Total Maximum Daily Loads

for

Zorinsky Lake – Douglas County, Nebraska

Parameters of Concern: Siltation, Nutrients and Organic Enrichment/Low Dissolved Oxygen

Pollutants Addressed: Sediment and Phosphorus

Nebraska Department of Environmental Quality
Planning Unit, Water Quality Division

Final Draft – June 2002

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EXECUTIVE SUMMARY

Zorinsky Lake is listed on the 1998 Nebraska Section 303(d) List of Impaired Waters (NDEQ 1998) due to impairment by siltation, nutrients, organic enrichment/low dissolved oxygen and pesticides. As such it has been targeted as a high priority water for TMDL development. This document presents TMDLs for sediment; nutrients (i.e., phosphorus) and organic enrichment/low dissolved oxygen, designed to allow Zorinsky Lake to fully support its designated uses in addition to water quality goals established through the *Community Based Watershed Management Process* (COPRPP 1999). The information contained herein should be considered 3 TMDLs that target 2 pollutants. Specifically, sedimentation has been targeted to address the siltation impairment and phosphorus is the pollutant targeted to address the nutrient and organic enrichment/low dissolved oxygen impairments.

Recent revisions to Nebraska's water quality standards criteria will allow the de-listing of Zorinsky Lake for impairment caused by pesticides (i.e., atrazine), therefore this parameter will not be addressed. This change will be reflected on the 2002 Section 303(d) List.

These TMDLs have been prepared to comply with the current (1992) regulations found at 40 CFR Part 130.7.

1. **Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:** Zorinsky Lake, Site No. 18, Sec. 34-15N-11E, Lat. 41'13"17, Long. 96'69"27, Douglas County.
2. **Identification of the pollutant and applicable water quality standards:** The pollutant causing impairment of water quality standards is excessive sediment and nutrients (low dissolved oxygen / organic enrichment). Designated uses for Zorinsky Lake in Title 117 – Nebraska Surface Water Quality Standards (NDEQ 2000) are recreation, aquatic life - Warmwater Class A, agricultural water supply, and aesthetics. Excessive sediment and nutrient inputs have been determined to be impairing the aesthetic and aquatic life water quality criteria assigned to Zorinsky Lake. The support level of the assigned uses are determined from procedures outlines in NDEQ Standard Operating Procedure for Determining Beneficial Use Support for Lakes and Reservoirs (NDEQ 1999).
3. **Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards:** Bathymetric survey data, the Agricultural Nonpoint Source Pollution (AGNPS) model (Young, et al, 1996) and the water quality model EUTROMOD, which utilizes the *Universal Soil Loss Equation* (Reckhow 1992) were employed to determine the current and maximum sediment and nutrient loads that will maintain compliance with water quality standards and established water quality goals.

4. **Quantification of the amount or degree by which the current pollutant load in the waterbody, including the pollutant from upstream sources that is being accounted for as background loading, deviates from the pollutant load needed to attain and maintain water quality standards:** The sediment loads for a typical year and recent land use patterns are exceeding the 5,000 tons/year target by 25,000 tons/year. Sediment loading for the entire watershed is estimated at ~30,000 "average annual" tons/year. Zorinsky Lake's west basin is receiving an estimated 29,500 tons/year, of which 68% (20,060 tons) is retained and 32% (9,440 tons) passed on to the east basin. To meet the water quality target, an 84% reduction from the current load is necessary.

   The total annual phosphorus load to Zorinsky Lake's is estimated to be ~11,950 pounds/year. The targeted total phosphorus loading capacity for Zorinsky Lake is ~3,130 pounds/year based on in-lake response modeling results (see COPRPP 1999). To achieve and maintain both basin's (e.g., east and west) in-lake water quality goals and protect for assigned beneficial uses, a loading reduction of 73% (~4,930 pounds/year) to the west basin is required.

5. **Identification of pollution source category(s):** Nonpoint sources of pollution have been identified as the cause of impairment to Zorinsky Lake.
6. **Wasteload allocations for pollutants from point sources:** No point sources exist in the Zorinsky Lake watershed; therefore the wasteload allocation will be set at zero.
7. **Load allocations for pollutants from nonpoint sources:** Load allocations designed to achieve compliance with the TMDLs were developed for sediment and phosphorus pollutant sources identified in the Zorinsky Lake watershed. The load allocations were developed by estimating the loading associated with expected future land uses and development in the Zorinsky Lake watershed. Future land use in the watershed is expected to continue to change from agriculture and construction into residential development. No specific load allocation was set for "background" contributions because pollutant loads were determined to originate solely from nonpoint sources.
8. **A margin of safety:** These TMDLs contains an implicit margin of safety through inclusion of conservative analytical assumptions included the watershed modeling process. Model inputs for the *Universal Soil Loss Equation (*USLE*)* and *EUTROMOD* model required *"average values"* for soil and climatic conditions for the particular area being evaluated. The resulting sediment and phosphorus load estimates, predicted by the model, are then expressed as a "long-term averages".

9. **Consideration of seasonal variation:** These TMDLs were conducted with an explicit consideration of seasonal variation. Excessive sedimentation occurs on a year-round basis, therefore an annual loading period was used to evaluate storage capacity loss. Watershed model parameter inputs also required that seasonal changes (i.e., vegetative, cover and practice factors) be accounted for. An annual loading period was also utilized in modeling Zorinsky Lake's assimilative capacity for phosphorus. In-lake model parameter inputs also required that seasonal changes (i.e., in-lake phosphorus concentrations, precipitation, vegetative, cover and practice factors) be accounted for.
10. **Allowance for reasonably foreseeable increases in pollutant loads:** There was no allowance allocated for future growth because continued residential growth in the watershed will result in a net decrease in the sediment load.
11. ***Implementation plan:*** *Although not required by the current regulations, an implementation plan (COPRPP 1999 – see attached copy) has been developed to address the sediment and phosphorus loading reductions necessary to meet established water quality goals and criteria. This implementation plan was a product of a Section 319 "Community Based Watershed Management Plan Project" sponsored by the City of Omaha Parks, Recreation & Public Property Department.*

The TMDLs included in the following text can be considered "phased TMDLs" and as such are an iterative approach to managing water quality based on the feedback mechanism of implementing the required monitoring plan that will determine the adequacy of load reductions to meet water quality standards and revision of the TMDL in the future if necessary. A description of the future monitoring (Section 5.0) that is planned has been included.

Monitoring is essential to all TMDLs in order to:

- Assess the future beneficial use status;
- Determine if the water quality is improving, degrading or remaining status quo;
- Evaluate the effectiveness of implemented best management practices.

The additional data collected should be used to determine if the implemented TMDL and watershed management plan have been or are effective in addressing the identified water quality impairments. As well the data and information can be used to determine if the TMDLs have accurately identified the required components (i.e. loading/assimilative capacity, load allocations, in lake response to pollutant loads, etc.) and if revisions are appropriate.

1. Introduction

Zorinsky Lake is listed on the 1998 Nebraska Section 303(d) List of Impaired Waters (NDEQ 1998) due to impairment by siltation, nutrients, organic enrichment/low dissolved oxygen (D.O.) and pesticides. As such, it has been targeted as a high priority for TMDL development. *This document presents TMDLs for three identified parameters: siltation, nutrients, and organic enrichment/low dissolved oxygen. To meet stakeholder defined water quality goals and designated beneficial uses, the specific pollutants (and impairments) to be addressed are sediment (siltation) and phosphorus (nutrients and organic enrichment/low dissolved oxygen).*

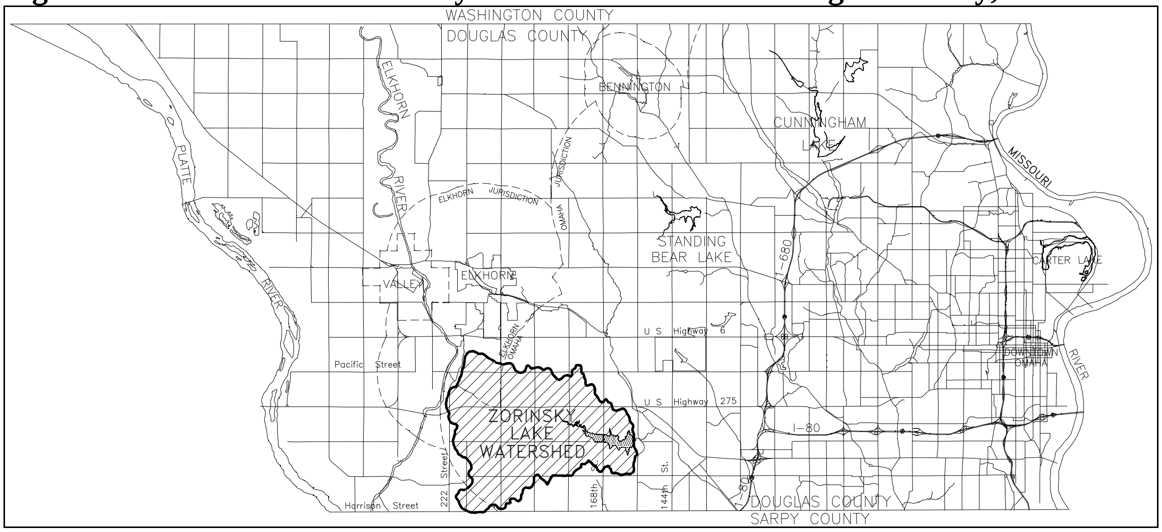
1.1 Background Information: Zorinsky Lake, a 253 acre reservoir located in Douglas County, Nebraska, was constructed in the mid-1980s primarily for flood control with recreation as a secondary benefit by the U.S. Army Corps of Engineers (USACE) (Figure 1.1.1). Physical description information for Zorinsky Lake is presented in Table 1.1. Historically, eastern Nebraska has sustained the majority of the state's population while western Nebraska has contained most of the recreational lands. As a result, lakes which are located in eastern Nebraska are extensively used and have become an important recreational resource.

The U.S. Army Corps of Engineers reported an estimated 575,000 visitor hours at the Zorinsky Lake Recreation Area in 1993, increasing to 838,000 hours in 1996. This represents approximately 247,000 visitors in 1993 and 360,000 visitors in 1996, reflecting an increase of almost 46% in recreation area use.

Table 1.1 Physical Description of Zorinsky Lake

Parameter	Zorinsky Lake
State	Nebraska
County	Douglas
Latitude (center of dam)	41'13"17
Longitude (center of dam)	96'69"27
Section, Township, Range	Sec 34, T15N, R11E
Surface Area, in acres (ha)	253 (101.2)
Shoreline Length, in miles	5.5
Mean Depth, in feet (m)	13.7 (4.2)
Volume, in acre-feet (m^3)	3,470 (4.3 x 10^{-6})
Number of Major Inlets	2
Watershed Area, in acres	10,440.6
Lake to Watershed Area Ratio	1:41.5

Figure 1.1.1 Location of Zorinsky Lake's Watershed in Douglas County, Nebraska



1.1.2 Waterbody Description

1.1.2.1 Waterbody Name: Zorinsky Lake

Lake Identification Number: MT1-L0050 (Title 117 – Nebraska Surface Water Quality Standards)

1.1.2.2 Major River Basin: Missouri River, Code 09

Minor River Basin: Lower Missouri River, Code 12

1.1.2.3 Hydrologic Unit Code:10230006

1.1.2.4 Assigned Beneficial Uses: Recreation, Aquatic Life - Warmwater Class A, Agricultural Water Supply, and Aesthetics (NDEQ 2000, Title 117 – Nebraska Surface Water Quality Standards)

1.1.2.5 Major Tributaries: Zorinsky Lake was constructed on Box Elder Creek, a tributary of West Papillion Creek in Douglas County, Nebraska.

1.1.3 Watershed Characterization

1.1.3.1 Physical Features: The Zorinsky Lake watershed covers 10,440 acres and is located in the low plains ecoregion in east-central Nebraska (JJM 1992). The reservoir was completed in 1984, and the dam structure was closed in 1989. Development in the watershed has been in continual transition from agricultural to urban land uses since this time.

The Zorinsky Lake watershed is dissected by several tributaries, all leading to Box Elder Creek, which empties into Zorinsky Lake. The numerous subwatersheds, created by the tributaries, are bounded by relatively flat ridges, which then descend to the more level creek beds. The generally steep topography, once disturbed by construction and agricultural activities, has a tendency to erode, delivering sediments into the tributaries and Zorinsky Lake. These disturbances have also caused increased flows, which in turn has resulted in accelerated streambank erosion, another contributor of sediment to the lake.

The soils which make up the land play a large part in the erosive nature of the land in the watershed. There are only two primary soil associations in the watershed, the Judson and Marshall-Ponca (SCS 1975). The Judson association is considered very productive, with a high organic matter content and medium runoff potential. The Marshall-Ponca association, formed from the fine particles of loess soils, has a low organic matter content, is less productive and has a high runoff potential. Both soil associations are suited to cultivated crops, as well as grass and windbreak plantings, and they provide habitat for wildlife. Nearly all soils in the watershed have highly to moderately erosive properties.

1.1.3.2 **Climate:** The climate in the area is classified as moist and subhumid, characterized by warm summers and cold, dry winters (JJM 1992). Average annual precipitation in the basin is 28.6 inches, with 75 percent occurring between April and September. Intense thunderstorms are common and have produced daily rainfall amounts in excess of 7 inches (JJM 1992).

1.1.3.3 **Demographics:** The information presented below on Omaha's demographics was compiled by the Greater Omaha Chamber of Commerce (2000). Omaha currently has a population of about 373,361 and ranks as the nation's 45th largest city. However, the Omaha metro area actually consists of five counties (Douglas, Sarpy, Cass and Washington counties in Nebraska and Pottawattamie County in Iowa) with population of 693,900. Within a 50-mile radius of Omaha resides a population of over one million.

Omaha has shown steady population growth for the past five decades and the Omaha area alone has increased 8.5% since 1990. Steady growth of the five-county Omaha metropolitan area population is expected to continue.

1.1.3.4 **Land Uses:** The area around Zorinsky Lake had historically been undeveloped, with open/undeveloped and cropland comprising the majority of land use in the watershed (JJM 1992). However, urbanization of the watershed is occurring from the lake in westward direction. Land uses within the watershed were updated through field verification in 1996 and are presented in Table 1.1.3.4.

Table 1.1.3.4 Land Use Categories and Percent of Watershed they Comprise

Land Use Category	Percent of Watershed
Cropland	48.0%
Open/undeveloped	17.0%
Residential	18.0%
Wooded	5.0%
Construction	6.0%
Commercial/Industrial	2.0%
Open Water/Wetland	3.0%
Feedlots	0.0%
Pasture	1.0%

Changes in land use since the *Diagnostic/Feasibility Study for Ed Zorinsky Lake* (JJM 1992) reflect the greatest shifts occurred in the construction site and residential land uses with increases of 6 and 4.4%, respectively. Decreases are most pronounced in the woodland and cropland categories, with reductions of 4.1 and 3.5% respectively. It is expected that these trends will continue.

2. Sediment TMDL to Address Sedimentation / Siltation Impairments

2.1 Problem Identification

This section details the extent and nature of the water quality impairments caused by excessive sedimentation in Zorinsky Lake.

2.1.1 **Water Quality Criteria Violated and/or Beneficial Uses Impaired:** The *Aquatic Life* – Warmwater Class "A" and *Aesthetics* beneficial uses assigned to Zorinsky Lake (NDEQ 1998) are being impaired due to excessive sedimentation.

2.1.2 **Data Sources:** Original reservoir storage capacity data was derived from USACE "as-built" construction plans (USACE 1983). Current storage capacities for Zorinsky Lake's east and west basins were calculated by NDEQ using USACE's (1997) sedimentation study data in which Geographic Positioning System (GIS) equipment was utilized.

2.1.3 **Water Quality Data Assessment:** Nebraska does not have a numeric water quality standard for sediment, but in 1998 the NDEQ adopted a method to evaluate the severity of sedimentation in reservoirs. This method utilizes the percent of reservoir multi-purpose pool (e.g., conservation and sediment pool combined) volume loss on an average annual basis. Severity of sedimentation conditions has been classified into four assessment categories:

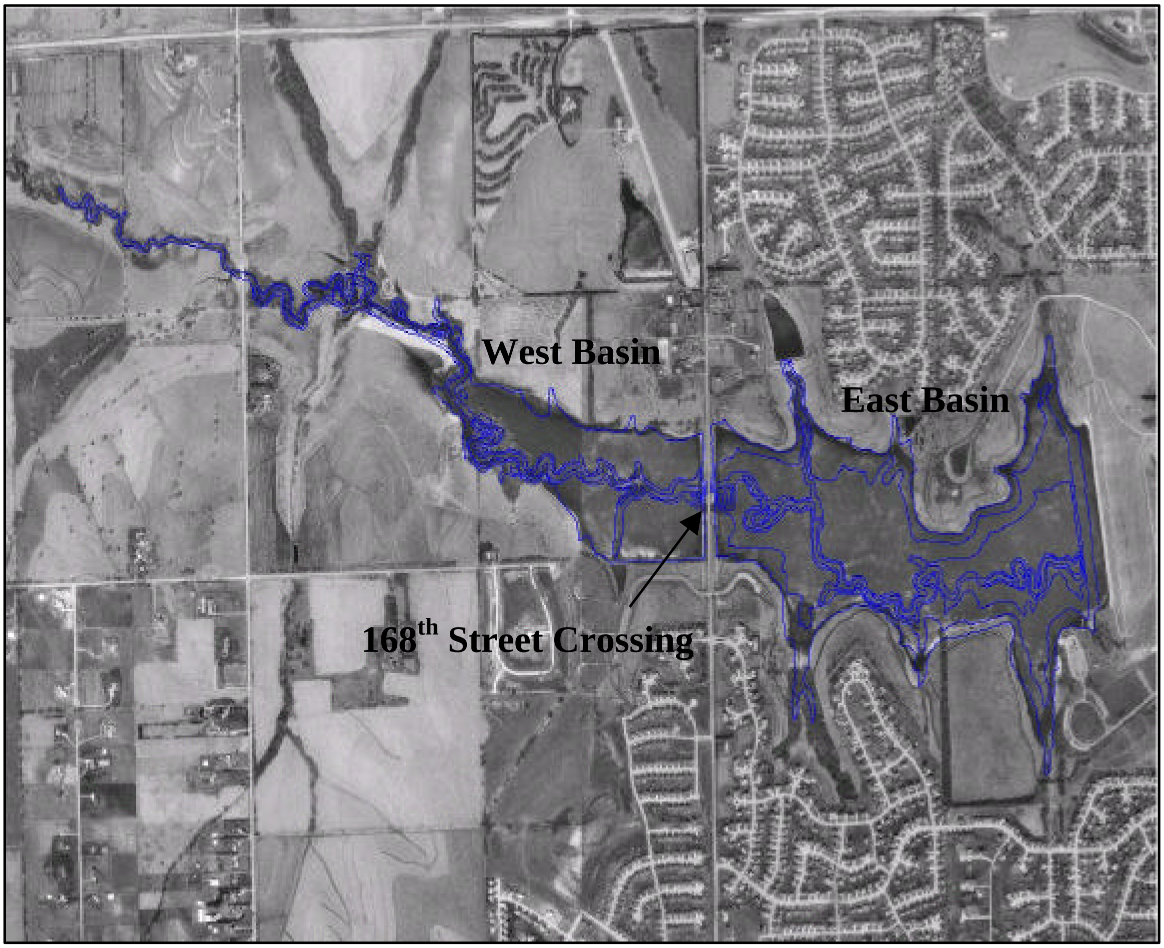
Substantial - ≥ 0.75%
Moderate - ≥ 0.50 to <0.75%
Slight - ≥ 0.25 to < 0.50%
Minimal - < 0.25%

This criterion was also used as the basis for placing reservoirs on the 1998 Section 303(d) list for sedimentation. Reservoirs documented as having an average annual volume loss greater-than or equal-to 0.75% were classified in the "substantial category, and placed on the 1998 list.

2.1.3.1 **Water Quality Conditions:** Based on USACE (1983) "as-built" plans, Zorinsky Lake's multi-purpose pool (elevation - 1,110 ft) storage capacity was 3,472 acre-feet prior at the time of reservoir construction. In 1997, the NDEQ determined the current volume to be ~2,977 acre-feet. The current multi-purpose volume reflects a storage capacity reduction of ~495 acre-feet. This is equivalent to a 14% volume loss since the lake's construction in 1984.

2.1.3.2 **Severity and Extent of Water Quality Problem:** The average annual multi-purpose pool volume loss in Zorinsky Lake is ~1.0%, which falls within NDEQ's highest severity classification category termed "Substantial". Analysis to determine where the sediment entering Zorinky Lake was being deposited revealed that Zorinsky Lake's west basin (Figure 2.1.3.2) has already lost ~30% of its original multi-purpose volume (reduced from 606 to 429 acre-feet over 14 years), for an average annual loss of ~2.1%. In comparison, the larger, east basin has shown an 11% volume reduction (2,866 reduced to 2,548 acre-feet over 14 years) over the same time period for an average annual loss of ~0.79%.

Figure 2.1.3.2 Aerial Photograph Showing Zorinsky Lake's East and West Basins



2.1.4 Potential Pollution Sources

2.1.4.1 **Point Sources:** No point sources exist in the Zorinsky Lake watershed.

2.1.4.2 **Nonpoint Sources:** Multiple nonpoint sediment sources have been identified in the Zorinsky Lake watershed. They include streambank and gully erosion, construction and development activities, agricultural, and numerous other land uses (i.e., grasslands, wooded, etc.).

2.1.4.3 **Natural Background Conditions:** Natural background contributions of sediment were not separated from the total nonpoint source load.

2.2 TMDL Endpoint

The endpoint for this sedimentation TMDL is based on both narrative criteria with numeric and stakeholder water quality targets. As described below, annual volume loss targets in comparison with current sediment load estimates; allowed for the determination of the allowable load (i.e., desired endpoint), and the associated degree of sediment load reduction needed to attain assigned beneficial uses and stakeholder water quality targets.

2.2.1 Criteria for Assessing Water Quality Standards Attainment

2.2.1.1 Numeric Water Quality Standards Criteria:

Numeric Water Quality Standards Criteria: As previously outlined in Section 2.1.3, Nebraska does not have a numeric water quality standard for sediment.

2.2.1.2

Quantification of Narrative Water Quality Standards Criteria: The Warmwater Class "A" Aquatic Life use is protected through the "reservoir sedimentation assessment criteria" utilized by NDEQ. Based on this assessment procedure, the reservoir's average annual multi-purpose volume loss shall not exceed 0.75%. In support of this criteria, Nebraska's water quality standards for "Aesthetics" states in part, "To be aesthetically acceptable, waters shall be free from human-induced pollution which causes floating, suspended, colloidal, or settleable materials that produce objectionable films, colors, turbidity, or deposits" (NDEQ 2000).

2.2.1.3

Local Stakeholder Defined Criteria: Through stakeholder meetings held in the Zorinsky Lake watershed (COPRPP 1999), in-lake water quality targets were established to maintain and enhance aquatic habitats in addition to fully supporting the desired in-lake fishery. Based on studies which have concluded lakes that maintained 0.25-0.50% volume loss' only exhibited slight visual impact, watershed stakeholder's established an annual maximum volume loss rate (i.e., endpoint) not to exceed 0.40% in both the west and east portions of Zorinsky Lake (COPRPP 1999).

2.2.2 Selection of Environmental Conditions

There is no specific "environmental or critical condition" associated with this sediment TMDL because once this pollutant type settles in the reservoir it is assumed to have an infinite residence time and is occurring on a year-round basis.

2.2.3 Waterbody Pollutant Loading Capacity

The loading capacity for this TMDL is defined as the amount of sediment Zorinsky Lake can receive on an annual basis and still meet its assigned beneficial use criteria and established in-lake water quality targets. To achieve an average annual multi-purpose pool volume loss rate of less than 0.40%, the sediment loading capacity for Zorinsky Lake's west basin has been set at 5,000 tons/years. Of this, approximately 32% of the sediment load is estimated to pass through into the east basin. This resulting assimilative capacity for the west basin is approximately 3,400 tons/year. If this loading capacity is achieved in the west basin, the east basin will also meet the assigned beneficial use criteria and established in-lake water quality target (i.e., volume loss $\leq$ 0.40%/year).

2.3 Pollution Source Assessment

A combination of methods were used for the Zorinsky Lake source assessment: 1) The Agricultural Nonpoint Source (AGNPS) model (Young 1986) was used to evaluate individual storm event loads and identify critical erosion areas 2) the EUTROMOD model (Reckhow 1992) which utilizes the *Universal Soil Loss Equation* (USLE) was employed to estimate annual sediment loads from the watershed, and 3) existing studies (e.g., storage capacity changes) and monitored data were used as a verification for the modeled sediment load predictions.

2.3.1 Existing Pollutant Load

The existing sediment load to Zorinsky Lake is estimated to be ~30,000 tons/year The EUTROMOD model estimated "*average annual*" sediment contributions from sheet and rill erosion at ~24,531 tons/year with an additional ~4,900 tons/year being contributed from streambank and gully erosion (NRCS 1997). Sediment loading directly to the west basin is estimated to be ~29,500 tons/year and ~500 tons/years to the east. Modeling results indicate that ~68% (20,060 tons) of the sediment entering the west basin is retained and ~32% (9,440) of the load is passed on to the east basin. The total average annual sediment load for the east basin is 9,940 tons (9,440 tons being passed plus 500 tons being directly deposited from the surrounding watershed).

2.3.2 Deviance From Loading Capacity

The sediment loading capacity of Zorinsky Lake is currently being exceeded by ~24,500 tons/year. Sediment loadings for the entire watershed are estimated at ~30,000 tons/year and of this, ~29,500 tons/year are delivered directly to the west basin. To achieve an average annual multi-purpose pool volume loss rate of less than 0.40% (i.e., the watershed stakeholder's defined endpoint/loading capacity), the delivered sediment load to the west basin should not exceed 5,000 tons/years. If this loading reduction is achieved in the west basin, the east basin will also meet the assigned beneficial use criteria and established in-lake water quality target (i.e., volume loss $\leq$ 0.40%/year).

2.3.3 Identification of Pollutant Sources

Since there are no point source discharges in the Zorinsky Lake watershed, nonpoint sediment source identification and quantification was completed through application of the EUTROMOD (USLE) model and field reconnaissance surveys. Modeling efforts required that Zorinsky Lake's 10,440 acre watershed be delineated into 38 subwatersheds (Figure 2.3.3) with 36 being modeled and documenting a multitude of site specific parameters (e.g., land use, acres, conservation measures, land slope, soil erodibility, soil tillage practices, etc). Utilizing a GIS based data management system, identification of sediment pollutant sources and their respective contributions were completed subwatershed by subwatershed.

2.3.3.1 Nonpoint Sources of Sediment

Sediment pollution sources in the Zorinsky Lake watershed were identified based on land use types presented in Table 2.3.3.1. Land under development (i.e., construction) was identified as the largest, single contributor (15,602 tons/year) of all sources followed by agriculture (6,928 tons/year). Streambanks and gullies were also identified as major sediment sources, contributing approximately 5,000 tons/year.

Figure 2.3.3 Zorinsky Lake's Watershed and Subwatershed Boundaries

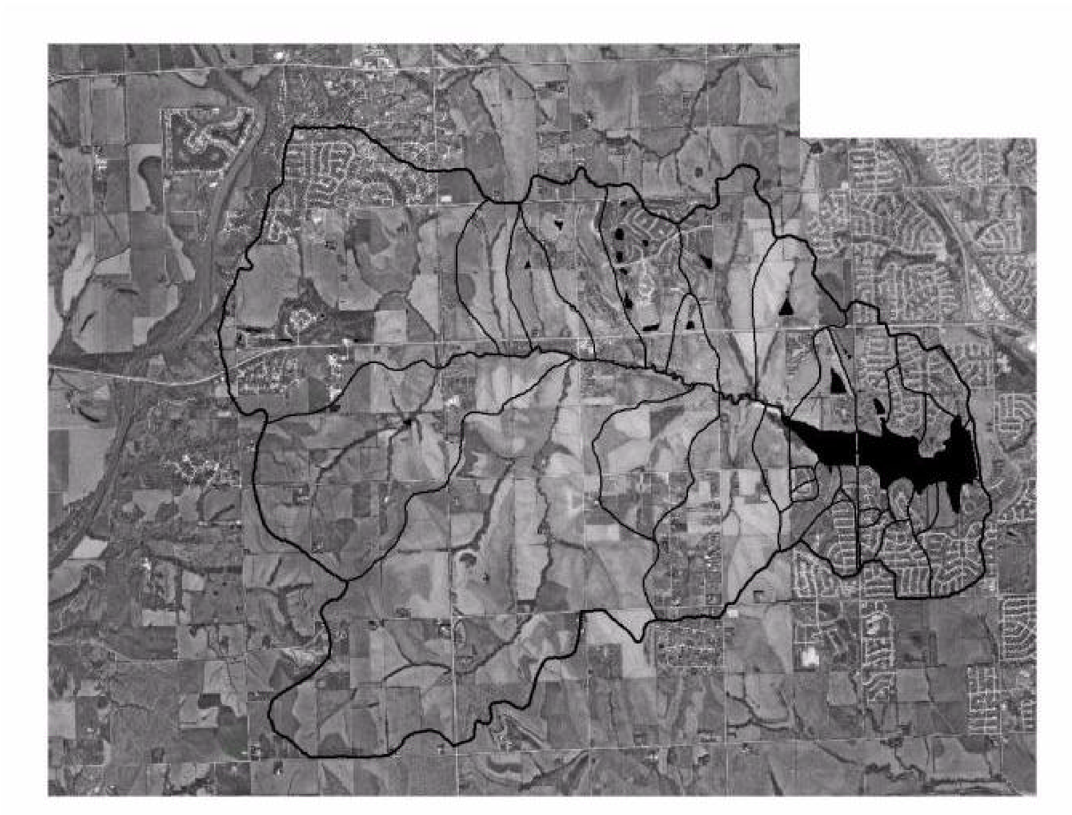


Table 2.3.3.1 Sediment Contributions by Land Use Category

Land Use Category	Total Acres Modeled	Net Soil Delivery (tons/year)	Net Soil Loss (tons/acre/year)
Grass	1,385.4	721.1	0.52
Wooded	815.4	766.5	0.94
Pasture	148.5	71.2	0.48
High Density Res.	980.8	236.6	0.24
Low Density Res.	876.0	188.9	0.22
Construction	656.3	15,602.7	23.8
Commercial	65.1	16.3	0.25
Agriculture	4,990.1	6928.2	1.4
Subtotal	**9,917.5**	**~24,531.5**	
Streambank and Gully*	-----	~5,000.0	
Total	**9,917.5**	**~30,000.0**	

* - Streambank and gully contribution is an estimate based on the total sediment load

2.3.4 Linkage of Sources to Endpoint

The average annual sediment load of ~30,000 tons to Zorinsky Lake has been determined to originate entirely from nonpoint sources. To meet this TMDL's desired endpoint, the annual nonpoint source sediment contribution of 29,500 tons to Zorinsky Lake's *west* basin needs to be reduced by 83% or 24,500 tons/year. If this loading reduction target is achieved in the west basin, the east basin will also meet the assigned beneficial use criteria and established in-lake water quality targets (i.e., volume loss $\leq$ 0.40%/year).

2.4 Pollutant Allocation

Based on the defined sediment loading capacity of Zorinsky Lake, an *"allocation"* strategy was developed by the Zorinsky Lake technical advisory team with input from stakeholders (COPRPP 1999). This strategy is further described in the next section.

2.4.1 Waste Load Allocation

Since there are no point source contributors of sediment in the Zorinsky Lake watershed, the Waste Load Allocation (WLA) is "zero" (0 tons/year).

2.4.2 Load Allocations

The Load Allocation (LA) of 5,000 tons/year will be distributed among the nonpoint sources. No single land treatment alternative would be expected to accomplish the targeted sediment load reduction of 24,500 tons/year. Rather, several levels of sediment control would be necessary to achieve the goal of a maximum sediment load of 5,000 tons/year to the west basin including:

- Construction site erosion and sediment control measures in addition to current requirements
- Regional scale grade and sediment control structures to be located on major tributaries leading to the lake
- Increased soil conservation treatment on agricultural/undeveloped land
- A large sediment retention structure immediately west of the Zorinsky Lake's west basin

A more detailed description of the different levels of land treatment and management alternatives can be found *in "A Community-Based Watershed Management Plan for Zorinsky Lake*" (COPRPP 1999).

2.4.3 Margin of Safety

The margin of safety (MOS) associated with this sediment TMDL will be three fold:

1) The Universal Soil Loss Equation (USLE) requires average values for soil and climatic conditions for the particular area being evaluated. The resulting soil loss/load estimate predicted by the model is expressed as a long-term average. Sediment loads are then considered to be conservative and an implicit margin of safety has been factored into the load estimate,
2) The land use estimates used in the EUTROMOD model were based upon 1996 usages. Since that time and due to the proximity to the City of Omaha, the watershed has seen a transition from agricultural to residential neighborhoods. This action, when occurring in other watersheds has reduced the sediment contributions,
3) The effects of sedimentation are most greatly realized when deposition occurs in the multi-purpose pool. Losses through the outlet and deposition to the flood storage zone will not be separated out. This assumes then that all the sediment delivered is deposited in the multi-purpose pool.

2.5 Sediment TMDL Summary

WLA (0 tons/year) + LA (+ Background) (5,000 tons/year) / MOS (Implicit) = LC (5,000 tons/year).

3. Nutrient TMDL to Address Nutrient and Low D.O. / Organic Enrichment Impairments

3.1 Problem Identification

Zorinsky Lake was placed on the 303d based on stressor/indicators "low dissolved oxygen and organic enrichment". In-lake conditions indicate that accelerated eutrophication caused by excessive nutrient loading is the primary reason. The linkage between accelerated eutrophication and water quality impairments has been repeatedly documented (USEPA 1999). Eastern Nebraska reservoirs classified as being eutrophic or hypertrophic are generally high in phosphorus, particularly in agricultural watersheds that produce high sediment yields. Zorinsky Lake's watershed and in-lake conditions have resulted in phosphorus being the target indicator (i.e., parameter of concern) for this TMDL. The following section details the extent and nature of the water quality impairments related to accelerated eutrophication in Zorinsky Lake.

3.1.1 Water Quality Criteria Violated and /or Beneficial Uses Impaired: Zorinsky Lake's assigned beneficial use for *Aquatic Life* is listed as impaired due the State's dissolved oxygen criteria (5.0 mg/l) being violated (NDEQ 1998, 2002).

3.1.2 Data Sources: In 1996, the NDEQ initiated a monitoring program to characterize Zorinsky Lake's current water quality and watershed conditions. Monitoring locations included sites in Zorinsky Lake's shallower west basin (maximum depth at sample location – 3 meters) and at the deepwater site (maximum depth at sample location – 8 meters) in its east basin. Parameters measured included: dissolved oxygen, total Kejldahl nitrogen, nitrate/nitrite nitrogen, dissolved ortho-phosphorus, total phosphorus, total suspended solids, chlorophyll *a*, and secchi transparency readings. An initial summary of these data are presented in *A Community-Based Watershed Management Plan for Zorinsky* (COPRPP 1999). Assessments presented in this TMDL include water quality data collected through the year 2001.

3.1.3 Water Quality Data Assessment: Beneficial use assessment procedures as they relate to dissolved oxygen require that concentrations be measured in a "top to bottom" profile above the stratified layer. Measurements are then averaged and compared to the 5.0 mg/l aquatic life use criteria which applies from April 1 through September 30 (NDEQ 1999). A minimum of ten data points (e.g., sampling dates) within the last five years is required to be considered a monitored assessment. If the standard is not met in more than 10% of the samples, the waterbody is considered to be in "partial" support of its assigned Warmwater Class "A" *Aquatic Life* beneficial use, which leads to 303(d) listing.

Since Nebraska currently does not have water quality criteria for nutrients, a biomass trophic state index (TSI) (Carlson 1977; Carlson and Simpson 1996) is used as the metric for evaluating this sources/stressor. TSI's calculated from transparency (secchi depth), chlorophyll *a,* and total phosphorus concentration data, were utilized to infer whether algal growth was nutrient or light limited (if the three indices are approximately equal, it can be inferred that algal growth is phosphorus limited (USEPA 1999)). Also, the average of the three TSI scores was used a single measure of lake condition (e.g., oligotrophic, mesotrpophic, eutrophic or hypertrophic) as described in Carlson and Simpson (1996). The following classification is used to interpret the TSI:

TSI<40	Oligotrophic
35<TSI< 45	Mesotrophic
TSI>45	Eutrophic
TSI>60	Hypertrophic

3.1.3.1 **Water Quality Conditions:** Zorinsky Lake is physically divided into 2 separate basins by the 168th road crossing (Figure 3.1.3.2). Though the two portions are connected by a narrow channel, the constriction has shown to have a profound effect on each basin's water quality.

Dissolved oxygen assessments were based on profiles scheduled to be measured monthly from May through September from 1997 to 2001. Dissolved oxygen data for both the east and west basin of Zorinsky Lake revealed numerous excursions of the 5.0 mg/l standard below the stratified layer and a few in the epilimnion, where the standard applies (i.e., the standard applies above the stratified layer if stratification is present, or to the entire water column if it is not present). From 1997 to 2001, 2 (11.7%) out of 17 profiles in Zorinsky Lake's east basin (deepwater site) did not meet the 5.0 mg/l standard. For that same period, 2 (13%) out of 15 profiles in the shallower, west basin, did not meet the standard as well.

Trophic state indice scores for Zorinsky Lake's east basin (deepwater site) collected May through September from 1997 to 2000 included:

TSI (secchi depth) = 62.0
TSI (chlorophyll *a*) = 61.8
TSI (total phosphorus) = 66.0
TSI (mean score) = 63.3

The mean TSI score of 63.3 classifies Zorinsky Lake as being "hypertrophic." Individual TSI scores are also very similar, which indicates Zorinsky Lake's east basin is phosphorus limited.

West basin TSI scores for the same monitoring period were:

TSI (secchi depth) = 70.1
TSI (chlorophyll *a*) = 66.5
TSI (total phosphorus) = 73.4
TSI (mean score) = 70.0

The mean TSI score of 70.0 also classifies Zorinsky Lake's west basin as being "hypertrophic." The individual TSI scores are also very similar, which further supports the theory of Zorinsky Lake being a phosphorus limited system. The west basin's higher TSI score for secchi depth is suspected to be a result of the high sediment trapping efficiency due to the 168th constriction; causing higher suspended solids concentrations and lower water transparencies.

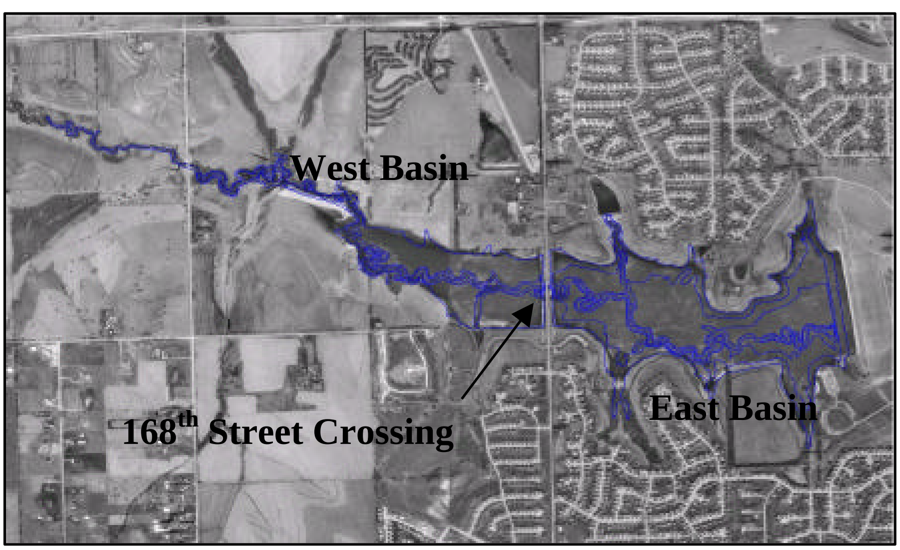
Data also suggests that Zorinsky Lake's east basin's water transparency is decreasing over time. Data collected in 1996 and 1997 compared to that from 1993 through 1995, revealed that median secchi transparency measurements have significantly decreased (70.9 inches in 1993 - 1995 to 30.0 inches in 1996 and 35.3 inches in 1997).

3.1.3.2 Severity and Extent of Water Quality Problem:

Zorinsky Lake is currently not supporting its assigned Warmwater Class "A" *Aquatic Life* beneficial use for dissolved oxygen. Data assessments revealed that between 1997 and 2001, the 5.0 mg/l standard was not met in 11.7% of the samples collected in Zorinsky's east basin and 13.0% in the west.

The TSI classification of Zorinsky Lake as hypertrophic and being phosphorus limited, provides strong evidence that excessive nutrient loading (i.e., phosphorus) to Zorinsky Lake is contributing to the dissolved oxygen / organic enrichment related problems.

Figure 3.1.3.2 Aerial Photograph Showing Zorinsky Lake's East and West Basins



3.1.4 Potential Pollution Sources

3.1.4.1 **Point Sources:** No point sources exist in the Zorinsky Lake watershed.

3.1.4.2 **Nonpoint Sources:** Multiple nonpoint phosphorus sources have been identified in the Zorinsky Lake watershed. They include streambank and gully erosion, construction and development activities, agricultural, and numerous other landuses (i.e., urban, grasslands, wooded, etc.).

3.1.4.3 **Natural Background Conditions:** Natural background contributions of phosphorus were not separated from the total nonpoint source load.

3.2 TMDL Endpoint

The endpoint for this nutrient TMDL is based on both narrative criteria with numeric and stakeholder water quality targets. As described below, phosphorus load targets in comparison with current load estimates, allowed for the determination of the allowable load (i.e., desired endpoint), and the associated degree of phosphorus load reduction needed to attain designated beneficial uses and stakeholder water quality targets.

3.2.1 Criteria for Assessing Water Quality Standards Attainment

3.2.1.1 **Numeric Water Quality Standards Criteria:** Nebraska's dissolved oxygen criteria (5.0 mg/l) (NDEQ 2002) is the applicable numeric water quality standard for determining attainment of Zorinsky Lake's Warmwater Class "A" *Aquatic Life* beneficial use.

3.2.1.2 **Quantification of Narrative Water Quality Standards Criteria:** As previously outlined in Section 3.1.3, Nebraska does not have numeric water quality standards for nutrients. In support of the dissolved oxygen criteria, Nebraska's water quality standards for "Aesthetics" states in part, "To be aesthetically acceptable, waters shall be free from human-induced pollution which causes floating, suspended, colloidal, or settleable materials that produce objectionable films, colors, turbidity, or deposits (NDEQ 2000).

Ultimately the public will decide if a waterbody is aesthetically acceptable or un-acceptable. Therefore, the goals/endpoints used for this TMDL have been established by the Zorinsky Lake watershed stakeholder's.

3.2.1.3 Local Stakeholder Defined Criteria: Through stakeholder meetings held in the Zorinsky Lake watershed, in-lake water quality objectives were established based on the public's goals (COPRPP 1999). Specifically, the public established a goal to increase water clarity in both the east and west portions of Zorinsky Lake, such that all the desired recreational, aquatic and aesthetic beneficial uses are not degraded. Based on this qualitative goal, median water clarity objectives were established for Zorinsky's west and east basin's (>30 inches and >36 inches respectively; see Table 3.2.3.1).

Given these stakeholder derived clarity objectives, "growing season" mean concentration objectives were also determined for chlorophyll *a* and total phosphorus utilizing the in-lake response model EUTROMOD (Reckhow 1992) (Table 3.2.3.1). The modeling process involved scenario testing various annual phosphorus loads to Zorinsky Lake until the desired water clarity objective was achieved (e.g., 30 and 36 inches). Mean concentration objectives for chlorophyll *a* and total phosphorus are a calculated product of the modeling process.

Table 3.2.1.3 Zorinsky Lake's "Growing Season" Water Quality Objectives

Parameter	West Basin	East Basin
Median Water Clarity – Secchi Depth	>30 inches	>36 inches
Mean Chlorophyll *a* Concentration*	<22 mg/m^3	<17 mg/m^3
Mean Total Phosphorus Concentration*	<0.08 mg/l	<0.05 mg/l

3.2.2 Selection of Environmental Conditions

The "critical condition" for which this nutrient TMDL applies is the entire year. An annual loading period was utilized in modeling Zorinsky Lake's assimilative capacity and for estimating loading reductions necessary to meet in-lake water quality targets. This approach also takes into consideration that nutrients being lost from the water column and trapped in the bottom sediments have the potential to re-enter the water column at a later time. Furthermore, implementation of non-point source controls will target those times when a large percent of the loading is occurring.

3.2.3 Waterbody Pollutant Loading Capacity

The loading capacity for this nutrient TMDL is defined as the amount of phosphorus Zorinsky Lake can receive on an annual basis and still meet its assigned beneficial use criteria and established in-lake, stakeholder defined water quality targets. Based on modeling efforts conducted by the NDEQ (see COPRPP 1999), the targeted loading capacity for phosphorus in the west basin is 3,130 pounds/year and 1,680 pounds/year in the east. The EUTROMOD model predicted that if the west basin received 3,130 pounds/year of phosphorus, the water quality targets (see table 3.2.1.3) for "clarity", "chlorophyll *a*" and "mean total phosphorus concentration" would be achieved. The model also predicted that if the loading capacity of 3,130 pounds/year is achieved in the west basin, the established water quality targets for the east basin should be met (e.g., water clarity, chlorophyll *a* and phosphorus targets).

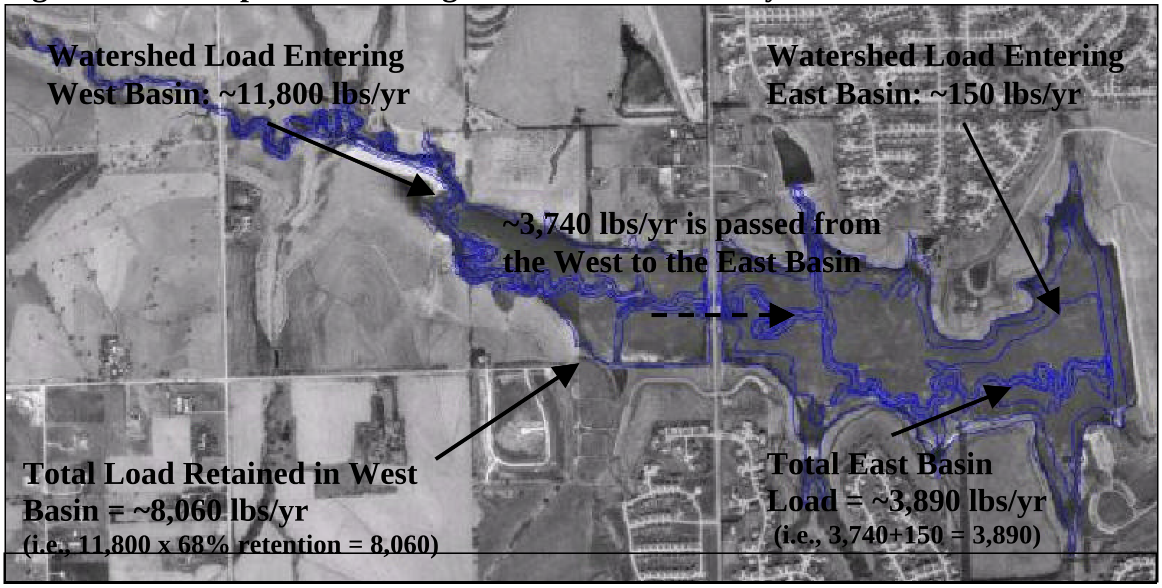
3.3 Pollution Source Assessment

A combination of methods were used for the Zorinsky Lake pollution source assessment: 1) The Agricultural Nonpoint Source (AGNPS) model (Young 1986) was used to evaluate individual storm event loads and identify critical erosion areas 2) the EUTROMOD model (Reckhow 1992) was employed to estimate annual phosphorus loads from the watershed and to run lake response scenarios, and 3) monitoring data was used as a verification for the modeled phosphorus load predictions.

3.3.1 Existing Phosphorus Load

The annual total phosphorus load to Zorinsky Lake is estimated to be ~11,950 pounds/year. Of this load, ~11,800 pounds/year is delivered directly to Zorinsky Lake's west basin and ~150 to the east basin from their respective drainage areas (i.e., surrounding watershed area draining directly to them). The west basin is estimated to have an ~68% retention rate; meaning ~8,060 of ~11,800 pounds/year is retained and ~3,740 pounds/year is passed to the east basin. Given this retention rate, the total annual load for the east basin is ~3,890 pounds/year (see Figure 3.3.1).

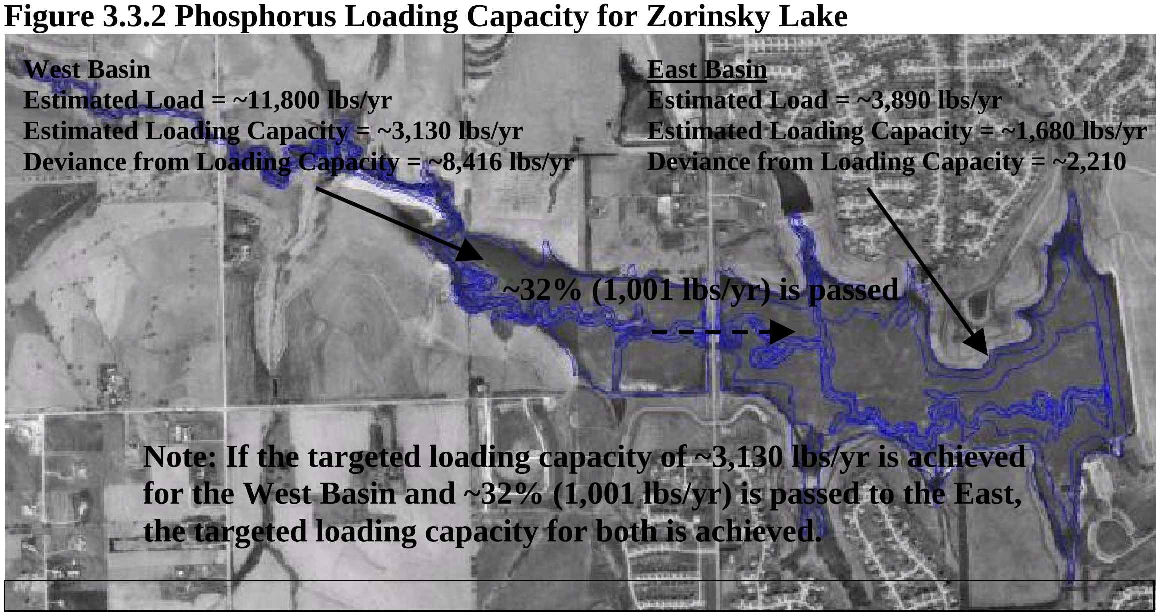
Figure 3.3.1 Phosphorus Loading Estimates for Zorinsky Lake



3.3.2 Deviance From Loading Capacity

The targeted total phosphorus loading capacity for Zorinsky Lake is ~3,130 pounds/year based on in-lake response modeling results (see COPRPP 1999). To achieve and maintain both basin's (e.g., east and west) in-lake stakeholder defined water quality goals and protect for assigned beneficial uses, a loading reduction of 73% (~8,614 pounds/year) to the west basin is required. If this loading reduction is achieved, the east basin is expected to meet its estimated loading capacity of ~1,680 pounds/year (see Figure 3.3.2).

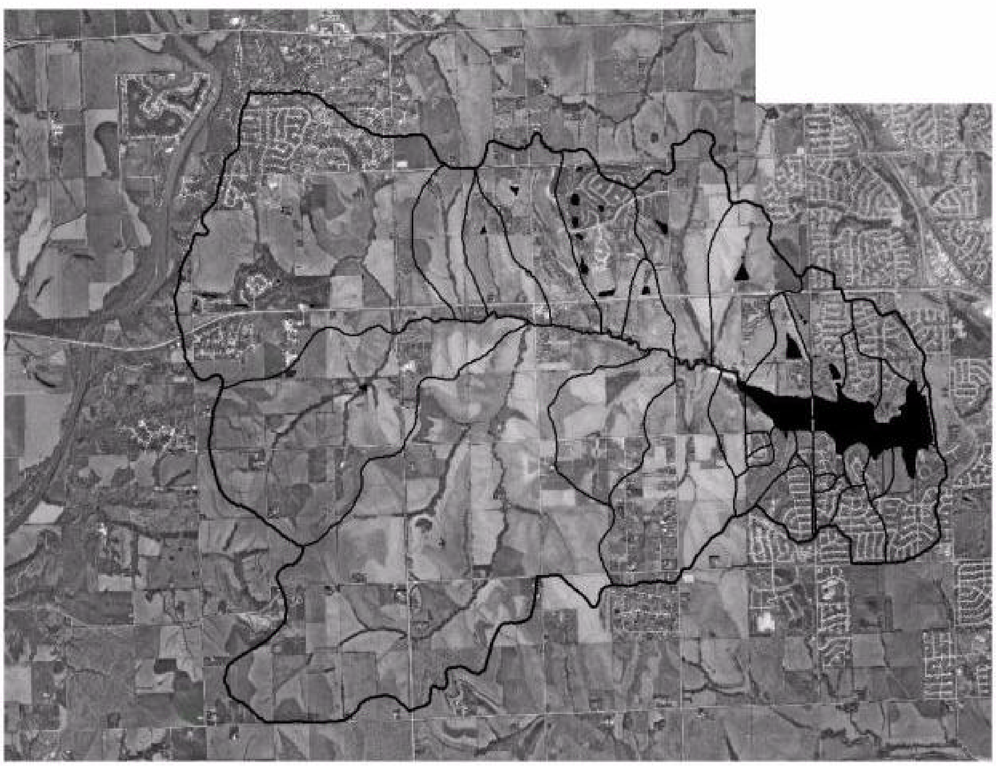
Figure 3.3.2 Phosphorus Loading Capacity for Zorinsky Lake



3.3.3 Identification of Pollutant Sources

Since there are no point source discharges in the Zorinsky Lake watershed, nonpoint source identification and quantification for phosphorus were completed through application of the EUTROMOD (Reckhow 1992) model. Modeling efforts required that Zorinsky Lake's 10,440 acre watershed be delineated into 38 subwatersheds (Figure 3.3.3) with 36 being modeled and documenting a multitude of site specific parameters (e.g., land use, acres, conservation measures, land slope, soil erodibility, soil tillage practices, etc). Utilizing a GIS based data management system, identification of sediment pollutant sources and their respective contributions were completed subwatershed by subwatershed. Calibration of the model was completed using in-lake phosphorus concentration data.

Figure 3.3.3 Zorinsky Lake's Watershed and Subwatershed Boundaries



3.3.3.1 Nonpoint Sources of Phosphorus

Phosphorus pollution sources in the Zorinsky Lake watershed were identified based on land use types presented in Table 3.3.3.1. The total phosphorus load to Zorinsky Lake was estimated to be ~11,950 pounds/year. Land under development (i.e., construction) was identified as the largest, single contributor (~8,152 pounds/year) of all sources followed by agriculture (~3,152 pounds/year).

Table 3.3.3.1 Phosphorus Contributions by Land Use Category

Land Use Category	Total Acres Modeled	Net Total Phosphorus Delivered (pounds/year)	Net Total Phosphorus Delivered (pounds/acre/year)
Grass	1,385.0	164.5	0.12
Wooded	777.9	76.0	1.01
Pasture	148.5	47.0	0.32
High Density Res.	873.5	89.2	0.10
Low Density Res.	980.8	262.6	0.27
Construction	651.0	8,152.0	12.52
Commercial	57.6	6.5	0.11
Agriculture	4,953.8	3,152.5	0.64
Total	**9,828.3**	**11,950.2**	

3.3.4 Linkage of Sources to Endpoint

The average annual phosphorus load of ~11,950 pounds to Zorinsky Lake has been determined to originate entirely from nonpoint sources. To meet this TMDL's desired endpoint, the annual nonpoint source phosphorus contribution of ~11,800 pounds to Zorinsky Lake's *west* basin needs to be reduced by 73% or ~8,614 pounds/year. If this loading reduction target is achieved given the west basin's estimated 68% retention rate, the east basin's loading reduction target of ~1,680 pounds/year is expected to be met.

3.4 Pollutant Allocation

Based on the defined phosphorus and sediment loading capacities of Zorinsky Lake, an *"allocation"* strategy was developed by the Zorinsky Lake technical advisory team with input from stakeholders (COPRPP 1999). This strategy is further described in next section.

3.4.1 Waste Load Allocation

Since there are no point source contributors of phosphorus in the Zorinsky Lake watershed, the Waste Load Allocation (WLA) is "zero" (0 pounds/year).

3.4.2 Load Allocations

The Load Allocation (LA) for this nutrient TMDL is 3,130 pounds/year of phosphorus and will be distributed among the identified nonpoint sources. Given phosphorus' strong affinity for particulate material, loading allocations will be identical for to those developed for sediment. Data revealed that for construction and agricultural land, particulate phosphorus comprised ~70-97% the individual event loads monitored and only ~38-48% in the urban areas. Also, phosphorus source contribution percentages closely resembled those determined for sediment, therefore pollution control / management efforts will be similar. As with sediment, it was acknowledged that no single land treatment alternative could accomplish the targeted load reductions. Rather, several levels of control would be necessary to achieve the targeted load reductions such as:

- Construction site erosion and sediment control measures in addition to current requirements
- Regional scale grade and sediment control structures to be located on major tributaries leading to the lake
- Increased soil conservation treatment on agricultural/undeveloped land
- A large sediment retention structure immediately west of the Zorinsky Lake's west basin

A more detailed description of the different levels of land treatment and management alternatives can be found *in "A Community-Based Watershed Management Plan for Zorinsky Lake*" (COPRPP 1999).

3.4.3 Margin of Safety

The margin of safety for the nutrient TMDL will be: 1) Phosphorus can be discharge from the Zorinsky Lake reservoir outlet without being utilized. While this reduction is realized in the system, the TMDL will not account for this and assume the phosphorus load delivered to the lake remains available for algae production, 2) The land use estimates used in the EUTROMOD model were based upon 1996 usages. Since that time and due to the proximity to the City of Omaha, the watershed has seen a transition from agricultural to residential neighborhoods. This action, when occurring in other watersheds has reduced the nutrient contributions.

3.5 Phosphorus TMDL Summary

WLA (0 pounds/year) + LA (+Background) (3,130 pounds/year) / MOS (Implicit) = LC (3,130 pounds/year).

4.0 Implementation Plan

The implementation plan for the Zorinsky Lake TMDL is unique because the required activities targeted at reducing the NPS nutrient/sediment loadings are presently occurring, independent of this TMDL. A community-based implementation plan has been developed though a public participation process (see attached copy of *"A Community-Based Watershed Management Plan for Zorinsky Lake*", COPRPP 1999).

The goal of TMDLs is to improve water quality to the point of the waterbody fully attaining assigned beneficial uses. It is however recognized that achieving the necessary reductions is highly dependent upon the complexity of the problem and the resources available.

5.0 Monitoring Plan

Monitoring of Zorinsky Lake will be conducted in the future to determine if the water quality is improving, degrading or remaining status quo. As well, monitoring will be conducted to evaluate the effectiveness of implemented best management practices (BMPs). The NDEQ has entered into an agreement with the USACE to whereby the USACE will conduct annual monitoring and forward the results to NDEQ for assessment. Also, the USACE will periodically evaluate the impacts of sedimentation (bathymetry). Monitoring by the USACE will begin in the Summer 2002.

6.0 Public Participation

The availability if this TMDL in draft form was published in the Lincoln Journal Star and Omaha World Herald. The public notice/comment period was from ___, 2002 through ___ , 2002. This TMDL was also made available to the public on the NDEQ Internet site and copies of the draft TMDL were mailed identified stakeholders. In addition, all aspects of these TMDLs have been brought in front of the stakeholders though the *Community Based Watershed Management Planning Process.*

7.0 References

Carlson, R.E. 1977. A trophic state index for lakes. *Limnology and Oceanography* 25:378-382.

Carlson, R.E., and J. Simpson. 1996. *A coordinator's guide to volunteer lake monitoring methods*. North American Lake Management Society and the Educational Foundation of America.

COPRPP 1999. A Community-Based Watershed Management Plan for Zorinsky Lake. Omaha Parks, Recreation and Public Property. Omaha, Nebraska.

GOCC 2000. Metro Omaha Statistical Profile – 2000. Greater Omaha Chamber of Commerce. Omaha, Nebraska.

JJM 1992. Volume 5: Diagnostic/Feasibility Study for Zorinsky Lake, Douglas County, Nebraska. James M. Montgomery, Consulting Engineers, Inc.

NDEQ 1998. 1998 Nebraska Water Quality Report. Nebraska Department of Environmental Quality, Water Quality Division. Lincoln, Nebraska.

NDEQ 1999. Standard Operating Procedure for Assessing Beneficial Use Support on Lakes and Reservoirs. Nebraska Department of Environmental Quality, Water Quality Division. Lincoln, Nebraska.

NDEQ 2000. Title117 – Nebraska Surface Water Quality Standards. Nebraska Department of Environmental Quality, Water Quality Division. Lincoln, Nebraska.

NDEQ 2002. 2001 Nebraska Water Quality Report – un-published report. Nebraska Department of Environmental Quality, Water Quality Division. Lincoln, Nebraska.

NRCS 1997. Personal communication with Scott Sumsion. USDA Natural Resources Conservation Service. Lincoln, Nebraska.

Reckhow, K.H. 1992. EUTROMOD Nutrient Loading and Lake Eutrophication Model. Duke University School of the Environment. Durham, North Carolina.

SCS 1975. Soil Survey of Douglas County and Sarpy Counties, Nebraska. U.S. Department of Agriculture Soil Conservation Service, USDA, Washington DC.

7.0 References Con't

USEPA 1999. Protocol for Developing Nutrient TMDLs. United States Environmental Protection Agency. Office of Water, 4503 F, Wahington, DC.

USACE 1983. Reservoir Capacity Table for Site 18 - Unpublished Report. United States Army Corps of Engineers, Engineering Division, Omaha District, Omaha, Nebraska.

USACE 1997. Reservoir Volume Geographic Positioning System Data for Site 18, Unpublished Data. United States Army Corps of Engineers, Engineering Division, Omaha District, Omaha, Nebraska.

Appendix A: EUTROMOD Model inputs

The EUTROMOD model was utilized to estimate average annual sediment (sheet and rill) erosion and nutrient loading by sub-watersheds and land use to Zorinsky Lake. Due to the variation in land uses, land use acreages and existing treatments (i.e. retention ponds), each watershed was modeled separately and the results summed. The final products of the modeling can be found in Tables 2.3.3.1 and 3.3.3.1 for sediment and phosphorus, respectively. Table A.1 presents the various land uses and the total acreages within the watershed. For modeling purposes the agriculture category was further segregated into crops grown and conservation practices. Tables A.2-A.4 contain the EUTROMOD model inputs.

Table A.1 Land Use (1996) within the Zorinsky Lake Watershed

Land Use Category	Total Acres Modeled
Grass	1,385.0
Wooded	777.9
Pasture	148.5
High Density Res.	873.5
Low Density Res.	980.8
Construction	651.0
Commercial	57.6
Agriculture	4,953.8
Total	**9,828.3**

Table A.2 EUTROMOD/USLE Model Inputs for Zorinsky Lake Subwatersheds

Land Use	Runoff Coefficient (RC)	Rainfall Erosivity (RE)	Soil Erodibility (K)	Topographic Factor (LS)	Cropping Factor (C)	Practice Factor (P)
Acreages/Farmsteads/Low Density Residential	0.20	277	0.26	0.8	0.01	1.00
Construction	0.35	277	0.26	0.8	0.60	1.00
Grass/Idle	0.10	277	0.26	0.8	0.04	1.00
Row Crop (TR,CT)	0.25	277	0.26	0.8	0.09	0.75
Row Crop (NTR,CT)	0.25	277	0.26	0.8	0.25	1.00
Wooded	0.10	277	0.26	0.8	0.03-0.04	1.00
Residential - High Density	0.45	277	0.26	0.8	0.01	1.00
Pasture	0.25	277	0.26	0.8	0.25	1.00
Corn (NT)	0.25	277	0.26	0.8	0.09	1.00
Corn (TR, CT)	0.35	277	0.26	0.8	0.25	0.50
Corn (TR, NT)	0.25	277	0.26	0.8	0.09	0.75
Corn (NTR, CT)	0.25	277	0.26	0.8	0.25	1.00
Cover Crop (NTR, CT)	0.22	277	0.26	0.8	0.14	1.00
Commercial/Industrial	0.25	277	0.26	0.8	0.01	1.00
Beans (TR, NT)	0.25	277	0.26	0.8	0.09	0.50
Beans (NT)	0.25	277	0.26	0.8	0.09	1

Land Use Key: TR = Terraced
NT = No Till
CT = Conventional Tillage
NTR = Not Terraced

Table A.3 EUTROMOD Model Inputs for Zorinsky Lake Subwatersheds

Land Use	Dissolved Phosphorus	Sediment Attached Phosphorus	Total Phosphorus	Dissolved Nitrogen	Sediment Attached Nitrogen	Total Nitrogen
Acreages/Farmsteads/Low Density Residential			0.1			1.75
Construction	0.2	313		2	735	
Grass/Idle	0.15	313		3	735	
Row Crop (NTR, CT)	0.26	313		2.9	735	
Row Crop (TR, CT)	0.4	313		2.9	735	
Wooded	0.008	313		0.06	735	
Residential - High Density			0.2-18			1.5-50
Pasture	0.25	313		3	735	
Corn (NT)	1	313		6.3	735	
Corn (TR, NT)	1	313		6.3	735	
Cover Crop (NTR, CT)	0.3	313		1.8	735	
Commercial/Industrial	0.2	313		1.75	735	
Beans (TR, NT)	1	313		6.3	735	
Beans (NT)	1	313		6.3	735	
Precipitation			0.05			0.1

Table A.4 EUTROMOD Model Inputs for Zorinsky Lake Subwatersheds

Miscellaneous Inputs	Value
Precipitation Mean	73 cm
Precipitation Cv	0.25
P Enrichment	2
N Enrichment	1.6 – 2
Trapping Efficiency Range	0.1 – 1.0

Land use information and conservation practices was initially obtained from digital ortho-photo quadrangles (aerial photos) and verified/updated using information provided by the Natural Resource Conservation Service.

Four sub-watersheds were monitored in 1996-97 to characterize base flow and storm water runoff. The four locations were chosen based upon the predominant land uses with the sub-watershed and the results were considered indicative of other similar areas with the Zorinsky Lake Watershed (CORPP, 1999). The monitoring information was used to make a relative comparison to the EUTROMOD model results and verify the model was sufficient at predicting sediment and phosphorus loads from the various land uses. Figure A.1 shows the locations of the monitoring sites.

Figure A.1 Location of Zorinsky Lake Stream Runoff Monitoring Sites