

Multiple-Use Landscapes: Reclaimed Phosphate Mined Lands¹

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Introduction

Phosphate is a critical nutrient for plant growth and an essential component of the agricultural fertilizer that helps sustain the world's growing population. In 2010, seven mines in Florida produced approximately 10% of the world's industrial phosphate supply and accounted for more than 65% of the phosphate produced in the United States (USGS 2011). In Florida, phosphate is extracted from the Earth via strip-mining, and thousands of acres are disturbed annually. To date, more than 300,000 acres in Florida have been disturbed by phosphate mining (Brown 2005).

The Florida Legislature has recognized that mining is a temporary land use, and all lands mined for phosphate after June 30, 1975 are subject to mandatory land reclamation (Florida Department of Environmental Protection [FDEP] 2006). Paragraph 378.202(1) of the Florida Statutes states that, "It is the intent of the Legislature that mined lands be reclaimed to a beneficial use in a timely manner and in a manner which recognizes the diversity among mines, mining operations, and types of lands which are mined." In excess of 190,000 acres in Florida have been or are subject to mandatory reclamation requirements (FDEP 2011). Lands mined for phosphate in Florida have been reclaimed to various uses including agriculture, forestry, residential/commercial development, water supply projects, recreational areas, and restored native ecosystems, among others.

Phosphate mining is a temporary land use. The jobs and economic activity associated with mining depart an area once the resource is exhausted. In contrast, the landscape created as a result of mining and reclamation will exist in perpetuity. The legacy of mining is determined by the suitability of the post-mining landscape to support beneficial uses. Communities affected by mining activities need to have reclamation result in lands with high potential to provide sustainable economic opportunities while maintaining ecosystem services and ecological functions.

This publication provides a brief overview of the landscapes being created as a result of phosphate mining and reclamation activities in Florida. Many of the concepts discussed in this document represent current practices of the Florida phosphate industry. All individuals involved in planning reclamation projects should have a vision for an ecologically sound and economically sustainable post-mining landscape from the beginning of the project.

Maintaining water quality during mining and reclamation is essential for creating high-functioning post-reclamation landscapes. During mining operations, disturbed areas are isolated (severed) from the landscape by the construction of a ditch and berm. The drainage and stormwater originating from active mining areas are managed through the mine-water recirculation system, and much of this water is used to support mining operations. During wet periods, excess water may exist within the mine site. This excess water may

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be discharged through permitted outfalls. All discharges from active mining areas are required to meet applicable water quality standards. Therefore, active phosphate mining in Florida typically does not cause violations of water quality standards in receiving waters. Florida phosphate mines typically do not develop problems with acid mine drainage or metal contamination.

Although Florida phosphate mines may be tens of thousands of acres in size, only a fraction of the land within the mine boundary is actually severed from its natural watershed at any given time. In the majority of cases, reclamation activities follow immediately behind the dragline, and reclamation is completed within a few years following the cessation of mining in a particular area. Once the land has been backfilled, contoured, and sufficiently re-vegetated to prevent turbid runoff, the lands are re-integrated with the landscape, and drainage patterns are restored to approximate pre-mining conditions. Therefore, the notion that tens of thousands of acres within a mine are severed from the landscape during mining is a fallacy. Reconnecting the watershed should not be confused with “release” of the land from reclamation requirements, which may not occur for several years following initial reclamation and reconnection to the watershed.

Reconnecting reclaimed lands back to the watershed results in less stormwater that needs to be managed and treated by the mining companies. Therefore, reconnection is advantageous because it can reduce environmental liability. Also, reconnecting the reclaimed lands to the watershed has societal and ecological benefits because reconnection can restore the flows of water and the functions of restored wetlands (i.e., detrital export and fish and wildlife habitat) to the watershed.

Reclamation Planning for Multiple-Use Landscapes

Florida Statute 378.202(1) indicates that the intent of the reclamation law is to return mined lands to a “beneficial use” following mining. Reclamation planners should plan to create reclaimed landscapes that maximize social, economic, and ecological benefits, provide quality of life and sustainable jobs for local communities, and maximize environmental protection. The primary focus of phosphate mine reclamation plans should be the community’s needs for a sustainable landscape. Components necessary for sustainable development include economic opportunities (e.g., industry, small businesses, and housing) and production of renewable natural resources (e.g., forest products

and agriculture). Sustainable landscapes must protect local ecology and water quality, and provide recreational opportunities, such as parks and hunting and fishing areas. Sustainable landscapes in Central Florida must place particular emphasis on water conservation because that region’s water supply is a limiting factor for community development.

Reconstruction of a landscape after mining provides a unique opportunity to create landscapes that maximize economic opportunities while providing enhanced water quality protection and appropriate habitat for fish and wildlife. In natural landscapes, ecological systems are already in place. There is no ability to relocate a natural area to an alternate location or to reduce the competition for space between economic development and conservation. Conversely, in reclaimed landscapes, economic development areas could be strategically located where they will minimally affect fish, wildlife, and water quality. At the same time, wetlands and other natural ecological systems can be located where their functions can be realized to a greater extent. Lands with high suitability for development can be strategically located in areas that can minimize future adverse interactions between development and the environment. Similarly, ecologically-important landscape components can be sited where the likelihood of future impacts is decreased. Many types of reclaimed landforms have proven suitable for development, and many examples of commercial and residential development exist on reclaimed phosphate mined lands. Examples can be observed in Lakeland, FL, particularly in the southern portion of the city (see Figure 1). Additionally, numerous examples of successful forestry, citrus, high-value crops, and cattle operations exist on reclaimed phosphate mined lands (Wilson and Hanlon 2012b).

Reclaimed phosphate mined lands are also being used for water quality improvement projects and ecological restoration. For example, CF Industries, Inc., has developed a water supply project consisting of a series of water treatment wetlands and a sand tailings filter that will eventually have the capacity to return approximately 2 million gallons per day back into the Floridan Aquifer. Sand tailings have proven to be an excellent material for water filtration (Schreuder and Pichler 2010). In addition to the water supply benefit, the wetlands and the associated water storage reservoir provide habitat for many species of water-dependent wildlife, such as wading birds, raptors, reptiles, fishes, otters, and others.

Soil type is a major determining factor for how suitable reclaimed land is for a particular use (Wilson and Hanlon



Figure 1. Residential and commercial development on phosphate mined lands, in Lakeland, Florida. The east/west-oriented road in the southern part of the map is the Polk Parkway. A commercial center, golf course community, and high-density housing developments throughout the central portion of this aerial photograph were constructed on mined land. Credits: M. Wilson

2012a). Therefore, it makes sense to target soil types suitable for building in areas where future development is most likely to occur. Sand tailings have proven to be excellent substrates for residential/commercial development, and local governments often request that sand tailings soils be strategically placed in areas targeted as potential development corridors (Wilson and Hanlon 2012a). Maximizing the developable land in strategic development corridors is advantageous, but these areas should also include some natural features in the developed landscape to treat and convey drainage and stormwater runoff, provide aesthetic value, and provide necessary wetland and aquatic functions in the upper portions of watersheds.

In Florida, several examples exist of phosphate mined lands that have been reclaimed to provide quality recreational uses. At the Potash Corp. phosphate mine in Hamilton County, the company cooperated with the Florida Fish and Wildlife Conservation Commission to establish a wildlife management area that is currently home to thriving populations of different waterfowl species and provides local hunters and birdwatchers with an appropriate landscape. Another example is the Alafia River State Park. It is a former phosphate mine that was reclaimed to become one of the most visited parks in Florida. At this park, the disturbed landscape has had several decades to regenerate. Today, it

consists of forested rolling mine spoils and pit lakes, which are popular with local mountain bike enthusiasts for their unique topography.

Reclaimed phosphate mine pit lakes are probably one of the better known landforms because of their recreational value. Removing the phosphate ore (matrix) from the ground causes a deficit in the volume of materials available for land reclamation. Restoring the landscape to near pre-mining elevations necessitates the creation of lakes, and mine pit lakes constitute significant components of post-phosphate mining landscapes. These lakes serve multiple functions, including uses for wildlife habitat, boating, fishing, water supply, and aesthetic value. Florida phosphate mine pit lakes typically maintain good water quality and support healthy populations of fish and wildlife (Wilson and Hanlon 2012b). Once reclaimed and stabilized, phosphate mine pit lakes can provide excellent recreational activities and habitats that can be incorporated into the regional wildlife corridors. These lakes also have aesthetic value, and several residential developments have been constructed on the shores of reclaimed phosphate mine pit lakes. Hardee Lakes Park in Hardee County and Peace River Park in Polk County are popular spots for fishing and hiking. Tenoroc Fish Management Area is a former phosphate mine that has been restored to fishing lakes and marshlands to provide clean water to the Peace River. Its thriving populations of sport fish and close proximity to the city of Lakeland make it a favorite spot for many local fishermen.

Preservation of Intact Natural Communities

Because phosphate extraction occurs via strip mining, large tracts of land are subjected to disturbance. The Central Florida phosphate mining district is composed of a mix of agricultural lands, natural areas, and small rural communities. Many natural features, including streams and wetlands, are disturbed by extraction of the phosphate ore. The larger streams and riparian corridors can be thought of as the ecological and hydrological backbones of the landscape. These complex systems can be difficult to restore and should be left intact to the greatest extent possible. Fortunately, current regulatory and mining practices typically require that mining operations avoid substantial impacts to major drainage features and associated riparian habitats, as well as most of the high-quality wetland systems (see Figures 2 and 3). Avoiding the major streams and high-quality wetland systems will result in undisturbed refuges of natural areas. These natural areas can accommodate a fraction of the fish and wildlife displaced by the mining operation, which

helps maintain reservoirs of genetic material appropriate for the local ecotype. In turn, these reservoirs can serve as source populations of flora and fauna that then colonize the reclaimed landscape. In addition to the drainage features themselves, an adequate amount of riparian buffer should also be left intact to filter pollutants, provide water quality enhancement, and provide cover and refuge for wildlife.

The preservation areas provide a framework for rebuilding the post-mining landscape. The reclamation plan should be integrated with and complement the plan for preservation, resulting in planned habitat areas. Restored habitats should be strategically located away from major roads and future development corridors and near the preserved native habitats. Consolidating reclaimed natural

habitats along existing ecological “veins and arteries” of the landscape should result in a net increase in the average size of tracts of native habitats and a net reduction in habitat fragmentation. This approach could result in greater habitat value for fish and wildlife and could restore many wetland functions lost because of the higher degree of connectivity to downstream areas. With limited land use restriction, combining the preserved natural systems and the reclaimed native habitats can help maintain ecological and water quality functions while also providing sustainable economic uses such as limited cattle grazing and forestry operations (Florida Department of Agriculture and Consumer Services [FDACS] 2008; FDACS 2011). Restoring native habitats close to preserved riparian systems should also lessen impacts from future development.



Figure 2. Typical pre-mining landscape in the Central Florida phosphate district. The forested areas in the background will all be preserved. The herbaceous wetlands in the mining area have all had their hydropatterns substantially altered by agricultural ditching. Credits: M. Wilson



Figure 3. Preserved wetland at a phosphate mine in Hardee County. Credits: M. Wilson

Because of the riparian systems’ linear nature, preserving these areas can maintain major corridors for the movement of fish and wildlife (Cates 1992). With a few strategic connections, these corridors within the major drainage basins can be interconnected with other tracts of conservation lands, thereby providing regional ecological functions, such as gene flow between wildlife populations. Strategically placing native habitats in the lower portion of the watershed would provide buffer zones along the streams and other drainage features. These “vegetative filter strips” (e.g., Dillaha et al. 1989; Munoz-Carpena, Kuo, and Li 2007) allow pollutants to be processed/retained by biota and soils before entering waterways, thereby providing enhanced water quality protection. Restoring wetlands at lower points in the landscape also strategically places wetland functions at points in the landscape where ecosystem services can be effectively rendered.

Strip mining disturbs large contiguous blocks of land, and as a result, phosphate mining activities in Florida often impact intact ecological systems. The Florida phosphate mine reclamation law requires acre-for-acre and type-for-type replacement of wetlands and other surface waters and linear foot for linear foot replacement of streams (FDEP 2006). As mentioned above, current regulatory practices require avoiding most major riparian systems as well as most high-quality wetland systems. Restoring wetlands and other surface waters is required to maintain or improve the water quality and biological functions of the wetlands as well as other surface waters that existed before mining operations. While exact replication of conditions existing before mining is not a reasonable expectation, analogs of many pre-mining native wetland community types have been restored, including floodplain swamps, basin swamps, stream channels, freshwater marshes, wet prairies, hydric



Figure 4. An approximately one-year-old reclaimed parcel at a phosphate mine in Hardee County. This area is targeted to become a forested wetland in a matrix of pine flatwoods. The taller trees were transplanted. Hundreds of tree seedlings are established in the ground cover. The upland areas received approximately one foot of flatwoods topsoil, and the wetland in the background received approximately one foot of wetland muck. Credits: M. Wilson

pine flatwoods, and bayhead swamps (see Figures 4, 5, and 6). Also, at least 10% of the reclaimed upland area is required to be forested, and upland reclamation may include restoration of native community types such as sandhill, scrub, pine flatwoods, mixed upland forests, and palmetto prairies.

Lack of genetic material has been identified as a major factor limiting the reestablishment of native vegetation communities on reclaimed phosphate mine landscapes in Florida. To the greatest extent possible, topsoil from mined areas should be conserved and re-used as part of the restoration of natural communities. Topsoil provides soil organic matter, which has numerous benefits to soil quality such as enhanced cation exchange capacity, water-holding capacity, a nutrient pool, and an active microbial community. Topsoil also provides a seed bank, which helps facilitate development of restored native community types.

Much of the land affected by phosphate mining in Central Florida is altered from its natural condition via agricultural drainage and land clearing. For individuals interested in restoring historical ecological functions, historical aerial photography can provide valuable information about the historic ecological conditions. These can serve as a target for contemporary reclamation activities. In cases where the hydropatterns of wetlands have been severely altered, there exists an opportunity to restore ecological functions. In many cases, wetlands with deeper, longer hydropatterns can be created to mitigate the mining of wetlands that currently



Figure 5. Freshly-placed muck in an herbaceous wetland restoration project. Credits: M. Wilson



Figure 6. Herbaceous wetland restoration project at a phosphate mine in Hardee County. Credits: M. Wilson

provide marginal ecological and water quality functions because of the degradation from past agricultural disturbance. Similarly, mining may further affect agriculturally-impacted streams that lack riparian buffers, are relatively straight due to human excavation, and lack appropriate habitat for many aquatic fauna (see Figure 7). Current regulatory practices at the state level require mitigation in the form of restored stream systems. In many cases, these streams systems are longer and better-buffered systems that exhibit more appropriate habitats and more closely represent natural streams in peninsular Florida. Several excellent examples of restored streams exist in landscapes currently being created (see Figures 8, 9, and 10).



Figure 7. First-order stream in an area targeted for mining. Note the straightening of the channel and lack of riparian buffer. The larger receiving stream in the background will be preserved. Credits: M. Wilson



Figure 9. Restored stream on phosphate-mined land in Hardee County. Credits: M. Wilson



Figure 8. Restored stream on phosphate-mined land in Hardee County. Credits: M. Wilson



Figure 10. Restored stream on phosphate-mined land in Polk County. Credits: M. Wilson

Long-Term Management of Clay Settling Areas

Clay settling areas (CSAs) constitute approximately 40% of reclaimed phosphate mined landscapes in Florida and likely present the largest hurdle for the reclamation of phosphate-mined lands. Because clays have shrink/swell properties, reclaimed CSAs are generally unsuitable for construction of roads or buildings, although limited developments have been successfully established. The footprint of future CSAs should be minimized, and storage capacity in existing CSAs should be used to the maximum extent possible before new CSAs are constructed.

Clays consolidate with time, and consolidation usually continues for many decades following reclamation. In many older CSAs, continued consolidation has resulted in areas targeted for beneficial agricultural or other ecological post-reclamation uses to become areas of impounded open water or low-quality wetlands often covered with nuisance and exotic vegetation. These impounded areas have diminished capacity to provide beneficial economic use, and the low-quality of the wetland communities limits their benefit to fish and wildlife conservation. Also, the impoundment of water results in a loss of runoff to supply streams in the affected watershed. In areas such as the Peace River Basin, the elimination of these areas from the watershed likely contributes to reduced stream flows (FDEP 2007).

Because of consolidation and its problems, CSAs represent a long-term liability for the local communities and regulatory agencies. As a result, phosphate mining companies should be required to manage long-term CSA consolidation. Long-term management is needed on the CSAs to maintain drainage throughout the consolidation process, ensure that water is routed off the settling areas to avoid the development of large areas of impounded water, and maintain the reclaimed lands in a state so that beneficial post-reclamation land uses are supported for the long term. One possible method to counteract the continued consolidation would be to install adjustable outfalls on the reclaimed CSAs such that the invert could be easily lowered as the clays continue to consolidate. Ditching may also be needed throughout the long-term consolidation phase to maintain positive drainage. Water quality must also be maintained in the waters receiving discharges from these areas as consolidation occurs.

Several potential post-reclamation land uses have been established on CSAs, such as production of tree crops (Tamang 2005), biomass crops (Rockwood, Carter, and Stricker 2008; Mislevy, Blue, and Roessler 1989), row crops (Mulkey, Clouser, and Taylor 1994; Mislevy et al. 1991), forage crops (Mislevy, Blue, and Roessler 1990), rice production (Jones, Riddle, and Eitzen 1994), pastureland, water storage reservoirs, treatment wetlands, and habitats for wildlife such as fish, waterfowl, and upland game. There has been some interest in establishing renewable energy projects (i.e., solar farms) on reclaimed CSA land, but the instability of the phosphatic clay may pose challenges to that. The surfaces of the reclaimed CSAs will be the areas of highest elevations in the reclaimed watersheds. Therefore, restoration of some wetland functions, such as floodwater storage, sediment retention, and nutrient retention, may be limited in a watershed context. However, restoring some wetland functions on CSAs may be possible and may be consistent with the creation of multiple-use landscapes (Hanlon et al. 2011).

Reclaimed CSAs have proven suitable for a number of agricultural uses including forestry, cattle grazing, and food crop production. The clays are highly fertile and have much higher moisture retention capacity than typical soils in Central Florida. However, working the fine-textured, sticky clay is energy-intensive and inflicts substantial wear and tear on farming machinery. Despite the challenges posed by the clay, profit margins for agricultural production on phosphatic clay soils have been demonstrated to be comparable to production on native Florida soils (Rahmani and Degner 1994). Several management strategies have been proposed

to ameliorate problems with farming the phosphatic clay soils. Sloped planting beds (macrobeds) have been used to enhance drainage on clay settling areas. Using non-clay soil or topsoil to create a “cap” on clay settling areas could partially ameliorate problems with stickiness and trafficability. Similarly, strategic use of the overburden materials used to construct the dam walls during reclamation could enhance post-reclamation land suitability. Proper planning and strategic construction of the pre-clay-disposal containment area could provide permanent benefits to the ultimate reclaimed landscape. For example, it has been proposed that pre-forming the subsurface mine spoils in the CSA before introducing the phosphatic clays could affect future consolidation of the land surface and facilitate the establishment of desirable characteristics in the reclaimed CSA landforms (Hanlon et al. 2011).

Summary

Reclaimed phosphate mine land in Florida can have many types of beneficial uses. With proper planning and consideration, these areas can become multiple-use landscapes that provide sustainable economic opportunities, protect water quality, provide recreational opportunities, and maintain healthy populations of fish, wildlife, and humans. The key to ensuring the best post-reclamation land uses is by engaging the public at the local level. This type of involvement will ensure the post-reclamation land is used in a way that provides the highest quality of life possible for the affected communities while protecting the local ecology and allowing for the development of sustainable economic opportunities.

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