Publication No. 01-139-170

# A COMPARATIVE ANALYSIS OF ENVIRONMENTAL IMPACTS: PHOSPHOGYPSUM VERSUS BORROW PITS

*Prepared by*
University of South Florida

*under a grant sponsored by*

FIPR
Florida Institute of Phosphate Research

December 2000

The Florida Institute of Phosphate Research was created in 1978 by the Florida Legislature (Chapter 378.101, Florida Statutes) and empowered to conduct research supportive to the responsible development of the state's phosphate resources. The Institute has targeted areas of research responsibility. These are: reclamation alternatives in mining and processing, including wetlands reclamation, phosphogypsum storage areas and phosphatic clay containment areas; methods for more efficient, economical and environmentally balanced phosphate recovery and processing; disposal and utilization of phosphatic clay; and environmental effects involving the health and welfare of the people, including those effects related to radiation and water consumption

FIPR is located in Polk County, in the heart of the central Florida phosphate district. The Institute seeks to serve as an information center on phosphate-related topics and welcomes information requests made in person, or by mail, email, or telephone.

## Research Staff

**Executive Director**
**Paul R. Clifford**

**Research Directors**

| | |
|---|---|
| **G. Michael Lloyd, Jr.** | **-Chemical Processing** |
| **J. Patrick Zhang** | **-Mining & Beneficiation** |
| **Steven G. Richardson** | **-Reclamation** |
| **Brian K. Birky** | **-Public Health** |

Florida Institute of Phosphate Research
1855 West Main Street
Bartow, Florida 33830
(863) 534-7160
Fax: (863) 534-7165

# A COMPARATIVE ANALYSIS OF ENVIRONMENTAL IMPACTS: PHOSPHOGYPSUM VERSUS BORROW PITS

FINAL REPORT

Patricia M. Dooris and Dean F. Martin
Principal Investigators

with

Scott Emery, David E. Sumpter, Melissa Derby, Maria T. Gallardo,
and Barbara B. Martin

The Institute for Environmental Studies
Department of Chemistry
UNIVERSITY OF SOUTH FLORIDA
Tampa, Florida 33620

Prepared for

FLORIDA INSTITUTE OF PHOSPHATE RESEARCH
1855 West Main Street
Bartow, Florida 33830 USA

Project Manager: G. Michael Lloyd, Jr.
FIPR Project Number: 96-01-139R

December 2000

## PERSPECTIVE

One of the more curious facts of life that we encounter almost every day is the almost universal agreement that it is better to attempt to find uses for wastes/byproducts than to just continue to accumulate them. This concept is also actively promoted by the regulatory agencies. However, whenever one starts getting down to specific cases, attitudes seem to change and when the material to be recycled is phosphogypsum, opinion rules and scientific data can be ignored.

This project looked at the environmental impacts of creating borrow pits to obtain fill for road building versus using phosphogypsum as fill material. Borrow pits have long been a matter of concern for both the environmental community and transportation officials but there has been nothing available that could replace soil as fill. This report shows that there are decided environmental advantages to using phosphogypsum for fill for roads.

There are still some questions to be answered. The cost for road building would increase. Are the environmental benefits worth the additional cost? There should be no question that the phosphogypsum could be used without concern for water leaching the phosphogypsum away, resulting in surface water contamination. The techniques used for closing phosphogypsum stacks has demonstrated that this problem is controllable.

The facts are presented fairly in this report. Only time will tell how this information will be used.

# ABSTRACT

Over 30 million tons of phosphogypsum are produced annually in Florida, and are stockpiled indefinitely in stacks, and the total amount stored in USA is 750-1000 million tons. The possibility of using this material for road construction has been explored.

The present study was a comparison of the environmental impacts of using phosphogypsum versus conventional fill materials (e.g., from borrow pits) for road construction. A hypothetical road was considered that had the characteristics of the Veterans Expressway in northwest Hillsborough County, but one constructed using phosphogypsum instead of conventional fill. The effect of the two approaches on plant and animal communities, surface and groundwater, was considered. No significant impacts to plants and animals would be expected in connection with the use of phosphogypsum as road fill for the hypothetical highway because generation of fill material would not involve disturbance to an existing ecosystem.

The comparative treatment was extended to other aspects of the environment represented by the two roads, and the comparison matrix, which was constructed using integral numbers to depict impacts involving four categories (plant and animal communities, water quality, water resources, and air quality), favored use of phosphogypsum as roadfill.

In addition, an opinion survey was conducted to identify as many issues and concerns as possible.

**ACKNOWLEDGMENT**

We are grateful for the helpful comments and useful insights of the Project Manager, G. Michael Lloyd, Jr.

**TABLE OF CONTENTS**

## TABLE OF CONTENTS (CONT.)

# EXECUTIVE SUMMARY

A comparison of the environmental impacts of using phosphogypsum versus conventional fill materials (e.g., from borrow pits) for road construction. A hypothetical road was considered that had the characteristics of the Veterans Expressway in northwest Hillsborough County, but one constructed using phosphogypsum instead of conventional fill. The hypothetical road was approximately 12 miles long, a limited access road with a variable width to accommodate four to eight lanes, median, and paved shoulders, and one that required 213,000 cubic yards of fill material (phosphogypsum). Then a comparison was made of the environmental impacts of using the two different roadfill materials.

The effect of the two approaches on the plant and animal communities was considered, as was the impact on the surface and ground water. For example, the use of borrow pits (six) involved the disturbing of 114 acres, mostly of pine flatwoods and palmetto prairie, but also a slight amount of mesic hammock. This appeared to result in the following changes: 147 species of vertebrates were extirpated, 26 species benefited, and 54 new species appeared. In contrast, no significant impacts to plants and animals would be expected in connection with the use of phosphogypsum as road fill for the hypothetical highway because generation of fill material would not involve disturbance to an existing ecosystem. (It was presumed that the use of this fill would not be stockpiled in a manner to permit erosion at the construction site, that pile protection would be effected by means of various covers).

The comparative treatment was extended to other aspects of the environment represented by the Veterans Expressway and the hypothetical road, and a summary was made of the comparative impacts. A comparison matrix was constructed using integral numbers to depict impacts ranging from -5 (most impact) to 0 (none) to +5, showing most benefit on the part of the project on a given resource. Values were subjective, based upon investigators' experience. Four categories (plant and animal communities, water quality, water resources, and air quality) were considered. The cumulative total was +12 for phosphogypsum and -6 for conventional fill material.

In addition, an opinion survey was conducted to identify as many issues and concerns as possible without expressing a biased (pro or con) opinion on the part of the interviewers. Some 47 persons were interviewed, all with some level of understanding of either borrow pit or phosphogypsum use. Public health and safety issues were raised about both sources of roadfill, and useful insights were raised.

Three recommendations are made: (1) Perform a formal risk analysis assessment procedure to analyze the risks of gamma radiation to animals, particularly endangered vertebrates, as a result of using phosphogypsum roadfill material; (2) develop a land-restoration plan for an area following reduction to land surface of an existing phosphogypsum stack; and (3) investigate the cumulative environmental impacts using phosphogypsum in roadway construction.

# INTRODUCTION

## BACKGROUND

It is estimated that over 30 million tons of phosphogypsum (hereafter, PG) are produced annually in the state of Florida. Conventionally, this material is stockpiled indefinitely in stacks observable on the side of the roads in central Florida. The stacks are extensive in size, and it has been estimated that smallest of these stacks is approximately five million tons of PG (Lloyd 1988; Lloyd 1997); a typical gypsum stack can reach 200 feet high and occupy 400-600 acres (FIPR 1995). As one would expect, the size of PG stacks is directly related to the production of phosphatic products, particularly fertilizer, and in just one year, over 30 million tons of gypsum will be produced.. The amount of PG now stored is estimated at 750-1,000 million tons in Florida, Louisiana, Texas, Mississippi, North Carolina, Minnesota, and Wyoming (FIPR 1994). The material is 92% pure, and the principal contaminants are acids, insoluble phosphate materials, fluoride, and radium (Borris and Boody 1980). As of now, over 20 of these stacks are in Florida and they cover more than 6,000 acres, totaling over 700 million tons of gypsum. The problem is a substantial one, and the industry is very much interested in using this material in other ways.

Several projects have involved an investigation into the use of gypsum for a variety of purposes, including as roadfill material (May 1983; Lloyd 1985; Chang 1989; Chang 1990; FIPR and FSU 1996), and several roads and parking lots made from PG and cement/PG are in daily use in Florida and Texas (FIPR 1994) with no reported impact of an environmental nature (Nifong and Harris 1993). Workers at the University of Miami (Chang and Mantell 1990), Mobil Corporation in Texas (Roessler 1990), and the University of Florida (Ho 1990) have described PG road applications.

Chang (1990) noted that PG had good binding properties under compaction and that the use of this material in roller-compacted concrete led to superior compaction and enhanced strength properties. No water was added to the mix ingredients during the two demonstration projects; the necessary moisture came from the natural moisture content of the ingredients. PG provided additional fines for greater compactability and surface finish; there was no adverse effect on long-term durability.

Ho (1990) reported that experimental county roads were constructed in Polk and Columbia Counties in 1986 and 1987. For these projects, design specifications required that the PG mixture be compacted to 95%. For the White Springs Road project in Columbia County, Clegg Impact values (CIV) were obtained. Both White Springs Road (Columbia County) and Parrish Road in Polk County were reported as "performing satisfactorily under local traffic as intended," though there are examples of freeze damage to the White Springs Road from the Christmas freeze of 1989 (Ho 1990).

PG is classified as an A-4 silty soil with a rating of fair to poor as a subgrade material, based upon a classification used by state DOTs (Taha and others 1992). Design standards used by Florida DOT permit A-4 silty soils to be used at least five feet below grade elevation and above the water table (Ho 1995). Thus PG can be used on embankments more than five feet above the water table, provided that leachates through the embankment will not affect water quality or other environmental constraints.

Moisture has an adverse effect on gypsum (Ho 1995). It is very sensitive to moisture during compaction, especially on the wet side of optimum moisture content. Because of the effect of water on gypsum, Ho (1995) noted that the handling and placing of this material should be avoided during the rainy season.

PG can be stabilized. Ho (1995) also noted that research has indicated that PG stabilized with cement may be used as a roadway base. Saylak (1995) addressed the issues of stabilization with Portland cement, fly ash, or both (Chang and Mantell 1990). Saylak (1995) noted that research on other types of by-product gypsums has continued following the EPA restriction in use of PG. The results of laboratory and field test[s] indicate that mix design rational [sic] and construction procedures successfully demonstrated on these gypsums can be applied to PG as well.

Aside from the engineering concerns relating to long-term integrity of PG as a roadbed material, the primary concern in the use of PG for road building relates to the potential human health effects of the radioactivity residing in PG. Research has found that the amount of radiation from PG test roads is at environmentally acceptable levels. Roessler (1990) reported on the radiological impact from the use of PG as aggregate material. "The gamma radiation reflected the PG concentrations." Sections with 100% cement-stabilized PG had slight incremental levels--12 micro roentgen/hr., or about 2-2.5 times the vicinity background. The study did not determine whether asphalt paving has an attenuating effect on the radon produced by the road base. The available data did suggest the interesting observation that "asphalt contains radium-226 and constitutes a greater source of radon than the [PG]-containing base." (Roessler 1990). The Environmental Protection Agency (EPA) classifies PG as "technologically enhanced natural radioactive material." The designation is applied because PG contains roughly 90% of the radium that occurs as a trace element in the phosphate rock that was processed. The average radium concentration is 30-pCi/g dry weight (which varies with the source), and the radium ultimately decays to radon-222, which has a half-life of 3.8 days (FIPR 1994; Zumdahl 1989). Scientists taking part in the Fact-Finding Forum in 1995 concluded that the additional risks associated with the use of phosphogypsum are minimal to non-existent (FIPR and FSU 1996).

**PURPOSE OF THE PROJECT**

The purpose of this project is to develop information which can be useful in the decision-making process involving the potential uses of PG as fill material for roadway construction in the future. Specifically, the project examines the use of PG for the construction of roadways in Florida, and it focuses on a comparison of using PG for roadbed material versus using fill obtained by means of land clearing, excavation, and extraction of native soils suitable for construction.

## GENERAL PROJECT APPROACH AND METHODOLOGY

### General Approach

In order to compare the environmental impacts of using PG versus earth fill for roadway construction, the project used a comparative analysis process. A recently completed roadway project, which had employed conventional fill material, was selected as the standard against which an identical, hypothetical project using PG for fill was compared. The actual roadway project selected was the Veterans Expressway, a limited-access toll facility constructed in the early-mid 1990's. The hypothetical project was a roadway of the same specifications as the Veterans Expressway constructed with the use of PG instead of conventional fill.

### Location and General Description of the Roadway Project

The Veterans Expressway, a limited access toll road located in Hillsborough County, connects the northern portion of the County (at SR 597) with the area around Tampa International Airport (at I-275). The width of the roadway varies along the facility length to accommodate from four to eight travel lanes, median, and paved shoulders. Right-of-way (ROW) varies from the minimum practicable to 250 feet additional ROW is required for interchanges and toll plazas. To acquire the necessary fill, a total of six borrow areas were utilized from which 213,000 cubic yards of material were generated (FHWA and FDOT 1987; FDOT 1992).

### Impact Analysis Approach

In an ecological analysis of the impacts of any project upon plants and animals, the primary concerns are the consequences to the long-term viability of the populations of living things in the project area. Plant and animal populations exist within complex and, as yet, not wholly understood, relationships with each other and with the environment in which they live. Taken together, the plants, animals, and their physical environment compose an ecosystem, and that is the level at which impacts should be evaluated (Frissell and Bayles 1996). However, the definition of the geographical limits of an ecosystem frequently is a difficult task, particularly when attempting to factor in ground water hydrology. In addition, ecosystem-wide data are often sparse or entirely absent for an area. For these, and other, reasons, impact analyses often are performed at the community and population levels, a technique which facilitates the incorporation of data collected by others. This ecological impact analysis will focus, then, on these two levels of ecological organization, the population and community. The analysis will incorporate also an evaluation of the immediate effects of the project upon the water and land resources in the area. Further, the occurrence of cumulative environmental effects will be mentioned briefly because, while assessing cumulative impacts is seldom done in the usual impacts analysis document, cumulative impacts should be considered in order to address ecosystem-level and sustainability issues.

**Ecological Relationships.** In communities at this level, impact analyses are concerned chiefly with the long-term maintenance of the ecological relationships which operate within the community. It is at this level that populations of plants and animals interact with each other in both a lateral (horizontal) and hierarchical (vertical) manner. Such interactions can be either critical or non-essential to population viability. Those non-essential relationships are replaceable by other interactions and relationships, and the affected populations will continue to thrive. Those relationships, which are critical, however, are irreplaceable, and their disruption can result in the extirpation of a population from a particular area. It is of major importance during an impact analysis, then, to identify these critical relationships in communities, which face potential disturbance from a project. In order to accomplish such an analysis, ecologists utilize several community characteristics as barometers of the degree of change tolerable by a community.

The community can be described by means of several community characteristics or parameters, including dominance, species diversity, structural complexity and stability, niche availability, and metabolic role within an ecosystem. For the purposes of this document, we will focus on dominance and species diversity, with some attention to structural complexity/stability. Also, for ease of discussion, plant communities and animal communities will be discussed separately when feasible.

**Populations.** Populations, composed of interacting members of a single species, represent the level at which most humans relate to living things, chiefly because most human experience makes it easier to grasp the concept of population. For example, in a population of black bear in Hernando County, it is easier to consider the individual bears, their competition for food and for mates, their parent-offspring interactions, their establishment of territory, etc. than to consider the bears selection of food sources, their interactions with other animal species, their use of other non-food plants, etc. The latter set of relationships is more complex than the former, and involves many unfamiliar organisms many of whose ecological roles remain poorly understood. Therefore, an analysis of populations is useful for impact analysis purposes, if only to assist human decision-makers in understanding the ramifications of a project's effects in an area.

The primary parameter evaluated in such an analysis of populations is abundance, that is, the number of individuals of a species utilizing the resources of an area for survival. In this document, abundance will be the focus of the discussion relating to populations.

# ECOLOGICAL DESCRIPTION OF THE PROJECT AREA

## PLANTS AND ANIMALS

### Plant Communities

The plant communities that were disturbed for the purpose of obtaining fill material in the project area were pine flatwoods (including palmetto prairies) and mesic hammock (Table 1).

Of these two communities, the pine flatwoods/palmetto community is by far the most common in Florida and, in covering approximately 50% of the state, it represents the most extensive of Florida's plant communities and is found throughout the state from Palm Beach County northward on the Atlantic coast, from Lee County to Bay County on the Gulf Coast, and from Hendry County to Baker County in the interior of the state (Taylor 1998). Pine flatwoods in Florida have been of interest to western man, primarily as a source of timber, for over 300 years, and one of the first scientific observations of the community is that of Bartram made during his excursions in the state in the late 1700's (van Doren 1955).

**Dominance in Pine Flatwoods**. In pine flatwoods, both the dominance and diversity characteristics of the community are greatly affected by the frequency with which it is subjected to fire. The typical flatwoods in which fire has occurred approximately every 3-5 years will appear superficially as a community having two primary strata: the trees and shrubs. Just as Bartram in the 1790's was impressed with the bi-level community structure of flatwoods, the modern observer can determine visually that dominance in this community is shared by both tree and shrub species. In the project area, the dominant tree species in this community are slash pine (*Pinus elliottii* var. *elliottii*) and, to a much lesser extent, longleaf pine (*Pinus palustris*).

Shrub species include the abundant saw palmetto (*Serenoa repens*), while southern bayberry (*Myrica cerifera*), gallberry (*Ilex glabra*), highbush blueberry (*Vaccinium corymbosum*), rusty lyonia (*Lyonia ferruginea*), and pawpaw (*Asimina reticulata*) are common associates in the project area. Tarflower (*Bejaria racemosa*), winged sumac (*Rhus copallina*), persimmon (*Diospyros virginiana*), and eastern false willow (*Baccharis halimifolia*) occur somewhat less often.

Herbs include a variety of grasses and, depending upon the frequency of dampness, species such as Baldwin's sedge (*Eleocharis baldwinii*), blazing star (*Liatris* sp.), broomsedge (*A. virginicus*), bushy bluestem (*Andropogon glomeratus*), coinwort (*Centella asiatica*), paintbrush (*Carphephorus corymbosus*), St. John's Wort (*Hypericum fasciculatum* and *H. tetrapetalum*), sundew (*Drosera* sp.), wiregrass (*Aristida stricta*), a wide variety of flowering herbs, particularly in the family Asteraceae) (Abrahamson and Hartnett 1990).

If fire frequency is reduced in pine flatwoods, the natural pattern of ecological succession in central Florida will progress, and the flatwoods will change in both appearance and species composition. In the project area, fire suppression results in flatwoods having a very dense, tall shrub layer, which is composed of the saplings of hardwood species, chiefly oaks, together with large wax myrtles and gallberry. The shrub layer can become virtually impenetrable and the flatwoods loses its open appearance. As for species composition, that community characteristic changes first in the shrub layer as hardwood species establish themselves. Later, the canopy layer, formerly dominated by slash pine in the project area, gives way to mature hardwood species as the saplings of oak, hickory, and magnolia grow to large size. The shift from an open flatwoods through a dense transitional community to a mature hardwood community has significant implications for wildlife utilization.

Palmetto prairies are very similar to pine flatwoods with the exception that tree species are virtually absent.

The pine flatwoods community, while very common in Florida, plays two important ecological roles. First, it has been referred to the matrix that ties together and merges with other Florida vegetation types (Edmisten 1963), and it can be viewed as the connection between other, less extensive, plant communities. Second, pine flatwoods/palmetto prairies provide essential habitat both for animal species whose activities are restricted to that community and for animal species, which must move overland between wetlands, hammocks, and other habitats. Therefore, this community, often regarded as a relatively unimportant background for other plant communities, contributes significantly to the viability of many of Florida's wildlife species.

**Diversity in Pine Flatwoods.** Pine flatwoods are not noteworthy for the diversity of trees or of shrubs. Relative to herbs, however, one can say that species diversity in some areas of flatwoods is outstanding. Herbaceous species are known to respond favorably to fire, and herb diversity is high in those flatwoods, which have been subjected to relatively frequently fire. Grasses and wildflowers, the most visible members of the herbaceous component of a flatwoods, are particularly abundant following fire. Estimates of species richness for pine flatwoods are not numerous; however, the literature suggests that the community, while generally considered one of the less diverse terrestrial systems in the state, can rival mixed hardwood communities, depending upon degree of fire suppression, moisture conditions, and age of the particular system (Abrahamson and Hartnett 1990).

**Listed Plant Species in Pine Flatwoods.** In the pine flatwoods communities in which the project site is located, the potential for encountering plant species listed as endangered or threatened is low as compared to communities studied in Orange, Volusia, and other, more northern, counties. However, listed species which are present in the area include: two species most commonly seen in damp flatwoods soils, the small butterwort (*Pinguicula pumila*) and the hooded pitcher plant (*Sarracenia minor*); several terrestrial orchid species, the Bearded grass pink (*Calopogon barbatus*), pale grass pink (*Calopogon pallidus*), multi-flowered grass pink (*Calapogon multiflorus*), rose-orchid (C*leistes divaricata*), yellow-fringed orchid (*Platanthera ciliaris*), snowy orchid (*Platanthera nivea*), rose pogonia

(*Pogonia ophioglossoides*), grass-leaved ladies' tresses (*Spiranthes praecox*); and the showy pine lily (*Lilium catesbaei*).

The second plant community disturbed by the acquisition of fill material is mesic hammock. The hammock community does not cover areas in Florida as vast as the pine flatwoods community, yet it is distributed throughout the state and covers approximately 15 % of Florida. It occurs chiefly as narrow bands of vegetation, which can be described best as a dense forest (Platt and Schwartz 1990). While hammocks were mentioned by William Bartram, the serious study of Florida hammocks begins with the extensive work of Roland Harper (Harper 1905; Harper 1914; Harper 1915), and has matured in the more modern work begun by Monk in the 1950's and 1960's (Monk 1960; Monk 1965). Such studies have revealed that the community referred to as a hammock is a grouping of several types of forested systems, whose composition is dependent upon the moisture characteristics of the area and the geographical location of the area in the state. The type of system which was disturbed for fill acquisition, a mesic hammock, is characterized as a dense, mixed evergreen-deciduous forest which only very rarely experiences even saturation of forest soils (Platt and Schwartz 1990; Dooris and Wharton 1987).

In the past, the mesic hammock community has interested both early and modern Floridians for a number of reasons. Initial interest focused upon the extensive timber resources represented by the system. Also, the community occupies soils outstanding for several types of agricultural development, including the raising of cattle and citrus (Soil Conservation Service 1989). And, in the late 1800's and early 1900's, the hammocks, particularly those in central Florida, were also exploited for their tourist appeal (WPA 1984). Since the early 1900's, the ecological value of this community has been recognized, and it is now known that it is a highly diverse community of plants (discussed below), and it provides habitat for a large number of animal species, many of which live in Florida at the southern limit of their geographic ranges.

**Dominance in Mesic Hammocks.** In this part of Florida, mesic hammocks are characterized by a large number of tree species in both the overstory and the understory. Compared to the tree component of this community neither shrubs nor herbs are as well represented either in terms of the number of species or in the number of individuals present (unless canopy openness has been increased by some disturbance factor). Also, in contrast to the pine flatwoods, the mesic hammocks have some species of vines, which occur frequently.

In the project area, the hammock overstory is dominated by several species of oaks (*Quercus* sp.), but live oak (*Quercus virginiana*) is the most common. The oaks share dominance with pignut hickory (*Carya glabra*), southern magnolia (*Magnolia grandiflora*), Florida elm (*Ulmus floridana*), cabbage palm (*Sabal palmetto*), and sweetgum (*Liquidambar styraciflua*). Woody species of the mesic hammock understory can include saplings of those species just mentioned together with American holly (*Ilex opaca*), possum haw (*Viburnum nudum*), red maple (*Acer rubrum*) and southern bayberry (*Myrica cerifera*). In this area, dominance among the trees is variable, depending upon the degree of disturbance to which the particular community has been subjected. In relatively undisturbed hammocks, live oak and pignut hickory are, by far, the most common trees, sometimes representing up to 75-85% of all individual trees in a hammock. The other tree species are represented by only a few individuals.

In the project area, the dominant shrub is saw palmetto (*Serenoa repens*). Other shrub species include beauty berry (*Callicarpa americana*), devil's walkingstick (*Aralia spinosa*), hog plum (*Ximenia americana*), laurel cherry (*Prunus caroliniana*), sparkleberry (*Vaccinium arboreum*), Virginia willow (*Itea virginica*), wild cherry (*Prunus serotina*), winged sumac (*Rhus copallinum*).

Vine species include Carolina yellow jasmine (*Gelsemium sempervirens*), grape (*Vitis* sp.), greenbrier (*Smilax bona nox*), wild sarsaparilla (*Smilax pumila*), while skunk vine (*Paederia foetida*) may be present in disturbed systems.

Herbs include several species of grasses and ferns, together with blackberry (*Rubus* sp.), cherokee bean (*Erythrina herbacea*), green dragon (*Arisaema dracontium*), ironweed (*Vernonia angustifolia*), jack-in-the-pulpit (*Arisaema triphyllum*), milk pea (*Galactia regularis*), violet (*Violet sororia*), and partridge berry (*Mitchella repens*), with no single species dominant in this diverse vegetational component (Dooris 1996).

**Diversity in Mesic Hammocks.** The diversity in the tree species composing mesic hammocks is a hallmark of the community. In particular, the trees and herbs are highly diverse. Estimates of the number of very common species occurring in a hammock in the project area could range to approximately 60 to 75 trees, shrubs, and herbs (Dooris and Wharton 1987; Harper 1914). Uncommon species may number as many as 150. Hammocks are considered as having the highest plant species diversity of any plant community in the state, and species diversity of Florida's hammocks compares very favorably with that of other upland hardwood communities in the entire eastern United States (Platt and Schwartz 1990).

**Listed Plant Species in Mesic Hammocks.** Listed plant species occurring in the project area include green fly orchid (*Epidendron conopseum*), needle palm (*Rhapdidophyllum hystrix*), rain lily (*Zephyranthes atamasca*), spring coralroot (*Corallorhiza wisteriana*), and several ferns.

## Animals

Both the pine flatwoods and mesic hammock communities provide excellent wildlife habitat in terms of available food and refuge sites (Table 1, below). Approximately 181 vertebrate species can be expected in the pine flatwoods/prairie community, while 102 species could be commonly found in the mesic hammock community type in this region of the state. Of these species, 94 utilize the resources of both the pine flatwoods and mesic hammock communities. Tables A-1, A-2, and A-3 in Appendix A provide a complete listing of the species expected to occur in the plant communities of the project area.

**Table 1. Number of Vertebrate Species Expected to Utilize Either the Pine Flatwoods/Grassland Communities or Mesic Hammocks or Both Communities in the Project Area.**

| Vertebrate Group | Pine Flatwoods & Grassland Communities | Mesic Hammocks | Both Communities |
|---|---|---|---|
| Mammals | 35 | 25 | 24 |
| Birds | 95 | 47 | 43 |
| Reptiles | 37 | 22 | 19 |
| Amphibians | 14 | 8 | 8 |
| TOTAL SPECIES | 181 | 102 | 94 |

See Appendix A for a complete listing of expected vertebrate species.

Twelve of the species occurring in these two communities in the project area are listed by the Florida Fish and Wildlife Conservation Commission as endangered (E), threatened (T), or of special concern (SSC) (Table 2). Not included in these numbers are the Florida panther and the Florida black bear, which, while they utilize the two communities in other parts of the state, are unlikely residents of this project area.

**Table 2. Species Listed as Either Endangered, Threatened, or of Special Concern (Florida Fish and Wildlife Conservation Commission, 1997).**

| Species | Status | Species | Status |
|---|---|---|---|
| American alligator | SSC | Peregrine falcon | E |
| Gopher tortoise | SSC | Burrowing owl | SSC |
| Florida pine snake | SSC | Grasshopper sparrow | E |
| Eastern indigo snake | T | Southern short-tailed shrew | SSC |
| Southern bald eagle | T | Sherman’s fox squirrel | SSC |
| Southeastern American kestrel | T | Florida mouse | SSC |

## SURFACE WATER AND GROUND WATER RESOURCES

The project area, located in Hillsborough County, traverses an area characterized by several small lakes, streams, and wetlands associated with the Brushy Creek and Brooker Creek watersheds. All but two of the six borrow pits and pit complexes created for the Veteran’s Expressway were constructed adjacent to forested wetlands. Borrow pits constructed in such locations can result in changes to the hydroperiods in the wetlands as the bottom elevations of the pits generally are lower than those of the wetlands. In addition, the pits, situated upgradient from the wetland, can intercept runoff from a portion of the wetlands basin, further reducing the volume of water entering the wetland. The overall effect of the borrow pit on the wetland is one of eventual reduction of hydroperiod, despite the common design of most pits which allows for discharge to adjoining wetlands during high water conditions. Reduced hydroperiods in wetlands are linked to a suite of ecological consequences, all of which can be described as adverse (Rochow 1998).

## WATER QUALITY

Water quality data for the project area is sparse as a whole and does not exist for the wetlands, which were affected by the Veteran's Expressway project. It can be expected that the water quality of the wetlands will be altered by the construction and operation of adjoining borrow pits. However, if the pits result in a virtually continuous condition of dryness, as has been observed (Dooris, personal observations, 1993-99), the issue of wetland water quality becomes moot.

## ENVIRONMENTAL IMPACTS OF USING CONVENTIONAL FILL MATERIAL FOR ROAD CONSTRUCTION ON THE VETERANS EXPRESSWAY

### PLANTS AND ANIMALS

To generate the fill necessary for the roadway project, 114 acres of land were disturbed (see Table 3).

**Table 3. Plant Communities and the Acres of Each Community Disturbed for the Purpose of Obtaining Fill Material for the Veterans Expressway.**

| Plant Community | Acres |
|---|---|
| Pine flatwoods/palmetto prairie | 113.9 |
| Mesic hammock | 1.2 |
| TOTAL ACRES | 114.1 |

The disturbance was one of a permanent nature in that the existing plant community on the site was removed completely, together with underlying soils. Vegetation was discarded using various methods, and the resulting system was unlike the original one. In cases in which a portion of a plant community is extirpated from an area, several ecological consequences may follow including, the following:

1. Loss of community metabolic benefits, i.e. local atmospheric cooling, oxygen production, nutrient exchange;
2. Disruption of the normal patterns of ecological succession in a community;
    a. Loss of habitat for animal species;
    b. Change in dominance;
    c. Change in diversity; and
    d. Change in biological production.

The first parameter, relating to community metabolism, is difficult to address in impact analysis of this type because highly specialized data on pre- and post-project conditions are required. These data are not available, therefore, a thorough discussion of this parameter as it changes with the disturbance associated with fill acquisition cannot be provided in this document. However, it can be stated that the conversion of a terrestrial community to an aquatic community as generally happens in the case of conventional fill acquisition techniques in this area brings about significant local ecological change. The consequences of this change require considerable further study, both on an individual and a cumulative basis, in order to discern the real impacts on community metabolic benefits of obtaining fill.

The second parameter, relating to changes in patterns of ecological succession, is extremely important, and from it, all of the other parameter changes follow. The normal succession trend in flatwoods/prairies in the project area is, in the absence of fire, toward a community dominated by mixed hardwood species (not unlike a mesic hammock). However, the excavation of fill material terminates that natural process, and removes the product of ecological succession, the flatwoods community, virtually overnight. In place of the former community, bare soils remain. In this case, a hole results which fills with water and eventually a pond or lake comes into being. This new community is quite different from the former one in terms of habitat function, dominance, diversity, and biological production. In addition, the pond or lake is a nascent community, and it will take time to mature, stabilize, and to contribute to the area's biological production; whereas, the community that is replaced was already contributing substantial biological benefits to the area. First, the habitat functions that are provided by the pond/lake are appropriate to an entirely different range of vertebrate species than those which use the terrestrial community replaced by the pond. The most obvious difference, of course, is in the fact that the pond has the potential to support fish populations, while the terrestrial community does not, and, assuming that fish are able to colonize the pond by some means, it can be expected that fish will become established eventually. Very likely, the pond will support more species of amphibians and reptiles in addition to the species already utilizing the flatwoods. Bird species probably will be less numerous, and the species supported by the pond will, of course, be much different. Very possibly a few more mammalian species will utilize the ponds, attracted by reliable sources of water.

Second, dominance of plant species will change dramatically. The most obvious change will be a trend to dominance by a very few herbaceous species, rather than by tree species. The species adapted to the aquatic environment will be different than those in the flatwoods community. Further, those species which become established in the pond will have colonized the new habitat from other, nearby, ponds. In central Florida, the pond can be expected to become a system dominated by cattail (*Typha* sp.) and Peruvian seedbox (*Ludwigia peruviana*) unless planting of other, more desirable, species is done and maintenance is performed on a long-term basis. Therefore, the end result of borrow pit construction will most likely be a community of lower biological benefit than the flatwoods or hammock communities.

Third, along with the change in dominance, diversity will change markedly. Initially, the pond will support a very few species; later, diversity will increase significantly. A stabilization period will follow during which diversity will be somewhat lower. The period of time required for pond stabilization will vary considerably from pond to pond, and it is not possible to predict the actual time frame for a particular pond. It is known, however, that the design characteristics of the pond can expedite or inhibit the system's stabilization process. Such characteristics include: depth and bathymetry, side slopes, substrate, presence of littoral zones, and water quality.

Fourth, stable biological production will change as a terrestrial community gives way to an aquatic community. Generally, aquatic communities in Florida eventually achieve a level of biological production which exceeds that of a flatwoods community. However, the time involved for a pond to reach such a level is, as already mentioned, difficult to predict. Meanwhile, new ponds my be over-productive and suffer from unsightly algae blooms which deter animal colonization. Given time and a proper design, most ponds will begin to contribute in a positive manner to an areas biological production.

Insofar as mesic hammocks are concerned, the ecological impacts associated with the replacement of a terrestrial community with another, while generally involving the same parameters, are somewhat different than those above described for flatwoods. First, the community that replaces the hammock following excavation may or may not be an aquatic community. The depth of the excavation will determine whether the new community is a pond or a shallow, herbaceous depression.

Second, mesic hammocks are not as common as flatwoods, particular in the project area, and the loss of all or part of a stable hammock community is considered more serious that a loss of flatwoods.

Third, while the change in dominance from trees to herbs will also occur when a hammock is replaced by either a terrestrial or an aquatic community, the most significant change in mesic hammocks is in diversity. As above described, hammocks is the most diverse terrestrial community in the state. Few aquatic communities will match the hammock in overall diversity, and, of course, no community will match the hammock in diversity of tree species. Should the final community be a grassy depression, biological diversity will be significantly less than that of a hammock.

Fourth, in terms of biological production, the hammock and the aquatic community would be much more similar than would the hammock and the grassy depression. As already described above, an aquatic community has a high potential to contribute positively to the area's biological production. A grassy depression is, by comparison, an extremely unproductive system, and the conversion of hammock to such a system represents a major biological loss. Assuming, however, that the resultant community is a small pond, its generation from the conversion of hammock still represents loss in biological production in the early stages of the pond's life. Later, as the pond develops, biological production increases to a point dependent upon several factors, including time since construction, nutrient input, and other disturbances.

Lastly, listed plant species will be affected by the conversion of either pine flatwoods or mesic hammock to a pond community. The listed species occurring in the two terrestrial communities that would be displaced would be eradicated from the excavation site itself. Further, the contribution that those individuals would make to the survival of the particular species to which they belonged would be lost, that is, the eradicated individuals would not provide genetic material for the production of future generations. Therefore, the species affected would be at greater risk of extinction unless protection measures, if any were feasible, were taken. Moreover, the pond which would result from borrow pit construction would very likely not contain plant species listed as threatened or endangered; most species which would colonize the pond would be common to the area. Therefore, there would be an overall loss of listed plant species in the area.

Animal populations existing in the immediate area of the borrow pit construction will be similarly affected. Terrestrial species will be extirpated, and species that are able to utilize the resulting aquatic habitat will establish themselves over time. Vertebrate species which would disappear from the construction area include the approximately 147 species listed in tables A-1 through A-3 as occurring in pine flatwoods, mesic hammock, and grassland habitats but not listed in the last column of the table. “BP” indicates species which would be benefited by the construction of the borrow pit (Table A-3).

Listed species which, if already existing on the site, would disappear as a result of construction include: gopher tortoise, Florida pine snake, eastern indigo snake, southeastern kestrel, peregrine falcon, burrowing owl, grasshopper sparrow, Sherman’s fox squirrel, southern short-tailed shrew, and Florida mouse.

Species expected to occur in the area which would be benefited by the construction of the borrow pond include the 26 species which are listed as occurring in project area communities and are also listing in the last column of tables A-1 through A-3 (10 mammals, 5 birds, 3 reptiles, 8 amphibians). In addition to these species, species new to the project area would become established. It is estimated that approximately 54 species would fall into this category, including the listed species: American alligator, snowy egret, tricolored heron, little blue heron, limpkin, wood stork, roseate spoonbill, and white ibis (Table 4, below).

**Table 4. Change in the Distribution among the Vertebrate Groups in the Project Site as a Result of Borrow Pit Construction.**

| Vertebrate Group | Existing Species Extirpated | Existing Species Benefited | Species New to the Project Site |
|---|---|---|---|
| Mammals | 27 | 10 | 3 |
| Birds | 81 | 5 | 36 |
| Reptiles | 34 | 3 | 8 |
| Amphibians | 5 | 8 | 7 |
| TOTAL SPECIES | 147 | 26 | 54 |

*See Appendix A for a complete listing of expected vertebrate species.*

## SURFACE WATER AND GROUND WATER RESOURCES

With regard to surface water, conventional fill acquisition techniques generally result in new surface water bodies in an area. The presence of another small pond having no surface outlet will reduce surface runoff from the local area to an extent dependent upon the pond’s size, contributing basin, and position in the larger watershed of which it now becomes a part. The reduction in surface runoff will be a specific characteristic of each particular borrow pond and can be estimated using standard hydrologic methods.

The borrow pond will also have a different evaporation/transpiration (ET) rate than the terrestrial community that it displaced. ET from the pond can be expected to be generally higher than that of the flatwoods or hammock formerly occupying the site. Therefore, the hydrologic budget of the highly localized area around the pond will be altered.

With regard to ground water, the borrow ponds which result from conventional fill acquisition techniques will affect ground water if the pond is constructed so as to intercept the water table or to breach the discontinuous clay confining layer which separates the non-artesian system from the Floridan Aquifer. In view of the hydrogeology of the project area (Hancock and Smith, 1996), it is feasible that borrow pit construction could both intercept the water table and penetrate the clay confining layer. Therefore, the impacts to ground water resources from borrow pits would extend to both the non-artesian and the artesian systems. In effect, the pit would receive water from the water table and, potentially, from the Floridan Aquifer which would eventually fill the pit and result in a pond. The pond, then, would be a reflection of groundwater levels in the area and act as a permanent drain from the system. The overall effect of the pond would be a loss of water via evaporation and, later, transpiration as well as plants became established in the pond environment.

If the construction of the pit results in a pond which does not intercept the water table or penetrate the confining layer, but, instead, only comes very near, water from the pond would drain to the water table and act to recharge the system at a rate faster than that associated with the normal infiltration process though overlying soils. Basically, the pond, in capturing precipitation and surface runoff in the local area would then act as a reservoir from which water would drain to the ground water system.

Of the two scenarios briefly described, the more likely of the two is the former in which the pond acts to drain water from the groundwater system.

At the construction site, no actions taken during the laying down and compacting of the roadbed material should affect the surface water or ground water systems, assuming that standard erosion control practices are implemented.

## WATER QUALITY

Water quality impacts associated with conventional fill acquisition practices can involve both surface and ground water. The impacts relating to surface waters occur chiefly as a result of erosion of non-stabilized fill material into water bodies adjoining the roadway construction site. Standard erosion control measures designed to prevent this problem are generally effective to a large degree, thereby minimizing the surface water quality impacts of the sloughing of earthen fill used in roadbed and shoulder.

Ground water impacts involve the site from which the fill was obtained, i.e., the borrow pits used for fill acquisition. Borrow pits constructed for the generation of fill frequently are deep enough to intercept the water table in the non-artesian aquifer in many areas of Florida, including the project area used for this report. Such construction practices essentially result in the creation of a large diameter shallow well which fills with water and becomes a borrow pond in the post-construction phase. Water inputs to the new pit include direct rainfall, surface runoff, and drainage from the non-artesian aquifer. The upper Floridan Aquifer may discharge to the pond as well, depending upon the elevation of the potentiometric surface in the immediate vicinity of the pond. Water output from the post-construction pond generally occurs by means of evaporation from the water's surface. However, lateral and downward leakage from the pond to the non-artesian aquifer may occur depending upon the elevation of the pond and water elevation in the aquifer. Further, there is a possibility that the pond may discharge to the upper Floridan Aquifer, again depending upon the elevation of the potentiometric surface. The end results are ponds which are in close contact with the ground water system and the increased vulnerability of the ground water system to contamination (Hancock and Smith 1996). In the project area, the water table ranges between 0–15 feet of the land surface (Coffin and Fletcher 1999); therefore, contamination of water in the non-artesian aquifer as a result of leakage from borrow ponds is very likely. The potentiometric surface can vary within 10-20 feet of the land surface in response to rainfall and local water use patterns (Metz et al. 1998). Further, the contamination potential of the Upper Floridan Aquifer can be significantly increased in the presence of several factors in affected regions of the system in which:

a. the rate of downward leakage is accelerated by the discontinuous nature of the confining unit separating the non-artesian aquifer from the artesian aquifer;
b. sinkhole formation is likely due to the karstic nature of the underlying geology;
c. recharge to the Aquifer has been induced as a result of large-scale ground water withdrawals (Swancar and Hutchinson 1992).

All of the above conditions are prevalent in the project area where the integrity of the ground water system is of particular importance, making the commonplace construction of borrow pits a questionable practice.

A variety of water quality characteristics and constituents are of potential concern relative to the contamination via downward leakage from borrow ponds to the water table and the upper Floridan, including: metals, nitrogen and phosphorus (from fertilizers), and organic materials (from pesticides, herbicides). Other constituents of surface water such as suspended and dissolved solids, most inorganic ions, and pH are generally not major problems in this context as the chemical character of surface waters is generally similar to that of water in the non-artesian system (Hancock and Smith 1996). An increase in the rate of downward leakage of surface water to the non-artesian aquifer could result in an increase in the concentration of undesirable materials in the water table.

As for the upper Floridan, that aquifer is generally more mineralized than either surface water or water in the non-artesian aquifer; therefore, there is no serious concern for constituents such as suspended and dissolved solids, most inorganic ions, and pH. The same concern described above relative to metals, nitrogen and phosphorus, and organic materials exists, and contamination of water in the non-artesian aquifer overlying the upper Floridan will eventually result in contamination of water in the artesian system.

Measures to prevent direct contamination of the ground water system from borrow ponds can be taken during the roadway planning process. Borrow pits (later, borrow ponds) can be sited to avoid areas which are especially sensitive to ground water contamination. Pits can be designed and constructed so as not to intercept either the water table or the geologic formations of the artesian system close to land surface. However in reality, other practical considerations may take precedence over ground water contamination issues. For example, with regard to the siting of borrow pits during the initial design phase of a roadway project, the cost to acquire the rights to extract fill from land for the pits is a major consideration, and the fewer pits needed for a project, the less costly the fill. The costs to haul fill from the pit to the point of construction together with the quality and quantity of fill material from each pit are also of principal importance. In preparing specifications for each borrow pit, major criteria include the efficiency and optimization of fill extraction as they are related to the pit's depth and shape. And, in the construction of borrow pits, the design specifications must be followed carefully in order to insure that the resultant pits are not too deep; and the actual pit dimensions must be field verified and corrections made, if necessary--sometimes an expensive proposition.

## ENVIRONMENTAL IMPACTS OF USING PHOSPHOGYPSUM FOR ROAD CONSTRUCTION

### PLANTS AND ANIMALS

No significant impacts to plants and animals are expected in connection with the use of PG for roadfill material. Because the generation of fill material will not involve disturbance to an existing ecosystem, no impacts will occur in the fill acquisition phase of a roadway construction project. As for the potential for impacts at the site of construction itself, impacts should not occur providing the PG used as fill is not stockpiled in a manner which would allow erosion of the pile slopes and the subsequent escape of PG into the environment. Therefore, the use of PG as fill would necessitate proper scheduling of fill delivery to prevent the long-term storage of unduly large amounts of PG on site. The PG which must be stored on site would have to be protected in such a way as to exclude the interaction of rain and wind with the material. Pile protection could be effected by means of various covers.

The use of PG as fill would also allow the reduction of impacts at the current sites of PG stockpiling. As PG reserves were used and large piles of the material were eliminated in central Florida, opportunities to restore substantial acreage of native plant communities and wildlife habitat would present themselves. Former pile storage sites could be transformed into areas benefiting both wildlife species and human residents in the vicinity. Further, the possibility to design and manage restored sites to satisfy permit-related mitigation requirements of roadway and other projects is a real one. Utilizing former PG pile storage sites as site for habitat restoration would reduce the overall impact level of transportation corridors in Florida as compared to conventional fill acquisition and use practices.

### SURFACE WATER AND GROUND WATER RESOURCES

The use of PG for road building purposes is not expected to result in impacts to either the surface or ground water system. Acquisition of the material will not require excavation significantly below ground surface; therefore, the integrity of the underlying geologic formations should remain intact.

At the construction site, no actions taken during the laying down and compacting of the roadfill material should affect the surface water or ground water systems, assuming that standard erosion control practices are implemented.

**WATER QUALITY**

As in the case of conventional fill material, PG used for roadfill construction could affect water quality of surface waters adjacent to the construction site if unprotected PG stockpiles are subjected to prolonged exposure to wind and rain. As described above, measures to prevent erosion of fill stockpiles, together with proper scheduling to prevent the retention of large amounts of unprotected PG on site, can eliminate the potential for escape of PG into the environment.

As for water quality impacts of PG in the ground water system, the potential for contamination is low (Nifong and Harris 1993). This statement is true, particularly if leaching from PG stockpiles to underlying aquifers during construction is minimized as already described. Once incorporated into the roadbed and upon paving, PG will be largely secured from the effects of rain and wind; therefore, decreasing the leaching potential to zero. Moreover, combining, or stabilizing, PG with other materials, such as Portland cement, can materially reduce the interaction of PG and rain, thereby further preventing undesirable materials in PG from escaping into the environment (Ho 1995).

The reduction of the potential for environmental impacts from the use of PG for roadway construction is on the whole dependent upon construction phasing and site management practices.

## AIR QUALITY

Virtually any roadway construction project will generate highly localized air quality problems due to particulates on a temporary basis. In roadway projects in which conventional fill is used, the particulates are natural soil particles of a size equal to or less than the size of silt particles. Long-term inhalation of such particles can be harmful to animals and can damage plants adjacent to the construction site. Fugitive dust is also a nuisance to residents in the vicinity of the construction. Accordingly, measures are taken during construction to minimize the escape of particles into the atmosphere, although complete elimination of the problem is generally not achieved in actuality.

On a site in which PG is being utilized on a large-scale for roadfill construction, the escape of particles from protected piles into the atmosphere can be drastically minimized, thereby reducing air quality degradation in the local area. Of historical concern with regard to the use of PG in roadway construction is the release into the atmosphere of radioactivity in the form of radon and gamma radiation. Data suggest that the risk to humans, and presumably to animals, from PG-related radon from roadway construction in which PG is being utilized is extremely small. The effects of gamma radiation on humans are also well known and should be considered in using PG for roadway work (FIPR and FSU 1996). However, in animals, the effects of gamma radiation are much less known, yet they may be a factor of concern should PG achieve widespread use in the state as fill material. Mobile animals whose range includes roadways constructed using PG will encounter gamma radiation as they approach the roadway at close range. Long-term, low-level exposure may pose some hazard to such animals, particularly endangered animals already under stress.

## CUMULATIVE IMPACTS

Cumulative environmental impacts have been defined as well as those impacts which "result from the interactions of many incremental activities, each of which may have an insignificant effect when viewed alone, but which become cumulatively significant when seen in the aggregate." Such impacts may "have short-term or long-term effects and may appear soon after disturbance or be delayed" (Dickert and Tuttle 1985). The discussion in this report concerning the environmental impacts associated with the use of conventional fill versus PG in roadway construction did not consider in any detail the cumulative impacts of the actual project that was built using conventional fill acquisition practices. That is, the discussion related to impacts connected with a particular project only. Effort was not made to put that project in the context of all of the other past projects in the area which also had resulted in the construction of borrow ponds or their equivalent. Moreover, no effort was made here to describe the impact of this project in the light of planned future projects. A cumulative impact assessment would require a somewhat different approach from the one employed here but would be quite helpful in an understanding of the long-term effects of the use of conventional fill in roadway construction. In an urbanizing area such as the project area, it is particularly important to investigate the cumulative impacts of all project components as more and more projects are planned and constructed (Hunsacker 1998). However, a cumulative impact assessment is not routinely performed in practice.

With regard to the use of PG also, an assessment of the cumulative impacts involved with its use in roadway construction on a large scale, long-term basis should be investigated. In so doing, it would become obvious that roadway construction using waste materials such as PG as fill would reduce or eliminate the major environmental impacts which have been associated to date with conventional fill: ground water contamination and significant losses in habitat and wildlife.

## SUMMARY COMPARISON OF THE ENVIRONMENTAL IMPACTS OF USING PG VERSUS CONVENTIONAL FILL FOR ROADWAY CONSTRUCTION

Table 5 compares in summary fashion the impacts to plants, animals, and water quality associated with the use of PG and conventional fill in roadway construction. The table is plain matrix which is a proven technique in widespread use to summarize the comparative environmental impacts of two or more projects (Canter 1998). The table compares both benefits and impacts of the two projects as they affect selected resources and processes. Therefore, the table permits the evaluation of a project in terms of its environmental impact (defined here as a negative quantity), its environmental benefit (a positive quantity or benefit), and its lack of any environmental effect at all.

The scale which is employed here to depict project impact and benefit is one of several types of scales which are available for achieving a simple ranking of projects for decision-making purposes. The scale, expressed in whole numbers only, depicts impact within the range from –5 to –1 and shows benefit within the range from +1 to +5. The number –5 indicates the most impact and +5 indicates the most benefit. Numbers between –4 and +4 are of intermediate impact/benefit. A zero indicates no effect on the part of the project on the resource in question. The assignment of a numerical "grade" to a project is done subjectively based upon experience of the investigators and published information.

**Table 5. Comparison Matrix of Environmental Impacts and Benefits Associated with the Use of PG Versus Conventional Fill Material for Roadway Construction.**

| Environmental Impact | Phosphogypsum | Conventional Fill Material |
|---|---|---|
| A. Plant and Animal Communities | | |
| 1. Dominance | +3 | -1 |
| 2. Diversity | +5 | -1 |
| 3. Biological Production | +5 | +3 |
| 4. Listed Species | +2 | +3 |
| B. Water Quality | | |
| 1. Surface Water | -1 | -1 |
| 2. Ground Water | 0* | -4 |
| C. Water Resources | | |
| 1. Surface Water | -1 | -1 |
| 2. Ground Water | 0* | -3 |
| D. Air Quality | -1 | -1 |
| E. Cumulative Impacts | ? | ? |
| TOTAL SCORE | 12 | -6 |

* Assuming appropriate precautions.

From Table 5, it can be concluded that the use of PG for roadfill material could result in net benefits to the environment. The primary benefits of using PG relate to the potential for habitat restoration and wildlife enhancement in the areas now being used for storage of PG stacks and in the prevention of habitat losses by the replacement of conventional fill with PG. These significant benefits would accrue only if a restoration effort actually occurred following the depletion of the PG due to its use elsewhere. If no restoration were accomplished, the benefits to plant and animal communities would not be realized and the use of PG would be determined as providing fewer benefits to the environment. The remaining benefits to plant and animal communities would involve only the preservation of habitat that would have been lost to borrow pits.

The use of conventional fill material also is associated with benefits to plants and animals. Because it is expected that an aquatic community would result from the excavation of a borrow pit, biological productivity would increase in the area if the pit had been excavated in a flatwoods community. If the area were a mesic hammock, on the other hand, productivity would likely decline overall.

As for listed species, many of the listed species in Florida are wetland-dependent species or species that would use a pond at least occasionally. Therefore, the construction of a pond would provide benefits to the environment in the area.

One of the primary drawbacks to the use of conventional fill is the potential for groundwater contamination resulting after the construction is completed when the area is left with essentially an open hole to the ground water system. Because a large proportion of the area's potable supply is derived from groundwater sources, contamination of the resource is particularly serious, and projects that increase the possibility of contamination are detrimental to the environment.

No score is provided for cumulative impacts as they have not been evaluated for this report. Cumulative impacts are included in this table in order to raise awareness of the need to evaluate the long-term impacts of any widespread practice such as the construction of borrow pits or the proposed use of PG on a large-scale. Because no score for this impact category is assigned to either project, the total scores are not affected by the inclusion of cumulative impacts in the matrix.

# USERS GROUP SURVEY

## INTRODUCTION

This section of the report describes the results of interviews and analyses conducted by the IES project team members regarding the use of phosphogypsum (PG) and/or the excavation of borrow pits (BPs) for use as roadfill material. The purpose of this endeavor was to identify as many issues and concerns as possible, without expressing a biased (pro or con) opinion on the part of the interviewers. The goal of this effort was to provide as complete a listing as possible of issues to be addressed by any organization that might seek to utilize PG in road construction. A summary of the survey results is included below; details concerning the issues raised and the questions asked are included in Appendix B.

The first step in this process was to research the available literature on PG use in roadbeds and of BP use. From this research, a list of potential issues was developed. This list was kept separate and apart from the subsequent interview process, and was used as a post-interview check as to whether the interviews had: (1) resulted in new issues not uncovered during the literature research phase; and (2) succeeded in enumerating most if not all the issues uncovered during the research phase.

The second step was to identify roughly 70 individuals with some level of understanding of either PG use or of BP use. The interviewers were careful to NOT attempt to "educate" any person being interviewed, as it was believed that any such effort could introduce bias into the results received (for example, if an interviewer was describing major constituents in PG, but failed to mention a given constituent, the person being interviewed might neglect to mention a potential issue regarding that constituent, assuming it was not present in PG). Given that no "education" of the person being interviewed was permitted, a person with no knowledge of PG or of BPs was not able to address the subject matter. This required that an initial listing of people who already had some knowledge of the matters be developed. This initial listing was developed from the literature research undertaken in the first step of the process. This list expanded when different people being interviewed provided the interviewer with additional people to speak with. The list was specifically designed to include individuals who might be classified as opponents as well as proponents of PG use. The list included scientists, environmentalists, engineers, public activists, and public health specialists. Again, the goal was to develop as complete a listing of potential issues as possible. Attempts were made to contact a total of 70 people. Of these, 47 were successfully contacted and actually interviewed. A list of all people interviewed is included in this report (Table 6).

Every attempt was made to conduct the interviews in an unbiased manner. To facilitate the elucidation of issues by the person being interviewed, the person was assured that his/her name would *not* be associated with a particular issue in any way. People were more willing to proffer ideas freely, without fear of their name being placed next to an issue which might cause them embarrassment or problems. Also, the people being interviewed had their issues checked for accuracy by the interviewer during the interview (if the interview was conducted verbally) before the given issue was included in this report. All issues are provided exactly as relayed to the interviewer, so as to not risk inadvertent modifications of a given person's issue. If the issues were provided to us in written form, they are included as received (with the exception of spelling/grammatical corrections if necessary and to delete words which would clearly serve to identify that person as the one making a given statement).

The third step in the process was to examine and summarize the issues and concerns received and compare those with the list developed in the initial step of the process. Only at this point in the process has the IES project team modified any wording of any issue provided by an interviewee. We have made every attempt even at this step to not slant the meaning of a particular issue provided by an individual.

Categorizing the issues/concerns was done solely to assist the reader in maintaining a given line of thought. Categories are NOT listed in any type of prioritization as to importance. Certain people provided statements of position rather than elucidating issues. These are also included. While such statements do not add to the list of issues, they are deemed useful in providing insight into "perceptions" which may exist, and which may themselves need to be addressed in some manner.

## BACKGROUND

The idea of utilizing phosphogypsum as a constituent in roadfill material is not a new one. The concept has been considered for at least twenty years, and several road sections using PG have been in existence for over a decade. Controversy over the use of PG for this purpose is also not new. The uncertainties with respect to public health have prompted the United States Environmental Protection Agency (EPA) to promulgate a rule which places restrictions on the use of PG for various uses, including for use in road construction.

Borrow pits have been utilized extensively in Florida as a source for roadfill material, and there are no federal restrictions specific to borrow pits. However, there are state and local land use-related controls which pertain to the excavation of borrow pits.

Florida has a large number of PG stacks, and is a leading producer of PG on an annual basis. Florida is also a state which relies heavily on borrow pits for most of its roadfill material. Without substantial topographic relief, it is often difficult to obtain fill material in most regions of the state by the usual means of digging into the side slopes of hills. As a result, most fill is generated via the excavation of open pits in the ground.

**Instructions, Protocols, and Procedures Used by the Interviewers**

The interviewer related information to each person being interviewed: The interviewer explained that he/she is calling on behalf of the Institute for Environmental Studies at the University of South Florida. The whole project is looking at environmental and public health and perception issues pertaining to the use of borrow pits for roadfill material and with the possible use of phosphogypsum for roadbed material. The part the person being interviewed will play is to help identify individuals who have some knowledge of the subject matter, and solicit their opinions as to what issues need to be addressed, what questions need to be asked and answered, to fully encompass the environmental, public health, and perception aspects of borrow pits and/or phosphogypsum use for roadfills.

The interviewer asked the person being interviewed to think about what aspects of borrow pit use and/or phosphogypsum use are of concern to them or which may be of concern to others. The interviewer asked them to relay those to us either in written or oral form, whichever way they felt most comfortable. If a verbal interview, the interviewer wrote down the person's issues and questions. We presented or read to the person their final set of issues/questions before we placed them in the report, to make certain we had described the thoughts accurately.

The interviewer placed the person's name as an individual being interviewed in the report. However, the interviewer did not identify or associate that person's name with any given issue. This assures the person can speak freely and without worry of being labeled with a given idea.

The interviewer did not act as an advocate of or an opponent of the subject matter. Our goal is to make certain the Institute has as complete a picture of the issues as possible. The interviewer did not make any value judgments of any issue/question.

The interviewer told the person he/she had been selected as a result of our research into the subject matter. Our research indicated he/she has knowledge of the subject matter. The interviewer did not choose to interview individuals with no knowledge of the subject matter, given that the interviewer would first have to provide a certain level of education, and hence may be subject to accusations that the education was biased in one direction or another. The interviewer interviewed a wide range of technical and non-technical people for this report.

The person's questions/issues expressed could be general or specific. However, we informed people that the more specific the question they posed, the more likely it can later be examined and answered. To provide an example: a person might state that he is concerned over impacts to public health over the use of phosphogypsum as roadbed. Or, he might state that he believes there needs to be demonstrable proof that the use of phosphogypsum in roadbeds will not result in any increases in radiation levels from the roadways, and would not result in any contamination of groundwater. Either way it was stated was placed within the report.

The interviewer could assist the person being interviewed in framing a question/issue as that person preferred it to be framed, but we did not dictate what questions are appropriate to ask, or what issues are appropriate to bring up.

In the initial contact with that person, the interviewer informed them that we would accept their ideas now, or if they preferred to think about it for a few days before the interview, arranged a time and date convenient for them to have the interviewer call them again. If the person preferred to put their issues and questions in writing, that was also acceptable. We stressed that we wanted to make this as convenient for the person being interviewed as possible.

The person on the phone at this point would elect to either set up a date and time for a phone interview, would decide to provide you their thoughts at that moment, or would choose to write down their thoughts and send them to us. Some preferred a face to face interview.

If the interview was verbal, the interviewer concentrated on first understanding the question/issue they are attempting to describe. The interviewer listened carefully, making notes as he listened. After the person completed expressing a thought, the interviewer would stop and verbally restate that thought back to the person, so as to be certain he really did understand it. At that point, the interviewer would jot down the complete thought before continuing with the next thought. The interviewer would make certain he was pleasant and conversational during the interview. This makes the interview more enjoyable for both parties, and tends to promote free flow of ideas, which is what is desired here.

When a person indicated that they had provided the interviewer with all they could think of, the interviewer offered to have him/her contact us if they have any other ideas after the interview.

The interviewer would read the questions/issues back to the person and obtain their concurrence with how each was written down. The interviewer would inform them that if their issue is modified following the interview, they will be contacted again with the modified wording. If not, we will state the issue as originally provided us.

Following the completion of all interviews, we compared the responses received to the list of issues we had identified from our own research into the subject matter. This list was compiled as a way of checking our research against the cumulative knowledge base of the people interviewed. If after all the interviews, there were still issues from our research list which had not been identified by one or more persons interviewed, our final report will identify those specific issues.

## SUMMARY OF SURVEY RESULTS

In this section of the report, the comments and issues provided in the interviews have been summarized. It is important to understand that any attempt to summarize or synthesize opinions is bound to introduce some bias into the process. The reader is encouraged to study the individual comments and opinions provided to obtain the clearest picture of the opinions of every person interviewed before reading the following summations.

Both BPs and PG had proponents and detractors. Comments which promote either BP use or PG use may be read within the comments provided by the people interviewed, but are not summarized here. Certain individuals pointed out that the crux of the problem was the lifestyle led in this country. There are alternatives to more/wider roads and green lawns that would reduce the need for both BPs and PG production.

BPs were characterized by most people as an ecological and aesthetic problem, with a potential to degrade or contaminate groundwater and/or surface water. PG use in road fill also had ecological and aesthetic aspects, but the major focus of most people centered around public health related matters.

The ecological issues involving the use of BPs included: fragmentation of habitat; creation of steep-sided, deep water with minimal littoral zone (a "biological desert"); loss of natural soil horizon hence difficulties with re-establishment of natural vegetative communities on the sides (different pH, etc); loss of natural sheet flow; poor water quality; nuisance vegetation; reduction in biodiversity; disruption of bioenergetic pathways; loss of upland habitat; lowering of nearby wetland water levels; lowering of nearby water table.

The ecological issues involved in the use of PG for roadfill involved mostly concerns over impacts to the health of organisms exposed to the material, either through direct contact, or weathering-related breakdown of the material. There was discussion of whether the pH and/or alkalinity of PG would assist or hinder efforts to revegetate roadsides with native species.

Water quality issues involving the use of BPs primarily involved the possibility of introducing contaminants into either groundwater or surface water via the loss of the natural filtering properties of the soil, and the presence of a "pit" conducive to disposing of unwanted materials.

Water quality issues involving PG for roadbed were related to public health concerns as well as possible exposure of ecological receptors. If PG stacks required liners to prevent contamination of groundwater, wouldn't the same type of concern hold for PG use as roadbed? Radium 226/228, radon, various metals, inorganics, and volatiles were mentioned by various individuals as possible concerns. Breakdown of the PG material over time and the subsequent release of contaminants was also an issue. Would breakdown/weathering actually create contaminants (such as sulfur dioxide, phosphoric acid, or other compounds)?

There were several public health and safety issues involving BPs. One involved the safety issue of people (especially children) falling into the pits. Another issue involved large trucks transporting the material. One individual raised the issue of bringing higher radioactive portions of the geologic strata to the surface via digging of BPs, and the resultant increased exposure of people to the higher radioactivity. Another talked of the increases in mosquitoes from having the pit act as a breeding ground.

Public health related issues were perhaps the most frequently mentioned concern from those interviewed with respect to PG use in roadbed. The term "overriding" was utilized in this regard. Exposing people to constituents in PG in water and air was mentioned as an issue frequently. In addition to those constituents listed in the paragraph involving water quality, concerns were expressed over inhalation of the airborne PG crystals (the question was expressed in terms of an asbestos-like problem in the lungs), and the possibility that other potentially harmful materials may have been "dumped" in a gypsum stack in the past and inadvertently spread as part of the roadfill.

Questions were asked regarding the relative structural integrity of BP material versus PG in roadbed use. Which last longer? Which require less maintenance? One person suggested PG for use in pothole repair rather than for roadbed material. Questions were also asked regarding the relative economics of each.

Issues involving regulations of both BPs and PG use in roadbed were brought up by multiple persons. Several stressed the need for regulations to "restore" BPS to a more ecological and/or aesthetically attractive form following construction. Regulation of PG use centered on ensuring that public health is not threatened. A number of people spoke of the need for appropriate research to be conducted by unbiased parties. Planning on a more holistic basis was recommended along with risk management and net ecosystem benefit type approaches to both BP use and PG use.

**Table 6. List of People Interviewed.**

| Name | Title | Professional Affiliation |
|---|---|---|
| Barnwell, Mary | Ecologist | SWFWMD, Brooksville |
| Bayer, John | | PolySum Technologies LLC |
| Bissett, Nancy | Restoration Ecologist Horticulturist | The Natives |
| Bissett, William F. | Landscape Architect | The Natives |
| Brown, Mark | | FDOT, Tampa |
| Burkhart, Dawn | | Polk County Engineering Division |
| Cameron, John | | IMC Agrico |
| Carpenter, David | Environmental Manager | SWFWMD, Bartow |

**Table 6. List of People Interviewed (Cont.).**

| | | |
|---|---|---|
| Checkoway, Harvey | Ph.D. | Univ. of Washington, Department of Environmental Health |
| Cleckley, William | Lands Coordinator | NWFWMD |
| Clewell, Andre | Ph.D., Restoration Specialist | Clewell & Assoc., Inc. |
| DeGrove, Bruce | | Florida Phosphate Council |
| Duever, Michael | | The Nature Conservancy |
| Durbin, Doug | Ph.D. | Biological Research Associates |
| Elzerman, Alan W. | | Clemson University |
| Featheringill, CeCe | Senior Management Analyst | FDEP, Tampa |
| Godwin, Walter | | SJRWMD |
| Gray, Paul N. | | National Audubon Society |
| Hayes, Howard | | FDEP |
| Keen, Parker | | Cargill Fertilizer |
| King, Tim | | Florida Game and Freshwater Fish Commission |
| Kulakowski, Zoe | | FDEP |
| Lightsey, Debbie | Geotechnical Engineer | Department of Transportation |
| L.A.M.* | Biologist | St. Petersburg |
| Marburger, Joy | | SJRWMD |
| Mathias, Jeff | | Boston |
| Maura, Clarence | | USDA Natural Resource Conservation Service |
| Meyer, Roland | Ph.D. | Univ. of California at Davis |
| Minazian, Leo | | FDEP |
| Mushinsky, Henry | Ph.D. | Univ. of South Florida, Department of Biology |
| O'Dell, Gene | Public Information Director | Department of Transportation |
| Palmer, Tom | Journalist | The Ledger, Lakeland |
| P. S.* | Agronomist | |
| Reese, Tom | | Manasota-88 |
| Roessler, Charles | Ph.D. | Univ. of Florida, Dept. of Environmental Sciences |
| Ryan, John | | League of Environmental Organizations |
| Saylak, Don | Ph.D., Research Engineer | Texas A&M Univ. |

**Table 6. List of People Interviewed (Cont.).**

| | | |
|---|---|---|
| Seamon, Grey | | The Nature Conservancy |
| Stricker, Jim | | Polk County Extension Service |
| Sumner, Malcolm | Ph.D., Coordinator of Environmental Soil Science Program | Univ. of Georgia |
| Sumpter, David | Wildlife Biologist | Environmental Consultant |
| Tedder, Richard | | FDEP |
| Touchton, John | | CF Industries |
| Traxler, Greg | Ph.D. | Dept. of Agricultural Economics and Rural Sociology |
| Art Wade | Environmental Permit Coordinator | Polk County Engineering Dept. |
| Wells, Sandra Vardaman | | |

Note: * This individual requested anonymity.

## RECOMMENDATIONS

**1. Perform a formal Risk Assessment procedure to analyze the risks of gamma radiation to animals, particularly endangered vertebrates, as a result of using PG as roadfill material.**

This work would involve primarily an investigation of the immediate risks to animals resulting from exposure to PG. An outcome of the study should include specific information regarding the management of PG from the stack to the construction site. This information would be helpful not only in reducing wildlife exposure to gamma radiation but also in protection measures for humans involved in the handling PG at the construction site.

**2. Develop a land restoration plan for an area following the reduction to land surface of an existing PG stack.**

The actual feasibility of restoration is an important contributor to the benefit potential of using PG for roadway construction. Therefore, a thorough investigation of the techniques, costs, and resulting specific benefits to plant, animal, and human communities is warranted.

**3. Investigate the cumulative environmental impacts of using PG in roadway construction.**

Cumulative impacts of any type of project which has been or could be implemented on a large-scale are difficult to assess. However, in the case of PG use, the level of public concern regarding long-term exposure to radiation is of such a magnitude that a study of this nature is justified.

## REFERENCES


Abrahamson WG, Hartnett DC. 1990. Pine flatwoods and dry prairies. In: Myers RL, Ewel JJ, editors. 1990. Ecosystems of Florida. Orlando (FL): University of Central Florida Press.

[Anonymous]. 1984. WPA guide to Florida. Reprint of 1939 WPA Guide to Florida. New York: Pantheon Books.

Borris DP, Boody PW, editors. 1980. Phosphogypsum. Proceedings of the International Symposium on Phosphogypsum, 5-7 November 1980 (Vols 1, 2) . Bartow (FL): Florida Institute of Phosphate Research. p 661.

Canter LW. 1998. Methods for effective EIA practice. In: Porter AL, Fittipaldi JJ, editors. Environmental methods review. Atlanta: Army Environmental Policy Institute, Georgia Institute of Technology. p 58-68.

Chang WF. 1989. Phosphogypsum for secondary road construction. Miami: University of Miami.

Chang WF, editor. 1990. Proceedings of the Third International Symposium on Phosphogypsum, December 1990, Orlando. Bartow (FL): Florida Institute of Phosphate Research. FIPR Publication No. 01-060-083. p 773.

Chang WF. 1990a. Roller compacted concrete utilizing phosphogypsum. In: Chang (1990). p 623-631.

Chang WF, Mantell MI. 1990. Engineering properties and construction applications of phosphogypsum. Coral Gables (FL): University of Miami Press.

Coffin JE, Fletcher WL. 1999. Water resources data – Florida. Water year 1998. Vol. 3B. Tampa: US Geological Survey.

Dickert TG, Tuttle AE. 1985. Cumulative impact assessment in environmental planning: a coastal wetland watershed example. Environmental Impact Assessment Review 5:37-64.

Dooris PM, Wharton BR. 1987. Hernando County's Big Hammock Region. Report prepared for Hernando County Div. of Planning and Development. Brooksville, FL. p 74 .

Dooris PM. 1996. Cypress Bridge Wellfield ninth annual report. Prepared for West Coast Regional Water Supply Authority. Clearwater, FL. Tampa: University of South Florida Institute for Environmental Studies.

Edmisten JA. 1963. The ecology of the Florida pine flatwoods. Doctoral dissertation. Gainesville (FL): University of Florida. p 107.

Florida Department of Transportation (FDOT). 1992. FEIS Re-evaluation: Northwest Hillsborough Expressway from I-275 to SR 597. Tampa: Florida Department of Transportation.

Florida Game & Fresh Water Fish Commission. 1984. Official lists of endangered and potentially endangered fauna and flora in Florida. Tallahassee (FL): Florida Game and Fresh Water Fish Commission.

Florida Fish and Wildlife Conservation Commission. 1997. Florida's endangered species, threatened species, and species of special concern. Official lists. Tallahassee (FL): Florida Fish and Wildlife Conservation Commission.

Florida Institute of Phosphate Research (FIPR). 1994. Phosphogypsum. Potential sustainable uses. Unpublished summary. September, Rev. 12/12/1994. Bartow (FL): Florida Institute of Phosphate Research. p 4.

Florida Institute of Phosphate Research. 1995. Strategic initiatives and applied research priorities. Bartow (FL): Florida Institute of Phosphate Research.

Florida Institute of Phosphate Research and Florida State University. 1996. Proceedings of the phosphogypsum fact-finding forum, Dec. 7, 1995. Tallahassee, Florida. Publication No. 01-132-117. Bartow (FL): Florida Institute of Phosphate Research.

Federal Highway Administration (FHWA) and Florida Department of Transportation (FDOT). 1987. Final EIS: Northwest Hillsborough Expressway. Tallahassee (FL): FHWA & FDOT.

Frissell CA, Bayles D. 1996. Ecosystem management and the conservation of aquatic biodiversity and ecological integrity. Water Resources Bulletin 32(2): 229-238.

Hancock MC, Smith DA. 1996. Northern Tampa Bay water resources assessment project, vol. 2. Brooksville (FL): Southwest Florida Water Management District.

Harper RM. 1905. A hammock, hommock, or a hummock. Science 22: 400-402.

Harper RM. 1914. Geography and vegetation of northern Florida. Florida Geological Survey, Sixth Annual Report. p 163-451.

Harper RM. 1915. Vegetation types. In: Sellards EH, Harper RM, Mooney EN, Latimer WJ, Gunter H, Gunter E, editors. Natural resources of an area in central Florida. Tallahassee (FL): Florida Geological Survey. Seventh Annual Report. p 135-188.

Ho RKH. 1990. Pavement evaluation of two gypsum stabilized county roads. In: Chang (1990). p 603-622.

Ho RKH. 1995. Preliminary investigation of phosphogypsum for embankment construction. Statement made at FIPR (1995a).

Hunsaker CT. 1998. Cumulative effects assessment. In: Porter AL, Fittipaldi JJ, editors. Environmental methods review: retooling impact assessment for the next century. Atlanta, Army Environmental Policy Institute. Georgia Institute of Technology.

Lloyd GM Jr. 1985. Phosphogypsum: a review of the Florida Institute of Phosphate Research programs to develop uses for phosphogypsum. Bartow (FL): Florida Institute of Phosphate Research.

Lloyd GM Jr, editor. 1988. Proceedings of the Second International Symposium on Phosphogypsum. December 1986. University of Miami. Bartow (FL): Florida Institute of Phosphate Research. FIPR Publication No. 01-037-055. p 480, p 416.

Lloyd GM Jr. 1997. Conversation with Mr. Lloyd. Bartow (FL): Florida Institute of Phosphate Research.

May A. 1983. Use of Florida phosphogypsum in synthetic construction aggregate. Washington (DC): U.S. Bureau of Mines.

Metz PA, Mattie JA, Torres AE, Corral MA. 1998. Potentiometric surface of the upper Floridan Aquifer, west-central Florida, September, 1997. USGS Open-File Report 98-100. Tampa: US Geological Survey.

Monk CD. 1960. A preliminary study on the relationships between the vegetation of a mesic hammock community and a sandhill community. Quarterly Journal of the Florida Academy of Sciences 23: 1-12.

Monk CD. 1965. Southern mixed hardwood forests of north central Florida. Ecological Monographs 35: 335-354.

Nifong GD, Harris JK. 1993. Environmental monitoring of Polk and Columbia Counties experimental phosphogypsum roads. Bartow (FL): Florida Institute of Phosphate Research.

Platt WJ, Schwartz MW 1990. Temperate hardwood forests. In: Myers R, Ewel JJ, editors. Ecosystems of Florida. Gainesville (FL): University Presses of Florida. p 194-229.

Rochow TF. 1998. The effects of water table changes in fresh water marsh and cypress wetlands. Env. Section Tech., Report 1998-1. Brooksville (FL): Southwest Florida Water Management District.

Roessler CE. 1990. Radon emanation from roads constructed with PG aggregates. In: Chang (1990). p 30-43.

Saylak D. 1995. Design, construction and evaluation of experimental stabilized gypsum roadbases. Statement presented in FIPR (1996). p 93-97.

Soil Conservation Service. 1989. Soil survey of Hillsborough County, Florida. Tallahassee (FL): US Department of Agriculture and the Florida Department of Agriculture and Consumer Services.

Swancar A, Hutchinson CB. 1992. Chemical and isotopic composition and potential for contamination of water in the upper Floridan Aquifer, west-central Florida, 1986-89. USGS Open File Report 92-47. Tampa: US Geological Survey.

Taha RR, Seals K, Tittlebaum ME, Thornsberry W, Houston JT. 1992. The use of by-product phosphogypsum in road construction. Transportation Research Record 1345.

Taylor WK. 1998. Florida wildflowers in their natural communities. Gainesville (FL): University Press of Florida.

US Department of Energy. 1997. The expansion and operation of the central shops borrow pit at the Savannah River site. Savannah River Laboratory, Aiken, SC.

Van Doren M, editor. 1955. The travels of William Bartram. New York: Dover Press.

Zumdahl SS. 1989. Chemistry (2nd ed). Boston (MA): D.C. Heath. p 949.

## OTHER LITERATURE REVIEWED


Ashton RE Jr, Ashton PS. 1988a. Handbook of reptiles and amphibians of Florida: Part one, the snakes. Miami: Windward Publishing.

Ashton RE Jr, Ashton PS. 1988b. Handbook of reptiles and amphibians of Florida: Part three, the amphibians. Miami: Windward Publishing.

Ashton RE Jr, Ashton PS. 1991. Handbook of reptiles and amphibians of Florida: Part two, the lizards, turtles, and crocodilians. Miami: Windward Publishing.

Berish CW. 1990. Potential hazards of phosphogypsum storage in central Florida. In: Chang (1990). p 1-29.

Blanchard RL, Horton TR. 1988. Supplementary radon-222 flux measurements on Florida phosphogypsum stacks. SC&A, Inc. McLean, VA. Unpublished. Cited by Berish, 1990.

Chang WF. 1987. Reclamation, reconstruction and reuse of phosphogypsum for building materials. Coral Gables (FL): University of Miami.

Chang WF. 1988. A demonstration project: roller compacted concrete utilizing phosphogypsum. Coral Gables (FL): University of Miami.

Horton TR, Blanchard RL, Windham ST. 1988. A long term study of radon and airborne particulates at phosphogypsum stacks in central Florida. (EPA 520/5-88-021). Montgomery (AL): US Environmental Protection Agency, Office of Radiation Programs, Eastern Environmental Radiation Facility.

Hunter AH. 1989. Use of phosphogypsum fortified with other selected essential elements as a soil amendment on low cation exchange soils. Agro Services International, Inc.

Kale HW II, Maehr DS. 1990. Florida birds. Sarasota (FL): Pineapple Press, Inc.

Kouloheris AP. 1981. Evaluation of potential commercial processes for the production of sulfuric acid from phosphogypsum. Zellars-Williams, Inc.

Miller WP. 1989. Use of gypsum to improve physical properties and water relations in southeastern soils. Athens (GA): University of Georgia.

Mullins GL, Mitchell CC Jr. 1990. Use of phosphogypsum to increase yield and quality of annual forages. Auburn (AL): Auburn University.

National Emission Standards for Hazardous Air Pollutants (NESHAPS). 1989. Environmental impact statement for radionuclides. Washington (DC): US Environmental Protection Agency, Office of Radiation Programs (NAR-459). EPA 520/1-89-005.

Stevenson HM. 1976. Vertebrates of Florida. Gainesville (FL): University Presses of Florida.

Sumner ME. 1990. Gypsum as an ameliorant for the subsoil acidity syndrome. Athens (GA): University of Georgia.

Sumner ME. 1995. Literature review on gypsum as a calcium and sulfur source for crops and soils in the southeastern United States. Athens (GA): University of Georgia.

Traxler G. 1996. The economic benefit of phosphogypsum use in agriculture in the southeastern United States. Auburn (AL): Auburn University.

University of Florida. 1996. Influence of phosphogypsum on forage yield and quality and on the environment in typical Florida spodosol soils. Volume I. Forage yields and quality of bahiagrass and annual ryegrass pastures fertilized with phosphogypsum as a source of sulfur and calcium. Gainesville (FL): University of Florida.

University of Florida. 1996. Influence of phosphogypsum on forage yield and quality and on the environment in typical Florida spodosol soils. Volume II. Environmental aspects associated with phosphogypsum applied as a source of sulfur and calcium to bahiagrass and annual ryegrass pastures growing on Florida spodosol soils. Gainesville (FL): University of Florida.

# APPENDIX A

# LIST OF VERTEBRATE SPECIES EXPECTED IN THE PROJECT AREA

**Table A-1. Species That Potentially Use Habitats Displaced or Created by the Borrow Pits Excavated for the Veterans Expressway. Reptiles and Amphibians.**

| | | HABITATS | | | | |
|---|---|---|---|---|---|---|
| COMMON NAME | SCIENTIFIC NAME[1] | PF | CS | MH | GSS | BP |
| Oak Toad | Bufo quercicus | X | X | | | X |
| Southern Toad | Bufo terrestris | X | X | X | X | |
| Florida Cricket Frog | Acris gryllus dorsalis | X | X | | | X |
| Green Treefrog | Hyla cinerea | X | X | X | | X |
| Pinewoods Treefrog | Hyla femoralis | X | X | X | X | |
| Barking Treefrog | Hyla gratiosa | X | | | | |
| Squirrel Treefrog | Hyla squirella | X | X | X | X | |
| Little Grass Frog | Limnaoedus ocularis | X | X | | X | X |
| Florida Chorus Frog | Pseudacris nigrita verrucosa | X | X | | X | X |
| Eastern Narrowmouth Toad | Gastrophryne carolinensis carolinensis | X | X | X | X | X |
| Eastern Spadefoot Toad | Scaphiopus holbrookii holbrookii | X | X | X | X | X |
| Bullfrog | Rana catesbeiana | | X | | | X |
| Pig Frog | Rana grylio | | X | | | X |
| Southern Leopard Frog | Rana utricularia | | X | | | X |

[1] Source of scientific and common names: Collins, J.T., R. Conant, J.E. Huheey, J.L. Knight, E.M. Rundquist, and H.M. Smith, 1982. Standard common and current sceintific names for North American amphibians and reptiles. Society for the Study of Amphibians and Reptiles, Miami Univ., Oxford, Ohio.

[2] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|
| Two-toed Amphiuma | Amphiuma means | | X | | | X |
| Dwarf Siren | Pseudobranchus striatus | | X | | | X |
| Greater Siren | Siren lacertina | | X | | | X |
| Eastern Lesser Siren | Siren intermedia intermedia | | X | | | X |
| Southern Dusky Salamander | Desmognathus auriculatus | X | X | | | X |
| Slimy Salamander | Plethodon glutinosus glutinosus | X | | X | X | X |
| Peninsula Newt | Notopthalmus viridescens piaropicola | | X | | | |
| Greenhouse Frog | Eleutherodactylus planirostris planirostris | X | X | X | X | |
| American Alligator | Alligator mississippiensis | | X | | | X |
| Eastern Slender Glass Lizard | Ophisaurus attenuatus longicaudus | X | | X | X | |
| Island Glass Lizard | Ophisaurus compressus | X | | | | |
| Eastern Glass Lizard | Ophisaurus ventralis | X | | X | X | |
| Southern Fence Lizard | Sceloporus undulatus undulatus | X | | | X | |
| Peninsula Mole Skink | Eumeces egregius onocrepis | | | | X | |
| Southeastern Five-lined Skink | Eumeces inexpectatus | X | X | X | X | |

[1] Source of scientific and common names: Collins, J.T., R. Conant, J.E. Huheey, J.L. Knight, E.M. Rundquist, and H.M. Smith, 1982. Standard common and current sceintific names for North American amphibians and reptiles. Society for the Study of Amphibians and Reptiles, Miami Univ., Oxford, Ohio.

[2] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|
| Ground Skink | Scincella lateralis | X | X | X | X | |
| Six-lined Racerunner | Cnemidophorus sexlineatus sexlineatus | X | | | X | |
| Florida Chicken Turtle | Deirochelys reticularia | | | | | X |
| Florida Box Turtle | Terrapene carolina bauri | X | X | X | X | |
| Gulf Coast Box Turtle | Terrapene carolina major | X | X | X | | |
| Striped Mud Turtle | Kinosternon baurii | X | X | X | | |
| Florida Mud Turtle | Kinosternon subrubrum steindachachneri | | X | X | | |
| Stinkpot | Sternotherus odoratus | | X | X | | X |
| Peninsula Cooter | Pseudomys floridana peninsularis | | X | | | X |
| Red-bellied Turtle | Pseudomys nelsoni | | X | | | X |
| Florida Snapping Turtle | Chelydra serpentina osceola | | X | | | X |
| Gopher Tortoise | Gopherus polyphemus | X | | X | X | |
| Florida Softshell | Apalone ferox | | X | | | X |
| Green Anole | Anolis carolinensis | X | X | X | | |
| Brown Anole | Anolis sagrei sagrei | X | | X | X | |

[1] Source of scientific and common names: Collins, J.T., R. Conant, J.E. Huheey, J.L. Knight, E.M. Rundquist, and H.M. Smith, 1982. Standard common and current sceintific names for North American amphibians and reptiles. Society for the Study of Amphibians and Reptiles, Miami Univ., Oxford, Ohio.

[2] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|
| Florida Scarlet Snake | Cemophora coccinea coccinea | X | X | X | | |
| Southern Black Racer | Coluber constrictor priapus | X | X | X | X | |
| Southern Ringneck Snake | Dradophis punctatus punctatus | X | X | X | X | |
| Eastern Indigo Snake | Drymarchon corais couperi | X | | | X | |
| Corn Snake | Elaphe guttata guttata | X | X | X | X | |
| Yellow Rat Snake | Elaphe obsoleta quadrivittata | X | X | X | X | |
| Eastern Mud Snake | Farancia abacura abacura | | X | | | X |
| Eastern Hognose Snake | Heterodon platyrhinos | X | | | X | |
| Southern Hognose Snake | Heterodon simus | X | | | X | |
| Common Kingsnake | Lampropeltis getulus | X | X | X | X | |
| Scarlet Kingsnake | Lampropeltis triangulum elapsoides | X | | X | | |
| Eastern Coachwhip | Masticophis flagellum flagellum | X | | | X | |
| Florida Green Water Snake | Nerodia floridana | | X | | | X |
| Florida Banded Water Snake | Nerodia fasciata pictiventris | | X | | | |
| Brown Water Snake | Nerodia taxispilota | | X | | | X |
| Rough Green Snake | Opheodrys aestivus | X | X | | X | |

[1] Source of scientific and common names: Collins, J.T., R. Conant, J.E. Huheey, J.L. Knight, E.M. Rundquist, and H.M. Smith, 1982. Standard common and current sceintific names for North American amphibians and reptiles. Society for the Study of Amphibians and Reptiles, Miami Univ., Oxford, Ohio.

[2] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|
| Florida Pine Snake | Pituophis melanoleucus mugitus | X | | | X | |
| Striped Crayfish Snake | Regina alleni | | X | X | | X |
| Pine Woods Snake | Rhadinaea flavilata | X | X | X | X | |
| South Florida Swamp Snake | Seminatrix pygaea cyclas | X | X | | | X |
| Florida Brown Snake | Storeria dekayi victa | X | X | | X | X |
| Florida Crowned Snake | Tantilla relicta | X | | | | |
| Peninsula Ribbon Snake | Thamnophis sauritus sackenii | X | X | X | X | |
| Eastern Garter Snake | Thamnophis sirtalis sirtalis | X | X | | X | |
| Eastern Coral Snake | Micrurus fulvius fulvius | X | | | | |
| Florida Cottonmouth | Agkistrodon piscivorus conanti | X | X | | | X |
| Eastern Diamondback Rattlesnake | Crotalus adamanteus | X | X | | X | |
| Dusky Pigmy Rattlesnake | Sistrurus miliarius barbouri | X | X | | X | |

[1] Source of scientific and common names: Collins, J.T., R. Conant, J.E. Huheey, J.L. Knight, E.M. Rundquist, and H.M. Smith, 1982. Standard common and current sceintific names for North American amphibians and reptiles. Society for the Study of Amphibians and Reptiles, Miami Univ., Oxford, Ohio.

[2] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

**Table A-2. Species That Potentially Use Habitats Displaced or Created by the Borrow Pits Excavated for the Veterans Expressway. Birds.**

| | | | HABITATS | | | | |
|---|---|---|---|---|---|---|---|
| COMMON NAME | SCIENTIFIC NAME[1] | SEASON[2] | PF | CS | MH | GSS | BP |
| Pied-billed Grebe | Podilymbus podiceps | y | | | | | X |
| Double-crested Cormorant | Phalacrocorax auritus | y | | X | | | X |
| Anhinga | Anhinga anhinga | y | | X | | | X |
| American Bittern | Botaurus lentiginosus | y | | | | | X |
| Least Bittern | Ixobrychus exilis | s | | | | | X |
| Great Blue Heron | Ardea herodias | y | | X | | | X |
| Great Egret | Casmerodius albus | y | | X | | | X |
| Snowy Egret | Egretta thula | y | | X | | | X |
| Cattle Egret | Bubulcus ibis | y | | | | X | X |
| Tricolored Heron | Egretta tricolor | y | | | | | X |
| Little Blue Heron | Egretta caerulea | y | | X | | | X |

[1] Source of scientific and common names: Robertson, Jr., W.B., G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Pub. No. 6. Gainesville, FL.

[2] y = year round resident; s = summer resident; w = winter resident.

[3] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | SEASON[2] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|---|
| Green-backed Heron | Butorides striatus | y | | X | | | X |
| Limpkin | Aramus guarauna | y | | X | | | |
| Wood Stork | Mycteria americana | y | | X | | | X |
| Roseate Spoonbill | Ajaia ajaja | y | | X | | | |
| White Ibis | Eudocimus albus | y | | X | | X | X |
| Glossy Ibis | Plegadis falcinellus | y | | X | | X | X |
| Green-winged Teal | Anas crecca | w | | | | | X |
| Wood Duck | Aix sponsa | y | | X | | | |
| American Black Duck | Anas rubripes | w | | X | | | X |
| Mottled Duck | Anas fulvigula | y | | X | | | X |
| Mallard | Anas platyrhynchos | w | | X | | | X |
| Northern Pintail | Anas acuta | w | | | | | X |
| Blue-winged Teal | Anas discors | w | | | | | X |
| Hooded Merganser | Lophodytes cucullatus | w | | X | | | X |

[1] Source of scientific and common names: Robertson, Jr., W.B., G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Pub. No. 6. Gainesville, FL.

[2] y = year round resident; s = summer resident; w = winter resident.

[3] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | SEASON[2] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|---|
| Black Vulture | Coragyps atratus | y | X | X | X | X | |
| Turkey Vulture | Cathartes aura | y | X | X | X | X | |
| Northern Harrier | Circus cyaneus | w | | | | X | |
| Bald Eagle | Haliaeetus leucocephalus | y | X | | | X | |
| American Swallow-tailed Kite | Elanoides forficatus | s | X | X | | X | |
| Cooper's Hawk | Accipiter cooperii | y | X | | | X | |
| Sharp-shinned Hawk | Accipiter striatus | w | X | | | | |
| Red-tailed Hawk | Buteo jamaicensis | y | X | X | X | X | |
| Red-shouldered Hawk | Buteo lineatus | y | X | X | X | X | |
| American Kestrel | Falco sparverius | w | X | | | X | |
| Southeastern American Kestrel | Falco sparverius paulus | y | X | | | X | |
| Osprey | Pandion haliaetus | y | | | | X | X |
| Merlin | Falco columbarius | w | | | | X | X |

[1] Source of scientific and common names: Robertson, Jr., W.B., G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Pub. No. 6. Gainesville, FL.

[2] y = year round resident; s = summer resident; w = winter resident.

[3] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | SEASON[2] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|---|
| Peregrine Falcon | Falco peregrinus | w | | | | X | |
| Wild Turkey | Meleagris gallopavo | y | X | X | X | X | |
| Northern Bobwhite | Colinus virginianus | y | X | X | X | X | |
| Sandhill Crane | Grus canadensis | y | | | | X | X |
| King Rail | Rallus elegans | y | | | | | X |
| Virginia Rail | Rallus limicola | w | | | | | X |
| Sora | Porzana carolina | w | | | | | X |
| Common Moorhen | Gallinula chloropus | y | | | | | X |
| American Coot | Fulica americana | w | | | | | |
| Purple Gallinule | Porphyrula martinica | y | | | | | X |
| Black-necked Stilt | Himantopus mexicanus | s | | | | | X |
| Killdeer | Charadrius vociferus | y | | | | X | |
| Greater Yellowlegs | Tringa melanoleuca | w | | | | | X |
| Lesser Yellowlegs | Tringa flavipes | w | | | | | X |

[1] Source of scientific and common names: Robertson, Jr., W.B., G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Pub. No. 6. Gainesville, FL.

[2] y = year round resident; s = summer resident; w = winter resident.

[3] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | SEASON[2] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|---|
| Solitary Sandpiper | Tringa solitaria | w | | | | | X |
| Spotted Sandpiper | Actitis macularia | w | | | | | X |
| American Woodcock | Scolopax minor | w | | | X | X | |
| Common Snipe | Gallinago gallinago | w | | | | X | |
| Common Ground-Dove | Columbina passerina | y | X | | X | X | |
| Mourning Dove | Zenaida macroura | y | X | X | X | X | |
| Yellow-billed Cuckoo | Coccyzus americanus | s | X | X | X | | |
| Eastern Screech-Owl | Otus asio | y | X | X | X | X | |
| Great Horned Owl | Bubo virginianus | y | X | X | X | X | |
| Barn Owl | Tyto alba | y | X | | | X | |
| Barred Owl | Stix varia | y | X | X | X | X | |
| Burrowing Owl | Speotyto cunicularia | y | X | | | X | |
| Chuck-will's-widow | Caprimulgus carolinensis | s | X | | X | X | |

[1] Source of scientific and common names: Robertson, Jr., W.B., G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Pub. No. 6. Gainesville, FL.

[2] y = year round resident; s = summer resident; w = winter resident.

[3] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | SEASON[2] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|---|
| Whip-poor-will | Caprimulgus vociferus | w | X | | X | | |
| Common Nighthawk | Chordeiles minor | s | X | | | X | |
| Belted Kingfisher | Ceryle alcyon | w | | X | | | X |
| Chimney Swift | Chaetura pelagica | s | X | X | | X | X |
| Ruby-throated Hummingbird | Archilochus colubris | y | X | | X | | |
| Pileated Woodpecker | Dryocopus pileatus | y | X | X | X | | |
| Northern Flicker | Colaptes auratus | y | X | X | X | X | |
| Red-bellied Woodpecker | Melanerpes carolinus | y | X | X | X | | |
| Yellow-bellied Sapsucker | Sphyrapicus varius | w | X | X | X | | |
| Red-headed Woodpecker | Melanerpes erythrocephalus | y | X | | | X | |
| Hairy Woodpecker | Picoides villosus | y | X | X | X | | |
| Downy Woodpecker | Picoides pubescens | y | X | X | X | | |
| Great Crested Flycatcher | Myiarchus crinitus | y | X | X | X | X | X |
| Eastern Kingbird | Tyrannus tyrannus | s | X | | | X | X |

[1] Source of scientific and common names: Robertson, Jr., W.B., G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Pub. No. 6. Gainesville, FL.

[2] y = year round resident; s = summer resident; w = winter resident.

[3] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | SEASON[2] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|---|
| Eastern Phoebe | Sayornis phoebe | w | | | | X | X |
| Barn Swallow | Hirundo rustica | y | | | | X | X |
| Tree Swallow | Tachycineta bicolor | w | | | | X | X |
| Purple Martin | Progne subis | w | X | | | X | X |
| Blue Jay | Cyanocitta cristata | y | X | X | X | X | |
| Fish Crow | Corvus ossifragus | y | | | | | X |
| American Crow | Corvus brachyrhynchos | y | X | X | X | X | |
| Tufted Titmouse | Parus bicolor | y | X | X | X | | |
| Carolina Chickadee | Parus carolinensis | y | X | X | X | | |
| Brown-headed Nuthatch | Sitta pusilla | y | X | | | | |
| Brown Creeper | Certhia americana | w | X | | | | |
| Brown Thrasher | Toxostoma rufum | y | X | | | X | |
| Northern Mockingbird | Mimus polyglottos | y | X | | | X | |

[1] Source of scientific and common names: Robertson, Jr., W.B., G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Pub. No. 6. Gainesville, FL.

[2] y = year round resident; s = summer resident; w = winter resident.

[3] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | SEASON[2] | HABITATS | | | | |
|---|---|---|---|---|---|---|---|
| | | | PF | CS | MH | GSS | BP |
| Gray Catbird | Dumetella carolinensis | w | X | X | X | X | |
| House Wren | Troglodytes aedon | w | X | | | | |
| Carolina Wren | Thryothorus ludovicianus | y | X | X | X | X | |
| Marsh Wren | Cistothorus palustris | w | | | | | X |
| Sedge Wren | Cistothorus platensis | w | | | | | X |
| Hermit Thrush | Catharus guttatus | w | | | X | | |
| American Robin | Turdus migratorius | w | X | X | X | X | |
| Eastern Bluebird | Sialia sialis | y | X | | | X | |
| Ruby-crowned Kinglet | Regulus calendula | w | X | X | X | | |
| Blue-gray Gnatcatcher | Polioptila caerulea | y | X | X | X | | |
| Loggerhead Shrike | Lanius ludovicianus | y | | | | X | |
| European Starling | Sturnus vulgaris | Y | | | | X | |
| Cedar Waxwing | Bombycilla cedrorum | w | X | X | X | | |
| Solitary Vireo | Vireo solitarius | w | X | X | X | | |

[1] Source of scientific and common names: Robertson, Jr., W.B., G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Pub. No. 6. Gainesville, FL.

[2] y = year round resident; s = summer resident; w = winter resident.

[3] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | SEASON[2] | HABITATS | | | | |
|---|---|---|---|---|---|---|---|
| | | | PF | CS | MH | GSS | BP |
| Yellow-throated Vireo | Vireo flavifrons | s | | X | X | | |
| Red-eyed Vireo | Vireo olivaceus | s | | X | X | | |
| White-eyed Vireo | Vireo griseus | y | X | X | X | | |
| Black-and-white Warbler | Mniotilta varia | w | X | X | X | | |
| Yellow-rumped Warbler | Dendroica coronata | w | X | X | X | X | |
| Northern Parula | Parula americana | s | X | X | X | | |
| Yellow-throated Warbler | Dendroica dominica | s | X | X | | | |
| Prairie Warbler | Dendroica discolor | s | X | | | X | |
| Pine Warbler | Dendroica pinus | y | X | | | | |
| Palm Warbler | Dendroica palmarum | w | X | X | X | X | |
| Common Yellowthroat | Geothlypis trichas | y | X | X | | | |
| Ovenbird | Seiurus aurocapillus | w | X | X | X | | |
| Red-winged Blackbird | Agelaius phoeniceus | y | | | | | X |

[1] Source of scientific and common names: Robertson, Jr., W.B., G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Pub. No. 6. Gainesville, FL.

[2] y = year round resident; s = summer resident; w = winter resident.

[3] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | SEASON[2] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|---|
| Boat-tailed Grackle | Quiscalus major | y | | X | | | X |
| Brown-headed Cowbird | Molothrus alter | y | X | | | X | X |
| Common Grackle | Quiscalus quiscula | y | X | X | | X | |
| Eastern Meadowlark | Sturnella magna | y | | | | X | |
| Summer Tanager | Piranga rubra | s | X | | X | | |
| Northern Cardinal | Cardinalis cardinalis | y | X | X | X | X | |
| Indigo Bunting | Passerina cyanea | s | X | | | | |
| Blue Grosbeak | Guiraca caerulea | s | X | | | X | |
| Pine Siskin | Carduelis pinus | w | X | | | | |
| American Goldfinch | Carduelis tristis | w | X | X | | X | |
| Grasshopper Sparrow | Ammodramus savannarum | w | X | | | X | |
| Savannah Sparrow | Passerculus sandwichensis | w | X | | | X | |
| Henslow's Sparrow | Ammodramus henslowii | w | X | | | | |
| Rufous-sided Towhee | Pipilo erythropthalmus | y | X | | | X | |

[1] Source of scientific and common names: Robertson, Jr., W.B., G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Pub. No. 6. Gainesville, FL.

[2] y = year round resident; s = summer resident; w = winter resident.

[3] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | SEASON[2] | HABITATS | | | | |
|---|---|---|---|---|---|---|---|
| | | | PF | CS | MH | GSS | BP |
| Vesper Sparrow | Pooecetes gramineus | w | X | | | X | |
| Bachman's Sparrow | Aimophila aestivalis | y | X | | | | |
| Chipping Sparrow | Spizella passerina | w | X | | | X | |
| Field Sparrow | Spizella pusilla | w | | | | X | |
| White-throated Sparrow | Zonotrichia albicollis | w | X | | X | X | |
| Swamp Sparrow | Melospiza georgiana | w | X | X | X | X | |
| Song Sparrow | Melospiza melodia | w | X | X | | X | |

[1] Source of scientific and common names: Robertson, Jr., W.B., G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Pub. No. 6. Gainesville, FL.

[2] y = year round resident; s = summer resident; w = winter resident.
[3] Habitats:
CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

**Table A-3. Species That Potentially Use Habitats Displaced or Created by the Borrow Pits Excavated for the Veterans Expressway. Mammals.**

| | | HABITATS | | | | |
|---|---|---|---|---|---|---|
| COMMON NAME | SCIENTIFIC NAME[1] | PF | CS | MH | GSS | BP |
| Virginia Opossum | Didelphis virginiana | X | X | X | | |
| Southeastern Shrew | Sorex longirostris | | X | X | | |
| Least Shrew | Cryptotis parva | X | | | X | |
| Southern Short-tailed Shrew | Blarina carolinensis | X | X | X | X | |
| Eastern Mole | Scalopus aquaticus | X | | | X | |
| Southeastern Myotis | Myotis austroriparius | X | X | X | X | X |
| Eastern Red Bat | Lasiurus borealis | X | X | X | X | X |
| Seminole Bat | Lasiurus seminolus | X | X | X | X | X |
| Eastern Pipistrel | Pipistrellus subflavus | X | X | X | X | X |
| Big Brown Bat | Eptesicus fuscus | X | X | X | X | X |
| Evening Bat | Nycticeius humeralis | X | X | X | X | X |
| Northern Yellow Bat | Lasiurus intermedius | X | X | X | X | X |

[1] Source of scientific and common names: Jones Jr., J.K., R.S. Hoffman, D.W. Rice, C.Jones, R.J. Baker, and M.D. Engstrom. 1992. Revised Checklist of North American mammals north of Mexico, 1991. Occ. Papers Mus. Texas Tech. Univ. No. 146:1-23. Lubbock, Tex.

[2] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | HABITATS | | | | |
|---|---|---|---|---|---|---|
| | | PF | CS | MH | GSS | BP |
| Rafinesque's Big-eared Bat | Plecotus rafinesquii | X | X | X | X | X |
| Brazilian Free-tailed Bat | Tadarida brasiliensis | X | X | X | X | X |
| Raccoon | Procyon lotor | X | X | X | X | X |
| Longtail Weasel | Mustela frenata | X | X | X | X | |
| River Otter | Lutra canadensis | | X | | | X |
| Spotted Skunk | Spilogale putorius | X | | | X | |
| Striped Skunk | Mephitis mephitis | X | | | X | |
| Coyote | Canis latrans | X | | X | X | |
| Red Fox | Vulpes vulpes | X | | | X | |
| Gray Fox | Urocyon cinereoargenteus | X | X | X | X | |
| Bobcat | Lynx rufus | X | X | X | X | |
| Sherman's Fox Squirrel | Sciurus niger shermanii | X | | | | |
| Gray Squirrel | Sciurus carolinensis | | | X | | |
| Southern Flying Squirrel | Glaucomys volans | X | | X | | |
| Southeastern Pocket Gopher | Geomys pinetis | X | | | X | |

[1] Source of scientific and common names: Jones Jr., J.K., R.S. Hoffman, D.W. Rice, C.Jones, R.J. Baker, and M.D. Engstrom. 1992. Revised Checklist of North American mammals north of Mexico, 1991. Occ. Papers Mus. Texas Tech. Univ. No. 146:1-23. Lubbock, Tex.

[2] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

| COMMON NAME | SCIENTIFIC NAME[1] | HABITATS PF | CS | MH | GSS | BP |
|---|---|---|---|---|---|---|
| Eastern Harvest Mouse | Reithrodontomys humulis | X | | | X | |
| Oldfield Mouse | Peromyscus polionotus | | | | X | |
| Cotton Mouse | Peromyscus gossypinus | X | X | X | | |
| Golden Mouse | Ochrotomys nuttalli | X | | X | | |
| Florida Mouse | Podomys floridanus | X | | | X | |
| Eastern Woodrat | Neotoma floridana | X | X | X | | |
| Hispid Cotton Rat | Sigmodon hispidus | X | | | X | |
| Round-tailed Muskrat | Neofiber alleni | | | | | X |
| Eastern Cottontail | Sylvilagus floridanus | X | | | X | |
| Marsh Rabbit | Sylvilagus palustris | | | | | X |
| White-tailed Deer | Odocoilus virginianus | X | X | X | X | |
| Feral Hog | Sus scrufa | X | X | X | X | |
| Nine-banded Armadillo | Dasypus novemcinctus | X | X | X | X | |

[1] Source of scientific and common names: Jones Jr., J.K., R.S. Hoffman, D.W. Rice, C.Jones, R.J. Baker, and M.D. Engstrom. 1992. Revised Checklist of North American mammals north of Mexico, 1991. Occ. Papers Mus. Texas Tech. Univ. No. 146:1-23. Lubbock, Tex.

[2] Habitats:

CS = Cypress Swamp
MH = Mesic Hammock
PF = Pine Flatwood/Palmetto Prairie
GSS = Grassland/Oldfield/Improved Pasture
BP = Borrow Pit

# APPENDIX B

# USERS GROUP SURVEY RESULTS

## STEP 1: ISSUES IDENTIFIED FROM BACKGROUND RESEARCH

Background research involved discussions with IES team members and utilization of the following documents:

| | |
|---|---|
| 01-000-035 | Phosphogypsum: A Review of the Florida Institute of Phosphate Research Programs to Develop Uses for Phosphogypsum. G. Michael Lloyd, Jr. December, 1985 |
| 01-031-046* | Proceedings of the Third Workshop on By-Products of Phosphate Industries. University of Miami. November, 1986. (NTIS #PB92-128982/AS, PC A17/MF A03). |
| 01-014-048* | Reclamation, Reconstruction and Reuse of Phosphogypsum for Building Materials. Wen F. Chang, University of Miami. January, 1987. (NTIS #PB92-128990/AS, PC A15/MF A03). |
| 01-033-077<br>01-041-077 | Phosphogypsum for Secondary Road Construction. Wen F. Chang, University of Miami. June, 1989. |
| 01-132-117 | Proceedings of the Phosphogypsum Fact-Finding Forum. Florida Institute of Phosphate Research and The Florida Center for Public Management, FSU. February, 1996. |
| 03-100-129 | Habitat Factors Influencing the Distribution of Small Vertebrates on Unmined and Phosphate-Minded Uplands in Central Florida. Henry R. Mushinsky, Earl D. McCoy and Robert A. Kluson, University of South Florida, November 1996. |
| 03-101-130 | Meiofauna and Macrofauna in Six Headwater Streams of the Alafia River, Florida. Bruce C. Cowell, University of South Florida, June 1997. |
| 03-000-143 | Ecosystem Restoration Workshop Proceedings. April 25 and 26, 1996, Lakeland, Florida. Sponsored by Florida Institute of Phosphate Research and Society for Ecological Restoration. |
| 05-035-115 | Microbiology and Radiochemistry of Phosphogypsum. William C. Burnett, James B. Cowart, Paul LaRock, Carter D. Hull, Florida State University. May, 1995. |
| 05-041-124 | Risk Estimates for Uses of Phosphogypsum. Battelle Pacific Northwest Laboratories. Richard, Washington. April, 1996. |

05-038-141 Impact of High Rates of Phosphogypsum on Radon Emissions and on Radioactivity and Heavy Metals in Soils, Groundwater, and Bahiagrass Forage. J.E. Rechcigl, et al., University of Florida. March, 1998.

05-042-142 How Does Phosphogypsum Storage Affect Groundwaters? Dept. of Oceanography, Florida State University. March 1998.

The following sets of issues were developed following reviews of these articles on PG located in the library at FIPR, along with discussions with IES project team members regarding their past experiences with the subject matter. These issues have been placed in a question format, so that they might be more easily compared with the questions gathered from the interview process.

**QUESTIONS RELATED TO BORROW PITS FOR USE IN ROADBEDS**

BP1. Are wetlands allowed to be mined as borrow pits?
BP1a. If so, how many acres of wetlands have been lost as a result of this practice? In Florida? In the U.S.?

BP2. Are uplands allowed to be mined as borrow pits?
BP2a. If so, how many acres of uplands have been lost as a result of this practice? In Florida? In the U.S.?

BP3. Are there state-wide criteria for borrow pit construction in Florida?
BP3a. Are there depth limitations?
BP3b. Are there side-slope requirements?
BP3c. Are there size limitations?

BP4. Why are they called borrow pits when the material removed is not put back?

BP5. Are borrow pits hazards to children?
BP5a. Can a child slip and fall into one and drown?
BP5b. Are there requirements to fence off these pits to prevent children from accessing them?

BP6. Can or do borrow pits contaminate the groundwater?

BP7. Do borrow pits tend to dewater the water table aquifer by exposing the groundwater to evaporation?
BP7a. Is this loss significant?

BP8. Is there any testing done of the borrow material to make sure it is safe before it is placed on the roadbed?

BP9. How much money is a truck load of borrow pit dirt worth for use in a roadbed?

BP10. Is there any concern over air quality problems with respect to borrow pits?

BP11. Are there any regulations to make sure that a borrow pit doesn't turn into a weed-choked eyesore and public nuisance?

BP12. Are there regulations to prevent anyone from dumping wastes into the pit?

BP13. What are the secondary impact aspects of borrow pit construction? In other words, what additional impacts to habitat and wildlife are to be expected from development which may occur adjacent to the new "lake"?

BP14. Does the excavation of borrow pits promote habitat fragmentation? Does it impact travel and/or migration routes of animals?

BP15. Is there evidence to suggest that borrow pits routinely become valuable open water habitat?

BP16. Do the water level fluctuations in borrow pits mimic those of natural lakes, or is there a much greater range of wet season versus dry season water levels in these man-made systems?

**QUESTIONS RELATED TO PHOSPHOGYPSUM FOR USE IN ROADBED MATERIAL**

PG1. Is there any risk to human health from working with PG in roadbed material?
PG1a. In driving on roads having PG in the roadbed?
PG1b. In living/working in buildings near the road?
PG1c. In workers excavating for repairs/maintenance?

PG2. Is there any risk of contaminating groundwater from using PG in roadbed material?

PG3. Is there any way to test each truckload of PG before it is used in roadbed?
PG3a. Is the test economical to employ?

PG4. Will roads built over a PG road base fail more frequently than regular roads?

PG5. Will roads built over a PG base be a public safety problem because of poor loading qualities?

PG6. Will there be any impacts to plants or animals adjacent to the road or burrowing in the roadbed material?

PG7. Do any of the constituents in PG bioaccumulate in the food web?

PG8. What are the constituents in PG which can be a public health concern?

PG9. What are the constituents in PG which can be an ecological health concern?

PG10. Would an accident involving a PG hauling truck cause any more health problems than the same accident with a dirt hauling truck?

PG11. Can PG be used by itself, or should it be mixed with dirt or some other material?

PG12. Does PG cause any unwelcome odors or aesthetic problems if used as roadbed?

PG13. Can land use restrictions be placed on a road using PG as a base to prevent any future dwelling units from being built on the old roadbed?

## STEP 2: ISSUES/CONCERNS IDENTIFIED BY THE INDIVIDUALS INTERVIEWED

Out of a total of 70 people identified to be interviewed, a total of 47 were successfully interviewed. Their thoughts on BPs and/or PG use are provided as follows:

### Borrow Pit Issues/Concerns

At this time, phosphogypsum would be less economical to use as roadbed material due to hauling problems. Borrow pits are dug along the sides of the highway and are not limited to distance. With phosphogypsum, the distance to haul the materials from the mines would pose a problem.

If phosphogypsum were to be hauled in for roadbed material, where would it be stored and maintained so it will not be a threat to the environment?

Sees borrow pits as a viable resource.

Once reclaimed, good utilization occurs with recreation and fishing.

Homes are also being built around the ponds and people like to live around them.

---

If we mine limestone, we are disturbing the land in another fashion. If we were to use phosphogypsum, we would not be disturbing any land.

What costs would be associated with importing limestone if we do not use borrow pits?

Use of borrow pits as recharge ponds along roadways seems to have helped the cut and fill problem.

---

Where and how are materials used? Although poorly documented, there can be a problem using limerock to stabilize road surfaces or even exposing surface waters to groundwater runoff from mines or canals, as the pH of limerock and groundwater is typically more alkaline than it is for many Florida soils and surface waters. There is a potential for material leaching out of limestone applied to road surfaces into surrounding soils when it is wet and of wind-blown dust when it is dry, either of which can potentially affect nearby plant communities and soil organisms.

Is there any documentation of pH and leaching of materials over distance and time from roadbeds? I know there is interest in the topic.

It is important to maintain hydrologic connections with regards to raised road surfaces or land surfaces associated with borrow pits. There can be severe environmental effects associated with blocking water flows. Upslope water flow can be seasonally impounded, and downslope water flows can be reduced or eliminated, both of which can result in severe impacts on wetlands and other community types. These impacts can be direct from hydrologic alteration or indirect in terms of altered fire regimes. More frequent fires can occur in drier downstream areas if sheet flow is not maintained across raised land surfaces. Also, unnaturally reduced fire frequencies can occur in impounded areas. There needs to be lots of culverts, not just one, to maintain sheet flows particularly for a broad wetland.

Since it takes more water to fill a hole in the ground than it does a soil profile, water levels in surrounding lands can be drawn down significantly when a borrow pit is dug. Where substrates are porous, these drawdowns can occur over 1000s of feet from the borrow pit, and can potentially impact wetlands and other habitats on these land surfaces as mentioned above. These drawdowns can occur initially, if the pit is being enlarged rapidly, and it can occur whenever water tables are rising. This is an even bigger problem where water levels are lowered in a pit to facilitate mining.

---

Some borrow pits are also being created for construction and demolition landfills and other landfills.

Receives public complaints on noise, trucks, dust and kids roaming around pits and getting hurt (there was one instance where kids burrowed a cave that collapsed)

What effect do borrow pits have on listed species and wetlands?

Borrow pits that are not maintained can attract nuisance (for example, lakes are created from borrow pits and illegal dumping can be a problem). Borrow pits that have been reclaimed and return to good condition can later be sold as waterfront property.

The public, in general, does not want borrow pits in its neighborhoods.

There is no depth regulation on borrow pits at this time, only prevention of aquicludes. Depth is mostly dependent on type of equipment on site.

---

What is in phosphogypsum vs. what is in borrow pits?

Is there any toxic waste material in phosphogypsum that is not in borrow pits?

Is one cheaper to use than the other? If phosphogypsum costs less, would the expenses associated with monitoring it be equal, less or more compared to the use of borrows pit fill?

What dangers are there to the aquifer from using phosphogypsum and borrow pits?

---

I've done some more thinking on this issue and consulted some colleagues. I need to amend my initial comments significantly. As I mentioned, roadsides are corridors that invasive plants travel along, partly because of the soils, but also because of disturbance. Most of our pest plant species thrive in disturbed areas. My earlier comments that borrow pits are likely to have soils similar to the surrounding area were inaccurate. "Top soil" is only a few feet deep and borrow pits pull soil from depths much below that--so the borrow material is quite different from the surrounding "surface" areas. Mined soils (from borrow pits) can be high in sulfur, iron, or other minerals that greatly affect the roadside plant life and that raise concern about leaching into waterways. If the borrow pit is deep enough to penetrate subsurface aquifers--then we risk allowing surface contamination to get into our aquifers. Perhaps a good compromise would be to construct borrow pits from surface layers only--and contour the shallow borrow area to function as wetlands.

---

If we continue with borrow pits, will there be future storm water problems due to the substantial alteration of the landscape?

Concerned with an infrastructure problem affecting ecosystems, especially in central Florida, especially with so many other linear infrastructure projects, such as powerlines, pipelines, and roads checkerboarding across Florida.

Future infrastructure planning is needed on a holistic basis.

---

The use of borrow pit material requires finding out where to locate deposits and plan development accordingly in order to best utilize available resources.

Has not seen environmental impacts from borrow pit materials.

A problem that can occur from borrow pits is dumping or turning them into landfills.

Borrow pits sites need to be recontoured after use.

---

As one looks across the United States, there are beneficial ponds and lakes along the interstate system that were prior borrow pits. There is good water quality in the ponds and lakes that provides good fishing and boating. Some former borrow pits have been formed into waterfront property, and overall, people enjoy the benefits of these water bodies.

If we do not use borrow pits for roadbed material, where are you going to get the soils necessary for road construction?

There may not be a large research base with the effects of borrow pits on biota, plants and animal species. However, perhaps there is a benefit to a particular species, as there would be more water available to them. If the ponds and lakes from borrow pits are in the wetlands, it may be more beneficial to some species given that the water bodies would be more isolated and may or may not be associated with a moving stream.

If borrow pits were dug in an area where phosphate mining also occurs and there is some level of radioactivity in the deposits, it is likely that the soil near these deposits will contain some level of radioactivity as well which complicates the issue.

Is there a requirement for testing soils before an area is chosen for a borrow pit? Is there any state mandated concentration above which the soil can not be used?

---

Borrow pits are a better use for roadbed material than phosphogypsum.

---

How do borrow pits effect local hydrology and surface resources, and what negative effects to the environment are associated?

It is important for any foreign material to have a pH compatible with the native area, as a change in pH can cause a change in vegetation and will adversely affect the environment.

---

What economic issues surround hauling from borrow pits? For example, if clay was needed, what distance is necessary to haul materials vs. using phosphogypsum stacks?

Because borrow pits are basically artificial ponds, does this alter the water flow on a macro/micro basis? For example, is the flow of water sometimes fed into the ponds when it would have originally flowed to a river, and is there any impact to the environment from this?

For borrow pits in remote locations, are there any illegal dumping issues? Are there concerns with people dumping chemicals into the water?

Is there a threat of drowning in the older, deeper borrow pits?

Overall, he doesn't have a problem with borrow pits. He sees them as a good wildlife habitat because they are filled with water and made into artificial lakes.

---

During excavation of borrow pits, there is a chance of bringing higher radioactivity to the surface, as the lithology in this area of Florida is underlain by mineralized phosphate and associated uranium.

Radon does move with the air; therefore, if there is a pathway present, soil gas can move into a house, regardless of the foundation. I do not envision any problems associated with the use of this material in road building.

Need to do radon resistant construction if there is increased radon in soil. However, if the material is to be used as fill under structures, it may be prudent to evaluate the radioactivity (radium-226) content of various pits. This material may have elevated levels of radium-226, the source of radon-222. The soil air could potentially contain elevated levels of radon and carry radon into the structure if there is a pathway and sufficient driving force (pressure differential). This then suggests limiting the radium content of material used for fill and/or the use of radon-resistant construction methods.

---

Borrow pits tend to be near the road that uses the soils for roadbed material. The cost of transporting these soils any significant distance is prohibitive. There are really three issues associated with the use of borrow pits.

First, the borrow pits as a landscape feature: The issue of how borrow pits fit with the overall environmental landscape is a problem. Usually borrow pits are selected purely for economic reasons and only basic stabilization/reclamation is conducted. This creates areas that change the hydrology of an area and do not benefit, and many times harm, the local ecology. The taking of soils for the purpose of road building should be more thoughtfully planned. Many of these borrow pits could be used as stormwater treatment areas for road run-off. Instead, other areas are used that expand the impacts of road building.

Second, how much is too much: Borrow pits are often used to construct roads in areas where they should not be built at all. We find roads all over Florida where the entire road base is elevated through wetland systems that are cut off from their normal flows by elevated roads. No amount of culverts can alleviate these impacts when they occur mile after mile. Areas of SR 60 and Interstate 4 in central Florida are examples of the impacts that these elevated road bases create. Whether roadbed soils come from a centrally located pit or from the adjacent lands, the impact is the same. In my opinion a road that is elevated simply so it can get through wetlands should not have been built in the first place. These roads tend to connect areas of Florida that should not be developed in the first place. The Sunshine Parkway is a good example of these road boondoggles instigated by politics not common sense.

Third, how borrow pits should be used: There are legitimate safety reasons for the use of soils to elevate roads. Intersection overpasses, for example, cut down fatalities. Engineering limitations of soils in small areas of the road that could not be anticipated prior to construction may be appropriate to use borrow material to fix. Muck in small areas, for example, being replaced by fill comes to mind. But when these areas are a large part of the road, extending a mile or more, then the road should not have been built at all. The issue is the road and the borrow pits, not just the borrow pit.

The construction of this study leads to a single assumption; the examination of how acceptable the use of phosphogypsum will be over borrow pits in the environment.

---

There is no problem with using borrow pits at this time; however, he feels phosphogypsum would be more beneficial.

Ponds created from borrow pits could create a public health concern with regards to mosquitoes; however, the ponds can be beneficial and used as recreational activities.

---

Problems from borrow pits can occur, depending on where you dig.

Most problems from borrow pits are a function of the soil. If you dig in an area where there is benign material, there should not be a problem.

Overall, does not have a problem with using borrow pits as roadbed material.

---

There may be a potential problem with borrow pits that have been excavated down to the Floridan aquifer and other aquifers.

Borrow pits can be eyesores and accumulate a lot of storm water runoff. There can also be problems with illegal disposal of solid waste in these pits if access is not properly controlled.

I am not aware of any studies performed to substantiate any environmental impacts from excavation of borrow pits. There may be potential problems, however, due to runoff and disposal problems.

A previous study by the US Geological Survey (Water Resources Investigations Report 82-4094 dated 1983) on impacts of recharge from drainage into the Floridan aquifer in Orlando concluded there were no serious health hazards noted in water from supply wells during this study but did comment that there was a possible threat of pollution by drainage wells. Could dilution be a factor and would it relate to borrow pits?

---

Most people could not recognize a borrow pit and do not know they exist.

As long as borrow pits are left aesthetically pleasing or useful, he has no problem with them.

If borrow pits are excavated in residential areas, they are usually useful as retention ponds. If borrow pits are excavated in a non-residential area, they can be left empty with no one knowing they exist.

---

The following comments reflect this individual's personal opinion and not necessarily the employer's. BPs do have the potential to affect projects. In the vicinity of the Polk Parkway Project (route through Lakeland), BPs have "been popping up left and right."

What are the potential effects of BPs on groundwater?

This person's understanding is that water level data must be collected and submitted to appropriate agencies. Do BPs result in draining of water from nearby wetlands?

Says some BPs do get somewhat reclaimed, with stable side slopes added, seeding, sodding, etc.

Otherwise, this person has no opinion about BPs.

---

Hard to believe they're good. State just sort of leaves them in place. Doesn't know if there are any reclamation requirements now – thinks there probably are. Environmentally, it can't be a good thing to dig a large hole and leave it. Believes that in general, the fewer BPs, the better. Why do it if you don't need to? If he were in a regulatory position, would want to ensure that what remains after BP is created is as positive as possible. Says some BPs have recreational value which could be enhanced. (Emphasized that these comments are based solely on his personal observations.)

---

Depth is important in determining whether they allow much biological function (i.e., can't be too deep or too sharply sloped).

Has observed some BPs off Highway 100, east of I-95 in Flagler County which appear to be well-constructed – they're relatively shallow, relatively well-sloped, and appear revegetated. He's observed lots of birds and thinks these BPs likely serve a good biological function.

Hazardous to people if too sharply sloped.

---

BPs are reclaimed with native species but use non-native soil. This has two negative consequences: invasive species are introduced, and the plant profiles of native species are changed.

Reclaimed BPs usually do not result in a uniform crop.

---

Some BPs have been created which have other beneficial uses – as cattle watering ponds, man-made lakes which are amenities to new housing developments. More commonly, however, BPs are located near the roadbeds being created based on necessity and are not located next to an adjacent habitat. As a result, they often have problems associated with them. He knows of difficulties when BPs are created next to wetlands due to dewatering of the wetlands. Such permits are "difficult to manage" because the contractor is under an obligation to fulfill the need for roadbed material, even if doing so results in damage to adjacent habitats.

Some have been beneficial. More often, however, their location is based on proximity/necessity, with more adverse consequences to adjacent habitats.

Permits are "difficult to manage" because of conflicting goals (providing roadbed material while not adversely affecting habitats).

---

Involved in land management and acquisition. Thinks BPs, as well as PG stacks, are unsightly and would like to see both reduced. In his experience, BPs are nearly impossible to rehabilitate due to removal of soil horizons and accompanying nutrient loss. Those that are not converted to man-made lakes are usually restored with vegetation, but restoration is problematic and usually not completely successful. Trees in restored BPs, on average, grow at about one-fourth the rate they would have on adjacent property. In addition, there is little or no ground-cover vegetation present after many years following restoration attempts. Even 50 years later, it's obvious that it's a borrow pit.

Unsightly; restoration and/or rehabilitation efforts are costly and usually unsuccessful.

Could PG be used to refill and renourish BPs that don't have other uses; i.e., as man-made lakes?

---

In general, thinks we're overutilizing our resources in Florida. Should stop building roads. Ecologically, putting in a road is one of the most evil things you can do. Also, not enough attention is given to uplands (focus is more on wetlands).

It's been demonstrated that sinks dewater adjacent wetlands.

---

More knowledgeable about BPs than PG, but knows about Thornhill Road in Polk County. This person's understanding is that FDEP wanted more test wells than FIPR or DOT, so that the study of this experimental road hasn't been concluded.

As they are currently created, it is "terribly difficult" to mitigate them such that they become an ecological habitat. They have no "littoral zone" (i.e., no shelf) for proliferation of freshwater mollusks, nursery area for fish, or wading bird habitat.

In one instance, they recreated the littoral zone, but it was very expensive to do so after-the-fact.

If BPs were created with a littoral zone, they probably wouldn't be such a bad thing.

---

Whether BPs are a positive or negative depends a lot on when, where, and how constructed. DOT's BPs are usually deep with sharp slopes to prevent cattail growth; otherwise, there would be the ongoing time and expense of keeping them free of cattails. When they're created too close to wetlands, they can cut down the water level of the wetlands. DOT leaves it to the contractor to get his BPs permitted or allows BPs to be created within DOT right-of-way areas. Says the new requirement that BPs be permitted is a good thing.

Recent requirement that they be permitted "a good idea."

---

Borrow pits comprise some of the worst water quality in the State. They are commonly deep water areas, which leads to stratification and anoxic conditions. In addition to having low surface water quality, virtually all of the ponds intersect the surficial aquifer (and some may reach the intermediate or Floridan aquifer) which may provide a means of introducing contaminants into the groundwater.

Thinks BPs should be avoided whenever possible.

---

More familiar with borrow pits, including some in north Florida and others outside of Florida. Says we're always going to be building roads in Florida, either new ones or restoring old ones. Likewise, phosphate mining is going to continue in Florida as long as there are still deposits to be mined.

Are they disturbing intact habitats or not when creating a new borrow pit?

We can't afford to continue disturbing areas with intact groundcover – it's too hard to replace.

BPs this person has seen in other states have sometimes been "attractive nuisances" – young people using them for recreation and getting hurt.

Based on this person's limited knowledge of PG, thinks it could be good if it reduces/eliminates the need for more borrow pits. They're basically big holes in the ground which reduce biodiversity and, as such, are not desirable.

---

Mitigation is pretty bad. Mitigation performed just around the edges.

BPs are big open bodies of water leading right to the aquifer.

Would love to find an alternative to BPs, but knows we need the limerock for roadbed.

---

"They have to be done." Would need to know more about PG to decide if it's worth the trade-off.

---

BPs are basically "biological deserts." They're so deep that there's no phototrophic zone, except for a few feet along the shoreline (if at all). Even if they're created in areas where the worst nuisance plants are growing, the area is biologically better off with the nuisance plants than with the resulting BP. BPs rob the environment of a source of oxygen, carbon dioxide absorption, cooling mechanism, carbon sequestering ability, groundwater filtering ability. They're not a wading bird habitat because of their narrow shoreline and high wave action which discourages revegetation along the shoreline.

Borrow pits are a "bad idea," for the reasons given above.

Even the worst nuisance plants provide a better local habitat function and have a better global impact than BPs.

BPs remove pieces of earth and limestone in "checkerboard" fashion such that the groundwater filtering ability is gone. This is of particular concern in the vicinity of wellfields.

---

BPs are often the result of expanding roads inappropriately.

---

The BPs used for obtaining material for building and development, particularly in the south Florida area, are usually converted to stormwater basins surrounded by grass.

---

Thinks the excavation of BPs is an opportunity to create new aquatic environments, particularly if they're for public use. In the BP wetlands created in the Green Swamp area, people fish from them and use them quite a bit for recreation; however, they're on public land and therefore allow the public access to them. For roads in general, the BPs which are created may serve as the treatment areas for road runoff. In these cases, the attributes of BPs may be limited.

BPs can create aquatic habitats.

If BPs are created on public land and if they create a resource for public use, they may be good. In the uplands areas, it may be more beneficial to use material from outside the region, including PG.

Always a chance, however, that you're impacting existing habitats by creating new BPs.

---

Problem with most BPs is that there's no littoral zone. Very difficult to restore them to a natural system.

Most BPs are rectangular gashes and are unattractive and lack the natural features which are so important. Could be made much more useful to plants and animals if a littoral zone were created when the BP is created.

---

In Florida, the topography is fairly flat. Thus, when changes are made, even when thought slight, the impacts can be very significant. BP creation has been going on in this manner for a very long time, all over the country, but the impacts more significant in Florida. Here, BPs act as avenues to contaminate groundwater and disrupt surface biological systems. In Florida, BPs are not that beneficial – there are more minuses than pluses.

Stormwater management systems created from BPs cause more problems and fail to perform. If they (stormwater management systems) were created in such a way as to preserve the natural "sheet" flow of water as is typical of native Florida, they wouldn't result in stagnated water and an inability to handle flash floods, but they are created the way they are because doing otherwise would require more space and, therefore, less room for development. Similarly, if houses were built in such a way as to preserve natural "sheet" flow of water, houses and roads wouldn't have to be built up so much, meaning less fill would be required. Requirements that they be built up so many feet may not be legitimate.

In Florida, the minuses outweigh the pluses.

Avenue for contamination of groundwater.

Disrupt surface biological systems. Eliminating BPs and eliminating built-up surfaces and keeping natural sheet flow actually improves wildlife.

Hasn't seen any stormwater management systems created from BPs in Florida which actually work the way the designer thought they were going to work. Tampa Palms is an example – residents often complain that the water is algae-choked (stagnated) or not holding back flow when it should.

Thinks stormwater management is one of the biggest problems in Florida now.

Whether PG is used or not, the BP issue still needs to be confronted. Every year that passes means more BPs created. The amount of fill needed just to expand I-4 is mindboggling.

Developers, designers, and agencies should investigate alternatives to built-up house pads or roadbeds, thus eliminating or reducing BPs.

**Phosphogypsum Issues/Questions**

If phosphogypsum were used it would alleviate the stack problem.

Use of phosphogypsum as roadbed material is not encapsulate; therefore, radioactivity would be loose in the environment and would have to meet EPA air standards.

Radioactivity standards by the EPA would have to be lowered, or prove that there are less potential hazards from phosphogypsum than originally surmised.

Because phosphogypsum is stored on stacks, wind is blowing radioactive material from them.

Why can't phosphogypsum be processed in other countries like Morocco, thus leaving unused waste (ratio estimated at 5:1) in that country. Then, ship back only sellable product here, making the process more economical for producers.

Why can't we mine phosphate and then return phosphogypsum back into the mined area?

Why isn't the phosphate industry more open to other uses of phosphogypsum? For instance, one company uses phosphogypsum with recycled plastics and we have been unable to connect with the phosphate industry, even though EPA has approved this method.

Why can't we use phosphogypsum as artificial reef material? It could be made into a large boulder, melted, cooled, encapsulated with plastic and dumped off the coast.

How is the phosphate industry classifying stacks now and how will they be classified in the future when there are so many stacks and nowhere for them to be stored?

Why can't liners be made with phosphogypsum? The liners used under phosphogypsum stacks are made with polyethylene plastic. Instead, a liner could be made with 50% plastic and 50% phosphogypsum, providing a partial solution to the stack problem plus a very durable material that maintains a good seal. The phosphogypsum would also be encapsulated and not loose in the environment.

The public already has a perception that phosphogypsum is radioactive material.

---

Overall, sees nothing wrong with using phosphogypsum.

Thinks phosphogypsum is a resource that should be utilized.

Phosphate industry needs to share the costs associated with hauling, rolling, compacting and monitoring phosphogypsum if permission is granted to use it as roadbed material.

---

Can phosphogypsum be used economically as roadbed material?

There is a perception issue with problems of radon emission from phosphogypsum.

There have been past studies that show liquid impurities from phosphogypsum as negligible, as the water used to transport gypsum contains only 1-2% phosphoric acid and the phosphogypsum is exposed to rainfall.

Overall there is no problem with using phosphogypsum as roadbed material.

Personal agendas seem to be getting in the way of facts.

---

Although I have some experience with a part of this subject, I do not have much input for your purposes. All I can say is that under some conditions, the components of the phosphogypsum are mobile, which raises some concerns about spreading them around as roadbed material. Careful analyses are required.

---

Has no concerns with the use of phosphogypsum as roadbed material in terms of the environmental or public health issues.

Feels we are a bit over cautious and over regulated right now on phosphogypsum use.

---

If safety issues were benign, he would be in favor of phosphogypsum

Any time you dig a hole, you are disturbing the habitat. Use of phosphogypsum would decrease the need to disturb the habitat, which I favor.

There must not be any human health impacts from phosphogypsum if it were to be used for roadbed material.

There needs to be a study conducted by a non-biased organization in order for the public to be convinced of any findings. This study should not be funded by FIPR, or industry-related groups, rather an impartial research team, sponsored by some governmental agency, may be a logical funding source.

---

If phosphogypsum were proven to be more economical to use as roadbed material, what physical characteristics would make it more durable than using borrow pits?

What would be the impact to endangered species/plants/water/air if phosphogypsum were used? What current impacts to endangered species/plants/water/air are there from using borrow pits? Would endangered species clearance be required for phosphogypsum use?

What kind of testing would be required for roadbeds if phosphogypsum was used compared to testing already done on borrow pit fill? What would be the difference in costs?

---

What is in phosphogypsum vs. what is in borrow pits?

Is there any toxic waste material in phosphogypsum that is not in borrow pits?

Is one cheaper to use than the other? If phosphogypsum costs less, would the expenses associated with monitoring it be equal, less or more compared to the use of borrows pit fill?

What dangers are there to the aquifer from using phosphogypsum and borrow pits?

Would there be leaching of any toxins into the drinking water from phosphogypsum and what prevention measures would be used to protect public health and the environment?

What kind of research has been done in the past on this subject and who conducted it?

Who have we contacted and what information has been gathered to prove that there is no risk to public health and the environment in regards to phosphogypsum?

If phosphogypsum were to be used, what steps would be taken to prevent public health and environmental problems?

---

Using phosphogypsum is of even more concern. Not only might it provide a nutrient rich, disturbed, corridor for exotic plants to travel, it is my understanding that phosphogypsum has a substantial radioactive component, and is permeated with several kinds of acids (phosphoric acid, sulfuric acid, fluorides, etc.) and other pollutants of concern. Taking material with such a variety of pollution concerns and spreading it all around Florida could not only create problems--they would be widespread problems. If it did become a problem, whether for public or environmental health--it would be the type that would require billions of dollars to repair and be one of those, "What were they thinking when they did this?" --type environmental problems. I would not recommend using this material in roadbeds.

---

Mechanically, phosphogypsum is an excellent building material and would make good, stable roadbeds.

There are large quantities of phosphogypsum for future use, therefore greatly reducing the need for scattered borrow pits.

Low level radiation associated with phosphogypsum needs to be addressed; however, grassing slopes/roadsides and asphalt covers would mitigate long-term impacts.

There would need to be a database perhaps with DOT to identify where phosphogypsum was used as roadbed material to document locations for any changes in the future.

Water in the transport of gypsum is the major concern, not gypsum itself. Therefore, if we utilize it dry (minimum percent moisture), there will be minimal constituents from the water, greatly reducing the public health issue associated with the use of phosphogypsum.

---

Phosphogypsum is radioactive and EPA has restricted its re-use.

Metals present in phosphogypsum have concentrations that could cause human health problems.

Phosphogypsum concentrations of arsenic, cadmium, chromium, copper and nickel could cause adverse surface water impacts.

There could be ground water impacts from the metals/inorganics that could be dissolved in rainfall and percolate through the soil into groundwater.

Phosphogypsum might affect the drinking water supply quality. So, the location of the road to private drinking water wells and the depth of those wells are important.

Overall, there could be risks to humans, animals and other species, ground water and surface water.

How does phosphogypsum compare to borrow pits as roadbed material? Does phosphogypsum hold up longer? Will it need fewer repairs?

Currently, DEP is looking at deed restrictions to make sure that section of roadway will be exclusively built as roadways only. So, there will be certain land use institutional controls.

---

Phosphogypsum should be returned to the same hole from which it was mined. There may be some phosphogypsum left over, but at least if there is some undesirable characteristic it will be returned to the original site and the undesirable characteristic will not be stored in numerous places. If the phosphogypsum is returned to its place of origin, we will not be contaminating other sites with low level radioactivity.

EPA has the responsibility for setting some guidelines for use of phosphogypsum for land application. Gypsum as a source of calcium for peanut production is very valuable. Research needs to be conducted to determine if phosphogypsum can be a potential source of radioactivity in food and fiber production. This research should evaluate whether and if so how much radioactivity is transferred to food products used for human and animal consumption. This would help determine future uses of phosphogypsum.

In general, most heavy metals originating in rock phosphate deposits and transferred to the phosphogypsum byproduct become associated with the soil and are not easily solubilized and transported with the water. The use of liners with phosphogypsum stacks may or may not be well substantiated. If there is low level radioactivity in the ground anyway, why try to prevent materials from leaching into an area of soil where it is already present, particularly if the leachate will not likely reach the groundwater? In other words, we need to identify what are naturally occurring elements in relation to phosphate rock and define what is not acceptable, if anything, to be returned into its natural surroundings.

---

Absolutely against the use of phosphogypsum in any manner. Was involved in forcing the phosphate industry to use a liner to prevent contaminating groundwater with radioactive materials.

“Phosphogypsum should be prohibited not distributed.”

Phosphogypsum will never meet groundwater standards.

Phosphate industry is just being cheap and trying to avoid spending money to solve the phosphogypsum problem.

---

If phosphogypsum is determined to be acceptable roadbed material structurally, can the pH be neutralized?

Would phosphogypsum leach contaminants into adjacent soils and water?

Can phosphogypsum be made inert?

If it is determined that phosphogypsum will leach compounds into adjacent soils/water, incompatibility problems will occur due to differences in pH and compounds themselves.

---

Concerned with leaching of trace elements, especially arsenic, into surficial aquifer

Would there be fewer delays in road building, since the phosphogypsum seems to work better as a road material?

What are the economic impacts of using phosphogypsum? If a risk analysis/modeling were necessary before using phosphogypsum, would it add costs to the projects? Would monitoring of the roads be necessary following phosphogypsum use, and would it also be an additional cost?

---

Overall, phosphogypsum is reasonable to use as roadbed material as long as it is not later used for fill in building construction.

There needs to be certainty that a higher institution will provide adequate control to make sure abandoned roadbeds containing phosphogypsum are not later used under a house.

Since there is a shortage of aggregate, future costs may become a factor. Therefore, phosphogypsum may be a useful alternative.

---

Phosphogypsum carries with it the stigma of "radioactivity." That however is not a significant public health or environmental risk. The nature of outdoor roadbeds and the radiation exposure from "alpha" particles does not present a risk beyond normally occurring radiation sources in the natural or urban environment.

The greater concern is the contaminant components of the phosphogypsum. The combination of contaminants and pH creates a condition, in my opinion, that can allow the release of the contaminants from industrial processes and concentrates of naturally occurring compounds from the road base.

The solubility of phosphogypsum increases the likelihood for contamination from the road base. Under normal circumstances, using standard materials, fractures of the asphalt or an increase in the height of groundwater in the area (creating contact with the subsurface of the road) will cause deterioration in the road base material and failure of the road. The failure of the road base without phosphogypsum creates no off-site impacts from contaminants. The same cannot be said of phosphogypsum.

Research has been so focused on the radioactive nature of phosphogypsum that little "real world" research has been conducted. Until this research is thoroughly conducted, I believe that we will be facing the possibility that roadbed failure will lead to off-site contamination.

The construction of this study leads to a single assumption; the examination of how acceptable the use of phosphogypsum will be over borrow pits in the environment.

Until phosphogypsum is tested to determine what “real world” conditions will cause harmful effects, there is no comparison.

---

There is no reason why phosphogypsum should not be used as roadbed material. Perceived environmental and public health hazards have been overblown.

---

There is absolutely no problem with using phosphogypsum as roadbed material.

Phosphogypsum could be used agriculturally also.

The current EPA ruling that houses will be built on roads and children will eat the sub-base of the roads is ridiculous.

---

Two roads were installed around 1986 and 1987 using phosphogypsum in Polk (Parrish Rd) and Columbia (White Springs Rd) Counties. Groundwater was monitored and in both cases, the data suggested some impacts may have occurred from the phosphogypsum sub base. However, this data was found to be inconclusive. There were no background samples or groundwater flow direction contouring completed before or during this monitoring. Also, there may be impacts from other sources. For example, the Parrish road is located near land which has been mined for phosphate and reclaimed. In the case of White Springs Road, local farmers in the area may have used phosphogypsum as a soil amendment. Therefore, it is unclear if the data is being skewed by these factors. Metal concentrations for some metals in the phosphogypsum were noted to be higher than corresponding concentrations typically found in Florida soils and it is a concern that the material may end up in a residential area.

How can we make sure roadbed material consisting of phosphogypsum will not end up in a residential area? One idea is institutional control—no one can remove the material without the institution’s knowledge.

A third test road is currently pending and will provide more accurate information, as background data will be collected and groundwater flow will be contoured. Also, the road will be located in a more suitable location for research in terms of other potential sources of contamination. Therefore, the study should be comprehensive and definitive. However, the previous roads were built so long ago, it may take years to collect the data to complete the study.

The reported ideal mixture is one part phosphogypsum and two parts soil. This was used on Parrish Road, which has been visited recently and remains intact. A portion of the sub-base of White Springs Rd. was 100% phosphogypsum and was partially washed away as it was located in a flood plain.

The use of phosphogypsum may be a hard sell to the public. Environmental groups will probably be upset about it. However, if we have a lot of data supporting the use of phosphogypsum, it would help.

---

Phosphogypsum could be used as good roadbed material.

Has some concerns with solubility. Will phosphogypsum dissolve and wash out if it were to be used as roadbed material?

If there is a solubility issue, can it be mixed with an aggregate or be hardened in another way?

Can phosphogypsum be formed into a product that will not dissolve as readily?
Has no concerns with radioactivity and feels this issue has been blown out of proportion. The public is subject to more radiation levels from granite, television, flying and ore deposits than the levels of radiation from phosphogypsum, especially in the state it is in.

---

Used to work for the phosphate industry. Radiological activity measured when working there was always “minimal.” Polk County wants to use it and has proposed using it for Thornhill Road between Bartow and Winter Haven. Every time FIPR meets an obligation with EPA/DEP, the agency(s) create a new one. In his opinion, they aren’t logical hurdles. Said an acquaintance from FIPR recounted his interactions with EPA several months ago and that the way the individual had been treated by EPA (creating hurdles) bothered him. DEP previously was very much in favor of PG use but now appears to be “standing in the way.”

Thinks the stacks are “serious eyesores.”

Personally, would like to see it used, but is concerned that it proceed slowly and that data is collected over the long-term.

What are the levels of radiological activity? One or two samples does not comprise a study.

Are there any adverse effects to people driving on it?  Living within 50 or 100 feet from such a roadbed?

How do the levels of radiological activity compare to levels people are exposed to from other sources?

What is the likelihood of PG getting into the groundwater or even surface water?  Says it already likely contaminates groundwater at some of the older stacks which have only clay liners.

---

An advocate of finding a use for PG.  Its use as roadbed or fill material seems like a worthwhile and valuable thing to do.  The economic benefits are foremost.  Wouldn't have to bring in fill materials and could minimize the growth of the gypsum stacks.  The phosphate industry would love to slow the growth of the gypsum stacks because they're expensive to create.

A Canadian company near White Springs, Florida (PCS) has been able to sell the PG generated from mining in that area, although only at their cost, because the radium levels don't exceed 10 pCi/g.  Calcium sulfate is a beneficial agricultural supplement, and farmers in the area are happy to receive the material.  PCS only breaks even on it, and the reuse of this material doesn't even make a dent in the total amount of gypsum being generated state-wide.

A lot of people have done much looking into cleaning up the PG to allow more alternatives for its use.  Thus far, no one's come up with a process to make cleaning up the PG a practical alternative, and there's not a sufficient market for the resulting yellow cake (extracted uranium) to make it worth-while.

Gypsum is more "user friendly" than limerock in constructing roadbed because, after a rainfall, the gypsum can immediately be used without having to dry out (says it's not that soluble in water), whereas the limerock has to dry out, delaying construction. Believes EPA's risk assessment regarding its use as roadbed is "bizarre" and flawed; however, the public generally is fearful of anything termed "radioactive," and EPA subscribes to a "linear threshold" approach wherein any additional gamma ray is undesirable.  Personally does not have what is considered to be an excess fear of "radioactivity" and, for example, would love to have the option of buying irradiated food.

There is a theory termed "homesis," which suggests that people subjected to low levels of radiation are actually healthier than people who are not.  One possible explanation for studies conducted on people surviving radioactive exposure who appear to be healthier in the long-run than the general population is that their immune systems were stimulated. There is no consensus, however, that homesis is even occurring.

---

Greatly involved in the efforts to determine whether PG can be safely used for roadbed material. At this time, an impartial party working to ensure that statistical methods of selection of PG for characterization and use and groundwater monitoring network are valid.

Would have to be shown to be protective of the environment and no risk to human health.

---

No direct experience or knowledge of PG, so isn't sure of its chemical composition.

What is the pH of PG?

Would residual phosphate wash out of the PG used as roadbed and possibly promote unwanted growth?

Would it be used with a liner?

---

Don't know what the impacts would be to the environment.

Reuse of PG would require more research to confirm no negative impacts to the environment.

Places like Florida with extremely high heat and humidity would probably cause PG to breakdown similar to the way asphalt does under high heat.

---

Not as familiar with PG or its potential use as roadbed. Believes there are contaminants contained in the PG and that most others in the industry accept this as true. Believes that there's a potential for health risks with the use of PG on a wide-spread basis and as a citizen/parent has some concerns. Does not know whether in fact there are health risks and would want it addressed. Public health should be the overriding concern, and decisions regarding its use should be based on public health concerns, not economics.

Had a vague concern about its use as roadbed. From what he's been told by those working in the phosphate industry, PG stacks are big disposal areas for more than just PG. Other chemical wastes are pumped into the stacks.

There has been a general lack of governmental control of the phosphate industry relative to other industries in the state. As a consequence, there are increased risks, and not due to the PG stacks alone.

Doesn't know if there is truly a health risk, but would want it addressed as part of a larger picture and not have the decision as to its use based purely on economics.

If use of PG is not a health risk, then it's in our best interest to use it up.

---

Has done research on workers in the phosphate industry, but the work never really addressed the use of PG for roadbed. Has heard the question before. Knows about residual radioactivity but not much else.

---

Radon gas and other sources of radioactivity a concern.

Is PG the same density, grain-size as sand or material currently used?

What is the pH and alkalinity of PG, and would this affect right-of-way vegetation or its possible use in backfilling BPs?

Does PG percolate or leach water comparably to sand or what's currently in use? If not, would its use create subsurface road problems similar to those areas where concrete has been used in highway construction; e.g., erosion undermining the roadway foundation?

Concerned about leaching of any trace elements and/or micro-nutrients contained in the PG, either harmful or beneficial to right-of-way vegetation, which could positively or negatively impact right-of-way stabilization.

Thinks use of PG as roadbed material is a possibility but opposes its use in rural roads as a replacement to clay unless it can act as a binding material and enhance clay stabilization. PG dust and associated aesthetic issue may be a problem for rural road use considerations.

---

Is aware of the fact that PG is radioactive. From what has been read, thinks that some of this may be from tailings added to the stack.

Thinks reusing PG is a great idea, especially if it reduces mining.

Would have to know that it's safe and that it meets DOT specifications.

It's been proposed in a lot of meetings.

In this person's experience, phosphate industry representatives and contractors attending meetings are skeptical when told that we've reached the limit on mining in Florida.

Thinks it's time to sacrifice cost for the good of public health and welfare.

Sees PG use as being similar to other proposals being made for water use; i.e., similar to recycling of wastewater or desalination, rather than continuing to use groundwater or lakes, etc., for water sources.

---

The first thing that comes to mind is radioactivity.

What would be the pH in the surrounding soil if PG were used? Much effort is now being made to restore roadsides to natural states. Don't want to use materials which raise the pH. Elevated soil pH gives “weedy” plants a competitive advantage.

When offering advice about roadways, the first question usually has to do with pH. In this person’s business, they try to use baked tile in lieu of limerock for this reason.

PG probably has a low initial pH. If so, this could actually be an advantage over materials currently used, such as limerock.

---

Says reuse of PG is “a great idea.” A “wonderful way to get rid of a whole lot of material for which there’s no other use.”

Roadbed is “a great way to use up the phosphogypsum.”

---

Knows there have been a lot of test cases with PG (Polk County, Hamilton County, White Springs). Thinks it’s probably not viable as a replacement to sand/soil used to build up areas above flood levels since the volume of PG needed would be great and, therefore, the risk possibly higher than desired; however, could be a viable replacement for the limerock. But could be used as a replacement for sand/soil depending on how high the water table is. Radon is a problem. There are only a limited number of mining operations for limerock – some in Brooksville and several others in south Florida. A problem mining limerock in south Florida because of all the wetlands areas which must be avoided.

In the test roads, the asphalt extends beyond the PG roadbed so there is no direct exposure. However, there is percolation of water through the asphalt. Radon levels in the test roads have been low – well within limits.

Thinks it’s a public perception problem. DEP would probably approve its use if EPA approved it. If so, DOT would not have any objection. They leave it to the contractor to select his own source of materials as long as competitive bids are received, and PG would likely be cheap and therefore selected by the contractor for use. Doesn’t see any other viable alternative for PG. If it hasn’t been approved for use as roadbed, it’s not likely to ever be used for building materials. DOT doesn’t fund experimental roads, but probably would spend some money for groundwater monitoring. Thinks FIPR should put more effort/money into the project. However, they are not unbiased…generally lean toward what’s favorable for the phosphate industry.

What criteria have to be in place?

How close in proximity to private or public wells could it be used?

Thinks it’s a viable alternative but that it’s “sort of died on the vine.”

Would like to see the results of past studies (test roads, etc.). Doesn’t think they’ve been made readily available.

Maybe not appropriate or even economically feasible to be used all over the state (due to transportation costs), but definitely something to consider.  Might make the most sense to be used for roads in areas near existing PG stacks.

Hillsborough County environmentally sensitive.  Its best use might be in rural areas. However, what's the remedy if, after construction, it's too high in radon or something else?  How much higher than the limit would it have to be to require a remedy?

Pothole repair may be a better use since the quantities used would be relatively small and spread out over larger areas.

Says impermeable liners are expensive but maybe a liner could be used with PG roadbed.

Some PG stacks are not lined and are therefore already likely contaminating the groundwater where they're located.  PG use as roadbed "definitely worth pursuing.  The gyp stacks are not going anywhere."

Possibly treat the PG to get the radon levels down before use.  If so, it would be even more suitable.

---

There are "many, many benefits" to the use of PG as roadbase.  It's been talked about for years, and is believed that EPA is "dragging their feet" in finding a way to allow for the safe utilization of this material.  Understands that the main concern is that someone would build a house on a former roadbed that used PG.  Thinks the scientific aspects have been overshadowed by policy issues.  While this person's work is not directly with PG itself, he has followed the issue for several years and, based upon discussions with FIPR and phosphate industry scientists and engineers, he thinks there are solutions to all of the obstacles.

"It makes sense."  Thinks there are policy solutions to all of the potential concerns (i.e., land-use restrictions where used, etc.).

Main concern is that a house would be built over a former roadbed.  Thinks that can be precluded with policy.

---

Before phosphogypsum was taken out of service, it was being used successfully as roadbed material in Texas by companies such as Mobil and Gulf States.  When, as a result of EPA action, it could no longer by used, this person's research turned to gypsum byproduct generated by coal-burning power plants.  It's still gypsum (calcium sulfate dihydrate, calcium sulfite) but is not radioactive.  In general, these jobs – both with PG and coal gypsum -- have been successful.  One goal has been to stabilize the sulfate and minimize sulfate attack.  This is usually accomplished by mixing the gypsum with other materials such as concrete.

The problem with PG being approved for use has been its radiological activity. Worked with it for years, and spoke of a research article appendix in which the levels of radioactivity in PG were found to not be dangerous to students who had worked with it extensively. EPA shut down the operation throughout the country, however. There is some question as to whether EPA's model for determining the risks associated with PG was correct.

Texas is continuing to explore the use of alternate materials, including gypsum from sources other than phosphate mining. These types of gypsum, including coal gypsum, don't have the same restrictions on use and research as PG. Says he can't get even one bucketful of PG for his research, even though there's a plant nearby. Nobody at Mobil, Gulf States, or any of the student population has ever reported any hazard. Over 40 students who worked with PG have graduated since 1989, and none has reported any problem.

He has always felt that PG was safe. There is a large PG stack in Houston where PG is continuing to be stockpiled. It was being depleted until its use was shut down by EPA, and now the stack is building up again. He has heard that the PG stacks have less radiological activity than the granite used to build the Houston post office. Nevertheless, his research with PG dried up. Louisiana also has a large problem with PG stacks.

He is not suggesting that EPA's decision be overturned but thinks it may have been an over-reaction. He is personally not concerned with the money-making aspects of the use of PG or other gypsum byproduct – his focus is on finding alternate construction materials. East Texas does not have a large supply of naturally-occurring materials which are suitable.

---

Works mainly in north Florida and doesn't have a lot of direct experience with phosphate mining.

Knows PG has slight radioactivity and that no other use for PG has been found.

Would PG last as long as limestone roadbed (or what's currently being used)? This would be a concern.

Would PG be used as a complete replacement for roadbed, or would it have to be blended with what's currently being used?

Would anything different (i.e., more costly) have to be done to prepare an area for PG roadbed as opposed to materials currently used?

Would want to see a cost comparison of roadbed using PG vs. roadbed as currently constructed.

Cost/benefit analysis of use of PG as roadbed?

Would the approval of PG for use as roadbed material cause an increase in the rate of mining due to there being an economic reward for generating PG?

---

What is the effect of PG on the environment?  What leaches out?

There must be environmental effects caused by PG; otherwise, it would already be spread back out instead of being placed in a big pile.

---

What kind of hazards does it pose to human health and the environment?

Would have to know more about groundwater, leaching, runoff to believe it's okay for use.

---

Not familiar with PG or its chemistry but knows it's slightly alkaline and rainwater is slightly acidic.  What happens to PG when it comes in contact with rainwater?

What would the leachate contain?

What happens to PG under UV light?

Is formation of sulfur dioxide a possibility?  Other sulfur-containing compounds?

If the gypsum stacks contain a liner, there's a reason for the liner.  The roadbed wouldn't be lined, so why would this be okay if it's not okay for the stack itself?

Would need to know how PG reacts chemically to form an opinion as to whether its use as roadbed material is a good idea.

PG is related to asbestos, or at least has a crystalline structure.  Can the airborne crystals pierce the lungs?

---

Thinks we're not getting to the heart of the problem, either in regard to BPs or PG use. Believes we're building roads where we shouldn't and not building enough roads where we should.  Thinks transportation planning needs improving.  Also believes that phosphate shouldn't be mined as aggressively.  Believes it is not necessary to maintain the kinds of lawns we do (over-fertilized) or use phosphate-based detergents to the extent that we do.  If the mindset were different, there would not be as great a demand for phosphate mining.  The over-use of phosphates in these ways results in excess nutrients going into bodies of water, resulting in excessive growth.  Thinks people should live with well-adapted local species, rather than artificially-created lawns requiring fertilizer.

Believes experimental use of PG is inappropriate.  We don't know enough about it to be spreading it throughout communities.  It's "not prudent" to use material on such a widespread basis when we don't know its reaction over a long period of time.  Thinks we should find solutions to PG in a much more limited use. Can't think of anything resulting in more exposure than using the material in roads. Understands that it is said to be "bound up," but from her experience, this is never truly the case. For example, I-75 has been torn up and rebuilt at given points in time to allow for heavier traffic, exposing the roadbed. Also, natural weathering, traffic may cause PG to break down.

---

We're not addressing the heart of the problem – overuse of phosphates. If demand were not as high, mining would not be as aggressive (and the stacks would not as big a problem).

Don't know enough about PG on a long-term basis to use it on such a widespread basis.

Materials said to be "bound up" never truly are due to natural weathering, traffic, or future repairs requiring that it be torn up and rebuilt.

---

Would be interested in seeing this material recycled as long as there's no problem with radon.

Should do an intense chemical study.

Thinks roads, possibly even bricks for building structures, could be a good use if there's not a lot of radon or radioactivity.

What is the pH of the phosphogypsum, and how does the pH change over time?

Thinks it might have to be buffered before being used as rainwater may result in the creation of sulfuric acid runoff.

Would any runoff affect nearby plants?

---

Not overly concerned with the radiation levels known to exist in the PG stacks. Believes the levels are so low that only if a house were built over a former road containing the material as roadbed and an individual were in a closed room for 70+ years would he or she have some significant radon exposure. Thinks most current roads/highways are going to remain roads/highways and not become residential property and that this could be properly regulated in other instances. Has suggested that test road(s) using PG as roadbed be created on Tenoroc, but it didn't come about because of low traffic (not enough use of the road to make it a viable study).

PG is "a problem." How do you get rid of it? Will it remain stacked up forever?

In the future, it's possible that it could be purified and used as wallboard, although there are already good sources of purified gypsum in the West.

Use as roadbed "not a bad idea." Thinks the potentially negative health effects from exposure to PG as roadbed have likely been exaggerated.

Because there's always a chance that you're impacting existing habitats by creating BPs, the use of PG would be a "plus" as there's no habitat that is being impacted by its use.

Didn't think the risk of a test road would jeopardize anything or anyone. The experts he's heard have said that the risk is marginal at best.

Volatiles would be a concern – what might volatilize out of the PG? The fertilizer plants may dispose of other things in the PG stack, not purely PG.

Properly regulated, doesn't think its use as roadbed would be a problem, but wouldn't want to see a "blanket" use of it. Thinks its use should be approved on a case-by-case basis; i.e., weighing the benefits of wetlands creation via borrow pits versus the benefits of reducing the gypsum stacks.

Trucks hauling PG would increase its cost for use as roadbed and risk of exposure

---

His understanding is that the only objection EPA has put forth regarding use of PG as roadbed material is in regard to risk management; i.e., it can't be used because a house can't be built on it. A lot of assumptions were made in reaching this decision which may never come to pass. Easements and covenants restricting land use could prevent houses from ever being built over PG roadbed. Another objection to PG use – if it's spread all over, is it going to leach down? In his opinion, research has shown that it can be mixed with other materials so that it won't flow down. These materials could be placed either below the PG or above it.

He doesn't believe it will ever be used for house pads due to EPA's risk management. Fill material is needed for development, and right now, BPs are the only source. Thinks there's virtually no risk from driving over it, because it would be mixed with other materials and covered with asphalt or concrete so that there'd be no fugitive dust. He heard that at CF Industries, the people working there don't wear badges anymore to monitor exposure to radioactivity because they did so for years and nothing was ever detected.

**Additional Issues:**

Risk management should carefully include the habitation of wildlife sites which they reside. This would result in a stricter requirement similar as to when an area is inhabited by humans.

As to the implementation of PG in roadbeds, would like a caveat that a demonstrated reduction of BPs occurs. This may not be that simple, but is needed, and may be part of the permit as part of a Net Ecosystem Benefit. Perhaps such a restriction could be placed on the land that would be intended and designated for the BP, thus truly reducing the amount of BPs.  It must be kept in mind that only certain lands have the potential to be used as a BP.

If PG can be fixed so that when used as roadbed, it doesn't migrate, and the possibility of houses ever being built over it is eliminated, and considering the negative aspects of BPs, then, the net result of the use of PG would be beneficial.

Some people will challenge its use just because it's radioactive.  However, some Florida beaches have higher radioactivity levels than the PG stacks.

In the past, workers at one phosphate plant wore badges to monitor for radioactivity, but nothing of significance was ever detected; therefore, the practice was discontinued. Would like to see the monitoring data for the various phosphate plants evaluated to confirm that similar findings were obtained.

Air monitoring of the stacks is a requirement – are the findings useful as to the PG use in roadbeds?

Hasn't seen definitive findings of test roads.  Can more research be generated from them to provide evidence of safety for PG use?

Thinks people in Florida are "dragging their feet" on this issue.  They've been talking about it for years, and people need to make it happen.  Should do whatever it takes to either prove that it's viable or, if not, move on.