Pilot Scale Development of a Septic-to-Sewer Conversion Prioritization Tool Using Analytical Hierarchy Process, Phase II: Landscape Vulnerability & Phase III: Expansion

Task 8b: Phase III Final Report

DEP Agreement # AT020

For the Florida Department of Environmental Protection,

Office of Environmental Accountability and Transparency

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List of Abbreviations

Abbreviations	Definitions
AHP	Analytic Hierarchy Process
ArcNLET-Py	ArcGIS-based nitrogen load estimation toolbox developed using python for ArcGIS pro
BPJ	Best Professional Judgement
DEM	Digital Elevation Model
ERG	Ecohydrology Research Group
DEP	Florida Department of Environmental Protection
FEMA	Federal Emergency Management Agency
FGS	Florida Geological Survey
LANLoad	Landscape Assessment of Nutrient Loading to Waterbodies
NFHL	National Flood Hazard Layer
NHDPlus HR	National Hydrography Dataset Plus High Resolution
NRCS	Natural Resources Conservation Service
OEAT	Office of Environmental Accountability and Transparency
OSTDS	Onsite Sewage Treatment and Disposal System
SFWMD	South Florida Water Management District
SMEs	Subject Matter Experts
SSURGO	Soil Survey Geographic Database
USDA	United States Department of Agriculture
USF-ERG	University of South Florida Ecohydrology Research Group
USGS	United States Geological Survey
WCAVA	Wakulla County Aquifer Vulnerability Assessment

Table of Contents

Executive Summary

Onsite sewage treatment disposal systems (OSTDS) in Florida number approximately 2.6 million and serve roughly one-third of the population. Nutrient transport from these systems can lead to water quality degradation through excess nutrient loading to nearby surface waterbodies. The Florida Department of Environmental Protection (DEP, Department) has identified several factors influencing the impact of OSTDS drain fields on surface waterbodies, such as distance to surface waterbody, depth to groundwater, hydraulic conductivity, topography, and the density and age of OSTDS (DEP Agreement No. AT006). While a step in the correct direction, prioritizing these factors is essential for assessing the vulnerability of surface waterbodies to OSTDS and guiding initiatives like septic-to-sewer conversions and remediation plans.

In Phase I of this project (DEP Agreement No. AT015), the Department partnered with the University of South Florida Ecohydrology Research Group (USF-ERG) to develop an approach to map the landscape-scale risk of nutrient loading from OSTDS to surface waterbodies, piloting the approach in St. Lucie County, FL. The USF-ERG started with the top six physical landscape parameters identified in a previous workshop: distance to surface waterbody, depth to groundwater, hydraulic conductivity, potential for flooding, topography (slope), and depth to karst (DEP Agreement No. AT006). The Department and the USF-ERG then convened a subject-matter experts (SMEs) workshop (Phase I, DEP Agreement No. AT015) to conduct Analytic Hierarchy Process (AHP) analysis to determine the relative importance (weights) of each of the 6 parameters. An advantage of AHP is the ability to assess the internal consistency of SME responses through calculation of a consistency ratio. Models with consistency ratio values lower than 0.1 are considered internally consistent (R. W. Saaty, 1987). The consistency ratio of the relative weights assigned by SMEs to parameters was 0.01, indicating high internal consistency.

In Phase II of this project (Phase II, DEP Agreement No. AT020), the Department and the USF-ERG continued their collaboration to develop a pilot scale OSTDS vulnerability model using St. Lucie County as a pilot study area. The Phase II tasks included selecting representative geospatial datasets, defining and applying objective strategies to resolve dataset anomalies (e.g., slivers and missing data attributes), ranking within datasets, and constructing the final model. Once the model was complete, the USF-ERG performed a sensitivity analysis to investigate model response to changes in parameter weights and classification methods for ranking. The USF-ERG additionally evaluated the model by comparison to output from two independent assessment methods, one which relies on a numerical nutrient loading model (ArcNLET), and one which relies on the best professional judgment of SMEs. The Phase II pilot scale model had a high degree of concurrence (80%) with both evaluation methods. The name of the model was updated to "Landscape Assessment of Nutrient Loading to Waterbodies" (LANLoad) to reflect the versatility of the model output. It is not limited to OSTDS considerations but could additionally be used to support management decisions regarding other activities involving nutrient application to the landscape.

In Phase III, the USF-ERG expanded LANLoad to two study areas: the region defined by the Northern Everglades and Estuaries Protection Program (NEEPP), and Wakulla County. The NEEPP study area partially overlaps with the Phase II LANLoad Pilot Study area (St. Lucie County) thus, expansion of LANLoad to NEEPP was expected to be relatively straightforward. In

contrast, LANLoad had not previously been developed in a springs region of Florida, and the expansion to Wakulla County was a pilot study. The primary objective of the pilot study was to determine whether LANLoad could be applied to springs regions "as is" with minor regionalization, or whether it would be necessary to revisit the underlying parameters to enhance sensitivity to surface waters originating as springs.

Phase III consists of the following tasks:
- Task 5: Review Phase II Evaluation, Obtain and Review Phase III Datasets
- Task 6: Product Development and Review
- Task 7: Evaluation
- Task 8: Final Report and Geodatabase

The deliverables associated with Tasks 5-7 consist of three interim reports which have been updated and included as Sections in The Final Report (this document). Additional deliverables, not included in this document, include the LANLoad geodatabases developed for each study area, meeting notes and slides, and travel documentation.

The USF-ERG evaluated the consistency of the Phase III LANLoad output for NEEPP (Figure 1) to output generated by two independent methods, a Python-based version of ArcNLET, ArcNLET-Py, and the best professional judgement of SMEs from the private, public, and academic sectors. Both methods were conducted on study area locations chosen through a stratified sampling and both were conducted blind, i.e., neither those modelling nutrient loads using ArcNLET-Py nor SMEs had access to output generated by LANLoad. There was 100% consistency between ArcNLET-PY and LANLoad and 92% consistency between SMEs and LANLoad in the NEEPP study area.

The USF-ERG evaluated the consistency of the Phase III LANLoad output for Wakulla (Figure 2) to output generated by the Wakulla County Aquifer Vulnerability Assessment (WCAVA). WCAVA was selected for this evaluation because ArcNLET has not been successfully tested in springs regions (M. Ye, per, comm), and WCAVA is the only available county-wide model specifically focused on water quality vulnerability related to nutrient pollution. WCAVA was developed by the Department (Florida Geological Survey) to identify regions where nutrient additions could compromise water quality in aquifers. There was low concurrence between the LANLoad-Wakulla and WCAVA, highlighting that although both models work well, they are designed to answer different questions. WCAVA is designed to detect locations where an underlying aquifer is vulnerable to nutrient input whereas LANLoad, as currently formatted, is designed to determine the likelihood nutrient addition would be transported to nearby surface waterbodies. Approaches to modify LANLoad to enhance sensitivity to surface waters originating as springs could include changes to the parameter selection, parameter weights, and/or selection of alternative geospatial datasets to represent the parameters.

Individual summaries by study area are provided below. The remaining sections of this document contain detailed reports of the methods and results of each task.

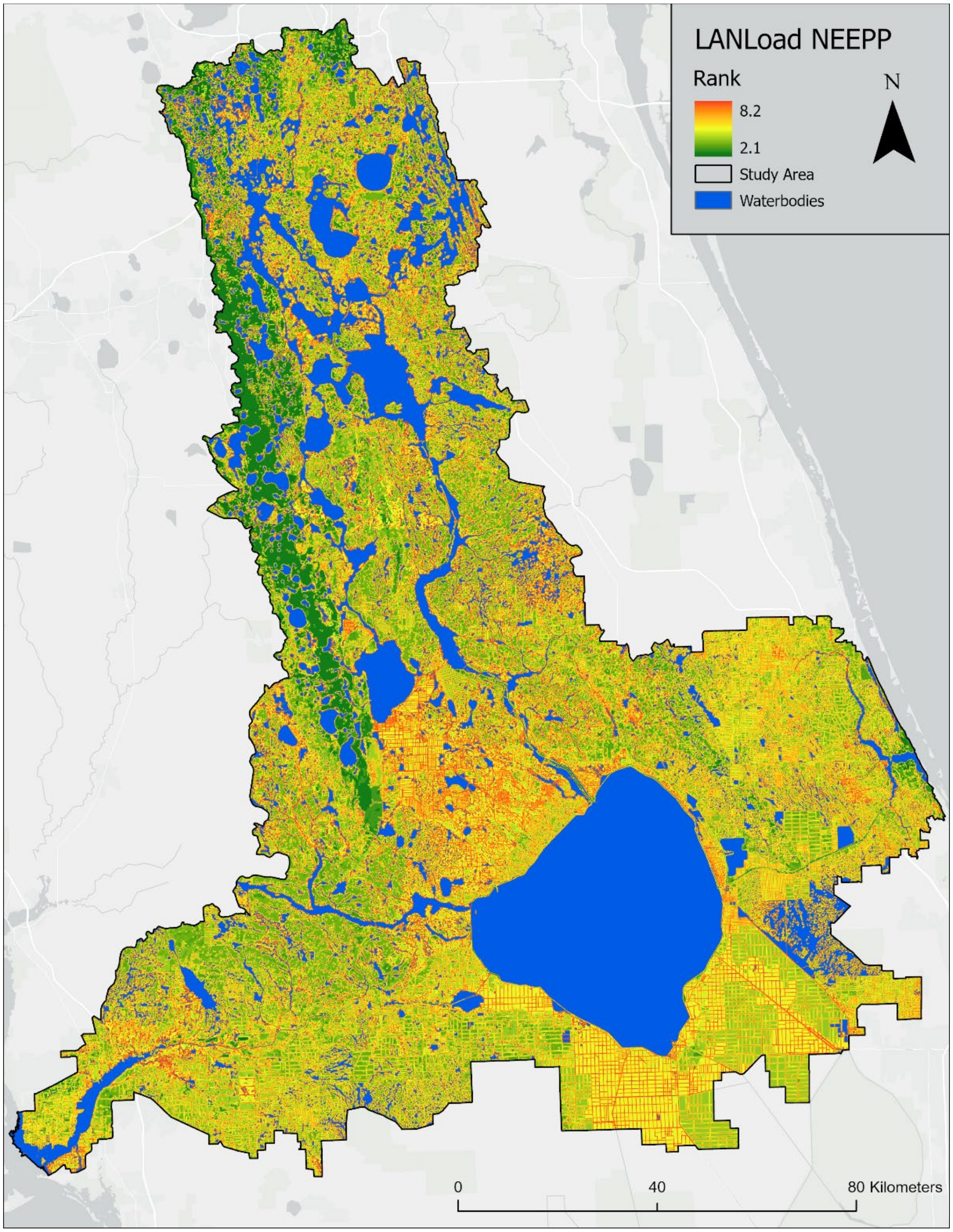

Figure 1. Landscape Assessment of Nutrient Loading to Waterbodies (LANLoad) model developed for the Northern Everglades and estuaries Protection Program (NEEPP)

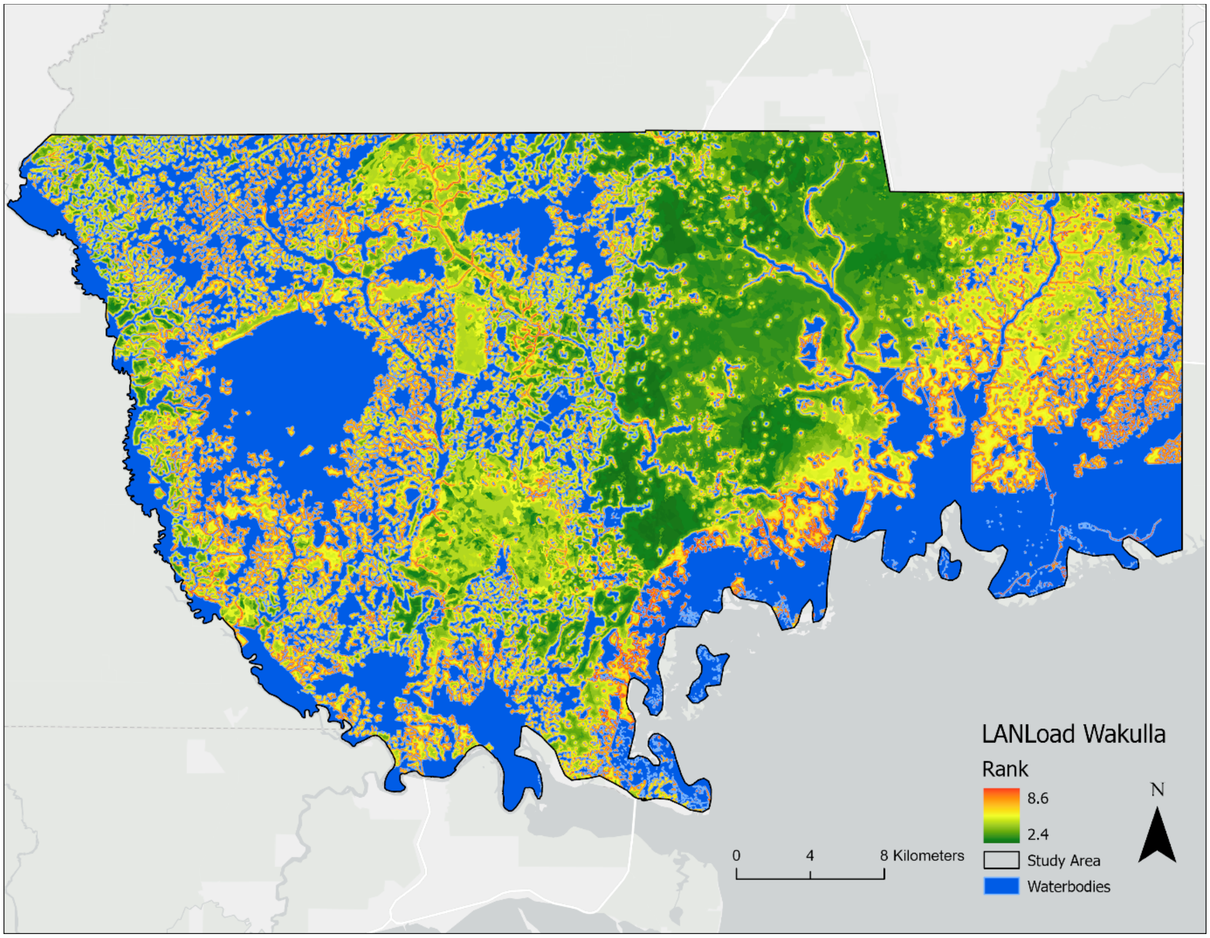

Figure 2. Landscape Assessment of Nutrient Loading to Waterbodies (LANLoad) model developed for Wakulla County

Summary by Study Area

Northern Everglades and Estuaries Protection Program (NEEPP)

Task 5 Summary for NEEPP: Review Phase II Evaluation, Obtain and Review Phase III Datasets

In Phase III, the LANLoad model developed in the Northern Everglades and Estuaries Protection Program (NEEPP) was evaluated (Task 7) using the same general two-part workflow implemented in the Phase II LANLoad Pilot Study. In brief, the categories assigned by LANLoad at locations (evaluation polygons) are compared to those predicted by two independent methods, 1) modeled groundwater nutrient loading (ArcNLET) and 2) SMEs assessment based on best professional judgement. In the first part of Phase III Task 5, the USF-ERG reviewed the results of the Phase II evaluation to determine whether there were trends in the results that pointed to practicable modifications that should be made to LANLoad, to the evaluation design, or to the evaluation instructions to improve the Phase III evaluation process.

The review of the Phase II evaluation of ArcNLET and LANLoad focused on the two polygons assigned to different categories by ArcNLET and LANLoad. In addition to the intended differences in the physical properties of the polygons, there were differences in the design of the evaluation polygons that made interpretation of the evaluation results unclear. This analysis of the Phase II evaluation highlighted the importance of maintaining consistent both the size of subsampled evaluation locations (polygons) and the density of hypothetical nutrient point sources when the evaluation is based on a *relative* categorization of evaluation polygons. In Phase III, polygons had a uniform size, shape, and density of hypothetical nutrient points to facilitate interpretation of the results.

The review of the Phase II evaluation of SMEs and LANLoad revealed significant inconsistencies between SME B and SME D with LANLoad output, agreeing with Phase II LANLoad classifications only 60% and 33% of the time, respectively and frequently disagreeing with classifications made by other SMEs. During this review, the USF-ERG learned these discrepancies may have stemmed from differing assumptions about the importance of natural versus engineered water features and varied interpretations of nutrient fate processes, such as denitrification near wetlands or in shallow groundwater areas. However, the USF-ERG also learned SMEs may have experienced a technical issue with rendering the waterbodies layer in Survey123 during Phase II that may have influenced their results. In Phase III, instructions provided to SMEs were clarified, and the rendering issue was resolved by simplifying the waterbodies layer to improve pan and zoom performance.

In the second part of Task 5, the USF-ERG acquired and reviewed geospatial datasets, resolving spatial anomalies and other attributes in preparation for Task 6. This review indicated that core methodologies from Phase II remained sound, but updates would improve data quality and operational performance. The raster resolution was adjusted from 2.5 ft to 10 m to better match the scale of foundational datasets such as the Florida NHD and SSURGO soils, following NRCS recommendations and the scale-resolution principles relationship (Tobler 1987). Two spatial analysis procedures were also refined: slope and distance to waterbodies are now calculated using downslope-only features, by incorporating surface elevation into the analysis.

<u>Task 6 Summary for NEEPP: Product Development and Review</u>

The USF-ERG updated the Phase II LANLoad Pilot Study classification system and data ranges to reflect the underlying datasets corresponding to the NEEPP region, culminating in development of Phase III LANLoad NEEPP (Figure 1).

LANLoad NEEPP was developed using a consistent set of input parameters, datasets, and data sources, as described in Task 5. Although the underlying methodology and model structure remained the same, differences in internal data rankings were necessary to accurately reflect local conditions. For example, there are flood zones uniquely present in NEEPP. However, the weights assigned to each parameter, as well as the underlying methodology, internal logic, and model structure are consistent from Phase II to Phase III.

Task 7 Summary for NEEPP: Evaluation

In the NEEPP, LANLoad was assessed using the same general approaches applied in Phase II, with some modifications to the evaluation procedure as described in Task 5. Subsample locations (evaluation polygons) were selected through stratified random sampling and the evaluations were conducted blind, i.e., participants did not have access to LANLoad output. In the first approach, groundwater nutrient loading to surface waterbodies was modeled from a total of 500 hypothetical nutrient sources (50 in each of ten evaluation polygons) using ArcNLET-Py, an updated version of ArcNLET based on Python programming (Mao et al., 2024a). The modelled nutrient loads were summed by polygon and used to sort polygons into two groups reflecting the relative likelihood (higher versus lower likelihood) that nutrients applied to the locations delineated by the evaluation polygons would be transferred to surface waters. In the second approach, SMEs categorized locations by relative likelihood based on best professional judgement. Project SMEs are professionals from private, government, and academic sectors.

The evaluation results indicate a 100% consistency between Phase III LANLoad and ArcNLET-Py rankings and a 92% consistency between Phase III LANLoad and SMEs rankings. This is an increase in consistency over the results of the Phase II LANLoad Pilot Study evaluation conducted in Phase II Task 3, which demonstrated 80% consistency between Phase II LANLoad Pilot Study and ArcNLET or SMEs rankings in the pilot study area. The higher consistency in Phase III may have resulted from a combination of updates made to LANLoad (Tasks 5 and 6) during Phase III, such as an increase in raster cell size, and improvements in the evaluation process discussed in Task 5.

Springs Region Pilot Study area (Wakulla County)

Task 5 Summary for Springs Region Pilot Study: Obtain and Review Phase III Datasets

In Phase III, the USF-ERG acquired and reviewed geospatial datasets, resolving spatial anomalies and other attributes in preparation for Task 6. This review indicated that core methodologies from Phase II remained sound, but updates would improve data quality and operational performance. The raster resolution was adjusted from 2.5 ft to 10 m to better match the scale of foundational datasets such as the Florida NHD and SSURGO soils, following NRCS recommendations and the scale-resolution principles relationship (Tobler 1987). Two spatial analysis procedures were also refined: slope and distance to surface waterbodies are now calculated using downslope-only features, by incorporating surface elevation into the analysis.

Task 6 Summary for Springs Region Pilot Study: Product Development and Review

The USF-ERG updated the Phase II LANLoad Pilot Study classification system and data ranges to reflect the underlying datasets corresponding to the Springs Region Pilot Study area (Wakulla County), culminating in development of Phase III LANLoad for Wakulla County (Figure 2).

LANLoad Wakulla County was developed using a consistent set of input parameters, datasets, and data sources, as described in Task 5. Although the underlying methodology and model structure remained the same, differences in internal data rankings were necessary to accurately reflect local conditions. For example, there are surficial geology deposits uniquely present in Wakulla County.

However, the weights assigned to each parameter, as well as the underlying methodology, internal logic, and model structure are consistent from Phase II to Phase III and between the two Phase III study areas.

Task 7 Summary for Springs Region Pilot Study: Evaluation

The LANLoad model was evaluated by comparison to output provided by the Wakulla County Aquifer Vulnerability Assessment (WCAVA), a GIS-based model developed to identify areas where the Floridan Aquifer System is most vulnerable to surface contamination (Baker et al., 2009). The WCAVA model output scores the aquifer as highly vulnerable in regions of Wakulla County where springs commonly occur. The intent of the comparison of LANLoad with WCAVA was to determine whether modifications would be necessary to LANLoad to enhance sensitivity near springs.

LANLoad and WCAVA had low consistency, demonstrating that modifications to the LANLoad structure, such as re-evaluating parameters or re-weighting parameters, would be required if the user expects landscapes characterized by a high frequency of springs to be ranked as more highly likely to convey nutrients to surface waters.

Overall Limitations and Other Considerations

The LANLoad model was developed and applied in two distinct regions of Florida: the NEEPP region and Wakulla County. In the NEEPP region, evaluation results indicate that LANLoad is performing very well, demonstrating strong consistency with two independent lines of evidence: modeled nutrient loads from ArcNLET-Py and SME BPJ. These findings suggest that LANLoad is functioning as intended and is suitable for expansion into other regions of Florida with similar hydrologic and geologic conditions.

In Wakulla County, LANLoad's performance was also considered in the context of a comparison with the Wakulla County Aquifer Vulnerability Assessment (WCAVA). Although this comparison revealed limited agreement between the two models, it is important to underscore that LANLoad is designed to estimate the likelihood of nutrient loading to surface waterbodies, whereas WCAVA focuses on aquifer vulnerability. These models were developed to answer fundamentally different questions. Therefore, the lack of alignment is not necessarily indicative of poor performance, but rather a reflection of the differing objectives of the two tools.

Beyond conceptual refinements, several broader considerations and limitations should be noted. First, while LANLoad has been evaluated through comparisons with other models and SMEs best professional judgement, and those evaluations suggest strong consistency, it has not yet been validated against field-based measurements. As such, model results should be interpreted as screening-level indicators rather than definitive predictions. This is consistent with the intended use of LANLoad as a landscape-scale planning and prioritization tool.

Second, the model's performance is inherently dependent on the quality and completeness of the underlying datasets. For example, the surface waterbodies layer is central to LANLoad's function, yet gaps remain in existing hydrography data particularly when representing small water features.

Similarly, the FEMA flood hazard layer, while representing the most comprehensive landscape-scale flood data available, varies considerably in coverage and level of detail across Florida.

Despite these limitations, LANLoad performs well and provides valuable insight at the regional scale. It serves as a useful screening and planning tool to support water resource management and identify areas of concern. Continued refinement of the model, guided by feedback from SMEs and comparison with emerging datasets, will further enhance its utility across diverse regions of Florida.

Task 5: Review Phase II Evaluation, Obtain and Review Phase III Datasets

This section of the report is divided into two subsections: (1) Review of the Phase II Evaluation Process and (2) Geospatial Datasets Selection and Review.

Review of the Phase II Evaluation Process

Phase II Evaluation Review: Overview

In Phase III, the LANLoad model developed in the Northern Everglades and Estuaries Protection Program (NEEPP) will be evaluated (Task 7) using the same general two-part workflow implemented in the Phase II LANLoad Pilot Study. In brief, the categories assigned by LANLoad at locations (polygons) within the pilot study area were compared to those predicted by two independent methods, 1) modeled groundwater nutrient loading (ArcNLET) and 2) subject matter expert (SMEs) assessment based on best professional judgement. For both methods, the USF-ERG used a stratified random approach to select evaluation polygons and the procedures were conducted blind, i.e., neither ArcNLET modelers nor SMEs had knowledge of the categories assigned to evaluation polygons by LANLoad.

During initial review of the Phase II SMEs evaluation results, the USF-ERG detected a pattern in the responses of two SMEs that suggested they may have experienced technical issues during the test or misunderstood the instructions. This observation motivated a review of the Phase II evaluation, including both the SMEs and ArcNLET evaluations. The goal of this review was to determine whether there were trends in the Phase II LANLoad Pilot Study evaluation results that point to practicable modifications that should be made to LANLoad, to the evaluation design, or to the evaluation instructions.

The methods and results of this review are documented in this section.

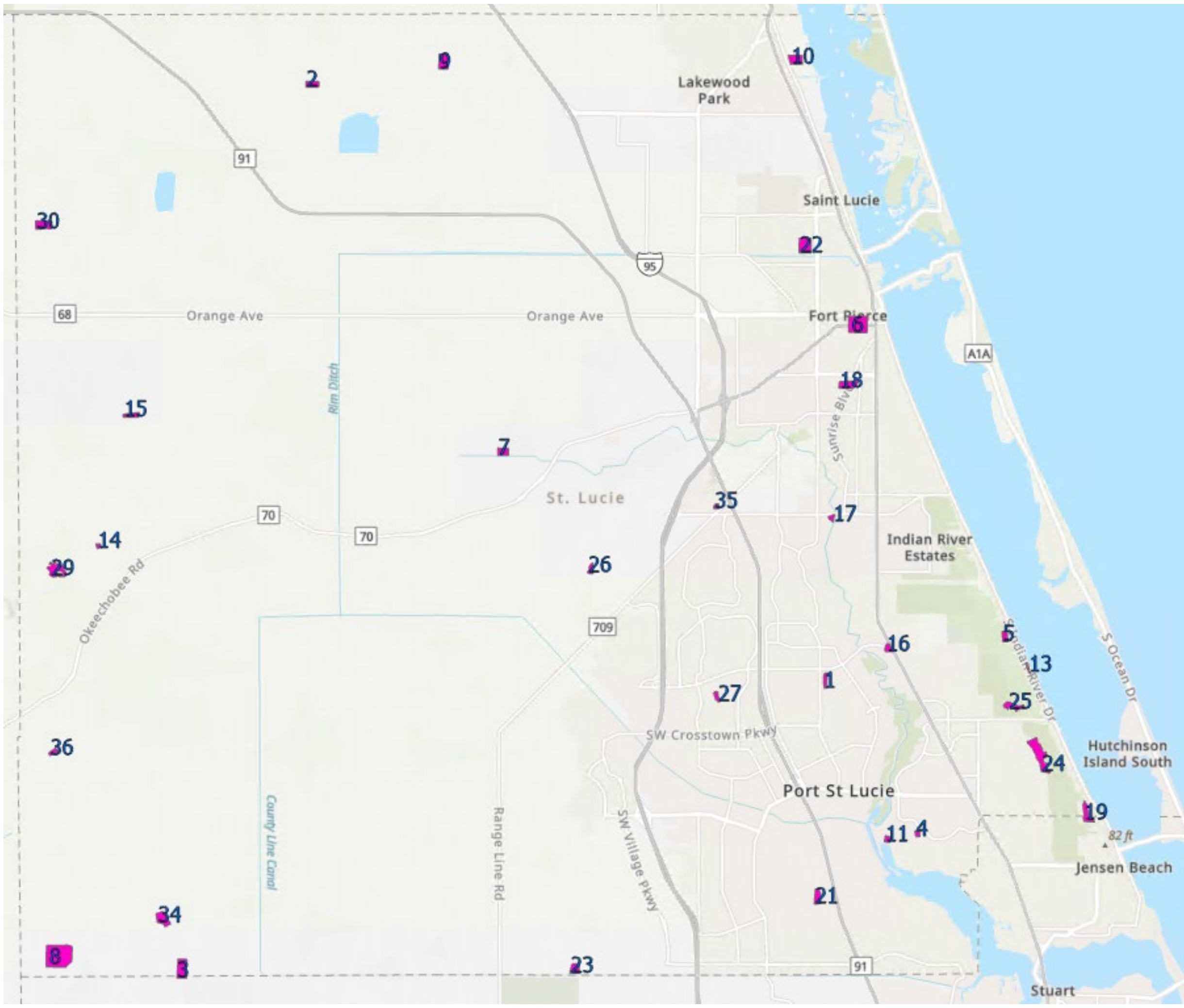

Figure 3. Distribution of the 30 evaluation polygons used for the Phase II LANLoad Pilot Study (St Lucie County) evaluation. The number next to each polygon corresponds to the polygon ID number. Note the variable sizes of the polygons.

Phase II ArcNLET Evaluation Review

The categories assigned to two of the ten ArcNLET evaluation polygons differed depending on the model used. Using Phase II LANLoad, Polygon # 3 was assigned to a "low" category, indicating nutrients added at that location would have a low likelihood of reaching a waterbody, while Polygon #29 location was assigned to a "high" category (Figure 3, Table 1). In contrast, the ArcNLET-modeled nutrient loads reaching waterbodies were higher for Polygon #29 than for Polygon #3. Neither Phase II LANLoad nor ArcNLET results were based on field collected data, thus, neither model is conclusively more accurate than the other; nevertheless, the discrepancy warranted investigation.

The ArcNLET modelers based their categorization of the polygons on the sum of the modeled nutrient loads originating from hypothetical point sources within each polygon. The differences in the physical properties of the locations delineated by the polygons may have influenced the results of the two models differently. In this case, Polygon #3 has a higher average distance to waterbodies and a higher hydraulic conductivity than Polygon #29 (Table 1). The different categories assigned through Phase II LANLoad and ArcNLET may reflect inherent differences in the relative importance each model places on these parameters. This is the type of insight the evaluation was intended to uncover.

However, there were additional differences between the sizes of the polygons and the distribution of the hypothetical point sources within polygons that may have had an unexpected effect on the ArcNLET results. The final categorization of the polygons is a *relative* categorization, i.e., five of the ten evaluation polygons are ultimately assigned to the "higher" category and five to the "lower" category. Since the categorization is relative, extraneous differences between polygons could influence the final categorization. In the Phase II evaluation, Polygon #3 was smaller than Polygon #29 and had a higher density of hypothetical points of nutrient addition (Figure 4). These design differences, rather than the differences in the physical landscape properties, may have resulted in the discrepancy between categories assigned by Phase II LANLoad and by ArcNLET. This analysis resulted in a design change recommendation for the Phase III evaluation to facilitate interpretation of the results. In Phase III, the polygon size, shape, the density of the hypothetical nutrient source points within polygons was consistent across all evaluation polygons.

Table 1. Characteristics of two polygons with differing ArcNLET and Phase II LANLoad results.

Polygon Unique ID	Phase II LANLoad Category	ArcNLET Category	Average distance to water (m)	Average slope to waterbody (radians)	Average depth to water (cm)	Average hydraulic conductivity (um/s)	Percentage lithology	Percentage flood zone
3	Lower	Higher	370.65	0.03	178.39	176.69	Sand (100%)	X (100%)
29	Higher	Lower	41.38	0.17	13.52	47.91	Shells, sand, clay (100%)	X (100%)

a) b)

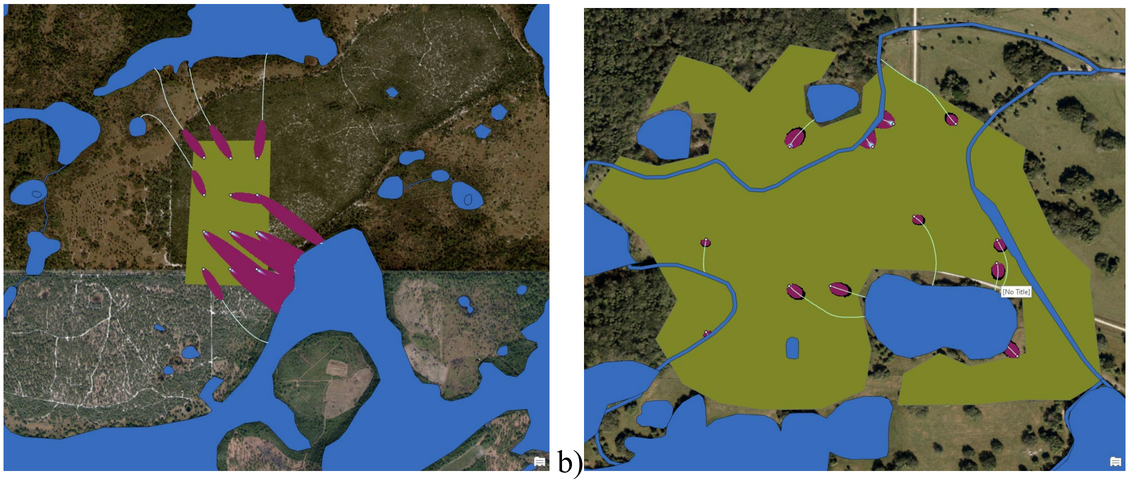

Figure 4. The relative size, point distribution, and modeled nutrient plumes for a) Polygon #3, b) Polygon # 29. The blue shading indicates the locations of waterbodies, the green shading indicates the extent of the polygons, and the purple ovals represent the nutrient plumes that are predicted to occur at each source point using ArcNLET. (Figure Source: Dr. Wei Mao, FSU)

Phase II Subject Matter Expert Evaluation Review

This review consisted of the following steps:

- Identification of SMEs whose categorization of polygons diverged from broader trends
- Targeted SME interviews
- Review of polygons to which ≥3 SMEs assigned a category different than that assigned by Phase II LANLoad
- Review of the geospatial data provided to SMEs during their evaluations
- Additional testing of the Survey 123 platform

Two of the seven SMEs provided responses that differed considerably from Phase II LANLoad and from responses provided by the other SMEs. The responses from SME B and SME D were 60% and 33% consistent with Phase II LANLoad, respectively (Table 2). Furthermore, the responses of these SMEs were only 60% and 33% consistent with responses provided by most of the SMEs for individual polygons (Tables 2 and 3). The USF-ERG conducted interviews with these SMEs to gain insight into the strategies they used to assign categories during the evaluation.

While Phase II LANLoad categorizes landscape location based on the likelihood that nutrients applied at that location will reach any mapped surface waterbody, SME B and D also considered the *type* of waterbody likely to be intercepted. Specifically, SME B prioritized the distance to waterbodies parameter more when the adjacent waterbody was natural, rather than artificial and often rated polygons lower if they were far from the Indian River Lagoon (IRL), regardless of the proximity of other waterbodies.

Table 2. Categories assigned by Phase II LANLoad and by SMEs reflecting the likelihood nutrients applied in these polygons would reach surface waters. Highlighting indicates instances in which responses provided by SME B and SME D differ from the majority of SMEs responses.

Polygon Unique ID	Phase II LANLoad	SME A	SME B	SME C	SME D	SME E	SME F	SME G
1	Lower	Lower	Higher	Lower	Higher	Lower	Higher	Lower
2	Lower	Higher	Lower	Lower	Lower	Lower	Lower	Lower
3	Lower	Lower	Higher	Lower	Higher	Lower	Lower	Lower
4	Lower	Lower	Higher	Lower	Lower	Lower	Lower	Lower
5	Lower	Lower	Higher	Lower	Higher	Lower	Lower	Lower
6	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower
7	Higher	Higher	Lower	Higher	Lower	Higher	Higher	Higher
8	Higher	Higher	Higher	Higher	Lower	Higher	Higher	Higher
9	Higher	Higher	Lower	Higher	Lower	Higher	Higher	Higher
10	Higher	Higher	Higher	Higher	Lower	Higher	Higher	Higher
11	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher
13	Higher	Lower	Higher	Lower	Higher	Higher	Lower	Higher
14	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Lower
15	Higher	Higher	Lower	Higher	Lower	Higher	Higher	Higher
16	Lower	Lower	Lower	Lower	Higher	Lower	Lower	Lower
17	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher
18	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower
19	Lower	Lower	Higher	Lower	Higher	Lower	Lower	Lower
21	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher
22	Lower	Lower	Higher	Lower	Higher	Lower	Lower	Lower
23	Higher	Higher	Lower	Higher	Higher	Higher	Higher	Higher
24	Higher	Higher	Higher	Higher	Lower	Higher	Higher	Higher
25	Higher	Lower	Higher	Higher	Lower	Higher	Higher	Higher
26	Lower	Lower	Lower	Lower	Higher	Lower	Lower	Lower
27	Higher	Higher	Higher	Higher	Lower	Higher	Higher	Higher
29	Higher	Higher	Lower	Higher	Lower	Higher	Higher	Higher
30	Higher	Higher	Lower	Higher	Lower	Lower	Higher	Higher
34	Lower	Lower	Lower	Lower	Higher	Lower	Lower	Lower
35	Lower	Lower	Lower	Lower	Higher	Lower	Lower	Lower
36	Lower	Lower	Lower	Lower	Higher	Lower	Lower	Lower
Consistency with LANLoad categorizations (%)		87	60	93	33	93	93	100

SME D prioritized the potential for denitrification when interpreting polygon distance to waterbodies and depth to groundwater. Whereas LANLoad treats all waterbodies equally, SME D considered nutrient addition to surface water containing wetlands to be less critical than nutrient addition to surface waters without wetlands. Similarly, SME D considered nutrients added to polygons with a shallow depth to groundwater to have a greater opportunity for denitrification and a lower likelihood of reaching surface waters.

However, additional testing of the online platform (Survey 123) revealed the waterbody spatial layer occasionally experienced a rendering delay. This may have unexpectedly affected SMEs perception of the distribution of waterbodies relative to polygons and affected their determination regarding whether a polygon belonged in the "higher" likelihood category versus the "lower" category. This issue makes it difficult to conclusively interpret the Phase II results but was addressed in Phase III by reducing the size of the waterbody spatial layer and by clearly instructing SMEs to categorize polygons while at a workstation with high internet speed.

There were four polygons to which ≥ 3 SMEs assigned a category that was different than that assigned by LANLoad. Despite these differences, for each of these polygons, the majority of the SMEs assigned the same category as did LANLoad (Table 3). There were no apparent patterns regarding the spatial distribution or landscape position that would explain the discrepancies between SMEs responses.

Table 3. Landscape position and categorization of the four polygons to which ≥ 3 SMEs assigned a category that differed from that assigned by LANLoad.

Polygon Unique ID	Description of Landscape	LANLoad Rank	SMEs Response Frequency	Majority SMEs Response
1	Urban	Lower	3 highs 4 lows	Lower
13	Houses next to IRL	Higher	4 highs 3 lows	Higher
14	Pasture	Lower	3 highs 4 lows	Lower
30	Old agriculture with canals	Higher	4 highs 3 lows	Higher

Phase II Evaluation Review Discussion

LANLoad Phase II included a final evaluation task in which polygons were assigned to a "higher" or "lower" category based on the likelihood that nutrients added at those locations would reach a waterbody. Polygons were categorized using three assessment methods: LANLoad, ArcNLET, and SMEs best professional judgement. None of these methods are based on field data collection, so this was not a validation. Rather, it was an *evaluation* of the consistency of LANLoad categories to those derived from two other common assessment methods.

During the evaluation, categories were assigned to polygons based on their properties *relative* to other evaluation polygons, making it important to minimize extraneous differences among polygons, such as the density of hypothetical nutrient addition points and the reliability of the waterbodies geospatial layer.

As a result of this analysis, the USF-ERG identified five recommendations to improve the evaluation procedure in Phase III:

1) Evaluation polygons should be uniform in size and shape.
2) The distribution of hypothetical nutrient addition points within polygons that form the basis of ArcNLET modeling should be uniform between polygons.
3) Instructions to SMEs should more clearly state SMEs should assess the relative likelihood of nutrients applied at locations within polygons to all waterbodies depicted in the waterbodies layer.
4) Instructions to SMEs should highlight the importance of conducting the online dataset review at a workstation with fast internet speed.
5) The extent of the surface water geospatial layer should be reduced so it renders more quickly after SMEs pan across geospatial datasets.

Phase III Geospatial Datasets Selection and Review

Phase III Geospatial Datasets Selection & Review: Overview

In this task, the USF-ERG acquired and reviewed the geospatial datasets corresponding to each Landscape Assessment of Nutrient Loading to Waterbodies (LANLoad) parameter, eliminated anomalies (e.g., slivers and missing values), and calculated the raw values that will be ranked and classified in Task 6.

The USF-ERG adhered to the dataset selection and acquisition guidelines established in Phase II LANLoad Pilot Study, reproduced below, to select and acquire datasets for the Phase III study areas. Consequently, the Phase III geospatial dataset sources are the same sources utilized in Phase II, with one exception. In Phase II, the USF-ERG sourced NHD datasets directly from the NHDPlus HR data website. However, the information on this website is no longer updated for the State of Florida. Upon recommendation from the Florida Department of Environmental Protection (DEP) (P. Maharaj, personal communication, November 5, 2024), the Florida NHD dataset was newly sourced from the DEP GIS website (Table 4).

> *Recommended Dataset Selection and Acquisition Guidelines (established in Phase II LANLoad Pilot Study):*
>
> - *Datasets should be acquired from primary sources. Exceptions may occur if the dataset from a secondary source has been enhanced and this enhancement would benefit the project. In all cases, the source and acquisition date should be documented.*
> - *Dataset selection priorities:*
>   - *Relevance: Datasets that reflect the parameters selected by SMEs (Phase 1, AT015).*
>   - *Coverage: Statewide preferred over local coverage.*
>   - *Longevity: Government sources preferred as these will likely be updated.*
>   - *Transparency: Datasets in widespread use, publicly available, and include metadata.*

Table 4. Acquisition details of Phase III geospatial datasets corresponding to parameters selected in Phase I. Dataset sources: Florida Department of Environmental Protection (DEP), National Resources Conservation Service (NRCS), South Florida Water Management District (SFWMD), Federal Emergency Management Agency (FEMA), and Florida Geological Survey (FGS).

<table>
<tr><th>Parameter</th><th>Geospatial Dataset</th><th>Source</th><th>Date Acquired</th></tr>
<tr><td rowspan="4">Waterbodies</td><td>Florida NHD Waterbody Polygons</td><td>DEP</td><td rowspan="3">11/8/2024</td></tr>
<tr><td>Florida NHD Area Polygons</td><td>DEP</td></tr>
<tr><td>Florida NHD Flowlines</td><td>DEP</td></tr>
<tr><td>Soil Survey Geographic Dataset (SSURGO)</td><td>NRCS</td><td>9/20/2024</td></tr>
<tr><td>Distance to Waterbodies</td><td>DEM + Waterbodies</td><td>SFWMD, USGS</td><td>9/24/2024</td></tr>
<tr><td>Depth to Groundwater</td><td>Soil Survey Geographic Dataset (SSURGO)</td><td>NRCS</td><td>9/20/2024</td></tr>
<tr><td>Hydraulic Conductivity</td><td>Soil Survey Geographic Dataset (SSURGO)</td><td>NRCS</td><td>9/20/2024</td></tr>
<tr><td>Potential for Flooding</td><td>National Flood Hazard Layer (NFHL)</td><td>FEMA</td><td>9/9/2024</td></tr>
<tr><td>Topography (slope)</td><td>DEM + Distance to Waterbodies</td><td>SFWMD, USGS, USF</td><td>9/24/2024</td></tr>
<tr><td>Surficial Karstic Deposits</td><td>Surficial Geology of Florida</td><td>FGS</td><td>9/16/2024</td></tr>
</table>

The USF-ERG used ArcGIS Pro 3.4.2 (ESRI) to review each dataset for anomalies and implemented procedures to “cleanse” each dataset. Those procedures are detailed below but were consistent with those used in similar situations in Phase II LANLoad Pilot Study. LANLoad requires accurate and complete input data for all terrestrial locations. If data for any parameter in any terrestrial location is inaccurate, the model will return a misleading value for that location; if data for any parameter in any terrestrial location is missing, the model will return a null value for that location. It should be noted that anomalies included within the boundaries of LANLoad Waterbodies are not problematic. LANLoad categorizes terrestrial landscapes based on the likelihood nutrients applied on land would be transferred to waterbodies. Thus, LANLoad Waterbody features themselves are not assigned to a likelihood category, and anomalies in other datasets that are located within LANLoad Waterbody features are removed from analysis.

The raster cell size in the Phase II LANLoad Pilot Study analyses was 2.5 x 2.5 ft, which corresponded to the regional LiDAR raster cell size. In Phase III, the USF-ERG increased the analysis raster cell size to 10 x 10 m to facilitate processing and to reflect the mapping scales of the multi-resolution Florida NHD and SSURGO datasets. SSURGO is natively a vector product with data collected at scales ranging from 1:12,000 to 1: 63,360 (A. Stumm (GIS Specialist & Soil Scientist NRCS), personal communication, January 17, 2025). The high-resolution Florida NHD is also a vector product and is based on a 1:24,000 mapping scale (Florida Department of

Environmental Protection, 2025). Given that the datasets range in mapping scales from 1:12,000 to 1:63,360, using a coarser raster resolution (i.e. 10 m) is appropriate, aligning with NRCS guidance (A. Stumm (GIS Specialist & Soil Scientist NRCS), personal communication, January 17, 2025) and supported by an authoritative resolution-scale relationship (Tobler 1987).

In Phase III, the USF-ERG updated the method used to calculate the distance between individual raster cells and waterbodies to restrict the analysis only to waterbodies lower in elevation than the raster cell under consideration. Specifically, the distance measurement was made from each raster cell centroid to the edge of the nearest downslope waterbody using the Distance Accumulation tool (ArcGIS Pro 3.4.2). In Phase II LANLoad Pilot Study, the pilot study area was very flat, and the method used to calculate the distance between individual raster cells and waterbodies was simply the shortest distance from each raster cell centroid to the edge of the nearest waterbody, without considering topographic location of the waterbody. The updated method is more appropriate for study areas with greater variation in elevation.

Additionally, the USF-ERG updated the method used to calculate the slope between individual raster cells and waterbodies. In Phase III, the analysis only includes waterbodies that are at a lower elevation than the raster cell being analyzed. Specifically, the slope was calculated by subtracting the elevation of the nearest downslope waterbody from the elevation at the raster cell centroid, then dividing this difference by the distance to that waterbody. In Phase II LANLoad Pilot Study, slope was calculated using the difference between each raster cell centroids elevation and the average elevation of natural waterbodies within each quarter-township. The updated method is more appropriate for study areas with greater variation in elevation.

The results of the dataset anomaly review, along with a comparison to the Phase II LANLoad Pilot Study procedures and outcomes, are discussed separately for each of the two Phase III study areas: Northern Everglades and Estuaries Protection Program (NEEPP) and Wakulla County. The ranges of raw values and corresponding categories for each parameter are also presented and compared to those observed in Phase II LANLoad Pilot Study (Table 5).

Table 5. Summary of Raw Value Ranges for Numeric Parameters in Phase II LANLoad Pilot Study and Phase III

Parameter	Raw Values, Phase II LANLoad Pilot Study	Raw Values, Phase III - NEEPP	Raw values, Phase III - Wakulla
Distance to Waterbodies (m)*	0.7 – 975	1 – 1912	0.5 – 1873
Depth to Groundwater (cm)	0 - 201	0 - 201	0 - 157
Hydraulic Conductivity (um/s)	10.35 – 244.7	9.2 - 247	18.5 – 230.4
Topography (slope) (radians)*	0 – 1.55	0 – 1.57	0 – 1.52

* The method used to calculate these parameters was different in Phase II LANLoad Pilot Study and Phase III; see text for details.

Phase III Geospatial Datasets Selection and Review Northern Everglades and Estuaries Protection Program (NEEPP)

NEEPP Waterbodies

The *NEEPP Waterbodies* geospatial dataset (Figure 5) is comprised of features from four source datasets (Table 4). The Florida NHD Flowlines were buffered by 10 m, and all features were merged into a single dataset. There were no anomalies in those underlying datasets.

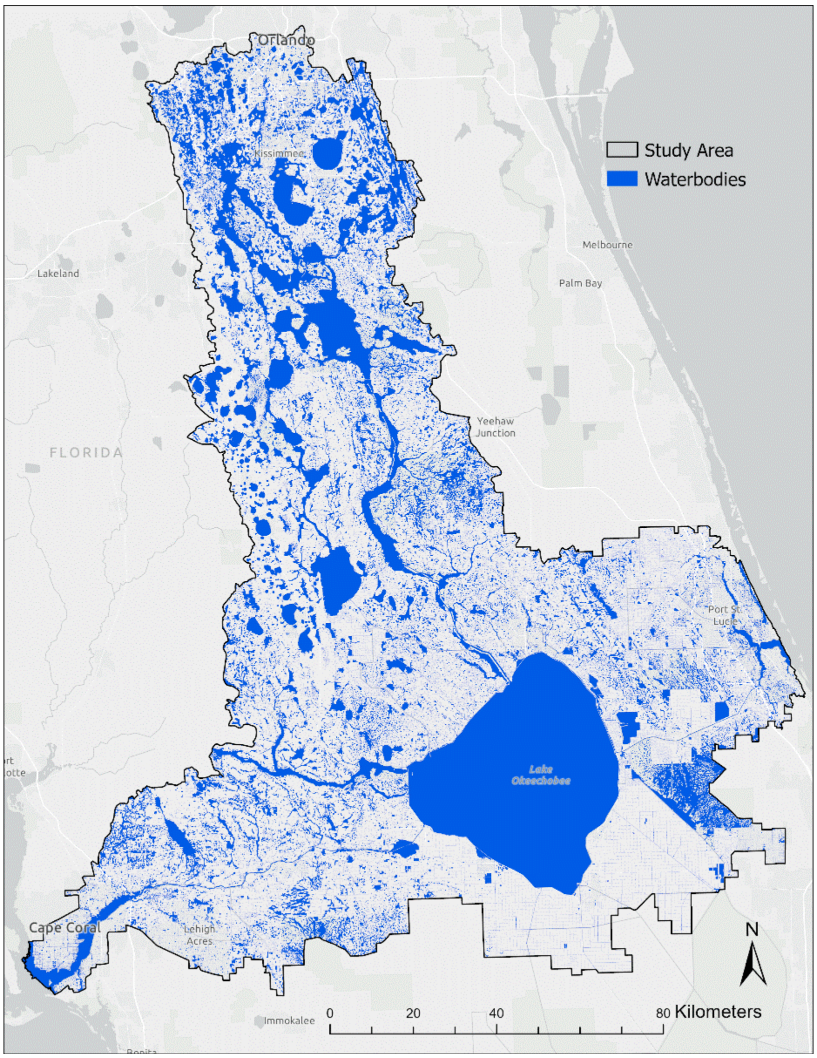

Figure 5. Distribution of Waterbodies in the NEEPP

Distance to Waterbodies

The source of the raw values used in the *Distance to Waterbodies* geospatial dataset (Figure 6) is the *NEEPP Waterbodies* geospatial dataset (Figure 5, Table 4).

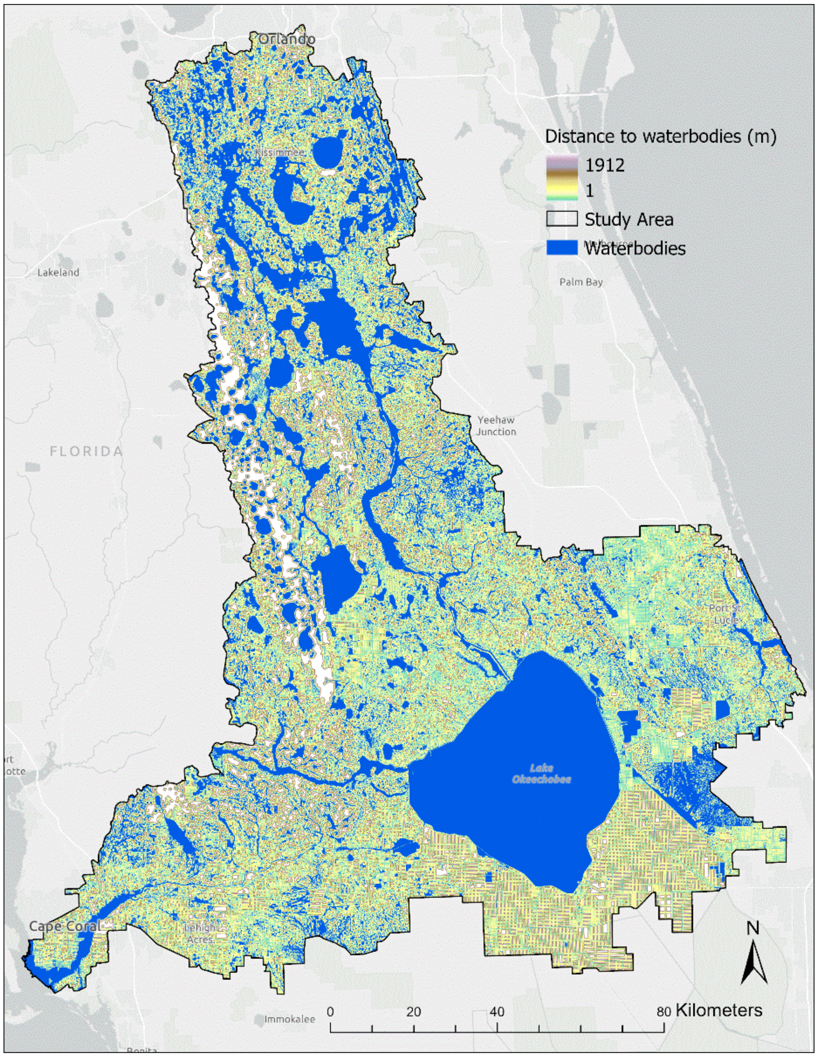

Figure 6. Distance to Waterbodies - NEEPP

Range in Raw Values, Distance to Waterbodies (m)

- Phase II LANLoad Pilot Study - St. Lucie County: 0 - 975
- Phase III - NEEPP: 0 - 1912

Depth to Groundwater

The source of the raw values used in the *Depth to Groundwater* geospatial dataset (Figure 7) is the attribute called "weighted average depth to water table" in SSURGO (Table 4).

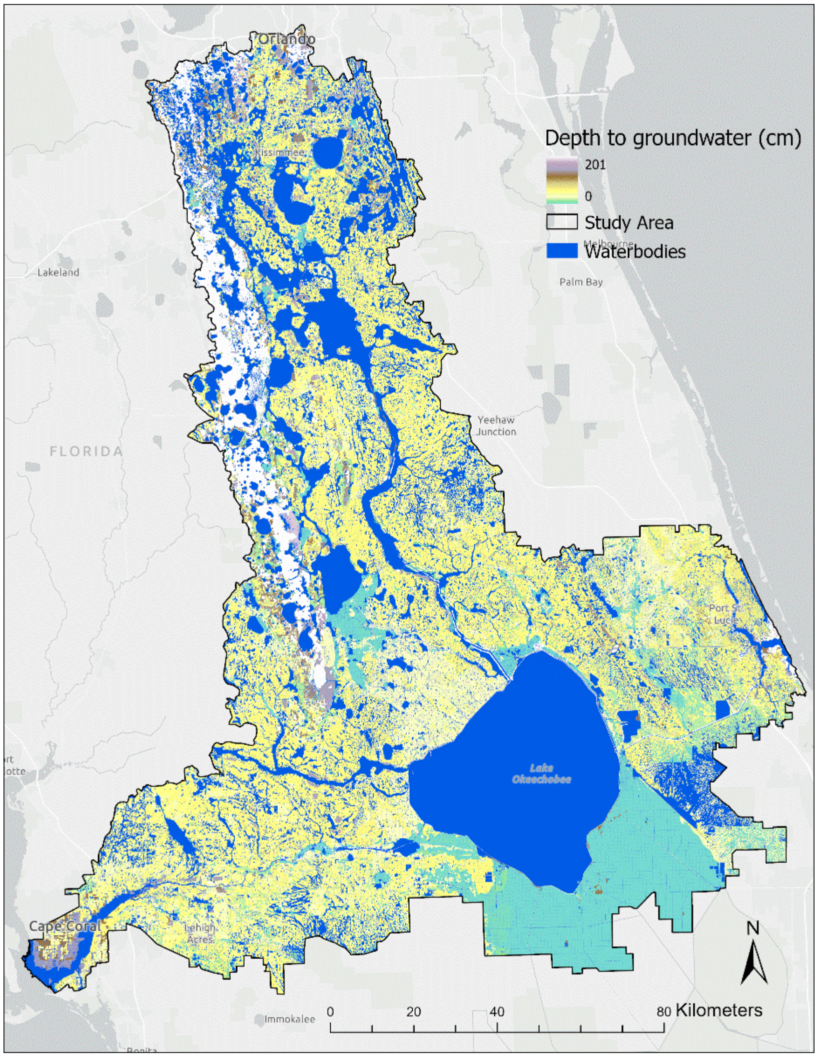

Figure 7. Raw values of Depth to Groundwater - NEEPP

The standard SSURGO "weighted average depth to water table" contained 3,272 Null values across 18 categories (Table 6) in the NEEPP study area. Most of the Null values (2,949) were associated with waterbodies and were therefore not a cause for concern (see "Overview"). The remaining null values included 16 map units and covered 0.5% of the NEEPP area (Table 6). The Web Soil Survey (Map Unit Description Reports, Soil Survey Staff, 2024) described the depth to water for 14 of the 16 map units as "more than 80 inches." The Web Soil Survey was updated in 2025 and newly provides depth to water table information for the remaining two units. This includes "Pits" which are newly assigned a depth to water table value of > 200cm (Soil Survey Staff 2025). According to soil survey manuscripts (e.g. Readle, 1979; Watts & Stankey, 1980), pits are not assigned a value that reflects the fact that the depth to water in these areas is ">200 cm."

However, for the sake of consistency, the value attributed by Soil Survey Staff (2025) was similarly adopted for Pits and a depth to water value of 201 cm (~ 80 inches) was assigned to the map units listed in Table 6.

Table 6. NEEPP - SSURGO map unit descriptions with missing depth to water table data (Soil Survey Staff, 2024). The revised depth to water values were assigned based on additional information in the Web Soil Survey (2025). Water-related units were excluded from revision as depth to water is not applicable.

SSURGO map unit description	Depth to water table as per Web Soil Survey	# of polygons with null depth to water values[1]	Depth to water assigned (cm)
Arents very steep	More than 80 inches	51	201
Arents, 45 to 65 percent slopes	More than 80 inches	18	201
Arents water complex	More than 80 inches	9	201
Apopka sand, 5 to 12 percent slopes	More than 80 inches	3	201
Candler sand, 12 to 40 percent slopes	More than 80 inches	9	201
Candler-Urban land complex, 0 to 5 percent slopes	More than 80 inches	11	201
Kendrick sand, 0 to 5 percent slopes	More than 80 inches	6	201
Kendrick sand, 5 to 8 percent slopes	More than 80 inches	3	201
Lake sand, 5 to 12 percent slopes	More than 80 inches	5	201
Lake sand, 0 to 5 percent slopes	More than 80 inches	13	201
Borrow pits	> 200 cm	2	201
Pits	> 200 cm	54	201
Quartzipsamments, shaped, 0 to 5 percent slopes	More than 80 inches	3	201
Udorthents excavated	More than 80 inches	69	201
'Udorthents, 0 to 35 percent slopes	More than 80 inches	36	201
'Udorthents, 2 to 35 percent slopes	More than 80 inches	31	201
Water	NA	2,948	Not applicable
Waters of the Gulf	NA	1	Not applicable

[1] The sum of the area of the terrestrial polygons (16 map units) is equal to 0.5% of the NEEPP area

Range in Raw Values, Depth to Groundwater (cm)

- Phase II LANLoad Pilot Study - St. Lucie County: 0 - 201
- Phase III - NEEPP: 0 - 201

Hydraulic Conductivity

The source of the raw values used in the *Hydraulic Conductivity* geospatial dataset (Figure 8) is the attribute called "weighted average hydraulic conductivity" in SSURGO (Table 4).

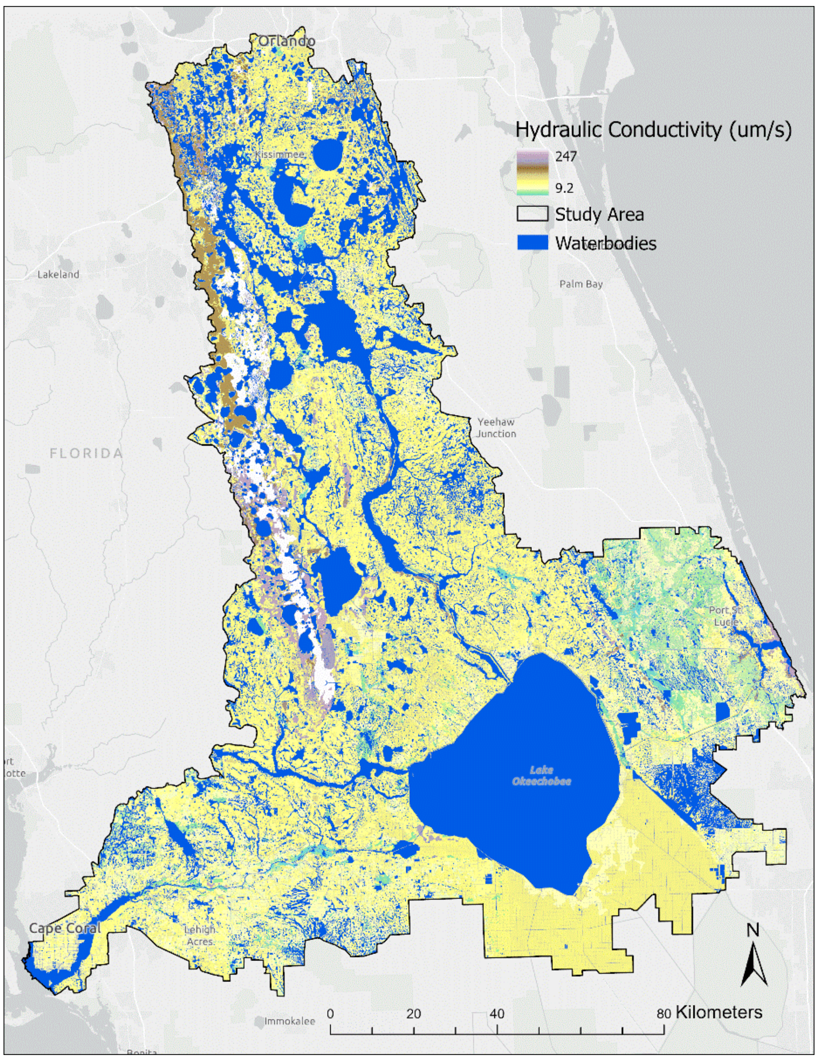

Figure 8. Raw values of Hydraulic Conductivity - NEEPP

The weighted average hydraulic conductivity contained 3,074 Null values distributed across five categories (Table 7). Most of the Null values were associated with categories representing "water" (2,949), which are handled separately in the model through the waterbodies layers and do not present a concern. The remaining Null values were comprised of small, scattered polygons across the study area and cover 0.02% of the total study area

Table 7. Map unit descriptions of polygons missing hydraulic conductivity values - NEEPP

SSURGO map unit description	# of polygons
Udorthents excavated	69
Borrow pits	2
Pits	54
Water	2,948
Water of the Gulf	1

The SSURGO Map Unit Description Reports associated with the remaining map units did not contain additional information related to hydraulic conductivity (Soil Survey Staff, 2025). Udorthents Excavated and Pits are described in the Map Unit Description Reports as associated with "human-altered and human-transported soils" (USDA, 2017). This description is consistent with the basemap imagery in NEEPP locations mapped as Udorthents Excavated or Pits. These map unit polygons are small, and because information on likely hydraulic conductivity was lacking, they were spatially merged with the adjoining map unit polygon that shared the longest border and assigned the corresponding hydraulic conductivity value. This is consistent with the protocol established in Phase II LANLoad Pilot Study.

Range in Raw Values, Depth to Waterbodies (µm/s)

- Phase II LANLoad Pilot Study - St. Lucie County: 10.35 - 244.7
- Phase III - NEEPP: 9.2 - 247

Potential for Flooding

The source of the raw values used in the *Potential for Flooding* geospatial dataset are the attributes called “Flood Zone” and “Flood Zone Subtype” in the National Flood Hazard Layer (Table 4). The NEEPP study area included one additional flood zone category, and two additional Flood Zone Subtypes for Flood Zone X, not identified in Phase II (Table 8). Additionally, this dataset included small sliver polygons within our study area. Each sliver polygon was merged with the adjacent polygon sharing the longest border.

Three polygons (3% of the study area) were classified in the original dataset as Flood Zone D, which is described as an “area with possible but undetermined flood hazards” (FEMA, 2025). Upon review, it was determined there was no discernible pattern related to this classification and elevation, or the presence of water features. Neither the Florida State Geographic Information Officer nor the Florida Chief Resilience Officer were aware of alternative statewide flood datasets. It was ultimately confirmed that the FEMA Flood Hazard Layer remains the only comprehensive product available (W. Brooks, personal communication, December 20, 2024). As a result, each

Flood Zone D polygon was assigned to the flood zone classification of the neighboring polygon with which it shares the longest boundary (Figure 9).

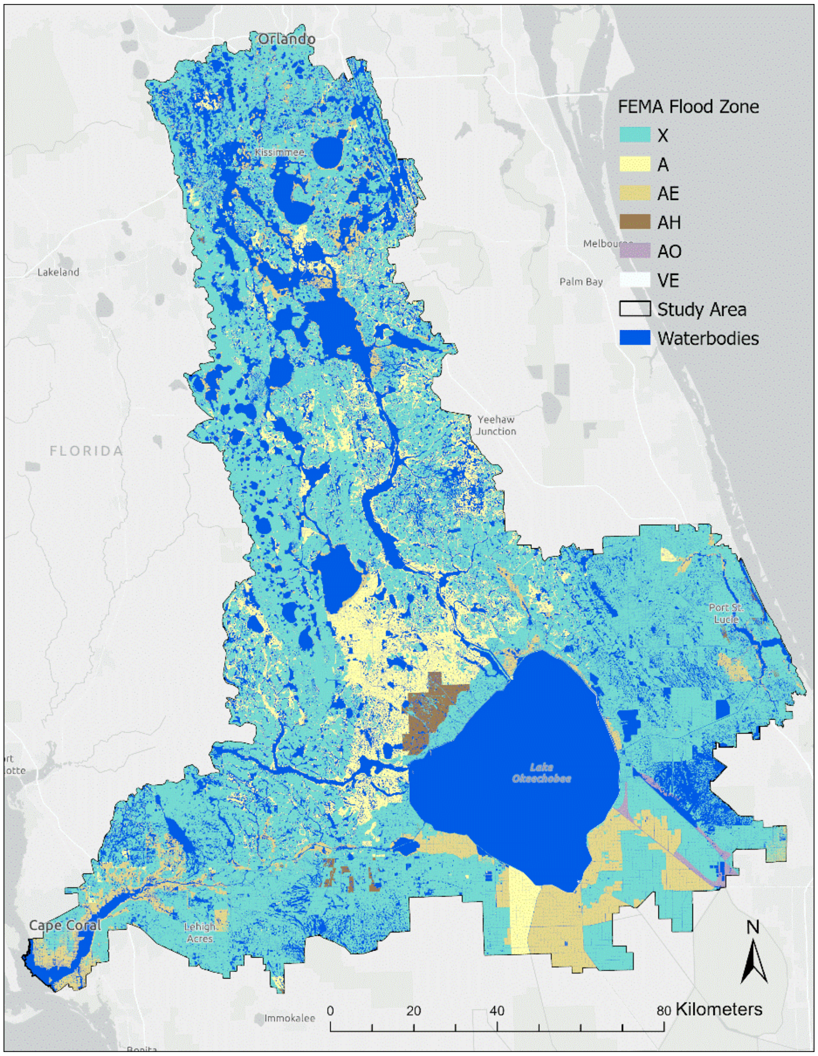

Figure 9. Raw values of FEMA Flood Hazard layer - NEEPP

Table 8. Flood Zones (FEMA) included in Phase II LANLoad Pilot Study and in Phase III - NEEPP

<table>
<tr><th colspan="2">Phase II LANLoad Pilot Study</th><th colspan="2">Phase III - NEEPP</th></tr>
<tr><th>Flood Zone</th><th>Flood Zone subtype</th><th>Flood Zone</th><th>Flood Zone subtype</th></tr>
<tr><td rowspan="4">X</td><td rowspan="2">0.2 PCT Annual chance flood hazard</td><td rowspan="4">X</td><td>0.2 PCT Annual chance flood hazard</td></tr>
<tr><td>1 PCT Depth less than 1 foot</td></tr>
<tr><td rowspan="2">Area of minimal flood hazard</td><td>Area with reduced flood risk due to levee</td></tr>
<tr><td>Area of minimal flood hazard</td></tr>
<tr><td>A</td><td>1 PCT Annual chance flood hazard</td><td>A</td><td>1 PCT Annual chance flood hazard</td></tr>
<tr><td rowspan="2">AE</td><td>1 PCT Annual chance flood hazard</td><td rowspan="2">AE</td><td>1 PCT Annual chance flood hazard</td></tr>
<tr><td>Regulatory Floodway</td><td>Regulatory Floodway</td></tr>
<tr><td>AH</td><td>1 PCT Annual chance flood hazard</td><td>AH</td><td>1 PCT Annual chance flood hazard</td></tr>
<tr><td>AO</td><td>1 PCT Annual chance flood hazard</td><td>AO</td><td>1 PCT Annual chance flood hazard</td></tr>
<tr><td>VE</td><td>1 PCT Annual chance flood hazard</td><td>VE</td><td>1 PCT Annual chance flood hazard</td></tr>
<tr><td></td><td></td><td>D</td><td>Area with possible but undetermined flood hazards</td></tr>
</table>

Slope

The sources of the raw values used in the *Slope* geospatial dataset (Figure 10) are the *LiDAR derived DEM* and the *Distance to Waterbodies* geospatial dataset (Figure 6, Table 4). There were no anomalies in these datasets.

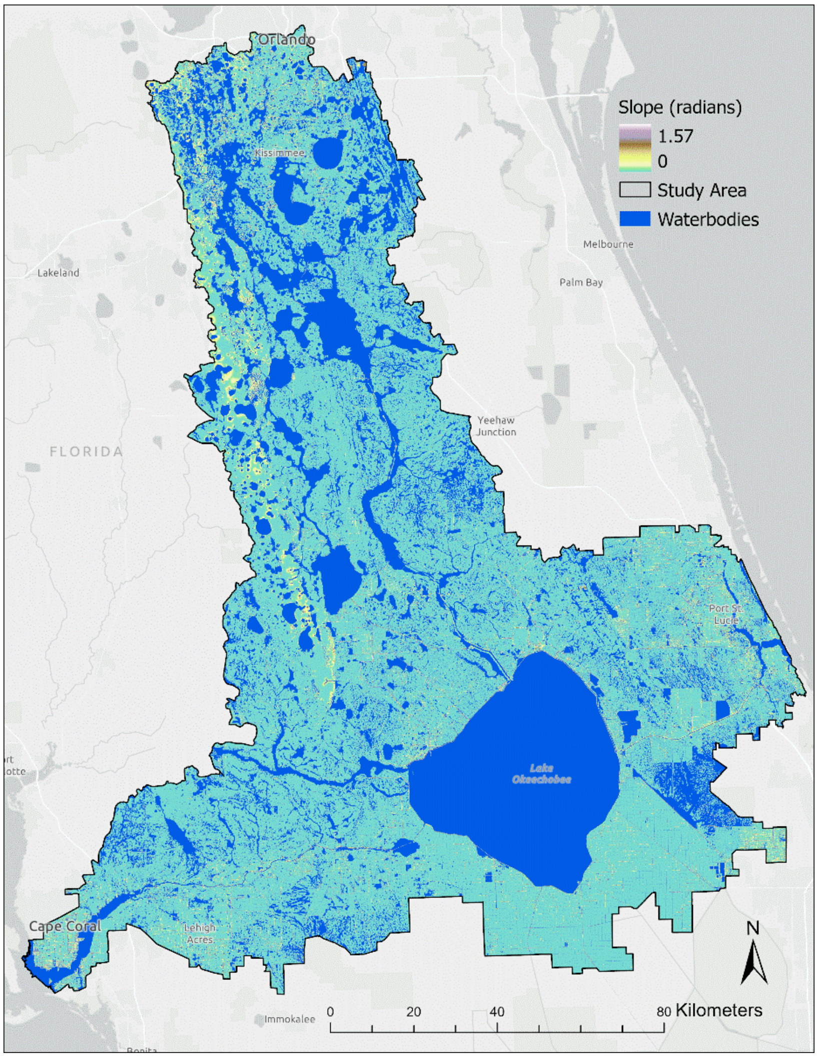

Figure 10. Raw values of Slope - NEEPP

Range in Raw Values, Slope (radians)

- Phase II LANLoad Pilot Study - St. Lucie County: 0 - 1.55
- Phase III - NEEPP: 0 - 1.57

Surficial Karstic Deposits

The source of the raw values used in the *Surficial Karstic Deposits* geospatial dataset (Figure 11) is the attribute called "Lithology" in the Surficial Geology of Florida (Table 4). Additionally, this dataset contained sliver polygons within our study area. These sliver polygons were each merged with the adjacent polygon sharing the longest border.

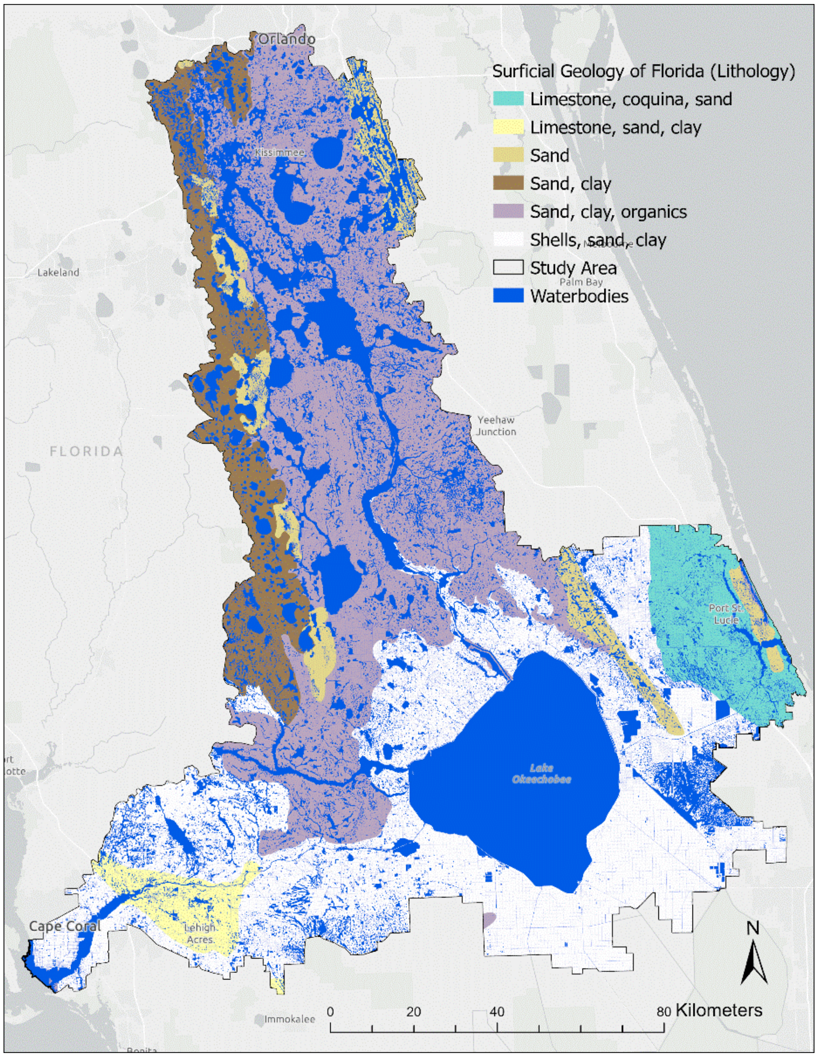

Figure 11. Raw values of Surficial Geology of Florida (Lithology) - NEEPP

The Professional Geologist Administrator (Alan Baker, P.G.) at the Florida Geological Survey confirmed the Surficial Geology of Florida dataset is the most suitable representation of surficial karstic deposits for these purposes. The NEEPP study area includes six distinct mapping units and contains one new surficial karstic deposit unit that was not present in the Phase II LANLoad Pilot Study area (Table 9).

Table 9. Surficial Geology included in Phase II LANLoad Pilot Study and in Phase III - NEEPP

Phase II LANLoad Pilot Study				**Phase III - NEEPP**	
Geologic Unit	Lithology	Geologic History	Geologic Unit	Lithology	Geologic History
Anastasia Formation	Limestone, coquina, sand	Pleistocene	Anastasia Formation	Limestone, coquina, sand	Pleistocene
			Tamiami Formation	Limestone, sand, clay	Pliocene
Beach ridge and dune	Sand	Pleistocene/Holocene	Beach ridge and dune; Dunes	Sand	Pleistocene/Holocene; Pliocene/Pleistocene
			Cypresshead Formation; Reworked Cypresshead sediments	Sand, clay	Pliocene; Pliocene/Pleistocene
Holocene sediments; Undifferentiated sediments	Sand, clay, organics	Holocene; Pleistocene/Holocene	Holocene sediments; Undifferentiated sediments	Sand, clay, organics	Holocene; Pleistocene/Holocene
Shelly sediments of Plio-Pleistocene age	Shells, sand, clay	Pliocene/Pleistocene	Shelly sediments of Plio-Pleistocene age	Shells, sand, clay	Pliocene/Pleistocene

Phase III Geospatial Datasets Selection and Review Springs Region Pilot Study (Wakulla County)

Wakulla County Waterbodies

The *Wakulla County Waterbodies* geospatial dataset (Figure 12) is comprised of features from four source datasets (Table 4). The Florida NHD Flowlines were buffered by 10 m, and all features were merged into a single dataset. There were no anomalies in those underlying datasets.

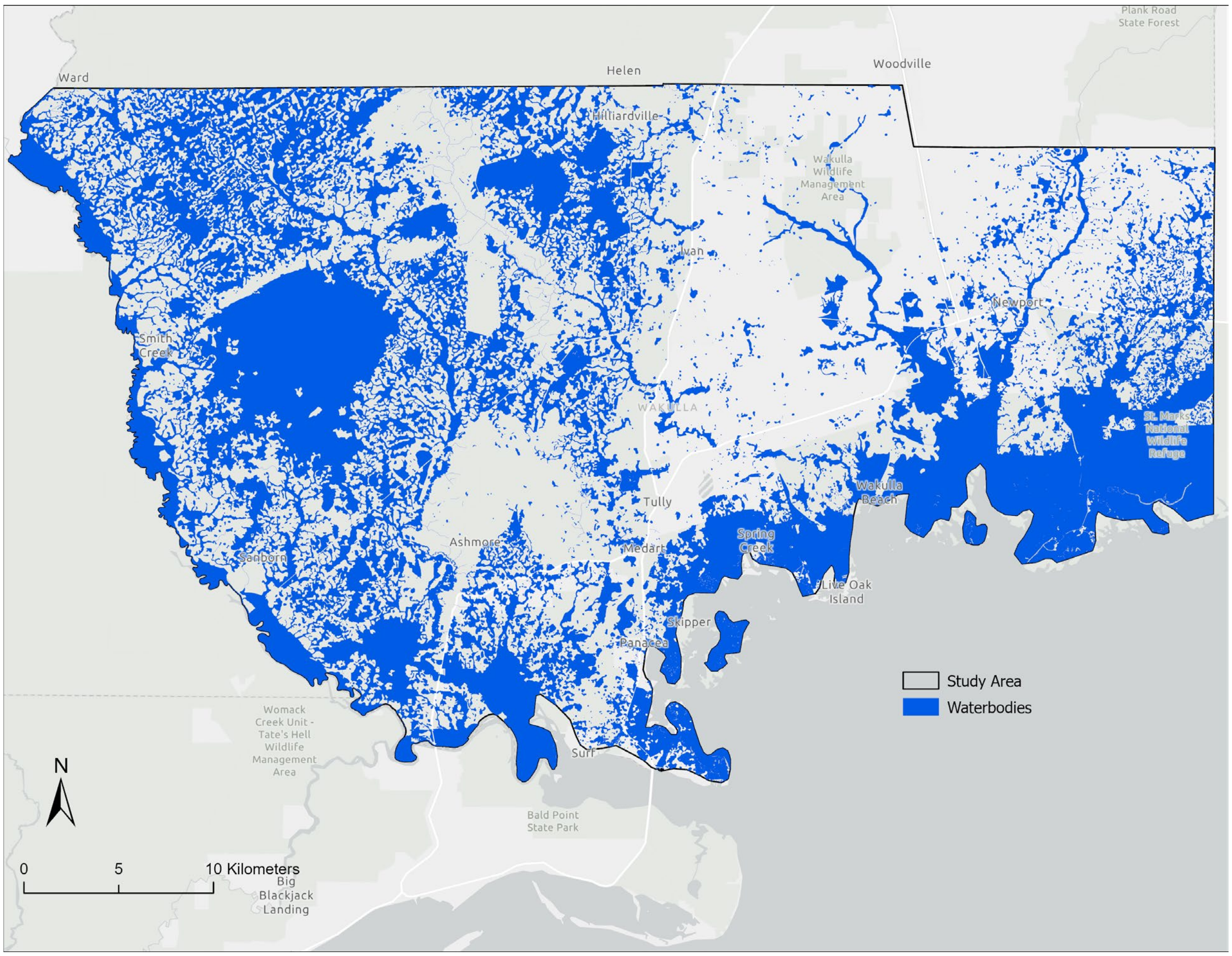

Figure 12. Distribution of Waterbodies in Wakulla County.

Distance to Waterbodies

The source of the raw values used in the *Distance to Waterbodies* geospatial dataset (Figure 13) is the *Wakulla County Waterbodies* geospatial dataset (Figure 12, Table 4).

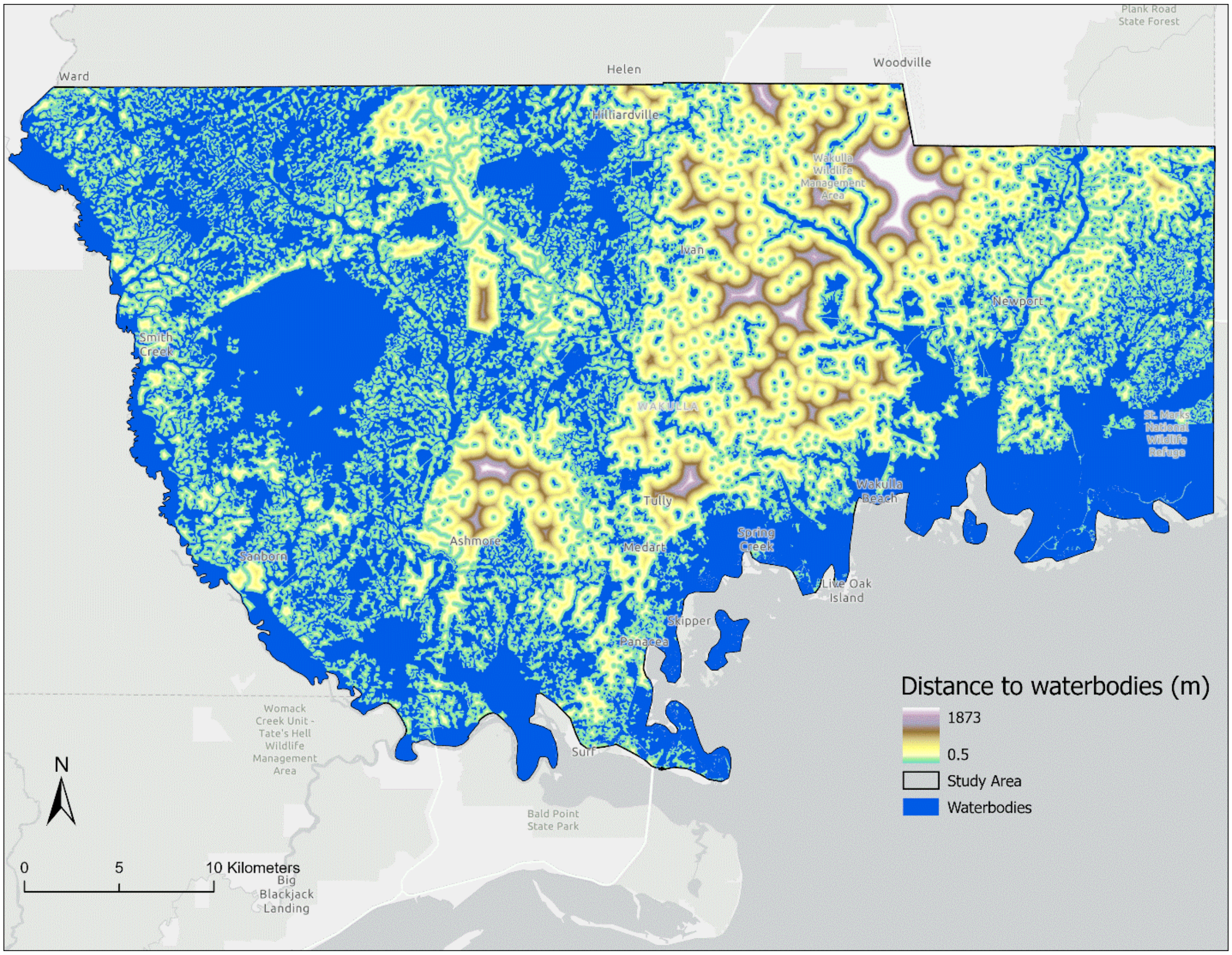

Figure 13. Raw values Distance to Waterbodies - Wakulla County.

Range in Raw Values, Distance to Waterbodies (m)

- Phase II LANLoad Pilot Study - St. Lucie County: 0 - 975
- Phase III - Wakulla County: 0.5 - 1873

Depth to Groundwater

The source of the raw values used in the *Depth to Groundwater* geospatial dataset (Figure 14) is the attribute called "weighted average depth to water table" in SSURGO (Table 4). In our study area, the only Null values encountered were related to areas categorized as "water," which does not present a concern for our model, since these areas are handled separately as waterbodies.

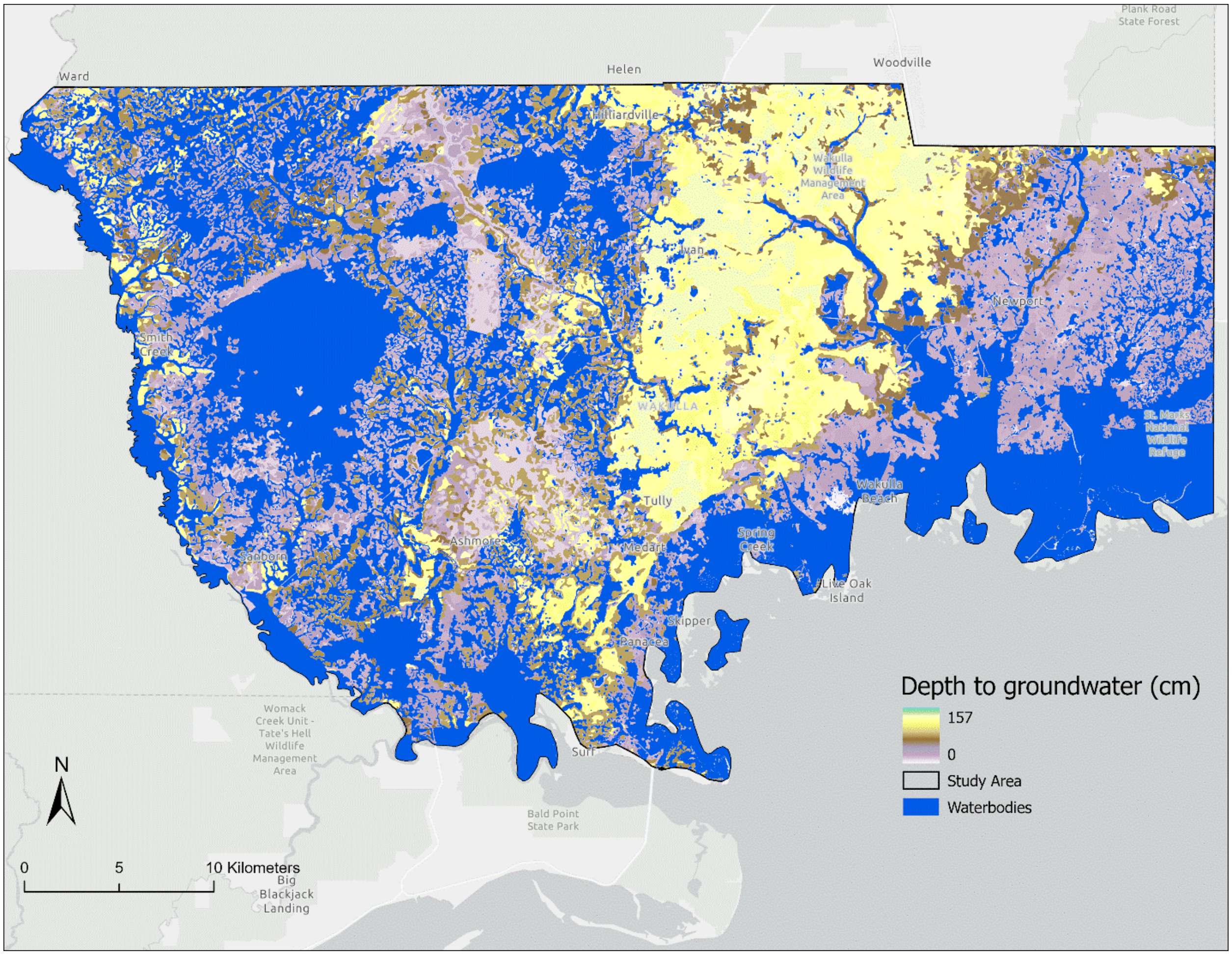

Figure 14. Raw values of Depth to Groundwater - Wakulla County.

Range in Raw Values, Depth to Groundwater (cm)

- Phase II LANLoad Pilot Study - St. Lucie County: 0 - 201
- Phase III - Wakulla County: 0 - 201

Hydraulic Conductivity

The source of the raw values used in the *Hydraulic Conductivity* geospatial dataset (Figure 15) is the attribute "weighted average hydraulic conductivity" in SSURGO (Table 4). In our study area, the only null values encountered were related to areas categorized as "water", which does not present a concern for our model since these areas are handled separately as waterbodies (see "Overview").

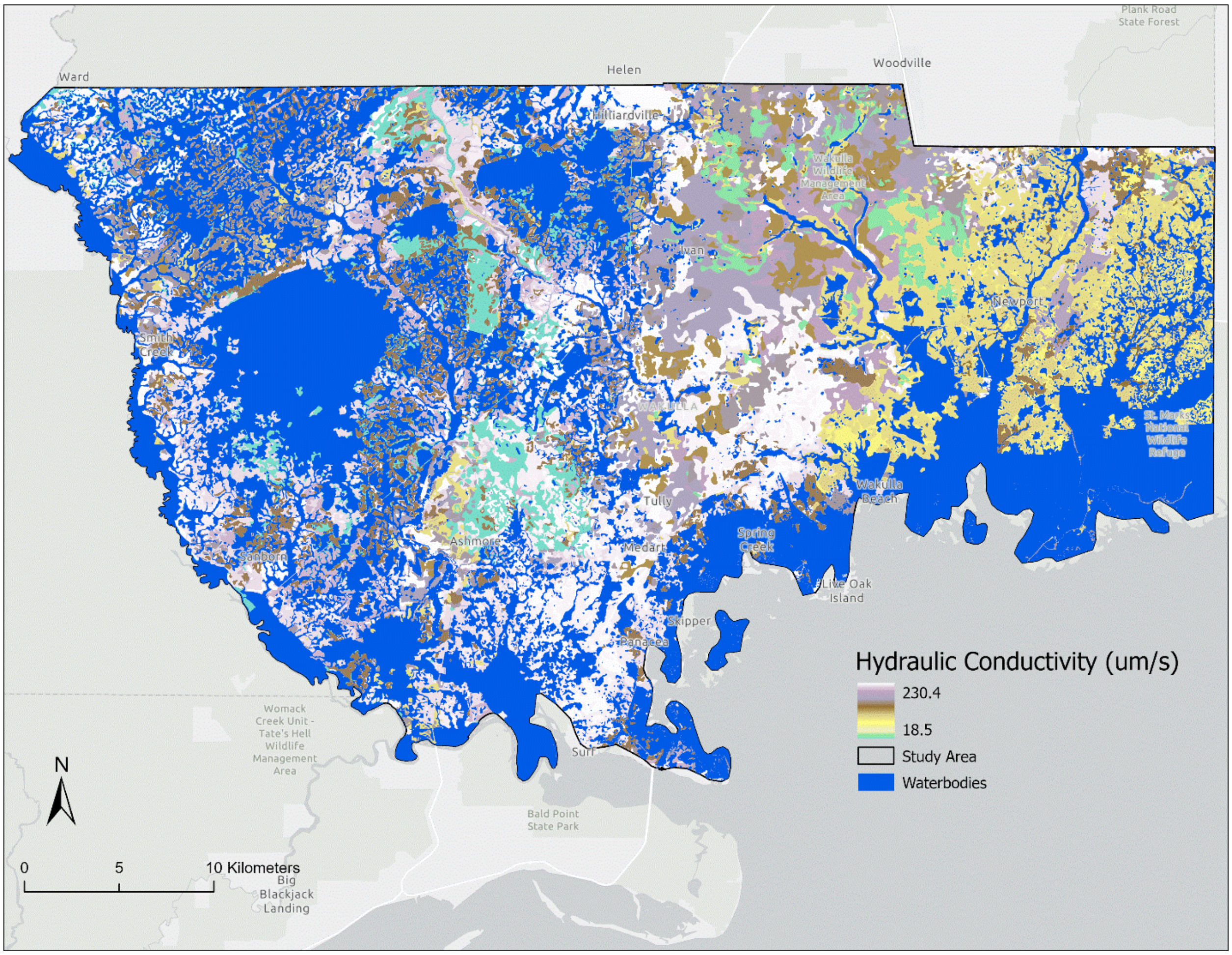

Figure 15. Raw values of Hydraulic Conductivity - Wakulla County

Range in Raw Values, Depth to Waterbodies (µm/s)

- Phase II LANLoad Pilot Study - St. Lucie County: 10.35 - 244.7
- Phase III - Wakulla County: 18.5 - 230.4

Potential for Flooding

The source of the raw values used in the *Potential for Flooding* geospatial dataset are the attributes called "Flood Zone" and "Flood Zone Subtype" in the National Flood Hazard Layer (Table 4). The Phase II, Pilot Study, St. Lucie area included two additional flood zones, not identified in the Wakulla County study area: Flood Zone AH and Flood Zone AO (Table 10, Figure 16).

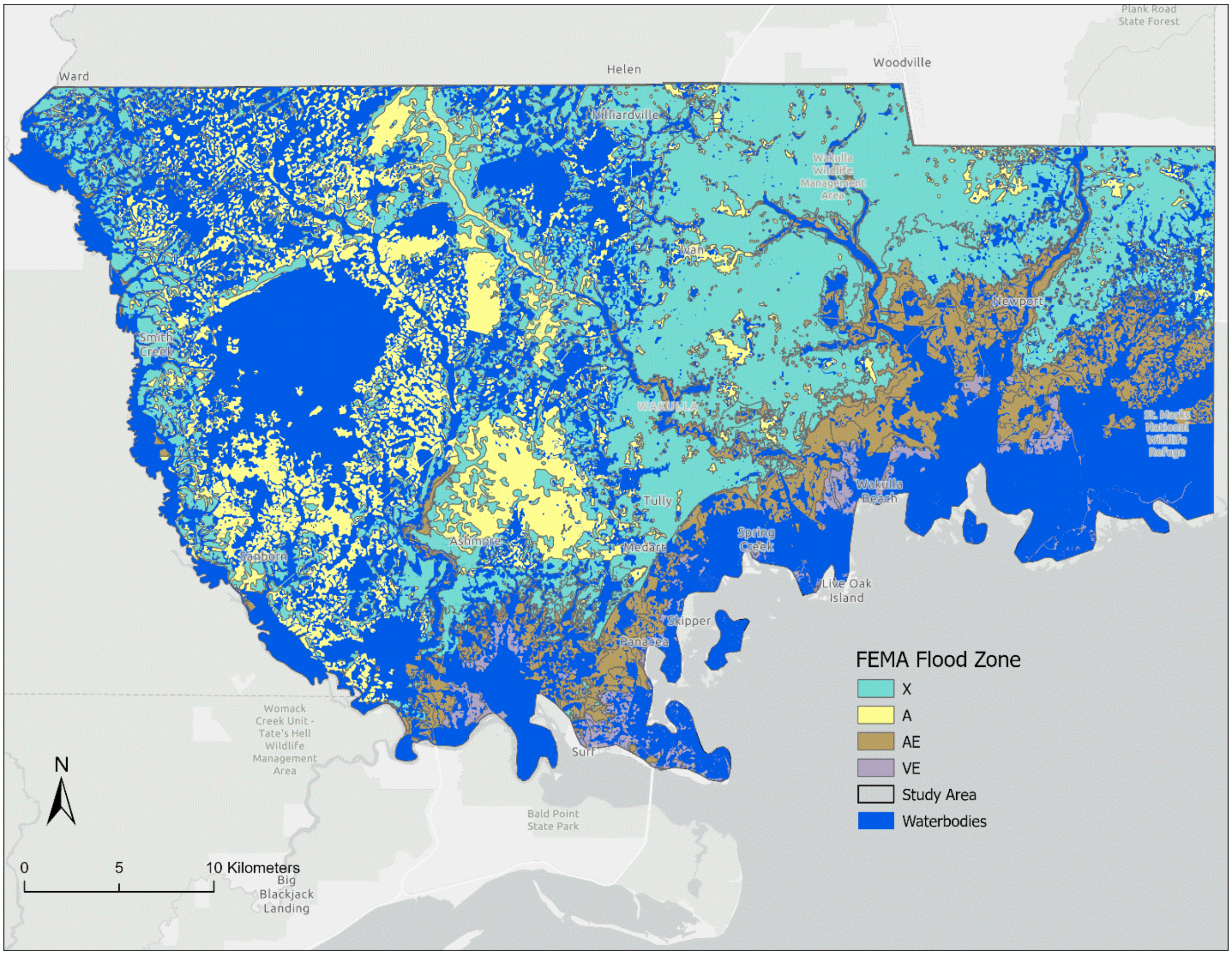

Figure 16. Raw values of FEMA Flood Hazard layer - Wakulla County

Table 10. Flood Zones (FEMA) included in Phase II LANLoad Pilot Study and in Phase III - Wakulla County

<table>
<tr><th colspan="2">Phase II LANLoad Pilot Study</th><th colspan="2">Phase III - Wakulla County</th></tr>
<tr><th>Flood Zone</th><th>Flood Zone subtype</th><th>Flood Zone</th><th>Flood Zone subtype</th></tr>
<tr><td rowspan="4">X</td><td rowspan="2">0.2 PCT Annual chance flood hazard</td><td rowspan="4">X</td><td>0.2 PCT Annual chance flood hazard</td></tr>
<tr><td>1 PCT Depth less than 1 foot</td></tr>
<tr><td rowspan="2">Area of minimal flood hazard</td><td>Area with reduced flood risk due to levee</td></tr>
<tr><td>Area of minimal flood hazard</td></tr>
<tr><td>A</td><td>1 PCT Annual chance flood hazard</td><td>A</td><td>1 PCT Annual chance flood hazard</td></tr>
<tr><td rowspan="2">AE</td><td>1 PCT Annual chance flood hazard</td><td rowspan="2">AE</td><td>1 PCT Annual chance flood hazard</td></tr>
<tr><td>Regulatory Floodway</td><td>Regulatory Floodway</td></tr>
<tr><td>AH</td><td>1 PCT Annual chance flood hazard</td><td></td><td></td></tr>
<tr><td>AO</td><td>1 PCT Annual chance flood hazard</td><td></td><td></td></tr>
<tr><td>VE</td><td>1 PCT Annual chance flood hazard</td><td>VE</td><td>1 PCT Annual chance flood hazard</td></tr>
</table>

Slope

The sources of the raw values used in the *Slope* geospatial dataset (Figure 17) are the *LiDAR derived DEM* and the *Distance to Waterbodies* geospatial dataset (Figure 13, Table 4). There were no anomalies in those datasets.

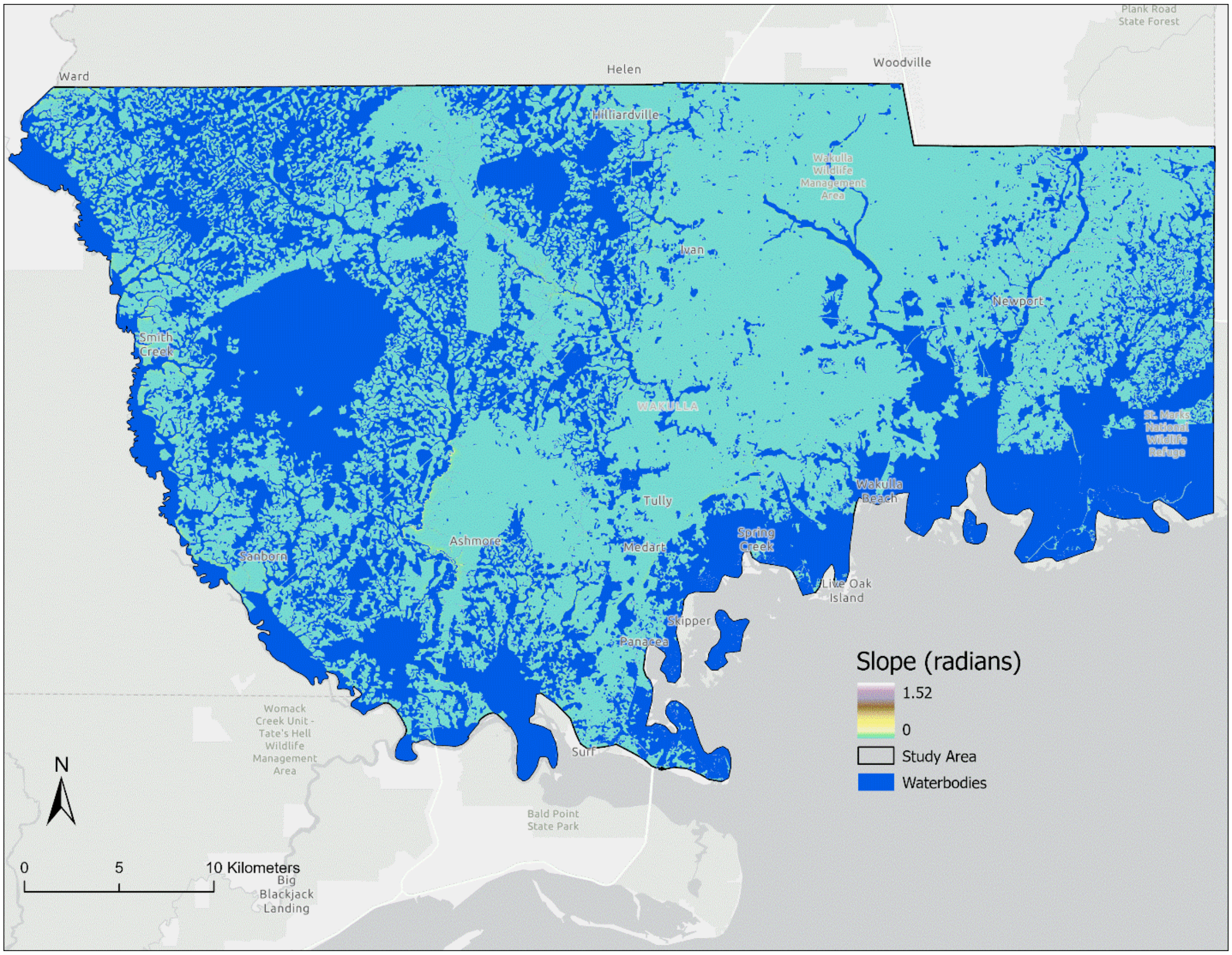

Figure 17. Raw values of Slope - Wakulla County

Range in Raw Values, Slope (radians)

- Phase II LANLoad Pilot Study - St. Lucie County: 0 - 1.55
- Phase III - Wakulla County: 0 - 1.52

Surficial Karstic Deposits

The source of the raw values used in the *Surficial Karstic Deposits* geospatial dataset (Figure 18) is the attribute called “Lithology” in the Surficial Geology of Florida (Table 4). Additionally, this dataset presented sliver polygons within our study area. Each sliver polygon was merged with the adjacent polygon sharing the longest border.

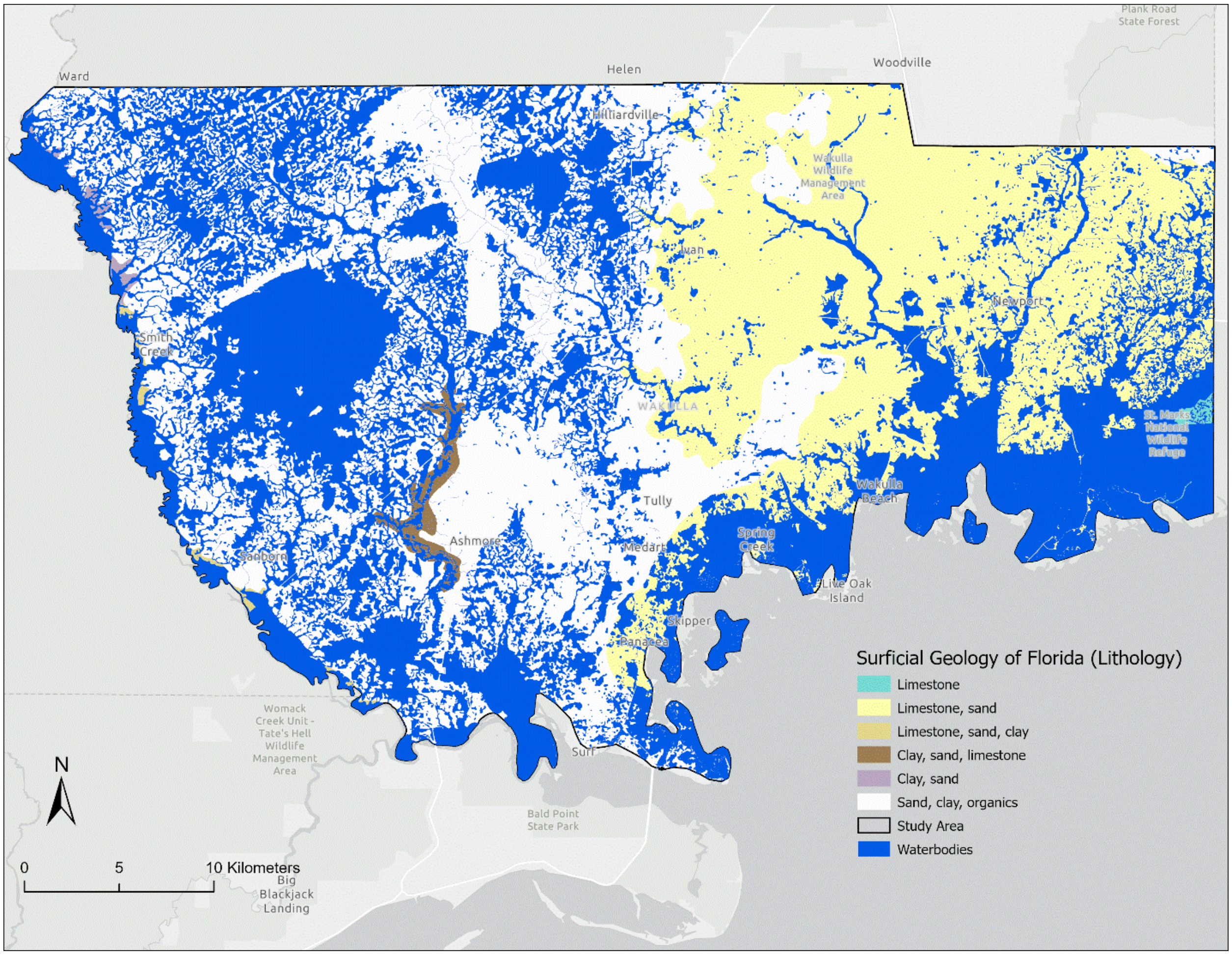

Figure 18. Raw values of Surficial Geology (Lithology) of Florida - Wakulla County

The Professional Geologist Administrator (Alan Baker, P.G.) at the Florida Geological Survey confirmed the most suitable dataset available for this study is the Surficial Geology of Florida.

The geologic composition of the Phase III – Wakulla County study area differs from that of the Phase II LANLoad Pilot Study area (Table 11).

Table 11. Surficial Geology included in Phase II LANLoad Pilot Study and in Phase III - Wakulla

Phase II LANLoad Pilot Study			**Phase III - Wakulla County**		
Geologic Unit	Lithology	Geologic History	Geologic Unit	Lithology	Geologic History
			Suwannee Limestone	Limestone	Oligocene
			St. Marks Formation	Limestone, sand	Miocene
Anastasia Formation	Limestone, coquina, sand	Pleistocene			
			Intracoastal Formation	Limestone, sand, clay	Pliocene
			Hawthorn Group, Torreya	Clay, sand, limestone	Miocene
			Jackson Bluff Formation	Clay, Sand	Pliocene
Beach ridge and dune	Sand	Pleistocene/Holocene			
Holocene sediments; Undifferentiated sediments	Sand, clay, organics	Holocene; Pleistocene/Holocene	Alluvium; Holocene sediments; Undifferentiated sediments	Sand, clay, organics	Pleistocene/Holocene; Holocene; Pleistocene/Holocene
Shelly sediments of Plio-Pleistocene age	Shells, sand, clay	Pliocene/Pleistocene			

Task 6: Product Development and Review

This section of the report is divided into two subsections: (1) Task 6a: Product Development and Review - NEEPP, and (2) Task 6b: Product Development and Review - Wakulla County.

Task 6, Section 1

Task 6a: Product Development and Review - NEEPP

Overview

The USF-ERG updated the Phase II LANLoad Pilot Study classification rules and ranking criteria to reflect the physical characteristics of the Phase III NEEPP study areas, culminating in development of Phase III LANLoad for NEEPP. The updates, documented in this section, account for the data ranges, spatial resolution, and environmental conditions characteristic of NEEPP.

The raw datasets referenced in this section are described in Phase III, Task 5, and are summarized in Table 12 below.

Table 12. Acquisition details of Phase III geospatial datasets corresponding to parameters selected in Phase I

Parameter	Geospatial Dataset	Source*	Date Acquired
Waterbodies	Florida NHD Waterbody Polygons	DEP	11/8/2024
	Florida NHD Area Polygons	DEP	
	Florida NHD Flowlines	DEP	
	Soil Survey Geographic Dataset (SSURGO)	NRCS	9/20/2024
Distance to Waterbodies	DEM + Waterbodies	SFWMD, USGS	9/24/2024
Depth to Groundwater	Soil Survey Geographic Dataset (SSURGO)	NRCS	9/20/2024
Hydraulic Conductivity	Soil Survey Geographic Dataset (SSURGO)	NRCS	9/20/2024
Potential for Flooding	National Flood Hazard Layer (NFHL)	FEMA	9/9/2024
Topography (slope)	DEM + Distance to Waterbodies	SFWMD, USGS, USF	9/24/2024
Surficial Karstic Deposits	Surficial Geology of Florida	FGS	9/16/2024

*Florida Department of Environmental Protection (DEP), National Resources Conservation Service (NRCS), South Florida Water Management District (SFWMD), Federal Emergency Management Agency (FEMA), and Florida Geological Survey (FGS)

Product Development: NEEPP

LANLoad map - NEEPP

The LANLoad model was developed in ArcGIS Pro 3.4.2 (ESRI) using a weighted overlay analysis of the six classified and ranked parameters. Parameters weights were assigned through the Analytical Hierarchy Process (AHP) with input from subject matter experts (SMEs) as part of DEP Agreement AT015 (Table 13). The corresponding geospatial datasets were identified and cleansed of anomalies, and the dataset attribute values were classified into ranks. Once complete, the LANLoad model produced a single, static map (Figure 19).

Table 13. Parameters and weights used in LANLoad (developed as part of DEP Agreement AT015)

Parameter	Weight (%)
Distance to Waterbody	30.0
Depth to Groundwater	21.6
Hydraulic Conductivity	20.7
Potential for Flooding	10.9
Topography (Slope)	9.8
Surficial Karstic Deposits	7.0

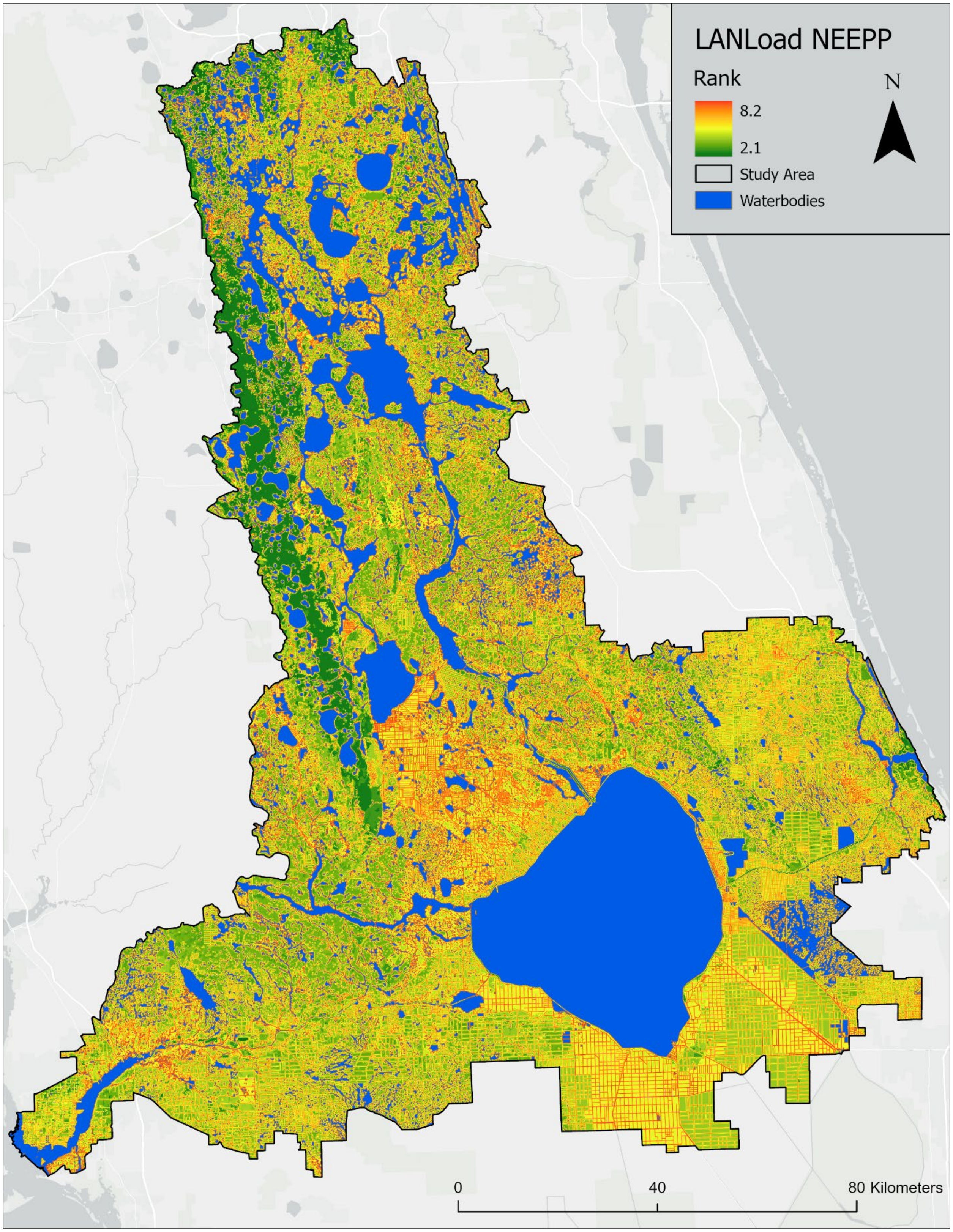

Figure 19. Landscape Assessment of Nutrient Loading to Waterbodies (LANLoad) model developed for the Northern Everglades and Estuaries Protection Program (NEEPP)

Distance to Waterbodies ranked

The range in raw values was 0 m – 1912 m. The raw values were classified into nine categories (Table 14, Figure 20).
The major divisions are reflective of modeling results in sandy soils, which are typical of this region. Modeling indicates that while much of the inorganic nitrogen from point sources is attenuated within the first 100 meters in sandy soils, elevated concentrations can persist up to 200 meters and, depending on soil type, beyond 200 meters (Mao et al., 2024).

Table 14. Classification and ranks for Distance to Waterbodies - NEEPP

Classification method	Range (m)	Rank
One interval	199.95+	1
One interval	99.97 – 199.95	2
Equal intervals	85.59 – 99.97	3
	71.32 – 85.59	4
	57.06 – 71.32	5
	42.80 – 57.06	6
	28.53 – 42.80	7
	14.02 – 28.53	8
	0.76 – 14.02	9

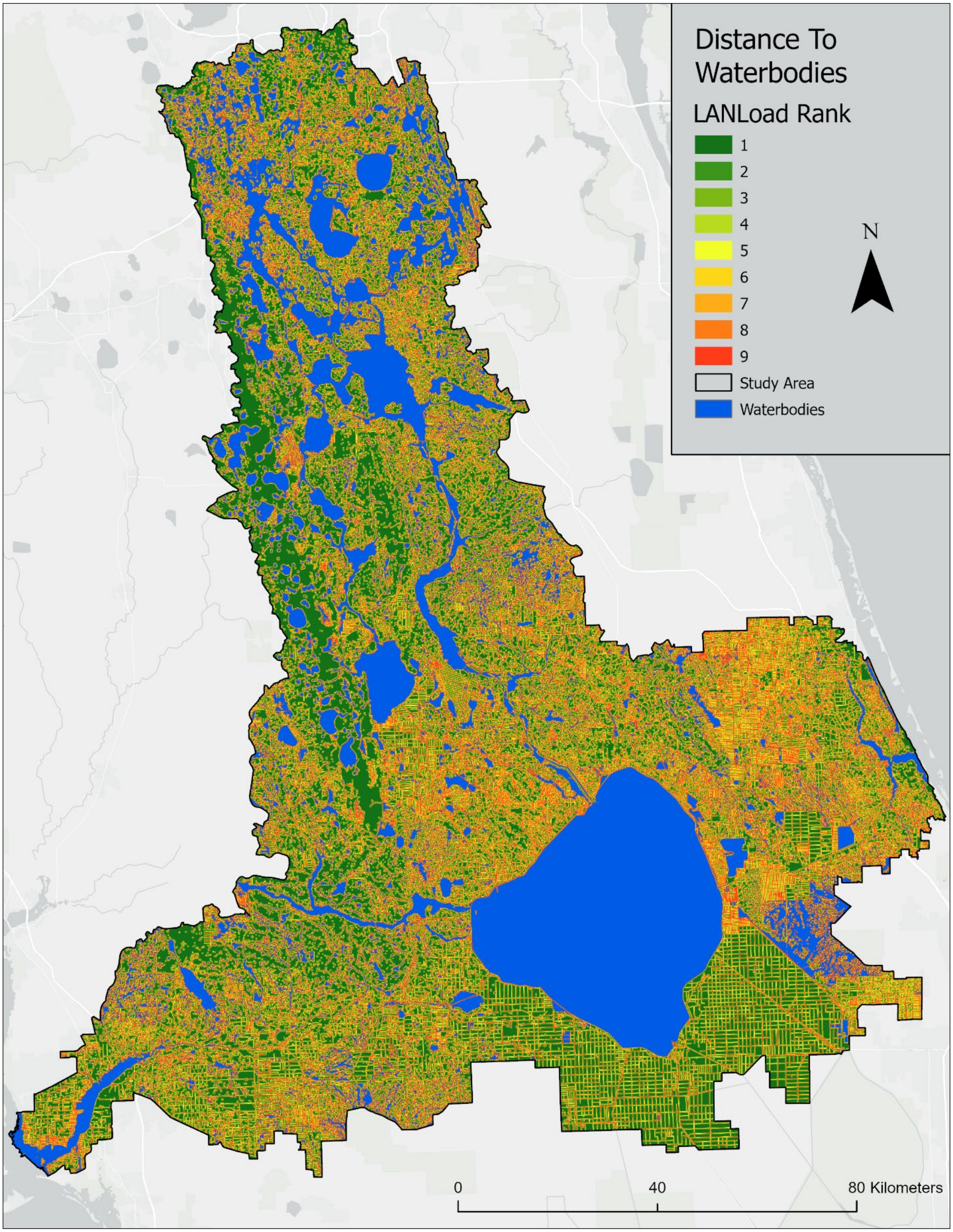

Figure 20. Ranked likelihood for nutrient loading (to waterbodies), based on Distance to Waterbodies – NEEPP

Depth to Groundwater ranked

The range in raw values was 0 cm to 201 cm. The raw values were classified into nine ranks (Table 15, Figure 21) with finer breaks between 0 and 100.1 cm to reflect the high amount of inorganic nitrogen attenuation that occurs within the first 100 cm of a point source. This classification also acknowledges that inorganic nitrogen attenuation continues beyond the highest Depth to Water value included in the SSURGO database, i.e., >200cm (Beal et al., 2005; Mao et al., 2024b).

Table 15. Classification and ranks for Depth to Groundwater - NEEPP

Classification method	Range (cm)	Rank
One interval	200+	1
One interval	100.1 – 200	2
Equal intervals	85.8 – 100.1	3
	71.5 – 85.8	4
	57.2 – 71.5	5
	42.9 – 57.2	6
	28.6 – 42.9	7
	14.3 – 28.6	8
	0 – 14.3	9

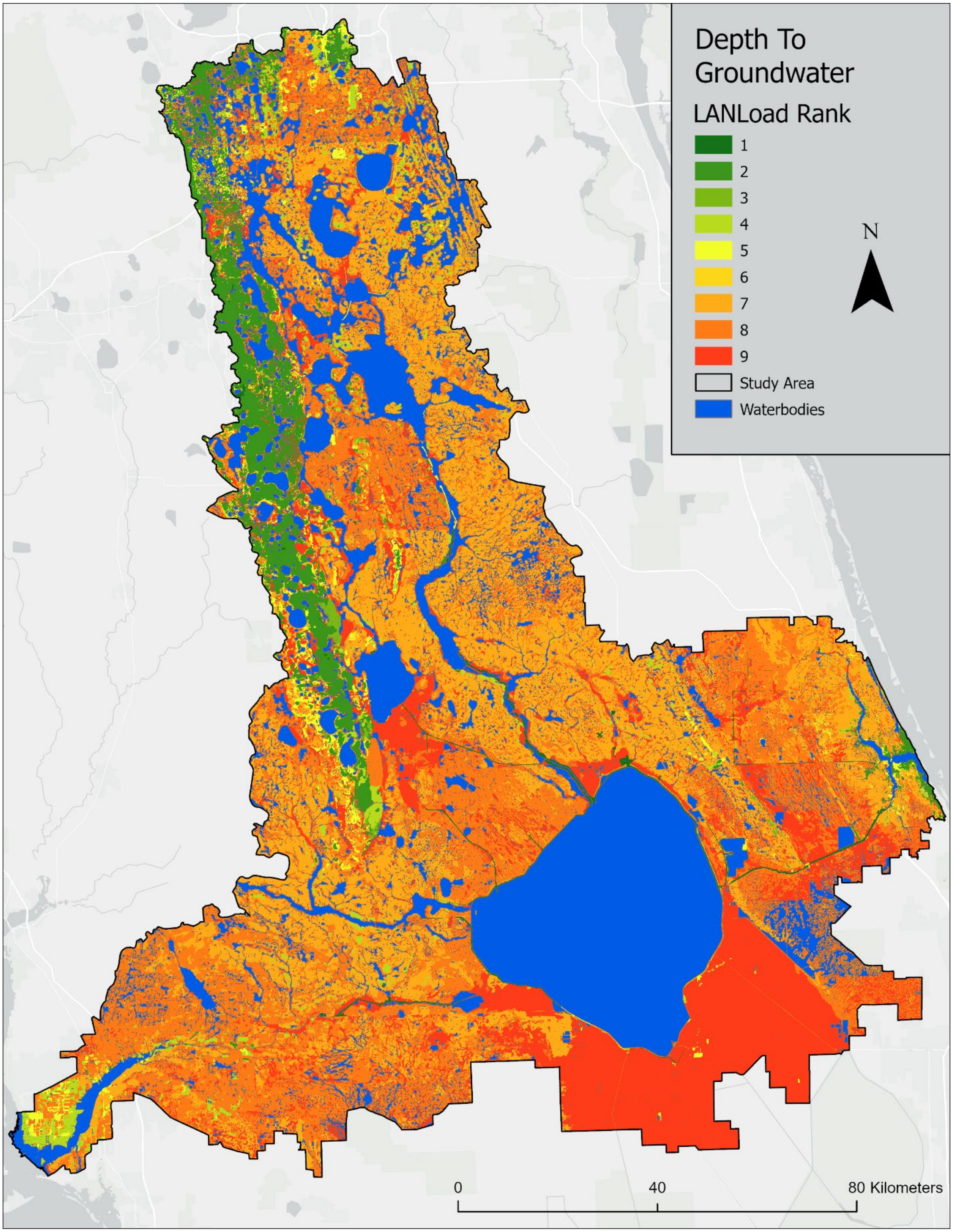

Figure 21. Ranked likelihood for nutrient loading (to waterbodies), based on Depth to Groundwater - NEEPP

Hydraulic Conductivity ranked

The range in raw values was 9.2 um/s to 247 um/s. The raw values were classified into nine ranks. The first four are based on divisions used in the USDA Soil Survey Manual hydraulic conductivity classification (Soil Science Division Staff, 2017) with additional divisions between 10 and 100 um/s, to reflect the regional diversity of sandy soils in Florida (Table 16, Figure 22).

Table 16. Classification and ranks for Hydraulic Conductivity - NEEPP

Classification method	**Range (µm/s)**	**Rank**
Soil Survey Manual	< 0.01	1
	0.01 – 0.1	2
	0.1 – 1	3
	1 – 10	4
Equal intervals	10 – 25	5
	25 – 50	6
	50 – 75	7
	75 – 100	8
One interval	100+	9

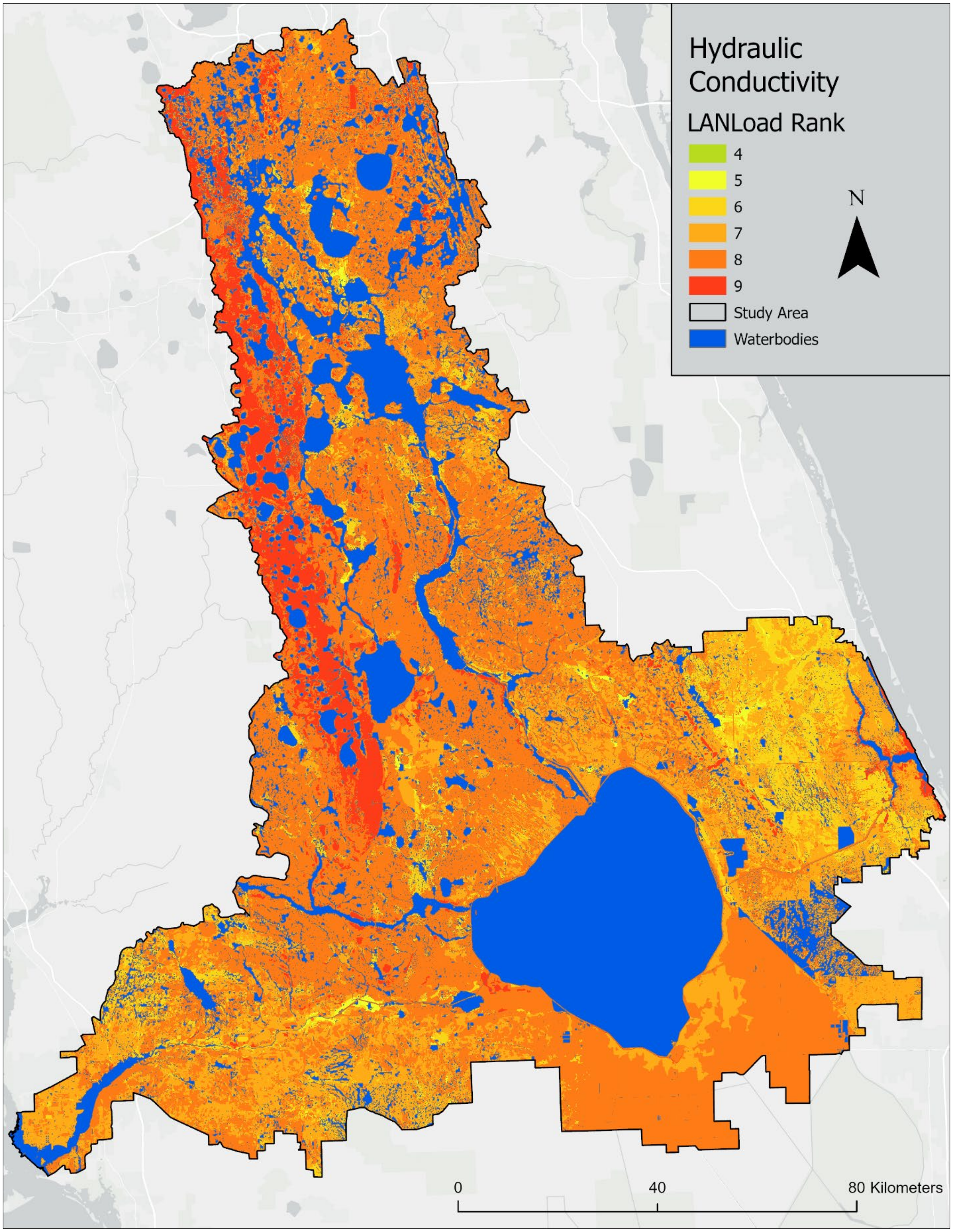

Figure 22. Ranked likelihood for nutrient loading (to waterbodies), based on Hydraulic Conductivity - NEEPP

Potential for Flooding ranked

The Potential for Flooding layer was classified into six ranks based on the flood zone and flood zone subtypes, with Zone X (minimal flooding) assigned the lowest rank and regulatory floodways in Zone AE assigned the highest. Intermediate rankings reflect increasing flood risk, including areas protected by levees, areas with a 0.2% or 1% annual chance of flooding, and areas with shallow flooding depths (Table 17, Figure 23).

Table 17. Classification and ranks for Potential for Flooding - NEEPP

Classification method	Category	Rank
Flood zone rank definition and flood zone	Flood zone X (area of minimal flooding)	1
	Flood zone X (Area with reduced flood risk due to levee)	3
	Flood zone X (0.2% annual chance flood)	5
	Flood zone X (1% annual chance flood, depth <1 foot)	7
	Flood zones AE, A, AH, VE, AO (1% annual chance flood)	8
	Flood zone AE (regulatory floodway)	9

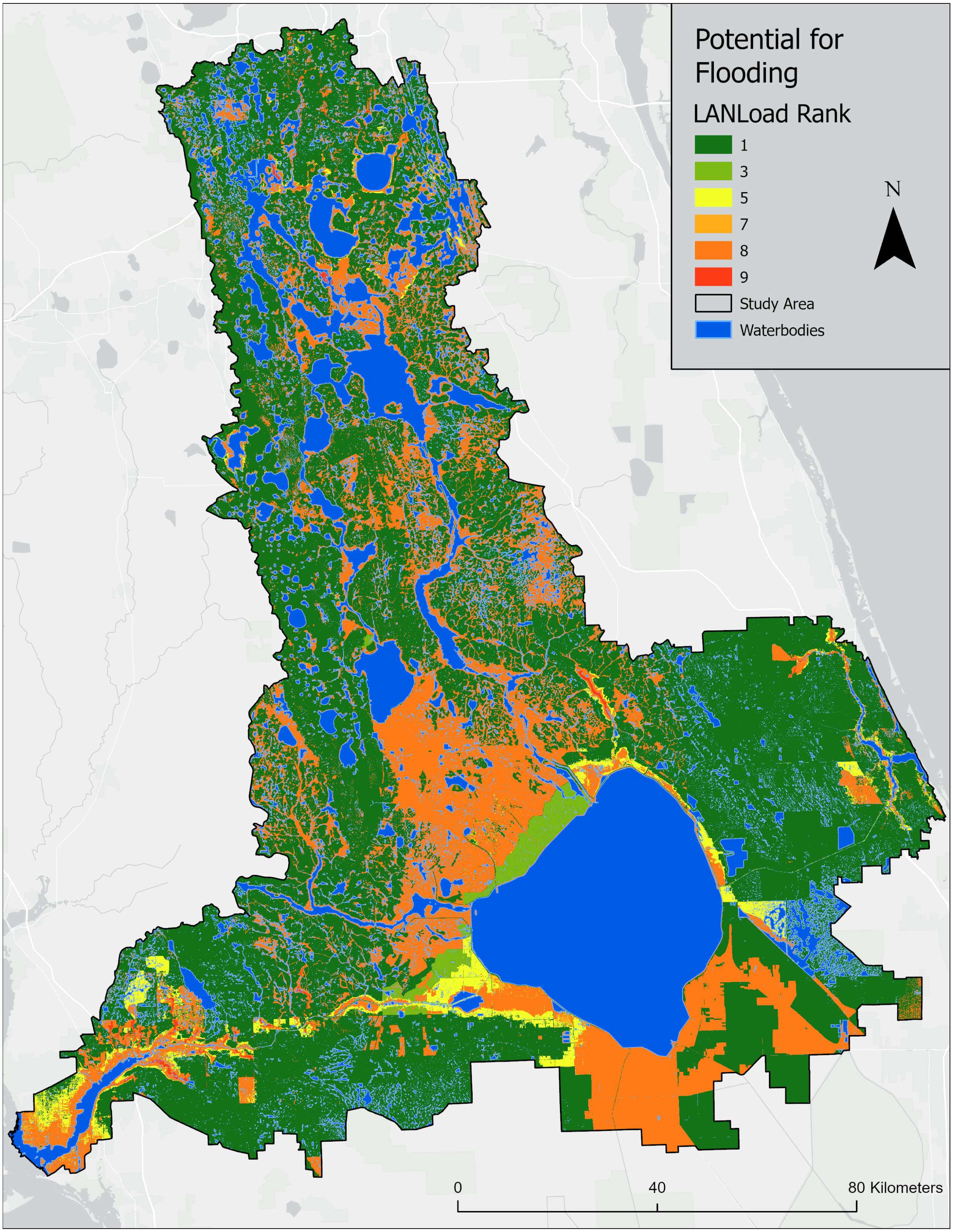

Figure 23. Ranked likelihood for nutrient loading (to waterbodies), based on Potential for Flooding - NEEPP

Slope ranked

The slope was calculated by subtracting the elevation of the nearest downslope waterbody from the elevation at the raster cell centroid, then dividing this difference by the distance to that waterbody. The range in raw values was 0 (rad) to 1.57 (rad). These values were categorized into nine ranks (Table 18, Figure 24) with a higher slope indicative of greater risk of nitrogen transport.

Table 18. Classification and ranks for Slope - NEEPP

Classification method	Range (rads)	Range (degrees)	Rank
Equal intervals	0	0	1
	0 – 0.20	0 – 11.5	2
	0.20 – 0.39	11.5 – 22.3	3
	0.39 – 0.59	22.3 – 33.8	4
	0.59 – 0.78	33.8 – 44.7	5
	0.78 – 0.98	44.7 – 56.1	6
	0.98 – 1.18	56.1 – 67.6	7
	1.18 – 1.37	67.6 – 78.5	8
	1.37 – 1.57	78.5 - 90	9

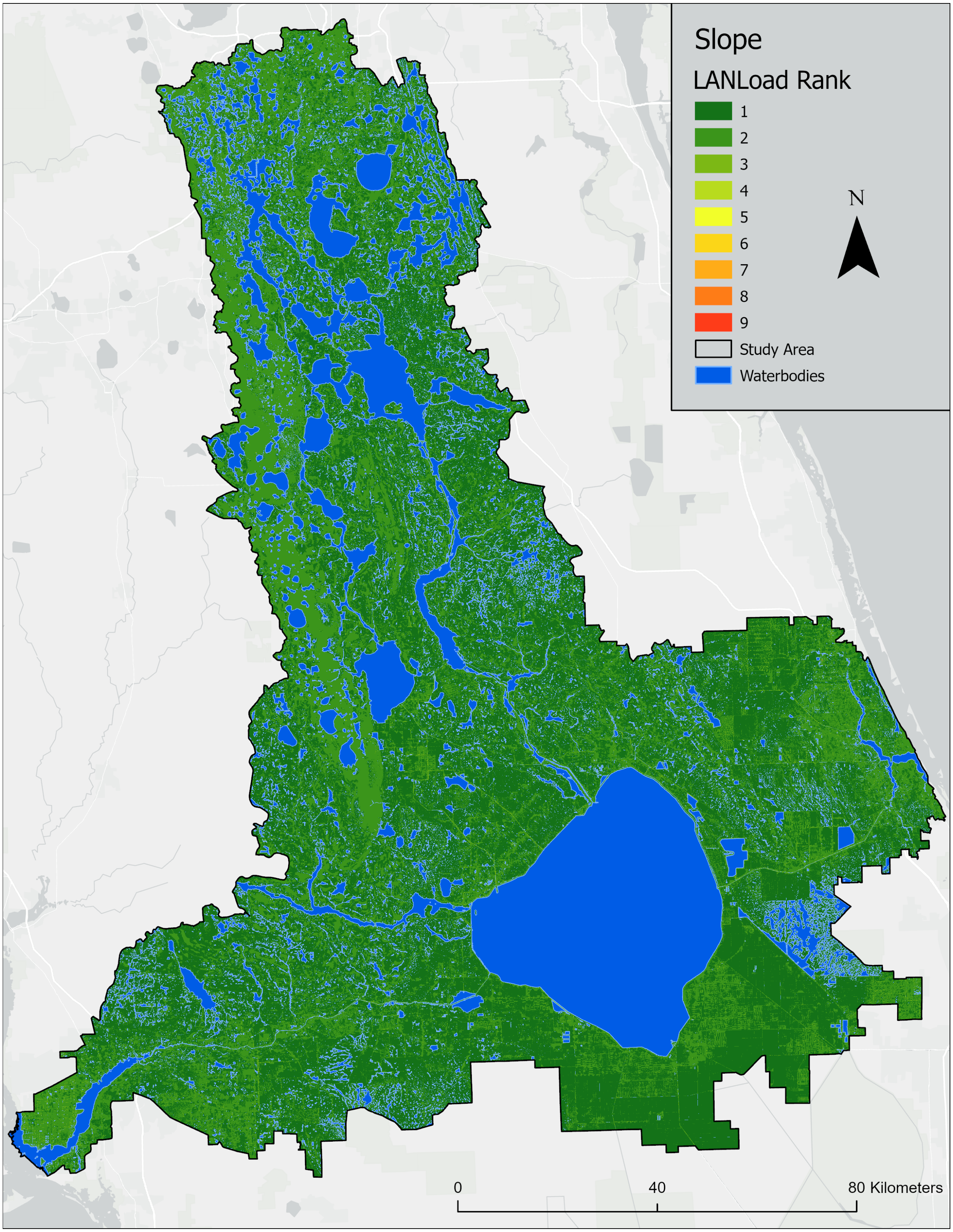

Figure 24. Ranked likelihood for nutrient loading (to waterbodies), based on Slope - NEEPP

Surficial Karstic Deposits ranked

The Phase III – NEEPP study area is geologically similar to the Phase II LANLoad Pilot Study area, with both areas sharing comparable surficial characteristics and geologic formations. While the NEEPP area includes one additional surficial karstic deposit not present in the Phase II LANLoad Pilot Study area, this unit does not alter the ranking or classification methodologies established in Phase II LANLoad Pilot Study. The presence or absence of surficial limestone remains the basis for classification (Table 19, Figure 25).

Table 19. Classification and ranks for the Lithology - NEEPP

Classification method	Classification Category	Rank
Binary based on presence/absence of limestone	Sand; Sand, clay, organics; Sand, clay; Shells, sand, clay	3
	Limestone, coquina, sand; Limestone, sand, clay	7

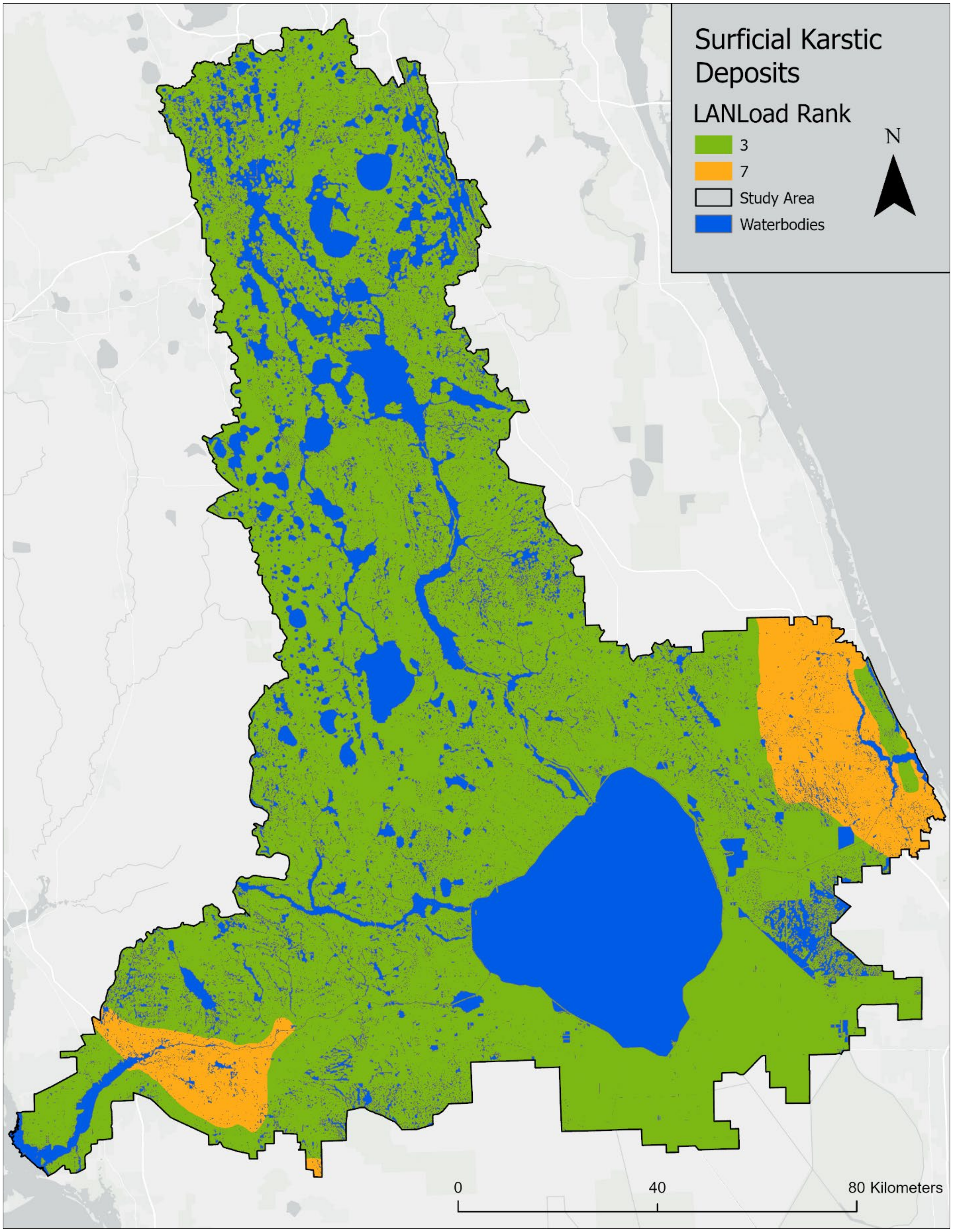

Figure 25. Ranked likelihood for nutrient loading (to waterbodies), based on Surficial Karstic Deposits - NEEPP

Task 6, Section 2

Task 6b: Product Development and Review – Springs Region Pilot Study (Wakulla County)

Overview

The USF-ERG updated the Phase II LANLoad Pilot Study classification rules and ranking criteria to reflect the physical characteristics of the Phase III Spring Region Pilot Study area (Wakulla County), culminating in development of Phase III LANLoad for Wakulla County. The updates, documented in this section, account for the data ranges, spatial resolution, and environmental conditions characteristic of Wakulla County.

The raw datasets referenced in this section are described in Phase III, Task 5, and are summarized in Table 20.

Table 20. Acquisition details of Phase III geospatial datasets corresponding to parameters selected in Phase I

Parameter	Geospatial Dataset	Source*	Date Acquired
Waterbodies	Florida NHD Waterbody Polygons	DEP	11/8/2024
	Florida NHD Area Polygons	DEP	
	Florida NHD Flowlines	DEP	
	Soil Survey Geographic Dataset (SSURGO)	NRCS	9/20/2024
Distance to Waterbodies	DEM + Waterbodies	SFWMD, USGS	9/24/2024
Depth to Groundwater	Soil Survey Geographic Dataset (SSURGO)	NRCS	9/20/2024
Hydraulic Conductivity	Soil Survey Geographic Dataset (SSURGO)	NRCS	9/20/2024
Potential for Flooding	National Flood Hazard Layer (NFHL)	FEMA	9/9/2024
Topography (slope)	DEM + Distance to Waterbodies	SFWMD, USGS, USF	9/24/2024
Surficial Karstic Deposits	Surficial Geology of Florida	FGS	9/16/2024

*Florida Department of Environmental Protection (DEP), National Resources Conservation Service (NRCS), South Florida Water Management District (SFWMD), Federal Emergency Management Agency (FEMA), and Florida Geological Survey (FGS)

Product Development: Springs Region Pilot Study (Wakulla County)

LANLoad map - Wakulla County

The LANLoad model was developed in ArcGIS Pro 3.4.2 (ESRI) using a weighted overlay analysis of the six classified and ranked parameters. Parameter weights were assigned through the Analytical Hierarchy Process (AHP) with input from subject matter experts (SMEs) as part of DEP Agreement AT015 (Table 21). The corresponding geospatial datasets were identified and cleansed of anomalies and the dataset attribute values were classified into ranks. Once complete, the LANLoad model produced a single, static map (Figure 26).

Table 21. Parameters and weights applied in Phase III to Wakulla County (developed as part of DEP Agreement AT015)

Parameter	Weight (%)
Distance to Waterbody	30.0
Depth to Groundwater	21.6
Hydraulic Conductivity	20.7
Potential for Flooding	10.9
Topography (Slope)	9.8
Surficial Karstic Deposits	7.0

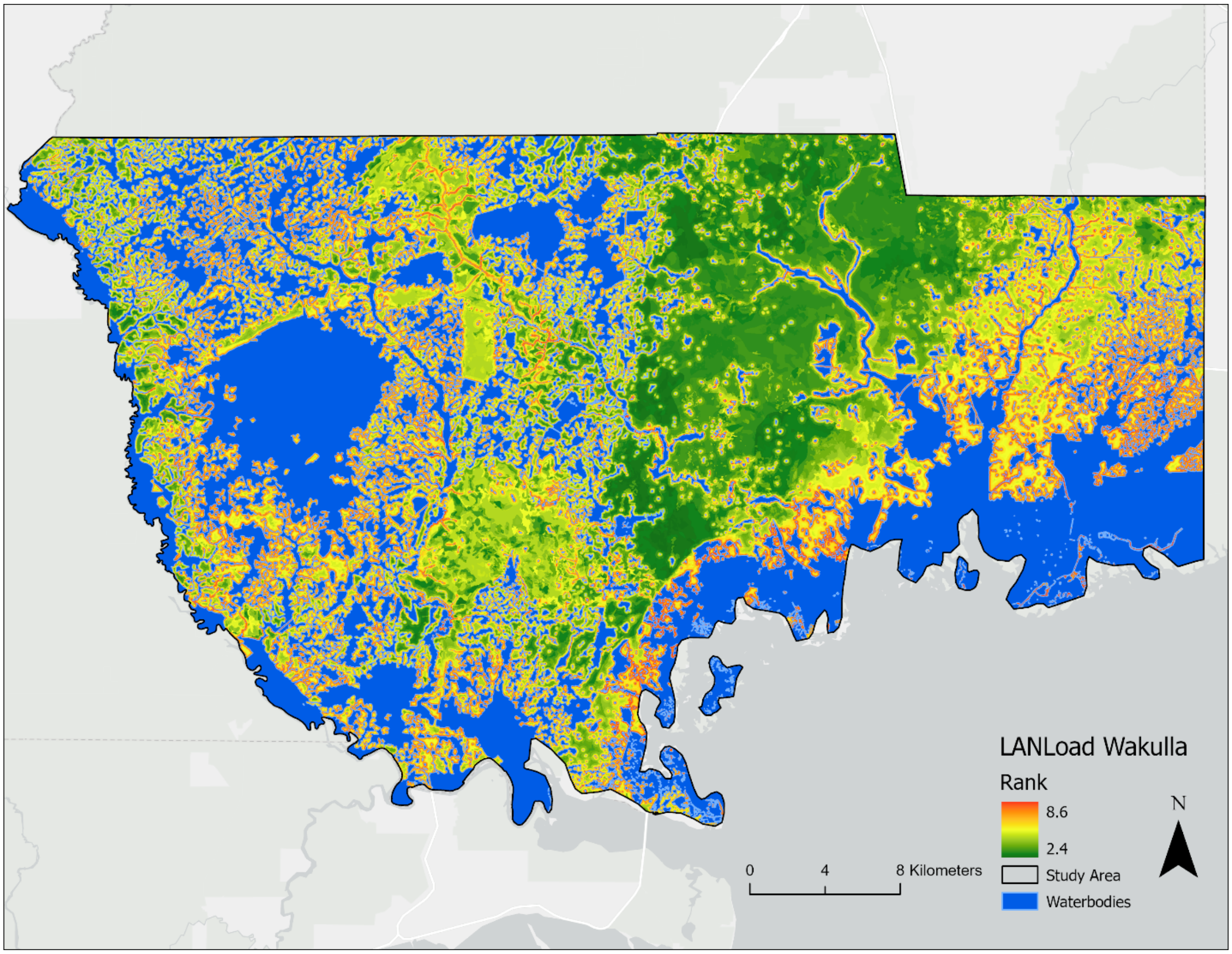

Figure 26. Landscape Assessment of Nutrient Loading to Waterbodies (LANLoad) model, Wakulla County

Distance to Waterbodies ranked

The range in raw values was 0.5 m to 1873 m. The raw values were classified into nine categories (Table 22, Figure 27). The major divisions are reflective of modeling results from peninsular Florida which indicate that while much of the inorganic nitrogen from point sources is attenuated within the first 100 meters, elevated concentrations can persist up to 200 meters and, depending on soil type, beyond 200 meters (Mao et al., 2024b).

Table 22. Classification and ranks for Distance to Waterbodies - Wakulla County

Classification method	Range (m)	Rank
One interval	199.95+	1
One interval	100 – 199.95	2
Equal intervals	85.78 – 100	3
	71.57 – 85.78	4
	57.36 – 71.57	5
	43.14 – 57.36	6
	28.93 – 43.14	7
	14.71 – 28.93	8
	0.5 – 14.71	9

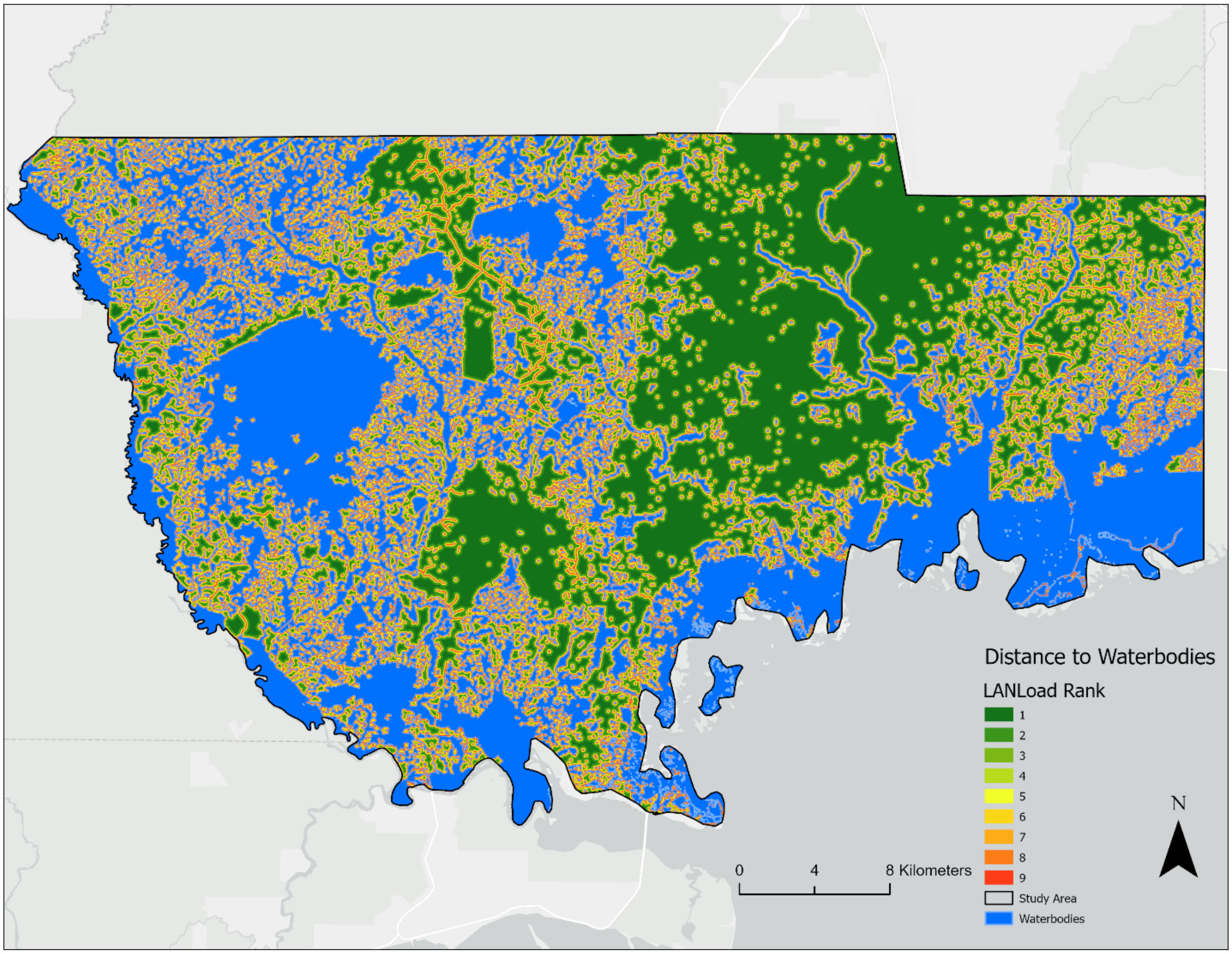

Figure 27. Ranked likelihood for nutrient loading (to waterbodies), based on Distance to Waterbodies - Wakulla County

Depth to Groundwater ranked

The range in raw values was 0 cm to 157 cm. The raw values were classified into nine ranks (Table 23, Figure 28) to reflect the high amount of inorganic nitrogen attenuation that occurs within the first 100 cm of a point source. This classification also acknowledges that inorganic nitrogen attenuation continues beyond the highest category represented in the SSURGO database, i.e., >200cm (Beal et al., 2005; Mao et al., 2024b).

Table 23. Classification and ranks for Depth to Groundwater - Wakulla County

Classification method	**Range (cm)**	**Rank**
One interval	200+	1
One interval	100.1 – 200	2
Equal intervals	85.8 – 100.1	3
	71.5 – 85.8	4
	57.2 – 71.5	5
	42.9 – 57.2	6
	28.6 – 42.9	7
	14.3 – 28.6	8
	0 – 14.3	9

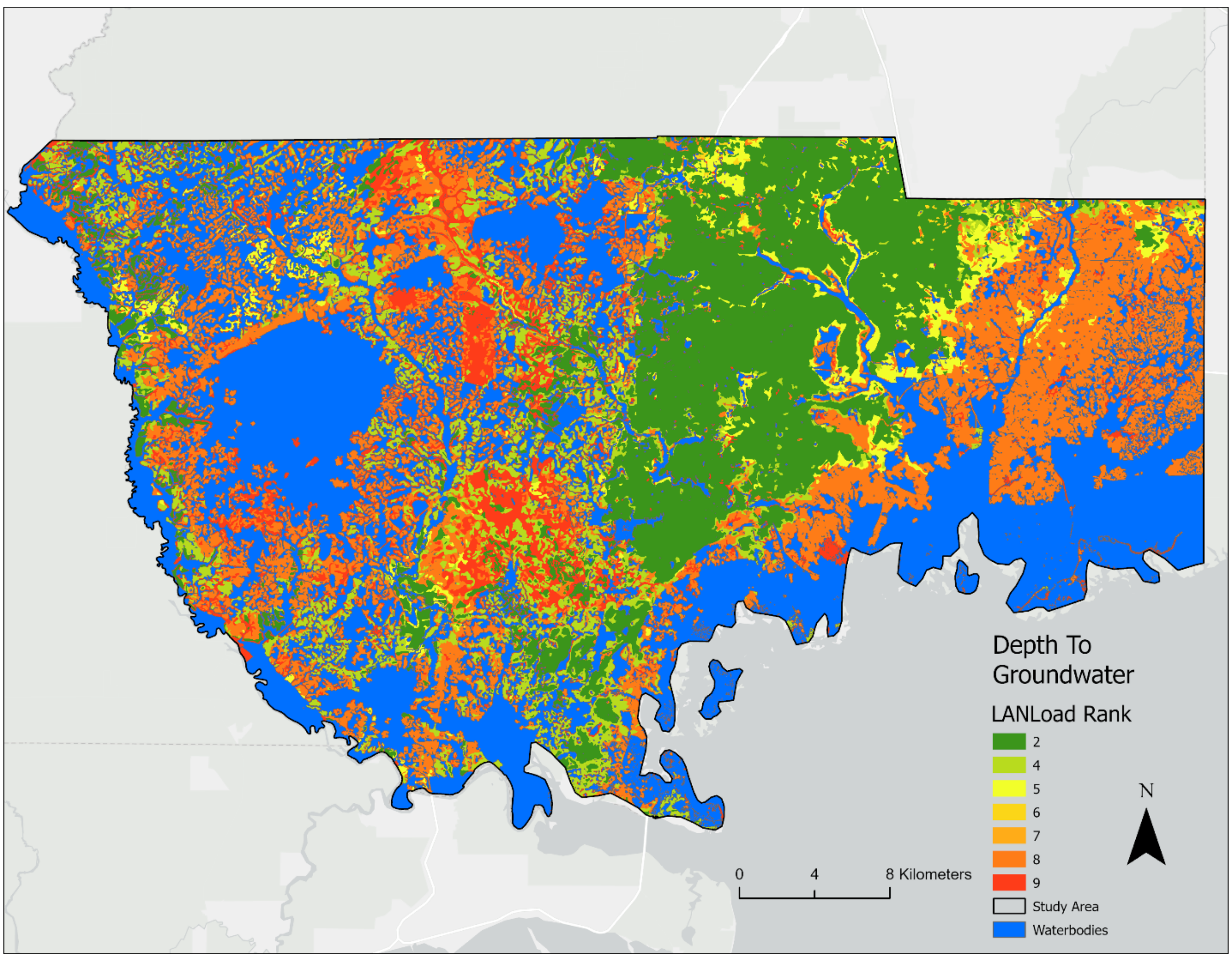

Figure 28. Ranked likelihood for nutrient loading (to waterbodies), based on Depth to Groundwater - Wakulla County

Hydraulic Conductivity ranked

The range in raw values was 18.5 um/s to 230.4 um/s. The raw values were classified into nine ranks. The first four are based on divisions used in the USDA Soil Survey Manual hydraulic conductivity classification (Soil Science Division Staff, 2017) with additional divisions between 10 and 100 um/s, to reflect the regional diversity of sandy soils in Florida (Table 24, Figure 29).

Table 24. Classification and ranks for Hydraulic Conductivity - Wakulla County

Classification method	**Range (µm/s)**	**Rank**
Soil Survey Manual	< 0.01	1
	0.01 – 0.1	2
	0.1 – 1	3
	1 – 10	4
Equal intervals	10 – 25	5
	25 – 50	6
	50 – 75	7
	75 – 100	8
One interval	100+	9

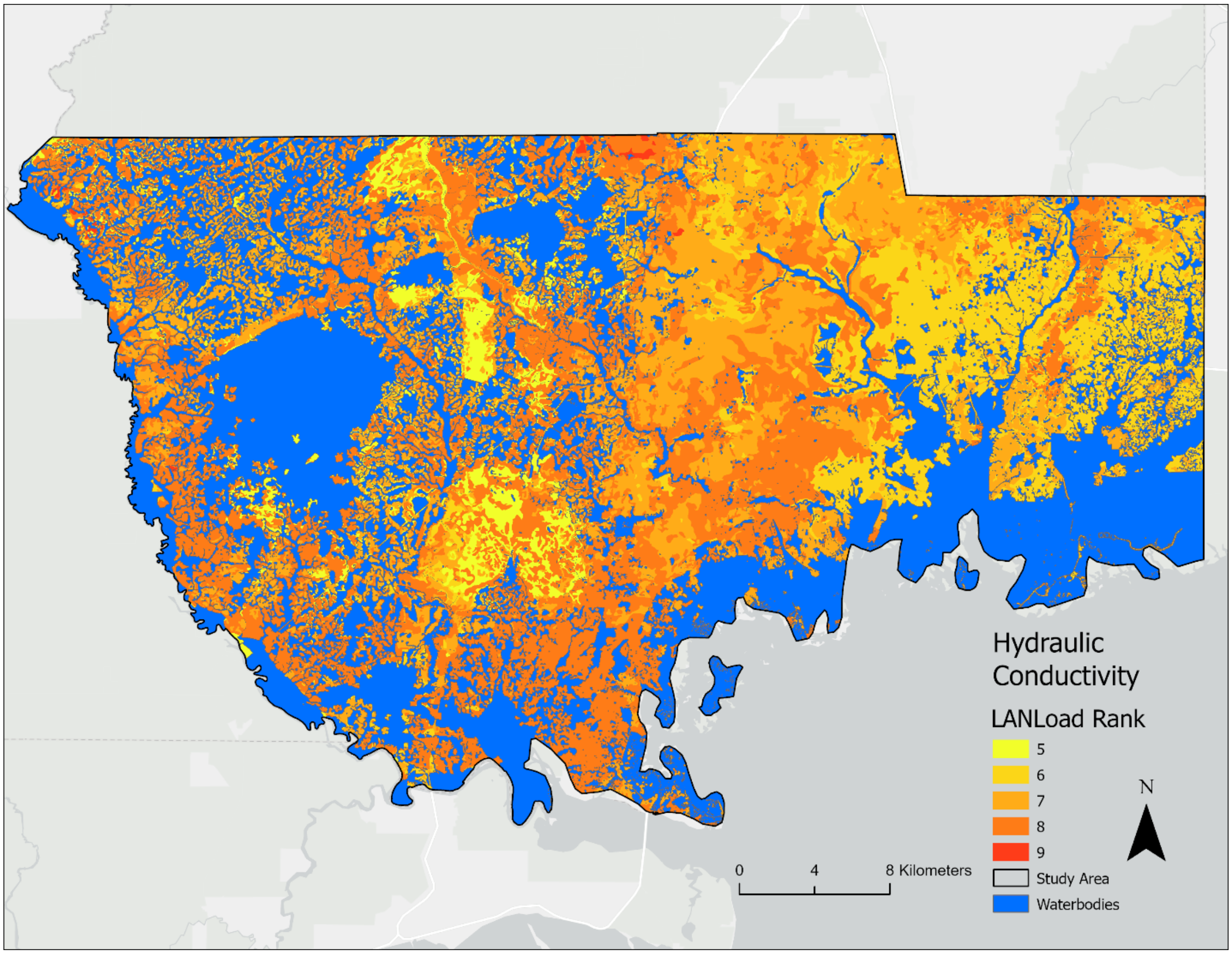

Figure 29. Ranked likelihood for nutrient loading (to waterbodies), based on Hydraulic Conductivity - Wakulla County

Potential for Flooding ranked

The Potential for Flooding layer was classified into four ranks based on the flood zone and flood zone subtypes, with Zone X (minimal flooding) assigned the lowest rank and regulatory floodways in Zone AE assigned the highest; intermediate ranks reflect increasing annual flood chance, including areas with a 0.2% or 1% annual chance of flooding (Table 25, Figure 30).

Table 25. Classification and ranks for Potential for Flooding - Wakulla County

Classification method	Category	Rank
Flood zone rank definition and flood zone	Flood zone X (area of minimal flooding)	1
	Flood zone X (0.2% annual chance flood)	5
	Flood zones AE, A, VE (1% annual chance flood)	8
	Flood zone AE (regulatory floodway)	9

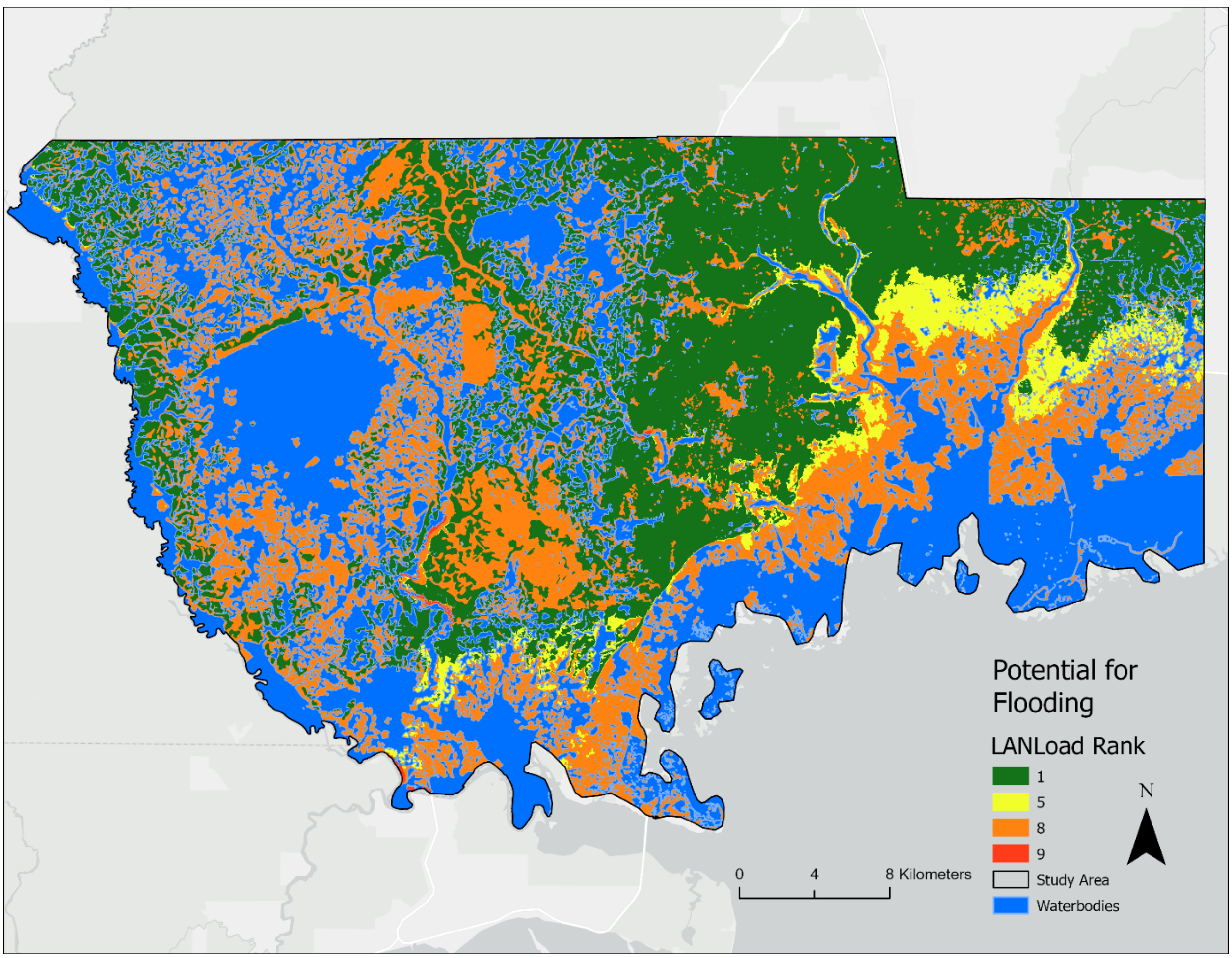

Figure 30. Ranked likelihood for nutrient loading (to waterbodies), based on Potential for Flooding - Wakulla County

Slope ranked

The slope was calculated by subtracting the elevation of the nearest downslope waterbody from the elevation at the raster cell centroid, then dividing this difference by the distance to that waterbody. The range in raw values was 0 (rad) to 1.52 (rad). These values were classified into nine ranks (Table 26, Figure 31) with a higher slope indicative of greater risk of nitrogen transport.

Table 26. Classification and ranks for Slope - Wakulla County

Classification method	Range (rads)	Range (degrees)	Rank
Equal intervals	0	0	1
	0 – 0.19	0 – 10.9	2
	0.19 – 0.38	10.9 – 21.8	3
	0.38 – 0.57	21.8 – 32.7	4
	0.57 – 0.76	32.7 – 43.5	5
	0.76 – 0.95	43.5 – 54.4	6
	0.95 – 1.14	54.4 – 65.3	7
	1.14 – 1.33	65.3 – 76.2	8
	1.33 – 1.52	76.2 – 87.09	9

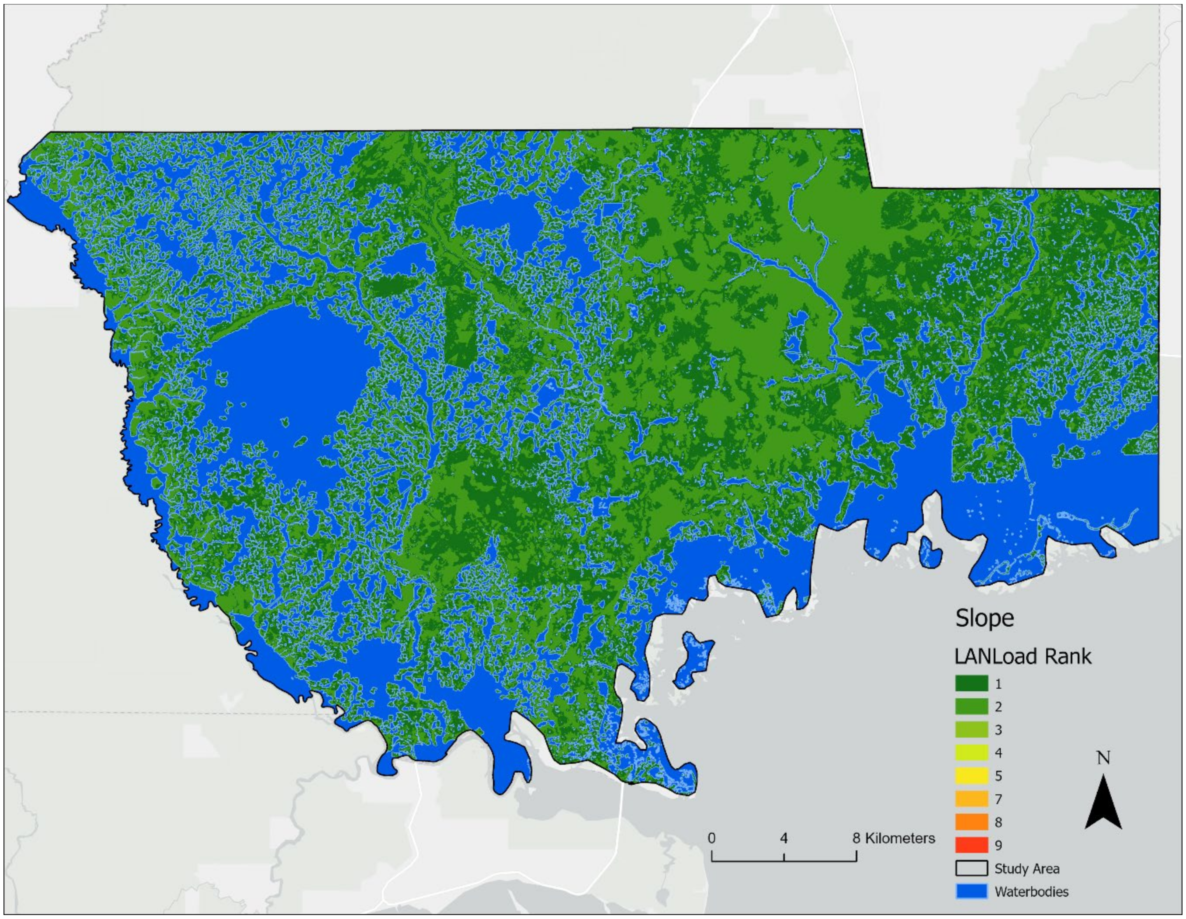

Figure 31. Ranked likelihood for nutrient loading (to waterbodies), based on Slope - Wakulla County

Surficial Karstic Deposits ranked

The geologic composition of the Phase III – Wakulla County study area as described in the Surficial Geology of Florida geospatial dataset (Table 9) includes deposits that are older than those found in locations where LANLoad has previously been applied (Phases I-II and Phase III-NEEPP). With time and weathering, the relatively young eogenetic Florida limestone or dolostone deposits have a greater opportunity to develop fractures and other secondary pores (Upchurch et al., 2019). Water preferentially flows through these features because they are more permeable than the surrounding rock matrix, increasing the potential for nutrient transport and, consequently, the nutrient loading likelihood. After consultation with Alan Baker, P.G., DEP, the USF-ERG added an additional rank to the Surficial Geology classification; limestone deposits of the older Miocene or Oligocene Epochs were ranked a "9" (Table 27, Figure 32).

Table 27. Classification and ranks for the Lithology – Wakulla County

Classification method	Surficial Geology Classification Category in Wakulla County	Rank
Based on presence/absence of surficial limestone; and limestone or dolostone deposit age	Other than Limestone	3
	Limestone of Pliocene or younger origin	7
	Limestone of Miocene or Oligocene origin	9

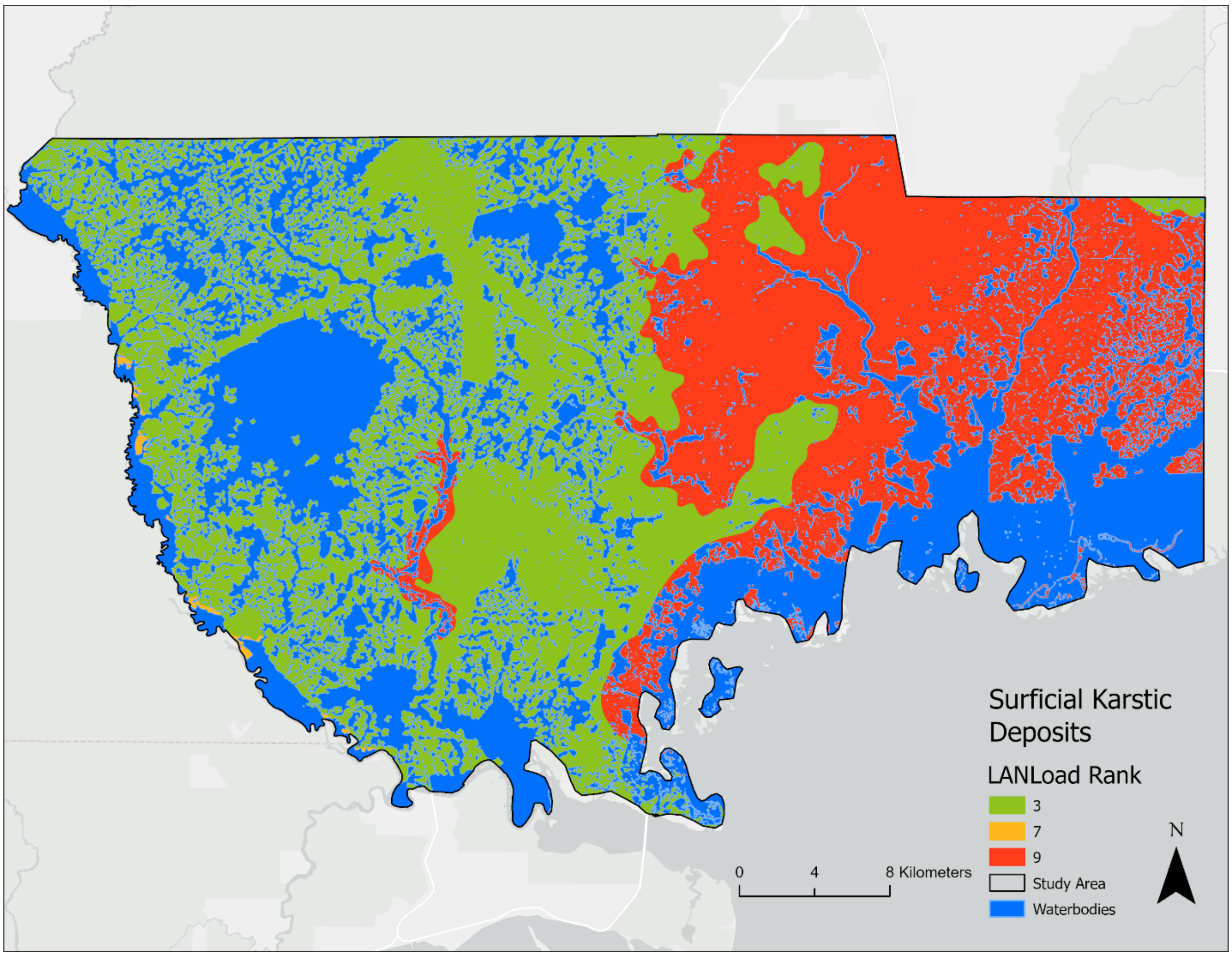

Figure 32. Ranked likelihood for nutrient loading (to waterbodies), based on Surficial Karstic Deposits - Wakulla County

Task 7: Evaluation

This section of the report is divided into two subsections: (1) Task 7a: Documentation of the methods and results of the LANLoad - NEEPP evaluation, and (2) Task 7b: Documentation of the methods and results of the LANLoad - Wakulla County evaluation.

Task 7, Section 1

Task 7a: Documentation of the methods and results of the LANLoad - NEEPP evaluation

Overview

The University of South Florida Ecohydrology Research Group (USF-ERG) evaluated the performance of the Landscape Assessment of Nutrient Loading to Waterbodies (LANLoad) model developed for the Northern Everglades and Estuaries Protection Program (NEEPP) by comparing the nutrient loading likelihood categories assigned by LANLoad at locations within the study area to those predicted by two independent methods.

Both methods were conducted on study area locations chosen through a random stratified sampling design and both were conducted blind, i.e., participants were not informed of the risk categories assigned to these locations by LANLoad. In the first approach, groundwater nutrient loading to waterbodies was modeled from 50 hypothetical nutrient sources in each of ten evaluation polygons (0.1 km^2) using ArcNLET-Py, a numerical model used to estimate nutrient loads to surface waterbodies from onsite sewage treatment and disposal systems (OSTDS) (Mao et al., 2024a; Rios et al., 2013). The modelled nutrient loads were summed by polygon and used to sort polygons into two groups reflecting the relative likelihood (higher versus lower likelihood) that nutrients applied to the locations delineated by the evaluation polygons would be transferred to surface waters. In the second approach, Subject Matter Experts (SMEs) categorized locations by relative likelihood based on best professional judgement (BPJ). Project SMEs are professionals from private, government, and academic sectors who, except for one new participant, were selected previously by the Florida Department of Environmental Protection (DEP, Department) to participate in the Analytical Hierarchy Process (AHP) workshop (DEP Agreement AT015) to select and rank the LANLoad parameters. The results of the evaluation described in this section indicate a 100% consistency between Phase III LANLoad and ArcNLET-Py rankings and a 92% consistency between Phase III LANLoad and SMEs rankings. This is an increase in consistency over the results of the Phase II LANLoad evaluation conducted in Task 3 which demonstrated 80% consistency between Phase II LANLoad and ArcNLET or SMEs rankings in the pilot study area.

The higher consistency in Phase III may have resulted from a combination of updates made to LANLoad (Tasks 5 and 6) during Phase III, such as an increase in raster cell size, and from improvements in the evaluation process. Listed below are some of the key recommendations resulting from an analysis of the Phase II LANLoad Pilot Study evaluation which have been implemented in the Phase III Evaluation (this task). A description of that analysis is provided in Task 5.

- Evaluation polygons should be uniform in size and shape.
- The distribution of hypothetical nutrient addition points within polygons that form the basis of ArcNLET-Py modeling should be uniform.
- Instructions to SMEs should more clearly state SMEs should assess the relative likelihood of nutrients applied at locations within polygons to the waterbodies depicted in the waterbody layer.
- Instructions to SMEs should highlight the importance of conducting the online dataset review at a workstation with fast internet speed.

- The extent of the waterbody geospatial layer viewable by SMEs should be reduced so it renders more quickly after SMEs pan across geospatial datasets.

Methods

Spatial analyses were conducted using ArcGIS Pro 3.4.2 (ESRI). ArcNLET modeling was performed using the ArcNLET-Py version of the software, which was downloaded from the ArcNLET-Py GitHub repository (May 2025).

In preparation for the SMEs evaluation, the Department incorporated geospatial information viewable by SMEs to the Survey123 platform. The Department collected responses recorded by the SMEs in Survey 123 during the evaluation and delivered them to the USF-ERG for analysis.

Evaluation Polygon Delineation and Selection

The USF-ERG delineated 140 polygons from the LANLoad map of the study area and selected subsets of these for evaluation, "evaluation polygons," using a stratified random sampling design. The range in likelihood ranks in the project area was 2 to 8. During delineation, LANLoad was viewed at a scale of 1:5000 to delineate contiguous sets of raster cells (0.1 km^2) classified as either very low/low likelihood (LANLoad ranks 2, 3, and 4), which were called "Lower Likelihood" for the purposes of this evaluation, or very high/high likelihood (LANLoad ranks 6, 7, and 8), which were called "Higher Likelihood" for the purposes of this evaluation. The likelihood rank of 5 was the midpoint between the two likelihood clusters and was not included in the analysis.

The USF-ERG stratified the NEEPP study area by major geomorphic provinces (14 total) and selected polygons randomly (based on ID number and using a random number generator), until a minimum of one Lower Likelihood and one Higher Likelihood polygon had been selected for the SMEs evaluation per major geomorphic province. The total pool of SMEs evaluation polygons was 30, fifteen Lower Likelihood and fifteen Higher Likelihood polygons. Of these, a subset of five from each category were selected for ArcNLET-Py evaluation (Figure 33).

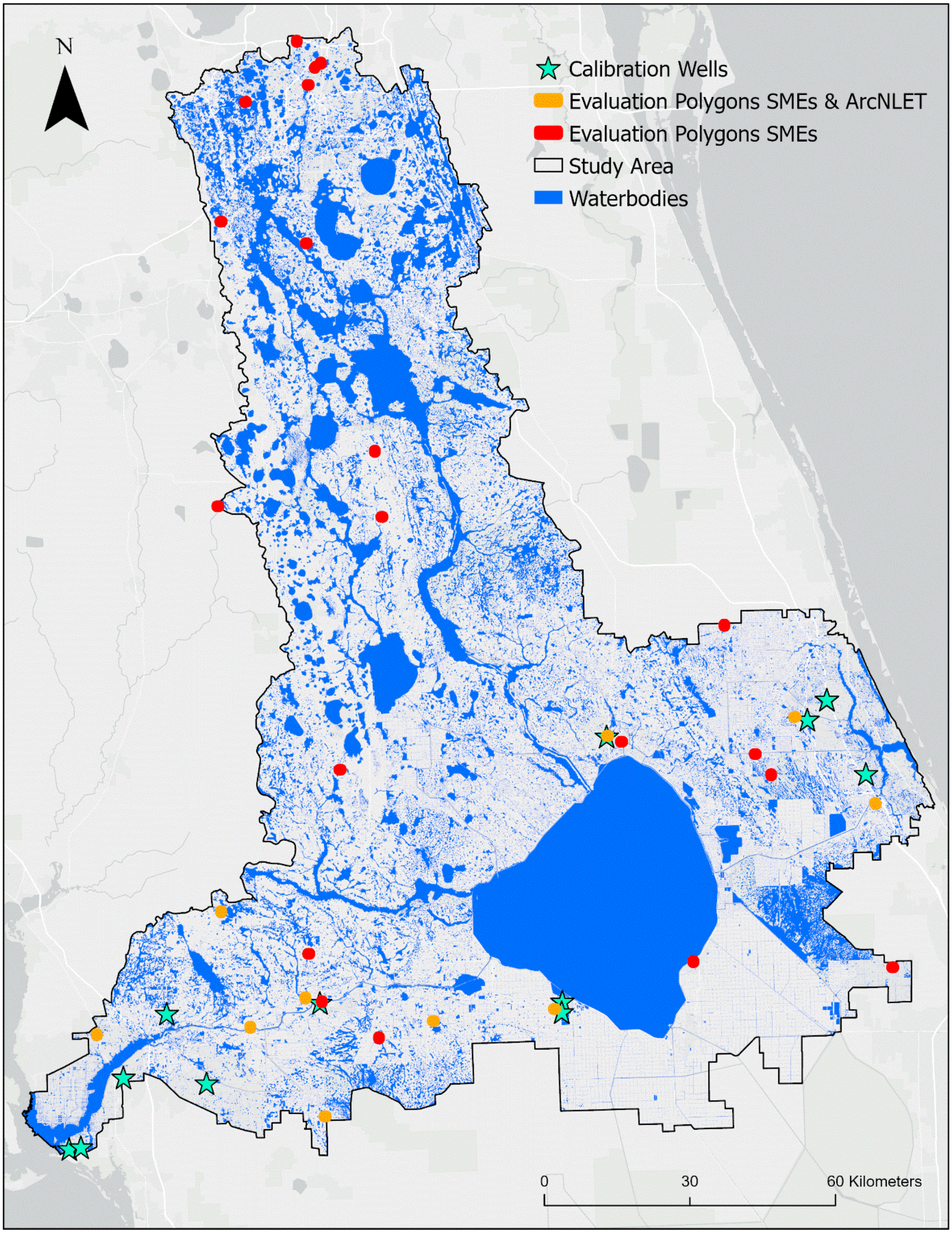

Figure 33. Distribution of the LANLoad evaluation polygons and of the wells used to select a smoothing factor for ArcNLET (ArcNLET-Py). Data for calibration wells were accessed from the National Pollutant Discharge Elimination System (NPDES) database (FDEP 2025).

ArcNLET-Py Evaluation

The ArcGIS-based Nitrate Load Estimation Toolbox, ArcNLET, was developed by researchers at the Florida State University to simulate nutrient transport from OSTDS point sources in groundwater and estimate nutrient loading to waterbodies (Mao et al., 2024b; Rios et al., 2013). In a prior phase of this project (Phase II), these researchers ("FSU ArcNLET Team") applied ArcNLET to the Phase II LANLoad Pilot Study area as part of the Phase II Pilot Study evaluation. They modeled the nutrient loading from 120 hypothetical OSTDS effluent points. Because the Phase II LANLoad Pilot Study area partially overlaps with the Phase III - NEEPP study area, this earlier work provided a strong technical foundation for modeling performed by the USF-ERG ArcNLET Team in Phase III. The timing of Phase III coincided with the release of a new Python based version of ArcNLET, ArcNLET-Py by the FSU ArcNLET Team. In Phase III of this project, the study area was expanded, and the USF-ERG ArcNLET Team ran ArcNLET-Py, working in consultation with the FSU ArcNLET Team to calibrate the model.

Point source locations are necessary to run ArcNLET-Py, unlike LANLoad. For this exercise, hypothetical point source locations were established within each evaluation polygon at a density reflective of the housing density of a typical suburban neighborhood in the study area. Fifty point sources were added to each of the 10 evaluation polygons, for a total of 500 hypothetical point source locations. The USF-ERG ArcNLET Team modeled nitrogen plumes and loads using ArcNLET at these 500 locations to quantify the nutrient loads (NO_3, NH_4, total inorganic N) intersecting waterbodies and then summed the daily load by evaluation polygon. The five polygons with the highest modeled loads to waterbodies were ranked as "ArcNLET Higher Likelihood" and the five with the lowest loads were ranked as "ArcNLET Lower Likelihood". Members of the USF-ERG ArcNLET Team were not involved in the design or development of LANLoad and did not have access to the LANLoad results.

In addition to point source locations, the ArcNLET-Py user must also input a study area layer, a waterbody layer, and a DEM. Other required input layers such as Hydraulic Conductivity, Porosity, Velocity Magnitude, Velocity Direction, etc. are automatically generated by ArcNLET-Py, based on the study area layer and the DEM. In addition to input layers, the user must also select a series of settings such as the DEM smoothing factor, smoothing cell size, merge waterbodies, waterbodies resolution, hydraulic parameters, nitrification parameters, denitrification parameters, and mass input of nitrogen (mg/d) source (Core et al. 2023).

The USF-ERG Team and the USF-LANLoad Teams worked independently and adhered strictly to standard procedures for their assigned model. This resulted in some small differences in the final waterbody input layers used by the two teams. In ArcNLET, unlike LANLoad, the user conducts an initial review of aerial imagery proximal to nutrient sources and adds any missing waterbodies to that dataset (W. Mao (FSU) personal communication, January 2025). In accordance with this standard, the USF-ERG ArcNLET Team added a few small waterbodies to the initial waterbodies dataset (NEEPP Waterbodies, Table 4) proximal to four of the ten ArcNLET-Py evaluation polygons (e.g., see Figure 34) resulting in a modified ArcNLET-Py waterbody input dataset. In contrast, the USF-ERG LANLoad Team did not add waterbodies to the NEEPP Waterbody dataset prior to use in LANLoad, as standard LANLoad procedures do not include waterbody layer edits.

The USF-ERG ArcNLET Team introduced a second modification to the ArcNLET waterbody layer to resolve aberrant nutrient plume behavior emanating from one of the ten ArcNLET-Py evaluation polygons. The flow path initially modelled from this polygon failed to terminate upon reaching waterbodies despite the "Flow Path Truncation" option being enabled. This behavior can result from discrepancies between the surface waterbody input shapefile and the waterbody raster file that ArcNLET generates internally and often can be resolved by adding a small buffer to the input waterbody shapefile prior to rasterization (Dr Wei Mao, personal communication, January 2025). The USF-ERG ArcNLET Team applied a buffer (3 meters) around the waterbodies adjacent to this polygon to ensure that nutrient flow paths were correctly terminated upon reaching surface waters. This modification was not required for LANLoad nor implemented by the USF-ERG LANLoad Team.

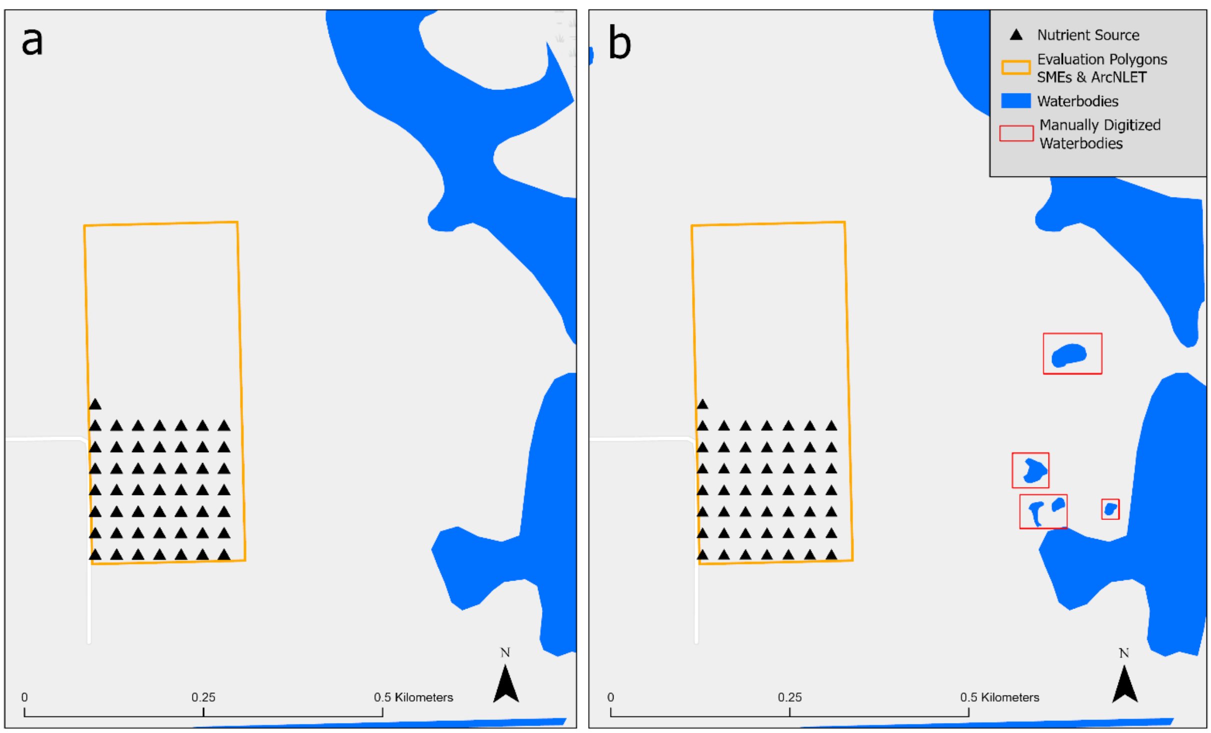

Figure 34. Waterbody layer proximal to Polygon ID 1005 before (a) and after (b) hand digitization of waterbodies. Small waterbodies evident on aerial imagery were missing from the LANLoad Waterbody geospatial dataset neighboring four evaluation polygons. The missing waterbodies were hand-digitized and added to the ArcNLET-Py Waterbody layer in preparation for ArcNLET-Py nutrient modeling as per standard ArcNLET-Py protocol.

A central assumption of the ArcNLET-Py model is that the water table in the surficial aquifer is a subdued replica of the land surface topography, which allows for simplification of groundwater flow modeling using a smoothed digital elevation model (DEM) as proxy for hydraulic head distribution (Mao et al. 2024b, Rios et al. 2013). In ArcNLET-Py, the smoothing of the DEM is achieved through a user-defined moving-window averaging process, where the number of iterations, referred to as the "smoothing factor," controls how closely the smoothed surface DEM mimics the actual water table (Core et al. 2023).

During Phase II, the FSU ArcNLET Team selected "50" as the smoothing factor for the pilot study area. In Phase III, the USF-ERG ArcNLET Team tested the suitability of 40, 50, or 60 by analyzing the relationship between observed average groundwater elevations and the elevation predicted using each of the three smoothing factors. The USF-ERG ArcNLET Team used publicly available groundwater elevation data (National Pollutant Discharge Elimination System (NPDES) database (FDEP 2025)) from 33 wells, each with a minimum of two data points (one for the dry season and one for the wet season), and the LANLoad 10-meter resolution DEM for this analysis. The smoothing factors of 40 and 60 resulted in slightly lower R^2 values, 0.84 and 0.81, respectively, than resulted from a smoothing factor of 50, R^2 0.85. The smoothing factor of 50 was utilized for Phase III- NEEPP (Figure 35).

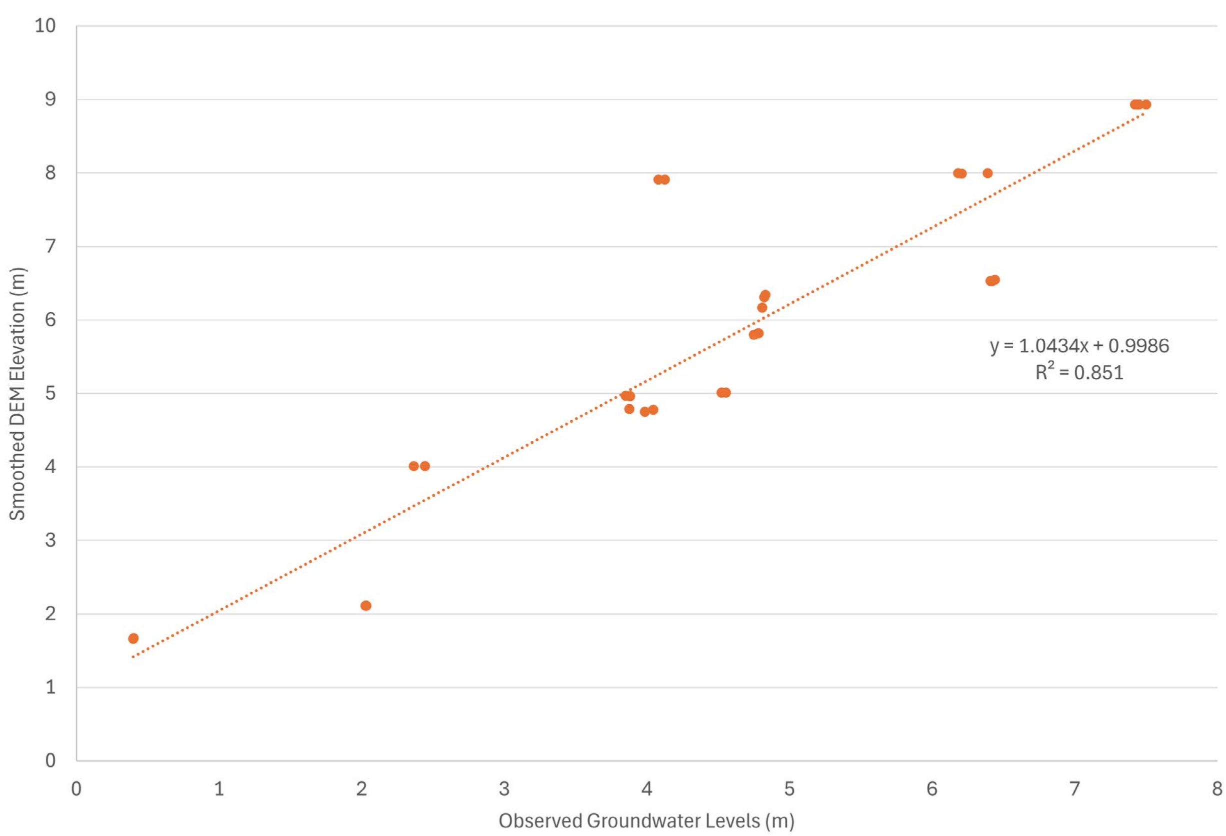

Figure 35. Comparison of smoothed Digital Elevation Model (DEM) values and observed groundwater levels at calibration wells (NPDES database).

ArcNLET-Py was released just prior to the Phase III LANLoad-NEEPP evaluation and contained a programming error that resulted in the USF-ERG ArcNLET Team running the models twice. The initial work-around recommended by the FSU ArcNLET Team was to use the "Specified Z" setting. The model was run once using this setting and again, when the programming error had been reported resolved, using the "Input Mass Rate" setting. The model results curiously differed depending on which setting was selected. However, the relative loading among evaluation polygons was unaffected. In other words, the final categorization of polygons (Lower Likelihood versus Higher Likelihood) was unaffected by the choice of "Input Mass Rate" versus "Specified Z". In the text that follows, we present results based on the "Input Mass Rate" setting. A complete list of all user-defined settings used in Phase II LANLoad Pilot Study, Phase III Input Mass Rate, and Phase III Specified Z is provided in Appendix I.

Subject Matter Expert Evaluation

Project SMEs assessed the relative likelihood of nutrient loading from 30 SMEs evaluation polygon to neighboring waterbodies using a relative scale, i.e., Higher Likelihood vs Lower Likelihood. The eight participating project SMEs represented academia, private industry, and state and local agencies (Table 28). During the evaluation (April 2025), SMEs did not have access to LANLoad results. However, they were provided access to the datasets used to develop LANLoad in an interactive map (Survey 123) developed in collaboration with the Department of Environmental Protection - Office of Environmental Accountability and Transparency (FDEP-OEAT). The Survey 123 datasets included the SMEs evaluation polygon locations, geospatial datasets representing the six LANLoad parameters, and a summary of the polygon landscape attributes (i.e., average distance to waterbody, average depth to water, average hydraulic conductivity, flood zones summarized by percentage area of polygon, average slope to nearest waterbody, and lithology summarized by percentage area of polygon).

In preparation for the SMEs evaluation, the USF-ERG worked closely with the FDEP-OEAT to ensure the Survey123 platform functioned properly and to prepare written SME instructions (Appendix II). SMEs attended an online meeting in which they were provided with instructions and orientation to the Survey 123 platform, but they conducted the evaluation exercise independently.

The instructions provided to SMEs during the online meeting and in written form (Appendix II) are summarized below.

1. Use the information provided on the Survey 123 platform to review the landscape properties of each of the 30 evaluation polygons.
2. Sort the 30 evaluation polygons into two categories based on the relative likelihood that a uniform amount of nutrients added to soils (as if from OSTDS effluent) at these locations would reach nearby waterbodies, 15 Higher Likelihood polygons and 15 Lower Likelihood polygons.
3. Categorize the evaluation polygons strictly on physical properties of the landscape, not on the current presence/absence of potential nutrient sources.
4. Record and submit answers using Survey 123.

Table 28. Participants (Subject Matter Experts) in the LANLoad SMEs Evaluation, alphabetical by last name.

Subject Matter Expert	Affiliation
Alan Baker, P.G.	State Government
Roxanne Groover	Industry
Sam Hankinson, P.G.	State Government
Brian Ingram	Local Government
Lisa Kreiger	Local Government
Mark Rains, Ph.D., PWS	Academia
Eb Roeder, Ph.D., P.E.	State Government
Ming Ye, Ph.D.	Academia

Results

ArcNLET-Py Evaluation

Overall, the range in nutrient loads intercepting waterbodies from the 500 hypothetical point sources was 0 g to 73.9 g total inorganic nitrogen per day (Table 29, Figure 36). There was 100% consistency between the likelihood categories assigned based on ArcNLET-Py results and those assigned by LANLoad.

Table 29. Nutrient loading to waterbodies modeled by ArcNLET-Py from 500-point source locations aggregated by polygon (50 locations within each polygon) and the relative likelihood category assigned by the USF-ERG ArcNLET Team based on ArcNLET-Py results and by LANLoad.

Polygon ID	# Nutrient Load Source Locations	# of Plumes (NO_3) that reach a waterbody	# of Plumes (NH_4) that reach a waterbody	NO_3 Mass Output (g/d)	NH_4 Mass Output (g/d)	Total Output (g/d)	ArcNLET-Py Rank	LANLoad Rank
1002*	50	39	41	492.8	267.7	760.5	Higher	Higher
1005	50	0	0	0	0	0	Lower	Lower
1009	50	0	0	0	0	0	Lower	Lower
1018**	50	0	0	0	0	0	Lower	Lower
1019	50	22	29	381	59.1	440.1	Higher	Higher
1021**	50	50	50	597.4	365	962.5	Higher	Higher
1022**	50	0	0	0	0	0	Lower	Lower
1026	50	47	47	630.8	262.5	893.2	Higher	Higher
1029**	50	45	47	478.5	347.2	825.7	Higher	Higher
1030	50	0	0	0	0	0	Lower	Lower

* Waterbodies were buffered (3m) prior to input into ArcNLET-Py

** Waterbodies were added (hand-digitized) in the vicinity of these polygons prior to input into ArcNLET-Py

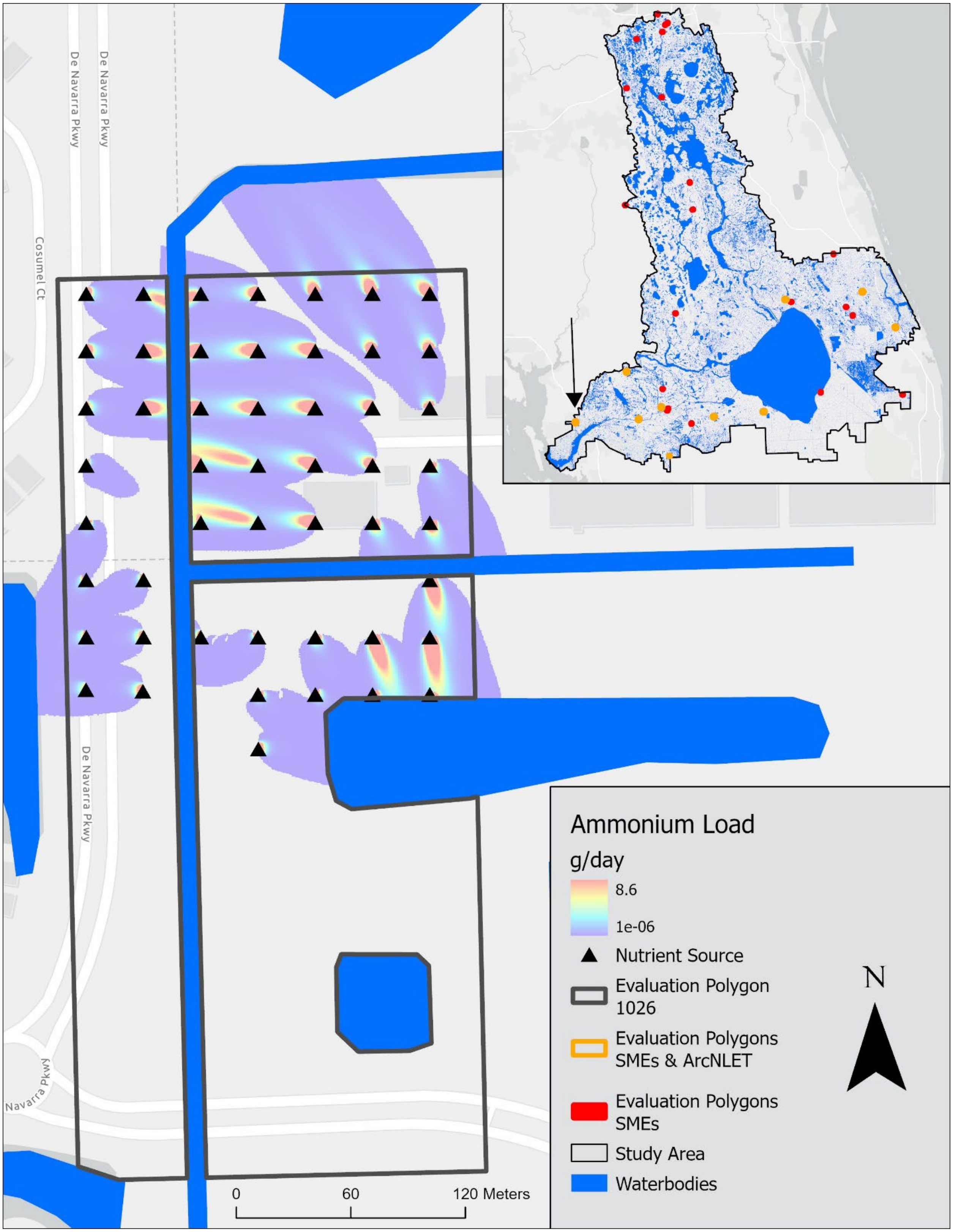

Figure 36. Example of ammonium plume behavior as modeled by ArcNLET-Py (Polygon 1026).

Subject Matter Expert Evaluation

Overall, the SMEs evaluation results were highly consistent with LANLoad across NEEPP, with both assigning the same likelihood category to 97% of the polygons. Five of the eight SMEs were at least 90% consistent with LANLoad rankings, while the remaining three had consistency rates of at least 73% (Table 30).

The polygon with the lowest level of agreement between likelihood categories assigned by SMEs and by LANLoad was Polygon #20. LANLoad categorized Polygon #20 as having a low likelihood of nutrient loading, while SMEs were evenly split, half rating it "Low", and half rating it "High" (Table 30).

Polygon 20 has the following characteristics:

- Distance to waterbodies: 150 m
- Depth to groundwater: 11 cm
- Hydraulic conductivity: 53.3 µm/s
- Slope: 0.01 radians
- Flood zone: Minimal flood hazard
- Surficial Karstic Deposits: Shells, sand, and clay

Given the relatively far distance to water, moderate hydraulic conductivity, low flood risk and low slope of this polygon and the relative weights attributed to these parameters by LANLoad (30%, 20.7%, 10,9%, 9.8%, respectively) it is unsurprising LANLoad ranked this polygon as "Low Likelihood". However, Polygon 20 also has a shallow water table, and this may have motivated some SMEs to rate it as "High".

Table 30. Comparison of the relative likelihood categories assigned by the LANLoad model and by individual Subject Matter Experts. Names have been removed to preserve anonymity.

Polygon ID	LANLoad Rank	SME A	SME B	SME C	SME D	SME E	SME F	SME G	SME H	Total consistency per polygon (%)
1	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	100
2*	Higher	Higher	Higher	Higher	Higher	Higher	Lower	Higher	Higher	87.5
3	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	100
4	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Higher	Lower	87.5
5*	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	100
6	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	100
7	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Higher	Lower	87.5
8	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Lower	Higher	87.5
9*	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	100
10	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	100
11	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	100
12	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	100
13	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Lower	Higher	87.5
14	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Lower	Higher	75
15	Lower	Lower	Lower	Lower	Lower	Lower	Higher	Lower	Lower	87.5
16	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	100
17	Lower	Lower	Lower	Higher	Lower	Lower	Lower	Lower	Lower	87.5
18*	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Higher	Lower	87.5
19*	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	100
20	Lower	Lower	Higher	Higher	Lower	Lower	Higher	Higher	Lower	50
21*	Higher	Higher	Lower	Higher	Higher	Higher	Lower	Higher	Higher	75
22*	Lower	Lower	Lower	Lower	Lower	Higher	Lower	Lower	Lower	87.5
23	Higher	Higher	Higher	Higher	Higher	Lower	Higher	Lower	Higher	75
24	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	100
25	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	100
26*	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Higher	Higher	87.5
27	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	100
28	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	100
29*	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	100
30*	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	100
Consistency between SME and LANLoad categorizations (%)		100	93	87	100	93	87	73	100	

Blue highlighting indicates departures from LANLoad

*Polygons also included in the ArcNLET-Py evaluation. The original polygon ID numbers, used in the ArcNLET-Py evaluation (Table 29), correspond to 1000 plus the value of the Polygon ID for SMEs Evaluation. For example, SMEs Evaluation Polygon #2 is ArcNLET-Py Polygon #1002.

Confusion Matrices

Confusion matrices are commonly used to evaluate classification performance by comparing predicted classifications against a reference or observed classification. The USF-ERG used confusion matrices to assess the level of consistency between LANLoad classifications and two independent methods: ArcNLET-Py and SMEs evaluations. The results of both methods of evaluation were highly consistent with LANLoad. The ArcNLET-Py evaluation was 100% consistent with LANLoad (Table 31) and the SME evaluation was 92% consistent (Table 32).

Table 31. Likelihood categories assigned to ten polygons by ArcNLET-Py and by LANLoad organized into a confusion matrix (total polygons: 10)

	LANLoad Higher	LANLoad Lower	Total
ArcNLET-Py Higher	5	0	5
ArcNLET-Py Lower	0	5	5
Total	5	5	10

Table 32. Likelihood categories assigned to 30 polygons by eight SMEs (total categories assigned by all SMEs, 240) organized into a confusion matrix

	LANLoad Higher	LANLoad Lower	Total
SMEs Higher	110	10	120
SMEs Lower	10	110	120
Total	120	120	240

Discussion

The results indicate that LANLoad performs consistently when compared to both a numerical nutrient loading model (ArcNLET-Py) and SMEs best professional judgment. Several refinements to the evaluation methodology were made in Phase III based on lessons learned during the Phase II evaluation and summarized in Phase III Task 5 “Phase II Evaluation Review.” These include standardizing the size of evaluation polygons and maintaining consistent point density in the ArcNLET-Py evaluation. These improvements led to stronger agreement across evaluation methods.

There was 100% consistency between the likelihood categories assigned to polygons based on LANLoad and by ArcNLET-Py models of nitrate, ammonium, or total nitrogen loading to neighboring waterbodies. Enhancements to the SMEs evaluation process, such as clearer instructions and faster, more reliable rendering of geospatial layers in the Survey123 platform, also contributed to more consistent responses and positive feedback from participants. As a result, LANLoad relative likelihood categories matched those of SMEs best professional judgment in 92% of cases. This strong alignment demonstrates the effectiveness of LANLoad as both a standalone tool and a complementary screening method to support more detailed modeling or expert evaluations.

It is important to note that neither LANLoad, ArcNLET-Py, nor the SMEs assessments were based on field data. Therefore, the high level of agreement should be interpreted as consistency among methods, not as confirmation of accuracy. Still, the consistency suggests LANLoad can be used with confidence to identify areas with potential nutrient loading to waterbodies, particularly in large-scale assessments where efficiency and consistency are essential.

No inconsistencies were observed between LANLoad and ArcNLET-Py, despite differences in model inputs and structure. This suggests that the models produce comparable outputs even when using different approaches. Inconsistencies between LANLoad and SME best professional judgment were rare and showed no conclusive pattern.

Overall, these results support LANLoad as a reliable, efficient, and consistent method for assessing the likelihood of nutrient loading to waterbodies across the landscape.

Task 7, Section 2

Task 7b: Documentation of the methods and results of the Springs Region Pilot Study evaluation (Wakulla County)

Overview

The University of South Florida Ecohydrology Research Group (USF-ERG) evaluated the Landscape Assessment of Nutrient Loading to Waterbodies (LANLoad) model by comparing its nutrient loading likelihood categories to the results of the Wakulla County Aquifer Vulnerability Assessment (WCAVA) model. WCAVA is a GIS-based model developed to identify areas where the Floridan Aquifer System is most vulnerable to surface contamination (Baker et al., 2009). WCAVA was selected for this evaluation because ArcNLET has not been successfully tested in springs regions (M. Ye (FSU) personal communication, May 2024) and WCAVA is the only available county-wide model specifically focused on water quality vulnerability related to nutrient pollution. The WCAVA model output scores the aquifer as highly vulnerable in regions of Wakulla County where springs commonly occur. The intent of the comparison of LANLoad with WCAVA was to determine whether modifications would be necessary to LANLoad to enhance sensitivity near springs.

Methods

Spatial analyses were conducted using ArcGIS Pro 3.4.2 (ESRI).

The USF-ERG reviewed the WCAVA documentation and geospatial datasets (Baker et al., 2009). and met with the primary author of WCAVA. These discussions provided insight into the model design, including key assumptions, limitations, and intended applications and helped to identify conceptual overlaps and differences between the LANLoad and WCAVA models.

The USF-ERG also conducted a comparison of model outputs at locations intersected by 30 randomly selected points distributed across Wakulla County. The points were selected from an initial pool defined by a fishnet (10m x 10m), excluding waterbodies, stratified by the presence or absence of surficial limestone, as defined by the Surficial Geology of Florida dataset used to develop LANLoad (Table 20). The USF-ERG used point ID and a random number generator to select 15 points each from areas with and without surficial limestone for a total of 30 Wakulla evaluation points (Figure 37). The USF-ERG compared the WCAVA vulnerability rating and the LANLoad Likelihood at locations intersected by each of the 30 Wakulla evaluation points.

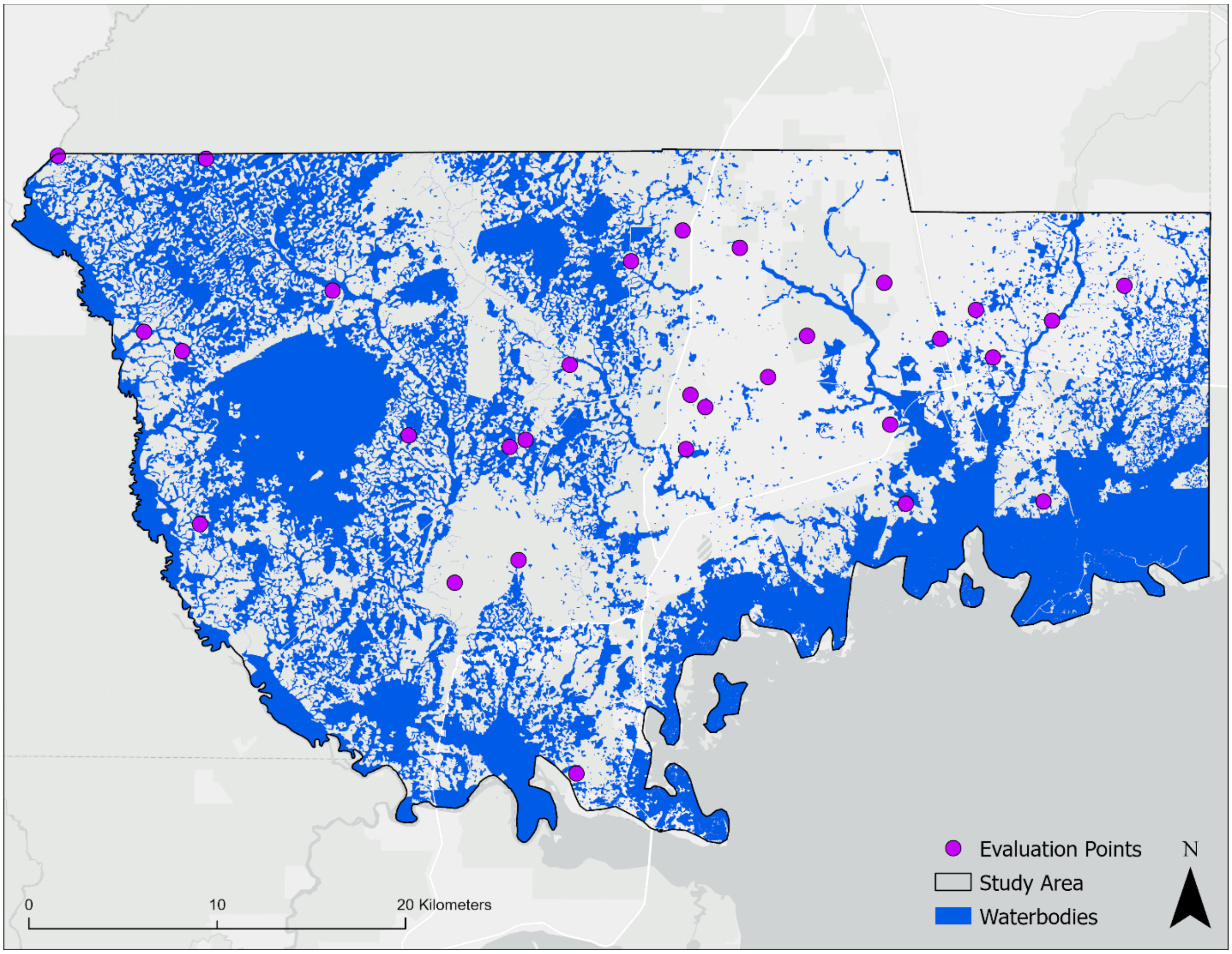

Figure 37. Distribution of Wakulla evaluation points

Results

The review of WCAVA background materials confirmed the focus of WCAVA differs from that of the current version of LANLoad. WCAVA was developed to identify areas within Wakulla County where the Floridan Aquifer System is most vulnerable to contamination from surface activities. WCAVA incorporates three main data input parameters. The strongest predictor of aquifer vulnerability was soil pedality, followed by proximity to karst features, and overburden thickness. The modeling process generated a response parameter (vulnerability map) consisting of raster cells with a resolution of 30m x 30m, reflective of the resolution of key input data available when WCAVA was developed (Baker et al. 2009).

In contrast, the current version of LANLoad was developed to evaluate the likelihood of nutrient loading to surface waterbodies based on the physical properties of distance to waterbodies, depth to groundwater, hydraulic conductivity, potential for flooding, slope, and surficial karstic deposits. While both models evaluate the potential for nutrient loading to waterbodies based on physical parameters, WCAVA addresses subsurface vulnerability to contamination, whereas LANLoad is focused on the likelihood of nutrient transport to surface waters. It is visually, i.e., qualitatively, apparent that the outputs of these models, which were developed for different purposes, are different (Figure 38).

The results of the quantitative comparison of LANLoad and WCAVA ratings at 30 Wakulla evaluation points similarly indicated low consistency between the two models (Table 33, Table 34). Lower LANLoad ranks are associated with higher WCAVA relative vulnerability categories, with mean LANLoad values increasing from the "Most Vulnerable" to the "Less Vulnerable" WCAVA vulnerability categories (Table 34).

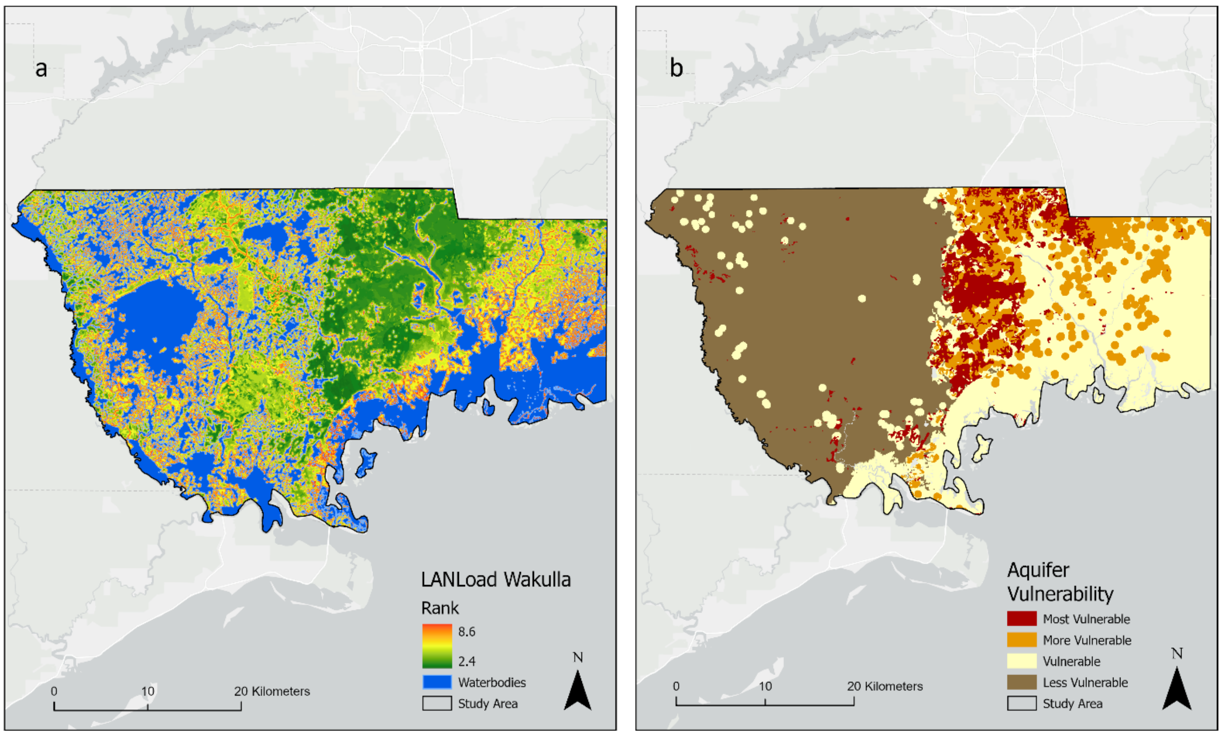

Figure 38. (a) LANLoad model results for Wakulla County and (b) WCAVA model results displaying aquifer vulnerability categories for Wakulla County. In LANLoad, a numerically higher rank indicates greater likelihood of nutrient transfer to waterbodies.

Table 33. Comparison of the LANLoad and WCAVA outputs at 30 evaluation locations

Point_ID	Lithology	LANLoad rank	WCAVA Relative Vulnerability
29	Karst	2.9	Vulnerable
20	Karst	3.1	More Vulnerable
21	Karst	3.1	Most Vulnerable
25	Karst	3.1	More Vulnerable
30	Karst	3.1	More Vulnerable
22	Karst	3.2	Most Vulnerable
18	Karst	3.5	Most Vulnerable
24	Karst	3.9	More Vulnerable
19	Karst	4.0	Vulnerable
27	Karst	5.0	Most Vulnerable
28	Karst	5.1	Vulnerable
17	Karst	5.3	More Vulnerable
16	Karst	5.4	More Vulnerable
23	Karst	6.4	Vulnerable
26	Karst	6.4	Vulnerable
13	No Karst	2.7	More Vulnerable
3	No Karst	2.9	Less Vulnerable
2	No Karst	3.1	Less Vulnerable
10	No Karst	3.6	Less Vulnerable
11	No Karst	3.9	Less Vulnerable
6	No Karst	4.2	Less Vulnerable
1	No Karst	4.3	Vulnerable
5	No Karst	4.7	Less Vulnerable
9	No Karst	5.5	Less Vulnerable
8	No Karst	5.9	Less Vulnerable
15	No Karst	5.9	Less Vulnerable
4	No Karst	6.2	Less Vulnerable
7	No Karst	6.3	Less Vulnerable
12	No Karst	6.3	Less Vulnerable
14	No Karst	6.6	Less Vulnerable

Table 34. Mean values of LANLoad output at evaluation points grouped by WCAVA vulnerability category

WCAVA Relative Vulnerability	Number of Evaluation Points	Mean LANLoad Rank
Most Vulnerable	4	3.7
More Vulnerable	7	3.8
Vulnerable	6	4.8
Less Vulnerable	13	5.0

Discussion

The comparison between WCAVA and LANLoad highlights that, at present, the two models are fundamentally designed to answer different questions. WCAVA is designed to detect locations where an underlying aquifer is vulnerable to nutrient input whereas LANLoad, as currently formatted, is designed to determine the likelihood nutrient addition would be transported to nearby surface waterbodies. Both models appear to be performing well within the scope of their intended applications.

The results of this evaluation illustrate that LANLoad currently does not rank nutrient transfer to surface waters uniformly more likely to occur in regions with surficial karstic deposits than in regions lacking surficial karstic deposits. This may be due, in part to the low importance placed on the Surficial Karstic Deposit parameter by Subject Matter Experts when LANLoad was initially developed for St Lucie County. Approaches to modify LANLoad for application in springs regions may include changes to the parameter selection, parameter weights, and/or selection of alternative geospatial datasets to represent the parameters.

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Appendix I: ArcNLET Settings (Task 7)

Parameters	Phase II LANLoad Pilot Study (FSU)	LANLoad Phase III MIR (USF-ERG)	LANLoad Phase III Specified Z (USF-ERG)
0-Preprocessing			
Top Depth (cm)	0	0	0
Bottom Depth (cm)	200	200	200
Extraction Method	Harmonic mean for Ks	Harmonic mean for Ks	Harmonic mean for Ks
Raster Cell Size (m)	10	10	10
Output Spatial SSURGO Data (Shapefile)	N/A	N/A	N/A
1-Groundwater Flow			
Smoothing Factor	40	50	50
Smoothing Cell	7	7	7
Fill Sinks	X	X	X
Merged Waterbodies (Smoothiung Factor after Merging)	5, 2	5, 2	5, 2
Changing Smoothing Cell	X	X	X
Z-Factor	1	1	1
Maximum number of continuous smoothing	50	50	50
2-Particle Tracking			
Flow Path Truncation	Y	Y	Y
WB Raster Resolution (m)	10	1	1
Step Size (m)	5	5	5
Max Steps	1000	1000	1000
3-VZMOD (Optional)			
Types of contaminats	Nitrogen	Nitrogen	Nitrogen

Single or multiple OSTDS	Multiple OSTDS	Multiple OSTDS	Multiple OSTDS
Heterogeneous Ks and Θs	Y	Y	Y
Calculate depth to water table	Y	Y	Y
Multiple soil types	Y	Y	Y
Concentration of NH4-N (mg/L)	40	40	40
Concentration of NO3-N	0.01	0.01	0.01
Distance (cm)	73.76	73.76	73.76
Hydraulic Loading Rate (cm/d)	2	2	2
Knit(1/d)	0.25	0.25	0.25
Top-nit(˚C)	25	25	25
βnit(-)	0.347	0.347	0.347
e2 (-)	2.267	2.267	2.267
e3 (-)	1.104	1.104	1.104
fs (-)	0	0	0
fwp (-)	0	0	0
Swp (-)	0.154	0.154	0.154
Sl (-)	0.665	0.665	0.665
Sh (-)	0.809	0.809	0.809
Kdnt (1/d)	0.4	0.4	0.4
Topt-dnt (˚C)	26	26	26
βdnt (-)	0.347	0.347	0.347
Sdnt (-)	0	0	0
Dispersion coefficient (cm^2/d)	4.32	4.32	4.32
Bulk Density ρ (g/cm^3)	1.5	1.5	1.5
Temperature (˚C)	25.5	25.5	25.5
4-Transport			
Types of contaminants	Nitrogen	Nitrogen	Nitrogen
Consideration of NH4-N	Y	Y	Y
Solution type	DomenicoRobbinsSSDecay2D	DomenicoRobbinsSSDecay2D	DomenicoRobbinsSSDecay2D

Plume warping control point spacing (Cells)	48	48	48
Plume warping method	Spline	Spline	Spline
Threshold Concentration	0.000001	0.000001	0.000001
Postprocessing	Medium	Medium	Medium
Domenico Bdy.	Specified Input Mass Rate	Specified Input Mass Rate	Specified Z
Maximum plumes of continuous calculation for one time	400	400	400
Mass input of nitrogen (mg/d)	20000	20000	N/A
Source Dimension Y (m)	6	6	6
Mazimum Z (m)	Y	Y	Y
Zmax (m)	1.5	1.5	1.5
Plume cell size (m)	0.4	0.4	0.4
Volume Conversion Factor	1000	1000	1000
Bulk Density (g/cm^3)	1.42	1.42	1.42
Concentration of NO3-N (mg/l)	40	40	40
NO3-N Dispersivity αL (m)	2.113	2.113	2.113
NO3-N Dispersivity αTH (m)	0.234	0.234	0.234
Denitrification Decay Rate (1/d)	0.008	0.008	0.008
Concentration of NH4-N (mg/l)	10	10	10
NH4-N Dispersivity αL (m)	2.113	2.113	2.113
NH4-N Dispersivity αTH (m)	0.234	0.234	0.234

Nitrification Decay Rate (1/d)	0.0001	0.0001	0.0001
kd for NH4-N (cm^3/g)	2	2	2
5-Load Estimation			
Types of contaminants	Nitrogen	Nitrogen	Nitrogen
Consideration of NH4-N	Y	Y	Y
Risk Factor	1	1	1

Appendix II: SME Evaluation Instructions (Task 7)

LANLoad (NEEPP) Subject Matter Expert Evaluation
April 2025, AT020

Introduction
The Landscape Assessment of Nutrient Loading to Waterbodies (LANLoad) tool uses six physical landscape parameters to assess the relative likelihood that nutrient inputs at specific sites would be conveyed to a waterbody. The tool was piloted in St. Lucie County, where its output showed ~80% agreement with (1) an independent numerical model (ArcNLET) and (2) subject matter experts. LANLoad is currently being expanded to the Northern Everglades & Estuaries Protection Program (NEEPP) region - the basis for this activity. Within the NEEPP region, 30 polygons were chosen based on the tool output representing relatively high or low likelihood that nutrients would be conveyed to a waterbody.

Overview

- **Purpose:** Evaluate the consistency between categories assigned by LANLoad and those assigned by subject matter experts (SMEs) using best professional judgement.
- **Assessment Area:** Northern Everglades & Estuaries Protection Program (NEEPP) region
- **Task:** SMEs will assign polygons to a category (high or low) that reflects the relative likelihood that nutrients at that site would be conveyed to a waterbody.
- **Format:** There will be a brief orientation (virtual) followed by a work session in which SMEs will work independently to review polygon datasets provided in Survey 123 and Excel format, assign polygons to relative categories and submit answers via Survey 123. SMEs will not have access to the LANLoad tool or results during the exercise.

Key Points

- **Fast Internet Speed is essential.** The spatial layers in Survey123 require fast internet speed to load properly. DEP SMEs should use the DEP network and external SMEs should use the fastest speed available.

- **Base assessments strictly on physical properties of the landscape, i.e., do not consider the current presence/absence of potential nutrient sources.**
    - The LANLoad tool is based on physical landscape factors (Table 1) and does not include land use factors such as development density or the presence, age, or density of existing OSTDS. Those factors will be considered separately.
    - Assess the relative likelihood that nutrient addition at the polygon location would be conveyed to the waterbodies depicted in Survey 123.

- **Use a Relative Scale:** Rank 15 polygons as "higher likelihood" and 15 as "lower likelihood" relative to each other. This exercise considers a hypothetical equal nutrient input across all 30 polygons.

Step-by-Step Procedure

- **Survey 123 Link:** https://experience.arcgis.com/experience/e944ff7ec6dc4545a0fa5085f99cc2bf

- **Explore the Survey 123 Map. Access to fast internet speed is essential:**
    - The Survey 123 layers corresponding to the six parameters are listed in Table 1.
    - Use the left panel in Survey 123 to zoom to each polygon.
    - Turn layers on/off as needed.

- Expanded definition information is provided for two of the six datasets:
    - *FEMA Flood Zone:* FEMA flood zone definitions can be viewed by selecting the blue box in the upper right-hand corner of Survey 123 called: "FEMA Flood Layer Summary".
    - *Surficial Geology*: For the relationship between the Surficial Geology dataset and the probability of shallow limestone deposits, see the footnote in Table 1 (this document).

- **Review Tabulated Polygon Data:**
  - Data tabulated for each polygon can be accessed via Survey 123 pop ups or by referring to the Excel sheet.
  - For parameters using continuous data, such as Distance to Waterbody, the corresponding value was calculated for each $100m^2$ cell within a polygon. The mean of those values is the "average value" tabulated for each polygon.

- **Assign Polygon Category in Survey 123:**
  - Sort the 30 polygons into two categories: "higher likelihood" (15 polygons) or "lower likelihood" (15 polygons)
  - Record the category for each polygon in Survey 123
  - Record comments in the space provided (optional but encouraged!)

- **Submit Your Evaluation via Survey 123:**
  - Provide overall feedback in the comment box and click submit when finished.

Your expertise is greatly valued. Thank you for your participation.

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Table II.1. The LANLoad physical parameters and the corresponding geospatial and tabulated datasets.

Parameter	Geospatial Source	Survey 123 Layer	Tabulated Data[2]
Distance to Waterbodies	Digital Elevation Model (SFWMD, USGS) and Waterbodies[1]	Distance to Waterbody (m)	Average Distance to Waterbody (m)
Depth to Groundwater	SSURGO (NRCS)	Depth to Water (cm)	Average Depth to Water (cm)
Hydraulic Conductivity	SSURGO (NRCS)	Hydraulic Conductivity (um/s)	Average Hydraulic Conductivity (um/s)
Potential for Flooding	National Flood Hazard (FEMA)	FEMA Flood Zone	The FEMA flood zones intersected by the polygon (percent by area)
Topography (slope)	DEM (SFWMD, USGS) and Waterbodies[1]	Contour lines (5ft intervals)	Average slope (radians) to the nearest waterbody downslope of the polygon
Surficial Karstic Deposits	Surficial Geology of Florida[3] (FGS)	Surficial Geology of Florida	The surficial geology units intersected by the polygon (percent by area)

[1]The waterbody distribution layer is a compilation of water features from the Florida NHD waterbodies, polygons, and flowlines (FDEP) and the SSURGO dataset (NRCS).

[2] Average values are calculated across 100m^2 cells within polygons.

[3] Text from The Surficial Geology of Florida metadata: *"... If the shallowest occurrence of the karstic limestone is 20 feet (6.1 meters) or less below land surface, the limestone formation was mapped. If the limestone is more than 20 feet (6.1 meters) below land surface, an undifferentiated siliciclastic unit was mapped."*