WORKPLAN:
LIZARD LAKE RESTORATION DIAGNOSTIC AND FEASIBILITY STUDY

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ARTICLE I. Statement of Contract Purpose

To provide the Iowa Department of Natural Resources (referred to below as DNR) with a diagnostic and feasibility study of Lizard Lake, Pocahontas County, Iowa for planning a lake restoration program on the lake and its watershed.

ARTICLE II. Description of Work and Services

G. Diagnostic Study

1. ***Create working group of interested parties:*** Coordination with State and local goals will be assured by establishing and working with an advisory committee including members of relevant DNR programs, as well as interested parties and personnel from other agencies. This committee will be established in the early stages of the work and will be consulted regularly as the work advances. The tasks of this working group will include identification of restoration alternatives, location of diverse information sources, liaison with stakeholder groups, and the evaluation of restoration means and endpoints.
2. ***Identification, location, and surface hydrology***: The study will include the identification and location of the lake, the general hydrologic relationship to associated upstream and downstream waters, and the approved state water quality standards for the lake.
3. ***Water quality monitoring and assessment work:*** This contract provides for water quality monitoring work from September 1, 2006, to August 31, 2007. This work will encompass a limnological, or lake, monitoring program and an event focused tributary monitoring program. Data derived from this project will be used to compare past to present monitoring data for exploring trends within Lizard Lake and to compare Lizard Lake to lakes throughout Iowa. The sampling scheme planned here is more intensive than normally performed in Iowa's extensive, routine lake survey for examining the spatial structure, ecological function, and annual nutrient budget for the lake. The data will also allow the evaluation of internal loading as a potential source of nutrients to Lizard Lake. Data and information will be posted on the Web in as near real-time as is practically possible. Likely targets will be that field, chemical and phytoplankton data will be displayed within 30 days of collection. Zooplankton data will be available by winter of a given sampling season.
4. ***Limnological monitoring program***: The results of the following limnological monitoring program will be presented and discussed. Three sampling stations will be established at the deep points in the lake, and ISU will monitor and take samples from these sites for the duration of the project. Because of the event-driven nature of water quality in Iowa lakes, the lake will be sampled twice each month from March through June and once each month from July through November. The lake will be sampled monthly through December, January, and February as possible due to frequent thin ice conditions throughout the winter. Samples will be collected from the surface down

to 0.5 m from the bottom. Approximate maximum depth at the three sampling locations is 1.0m, so each sample set will include a mixed zone water sample collected using an integrated column sampler from the surface down to 0.5m. All samples will be analyzed for total phosphorus, soluble reactive phosphorus, nitrite plus nitrate nitrogen, ionized and unionized ammonia, total nitrogen; dissolved organic carbon; total dissolved carbon; total, volatile, and inorganic suspended solids; chlorophyll *a* (as in index of standing biomass), plankton composition, silica, pH, and alkalinity. Phytoplankton community composition in the mixed zone sample will be determined through algal order identification, cell counts, and cell volumes, and reported in terms of relative biovolumes of each order identified. Zooplankton will be collected down to the mixed zone depth using a Wisconsin net. Zooplankton composition and size distribution will be determined microscopically. Secchi disk transparency will be also determined at each sampling site. In addition, lake profile data (via a YSI sonde) will be collected for pH; specific conductivity; temperature; dissolved oxygen; and turbidity. All samples will be collected between 0700 and 1600 hours and analyzed for the parameters listed in Table 1. Two hourly series of samples (two extra sets of samples taken on each of two different sampling events) will be collected over days with a diurnal weather developing from calm to windy conditions to evaluate nutrients loaded to the water column by wind and wave action.

5. ***Tributary analyses***: Tributary samples will be collected in concert with limnological data to establish a nutrient budget for the lake and to localize nutrient and sediment sources within the lake's subwatersheds. This will also help to relate water quality to watershed composition and configuration as well as predict water quality changes under restoration land use scenarios. Water samples will be taken from 6 selected and established tributary and outflow sites, when they are flowing, on the same days that the lake is sampled (Fig. 1). Water samples will be taken on a regular basis (twice per month from March through June and once per month from July through November). The tributaries will be sampled monthly through December, January, and February as possible due to ice conditions throughout the winter. ISU will collect the samples and hydrological information on all regular sampling dates between September 2006 and August 2007. Because material flux is likely to be event-driven, we will establish at least one point in the watershed where flow will be monitored continuously using electronic means to calculate the hydraulic budget of the lake (see below). ISU will make an effort to time sampling events within a given month with periods of high tributary flow since these tend to deliver the majority of nutrients and materials. This will be accomplished by monitoring regional USGS gaging stations as indicators of regional high flow conditions or sampling after local storm events. A storm event will be categorized as a precipitation event yielding greater than one-inch of water in a 24-hour period in the Lizard Lake watershed. ISU will attempt to sample the tributaries of Lizard Lake the day after observation of a storm event. It is understood that it is not possible to pre-determine the point of the peak of the stormflow hydrograph, and that samples thus may reflect the rising or falling arms of the storm flow pulse. Analyses to be performed on samples from tributary sites include total phosphorus; soluble reactive phosphorus; nitrite plus nitrate, ionized and unionized ammonia, total nitrogen; total suspended solids; E. coli bacteria; Total Coliform bacteria; pH and alkalinity. Field measurements will be taken for pH; temperature; dissolved oxygen; specific conductivity; turbidity; and discharge. All samples will be collected between 0700 and 1600 hours and analyzed for the parameters listed in Table 2.
6. ***Real-time water level recording:*** Water levels at one site within the watershed will be remotely measured in real-time with automated water level loggers (Fig. 1). Daily water levels will be used along with in-field discharge measurements to form discharge rating curves for these sites. Continuous flow monitoring is important for establishing

the hydrograph in a complete as possible a manner to estimate the true hydrologic loading of the lake and thus its water and nutrient budget. In this way, we will be able to relate water chemistry measures to the actual phase of the hydrograph in each sub basin. Water level sensors will be chosen for specifications appropriate to physical characteristics of sampling sites of interest.

7. ***Precipitation:*** Atmospheric deposition of phosphorus and nitrogen will be determined using regional precipitation values and estimates of atmospheric transport presented by Anderson and Downing, (2005).
8. ***Lake and tributary bacterial monitoring:*** Bacterial populations in Iowa lakes have led to public concern about the safety and quality of these recreational resources. To address this issue, ISU will undertake lake bacteria sample collecting on the same days that the lake is sampled. Monitoring bacteria at high frequency and coordinated with rain events is needed to supply information on the range of bacteria concentrations encountered. These lake bacteria samples will be analyzed for the number of *E. coli* and total coliform colonies present, and will be used to identify temporal trends in bacterial concentrations. Samples will be collected near the points of most likely body-contact recreation and at tributary monitoring sites.
9. ***Sublittoral Benthic Macroinvertebrates:*** One of the most important and diagnostic aspects of the biotic impact of water quality is health and quantity of the sublittoral macrobenthic community. This aspect of Iowa lakes has not been estimated systematically and therefore represents an important missing source of information. Participants at a recent EPA sponsored meeting on the new National Lakes Survey (Chicago, IL, April 2006) indicated that the sublittoral macrobenthos community is one of the top essential types of information needed to compare the ecological integrity of the nation's lakes. Benthic macroinvertebrates will be sampled once in each year during the late summer or early fall to avoid missing insect taxa that mature to adult stages and emerge from the sediment during the summer season (Merritt and Cummins 1996; Mandaville 2002). Using a Petite Ponar sampler (Downing 1984), sublittoral zone samples will be taken from three sites with two grab samples per site and bulked (Gerritsen et al. 1998). The bulk sample will be sieved in the field using a bucket sieve with 0.5 mm size mesh and preserved with 70% ethanol (Johnson 1998; Hämäläinen et al. 2003; Holopainen et al. 2003). Organisms will be identified (Merritt and Cummins 1996) and measured in the lab to the lowest possible taxonomic level. A minimum of 100 organisms (Barbour et al. 1999) will be identified and measured per subsample using a dissection scope (Benke et al. 1999). Samples will be preserved in 70% ethanol for storage.
10. ***Littoral zone habitat evaluation.*** The presence or absence of aquatic macrophyte dominated littoral zone habitat will be evaluated and species lists of aquatic macrophytes will be established throughout the course of the study. This is important both for the establishment of baseline, pre-restoration conditions and as an assessment of habitat diversity. Presence of macrophyte beds with the most abundant vegetation will be mapped as part of the overall habitat analysis. Additionally, macrophyte distributions in lakes are indicative of water clarity, and thus, also lake degradation. If available, we intend to analyze a historical series of photographs to assess distributional changes in macrophytes over time in Lizard Lake. We will also collect, identify, and determine arial extent of macrophytes in Lizard Lake once during the summer of 2007. These data will then be compared to the historical record to assess one measure of lake degradation. Prediction of future water quality conditions based on differing management scenarios will be made from this historic data set.
11. ***Lake mapping and sediment analyses***: Lake bathymetry and soft sediment thickness will be mapped and sediment core samples will be collected. This need is most critical in evaluating the pertinence of dredging as an in-lake management strategy. ISU will have sediments analyzed by University of Iowa Hygienic Laboratory

or another contract laboratory to determine the concentrations of nutrients and possible toxic substances in sediment and sediment elutriates. Analyses to be performed are indicated in Table 3.

12. ***Surficial diatom analyses***: Participants at a recent EPA sponsored meeting on the new National Lakes Survey (Chicago, IL, April 2006) indicated that the sublittoral macrobenthos community is one of the top essential types of information needed to establish the least impacted condition. This approach uses samples of diatom frustules from a depth within lake sediments that predates highest rates of environmental perturbation and compares them to "transfer functions" that relate ambient conditions to surficial sediment diatoms. Transfer functions are created from modern surficial sediment analyses and modern nutrient chemistry to allow hind-casting of prior conditions. Unfortunately, current transfer functions have not been extended to Iowa's lake conditions. We will move this effort forward by sampling surficial sediment diatoms once late in the summer or early fall in conjunction with the benthic macroinvertebrate sampling. A coring sampler will be used to obtain an undisturbed 1 cm deep substrate surface sample and samples of diatoms at greater depth (Baker et al. 1997; Gerritsen et al. 1998). Cored samples will be placed in a sealable bag and preserved at 4° C (Baker et al. 1997; Gerritsen et al. 1998). Samples will be divested of organic material and slides made using standard procedures (Gerritsen et al. 1998). Samples will be embedded in suitable slide mounting medium for long-term preservation. We have secured the collaboration of John Smol (University of Waterloo, Canada), a long-time colleague and founder and editor of the *Journal of Paleolimnology* in completing this work.
13. ***Fish analyses:*** DNR will collect a representative sample of fish (maximum of 4 fish), and ISU will deliver them to the University of Iowa Hygienic Laboratory or another contract laboratory for analysis. The characteristics of fish to be analyzed are also indicated in Table 4.
14. ***ISU-CARD Economic Study:*** As part of an on-going study (www.card.iastate.edu/lakes), we will examine Lizard Lake with respect to the potential public benefit to be derived from lake water quality restoration.
15. ***Description of public access***: A description will be made of the public access to the lake including the number of public parks, public access points, boat ramps, and the availability of public transportation to these access points.
16. ***Population characteristics assessment:*** Census records and area-wide planning agency information will be used to describe the size and economic structure of the population residing near the lake.
17. ***History of lake use***: Records from the DNR will be used to summarize the historical uses of the lake including recreation up to the present time and how these uses may have changed because of water quality degradation. Information to be used in this assessment will include fishery information, recreation information (DNR recreational use surveys and state park attendance data) and local tourism information.
18. ***Comparison of use with other lakes***: Using DNR recreational use surveys, the use of Lizard Lake will be compared with the use of other lakes within 80 kilometers.
19. ***Impact of lake degradation***: A discussion will be included if a particular segment of the lake user population is or will be more adversely impacted by lake degradation or restoration.
20. ***Point-source pollution inventory***: From the records of local and state agencies, an itemized inventory of known point source pollution discharges affecting or which have affected lake water quality over the past five years will be assembled, including abatement actions for these discharges that have been taken, or are in progress.
21. ***Fisheries analysis***: Fisheries data, for example species composition, relative abundance, growth rate of the major fish species and harvest rates, will be compiled by DNR fisheries biologists and integrated into the diagnostic feasibility study.

Integration of these and other relevant fisheries data with the Iowa Lakes Information System will allow for an analysis of current water quality and fisheries information. Information on past winterkills will be included along with estimates of their effects on fishing quality in the lake.

22. ***Geographic information systems analysis:*** A description will be made of the land uses in the lake watershed, listing each use classification as a percentage of the whole. Studies using watershed modeling programs will be used to evaluate various land management alternatives. Land-use data will be used in conjunction with a GIS analysis of the drainage basin to identify portions of the watershed with the potential for producing the largest amounts of pollutants. Using existing records, the study will also provide a geological description of the drainage basin including soil types.
23. ***Additional products from this program***:
    a. Study plans, data, and work in progress will be posted on a web site to allow better visibility and public input to the feasibility study process.
    b. Digitized landuse data and modeled output for the drainage basin will be supplied to DNR in ArcGIS format.
    c. Representative digital images of dominant aquatic organisms will be supplied for use in web sites and publicity.

Tables of Analyses to be Performed on Lizard Lake

Table 1. Analyses to be performed on lake samples in this survey.

Analyzed Regularly from YSI Profile Data	Analyzed Regularly from (0-0.5m) Mixed Zone Integrated Samples	Analyzed Regularly from (0-0.5m) Mixed Zone Integrated Samples
Temperature YSI	Total P	Phytoplankton Composition
Dissolved O_2 YSI	Soluble Reactive P	Zooplankton Composition
pH YSI	Total N	Secchi Disk Transparency
Specific Conductivity YSI	$NO_2 + NO_3$	Silica
Turbidity YSI	NH_4	pH
	Unionized NH_3	Alkalinity
	Total Suspended Solids	Microcystin
	Inorganic Suspended Solids	
	Volatile Suspended Solids	
	Dissolved Organic Carbon	
	Total Dissolved Carbon	*E. coli*
	Chlorophyll *a*	Total Coliform

Table 2. Analyses to be performed on tributaries samples in this survey.

Analyzed Regularly at Tributary Sites	Analyzed Regularly at Tributary Sites
Field	**Lab**
Temperature YSI	Total Phosphorus
Dissolved Oxygen YSI	Soluble Reactive Phosphorus
pH YSI	Total N
Specific Conductivity YSI	$NO_2 + NO_3$
Turbidity YSI	NH_4
Discharge	Unionized NH_3
	Total Suspended Solids
	pH
	Alkalinity
	E. coli
	Total Coliform

Table 3. Analyses to be performed on sediments and sediment elutriates sampled in this survey.

Bottom Sediments
Chlorohydrocarbon Insecticides
Arochlors (PCB's)
Nitrogen containing herbicides
Organophosphate insecticides
Acid herbicides
Nitrate + Nitrite N
Total Kjeldahl Nitrogen(TKN)
Total Phosphate P
Heavy Metal Profile- Antimony, Arsenic, Barium, Cadmium, Chromium, Lead, Nickel, Selenium, Silver, Thallium, Zinc,
Mercury
Sediment Elutriates
Nitrogen containing herbicides
Organophosphate insecticides
Chlorinated Hydrocarbon insecticides
Arochlors (PCB's)
Acid herbicides
Nitrate + Nitrite N
Total Kjeldahl Nitrogen
Total Phosphate P
Heavy Metal Profile- Antimony, Arsenic, Barium, Cadmium, Chromium, Lead, Nickel, Selenium, Silver, Thallium, Zinc,
Mercury

Table 4. Analyses to be performed on fish sampled in this survey.

Fish Flesh
Nitrogen containing herbicides
Organophosphate insecticides
Acid herbicides
Chlorinated Hydrocarbon insecticides
Arochlors (PCB's)
Mercury

Fish samples will have an additional grinding fee of $150. This is not per sample, it is a total cost.

H. Feasibility Study

19. ***Lake restoration alternatives report***: The most cost-effective alternatives for lake restoration will be identified with an identification and justification of potential alternatives. This will include a discussion of projected water quality improvement, and preliminary estimates of cost of principal alternatives. The discussion of each of the most likely alternatives and the potential lake restoration procedure will include descriptions specifying the activities that would be undertaken under each, indicating how and where these procedures would be implemented, and presenting a quantitative analysis of the water quality control effectiveness and the lake water quality improvement that would be anticipated. These alternatives will be developed in collaboration with the working group described in article 1 of the diagnostic study.
20. ***Shallow*-lake management:** Appropriateness and feasibility of shallow-lake management will be addressed. The habitat distribution will be forecast for proposed restoration scenarios. This will include projections of open water and vegetated littoral habitat.
21. ***Economic Cost / Benefit Analysis***: There will be a summary of the cost and benefits of potential restoration efforts. Information from the ISU-CARD study will be used in part to analyze various restoration scenarios.
22. ***Anticipated changes to aquatic biota***: There will be a discussion of the particular benefits expected from implementing the project, including changes in aquatic biota that may result from the enhanced water quality.
23. ***Monitoring program design***: A monitoring program will be designed to assess the effectiveness of the proposed restoration following appropriate guidelines for such monitoring programs.
24. ***Assistance in public hearing process:*** Once the pertinent information has been assembled and preliminary explorations have been made of the various alternatives for lake restoration, ISU personnel will assist DNR in the conduct of a public hearing scheduled to give the public an opportunity to assist in the development, evaluation, and selection of alternatives; and to assist in assessing potential adverse environmental impacts; and in identifying measures to mitigate any adverse impacts that were identified. A summary of the public participation activities will be included in the final report.

ARTICLE III. Milestone Schedule

- September 1, 2006 - Initiation of fieldwork including sampling, lake mapping and GIS.
- August 31, 2007 - Complete field sampling for limnological survey.
- October 1, 2007 - Complete rough draft of diagnostic study.
- November 1, 2007 - Complete final draft of diagnostic study. Submit results of feasibility study to the public with suggested alternatives for restoration.

Fig.1 Proposed tributary sampling locations for Lizard Lake, Pocahontas County.

Source: Iowa DNR Interactive Mapping