meeting Summary, 13 Dec 2001.

[4] Florida Department of Environmental Protection. Case no. 01-1615. Interdepartmental update. 9 Jan 2002.

[5] Tampa Bay Estuary, Florida Department of Environmental Protection. Piney Point Discharge and Red Tide in Tampa Bay. Interdepartmental update, 7 Dec 2001.

[6] Agency on Bay Management, Tampa Bay Regional Planning Council. November Meeting Agenda, 13 Dec 2001.

[7] "Borden Plant Will Discharge Water on a Regular Basis," Sarasota Herald-Tribune, 9 April 1966.

[8] Allan Bedwell, Florida Department of Environmental Protection. "Re: request for emergency permit under the Marine Protection, Research, and Sanctuaries Act." Personal Letter to Jimmy Palmer, United States Environmental Protection Agency, 21 Feb 2003.

[9] Ibid.

[10] Florida Department of Environmental Protection, Interagency PowerPoint Presentation, 15 March 2002.

[11] Agency on Bay Management, Tampa Bay Regional Planning Council. "April 10th joint meeting of the Agency on Bay Management's natural resources/environmental impact review committee and the Tampa Bay Estuary Program technical advisory committee's water quality modeling subcommittee." Memo, 31 March 2003.

[12] Florida Department of Environmental Protection. Official response to queries from Southwest Florida Water Management District. 9 Jan 2002.

[13] Ibid.

[14] John P. Smol, Pollution of Lakes and Rivers: A Paleoenvironmental Perspective. Key Issues in Environmental Change, vol. 5 (New York: Oxford University Press Inc, 2002).

[15] George Henderson, Florida Fish and Wildlife Conservation Commission, PowerPoint Presentation, 11 September 2003.

[16] Fl Senate, Phosphate mining: Senate staff analysis and economic impact statement. Bill CS/SB 18-E, 22 Oct 2003.

[17] Lucia Ross. "DEP, Cargill agree to long-term solution to Mulberry Phosphate's environmental problems." Press release, 7 May 2002.

[18] Florida Department of Environmental Protection, "Piney Point Briefing," PowerPoint Presentation, 11 September 2003.

[19] Rob Brown, Florida Department of Environmental Protection, interview by author, 22 July 2004.

[20] "Borden Official Cites Plant Impact," Sarasota Herald-Tribune, 14 April 1967.

[21] Florida Department of Environmental Protection, "Piney Point Briefing," PowerPoint Presentation, 11 September 2003.

[22] Fred Crafa, chief water chemist at St Petersburg Water, personal communication, 15 July 2003.

[23] Agency on Bay Management, Tampa Bay Regional Planning Council. "Meeting of the solutions subgroup for solutions to the Piney Point discharge into Bishop Harbor." Meeting Agenda, 4 Feb 2002.

[24] Florida Department of Environmental Protection. "Piney Point status update." Memo, 7 May 2002.

[25] Bedwell to Palmer.

[26] Florida Department of Environmental Protection. Request for emergency permit under the Marine Protection, Research and Sanctuaries Act (Tallahassee, FL: Feb 2003).

[27] Tampa Bay Estuary, Florida Department of Environmental Protection. Piney Point Discharge and Red Tide in Tampa Bay. Interdepartmental update, 7 Dec 2001.

[28] Florida Department of Environmental Protection. Official responses to queries from the Environmental Protection Agency concerning Piney Point Marine Protection, Research, and Sanctuaries Act emergency permit application.

[29] Sam Zamani <Sam.Zamani@dep.state.fl.us> "Piney Point," 28 Jan 2002, personal e-mail to George Henderson et al, Florida Department of Environmental Protection (14 June 2004).

[30] Florida Department of Environmental Protection. Official response to queries from Southwest Florida Water Management District. 9 Jan 2002.

[31] Craig Pittman, Julie Hauserman, and Candice Rondeaux, "A $140-Million Mess," St Petersburg Times, 6 July 2003.

[32] Florida Department of Environmental Protection. Request for emergency permit under the Marine Protection, Research and Sanctuaries Act (Tallahassee, FL: Feb 2003).

[33] Charlie Hunsicker, <charlie.hunsicker@co.manatee.fl.us> "Draft letter for congressional appropriations (edited)," 16 April 2002, personal email to Melissa Klein <mel.klein@fpl.com> (14 June 2004).

[34] Charlie Hunsicker, <charlie.hunsicker@co.manatee.fl.us> "Draft letter for congressional appropriations (edited)," 14 May 2002, personal email to Melissa Figge, <Melissa.Figge@mail.house.gov> (14 June 2004).

[35] Florida Department of Environmental Protection. "Piney Point status update." Memo, 25 April 2003.

[36] Florida Department of Environmental Protection, "Timeline," Myflorida.com, 1 April 2004, <http://www.dep.state.fl.us/secretary/news/2003/pp/timeline_102403.pdf> (17 May 2004).

[37] Florida Department of Environmental Protection, "Timeline," Myflorida.com, 1 April 2004, <http://www.dep.state.fl.us/secretary/news/2003/pp/timeline_102403.pdf> (17 May 2004).

[38] Florida Department of Environmental Protection. Request for emergency permit under the Marine Protection, Research and Sanctuaries Act (Tallahassee, FL: Feb 2003).

[39] Florida Department of Environmental Protection. "Piney Point status update." Memo, 7 Oct 2003.

[40] United States Environmental Protection Agency. EPA process of issuing an emergency permit for ocean disposal of treated wastewater in the Gulf of Mexico from the Piney Point phosphate facility in Manatee County, Florida. Fact sheet, 3 April 2003.

[41] Florida Department of Environmental Protection, "Timeline," Myflorida.com, 1 April 2004, <http://www.dep.state.fl.us/secretary/news/2003/pp/timeline_102403.pdf> (17 May 2004).

[42] George Henderson, Florida Fish and Wildlife Conservation Commission, PowerPoint Presentation, 11 September 2003.

[43] Florida Department of Environmental Protection. "Piney Point status update." Memo, 25 April 2003.

[44] Dr. Eric Steimle, Visiting Professor at the University of South Florida, personal communication, 28 July 2004.

[45] Division for Ocean Affairs and the Law of the Sea, "United Nations Convention on the Law of the Sea of 10 December 1982: Overview and Full Text," Oceans and Law of the Sea, United Nations, 10 February 2004 <http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm> (19 May 2004).

[46] Susan J. Buck, "The Oceans," in The Global Commons: An Introduction (Washington DC: Island Press, 1998).

[47] Dr. Mary Matthews, Tethys Consulting, Inc, personal communication, 15 July 2004.

[48] Dr. Mary Matthews, Tethys Consulting, Inc, personal communication, 15 July 2004.

[49] Deborah Getzoff, Tampa Bay Estuary Program. Extension of Piney Point gulf dispersion permit. Personal letter to J. I. Palmer, U. S. Environmental Protection Agency, 18 Nov 2003.

[50] Florida Department of Environmental Protection. "Piney Point status update." Memo, 11 May 2004.

[51] United States Environmental Protection Agency. EPA process of issuing an emergency permit for ocean disposal of treated wastewater in the Gulf of Mexico from the Piney Point phosphate facility in Manatee County, Florida. Fact sheet, 3 April 2003.

[52] Agency on Bay Management, Tampa Bay Regional Planning Council. "April 10th joint meeting of the Agency on Bay Management's natural resources/environmental impact review committee and the Tampa Bay Estuary Program technical advisory committee's water quality modeling subcommittee." Meeting Agenda, 10 April 2003.

[53] Agency on Bay Management, Tampa Bay Regional Planning Council. November Meeting Summary, 13 Dec 2001.

[54] Craig Pittman, Julie Hauserman, and Candice Rondeaux, "A $140-Million Mess," St Petersburg Times, 6 July 2003.

[55] Joseph Bakker, Bureau of Mine Reclamation, "Public Workshop Regarding the Proposed Amendments to Chapter 62-673, F. A. C., Phosphogypsum Management" (Tallahassee, FL: Florida Department of Environmental Protection, 9 October 2003).

[56] Mark Derr, Some Kind of Paradise: A Chronicle of Man and the Land In Florida (Gainesville, FL: University Press of Florida, 1998).

[57] Lucia Ross. "DEP, Cargill agree to long-term solution to Mulberry Phosphate's environmental problems." Press release, 7 May 2002.

[58] The Ocean Conservancy, "U. S. EPA Denies Permit for Florida to Continue Ocean Dumping," EMS: Environmental Media Services, 1 December 2003 <http://www.ems.org/rls/2003/12/01/us_epa_denies_pe.html> (25 May 2004)

[59] "Phosphate Mining Waste Fiasco Was Legally Allowed to Happen," Boca Sierra: The Mouth of the Sierra Club, (June 2004), 1.

Chapter 5. The Environmental Legislation Surrounding Piney Point

Piney Point, like other agro-chemical plants in the state of Florida, developed its production standards and land use practices to meet the changing framework of environmental legislation.[1] Commercial grade phosphate production pollution takes myriad forms, but often includes toxic emissions of sulfur dioxide and fluoride.[2] Waterways may be threatened by radioactive tailings, elevated nutrients including nitrogen and phosphorus, and toxic metals such as arsenic.[3] Mined areas pose a risk of erosion, water table contamination, and invasive species colonization.[4] Gypsum stacks contain organic solvents from beneficiation, as well as low grade radioactivity, and the process water from the phosphoric slurry is invariably acidic.[5] From a regulatory standpoint, each is a separate risk factor; no cumulative picture is possible. For Piney Point, and the Florida Phosphate industry as a whole, the evolution of management strategies generated from both within and outside the industry has been highly variable over the last 50 years.[6]

In 1965, when Borden Chemicals first opened its doors, the state of Florida lacked comprehensive enforcement capabilities for regulation of air, land, and water pollution. In the late 1940s several well publicized cases of toxic smog in Los Angeles, New York City, and other metropolitan areas spurred the government to pass the first of a series of environmental measures to improve air quality.[7,8] The Air Pollution Control Act of 1955 acknowledged that air pollution was a problem of national importance and mandated $5 million annually for five years to study the problem.[9] This act was renewed and expanded in 1960, but since it lacked regulatory enforcement or definitions of allowable toxins, it

remained largely ineffective. For these reasons, concerned citizens in Polk County in the early 1960s petitioned the Florida state government to do something about air pollution on its own. The state and local government created the Polk-Hillsborough Clean Air Zone, which sought to limit fluoride emissions to 0.4 lbs per ton of processed rock.[10, 11, 12] These regulations were largely ineffective because, as Frank Cross Jr. of the Manatee County Department of Environmental Management remarked in 1966, the regulator at the local level had many powers to sample air quality and make recommendations, but without regulatory standards mandated at a federal level and given enforcement dollars, the state and county could recommend change, but could not fine or shutdown an offender.[13]

Widely credited as the most important piece of environmental legislation of the 1960s, the 1963 Clean Air Act changed the way many electrical utilities did business.[14] It did not make obvious changes for the phosphate industry, because it was primarily concerned with automobile and coal fired power plant particulate emissions. However, the success of the Clean Air Act, which directed states to create maximum pollution standards, would provide a tentative first step into well funded and well researched air quality reviews (budgeted $95 million for five years).[15] Even so, standardization of test methodology, as well as regulated industries' financial pressuring, blocked more radical standards, and the enforcement of any new air pollution measure was immediately challenged in court.[16] This is not to say that the phosphate industry no longer challenges legislation affecting them. This practice continues. But since the hallmark legislation of the 1960s, polluting industries sue the Environmental Protection Agency or the state

environmental agency rather than local governments, which are often not capable of adequately defending or legally enforcing their regulations.[17]

During the later 1960s, the awakening environmental movement and the obvious negative effects of pollution forced policy makers to pass and approve the radically progressive environmental legislation of the 1970s. The 1970 Clean Air Act represented a totally rewritten set of guidelines for air pollution.[18] To enforce these air regulations and update and expand the water quality mission of the Federal Water Quality Administration, President Nixon created the Environmental Protection Agency (EPA). The EPA would absorb the responsibilities of several individual offices within the Department of Interior, and regulate environmentally destructive industries across the United States.[19]

The combination of a Clean Air Act, and an agency to enforce that same Act, led to National Ambient Air Quality Standards (NAAQS) and New Source Performance Standards (NSPS) by the beginning of 1971.[20] The NAAQS gave the EPA regulatory authority to enforce codified standards for air pollution from a broad range of industries, including phosphate companies.[21] Borden chemicals now had no recourse but to add additional scrubber technology and retrofit their ammonium mixing vats to reduce sulfur dioxide and fluoride emissions. The NSPS portion of the Act regulated the introduction of polluting industry into any area. Both building a new phosphate plant and expanding upon an already operational plant would require agreements to conform to environmentally sound standards.

Another relevant aspect of the new Act was its "injured party" status re-definition. Under the 1970 rules, any citizen or group could make a claim to or even against the

government in the case of non-compliance by a corporate entity.[22] By broadening the right to sue, concerned parties that were not local landowners or otherwise immediate recipients could address pollution legally as an injured party. The ramifications, such as greater ability to claim injury and the applications to different business practices are complex and mostly on a case by case basis. Multiple suits in the 1970s were leveled against Piney Point under this re-definition.[23] The new entitlements predominantly gave environmental focus groups the ability to sue practically any American company believed to be in violation of the new laws. Even if these lawsuits were not successful, though many certainly were, individual lawsuits very often brought the company to the EPA's attention and increased the possibility of more litigation. Many companies chose to at least partially comply with new mandates as a way to avoid the expense of multiple lawsuits.

During this period, states were creating or reinforcing their own environmental protection agencies, which began to have a framework of national legislative powers to draw on for their local enforcement.[24] Moderately funded state regulatory agencies emerged, all of which possessed the authority to make stricter regulations than the EPA, or, if they did not, were still mandated to enforce the national pollution criteria.[25]

A comprehensive water pollution act came soon after and, like the Clean Air Act, the Clean Water Act of 1972 (as it came to be known) had gone through several revisions since the original 1948 Water Pollution Control Act.[26] Earlier iterations of the Act lacked "regulatory teeth," standardization, and specific guidelines for what constituted a violation, as well as comprehensive funding.[27] The Clean Water Act of 1972, and its later re-authorizations and modifications in 1977 and 1987, promoted the establishment of

sewage treatment facilities, the preservation of potable water sources, and the reduction of pathogenic organisms in marine and estuarine ecosystems.[28]

Phosphate plants, especially Piney Point, fell under this regulatory heading after Piney Point was implicated in Bishop Harbor's algal blooms. The FDEP began regularly monitoring wells both on and off site. They also required tighter maintenance of the ditchline connecting Piney Point's gypstacks with Bishop's Harbor.[29] In fact, one reason why Mulberry Phosphate could not make Piney Point operational, despite $30 million in renovations, was the tighter regulation present from the 1977 amendment of the Clean Water Act.[30]

The Marine Protection, Research and Sanctuaries Act passed in 1972.[31] Unofficially known as the Ocean Dumping Ban, it completely revised the way American municipalities and industry disposed of waste. These regulations became very relevant to disposal of Piney Point's phosphoric wastewater since it was this law which DEP asked to violate for emergency wastewater discharges.

Other important laws which impacted Piney Point and the Phosphate industry were those that regulated land use practices. The Mandatory Reclamation Act of 1975, a state law, required that all lands mined in the state of Florida be reclaimed by the extractive industry.[32] Specifically geared toward phosphate operations, this regulation led directly to the Phosphate Severance Tax as a way to reclaim lands impacted by mining prior to 1975. The Non-Mandatory Reclamation Land Trust Fund continues to provide the majority of funding for the decommissioning of Piney Point, as well as for the contract with Cargill for management of the Mulberry Phosphate facility.

The Resource Conservation and Recovery Act (RCRA) of 1976 gave phosphate companies the opportunity to apply for grants to improve recycling and reduction of waste materials.[33] At the same time, the 1976 Toxic Substances Control Act began to create a toxic materials database and further limit where and how Piney Point and other sulfur acid factories could dispose of their hazardous wastes.[34] Ultimately the issue of abandoned and actively dangerous toxic materials required further legislation. In 1980, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) authorized the funding for disposal and reclamation of hazardous wastes.[35] This program has since been used to reclaim abandoned beneficiation plants, slime ponds, and sulfuric acid plants in Hillsborough, Escambia, and Pinellas County.

The Superfund Provisions of CERCLA, 1986, actually provide the mandate to fund and remediate toxic wastes where there is no responsible corporate entity.[36] EPA determines which sites will be remediated using lengthy risk assessments.[37] Piney Point was considered for Superfund sponsorship, but ironically DEP decided that if they waited for EPA to complete their assessments for risk based funding, the risk would have come and gone. The berm walls would already have collapsed.[38]

These laws form the major regulatory guidelines for how the state of Florida regulates phosphate. Additional laws governing the preservation of wetlands limits new mining permits, and some additional legal provisions for corporate operators of phosphate plants passed the legislature in 1993.[39] These provisions required phosphate operators to submit yearly financial analysis statements to the Bureau of Mines, a department in the DEP. This was done for Piney Point, but as is often the case at a state regulatory agency, Mulberry Phosphate was given additional time to complete these

financial records after it reduced its active maintenance in 1999. The Bureau of Mines works exclusively with the industry and seems to function more as a partner to the industry rather than as an adversary. It is not unheard of therefore to give a phosphate plant an additional six months to comply with a regulation, or reducing a fine to ensure prompt payment.[40]

After the Piney Point Bankruptcy, state legislation passed that increased financial accountability standards for phosphate companies, and increased the Phosphate Severance Tax (2003) to help pay for the spill.[41] Democratic representatives to the legislature proposed other measures, but these did not receive approval from the Republican majority in the House or the Senate (2002-2004).[42]

Regardless, the overall trend for phosphate companies and other industries has been increased regulation and higher environmental standards. Each time a company fails to satisfy the existing requirements, as Mulberry Phosphate failed to do, the regulations become tighter. Although this may eventually have negative repercussions in terms of decreased production and profit, it also has highly positive consequences – that is, the preservation of the environment and the assurance of clean air, land, and water, as well as ethical business practices.

This paper has attempted to demonstrate the skill and care with which DEP responded to the Piney Point bankruptcy, while acknowledging that some errors in judgment were made and some standards had to be compromised. Piney Point and its bankrupcy symbolically ties us to Florida's original industrial economy, and literally reminds us that the health of our waterways is not an abstract concept but a fragile reality. This is made more important by Florida's growing dependence on a service economy and

its increasing population. The population at large, including Florida's important business groups, need to recognize that stringent environmental standards are a practical necessity.

[1] Jacobs Engineering Group, "Phosphate Rock Treatment for Waste Reduction," Florida Institute of Phosphate Research Publications (1995).

[2] J. Martin, et al, "Environmental Impact of Fertilizer Industries Evaluated by PIXE," Nuclear Instruments & Methods in Physics Research 103 no. 4 (1995): 477-481.

[3] Tampa Bay Regional Planning Council, "State of Tampa Bay," Florida Department of Environmental Protection, 1991.

[4] Tampa Bay Regional Planning Council. "Habitat Restoration Study for the Tampa Bay Region," Florida Department of Environment Protection, 1986.

[5] Michael Mew, "Phosphate Rock," Mining Annual Review (2001).

[6] Richard N. L. Andrews, "Risk Based Decision Making," in Environmental Policy: New Directions for the Twenty First Century, eds. Norman J. Vig and Michael E. Kraft, 5th ed. (Washington DC: CQ Press, 2003).

[7] Zachary A. Smith, The Environmental Policy Paradox. 3rd ed. (Upper Saddle River: Prentice Hall, 2000).

[8] American Meteorological Society, The Clean Air Act, 1999, <http://www.ametsoc.org/sloan/cleanair> (14 June 2004)

[9] Michael H. Brown, The Toxic Cloud (New York: Harper and Row, 1987).

[10] "Pollution Control Ordinance Skirted," Sarasota Herald-Tribune, 1 October 1965, p. 21.

[11] "Manatee Unit Advises Against Air Pollution Control District," Sarasota Herald-Tribune, 23 November 1965.

[12] Scott Dewey, Don't Breathe the Air: Air Pollution and U.S. Environmental Politics, 1945-1970 (College Station: Texas A&M Press, 2000).

[13] Editorial, "At Last They Admit It," Bradenton Herald, 20 June 1966, 4-A.

[14] Jacqueline Vaughn Switzer, Environmental Politics: Domestic and Global Dimensions, 3rd ed. (Boston: Bedford/St. Martin's Press, 2001).

[15] Myrick A. Freeman, "Economics, Incentives, and Environmental Regulation," in Environmental Policy: New Directions for the Twenty First Century, eds. Norman J. Vig and Michael E. Kraft, 4th ed. (Washington D.C.: CQ Press, 2003).

[16] Zachary A. Smith, The Environmental Policy Paradox. 3rd ed. (Upper Saddle River: Prentice Hall, 2000).

[17] Jacqueline Vaughn Switzer, Environmental Politics: Domestic and Global Dimensions, 3rd ed. (Boston: Bedford/St. Martin's Press, 2001).

[18] R. Gottlieb, ed. Reducing Toxics: A New Approach to Policy and Industrial Decision-making (Washington DC: Island Press, 1995).

[19] American Meteorological Society, The Clean Air Act, 1999, <http://www.ametsoc.org/sloan/cleanair> (14 June 2004)

[20] Environmental Protection Agency, National Ambient Air Quality Standards (NAAQS)," 4 February 2004, <http://www.epa.gov/naaqs> (18 June 2004).

[21] Environmental Protection Agency, New Source Review: Basic Information, 30 June 2004, <http://www.epa.gov/nsr/info.html> (8 July 2004).

[22] American Meteorological Society, The Clean Air Act, 1999, <http://www.ametsoc.org/sloan/cleanair> (14 June 2004).

[23] Thomas W. Reese, "Piney Point Phosphates' Phosphogypsum Stack System, Manatee County, Florida," personal letter to David B. Struhs, Department of Environmental Protection, 8 January 2001.

[24] Central Florida Phosphate Industry: Background and Alternatives Assessment, Final Areawide Environmental Impact Statement, vol. 2 (Atlanta, GA: United States Environmental Protection Agency, 1978).

[25] Vishwa Sate, Florida Department of Environmental Protection, personal communication, 27 July 2004.

[26] U. S. Fish and Wildlife Service, "Federal Water Pollution Control Act," Official Website, 2004, <http://laws.fws.gov/lawsdigest/fwatrpo.html> (15 March 2004): Resource Laws.

[27] Sheldon Krimsky and Alonzo Plough, Environmental Hazards: Communicating Risks as a Social Process (Dover: Auburn House, 1989).

[28] Michael E. Kraft, "Environmental Policy in Congress: From Consensus to Gridlock," in Environmental Policy: New Directions for the Twenty First Century, eds. Norman J. Vig and Michael E. Kraft, 5th ed. (Washington DC: CQ Press, 2003).

[29] Vishwa Sate, Florida Department of Environmental Protection, personal communication, 27 July 2004.

[30] Vishwa Sate, Florida Department of Environmental Protection, personal communication, 27 July 2004.

[31] Environmental Protection Agency, "Marine Protection, Research, and Sanctuaries Act, 1972," EPA Website, 2004, <http://www.epa.gov> (12 June 2004).

[32] Florida Institute of Phosphate Research, "Severance Tax on Phosphate Rock," FIPR Website, 9 March 2001, < http://www.fipr.state.fl.us/sevtax99.htm> (12 April 2004).

[33] Walter Rosenbaum, "The Politics of Hazardous Waste Management," in The Politics of Hazardous Waste Management, eds. James Lester and Ann O'm. (Durham: Duke University Press, 1983).

[34] Environmental Protection Agency, "Toxic Substances Control Act," EPA Website, 2004, <http://www.epa.gov> (12 June 2004).

[35] Environmental Protection Agency, "Comprehensive Environmental Response Compensation and Liability Act," EPA Website, 2004, <http://www.epa.gov> (12 June 2004).

[36] Judith A. Layzer, "Love Canal: Hazardous Waste and the Politics of Fear," in The Environmental Case: Translating Values Into Policy (Washington DC: CQ Press, 2002).

[37] Walter A. Rosenbaum, "Risk Assessment and the Limits of Science," Environmental Politics and Policy, 5th ed. (Washington DC: CQ Press, 2002).

[38] George Henderson, Florida Fish and Wildlife Conservation Commission, personal communication, 15 June 2004.

[39] Thomas W. Reese, interagency memo to the Department of Environmental Protection, 2002.

[40] Craig Pittman, Julie Hauserman, and Candice Rondeaux, "A $140-Million Mess," St Petersburg Times, 6 July 2003.

[41] Senate, Phosphate mining: Senate staff analysis and economic impact statement. Bill CS/SB 18-E, 22 Oct 2003.

[42] George Henderson, Florida Fish and Wildlife Conservation Commission, personal communication, 15 June 2004.

Bibliography

"Act on Air Pollution to be Aired," Sarasota Herald-Tribune. 8 January 1965, p. 17.

Agassiz, Garnault. "Florida in Tomorrow's Sun," Suniland 3, no. 2 (1925): 37-45, 88-94, 113-133.

Agency on Bay Management. February 2, 2002 Task Force Meeting. Memo, 25 Jan 2002.

--- April 10th joint meeting of the Agency on Bay Management's natural resources/environmental impact review committee and the Tampa Bay Estuary Program technical advisory committee's water quality modeling subcommittee. Memo, 31 March 2003.

--- March Meeting Summary, 13 March 2003.

--- Meeting of the solutions subgroup for solutions to the Piney Point discharge into Bishop Harbor. Meeting Agenda, 4 Feb 2002.

--- Meeting of the task force for monitoring and solutions to the Piney Point discharge into Bishop Harbor. Meeting Agenda, 10 Jan 2002.

--- November Meeting Agenda, 13 Dec 2001.

--- Task force recommendations for Piney Point monitoring. Memo, 24 Jan 2002.

"Air Pollution Citizen Meet Set Tonight." Sarasota Herald-Tribune, 23 November 1965, sec. 2.

"America Grows on Florida Phosphate." Florida Phosphate Council Public Relations Document (Tallahassee, FL: Florida Phosphate Council, 2002).

American Meteorological Society. The Clean Air Act, 1999, <http://www.ametsoc.org/sloan/cleanair> (14 June 2004).

"Ammonium Phosphate." Inorganic Chemical Industry, United States Environmental Protection Agency, January 1995, <http://www.epa.gov/ttn/chief/ap42/ch08/final/ c08s05-3.pdf> (19 June 2004).

Andrews, Richard N. L. "Risk Based Decision Making," in Environmental Policy: New Directions for the Twenty First Century, eds. Norman J. Vig and Michael E. Kraft, 5th ed. (Washington DC: CQ Press, 2003).

Bakker, Joseph. Bureau of Mine Reclamation. "Public Workshop Regarding the Proposed Amendments to Chapter 62-673, F. A. C., Phosphogypsum Management" Tallahassee, FL: Florida Department of Environmental Protection, 9 October 2003.

Barry, Rick. "The Spoonfuls of Wastewater are Adding Up." The Tampa Tribune, 31 August 2003, sec B.

Bedwell, Allan. "Emergency Permit No. OD-03. Request for Time Extension." Department of Environmental Protection. Memo, 21 October 2003.

--- Re: request for emergency permit under the Marine Protection, Research, and Sanctuaries Act. Personal Letter to Jimmy Palmer, United States Environmental Protection Agency, 21 Feb 2003.

Bergmann, Norma. "Air Sampling Stands Guard Over Pollution." The Tampa Tribune, 6 August 1966.

--- "No Test Ports Found for Stack Sampling." Sarasota Herald-Tribune, 24 November 1966,

sec. 2.

Blakey, Arch Fredric. The Florida Phosphate Industry: A History of the Development and Use of a Vital Mineral. Cambridge: Harvard University Press, 1973.

Blocker, Pauline. "Florida's Phosphate Mining Crisis." Whose Florida, <http://www. whoseflorida. com/misc_pages/phosphate_mining_crisis.htm> (2 July 2004).

"Borden Official Cites Plant Impact," Sarasota Herald-Tribune, 14 April 1967.

"Borden Plant Will Discharge Water on a Regular Basis," Sarasota Herald-Tribune, 9 April

1966.

Bouffard, Kevin. " Following Phosphate; As Mining Operations Move South, Fertilizer Plants Will Stay In Polk County; Economic Mainstay."Lakeland Ledger, 5 January 2003, sec. A.

--- "IMC Phosphate Requests Delay of Florida Mine Review." The Lakeland Ledger, 29 July 2003.

--- "Official Says Florida Phosphate Mining Industry's Future In Doubt," Lakeland Ledger, 18 October 2002, sec. A.

--- "Official Says Florida Phosphate-Mining Industry's Future in Doubt." The Lakeland Ledger, 18 October 2002.

--- "Political Controversies Continue to Dog Phosphate Mining." Lakeland Ledger, 6 Jan 2003, sec. A.

Bourdon, B., et al. "Introduction to U-Series Geochemistry," Reviews in Mineral Geochemistry 52 (2003): 1-21.

Brown, Canter. Florida's Peace River Frontier. Orlando: University of Central Florida Press, 1991.

Brown, Michael H. The Toxic Cloud. New York: Harper and Row, 1987.

Brown, Robert, Florida Department of Environmental Protection. Personal interview, 22 July 2004.

Brown, William. "Manatee Board Approached: Two Groups Urge Adopting State Pollution Rules," St Petersburg Times, 17 November 1965.

Buck, Susan J. "The Oceans," in The Global Commons: An Introduction. Washington DC: Island Press, 1998.

Burnett, Clyde. "Grower Files Air Pollution Suit in Court in Tampa," The Herald-Tribune. 8 October 1965, sec. 2.

Burnett, Gene M. Florida's Past: People and Events that Shaped the State, vol. 3 Sarasota, FL: Pineapple Press, 1991.

Burnett, William, and Elzerman, Alan. "Nuclide Migration and Environmental Radiochemistry of Florida Phosphogypsum," Journal of Environmental Radioactivity 54 (2001): 27-51.

Busnach, E., Mehrez, A., and Sinuanystern, Z. "A Production Problem In Phosphate Mining." Journal of the Operational Research Society 36, no. 4 (1985).

Carroll, Scott. "Rain Re-Elevates Waste Problems At Piney Point." Sarasota Herald Tribune, 12 August 2003, Metro 3.

Carroll, Scott, and Hull, Victor. "Piney Point Controversy, Wastewater Still Flowing: Toxin's Effect On Gulf Unknown," Sarasota Herald Tribune, 4 July 2003, sec. B.

Central Florida Phosphate Industry: Background and Alternatives Asessment. Final

Areawide Environmental Impact Statement, vol. 2. Atlanta, GA: United States Environmental Protection Agency, 1978.

Checkoway, H., Heyer, N. J., and Demers, P. A. "An Updated Mortality Follow-up Study of Florida Phosphate Industry Workers." American Journal of Industrial Medicine 30 no. 4 (1996): 452-460.

Clifford, P., Lloyd, M., and Zhang, P. "Technology Research Improves Phosphate Economics," Mining Engineering 50 (1998).

Clifford, Paul, Lloyd, G. Michael Jr., and Zhang, Patrick. "Technology Research Improves Phosphate Economics," Mining Engineering 50, no. 4 (1998): 46-51.

Comfort, Iris Tracy. Florida's Geological Treasures. Baldwin Park, CA: Gem Guides Book Co, 1998.

Compton, Glenn. Sun Herald, 21 October 2003, Letter to the Editor.

Congressman Miller. Draft legislative memo to Henry Bonilla, Chairman, Subcommittee on Agriculture, Rural Development, Food and Drug Administration.

Connelly, James, and Smith, Graham. Politics and the Environment: From Theory to Practice. New York: Routledge, 1999.

Connet, Michael. "The Phosphate Fertilizer Industry." Fluoride Action Network Website, May 2003 <http://www.fluoridealert.org/phosphate/overview.htm> (3 July 2004).

Cook, P. J., and Shergold, J. H., eds. Phosphate Deposits of the World: Proterozoic and Cambrian Phosphorites, vol 1. Cambridge: Cambridge University Press, 1986.

Crone, Hugh. "Toxicity and Dosage: The Varying Shades of Gray." Chemicals and Society: A Guide To The New Chemical Age. Cambridge: Cambridge University Press, 1986.

Derr, Mark. Some Kind of Paradise: A Chronicle of Man and the Land In Florida. Gainesville, FL: University Press of Florida, 1998.

Dewey, Scott H. "The Fickle Finger of Phosphate: Central Florida Air Pollution and the Failure of Environmental Policy, 1957-1970." The Journal of Southern History 3 (1999): 565-603.

--- Don't Breathe the Air: Air Pollution and U.S. Environmental Politics, 1945-1970. College Station: Texas A&M Press, 2000.

"Diammonium Phosphate (DAP) Production from Saudi Arabian Phosphate Deposits," Azom.com: The Premier Online Materials Information Site, 2004, <http://www.azom.com/ details.asp?ArticleID=2083#_Origins_of_Phosphate> (10 March 2004).

Division for Ocean Affairs and the Law of the Sea. "United Nations Convention on the Law of the Sea of 10 December 1982: Overview and Full Text." Oceans and Law of the Sea, United Nations, 10 February 2004 <http://www.un.org/Depts/los/convention_agreements/convention_overview _convention.htm> (19 May 2004).

Dooris, Patricia, et al. "A Comparitive Analysis of Environmental Impacts: Phosphogypsum vs. Borrow Pits." Florida Institute of Phosphate Research Publications (2000).

Dunkelberger, Lloyd. "Phosphate Tax Deal Will Fund Cleanup; Industry's Impact." Lakeland Ledger, 16 May 2003, sec A.

Editorial. "A Regulatory Disaster." St. Petersburg Times, 9 July 2003, sec. A.

Editorial. "At Last They Admit It." Bradenton Herald, 20 June 1966, 4-A.

Editorial. "Maximum Safeguards Mandatory." St Petersburg Times, 24 September 1965, sec. A.

Editorial. "Phosphate Dangers Pile Up; Florida Needs a Plan For Dealing With Its Towering Stacks of Waste." Sarasota Herald-Tribune, 19 July 2003, sec. A.

Environmental Protection Agency. "Ammonium Phosphate." EPA Website, July 1993 <http://www.epa.gov/ttn/chief/ap42/ch08/final/c08s05-3.pdf> (25 May 2004): Inorganic Chemical Industry.

--- "National Ambient Air Quality Standards (NAAQS)," EPA Website, 4 February 2004, <http://www.epa.gov/naaqs> (18 June 2004).

--- EPA process of issuing an emergency permit for ocean disposal of treated wastewater in the Gulf of Mexico from the Piney Point phosphate facility in Manatee County, Florida. Fact sheet, 3 April 2003.

--- "Fact Sheet: Amendments to the Final Rules to Reduce Toxic Air Emissions from Phosphoric and Manufacturing Plants and Phosphate Fertilizers Production Plants." 7 June 2002 <http://www.epa.gov/ttn/oarpg/t3/fact_sheets/pampfpp_afs.pdf> (19 June 2004).

--- "Fact Sheet: Proposed Air Toxics Regulation for the Phosphoric Acid and Phosphate Fertiliizers Industries." 20 December 1996, < http://www.epa.gov/ttn/ oarpg/t3/fact_sheets/fertfact.pdf> (19 June 2004).

--- "New Source Review: Basic Information," EPA Website, 30 June 2004, <http://www.epa.gov/nsr/info.html> (8 July 2004).

--- "Pollution Prevention Policy Statement." Federal Registar 54 (1989): 3845-3847.

--- "Phosphate Rock Processing," Myflorida.com, January 1995, <http://www. epa.gov/ttn/chief/ ap42/ch11/ final/c11s21.pdf> (19 June 2004).

Environmental Protection Commission of Hillsborough County. "Final Damage Assessment And Restoration Plan and Environmental Assessment For The December 7, 1997 Alafia River Spill." U.S. Fish and Wildlife Service, 2000.

Evangelou, V. P. Environmental Soil and Water Chemistry: Principles and Applications New York: Wiley and Sons, Inc., 1998.

Faithful, Myrtle B. "Borden Plant Target in Pollution Hearing." Bradenton Herald, 11 Jan 1967, sec. 1-B.

"First Charts of Pollution in Manatee." Sarasota Herald-Tribune, 27 March 1966, sec. 2.

Florida Department of Corrections. "Florida Corrections: Centuries of Progress, 1877-1895." Florida Department of Corrections Website, Myflorida.com, 2004, <http://www.dc.state.fl.us/ oth/timeline/1877 1895.html> (3 June 2004): Facts, Fallicies, and FAQs.

Florida Department of Environmental Protection. "Piney Point Briefing," PowerPoint Presentation, 11 September 2003.

--- "Timeline." Myflorida.com. 1 April 2004, <http://www.dep.state.fl.us/secretary/ news/2003/pp/timeline_102403.pdf> (17 May 2004).

--- "Wastewater." Myflorida.com. 26 March 2004, <http://www.dep.state.fl.us/water/ wastewater/iw/phosphate.htm> (15 June 2004).

---"Florida's Minerals: Making Modern Life Possible." Myflorida.com. 2004, <http://www.dep.state.fl.us/geology/geologicaltopics/minerals.htm> (1 July 2004).

--- Official response to queries from Southwest Florida Water Management District. 9 Jan 2002.

--- "Piney Point status update." Memo, 7 May 2002.

--- Additional information [for the] emergency permit application. 3 March 2003.

--- Application for an emergency discharge permit under the Marine Protection, Research, and Sanctuaries Act. Federal consistency certification. Draft. 4 March 2003.

--- Bankruptcy proceedings. Official reciever authorization, case no. 01-1650. Jan 2001.

--- Case no. 01-1615. Interdepartmental update. 9 Jan 2002.

--- Case No. 02-1054. Memo, 29 Sep 2003.

--- Offical responses to queries from the Environmental Protection Agency concerning Piney Point Marine Protection, Research, and Sanctuaries Act emergency permit application.

--- "Piney Point status update." Memo, 7 Oct 2003.

--- "Piney Point status update." Memo, 25 March 2003.

--- "Piney Point status update." Memo, 11 May 2004.

--- "Piney Point status update." Memo, 8 June 2004.

--- "Piney Point status update." Memo, 25 April 2003.

--- Request for emergency permit under the Marine Protection, Research and Sanctuaries Act (Tallahassee, FL: Feb 2003).

--- "Update on monitoring activity at Piney Point/Bishop Harbor." Memo, 3 June 2003.

Florida Institute of Phosphate Research. FIPR Website, 15 December 2003, <http://www.fipr.state.fl.us/ > (25 June 2004)

"Florida Phosphate Facts." Florida Phosphate Council Public Relations Document. Tallahassee, FL: Florida Phosphate Council, 2002.

Forstner, Ulrich. "Contaminated Sediments" in Lecture Notes in Earth Sciences (Berlin: Springer-Verlag, 1985).

Freeman, Myrick A. "Economics, Incentives, and Environmental Regulation." In Environmental Policy: New Directions for the Twenty First Century, eds. Norman J. Vig and Michael E. Kraft, 4th ed. (Washington D.C.: CQ Press, 2003).

Fuller, R. B. "History and Development of the Mining of Phosphate Rock." In Manual on Phosphates in Agriculture (Baltimore: The Davidson Chemical Corporation, 1951).

Gannon, Michael. Florida: A Short History. Gainesville, FL: University Press of Florida, 1993.

Garrison, Tom. Oceanography: An Introduction to Marine Science. 4th ed. Pacific Grove, CA:Wadsworth/Thomson Learning, 2002.

Getzoff, Deborah, Tampa Bay Estuary Program. "Extension of Piney Point gulf dispersion permit." Personal letter to J. I. Palmer, U. S. Environmental Protection Agency, 18 Nov 2003.

Gottlieb, R., ed. Reducing Toxics: A New Approach to Policy and Industrial Decision-making. Washington DC: Island Press, 1995.

Grimm, Kurt Andrew. "Phosphorites Feed People: Finite Fertilizer Ores Impact Canadian and Global Food Security." Dr. Kurt A. Grimm personal website. <http://www.eos.ubc.ca/personal/grimm/ phosphorites.html> (1 July 2004), Phosphorites Feed People.

Gulf East Coast Intermodal, LLC. Personal letter to George Sharrok, Florida Department of Environmental Protection, 29 Jan 2002.

Harper, Scott. "Chesapeake Fertilizer Company Fined For Pollution." The Virginian Pilot. 3 August 2002, sec. A.

Hull, C. D., and Burnett, W. C. "Radiochemistry of Florida Phosphogypsum." Journal of Environmental Radioactivity 32, no. 2 (1996): 213-238.

Hunsicker, Charlie. <charlie.hunsicker@co.manatee.fl.us> "Draft letter for congressional appropriations (edited)." 14 May 2002, personal email to Melissa Figge, <Melissa.Figge@mail.house.gov> (14 June 2004).

--- <charlie.hunsicker@co.manatee.fl.us> "Draft letter for congressional appropriations (edited)," 16 April 2002, personal email to Melissa Klein <mel.klein@fpl.com> (14 June 2004).

IMC Global. "Phosphate Production Techniques." IMC Global Website, 2001 <http://www.imcglobal.com/general/education_corner/phosphates/techniques.htm> (4 July 2004): Education Corner.

Isbitts, Steven. "No Harm Evident As Waste Dumping Continues In Gulf." Tampa Tribune, 7 July 2003, sec. B.

Jacobs Engineering Group. "Phosphate Rock Treatment for Waste Reduction." Florida

Institute of Phosphate Research Publications (1995).

Janicki Environmental, Inc. Interim nutrient loading target for Bishop Harbor, Florida. Technical memorandum, 28 March 2003.

Johnson, Dexter. "Phosphate Producers Anticipate Higher Demand, Firmer Prices." Chemical Market Reporter 253, no. 15 (1998).

Kalff, Jacob. Limnology: Inland Water Ecosystems. Upper Saddle River, NJ: Prentice-Hall, Inc., 2002.

Kamalick, K. "Strike Averted at Big IMC Phosphate Plant in Florida." Chemical News and Intelligence. 2 Nov 2001.

Krimsky, Sheldon, and Plough, Alzono. Environmental Hazards: Communicating Risks as a Social Process. Dover: Auburn House, 1989.

Lane, Edward, ed. "Florida's Geological History and Geological Resources." Special Publication No. 35. Tallahassee, FL: Florida Geological Survey, 1994.

--- "The Florida Geological Survey: An Illustrated Chronical and Brief History," Special Publications, no. 42. Tallahassee, FL: Florida Geological Survey, 1998.

Layzer, Judith A. "Love Canal: Hazardous Waste and the Politics of Fear." in The Environmental Case: Translating Values Into Policy. Washington DC: CQ Press, 2002.

Legislature of the State of Florida. "Providing for the Regulation and Correction of Air Pollution in All Areas of Manatee County." government document, 1965.

Lewis, Roy, and Estevez, Steven. "The Ecology of Tampa Bay, Florida: An Estuarine Profile." *Biological Report* 85, no. 7 (1998):18.

"Manatee Unit Advises Against Air Pollution Control District." Sarasota Herald-Tribune, 23 November 1965.

Matus, Ron. "Well-Water Risk near Coronet Hard to Pin Down." St Petersburg Times, 28 September 2003, sec. B3.

Martin, D., Dorris, P., and Sumpter, D. "Environmental Impacts of Phosphoypsum vs. Borrow Pits in Roadfill Construction." Journal of Environmental Science and Health: Toxic/Hazardous Substances & Environmental Engineering 36 no. 10 (2001).

Martin, J., et al. "Environmental Impact of Fertilizer Industries Evaluated by PIXE," Nuclear Instruments& Methods in Physics Research 103 no. 4 (1995): 477-481.

McClellan, Guerry. "Outline of John Compton's 'Origin and Paleogeographic Significance of Florida's Phosphorite Deposits,' Chapter 12," in Geology of Florida Class Website, University of Florida Geology Department, <http://www.clas.ufl.edu/users/guerry/ GLY4155/phosphorite.html> (1 July 2004).

McDaniel, Carl N. and Gowdy, John M. Paradise For Sale: A Parable of Nature (Berkeley: University of California Press, 2000).

McHardy, J. C. "Future Trends In Florida Phosphate Mining, Beneficiation and Tailings." Mining Engineering 35 no. 8 (1983): 1196-1200.

McNabb, G. J., Kirk, J. A., and Thompson, J. L. "Radionuclides from Phosphate Ore-Processing Plants: Environmental Impact after 30 Years of Operation." Health Physics 37 no. 4 (1979).

Meadows, Andrew. "Searching for New Digs." Tampa Tribune, 4 Nov 2002, sec. D.

Mew, Michael. "Phosphate Rock," Mining Annual Review (October 2001).

Michael, J. "Redistribution of Uranium and Thorium Series Isotopes during Isovolumetric Weathering of Granite." Geochimica Cosmochimica Acta 48 (1984): 1249-1255.

Miller, W. P., and Sumner, M. E. "Agricultural and Industrial Uses of By-Product Gypsums." Agricultural Uses of By-Products and Wastes ACS Symposium Series 668 (1997).

Mislevy P., and Blue, W. G. "Reclamation of Quartz Sand Tailings From Phosphate Mining." Journal of Environmental Quality 10 no. 4 (1981): 449-453.

Moore, Don. "Commissioners Negotiate: Bordens' Water Use May Double." The Tampa Tribune, 4 February 1966, sec. 2-B.

Othman, I., Alhushari, M., and Raja, G. "Radiation Exposure Levels in Phosphate Mining Activities," Radiation Protection Dosimetry 45 nos. 1-4 (1992): 197-201.

Palmer, Tom. "Shuttered Property: More Than Two Years After Shutdown, Mulberry Phosphates Sits In Bankruptcy, Land in Limbo." Lakeland Ledger, 10 March 2002, sec. A.

Parsons, Victoria, and Hoppe, Mary Kelley. "Piney Point: back from the brink?" Tampa Bay Soundings, summer 2002, 1, 6-7.

Partney, Stephen H. "Regulatory Status of Waste Clay Ponds in Florida," Mining Engineering 50, no. 4 (1998).

"Peace River Called 'Worst Case,'" The Bradenton Herald, 20 March 1967.

"Phosphate Dangers Pile Up," Sarasota Herald Tribune, 19 July 2003, sec. A.

"Phosphate Fiascoes: Hillsborough Plant's Problems Show Need for Comprehensive Study," Sarasota Herald Tribune, 4 August 2003, sec. A8.

"Phosphate Mining Waste Fiasco Was Legally Allowed to Happen," Boca Sierra: The Mouth of the Sierra Club, June 2004: 1.

"Phosphate," Wikipedia: The Free Encyclopedia, 24 June 2004, <http://en.wikipedia.org/wiki/ Phosphate> (1 July 2004).

Pittman, Craig, Hauserman, Julie, and Rondeaux, Candice, "Bending the Rules at Piney Point: A $140 Million Mess," St. Petersburg Times, 6 July 2003, sec. A.

--- "Phosphate Companies Don't Measure Up," St. Petersburg Times, 20 Sep 2003, sec. B.

--- "Piney Point Dumping in Gulf Called to a Halt," St Petersburg Times, 26 November 2003.

Pittman, W. E., "Technology and Environmentalism in the Florida Phosphate Industry." Papers of the American Chemical Society 187 (1984).

"Plant Pollution Level Seen as OK." Sarasota Herald-Tribune, 30 March 1966, sec. 2.

"Pollution Control Ordinance Skirted." Sarasota Herald-Tribune, 1 October 1965, p. 21.

"Pollution Samples Taken," St Petersburg Times, 14 July 1967.

Porcelli, Donald, and Swarzinsky, Peter. "The Behavior of U- and Th-series Nuclides in Groundwater." In Uranium-Series Geochemistry, eds. B. Bourdon et al. Reviews in Mineralogy and Geochemistry. Washington, D. C.: Mineralogical Society of America, 2004.

Randazzo, Anthony, and Jones, Douglas S., eds. The Geology of Florida. Gainsville, FL: University of Florida Press, 1995.

Rechcigl, J. E., et al. "Predicting the Long-Term Impact of High Rates of

Phosphogypsum Applications on Radioactivity in Soil, Groundwater, and Bahiagrass Forage and on Radon Emissions." Florida Institute of Phosphate Research (1997).

Reese, Thomas W. Piney Point Phosphates' Phosphogypsum Stack System, Manatee County, Florida. Personal letter to David B. Struhs, Department of Environmental Protection, 8 Jan 2001.

"A Regulatory Disaster." St Petersburg Times, 9 July 2003, 10A.

Roger Ross. "Two Experts Differ on Effect of Effluent Discharge." Sarasota Herald-Tribune,

29 April 1966, sec. A.

Rosenbaum, Walter A. Politics and the Environment: Politics and Policy, 5th ed. Washington, D.C.: CQ Press, 2002, 345, 347-53.

--- "The Politics of Hazardous Waste Management," in The Politics of Hazardous Waste Management, eds. James Lester and Ann O'm. (Durham: Duke University Press, 1983).

Ross, Lucia. DEP, Cargill agree to long-term solution to Mulberry Phosphate's environmental problems. Press release, 7 May 2002.

Ross, Roger. "Borden Plant Water Pollution Test Set: Samples Now Being Collected." Sarasota Herald-Tribune, 1 August 1966, sec. 2.

--- "Borden Pledges Boosted Effort to Keep Fluoride Emissions Within Plant Area." The Herald-Tribune, 23 November 1967.

--- "Potential Chemical Hazard Cleared Up." Sarasota Herald-Tribune, 22 March 1967, sec. 2.

Ruckelhouse, William. "Science, Risk, and Public Policy." Science 221 (1983): 1027-1028.

Rushefsky, Mark E. "The Misuse of Science In Governmental Decision-Making." Science Technology & Human Values 9, no. 3 (1984): 47-59.

Rutherford, P. M., Dudas, M. J., and Samek, R. A. "Environmental Impacts of Phosphogypsum," Science of the Total Environment 149 no. 1-2 (1994): 1-38.

Sasso, Michael. "Phosphate Faces Challenges; Experts Say Competition Abroad and Public Opposition Plagues the Industry." Lakeland Ledger, 19 October 2003, sec. E.

Satchell, Michael. "Sinkholes and stacks." U.S. News and World Report, 12 June 1995, 53-56.

Sathiakumar, Nalini, et al. "Epidemiological Evidence on the Relationship between Mists Containing Sulfuric Acid and Respiratory Tract Cancer." Critical Reviews in Toxicology 27, no. 3 (1997):233-251.

Scott, Thomas M., et al. "Geologic Map of the State of Florida." South Florida Information Access, Florida Geological Survey, 2001, <http://sflwww.er.usgs.gov/publications/maps/florida_geology/> (2 July 2004).

Senate. Phosphate mining: Senate staff analysis and economic impact statement. Bill CS/SB 18-E, 22 Oct 2003.

Sharpley, A. N. "Soil Phosphorus Dynamics: Agronomic and Environmental Impacts." Ecological Engineering 5 (1995): 2-3.

Sigman, Hilary. "Hazardous Waste and Toxic Substance Policies." In Public Policies For Environmental Protection, eds. Paul R. Portney and Robert N. Stavins. 2nd ed. Washington DC: Resources For the Future Press, 2000.

Singh, S. P., Ma, L, and Harris, W. G. "Heavy Metal Interactions with Phosphoric Clay: Sorption and Desorption Behavior." Journal of Environmental Quality 30, no 6 (2001).

Smith, Zachary A. The Environmental Policy Pardox. 3rd ed. (Upper Saddle River: Prentice Hall, 2000).

Smol, John P. Pollution of Lakes and Rivers: A Paleoenvironmental Perspective. Key Issues in Environmental Change, vol. 5. New York: Oxford University Press Inc, 2002.

Spaeth, Bob, Southern Offshore Fishing Association. Interview by Rob Lorei. Radioactivity. WMNF St Petersburg.

Steidinger, Karen A. "Basic Factors Influencing Red Tides." In First International Conference on Toxic Dinoflagellate Blooms. Boston: Massachusetts Science and Technology Foundation, 1975, 153-162.

Steidinger, Karen A. "Implications of Dinoflagellate Life Cycles on Initiation of Gymnodinium breve Red Tides." Environmental Letters 9, no. 2 (1975): 129-139.

Switzer, Jacqueline Vaughn. Environmental Politics: Domestic and Global Dimensions, 3rd ed. Boston: Bedford/St. Martin's Press, 2001.

Tampa Bay Estuary, Florida Department of Environmental Protection. Piney Point Discharge and Red Tide in Tampa Bay. Interdepartmental update, 7 Dec 2001.

Tampa Bay Regional Planning Council. "Habitat Restoration Study for the Tampa Bay Region." Florida Department of Environmental Regulation, 1986.

--- "State of Tampa Bay." Florida Department of Environmental Protection, 1991.

--- "State of Tampa Bay." Florida Department of Environmental Regulation, 1993.

--- "The Future of Tampa Bay." Florida Department of Environmental Regulation, 1989.

--- "Habitat Restoration Study For the Tampa Bay Region." Florida Department of Environment Protection, 1986.

The Ministry of Communication. "A Focus on the 21st Century." The Kingdom of Morocco, Moroccan Government, 2004, <http://www.mincom.gov.ma/english/invest/Business/economic %20overview.htm> (10 March 2004).

The Ocean Conservancy. "U. S. EPA Denies Permit for Florida to Continue Ocean Dumping." EMS: Environmental Media Services, 1 December 2003 <http://www.ems.org/rls/2003/12/01/ us_epa_denies_pe.html> (25 May 2004)

Timchak, Louis J. Jr. Personal letter to Sam Zamani, Florida Department of Environmental Protection, 27 Nov 2001.

Todd, Tom. "Pollution Safeguards Planned by Borden Co. at New Manatee Plant." The Tampa Tribune, 9 April 1966.

Travis, Curtiss, et al. "Cancer Risk Management: A Review of 132 Federal Regulatory Decisions." Environmental Science and Technology 21 (1987): 415-420.

Trigaux, Robert. "Executives Turn their Backs on the Piney Point Disaster." St. Petersburg Times, 18 August 2003, sec. E.

Uebelhoer, Gary. Piney Point Closure: Water Management Alternatives. Environmental Consulting & Technology, 9 October 2003, powerpoint.

Unger, Howard M. "Failed Phosphate Plant Is Tough Sell," The Sarasota Herald-Tribune, 17 February 2002, sec. B.

Wasson, David. "Phosphate Makers Moving Closer to Tax Increase." The Tampa Tribune, 25 October 2003, sec. B.

Woods, William I. "The Qualitative Analysis of Soil Phosphate." American Antiquity 42, no. 2 (1977): 248-252.

Young, John. "Mining the Earth." Worldwatch Paper 109 (Worldwatch Institute, 1992).

Zamani, Sam. <Sam.Zamani@dep.state.fl.us> "Piney Point." 28 Jan 2002, personal e-mail to George Henderson et al, Florida Department of Environmental Protection (14 June 2004).

Zamani, Sam, Florida Department of Environmental Protection, Bureau of Mines. "Piney Point," 15 June 2004, personal e-mail (15 June 2004).