LAND USE SUITABILITY INDEX
FOR USE IN HARDEE COUNTY

Prepared by:

CENTRAL FLORIDA REGIONAL PLANNING COUNCIL

For:

HARDEE COUNTY
BOARD OF COUNTY COMMISSIONERS

Submitted:
June 6, 2002

Adopted:
November 14, 2002
(Resolution No. 03-05)

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INTRODUCTION

The primary task of this study was to develop a land suitability index that is applicable to all potentially developable lands in Hardee County, Florida. Development of the index is part of the ongoing revision of the Future Land Use Element of Hardee County's Comprehensive Plan and the Hardee County Mining Ordinance (Ordinance No. 1999-02).

Among the proposed revisions to the Future Land Use Element, under Objective L7 (Protect the economic viability of future land development in the County), is Policy 7.1, which states:

> The County shall adopt a "Land Use Suitability Index" to assess the ability of reclaimed lands to support and sustain various types of future development. The Index shall ultimately be employed to determine the value and contribution of post-mining scenarios to the economy and future growth of Hardee County.

Proposed revisions to the Hardee County Mining Ordinance (Ordinance No. 1999-02) include certain "Economic Diversity Requirements," among which will be the repatriation of reclaimed lands, certain minimum "Land Use Suitability" requirements, re-mapping of mined/reclaimed soils, a "no-mine" overlay, and other requirements.

According to current estimates, phosphate mining companies own nearly 100,000 acres of lands within Hardee County,[1] an amount roughly equal to a quarter of the county area. With the exception of Cargill's South Fort Meade Mine, these lands are situated west of the Peace River. It is these lands that are the focus of the present study. It is hoped that this study builds upon the results of an earlier regional land use planning and reclamation study conducted by the Central Florida Regional Planning Council on the phosphate mining industry (Long and Orne, 1990). Like that study, the present one represents an initial effort to develop and evaluate current and projected land use suitability information for Hardee County. The present study is also, in part, a response to Long and Orne's plea for more a comprehensive and integrated approach to the future land use planning of reclaimed mined lands.

SCOPE OF WORK

The original scope of services called for the development of a land suitability index that could be applied to all mined-reclaimed phosphate lands in Hardee County (Figure 1). Early in the project, it was decided that the index would be county-wide in application in order to place the land suitability of reclaimed lands into a broader geographic context and to facilitate comparisons with the suitability of unmined lands. Aside from that modification, the project followed the work plan set forth in the scope of services.

The general approach taken in the development of the land suitability index was to make full use of existing soil mapping and attribute data from the USDA Natural Resources Conservation Service's (NRCS) Soil Survey Geographic Database (referred to as SSURGO). SSURGO is a digital version of NRCS soils data and was chosen for use in this study because the data is

county-wide and because many of the soil attributes directly relate to land use suitability. Although the published (hardcopy) soil survey of Hardee County (Robbins et al., 1984) was frequently consulted in this study, SSURGO served as the principal source for soil data for two reasons: (1) it contained updated attribute data not contained in the hardcopy survey, and (2) it was in digital format, which enabled the study team to use GIS and database management softwares in the development of the land suitability index and the creation of corresponding land suitability maps. The published soil survey, however, was routinely consulted for narrative material on the soils and their associated attributes.

The project was broken down into four tasks. During Task 1, the post-reclamation (i.e., "future") soil mapping units that were determined to be equivalent to the various reclaimed landforms were identified. During Task 2, the associated soil attributes from NRCS's Soil Survey Geographic (SSURGO) Database were linked to the post-reclamation soils. Task 3 was devoted to building the land suitability index. This index included two subindices, one for agricultural suitability and one for urban suitability, with each mapped soil mapping unit assigned a suitability rank for each subindex. Task 4 linked the resulting index and subindices to the digital county soils mapping file and generated a series of maps displaying the existing (pre-mining) agricultural, urban, and combined agricultural-urban (i.e., overall land) suitability rankings. As an example of how the index can be applied to post-reclamation landforms, a map series focusing on IMC Phosphates' proposed Ona Mine was also produced[2]. As an extension of Task 4, comparisons were made between the existing (pre-mining) and post-reclamation conditions with respect to shifts in land suitability index values, not only for the Ona Mine site, but also for the estimated 100,000 acres of land owned by phosphate mining companies in Hardee County. To facilitate county-wide comparisons, an estimate of post-reclamation conditions was computed based on extrapolations from the Ona Mine comparisons.

MATERIALS AND METHODS

Mapping of the Future Soils in the Post-Reclamation Landscape

Mapping of the soils in Hardee County was based on 1970 aerial photographs (Robbins et al., 1984). Because phosphate mining had not yet begun in the county by that date, no soils ("land areas") directly resulting from mining or mine reclamation activities were identified or mapped. For the purposes of this study, the soils as mapped in the soil survey were taken to represent "existing" conditions. Unlike Hardee County, phosphate mining had long been underway in adjoining Polk and Hillsborough counties by the time their respective soil surveys were performed. The Polk County soil survey was issued in 1990 (Ford et al., 1990) and the Hillsborough County soil survey was issued the previous year (Doolittle et al., 1989). Consequently, several soil types resulting from phosphate mining were described and mapped in these two counties.

Mapping the future (post-reclamation) soils in Hardee County required that two steps be taken. First, those soil types corresponding to the various types of post-reclamation[3] landforms had to be identified. Second, the extent of these landforms within the areas proposed for mining in Hardee County, as shown on mine-specific post-reclamation soil maps or waste disposal plans, had to be mapped. A total of 14 soil types in Polk and Hillsborough counties that are associated with phosphate mining and/or reclamation were identified. In Polk County, these included

Hydraquents, clayey (Slickens); *Arents-Water complex*; *Neilhurst sand, 0-5% slopes*; *Haplaquents clay*; *Arents-Urban land complex, organic substratum*; *Neilhurst-Urban land complex, 1-5% slopes*; *Arents, 0-5% slopes*; and *Gypsum land*. In Hillsborough County these included: *Arents, nearly level*; *Gypsum land*; *Arents, very steep*; *Quartzipsamments, nearly level*; *Slickens*; and *Haplaquents, clayey*.

On March 22, 2002, the study team met with two NRCS resource soil scientists at NRCS' Bartow field office. Richard D. Ford (principal author of the Polk County soil survey) represented Polk County and Juan A. Vega represented Hardee County. The objective of the meeting was threefold: (1) review the above listing of phosphate mine-related soils, (2) obtain NRCS guidance in eliminating soil mapping units not considered representative of post-reclamation landforms (but rather of active mining or early reclamation landforms), and (3) identify which pairs of soil mapping units from Polk and Hillsborough counties were taxonomically equivalent, and equate these paired soil mapping units with their corresponding post-reclamation landforms.[4] As a result of that meeting, the original list of 14 soil mapping units was narrowed down to three paired mapping units considered to be the soil equivalents of three post-reclamation landforms: clay setting areas, sand-tailings, and overburden (Table 1). It was also recognized that NRCS would probably recognize sand-clay mix settling areas, which are currently being created by CF Industries, Inc. (CFI) at its Hardee Phosphate Complex, as one or additional post-reclamation soil mapping units. Currently, there appears to be no soil equivalent to sand-clay mixes in Florida.[5]

On May 1, 2002, the study team, accompanied by Messrs. Ford and Vega, joined CFI's John Kiefer on an inspection of several of CFI's sand-clay reclamation sites. Aside from an early field evaluation of initial stages of sand-clay reclamation (Garlanger, 1982), little published information is available on sand-clay mixes, particularly from a soils perspective. Based on that site visit, the study team concluded that, because of differential horizontal and vertical settling of the sand fraction, sand-clay mix comprise up to four different mine-related soil types ranging from clayey to sandy in texture[6]. However, for the purposes of this study, the study team felt that the sand-clay settling areas could be grouped with the clay settling areas and be assigned the same soil ratings and limitations ascribed to clayey haplaquents.[7]

Assignment of Associated NRCS Soils Attributes to the Future Soils

Once the future soils were equated with existing soil types, assignment of the associated NRCS soils attributes to the future soils was a simple spreadsheet exercise. Because the soil ratings and limitations of the paired Polk-Hillsborough soil types were virtually identical with respect to one another, a single database record for each of the three future soil types was created by copying over those SSURGO soil attributes needed for constructing the land suitability index. For example, for any clay settling area, the soil attributes shared by clayey Haplaquents were linked to it; for any sand tailing area, attributes for Neilhurst/Quartzipsamments soils were linked; and for any overburden or overburden-sand tailing areas, the Arents attributes were linked. At present, post-reclamation soils mapping is available only for the proposed Ona Mine (Figure 2), so the SSURGO soils attributes were linked to this file[8]. As new or revised post-reclamation soils or waste disposal plan maps become available for mines in Hardee County, this same linkage procedure can be quickly performed and the maps made ready for calculating land suitability index values.

Development of the Land Suitability Index

Land suitability is a central feature of the land evaluation process. Many different land evaluation systems have been devised to classify land for specific purposes. Among the more widely known systems are USDA's Land Capability Classification (Klingebiel and Montgomery, 1961) and Land Evaluation Site Assessment (U.S. Department of Agriculture, Soil Conservation Service, 1983), the various FAO land evaluation systems (Food and Agriculture Organization of the United Nations, 1985), the Fertility Capability Soil Classification System (Sánchez, Couto and Buol, 1982), U.S. Bureau of Reclamation's Land Suitability for Irrigation (U.S. Department of the Interior, Bureau of Reclamation. 1951). Land evaluation can be defined as "the process of assessment of land performance when [the land is] used for specified purposes" (Food and Agriculture Organization of the United Nations, 1985); or put another way, "all methods to explain or predict the use potential of land" (Van Diepen et al., 1991). Land evaluation can be a vital tool for land use planning and can be used by both land users or by land planners. Land evaluation offers a diverse set of analytical techniques to describe land uses, predict the physical and economic responses of land to these land uses, and optimize land use in the face of multiple objectives and constraints (Rossiter, 2002).

In developing an appropriate land suitability classification system for Hardee County, the availability of an information source that was widely recognized, mapable, and county-wide in geographic extent were of paramount concerns. The only dataset that satisfied these concerns was the USDA-NRCS Soil Survey Geographic (SSURGO) database. SSURGO consists of geo-referenced digital spatial data, metadata, and a tabular soil database documenting the properties for each soil type (USDA-NRCS, 2002). SSURGO includes the land capability classes and subclasses for each soil type in Hardee County, as well as soil potential ratings for a variety of urban-type land uses and land features.

Each soil in the county, with the exception of the *Water* and *Pits* soil mapping units, was assigned an agricultural suitability value of 1 to 5 and a corresponding urban suitability value of 1 to 5 (with "1" denoting the highest relative suitability and "5" the least relative suitability). To create an overall land suitability index value on a scale of 1 to 10, each soil's score on the two subindices was summed and reduced by one. A score of "10" was be reserved for *Water* and *Pits*. A land suitability score of "1" denotes the soil mapping units with the highest relative land suitability for urban and agricultural development, while a score of "10" denotes soil mapping units with the lowest relative land suitability.

Agricultural Suitability Subindex. The *agricultural suitability subindex* proposed for Hardee County is based entirely on NRCS's land capability classification system[9]. Originally formulated in 1938 (Norton, 1938), the land capability classification (LCC) is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time. The basic aim of the LCC is to rank all soils from "best" to "worst" according to the degree of relatively permanent physical limitations to productive land use (e.g., agriculture, grazing, and forestry) (Rossiter, 2002). NRCS's National Resources Inventory[10] information and many field office technical guides have developed guidelines and procedures for assigning soils to one or another of these classes. The system has been adopted in many textbooks and has wide public acceptance, both nationally and internationally.[11] The 1985 Farm Bill incorporated the LCC system and several state

legislatures have incorporated the LCC in farm conservation laws (Klingebiel and Montgomery, 1961; USDA-NRCS, 2001: §622.02).[12]

The LCC is one of a number of NRCS-based interpretive groupings of soils made primarily for agricultural purposes. As with all interpretive groupings, the LCC begins with the individual soil mapping units, which are building stones of these groupings. The soil mapping unit (the unit that is mapped in soil surveys, including the Hardee County soil survey) provides the basis for all interpretive groupings of soils, including the LCC groupings. It provides the information needed for developing capability units, and well as forest site, crop suitability, range site, engineering, and other interpretive groupings (Klingebiel and Montgomery, 1961).

Although the original and still primary purpose of the LCC is for farm planning, NRCS has made other uses of the LCC ratings, including land use planning and inventorying conservation needs. After World War II, the land capability classification was also being used for tax assessment purposes (Helms, 1992). The current version of the LCC is detailed in Agricultural Handbook 210, Land-Capability Classification, issued in 1961 (Klingebiel and Montgomery, 1961).

The LCC is subdivided into capability class and capability subclass, and these are assigned to soil mapping units (map unit components) in the national soil information system and incorporated in the SSURGO database. The capability class is the broadest category in the LCC. It groups together those soils sharing the same relative degree of hazard or limitation. The only information concerning general agricultural limitations in soil use are obtained at the capability class level. For information on soil suitability with respect to woodland or range use, the range site and woodland-suitability groupings should be consulted (Klingebiel and Montgomery, 1961).

There are eight capability classes in the LCC system. These classes are differentiated on the basis of soil and climatic limitations in relation to the use, management, and soil productivity. Classes are based on both degree and number of limitations affecting kind of use, risks of soil damage if mismanaged, needs for soil management, and risks of crop failure. The risks of soil damage or limitations in use become progressively greater from class 1 to class 8. Soils in the first four classes are considered *arable soils* (soils suitable for long-term sustained use for cultivated crops) and are grouped according to their potentialities and limitations for sustained production of the common cultivated crops that do not require specialized site conditions. *Non-arable soils* are similarly grouped but in terms of production of permanent vegetation and according to their risks of soil damage if mismanaged. Some soils in classes 5 and 6 are also capable of producing specialized crops, such as certain fruits and ornamentals, and even field and vegetable crops under highly intensive management involving elaborate practices for soil and water conservation (Helms, 1992; Klingebiel and Montgomery, 1961).

The following class definitions are taken from the USDA-NRCS's National Soil Survey Handbook (§622.02):

- *Class 1* soils have slight limitations that restrict their use.
- *Class 2* soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.
- *Class 3* soils have severe limitations that reduce the choice of plants or require special conservation practices, or both.

- *Class 4* soils have very severe limitations that restrict the choice of plants or require very careful management, or both.
- *Class 5* soils have little or no hazard of erosion but have other limitations, impractical to remove, that limit their use mainly to pasture, range, forestland, or wildlife food and cover.
- *Class 6* soils have severe limitations that make them generally unsuited to cultivation and that limit their use mainly to pasture, range, forestland, or wildlife food and cover.
- *Class 7* soils have very severe limitations that make them unsuited to cultivation and that restrict their use mainly to grazing, forestland, or wildlife.
- *Class 8* soils and miscellaneous areas have limitations that preclude their use for commercial plant production and limit their use to recreation, wildlife, or water supply or for esthetic purposes (USDA-NRCS, 2001).

Table 2 summarizes the limitations, land uses, corrective measures, and capability subclasses associated with these eight land capability classes. This table shows that as the limitations increase in severity, the possible land uses decrease in intensity, and greater corrective measures are needed.

The capability subclass is the second category in the land capability classification system. It identifies major management concerns associated with each soil type. Subclass codes *e*, *w*, *s*, and *c* are used for land capability subclasses. Subclass *e* is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Subclass *w* is made up of soils for which excess water is the dominant hazard or limitation affecting their use. S*ubclass s* is made up of soils that have soil limitations within the rooting zone. Subclass *c* is made up of soils for which the climate (the temperature or lack of moisture) is the major hazard or limitation affecting their use (Klingebiel and Montgomery,1961; USDA-NRCS, 2001: §622.02). Some states utilize a *capability unit*, which provides specific information on the nature of the limitation identified at the subclass level.[13] For the present study, it was decided that the class level alone (not the subclass) provided sufficient basis for constructing an agricultural suitability subindex.

It should be noted that the LCC class and subclass codes assigned to a particular soil type were not meant to be permanent. Any number of changes in the land such as accelerated erosion, accumulation of salts, artificial drainage, or supplies of irrigation water would call for reclassification of the area. Likewise the introduction of new crops and farming methods would call for a reappraisal of a soil's rating (Helms, 1992; Klingebiel and Montgomery, 1961).

The soils of Hardee County, as currently mapped, are grouped into one of five capability classes. Although there is no Class 1, 2, or 8 soils, Classes 3 through 7 are present. Table 3 lists the acreage and proportionate extent of the soils grouped by LCC class. Nearly three-fourths of the County is underlain with arable soils (Classes 1 through 4), with Class 3 soils accounting for 17.6 percent and Class 4 55.1 percent. Among the nonarable soil group (Classes 5 through 8), Class 5 accounts for 12.6 percent, Class 6 3.2 percent, and Class 7 11.3 percent.

After the LCC class codes were compiled for each existing and future soil type (soil mapping unit), one final step was taken in order to construct the agricultural suitability subindex. LCC Class 3 soils were assigned an index value of 1 (the highest rank), Class 4 an index value of 2,

Class 5 an index value of 3, Class 6 and index value of 4, and Class 7 an index value of 5 (the lowest rank).

Urban Suitability Subindex. The *Urban Suitability Subindex* was constructed by averaging the soils-based limitation ratings for six attributes and partitioning these averages into "natural" classes.[14] Five of the selected attributes are representative of uses typical of urban settings. Four are associated with building site development (dwellings without basements, small commercial buildings, local roads and streets, and lawns and landscaping) and one is associated with sanitary facilities (septic tank absorption fields). The NRCS assigned one of three possible ratings for these limitations (slight, moderate, and severe). A sixth attribute, soil drainage class, was later added because most of the soils ratings limitations were due to wetness. Adding the drainage attribute helped further differentiate among the lower rated soils.

According to the Hardee County soil survey:

> The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and the limitations are minor and easily overcome; *moderate* if the soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction coasts, and possibly increased maintenance are required (Robbins et al. 1984: 41).

Dwellings without basements and *small commercial buildings* are structures built on shallow foundations on undisturbed soil. The load limit equals that of a single-family dwelling three stories or less in height. The limitation ratings are based on soil properties, site features, and observed performance of the soils as these relate to the potential movement of footings, ease of excavation and construction, and landscaping and grading involving cuts and fills less than five feet.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic year-round. They have a sub-grade of cut or fill soil material, a base of gravel, crushed rock, or stabilized soil material, and flexible or rigid surface. Cuts and fills are generally less than six feet. The limitation ratings are based on soil properties, site features, and observed performance of the soils as these affect the ease of excavating or grading and traffic supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The limitation ratings are based on soil properties, site features, and observed performance of the soils as these affect plant growth and trafficability after vegetation is established.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. The limitation ratings are based on soil properties, site features, and observed performance of the soils (specifically between 24 and 72 inches depth) as these affect absorption of the effluent or interfere with installation (Robbins et al. 1984: 42).

Soil Drainage Classes identify the natural drainage condition of the soil. It provides a guide to the limitations and potentials of the soil for field crops, forestry, range, wildlife, and recreational uses. The class roughly indicates the degree, frequency, and duration of wetness, which are factors in rating soils for various uses (USDA-NRCS 2001: 618-16). *Excessively drained* soils are the driest of the soils in Hardee County, followed, in order of increasing wetness, by *well drained*, *moderately well drained*, *somewhat poorly drained*, *poorly drained*, and *very poorly drained* soils. The latter soils are invariably hydric and are associated with historic wetlands (Robbins et al. 1984).

The following steps were followed in constructing the urban suitability subindex for the existing and future soils. For the four building site development and septic tank criteria, a rating of "slight" was assigned a score of 1, a "moderate" rating a score of 3, and a "severe" rating a score of 5. For the drainage classes, excessively and well drained soils were assigned a soil of 1, moderately well drained soils a score of 2, somewhat poorly drained soils a score of 3, poorly drained soils a score of 4, and very poorly drained soils a score of 5. Next, the six scores for each soil were summed and an average score computed. The average scores were then grouped into five classes using natural breaks using ArcView GIS software (version 3.2a). This method identifies breakpoints by looking for groupings and patterns inherent in the data. A complex statistical formula (Jenks optimization) that minimizes variation within each class was used (ESRI, 1996).

Land Suitability Index. As indicated previously, building the land suitability index was a simple matter of adding the agricultural and urban subindices together and reducing that value by one and assigned a score of 10 to *Water* and *Pits*. Again, a land suitability score of 1 denotes the soil mapping units with the highest relative land suitability for urban and agricultural development, while a score of 10 denotes soil mapping units with the lowest relative land suitability.

The land suitability index, as well as its component agricultural and urban subindices, was compiled as three separate stand-alone dBASE IV (.dbf) format database file using Excel 2000 spreadsheet software. Each record in these database files includes a unique soil map unit identification symbol (the MUID field in the SSURGO files) and its corresponding index or subindex score. These files are reproduced in Appendix A (the soil mapping unit name, or soil type name, was added in order to make the data more interpretable for the reader).

Map Preparation

A series of maps showing the existing agricultural, urban, and overall land suitability for all of Hardee County and for IMC Phosphates' proposed Ona Mine was created using ArcView GIS software (version 3.2a). A second series of maps focusing on the proposed Ona Mine and showing the post-reclamation agricultural, urban, and overall land suitability index results was also generated.

Comparing Existing Versus Future Land Suitability

Total acreage by agricultural, urban, and overall land suitability index scores was extracted from the completed index and subindex database files. The Ona Mine was evaluated in terms of within-class proportional shifts between existing and future conditions for the three indices (e.g.,

percent increase or decrease in the geographic extent of Class 1 agricultural suitability areas between existing and future conditions). Without the benefit of post-reclamation soils or reclamation plans from all the phosphate mining firms (save for the proposed Ona Mine) that have existing or planned mines in Hardee County, an estimate of these within-class shifts was computed. This estimate assumed that the proportion of post-reclamation landform and no-mine (preserved) areas and the same proportional shifts evident in the Ona Mine data would apply to the remaining mine properties. As additional post-reclamation soils become available, this estimate can be refined.

RESULTS

It is evident, after applying the agricultural, urban, and the overall land suitability index that Hardee County is endowed with an abundance of land suitable for agricultural uses, but a relative scarcity of lands naturally suited for urban uses. The results of applying the index to all of Hardee County, as well as to the proposed Ona Mine, are presented in Tables 4 through 11 and are graphically portrayed on Figures 3 through 11.

Existing Agricultural Suitability

Approximately three-quarters of the lands in Hardee County scored 2 or higher on the existing agricultural suitability subindex (Table 4; Figure 3). Class 2 lands are most prevalent, occupying 57.6 percent of the county, followed, in descending order of extent, by Class 1 (17.6%), Class 3 (12.6%), Class 5 (8.8%), and Class 4 (3.2%). Generally speaking, Class 1 lands occur in the better drained soils along portions of the major streams in the county (Peace River and Payne, Horse, Troublesome, and Charlie creeks). Class 2 lands are predominant throughout the flatwoods sections of the county. Class 3, 4, and 5 lands occupy stream floodplains, flatwoods sloughs, and wetlands.

Existing Urban Suitability

Most of the county (77%) rates as Class 4 urban lands (Table 5; Figure 4). An additional 11.5 percent rates as Class 5. Higher rated lands are significantly less frequent, with Class 1 accounting for less than one percent, Class 2 just over two percent, and Class 3 nearly nine percent. The generally poor rating of the county lands on the urban suitability subindex is largely a reflection of the prevalence of the low-lying topography and the poorly drained nature of the soils.

Existing Overall Land Suitability

Over half of the county (55.3%) falls in the Class 5 category using the land suitability index (Table 6; Figure 5), an additional 17.5 percent Class 6, 9.4 percent Class 4, 8.6 percent Class 9, and 6.5 percent Class 3. The remaining classes make up less than one percent. The more suitable lands (Classes 1 and 2) are concentrated in the uplands around Payne Creek and along portions of the Peace River, with smaller areas scattered throughout all sections of the county. As with the agricultural land ratings, flat topography and soil wetness were major factors accounting for the prevalence of lower ranked lands.

Comparison of Existing and Future Land Suitability

The draft post-reclamation soils map for the proposed Ona Mine provided an opportunity to illustrate the value of the land suitability index for evaluating effects of mining on land suitability as reflected by the index (Figure 2 above). Specifically, the index may be used to examine the geographic extent of shifts in land suitability between existing (pre-mining) and future (post-reclamation) conditions for a given unit of land. As proposed, it is estimated that, upon completion of reclamation, the Ona lands will consist of 7,072 acres of sand tailing fill, 6,896 acres of phosphatic colloidal clays, 5,012 acres of overburden, 4,903 acres of preservation area, and 338 acres of unmined-disturbed soils.

Ona Mine - Future Agricultural Suitability. Figures 6 and 7 show the existing and future agricultural suitability, respectively, of the proposed Ona Mine property. A comparison of the two figures reveals a significant downward shift in agricultural suitability. The shifts are also quite evident when examined in tabular form (Table 7). Class 1 agricultural lands will be reduced by nearly 1,300 acres, Class 2 lands by over 12,600 acres, and Class 3 lands by 850 acres. In place of these higher ranked agricultural lands will be dramatic increases in lower ranked agricultural lands, with Class 4 lands showing the most marked gains (over 10,000 acres), followed by Class 5 lands (nearly 4,400 acres).

Ona Mine - Future Urban Suitability. Figures 8 and 9 show the existing and future urban suitability, respectively, of the proposed Ona Mine property. Unlike the shifts for agricultural lands, pre-post mining shifts in urban land suitability are less dramatic and mainly involve offsetting increases/decreases in the mid to lower ranked lands. A significant increase in Class 3 urban lands occurs, largely at the expense of Class 4 lands (Table 8). Existing Class 1 and 2 urban lands are limited to nearly 440 acres, all of which shifts to Class 3 lands after mining. Class 5 lands are essentially unaffected.

Ona Mine - Future Overall Land Suitability. Figures 10 and 11 show the existing and future overall land suitability, respectively, of the proposed Ona Mine property. Overall, there is a downward shift in land classes, which is largely an artifact of the pronounced decline in agricultural suitability (Table 9). There are no Class 1 or 2 lands, and limited acreage of Class 3, 7, and 10 lands. The predominant class represented at Ona, Class 5, shows the largest decline in raw numbers and percentage, with over 12,000 acres being replaced by Class 6 and 9 lands. A significant but lesser magnitude decline in Class 4 lands is also evident.

Countywide - Future Agricultural Suitability. Extrapolating the results of the projected agricultural, urban and overall land suitability shifts for the Ona Mine to these lands, an approximate estimate of the effects on phosphate mining on suitability values can be obtained. Table 10 presents an extrapolated comparison of agricultural and urban suitability values between existing and future conditions. For the purposes of this comparison, it is assumed that the lands owned by mining companies have same proportion of soils as has the proposed Ona Mine. It is estimated that approximately 5,500 acres of Class 1 lands, 54,500 acres of Class 2 lands, and 3,700 acres of Class 3 lands will be replaced by 45,000 acres of Class 4 lands and 19,000 acres of Class 5 lands.

Countywide - Future Urban Suitability. Shifts in urban suitability primarily involve a reversal of acreage between Class 3 and 4 lands (Table 10). Approximately 600 acres of Class 1 lands

and 1,700 acres of Class 2 lands will be lost. Although Class 4 loses over 60,000 acres, the loss is offset by gains in Class 3 (44,300 acres) and Class 5 lands (19,500 acres). Class 1 and 2 lands will remain essentially unchanged.

Countywide - Future Overall Land Suitability. In terms of the overall, or combined, land suitability values, there is a downward shift in land classes, which, like the Ona results, is largely an artifact of the pronounced decline in agricultural suitability in combination with mid-value shifts in urban suitability which tend to negate each other (Table 11). Because there are no Class 1 or 2 lands at the Ona Mine, approximations for these classes could not be made. The predominant class represented for the mining lands is Class 5. It is also the land class most adversely affected in terms of reduced areal extent and percentage, with an esimated 47,300 acres being replaced by Class 6 and 9 lands. A significant but lesser magnitude decline in Class 4 lands is also evident. The remaining classes were either minimally affected (Class 3 and 4) or were of limited extent (Class 7 and 10).

DISCUSSION

Several studies have been published in the past two decades that address the agricultural potential of reclaimed phosphate mined lands. One of the more ambitious of these was the Mined Lands Agricultural Research and Demonstration Project (MLARD), a ten-year program of research that examined the agricultural potential of colloidal phosphatic clay. Summary results of this decade-long study were published by the Florida Institute of Phosphate Research (FIPR) in the mid-1990s (Shibles, 1994); Hanlon et al., 1996). An overview and retrospective of the MLARD project was recently presented by James Stricker, the Principal Investigator and Project Director of the MLARD project (Stricker, 2000). The MLARD program also published a number of detailed studies addressing various aspects of the project.[15] In addition to other findings, MLARD researchers also developed recommendations for modifying reclamation techniques to better prepare reclaimed lands for agricultural use (Hanlon et al., 1994). Prior to and concurrent with the MLARD project, Dr. Paul Mislevy and associates, based at the University of Florida's Range Cattle and Education Research Center in Ona, published a number of studies on the viability of producing certain forage crops on phosphatic clays (Mislevy and Blue, 1981a, 1981b, and 1981c; Mislevy et al., 1989, 1990a, 1990b, 1991a, and 1991b; Blue and Mislevy, n.d., and 1990).

Aside from the MLARD studies and Mislevy's research, there is little published research relating to the agricultural potential or productivity of reclaimed mine lands. Most such research was funded by FIPR, and is now somewhat dated. These investigations examined cash crop production on sand-clay mix (Bromwell and Carrier, 1989) and citrus plantings (Zellars-Williams, 1988). The Zellars-Williams investigated citrus plantings on overburden and sand tailings, and to a lesser extent, on sand-clay mix. The authors concluded that overburden was a viable substrate for citrus growth but that there was insufficient evidence to determine whether citrus could be grown economically on sand tailings. The authors also cited economics or profitability as constraints on the future of citriculture on sand tailings fill (Zellars-Williams, 1988). The Bromwell and Carrier study demonstrated that these soils can produce commercially important crops but that trafficability[16] problems increased as the ratio of clay to sand increased (Bromwell and Carrier, 1989). Notwithstanding the rather optimistic results of these studies, very little acreage of reclaimed land have been used for commercial agriculture (e.g., row or field

crops) or citriculture. The predominant agricultural use is improved pasture. According to SWFMWD's 1999-2000 land use/land cover mapping, of the estimated 48,775 acres of mined soils in Hillsborough and Polk counties, only 675 acres (just over 1%) are in citrus, 33 acres in row crops, and six acres in nurseries/vineyards (probably sod farms). Roughly 3,510 acres (7.2%) is classified cropland/pastureland (a catch-all category that SWFWMD GIS staff has suggested is largely pasture land), and 202 acres is classified as open rural land.

A thorough review of the findings of the MLARD project findings is beyond the scope of the present study. It is appropriate, however, to summarize some its key findings as they relate to present-future agricultural suitability assessment. MLARD successfully demonstrated that phosphatic clays are "fertile" soils that are capable of growing high quality commercial crops such as forage grasses, tropical cultivars, and biomass crops (although grain yields were marginal). However, numerous problems and limitations were also documented (Hanlon et al., 1996; Stricker 2000). One of the most difficult problems to overcome was the inability to work the phosphatic clays when wet. Phosphatic clays are documented to be extremely low in permeability, pose safety risks and trafficability problems, and require costly drainage improvements and maintenance. These soils are also often highly variable in surface topography (due to differential horizontal and vertical settling), texture, and substrate consistency. Water quality concerns arising from stormwater runoff were also cited. Because of the unworkable nature of phosphatic clays when wet, farming is effectively limited to the dry season, and even then, the occasional winter storms associated with the passage of cold fronts may hinder access to crop fields, and provides the potential for total crop failure, depending on drainage and surface conditions.

Specialized, non-conventional farming technologies are needed for site preparation, tillage, and harvesting on phosphatic clays (Shibles, 1994; Stricker, 2000). This may add significantly to agricultural production costs. Another problem cited by the MLARD research is an apparent lack of markets and market capacity for agricultural crops grown on phosphatic clays. In addition, short-term land leases, which are traditionally used by phosphate mining companies, have discouraged investments on the part of the lessees for drainage and other capital improvements (Stricker 2000; Hanlon et al., 1996). Invasive exotic plant species also pose serious management and maintenance problems, not only for reclaimed lands, but potentially for adjacent or nearby properties. A recent study found 11 species listed as exotic/nuisance plant species by the Florida Exotic Pest Plant Council on naturally reclaimed clay settling areas (Doherty, 1991; Erwin et al., 1997). Clearing of these and other plants that typically form a dense vegetative growth adds to the cost of converting clay settling areas to agricultural use. Finally, there is concern over the adverse public perceptions of growing and/or consuming crops grown on phosphatic clays due to elevated levels of radionuclides (Guidry 1990; Guidry et al., 1991; Stricker 2000).

Simply stated, agricultural production on phosphatic clays is a risky venture. In the words of the MLAR/D project manager, "rather than being performed at optimum times, disease and insect control or even final harvest may be limited to periods of dry weather. Such rain delays can often result in *crop/economic loss*, creating a *high risk* setting when crop production on phosphatic clay is approached in a conventional manner" (Shibles 1994: xxxi) [emphasis added]. This clearly implies that non-conventional approaches to farming will be required, which translates into increased production costs. In consideration of the MLARD findings, the LCC Class 7 rating assigned to phosphatic clays is appropriate given the factors upon which the

classification system is based: (1) inherent physical soil limitations that constrain land use; (2) the risks of soil damage; (3) the need for soil management; and (4) risks of crop failure. Moreover, the absence of commercial agricultural land uses reflects the limitations imposed by the surface disposal of phosphatic waste clays.

With respect to the agricultural use potential of overburden and sand tailings, their Class 6 rating is not very dissimilar to the LCC ratings for unmined soils traditionally used for citriculture. These latter soils are generally dry mineral sands of very low fertility (e.g., Candler, Astatula, or St. Lucie soil series). According to SWFWMD's 1999-2000 land use/land cover data, nearly all of the 675 acres of citrus groves on mined soils occur on overburden or sand tailings fill.[17]

The less dramatic declines obtained for the pre-mining versus post-reclamation urban suitability assessment are consistent with recent land use data from the region. Considering SWFMWD's 1999-2000 land use/land cover within Hillsborough and Polk counties' mined soil areas, there is some acreage in urban uses. Approximately 2,400 acres has been converted to residential development, 640 acres to commercial uses, 140 acres to institutional uses, 650 acres to industrial uses, and 1,270 acres to recreational uses. Much of this urban land conversion has taken place in the southern and eastern portions of Lakeland. Consistent with the adage, "location, location, location," where reclaimed overburden and sand tailing landforms are situated in the path of urban growth, and real estate values are elevated, such as along State Road 37, such lands may be viewed as developable. Under "bullish" market conditions, developers might be willing to pay the extra costs potentially associated with building on reclaimed lands. However, little if any urban development has taken place on waste clay disposal sites, which is understandable given the extreme physical shortcomings of clays as support for foundations as cited in AASHTO and Unified Soil Classification System ratings for clay soils (cf. Dunn et al., 1980; Wagner 1957).

CONCLUSIONS

The land suitability index developed as part of this study provides a basic method of assessing the capability of reclaimed lands to support sustainable future agricultural and urban development. It is based on the USDA's land capability classification system and represents a technically reasonable use of a well-known, widely accepted, readily available, county-wide land suitability database. As new information on a soil's physical properties, or new farming techniques, improved management systems, or other social or technological innovations are developed and implemented, the LCC ratings may well be reclassified.

The results of this study indicate that future land use patterns, in particular the ability to support various types of commercial agriculture and urban development, may be substantially altered as a result of large-scale phosphate mining in Hardee County.

ENDNOTES

[1] Based on the latest preliminary mapping information from Florida DEP-Bureau of Mine Reclamation, four different phosphate companies (Cargill, CF Industries, Farmland Hydro L.P., and IMC Phosphates, Inc.) collectively own approximately 99, 650 acres of land in Hardee County.

[2] The Ona Mine's property boundary and post-reclamation soils GIS files are draft products, subject to revision. They are intended only to illustrate how the land suitability index can be applied. Among the strengths of the index is its adaptability to changing property and soil boundaries. When an updated version of the Ona Mine files, or for that matter any of the phosphate mines, becomes available, the index can simply be linked to the electronic versions of these files and an updated index map can be immediately produced.

[3] This study sought to identify soils whose landforms represent an advanced or completed state of reclamation. Soils representing active mining or early stages in the reclamation process were deemed irrelevant, as these soils and their associated landforms would eventually be replaced by other soils and landforms representing advanced or completed reclamation.

[4] Eight soil types were eliminated from further consideration as future soils candidates. The eliminated soils were *Arents-Urban land complex*; *Arents, very steep*; *Arents-Water complex*; *Gypsum land*; *Hydraquents, clayey*; *Neilhurst-urban land complex*; and *Slickens*. Although no phosphogypsum stacks in Hardee County are planned for the foreseeable future, its associated soil type, *Gypsum land*, was included in the land suitability index as these represent a potential future post-reclamation landform type.

[5] Although one or more of the older settling areas at the PCS Phosphate Mine in Aurora, NC, were reported to contain a sand-clay mix, both the printed Beaufort County soil survey (issued in 1995) and the associated SSURGO data simply labeled the PCS settling areas as "Slime Ponds" and provided no attribute data. The printed survey did not even recognize Slime Ponds as a soil mapping unit.

[6] Sandier material tended to form deltaic fans around the discharge pipes. The sand-to-clay ratio also appeared to be higher near the discharge pipe. The farther from the discharge pipe, the lower the sand-to-clay ratio.

[7] It was surmised that NRCS would have assigned land use-related ratings and limitations to sand-clay settling areas very much like those currently assigned to clay settling areas (i.e., similar, if not identical, land capability class/subclass, and suitability for houses, small commercial buildings, local streets and highways, lawns and landscaping, and septic tank absorption fields).

[8] The post-reclamation soils mapping of the proposed Ona Mine was obtained from IMC Phosphates' as part of an ongoing Development of Regional Impact (DRI) review. The file is an ArcInfo coverage named "Post_soils" and is dated April 19, 2000. It is a draft version of post-reclamation soils and is subject to change as the DRI review proceeds.

[9] An attempt was made to incorporate crop yield data (tomato, grapefruit, orange, and bahiagrass) and rangeland productivity. The crop yield data was not complete, with several soil types having no data. The rangeland data was not included in the SSURGO dataset, but was included in the published soil survey. However, because of the deficiencies in the crop yield data, it was decided to abort a multi-criteria approach and instead use the Land Capability Classification ratings.

[10] The National Resources Inventory is (NRI) is a statistically based sample of land use and natural resource conditions and trends on U.S. nonfederal lands. It is the most comprehensive database of its kind ever attempted anywhere in the world. The NSI serves as the Federal Government's principal source of information on the status, condition, and trends of soil, water, and related resources in the United States. More information on the NRI can be found on the NRI website at http://www.nrcs.usda.gov/technical/NRI.

[11] Canada, Great Britain, the Pacific Rim countries, and others have modeled their respective adopted land capability classifications after the USDA system.

[12] In assigning soils to the various capability groupings a number of assumptions are made: (1) the system considers only *relatively-permanent* land characteristics (for this reason, physical LCs such as stoniness are given more weight than chemical LCs such as pH), (2) within a class there may be very different soils but with the same degree (in a subclass, also kind) of limitations; (3) it is not a productivity rating; (4) Class 4 land could be more productive than class 1 but also be more fragile; (5) no attempt was made to determine profitability; (6) a single, moderately-high level of management is assumed; (7) if major land improvements are made, the land should be reclassified; (8) the cost of the land improvement is not considered; (9) geographic factors such as distance to market, kinds of roads, size and shape of soil areas, location within a farm or field etc. are not included.

[13] Capability unit information was not presented in either the printed or SSURGO versions of the Hardee County soil survey.

[14] An attempt was made to incorporate AASHTO or Unified Soil Classification System (USCS) ratings as criteria. However, these systems tended to group the soils of Hardee County into only two classes, making AASHTO and USCS of limited value for building a suitability index.

[15] For a complete listing of these studies, the reader is encouraged to consult Shibles (1996) and Hanlon and associates (1994).

[16] Trafficability (as used in the MLARD studies) refers to the accessibility to traffic for field operations, especially after a rainfall for irrigation. The clay is slippery and sticky, causing tractors and other vehicles to lose traction or become mired (Hanlon et al., 1996: 36).

[17] A small (~1.7 acre) grove is currently on CF Industries land in northwestern Hardee County. Other citrus groves may be growing on mined soils in other sections of Hardee County, but because NRCS has not yet mapped mined lands in the County, such as areas were not identified in this study.

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TABLES

Table 1. Post-reclamation soil types in Polk and Hillsborough counties and their associated post-reclamation landforms.

Equivalent (Paired) Soil Types	Associated Post-Reclamation Landforms
Haplaquents clay (P) / Haplaquents, clayey (H)	Clay setting areas
Arents, 0-5% slopes (P) / Arents (H)	Overburden or overburden/sand tailings mix
Neilhurst sand, 0-5% slopes (P) / Quartzipsamments, nearly level (H)	Sand tailings
new soil to be identified	sand-clay setting areas

Source: soils surveys for Polk and Hillsborough counties (Ford et al. 1990; Doolittle et al. 1989).
(P) denotes Polk County soil type, (H) denotes Hillsborough County soil type.

Table 2. Land capability classes and their limitations, land uses, and corrective measures.

Capability Class	Limitations	Possible Land Use	Possible Corrective Measures	Possible Capability Subclasses
1	No limitations for cropland	Very intense cultivation of field crops	Fertilization to maintain productivity	None
2	Moderate limitations for cropland	Intense cultivation of field crops	Drainage, fertilization, conservation	e, w, s, c
3	Severe limitations for cropland	Moderate cultivation of field crops	Drainage, fertilization, conservation	e, w, s, c
4	Very severe limitations for cropland	Limited cultivation of field crops	Drainage, fertilization, conservation	e, w, s, c
5	Slight to moderate limitations for grassland	Intense grazing	Not feasible	w
6	Severe limitations for grassland	Moderate grazing	No	e, w, s
7	Very severe limitations for grassland	Limited grazing	No	e, w, s
8	Non-agricultural land (i.e., badlands, mine tailings)	Wildlife, recreation	No	None

Source: adapted from Agricultural Handbook 210 (Kingebiel and Montgomery, 1961) by the Illinois Deparment of Natural Resources - Office of Mines and Minerals (http://dnr.state.il.us/mines/lrd/capclass.htm)

Table 3. Acreage and proportionate extent of soils by USDA Land Capability Class in Hardee County.

Land Capability Class	Total Acreage	Percent
1	0	0.0
2	0	0.0
3	71,978	17.6
4	235,463	57.6
5	51,367	12.6
6	12,922	3.2
7	35,845	8.8
8	0	0
	407,575	99.8

Note: *water* and *pits* are not assigned a capability class, hence their acreage (927 ac) is not included.
Source: SSURGO data for Hardee County.

Table 4. Acres and proportionate extent of lands by agricultural suitability in Hardee County.

Index	Acres	%
0	927	0.2
1	71,978	17.6
2	235,463	57.6
3	51,367	12.6
4	12,922	3.2
5	35,845	8.8
Totals	408,502	100.0

Note: "0" denotes unrated soil mapping units (i.e., water and pits)

Table 5. Acres and proportionate extent of lands by urban suitability in Hardee County.

Index	Acres	%
0	927	0.2
1	2,667	0.7
2	8,442	2.1
3	36,488	8.9
4	314,506	77.0
5	45,472	11.1
Totals	408,502	100.0

Note: "0" denotes unrated soil mapping units (i.e., water and pits)

Table 6. Acres and proportionate extent of lands by land suitability in Hardee County.

Index	Acres	%
1	168	0.0
2	8,275	2.0
3	26,725	6.5
4	38,458	9.4
5	226,003	55.3
6	71,608	17.5
7	1,343	0.3
8	0	0.0
9	34,995	8.6
10	927	0.2
Totals	408,502	100.0

Note: "10" denotes *water* and *pits* soil mapping units

Table 7. Comparison of agricultural suitability between existing (pre-mining) and future (post-reclamation) conditions at IMCP's proposed Ona Mine.

Index	Pre-mining (acres)	% of Property	Post-mining (acres)	% of Property	Difference (acres)	% Change
0	5.2	<0.1	0.0	<0.1	-5.2	<0.1
1	1,758.3	7.6	461.1	2.0	-1,297.2	-5.6
2	14,695.7	63.5	2,043.0	8.8	-12,652.7	-54.7
3	2,271.9	9.8	1,421.6	6.1	-850.3	-3.7
4	1,568.4	6.8	11,984.4	51.8	10,416.0	45.0
5	2,834.8	12.3	7,225.6	31.2	4,390.8	18.9

Note: "0" denotes unrated soil mapping units (i.e., water and pits)

Table 8. Comparison of urban suitability between existing (pre-mining) and future (post-reclamation) conditions at IMCP's proposed Ona Mine.

Index	Pre-mining (acres)	% of Property	Post-mining (acres)	% of Property	Difference (acres)	% Change
0	5.2	<0.1	0.0	<0.1	5.2	<0.1
1	37.5	0.2	0.0	0.0	-37.5	-0.2
2	419.6	1.8	21.1	0.1	-399.0	-1.7
3	1,068.0	4.6	11,935.8	51.6	10,868.0	47
4	17,790.3	76.9	3,637.0	15.7	-14,153.0	-61.2
5	3,813.7	16.5	7,541.9	32.6	3,728.0	16.1

Note: "0" denotes unrated soil mapping units (i.e., water and pits)

Table 9. Comparison of land suitability between existing (pre-mining) and future (post-reclamation) conditions at IMCP's proposed Ona Mine.

Index	Pre-mining (acres)	% of Property	Post-mining (acres)	% of Property	Difference (acres)	% Change
3	42.6	0.2	1.9	0.0	-40.7	-0.2
4	1,715.7	7.4	459.2	2.0	-1,256.5	-5.4
5	14,136.4	61.1	1,747.8	7.6	-12,351.1	-53.3
6	4,313.7	18.6	13,671.8	59.1	9,320.6	40.3
7	123.4	0.5	29.4	0.1	-94.0	-0.4
9	2,797.3	12.1	7,225.6	31.2	4,428.3	19.1
10	5.2	0.0	0	0.0	-5.2	-5.2

Note: "10" denotes *water* and *pits* soil mapping units

Table 10. Comparison of agricultural and urban suitability between existing (pre-mining) and estimated future (post-reclamation) conditions in the phosphate mining company lands in Hardee County.

Agricultural Suitability			Urban Suitability		
Index	Existing (acres)	Future (acres)	Index	Existing (acres)	Future (acres)
0	45	0	0	45	0
1	7,554	2,092	1	606	0
2	63,265	8,764	2	1,792	99
3	9,776	6,075	3	7,083	51,389
4	6,750	51,588	4	76,181	15,636
5	12,201	31,072	5	13,884	32,467
Totals	99,591	99,591	Totals	99,591	99,591

Note: "0" denotes unrated soil mapping units (i.e., water and pits)
Existing anf future acres are proportional approximations based on the existing future acres derived for the proposed Ona Mine.

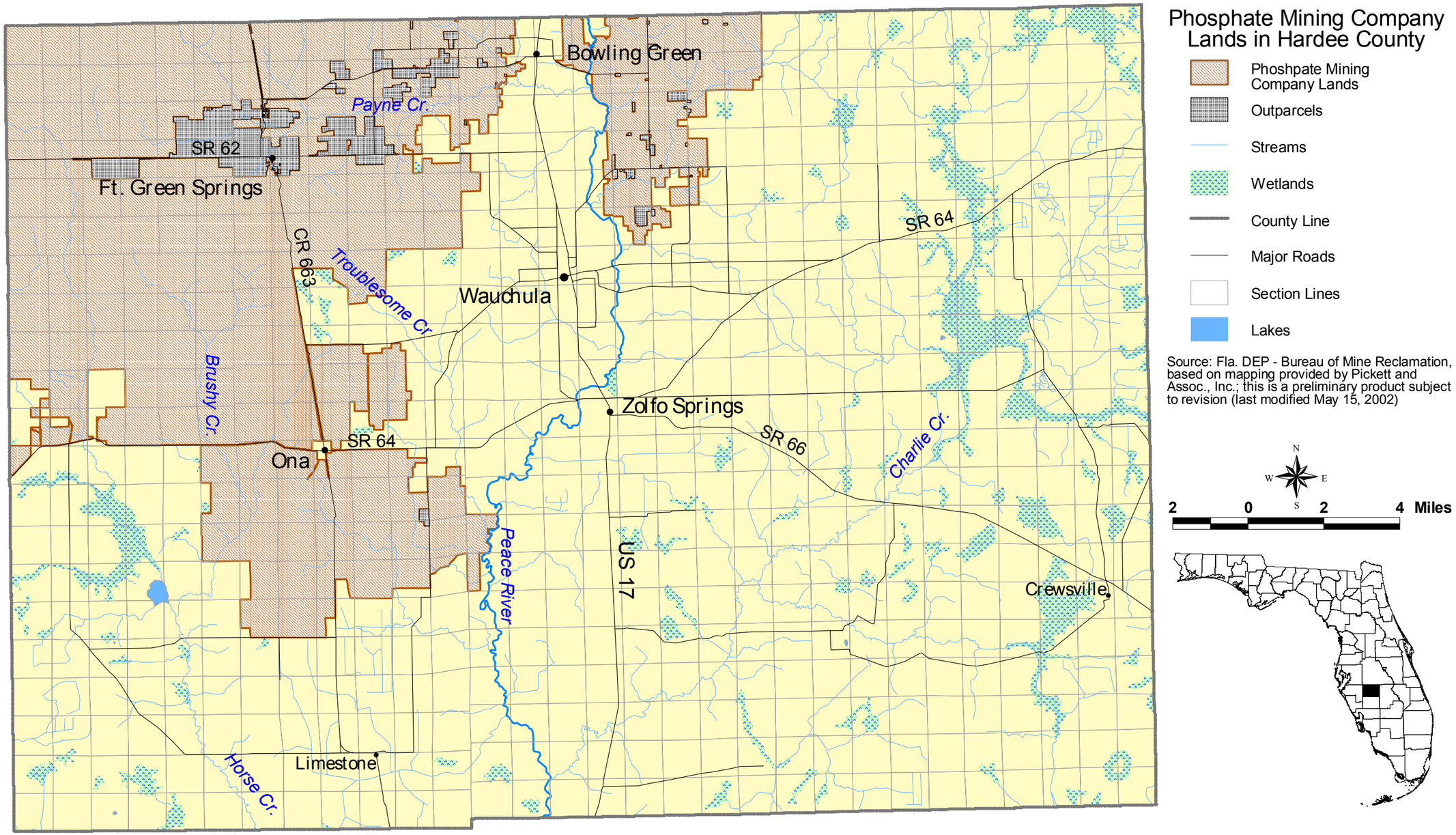
Table 11. Comparison of land suitability between existing (pre-mining) and estimated future (post-reclamation) conditions in the phosphate mining company lands in Hardee County.

	Land Suitability	
Index	Existing (acres)	Future (acres)
1	76	0
2	1,752	0
3	3,873	0
4	9,944	1,992
5	55,275	7,569
6	19,077	58,858
7	386	100
9	9,163	31,072
10	45	0
Totals	99,591	99,591

Note: "10" denotes water and pit soil mapping units
Existing anf future acres are proportional approximations based on the existing future acres derived for the proposed Ona Mine.

FIGURES

Figure 1. Map of Hardee County showing extent of current land holdings of the phosphate mining companies.



Phosphate Mining Company Lands in Hardee County

- Phoshpate Mining Company Lands
- Outparcels
- Streams
- Wetlands
- County Line
- Major Roads
- Section Lines
- Lakes

Source: Fla. DEP - Bureau of Mine Reclamation, based on mapping provided by Pickett and Assoc., Inc.; this is a preliminary product subject to revision (last modified May 15, 2002)

N W E S

2 0 2 4 Miles

Figure 2. Map of post-reclamation soils - proposed Ona Mine.

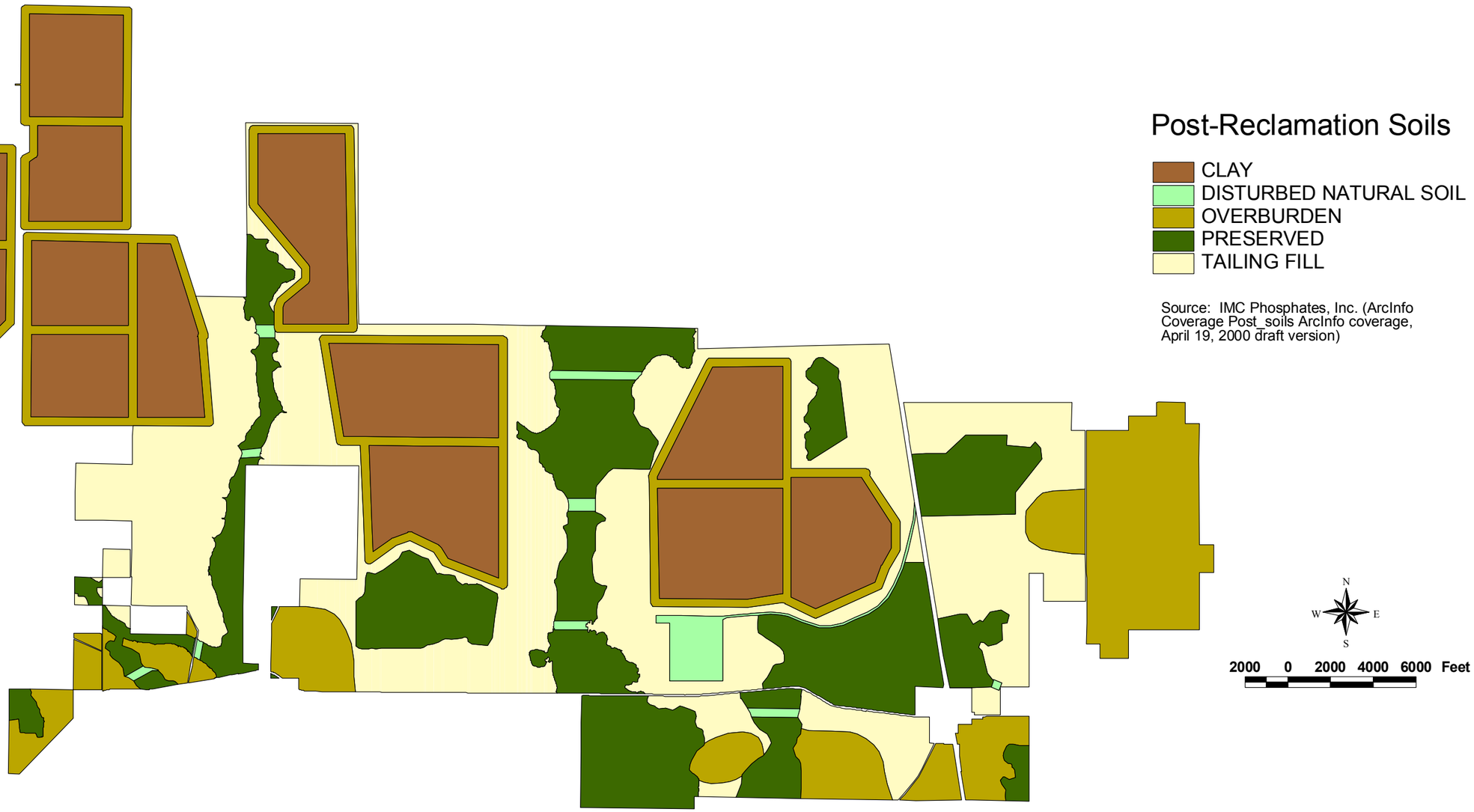


Figure 3. Map of existing agricultural suitability - Hardee County.

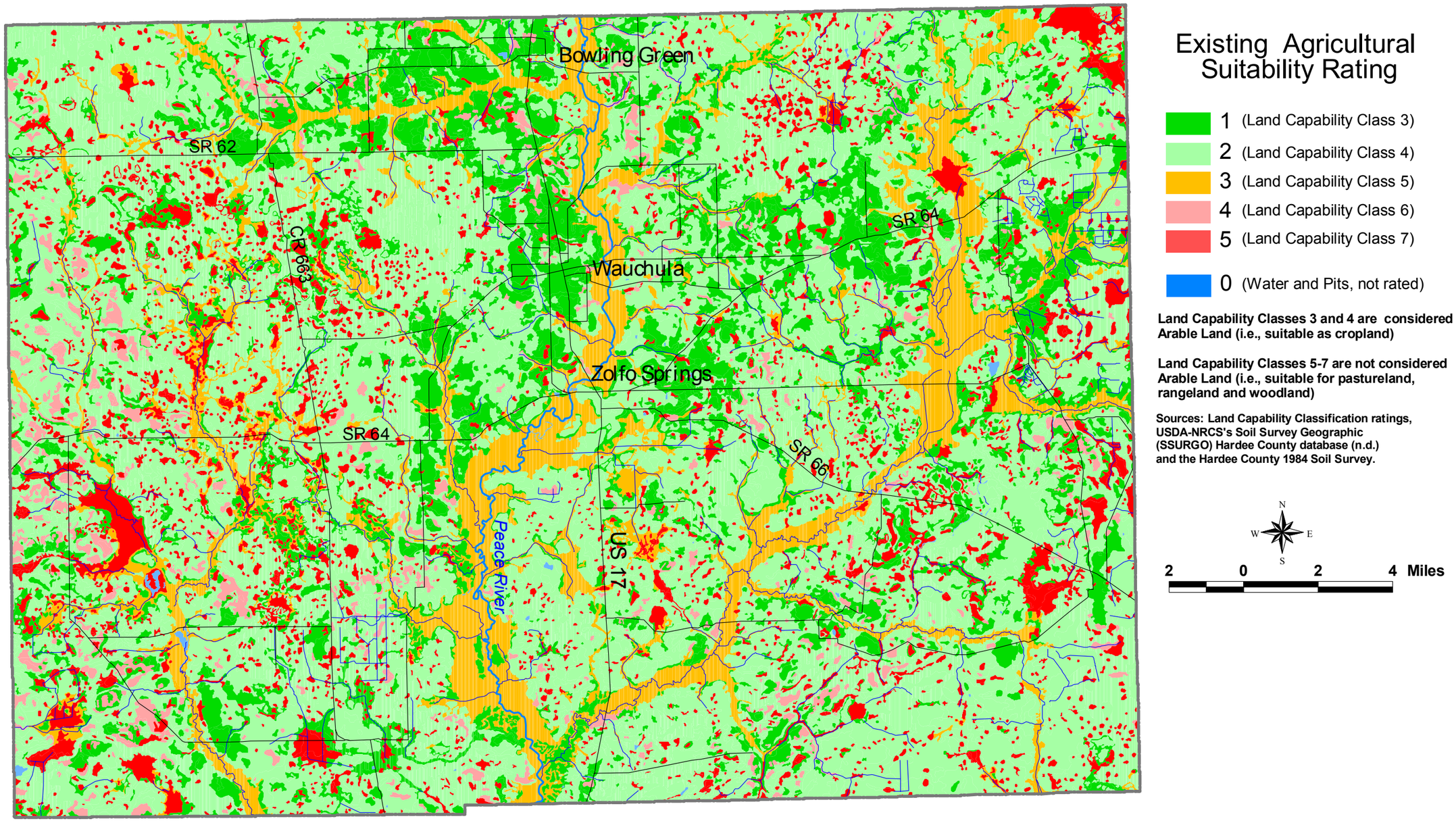


Figure 4. Map of existing urban suitability - Hardee County.

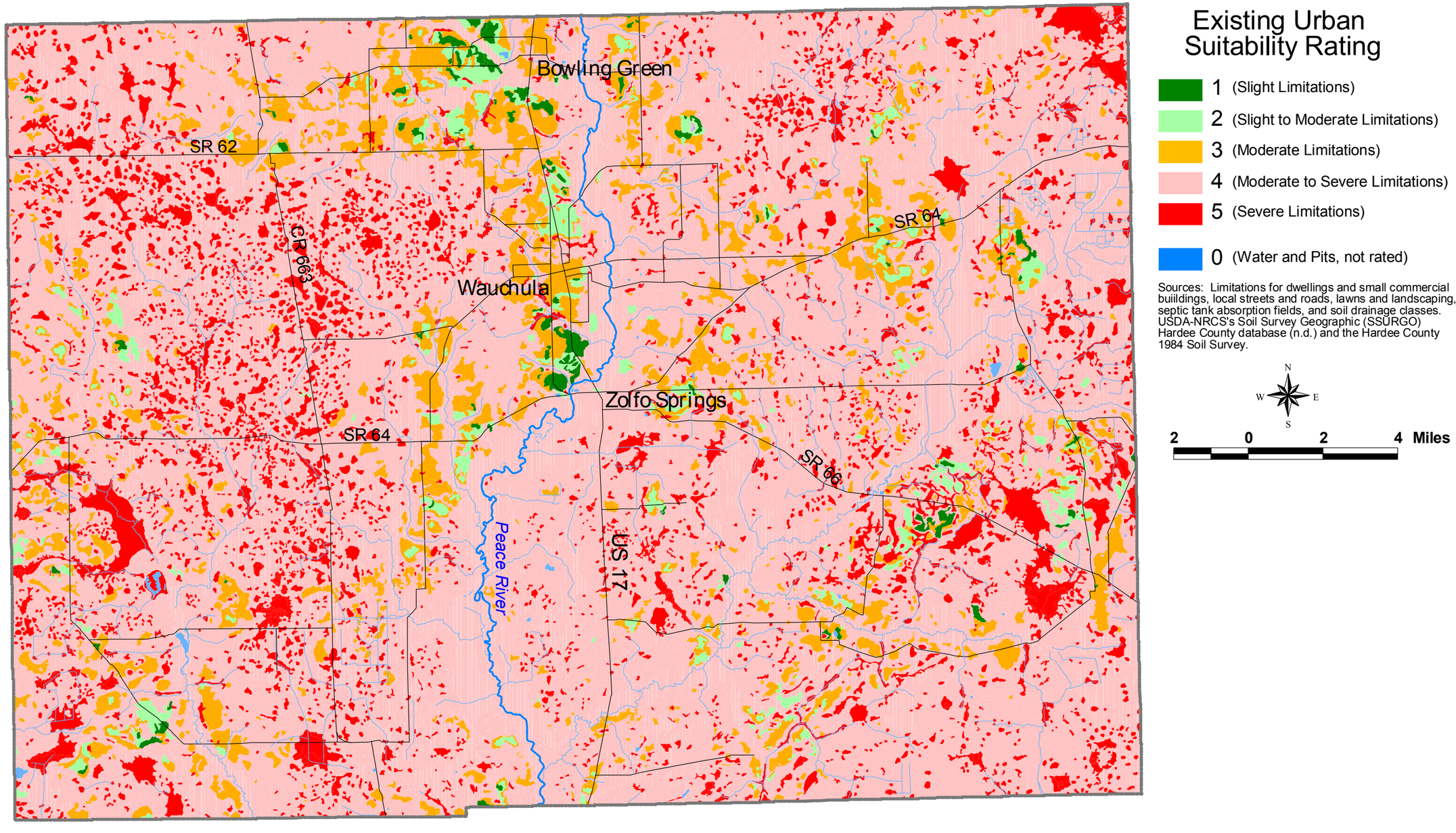


Figure 5. Map of existing land suitability - Hardee County.

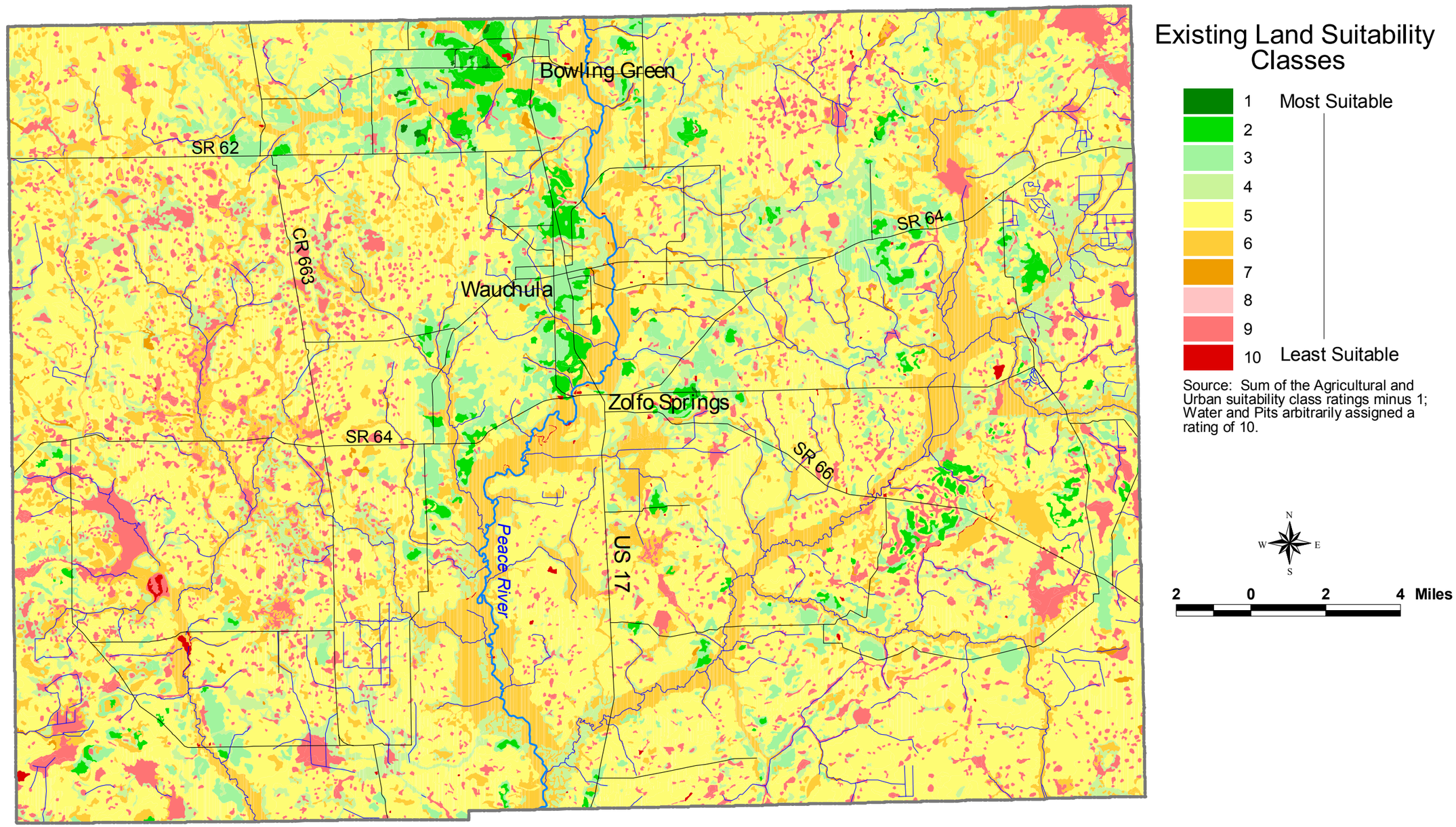


Figure 6. Map of existing agricultural suitability - proposed Ona Mine.

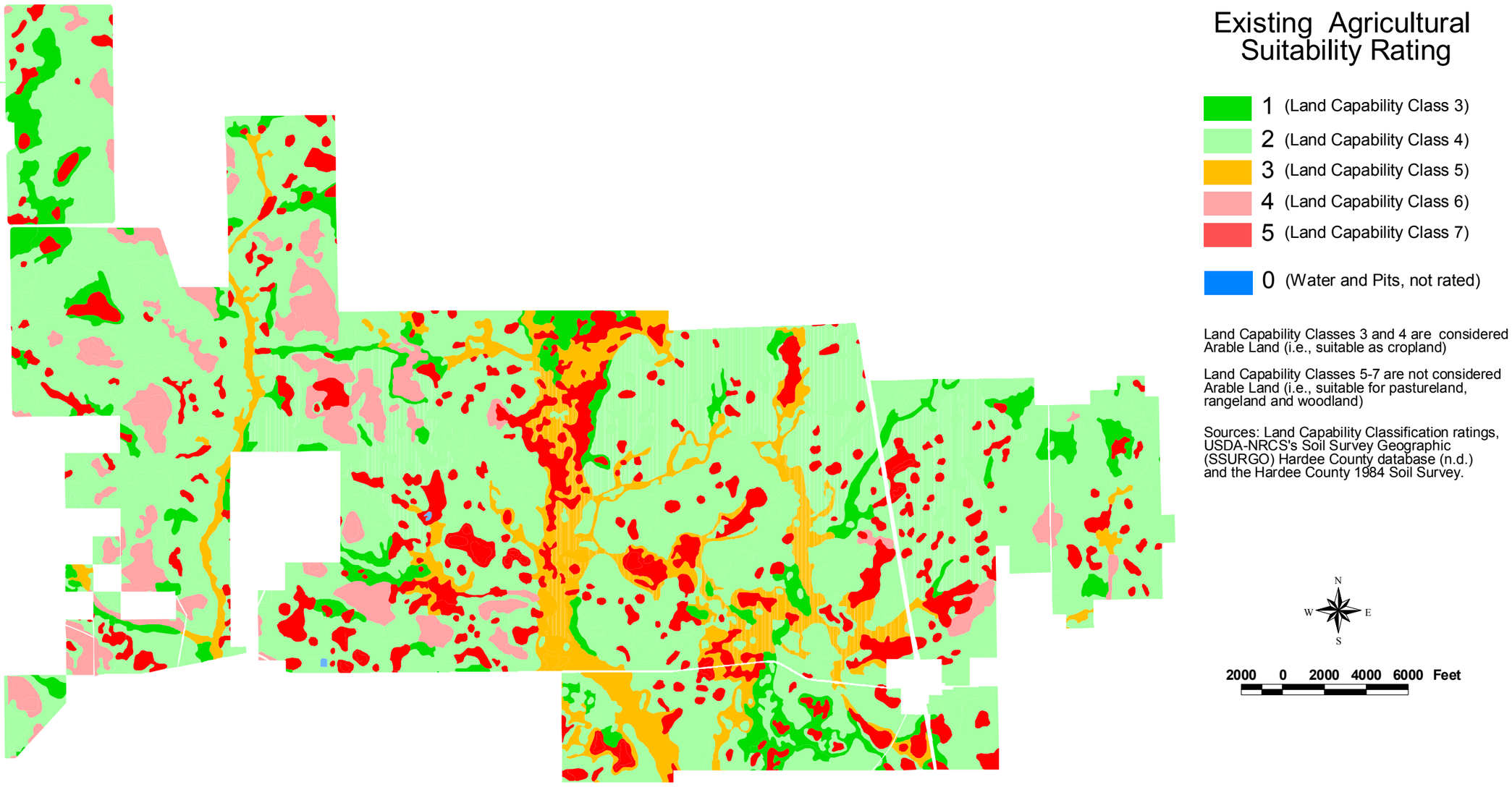


Figure 7. Map of future agricultural suitability - proposed Ona Mine.

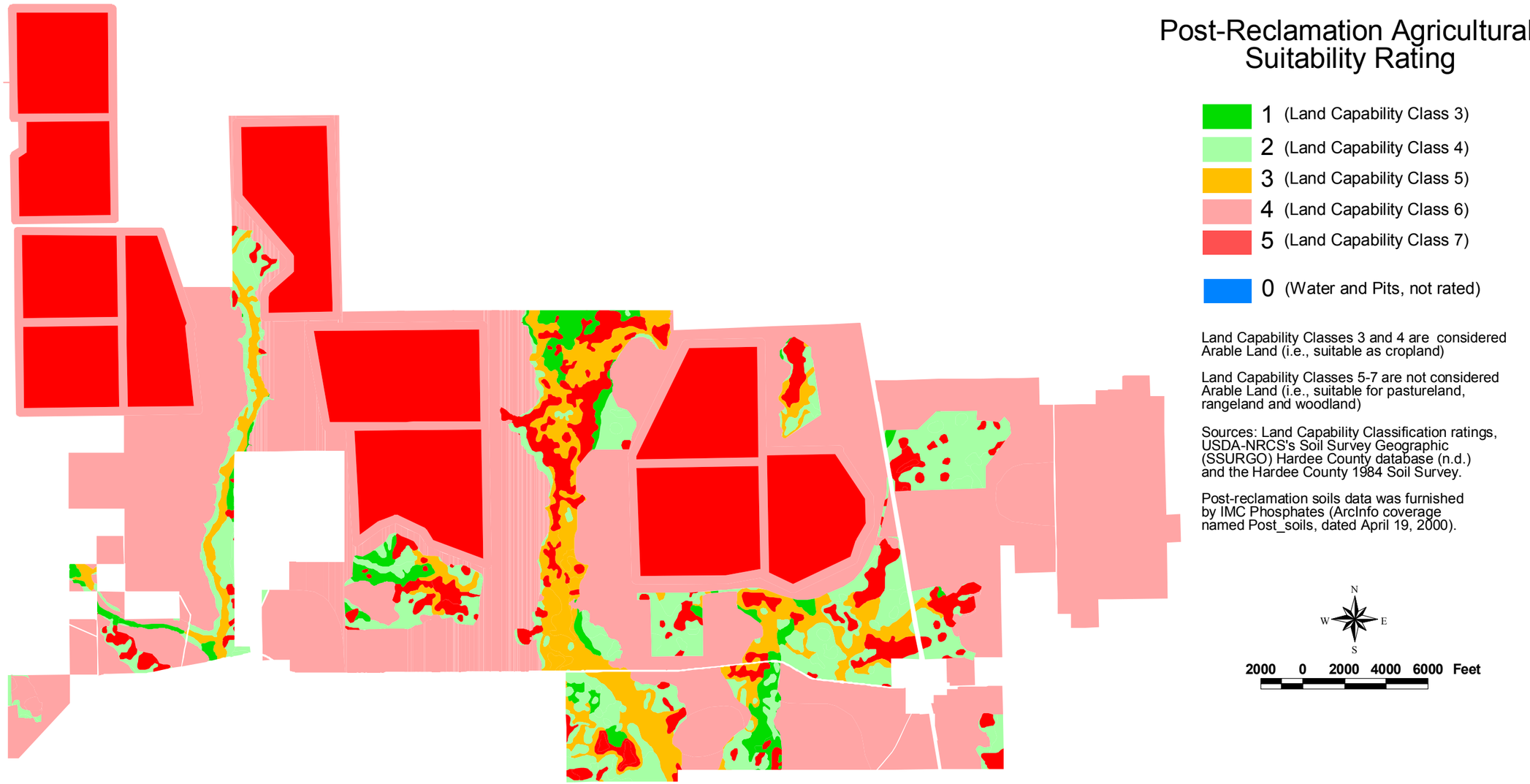


Figure 8. Map of existing urban suitability - proposed Ona Mine.

Figure 9. Map of future urban suitability - proposed Ona Mine.

Post-Reclamation Urban Suitability Rating

1 (Slight Limitations)

2 (Slight to Moderate Limitations)

3 (Moderate Limitations)

4 (Moderate to Severe Limitations)

5 (Severe Limitations)

0 (Water and Pits, not rated)

Sources: Limitations for dwellings and small commercial buiildings, local streets and roads, lawns and landscaping, septic tank absorption fields, and soil drainage classes. USDA-NRCS's Soil Survey Geographic (SSURGO) Hardee County database (n.d.) and the Hardee County 1984 Soil Survey.

Note: There are no Class 1 lands at Ona.

Post-reclamation soils data was furnished by IMC Phosphates (ArcInfo coverage named Post_soils, dated April 19, 2000).

N

W E

S

2000 0 2000 4000 6000 Feet

Figure 10. Map of existing land suitability - proposed Ona Mine.

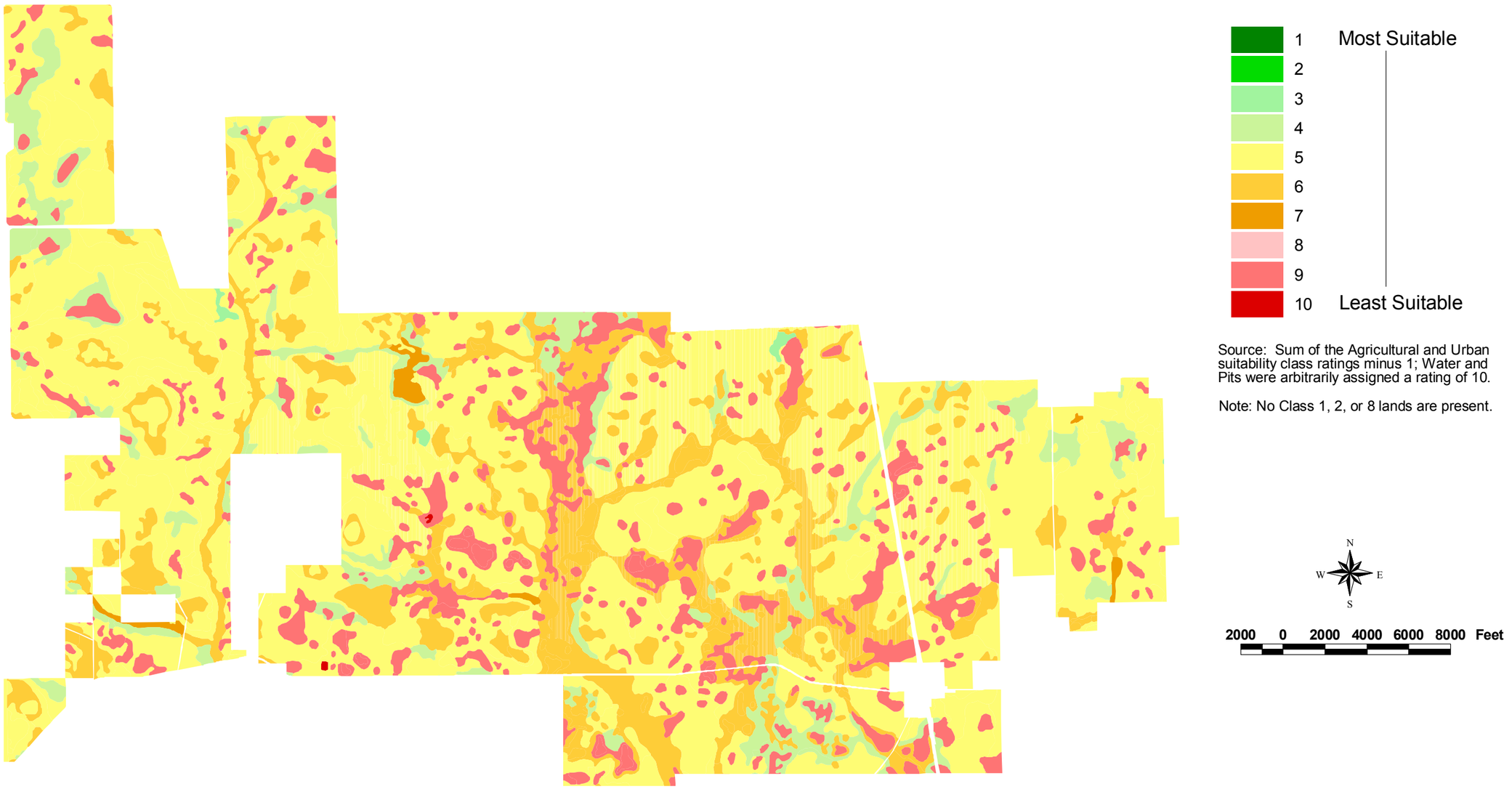


Figure 11. Map of future land suitability - proposed Ona Mine.

Post-Reclamation Land Suitability Classes

1 Most Suitable
2
3
4
5
6
7
8
9
10 Least Suitable

Source: Sum of the Agricultural and Urban suitability class ratings minus 1; Water and Pits were arbitrarily assigned a rating of 10.

Note: No Class 1, 2, 8, or 10 lands are present.

Post-reclamation soils data was furnished by IMC Phosphates (ArcInfo coverage named Post_soils, dated April 19, 2000).

N
W E
S

2000 0 2000 4000 6000 Feet

APPENDIX A

Soil mapping units and raw data used in compiling the agricultural, urban, and overall land suitability ratings

Appendix A. The Agricultural. Urban, and Overall Land Suitability Ratings Relational Database

		AGRICULTURE			URBAN								OVERALL
MUID[1]	Soil Type	LCSS[2]	LCSC[3]	Agri. Rating[4]	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping	Septic tank absorption fields	Drainage criteria[5]	Avg of 6 criteria	Natural Break Classes[6]	Land Suitability[7]
49001	ADAMSVILLE FINE SAND	3w	III	1	3	3	3	5	5	3	3.7	3	3
49002	ZOLFO SAND	3w	III	1	3	3	3	5	5	3	3.7	3	3
49003	FT. GREEN FINE SAND; 2 TO 5 PERCENT SLOPES	3w	III	1	5	5	5	5	5	3	4.7	4	4
49004	APOPKA FINE SAND; 0 TO 5 PERCENT SLOPES	3s	III	1	1	1	1	5	1	1	1.7	1	1
49005	TAVARES FINE SAND	3s	III	1	1	1	1	5	3	2	2.2	2	2
49006	CANDLER FINE SAND; 0 TO 5 PERCENT SLOPES	4s	IV	2	1	1	1	5	1	1	1.7	1	2
49007	BASINGER FINE SAND	4w	IV	2	5	5	5	5	5	4	4.8	4	5
49008	BRADENTON LOAMY FINE SAND; FREQUENTLY FLOODED	5w	V	3	5	5	5	5	5	4	4.8	4	6
49009	POPASH MUCKY FINE SAND	7w	VII	5	5	5	5	5	5	5	5.0	5	9
49010	POMONA FINE SAND	4w	IV	2	5	5	5	5	5	4	4.8	4	5
49011	FELDA FINE SAND	3w	III	1	5	5	5	5	5	4	4.8	4	4
49012	FELDA FINE SAND; FREQUENTLY FLOODED	5w	V	3	5	5	5	5	5	4	4.8	4	6
49013	FLORIDANA MUCKY FINE SAND; DEPRESSIONAL	7w	IV	2	5	5	5	5	5	5	5.0	5	6
49015	IMMOKALEE FINE SAND	4w	IV	2	5	5	5	5	5	4	4.8	4	5
49016	MYAKKA FINE SAND	4w	IV	2	5	5	5	5	5	3	4.7	4	5
49017	SMYRNA SAND	4w	IV	2	5	5	5	5	5	3	4.7	4	5
49018	CASSIA FINE SAND	6s	VI	4	3	3	3	3	5	3	3.3	3	6
49019	ONA FINE SAND	3w	III	1	5	5	5	5	5	4	4.8	4	4
49020	SAMSULA MUCK	7w	VII	5	5	5	5	5	5	5	5.0	5	9
49021	PLACID FINE SAND; DEPRESSIONAL	7w	VII	5	5	5	5	5	5	5	5.0	5	9
49022	POMELLO FINE SAND	6s	VI	4	3	3	3	5	5	2	3.5	3	6
49023	SPARR FINE SAND	3w	III	1	3	3	3	3	5	3	3.3	3	3
49024	JONATHAN SAND	6s	VI	4	1	1	1	5	5	2	2.5	2	5
49025	WABASSO FINE SAND	3w	III	1	5	5	5	5	5	3	4.7	4	4
49026	ELECTRA SAND	6s	VI	4	3	3	3	5	5	3	3.7	3	6
49027	BRADENTON-FELDA-CHOBEE ASSOCIATION; FREQUENTLY FLOODED	5w	V	3	5	5	5	5	5	4	4.8	4	6
49028	HOLOPAW FINE SAND	4w	IV	2	0	5	5	5	5	4	4.8	4	5
49029	PITS	not assigned	not assigned	0	5	0	0	0	0	0	0.0	0	10
49030	HONTOON MUCK	7w	VII	5	5	5	5	5	5	5	5.0	5	9
49031	POMPANO FINE SAND; FREQUENTLY FLOODED	6w	VI	4	5	5	5	5	5	4	4.8	4	7
49032	FELDA FINE SAND; DEPRESSIONAL	7w	VII	5	5	5	5	5	5	5	5.0	5	9
49033	MANATEE MUCKY FINE SAND; DEPRESSIONAL	7w	VII	5	5	5	5	5	5	5	5.0	5	9
49034	WAUCHULA FINE SAND	3w	III	1	5	5	5	5	5	4	4.8	4	4
49035	FARMTON FINE SAND	4w	IV	2	5	5	5	5	5	4	4.8	4	5
49036	KALIGA MUCK	7w	VII	5	5	5	5	5	5	5	5.0	5	9
49037	BASINGER FINE SAND DEPRESSIONAL	7w	VII	5	5	5	5	5	5	5	5.0	5	9
49038	ST. LUCIE FINE SAND	7s	VII	5	1	1	1	5	1	1	1.7	1	5
49039	BRADENTON LOAMY FINE SAND	3w	III	1	5	5	5	5	5	4	4.8	4	4
49099	Water	not assigned	not assigned	0	0	0	0	0	0	0	0.0	0	10
49991[8]	Haplaquents clay	7w	VII	5	5	5	5	5	5	5	5.0	5	9
49992[8]	Arents, nearly level and Arents, 0-5% slopes	6s	VI	4	3	3	3	5	5	1	3.3	3	6
49993[8]	Quartzipsamments, nearly level and Neilhurst sand, 0-5% slopes	6s	VI	4	2	2	2	5	5	4	3.3	3	6

[1] Mapunit Identification Symbol

[2] USDA Land Classification System Subclass

[3] USDA Land Capability System Class

[4] Agricultural Rating:
- 1 = LCC of 3
- 2 = LCC of 4
- 3 = LCC of 5
- 4 = LCC of 6
- 5 = LCC of 7

[5] Rating System for Drainage:
- 1 = Excessively drained and well drained
- 2 = Moderately well drained
- 3 = Somewhat poorly drained
- 4 = Poorly drained
- 5 = Very poorly drained

[6] Jenk's optimization (a statistical formula) was used within ArcView to partition the average values into classes separated by relatively large differences in the values

[7] Land Suitability Rating equals the sum of the agricultural rating plus the urban rating minus 1 with water and pits arbitrarily assigned a value of 10.

[8] These are provisional mapunit identification symbols assigned specifically for this study.