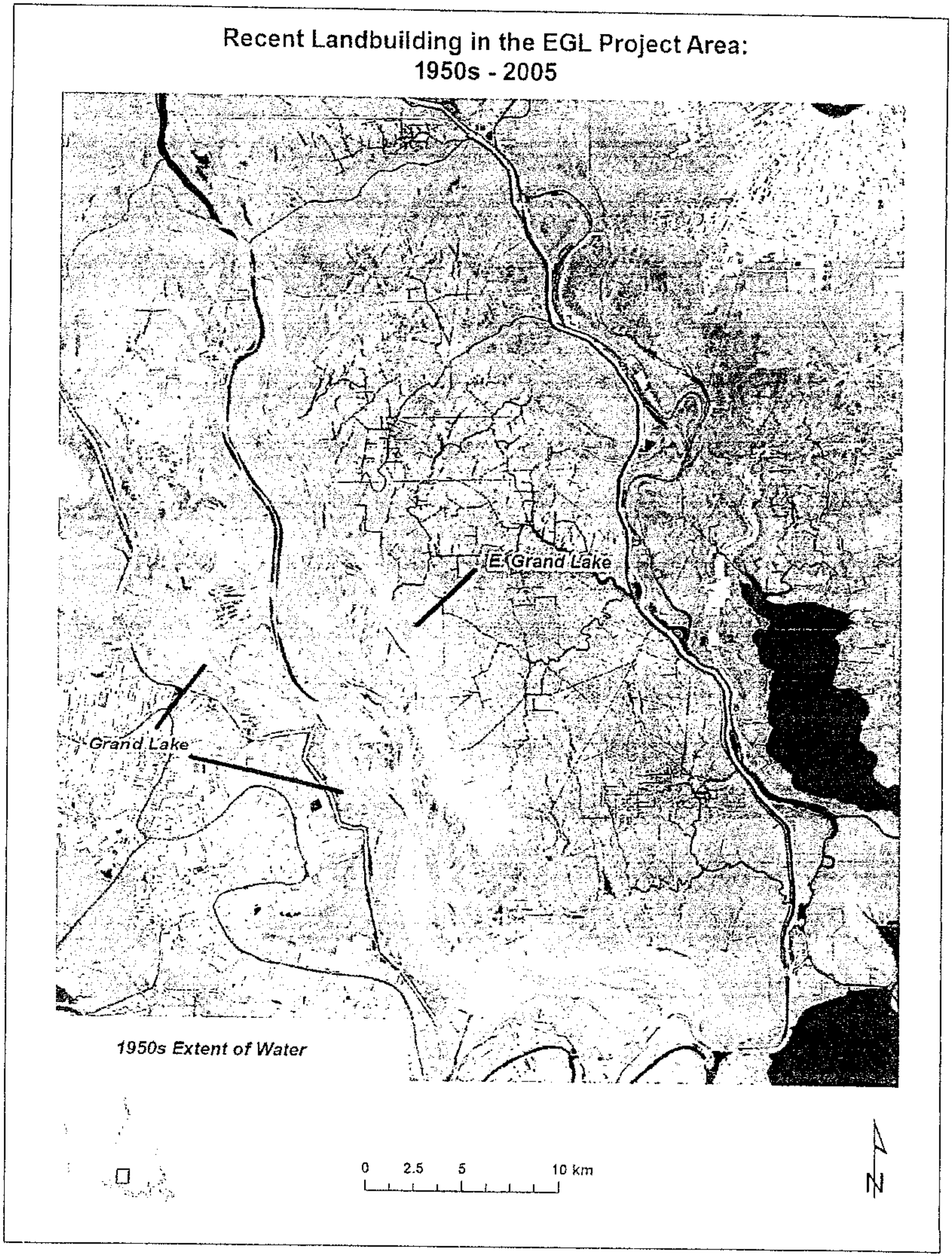
Recent Landbuilding in the EGL Project Area: 1950s - 2005

Figure 2. Transformation of open water to forested habitat due to excessive sediment deposition in Grand Lake and East Grand Lake from the 1950s to 2005. Extent of open water in the 1950s depicted as a semi-transparent light blue layer.

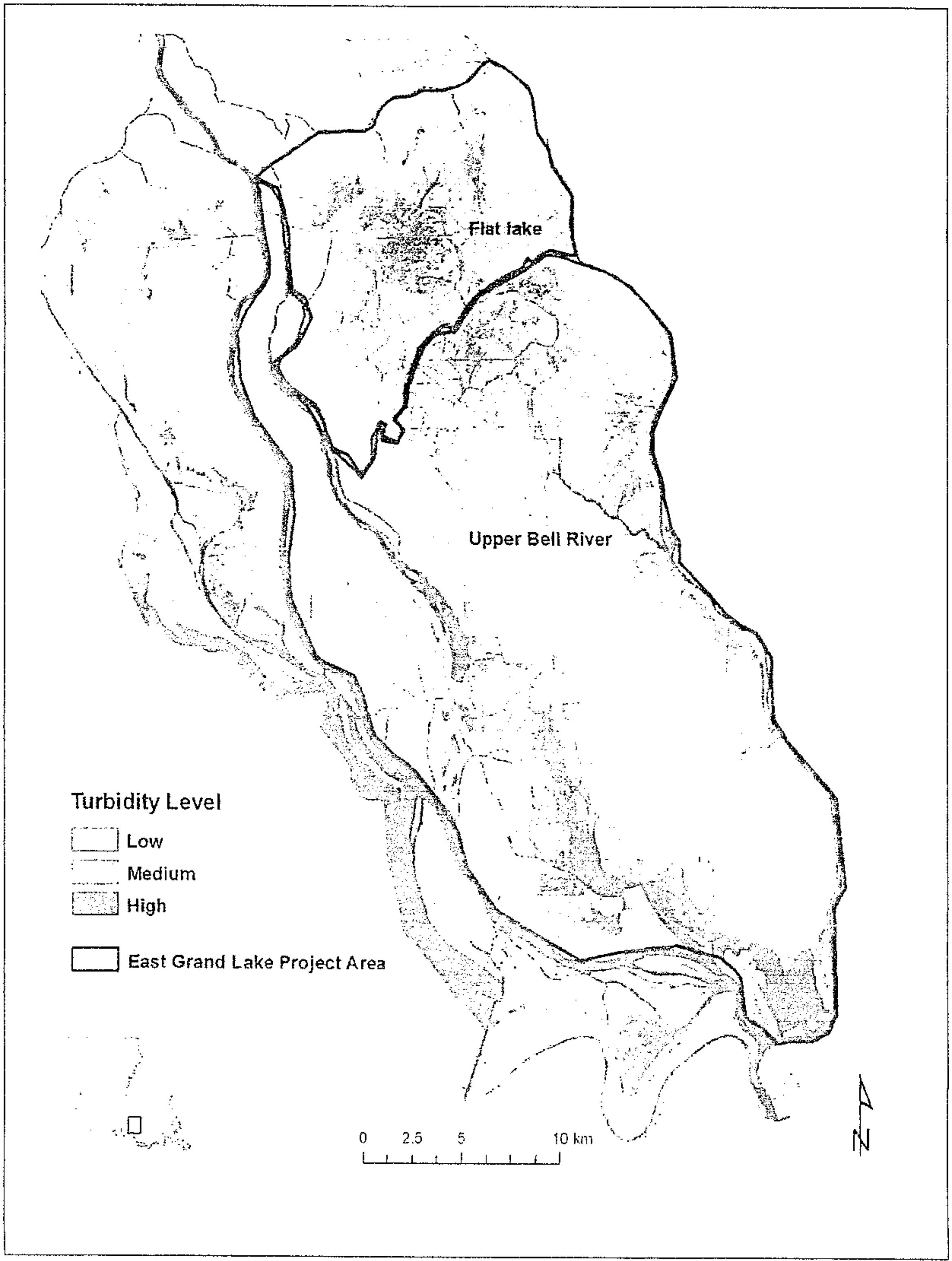

Figure 3. Turbidity levels derived from numerous satellite images of the East Grand Lake Project area. Faster moving turbid water is often associated with water having greater oxygen concentrations than slower moving non-turbid water.

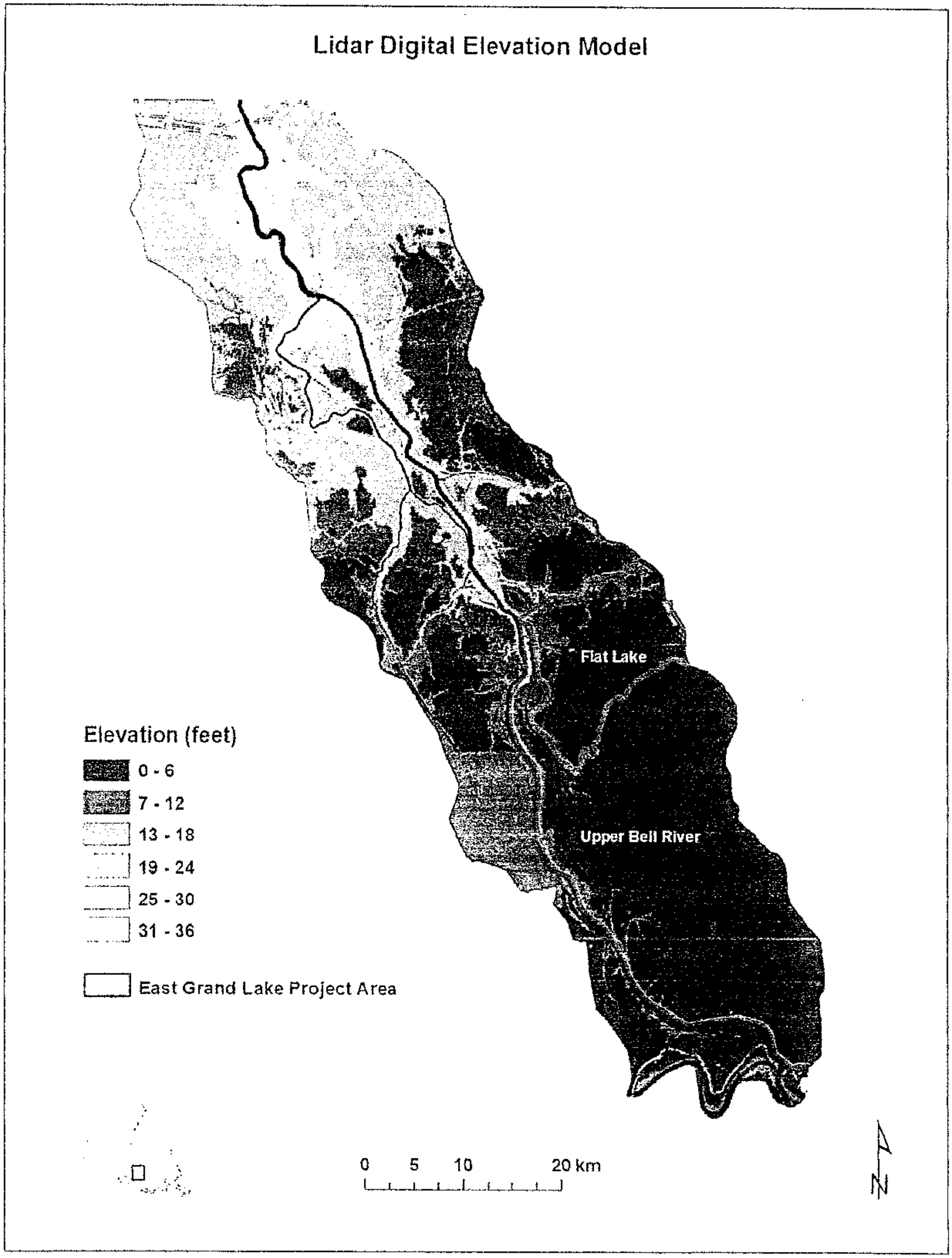

Figure 6. Lidar coverage showing the elevation of the Atchafalaya Basin from approximately 6 mi. N. of Krotz Springs, LA to Morgan City, LA. The elevation model depicts the relatively flat terrain within the East Grand Lake Project area as compared to the rest of the Atchafalaya Basin.

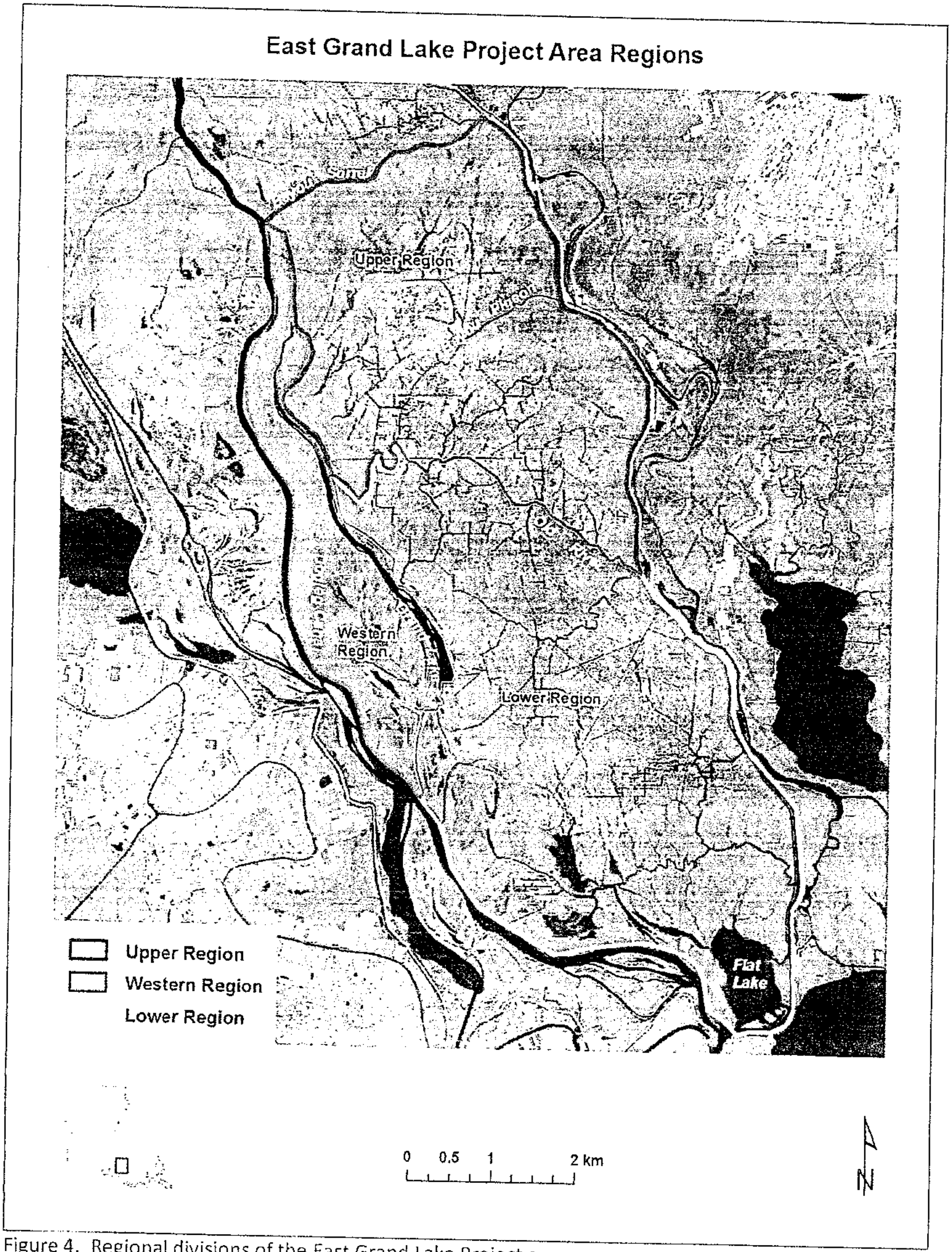

Figure 4. Regional divisions of the East Grand Lake Project area.

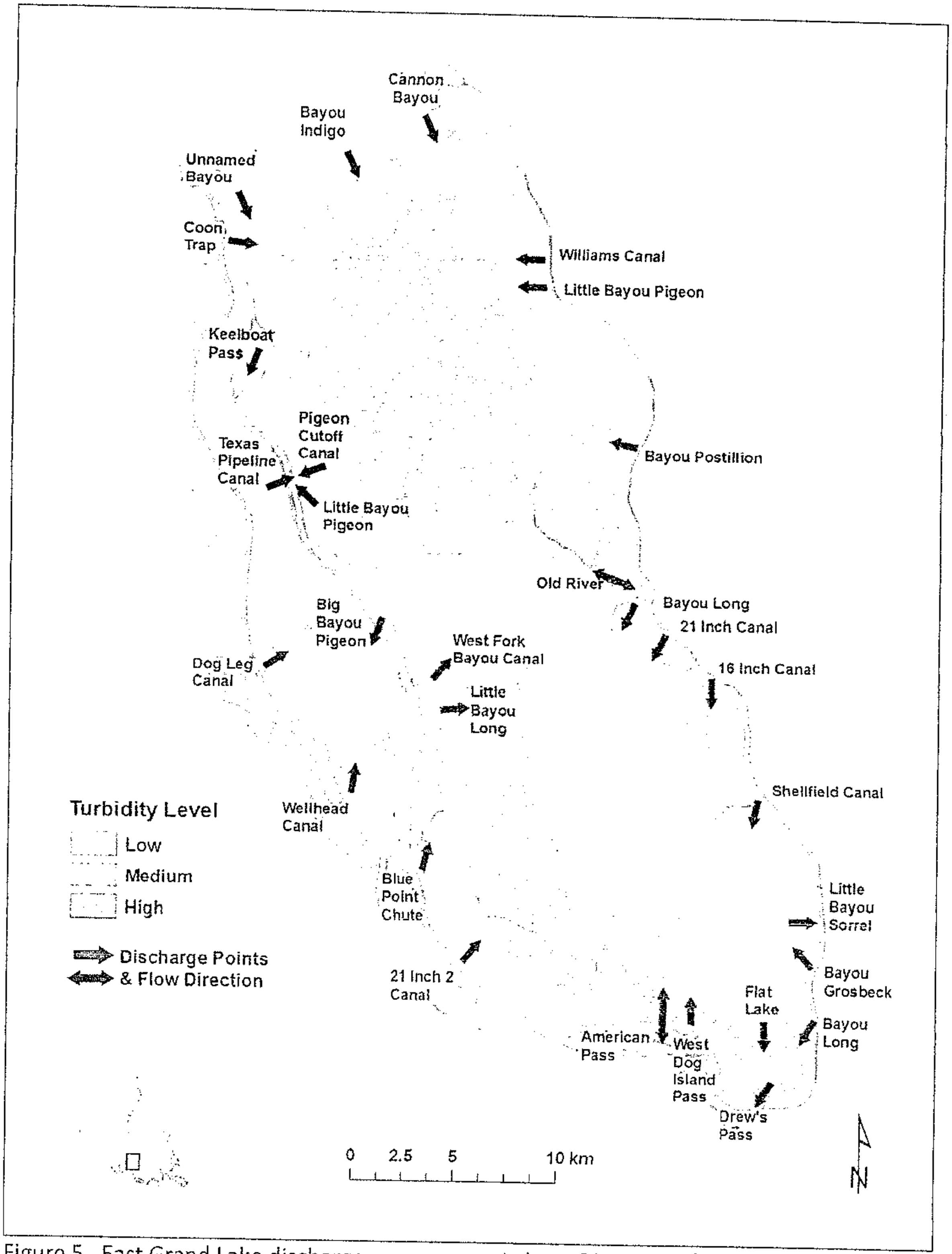

Figure 5. East Grand Lake discharge measurement sites. Direction of arrow depicts direction of flow. Figure depicts the extent of turbid water relative to the close proximity of discharge entering the unit.

EXHIBIT
C

Characterization of temporal and stage-related changes in water quality in major inflows into the Greater East Grand Lake area of the Atchafalaya River Basin

Submitted to:

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Proposal Title: Characterization of temporal and stage-related changes in water quality in major inflows into the Greater East Grand Lake area of the Atchafalaya River Basin.

The following proposal outlines research designed to collect data regarding the inflows of water and sediment into the Greater East Grand Lake area of the southern portion of the Atchafalaya River Basin (ARB). This portion of the ARB is one of the few areas that still provide relatively deepwater, lacustrine habitats that are critical as dissolved oxygen refugia for fishes and invertebrates during the latter stages of the flood pulse when much of the lower ARB becomes hypoxic from floodplain drainage. These data will complement water quality data collected to date from previous monitoring activities, and will specifically target major inflows into the Grand Lake area to identify the relative inputs of water and sediment from the Atchafalaya River and Intracoastal Waterway.

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INTRODUCTION

The Atchafalaya River Basin (ARB) has experienced tremendous changes in structure and biological productivity over the last century because of altered hydrology, high rates of sediment deposition, establishment of competitively-dominant exotic aquatic plants, oil and gas exploration and extraction, and commercial and recreational fishing activities (Podey et al. 2006). Hydrologic changes have been particularly evident, resulting from main channel dredging in the Atchafalaya River, construction of mainstem levees and the Intracoastal Waterway, and spoil banks associated with the construction of east-west canals to facilitate exploration and extraction of oil, gas and timber resources. These hydrologic changes have significantly altered the magnitude, velocity, and movement of water in the ARB during the annual flood pulse, increasing the stage levels required for floodplain inundation. When overflow areas eventually flood, levees and spoil banks impair the exchange of water between permanent channels and floodplain habitats, and reduce the rate at which water drains from the overflow areas as river stages drop during late spring and summer. Extended water retention combined with rising water temperatures and high loads of terrestrially- and aquatically-derived organic debris result in low dissolved oxygen (DO) levels on the inundated floodplain, with hypoxic conditions spreading to canals and bayous as floodwaters recede (Kaller et al. 2009). Previous studies have documented reduced abundance and diversity of zooplankton, aquatic macroinvertebrates, and larval, juvenile, and adult fishes in hypoxic areas of the ARB (Davidson et al. 1998; Fontenot et al. 2001; Rutherford et al. 2001; Kelso et al. 2005).

Since the late 1990's, a coordinated effort by the U.S. Army Corps of Engineers – New Orleans District (CEMVNM), Louisiana Department of Natural Resources (LDNR), Louisiana Department of Wildlife and Fisheries, Louisiana Department of Agriculture and Forestry, U.S. Geological Survey – Water Resources Division (USGS-WRD), USGS – Biological Resources Division, U.S. Fish and Wildlife Service (USFWS), and Louisiana State University Agricultural Center – School of Renewable Natural Resources (AgCenter), has been aimed at developing and implementing projects to restore and protect the natural habitats in the ARB that directly and indirectly support the tremendous cultural, socioeconomic, and ecological importance of this unique ecosystem. As essential goal of ARB management is to prolong the expected life of aquatic habitats by managing sediment inputs, while at the same time improving water circulation to restore and maintain adequate water quality. A basic part of these plans is the incorporation of a floodwater routing strategy that will direct sediment-laden water to areas that would naturally be undergoing accretion (e.g., natural levees and selected floodplain areas), as well as incorporation of sediment traps in other areas to prolong the lifespan of the swamp and its associated aquatic, semi-aquatic, and terrestrial habitats.

A well-defined monitoring program is a critical part of the planning and execution of water management activities in the ARB Management Units. Monitoring water quality, habitat, fish populations, and the relationships between river stage and water flow in this area before, during, and after initiation of water management projects provides background data against which post-project data can be compared (e.g., Kelso and Kaller 2009). More importantly, monitoring activities permit assessment of natural variability in biological and physicochemical conditions that may influence perceived benefits of the management actions. The Atchafalaya Basin is an extremely complex ecosystem, with water circulation, water quality, and sedimentation being driven by the annual flood pulse, which exhibits considerable variability in the timing and duration of rising and falling stages (Kaller et al. 2009). In spring and early summer, these annual fluctuations in Atchafalaya River dynamics can interact with rising water temperatures to cause significant declines in water quality throughout the Basin (Sabo et al. 1999 a, b). Water quality problems are exacerbated by extensive beds of exotic macrophytes such as water hyacinth *Eichhornia crassipes*, *Hydrilla verticillata*, and *Salvinia* spp. (Walley 2007), which impede water circulation, shade the water column, and contribute significantly to the annual load of decomposing organic material and its effects on DO dynamics in the ARB.

PROJECT GOAL. The purpose of the proposed scope of work is to describe the relationships among flood pulse timing and duration and the physicochemistry of various inlets that currently supply water to the Greater East Grand Lake area in the southern portion of the ARB. This area provides one of the largest remaining areas of lacustrine, deep-water habitat that is likely critical to the survival of fishes and invertebrates during the widespread hypoxia that accompanies the latter stages of the flood pulse. As a consequence, maintaining water quality while at the same time minimizing sediment inputs are important water management objectives for this area. Monitoring will provide important data on how river stage, temperature, water flow, and sediment load interact to affect habitat quality in the Greater East Grand Lake area, and will form the basis for determining the feasibility, impacts, and alternatives for future water management efforts.

METHODS.

Analysis of the temporal and spatial variation in past water quality data indicate that the most beneficial new information can be attained by strategically setting the frequency, seasonal duration, and spatial distribution of monitoring so as to target specific hydrologic and physical circumstances. Our sample design will focus on collecting flow, water quality and habitat data at key locations along major inlets that supply water to the interior of the southern ARB (Figure 1). These locations include the Coon Trap/Bayou Sorrel/Big Pigeon area, the Bayou Long/South Grand Lake area, and the Little Bayou Sorrel/Flat Lake area. These site locations will allow us to build a dataset that can evaluate inflows of water and sediment into the swamp interior at various river stages, and will provide a much more detailed analysis of proposed water management alternatives designed to maximize water input and circulation while minimizing sedimentation of deeper water habitats. Although all sites will be visited a minimum of every three weeks, the sampling schedule will remain flexible, and sites may be visited as frequently as weekly during periods of changing river stages in order to determine variations in flow velocity and direction.

Our data collections will encompass 54 sites in the lower ARB that will be visited at least every three weeks during the flood pulse (Atchafalaya River states over 10 ft. at Butte LaRose, usually January/February through July/August), and at least monthly thereafter to continue physicochemical monitoring through the rest of the year. Physicochemical sampling will continue at floodplain locations while the swamp is accessible (river stage greater than 10 feet at the Butte LaRose gage). However, the relationship between the water level in the interior swamp and the Butte LaRose gage is not linear, and access to some of the interior sites may not be possible at lower stages or under conditions where physical obstructions (vegetation and woody debris) prohibit access. It is anticipated that these sites will be sampled for at least two water years to accumulate data over two flood pulses. Sampling frequency will never be less than monthly except for reasons of inaccessibility.

At each site, we will measure depth, macrophyte cover, flow direction and flow velocity (1 m below the surface), and we will also record dissolved oxygen, pH, temperature, turbidity, and specific conductance at the surface, middle, and bottom of the water column with an *in situ* water quality monitor (Required physicochemical data and units of measure are listed in Table 1). All water quality data will be collected based on protocols developed by the Atchafalaya River Basin Technical Advisory Group. When flow velocities are less than 60 cm/sec, integrated water samples will be collected for determination of suspended solids. Non-isokinetic depth-integrating samplers will be used to collect suspended sediment samples in those bayous and streams under low velocity conditions. It is assumed that the fines (silts and clays) are more uniformly distributed in the vertical than sand-fine mixtures and therefore do not require isokinetic sampling conditions to collect a representative suspended-sediment sample. Depth-integrated non-isokinetic samples will be collected with narrow-mouthed bottles placed in a weighted basket-like container, with the bottles secured in a vertical position. Once secured, the cap will be removed from the bottle, and the sampler will be lowered and raised at a constant speed through the water column. The sample bottle will not be allowed to overfill, as this may result in a biased sample due to more sediment being trapped in the bottle. If the bottle is overfilled, the sample will be discarded, the bottle will be rinsed with filtered de-ionized water, and the sample will be re-collected. Once collected, samples will be labelled, stored in the dark (to prevent the growth of algae), and delivered to the Baton Rouge USGS office. Complete field observations such as turbidity, comments on how much sediment is observed in the bottle, water color, water velocity and turbulence (wave action) will also be recorded at each site. This information is vital in quality controlling sediment data. Estimates of over-bank flooding will be recorded along all waterways traversed during the normal course of sample collection, consisting of GPS locations of transition points along artificial or natural levees or spoil banks where water access into the floodplain changes from restricted to unrestricted. This information will be used to describe the relationship between boundary conditions and river stage, as well as to ground-truth land/water classifications derived from satellite imagery.

DELIVERABLES

In addition to quarterly monitoring reports, annual reports will be delivered on 30 September 2010, and 2011. Annual reports will include data tables as well as analyses of flow velocity and habitat data in relation to river stage. All samples collected for solids analyses will be stored in the dark and delivered to the USGS office in Baton Rouge.

Table 1: Required water quality sampling parameters and units of measure

Parameter	Unit
Station Name / Number	Name of site where data is collected.
Station Location	Geographic coordinates of physical location of where data was taken in state plane Louisiana South NAD 83.
Date	Date data was taken shown MM-DD-YY.
Time	Military time of day data was taken.
Stage at Butte LaRose	Stage in feet.
Weather Conditions	A brief description of weather conditions at the time of data collection.
Agency Name	Name of agency collecting data.
Data Collector's Name	Name of agency person collecting data.
Water Column Position	Recorded as Surface, Middle or Bottom.
Temperature	Recorded in Celsius.
Dissolved Oxygen	Recorded in milligrams per liter.
Specific Conductance	Recorded in micro-Siemens per centimeter.
pH Level	pH unit.
Depth	Recorded in meters.
Secchi	Recorded in millimeters.
Current Velocity	Direction recorded in compass degrees, magnitude in meters per second.
Turbidity	Recorded in NTUs.
Water sample	Annotation if water sample collected for solids analyses
Water Color	A brief description of water color (black, brown, green).
Aquatic plants	Visual inspection of percentage of cover of dominant species.

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BUDGET

Budget Category	Year 1
Research Associates	$55,000
Fringe Benefits @ 34%	18,700
Graduate Students	18,000
Student Workers	8,000
Total Salaries	99,700
Travel	2,000
Operating Services	2,000
Supplies	13,000
Subtotal	116,700
Equipment - water quality equipment monitor, flow meter	8,000
Total Direct Cost	124,700
Modified Total Direct Cost (MTDC)	116,700
LSU AgCenter F&A Cost Rate (@ 21% MTDC)	24,507
Total Cost	149,207

BUDGET JUSTIFICATION

Salaries and wages: Salary and fringe benefits are requested for two research associates at the B.S./M.S. level, depending on experience. Research associates will be responsible for completing the field collections, data analyses, and reports. Salary is also requested for two graduate students (M.S. level - $18,000/year) and student workers (1,250 hours, $8/hour, about 1.0 student work year), who will help in the field and input data into the habitat and water quality databases.

Travel: Funds are requested to pay for travel costs associated with project administration meetings as well as regional, national, or international professional meetings to give presentations on project results.

Operating services: Funds are requested to pay mileage costs for SRNR motor pool vehicles, and printing.

Supplies: Funds are requested for purchase of expendable supplies and equipment, including gasoline and oil (field vehicles and boats), boat batteries, fuel tanks, dip nets, water sample containers, chemicals for water quality analyses, rain gear, waders, length boards, coolers, first aid supplies, and software.

Equipment: Funds are requested for equipment used to collect field data, including flow meters and water quality monitors.

Figure 1. Location of proposed sampling sites along major inflows to the southern portion of the ARB.

Category	Indicator	Explanation
Nutrients	Nitrogen Organic Nitrate plus nitrite Ammonia Total Phosphorus Filterable reactive Total	The nutrients nitrogen and phosphorus are essential for plant growth. High concentrations indicate potential for excessive weed and algal growth. Total nutrients are made up of a dissolved component (e.g. nitrate plus nitrite, ammonia and filterable reactive phosphorus) and an organic component, which is bound to carbon (e.g. organic nitrogen). Nutrients in the dissolved state can be readily used by plants.
Microalgal Growth	Chlorophyll-a	An indicator of algal biomass in the water. An increase in chlorophyll-a indicates potential eutrophication of the system. Consistently high or variable chlorophyll-a concentrations indicate the occurrence of algal blooms, which can be harmful to other aquatic organisms.
Water Clarity	Suspended solids	Small particles (soil, plankton, organic debris) suspended in water. High concentrations of suspended solids limit light penetration through water, and cause silting of the benthic (bottom) environment.
	Turbidity	A measure of light scattering by suspended particles in the water column, provides an indirect indication of light penetration.
	Secchi depth	The depth to which the black and white markings on a Secchi disc can be clearly seen from the surface of the water provides an indication of light penetration.
Oxygen	Dissolved oxygen	Essential for life processes of most aquatic organisms. Low concentrations of dissolved oxygen usually indicate the presence of excessive organic loads in the system, while high values can indicate excessive plant production (i.e. eutrophication). Many aquatic organisms will suffocate if there is insufficient volume of dissolved oxygen in the water.
pH	pH	A measure of the acidity or alkalinity of the water. Changes to pH can be caused by a range of potential water quality problems (e.g. low values due to acid sulfate runoff). Extremes of pH (less than 6.5 or greater than 9) can be toxic to aquatic organisms.
Salinity	Conductivity	A measure of the amount of dissolved salts in the water, and therefore an indicator of salinity. In fresh water, low conductivity indicates suitability for agricultural use. In salt waters low conductivity indicates of freshwater inflows such as stormwater runoff.
	Pesticides in sediments	Commonly used pesticides accumulate in the sediments of aquatic environments and may reach concentrations toxic to aquatic organisms.

R