

PROJECT TITLE: Comparison of Methods for Estimation of Annual Pollutant Loads from Storm Drain Discharges

SUBMITTED TO: Ben Higgins, Project Director  
Engineering Services  
Public Works, 901 N 6<sup>th</sup> St.  
Lincoln, Nebraska 68508

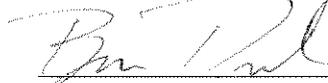
APPLICANT INSTITUTION: The University Of Nebraska-Lincoln  
312 North 14<sup>th</sup> Street, Alex West  
P.O. Box 880430  
Lincoln, NE 68588-0430

PROJECT PERIOD: May 15, 2007 through December 31, 2007

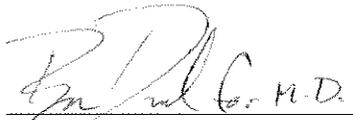
AMOUNT REQUESTED: \$15,439

PRINCIPAL INVESTIGATOR: Bruce Dvorak, Associate Professor  
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SIGNATURES:

  
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Bruce Dvorak, Ph.D.  
Principal Investigator

Date 5/2/07

  
\_\_\_\_\_  
Mohamed Dahab, Ph.D., Chair  
Civil Engineering

Date 5/2/07

  
\_\_\_\_\_  
Jeanne Wicks  
Director, Sponsored Programs

Date 5-2-7

PROPOSAL ACCEPTANCE:

\_\_\_\_\_  
Mayor Chris Beutler

Date \_\_\_\_\_

## A Proposal for: Comparison of Methods for Estimation of Annual Pollutant Loads from Storm Drain Discharges

### Overview

The proposed work concerns the estimation of the annual pollutant load of the cumulative discharges to the waters of the United States from Lincoln's municipal outfalls. Several methods of making this estimation exist. The proposed study concerns evaluating these methods for three Lincoln watersheds to provide data concerning which method may yield the most realistic pollutant load estimates. The proposal is separated into four portions: (1) estimation of the annual pollutant load from three Lincoln watersheds using Nation Wide Urban Runoff Program (NURP) data, (2) storm drain monitoring for three watersheds, and (3) development of regression equations based on the water quality monitoring data from the three watersheds, and (4) extrapolation of results from previous steps to estimate an approximate pollutant load from the city storm drain system to local streams and waterway for typical annual rainfall.

The overall value of the proposed work is to compare the simplest method of estimating annual pollutant mass loads of specific water quality contaminants from Lincoln's storm drains to actual data collected at three watersheds in Lincoln. The simplest method of estimating uses national average concentration estimates for each type of land use. It is unknown if these estimates are realistic for Lincoln. The second method is to utilize actual storm drain water quality data from three watersheds in Lincoln that has been collected over the past decade. Each of the three watersheds represents a different land use type for Lincoln. The comparison of the results from these two methods will suggest if the use of national average concentration data is realistic for Lincoln, or if the results from that method provide an over or underestimate of the pollutant loadings.

### I. Estimation of the Annual Pollutant Load from Three Lincoln watersheds using Nation Wide Urban Runoff Program (NURP) data.

Estimation of annual pollutant loadings from three watershed (listed in Table 1) using NURP data, land uses, and specific area rainfall amounts from nearby gages to calculate May thru September 2007 annual pollutant loads for selected constituents. At least two methods will be evaluated. The loads would be calculated for each significant rainfall event, the cumulative load over the course of the monitoring season (May thru September), and the extrapolated load for the typical annual rainfall for Lincoln, NE.

**Table 1. Watershed Locations that have been Monitored for Storm Water Quality.**

Monitoring Point Designation	1	2	3
Name Designation	Tipperary	N Street Storm Drain	Commerce Way
Location Description	400 ft west of 27th St. & Tipperary Trail	1st & N Sts.	400 ft west of NW 15th & W. Commerce Sts.
Latitude	40° 45' 56.4"	40° 48' 13.9"	40° 50' 52.1"
Longitude	96° 41' 2.27"	96° 43' 13.9"	96° 44' 30.6"
Receiving Stream	Beal Slough	Salt Creek	Oak Creek
Main Land-Use Type	Residential	Commercial	Industrial

Estimates will be made of the annual pollutant loads of the cumulative discharges to the waters of the United States from all identified municipal outfalls of Lincoln between May 1, 2007 and September 30, 2007. The annual pollutant loads will be estimated for:

- chemical oxygen demand (COD),
- biochemical oxygen demand - 5 day (BOD<sub>5</sub>),
- total suspended solids (TSS),
- total solids,
- total ammonia plus organic nitrogen
- total nitrogen
- dissolved phosphorus,
- total phosphorus, and
- cadmium,
- copper,
- lead, and
- zinc

One method of estimation of the annual pollutant loads will use the actual measured discharge from each watershed from each storm event multiplied by the estimated event mean concentration (EMC) for each pollutant based on the NURP (national average data) data for the specific land use. The second method will estimate the annual pollutant loads using climatic data for each rainfall event during the year, estimates of the event mean concentration of these cumulate discharges for each storm event, pollutant, and land use based on NURP (national average data), and basic land size and use data for each watershed. The land use size and use data will be provided by the City. As per Smullen et al. (1999) pollutant loads are estimated as the product of the area of urban land ( $A_i$ ), the rainfall-runoff depth as estimated by a modified rational formula approach ( $d_r$ ), and a constant pollutant concentration ( $C_i$ ), using the median event mean concentrations (EMCs) reported by NURP.

## **II. Storm Drain Monitoring for Selected Constituents for Three Watersheds**

In order to expand the storm water quality data set for understanding the annual pollutant loadings from Lincoln, three additional storm events will be monitored for three watersheds beyond those to be monitored under other contracts with the City. These additional three storm events will have a rainfall depth between 0.10 to 0.4 inches, which is less than those previously monitored. In addition, limited samples will be collected of dry weather flows from the three drainage sheds to characterize the dry weather flow water quality.

Samples shall be collected using city supplied equipment at points approved by the Nebraska Department of Environmental Quality (NDEQ). For these additional storm events it is proposed to analyze the following water quality parameters:

- Total suspended solids (TSS)
- Chemical oxygen demand (COD)
- Total Nitrogen
- Total Phosphorus
- Heavy metals (Cu and Zn)
- E.Coli.

## **Sampling Plan**

### Sampling Frequency and Locations

Wet weather monitoring will be performed at least three times during this contract at the three locations listed in Table 1. At least two grab samples of dry weather flows will be collected and analyzed from each of the three locations in Table 1. Monitoring shall be conducted between May 15 and September 30, 2007.

### Sample Collection

Samples and measurements taken as required within this permit shall be representative of the discharge. All samples shall be taken at the monitoring points specified in this permit and, unless otherwise specified, before the effluent joins or is diluted by any other waste stream, body of water or substance.

- a. Composite sampling shall be conducted in one of the following manners:
  - (1) less than 24 hours - a minimum of hourly discrete aliquots or a continuously drawn sample shall be collected during the discharge, or
  - (2) batch discharge - a minimum of three discrete aliquots shall be collected during each discharge.
- b. Composite samples shall be collected in one of the following manners:
  - (1) the volume of each aliquot must be proportional to either the waste stream flow at the time of sampling or the total waste stream flow since collection of the previous aliquot,
  - (2) a number of equal volume aliquots taken at varying time intervals in proportion to flow, and
  - (3) a sample continuously collected in proportion to flow.
- c. Grab samples shall consist of a single aliquot collected over a time period not exceeding 15 minutes.

### Sampling Equipment

Composite sampling equipment and flow measurement equipment will be supplied and installed at the sites by the City. The University of Nebraska shall be responsible for maintaining the monitoring equipment and associated appurtenances at the three urban runoff sampling locations. The University shall also be responsible for maintaining the all samplers, lines, bottles and batteries. Flow measurement devices and methods consistent with accepted scientific practices shall be used.

Samples will be collected using dedicated sample bottles. Bacterial samples will be collected in dedicated bottles supplied by the lab. Sampling personnel will be equipped with proper rain gear, boots, and rubber gloves. Sample bags will be stored in ice chests until they can be transferred to refrigerators in the UNL lab.

### Sample Handling

Sample containers will be placed in coolers loaded with ice and transported immediately to the UNL lab where they will be stored in refrigerators until analyses are conducted. Sample containers will be labeled according to sample location and time of sampling. For example a sample taken at BMP site 2, at location b, on October 13 at 4:35 in the afternoon will be labeled 2b-10/13/03-1635.

Standard Chain of Custody forms will be maintained for each sample collected. The Chain of Custody forms will include date, time, location, sample location number, sample identification number, analyses to be conducted, name and signature of sampler

#### Records and Field Notes

Field notes will be kept by the sampling team. Field notes will describe: time and date of storm, time interval from last storm, air temperature, wind, description of the stormwater (e.g., floating debris, oil sheen), and anything that is observed that could affect sample results. A copy of the "NPDES Form PE – Record of Physical Examination Observations Results" or similar type format, is required to be filled out for each outfall tested. Records of all sampling or monitoring information shall include:

- a. the date(s), exact place, time and methods of sampling or measurements,
- b. the name(s) of the individual(s) who performed the sampling or measurements,
- c. the date(s) the analyses were performed,
- d. the individual(s) who performed the analyses,
- e. the analytical techniques or methods used,
- f. the results of such analyses, and
- g. laboratory data, bench sheets and other required information.

#### **Analytical Plan**

Storm water shall be sampled in accordance with the requirements in 40 CFR 122, unless otherwise approved. The following parameters shall be monitored:

- a. **Grab Samples** shall be collected during the initial flush of the discharge. Samples shall be analyzed for the following parameters:  
temperature,  
E. Coli, and  
physical characteristics examination
- b. **Composite Samples shall be analyzed for the following parameters:**  
total suspended solids (TSS),  
nitrate plus nitrite nitrogen,  
chemical oxygen demand (COD), and  
total phosphorus.

Prior to analysis, samples will be stored at 4°C. Other preservatives used are noted in the description of the analytical method for that parameter. The following analytical methods will be used for each analysis. The UNL Civil Engineering laboratory facilities will be used unless otherwise specified.

#### Temperature

The temperature of the grab samples will be measured in the field using an alcohol thermometer with 1°C temperature increments following Method 2550 from Standard Methods for the Examination of Water and Wastewater (Standard Methods). The thermometer will be allowed to equilibrate and will be recorded to the nearest degree on the Chain of Custody sheet.

#### E. coli

E. coli samples will be analyzed by the State of Nebraska Health and Human Services Laboratory. Samples will be collected into sterile bottles, and dropped off for analysis within one hour of the rain

event. Enumeration by the State Lab will be done using the coli-lert-QT (quanti-tray method). The maximum holding time allowed for the E. coli samples is 8 hours.

#### Total Suspended Solids

Will be measured following Standard Method 2540. The maximum holding time allowed for solids samples is 7 days.

#### Total Kjeldahl Nitrogen

Total kjeldahl nitrogen (TKN) will be analyzed by the UNL Water Science laboratory using EPA Method 351.3. This method can be used to measure TKN concentrations between 0 - 150 mg/L. The maximum holding time allowed for TKN is 24 hours.

#### Chemical Oxygen Demand (COD)

COD will be analyzed using the dichromate methods (Standard Method 5220) and has a maximum holding time of 7 days, after nearly immediate sample acidification.

#### Total Phosphorous

Total Phosphorous will be analyzed according to Standard Method 4500-P. Samples for both total phosphorous may be sent to the UNL Water Science laboratory for analysis. The maximum holding time is 24 hours.

Averages shall be calculated as an arithmetic mean except bacterial counts which shall be calculated as a geometric mean. All monitoring records (calibration and maintenance records, monitoring records and information, and all reports) will be organized and placed in a location agreeable to the City of Lincoln in case they need to be reviewed in the future. The records will be retained for at least three years.

### **Quality Assurance, Quality Control**

UNL Civil Engineering (CIVE) will test 20 percent of the samples in duplicate (over the course of the year) to estimate the "relative percentage error" for each analysis performed by UNL CIVE. At least 6 blank samples will be tested for each analysis performed by UNL CIVE. The Method Detection Limit [MDL] (following Standard Methods for Water and Wastewater Analysis) will be determined at the start of the sampling season for each analysis performed by UNL CIVE. At least 6 standard samples with known concentrations will be tested for each analysis performed by UNL CIVE. Revised MDLs will be determined using this data. Three travel blanks will be taken to the field testing sites during one storm during the year and tested for all parameters. Six laboratory blanks will be analyzed for each parameter during the year.

### **III. Analysis of Additional Monitoring and Past Monitoring Data to Develop Water Quality Regression Equations.**

An analysis will be performed of the additional monitoring plus analysis of the previous and ongoing monitoring data for the three watersheds discussed in Phase II. A calculation of pollutant loads for May – September 2007 based on the physical data for the three watersheds will be performed based the used of regression equations and rainfall data. The regression models will be used to estimate the EMCs and annual pollutant loadings for the three watersheds in Lincoln for the 2007 year. The dry weather monitoring data will be used for the dry weather pollutant loads. Actual flow monitoring data from the three watersheds will be used for modeling the water volumes. The following water quality parameters will be evaluated:

- chemical oxygen demand (COD),
- total suspended solids (TSS),

total nitrogen  
total phosphorus,  
copper, and  
zinc

The results from this physical data will be compared with the NURP data (method performed in Phase I). A recommendation will be made concerning a method (one method or combination of the two) to extrapolate the results to the pollutant loadings from the entire city (Phase IV).

#### **IV. Extrapolation of Results From Previous Steps To Estimate An Approximate Pollutant Load From The City Storm Drain System.**

An extrapolation will be performed using the results of the previous steps to estimate an approximate pollutant load from the city storm drain system to local streams and waterway for typical annual rainfall. The calculations would be accomplished by using best available concentrations of pollutants, typical annual rainfall for Lincoln, NE, and land use areas for residential, commercial, and industrial classifications.

#### **Reports**

The University shall provide the City with all data taken as a result of the monitoring results. The final report shall include written confirmation that the Quality Assurance and Quality Control Plan was performed. The final report will be submitted by November 15, 2007. The final report submitted to the City will include:

- a. Rainfall event, flow, and pollutant concentration summary information;
- b. All monitoring results;
- c. Comparison of the two methods of estimating the annual pollutant loadings for three watersheds with a description of the methodology used; and.
- d. Calculated estimates of the estimating the annual pollutant loadings for the entire city of Lincoln.

#### **Budget Details:**

All equipment and supplies purchased for this project remain the property of UNL at the end of this project. This contract will be paid as a lump sum. This contract will be initiated as soon as possible after 1) appropriate approval by both UNL and the City of Lincoln, and 2) a qualified UNL student is recruited to carry out the work as specified above. The work will be carried out during the period between the approval date and December 31, 2007.

## Budget

### Personnel

Principal Investigators	
B. Dvorak	\$1,300
Fringe Subtotal x 0.28	\$364
Graduate Research Assistant (GRA) (lead – 3.5o.)	\$5,600
GRA (sampling assistance- 1 mo.)	\$1400
GRA Health Insurance (half year cost)	\$500
Graduate Fringe = GRA salary x .32	\$2,240
Undergraduate hourly worker (120 hr)	\$1,200
<b>Personnel &amp; Benefits Total</b>	<b>\$12,604</b>
Lab Testing Fees	\$900
Materials & Supplies, Equipment Maintenance	\$400
Operating (phone, copying, postage)	\$50
<b>TOTAL DIRECT COSTS</b>	<b>\$13,954</b>
Indirect Costs Rate x .10	\$1,395
<b>TOTAL PROJECT COSTS (A-F)</b>	<b>\$15,349</b>

### Reference:

Smullen, J. T.; Shallcross, A. L.; and Cave, K. A. (1999) "Updating the U.S nationwide urban runoff quality data base", Water Science Technology, 39(12), 9-16.