An Analysis of Bottomland Hardwood Areas at Three Proposed Reservoir Sites in Northeast Texas

Final Report to

Texas Water Development Board for the fulfillment of
interagency agreement No. 97-483-211

By

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February, 1997

INTRODUCTION

Bottomland hardwood forests usually occupy most sites within first and second terraces of river floodplains, low areas, seepages, and areas along river or creek channels. Hydrology is primarily responsible for the development of these bottomland forests. Flood water periodically or permanently inundates the soil and creates physiological stress on species which cannot tolerate anaerobic conditions.

Due to their high productivity, plant species diversity, and proximity to water bodies and river channels, bottomland hardwood forests are important for water resources, fish and wildlife, recreation, and biological conservation. Forested wetlands play a critical role in controlling erosion, recharging groundwater, maintaining water quality, and preventing flood damage. On the other hand, these forests are primary locations for economic development. Many areas have been cleared for agricultural purposes (farmland and pasture), timber production (logging and plantation), urbanization (industrial and residential development), or inundated for water development projects.

In Texas, industrialization and urbanization, as well as periodic droughts, have all driven the increasing demand for water resources and development of reservoirs. Loss of bottomland hardwood areas has been considered one of the important factors in the decision making for water development projects, which have to comply with federal and state regulations. This project studies the direct impact of three proposed reservoirs on bottomland hardwood forests in northeast Texas and provides essential data on loss of bottomland hardwood habitats for the Texas Water Development Board in planning for water development projects.

STUDY AREA

The study area is located in northeast Texas (Map 1). The proposed New Bonham reservoir is in Fannin County along the Bois-d'Arc Creek, a small tributary to the Red River. The other two sites (George Parkhouse I and Marvin Nichols I) are located in the Sulphur River basin.

The study area spans three ecoregions of Texas. A small area of the eastern most portion is a part of the pineywoods region of east Texas. Shortleaf pine (*Pinus echinata* Mill.), loblolly pine (*Pinus taeda* L.), and other oak and hardwood species dominate forest communities in the uplands and on hill slopes. The bottomlands and floodplains are mainly made up of bottomland hardwood species typical to east and southeast Texas. The western part of the study area contains a mixture of species and communities of post oak savanna and blackland prairie. Common species throughout the study area include eastern red cedar (*Juniperus virginiana* L.), post oak (*Q. stellata* Wangenh.), black hickory (*Carya texana* Buckl.), sweetgum (*Liquidambar styraciflua* L.), water oak (*Q. nigra* L.), southern red oak (*Q. falcata* Michx.), blackgum (*Nyssa sylvatica* Marsh.), blackjack oak (*Q. marilandica* Muenchh.), willow oak (*Q. phellos* L.), basket oak (*Q. michauxii* Nutt.), overcup oak (*Q. lyrata* Walt.), river birch (*Betula nigra* L.), red maple (*Acer rubrum* L.), green ash (*Fraxinus pennsylvanica* Marsh.), and

American elm (*Ulmus americana* L.). Almost all the vegetation types in the area have been subject to various human disturbances in the past.

METHODS

One Landsat Thematic Mapper (TM) satellite imagery scene, which covers all three proposed reservoir sites, was obtained from the Texas GAP Program at Texas Tech University, Lubbock, Texas. The TM imagery was originally acquired by the Earth Resources Observation Satellite Company (EROS) in June 1994 (path 26 and row 37). It contained 6-band data (with band 6 removed) in Universal Transverse Mercator (UTM) projection (Zone 15) with a spatial resolution of 30 meters, and it was subsequently transformed to Albers Conical Equal Area projection (datum NAD83) to assure that the areal distortion be minimal. In addition to the imagery, recent color infrared aerial photographs (NAPP 1995-96), which cover almost all areas would be impacted by the proposed reservoirs, were purchased from the USGS EROS Data Center, Sioux Falls, South Dakota (Appendix 1). The contour lines (10 ft. interval) and bottomland areas were delineated, scanned, and vectorized from USGS 7.5' quadrangle maps (mylar separates and paper maps). The road network was based on digital county road maps from the Texas Department of Transportation (TXDOT). Dam locations and reservoir pool elevations are based on the drawings in the technical designs reports for the three sites (Forrest and Cotton, Inc. 1966, Freese and Nichols, Inc. 1984). ERDAS Imagine (ERDAS Inc. 1994) and Arc/Info were utilized in the data processing, analysis, and classification.

The 6-band image data were subjected to two processes prior to the supervised classification. One was band reduction (from 6 to 3) by Principal Component Analysis (PCA). The 3 bands extracted account for most of the variation in the 6-band data, hence they can be relied upon as the primary data source for bottomland hardwood delineation in combination with contour data. The other process was unsupervised classification that categorized the raw 6-band data into 150 classes.

Training samples were collected from one field reconnaissance trip to the study area in November 1996. Ninety-three signature points/training samples were taken. Aerial photos were used to build confidence on photointerpretation of land covers and vegetation. There were more land cover types recognized in the field (primarily based on species composition and physiognomy) than described in this report. The final selection of land cover types and designation of vegetative units was determined by the interpretability of field-recognized cover types on the CIR aerial photography and the uniqueness of the Landsat signatures of these types. For example, pure pine and pure cedar were two distinguishable types in the field. Although these two types can be recognized on the CIR photograph, they do not have unique signatures on the unsupervised TM imagery. Therefore we combined the two to form a composite type pure pine/cedar.

After the field trip, a supervised classification was performed on the 150 unsupervised classes. Major sources of information used in this procedure were color infrared aerial photography, PCA processed imagery, and topography. A total of ten land cover types were recognized at New Bonham site, nine for George Parkhouse I and nine for Marvin Nichols I. The improvement of spatial and spectral resolutions of

TM imagery over Multispectral Scanner (MSS) data enabled us to distinguish more land cover types than those reported by Frye and Curtis (1990).

Areas for land cover types in the flooded areas were calculated by superimposing and masking classified imagery with contour layers. In cases where no exact contour lines exist for the mean or maximum water levels (pool elevation), areas for land cover types which will be under water were interpolated from the adjacent contour lines by assuming a linear relationship between elevation and area and an even distribution of land cover types. By 'linear relationship', we mean that the surface area increases linearly as elevation increases. The assumption of 'even distribution' implies that the areas of all cover types between two adjacent contour lines increase linearly as elevation increases, regardless of the actual patterns of distribution in the area between two adjacent contour lines. For example, we assume that the normal pool elevation of a dam is 523 ft. and two adjacent contours are 520 ft. and 530 ft. If the area from the dam location up to 520 ft. is 5,000 acres and from 520 ft to 530 ft. is 1,000 acres, the flooded area (below 523 ft.) will be 5,300 acres. Similarly, if there are 1,000 acres for cover type A from dam location to 520 ft. and 100 acres from 520 ft. to 530 ft., the total area of this type to be flooded will be 1,030 acres.

Due to time and season constraints, follow-up field visits were not conducted to verify the classified image for each site. Therefore, no accuracy matrix was constructed for the classified land cover types. Caution must be exercised in interpreting the results. However, we have high confidence in the distribution of bottomland hardwood forests and the calculated acreage in this report.

RESULTS

1. Description of Major Land Cover Types

Eleven vegetation/landcover types are recognized. Water and bare soil/ground are the types not considered as true vegetation types, although portions of these types may be partially covered by vegetation, particularly in urban areas. Vegetation types are pure pine/cedar, oak-hickory/upland oak, cedar-hardwood/pine-hardwood, secondary bottomland hardwood, bottomland hardwood, bottomland hardwood swamp, willow-sugarberry, grassland, and crops/managed grassland.

The following is a brief description of each land cover type:

Pure pine/cedar

This vegetation type is dominated almost completely by eastern red cedar, loblolly pine and shortleaf pine singly or in combination, at least in the overstory. In some cases, it may be planted slash pine stands. Abandoned fields can be invaded quickly by eastern red cedar. Stand ages and density vary greatly from place to place. This vegetation type can be found in a variety of habitats except in the wettest areas. Species abundance in the understory depends on the intensity of management and the age of the stands. Southern red oak, sweetgum, water oak, dogwood, and other hardwood species can coexist. Pure pine is a direct result of silvicultural practices, whereas cedar groves usually develop on abandoned agricultural field. The former is commonly found in the eastern part and the latter in the western part of the study area. The designation of pure pine/cedar means that there are more pines than cedars whereas pure cedar/pine means that there are more cedars than pines.

Oak-hickory/upland oak

Species commonly found in this type are post oak, black hickory, blackjack oak, and winged elm (*Ulmus alata* Michx.). Other associate species include southern red oak, sweetgum, dogwood (*Cornus florida* L.), and eastern red cedar (*Juniperus virginiana* L.). Soils are excessively-drained, poor in nutrients, and sandy on the ridges and hill tops. The herbaceous cover is sparse owing to dry conditions. In the western portion of the study area, the New Bonham site in particular, hickory presence is minimal. Therefore we termed it as upland oak.

Pine-hardwood/cedar-hardwood

This type is a mixture of pines (shortleaf and loblolly pines) and hardwood species including oaks, hickory, and many others, or a mixture of eastern red cedar and similar hardwood species.

Bottomland hardwood

Bottomland hardwood occurs on most sites within the first and second terraces of floodplains and flats along river channels. Species commonly found in this type include water oak, willow oak, blackgum, American elm, overcup oak, green ash, deciduous holly *(Ilex decidua* Walt.), sugarberry (*Celtis laevigata* Willd.), boxelder (*Acer negundo* L.), and American hornbeam (*Carpinus caroliniana* Walt.). Periodic inundation prevents the establishment of upland species and maintains the functioning of this type of vegetation.

Secondary bottomland hardwood

The species composition of this type is similar to that of the bottomland hardwood type. This type can be regarded as a subtype of the bottomland hardwood type and is successional towards that type. Species composition is usually simpler and trees are much younger than those found in the typical bottomland hardwood forests. As succession continues, the division between these two may eventually become indistinguishable.

Bottomland hardwood swamp

Extensive distribution of this type is at the Marvin Nichols I site, where frequent flooding favors species such as blackgum, willow (*Salix nigra* Marsh. var. *nigra*), green ash, river birch, willow oak, and American hornbeam. Presence of blackgum and other water resistant species (water oak, birch, and American elm), frequent flooding, and water-logging conditions characterize this type.

Willow-sugarberry

The willow-sugarberry type occurs along the river and creek channels, depressed areas, and at the confluence of lakes and creeks. This type exists in narrow strips rarely exceeding 100 meters in width. Other species coexisting in this type include river birch, cottonwood (*Populus deltaoides* Marsh.), red maple, water oak, sweetgum, pecan (*Carya illinoensis* (Wangehn.) K. Koch.), blackgum, bois d'arc (*Maclura pomifera* (Raf.) Schneid.) and American elm.

Grassland

These areas are dominated by grasses, graminoids (e.g. sedges and rushes), and other herbaceous species. Some of these areas were once forested, but were cut and converted to agricultural uses. This type includes pastures and natural grasslands. Some of the grassland areas are well developed in the absence of grazing and other disturbances.

Crops/managed grassland

This category is very similar to pasture/grassland except that the land is irrigated and managed for production of grains, cotton, and hay or for raising livestock.

Bare ground/soil

These are the areas with no or very little vegetation coverage. Industrial parks, and plowed field are two examples. However, plowed agricultural fields classified as bare soils may be temporary.

Water

This includes water bodies impounded by dams and in oxbow lakes, and open water in river channels with no or little vegetation cover overhead. Submersed aquatic vegetation may be present in some areas.

Four land cover types, bottomland hardwood, bottomland hardwood swamp, secondary bottomland hardwood, and willow-sugarberry can be considered as forested wetland types, i.e. bottomland hardwood forests, and are relatively compatible with the mixed bottomland hardwood forest type defined by Frye and Curtis (1990). Other types combined excluding grassland and crops are roughly equivalent to the mixed post oak forest type (Frye and Curtis 1990). We have to point out that secondary bottomland hardwood as defined in this report is a subtype of bottomland hardwood and its habitat quality is relatively poor. It did not show up substantially in the Marvin Nichols I site. However, we did include the area of this type in the results section and considered it as a part of bottomland hardwood (forested wetland forest). The other bottomland hardwood type, bottomland hardwood swamp, concentrates mainly in the eastern portion of the Marvin Nichols I site. There is a gradual transition to baldcypresshardwood swamp in similar habitat conditions to the east and southeast of the study area. Moreover, this type did not extend far into George Parkhouse I site and is absent from the New Bonham site.

2. Status of and Impact on Bottomland Hardwood Forest by Proposed Reservoirs

At New Bonham and George Parkhouse I sites, much of the bottomland has been converted to farmland or pasture and fragmented into small strips and patches (Map 1 and Map 2). The quality of extant bottomland hardwood forests is not as good as at the Marvin Nichols site. Newly built Cooper Lake just above the proposed George Parkhouse I reservoir may cause further decline of bottomland hardwood forests in the area due to alteration in hydrology. The construction of the proposed reservoirs will result in a potential loss of 2,646.7 ha (6,540.0 acres) of bottomland hardwood forests at New Bonham and 4,610.4 ha (11,392.1 acres) at George Parkhouse I (Table 1 and Table 2).

Currently, Marvin Nichols I site has the most extensive distribution of bottomland hardwood forests (14,641.1 ha or 36,177.5 acres) among the three sites (Table 3). Although agricultural fields have been invading the bottomland hardwood forests, frequent flooding in this section of the Sulphur River has prevented development further into these remnant bottomland areas. Along the main river channel, bottomland hardwood forests of high quality can still be found. The average width of bottomland hardwood forests is about 4 km (2.5 mi) in contrast to about 2 km (1.3 mi) at other two sites (Map 3). In addition, the hydrological regime has been altered less than at the other two sites. If the maximum water level is considered, an additional 2,000 ha

(4,800 acres) of bottomland hardwood forests at Marvin Nichols site will be subjected to inundation, while less than 200 ha (480 acres) of bottomland hardwood would be affected at each of the other sites.

CONCLUSION

About two times more bottomland hardwood forests will be lost to Marvin Nichols I reservoir than to the other two sites combined. On the other hand, substantial agricultural land will be lost at the New Bonham site (2,852.8 ha or 7,049.2 acres) and George Parkhouse I site (5,822.8 ha or 14,387.9 acres), while the loss of agricultural land is only 4,327.1 ha (10,692.1 acres) at the Marvin Nichols I site. Moreover, the quality and continuous distribution of bottomland hardwood forests at Marvin Nichols I site make the area a more desirable habitat for fish and wildlife. Nevertheless, all three proposed reservoirs will have negative impacts on the remnant bottomland hardwood forests.

ACKNOWLEDGMENTS

We are grateful to Kim Gibson and Daniel Thompson for their help in digitizing and vectorizing contour lines and Duane German for providing computer support and technical advice. Suggestions and comments by Roy Frye of Texas Parks and Wildlife and staff of Texas Water Development Board were incorporated in this final report.

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TABLES AND MAPS

APPENDICES

1. Indices of Color Infrared (CIR) aerial photographs and USGS 7.5' quadrangle topographic maps for the study area
2. Electronic Data (file name and software in parentheses):

   Raw Landsat TM imagery (2637raw.img, ERDAS Imagine v8.2)

   Unsupervised Classified Landsat TM imagery (2637iso.img, ERDAS Imagine v8.2)

   Classified TM imagery of New Bonham reservoir site (nb.img, ERDAS Imagine v8.2)

   Classified TM imagery of George Parkhouse I reservoir site (gp.img, ERDAS Imagine v8.2)

   Classified TM imagery of Marvin Nichols I reservoir site (mn.img, ERDAS Imagine v8.2)

   Road network and cities (rds_nb, rds_gp, rds_mn, ARC/INFO 7.0.4)

   Drainage systems (strms_nb, strms_gp, strms_mn, ARC/INFO 7.0.4)

   Contours (cnturs_nb, cnturs_gp, cnturs_mn, ARC/INFO 7.0.4)

   Polygon coverages derived from contours (poly_nb, poly_gp, poly_mn, ARC/INFO 7.0.4)

   Dam locations (dam_nb, dam_gp, dam_mn, ARC/INFO 7.0.4)

   Study site boundaries (box_nb, box_gp, box_mn, ARC/INFO 7.0.4)

Notes: all maps, imagery, and vector coverage are in Albers Equal Area Conic projection (datum NAD83) and have units in meters. Imagery data (.img) can be directly read by ARC/INFO.

Table 1 Summary of Land Cover Types in the Flooded Areas of Proposed New Bonham Reservoir

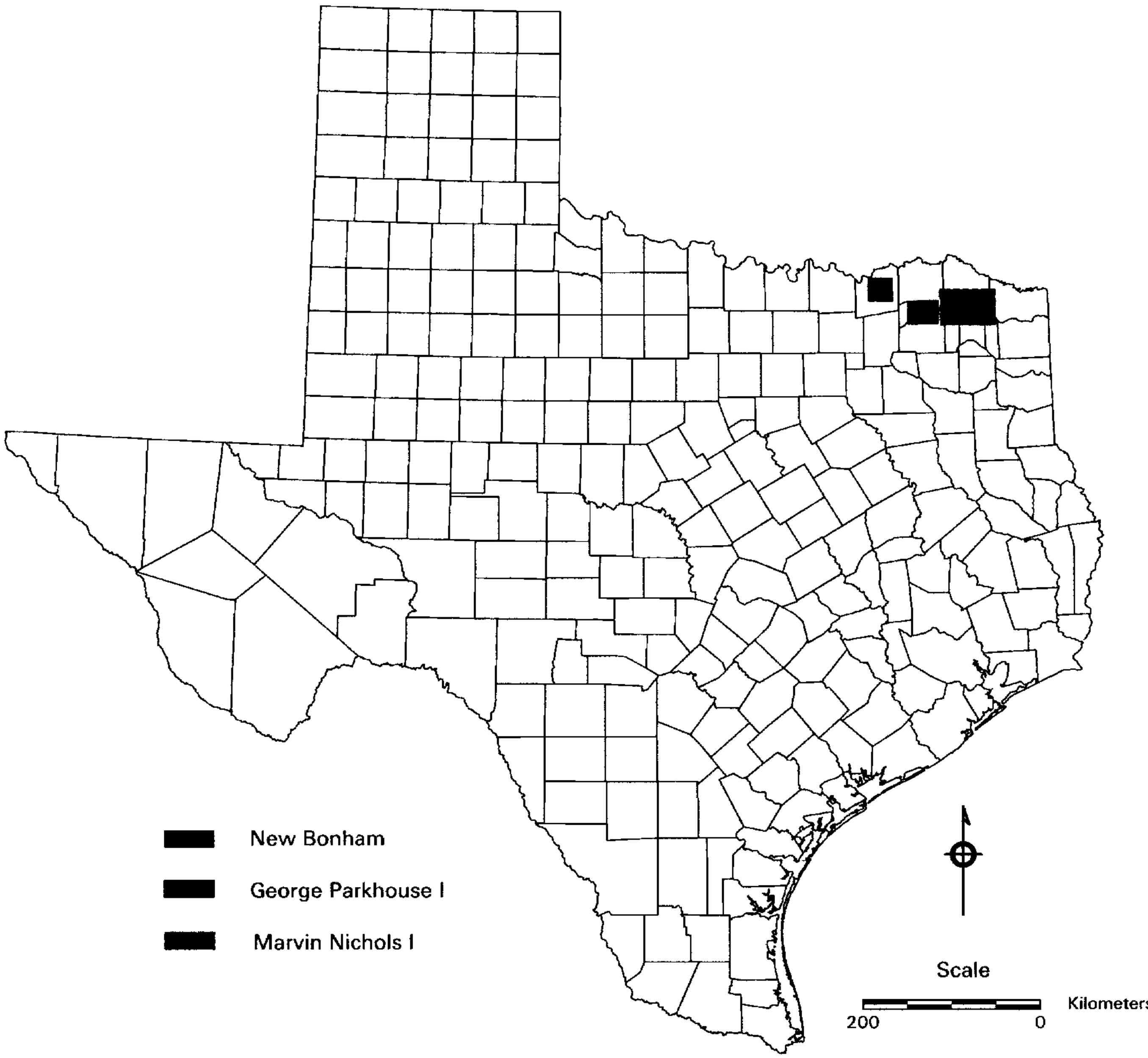
No.	Cover Type	Mean Pool Level (534 ft.)			Maximum Pool Level (540 ft.)		
		hectare	acre	%	hectare	acre	%
1	Water	36.2	89.4	0.6	41.5	102.5	0.5
2	Willow-Sugarberry	90.5	223.7	1.4	95.5	236.0	1.2
3	Bottomland Hardwood	2158.8	5334.4	32.9	2282.9	5641.1	29.6
4	Secondary Bottomland Hardwood	487.9	1205.6	7.4	559.1	1381.5	7.2
5	Upland Oak	539.1	1332.1	8.2	739.6	1827.6	9.6
6	Cedar-Hardwood	381.6	942.9	5.8	515.5	1273.8	6.7
7	Pure Cedar/Pine	12.0	29.7	0.2	14.1	34.9	0.2
8	Grassland	2851.5	7046.1	43.4	3451.3	8528.1	44.7
9	Crop/Managed Grassland	1.3	3.2	0.0	1.8	4.4	0.0
10	Bare Soil/Ground	12.5	30.9	0.2	13.1	32.5	0.2
	Total	6571.6	16238.1	100.0	7714.5	19062.3	100.0

Table 2 Summary of Land Cover Types in the Flooded Areas of Proposed George Parkhouse I Reservoir

No.	Cover Type	Mean Pool Level (401 ft.)			Maximum Pool Level (406 ft.)		
		hectare	acre	%	hectare	acre	%
1	Water	335.9	830.1	2.8	874.0	2159.5	6.5
2	Bottomland Hardwood	3817.7	9433.5	32.3	3851.6	9517.2	28.8
3	Secondary Bottomland Hardwood	792.7	1958.7	6.7	811.0	2004.0	6.1
4	Oak-Hickory	924.4	2284.0	7.8	1199.1	2963.0	9.0
5	Cedar-Hardwood/Pine-Hardwood	65.2	161.0	0.6	90.3	223.1	0.7
6	Pure Cedar/Pine	3.0	7.4	0.0	3.2	7.9	0.0
7	Grassland	4748.9	11734.3	40.2	5417.3	13385.9	40.5
8	Crop/Managed Grassland	1073.9	2653.7	9.1	1075.6	2657.7	8.0
9	Bare Soil/Ground	47.7	117.9	0.4	49.6	122.6	0.4
	Total	11809.4	29180.6	100.0	13371.6	33040.8	100.0

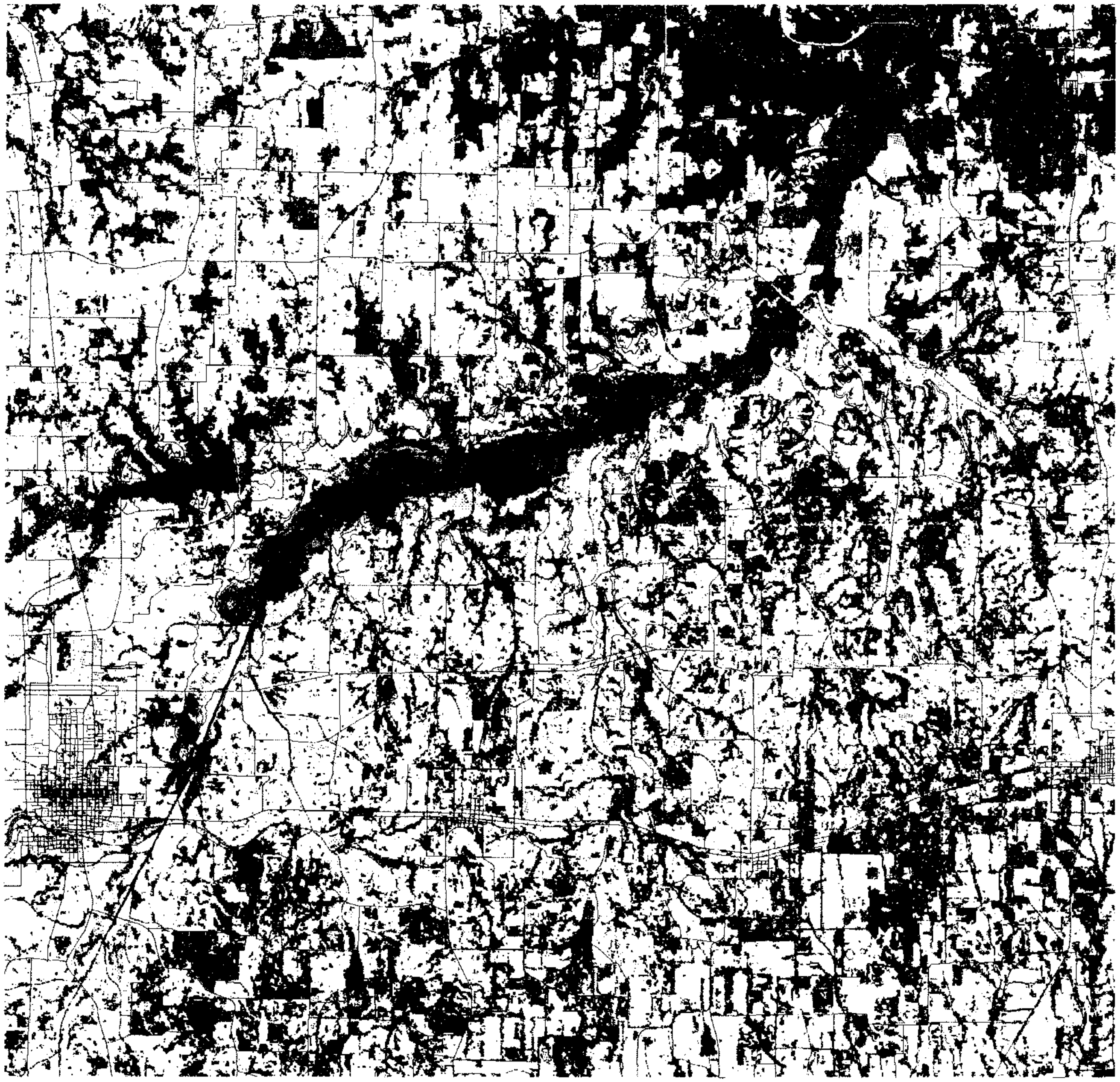
Table 3 Summary of Land Cover Types in the Flooded Areas of Proposed Marvin Nichols I Reservoir

No.	Cover Type	Mean Pool Level (312 ft.)			Maximum Pool Level (322.5 ft.)		
		hectare	acre	%	hectare	acre	%
1	Water	661.2	1633.9	2.4	899.9	2223.6	2.4
2	Bottomland Hardwood	10481.7	25899.9	38.1	12301.7	30397.1	33.3
3	Bottomland Hardwood Swamp	4159.4	10277.6	15.1	4255.8	10515.8	11.5
4	Oak-Hickory	6802.7	16809.3	24.7	10327.2	25518.1	27.9
5	Cedar-Hardwood/Pine-Hardwood	1020.3	2521.1	3.7	1771.0	4376.0	4.8
6	Pure Pine/Cedar	49.6	122.4	0.2	89.3	220.7	0.2
7	Grassland	4325.4	10687.9	15.7	7333.0	18119.6	19.8
8	Crops/Managed Grassland	1.7	4.1	0.0	2.9	7.3	0.0
9	Bare Soil/Ground	0.4	1.0	0.0	1.0	2.5	0.0
	Total	27502.3	67957.3	100.0	36981.8	91380.7	100.0



Map 1 Generalized Site Location of Three Proposed Reservoirs

Map 2 Land cover types at proposed New Bonham reservoir site and vicinity (see a large size map for more details)



New Bonham

Fannin County, Texas

Normal Water Level: 534 ft.
Maximum Water Level: 540 ft.
Top of Dam: 556.7 ft.

Legend

Cover Type

- Water
- Willow-Sugarberry
- Bottomland Hardwood
- Secondary Bottomland Hardwood
- Upland Oak
- Cedar-Hardwood
- Pure Cedar/Pine
- Grassland
- Crop/Managed Grassland
- Bare Soil/Ground

Linear Features

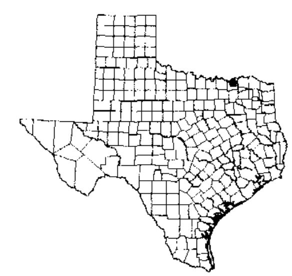
- Roads/Boundaries
- Streams/Rivers
- Contour (Elev. 530 ft.)
- Contour (Elev. 540 ft.)
- Dam Location

Scale

1 0 1 2 3 Kilometers

Data Source:

TM Imagery: EOSAT, June 1994
Road Network: Texas DOT, 1994
Contour: USGS 7.5' Quads



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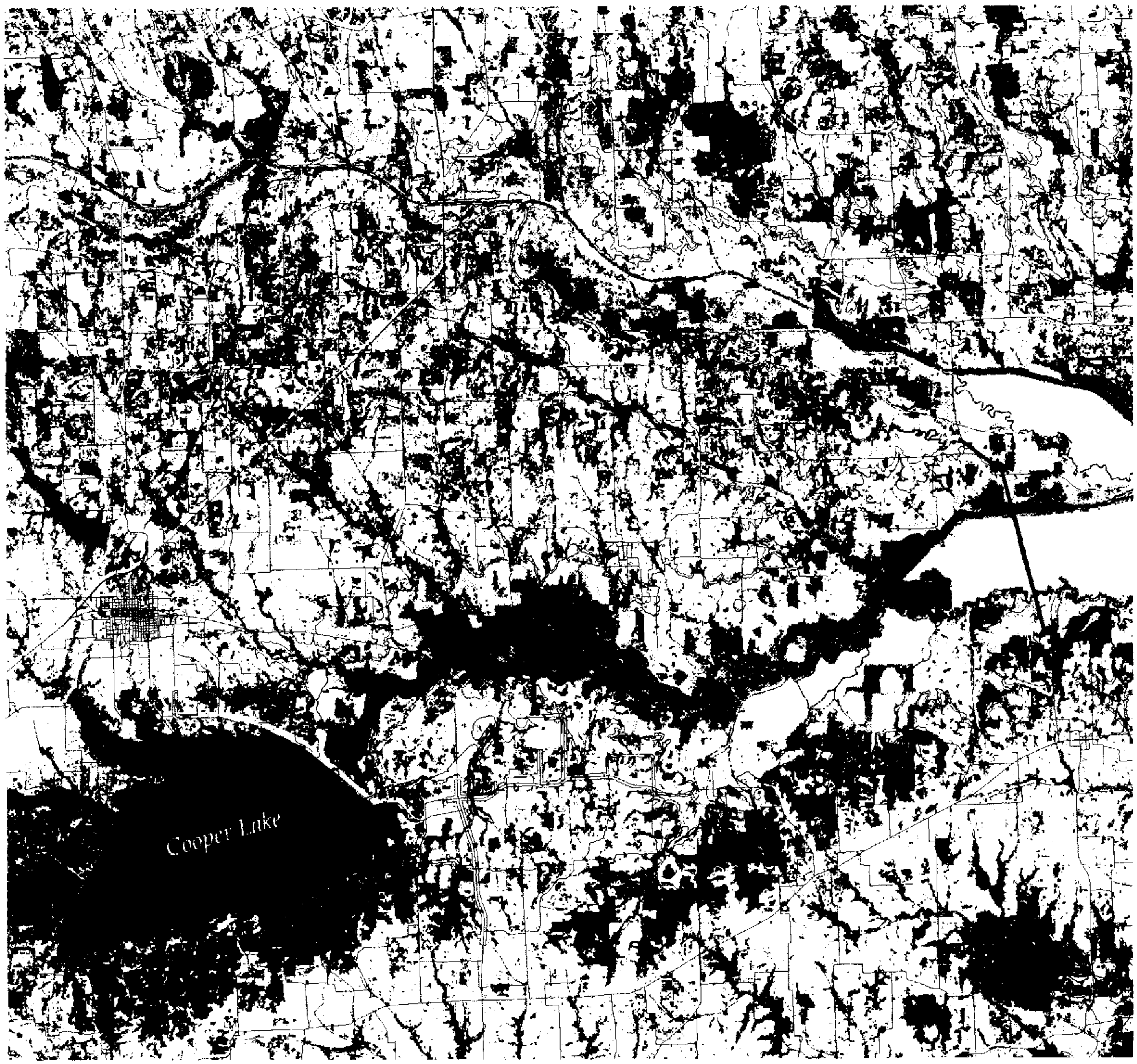
For: Texas Water Development Board

Date: Janunary 15, 1997



George Parkhouse I

Lamar, Delta, and Hopkins Counties

Normal Water Level: 401 ft.
Maximum Water Level: 406 ft.
Top of Dam: 412 ft.

Legend

Cover Type

- Water
- Bottomland Hardwood
- Secondary Bottomland Hardwood
- Oak Hickory
- Pine-hardwood/Cedar-Hardwood
- Pure Pine/Cedar
- Grassland
- Crops/Managed Grassland
- Bare Soil/Ground

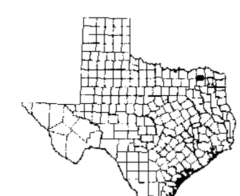
Linear Features

- Roads/Boundaries
- Streams/Rivers
- Contour (Elev. 400 ft.)
- Contour (Elev. 410 ft.)
- Dam Location

Scale

Data Source:

TM Imagery: EOSAT, June 1994
Road Network: Texas DOT, 1994
Contour: USGS 7.5' Quads



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For Texas Water Development Board

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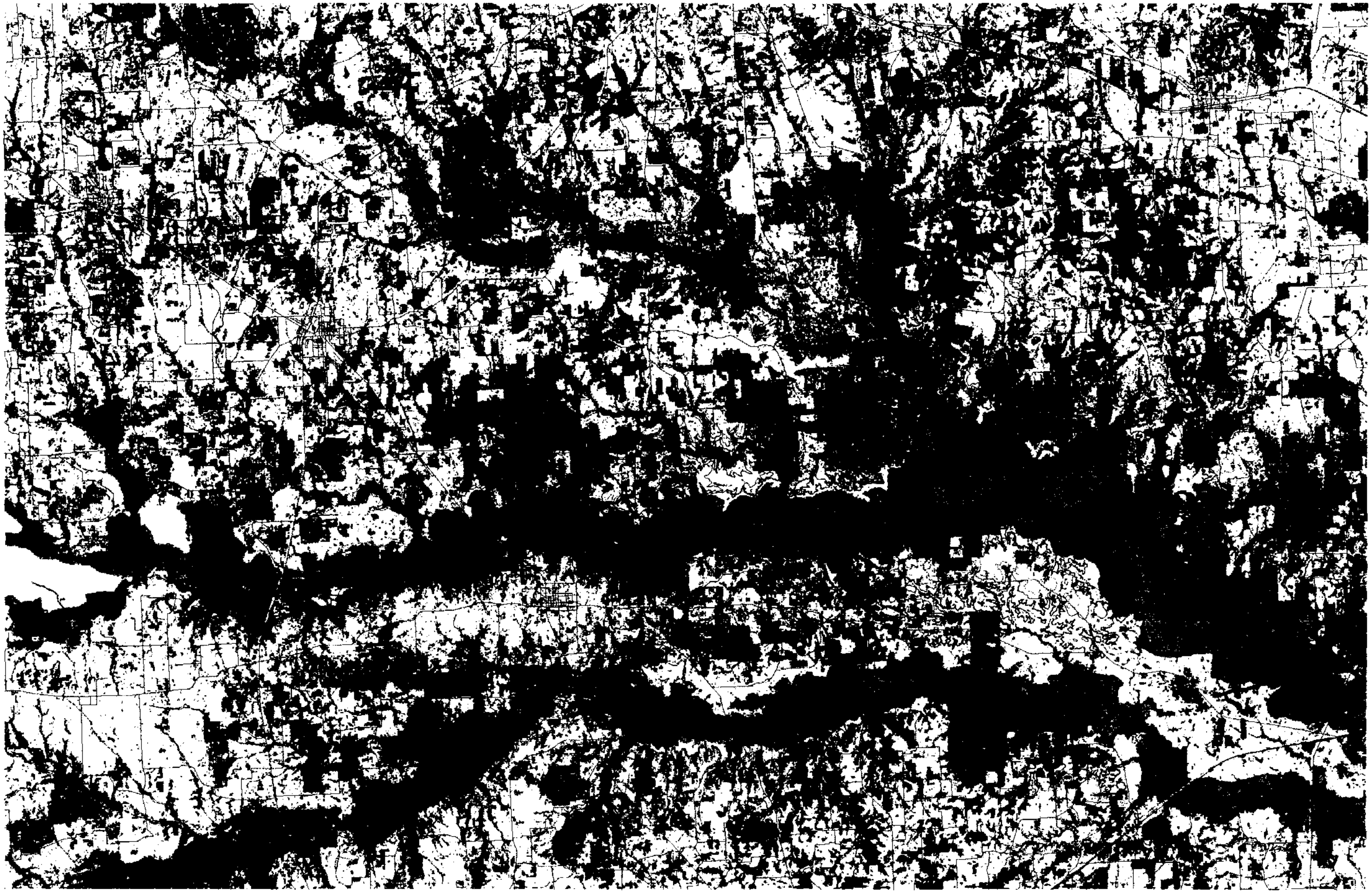
Map 4 Land cover types at proposed Marvin Nichols I reservoir site and vicinity
(see a large size map for more details)



Marvin Nichols I

Franklin, Titus, Morris, Bowie, and Red River Counties, Texas

Normal Water Level: 312 ft.
Maximum Water Level: 322.5 ft
Top of Dam: 330 ft

Legend

Cover Type

- Water
- Bottomland Hardwood
- Bottomland Hardwood Swamp
- Oak-Hickory
- Cedar-Hardwood/Pine-Hardwood
- Pure Pine/Cedar
- Grassland
- Crops/Managed Grassland
- Bare Soil/Ground

Linear Features

- Roads/Boundaries
- Streams/Rivers
- Contour (Elev. 310 ft.)
- Contour (Elev. 320 ft.)
- Contour (Elev. 330 ft.)
- Dam Location

Scale

2 0 2 4 6 Kilometers

Data Source:

TM Imagery: EOSAT, June 1994
Road Network: Texas DOT, 1994
Contour: USGS 7.5' Quads

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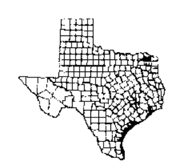
Texas Parks & Wildlife Department
Austin, Texas

For: Texas Water Development Board

Date: Janunary 22, 1997



Appendix 1. Indices of NAAP Color Infrared (CIR) aerial photographs and USGS 7.5' quadrangle topographic maps for the study area

New Bonham (6 quads, normal pool elev. 534 ft. above mean sea level, 540 ft. maximum, and 556.7 ft. top of dam) -- Fannin County

Lake Bonham	Lamasco	**Selfs***
Bonham	Dodd City	Honey Grove

8662-108 8739-36
8662-93** 8275-109
8662-110 8739-34
9594-150 8662-91 8275-107
8662-112 8739-32
9664-11 8662-89

George Parkhouse I (8 quads, normal pool elev. 401 ft., 406 ft. maximum, and 412 ft. top of dam) -- Hopkins and Delta Counties

Cooper N	Charleston	**Minter**	Cunningham
Cooper S	Tira	**Sulphur Bluff**	Michell Creek

9599-21 9599-13
8735-67 8276-182
8735-109 8735-11 9599-11
8736-48 8735-65 8276-180
8735-111 8735-13 9599-9
8735-63 8276-178

Marvin Nichols I (13 quads, normal pool elev. 312 ft. normal , 322.5 ft. maximum, and 330 ft. top of dam) -- Franklin, Lamar, Titus, Morris, Bowie and Red River Counties

Line Branch	Clarksville	Annona		
Bogata	Cuthand	Boxelder	Lydia	Hodgson
Hagansport	Talco	Wilkinson	**Coopers Chapel**	**Dalby Springs**

8697-121
8699-11 8697-199
9597-127 8699-123 8697-100
8273-24 8701-47 8697-197 8696-150
9597-125 8701-49 8697-98
8273-26 8701-45 8697-195 8696-148
9598-100 9597-123 8701-51 8697-96
9598-142 8273-28 8699-17 8697-193 8696-146
9598-98 9597-121 8697-129 8697-94
9597-147 9699-19 8697-191 8696-144
8697-92
8696-142

* Bold USGS 7.5' quad names indicate that the dam is located on those quads.
** 8662-93 was replaced by a wrong photo of 8663-93.