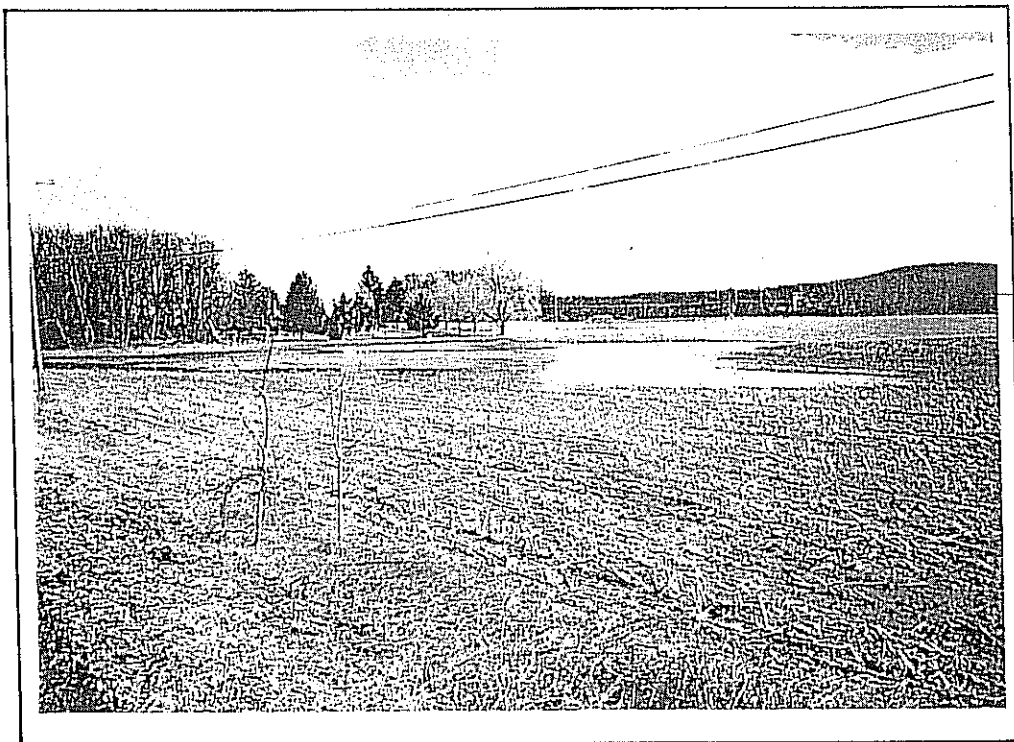


SENSITIVE ENVIRONMENTAL FEATURES

GROUNDWATER RECHARGE



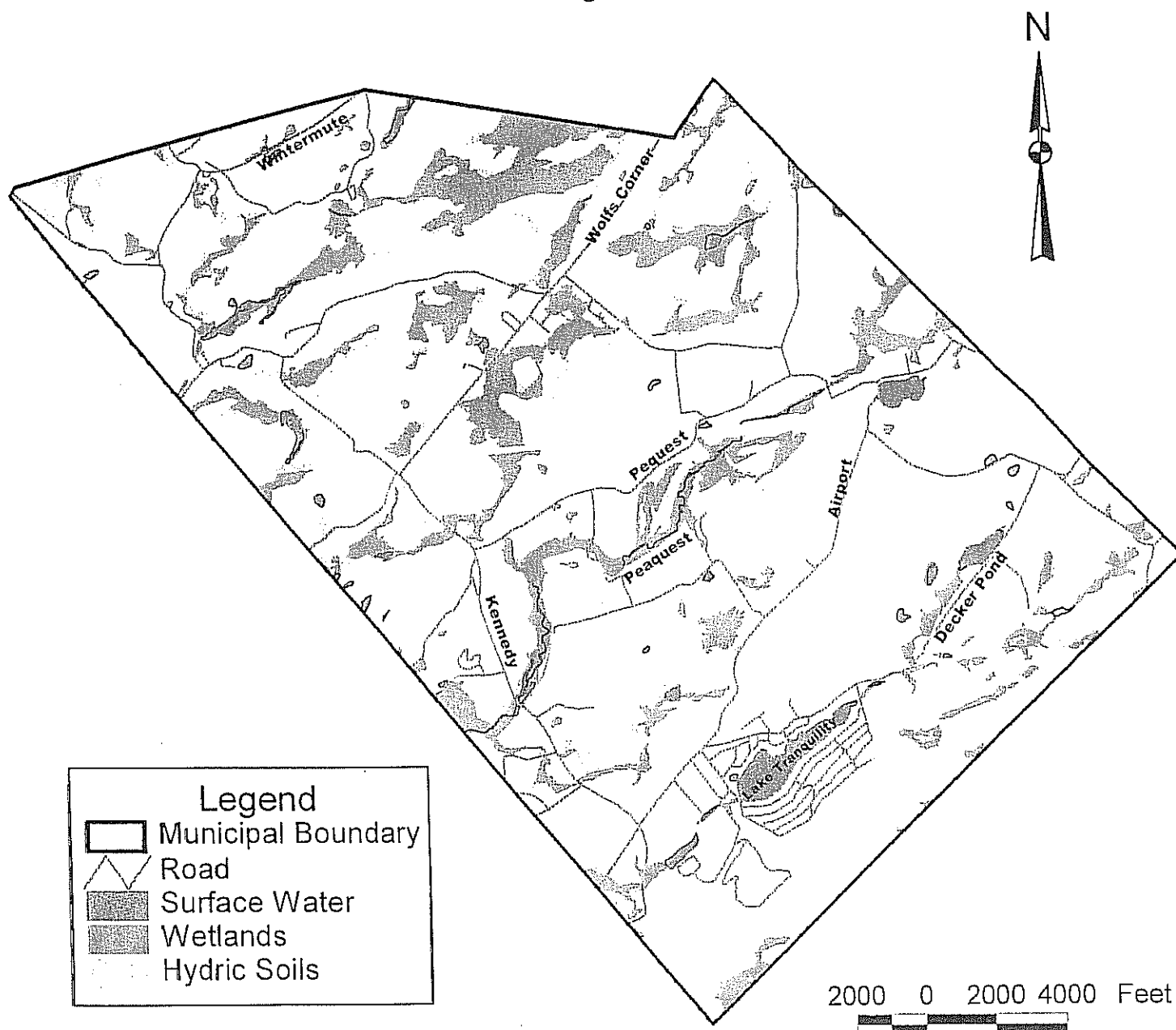
GREEN TOWNSHIP SUSSEX COUNTY, NEW JERSEY

PREPARED BY

ECO SYSTEMS ENVIRONMENTAL CONSULTANTS

17 INDIAN TERRACE, LAFAYETTE, N. J. 07848

Figure 1



Green Township Map of Surface Water and Hydric Soils

Map Sources: Roads from the US 1990 Census tract TIGER files

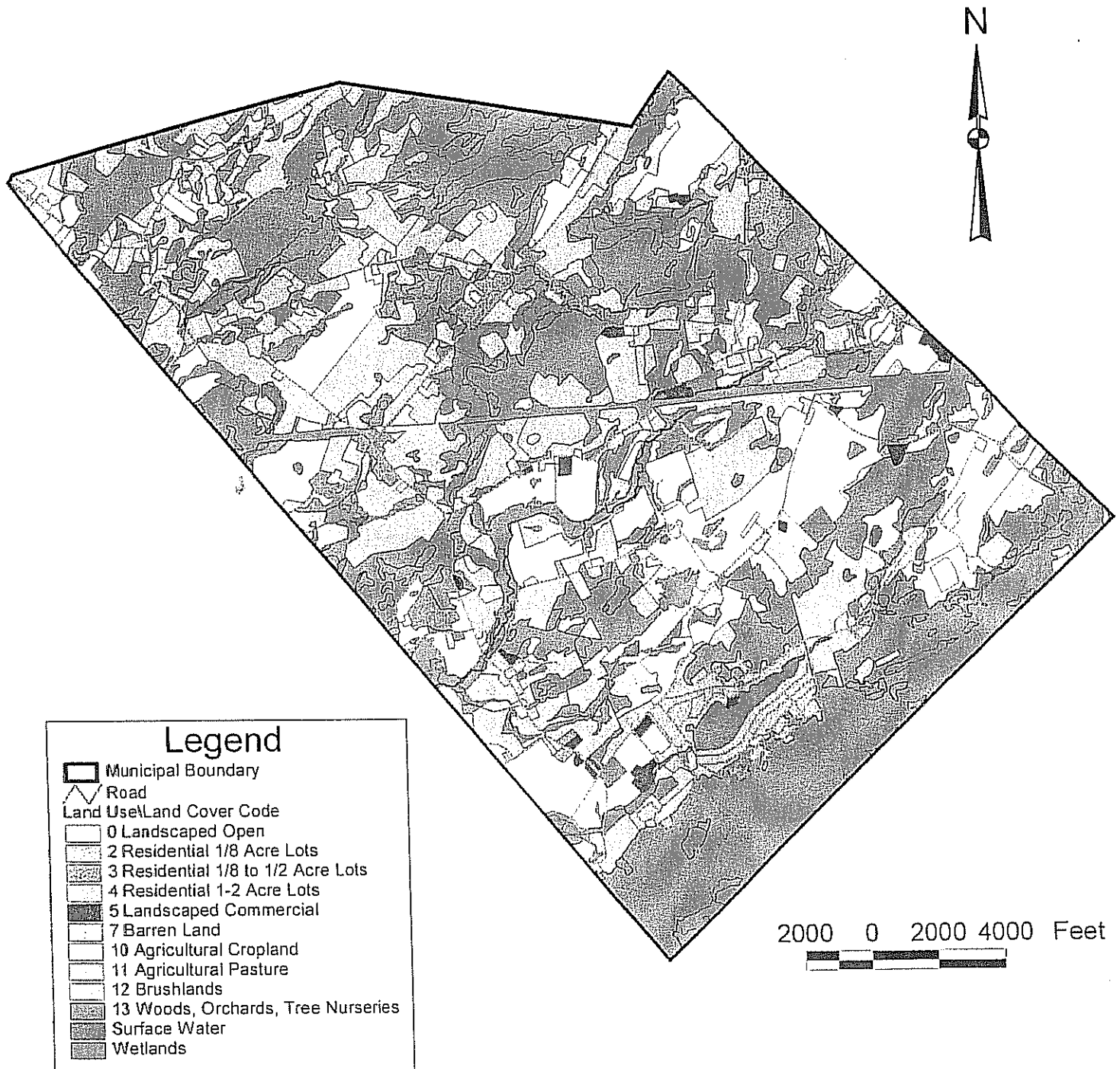
Municipal boundary, lakes, streams, LU/LC and freshwater wetlands from the NJDEP GIS Resource Data, Integrated fresh water wetlands with LU/LC

LU/LC data revised by John Robinson using data from Green Township Environmental Commission

Soils data from the NJDEP GIS Resource Data Series 1 Volume 3

Map prepared by GeoEnvironmental Research using ArcView (3.0a) software donated by the NJDEP

Figure 2



Green Township Map of Land Use/Land Cover

Map Sources: Roads from the US 1990 Census tract TIGER files

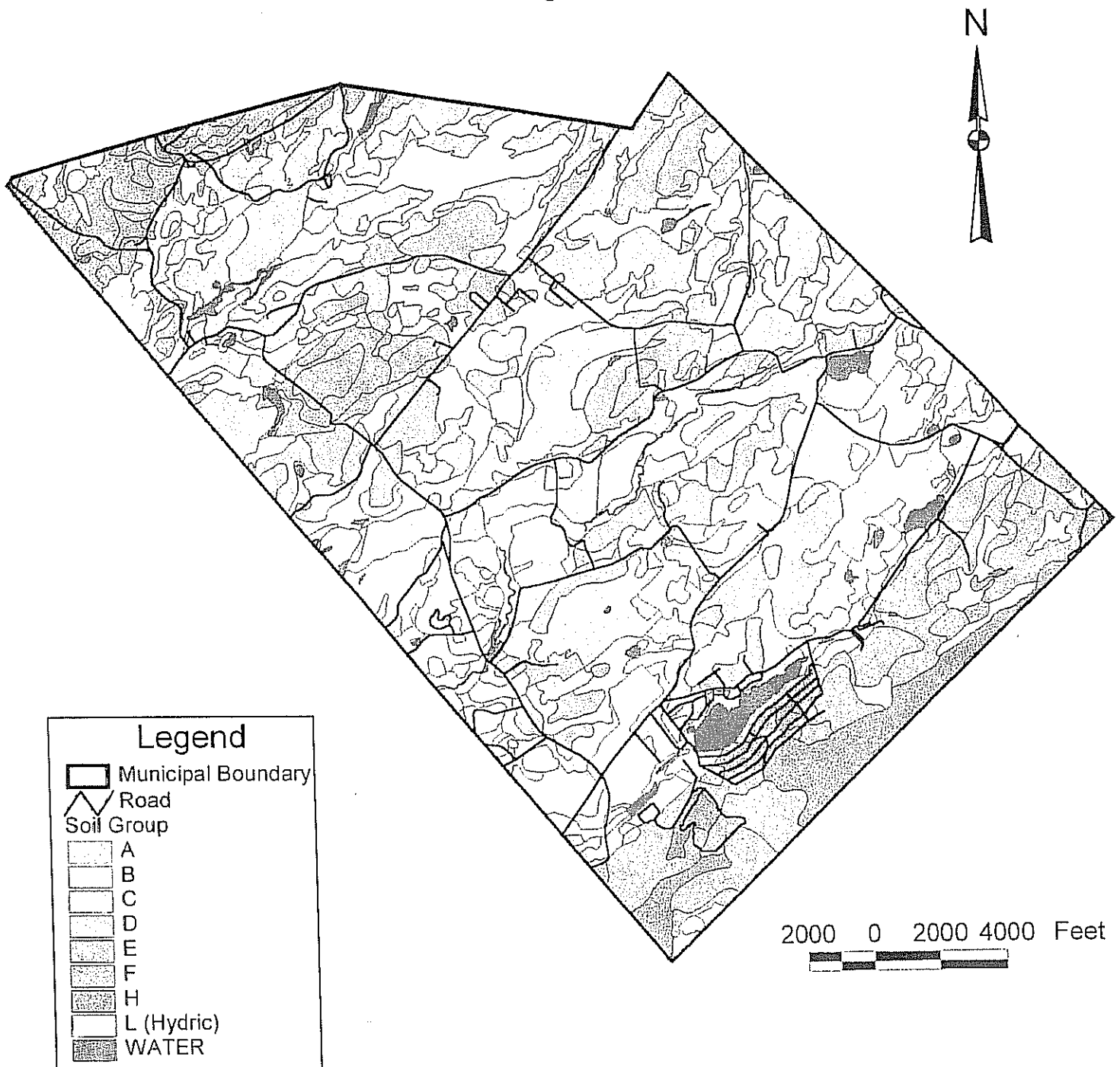
Municipal boundary, lakes, streams, LU/LC and freshwater wetlands from the NJDEP GIS Resource Data, Integrated fresh water wetlands with LU/LC

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Soils data from the NJDEP GIS Resource Data Series 1 Volume 3

Map prepared by GeoEnvironmental Research using ArcView (3.0a) software donated by the NJDEP

Figure 3



Green Township Map of Recharge Group Soils

Map Sources: Roads from the US 1990 Census tract TIGER files

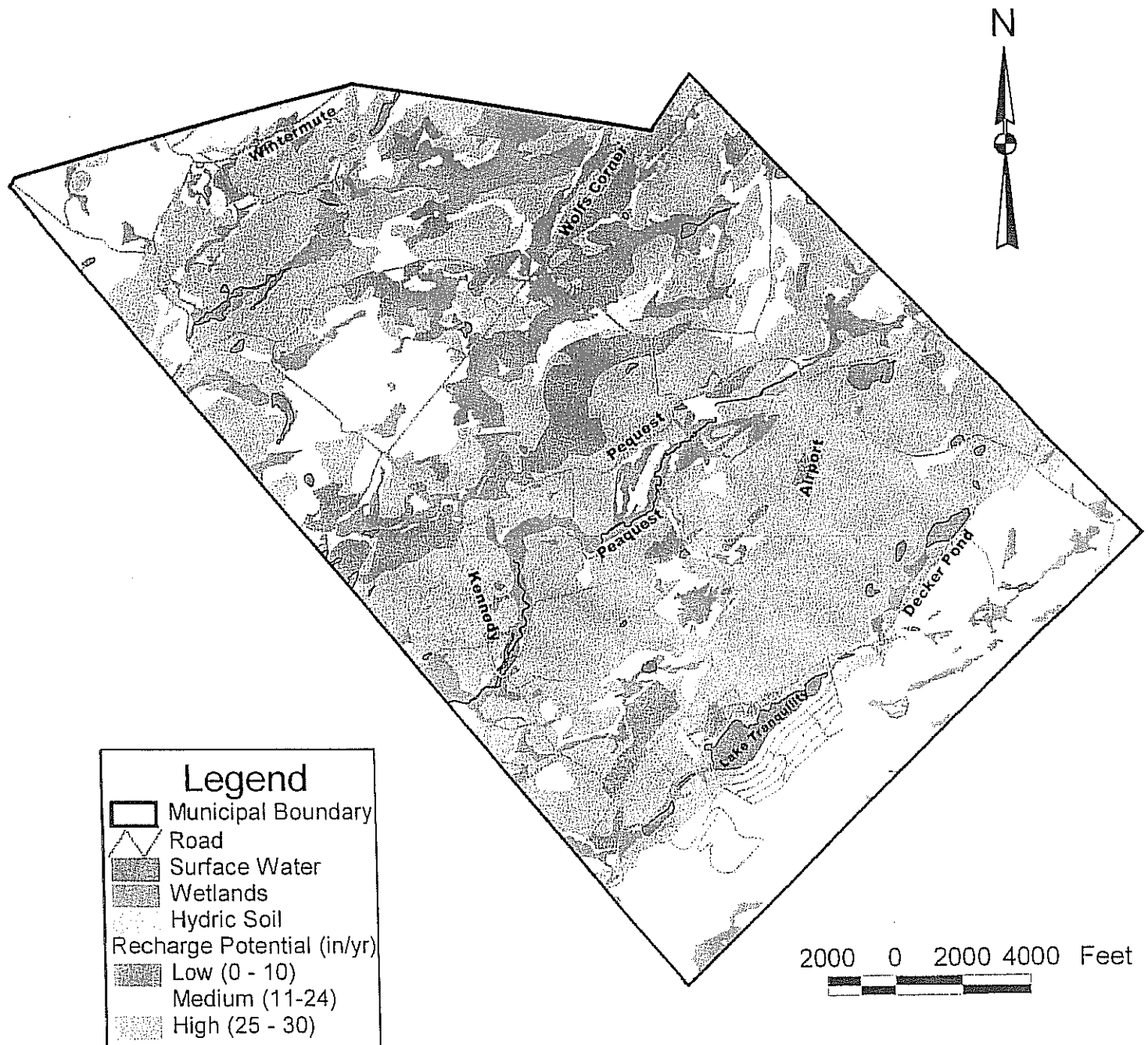
Municipal boundary, lakes, streams, LU/LC and freshwater wetlands from the NJDEP GIS Resource Data, Integrated fresh water wetlands with LU/LC

LU/LC data revised by John Robinson using data from Green Township Environmental Commission

Soils data from the NJDEP GIS Resource Data Series 1 Volume 3

Map prepared by GeoEnvironmental Research using ArcView (3.0a) software donated by the NJDEP

Figure 4



Green Township Groundwater Recharge Map

Map Sources: Roads from the US 1990 Census tract TIGER files

Municipal boundary, lakes, streams, LU/LC and freshwater wetlands from the NJDEP GIS Resource Data, Integrated fresh water wetlands with LU/LC

LU/LC data revised by John Robinson using data from Green Township Environmental Commission

Soils data from the NJDEP GIS Resource Data Series 1 Volume 3

Map prepared by GeoEnvironmental Research using ArcView (3.0a) software donated by the NJDEP

Figure 5

Area Vs. Recharge Group

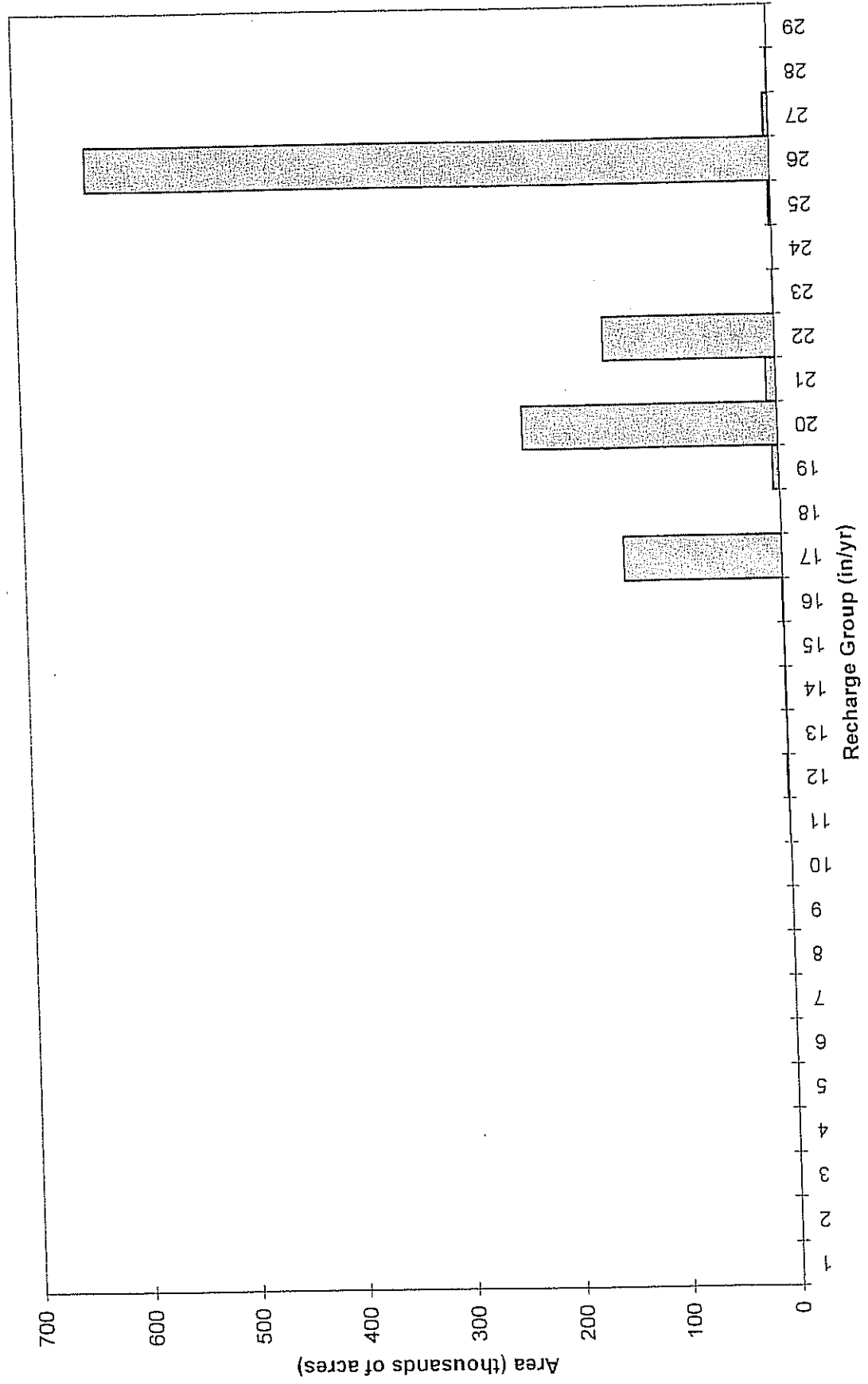
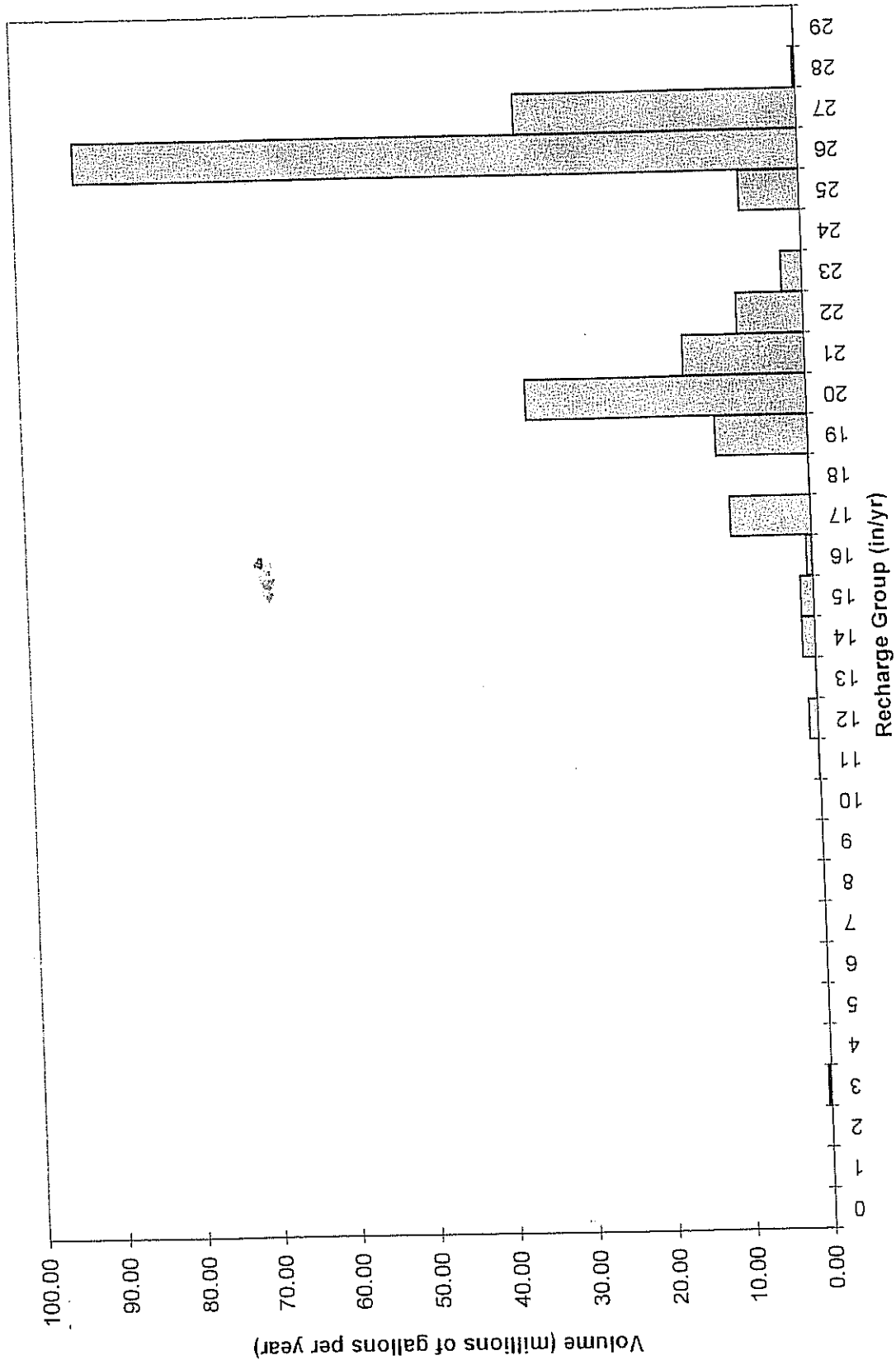


Figure 6

Groundwater Recharge Volume vs Recharge Group



Green Township Groundwater Recharge Mapping

1.0 Introduction

This document was prepared with the aid of a grant from the New Jersey Department of Environmental Protection, Office of Intergovernmental Affairs, Environmental Services Program (Grant # ES97059). A groundwater recharge map was prepared for the Green Township Environmental/ Heritage Commission for use as a planning tool. Groundwater recharge is defined as recharge which infiltrates into the ground to a depth below the root zone, based on a monthly soil-water-budget approach. The map was prepared by ranking land use/ land cover (LULC) categories and by grouping the various soil types based on groundwater recharge potential in accordance with the New Jersey Geologic Survey (NJGS) guidance document entitled "A Method for Evaluating Ground- Water Recharge Areas in New Jersey" (NJGS 1993). The various LULC categories were coded for recharge potential based on the imperviousness/ runoff nature of the land surface. The soil types were grouped and ranked for recharge potential based on permeability and runoff characteristics. The LULC and soils maps were then merged to create the groundwater recharge map. The resulting LULC and soil group combinations were classified by groundwater recharge potential (in inches per year) by accounting for precipitation, percolation potential, and evapotranspiration.

It is important to note that recharge potential was mapped irrespective of the aquifer materials present in the subsurface, and is therefore not considered to be a map of "aquifer recharge". In addition, the recharge potential of hydric soils, wetlands, and open waters cannot be determined by this method so these spatial features are excluded from the recharge map calculations, being mapped as a separate layer.

Results of the mapping indicate that the groundwater recharge of the land surface in Green Township ranges from 0 to 29.5 in/yr. The lower range of recharge occurs in areas composed of low permeability soils and land cover, whereas the higher range occurs in areas of high permeable soils. For map simplification, this recharge range was subdivided into low, moderate and high recharge rates based on the distribution of recharge against land surface area. Based on a distribution of area per recharge group, the selected ranges of 0 to 10 (low), 11 to 24 (moderate) and 25 to 30 (high) in/yr. indicate that the Township is dominated by high groundwater recharge potential.

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Green Township is about 16.5 square miles in size being located in the southwest portion of Sussex County, bounded to the southwest by Warren County. It is primarily a rural community with nearly half of its land use being agricultural. There is however, considerable development pressure in this area. The township is bounded to the southeast by Allamuchy Mountain which is composed of erosion resistant Pre-Cambrian gneiss bedrock. The township lies within the New Jersey Highlands and Appalachian Ridge and Valley physiographic provinces. The area of highest residential density is located around Lake Tranquility (Nugent, 1991).

The Pequest River and its associated floodplain and wetlands runs northeast-southwest through the township. The abandoned Blairstown rail cutoff is an historic and topographic feature which bisects Green and is observable on the map figures.

3.0 Methods

Mapping was conducted using a geographic information system (GIS). Arc/INFO (version 7.0) was used to digitize the revised LULC map, to merge (union) the LULC and soil map data sets, and to select and categorize the LULC - soils combinations. The map

data attribute tables were checked and edited using ArcView (version 3.0a). ArcView was also used to create the map layouts and to print the final copies.

4.0 Mapping

A number of digital data sets were used in the mapping. The township municipal boundary, wetlands, streams and lakes, and LULC data was taken from the NJDEP GIS Resource Data (NJDEP 1996). The road data (Figure 1) is from the US Census Bureau 1990 Topologically Integrated Geographic Encoding and Referencing (TIGER) files and includes some inaccuracies. The County soils map data are from the NJDEP GIS Resource Data volume 1 series 3. The project metadata is provided in Appendix A.

4.1 Land Use/ Land Cover

The LULC map was based on data from the digital NJDEP GIS Resource Data Series 1, Volume 4, Integrated Freshwater Wetlands with Land Use/ Land Cover (NJDEP 1996). This LULC map was interpreted by the Environmental Systems Research Institute ESRI (a NJDEP subcontractor) using 1986 aerial orthophoto quadrangles. For the Green mapping project, the existing LULC map data was revised by Rich Vohden, member of the environmental commission. The predominant revision was reinterpreting and subdividing agricultural land use into pasture and cropland. The existing LULC map data was subsequently revised by John Robinson of GeoEnvironmental Research (Figure 2). As specified in the NJGS guidance document, only parcels greater than 5 square acres were considered significant. Therefore, observed parcel changes less than 5 acres were not typically revised on the map.

The parcels were coded on a scale of 0 to 13 (in accordance with the guidance document) based on the percolation nature of the parcels (Table 1). Residential areas were coded per the guidance document as follows:

<u>Houses per 5 acres</u>	<u>Average lot size</u>	<u>LULC code</u>
Multi-family	1/8	1
10 - 40	1/8 to 1/2 acre	2
5 - 10	1/2 to 1 acre	3
2 - 5	1 to 2 acres	4

For this project, wooded areas (typically LULC code 9) were subdivided into brush (LULC code 12) and woods, orchards, shrubs and tree nurseries (LULC code 13). Agricultural land (LULC code 8) was subdivided into the suggested classes of cropland (LULC code 10) and legumes or permanent pasture types (LULC code 11). As indicated in the NJGS guidance-, wetlands, -were excluded from the recharge mapping (Figure 1).

4.2 Soils

The approximate 50 or so soil types present in the Township were reclassified into six soil groups (Figure 3) based on permeability and runoff potential. The groups were assigned to the various soil series as specified in the NJGS guidance document. "Made land", which is a soil classification for filled areas, was assigned a recharge value of 0 in/yr. As indicated in the NJGS guidance document, hydric soils (indicative of wetlands) were excluded from the mapping calculations (Figure 1).

4.3 Groundwater Recharge Map

The groundwater recharge map (Figure 4) was prepared using Arc/INFO to union the coded LULC and grouped soils maps. The recharge was classified in one - in/yr intervals ranging from 0 to 30 in/yr. Recharge (R) was calculated using the following formula:

$$\text{Recharge} = (\text{R-Factor} \times \text{C-factor} \times \text{B-factor}) - \text{R-constant}$$

Land-use/land-cover Definitions by LULC Code

(for specifics on using this table, see Section II-3a of main text, "Preparing LULC overlay")

LULC
Code

LULC descriptions

---- Urban/Suburban Features ----

- 0 Landscaped open space (0% impervious) - includes lawns, parks, athletic fields, golf courses, cemeteries, and their associated structures.
- 1 Residential (65% impervious), 1/8 acre lots - usually multi-family dwelling units.
- 2 Residential (33% impervious), greater than 1/8 acre up to and including 1/2 acre lots
- 3 Residential (23% impervious), greater than 1/2 acre up to and including 1 acre lots
- 4 Residential (17% impervious), greater than 1 acre up to and including 2 acre lots
- 5 Landscaped Commercial/Industrial/Institutional/Mixed-Use Areas - that contain some vegetated areas (approximately 15% of the total area is vegetated or 85% impervious). Use this category for highways that are wide enough to be mapped and contain exceptionally wide medial strips. Also use for large parking lots with substantial vegetated medians or "islands". Remember to separate landscaped open space and other undeveloped areas of five acres or more.
- 6 Unlandscaped Commercial/Industrial/Institutional/Mixed-Use Areas - that lack vegetated areas and are entirely impervious. Use for highways that are wide enough to be mapped but lack exceptionally wide medial strips. Also use for parking lots and developed areas that lack substantial vegetated medians or "islands".
- 7 Permanently unvegetated or sparsely vegetated areas (0% impervious-includes areas such as unpaved parking lots (for example at a fairground) and unvegetated pits.

---- Rural/Agricultural Features ----

- 8 Agricultural land -- includes all cropland, permanent pasture, meadows, and their associated structures
- 10 Agricultural land -- cropland, legumes
- 11 Agricultural land -- permanent pasture, meadow; regardless of whether grazed or mowed for hay.
- 9 Wooded areas -- includes woods, brush, orchards, shrub, tree nurseries, and their associated structures
- 12 Brush -- uncultivated areas of low to medium height shrubs, weeds, and grass.
- 13 Woods, orchards, shrubs, and tree nurseries

(1 through 5 assume that pervious portions of lots are fully vegetated with either grass, woods, or mixed. For large developments, remember to separate landscaped open space and other undeveloped areas of five acres or more.)

where the R-factor accounts for the pervious/runoff nature and permeability of the land, the C-factor is a climate factor which accounts for precipitation and wind (1.60 for Green Township). The B-factor is a basin factor (1.3) used by the NJDEP to account for the difference in calibration of calculated volumetric recharge to estimated stream baseflow for test basins with field data. The R-constant is the fraction of recharge removed by evapotranspiration.

The range in recharge was subdivided into three classes of low, medium and high recharge potential. The subdivisions were based on the evaluation of bar graphs depicting area vs. recharge group (Figure 5), and volume vs. recharge group (Figure 6). The data used to prepare the graphs is summarized in Table 2.

5.0 Results

The area vs recharge group chart (Figure 5) indicates that soil - land cover combinations do not exist to induce recharge rates of 0-2, 5-10, and 24 in/yr, therefore no areas in the Township received recharge from these groups. An insignificant but noticeable amount of area is characterized by recharge of 11 to 16 in/year, and a significant amount of area is characterized by recharge in the 17, 20 and 22 in/yr range. Based on this data, the range of recharge between 0 and 10 in/yr was classified as low, and the range of 11 to 24 in/yr was classified as medium.

The majority of the area in the township is characterized by the recharge group of 26 in/yr which covered about 635,000 acres which is the greatest area of any single recharge group. The range of 25 to 30 in/yr was classified as high, accounting for about 644 million gallons of recharge per year.

Table 2

Green Township
Groundwater Recharge Group Summary

Recharge Group (inches/year)	Groundwater Recharge Volume (1000000Gal/yr)	Area (Acres/1000)
0	na	na
1	na	na
2	na	na
3	0.32	0.1140
4	0.00	0.0081
5	na	na
6	na	na
7	na	na
8	na	na
9	na	na
10	na	na
11	0.06	0.4726
12	1.21	1.1816
13	0.07	0.2412
14	1.76	1.1672
15	1.73	0.6142
16	0.80	0.7375
17	10.28	146.3442
18	0.06	0.0057
19	11.80	6.1485
20	35.84	237.1789
21	15.58	9.4526
22	8.53	159.6107
23	2.71	0.5056
24	na	na
25	7.69	2.5775
26	92.43	635.4520
27	36.12	5.1777
28	0.34	0.9187
29	0.03	0.0020

na: not applicable

References

NJDEP, 1996, GIS Resource Data, Series 1 Volume 3, Northern New Jersey.

NJDEP, 1996, GIS Resource Data, Series 1 Volume 4, Tidelands Claims Maps and Integrated Freshwater Wetlands with Land Use/Land Cover.

New Jersey Geologic Survey, 1993, A Method for Evaluating Ground-Water Recharge Areas, NJDEP Maps and Publication Sales Office, Trenton, NJ 95 p.

Nugent Jefferey L., 1991, A Combination of Manual and Geographic Information System Techniques for Environmental Planning Mapping Analysis, Masters Thesis, Syracuse University, Syracuse, NY.

APPENDIX A
METADATA

README

This rechargemap metadata of Green Township (Sussex County) was prepared by GeoEnvironmental Research by digitally combining the revised LULC coverage with the Sussex County Soil Series Data.

The specific process used to perform the integration is discussed in more detail in the Recharge.doc file in this directory.

The basic procedure was to use the revised ITUM land use/land cover layer as the base layer and union it with the soils data. The resulting recharge coverage consisted of over 2574 polygons. About 10% of the polygons consisted of hydric soils, wetlands, or open waters which were deleted since their recharge potential is unknown. The procedure included selecting all of the available land use/ land cover combinations and assigning both recharge factors, and recharge constants to the polygon combinations. The coverage was converted to a shapefile for use in ArcView. The rechargemap.dbf file was joined with a table which included formulas to calculate actual recharge (in inches per year) from the recharge factors and recharge constants using the following calculation:

$$\text{Recharge} = (\text{R-factor} \times \text{C-factor} \times \text{B-factor}) - \text{R-constant}$$

where R-factor is a function of runoff and permeability, R-constant is a function of evapotranspiration and C-factor is a climate factor which accounts for precipitation and wind which is provided by the NJGS (1.60 for Green Township), and the B-factor is a basin factor which accounts for differences in modeled stream baseflow and field observations in NJ. Once the tables were joined, ArcView mapped the data as a unique value and the range of recharge values for Green (0 to 29.5 in/yr) were subdivided into low (0 to 10.9 in/yr), medium (11-24.9 in/yr) and high (25 to 30 in/yr) recharge groups.

The metadata for the two input coverages are described in detail in this document as Sussex County ITUM Data Dictionary Soils Data.

Note that all of the detail of the polygon recharge map, both in the delineations and coding, has been retained in the combined product. The integration process does create some special problems in the final data layer, particularly with respect to the creation of sliver polygons.

These polygons need to be analyzed on a case by case basis before a determination as to whether or not they should be eliminated, re-coded or retained. In most cases, these polygons are so small that even if incorrectly coded, they do not significantly alter any land use/land cover calculations.

Green rechargemap DATA DICTIONARY

COVERAGE NAME: recharge

DATA DESCRIPTION: Groundwater recharge map for Green Township.

KEYWORDS: landuse, soils, Green, groundwater,

CONTACTS

AGENCY: GeoEnvironmental Research

NAME: John Robinson

ADDRESS: PO Box 1028

Vernon, NJ 07462

PHONE: 973-209-7745

MANUSCRIPT MAP INFORMATION

	Sussex County		
BASEMAP:	Revised NJDEP LULC/USDA Soils	COORDINATE SYSTEM:	NJ
	State Plane Feet		
MAP DATE:	1997	DATUM:	NA

D27
SCALE: 24000 MAP ACCURACY: NM
AS
PROJECTION: Polyconic GEOGRAPHIC AREA: Co
unity
MAP MEDIA: Digital FEATURE TYPE: Po
ly

MAPPING METHODOLOGY AND MAPPING SOURCES:

Revised Landuse/landcover interpreted from 1991-92 Mark Hurd (1:12000) photos.

Soils from 1995? USDA NRCS Sussex County digital soil files.

MAPPING CRITERIA:

Landuse/landcover mapped using modified Anderson et al (1976) classification

system. Minimum revised mapping unit = 5.0 acres.

MAPPING ACCURACY AND DATA LIMITATIONS:

Basemap (photoquad) feature positions are good to about +/- 60 feet.

Delineated lines good to about +/- 20 feet from locations on manuscript.

MAP AUTOMATION

AUTOMATION DATE: June 1998 COORDINATE SYSTEM: NJ State Plane Feet
DATUM: NAD27 (projected to NAD83)
AUTOMATION METHODS: Arc/INFO union
PRODUCTION STAFF: John Robinson
AUTOMATION STATUS: complete
DATA AVAILABILITY: ARC/INFO Export (UNIX) on Zip disc, also converted to ArcView shapefile.

CARTOGRAPHIC QUALITY:

Data revisions were systematically plotted on basemap.
Node errors and dangles resolved. Code validity checked with FREQUENCY.

DISTRIBUTION RESTRICTIONS:

None

MAP ATTRIBUTES

DATABASE: Info

ITEM NAME -----	DESCRIPTION -----
LAND-USE	- Landuse/landcover code (four digit).
SOIL-LABEL	- SCS Soil label
PRIM-GEOL	- Primary geology
RECHARGE_CLASS	- Soils Group
RECHARGE_CONSTANT	- NJGS Assigned LULC/Soils poly combina tion for
RECHARGE_FACTOR	- runoff/permeablilty NJGS Assigned evapotranspiraton value
Lu_Code	- NJGS specified LULC code based on rec
harge/ runoff potential	
Recharge_g	- NJGS specified soil group cat
egory	
FACTOR	- Recharge factor (previously defined)
CONSTANT	- Recharge constant (previously defined
)	
C_FACTOR	- NJGS specified climate factor (1.63)
B_FACTOR	- NJGS specified basin factor (1.3)
RECHVAL	- Recharge value
RECHARGE	- Recharge value rounded to nearest inc
h	

LOOKUP AND/OR RELATED DATA FILES:

Lookup tables for landuse/landcover, soils

ATTRIBUTE QUALITY:

Frequencies run to check for valid attributes.

ADDITIONAL COMMENTS:

Green Township ITUM DATA DICTIONARY

COVERAGE NAME: lulc
DATA DESCRIPTION: Integrated Terrain Unit\ Groundwater recharge codes for Green Twp.
KEYWORDS: landuse, recharge

CONTACTS

AGENCY: GeoEnvironmental Research
NAME: John Robinson
ADDRESS: P.O. Box 1028
Vernon NJ 07462
PHONE: 973-209-7745

MANUSCRIPT MAP INFORMATION

BASEMAP: Photo-QuarterQuad	COORDINATE SYSTEM:
NJ State Plane Feet	
MAP DATE: 1991-92	DATUM:
NAD27	
SCALE: 12000	MAP ACCURACY:
NMAS	
PROJECTION: Polyconic	GEOGRAPHIC AREA:
Twonship	
MAP MEDIA: Mylar	FEATURE TYPE:
Poly	

MAPPING METHODOLOGY AND MAPPING SOURCES:

Existing Landuse/landcover revised from 1987 NJDEP lulc by Rich Volchert of the Green Township Environmental\Heritage Commission. Revisions predominately restricted to parcels greater than 5 acres.

MAPPING CRITERIA:

Mapping conducted based on lulc groundwater recharge codes published by the New Jersey Geologic Survey guidance document entitled "A Method for Evaluating Ground-Water Recharge Areas in New Jersey", 1993.

MAPPING ACCURACY AND DATA LIMITATIONS:

Basemap (photoquad) feature positions are good to about +/- 60 feet.

Delineated lines good to about +/- 20 feet from locations on manuscript.

MAP AUTOMATION

AUTOMATION DATE: June 1998

COORDINATE SYSTEM: NJ State Plane Feet

DATUM: NAD27 (projected to NAD83)

AUTOMATION METHODS: digitize

PRODUCTION STAFF: GeoEnvironmental Research, Vernon, NJ

AUTOMATION STATUS: complete

DATA AVAILABILITY: ARC/INFO Export (UNIX) on zip disc

CARTOGRAPHIC QUALITY:

Data has not been systematically plotted on mylar and checked to basemap.

Nodeerrors, labelerrors and slivers resolved. Code validity checked with

FREQUENCY.

DISTRIBUTION RESTRICTIONS:

None

MAP ATTRIBUTES

DATABASE: Info

ITEM NAME	DESCRIPTION
-----	-----
LAND-USE	- Landuse/landcover code (four digit).
Lu_code	- Recharge classification (code)

LOOKUP AND/OR RELATED DATA FILES:

ATTRIBUTE QUALITY:

LOOKUP TABLE DESCRIPTIONS:

ADDITIONAL COMMENTS:

This coverage is unioned with the soils coverage to create a groundwater recharge map.

Green Township

Groundwater Recharge Mapping

1.0 Introduction

This document was prepared with the aid of a grant from the New Jersey Department of Environmental Protection, Office of Intergovernmental Affairs, Environmental Services Program (Grant # ES97059). A groundwater recharge map was prepared for the Green Township Environmental/ Heritage Commission for use as a planning tool. Groundwater recharge is defined as recharge which infiltrates into the ground to a depth below the root zone, based on a monthly soil-water-budget approach. The map was prepared by ranking land use/ land cover (LULC) categories and by grouping the various soil types based on groundwater recharge potential in accordance with the New Jersey Geologic Survey (NJGS) guidance document entitled "A Method for Evaluating Ground- Water Recharge Areas in New Jersey" (NJGS 1993). The various LULC categories were coded for recharge potential based on the imperviousness/ runoff nature of the land surface. The soil types were grouped and ranked for recharge potential based on permeability and runoff characteristics. The LULC and soils maps were then merged to create the groundwater recharge map. The resulting LULC and soil group combinations were classified by groundwater recharge potential (in inches per year) by accounting for precipitation, percolation potential, and evapotranspiration.

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4.1 Land Use/ Land Cover

The LULC map was based on data from the digital NJDEP GIS Resource Data Series 1, Volume 4, Integrated Freshwater Wetlands with Land Use/ Land Cover (NJDEP 1996). This LULC map was interpreted by the Environmental Systems Research Institute ESRI (a NJDEP subcontractor) using 1986 aerial orthophoto quadrangles. For the Green mapping project, the existing LULC map data was revised by Rich Vohden, member of the environmental commission. The predominant revision was reinterpreting and subdividing agricultural land use into pasture and cropland. The existing LULC map data was subsequently revised by John Robinson of GeoEnvironmental Research (Figure 2). As specified in the NJGS guidance document, only parcels greater than 5 square acres were considered significant. Therefore, observed parcel changes less than 5 acres were not typically revised on the map.

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- 4 Residential (17% impervious), greater than 1 acre up to and including 2 acre lots
- 5 Landscaped Commercial/Industrial/Institutional/Mixed-Use Areas - that contain some vegetated areas (approximately 15% of the total area is vegetated or 85% impervious). Use this category for highways that are wide enough to be mapped and contain exceptionally wide medial strips. Also use for large parking lots with substantial vegetated medians or "islands". Remember to separate landscaped open space and other undeveloped areas of five acres or more.
- 6 Unlandscaped Commercial/Industrial/Institutional/Mixed-Use Areas - that lack vegetated areas and are entirely impervious. Use for highways that are wide enough to be mapped but lack exceptionally wide medial strips. Also use for parking lots and developed areas that lack substantial vegetated medians or "islands".
- 7 Permanently unvegetated or sparsely vegetated areas (0% impervious-includes areas such as unpaved parking lots (for example at a fairground) and unvegetated pits.

----- Rural/Agricultural Features -----

- 8 Agricultural land -- includes all cropland, permanent pasture, meadows, and their associated structures
- 10 Agricultural land -- cropland, legumes
- 11 Agricultural land -- permanent pasture, meadow; regardless of whether grazed or mowed for hay.
- 9 Wooded areas -- includes woods, brush, orchards, shrub, tree nurseries, and their associated structures
- 12 Brush -- uncultivated areas of low to medium height shrubs, weeds, and grass.
- 13 Woods, orchards, shrubs, and tree nurseries

(1 through 5 assume that pervious portions of lots are fully vegetated with either grass, woods, or mixed. For large developments, remember to separate landscaped open space and other undeveloped areas of five acres or more.)

where the R-factor accounts for the pervious/runoff nature and permeability of the land, the C-factor is a climate factor which accounts for precipitation and wind (1.60 for Green Township). The B-factor is a basin factor (1.3) used by the NJDEP to account for the difference in calibration of calculated volumetric recharge to estimated stream baseflow for test basins with field data. The R-constant is the fraction of recharge removed by evapotranspiration.

The range in recharge was subdivided into three classes of low, medium and high recharge potential. The subdivisions were based on the evaluation of bar graphs depicting area vs. recharge group (Figure 5), and volume vs. recharge group (Figure 6). The data used to prepare the graphs is summarized in Table 2.

5.0 Results

The area vs recharge group chart (Figure 5) indicates that soil - land cover combinations do not exist to induce recharge rates of 0-2, 5-10, and 24 in/yr, therefore no areas in the Township received recharge from these groups. An insignificant but noticeable amount of area is characterized by recharge of 11 to 16 in/year, and a significant amount of area is characterized by recharge in the 17, 20 and 22 in/yr range. Based on this data, the range of recharge between 0 and 10 in/yr was classified as low, and the range of 11 to 24 in/yr was classified as medium.

The majority of the area in the township is characterized by the recharge group of 26 in/yr which covered about 635,000 acres which is the greatest area of any single recharge group. The range of 25 to 30 in/yr was classified as high, accounting for about 644 million gallons of recharge per year.

Table 2

Green Township
Groundwater Recharge Group Summary

Recharge Group (inches/year)	Groundwater Recharge Volume (1000000Gal/yr)	Area (Acres/1000)
0	na	na
1	na	na
2	na	na
3	0.32	0.1140
4	0.00	0.0081
5	na	na
6	na	na
7	na	na
8	na	na
9	na	na
10	na	na
11	0.06	0.4726
12	1.21	1.1816
13	0.07	0.2412
14	1.76	1.1672
15	1.73	0.6142
16	0.80	0.7375
17	10.28	146.3442
18	0.06	0.0057
19	11.80	6.1485
20	35.84	237.1789
21	15.58	9.4526
22	8.53	159.6107
23	2.71	0.5056
24	na	na
25	7.69	2.5775
26	92.43	635.4520
27	36.12	5.1777
28	0.34	0.9187
29	0.03	0.0020

na: not applicable

References

NJDEP, 1996, GIS Resource Data, Series 1 Volume 3, Northern New Jersey.

NJDEP, 1996, GIS Resource Data, Series 1 Volume 4, Tidelands Claims Maps and Integrated Freshwater Wetlands with Land Use/Land Cover.

New Jersey Geologic Survey, 1993, A Method for Evaluating Ground-Water Recharge Areas, NJDEP Maps and Publication Sales Office, Trenton, NJ 95 p.

Nugent Jefferey L., 1991, A Combination of Manual and Geographic Information System Techniques for Environmental Planning Mapping Analysis, Masters Thesis, Syracuse University, Syracuse, NY.

APPENDIX A
METADATA

README

This rechargemap metadata of Green Township (Sussex County) was prepared by GeoEnvironmental Research by digitally combining the revised LULC coverage with the Sussex County Soil Series Data.

The specific process used to perform the integration is discussed in more detail in the Recharge.doc file in this directory.

The basic procedure was to use the revised ITUM land use/land cover layer as the base layer and union it with the soils data. The resulting recharge coverage consisted of over 2574 polygons. About 10% of the polygons consisted of hydric soils, wetlands, or open waters which were deleted since their recharge potential is unknown. The procedure included selecting all of the available land use/ land cover combinations and assigning both recharge factors, and recharge constants to the polygon combinations. The coverage was converted to a shapefile for use in ArcView. The rechargemap.dbf file was joined with a table which included formulas to calculate actual recharge (in inches per year) from the recharge factors and recharge constants using the following calculation:

$$\text{Recharge} = (\text{R-factor} \times \text{C-factor} \times \text{B-factor}) - \text{R-constant}$$

where R-factor is a function of runoff and permeability, R-constant is a function of evapotranspiration and C-factor is a climate factor which accounts for precipitation and wind which is provided by the NJGS (1.60 for Green Township), and the B-factor is a basin factor which accounts for differences in modeled stream baseflow and field observations in NJ. Once the tables were joined, ArcView mapped the data as a unique value and the range of recharge values for Green (0 to 29.5 in/yr) were subdivided into low (0 to 10.9 in/yr), medium (11-24.9 in/yr) and high (25 to 30 in/yr) recharge groups.

The metadata for the two input coverages are described in detail in this document as Sussex County ITUM Data Dictionary Soils Data.

Note that all of the detail of the polygon recharge map, both in the delineations and coding, has been retained in the combined product. The integration process does create some special problems in the final data layer, particularly with respect to the creation of sliver polygons.

These polygons need to be analyzed on a case by case basis before a determination as to whether or not they should be eliminated, re-coded or retained. In most cases, these polygons are so small that even if incorrectly coded, they do not significantly alter any land use/land cover calculations.

Green rechargemap DATA DICTIONARY

COVERAGE NAME: recharge

DATA DESCRIPTION: Groundwater recharge map for Green Township.

KEYWORDS: landuse, soils, Green, groundwater,

CONTACTS

AGENCY: GeoEnvironmental Research

NAME: John Robinson

ADDRESS: PO Box 1028

Vernon, NJ 07462

PHONE: 973-209-7745

MANUSCRIPT MAP INFORMATION

Sussex County

BASEMAP: Revised NJDEP LULC/USDA Soils COORDINATE SYSTEM: NJ
State Plane Feet

MAP DATE: 1997

DATUM: NA

D27
SCALE: 24000 MAP ACCURACY: NM
AS
PROJECTION: Polyconic GEOGRAPHIC AREA: Co
unty
MAP MEDIA: Digital FEATURE TYPE: Po
ly

MAPPING METHODOLOGY AND MAPPING SOURCES:

Revised Landuse/landcover interpreted from 1991-92 Mark Hurd (1:12000) photos.

Soils from 1995? USDA NRCS Sussex County
digital soil files.

MAPPING CRITERIA:

Landuse/landcover mapped using modified Anderson et al (1976) classification

system. Minimum revised mapping unit = 5.0 acres.

MAPPING ACCURACY AND DATA LIMITATIONS:

Basemap (photoquad) feature positions are good to about +/- 60 feet.

Delineated lines good to about +/- 20 feet from locations on manuscript.

MAP AUTOMATION

AUTOMATION DATE: June 1998 COORDINATE SYSTEM: NJ State Plane Feet
DATUM: NAD27 (projected to NAD83)
AUTOMATION METHODS: Arc/INFO union
PRODUCTION STAFF: John Robinson
AUTOMATION STATUS: complete
DATA AVAILABILITY: ARC/INFO Export (UNIX) on Zip disc, also converted to ArcView shapefile.

CARTOGRAPHIC QUALITY:

Data revisions were systematically plotted on basemap.

Node errors and dangles resolved. Code validity checked with FREQUENCY.

DISTRIBUTION RESTRICTIONS:

None

MAP ATTRIBUTES

DATABASE: Info

ITEM NAME -----	DESCRIPTION -----
LAND-USE	- Landuse/landcover code (four digit).
SOIL-LABEL	- SCS Soil label
PRIM-GEOL	- Primary geology
RECHARGE_CLASS	- Soils Group
RECHARGE_CONSTANT	- NJGS Assigned LULC/Soils poly combina
tion for	
	runoff/permeablilty
RECHARGE_FACTOR	- NJGS Assigned evapotranspiraton value
Lu_Code	- NJGS specified LULC code based on rec
harge/ runoff potential	
Recharge_g	- NJGS specified soil group cat
egory	
FACTOR	- Recharge factor (previously defined)
CONSTANT	- Recharge constant (previously defined
)	
C_FACTOR	- NJGS specified climate factor (1.63)
B_FACTOR	- NJGS specified basin factor (1.3)
RECHVAL	- Recharge value
RECHARGE	- Recharge value rounded to nearest inc
h	

LOOKUP AND/OR RELATED DATA FILES:

Lookup tables for landuse/landcover, soils

ATTRIBUTE QUALITY:

Frequencies run to check for valid attributes.

ADDITIONAL COMMENTS:

Green Township ITUM DATA DICTIONARY

COVERAGE NAME: lulc

DATA DESCRIPTION: Integrated Terrain Unit\ Groundwater recharge codes for Green Twp.

KEYWORDS: landuse, recharge

CONTACTS

AGENCY: GeoEnvironmental Research
NAME: John Robinson
ADDRESS: P.O. Box 1028
Vernon NJ 07462
PHONE: 973-209-7745

MANUSCRIPT MAP INFORMATION

BASEMAP: Photo-QuarterQuad
NJ State Plane Feet
MAP DATE: 1991-92
NAD27
SCALE: 12000
NMAS
PROJECTION: Polyconic
Township
MAP MEDIA: Mylar
Poly

COORDINATE SYSTEM:

DATUM:

MAP ACCURACY:

GEOGRAPHIC AREA:

FEATURE TYPE:

MAPPING METHODOLOGY AND MAPPING SOURCES:

Existing Landuse/landcover revised from 1987 NJDEP lulc by Rich Volchert of the Green Township Environmental\Heritage Commission. Revisions predominately restricted to parcels greater than 5 acres.

MAPPING CRITERIA:

Mapping conducted based on lulc groundwater recharge codes published by the New Jersey Geologic Survey guidance document entitled "A Method for Evaluating Ground-Water Recharge Areas in New Jersey", 1993.

MAPPING ACCURACY AND DATA LIMITATIONS:

Basemap (photoquad) feature positions are good to about +/- 60 feet.

Delineated lines good to about +/- 20 feet from locations on manuscript.

MAP AUTOMATION

AUTOMATION DATE: June 1998 COORDINATE SYSTEM: NJ State Plane Feet

DATUM: NAD27 (projected to NAD83)

AUTOMATION METHODS: digitize

PRODUCTION STAFF: GeoEnvironmental Research, Vernon, NJ

AUTOMATION STATUS: complete

DATA AVAILABILITY: ARC/INFO Export (UNIX) on zip disc

CARTOGRAPHIC QUALITY:

Data has not been systematically plotted on mylar and checked to basemap.

Nodeerrors, labelerrors and slivers resolved. Code validity checked with

FREQUENCY.

DISTRIBUTION RESTRICTIONS:

None

MAP ATTRIBUTES

DATABASE: Info

ITEM NAME	DESCRIPTION
-----	-----
LAND-USE	- Landuse/landcover code (four digit).
Lu_code	- Recharge classification (code)

LOOKUP AND/OR RELATED DATA FILES:

ATTRIBUTE QUALITY:

LOOKUP TABLE DESCRIPTIONS:

ADDITIONAL COMMENTS:

This coverage is unioned with the soils coverage to create a groundwater recharge map.

