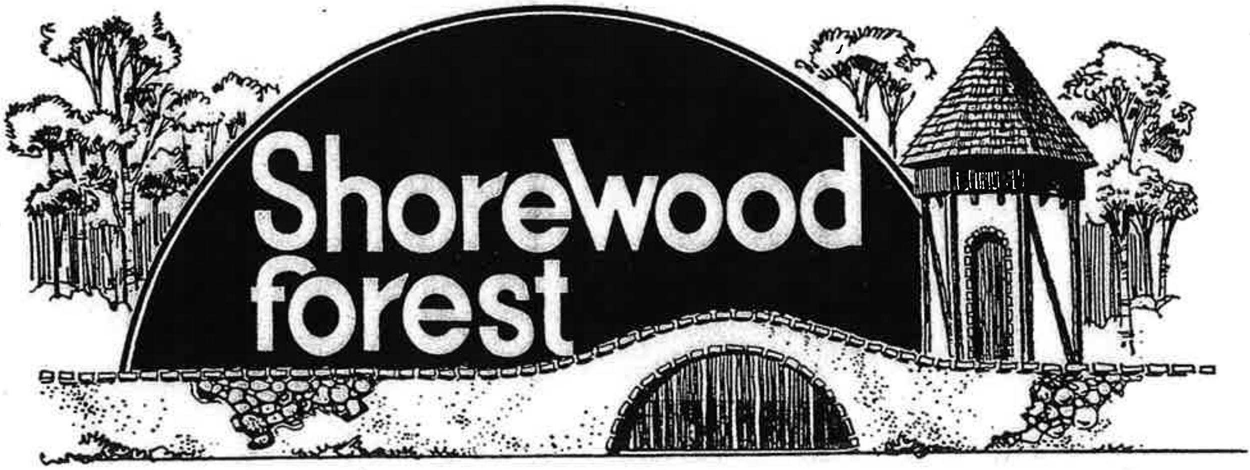
APPENDIX 4

PREVIOUS STUDIES

Shorewood Forest: Lake Louise

A Study for the Improvement, Restoration, and Protection...



Earth·Source Inc

Shorewood Forest:
Lake Louise

A Study for the Improvement, Restoration, and Protection...

Prepared for:

Shorewood Forest
Property Owners Association
Porter County, Indiana

Prepared by:

Earth·Source Inc
349 Airport North Office Park, Fort Wayne, IN 46825 (219) 489-8511

December 1990

TABLE OF ILLUSTRATIONS

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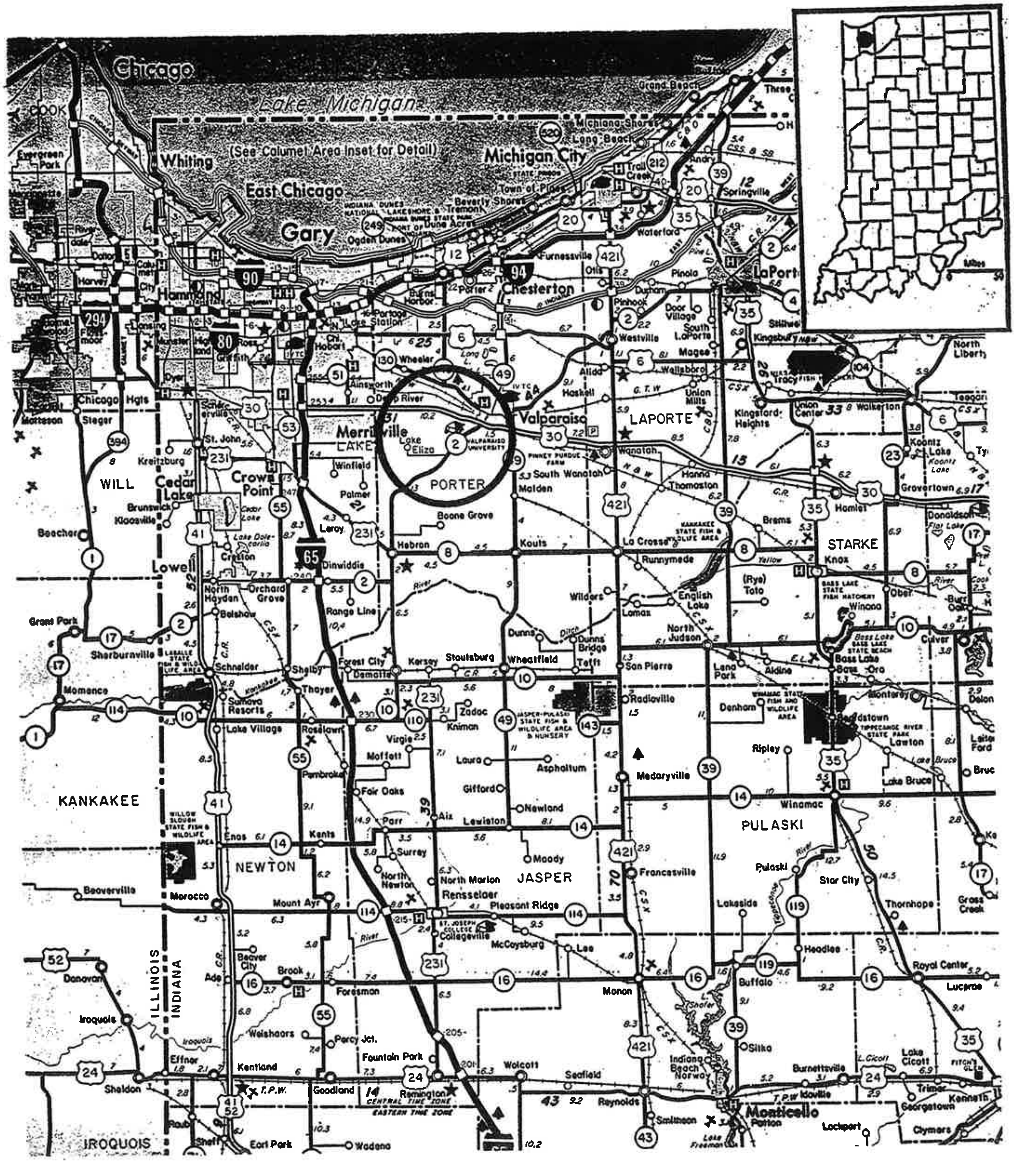
TABLE OF ILLUSTRATIONS



Regional Location Map

Executive Summary

EXECUTIVE SUMMARY

Most of the monitoring stations in Lake Louise displayed good (oligotrophic) to intermediate (mesotrophic) water quality during the current survey of 1990. A few stations, especially those at the northwest corner of the lake, and, near major point source discharges from the watershed show degraded water quality (eutrophic). The current macrophyte chemical control program has nearly completely eliminated all vascular plant species. The dominant vegetation in the lake was the macroalga Nitella and unidentified species of filamentous algae. The destruction of the vegetated littoral zone has in part resulted in a stunted population of bluegills of little recreational value. Water quality conditions are sufficient to support predator fish species for controlling bluegills, and their stocking is recommended. Dredging will be effective at reducing sediment phosphorus concentrations only in the immediate vicinity of watershed discharge inlets. Likewise, drawdown alone will meet with limited success. The best management approach to reduction of in-lake phosphorus cycling is a limited drawdown followed by sediment removal at watershed discharge points.

The principal contributing factor to the eutrophication of Lake Louise has been identified as nutrients and sediments primarily generated from on-site watershed sources, delivered by ditches into the lake. Stream borne sediment has been responsible for pronounced basin infilling of nearshore areas currently most evident in the southeast portion of the lake.

It is suggested that successful lake management will be hindered until watershed sediment and nutrient loading is drastically reduced. For this reason, priority should be given to implementation of the proposed constructed options detailed in the constructed options section of the report; development of the additional recommended constructed options; further study of more effective aquatic weed management; and utilizing the land treatment and erosion control methods detailed in the Erosion and Sediment Control Guidebook and Checklist.

Lake Louise 1.

INTRODUCTION

The present study was initiated because of lake residents' concerns regarding three problems:

1. Macrophyte and algal management problems resulting from eutrophication of the lake associated with increased input of phosphorus and nitrogen from the surrounding watershed.

2. Siltation and lake infilling associated both with delivery of sediments from the watershed as well as shoreline erosion.

3. A poor quality sport fishery dominated by stunted bluegills.

The current report has been separated into three subsections. The first section presents a detailed examination of the current water quality of Lake Louise. Eight tasks constitute the lake section of this report: 1) assessment of current water quality, 2) construction of a bottom map for the lake, 3) survey of aquatic macrophytes, 4) fisheries management, 5) assessment of dredging as a lake management option, 6) assessment of sediments as a nutrient source, 7) sediment contaminants, and 8) assessment of shoreline erosion.

The second section of this report summarizes our watershed investigations and consists of four tasks: 1) watershed identification by sub-watershed, 2) air photo interpretation, 3) computer modelling of the watershed, and 4) inlet monitoring. Management implications derived from our lake and watershed investigations constitute the third section of this report.

LAKE INVESTIGATIONS

TASK 1: CURRENT WATER QUALITY

Methods. Water quality parameters were collected during 1990 on 25 June and 13 August. A total of 27 sampling stations were established throughout Lake Louise (Figure 1). Dissolved oxygen and temperature profiles were determined with a YSI oxygen meter, and light transmission was estimated with a Secchi disc. Water samples for chemical and chlorophyll analyses were taken from composite samples of the water column where a Kemmerer bottle was used to collect water at each meter of the water column. All analyses were performed in certified laboratories according to EPA techniques (EPA-600/14-79-020, Methods for Chemical Analysis of Water and Wastes, Revised March 1983). Data for physical and chemical parameters for Lake Louise during the 1990 survey are presented in Table 1. In addition to presentation of data for individual stations, we have defined nine lake zones within Lake Louise for clearer assessment of intralake variability in individual parameters: Zone I (Stations 1-4), Zone II (Stations 5-7), Zone III (Station 8), Zone IV (Stations 9 and 15), Zone V (Stations 10-14), Zone VI (Stations 16-17), Zone VII (Stations 18-21), Zone VIII (Stations 22-26), and Zone IX (Station 27).

Physical/Chemical Parameters

Temperature. The water columns of northern Indiana lakes greater than approximately five meters deep remain thermally stratified throughout most of the year. As a result of density-temperature relationships, complete mixing of the water column from top to bottom occurs only when water temperature reaches a uniform 4o C, the maximum density of water. This occurs twice a year in temperate lakes (spring and fall) associated with seasonal climatic changes. The length of the mixing period depends on the rapidity of climate change and can vary from a few days to less than a month. Lakes displaying two mixing periods per year are termed dimictic.

During the stratified period, the water column of Indiana lakes is divided into three zones based on temperature-density relationships. The uppermost well-mixed zone is termed the epilimnion and extends from the surface to a depth roughly approximating the lower depth of wave action. The lowermost portion of the water column is the hypolimnion, a zone of density-isolated water that mixes with surface waters only during the short mixing periods. The portion of the water column that is transitional between the epilimnion and hypolimnion is termed the metalimnion. That one meter of the metalimnion displaying the greatest temperature change is called the thermocline.

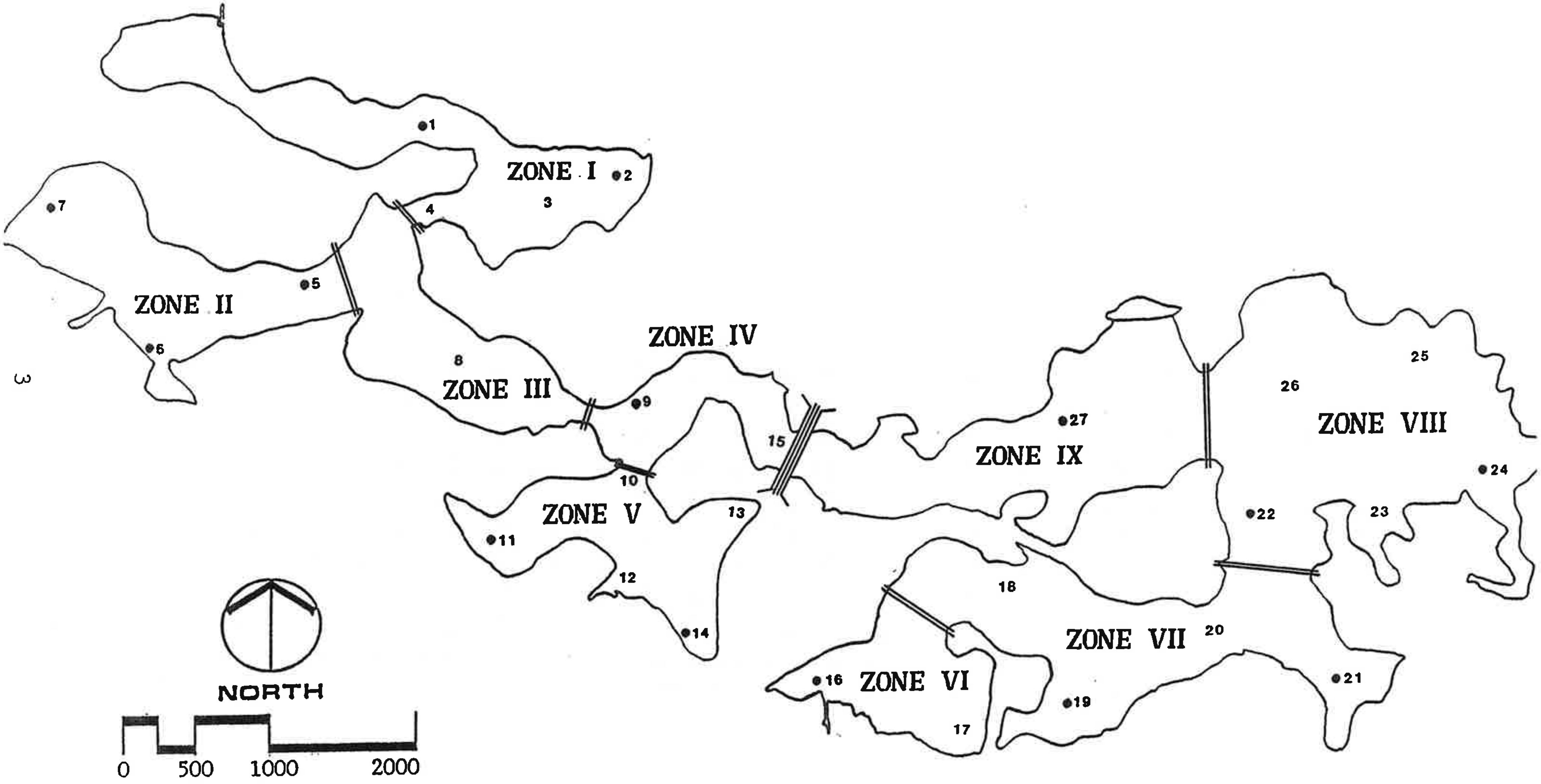


Figure 1. Limnological Sampling Stations on Lake Louise for 1990. Stations also Sampled for Sedimentological Investigations are Indicated with a Black Dot.

Shorewood Forest - Chem-I	Station #	1990	Zone I 1	2	3	4	Zone II 5	6	7	Zone III 8	Zone IV 9	Zone V 10	11	12	13	14	Zone IV 15	Zone VI 16	17	Zone VII 18	19	20	21	Zone VIII 22	23	24	25	26
Secchi	feet	6-25 8-13	0.54 0.32	5.7 0.32	4.1 0.28	5.8 3.8	5.6 5.5	3.11 3.6	5.2 5.3	6.1 6.1	6.5 5.4	7 5.11	4.2 4.3	4.1 3.7	5.8 5	5.2 3.11	8 9.3	0.31 3.4	5.2 6.4	5.4 5.6	4.11 4.1	5.9 5.7	4.3 4.3	8.11	5.3 9.9	4.7 8.3	4.8 10.5	6.11 10.11
Mean Dissolved Oxygen	mg/L	6-25 8-13	7.6 3.3	7.9 3.9	6.7 3.6	6.2 3.6	6.1 3.6	7.4 3.5	7.7 3.8	5.4 3.4	5.6 3.6	5.6 3.3	5.7 3.5	5.7 3.5	6.5 3.8	6.6 4.0	6.5 3.6	7.2 3.3	6.0 3.4	5.7 3.2	5.0 3.4	5.2 3.3	5.4 3.5	4.8 3.6	4.7 3.4	4.6 3.6	4.3 3.6	4.8 3.7
Ammonia	mg/L	6-25 8-13	0.18 0.29	0.4 0.18	0.43 0.21	0.29 0.19	0.23 0.2	0.22 0.17	0.98 0.15	0.22 0.16	0.15 0.17	0.51 0.11	0.57 0.1	0.37 0.11	0.38 0.1	0.32 0.12	0.24 0.15	0.32 0.15	0.28 0.14	0.2 0.16	0.23 0.16	0.22 0.07	0.27 0.12	0.18 0.1	0.31 0.14	0.33 0.09	0.18 0.12	0.17 0.11
Total Kjeldahl N	mg/L	6-25 8-13	2.1 6	2.1 3.75	5.1 1.67	1.7 1.67	1.28 2.08	0.43 1.67	0.85 1.25	1.28 0.83	0.4 1.67	6.8 1.25	6.4 1.67	4.2 2.08	4.7 2.5	5.9 2.92	1.7 2.08	3.39 0.83	3.81 1.67	5.5 1.67	1.69 1.25	3.38 2.5	1.69 1.67	5.9 4.17	3.39 2.08	4.29 1.67	2.1 1.67	2.5 1.25
Nitrate	mg/L	6-25 8-13	0 1.34	1.84 1.78	0.92 1.33	0.92 1.78	0.45 1.34	0 1.78	0.91 1.33	0.91 2.67	0.45 3.99	0.91 2.21	0 1.77	0.45 1.77	1.36 1.78	2.71 1.78	0 1.78	0 1.33	0.9 3.56	0.45 3.55	0.47 3.11	0 2.67	0.91 2.22	0 2.22	0.91 2.67	0.45 2.22	0.45 3.11	0.45 3.57
Nitrite-Nitrate	mg/L	6-25 8-13	0.007 0.01	0.004 0	0.007 0.01	0.003 0.003	0.003 0.007	0.003 0	0.003 0.007	0.003 0.007	0.003 0.003	0.003 0	0.007 0	0.007 0.003	0.02 0	0.02 0.01	0.007 0.003	0.01 0.003	0 0.007	0.054 0.007	0.07 0.01	0.003 0	0.003 0.01	0.017 0.003	0.003 0	0.007 0.001	0.007 0.003	0.003 0.01
Total Phosphorus	mg/L	6-25 8-13	1.7 1.06	1.3 0.42	1.68 0.33	0.53 0.47	0.65 0.49	0.44 0.43	0.37 0.44	0.14 1.32	0.44 0.77	0.51 2.46	0.24 0.99	0.62 0.24	0.56 0.3	0.62 0.29	0.59 0.21	0.84 0.19	0.54 0.17	0.47 0.22	1.66 0.22	0.85 0.13	4.13 0.2	0.48 0.13	0.81 0.16	0.94 0.34	0.38 0.14	0.64 0.16
Ortho Phosphorus	mg/L	6-25 8-13	0.54 0.01	1.66 0	0.67 0.01	0.04 0.01	0.04 0	0.04 0.01	0.03 0	0.03 0.01	0.03 0.01	0.01 0	0.02 0	0.02 0	0.06 0.01	0.02 0.02	0.06 0	0.06 0	0.04 0	0.02 0	0.77 0.01	0.01 0.01	3.39 0	0.03 0	0.16 0.01	0.02 0.01	0.02 0.02	0.03 0
Conductivity	umho/cm	6-25 8-13	320 324	330 341	340 339	300 325	330 332	330 318	340 330	330 322	350 328	340 335	340 340	360 335	350 336	350 335	350 342	350 354	340 356	310 344	340 358	310 343	340 345	340 347	320 337	340 334	300 340	340 344
TSS	mg/L	6-25 8-13	14 4	2 4	3 6	7 8	4 3	8 5	7 3	8 7	1 2	5 4	8 3	9 14	7 4	7 20	14 5	3 4	7 11	3 3	5 3	8 3	8 1	4 1	5 1	4 2	3 1	4 1
Alkalinity	mg/L	6-25 8-13	118	126	144	165	125	120	115	121	118	121	120	122	114	118	128	126	124	125	126	122	123	126	125	123	123	126
Chlorophyll	mg/m3	6-25 8-13	7.7	5.8	0.1	4.2	2.2	1.6	0.7	1.4	4.8	1.2	1.1	3.9	1.5	1.5	1.6	1.5	1.5	1.1	1.3	1.6	1.4	1.4	1	0.4	1.2	0.8

Table 1. Limnological Parameters Collected for 27 Stations of Lake Louise on 25 June and 13 August 1990.

With the exception of the two deepest stations, stations 26 and 27, Lake Louise lacked thermal stratification at all stations during both June and August 1990 (Figure 2). Stations 26 and 27 displayed only weak stratification beginning at a depth of 6 meters, and likely results from pronounced vertical mixing of the water column from motor boats.

Dissolved Oxygen. Midsummer oxygen values in the lower portion of the water column of lakes is governed by the degree of thermal stratification and the overall trophic state of the lake. The higher the trophic state (eutrophication) the greater the amount of organic matter falling to the bottom of the lake to decompose. If the lake is deep enough to stratify, oxygen is not replenished in the bottom layers readily and is consumed during the decomposition process. Thus, the higher the trophic state, the greater the likelihood that the lake becomes anoxic in the bottom of the water column (hypolimnion).

Dissolved oxygen remained relatively constant throughout the water column of individual stations during both June and August (Figure 3). Water column values were consistently lower throughout the water column during August than during June.

Mean oxygen values for the water column on both dates of 1990 are presented for both individual stations (Figure 4) and zones (Figure 5). Although considerable inter station variability was noted during June, this essentially disappeared by August as values at all stations decreased to less than 5 mg/L suggesting eutrophic conditions (Figure 5). Mean values for 1990 were greatest for Zone I and II at the western end of the lake and were lowest for Zones VIII and IX, the largest and deepest areas of the lake nearest the dam.

Secchi Disc Transparency. The depth that a Secchi disc can no longer be seen in a water column is indicative of both the amount of algae and inorganic sediment suspended in the water column to block light transmission. Thus, the shallower the Secchi depth during summer, the more productive (eutrophic) a lake is presumed to be. Water clarity during June 1990 was lowest at stations 1 and 16, immediately in front of stream inputs at the northwest and southeast corners of the lake, respectively (Figure 6). Conversely, clarity was best during June for stations of the two basins immediately west of the bridge (Zones 3 and 5) as well as immediately in front of the dam (Figure 7).

During August, stations 1-3 at the northwest corner of the lake were markedly less transparent than the rest of the lake, while those in the largest and deepest basins were clearer than a majority of the lake (Figures 6 and 7). Land clearance for the newest phase of Shorewood Forest north of

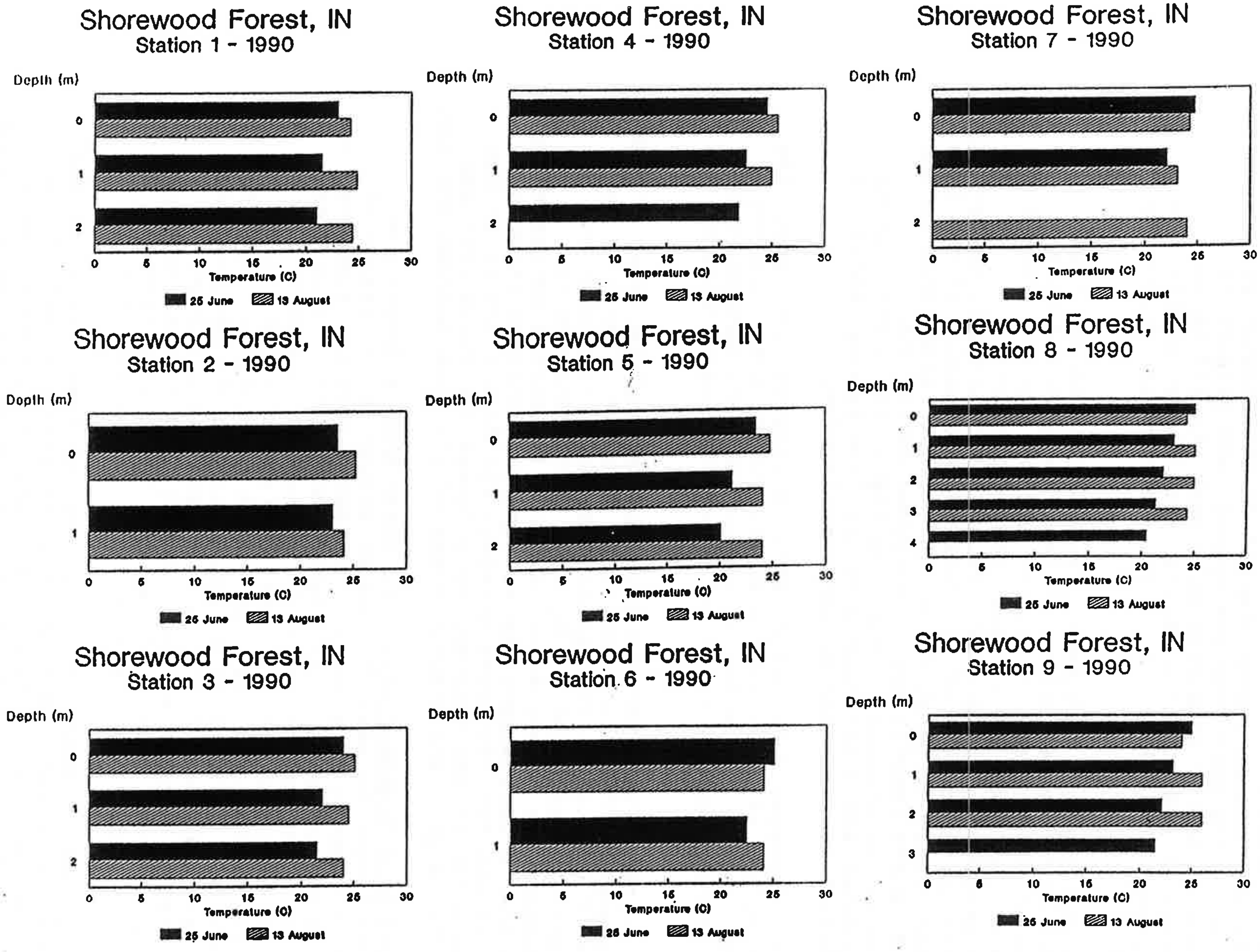
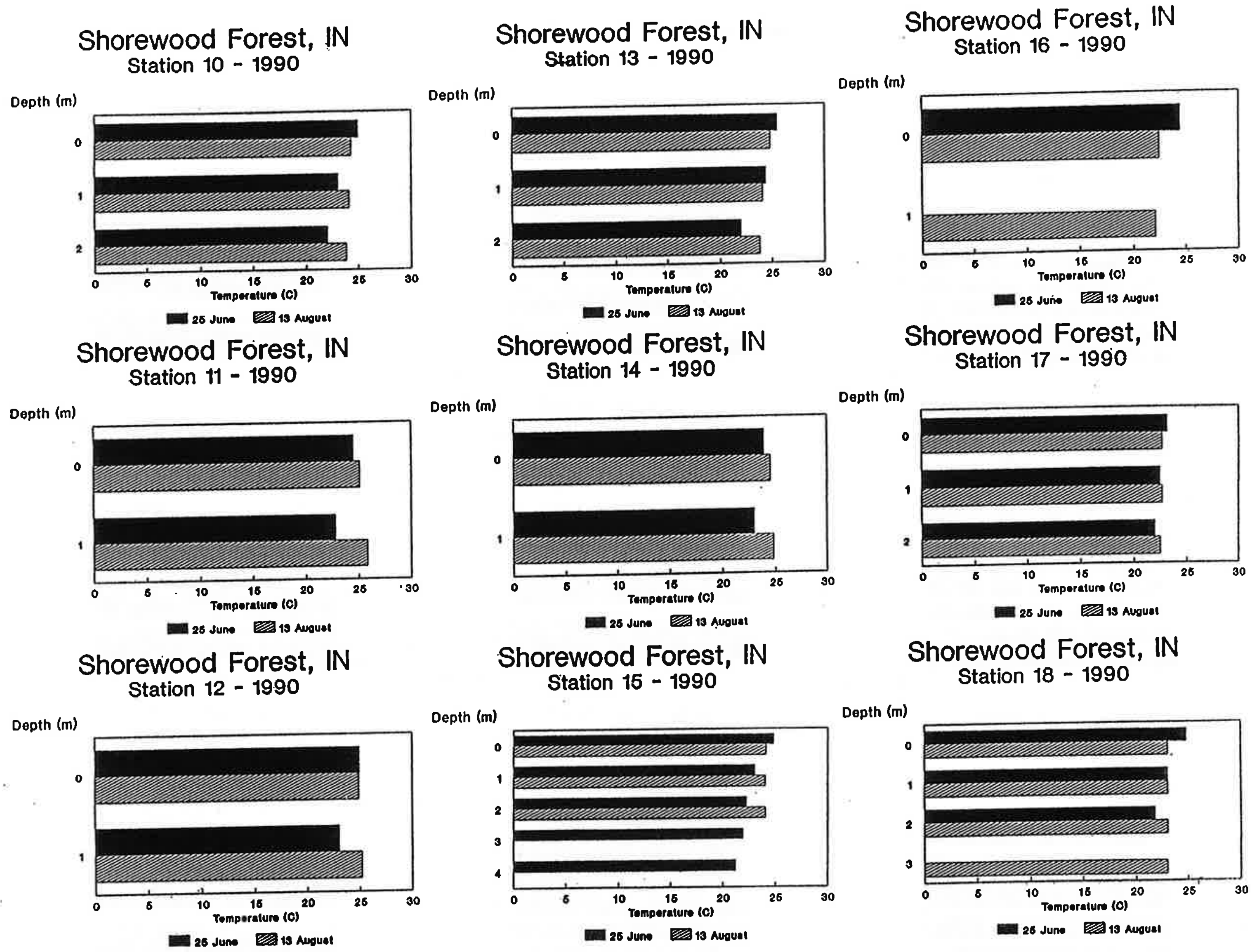


Figure 2. Temperature Profiles for Individual Stations for 25 June and 13 August 1990.



Shorewood Forest, IN
Station 10 - 1990

Shorewood Forest, IN
Station 13 - 1990

Shorewood Forest, IN
Station 16 - 1990

Shorewood Forest, IN
Station 11 - 1990

Shorewood Forest, IN
Station 14 - 1990

Shorewood Forest, IN
Station 17 - 1990

Shorewood Forest, IN
Station 12 - 1990

Shorewood Forest, IN
Station 15 - 1990

Shorewood Forest, IN
Station 18 - 1990

Figure 2. Continued

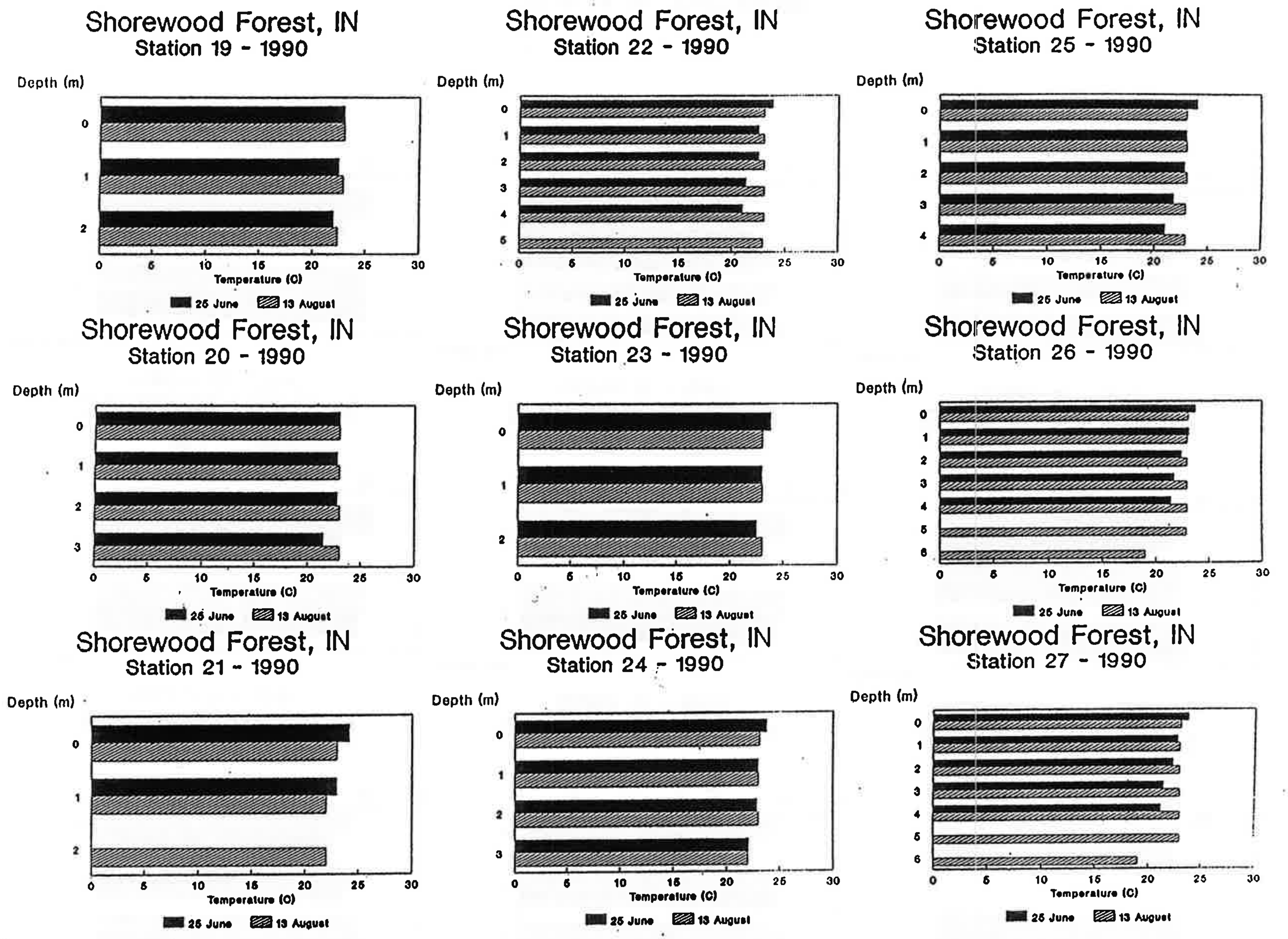


Figure 2. Continued

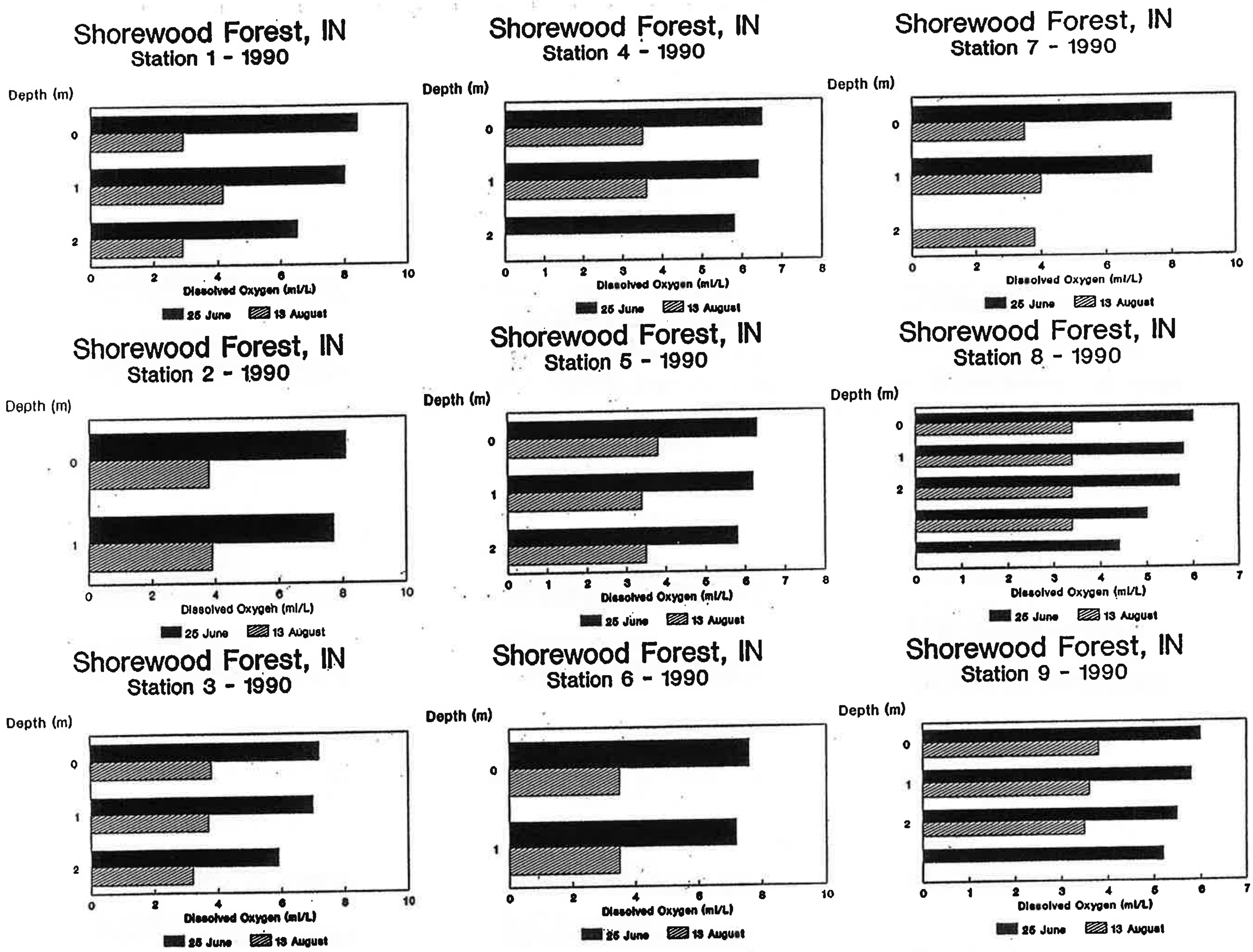
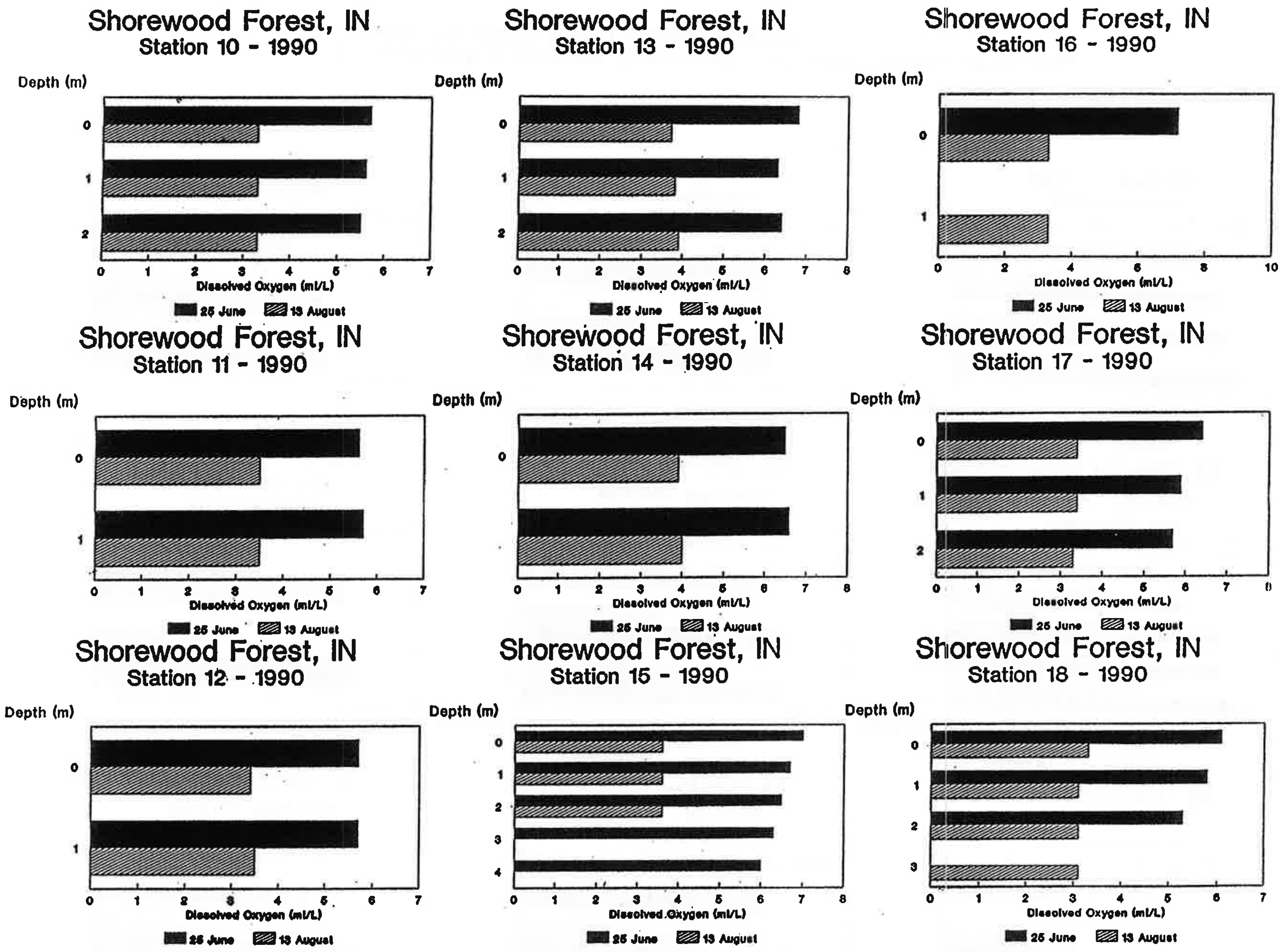


Figure 3. Dissolved Oxygen Profiles for Individual Stations for 25 June and 13 August 1990.



Shorewood Forest, IN
Station 10 - 1990

Shorewood Forest, IN
Station 13 - 1990

Shorewood Forest, IN
Station 16 - 1990

Shorewood Forest, IN
Station 11 - 1990

Shorewood Forest, IN
Station 14 - 1990

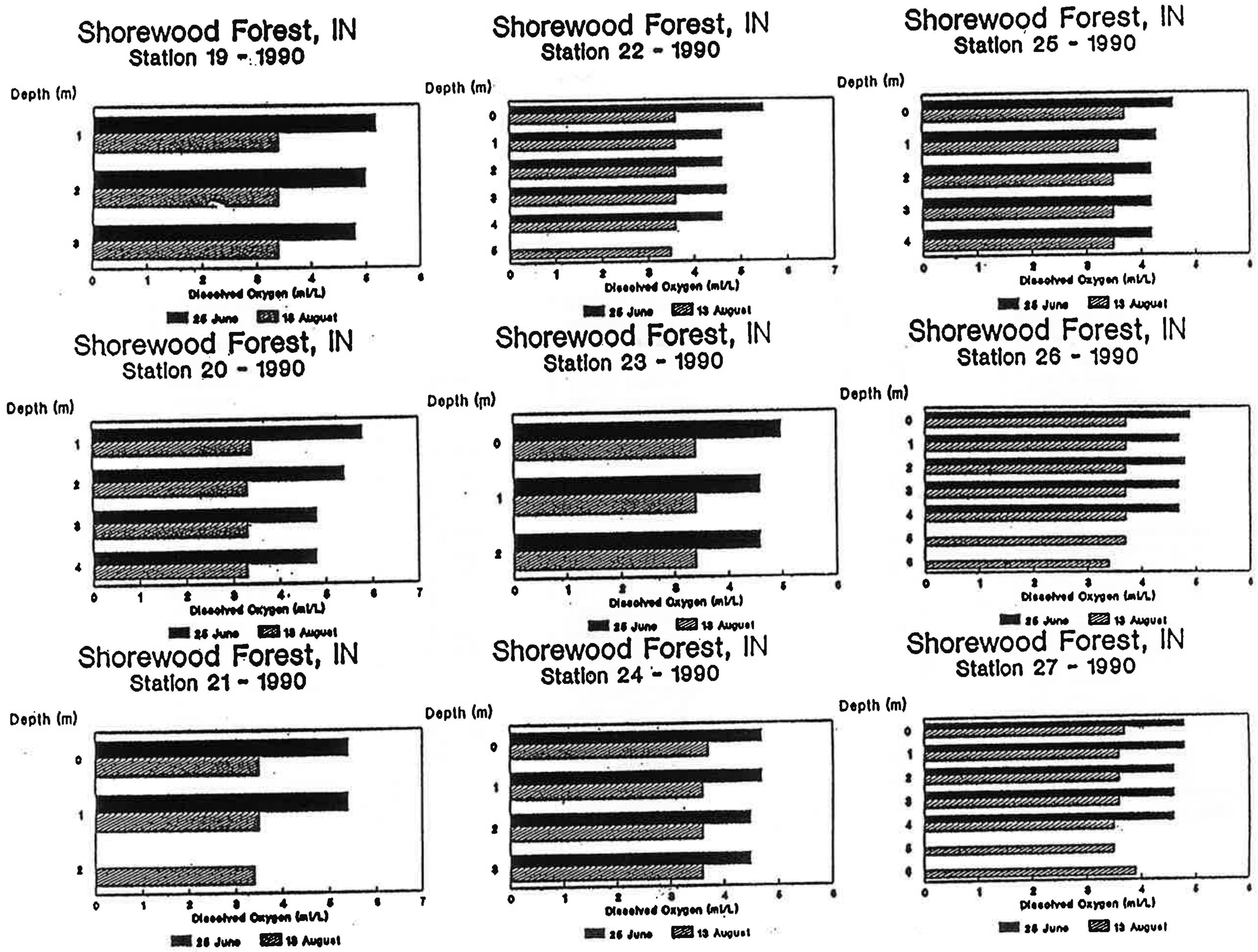
Shorewood Forest, IN
Station 17 - 1990

Shorewood Forest, IN
Station 12 - 1990

Shorewood Forest, IN
Station 15 - 1990

Shorewood Forest, IN
Station 18 - 1990

Figure 3. Continued



Shorewood Forest, IN
Station 19 - 1990

Shorewood Forest, IN
Station 22 - 1990

Shorewood Forest, IN
Station 25 - 1990

Shorewood Forest, IN
Station 20 - 1990

Shorewood Forest, IN
Station 23 - 1990

Shorewood Forest, IN
Station 26 - 1990

Shorewood Forest, IN
Station 21 - 1990

Shorewood Forest, IN
Station 24 - 1990

Shorewood Forest, IN
Station 27 - 1990

Figure 3. Continued

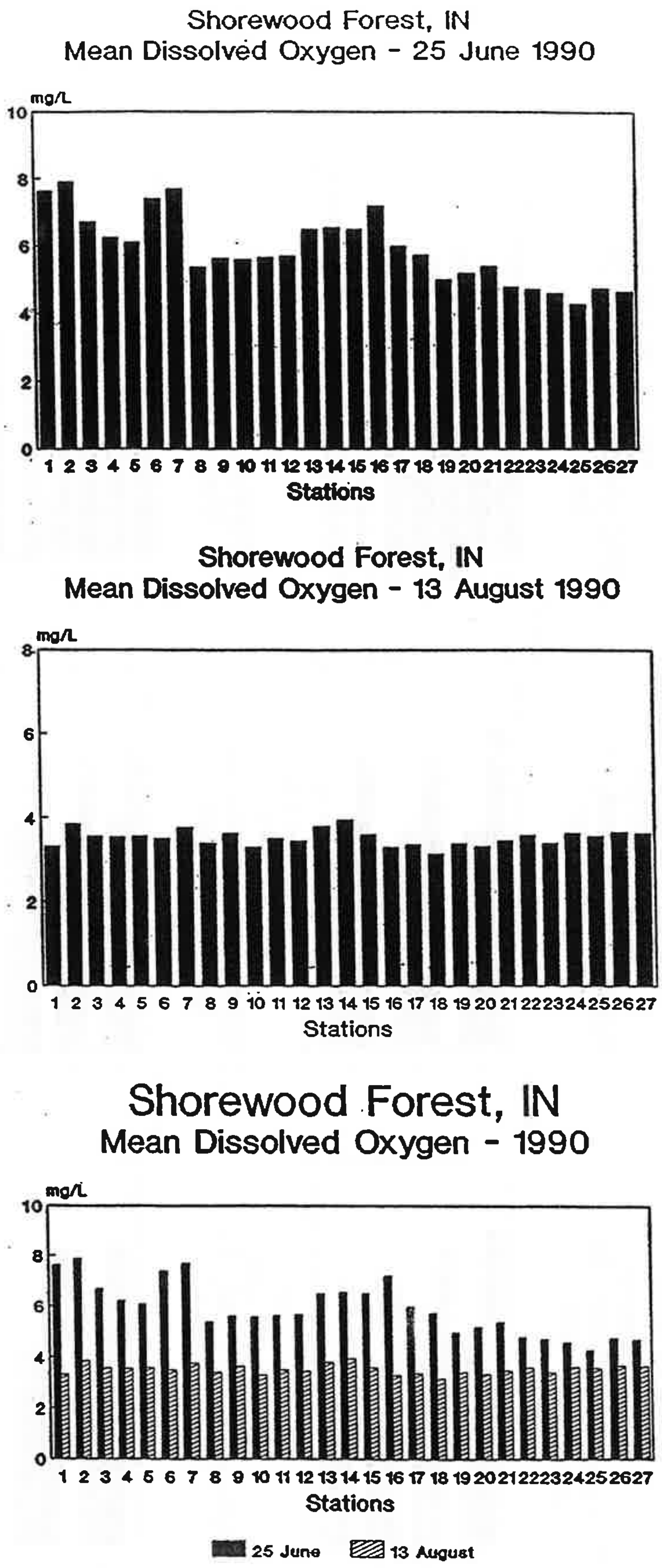
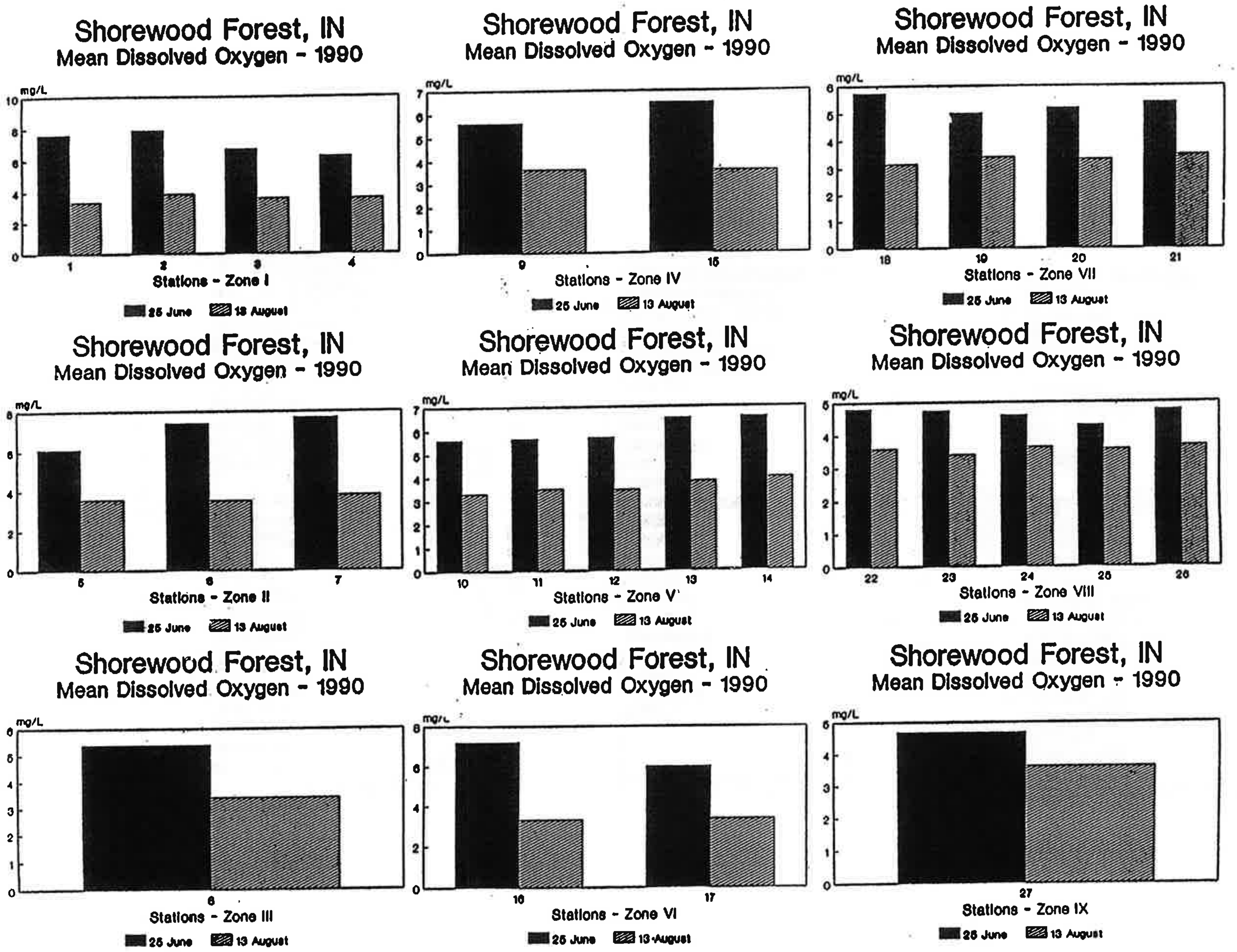


Figure 4. Mean Dissolved Oxygen Concentrations for Individual Stations for 25 June and 13 August 1990.



Shorewood Forest, IN
Mean Dissolved Oxygen - 1990

Shorewood Forest, IN
Mean Dissolved Oxygen - 1990

Shorewood Forest, IN
Mean Dissolved Oxygen - 1990

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Mean Dissolved Oxygen - 1990

Shorewood Forest, IN
Mean Dissolved Oxygen - 1990

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Mean Dissolved Oxygen - 1990

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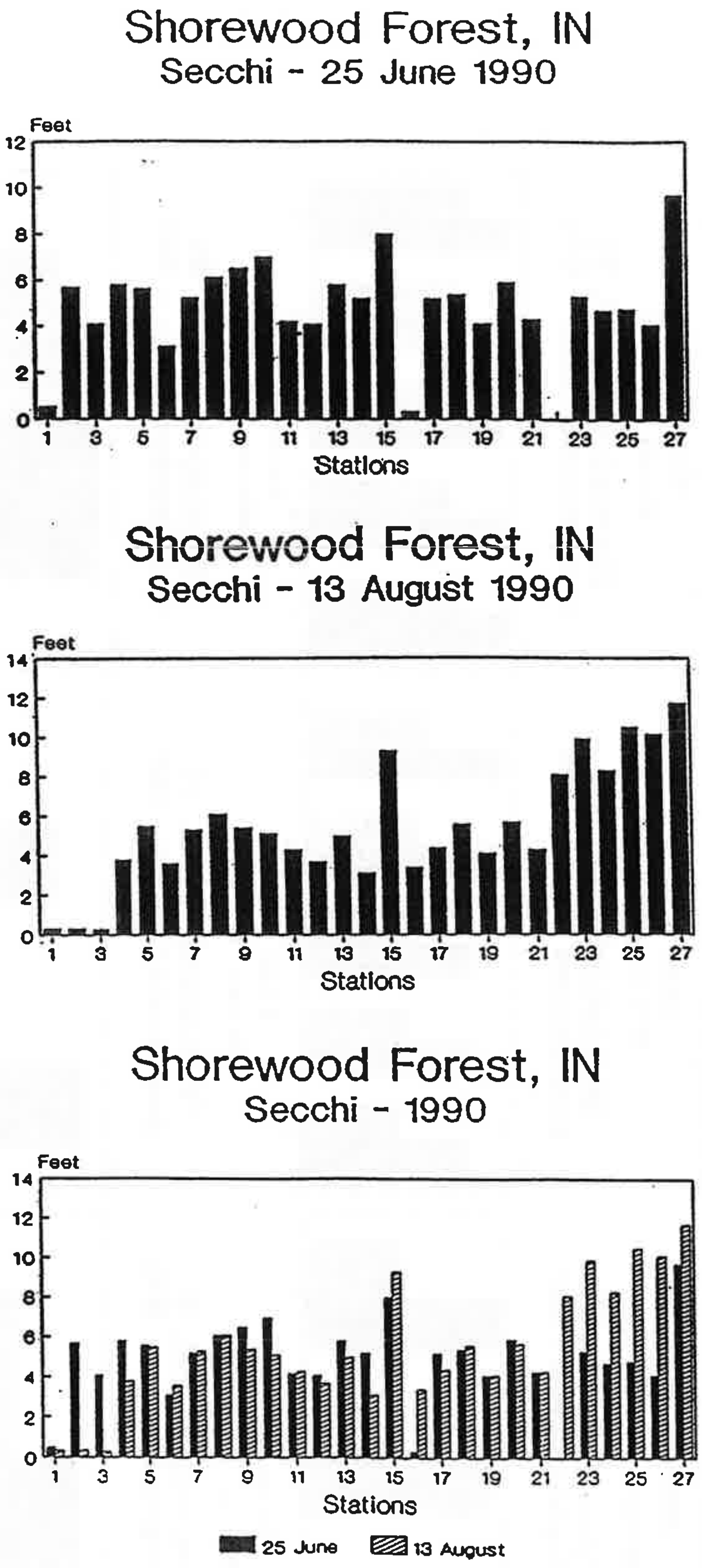
Mean Dissolved Oxygen - 1990

Shorewood Forest, IN
Mean Dissolved Oxygen - 1990

Shorewood Forest, IN
Mean Dissolved Oxygen - 1990

Figure 5. Mean Dissolved Oxygen Concentrations for Individual Zones for 25 June and 13 August 1990.


Shorewood Forest, IN
Secchi - 25 June 1990

Shorewood Forest, IN
Secchi - 13 August 1990

Shorewood Forest, IN
Secchi - 1990

Figure 6. Secchi Disc Transparency for Individual Stations for 25 June and 13 August 1990.

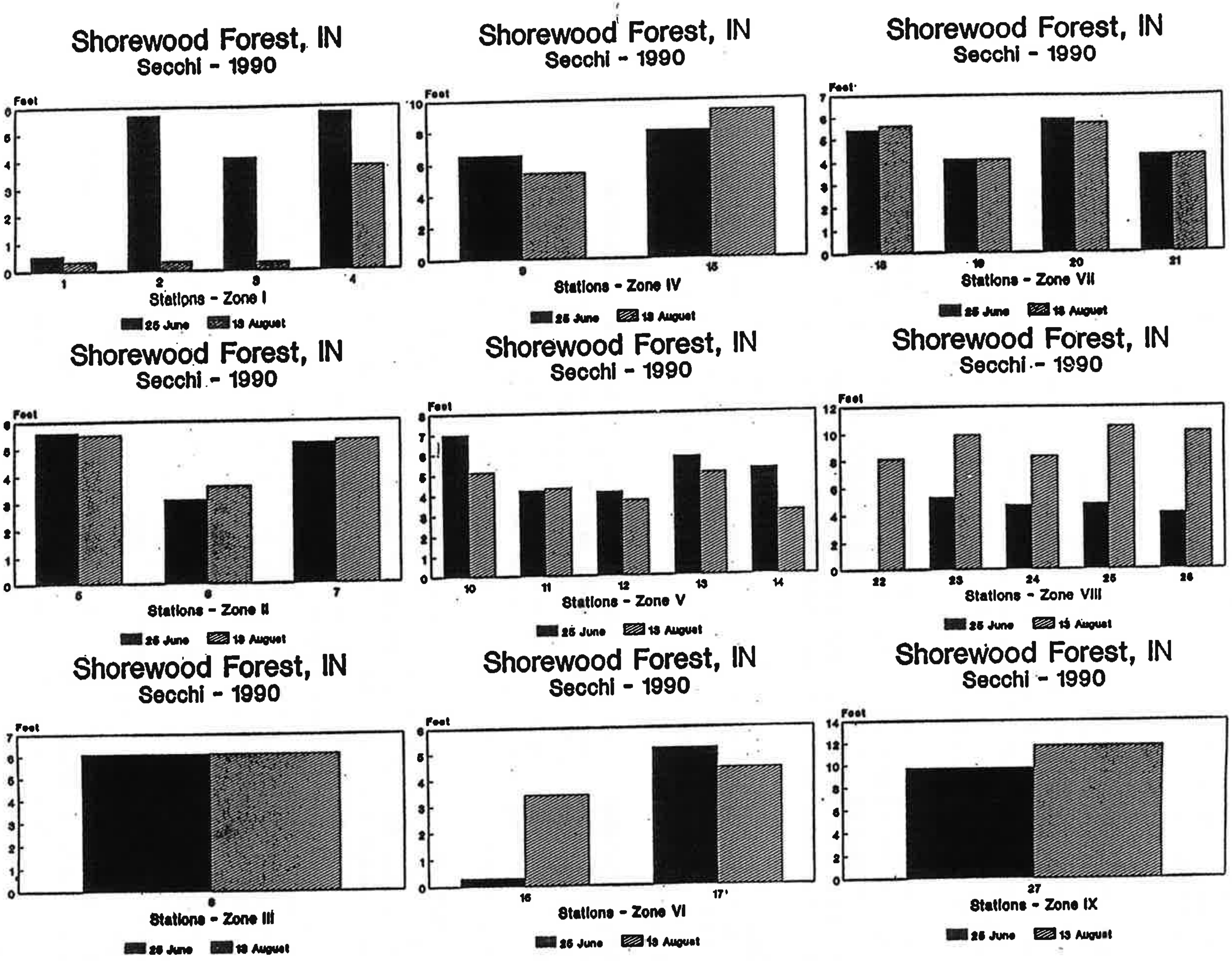


Figure 7. Secchi Disc Transparency for Individual Zones for 25 June and 13 August 1990.

the northwest corner of Lake Louise was clearly contributing substantial loading of silt to the lake during August and thus was responsible for the extremely low Secchi values for this portion of the lake.

Ammonia. Ammonia values for Lake Louise during June 1990 were consistently greater than reported for individual stations and zones during August (Figures 8 and 9). During both months, values tended to decrease throughout the lake from the northwest and southeast corners toward the dam reflecting point source inputs to the lake associated with streams at these locations.

Nitrite. Nitrite values during June were greatest for stations 18-19 (Zone VII) followed by stations 13 and 14 (Zone V) (Figures 10 and 11). The extent of inter station variability was markedly greater during August with values at most stations being lower than reported during June.

Nitrate. As noted for nitrite, nitrate values during June were greatest at station 14 of Zone V (Figures 12 and 13). Inter station variability was greater during August and values were greater at all but two stations than reported during June.

Kjeldahl Nitrogen. Values for the final nitrogen parameter, Kjeldahl nitrogen, were greatest during June in Zone V (stations 10-14) followed by Zones VI and VIII (Figures 14 and 15). During August, the maximum value was found at station 1 at the northwest corner of the lake associated with elevated input of silt from land clearance activities.

Total Phosphorus. Total phosphorus concentrations were greatest during June at station 21 of Zone VII, a small embayment bordering Devon Road (Figure 16-17). The second highest phosphorus values during June were for stations of Zone I at the northwest corner of Lake Louise. The rank ordering shifted during August with stations of Zones 3-5 displaying greatest values followed by Zone I. With the exception of stations of Zones 3-5, values reported for June were greater than those of August.

Ortho Phosphorus. As noted for total phosphorus, ortho phosphorus concentrations were greater in June than August (Figures 18 and 19). Maximum values during June were found at station 21 (Zone VII). Three of the four stations constituting Zone I at the northwest corner of the lake were conspicuously higher than the remainder of the lake, a fact that likely reflects watershed erosion and stream delivery of nutrients to the lake at this point. Inter station variability was markedly reduced by August with elevated values found only at stations 14 and 25.

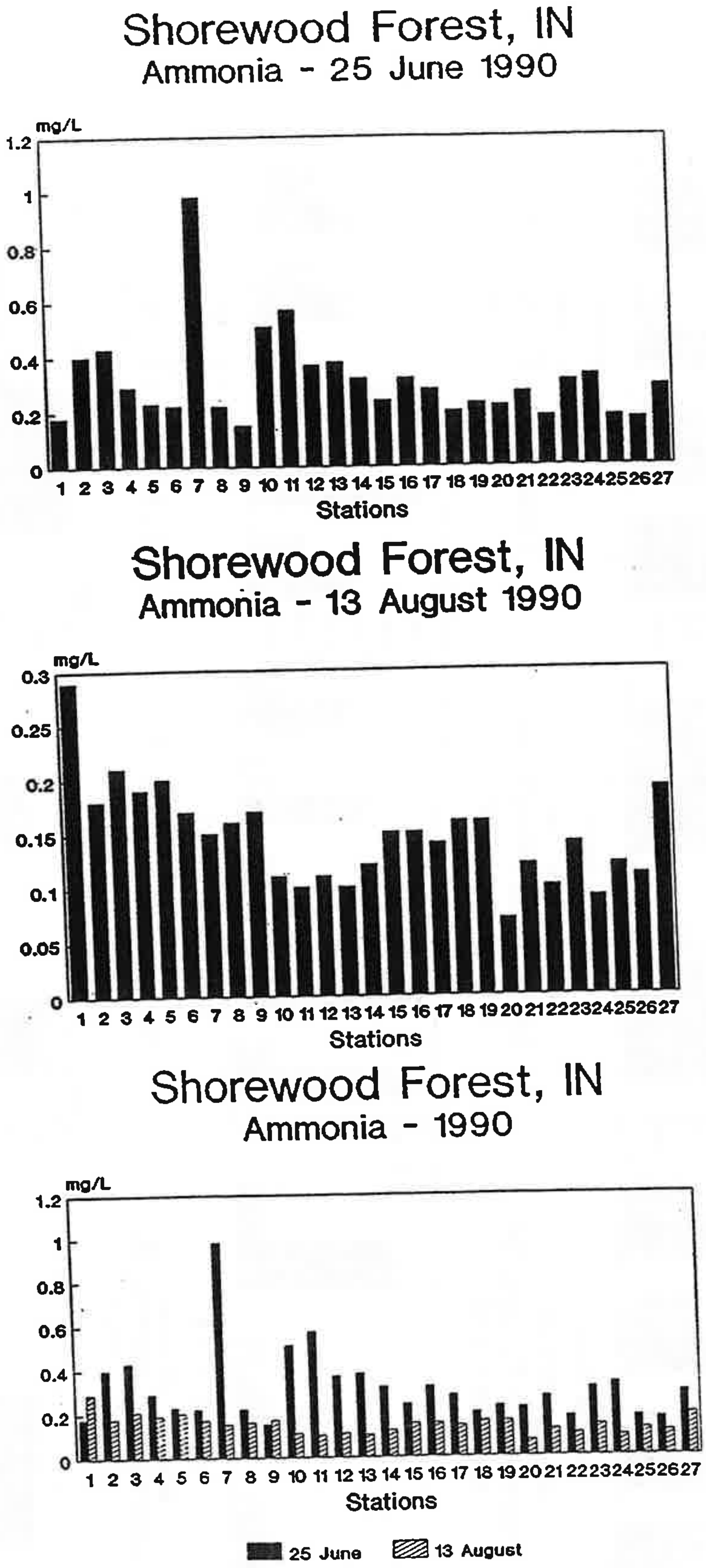


Figure 8. Ammonia Concentrations for Individual Stations for 25 June and 13 August 1990.

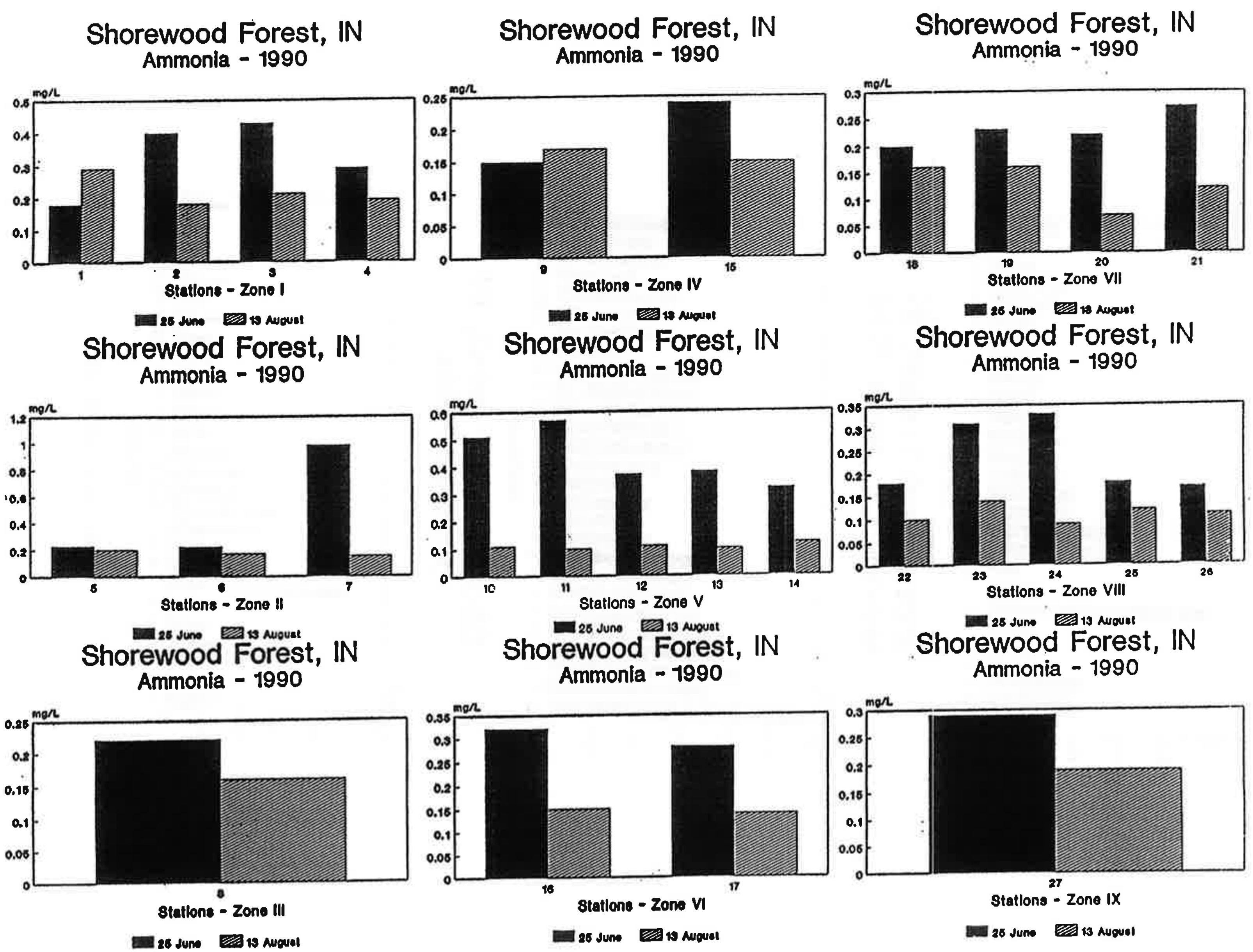


Figure 9. Ammonia Concentrations for Individual Zones for 25 June and 13 August 1990.

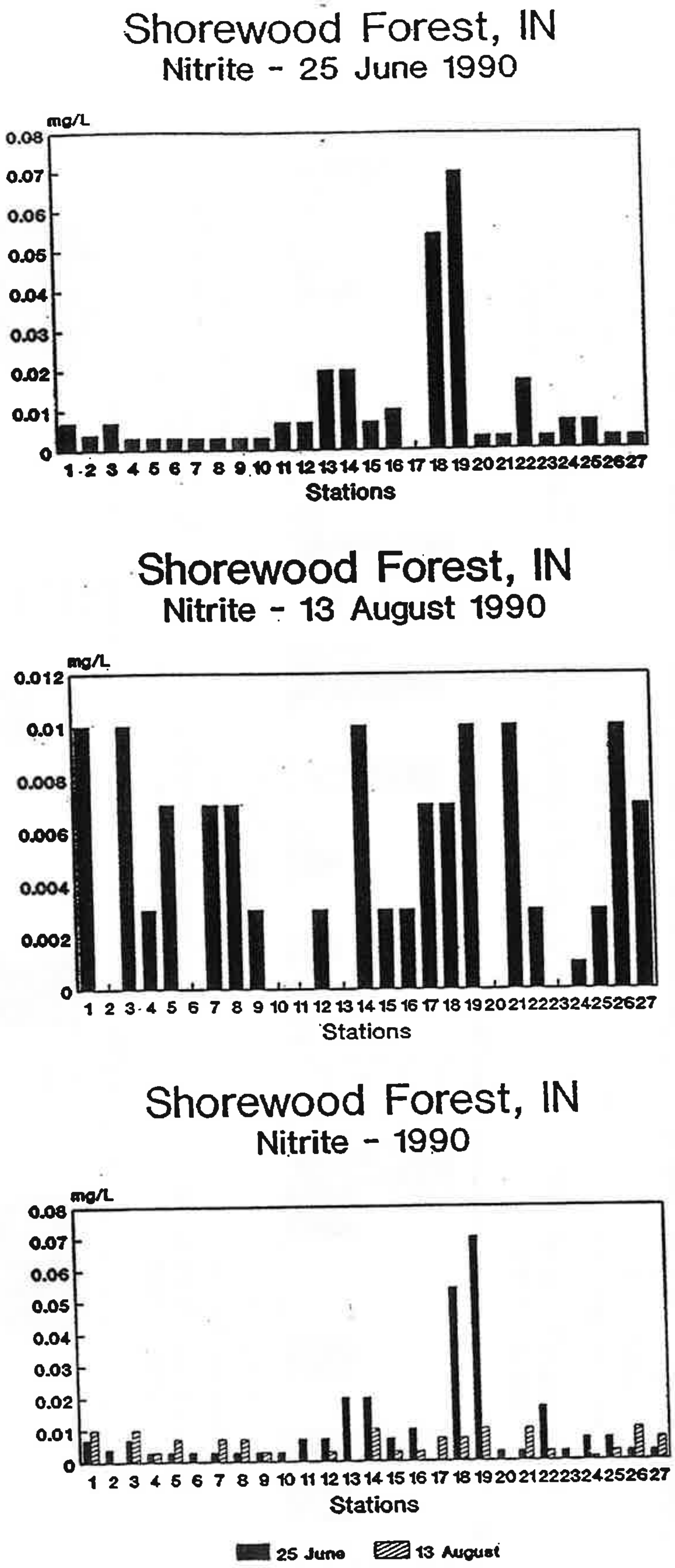


Figure 10. Nitrite Concentrations for Individual Stations for 25 June and 13 August 1990.

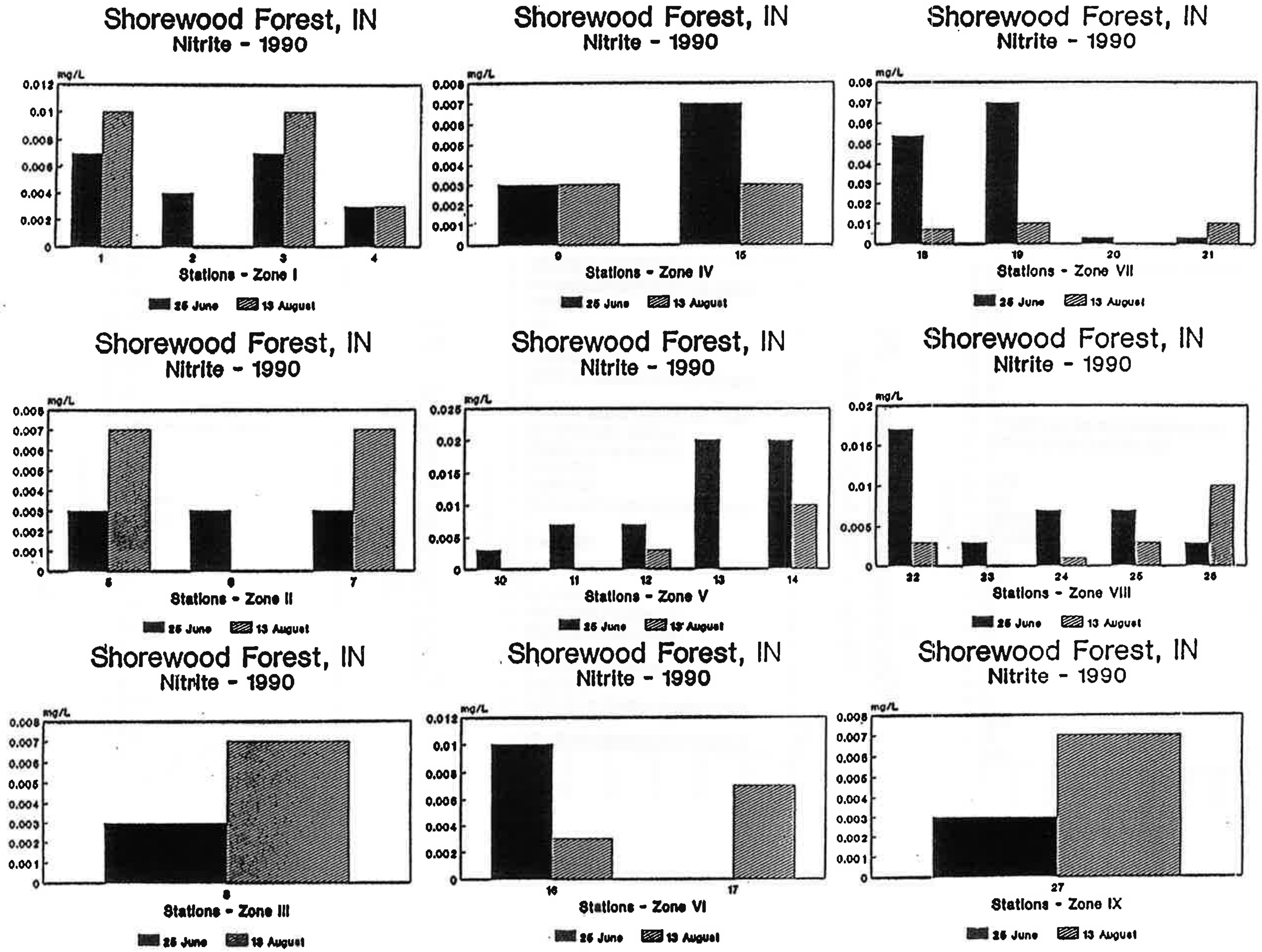


Figure 11. Nitrite Concentrations for Individual Zones for 25 June and 13 August 1990.

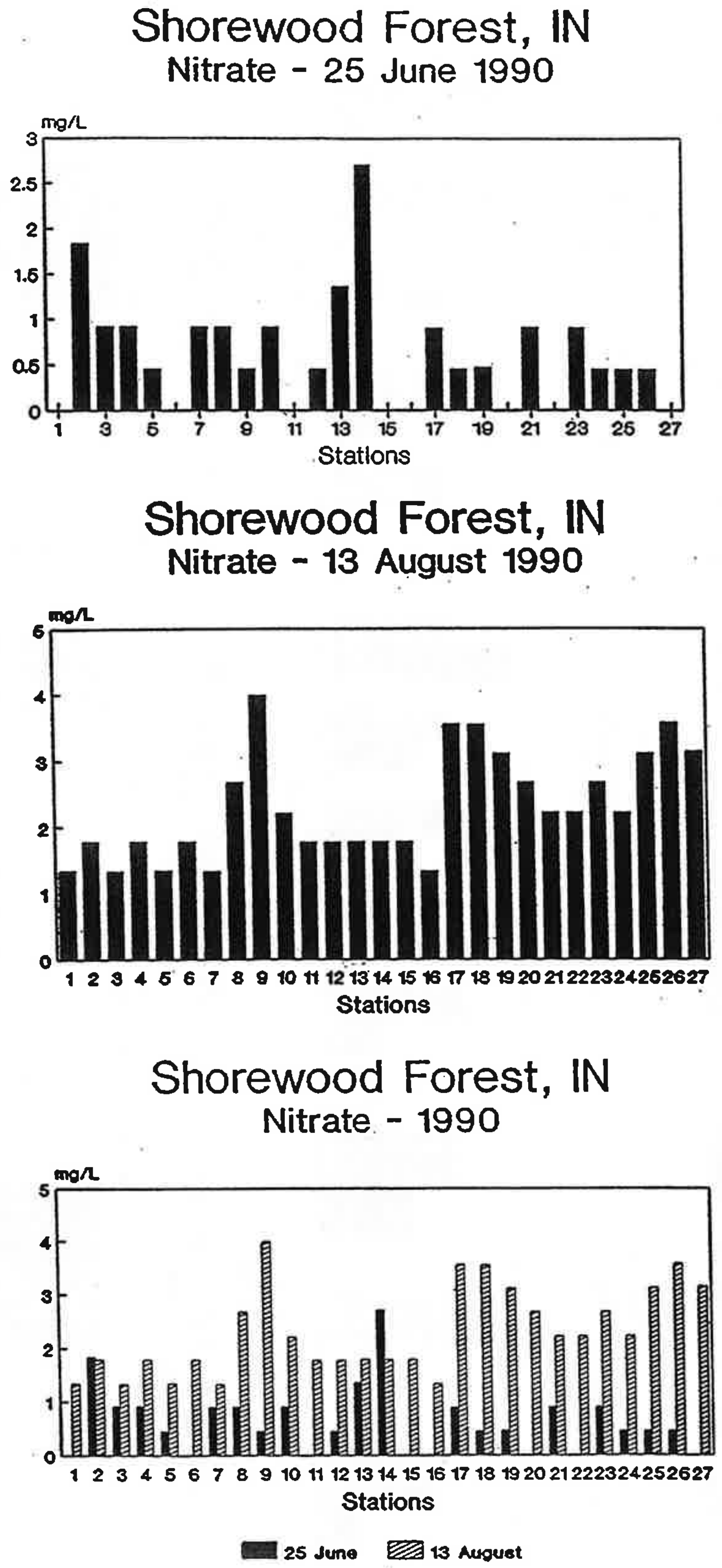
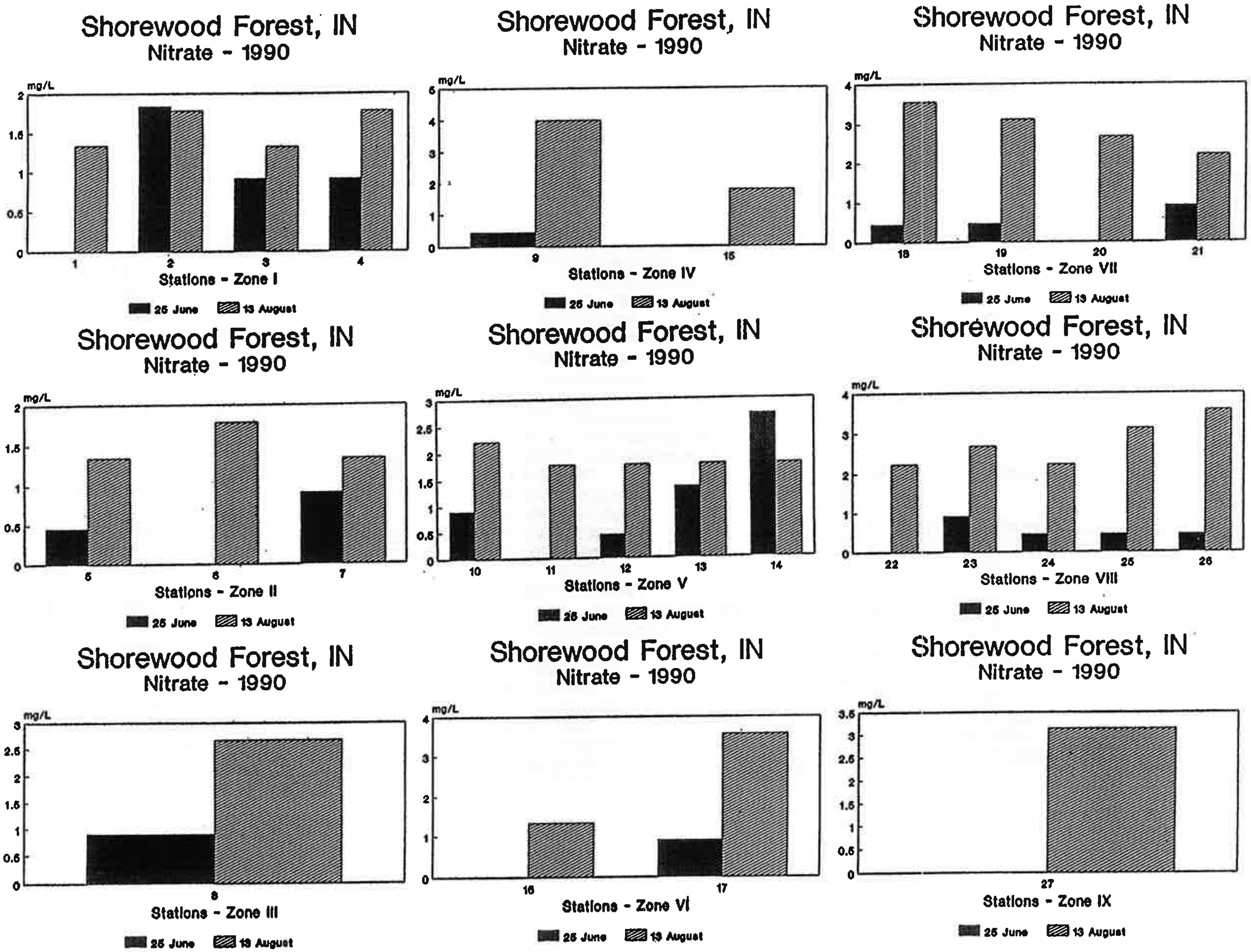


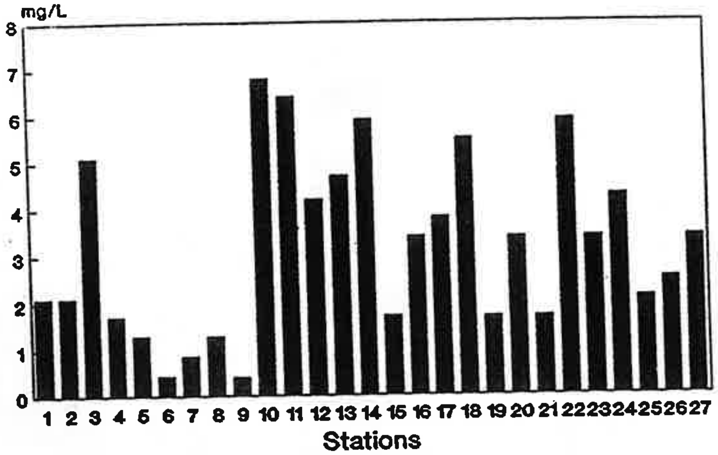
Figure 12. Nitrate Concentrations for Individual Stations for 25 June and 13 August 1990.



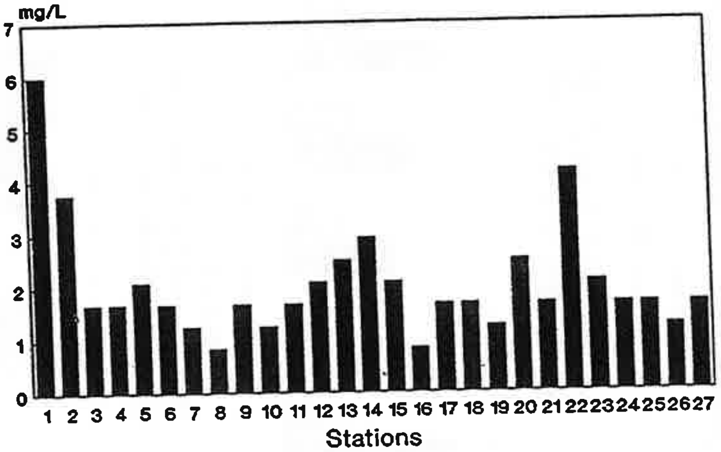
Shorewood Forest, IN
Nitrate - 1990

Figure 13. Nitrate Concentrations for Individual Zones for 25 June and 13 August 1990.

Shorewood Forest, IN
Total Kjeldahl N - 25 June 1990



Shorewood Forest, IN
Total Kjeldahl N - 13 August 1990



Shorewood Forest, IN
Total Kjeldahl N - 1990

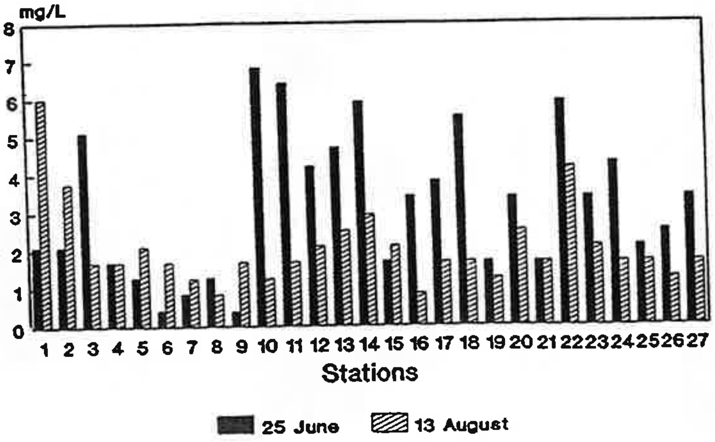


Figure 14. Total Kjeldahl Nitrogen Concentrations for Individual Stations for 25 June and 13 August 1990.

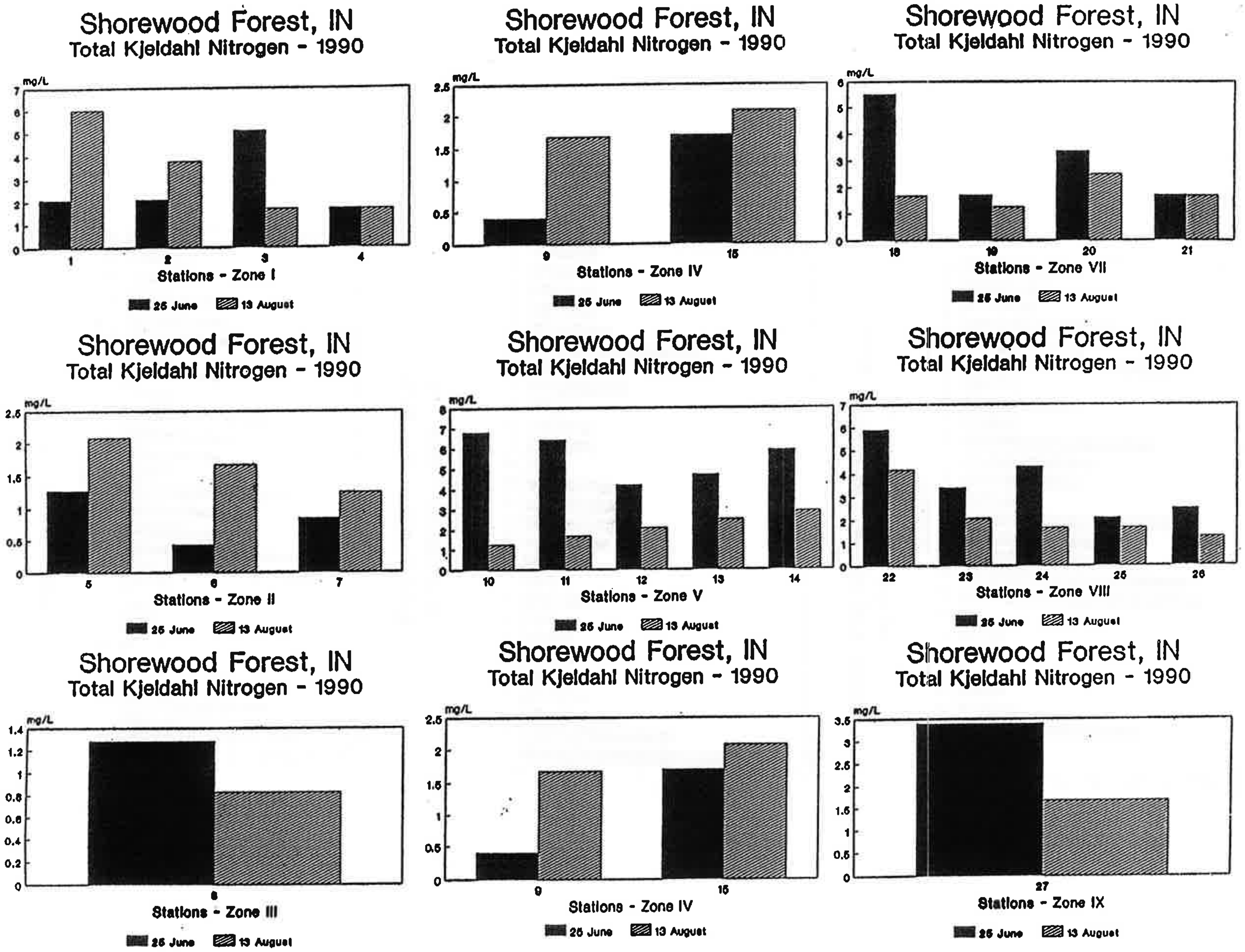


Figure 15. Total Kjeldahl Nitrogen Concentrations for Individual Zones for 25 June and 13 August 1990.

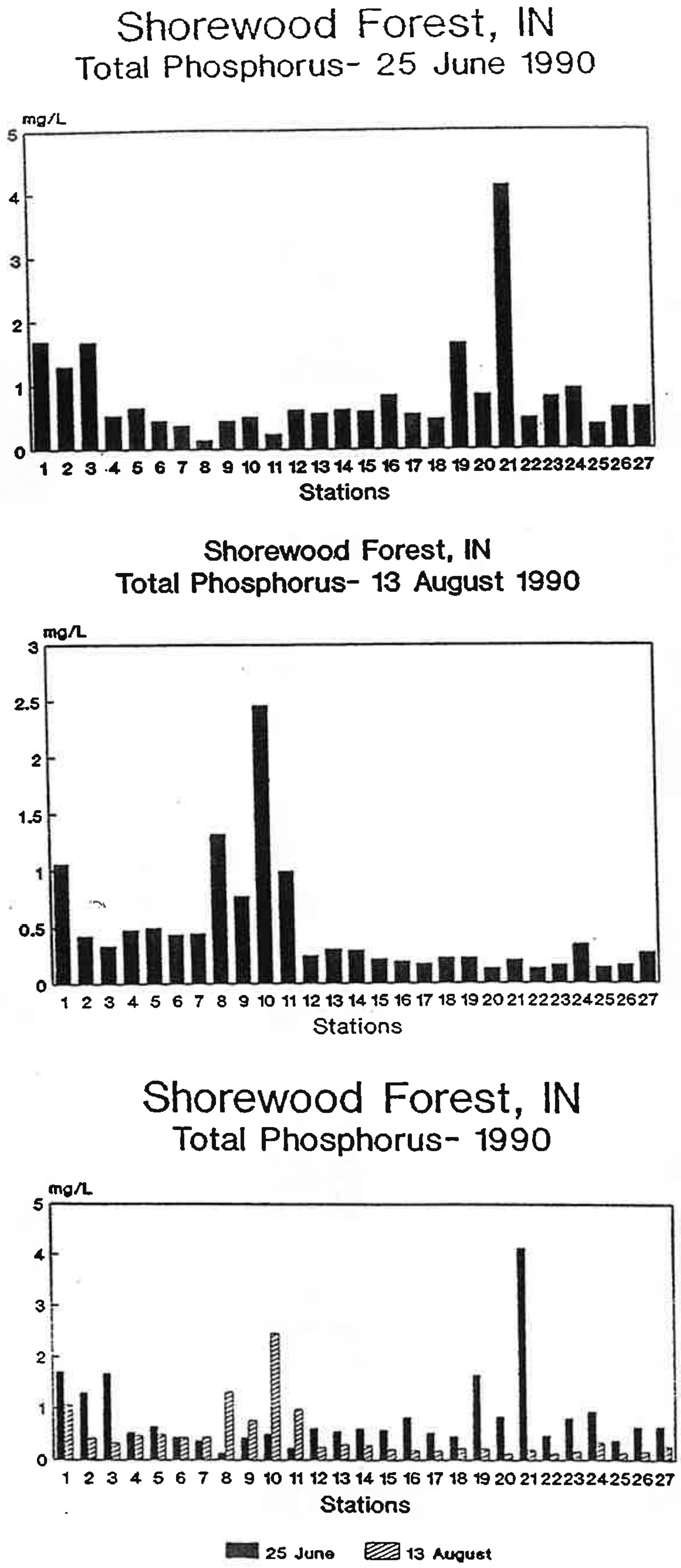


Figure 16. Total Phosphorus Concentrations for Individual Stations for 25 June and 13 August 1990.

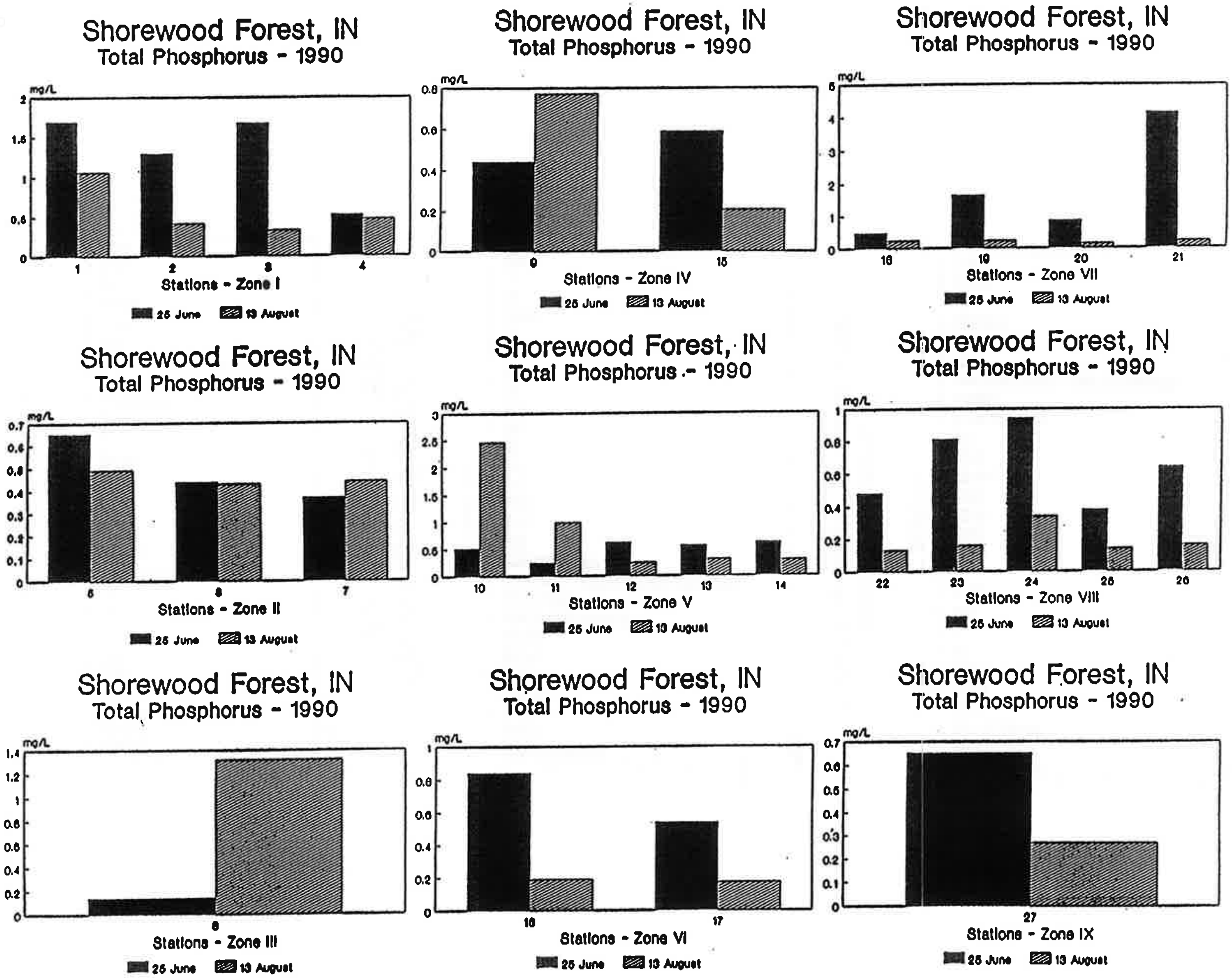
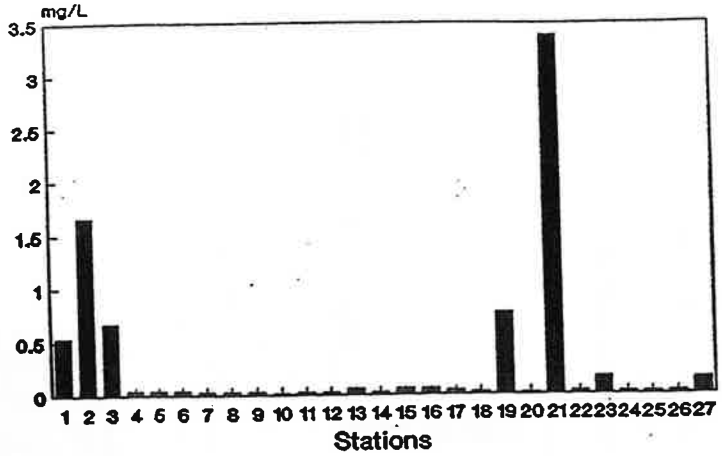
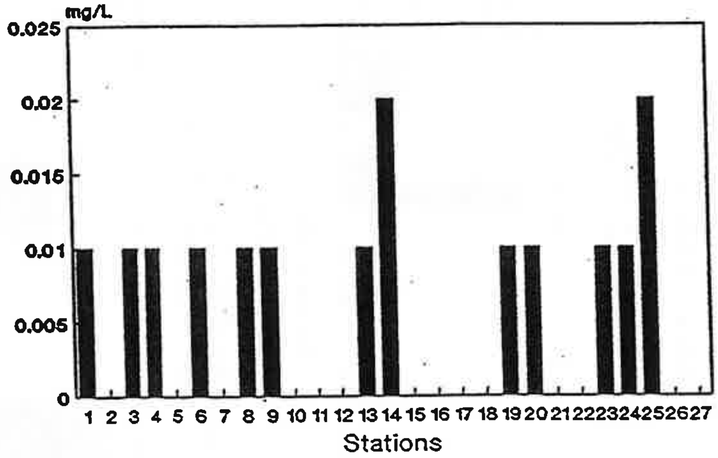


Figure 17. Total Phosphorus Concentrations for Individual Zones for 25 June and 13 August 1990.


Shorewood Forest, IN
Ortho Phosphorus - 25 June 1990


Shorewood Forest, IN
Ortho Phosphorus - 13 August 1990

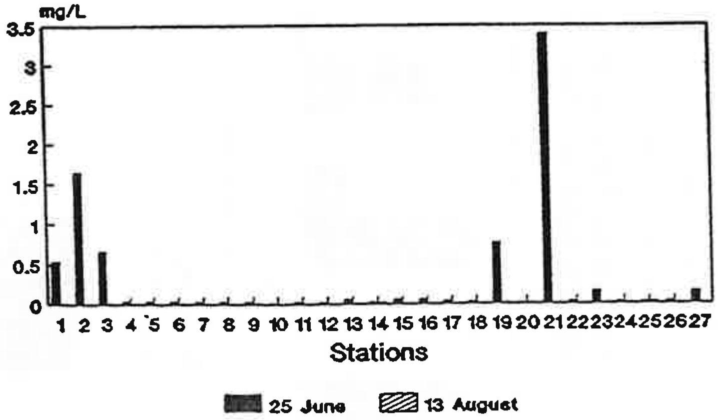

Shorewood Forest, IN
Ortho Phosphorus - 1990

Figure 18. Ortho Phosphorus Concentrations for Individual Stations for 25 June and 13 August 1990.

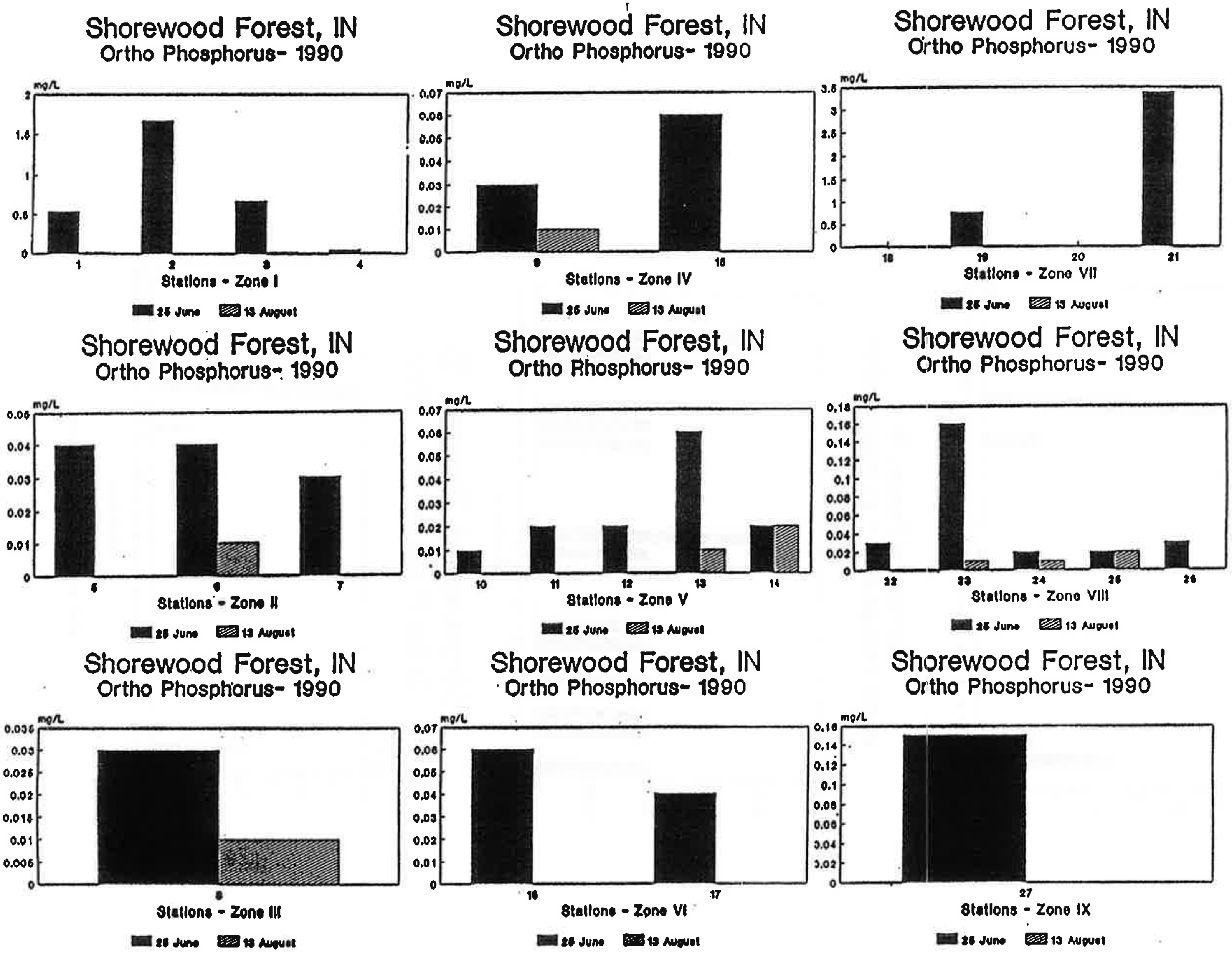


Figure 19. Ortho Phosphorus Concentrations for Individual Zones for 25 June and 13 August 1990.

Nitrogen:Phosphorus Ratios. The ratio of total nitrogen to total phosphorus can be useful in delineating which of these two essential nutrients is limiting primary production in lakes. Numerous authors (Baker et al. 1981, Kratzer and Brezonik 1981, Canfield 1983, Earth Source Inc. 1990) have proposed that N:P ratios less than 10 suggest nitrogen limitation, while those greater than 10 suggest phosphorus. The N:P ratios in Lake Louise were 2.3 in June and 4.5 in August 1990. These values suggest that the lake is nitrogen limited throughout the year but becomes less so by the end of the growing season.

Alkalinity. Alkalinity is a measure of the carbonate buffering capacity of lakes and can be a useful parameter for assessing changes in watershed delivery of erosion products through human activities. Maximum alkalinity values were found in Zone I and are a direct reflection of watershed disturbance for residential development and associated delivery of erosional material (Figures 20 and 21). The remainder of stations and zones displayed little variability in this parameter.

Conductivity. Conductivity is a measure of the electrolytic strength of lake water, and is closely related to alkalinity. It too can be useful as an indicator of watershed erosion intensity. Conductivity displayed little inter station or zone variability on either sampling date (Figures 22 and 23).

Chlorophyll. Chlorophyll is a good estimator of algal biomass in a lake. Concentrations less than 5 mg/m3 define low trophic state lakes (oligotrophic), values 5-10 mg/m3 intermediate trophic state (mesotrophic), and values greater than 10 mg/m3 high trophic state (eutrophic). While a vast majority of individual stations displayed chlorophyll values within the oligotrophic range, stations 1, 2, and 5 were clearly mesotrophic (intermediate water quality). Stations 1 and 2 (Zone I at the northwest corner of the lake) displayed the highest values of any of the 27 stations with station 1 almost being in the eutrophic range (Figures 24 and 25).

Total Suspended Solids. Total suspended solids provides a measure of the total amount of material suspended in the water column. A great deal of inter station variability in this parameter was noted during both June and August 1990, with maximum values found at stations 1, 15, and 27 during June and stations 12, 14, and 17 during August (Figure 26). Most stations displayed higher values during June than August, but no clear trends could be established within the lake for either month.

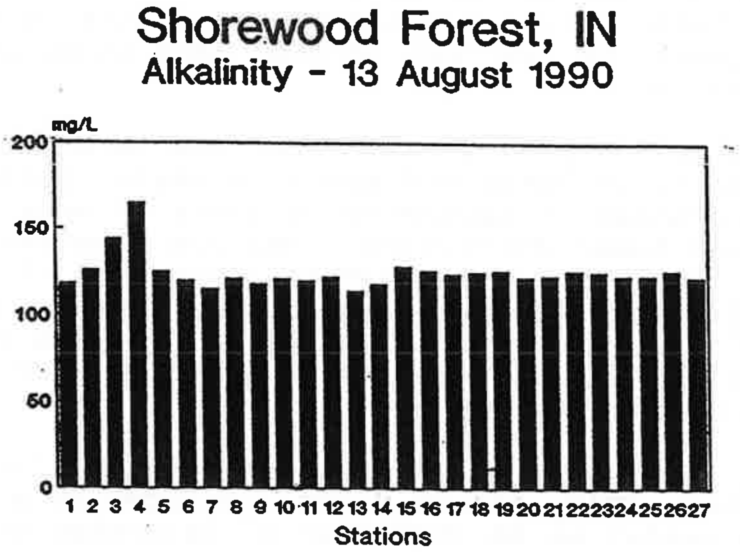


Figure 20. Alkalinity Concentrations for Individual Stations for 13 August 1990.

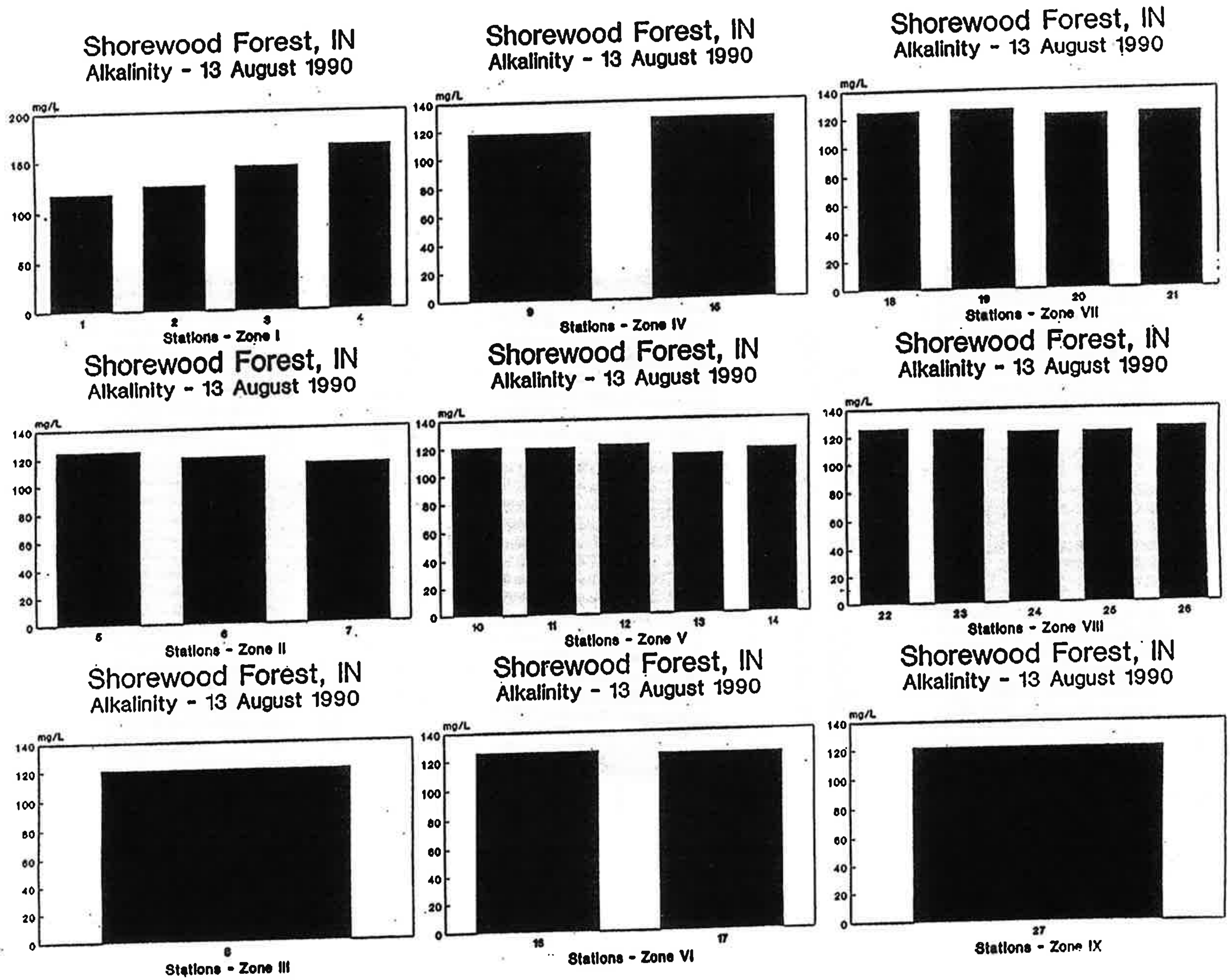


Figure 21. Alkalinity Concentrations for Individual Zones for 13 August 1990.

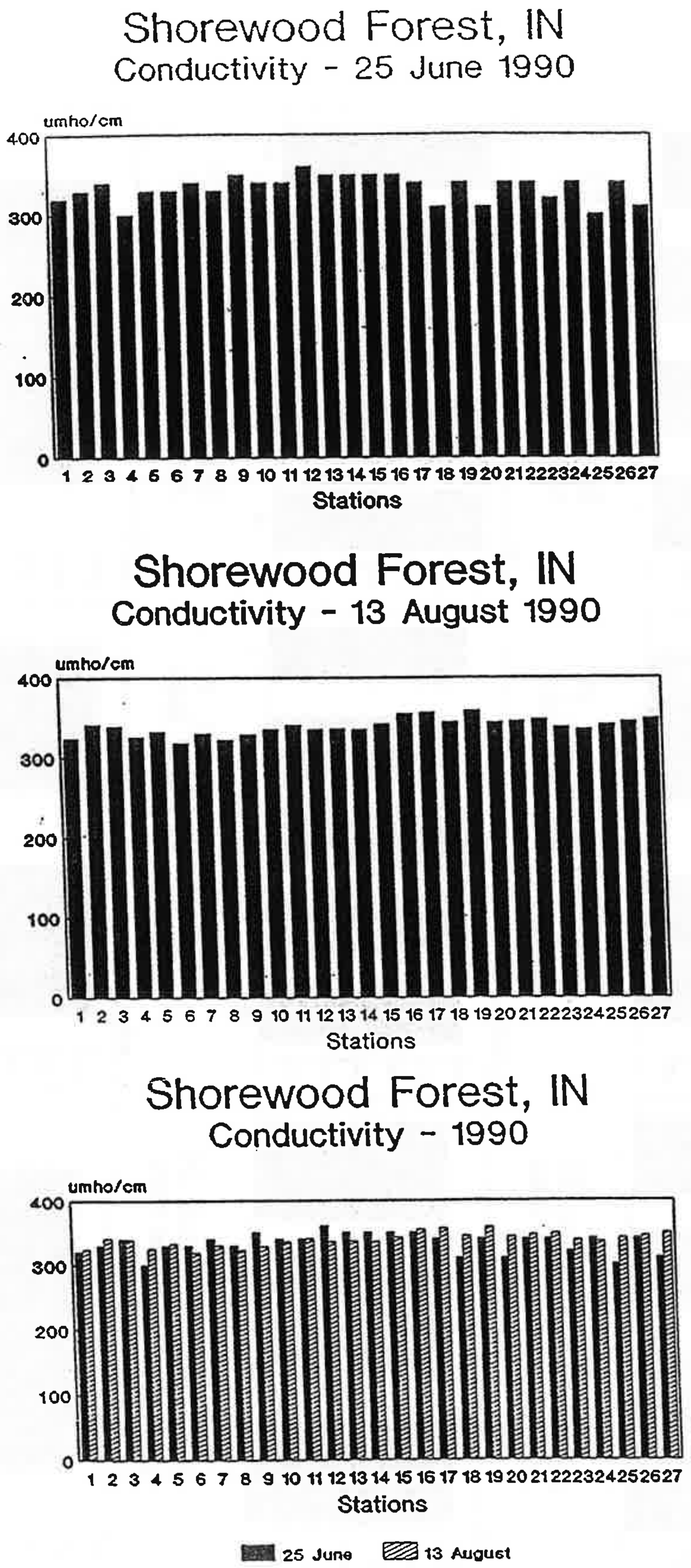


Figure 22. Conductivity Values for Individual Stations for 25 June and 13 August 1990.

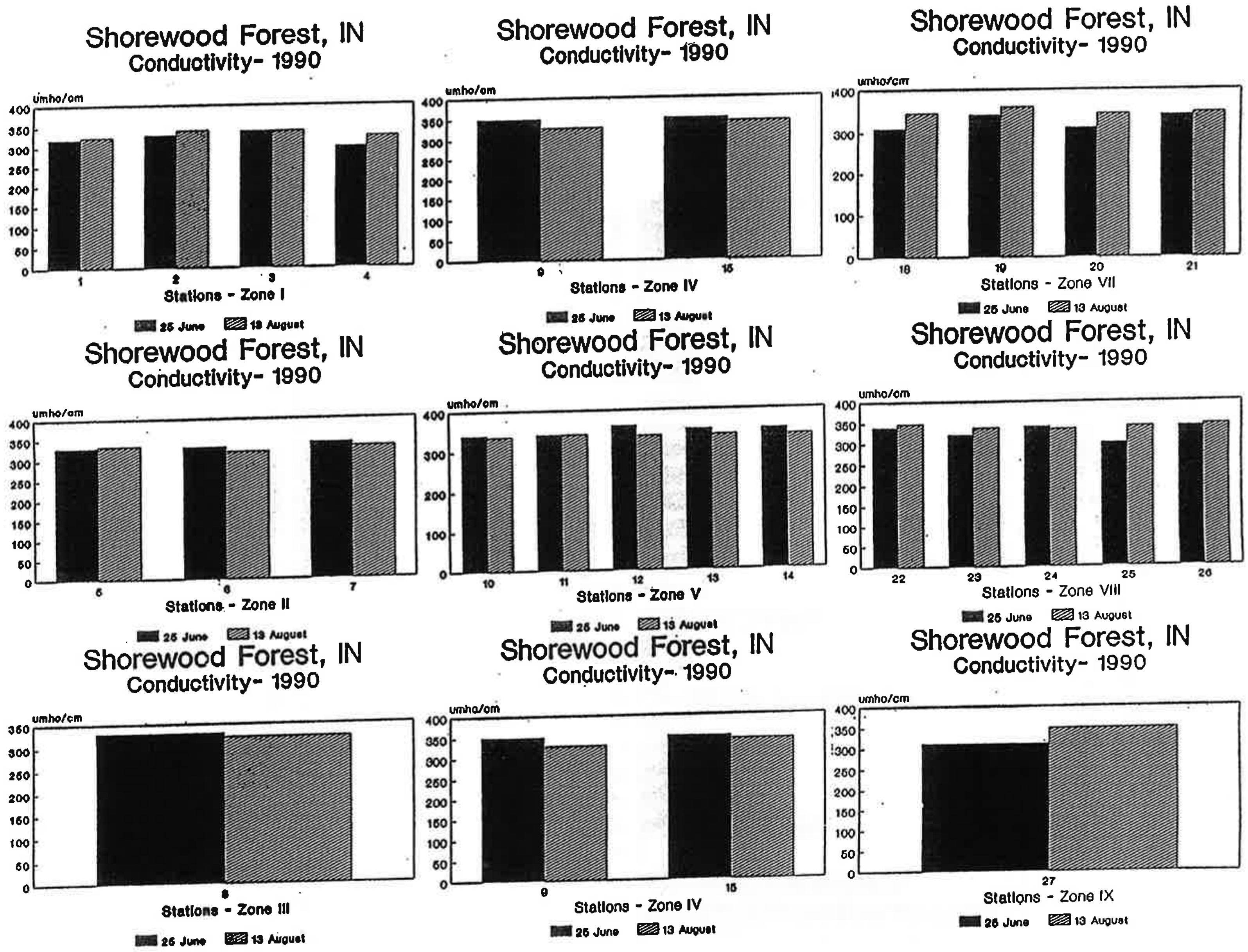


Figure 23. Conductivity Values for Individual Zones for 25 June and 13 August 1990.

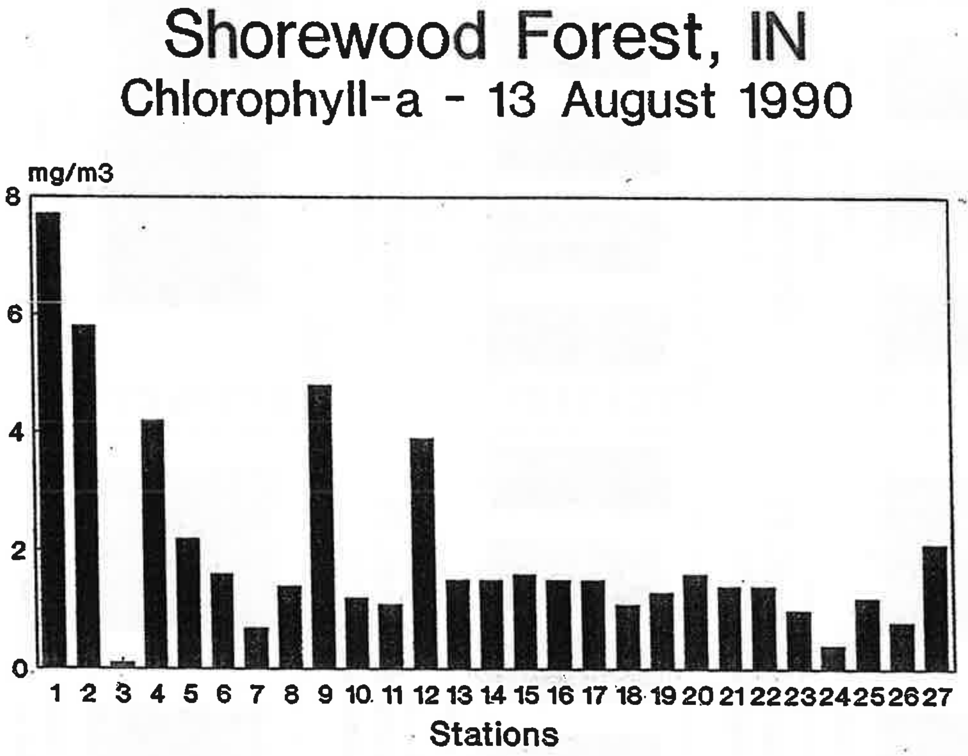


Figure 24. Chlorophyll Concentrations for Individual Stations for 13 August 1990.

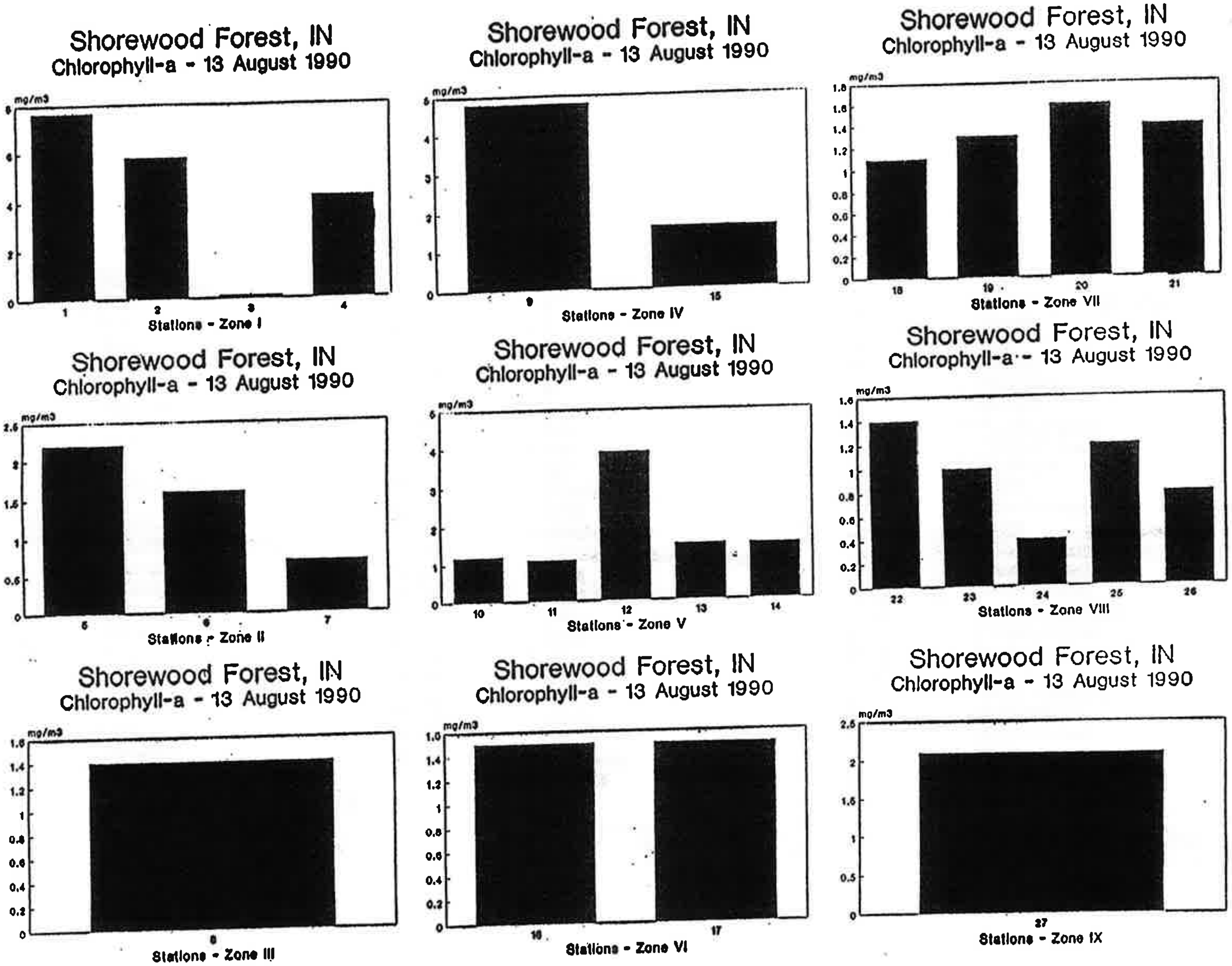
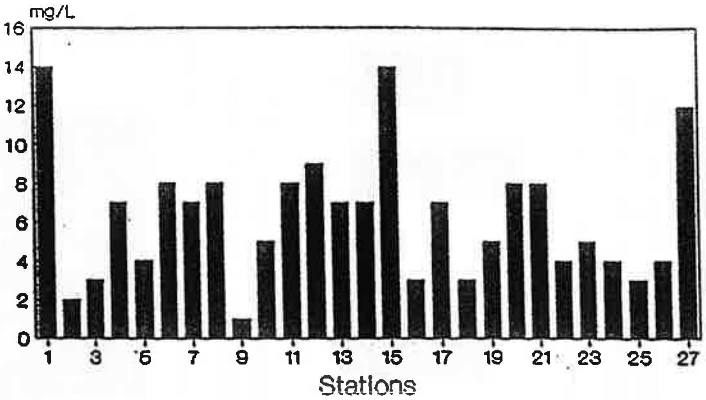
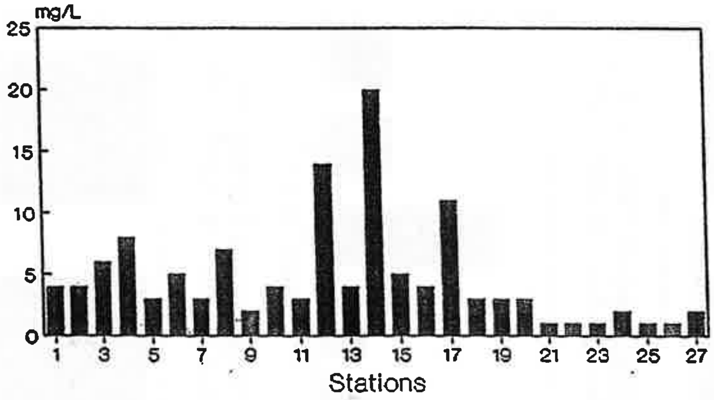


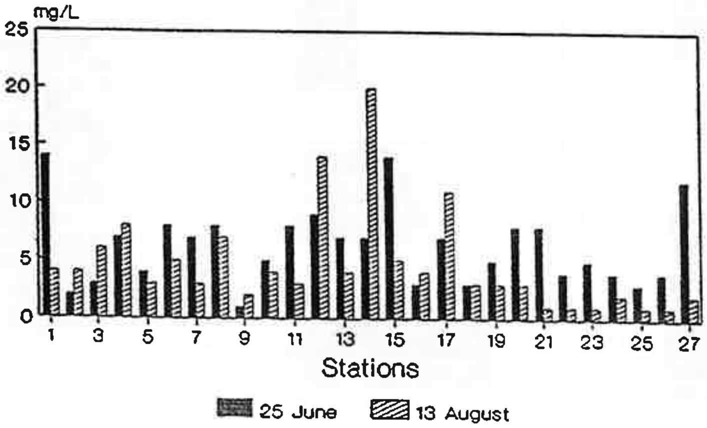
Figure 25. Chlorophyll Concentrations for Individual Zones for 13 August 1990.



Shorewood Forest, IN
Total Suspended Solids - 25 June 1990



Shorewood Forest, IN
Total Suspended Solids - 13 August 1990



Shorewood Forest, IN
Total Suspended Solids - 1990

Figure 26. Total Suspended Solid Concentrations for Individual Stations for 25 June and 13 August 1990.

TASK 2: BOTTOM MAP OF LAKE LOUISE

A Raytheon recording fathometer was used to develop bottom profiles of Lake Louise for construction of a detailed bottom map. Field work was completed during the second week of August 1990. A total of 80 cross-lake transects formed the data base for map construction. Our original intent was to compare the current bottom map with that of the original lake bottom map. Unfortunately, the original lake map or grading plan were not available. Therefore, the original bottom map was developed by transposing the established water control elevation (IDNR, Division of Water, 1974) on the pre-development topography map and extrapolating the corresponding depth contour intervals. Following standard format, five foot contours have been used for comparison of the current map (Figure 27A) with those of the pre-impoundment base topography map (Figure 27B).

It is clear that the Lake Louise bottom configuration has changed since impoundment in 1974. The findings of this study indicate the extent of basin infilling based on two specific points in time. As such, annual sediment accumulation rates may be inferred at 0.1 foot per year. However, it is likely that the majority of sediment accumulation (per zone) has taken place over a limited period of time, i.e. concurrent with adjacent watershed development. The results of this study indicate a 12% to 15% volume reduction in Lake Louise due to infilling, the equivalent of 270 to 340 acre feet of sediment accumulation.

Zone I exhibited the greatest infilling, with about a 49% reduction in volume. In 1974, the average depth in Zone I was greater than five feet, in 1990 however, no depths greater than five feet were reported. Given the high construction generated silt load observed in the lake during both sampling periods, and, the basin morphology in Zone I (constricted at the outlet) it is likely that this section had undergone significant infilling during lakefront and watershed development.

Basin infilling in Zone II is the third greatest reported, with a 35% reduction in volume. Approximately 85% of Zone II was greater than 5 feet in 1974. The 1990 bottom map shows approximately 40% of Zone II was less than five feet deep, with the remainder of the basin 5-10 feet. The most significant infilling was noted in the northwest corner.

Zone III appeared to exhibited the least change in volume, with approximately 2% infilling reported. This zone may have been excavated prior to impoundment. In 1990, Zone III had a maximum depth in excess of 17 feet, but the deep water zone was restricted to a small area in the center of the basin. This zone is characterized by moderately sloping sides that drop to depths of 5-10 feet within 20 feet of shore.

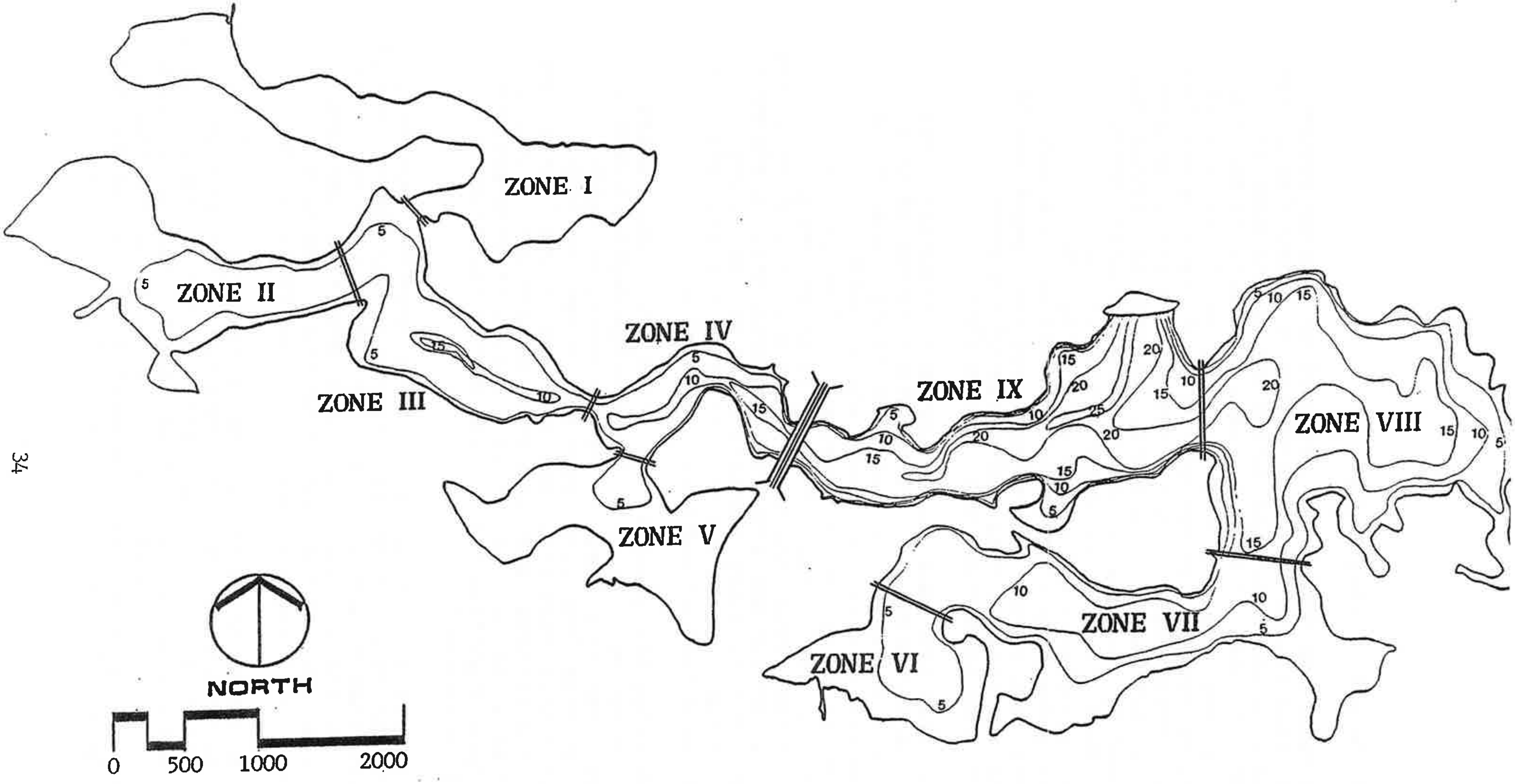


Figure 27A. Bathymetric Map of Lake Louise for 1990.

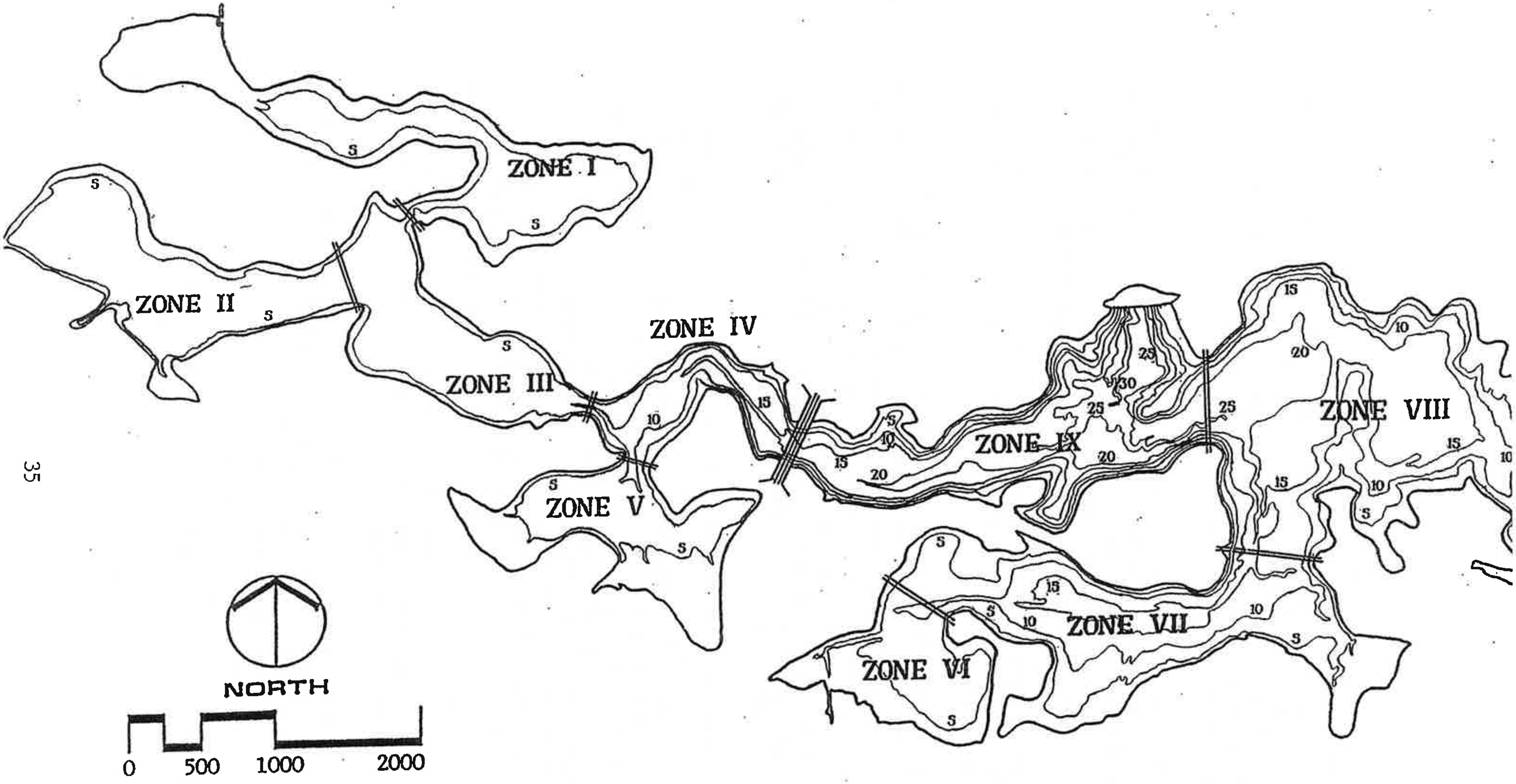


Figure 27B. Bathymetric Map of Lake Louise for 1974

A similar morphometry characterizes Zone IV, but this zone displays slightly deeper water especially immediately in front of the bridge. In addition, basin slope appears to be generally greater in Zone IV than Zone III. The greatest infilling in Zone IV is shown in a reduction in aerial coverage of depths between 10-15 feet, with overall infilling reported at approximately 12%.

In 1974, the average depth in Zone V was between 5-10 feet. In contrast, the 1990 bottom map shows the majority of Zone V to be extremely shallow (less than five feet). The notable exception is in the channel leading to Zone VI where depths are between 5 and 10 feet. Zone V is ranked second highest in basin infilling with approximately a 40% reduction from the original volume. This is most evident in nearshore areas, which appear to have experienced recent infilling from watershed sources.

In 1990, the area comprising Zone VI was about equally divided between 0-5 feet and 5-10 feet depths. The original bottom map shows the area to be dominated by depths of 5-10 feet. The area immediately in front of the ditch mouth at the western end of this zone appears to have undergone pronounced infilling recently, and sediments are extremely flocculent and easy to resuspend. Total infilling reported in Zone VI is about 17%.

Zone VII is characterized in 1990 by steep slopes on the northwestern side and moderate slopes on the north and east sides. The greatest change in bottom configuration has occurred along the south and east shore with a dramatic increase in the 0-5 foot depth contour interval. Maximum depths of 10-15 feet characterize the entire center of this basin. Sediments near the southern and eastern shore show evidence of recent infilling, while serious shoreline undercutting was noted on undeveloped portions of the western shore. As of the 1990 bottom map, a 17% volume reduction is reported in Zone VII, with the greatest sediment flux likely occurring in recent years. Due to current watershed development, Zone VII is expected to continue infilling at an accelerated rate unless watershed controls are implemented in the near future.

Zone VIII is characterized by gentle slopes throughout most of the basin with the exception of the west and northwest shores where steep slopes are found. Maximum depths in excess of 20 feet are found near the connection with Zone IX, but the center of the basin displays depths of 10-15 feet. The greatest infilling in Zone VIII has occurred in the 0-5 foot depth interval along the south east shore, and the 5-10 foot contour interval along the south shore. Much of the current infilling is attributed to watershed inputs (SW 1 and SW 2) delivered to Zone VII. Infilling in Zone VIII is approximately 8%.

Zone IX is characterized by both the steepest slopes and greatest depth of any of the nine zones defining Lake Louise. Depths in excess of 25 feet are found in a narrow trough in front of the dam, while a majority of the remaining area of the basin is greater than 15 feet deep. Clear evidence of shoreline erosion is found in front of all undeveloped parcels of land. Infilling in Zone IX is most likely associated with silt and clay drift from watershed loading in adjacent lake zones. This is supported by the reduction of the deeper depth contour intervals, specifically in the 15-20 foot range. Total infilling in Zone IX is approximately 6%.

The comparison of the aerial extent of individual depth contour intervals between 1974 and 1990 is presented in Figure 28. Approximately 45% of the lake area of Lake Louise is currently less than five feet deep, compared to approximately 25% in 1974. This is a 20% increase, or about 45 additional acres. The second most important depth contour is 5-10 feet, which constitutes 25% of the 1990 total lake area. In 1974 approximately 39% of the lake was 5-10 foot deep. The decrease in this depth interval is attributed to a shift to the shallower 0-5 foot depth range. Taken together, approximately 70% of Lake Louise is less than 10 feet deep. With the exception of a change in the maximum reported depth in 1990, 25-30 feet from 30-34 feet in 1974, the remaining contour intervals remained relatively constant.

TASK 3: AQUATIC MACROPHYTES

A raytheon recording fathometer was used to estimate the biovolume of aquatic macrophytes (weeds) in Lake Louise. A total of 80 transects spanning the width of the lake were used as the data base. The plant survey was conducted in August 1990 and thus represents summer plant extents. Plant biovolume is defined as the percent of the water column at a given location in the lake that is filled with plant biomass. Thus, it is a measure of the extent of macrophyte infestation throughout the lake system.

The aerial distribution of plant biovolume in Lake Louise is presented in Figure 29. For convenience, biovolume has been expressed in increments of 20% of water column infestation. Macrophytes generally were restricted to water depths less than 5 feet, thus limiting plant growth in the lake to near shore areas. Plant growth failed to exceed two feet in height anywhere in Lake Louise. Given the morphometry of the lake, a large area of the bottom (83%) was considered void of vegetation (Figure 30).

Our work at other Indiana lakes (Eviston and Crisman 1988, Crisman et al. 1990, Eviston et al. 1990) has demonstrated that the public perceives a macrophyte problem only when plant biovolume exceeds 80% of the water column.

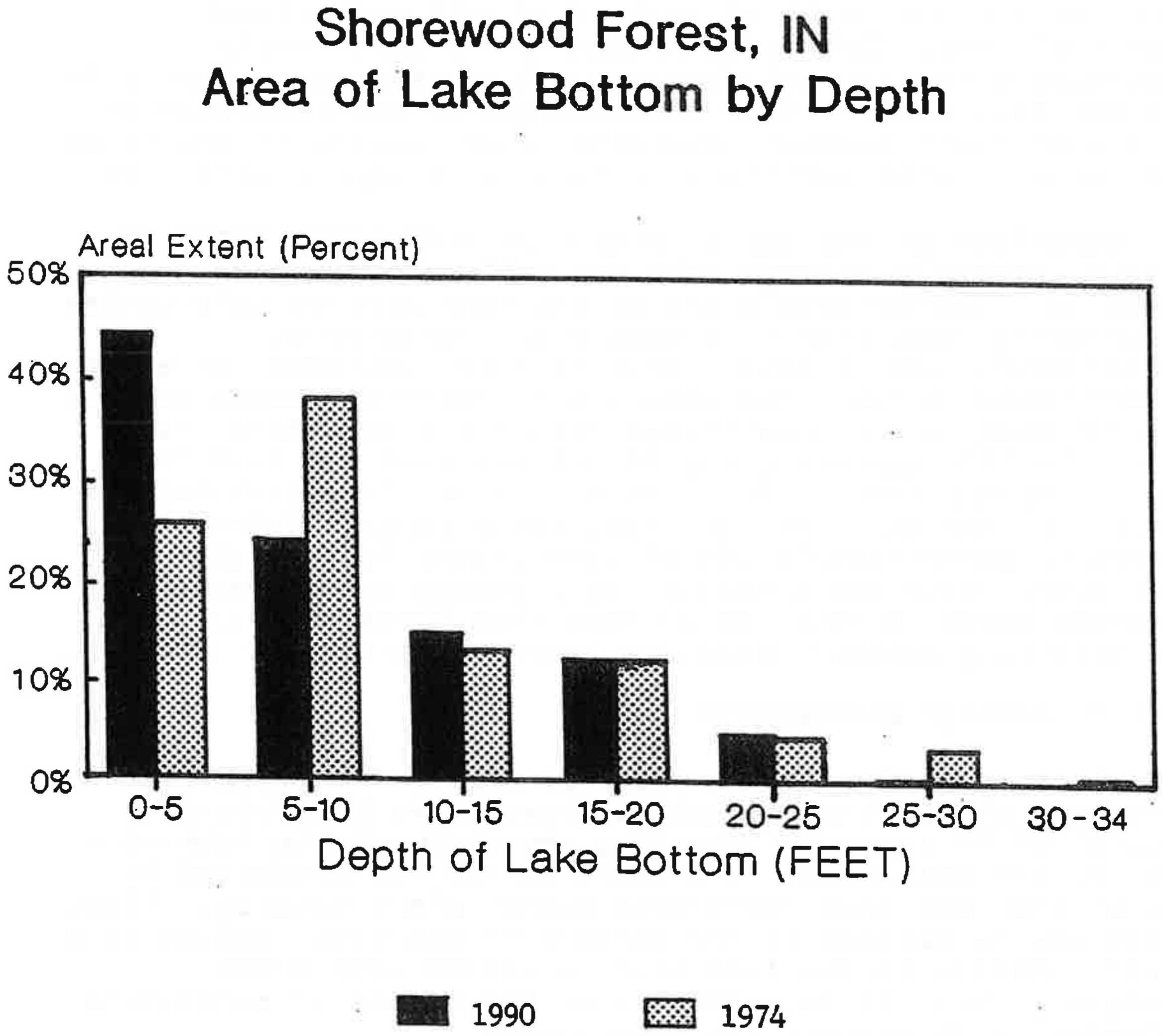


Figure 28. Comparison of the Aerial Extent of Individual Depth Contours of Lake Louise for 1974 versus 1990.

Following this reasoning, only a small area in Zone I could be characterized as having management problems with macrophytes during August 1990. Aquatic plant problems during August 1990 were found in only 8% of the total lake area. The depth distribution of macrophytes in Lake Louise is controlled in part by basin morphometry.

In addition to looking at the distribution of plant biomass in Lake Louise, a qualitative survey was made to determine the distribution of the major plant species in the system (Figure 30). The exotic species, Eurasian watermilfoil (Myriophyllum spicatum), has been posing management problems in Lake Louise in recent years. The 1990 chemical control program funded by the Shorewood Forest P.O.A. targeted this species and spraying was undertaken by Aquatic Control Inc. during the late spring. Our qualitative survey conducted during August indicated that this program was extremely successful and that watermilfoil had essentially been eliminated from the entire lake (Figure 31). In fact, the only vascular plant remaining in the lake in August was floating-leaved spatterdock (Nuphar). All of the macrophyte growth in Lake Louise during August was restricted to the macroalga Nitella and filamentous algae. The vegetated littoral zone had all but been eliminated from the lake.

TASK 4: FISHERIES MANAGEMENT

The Raytheon fathometer data recorded from the 80 cross lake transects were also used to provide a qualitative assessment of the fish community of Lake Louise. Echos of fish in the water column appeared on all fathometer recordings, and these were used to assess total fish abundance and the depth distribution of the population for the lake.

Total fish abundance in open water areas of Lake Louise was estimated at 17.56/1000 feet of fathometer transect. The greatest density of fish (31% total abundance) was at a depth of 2-3 feet (.8-.9 meters) with the second greatest density at 1-2 feet (.2-.6 meters) (Figure 32). Fish avoided depths shallower than 1 foot, the area of highest temperatures, and deeper than 5-6 feet (1.5-1.8 meters). In addition to pronounced vertical stratification of total abundance, fish also displayed strong horizontal stratification with an excess of 90% of all fish being found within 20 feet of shore.

The vertical distribution of fish in Lake Louise is unlikely affected by oxygen levels. On both sampling dates, sufficient oxygen concentrations were found throughout the water column at all stations to support fish populations at all depths (Figure 3). A more plausible explanation for the restriction of fish to shallow near shore areas is predation intensity. Given that macrophytes are extremely restricted in aerial extent throughout Lake Louise, small fish must

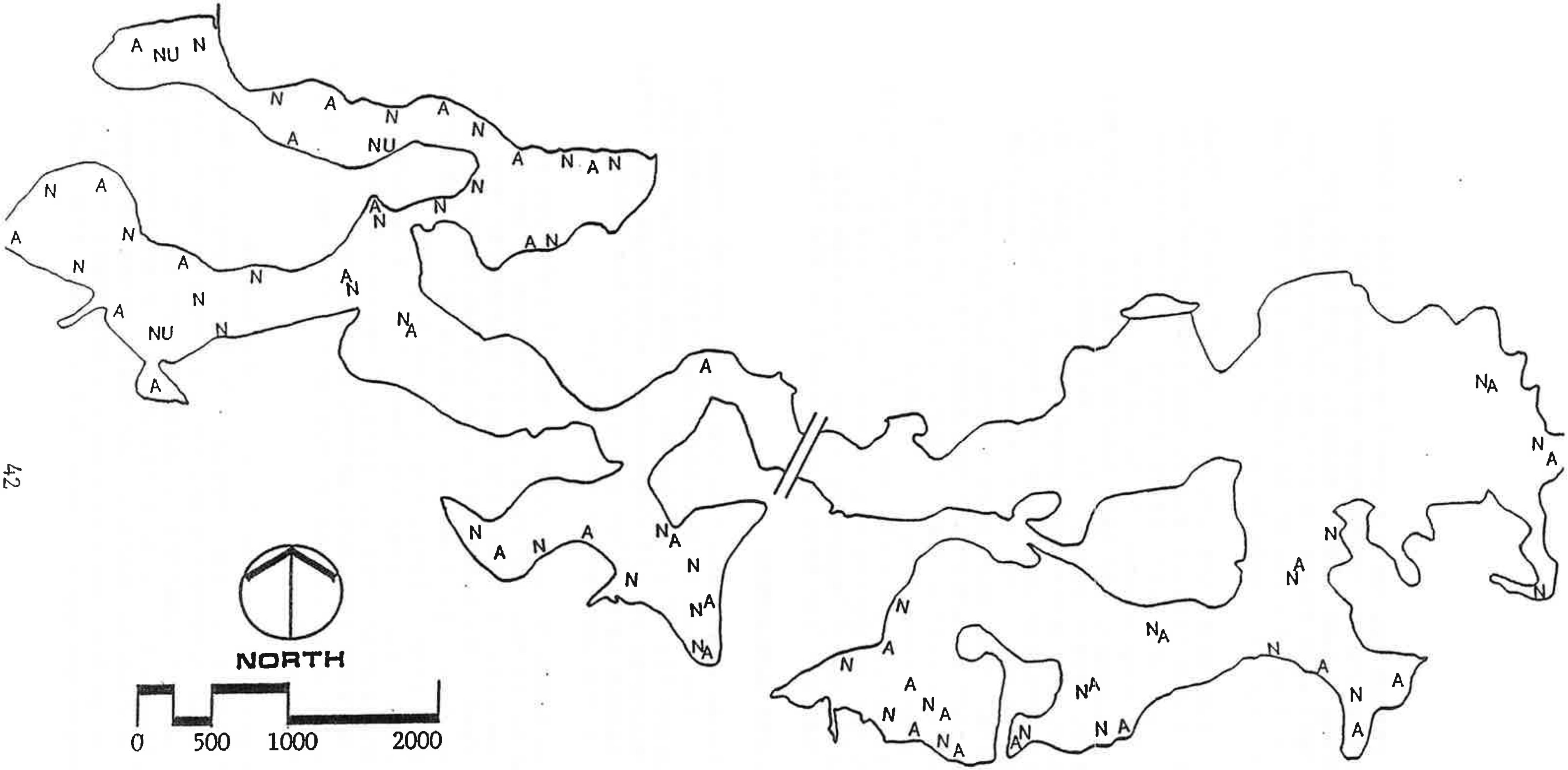


Figure 31. Distribution of Major Plant Taxa in Lake Louise in August 1990. Plants were: Filamentous Algae (A), Nitella (N), and Spatterdock (NU).

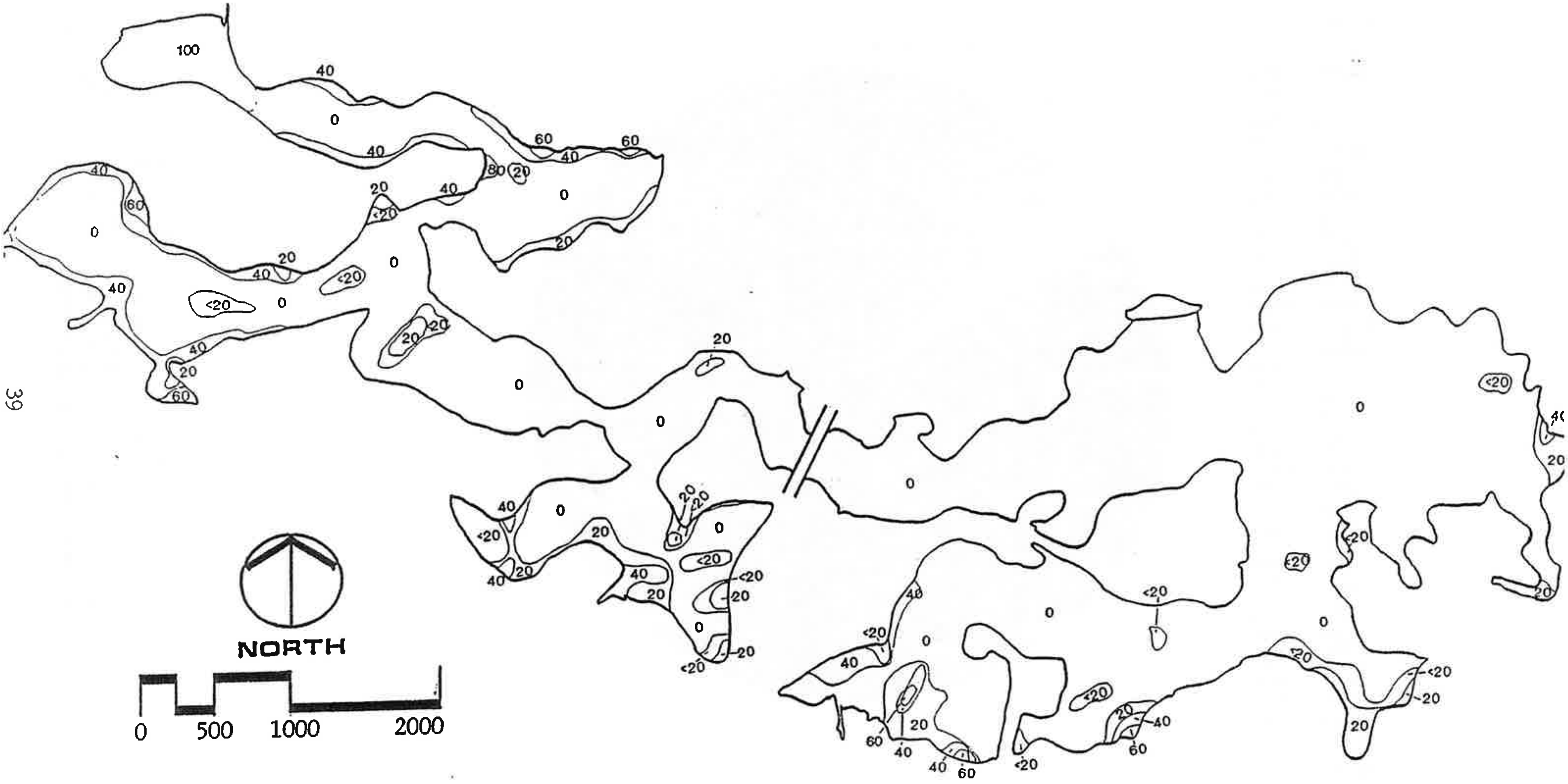


Figure 29. Distribution of Aquatic Macrophyte Biovolume in Lake Louise for August 1990. Contours are in Intervals of 20% Biovolume.

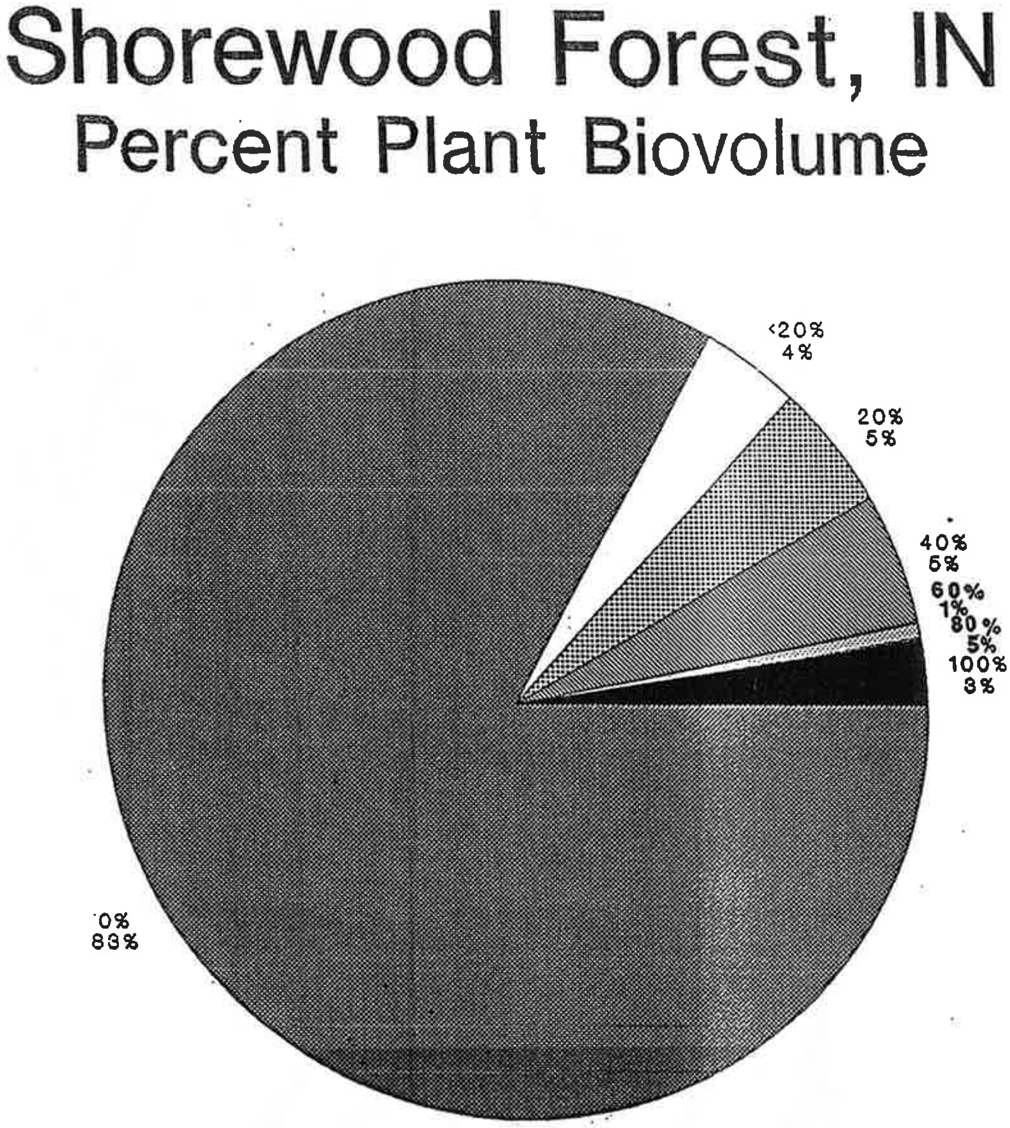


Figure 30. The Distribution of Plant Biovolume in Lake Louise Expressed as a Percent of Water Column Infestation. For Each Pie Segment, the Upper Percent is the Biovolume and the Lower is the Percent of Lake Area Represented by the Interval.

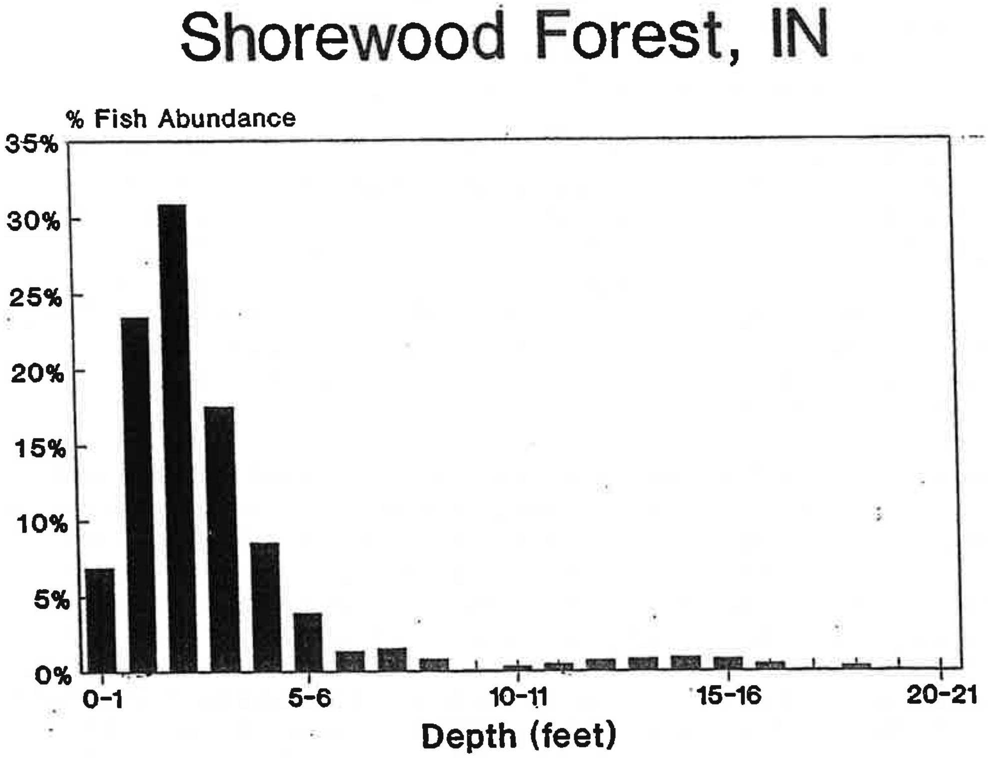


Figure 32. Semi-Quantitative Estimate of Fish in Lake Louise in August 1990 Expressed as Number of Individuals Per 1000 Feet of Fathometer Transect and Partitioned According to Water Depth.

remain in extremely shallow water to avoid predation by largemouth bass. Casual observation supports this interpretation as shoreline depths less than one foot deep are crowded with small stunted bluegills.

The estimate of 17.56 fish/1000 feet of transect is at least 50% lower than reported for comparably eutrophic lakes of northern Indiana including Bruce (28/1000 feet), Nyona (34-45/1000 feet), and South Mud (32/1000 feet) (Crisman et al. 1990, Eviston et al. 1990). Unlike Lake Louise, all of the latter lakes have extensive macrophyte beds that afford protection to small fish. Not only are fish populations lower than expected in Lake Louise, but they are also stunted and dominated by bluegills.

The fishery of Lake Louise provides an extremely poor sport fishery. If it is to be improved, measures must be taken to improve habitat as well as to increase the predator fish population. Given that residents desire relatively weed free shorelines, artificial habitats must be developed in order to provide breeding and nursery grounds for sport fish. The most common type of habitat used in reservoirs and lakes such as Lake Louise is brush piles placed in strategic locations away from homes. The second management need is to introduce predators into the lake to reduce the populations of stunted bluegills. It is obvious that largemouth populations are insufficient to provide adequate control on the bluegills. There appears to be sufficient oxygen throughout the water column of the lake during the summer period to support major predators including northern pike and walleye. The introduction of such fish should reduce the stunted bluegill population, and in the final analysis provide a good sport fishery for northern pike, walleye, and bluegills.

TASK 5: DREDGING AS A LAKE MANAGEMENT OPTION

Dredging can be used either to deepen lakes or to reduce sediment phosphorus recycling. Our investigation was designed to assess the feasibility of dredging as a management tool for Lake Louise using paleolimnological techniques. We were especially interested in determining inter lake variability in sediment physical parameters and total phosphorus in order to determine "hot spots" of phosphorus deposition in the lake and also how much sediment would have to be removed via dredging in order to reduce in-lake phosphorus pools significantly. Sediment samples were collected at 14 of the 27 stations in Lake Louise by means of an Ekman grab (Figure 1). Each sample was placed in a plastic bag and stored at 4o C until analyzed.

In addition to wet weight for each sample, organic content was calculated as the difference in weight between the wet weight and that after drying at 100o C for 24 hours. Inorganic content was calculated from the weight difference of the sample dried at 100o C for 24 hours and ashed at 500o C for one hour. Phosphorus was determined by the standard ascorbic acid colorimetric method using filtrate collected from an HCl digestion of the sediment sample.

With the exception of stations 1 (78%) and 7 (94%), water content of sediments from all stations was less than 70% on a weight basis (Figure 33). It appears that neither water depth nor location within the lake has a marked effect on how "soupy" sediments are. The water content of sediments from Lake Louise was within the range expected for residential reservoirs of northern Indiana but less than found in comparably eutrophic natural lakes.

Sediment inorganic content ranged from 65% at station 7 to 97% at station 24, with most stations being close to the maximum value (Figure 34). Conversely, organic content of sediments was less than 5% at most stations. Trends for inorganic and organic matter are consistent with other residential reservoirs in northwestern Indiana (Crisman and Eviston 1989).

It is conventional to express total phosphorus concentrations as a function of the total dry weight of sediment. In this way, deviations in the total phosphorus to sediment dry weight ratio can be used to delineate sections of the lake receiving phosphorus enrichment in excess of that delivered with sediments (Figure 35). Sediment total phosphorus concentrations were greatest at station 1 at the northwest corner of the lake and, with the exception of stations 2, 7, and 22, were approximately double those reported elsewhere in Lake Louise. The ratio of total phosphorus to sediment organic matter percentage for individuals demonstrates that both stations 1 and 7 display markedly greater ratios elsewhere in the lake. While the remaining stations display little variability in their ratios suggesting that phosphorus is entering Lake Louise in a form that is easily utilized for algal and macrophyte growth, it appears that stations 1 and 7 receive phosphorus from the watershed in excess of what can be immediately used biologically.

It appears that dredging will likely reduce sediment phosphorus significantly only in the immediate vicinity of point source discharges from the surrounding watershed. In particular, it appears to have its greatest potential in Zone I at the northwest corner of the lake. Given the expected increase in phosphorus loading from this section of the watershed associated with ongoing residential development and erosion, dredging may be a feasible management option. Surprisingly, sediments from Zone VI were not enriched in phosphorus in spite of their proximity to a watershed point source discharge.

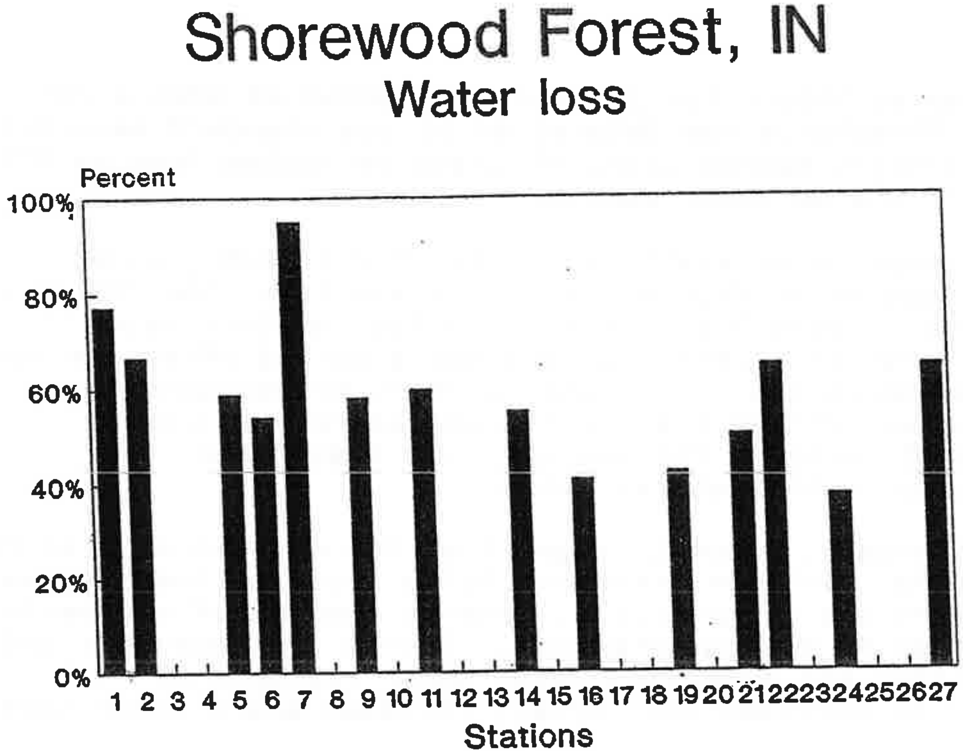


Figure 33. Percent Water in Sediments Collected from 14 Stations in Lake Louise.

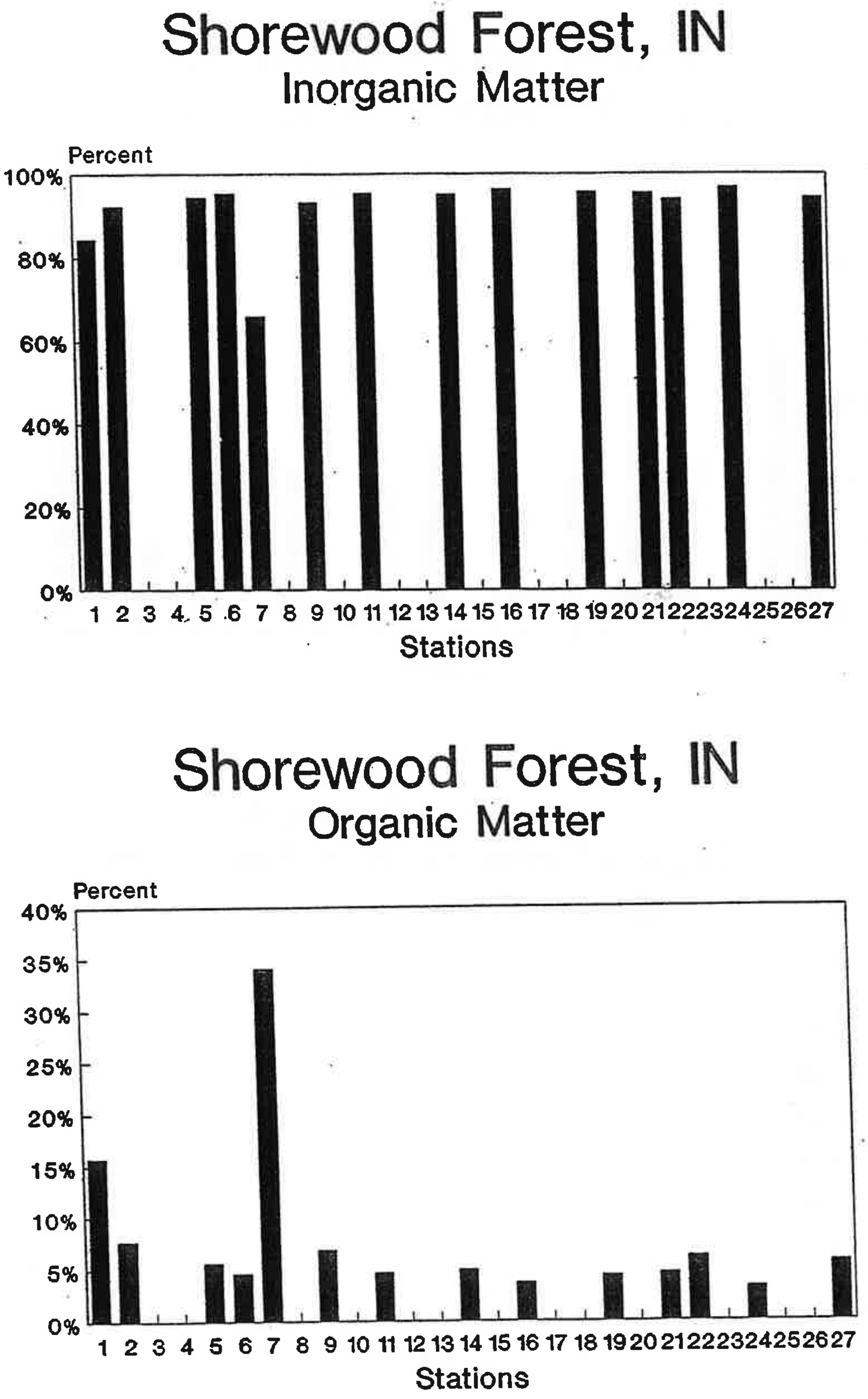


Figure 34. Percent Inorganic and Organic Matter in Sediments Collected from 14 Stations in Lake Louise.

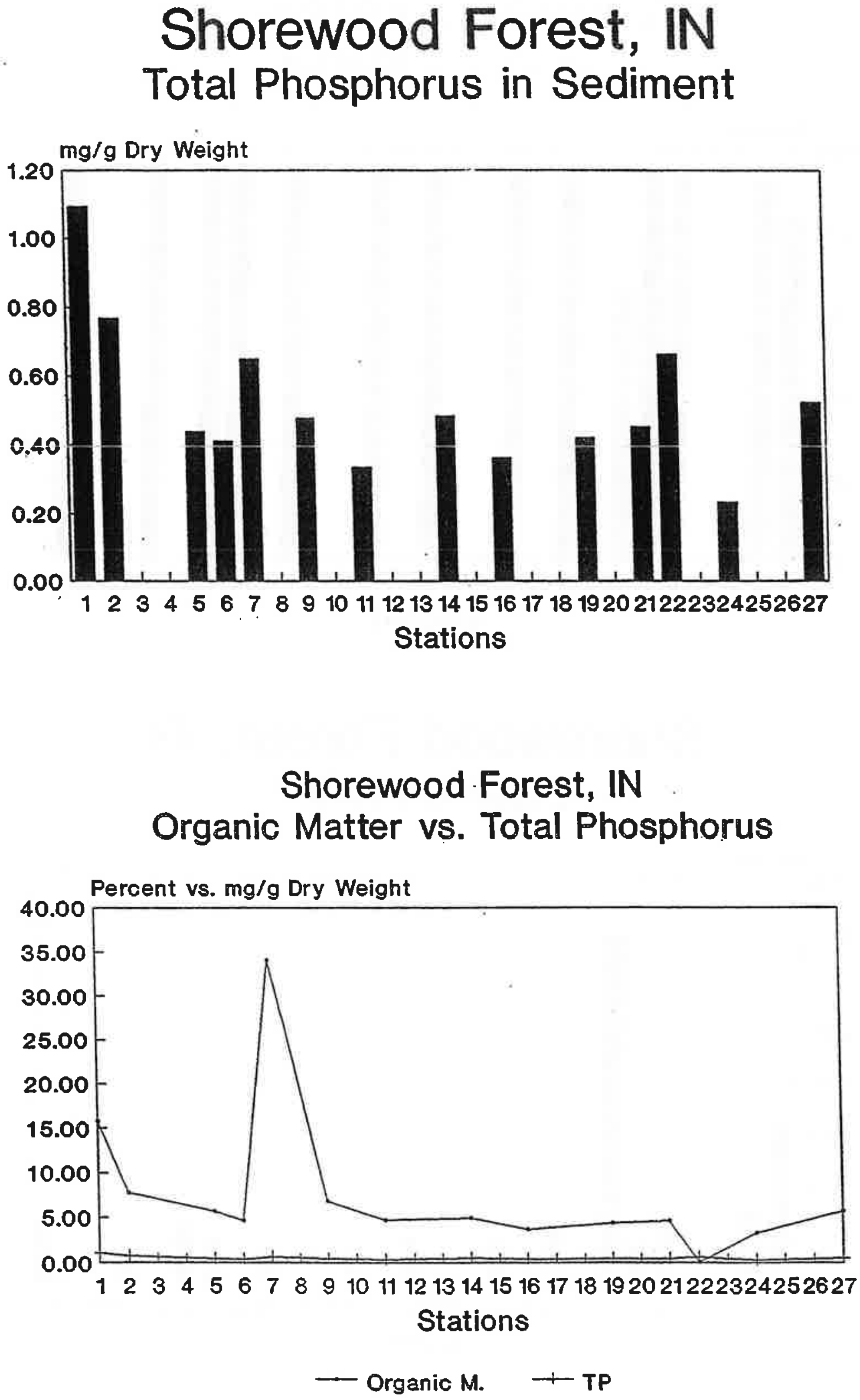


Figure 35. Total Phosphorus Concentrations and Comparison of Organic Matter Percent and Total Phosphorus/Gram Sediment Dry Weight for Sediments Collected from 14 Stations in Lake Louise.

TASK 6: SEDIMENTS AS A NUTRIENT SOURCE

Drawdown is normally proposed in cases where sediments are extremely flocculent and thus easily release phosphorus into the overlying water of ponds. In reservoir systems such as Lake Louise, drawdown is easily accomplished by periodic short term modification of lake stage at the outlet structure whereby sediments over large sections or the whole lake are exposed to air drying. In practice, allowing sediments to dry removes pore water thus consolidating sediments and often forming a hard surface crust to the bottom. Upon reflooding, this hard crust may remain firm thus hindering physical mixing of sediments and associated recycling of phosphorus to promote algal and weed growth.

Concurrent with the collection sediment for Task 5 (dredging) just described, additional sediments were taken at the same 14 stations for assessing phosphorus release from sediments following desiccation and reflooding (Figure 1). Sediments were collected with an Ekman grab and stored at 4o C until analyzed. In the laboratory, sediments were placed in a glass beaker, the overlying water was drawn off and the sediment surface allowed to dry out thoroughly. After complete desiccation, distilled water was added to the glass beakers to simulate reflooding. The same volume of water was added to all samples. After two weeks, samples of the overlying water from each sediment beaker were collected and analyzed for total phosphorus concentration. A sample of the same distilled water used for the experiment was also analyzed for total phosphorus to serve as a control situation. The results of sediment phosphorus release following subtraction of the control are provided in Figure 36.

Total phosphorus release from reflooded sediments ranged from 0.01 mg/L to 0.38 mg/L (Figure 36). The greatest release was for sediments collected at stations 16 and 19, both offshore from major watershed drainage discharge points. The next highest values were for stations 2 and 14. Water concentrations following drawdown at all stations were approximately 10 percent of those currently reported for the water column of Lake Louise.

It appears that sediment release of phosphorus following drawdown is relatively independent of actual sediment concentrations (Figure 36). For those stations in the vicinity of major watershed discharges, the data suggest that phosphorus is not easily released from sediments at stations 1 and 2 of Zone I, 6 and 7 of Zone II, and 21 of Zone VII. Surprisingly, in spite of comparable sediment concentrations to other stations in the lake, phosphorus in sediments from stations 16 (Zone VI) and 19 (Zone VII) is more likely to be released from the sediment matrix than observed at the other previously mentioned nearshore sites in the vicinity of watershed point source discharges. It is

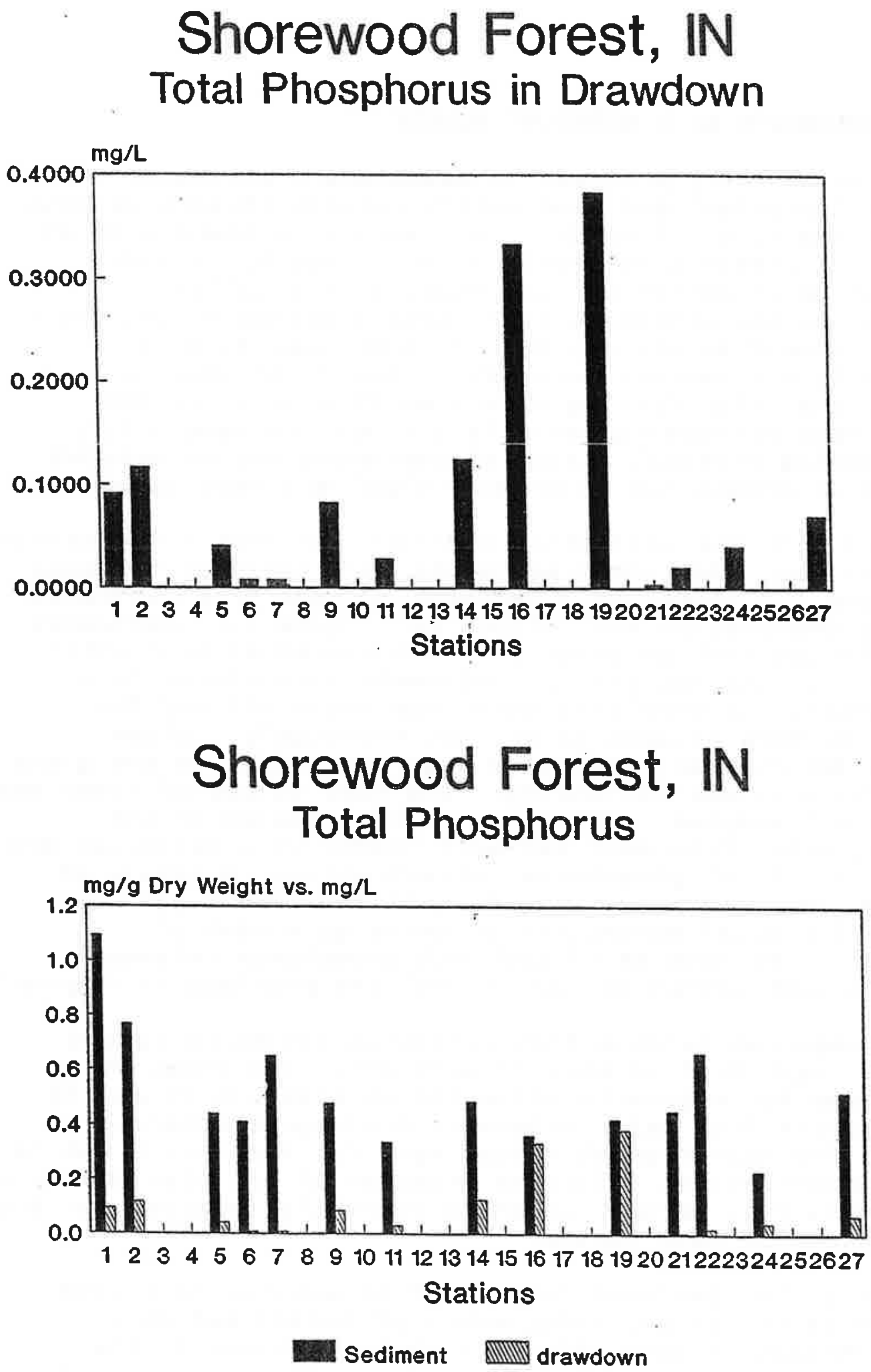


Figure 36. A) Total Phosphorus Released from Sediments Collected from 14 Stations in Lake Louise Following Dessication and Reflooding
B) Comparison of Sediment Phosphorus Release versus Water Column Phosphorus Values for Individual Stations of Lake Louise.

interesting to note that phosphorus appears to be relatively strongly bound to sediments at deep water stations and is not likely to be recycled into the water column for algal and macrophyte utilization.

It is likely that sediments are an important source of water column phosphorus especially in nearshore areas in the vicinity of watershed discharge points. While drawdown appears to be effective at sealing sediments at most locations in Lake Louise, it had little impact on sediments at the southeastern corner of the lake. In the latter area, dredging appears to be the only effective means of reducing sediment release into the water column significantly.

TASK 7: SEDIMENT CONTAMINANTS

If dredging is to be proposed as a lake management technique, it must be established that lake sediments are not contaminated with either metal or organic chemicals. If not properly accounted for, such chemicals could pose a pollution problem on the land disposal site. A total of 45 chemical parameters were measured on sediments collected at stations 9 and 15 in Lake Louise (Table 2). Aluminum, calcium, iron, magnesium and manganese concentrations were high but not uncharacteristic of lakes of northern Indiana. Neither these nor any heavy metal or organics were considered to pose a health or general pollution problem if sediments from the lake were to be disposed of on land.

TASK 8: SHORELINE EROSION

The entire shoreline of Lake Louise was surveyed to assess the extent of shoreline erosion. Two principal problems were noted: undercutting from waves generated by motor boats and land clearance for residential construction. Shoreline undercutting was most pronounced in the vicinity of undeveloped lots with numbers in the 420's and 430's (western shore of Zone VIII and southern shore of Zone IX). Numerous dead trees litter the nearshore areas, with several others still alive but growing at an angle approaching 45 degrees above the lake. In places, it appears that the shoreline has receded over five feet landward.

It is interesting that the zone of shoreline undercutting is almost entirely restricted to Zones VIII and XI where ski boats are allowed to operate. Waves generated from motor boats are undoubtedly the cause of the observed shoreline undercutting along undeveloped lots. The impact of power boats on sediment resuspension and associated water clarity was recently demonstrated at Lake Maxinkuckee, Indiana by Crisman et al. 1990. Fine sediments suspended into the water column by boat generated waves on weekends remain in suspension until the middle of the following week. Ski boats have also been implicated in shoreline and nearshore erosion

Table 2. Concentrations of Metals and Organic Chemical Contaminants in Surface Sediments of Lake Louise.

STATION 9

METALS	ug/g dry wgt	ORGANICS	ug/g dry wgt
% Solids	38.8	2,4,5-T	<0.064
Ag	<10	2,4,5-TP (Silvex)	<0.055
Al	14800	2,4-D	<0.385
Ba	73	2,4-DB	<0.290
Be	<2	B-BHC	<0.006
B	9.1	D-BHC	<0.009
Cd	3.1	Methoxychlor	<0.190
Ca	9390	Toxaphene	<0.250
Cr	22	4,4'-DDD	<0.118
Cu	123	4,4'-DDE	<0.003
Fe	22800	4,4'-DDT	<0.012
Pb	33	A-BHC	<0.003
Mg	8160	Aldrin	<0.004
Mn	701	Chlordane	<0.014
Mo	6.2	Dieldrin	<0.002
Na	198	Endosulfan I	<0.015
Ni	27	Endosulfan II	<0.003
Sr	10	Endosulfan sulfate	<0.069
Ti	138	Endrin aldehyde	<0.024
V	38	Endrin	<0.006
Zn	84	G-BHC (Lindane)	<0.004
		Heptachlor epoxide	<0.003
		Heptachlor	<0.088
		PCB's	<0.069

Table 2. Continued.

STATION 15

METALS	ug/g dry wgt	ORGANICS	ug/g dry wgt
% Solids	56.4	2,4,5-T	<0.05
Ag	<8	2,4,5-TP (Silvex)	<0.043
Al	14800	2,4-D	<0.300
Ba	67	2,4-DB	<0.230
Be	<2	B-BHC	<0.005
B	12	D-BHC	<0.007
Cd	3	Methoxychlor	<0.150
Ca	16900	Toxaphene	<0.200
Cr	41	4,4'-DDD	<0.009
Cu	46	4,4'-DDE	<0.002
Fe	24600	4,4'-DDT	<0.010
Pb	21	A-BHC	<0.002
Mg	9340	Aldrin	<0.003
Mn	481	Chlordane	<0.011
Mo	35	Dieldrin	<0.001
Na	152	Endosulfan I	<0.011
Ni	35	Endosulfan II	<0.002
Sr	16	Endosulfan sulfate	<0.055
Ti	131	Endrin aldehyde	<0.019
V	41	Endrin	<0.005
Zn	78	G-BHC (Lindane)	<0.002
		Heptachlor epoxide	<0.070
		Heptachlor	<0.002
		PCB's	<0.055

observed at Koontz Lake, Indiana (Crisman et al. 1989) and Lakes of the Four Seasons, Indiana (Crisman and Eviston 1989). It should be noted, however, that waves generated from large slow-moving pontoon boats can also promote serious shoreline erosion in channels and constricted segments of residentially developed reservoirs (Crisman and Eviston 1989).

While shoreline and watershed erosion was noted at most construction sites along the lake, the most pronounced erosion was associated with the new phase of residential development along the lake shore (Zone I) at the northwest corner of Shorewood Forest. Siltation was especially evident along a corridor cleared perpendicular to the lake for installation of a drainage culvert for discharge directly into the lake. Given that most lake shore lots have been developed, future development will progressively move farther from the lake. As exemplified by the current example, such development will likely exert as great or greater impact on Lake Louise than shoreline development if storm drainage is allowed to discharge directly into the lake.

It is clear that the shorelines of undeveloped lots be stabilized immediately, especially where ski boats are allowed to operate. Given the steepness of most lots, construction of sea walls or rip-rap infilling may be the most effective means of reducing shoreline erosion.

The Watershed 2.

INTRODUCTION

The approach of this section of the study is to specifically address the effects of "off-site" and "on-site" watershed use as they relate to the overall water quality of Lake Louise. The watershed investigation involved four levels of watershed study:

I. Overview of the entire watershed concentrating on the "off-site" lands of the watershed. This level of investigation will examine the agricultural lands and practices not located on the development proper.

II. Overview of the entire watershed concentrating on the "on-site" lands of the watershed. This level of investigation will examine developing lands and common areas located on the development. These areas may offer the greatest opportunity for sediment and nutrient control.

III. Identification of problem areas in sediment and nutrient loading from the development infrastructure. This level would include a segmented study of specific portions of the on-site development, such as at cul-de-sac scale.

IV. Development of a "check list" which may be used by the P.O.A. or other reviewing agencies in assessment of future construction. The "check list" would include listings of various site specific erosion control methods and materials; temporary and permanent flow diversion and drainage structures as well as bank protection measures.

The concerns to be identified in the watershed were as follows:

a. Watershed inputs of sediments/nutrients to the Lake;

b. What are the probable sources;

c. Can sediment/nutrient loading be quantified;

d. How can the sources of sediment/nutrients be reduced from affecting the lake?

The main purpose of this investigation was to target the area(s) which would be the highest priority(ies) for land treatment systems for trapping nutrients and sediments in the watershed. Possible solutions consist of settling basins, constructed wetlands, sediment traps, ponds, shallow water habitat areas, or variations in agricultural and non-agricultural land-use practices, etc. These terms are descriptive of similar broad-scale land treatment concepts that would reduce nutrient and sediment loading to the Lake Louise system. Other upland agricultural practices such as terracing, grassed waterways, conservation tillage, and animal waste disposal are all vital methods to improve the water quality of the lake. These practices, however, are largely beyond the direct control of the P.O.A. The Porter County SCS office has been appraised of the areas felt to be contributing excessive amounts of sediment and nutrients or that would otherwise benefit from programs beyond the scope of this study. The goal of this study is to focus on the site(s) of greatest potential; to most benefit the lake system in the shortest time; and to attempt to identify the process to create this system and its costs. The final considerations that would evaluate the feasibility and/or priority of such constructed projects would then be up to the Shorewood Forest P.O.A. leadership.

This study included the use of the following resources:

a. Reconnaissance of the entire watershed by site visits on several occasions;
b. Walking tours of some private property areas that could not be properly observed from public areas;
c. Aerial photographs (County Surveyor);
d. Aerial photographs (USDA - Soil Conservation Service, 1972 and 1976);
e. Aerial color infrared photographs (NAPP, 1987);
f. United States Geological Survey (USGS) map, Palmer Quadrangle;
g. United States Fish and Wildlife Service, National Wetland Inventory map, Palmer Quadrangle;
h. USDA - SCS Soil Survey of Porter County Indiana, issued 1981;
i. Porter County records: Auditor, Health, Highway, Surveyor, Treasurer, etc:,
j. Various meetings and/or telephone conversations with State & County agencies, local property owners and;
k. Reconnaissance by ESI to determine suitability of potential constructed option target sites.

WATERSHED INVESTIGATIONS

NATURAL FEATURES

The Shorewood Forest watershed falls in the Valparaiso Moraine Section of the Northwestern Morainal Natural Region (Homoya et al, 1985). The Northwestern Morainal Natural Region is one of the most diverse regions in Indiana. Natural community types common to this region include bog, fen, seep spring, marsh, lake, sedge meadow, prairie and various deciduous forest types. The aquatic communities may be characterized by the presence of bulrush, marsh fern, cattails, pond weeds, spatterdock, Virginia arrow-arum, orchids, and various species of sedges. The typical forest community which at one time covered over half of this natural region, marks the western limit of the beech-maple community of the lower Lake Michigan region. Other notable species include white and red oak, shagbark and pignut hickory, and black cherry.

Techniques useful in preserving these natural features include:

a. Avoid relocation of natural stream channels

b. Avoid building close to wooded ravines or stream banks.

c. Preserve natural vegetation adjacent to water areas.

d. Avoid construction in, or drainage of, wetlands.

e. Encourage preservation of remaining upland forest, wetlands and upland depressions possibly in the form of parks or common areas.

LAND-USE

Aerial photography is an intricate tool for use in many topographic and natural resource applications. In doing a land use study using aerial photography, several items must first be considered to provide the most accurate detailed information possible in obtaining the desired data.

First, and probably most important in doing a study of primarily agricultural usage, the "type" of photograph used is important. For the most part, two "types" of photographs exist: 1) those taken in the visible spectrum, and 2) those taken in ultraviolet or infrared spectrum of light. Since all living organisms emit energy in the electromagnetic spectrum and since our study is based primarily in an agricultural watershed area, color infrared photography was used. This type of photography delineates plants through size, density, and respiration, by photographing specific intensities of electromagnetic radiation emitted. Fallow lands, lake and wetlands appear as grey or black areas on the photo.

Second, the date in which the photographs were taken is an important consideration in the determination of the results and comparison to current trends. Month and day play a factor in the interpretation of the types of vegetation and wetlands described. An extreme example of this would be trying to distinguish agricultural usage on a photo taken in July compared to the same photo taken in December. The day is also a factor because of previous weather conditions. The photographs used for this study were taken on the June 2, 1987 fly-over at a scale of 1:10000 (Figure 37).

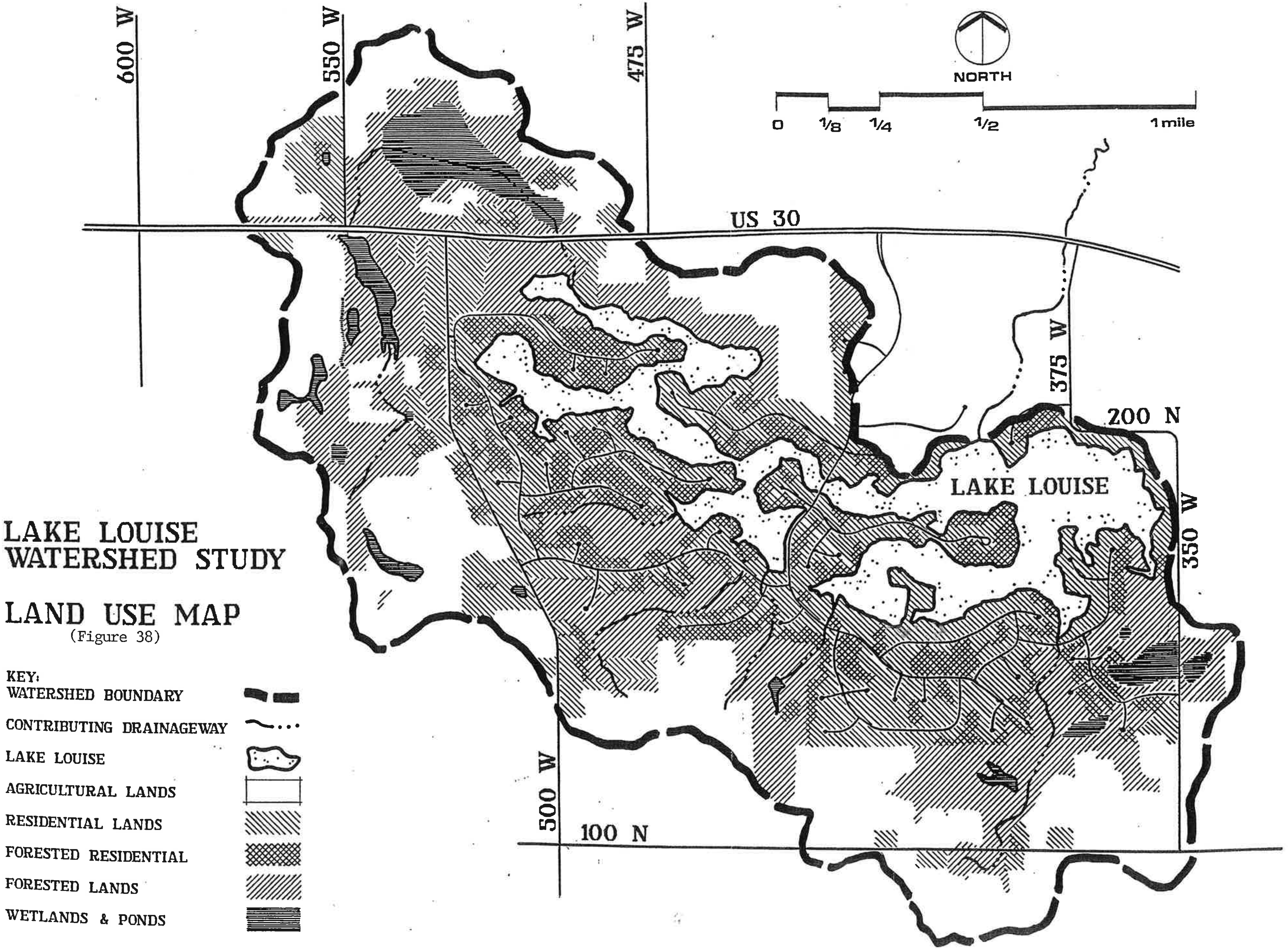
In doing the study of Shorewood Forest, the entire watershed was laid out on the photographs using a transparency, and then divided into respective sub-watersheds. The size of an overlay grid (1 acre) was then calculated, drawn, and then placed over the photos. From there, each sub-watershed was divided into the following land use categories:

* Agriculture
* Forested/Residential
* Lake Louise
* Forested
* Residential
* Wetland

Tabulated results are shown in Table 3. Additional graphical representation of each land use category is shown Figure 38.

Climatological data for Shorewood Forest watershed during May and June of 1987 indicates that the average precipitation for this time period was 1.14 inches above normal. Interpretation of this data, in conjunction with the aerial land-use study may overemphasize the amount distributed to the wetland category. Major wetland depressions were cross checked against the National Wetland Inventory maps for accuracy.

Figure 37. 1987, color infrared aerial photograph of the Lake Louise watershed. Overlapping photos were viewed using a stereo scope to determine land use.



LAKE LOUISE WATERSHED STUDY

LAND USE MAP

(Figure 38)

Aerial photographs are also examined for current prominent erosion or deposition sites. The results of this examination can direct some target site selection and priority considerations.

Table 3. WATERSHED LAND-USE CHARACTERISTICS

Total Watershed Area (acres)	1636.0
Drainage Area (acres)	1410.0
Agriculture	410.3
Forested	352.6
Forested/Residential	194.8
Residential	369.5
U.S. 30	11.6
Lake Louise	226.0
Wetland	71.2

Land Use Trends

Historically, there have been few major changes in land use in the Shorewood Forest watershed. The main land use prior to development of Shorewood Forest was agricultural. Minor shifts in the type of agricultural land use were frequent due to the varying demands of the world market. The seventies and early eighties saw a trend to convert pasture and grasslands to cropland, primarily due to declining livestock prices and fluctuations in grain prices. The areas effected most by this change were lands with severe slopes that previously had been forested or in pasture were being converted to row crop. Current and projected agricultural land-use trends in the Shorewood Forest watershed are to enlist more low production non-prime agricultural land to CRP type and land treatment programs. This will likely increase the amount of forestland and wetland throughout the watershed. This is a reflection of the HEL provision of the 1985 farm bill that calls for highly erodible fields to be farmed with conservation methods in order for the operator to be eligible for government programs. Forested lands and wetlands have witnessed the greatest decline due to drainage and development. The past 20 years have seen the conversion of about 500 acres of forested land and wetland to residential. Anticipated land-use trends in the Shorewood Forest watershed will be the continued residential development of forested and agricultural land. The future quality and preservation of Lake Louise will be dependent upon the methods and controls placed on future development as well as treatment efforts for existing watershed runoff impacts.

> The past ten years have witnessed an extraordinary revival of interest in the drainage and reclamation of our non-arable swamp lands, and it is safe to predict that no movement will be attended with more beneficial or far reaching consequences.

1914 "Drainage and Reclamation of Swamp and Overflowed Lands" Bulletin No. 2, Indiana Bureau of Legislative Information

According to the 1979 Cowardin et al classification system, water regimes range from temporarily to permanently flooded. Forty-seven percent of the wetlands located in the Shorewood Forest watershed have been impounded, excavated, ditched or partially drained. Eighty-eight percent are small, 1 to 5 acre, palustrine wetlands (Table 4). Palustrine is defined here as wetlands less than 20 acres in size, averaging less than 6 foot in depth, and dominated by trees, shrubs, and/or emergent vegetation (Mitsch and Gosselink, 1986). An explanation of wetland class may be found in Appendix A.

Table 4. Shorewood Forest water regime characteristics.

Palustrine	Occurrence	%Totals
< 10 Acres	30	88
> 10 Acres	4	12
Totals	34	100
Type		
Emergent	28	82
Forest	3	9
Scrub / Shrub	3	9
Totals	34	100
Water Regime		
Temporary	3	9
Saturated	1	3
Seasonal	10	29
Semi-permanent	11	32
Intermittently Exposed	6	18
Permanent	2	6
Unknown	1	3
Totals	34	100

Computer Modelling: Hydrology

The watershed of Lake Louise is a highly complex drainage basin. This is due to the natural morainal topography of the region, and drainage modifications necessary in the urbanization of this watershed. In developing the hydrology study for Shorewood Forest, the primary watershed was delineated to its smallest contributing drainages or subwatersheds. Twenty-eight contributing subwatersheds (SW) were delineated from the primary Lake Louise watershed (Figure 39), and targeted for an indepth study of hydrology.

The focus of the study, a computer model using SEDIMOT-II, (Warner, 1983) was used to project storm runoff, and hydrographs for five year storm events. Data used for the computer model were derived in part from the land use study. Cover types for each segment of the subwatershed were assessed using color infrared aerial photographs, soil input was supplied by the USDA-Soil Conservation Service (Porter County SCS), and slope segments were determined using information from the U.S. Geological Survey. Other factors involved in SEDIMOT-II include: storm type (SCS); event type, (in this case, modeling runs were made using rainfall depths from a SCS 5 year storm event); soil types; vegetative cover types; basin relief; drainage area; length of drainage segment; and if applicable, control structure type. A summary of input data is presented in Appendix B.

The modeling techniques used in the SEDIMOT-II program are divided into two major areas:

1) Rainfall Component. The rainfall component uses a given rainfall depth for a specific storm event, converted into a temporal storm pattern (storm duration over a given geographical area and time) because a large portion of the rainfall may occur over a small period of time with fluctuations in intensity.

2) Runoff Component. The runoff component determines the depth of rainfall in 0.1 hour increments given a 24 hour storm event (TR-55, 1986). The runoff is distributed over a period of time according to predicted rainfall. The runoff component is then used to determine hydrographs at specific locations throughout the watershed.

Results of this study were used to identify and rank subwatershed areas of greatest flow, and probable sources of direct sediment and nutrient loading. A summary of hydrology output is presented in Tables 5 and 7. This information was used to identify the nine subwatershed inlets monitoring stations. (For further discussion of inlet sampling see Stream Chemistry).

STATION	ALKALINITY (mg/L CaCO3)	CONDUCTIVITY (umho/cm)	NITROGEN: NITRATE/ NITRITE (mg/L)	TOTAL: PHOSPHORUS (mg/L)	ORTHO-PHOSPHORUS (mg/L)	TOTAL SUSPENI SOLIDS (mg/L)
SW 1	154.00	500.00	14.70	0.06	0.04	17.00
SW 2	134.00	490.00	12.30	0.05	0.05	4.00
SW 3	136.00	550.00	17.80	0.06	0.01	13.00
SW 5	230.00	690.00	17.50	0.03	0.02	2.00
SW 6	222.00	900.00	10.60	0.04	0.02	7.00
SW W	26.00	310.00	19.80	0.06	0.04	46.00
SW 7	32.00	660.00	13.80	0.11	0.11	3.00
SW 8	252.00	850.00	10.40	0.06	0.05	10.00
SW 9	238.00	750.00	16.00	0.08	0.06	8.00
SW 16	83.00	600.00	1.60	0.13	0.04	42.00

* The high value for TSS is attributed to an accumulation of rust particles in the well tap, and is not considered to be a normal discharge.

Table 9. Physical and Chemical Parameters for the 1990 Inlet Survey of Lake Louise.

Both alkalinity and conductivity displayed a great deal of variability between the stream stations. Total alkalinity ranged from 252 to 26 mg/L with the lowest values reported at the lake well and outflow from wetlands in SW 7. Specific conductivity ranged from 900.00 umho/cm at SW 6 to 310 umho/cm at the lake well. Inlet values for both parameters were much higher that those reported in the lake, with the exception of SW 7 and the lake well. It is likely that the wetlands in SW 7 and Lake Louise are trapping carbonates associated with primary production and sedimentation.

Nitrite/nitrate nitrogen ranged from 1.60 mg/L at SW 16 to 19.80 mg/L at SW-W, with the median value of 14.70 mg/L. Such values are considered very high. The fact that the lake well (SW W) sample was the greatest value reported indicates that ground water may be a significant nitrogen source in lake nutrient (nitrogen) loading. The low value reported at SW 16 is attributed to time of sample (minimal fertilizer residue) and insignificant ground water discharge. The high nitrogen values at lake inlets are surprizing considering the much lower values reported in the lake. It is apparent that the lake is effectively trapping nitrogen loading from the watershed. This is supported by the nitrogen:phosphorus ratio discussed in the Lake Investigations section of this report. Limiting the flow of nitrogen to Lake Louise, from watershed land-use sources is paramount in controlling and/or preventing the expansion of aquatic macrophytes in the lake.

Ortho-phosphorus, a soluble form of phosphorus, and total phosphorus were measured at all inlet stations. The rank ordering of the inlets for the two forms of phosphorus are similar. Ortho-phosphorus ranged from 0.11 mg/L to 0.01 mg/L. Total phosphorus ranged from 0.13 mg/L to 0.03 mg/L. The highest overall phosphorus values were reported from SW 7. Considering the time of year the sample was collected, this value likely reflects a release of nutrients stored in wetland vegetation, rather than the normal export from this subwatershed. It should be noted that phosphorus has been identified as the nutrient most frequently responsible declining water quality and expansion of algal blooms in Indiana lakes. It appears that Lake Louise is effectively trapping phosphorus exported from the watershed, most probably in the form of seasonal algal blooms. In general, the reported values are comparable to other lakes in Indiana.

Finally, total suspended solids were greatest for SW 16 reported at 42 mg/L. This value is considered very high and likely reflects road sediment. SW 1 followed with a value of 17 mg/L. The remaining interstation differences were relatively minor (13-2 mg/L).

Watershed Loading: Sediment

Watershed inputs of sediment to Lake Louise have been placed into three groups, or watershed source areas: off-site; on-site (developing lands); and on-site (incidental).

1. Off-Site Sediment Loading.

Off-site sediment loading areas are divided among three land-use cover types: Agricultural; Forested; and Developed (limited small residential and U.S. 30).

Erosion from agricultural lands is generally viewed as the primary source of sediment loading to lakes in Indiana. This however, is not the case in the Shorewood Forest Watershed. The agricultural lands in the off-site portion of the watershed are for the most part, well-maintained. The majority of these lands are in conservation tillage programs according to the Porter County SCS. Field investigations conducted by ESI throughout the course of this study confirmed that the majority of agricultural operations are utilizing some form of soil conservation practice: crop rotation, conservation tillage systems, crop residue, etc.

The off-site forested and developed lands are generally well stabilized, and do not present a great erosion threat to Lake Louise. This must be qualified, in that some of this land is intended or proposed for future residential development. At that time, those lands would be considered a high sedimentation threat to Lake Louise. This case is discussed further in the following section.

2. On-Site Sediment Loading (Developing Lands)

The established residences and common areas of Shorewood Forest are, for the most part, stabilized. This is to say that these areas have permanent cover and are not highly susceptible to erosion with the exception of gully or stream bank cutting in open drainages.

On-site sediment loading, specifically, erosion from developing lands, is determined to be the greatest sedimentation threat to Lake Louise. This is evident by the extent of lake infilling at the inflow from SW 1.

Sediment from developing lands is carried to the lake in stages during successive storm events. The constructed option proposed in SW 1, and recommended for SW's 2, 3, and 4, is designed to intercept sediment which has been dislodged. The Erosion and Sediment Control Guidebook and Checklist, Appendix E, was developed to control erosion of, and reduce transport of sediment from developing lands.

3. On-Site Sediment Loading (Incidental).

Incidental on-site sediment loading is responsible for the deltas which are readily observable at the mouths of inlets on SW's 8-28. The deltas are mainly comprised of 'heavy' (high specific gravity) sediment made up of coarse silt and sand. The deltas are formed when the 'heavy' sediment carried in at the inlets, is quickly dropped out of the flow due to the decrease in velocity of flow entering Lake Louise.

A partial source of this loading is attributed to small scale residential improvements, such as unprotected landscaping or minor home additions. The primary source of sediment in this group is thought to be road salt (ice sand). According to the Porter County Highway Department, the 8.9 miles of streets within the Shorewood Forest, Lake Louise watershed, are sanded an average of 37 times per year. It is estimated that over 7,800 cubic yards, or 10,500 tons of ice sand is applied per year in the Lake Louise watershed. The application rate and volume of ice sand placed on development roads is necessary for the safe operation of motor vehicle traffic. In fact, during unusually hard winters, the application rate may need to be increased. With the understanding that the ice sand is necessary, a means of preventing this sediment load from entering Lake Louise must be addressed. The box culverts usually located at the end of each cul-de-sac are "designed-in" partial solutions to this loading problem. A strict regiment of monitoring and maintenance cleaning of these structures and regular street cleaning is of paramount importance in preventing road borne sediment from entering the lake. Additional measures will be necessary in controlling the flow of development generated sediment to the lake. These measures include construction of control structures as recommended for SW 16, and utilizing the Erosion and Sediment Control Guidebook and Checklist. The constructed option recommended for SW 16 is considered to be 'typical' of constructed options which could be implemented on applicable inlets (drainage easements) in category 2. A concept design of this structure is presented in Figure 47 of the constructed options section of this report.

Erosion: Causes and Prevention

Erosion of soil is primarily caused by the force of raindrops striking the ground, and, secondly, by the force of water flowing in rills or channels. As rain falls on unprotected ground it breaks small particles of soil free. These soil particles are then carried away by sheets of water. Naturally, as the intensity of rainfall increases, velocity and volume (flow) of runoff increases, thus potential soil erosion increases.

Types of soil erosion probable or noted in the Shorewood Forest watershed:

1. Raindrop (or splash) erosion due to the impact of rain on unprotected land, i.e. developing lands.

2. Sheet erosion or overland flow causes exposed soil to be suspended by the action of the flowing water, this is common on sloping to nearly level unprotected land. This may be one of the most common forms of erosion on unprotected developing lands.

3. Rill and gully erosion is the result of concentrations of runoff water in rivulets. Rill erosion may cut several inches into the topsoil, gully erosion resulting from unmaintained rills or drainages may cut several feet into the surface.

4. Streambank and channel erosion is a result of scouring stream bottoms and undercutting of stream banks by high velocity flows.

The erosion potential of a given area may be determined by four criteria: 1) soils; 2) surface cover; 3) topography; and 4) climate. An understanding of soils, and the factors involved in making soil more susceptible to erosion include: soil texture, soil structure, soil content of clay or organic material, and soil permeability. Maintaining adequate surface cover, either in the form of vegetative cover or erosion control material, is important in reducing soil loss. The realization is that soil is a valuable resource, and particles are difficult and expensive to recover once erosion has begun.

Prevention is easier than correction!

Useful concepts in erosion prevention and control:

a. Maintain natural vegetative cover wherever possible.
b. Protect sloping areas. Vegetation is difficult to establish and maintain on eroded slopes.
c. Divert runoff from severely sloping areas.
d. Break up long slope lengths by landscaping when natural cover is not maintained.
e. Stabilize drainage areas immediately following any construction or "maintenance".
f. Leave natural buffer areas along streams and ditches.
g. Stabilize stream bank or ditch escarpments.
h. Utilize sediment ponds below "open" sloping lands.
i. Construct and maintain sediment control structures prior to construction of any lake or waterfront development.
j. Utilize the Erosion and Sediment Control Guidebook and Checklist whenever possible.

Watershed Loading: Nutrients

Watershed input of nutrients to Lake Louise have been placed into two groups, or watershed source areas: off-site (agricultural lands); and on-site (developed lands). Other sources commonly identified as adding to the cultural eutrophication of a lake, i.e. faulty septic systems, confinement and feedlot livestock operations, and industrial/commercial point source inputs were not considered to be a problem in the Lake Louise watershed.

1. Off-Site Nutrient Loading.

Nutrient loading associated with agricultural land-use has been determined to be the greatest off-site source in the Lake Louise watershed. Agricultural lands make up 410 acres of the total watershed, with a significant portion of the upper reaches of SW's 1-7 in agricultural production. Nutrient export from agricultural lands is influenced by a number of factors including soil type, fertilization rate, tillage practice, crop type, crop management practice. Nutrient export coefficients from agricultural lands in the Lake Louise watershed are based on Reckow and Simpson 1980. The mean predicted nutrient export from agricultural lands are as follows:

NITROGEN: 14.76 Pounds/Acre/Year. Thus, mean nitrogen export from agricultural lands is estimated at 6,051 pounds per year.

PHOSPHORUS: 1.01 Pounds/Acre/Year. Thus, mean phosphorus export from agricultural lands is estimated at 413.59 pounds per year.

Under normal circumstances, nutrient export from agricultural lands is one of the primary causes of eutrophication in Indiana lakes. Nutrient loading from agricultural lands is certainly a factor in the current water quality of Lake Louise, however, residential land-use is considered to have influenced the water quality of Lake Louise to a greater degree. This is due to the position of agricultural lands within the watershed, and drainage of these lands through large forested and wetland tracts. Nutrient loading of Lake Louise from these lands is expected to be approximately 60 percent less than the predicted export values. Mid-watershed removal of nutrients is attributed to physical and biotic processes (Eviston and Ellingson 1989).

2. On-Site Nutrient Loading.

On-site (urban lands) nutrient loading is influenced by housing density, vegetative cover, fertilizer application, pet density, waste handling, and common areas with nutrient loads or runoff channeled into storm drains from each SW area. Upon review of potential nutrient sources from the on-site watershed area, it was quickly determined that residential runoff, specifically fertilizer was the greatest watershed nutrient source to Lake Louise.

ESI and the Shorewood Forest P.O.A. prepared and circulated a questionnaire (Appendix C) to determine the frequency and use of lawn care products within the Lake Louise watershed. A random sample of Shorewood Forest residents was conducted to test the validity of this survey (Walpole 1983). The random sample of the population confirmed the survey results with similar application trends and distribution in the 'residential' land-use category. Results from the 'residential/forested' land-use category were inconclusive. This is due to varying rates of application (higher concentration of phosphorus in fertilizer over a smaller area) (Turgeon 1985), therefore the residential/forested land-use was excluded from the following discussion.

Of the 894 surveys distributed, the S.F.P.O.A. received 103 (11.5%) completed questionnaires. Survey results indicate that about 97 percent of Shorewood Forest residents use some form of lawn care product (fertilizer) at least once a year. The mean fertilizer application rate is 4 times per year, with the maximum reported application rate of 6 per year. Fifty-two percent of the population apply their own fertilizer (Scott's Turfbuilder 29-3-4, or Scott's Halt+2 27-3-3). Forty-five percent of the population use a professional lawn care service: Perma-Green, Lawn-Scape Pro, or Nutri-Lawn. It should be noted that Perma-Green and Lawn-Scape Pro have removed or substantially reduced phosphorus from their lawn treatment in Shorewood Forest. This is an important step in limiting the export of on-site phosphorus loading, however, based on the fact that Lake Louise is nitrogen limited (aquatic weed growth is 'limited' to the available amount of nitrogen in the water) residents must reconsider the current application rate of nitrogen in their lawn treatment. Nutri-Lawn declined to respond when queried about application rates or nutrient ratios.

Statistical inference of survey results indicate that residents apply fertilizer an average of 3,100 times per year. With respect to Lake Louise, the predicted nutrient export from residential lands within the on-site watershed are as follows:

NITROGEN: 22.65 Pounds/Acre/Year. Mean nitrogen export from residential lands is estimated at 8,370 pounds year.

PHOSPHORUS: 2.20 Pounds/Acre/Year. Mean phosphorus export from residential lands is estimated at 805 pounds per year. Mean phosphorus export from residential and forested residential lands is estimated at 3.30 Pounds/Acre/Year or, 1,220 pounds per year.

The average nutrient export from a 'typical' residential watershed is included for comparison: 7.52 Pounds of Nitrogen/Acre/Year and 2.06 Pounds of Phosphorus/Acre/Year. Obviously, the calculated nutrient export from the residential watershed of Lake Louise is above normal.

Residents are cautioned to use only as much fertilizer as their lawns require, as excess nutrients are likely to be carried into your lake. Applying too much fertilizer to lawns is not only uneconomical to the land owner, but is one of the primary causes of the algae blooms and expansion of aquatic 'weeds' in Lake Louise.

The following guidelines for fertilizer management have been adapted from the Indiana Clean Lakes Program (IDEM 1990). In addition to these guidelines, it is recommended that land owners have their soil tested prior to applying fertilizer. Instructions and/or sample kits may be available at the Porter County extension agent (Appendix D). Soil samples can be mailed to Purdue University for analysis at a minimal cost.

1. Use fertilizers containing less than 0.5 percent phosphorus in liquid form, or 3.0 percent in granular form.

2. Use organic fertilizers whenever possible. Organic fertilizers release their nutrients slowly.

3. Make sure that your soil is rich in organic matter (particles of leaves, grass and other rotted material). Nutrients in fertilizers stick to this organic matter until needed by plants.

4. DO NOT apply fertilizers to your lawn between November 15 and April 15. Plants can not use the nutrients during this period, allowing the fertilizer to run off into your lake.

5. Residents may wish to consider using lake water for irrigation and fertilization of lawns. One 0.5 inch application of lake water to lawns would provide an average of 5.36 pounds of nitrogen per 1000 square foot, and 2.14 pounds of phosphorus per 1000 square foot. This is comparable to the average annual application of fertilizer used by Shorewood Forest residents.

Results from the Wilson Ditch constructed wetland site (near Culver, Indiana), designed by Earth Source Inc., showed mean total phosphorous was reduced 90%, while mean total nitrogen (nitrate/nitrite) was reduced 85% during the 1988 summer monitoring program. Mean total phosphorous was reduced 60% and mean total nitrogen was reduced 65% during the 1988 winter monitoring program (Eviston and Ellingson 1990).

Constructed Wetland Habitat

Potential exists for the construction of sediment/nutrient control structures to increase the overall wildlife habitat and production capabilities for the Shorewood Forest area.

Primary fisheries production in the Shorewood Forest area could benefit greatly by increased wetlands. Virtually all sport fish production is dependent on wetlands, either for spawning, cover or planktonic food production. Game fish are major benefactors of increased wetland spawning area. They spawn in the wetlands and then return to the lake proper.

Increased wetlands will draw waterfowl away from areas of moderate human use. Productivity is likely to increase while the "nuisance factor" decreases. Song birds are drawn to wetlands for a number of reasons: nesting structure provided by persistent emergent vegetation (cattails); security cover; and food production. Species such as the Great Blue Heron, Yellow Rail, Great White Egret, and Yellow-headed Blackbird (all of which are state threatened, rare or of special concern) will locate near wetlands for many of the same reasons as their avian counter parts.

Fur-bearing animals like beaver, mink and muskrat depend on wetlands primarily for food, security cover and den sizes.

Muskrats and mink are likely be the first fur-bearers to colonize a shallow constructed wetland. These prolific mammals do well in areas which provide low water flow and emergent aquatic vegetation such as cattails. The beaver is another valued furbearer likely to colonize a constructed wetland in the Shorewood Forest Lake area.

If muskrat den/foraging or beaver den/dam building activity strays from or damages the constructed wetland and wetland structures it may become a nuisance, therefore, populations will require careful monitoring and controlled.

In summary, a constructed wetland is capable of increasing and supporting a diverse number of habitants. It should be noted that a constructed wetland is also constructed habitat. By design, these areas may attract species of special interest, through planned inclusions of required habitat components.

Sediment and Nutrient Removal

In order to quantify the effectiveness of a control structure or constructed/enhanced wetland in removing sediments and nutrients, it is first necessary to develop a concept design for the site. Using the conceptual designs presented later in this report, a flow model was developed. Flow models are used to determine particular hydraulic characteristics for a given site at a given point in time. In this case, flow models are used to determine the surface loading rate (SLR) (Barfield 1987). The SLR is used to derive the position of a particle (sediment) with a given diameter, within a system at any given point. With this information, a settling velocity can be predicted for particles entering a system based on particle size, distance and time. The predicted sediment removed is determined by the size of particles equal or larger to that of the design settling velocity.

Nutrients are removed from a system in two basic ways: 1) by biotic processes in which they are utilized by plants and bacteria or; 2) by physical processes in which nutrients bonded to sediment particles settle out. Nutrients often travel through a system bonded to particulate matter. Thus, as sediments are settled out, so are the nutrients attached to them. Sedimentation is the settling out of soil particles which have been transported by air or water. Sedimentation occurs when the velocity of the transport medium (water) is slowed adequately and for a sufficient period of time (detention time) to allow for the soil particles to settle out. Larger, heavier particles require high velocities of runoff to be transported and are quick to settle out. Smaller, lighter soil particles are transported by suspension or by moving (tumbling) along the surface. Fine silts and clay materials are generally transported in suspension. These smaller soil particles are difficult to recover once eroded. Substantially lower velocities and greater detention times are required to settle these particles out.

Specific site design would be necessary to predict the actual amounts of sediments and nutrients transported through a system or to quantify the amount removed by a specific control structure. It is possible, however, to relate sediment removal efficiencies using the SLR, with data from the concept plans and mean flow reported for the 5 year return storm.

Findings of this model indicate: that sediment equal to, or greater than 0.004 mm (very fine silt) will settle out of the system in the SW 1 constructed option (Figure 44); and sediment equal to, or greater than 0.062 mm (very fine sand) will settle out of the system in the SW 16 constructed option (Figure 47). Particle size based on a mean specific gravity of 2.65.

Constructed Options

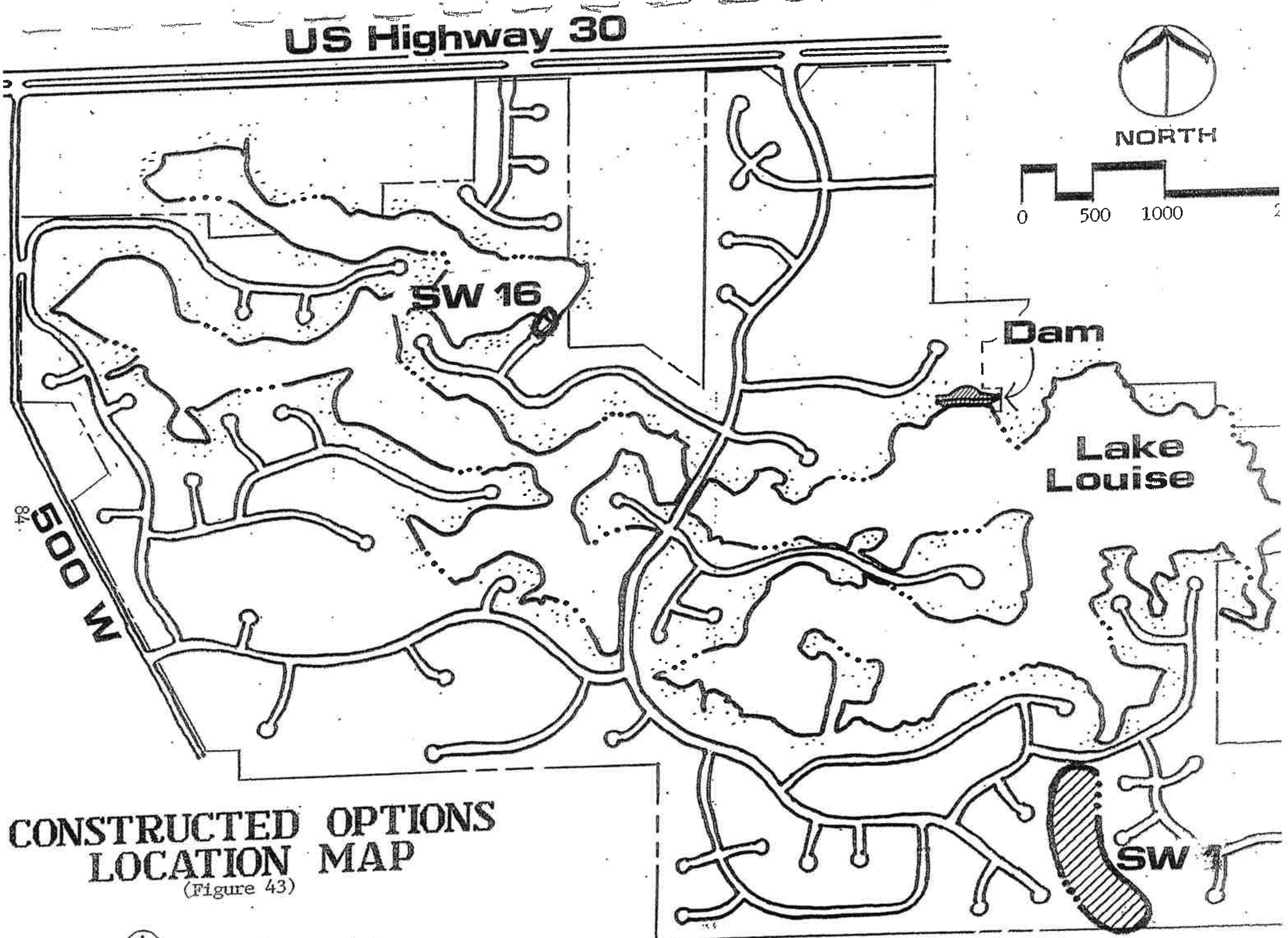
For more than 50 years, wetlands have been identified as water purifying systems for natural lakes (van der Valk, et al 1978). Wetland vegetation, benthic organisms, and soils perform as traps, at least seasonally, for nutrients, suspended sediments, metals, pathogens, and many agricultural chemicals (Kadlec and Kadlec 1978). Thus, during the course of the Shorewood Forest watershed study, a primary objective was to identify nutrient/sediment trap target sites on major contributing ditches. The primary criteria in selecting these sites were: location, topography, flow rates, soils, feasibility, current land use, size, environmental concerns, and sediment/nutrient loading characteristics of the drainage basin (Table 9). For the Shorewood Forest study, a 2' contour map of the on-site watershed was available,

Two sites in Shorewood Forest have been selected for preliminary design of constructed options (Figure 43). Site 1 is referred to as SW 1, which drains a large 'developing' area of the southeast portion of the watershed. Site 2 is located within the drainage easement of SW 16, which is typical of the cul-de-sac drainages of category 2 subwatersheds (SW 8-SW 28).

Project Descriptions:

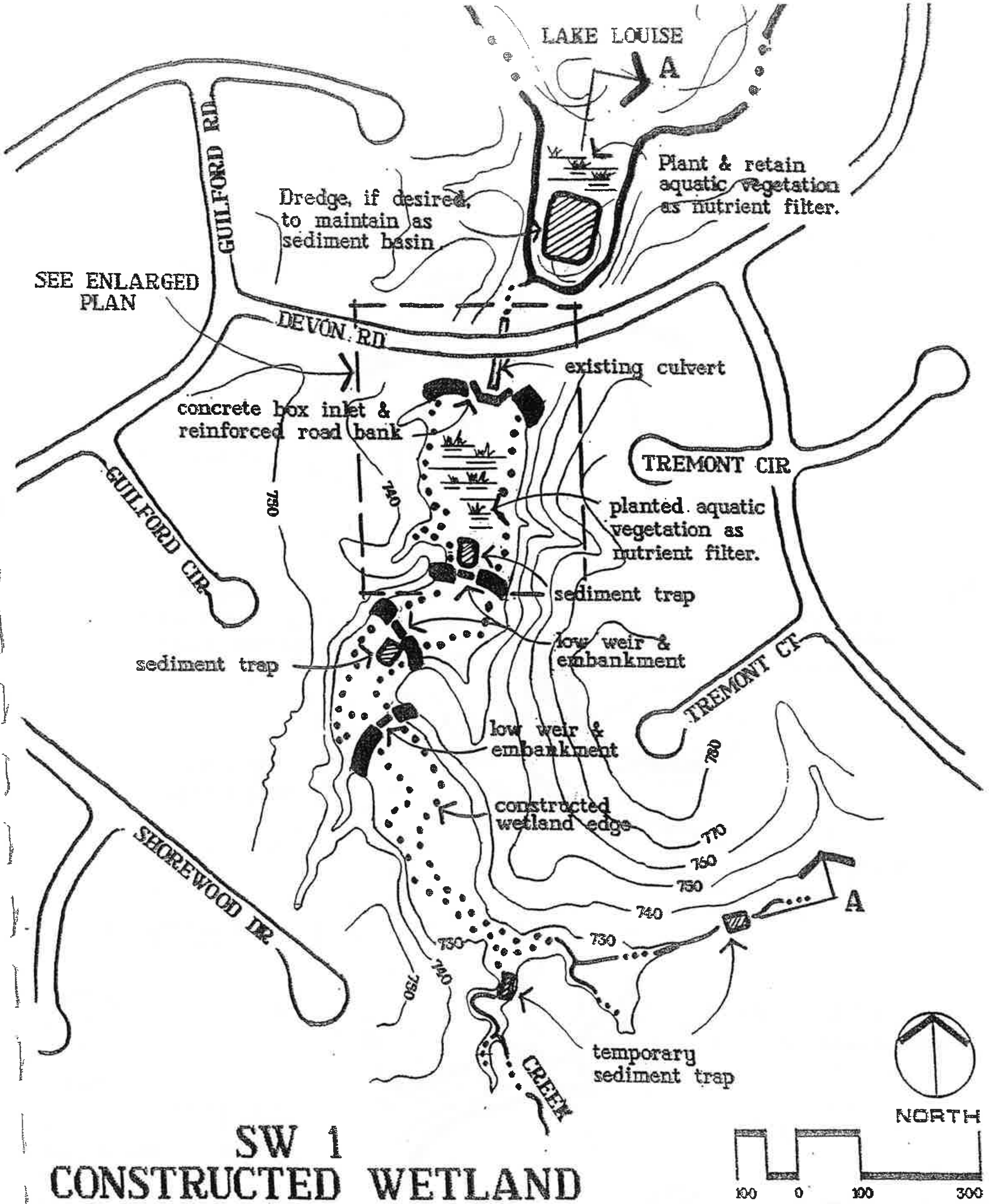
Site 1, SW 1

This proposal (Figures 44, 45, and 46) is the most ambitious individual project to be considered, as it must be, because of the relatively large contribution to Lake Louise by this segment of the watershed (as discussed throughout the report). To effect the best results, a large "contact" area is necessary. This means large shallow areas where hydric vegetation can effect nutrient removal as well as sediment and sediment bonded nutrient removal (see Sediment and Nutrient Removal). This site will also intercept sediment from critically erodible developing lands south and east of the site. To create the system illustrated would require: Excavation of temporary sediment traps on the two secondary streams above which flow into the primary inlet. A series of terrace type settling basins, and a small excavated shallow water area. The excavated material would be for baffles, islands, reinforcement along Devon Road bank, and low level embankments. A water control device and outfall structure would be located along Devon Road. The design would allow for high flows to go through the site while providing flood storage.



CONSTRUCTED OPTIONS LOCATION MAP
(Figure 43)

Earth·Source Inc
[illegible] Airport North Office Park, Fort Wayne, [illegible]

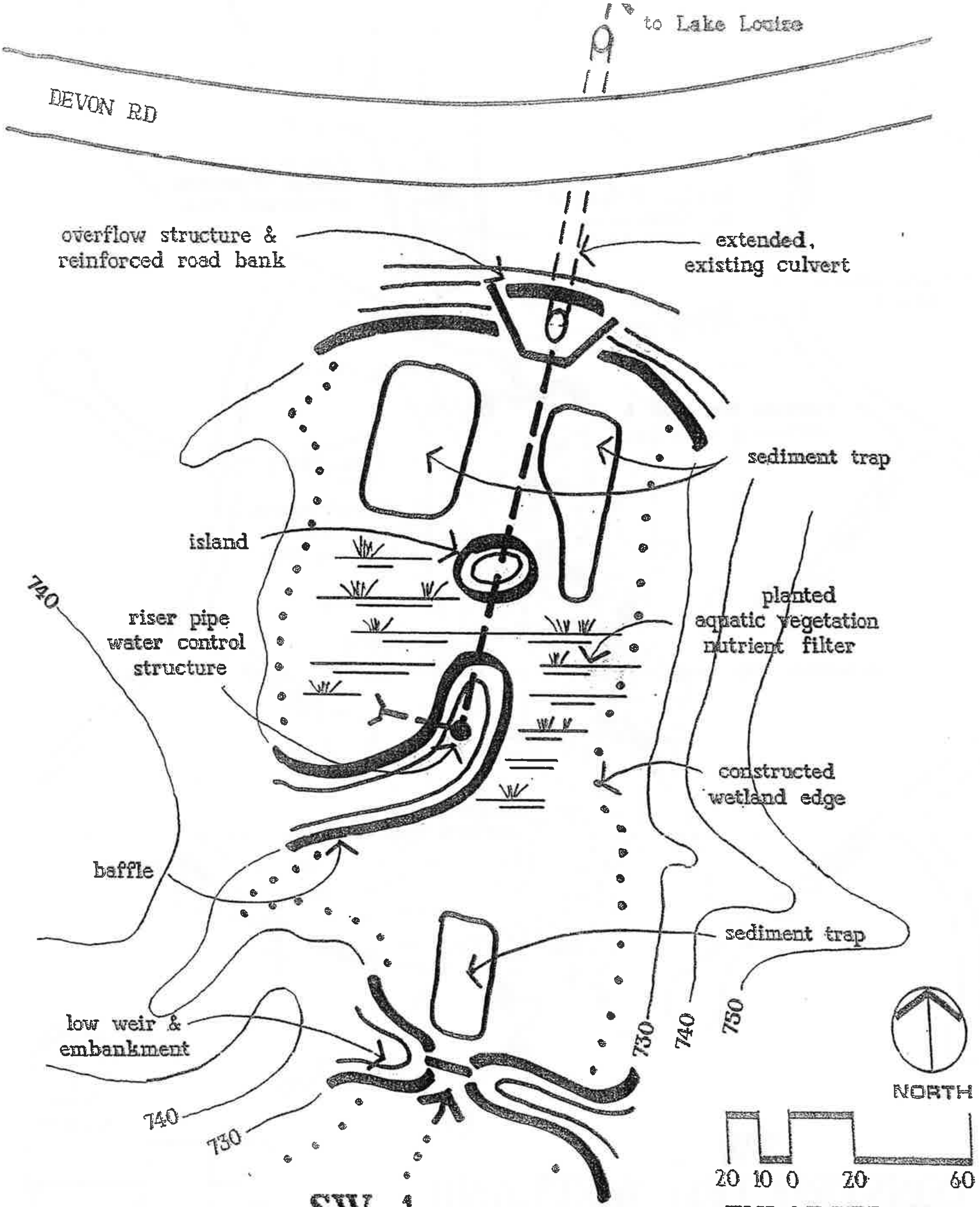


SW 1 CONSTRUCTED WETLAND OPTION

(Figure 44)

CONCEPT PLAN

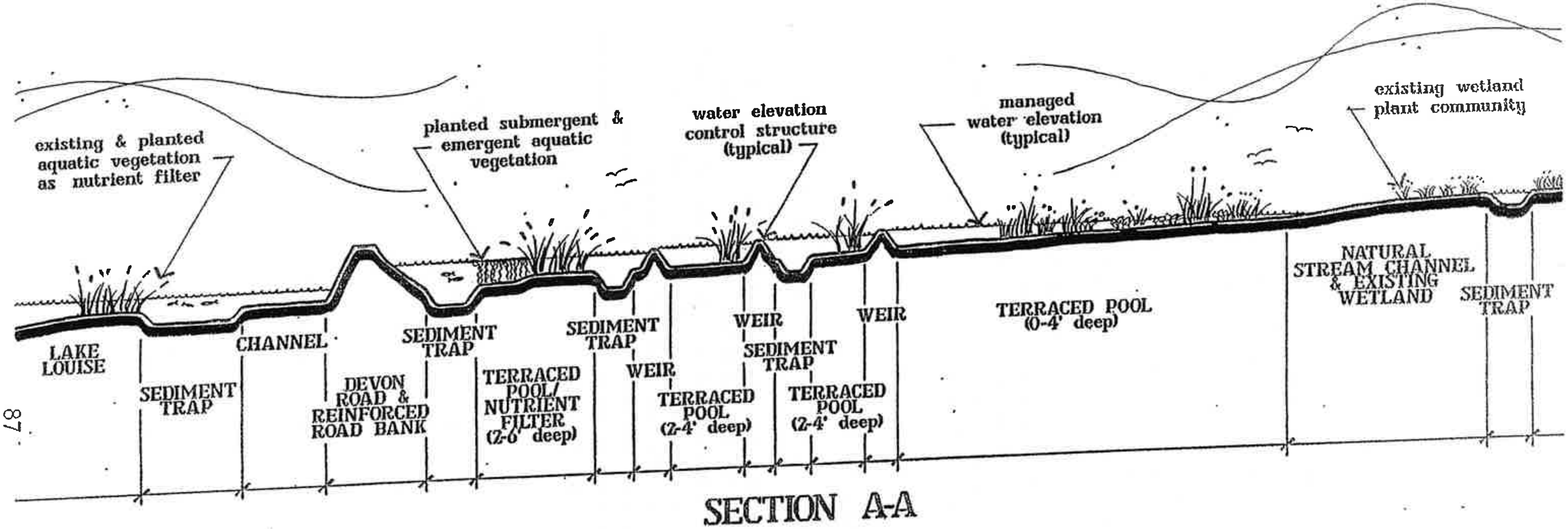
Earth·Source Inc



SW 1
CONSTRUCTED WETLAND
OPTION
(Figure 45)

ENLARGED PLAN

Earth·Source Inc



CONSTRUCTED WETLAND SECTION
(Figure 46)

Site 2, SW 16: CATEGORY 2 'TYPICAL'

The implementation of this constructed option (Figure 47) will capture an important area of on-site cul-de-sac drainage. The concept is essentially to trap heavy sediment particles consistent with road sediment, and filter urban run-off, specifically fertilizer. The constructed option is maintained within the existing Drainage Easement and will consist of a series of three treated timber terraces. The first terrace will include a gravel filter which will allow for sedimentation of larger particles, followed by two vegetated terraces for nutrient uptake. This concept is recommended for suitable drainageways in category 2.

It must be noted that constructed wetlands are not a panacea for lake restoration. Constructed wetlands are an effective means of amassing water borne sediment and nutrients, however, constructed options should be pursued in conjunction with limiting sources of sediments and nutrients throughout the watershed.

Cost Estimates for Constructed Options

The following estimates are offered to represent the anticipated cost factors for construction of suggested sites. During final design, some additional factors may become apparent. To verify existing 2' contour maps or prepare more definitive topography may be necessary and should be part of a proposed design fee. For final design and construction documents, an allowance of 15% to 20% of construction cost should be added to these estimates. Additional cost of services should be added for bidding, construction monitoring and construction administration.

Site 1 SW 1

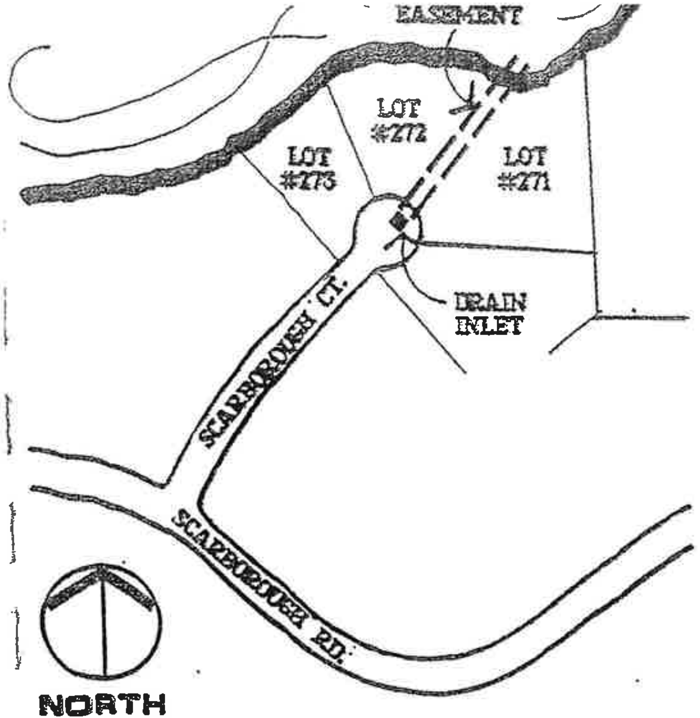
Cost items include clearing, sediment trap excavation, embankment fill, concrete weirs, excavation of nutrient trap, control structure, riser pipe outfall structure, erosion control materials, restoration and seeding.

Estimated cost range: $60,000 - 75,000.

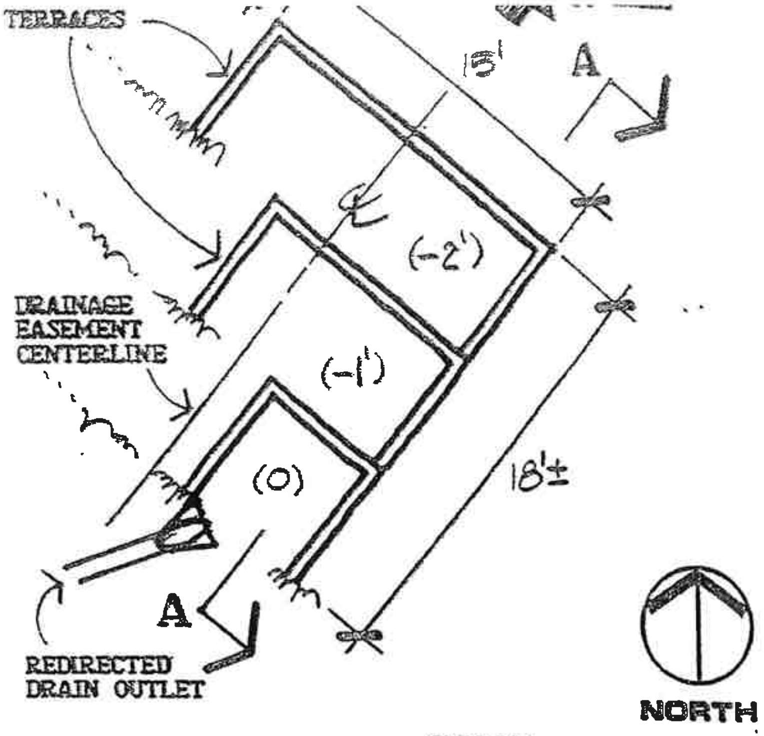
Site 2 SW 16: CATEGORY 2 'TYPICAL'

Cost items include excavation, terrace materials, erosion control materials, stone, restoration and seeding.

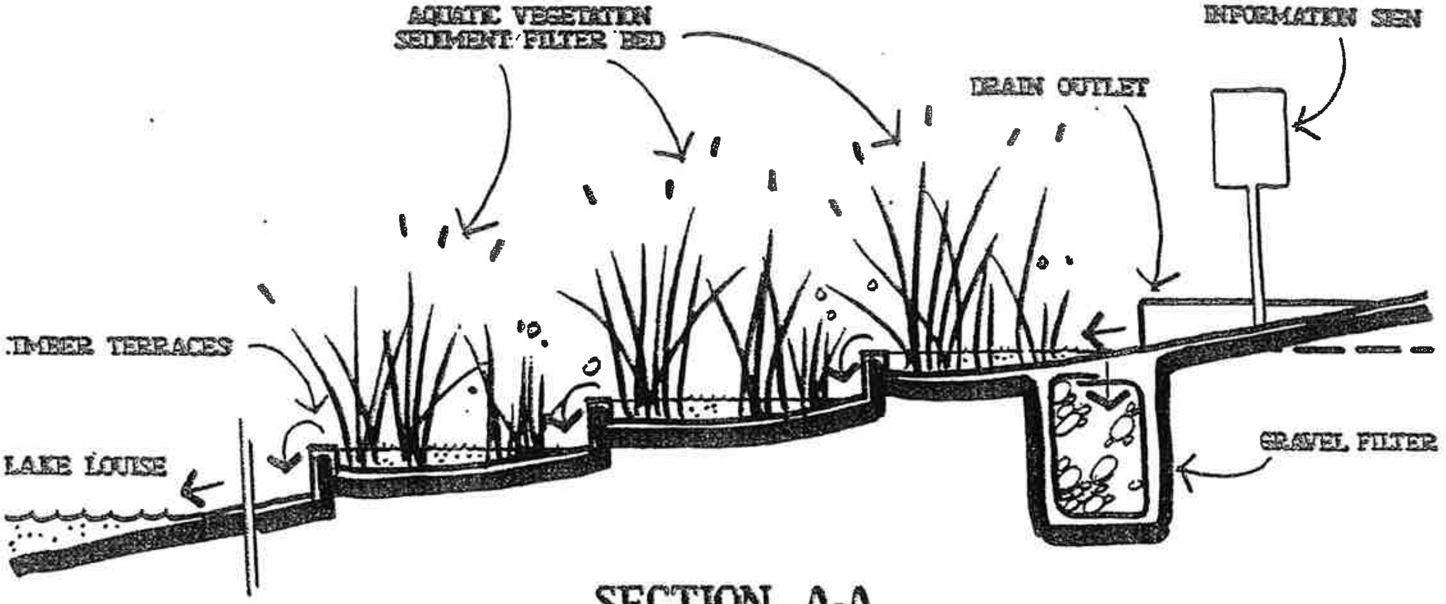
Estimated cost range: $ 1,500 - 2,000.



LOCATION MAP



CONCEPT PLAN



SECTION A-A

SW16
WETLAND TERRACE FILTER/SEDIMENT TRAPPING SYSTEM (Figure 47)

Earth·Source Inc

Conclusions & Recommendations 3.

CONCLUSIONS AND RECOMMENDATIONS

It is apparent that nutrient and sediment loading from the Shorewood Forest watershed has not decreased over recent history, although there is evidence that the primary loading areas have changed with respect to new development pressures. It is also apparent that the lake has met the availability of nutrients by the continued expansion of submergent macrophytes. This is evident by the high concentration of nutrients reported from the inlets compared to the much lower values reported in the lake. The frequent algal blooms reported in Lake Louise are likely due, in part, to nutrients released from decaying macrophytes following chemical weed control measures. Successful aquatic weed and sediment control is dependent on curtailing the flow of nutrients and sediment bonded nutrients to the lake from the watershed. For this reason, priority should be given to implementation of proposed constructed option on SW 1 and the 'typical' constructed options for category 2 subwatersheds (SW 16); development of the constructed options on SW 4, SW 2, and SW 3; further study of more effective aquatic weed management; reevaluation of individual lawn care (fertilizer) requirements; and utilizing the land treatment and erosion control methods detailed in the <u>Erosion and Sediment Control Guidebook and Checklist</u>.

TASK 1: CURRENT WATER QUALITY

The data collected as part of the current investigation form the only complete assessment of water quality in Lake Louise. As such, it is a complete data base against which future water quality changes can be gauged.

Lake Louise is oxygenated completely throughout its water column during summer and does not exhibit pronounced thermal stratification. While most lake stations, especially those of deeper water, exhibit conditions characteristic of low trophic state (oligotrophic), a few stations near major watershed inputs show clear signs of advancing eutrophication. This is clearly the case at the northwest corner of the lake where the surrounding land currently is being developed residentially. It is recommended that additional monitoring be done in Zone I to determine whether the high trophic state of the area is attributable to ongoing construction or reflects major nutrient inputs from other watershed sources. Other areas of the lake displaying signs of decreased water quality are located immediately offshore from point source drainage from the watershed. It is recommended that a less detailed limnological survey of the lake be made at 3-5 year intervals to keep abreast of any problems associated with water quality. While most stations displayed good water quality, several were close to being placed in the category of intermediate quality (mesotrophic).

TASK 2: BOTTOM MAP OF LAKE LOUISE

Approximately 45% of Lake Louise is less than five feet deep, with an additional 25% being less than ten feet deep. Given that most macrophyte problems in Indiana lakes are found in water less than 10-15 feet deep, almost 80% of the surface area of Lake Louise is susceptible to macrophyte problems. Given the morphometry of the lake, it is imperative that nutrient sources from the watershed be reduced to a point that eutrophication does not progress further. Undoubtedly, macrophyte problems will increase in the future if water quality continues to decline.

TASK 3: AQUATIC MACROPHYTES

The chemical control program of 1990 has been extremely effective at elimination of all vascular macrophytes in Lake Louise. The vegetated littoral zone is limited in aerial extent and restricted to Nitella and a few filamentous algal species. Chemical control in Lake Louise should be approached cautiously in the future, and its goal should not be the complete elimination of vegetation in the lake. Aquatic macrophytes serve to reduce shoreline erosion from boat generated waves, act as effective nutrient traps whereby watershed discharged nitrogen and phosphorus does not enter the water column to promote algal blooms, and are critical for a well developed sport fishery. The type of radical control currently employed on Lake Louise both promotes algal problems immediately as nutrients are released from dying macrophytes and reduces deep water oxygen concentrations through decomposition of dead macrophytes. If nutrient loading to the lake continues to increase and macrophytes are controlled as in 1990, the lake will be plagued by serious algal blooms throughout the latter half of summer. It is recommended that the macrophyte community be surveyed during the early summer of 1991 to determine which areas of the lake really need control. The current shotgun approach is both costly and likely to lead to additional lake management problems.

TASK 4: FISHERIES MANAGEMENT

The fishery of Lake Louise is in poor condition and appears to be dominated by stunted bluegills that crowd shoreline areas less than five feet deep. In part, the fishery problem is associated with the lack of a vegetated littoral zone. Vegetation is needed by many species for breeding sites and for protection of their young. It is recommended that predatory fish such as northern pike, largemouth bass, and possibly walleye be stocked to Lake Louise to reduce the stunted bluegill populations and provide a more balanced fishery. Part of the algal problem in Lake Louise is associated with the fact that bluegill eat zooplankton, the principal grazers on algae in lakes. By reducing the bluegill populations via predatory fish, zooplankton populations should increase and help keep algal biomass in check through their feeding activities.

TASK 5: DREDGING AS A LAKE MANAGEMENT OPTION

It appears that sediments in Lake Louise are both extremely inorganic and moderately compact, facilitating removal via dredging. Analysis of total phosphorus concentrations in sediments collected throughout the lake demonstrated that dredging will remove sediment nutrient pools significantly only in those areas immediately offshore from major watershed point source discharges. The most likely area to be dredged is at the northwest corner of Lake Louise (Zone I), whose watershed is currently being residentially developed. With this notable exception, it is recommended that dredging in Lake Louise be undertaken solely for aesthetic purposes in areas undergoing infilling from watershed discharge. Sediments removed from the lake should pose no serious health risk if land disposal is used.

TASK 6: SEDIMENTS AS A NUTRIENT SOURCE

Lake drawdown is normally proposed in cases where sediments are extremely flocculent and thus easily release phosphorus into the overlying water column. For the most part, sediment in Lake Louise are extremely inorganic and compact, thus minimizing resuspension and nutrient release via motor boat generated waves. Our laboratory investigations on sediments collected from 14 locations in Lake Louise suggested that sediments are an important source of water column phosphorus only in nearshore areas in the vicinity of watershed discharge points. While drawdown and associated desiccation could be effective at sealing phosphorus in sediments, it appears to have no impact on release rates from sediments collecting in the southeastern corner of the lake from watershed sources. It is recommended that watershed delivery of nutrients and sediments be corrected before any major in-lake management of these problems is addressed. When undertaken, it is recommended that a partial drawdown of lake level followed by sediment removal in areas near watershed discharge points is the best management approach to be taken for reducing in-lake nutrient cycling and associated algal and macrophyte problems.

TASK 7: SEDIMENT CONTAMINANTS

The sediments of Lake Louise did not display evidence of any chemical contamination from either metals or organic compounds. If dredging is considered as a lake management tool, it appears that disposal of spoil material on land should not pose any serious health problems.

TASK 8: SHORELINE EROSION

Shoreline erosion was noted at construction sites as well as along undeveloped lots bordering those areas of the lake open to skiing. The most pronounced construction erosion was related to the new phase of residential development ongoing along the shore of Lake Louise at its northwest corner. This watershed input is likely to continue throughout development, and lake has already shown signs of decreased water quality associated with. It is recommended that measures be taken immediately to reduce the impact of this development on Lake Louise. In particular, we are concerned with the drainage culvert that discharges into the lake. If at all possible, this flow should be directed elsewhere.

The second major type of erosion noted was associated with power boats. Waves generated from ski boats have undercut the banks of all undeveloped lots facing the skiing area of the lake to the point that many lots have receded over five feet landward. One only need look at the number of trees that have fallen into the lake as well as those still alive but hanging at steep angles to the water to appreciate the magnitude of the problem. Immediate action must be taken to insure that such erosion is corrected. If action is delayed until someone builds on the sites, serious infilling of the lake could result and be extremely costly to correct.

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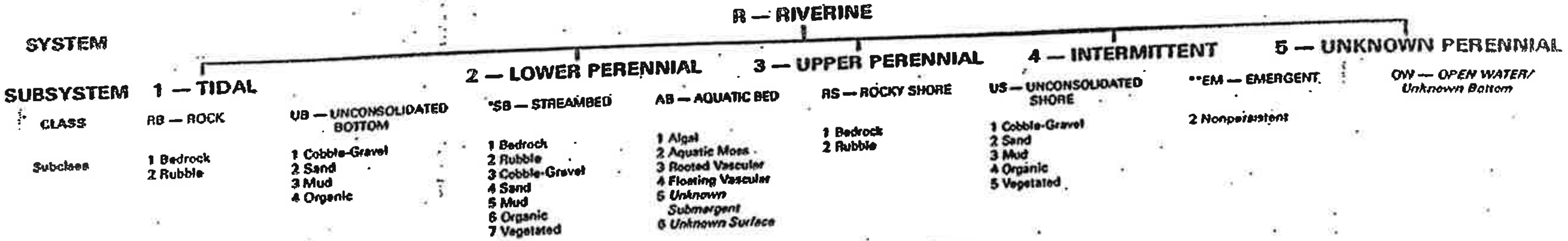
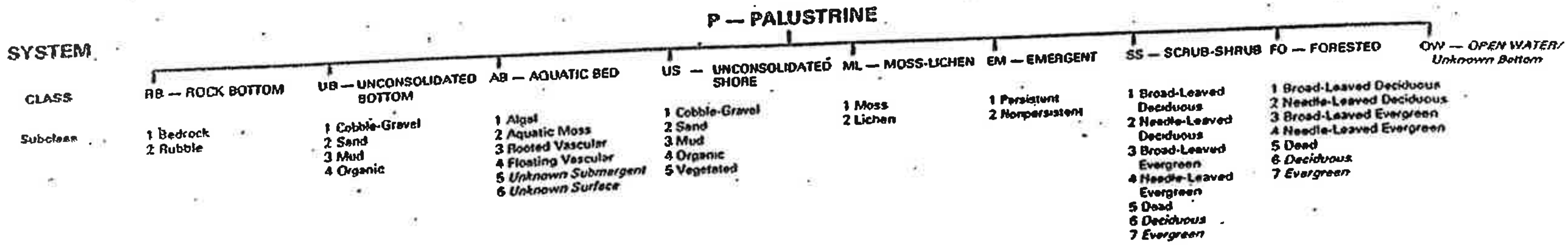
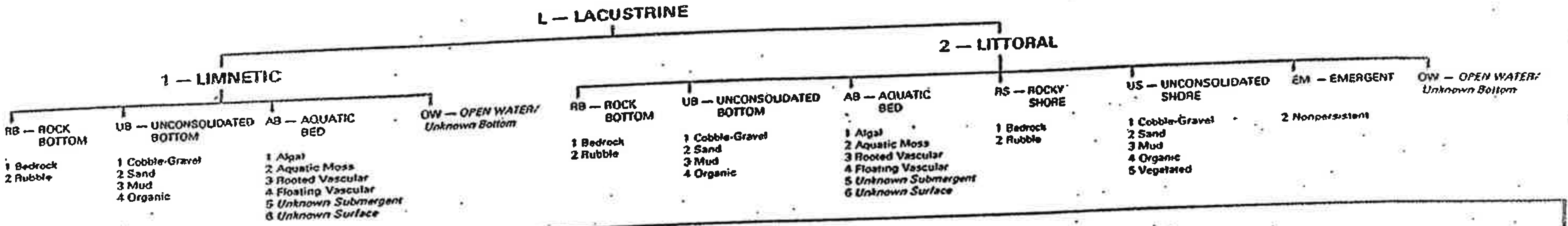
Appendix



*STREAMBED is limited to TIDAL and INTERMITTENT SUBSYSTEMS, and comprises the only CLASS in the INTERMITTENT SUBSYSTEM

**EMERGENT is limited to TIDAL and LOWER PERENNIAL SUBSYSTEMS. The remaining CLASSES are found in all SUBSYSTEMS.





MODIFIERS

In order to more adequately describe wetland and deepwater habitats one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

WATER REGIME

Non-Tidal

- A Temporarily Flooded
- B Saturated
- C Seasonally Flooded
- D *Seasonally Flooded/ Well Drained*
- E *Seasonally Flooded/ Saturated*
- F Semipermanently Flooded
- G Intermittently Exposed
- H Permanently Flooded
- J Intermittently Flooded
- K Artificially Flooded
- W Intermittently Flooded/Temporary
- Y Saturated/Semipermanent/ Seasonal
- Z Intermittently Exposed/Permanent
- U *Unknown*

Tidal

- K *Artificially Flooded*
- L Subtidal
- M Irregularly Exposed
- N Regularly Flooded
- P Irregularly Flooded
- *S Temporary-Tidal
- *R Seasonal-Tidal
- *T Semipermanent-Tidal
- *V Permanent-Tidal
- U *Unknown*

*These water regimes are only used in tidally influenced, freshwater systems.

WATER CHEMISTRY

Coastal Halinity

- 1 Hyperhaline
- 2 Euhaline
- 3 Mixohaline *(Brackish)*
- 4 Polyhaline
- 5 Mesohaline
- 6 Oligohaline
- 0 Fresh

Inland Salinity

- 7 Hypersaline
- 8 Eusaline
- 9 Mixosaline
- 0 Fresh

pH Modifiers for all Fresh Water

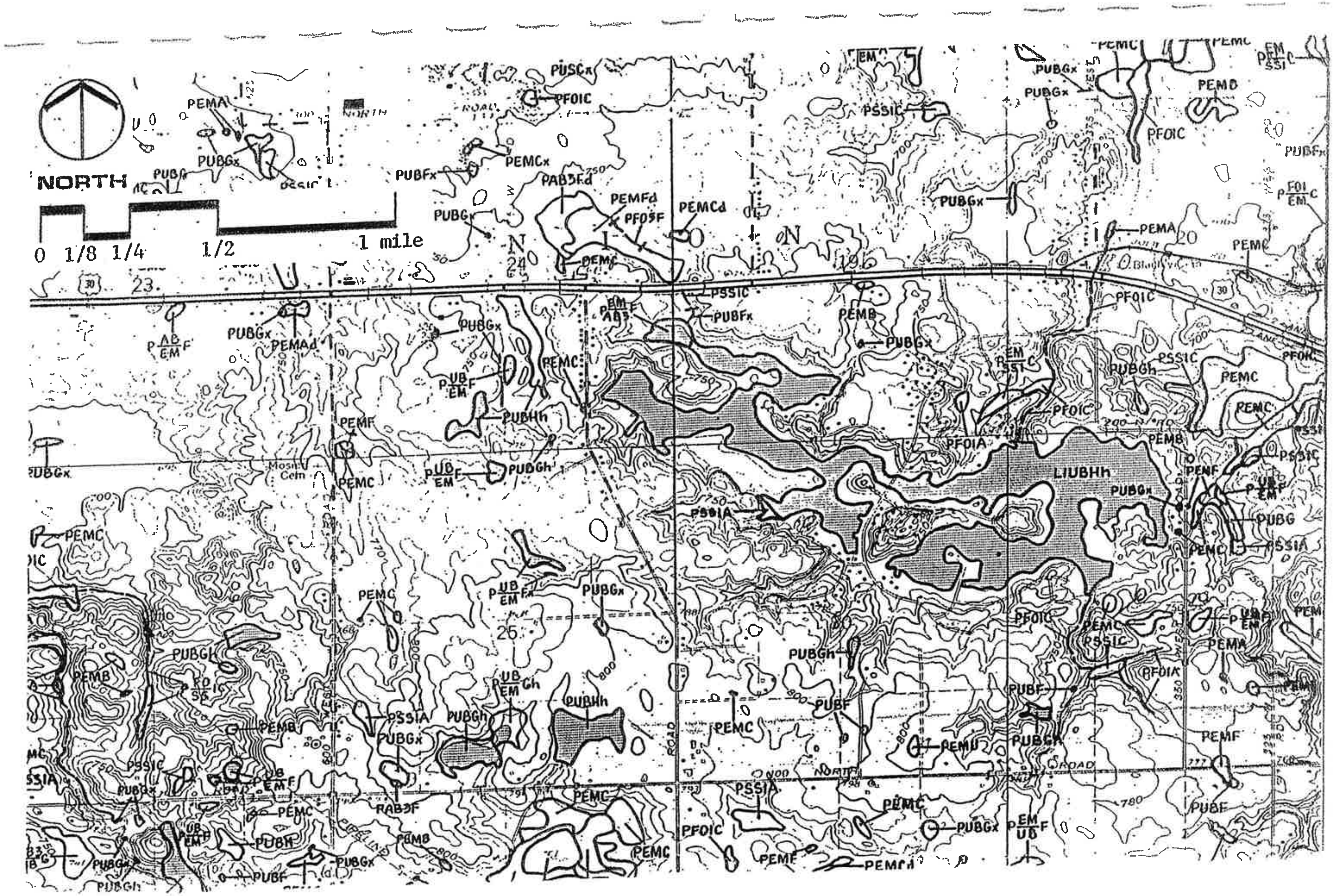
- a Acid
- t Circumneutral
- i Alkaline

SOIL

- g Organic
- n Mineral

SPECIAL MODIFIERS

- b *Beaver*
- d *Partially Drained/Ditched*
- f Farmed
- h *Diked/Impounded*
- r Artificial Substrate
- s *Spoil*
- x Excavated



NATIONAL WETLANDS INVENTORY
LAKE LOUISE AREA

APPENDIX B

INPUT PARAMETERS FOR SEDIMOT-II

HYDROLOGY DATA

STORM TYPE: SCS TYPE II

RAINFRALL DEPTH: 3.50 INCHES (5-YEAR)

STORM DURATION: 24.00 HOURS

TIME INCREMENT: 0.10 HOURS

HYDROLOGIC SOIL GROUP: B/C

LAND USE:	RUNOFF CURVE NUMBER:
AGRICULTURE -ACTIVE	71-88
AGRICULTURE -OTHER	72-81
FORESTED	55-73
FORESTED/RESIDENTIAL	65-77
RESIDENTIAL	74
WETLAND	30

SEDIMENTOLOGY DATA MODIFIED UNIVERSAL SOIL LOSS EQUATION

DELTA G: 1.60-2.65

LOAD COEFFICIENT: 1.50 (DEFAULT)

SUBMERGED BULK SPECIFIC GRAVITY: 1.25 (DEFAULT)

SOIL ERODIBILITY FACTOR: .17-.32

RAINFALL EROSITIVITY FACTOR: 127.29 EI UNIT

CONTROL PRACTICE FACTOR: .39-.64

PARTICLE DISTRIBUTION:	SIZE (mm):	PERCENT FINER
1	10.0000	100.00
2	5.0000	90.00
3	2.0000	80.00
4	1.0000	70.00
5	0.5000	60.00
6	0.2000	50.00
7	0.1000	40.00
8	0.0500	30.00
9	0.0200	20.00
10	0.0100	10.00
11	0.0050	5.00
12	0.0001	0.00

(APPENDIX C)

SAVE OUR LAKE COMMITTEE

LAWN CARE SURVEY

The purpose of this survey is to aid our lake study consultants in determining the overall use and frequency of lawn care products within Shorewood Forest.

Lot number or address: ______________________________
(IMPORTANT)
____

Name: ______________________________

Telephone: ____________________

1. Do you use a lawn service for fertilizer and chemical applications?

   ________Yes ________No ________No Response

2. Do you do your own lawn care applications of fertilizer and chemicals?

   ________Yes ________No ________No Response

3. (In either case), how many times of application per year (approximations is o.k.)

   ________Number ________No Response

Please return to P.O.A. Office by February 23, 1990.

THANK YOU for helping us to improve the management of our lake!

CHAIRMAN, JIM SEVCIK
464-0288

APPENDIX D

The following is a list of Federal, State and local agency contacts which may be useful in obtaining further information or permit requirements.

EPA
Wetland Protection Section
401 M Street SW
Washington, D.C. 20460
(202) 382-5043

EPA, Region V
230 S. Dearborn Street
Chicago, IL 60604
(312) 353-2079

US Army Corps of Engineers
20 Massachusetts Ave., NW
Washington, D.C. 20314
(202) 272-0169

US Army Corps of Engineers
Detroit District
P.O. Box 1027
Detroit, MI 48231
(313) 226-6773

US Fish & Wildlife Service
18th & C Streets, NW
Washington, D.C. 20240
(202) 343-4646

US Fish & Wildlife Service
Bloomington Field Office
718 N. Walnut Street
Bloomington, IN 47401
(812) 334-4267

IDNR
Division of Water
2475 Directors Row
Indianapolis, IN 46241
(317) 232-4160

IDEM
Office of Water Management
Chesapeake Building
105 South Meridian Street
Indianapolis, IN 46206
(317) 232-8476

IDNR
Div. of Soil Conservation
FLX1 Building
Purdue University
West Lafayette, IN 47907
(317) 494-8383

IDNR
Div. of Fish & Wildlife
607 State Office Building
Indianapolis, IN 46204
(317) 232-4080

Earth Source Inc. (consultant)
349 Airport North Office Park
Fort Wayne, IN 46825
(219) 489-8511

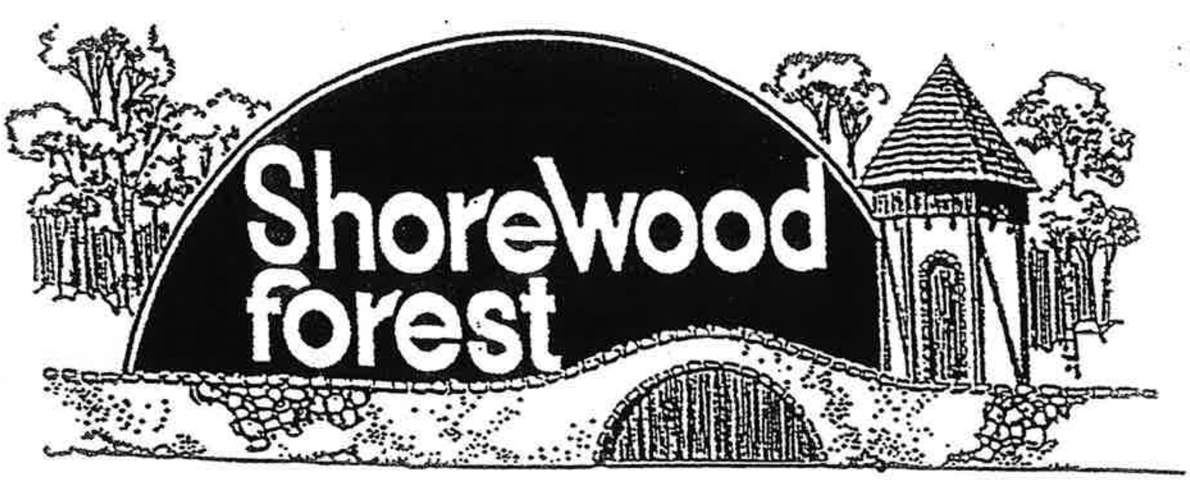
USDA-SCS, Porter County
910 Roosevelt Road
Valparaiso, IN 46383
(219) 462-6541

APPENDIX E

EROSION and SEDIMENT CONTROL GUIDEBOOK

EROSION AND SEDIMENT CONTROL GUIDEBOOK

for
Shorewood Forest Property
Owners Association



Earth·Source Inc
349 Airport North Office Park, Fort Wayne, IN 46825 (219) 489-8511

SOIL EROSION AND SEDIMENTATION CONTROL GUIDEBOOK

Purpose and Use

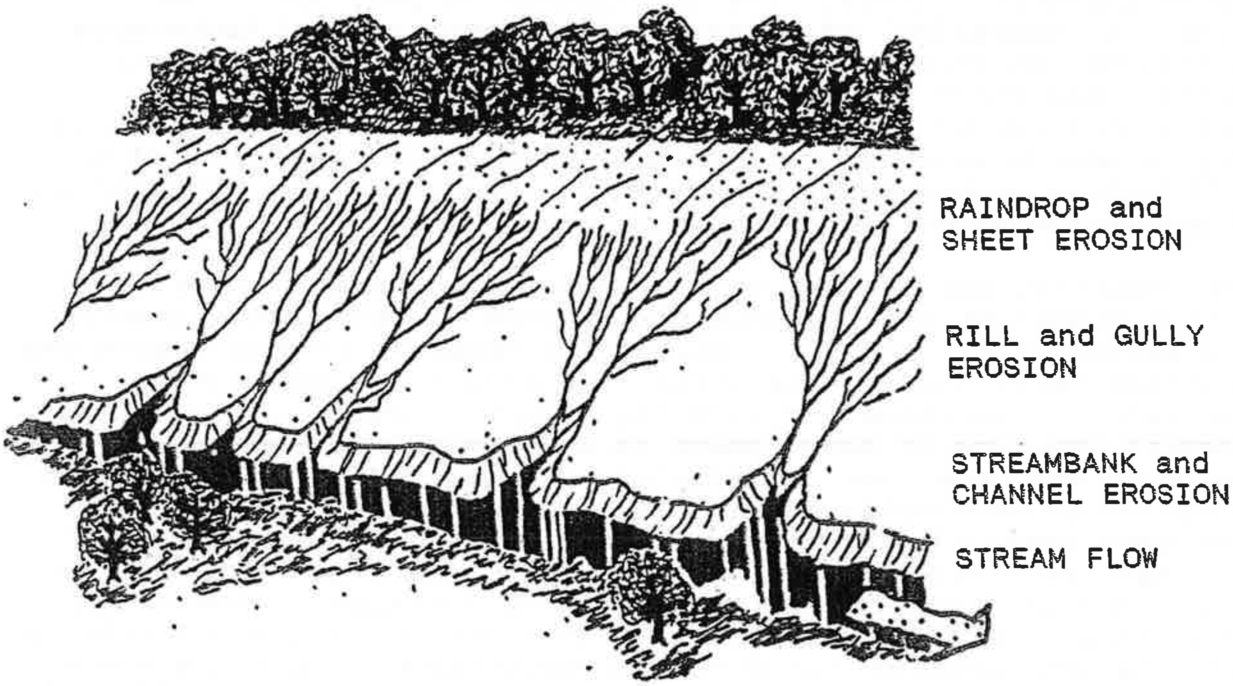
The purpose of this guidebook is to provide information on minimizing erosion and sediment on land undergoing development for individual or large scale residential use and other purposes. This guidebook pertains to soil, water, and plant conservation and their relationships in upgrading the quality of the environment within Shorewood Forest. The information is provided in two forms. A "checklist" of erosion and sediment control techniques is included which may be used by the Shorewood Forest Property Owners Association or other reviewing agency to assess future construction practices within the Shorewood Forest development as they relate to erosion and sediment prevention. Secondly, this guidebook provides general information concerning the fundamentals of soil erosion and sedimentation.

The checklist may be used to provide the developer or home owner with a number of options that may be used to help reduce erosion and sedimentation and their subsequent negative affects within the proposed development. The check list should be used anytime earthwork is performed or existing natural plant cover is removed. Whether the type of development is seemingly simple as in a building addition, new landscaping, or clearing of undergrowth in a ravine or as complex as new home construction or advancing to the next stage of construction within the development; earth will be disturbed, vegetation will be removed, and conditions will be right for soil erosion and sedimentation to occur. Some thirty individual control techniques are included within the checklist as well as the purposes for using the techniques, conditions where the techniques apply, and when (during construction) and for how long (temporary or permanent) the technique may be applied. An asterick (*) located next to an individual technique denotes that that particular technique should be carefully designed by a professional in a related field (landscape architect or engineer) before installation. An appendix is included that provides construction details for some commonly used, non-designed techniques. Careful consideration for each specific site condition should be given before applying any of the listed techniques.

A basic understanding of the types of erosion and sedimentation and the factors that influence them is needed to properly evaluate the measures chosen to control them.

Types of Erosion

Soil erosion is caused primarily by the force of falling raindrops and secondly by the force of water flowing in small rills or channels. The raindrops, falling on bare or sparsely vegetated soil, detach soil particles. Water moving in a sheet on the surface of the ground transports the loosened soil particles and carries these along as it flows. As the runoff gains in concentration and velocity, it cuts rills and gullies into the soil. As the velocity and the volume of flow increases, the greater is the erosive force and the resulting damage.



Raindrop Erosion results from the direct impact of falling drops of rain on soil particles. This impact dislodges soil particles that are easily transported by surface runoff.

Sheet Erosion is the removal of a layer of exposed surface soil by the action of water moving in broad sheets over the land. The stirring action of raindrops impacting the sheet of water, causes soil particles to be suspended in solution and transported downslope, even on nearly level land.

Rill and Gully Erosion is the result of runoff concentrating in rivulets, cutting several inches deep into the soil surface. These grooves are called rills. Gullies may develop in unrepaired rills or in other areas where a concentrated flow of water moves over the soil.

Streambank and Channel Erosion is caused as the volume and velocity of runoff increases. This action causes scouring of the stream channel bottom and erosion of the banks.

Factors Influencing Erosion

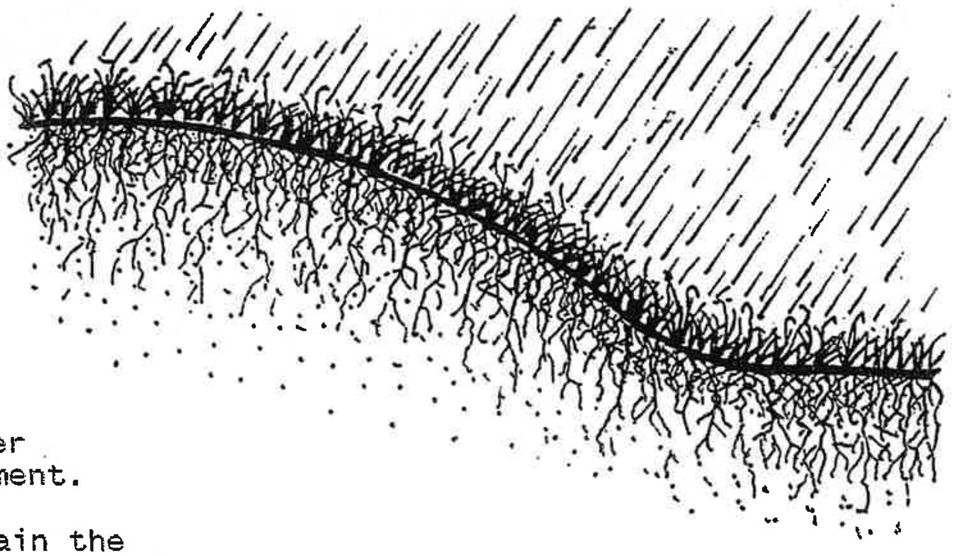
The inherent erosion potential of any development site is determined by four main factors: (1) soil type, (2) surface cover, (3) topography, and (4) climate.

Soil type - The soil properties which influence erosion are those which primarily affect the infiltration capacity of a soil and those which affect the resistance of the soil to breaking apart and to being carried away by flowing water.

Generally, soils that absorb water (soils with high organic content and those with a large percentage of open air spaces between particles) are slow to erode. Also, soils with intermediate sized particles (sands) tend to erode faster than clays and soils with particles coarser than sand.

During construction operations, soil particles may be mechanically dislodged allowing them to be easily transported by water; or the soil may become compacted reducing the soil's absorptive properties.

Surface cover - The amount and type of vegetative cover (plants) appears to be the single most important control on erosion. Plants:



1. Absorb the energy of falling rain.
2. Slow the velocity of runoff.
3. Retain runoff from the initial flow.
4. Act as a filter to catch sediment.
5. Help to maintain the absorptive capacity of the soil.
6. Hold soil particles in place.

Excessive amounts of vegetative cover are often removed during development exposing the soil to the forces of moving water.

Topography - The length and steepness of slopes are major factors in determining the potential erosion hazards of a site. Flat to slightly sloping lands produce shallow sheet-type flows and limited amounts of erosion. On steeper slopes, or on long slopes, the runoff water begins to concentrate in channels and the erosive force increases. Steepness and length of slopes are often increased by the layout of streets and the regrading of the site.

Climate - The frequency, intensity, and the duration or rainfall varies during the different seasons of the year. As both the volume and the velocity of runoff increase, the capacity of runoff to detach and transport soil particles also increases. During seasons of the year when storms are frequent, very intense, or of long duration, the risk of soil erosion are high. The seasons of the year therefore become important when considering scheduling of construction or phasing of a project.

Sedimentation

The settling out of the soil particles which have been transported by water is called physical sedimentation. The process takes place when the velocity of the water in which the soil particles are suspended is slowed sufficiently and for a long enough period of time to allow the particles to settle out. The coarsest, heaviest particles (gravel) are transported only a short distance and only when the water flow is at its maximum. Smaller, lighter particles (sand and coarse silt) move by rolling or bouncing along the bottom or stay in suspension over short distances while the water velocity is fairly high. Because of their slow settling rate, fine silt particles generally remain, for several hours, in suspension in the storm runoff that originally moved them. The still finer colloidal clays stay in suspension and contribute to water turbidity far from their source.

Soil particles are therefore more difficult to trap once they have been detached and become suspended in the runoff waters. Thus, preventing erosion from occurring is easier than trying to correct the resulting sediment problems.

Evaluating Erosion and Sedimentation Control Measures

There are three ways to accomplish urban soil erosion and sedimentation control:

1. Stop erosion in the watershed by soil stabilization or runoff control measures.

2. Allow erosion to take place and then control sediment before it leaves a site.

3. A combination of the two.

Every opportunity to provide protection to the soil surface should be taken. This helps prevent erosion and makes sediment control measures more efficient, effective, and less expensive as well as providing for a more attractive environment.

Sediment-trapping facilities should be used on large developments with mass grading. In this situation, erosion is allowed to take place and any sediment produced is trapped before it leaves the site. A minimum cost for sediment and erosion control for a construction site is usually accomplished by using a combination of erosion control and sediment-trapping measures.

The individual control techniques put forth in this guidebook will not be effective in protecting the developed land and the surrounding land and water when used by themselves. Each measure should be a component within a planned erosion and sediment control system and should be used in combination with the other techniques to more effectively protect the landscape. The best erosion and sediment control plan would be one that, after careful site investigation, implements one or more techniques from each of the four basic control groups: Natural Feature Protection, Soil Stabilization, Runoff Control, and Sediment Control.

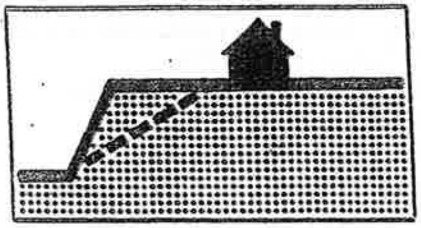
NATURAL FEATURE PROTECTION

Home buyers are attracted to natural settings. Many are willing to pay a premium for open space and natural areas that are a part of, or adjacent to the homesite. These include such features as streams, ponds, lakes, wetlands, woodlands, grasslands, and golf courses. Even more subtle features such as trees and shrubs can be preserved.

Regulations concerning flood plains and established easements along drainageways not only protect the homesite, but also aid in preserving many of the natural features of the landscape.

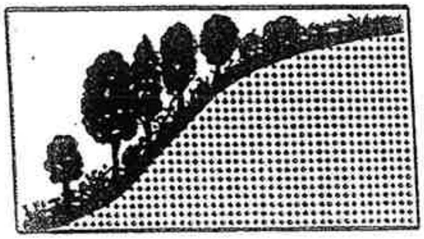
The techniques within this group are erosion control practices in that the best way to prevent erosion is to eliminate as much disturbance of the landscape as possible. Often times these natural features are very sensitive to disturbances and would be very difficult to restore once damage has been done. In the case of topsoil conservation, the very medium that supports plant growth can be managed to ensure a future environment for vegetative cover and subsequent erosion protection.

BUILDING SET-BACK



Building set-back distances from steep escarpments, particularly along streams, is a primary concern. The meandering of stream channels, and/or unstable bank conditions can endanger buildings. The set-back distance should be based upon the soil type at the brow of the hill and potential stream movement at the base of the hill. An on-site investigation by a qualified professional is usually essential.

PRESERVE VEGETATION



With care in planning and construction, existing vegetation can provide erosion control as well as other benefits to the development site. Streambanks are usually vegetated by trees and grass and should be protected. Any enlargement or alteration can usually be done from one side, allowing vegetation to remain in place on the opposite bank.

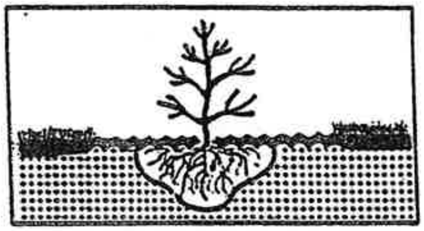
Natural wooded ravines and steep slopes should also be preserved as the trees can provide multi-purpose benefits.

PROTECTION OF TREES

Existing trees need to be properly marked and physically barricaded to avoid damage from construction equipment. Protection is typically provided by the installation of snow fencing at the dripline of the trees or group of trees to be protected. Special measures such as tree wells can sometimes be used successfully to save a tree whose roots unavoidably must be covered by soil.

An inventory of the species by a landscape architect may be important in the analysis of the use of the site.

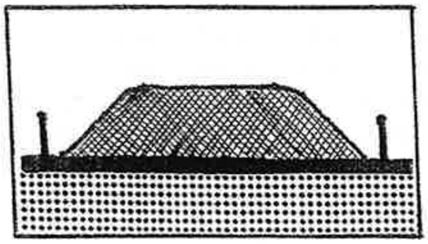
TREE PLANTING



The planting of trees and shrubs can greatly enhance a development site as well as increase the site's soil protection cover. Too often the wrong species are planted and the anticipated benefits are lost. Site limitations should also be considered, such as soil types, topography, septic systems, subsurface drains, utility lines, etc.

The establishment of trees and their natural understory plant companions can provide the maximum amount of soil erosion control. Consultation with a landscape architect during the planning stage can help ensure the success of landscape restoration.

TOPSOIL CONSERVATION



Removal and stockpiling of topsoil will ensure an adequate, uncompacted seed bed at the end of the project. The topsoil, or "A" Horizon, should be removed completely and stockpiled. The second layer, or "B" horizon, should also be removed and stockpiled in a separate location. Adequate measures should be taken to prevent erosion of the stockpiles. (See Temporary Seeding and Barrier Filters)

Replacement of topsoil is equally as important as the removal of topsoil. At the end of the project, prior to landscaping, the "B" Horizon and "A" Horizon should be replaced in proper sequence and at the approximate depths prior to their removal. Care should be taken to minimize compaction.

SOIL STABILIZATION

This group of practices refers to the establishment of some type of protective soil cover on ares subject to Raindrop, Sheet, Rill, and Wave Erosion. The purpose is to stabilize the soil, reduce damages from sediment and runoff to down stream areas, and enhance natural beauty. These practices are used in graded and cleared areas where a permanent or temporary cover is needed to control erosion.

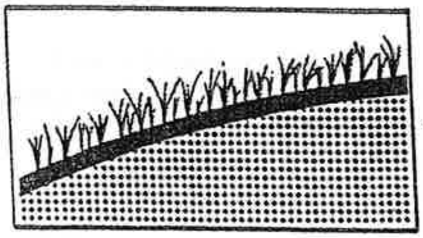
Vegetative soil cover is the preferred means of protection wherever possible as plants perform multiple functions in the role of soil stabilization. (See the section on Surface Cover in the introduction.) Non-vegetative covers have the advantage of providing instant protection alone or in conjunction with vegetative covers. Slope and Bank Protection and Shoreline Protection measures provide protection on critical or difficult to establish areas.

The cost in establishing soil cover in the project can be reduced by utilizing the following guidelines.

* Retain and protect as much existing vegetation as possible.
* Save existing on-site topsoil.
* Establish temporary protection as rapidly as possible.
* Select permanent vegetative establishment methods and plant species that are best adapted for controlling erosion and sedimentation on the site.
* Perform maintenance when needed.

(See Appendix: Seasonal Soil Protection Chart)

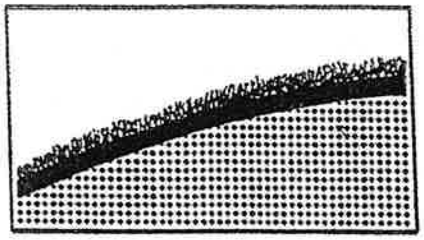
TEMPORARY SEEDING



Temporary Seeding serves to hold the soil in place until permanent cover is provided at the time of final land grading. Temporary seeding may be done on subsoil following the stripping and stockpiling of topsoil. Annual grasses which sprout rapidly and survive for only one growing season are suitable for temporary vegetative cover.

The use of Temporary Seedings may prevent costly maintenance work on drainageways, waterways, and other erosion control practices.

PERMANENT SEEDING

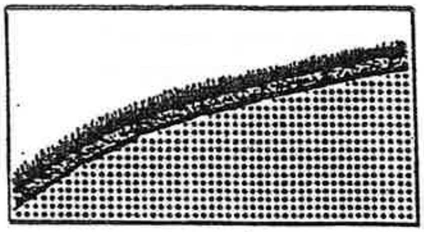


Most areas which must be stabilized following the final landgrading operations, require permanent vegetative cover. The most common means of establishment is the seeding of grasses, and/or legumes and grasses. The seeding of native wildflowers is also an option. Seeding is an inexpensive, widely available, easily installed technique.

Establishment depends upon seasonal and climatic conditions. Protection of the soil as well as the seed itself must be provided by non-vegetative cover means until establishment.

Dormant Seeding may be performed when seasonal temperatures have dropped below the level necessary to initiate seed germination. As soon as soil temperatures and moisture content are favorable, the seed well germinate and provide an early cover. Mulching is necessary on Dormant Seeding.

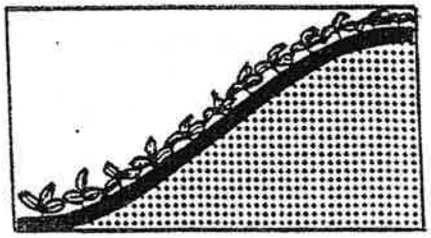
SODDING



Sodding is desirable where it is necessary to achieve an instant turf cover, and where it may be difficult to establish a cover by seeding. The advantages of sodding include immediate erosion control, less seasonal installation limitations, greater chance of success, instant usability of the area, and immediate visual effect. It is initially more costly to install sod than to seed.

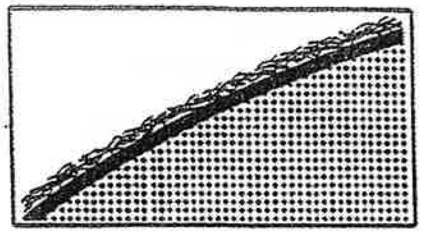
In swales and waterways where concentrated flow will occur, properly pegged sod is preferable to seed because there is no lag-time between installation land the time when the channel is protected by vegetation. Sod can serve as an instant vegetative filter to protect other erosion and sediment control measures. Establishment depends upon proper installation and adequate water.

GROUND COVER



Groundcover plants, used individually or collectively with woody plants (shrubs and trees), can provide erosion control on banks or slopes where maintenance of turf would be difficult or impossible. Non-vegetative soil protectors must be used during establishment of groundcover plantings.

MULCHING



The use of mulches has become a standard practice in carrying out vegetative soil cover measures. A mulch protects against rain and wind while seeds are germinating and helps to insure a vegetative stand. Mulch increases aeration of heavy clay soils as it gradually becomes mixed with the soil. It also prevents surface soil erosion, minimizes damage to soil structure due to compaction from heavy rains or walking on it when the soil is wet, and conserves soil moisture by reducing the amount of soil water evaporation. In most cases, mulching alone is not as effective as live covers, but it can provide substantial protection, particularly as temporary cover. It can be applied at any time the soil and site conditions are suitable for spreading and anchoring.

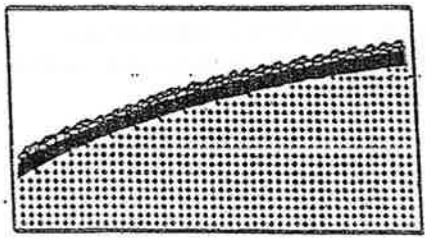
There are generally three categories of mulching materials:

Organic Mulches include straw, wood chips, and shredded bark.

Synthetic Mulches include emulsions or dispersions of vinyl compounds, asphalt, rubber or other substances which are mixed with water and applied to the soil. This technique is commonly referred to as hydro-mulching.

Mats are blanket-type materials installed directly on the soil surface. Mats, because of the manufacturing process involved, add a degree of structural stability to the soil when installed properly. (See Appendix for recommended installation procedures.)

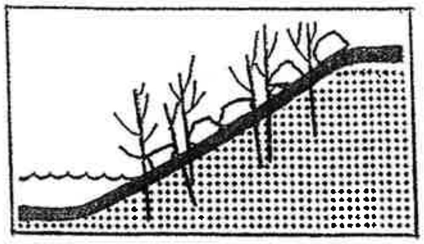
AGGREGATE COVER



Quarried or crushed stone makes an excellent inorganic mulch for short, low to moderately steep slopes. Aggregate cover provides immediate erosion protection for the ground surface (often where vegetation cannot be established) and allows infiltration of rainfall for vegetative growth. Surface water runoff should be diverted away from these areas as they are not as protective as grass.

An aggregate cover can provide immediate stabilization of future paved roads and parking lots. Rock rip-rap is also often used to protect lake shorelines and the outside bank of stream curves. (See Biotechnical Measures and Sea Walls)

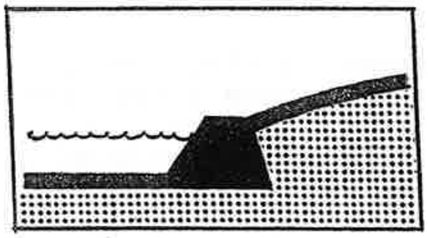
BIOTECHNICAL MEASURES



Biotechnical methods of soil stabilization rely upon the combination of the strengths of mechanical measures and vegetative measures to protect such areas as very steep slopes, stream banks, and lake shorelines. They are applicable where erosion problems cannot be solved by vegetative measures alone or where mechanical measures alone would be inappropriate.

Dormant season cuttings of fast-growing, easily-established shrubs or trees such as willow, alder, or shrub dogwood are typically placed within a framework of previously or simultaneously installed mechanical methods of stabilization such as rip-rap, rock-filled gabions, or pole cribs. The mechanical measures provide instant protection of the slope until the rapidly-growing vegetation is established. The living vegetation then provides a long-lasting, self-perpetuating, low-maintenance, aesthetically-pleasing form of natural erosion protection. As these measures are adapted to specific site conditions (angle of slope, soil type, and water and soil moisture levels) professional advice from a landscape architect should be sought to help ensure the success of this application.

SEA WALLS



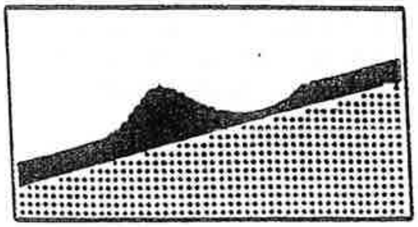
Sea walls are structural means of stabilizing lake shorelines. They protect the shoreline from the erosive action of waves caused by wind or motor boats. Wave action causes undercutting of the shoreline and eventual bank failure depositing sediment directly into the lake. Where natural shoreline vegetation (a lake's natural defense against shoreline erosion) cannot be established or is not desirable, structural means should be applied. Sea walls can be constructed of rock rip-rap, cast-in-place concrete, treated timbers, metal sheet pilings, or rock-filled gabions.

RUNOFF CONTROL

This group of practices refers to the installation of waterflow measures and structures on areas subject to Rill, Gully, and Channel Erosion. The purpose of these techniques is to divert runoff from erosion sensitive areas, to regulate or slow the flow of runoff, to protect downstream areas from damages associated with flooding and sedimentation, and to enhance natural beauty. These practices are used in graded and cleared areas and in natural or constructed drainageways where development has or will increase the amount of runoff produced on a site.

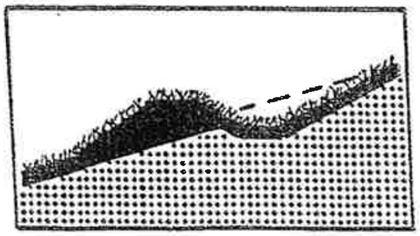
Landgrading eliminates the natural soil cover and often times increases the land's slope thereby increasing the amount and velocity of runoff. Diversions (berms or interceptor swales) intercept and safely alter the direction of flow of sheet runoff before it has a chance to become concentrated. They are used to protect erodible areas, direct sediment-laden runoff to sediment traps, and to shorten the length of long, steep slopes. Waterways provide a safe means of moving concentrated flows. Grade stabilization structures in effect reduce the steepness of slopes by providing a means to safely drop the flow vertically in a controlled manner. Lined aprons dissipate the amount of energy of the flow as it exits a structure. Retention and detention areas slow the flow of runoff by temporarily holding excess water until it can be safely added back into the hydrologic or water cycle.

TEMPORARY DIVERSIONS



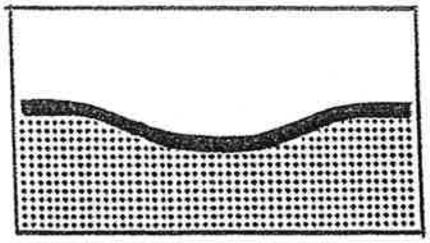
Consisting of a channel, a ridge, or a combination channel and ridge constructed across a sloping land, temporary diversions are installed frequently as an interim measure that facilitates some phase of construction. As a means of diverting unconcentrated flow, it usually has a life expectancy of one year or less.

PERMANENT DIVERSIONS



Consisting of a channel, a ridge, or a combination channel and ridge, a permanent diversion is usually installed as an integral part of an overall water management system. It usually is needed to protect adjoining properties or buildings from surface water runoff. Diversions can be visually pleasing as well as functional.

BARE CHANNEL

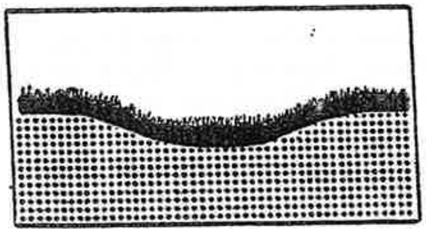


A bare channel is a constructed, non-vegetated or unlined channel used for safe conveyance of concentrated runoff. It is a temporary measure used only during construction to move water from undesired locations. Bare channels should only be used where runoff velocity is low. The shape of the channel should be wide and shallow so as not to promote gullying of the channel bottom.

The bare channel must be used in conjunction with some means of sediment control (see Sediment Filters and Sediment Basins).

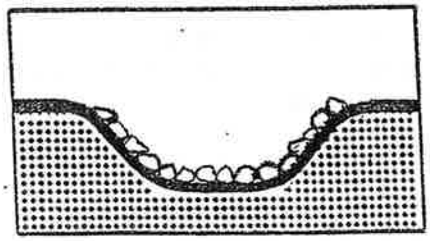
The cross-section or shape of waterway channels may be triangular, parabolic, or trapezoidal. The parabolic shape is the preferred cross-section. Most waterways constructed with a trapezoidal shape tend to revert to a parabolic shape. The triangular cross-section concentrates the flow in the 'V' of the channel causing higher and more erosive velocities.

GRASSED WATERWAY



A grassed waterway is a natural or constructed vegetated channel used for safe disposal of concentrated surface runoff water. The flow of water is normally wide and shallow. Grassed waterways or swales are used as emergency overflow areas for storm sewers, ponds, basins, and grade stabilization structures. Backyard swales can serve as outlets for downspouts.

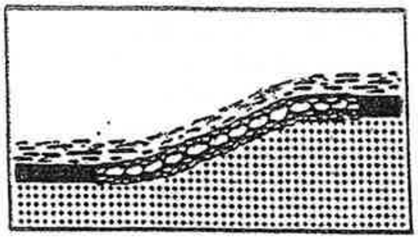
LINED CHANNEL



This is a channel with erosion resistant linings of concrete, stone, or other permanent material. This practice applies if the following or similar conditions exist:

* High velocities and deep flows resulting in concentrated runoff.
* Steep grades, wetness, prolonged base flow, where seepage or piping would cause erosion.
* Soils are highly erosive or other soil or environmental conditions prevent use of vegetation.

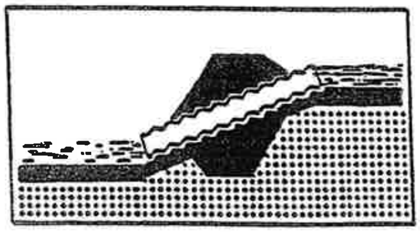
ROCK CHUTE STRUCTURE



A rock chute structure provides a practical and economical way of stabilizing grades as compared to some other kinds of grade stabilization structures. The structure is actually a protected, short, steep slope placed in series or at the end of a waterway to reduce the overall slope of the waterway. Rock chute structures are composed of rock rip-rap and a fabric underlayment on a graded slope.

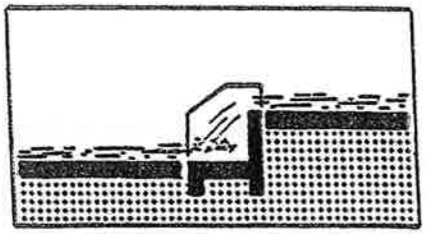
Special design considerations and construction procedures are important to insure the success of a Rock Chute structure. Rock chutes are used for low velocity, shallow slope situations.

PIPE SPILLWAYS



Straight pipe spillways can be used for a large range of overfalls, but have a limited capacity for conveying runoff. They are typically used as slope drains, culvert crossings under roads, and can be used as outlet spillways for retention, detention, or sediment basins. Straight pipe spillways have the disadvantage of requiring a substantial depth of ponded water behind the spillway before it flows to its full capacity.

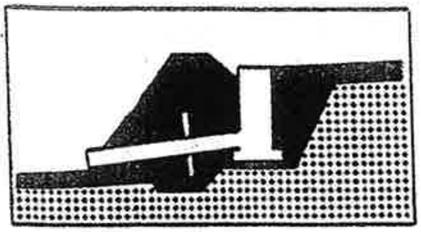
WEIR SPILLWAY



Weir spillways are used typically at the lower reaches of waterways, channels, and impoundments to drop water from one elevation to another, thus controlling gully erosion or channel erosion at that point. They are used under high flow, low elevation drop situations.

Weir spillways are usually built of reinforced concrete or they can be obtained as prefabricated metal structures. They are typically used in conjunction with a low earthen embankment.

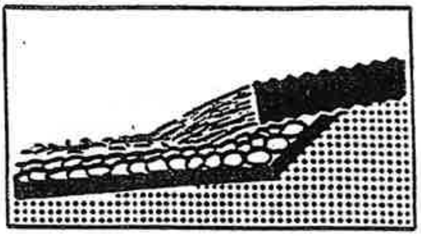
DROP INLET PIPE SPILLWAY



A drop inlet pipe spillway is similar to a plain pipe spillway except that the inlet is modified with a vertical pipe or constructed box. This allows for greater hydraulic efficiency of the piped spillway and allows for greater vertical drops of water runoff.

Spillways are typically used in conjunction with a low earthen embankment to detain excess runoff. (See Retention, Detention, and Sediment Basins)

OUTLET PROTECTION

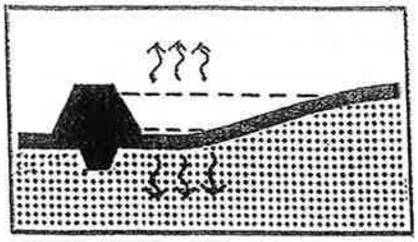


The outlets of pipes and structurally lined channels are points of potential critical erosion. To prevent scouring at stormwater outlets, a flow transition structure is needed which will absorb the initial impact of the flow and reduce the velocity to a level which will not erode the receiving channel. The most commonly used device for outlet protection is a lined apron, utilizing rock rip-rap, grouted rock rip-rap, or concrete.

RETENTION AND DETENTION AREAS

Increased runoff rates within urbanizing watersheds caused by the replacement of native plant ground cover with pavements and buildings can over tax downstream portions of the larger drainage system, causing flooding problems and scouring of channels. Where this situation exists or may become a problem, methods of delaying runoff, termed "detention" or "retention", are called for. Both of these terms involve the temporary storage of storm water in a naturally or constructed low area. An earthen embankment is usually constructed to hold the water. The means by which the excess water is removed denotes the difference between the two terms.

RETENTION BASIN

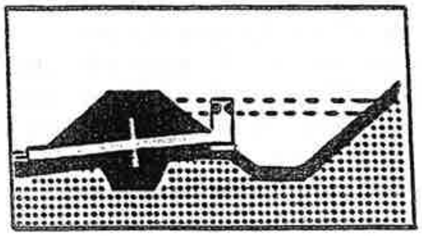


Retention areas are designed so that runoff is permanently retained on the development site and is allowed to percolate into the soil.

Permanent retention basins function best on gravelly or sandy soil conditions that permit percolation of the storm water runoff into the soil. Percolation can be enhanced by means of a filter bed similar to a septic absorption field.

Retention basins are typically constructed with a low earthen embankment and an emergency overflow structure.

DETENTION POND

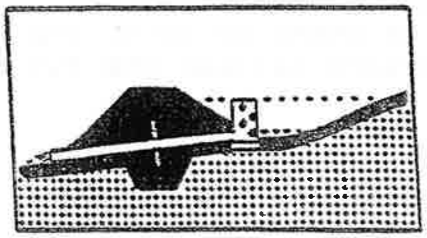


Detention areas are designed so that runoff is detained on site before being slowly released into a receiving channel at a rate that matches the rate of runoff before the development occurred.

Detention ponds, consisting of an embankment and outlet structure, have a normal pool level and a designed capacity for additional temporary flood water storage during a storm event. (See Grade Stabilization Structures)

A constructed wetland is a viable alternative to the Detention Pond. Working on the same principles but with a much shallower pool level than a pond, the wetland has aesthetic and recreational value, while providing natural water purification benefits and wildlife habitat.

DETENTION BASIN

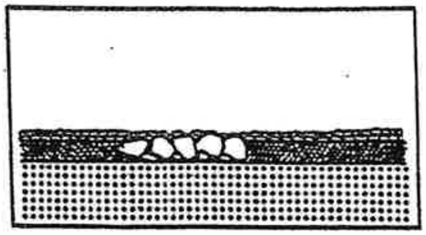


Constructed as a dry basin, the area provides temporary flood water storage during a storm event. These areas can provide multi-purpose uses such as recreational fields and open space. Asphalt or concrete surfaces can be shaped and/or utilized to provide temporary storage of runoff water (detention) and are commonly used in the design of parking lots.

SEDIMENT CONTROL

Sediment control practices are intended to provide for the management of sediment on-site to avoid damage to other water management practices and to adjacent properties. Soil erosion is allowed to occur and the sediment is then filtered or trapped before it leaves the construction site. The five groups of sediment control practices are Stabilized Construction Entrance, Dust and Traffic Control, Barrier Filters, Vegetative Filters, and Sediment Basins.

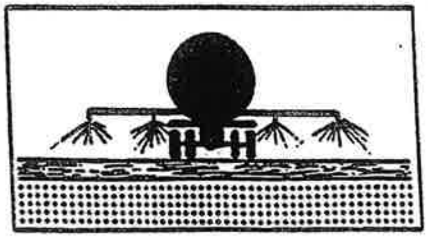
STABILIZED CONSTRUCTION ENTRANCE



Construction entrances and exits need to be stabilized to prevent tracking from vehicles leaving the site. Stone is located at these sites to reduce the transport of mud onto public roads. Temporary wash racks can also be utilized.

Further protection can be provided by stabilizing the entire rough graded road bed with fabric underlayment and a stone sub base. Residential driveways should be treated in this manner during construction.

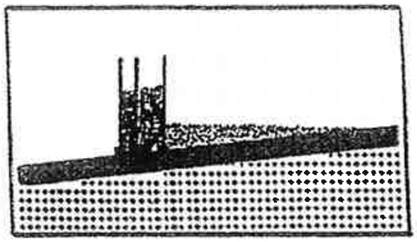
DUST CONTROL



Dust is often a problem on construction sites where it is generated by "heavy" earth moving activities. In planning for dust control, phasing of the project and utilizing temporary stabilization practices following grading can significantly reduce dust emissions. (See Soil Stabilization section)

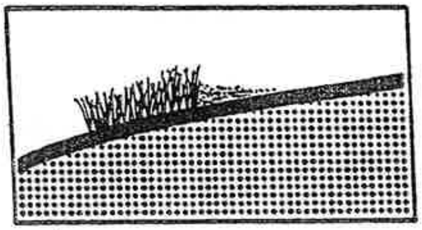
Water or dust control chemicals applied to transport roads during dry periods can significantly reduce dust problems. Requiring construction traffic to travel on assigned, stabilized construction roads will also reduce the amount of dust that leaves the site.

BARRIER FILTER



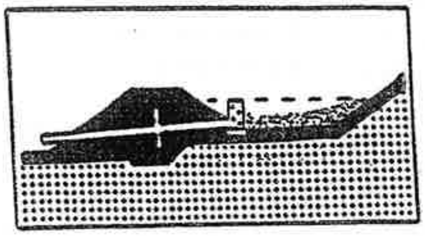
Barrier filters are temporary measures used to remove sediment from overland sheet flows and low velocity concentrated flows in drain channels. These measures remove sediment from runoff by creating an obstacle in the direct path of the runoff. The barrier slows the flow of runoff there by allowing some sediments to drop out of the flow. Two commonly used materials are staked straw bales and filter fabric curtains. (See the Appendix for recommended installation procedures.)

VEGETATIVE FILTER



The vegetative filter is a strip of grassed area through which storm water must flow before it enters streets, storm sewers, grassed waterways, channels, and reservoirs. As water containing sediment flows through the grass strip, some sediment is removed by filtering and by deposition as the flow velocity is reduced. The vegetative filter can be either existing vegetation or be planted or sodded before construction is started. A tall, dense, sturdy turf makes the best vegetative filter.

SEDIMENT BASIN



A sediment basin is designed to trap sediment in temporarily ponded water during a storm event. The purpose is to prevent undesirable deposition in downstream areas.

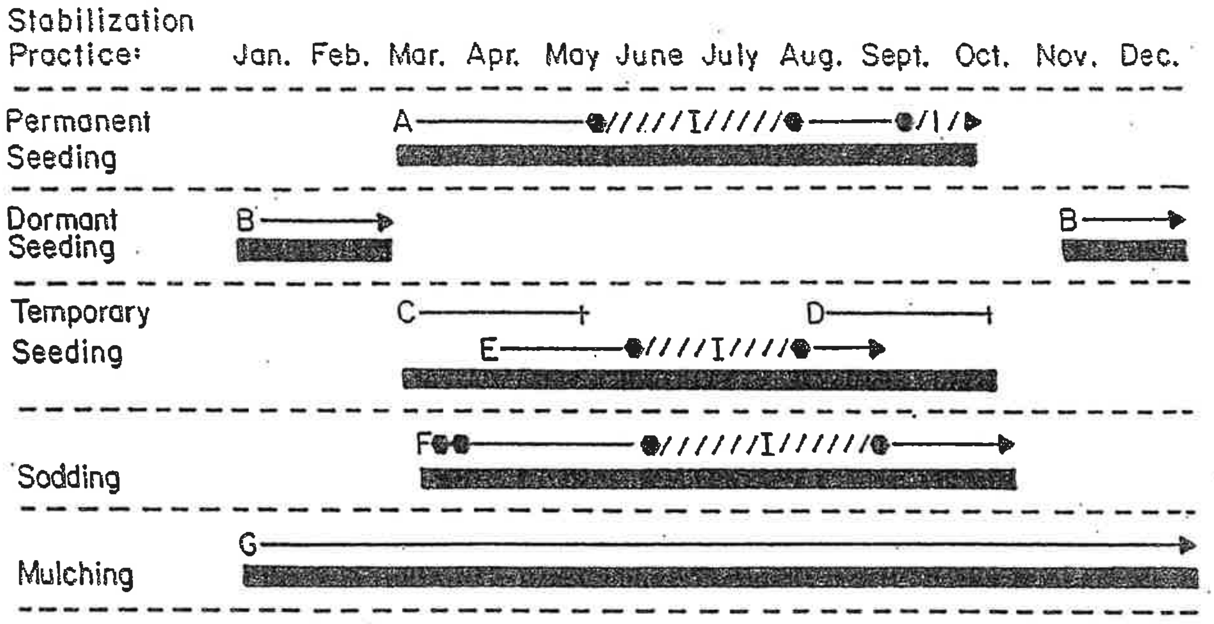
Not all sediment is trapped in the basin. The smaller clay and silt particles remain in suspension for a relatively long time. Only the large soil particles or conglomerates of the small particles settle in the basin.

Basins are located in small natural drainageways or low areas below the disturbed areas. They must not be located in a live stream. The basins can be constructed with an embankment, an excavated pit, or a combination of these to fit the particular site situation.

APPENDIX

INSTALLATION GUIDELINES FOR SELECTED EROSION AND SEDIMENT CONTROL TECHNIQUES

Seasonal Soil Protection Chart



A = Optimal planting period for most turf mixes when properly fertilized, hydro-mulched, or straw mulched.

B = Seed only when you are sure germination cannot occur and increase your seeding rate by 25% over normal rates.

C = Spring Oats 3 bu./acre.

D = Wheat or Rye 2 bu./acre.

E = Annual Ryegrass 50 lb./acre. (1lb./1000 sq. ft.)

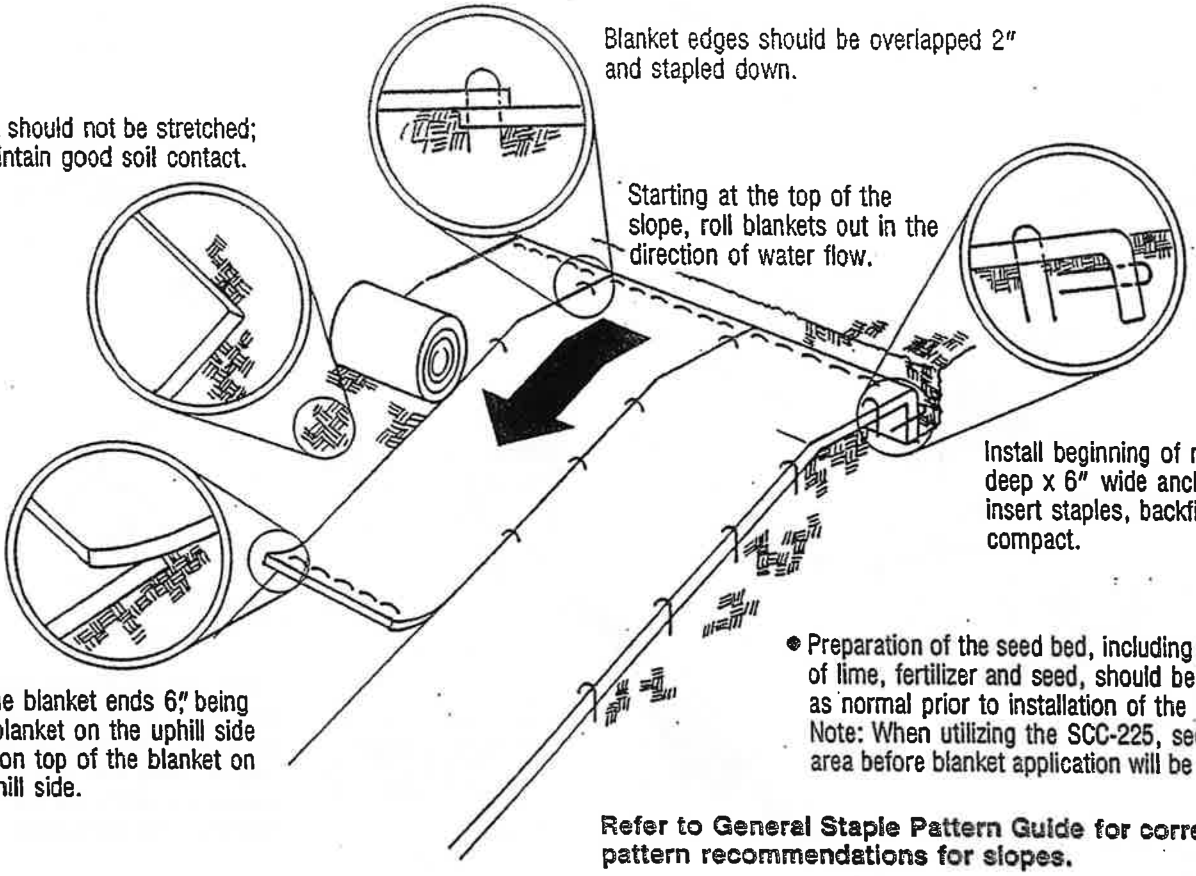
F = Sod

G = Straw Mulch 2 ton/acre.

●/I/● Irrigation needed during June, July, and September. Also reduce bluegrass % in mixes during this period.

●● Irrigation needed for 2 to 3 weeks after laying sod.

SLOPE
APPLICATIONS



Blanket edges should be overlapped 2″ and stapled down.

The blanket should not be stretched; it must maintain good soil contact.

Starting at the top of the slope, roll blankets out in the direction of water flow.

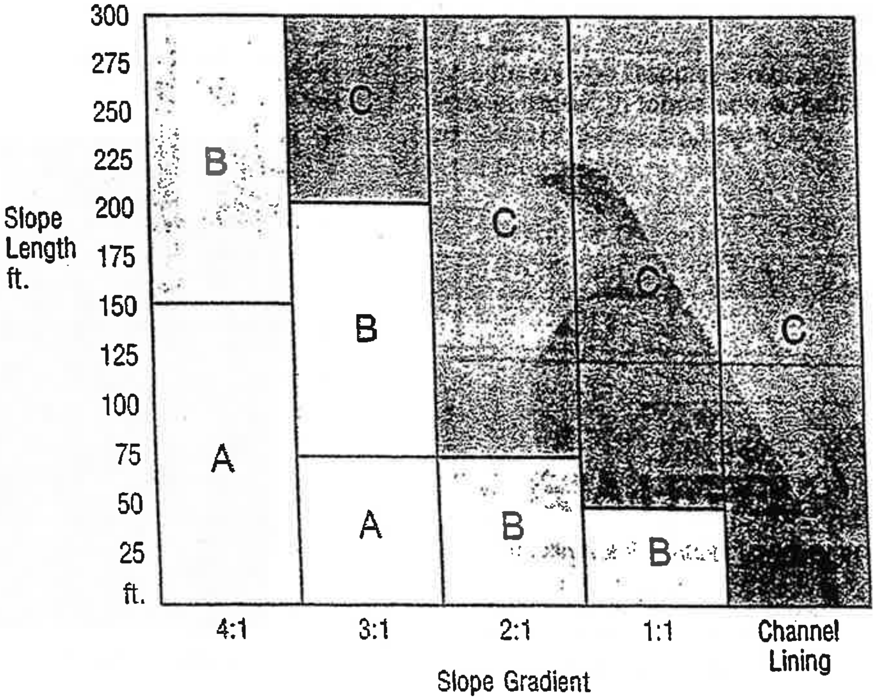
Install beginning of roll in a 6″ deep x 6″ wide anchor trench; insert staples, backfill soil and compact.

Overlap the blanket ends 6″ being sure the blanket on the uphill side is placed on top of the blanket on the downhill side.

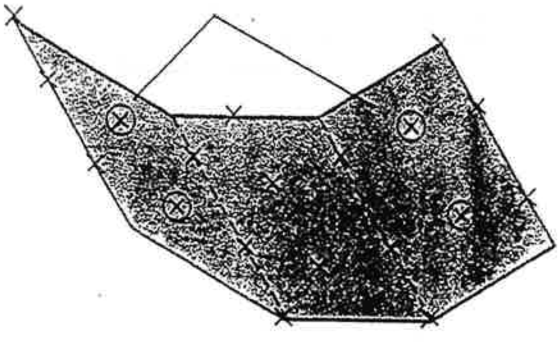
- Preparation of the seed bed, including application of lime, fertilizer and seed, should be conducted as normal prior to installation of the blanket. Note: When utilizing the SCC-225, seeding the area before blanket application will be eliminated.

Refer to General Staple Pattern Guide for correct staple pattern recommendations for slopes.

General Staple Recommendations

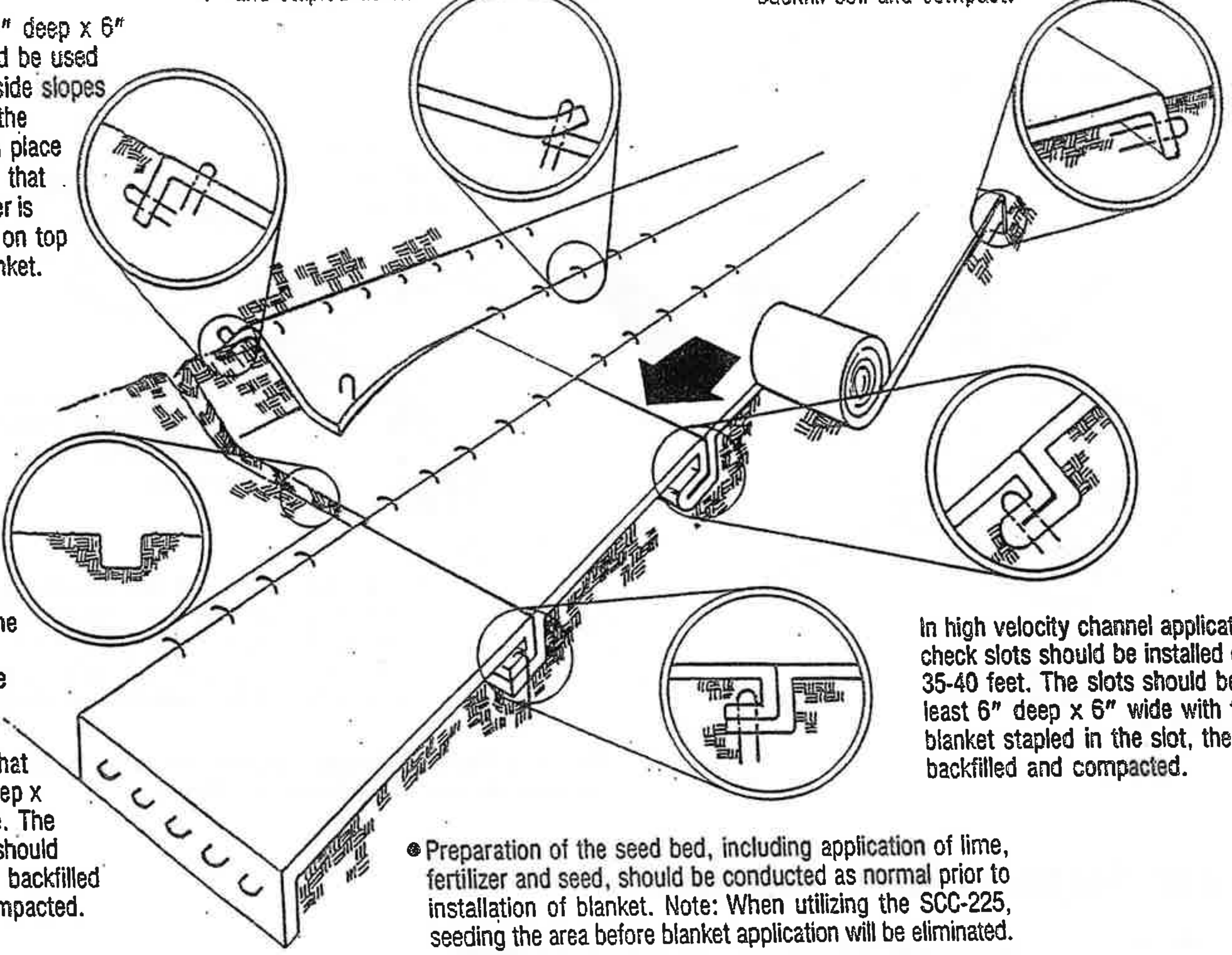


Additional staples as required due to depth of flow.



Channel linings utilize staple pattern "C" with additional staples on side slopes at projected water line.

CHANNEL
APPLICATIONS



Blanket edges should be overlapped 4″ and stapled down.

Install beginning of roll in a 6″ deep x 6″ wide anchor trench; insert staples, backfill soil and compact.

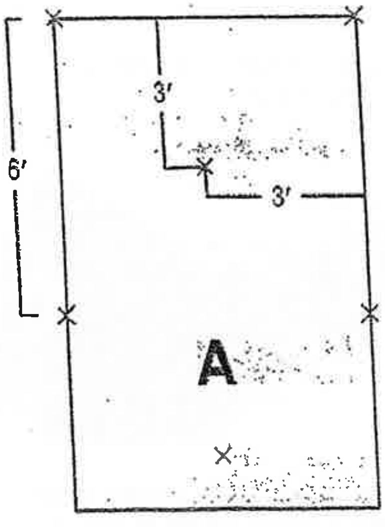
Trenches 6″ deep x 6″ wide should be used along the side slopes to anchor the blankets in place and insure that runoff water is channeled on top of the blanket.

The terminal end of the blanket should be stapled in a trench that is 6″ deep x 6″ wide. The trench should then be backfilled and compacted.

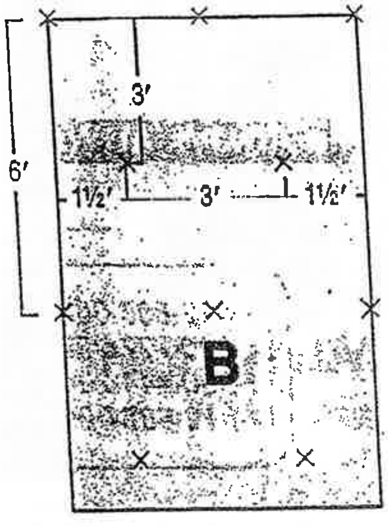
In high velocity channel applications, check slots should be installed every 35-40 feet. The slots should be at least 6″ deep x 6″ wide with the blanket stapled in the slot, then backfilled and compacted.

- Preparation of the seed bed, including application of lime, fertilizer and seed, should be conducted as normal prior to installation of blanket. Note: When utilizing the SCC-225, seeding the area before blanket application will be eliminated.

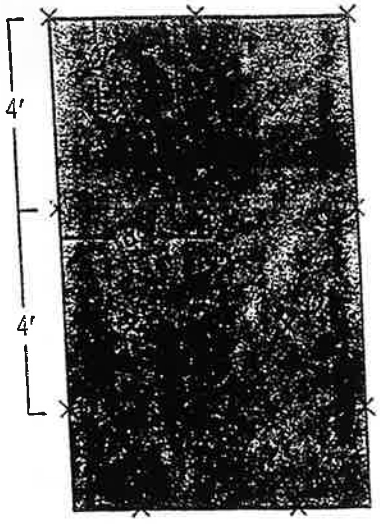
Refer to General Staple Pattern Guide for correct staple pattern recommendations for channels.



1 staple per sq. yd.

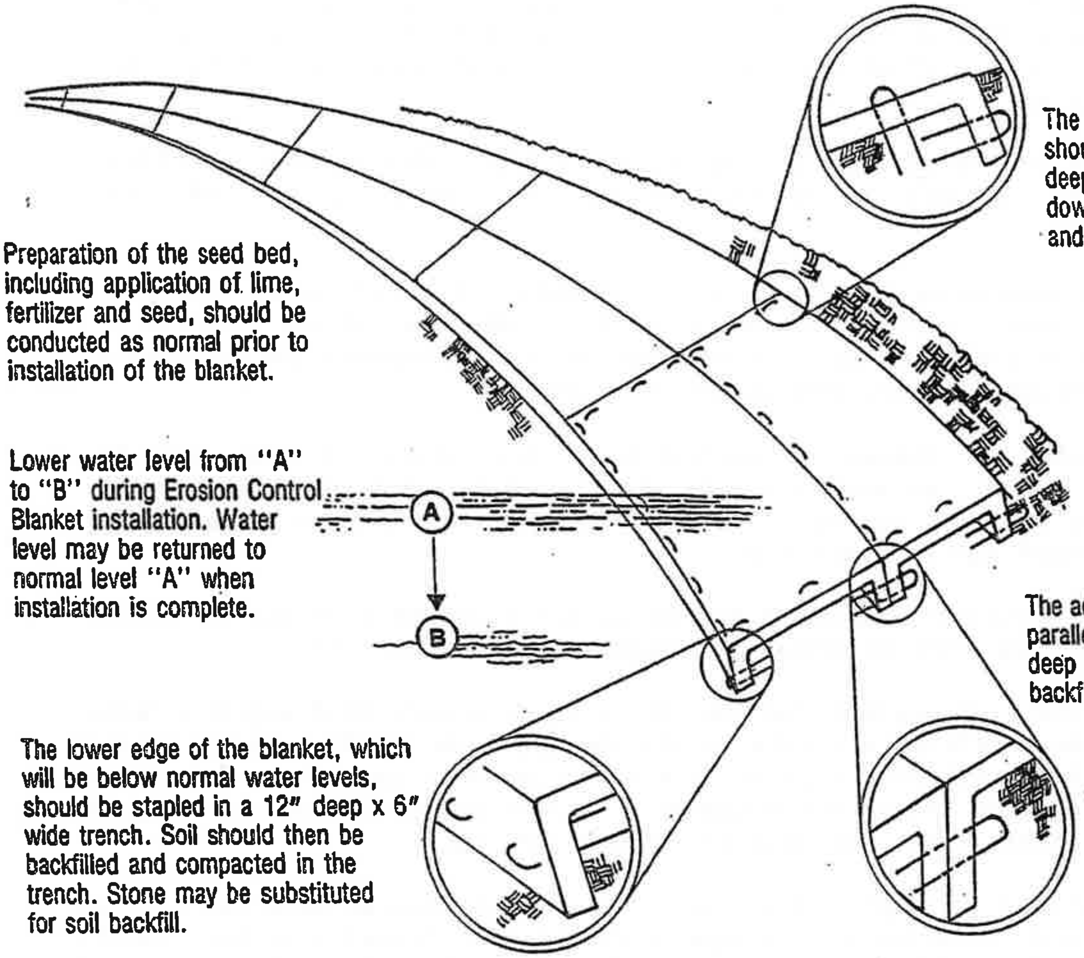


1½ staples per sq. yd.



2 staples per sq. yd.

SHORELINE
APPLICATIONS



- Preparation of the seed bed, including application of lime, fertilizer and seed, should be conducted as normal prior to installation of the blanket.

The top edge of the roll should be anchored in a 6″ deep x 6″ wide trench, stapled down, backfilled with soil, and compacted.

Lower water level from "A" to "B" during Erosion Control Blanket installation. Water level may be returned to normal level "A" when installation is complete.

The adjoining edges of blankets running parallel should be installed in a 6″ deep x 6″ wide trench, stapled down, backfilled with soil, and compacted.

The lower edge of the blanket, which will be below normal water levels, should be stapled in a 12″ deep x 6″ wide trench. Soil should then be backfilled and compacted in the trench. Stone may be substituted for soil backfill.

Staple Pattern C as shown by the General Staple Pattern Guide should be followed for shoreline applications. Note: In loose soil conditions, the use of 18″ metal pins with 1½″ flat washers attached may be necessary.

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FILTER FENCE

Sheet Flow Applications

Construction Guidelines

This sediment barrier utilizes burlap, standard strength or extra strength synthetic filter fabrics. It is designed for situations in which only sheet or overland flows are expected. In special cases burlap may be used in drainageways.

1. The height of the barrier should not exceed 36 inches (higher barriers may impound volumes of water sufficient to cause failure of the structure).

2. The fabric should be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are necessary, filter cloth should be spliced together only at a support post, with a minimum 6-inch overlap, and securely sealed.

3. Posts should be spaced a maximum of 10 feet apart at the barrier location and driven securely into the ground (minimum of 12 inches). When extra strength fabric is used without the wire support fence, post spacing shall not exceed 6 feet.

4. A trench should be excavated approximately 4 inches wide and 4 inches deep along the line of posts and upslope from the barrier.

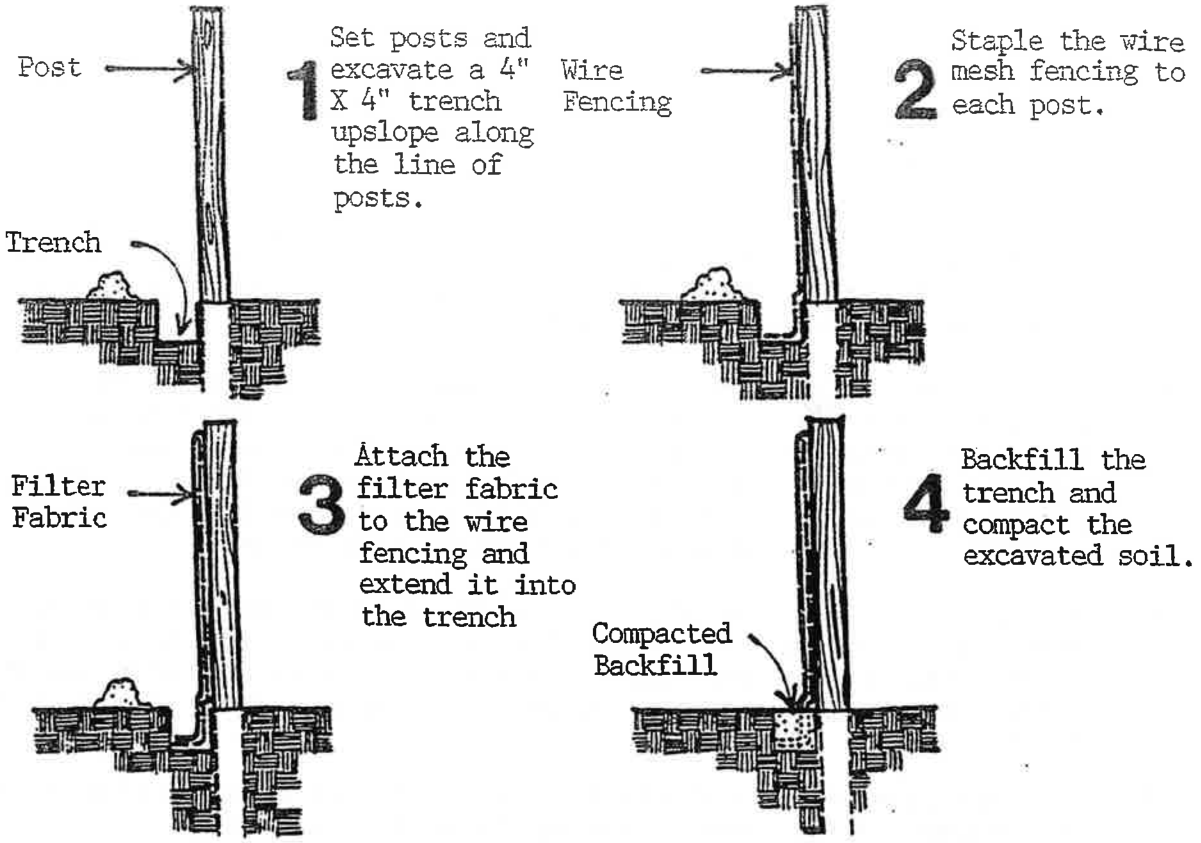
5. When standard strength filter fabric is used, a wire mesh support fence should be fastened securely to the upslope side of the posts using heavy duty 1 inch wire staples, tie wires or hog rings. The wire should extend into the trench a minimum of 2 inches and should not extend more than 36 inches above the original ground surface.

6. The standard strength filter fabric should be stapled or wired to the fence, and 8 inches of the fabric should be extended into the trench. The fabric should not extend more than 36 inches above the original ground surface. Filter fabric should not be stapled to existing trees.

7. When extra strength filter fabric or burlap and closer post spacing are used, the wire mesh support fence may be eliminated. In such a case, the filter fabric is stapled or wired directly to the posts with all other provisions of item No. 6 applying.

8. The trench shall be backfilled and the soil compacted over the filter fabric.

9. Filter barriers shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

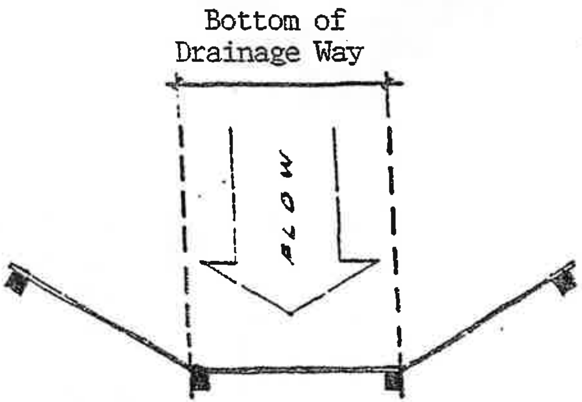


Channel Flow Applications

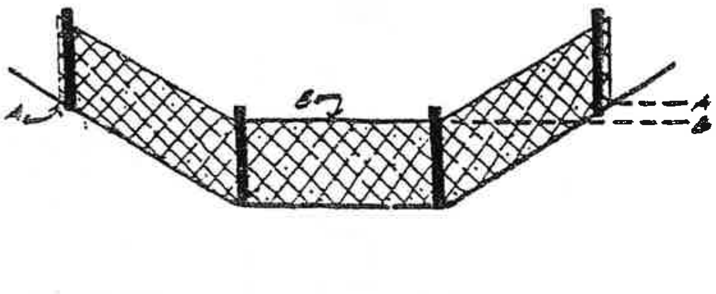
The preceeding steps for installing a synthetic filter barrier for sheet flow applications apply here, with the following additions:

The fenceline should be oriented perpendicular to the contour.

The barrier should be extended to such a length such that the bottoms of the ends of the fence are higher than the top of the fence at the lowest point in the drainageway. This is to assure that sediment laden runoff will be trapped.



PLAN



ELEVATION

Points 'A' should be higher than points 'B'

Design Guidelines

Sheet Flow Applications

1. Bales should be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.

2. All bales should all be either wire-bound or string-tied. Straw bales should be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales (in order to prevent deterioration of the bindings.)

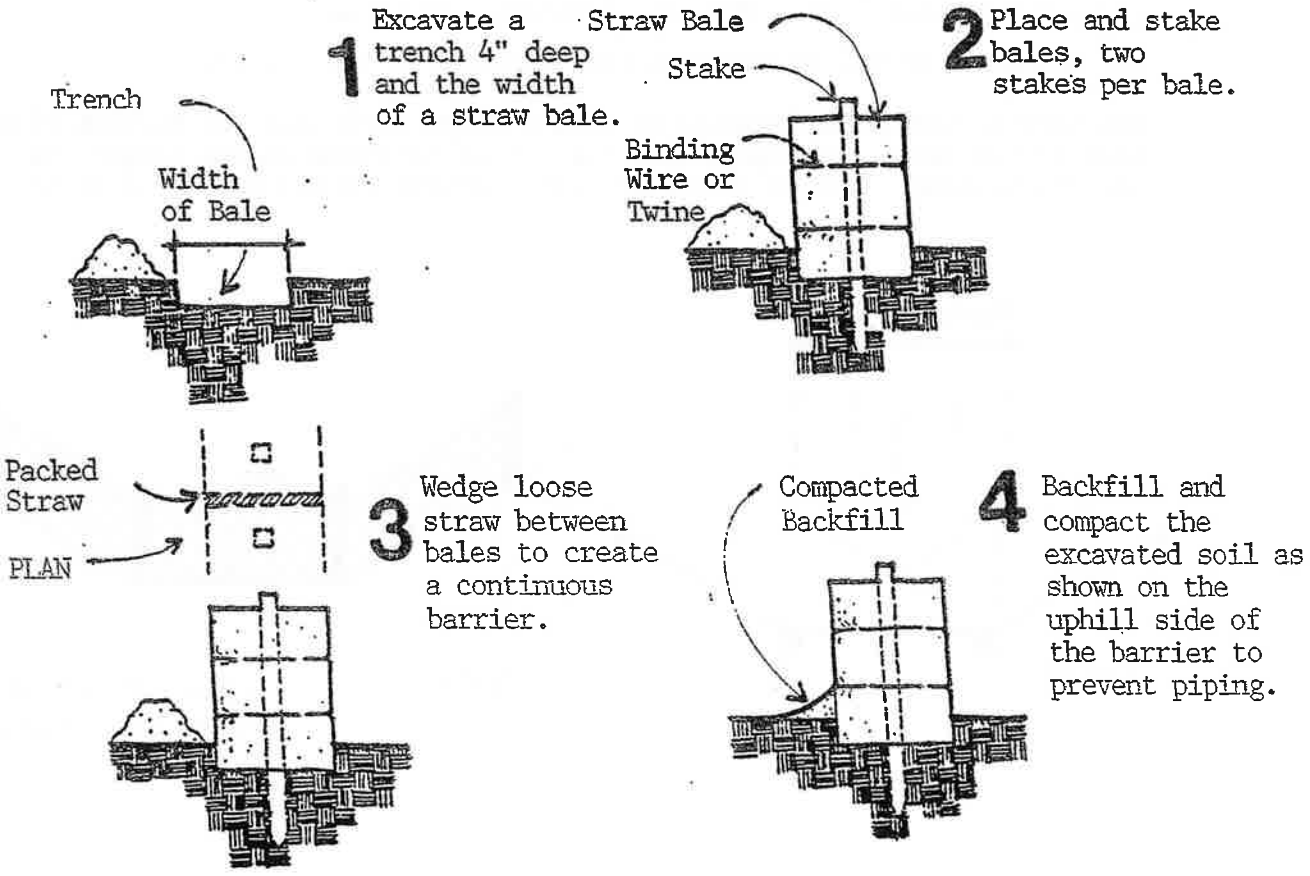
3. The barrier should be entrenched and backfilled. A trench should be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. After the bales are staked and chinked, the excavated soil should be backfilled against the barrier. Backfill soil should conform to the ground level on the downhill side and should be built up to 4 inches against the uphill side of the barrier.

4. Each bale should be securely anchored by at least two stakes of wood or steel driven through the bale. The first stake in each bale should be driven toward the previously laid bale to force the bales together. Stakes should be driven deep enough into the ground to securely anchor the bales.

5. The gaps between bales should be chinked (filled by wedging) with straw to prevent water from escaping between the bales.

6. Inspection should be frequent and repair or replacement should be made promptly as needed.

7. Straw bale barriers should be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.



1 Excavate a trench 4" deep and the width of a straw bale.

2 Place and stake bales, two stakes per bale.

3 Wedge loose straw between bales to create a continuous barrier.

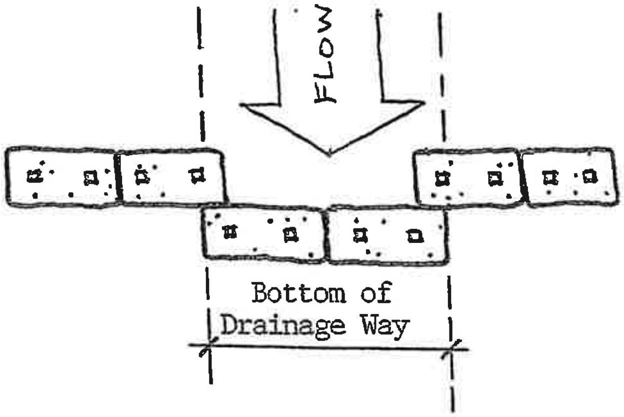
4 Backfill and compact the excavated soil as shown on the uphill side of the barrier to prevent piping.

Channel Flow Applications

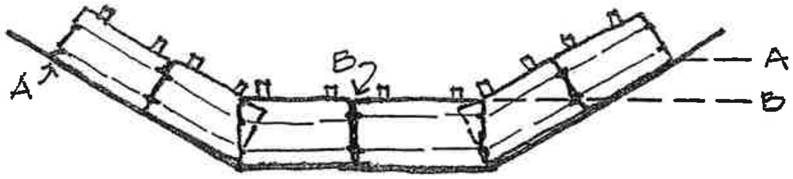
Except for item 1, the preceeding steps for installing a straw bale filter barrier for sheet flow applications apply here, with the following additions:

Bales should be placed in a double staggered row, lengthwise, oriented perpendicular to the contour, with ends of adjacent bales tightly abutting each other.

The barrier should be extended to such a length that the bottoms of the end bales are higher in elevation than the top the lowest middle bale to assure that sediment laden runoff will be trapped.



PLAN



ELEVATION

Points 'A' should be higher than points 'B'

CREDITS

Portions of the graphics, and text were adapted and edited from *A Study for the Improvement, Restoration, and Protection of Lake Bruce* by Earth Source Inc.; from *Developing Lands: Erosion and Sediment Control Guide* by The Maumee River Basin Commission; from *Urban Development Planning Guide* by The Hoosier Heartland Resource Conservation and Development Council, Inc.; from *Water Resources Protection Technology: A Handbook of Measures to Protect Water Resources in Land Development* by J. Toby Tourbier and Richard Westmacott; and from *Erosion Control* by Ernie Stoller.

For Shorewood Property Owners Association

Construction Project ______________________

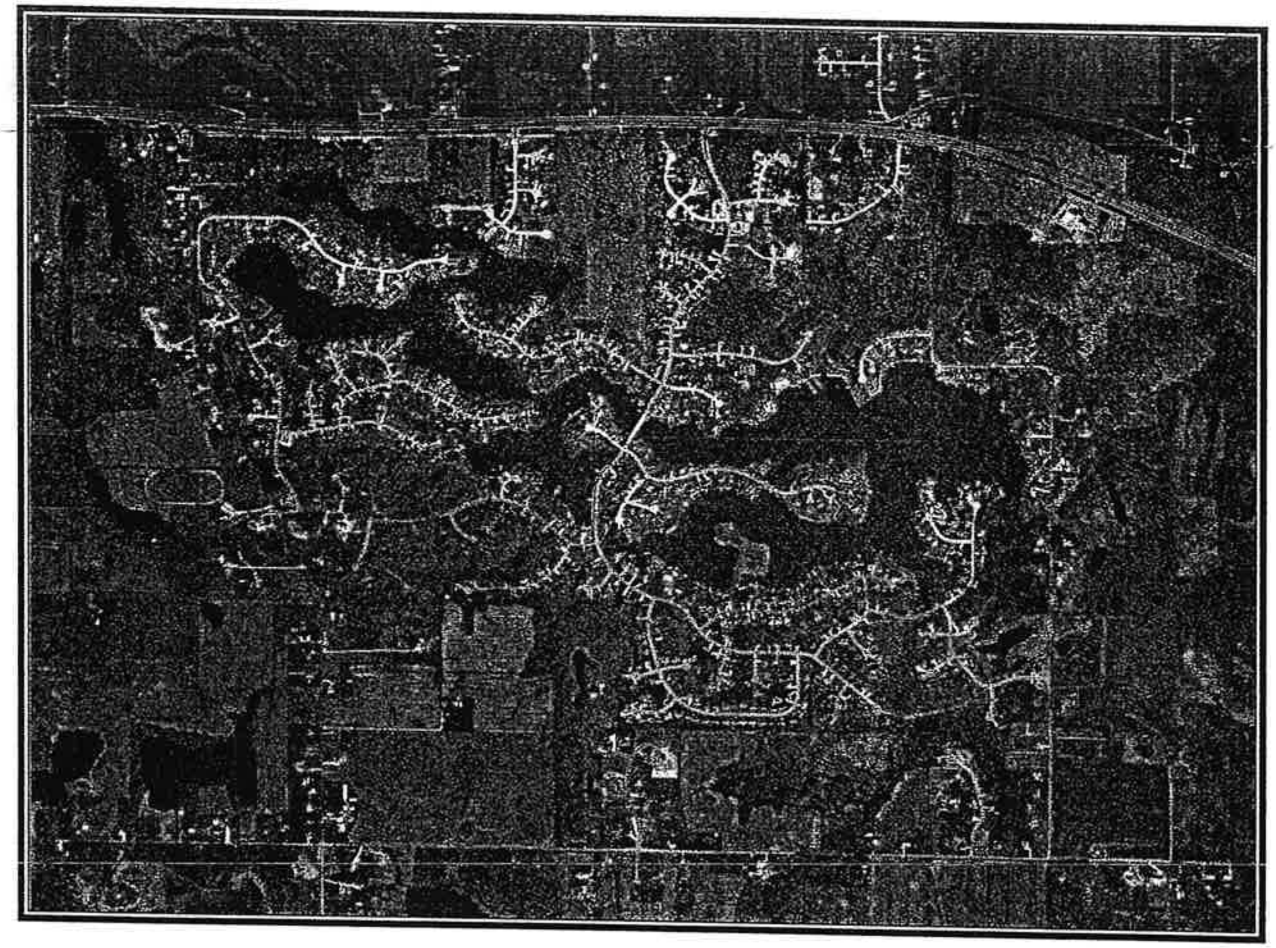
	CONTROL GROUP	CHECKLIST	CONTROL TECHNIQUE	CONTROL TECHNIQUE APPLICATIONS	DURING CONSTRUCTION	TEMPORARY	PERMANENT
NATURAL FEATURE CONSERVATION Enhance Existing Controls	NATURAL AREA PRESERVATION Techniques to prevent and control erosion using existing vegetation.		* Building Setback	USED TO PREVENT DAMAGE TO BUILDINGS CAUSED BY UNSTABLE BANK CONDITIONS.	▨		▨
			* Preserve Vegetation	USED TO PROVIDE EROSION CONTROL ON CRITICAL AREAS. NATURAL MODEL OF EROSION CONTROL MAY BE PART OF FINAL LANDSCAPE PLAN.	▨		▨
	TREE STAND ENHANCEMENT Techniques to improve vegetative cover.		Protection of Trees	USED TO PHYSICALLY BARRICADE VEGETATION FROM HEAVY CONSTRUCTION EQUIPMENT.	▨	▨	
			* Tree Planting	USED TO ENHANCE DEVELOPMENT AND TO PROVIDE ADDED SOIL STABILIZATION AND EROSION PREVENTION.			▨
	TOPSOIL CONSERVATION Technique to improve planting conditions.		Topsoil Conservation	USED TO ENSURE AN ADEQUATE, UNCOMPACTED GROWTH MEDIUM FOR PROPOSED REVEGETATION.	▨	▨	
SOIL STABILIZATION Control Raindrop, Sheet, & Wave Erosion	VEGETATIVE SOIL COVER Techniques to stabilize soil by preventing splash and sheet flow erosion.		Temporary Seeding	USED TO PROVIDE QUICK TEMPORARY COVER TO CONTROL EROSION WHEN PERMANENT SEEDING IS NOT DESIRED OR TIME OF YEAR IS INAPPROPRIATE.	▨	▨	
			Permanent Seeding	USED TO PROVIDE PERMANENT VEGETATIVE COVER TO CONTROL EROSION. FILTERS SEDIMENT FROM FLOWS. MAY BE PART OF FINAL LANDSCAPE PLAN.	▨		▨
			Sodding	USED TO PROVIDE QUICK PERMANENT COVER TO CONTROL EROSION. MAY BE USED ON STEEP SLOPES OR IN DRAINAGEWAYS INSTEAD OF SEEDING.	▨	▨	▨
			Ground Cover	USED TO STABILIZE SOIL WHERE LAWN IS NOT DESIRED. TREES, SHRUBS, VINES, OR GROUND COVERS MAY BE PART OF THE FINAL LANDSCAPE PLAN.			▨
	NON-VEGETATIVE COVER Techniques to stabilize soil by preventing splash and sheet flow erosion.		Mulches	USED AS INSURANCE FOR A SUCCESSFUL TEMPORARY OR PERMANENT SEEDING, CONTROLS UNWANTED VEGETATION, PRESERVES SOIL MOISTURE.	▨	▨	▨
			Aggregate Cover	USED AS SOIL COVER ON ROADS AND PARKING LOTS AND WHERE VEGETATION IS DIFFICULT TO ESTABLISH.	▨	▨	▨
	SLOPE AND BANK PROTECTION Techniques to stabilize very steep slopes.		* Biotechnical Measures	USED WHERE EROSION PROBLEMS CANNOT BE SOLVED BY VEGETATION ALONE OR WHERE MECHANICAL MEASURES ALONE ARE INAPPROPRIATE.			▨
	SHORELINE PROTECTION Techniques to dissipate energy in waves.		* Sea Walls	USED TO BREAK THE FORCE OF WAVES AND TO PROTECT THE SHORELINE FROM EROSION.			▨
RUNOFF CONTROL Control Rill, Gully, & Channel Erosion	DIVERSIONS Techniques to protect areas from undesirable surface flows of run off.		Temporary Diversion	USED AS AN INTERIM MEASURE TO FACILITATE SOME PHASE OF CONSTRUCTION.	▨	▨	
			* Permanent Diversion	USED AS AN INTEGRAL PART OF A SITE'S OVERALL WATER MANAGEMENT SYSTEM.	▨		▨
	WATERWAYS Techniques to convey concentrated runoff to desired outlet.		Bare Channel	USED TO TEMPORARILY CONVEY WATER WHEN VELOCITY OF FLOW IS VERY LOW. MUST BE USED IN CONJUNCTION WITH SEDIMENT CONTROL PRACTICES.	▨	▨	
			* Grassed Waterway	USED TO CONVEY WATER WHEN VELOCITY OF FLOW IS LOW TO MEDIUM.	▨	▨	▨
			* Lined Channel	USED WHEN VEGETATION WILL NOT PROTECT THE CHANNEL AGAINST HIGH VELOCITIES OF FLOW OR WHERE VEGETATION CANNOT BE ESTABLISHED.	▨	▨	▨
	GRADE STABILIZATION STRUCTURES Techniques that prevent erosion by reducing the length and slope of the drainageway.		* Rock Chute Structure	USED TO ECONOMICALLY STABILIZE GRADES WHERE FLOW VELOCITIES ARE SLOW AND WHERE SLOPES ARE GENTLE.	▨		▨
			* Piped Spillway	USED FOR RELATIVELY SHORT VERTICAL DROPS AND SMALL FLOWS.	▨		▨
			* Weir Spillway	USED FOR RELATIVELY SHORT VERTICAL DROPS AND MUCH GREATER FLOWS THAN PIPE STRUCTURES.	▨		▨
			* Drop Inlet Pipe Spillway	USED FOR LARGE VERTICAL DROPS AND LARGE FLOWS.	▨		▨
	OUTLET PROTECTION Technique to dissipate energy in flows.		Lined Apron	USED TO PREVENT SCOUR AT STORMWATER OUTLETS AND TO PROTECT DOWNSTREAM CHANNEL FROM HIGH VELOCITY FLOW DISCHARGING FROM STRUCTURES.	▨	▨	▨
	RETENTION AND DETENTION BASINS Techniques to control or delay amounts of runoff.		* Retention Basin	USED TO COLLECT AND HOLD WATER TO ALLOW WATER TO DISSIPATE BY EVAPORATION AND INFILTRATION.	▨		▨
			* Detention Basin	USED TO COLLECT AND HOLD WATER TEMPORARILY TO ALLOW WATER TO BE RELEASED AT PRE-CONSTRUCTION FLOW RATES.	▨		▨
SEDIMENT CONTROL Protect Off Site Areas	MUD AND DUST CONTROL Techniques to reduce amount of mud and dust that leave the site.		Stabilized Const. Entry	PREVENTS MUD FROM BEING PICKED UP AND CARRIED OFF SITE.	▨	▨	▨
			Dust & Traffic Control	PREVENTS DUST FROM LEAVING CONSTRUCTION SITE.	▨	▨	▨
	SEDIMENT FILTERS Techniques to reduce amount of sediment in low to medium velocity flows.		Barrier Filter	USED ALONG PROPERTY LINES, AT STORM SEWER INLETS, AND IN SOME WATERWAYS TO FILTER SEDIMENT FROM SHEET AND RILL RUNOFF. DRAINAGE AREA ARE OF LIMITED SIZE.	▨	▨	
			Vegetative Filter	USED ALONG DRAINAGEWAYS, PROPERTY LINES, AND LAKE SHORELINES TO FILTER SEDIMENT FROM SHEET RUNOFF. SIZE PROPORTIONATE TO DRAINAGE AREA.	▨	▨	▨
	SEDIMENT BASINS Technique to remove sediment in fast flows.		* Sediment Basin	USED IN NATURAL OR CONSTRUCTED CHANNELS TO TRAP AND STORE SEDIMENT AND OTHER WATER BORNE DEBRIS.	▨	▨	▨

An asterick (*) denotes technique that should be professionally designed.

Lake Louise Watershed Assessment

PORTER COUNTY, INDIANA

July 16, 2004



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INTRODUCTION

Lake Louise is a relatively shallow, 230-acre reservoir located southwest of Valparaiso, Indiana. Lake Louise forms the centerpiece of the Shorewood Forest residential subdivision, offering Shorewood Forest residents a place for fishing, boating, water-skiing, and swimming. While Lake Louise continues to provide hours of enjoyment for Shorewood Forest residents, residents have expressed a desire for better water clarity and fewer rooted plants and algae blooms. They have also voiced concern over the observed decrease in lake depth and wondered about their lake's life span.

Over the past fifteen years, Shorewood Forest residents have themselves, along with help from several consultants, conducted various types of lake and watershed assessments on Lake Louise and its 1600-acre watershed. Many of these assessments focused on the lake's water quality. A few, however, also provided recommendations for improving Lake Louise's water quality. While all of these studies added to the base of data on Lake Louise (which is crucial to understanding trends in water quality), scarce financial resources and lack of land ownership limited the ability of Shorewood Forest residents to implement many of the larger scale recommendations made in some of the reports.

As part of their on-going effort to better understand their lake and how to manage it, Shorewood Forest residents authorized a two part project in 2003 to document the lake's current ecological condition and assess the lake's 1600-acre watershed. The first part of the project focused on Lake Louise's current conditions. Water quality sampling was conducted in each of the main lobes on Lake Louise and at its representative point (the lake's deepest point) in late summer 2003. The results of the sampling showed that, in general, Lake Louise and its lobes possessed higher nutrient concentrations and poorer water clarity than the typical Indiana lake. Total phosphorus concentrations were particularly elevated and are likely the cause of the observed algal blooms. Algal blooms and sediment from the watershed, as well as bottom sediments re-suspended by boat and wave action, are responsible for the lake's poor clarity. Additionally, elevated phosphorus concentrations and poor water clarity create an environment that is ideal for growth of nuisance rooted plant species such as Eurasian water milfoil, which infests Lake Louise at times. In summary, the results of the water quality sampling conducted during the first part of this project indicated that nutrient, particularly phosphorus, and sediment loading were the primary causes of the problems voiced by Shorewood Forest residents.

The second part of the project, which is documented in this report, evaluated Lake Louise's watershed. A lake is, in essence, a reflection of its watershed. Watershed characteristics, such as watershed size, soil types, land use patterns, and lake morphometry, can influence a lake's water quality. Some watershed characteristics cannot be changed or managed. For example, it is impossible to change a watershed's geological history. These unalterable watershed characteristics define the lake's natural condition. Other watershed characteristics such as land use patterns can be changed resulting in a corresponding change in water quality. These alterable watershed characteristics can be managed to achieve a desired water quality, within the limits defined by the unalterable watershed characteristics.

The report that follows documents the results of the Lake Louise watershed investigation, including descriptions of major watershed characteristics that can influence water quality, and summarizes management techniques that can be implemented to improve the lake's water quality. The watershed investigation included a desktop study of available maps, review of historical studies to understand the lake's morphometry, computer assisted GIS (Geographical Information Systems) analysis of the watershed, and a walking and windshield tour of the Lake Louise watershed. The watershed investigation focused on that portion of the Lake Louise watershed that lies within Shorewood Forest, since it is the portion over which residents have the greatest control. Following analysis of the watershed, management recommendations to improve the lake's water quality were developed. At the request of the property owners association, management recommendations outlined in this report center on low cost techniques and those available to individual residents.

LAKE AND WATERSHED PHYSICAL CHARACTERISTICS

Table 1 presents some of the physical characteristics of Lake Louise and its watershed. Lake Louise is a medium to small sized reservoir with a surface area of approximately 230 acres. Lake Louise is fairly shallow with a mean depth of approximately 8 feet. This mean depth is based on bathymetric data presented in the 1990 study (Earth-Source, Inc., 1990) of the lake. A mean depth of 8 feet represents a 2-foot (20%) decrease in mean depth from a mean depth of 10 feet estimated from 1974 data. Like many reservoirs, Lake Louise's bathymetry varies considerably across its surface area. Its bays are generally less than 10 feet deep, with large portions of the bays less than 5 feet deep. In 1990, approximately 70% of the lake was less than 10 feet deep. The lake's deepest point is near its dam where the maximum depth extends to approximately 25 feet. The lake has a volume of approximately 1845 acre-ft.

Table 1. Physical characteristics of Lake Louise and its watershed

Physical Characteristic	
Lake Area	230 acres
Mean Depth	8 feet
Maximum Depth	25 feet
Lake Volume	1845 acre-ft
Watershed Area	1600 acres
Watershed Area to Lake Area Ratio	7:1
Estimated Hydraulic Residence Time	Approximately 1 year

Understanding the shallow nature of Lake Louise's is important for setting expectations regarding the lake's primary productivity levels (i.e. the amount of rooted plant and algae growth). Shallow lakes have the capacity to support more rooted plants than deeper lakes. In shallow lakes, there is still sufficient sunlight to support plant growth at the bottom of the lake, particularly if the lake is only 10 deep as is the case with Lake Louise. Most aquatic plant species common to Indiana grow to depths greater than 10 feet. Given the shallow nature of Lake Louise's bays, one should expect rooted plants to cover a fairly large portion of these bays.

Lake Louise's 1600-acre watershed extends to the north, south, and west of the lake (Figure 1). The lake's watershed is relatively small compared to the size of the Lake Louise. The result is a watershed area to lake area ratio of approximately 7:1. This means that for every acre of water in Lake Louise, seven acres of land drain to it. Lake Louise's watershed area to lake area ratio is more typical of glacial lakes than reservoirs. Many glacial lakes have watershed area to lake area ratios on the order of 10-50:1, whereas reservoirs have watershed area to lake area ratios near 300:1 (Vant, 1987).

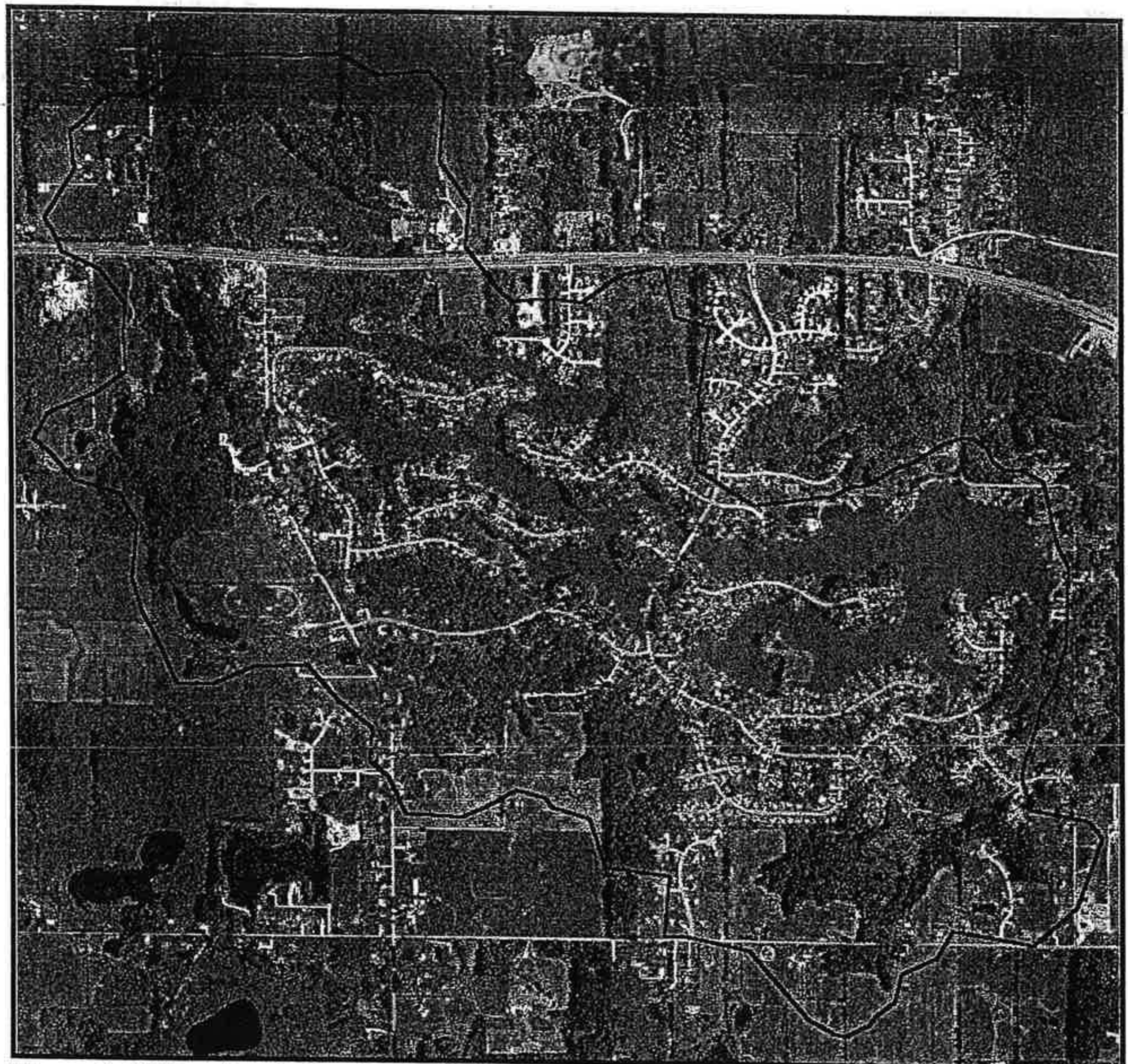

Figure 1. 2003 orthophoto with the Lake Louise watershed superimposed on it.

Watershed area to lake area ratios can affect the chemical and biological characteristics of a lake. For example, lakes with large watersheds have the potential to receive greater quantities of pollutants (sediments, nutrients, pesticides, etc.) from runoff than lakes with smaller watershed. For lakes with large watershed area to lake area ratios, watershed activities can potentially exert a greater influence on the health of the lake than lakes possessing small watershed area to lake area ratios. Conversely, for lakes with small watershed area to lake area ratios shoreline activities and internal lake processes may have a greater influence on the lake's health than lakes with large watershed area to lake area ratios.

Lake Louise's watershed area to lake area ratio is relatively small suggesting that in-lake processes and shoreline activities can have a significant affect on the lake's water quality. This is important in determining where management efforts should be focused. Additionally, the Shorewood Forest residential subdivision composes a large portion of the watershed suggesting good management of this land is critical to improving water quality in the lake.

Hydraulic residence time is another physical characteristic of Lake Louise and its watershed that should be considered when determining the direction management efforts to improve water quality in the lake. Hydraulic residence time refers to how long water stays in a lake before being replaced by fresh water from the lake's watershed or via direct precipitation. In lakes with long hydraulic residence times (i.e. several years), it is worthwhile to consider in-lake treatments to improve water quality. Because the water remains in the lake for extended periods, in-lake treatments tend to last several years on lakes with long hydraulic residence times. In contrast, lake managers of lakes with short residence times (i.e. several days up to a few months) should focus on watershed management techniques to improve water quality in these lakes. The water in lakes with short residence times is continually being replaced with new water from the watershed, so ensuring that the water entering lakes with short hydraulic residence times is clean is critical to ensuring good lake water quality.

Lake Louise has a hydraulic residence time of approximately one year. (Appendix 1 provides an explanation of the hydraulic residence time calculation for Lake Louise.) This means that, on average, water remains in the lake for approximately one year before it is replaced with new water from the watershed and/or atmosphere. A hydraulic residence time of one year is fairly long for reservoirs and is more typical of glacial lakes. It suggests Lake Louise's volume relative to its watershed size is greater than the lake volume to watershed area ratios for typical reservoirs. Lake Louise's relatively long hydraulic residence time also suggests that management efforts should focus on both in-lake processes and watershed processes.

It is important to note some caveats associated with the estimated hydraulic residence time for Lake Louise. Because there are no readily available, quantified estimates of groundwater movement into or out of Lake Louise, it was assumed that groundwater inputs to the lake equaled groundwater release from the lake. If groundwater inputs exceed groundwater outputs, Lake Louise would have a shorter hydraulic residence time than one year. The converse is true if groundwater outputs exceed groundwater inputs. Additionally, in calculating the hydraulic residence time estimate, Lake Louise was treated as a single basin. It is likely, however, that the bays have different individual residence times and these times differ from the residence time of the main portion of lake. Water likely flows slower through the bays and faster through the main portion of the lake, near the dam. This should also be considered when managing the lake's water quality.

Soils

Soils in the watershed, and in particular their ability to erode or sustain certain land use practices, can impact the water quality of a lake. For example, highly erodible soils are, as their name implies, easily erodible. Soils that erode from the landscape are transported to waterways or waterbodies where they impair water quality and often interfere with recreational uses by forming sediment deltas in the waterbodies and spoiling the aesthetic beauty of the lake. In addition, such soils carry attached nutrients, which further impair water quality by fertilizing rooted plants and algae in the lake.

Figure 2 shows the soils covering the Lake Louise watershed and highlights the dominance of highly erodible and potentially highly erodible soils in the watershed. Most of the highly erodible soils in the watershed lie immediately adjacent to Lake Louise or along drainages that empty into the lake. Much of the remainder of the watershed is mapped in potentially erodible soils. This suggests a large portion of the watershed is prone to erosion, potentially causing many of the problems noted above. It also emphasizes the need for good land management to curb erosion as much as possible.

The soils map of the watershed provides insight into the current condition of the lake. Long-time residents and scientific studies (Earth-Source, 1990) have noted a decrease in lake depth and volume. While current erosion from the landscape is likely continuing this decrease, the initial construction of homes along the lakeshore may have played a big role in the observed decrease in lake depth and volume. The potential for soil erosion on active construction sites is often *several orders of magnitude* greater than the potential for soil erosion on active agricultural sites. This fact, coupled with the prevalence in highly erodible soils along Lake Louise, means a significant portion of the loss in lake depth and volume likely occurred during the construction of Shorewood Forest.

While is it beneficial to understand the consequence of historical actions on the lake's depth and volume, many of the areas mapped in highly erodible soils along Lake Louise are currently stabilized and covered with lawns or impervious surface. These areas no longer pose a threat to the lake's water quality (at least, in terms of the direct input of sediment). Management efforts should focus on undeveloped areas that are mapped in highly erodible or potentially highly erodible soils. This includes many of the ravines draining to the lake and an area north of the lake that is currently slated for residential development. A discussion of ravine stabilization and erosion control on construction sites follows in the Watershed Management section of this report.

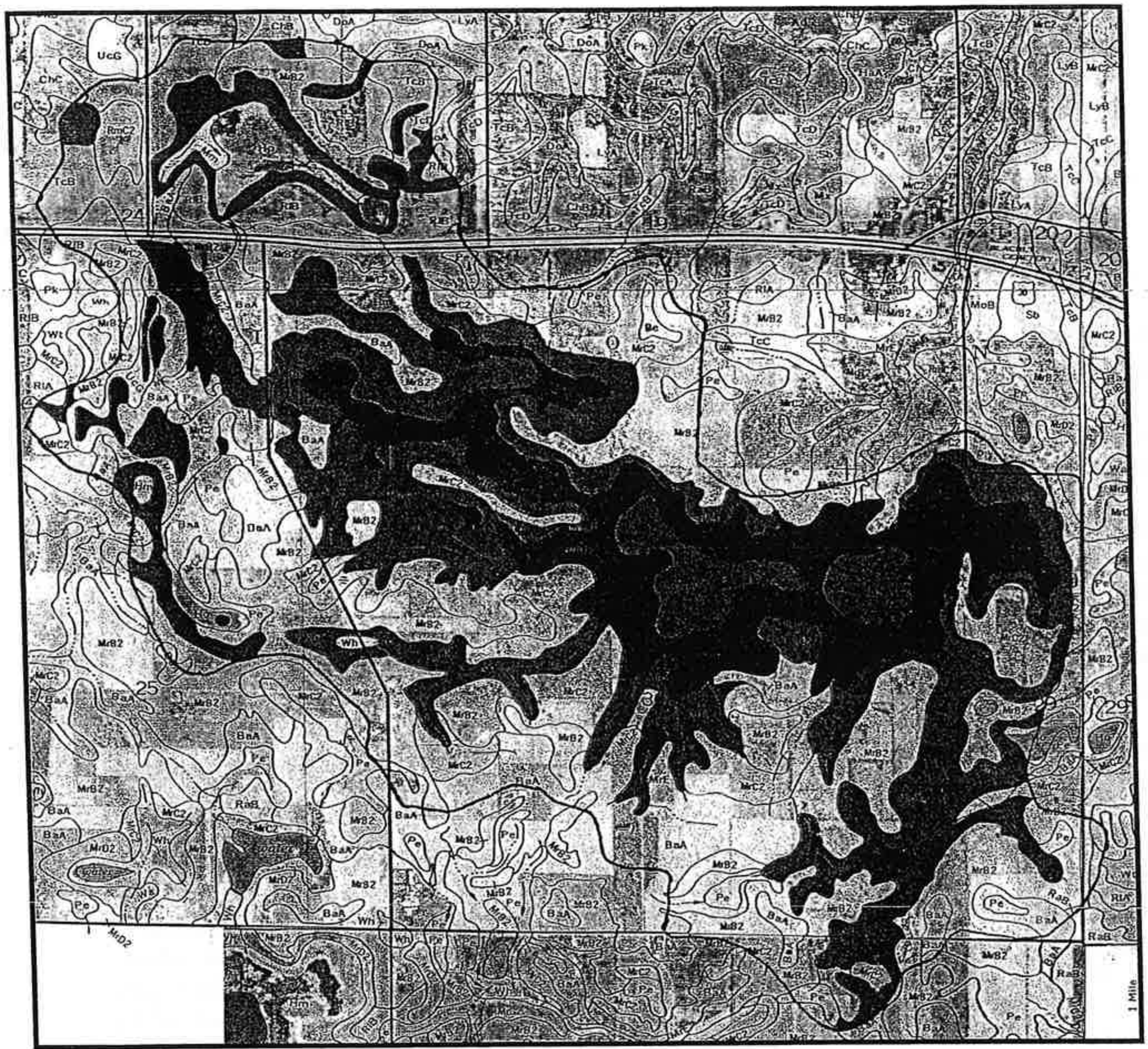

Figure 2. Soils covering the Lake Louise watershed. Highly erodible soils are shown in red; potentially highly erodible soils are shown in yellow.

Land Use

Like soils, how the land in a watershed is used can impact the water quality of a waterbody. Different land uses have the potential to contribute different amounts of nutrients, sediment, and toxins to receiving waterbodies. For example, Reckhow and Simpson compiled phosphorus export coefficients (amount of phosphorus lost per unit area of land) for various land uses by examining phosphorus loss rates from different land uses (Table 2). Several researchers have also examined the impact of specific urban and suburban land uses on water quality (Bannerman et al., 1992; Steuer et al., 1997; and Waschbusch et al., 2000). Bannerman et al. (1992) and Steuer et al. (1997) found high mean phosphorus concentrations in runoff from residential lawns (2.33-2.67 mg/L) and residential streets (0.14-1.31 mg/L). These concentrations are well above the threshold at which lakes might begin to experience algae blooms. (Lakes with total phosphorus concentrations above 0.03 mg/L will likely experience algae blooms.) Finally, the Center for Watershed Protection has estimated the association of increased levels of impervious surface in a watershed with increased delivery of phosphorus to receiving waterbodies (Caraco and Brown, 2001). Land use directly affects the amount of impervious surface in a watershed. Because of the effect watershed land use has on water quality of the receiving lake, mapping and understanding a watershed's land use is critical directing lake management efforts.

Table 2. Phosphorus export coefficients (units are kg/hectare except the septic systems category which are kg/capita-yr).

Estimate Range	Agriculture	Forested Land	Urban Land	Septic Systems
High	3.0	0.45	5.0	1.8
Middle	0.40-1.70	0.15-0.30	0.80-3.0	0.40-0.90
Low	0.10	0.20	0.50	0.30

Source: Reckhow and Simpson, 1980

Figure 3 and Table 3 present the land use in the Lake Louise watershed. (Land use data from the U.S. Geological Survey forms the basis of Figure 3.) Forested land and residential land use cover most of the watershed. Approximately 31% of the land draining to the lake is forested, while just over 29% of the land draining to the lake is used for residential purposes. Agricultural land and open fields (including fallow agricultural land and pastures) account for another third of the land use in the watershed. Wetlands cover approximately 6% of the watershed's landscape.

Table 3. Generalized land use the Lake Louise watershed.

Land Use	Watershed including Lake Louise		Watershed excluding Lake Louise	
	Area (acres)	Percent of Watershed	Area (acres)	Percent of Watershed
Forest	428	26.7%	428	31.1%
Residential	400	24.9%	400	29.1%
Wetland	82	5.1%	82	6.0%
Open water	241	15.0%	11	<1.0%
Agricultural	203	12.7%	203	14.8%
Pasture/grassland	250	15.6%	250	18.2%
Total	**1604**	**100.0%**	**1374**	**100%**

Most of the residential land falls in the USGS's 'low intensity' residential category. According to the USGS's definition, low intensity residential areas consist largely of single family homes, and impervious surface (driveways, sidewalks, roads, rooftops, etc.) cover 30-80% of the area. Using this definition and assuming that impervious surface covers about 50% of watershed's residential land (an estimate on the low side of the median), impervious surface covers approximately 15% of the watershed. This estimate of impervious surface coverage is above threshold at which the Center of Watershed Protection has found an associated decline in water quality.

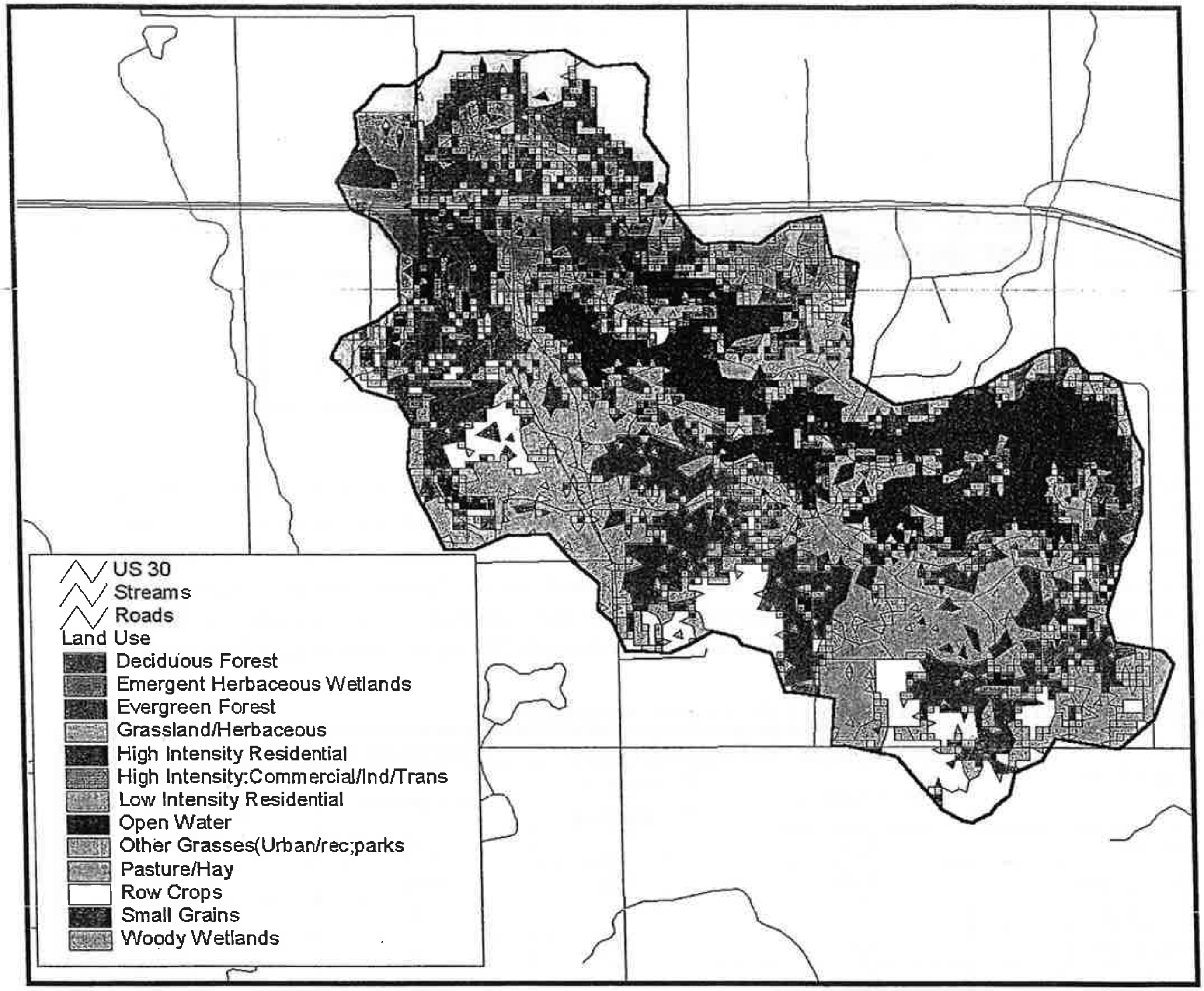

Figure 3. Land use in the Lake Louise watershed.

Watershed Characteristics Summary

The preceding sections described the characteristics of the Lake Louise watershed, with a particular emphasis on those characteristics that can influence the lake's water quality and life span. In summary, these sections note the following. Highly erodible and potentially highly erodible soils cover a large portion of Lake Louise's watershed, indicating a high potential for soil erosion. This potential should be considered when managing the various land uses in the watershed. Forested land and residential land are the predominant land uses in the watershed and impervious surfaces cover approximately 15% of the watershed. The relatively high percentage of land in residential use and high percentage of impervious surfaces means special attention should be given to reducing pollutants at their source since these land uses offer little in the way of pollutant conveyance reduction. Relative to other reservoirs, Lake Louise has a fairly low watershed area to lake area ratio suggesting near shore and in-lake processes may play a bigger role in affecting water quality than these areas do in the typical reservoir. This characteristic also means the Shorewood Forest residents have greater control over the fate of their lake's health than lake residents who live in watersheds where much of the watershed is not in their possession. Finally, Lake Louise has a longer hydraulic residence time than the typical reservoir, suggesting that in-lake treatments may have a greater impact on Lake Louise than the typical reservoir. This fact, coupled with data from the water quality analysis phase of this project (JFNew, 2003), indicates that in-lake treatments may need to be considered once watershed inputs are controlled to the extent feasible.

WATERSHED MANAGEMENT

Table 2 suggests the best way to reduce phosphorus export to a lake is to convert the lake's entire landscape to forested land. Obviously, this is not a feasible solution, but understanding why forested land has the lowest phosphorus (and generally any pollutant) export rates provides some insight into ways to manage the Lake Louise watershed to reduce its pollutant export rates. Two factors keep the loss of phosphorus (and most pollutants) from forested land to a minimum. First, as rain falls on multi-layered forested land, trees, shrubs, and herbaceous vegetation intercept the rain, preventing it from becoming runoff. The reduction in runoff necessarily decreases the loss of pollutants from the landscape. Second, as it continues to rain, some water reaches the ground and becomes runoff. However, the plants and humus on the forest floor filter the runoff, removing some of the pollutants in the runoff. The overall result is a decrease in both volume of runoff and a decrease in the pollutant concentration in the runoff. A third factor contributing to the low phosphorus export coefficient of forested land should also be noted: humans rarely, if ever, add phosphorus to forested land. These three factors, decreasing the amount or volume of runoff, decreasing the concentration of pollutants in the runoff, and reducing the amount of pollutant added to the landscape, are keys to low pollutant export from forested land. These three factors are the same keys to managing other landscapes, including residential areas, to improve water quality.

The following paragraphs outline management techniques that Shorewood Forest residents should take to improve the water quality of Lake Louise. The suggested management techniques generally involve methods to decrease the volume of storm water runoff, decrease the concentration of pollutants in the runoff, and reduce the amount of pollutant added to the landscape, the three keys responsible for low pollutant export rates observed in forested land. As noted in the introduction, this report focuses specifically on relatively low-cost management techniques that can be employed by individual landowners or groups of landowners. Because of Lake Louise's relatively low watershed area to lake area ratio and because Shorewood Forest occupies a large portion of the lake's watershed, Shorewood Forest residents have greater control over their lake's water quality than residents living on many other lakes in northern Indiana. Managing individual properties and common areas will be vital to improving Lake Louise's water quality.

Individual Property Management

There are several management techniques that individual property owners can employ to reduce the loss of pollutants from their properties. One of the most important techniques is to reduce or if possible eliminate the use of fertilizers and pesticides. These lawn care products are a source of nutrients and toxins to Lake Louise. Landowners typically apply more fertilizer to lawns and landscaped areas than necessary to achieve the desired results. Plants can only utilize a given amount of nutrients. Nutrients not absorbed by the plants or soil can run off into the lake either directly from those residents' lawns around the lake or indirectly via storm drains. This simply fertilizes the rooted plants and algae in the lake. At the very minimum, landowners should follow dosing recommendations on product labels and avoid fertilizer/pesticide use within 10 feet of hard surfaces (roads, driveways, sidewalks, etc.) and 10 to 15 feet of the lake's edge. Where possible, natural landscapes should be maintained to eliminate the need for pesticides and fertilizers. Alternatively, property owners should consider replacing high maintenance turf grasses with grasses that have lower maintenance requirements.

If a property owner considers fertilizer use necessary, the property owner should apply phosphorus-free fertilizers. (Slow release, organic, phosphorus free fertilizers are recommended.) Several researchers have found residential lawns to be critical sources of phosphorus (Bannerman et al., 1992 and Steury et al., 1997). Most lawn fertilizers contain both nitrogen and phosphorus. However, the soil usually contains enough natural phosphorus to allow for plant growth. As a consequence, fertilizers with only nitrogen work as well as those with both nutrients. The excess phosphorus that cannot be absorbed by the grass or plants can enter the lake, again either directly or via storm drains. Landowners can have their soil tested to ensure that their property does indeed have sufficient phosphorus and no additional phosphorus needs to be added. The Purdue University Extension Office or a local supplier can usually provide information on soil testing.

Another alternative to reducing fertilizer use or using only phosphorus free fertilizers is to use the lake water to hydrate and fertilize the lawn. The lake water contains both phosphorus and nitrogen and consequently may serve as a suitable fertilizer for lawns adjacent to the lake. This concept has been utilized at other eutrophic lakes with residential land use bordering the lake. By using lake water to fertilize the adjacent lawns, no new nutrients are added to the lake and some are potentially removed. This option is not feasible if Shorewood Forest prohibits this activity.

Other sources of nutrients and pathogens in runoff include lawn and animal waste. Shoreline landowners should also avoid depositing lawn waste such as leaves and grass clippings in the lake or channels draining to the lake as this adds to the nutrient base in these aquatic systems. Pet and other animal waste that enters the lake and channels also contribute nutrients and pathogens to the waterbodies. Yard, pet, and animal waste should be placed in residents' solid waste containers to be taken to the landfill rather than leaving the waste on the lawn to decompose.

Property owners who own shoreline property and who maintain turf grass lawns immediately adjacent to the lake should consider replacing the turf grass with a mix of native flowers and grasses to create a more natural shoreline. Natural shorelines provide vital functions to a healthy lake ecosystem. Native grasses and flowers slow overland flow and reduce flow volume by increasing infiltration of runoff better than turf grasses. Vegetative shorelines also help filter pollutants from runoff. By promoting infiltration of runoff and filtering runoff, native plant buffers reduce the amount of pollutants reaching the lake. Some studies have shown buffers around lakes and streams can reduce up to 80% of the sediment, 50% of the phosphorus, and 60% of the pathogens in runoff (Conservation Technology Information Center, 2000). Buffers immediately adjacent to the lake also protect the lake from wave action, which limits erosion, release oxygen to the water column for use by aquatic biota, and provide food, cover, and spawning/nesting habitat for a variety of fish, waterfowl, insects, mammals, and amphibians.

Extensive, tall plant buffers along lakeshores indirectly help eliminate a source of pollutants to a lake. Such buffers can discourage nuisance waterfowl, such as Canada geese, from taking up residence in the area. Canada geese prefer maintained lawns because they are easy to access from the water and any predators are clearly visible in lawn areas. Lawns also provide a vast food resource for the geese. Native vegetation is higher in profile than maintained lawns and has the potential to hide predators, increasing the risk for the geese. Some native vegetation such as blue iris and cattails are stiff, making it difficult for geese to access the lawn behind the vegetation. Geese are undoubtedly one of the major sources of nutrients to Lake Louise. Creating a more natural shoreline is important to reducing the population of geese in the area.

Various factors dictate which native species should be planted along a lakeshore. Plant species can require specific environmental conditions (i.e. sun exposure, soil type, soil moisture, etc.) to thrive. For example, pickerel weed and arrowhead should be planted in shallow water along the shoreline, while black-eyed susan and blazing star should be planted further upland from the water's edge. Additionally, landowner preferences in flower colors or vegetation height should be considered when planting a shoreline buffer. Lower profile plants and grass might be planted along the center portion of the shoreline to ensure a clear view of the lake, while taller profile plants and rushes might be considered for the outside edges of the property.

Finally, planting vegetative buffers along the channels draining to the lake is as important as planting buffers along the lakeshore. While most of the channels draining to the lake traverse wooded ravines, portions of some of these channels also cut through maintained lawns on private and community property. Replacing the turf grass immediately adjacent to the channels with native vegetation will provide many of the functions a natural shoreline provides for a lake. Appendix 2 contains a list of potential buffer species that may be appropriate for planting adjacent to Lake Louise and the channels draining to it.

Residents should disconnect stormwater drainage paths and consider the installation of vegetative filters, rain gardens, gravel infiltration trenches, or other drainage structures that promote infiltration and pollutant treatment over stormwater conveyance. While connecting downspouts with street drains keeps lawns well drained, these direct drainages prevent any pollutant treatment or infiltration (and therefore loss of stormwater volume) that the lawn or natural landscape may provide. Rain gardens are becoming more and more popular. These are easy for individual landowners to create, are relatively inexpensive, and can add to the aesthetic appeal of a yard. Shorewood Forest residents should consider installing these as a way to reduce runoff volume and filter pollutants in the runoff.

Individuals should take steps to prevent unnecessary pollutant release from their property. With regard to car maintenance, property owners should clean any automotive fluid (oil, antifreeze, etc.) spills immediately. Driveways and street fronts should be kept clean and free of sediment. Regular hardscape cleaning would help reduce sediment and sediment-attached nutrient loading to the waterbodies in the watershed. Street cleaning would also reduce the watershed loading of heavy metals and other toxicants associated with automobile use. Residents should avoid sweeping driveway silt and debris into storm drains. Rather, any sediment or debris collected during cleaning should be deposited in a solid waste container.

Finally, although only a small number of properties utilize septic systems to treat household waste, individual property owners with septic systems should take steps to minimize the water quality impacts of their on-site waste water treatment systems (i.e. septic systems). Overloaded or leaking septic systems deliver nutrients and other pollutants such as *E. coli* to nearby waterbodies. This can increase the waterbodies' productivity and threaten human health. To address the problems posed by septic systems, properties owners should conduct regular septic tank maintenance. This means homeowners should have their tanks pumped once a year. For forgetful residents, many septic system companies have programs in which the company automatically comes out once a year. Water conservation measures such as using low-flow toilets or taking shorter showers will also decrease loading to septic systems.

Street and Storm Drain Management

Bannerman et al. (1993) found streets to be critical source areas for most contaminants in residential areas and, thus, should be targeted for best management practices. Reducing pollutant flow from streets can be achieved by: 1. preventing pollutants from reaching the streets, 2. sweeping streets to prevent pollutants that reach the streets from reaching the storm drains, and 3. retrofitting storm drains to capture and remove pollutants from runoff reaching the drains. Streets themselves offer no treatment of pollutants that reach them, so Shorewood Forest residents should employ the management techniques described in the *Individual Property Management* section above to prevent pollutants from reaching the streets. Regular street cleaning is one method for removing pollutants, particularly large particles from streets. Because organized cleanings by the local street department are too infrequent to provide adequate cleaning, individual property owners must take the initiative to sweep the street in front of their properties. This is the lower cost alternative to purchasing a street cleaner. However, some residents may feel the investment in a street cleaner is worth the cost if the alternative is doing it themselves.

There are a variety of options available to treat stormwater once it reaches the storm drain. Many storm drain inlets have catch basins attached to them. These catch basins trap larger sediments and pollutants in stormwater runoff in a basin structure, while allowing lighter pollutants and dissolved materials to pass into the drain pipe system. In order to be effective, catch basins must be maintained. Current research indicates that when sediment and debris fill more than 60% of the catch basin volume, the basin reaches "steady state" meaning that the basin no longer removes sediment from storm water runoff (Pitt and Bissonnette, 1984). Storm flows re-suspend sediments in a basin at steady state and pass the pollutants through the system. Maintaining the catch basins associated with the Shorewood Forest storm drain system is a lower cost management technique that should be employed.

Another lower cost management technique is to retrofit storm drains with a catch basin insert. Catch basin inserts have been used with success in many areas of the country (Pitt et al., 2000; Aronson et al., 1983; Mineart and Singh, 1994; Port of Seattle, 1998) including Plymouth, Indiana (Bright, 2002). There are many varieties and models that are commercially available, and depending on the insert model, it may remove litter, vegetation, oils and grease, and medium to coarse sediment. Inserts have been shown to be ineffective at capturing pesticides, herbicides, toxic chemicals, and dissolved material including dissolved nutrients (Kristar Corporation, 2002).

The cost of retrofitting a catch basin to capture more pollutants varies greatly. Costs can range from filter bag inserts that cost around $100 to large swirl collectors that cost tens of thousands of dollars to install and have significant maintenance costs associated with them. When determining where to allocate financial resources to effectively manage the lake, Shorewood Forest residents should be aware of both the advantages and limitations of catch basin inserts. The advantages of properly maintaining catch basins and using inserts include: 1) relatively inexpensive cost; 2) effectiveness at removing larger debris and sediment; 3) space efficiency; 4) relative ease of installation. These advantages make the catch basin inserts fairly attractive for use in Shorewood Forest since the property owners association has limited financial resources and limited space available for storm water treatment.

It is important to understand the limitations of catch basins and inserts though to effectively weigh lake management options. For example, catch basins and inserts remove pollutants at lower rates than more expensive structural practices that require more space like wet ponds, sand filters, or wetlands (EPA, 2002). Additionally, if not properly maintained, catch basins can act as pollutant sources. Perhaps most importantly, catch basins do not effectively capture soluble and fine-sized particles (including phosphorus) which can be of great concern for lake ecosystems. This is of significant concern since algae blooms and nuisance levels of exotic rooted plant species, which are likely the result of high phosphorus loads to the lake, are listed as top problems in Lake Louise. Catch basins and their inserts would do very little to reduce phosphorus loading the lake. Shorewood Forest residents should keep these limitations in mind when deciding how to allocate financial resources among various lake and watershed management techniques.

Finally, Shorewood Forest residents should continue working with the local authorities to ensure road salting/sanding during the winter is minimized to the extent necessary to ensure safety. Often times, applications of the salt/sand mixture appear to exceed the amount necessary to ensure safety. All of this mixture will eventually reach the storm drains and could potentially reach the lake. Coordinating street cleaning once streets have de-iced would help decrease the load released to the lake. While working with the local authorities may not be an easy task, removing excess sand will definitely help water quality and slow lake in-filling.

Ravine Management

The wooded ravines scattered throughout Shorewood Forest require special attention. As shown in Figure 2, most of these ravines are mapped in highly erodible soil units. Consequently, these areas were prone to erosion prior to the development of Shorewood Forest. The Shorewood Forest subdivision, however, altered the landscapes natural hydrology. While much of the stormwater runoff from the developed portion of the subdivision are directed into storm drains, there was still likely a slight increase in the volume and velocity of runoff reaching these ravines following residential development. This increase in both the volume and velocity of runoff reaching the ravines increased the erosion from the channels at the bottom of these ravines.

Decreasing the volume and velocity of stormwater runoff reaching these ravines using the management techniques outlined above (maintaining buffers and using rain barrels or other rain gardens) will help reduce erosion in the ravine channels. Managing the channels themselves will also be important for reducing the amount of sediment and associated pollutants from reaching the lake. One of the more inexpensive techniques that can be employed is the installation of check dams along the length of the ravine channels. Check dams are rock structures placed across the width of the channel. These dams slow water in the channels, reducing the erosive potential of the water. As the water slows, heavier particles in the runoff may also drop out of suspension. Thus, the pollutant load to the lake is reduced.

The check dams will require some maintenance. As eroded material gets deposited behind the check dam, the check dam slowly loses its ability to trap more particles. Sediment, leaves, and other materials trapped behind the check dam must be removed. This is not only necessary to improve water quality, but also to improve the aesthetic appearance of the check dams. Removed materials should be disposed of in a solid waste container or stabilized in some other way to ensure the material does not erode back into the channel. Appendix 3 contains generalized drawings and specifications for constructing check dams taken from *Erosion Draw 2.0* (Salix Applied Earthcare, 1994).

Some of the ravines in Shorewood Forest (e.g. the ravines between Brockton Court and Roxbury Road and between Roxbury Road and Ashford Lane) are wooded with more or less natural vegetation surrounding the channels running through the ravines. In other areas, manicured lawn exists immediately adjacent to the ravine channels. In these areas, property owners should consider planting the land immediately adjacent to the channel to native vegetation. Native vegetation will provide the channel bank with better stability, reducing the likelihood of bank erosion. It will also increase the filtering capacity of the area, since native plants tend to infiltrate runoff water better than turf grasses. This landscaping should be done in addition to installation of rock check dams.

Another management option for improving water quality coming specifically from a ravine on the eastern edge of Shorewood Forest is to consider redirecting some of the existing drainage patterns. Currently, some of the stormwater from the Tremont Lane/Warrick Court area drains west into the Nature Preserve. Rather than entering the wetland on the south end of the preserve, water flows directly into the channel below the wetland. Some stormwater draining from a property off site to the south also bypasses the wetland and flows directly into the channel below the wetland. Redirecting this stormwater to the wetland would improve the water quality of the stormwater and control the timing of its release, which will indirectly reduce erosion in the ravine channel below the wetland. Working with a qualified engineering firm to determine whether the increase in hydrology to the wetland will impact (i.e. flood) the footpath during large storm events is recommended if this management option is pursued.

The stormwater from the Tremont Lane/Warrick Court area and the property off site to the south might be treated by constructing another wetland/pond in the Nature Preserve north of the footpath. If the property owners association owns Nature Preserve, the cost of acquiring the land is eliminated. However, for the best results, the pond or wetland should be designed by or in consultation with an experienced engineering firm. These costs should be considered in evaluating this option.

The construction of ponds, wetlands, and/or settling basins within the common areas located downstream of the channels traversing the wooded ravines of Shorewood Forest is an option to manage the water entering the Lake Louise. These structures should be designed by a qualified engineering firm, which will necessarily increase the cost of these projects. Because such management options are addressed in the Earth-Source (1990) report and because, at the request of the property owners association, this report focuses on lower cost management options, an in-depth discussion of these structures is not included here. They are, however, options for managing the lake.

Finally, small sediment traps could be installed in the lake where the ravine channels enter Lake Louise. At least one such sediment trap already exists on the east side of Lake Louise. Such traps could simply be shallow excavations with rock borders on the downstream side of the excavation. These types of structures are relatively inexpensive to construct and would not require extensive engineering consultation. However, they must be maintained (i.e. the sediment trapped within them must be removed) in order to remain effective. Additionally, it is important to note that these structures will likely only trap large particles, allowing dissolved nutrients and finer particles such as silt and clays to pass through the trap.

Future Development Management

The Shorewood Forest residents know first hand how frustrating (and expensive!) it is to try to "retrofit" a residential area to improve water quality. With better site planning, some of the pollutant load to Lake Louise may have been reduced, resulting in better water quality. While much of the subdivision is already developed, a small area is slotted for new development in the future. Designing and developing this land with the lake's water quality in mind will help ensure this new area does not unnecessarily add to the lake's pollutant load. When exploring ways to reduce the impact a new development may have on the lake's water quality, the developers should limit the amount of impervious surface in the development and focus on stormwater pollutant source and conveyance reduction (rather than, or at least in addition, to end-of-the-line pollutant reduction structures).

Based on current land use, approximately 15% of the Lake Louise watershed is covered by impervious surfaces. This exceeds the threshold above which researchers have observed a deterioration in water quality of water bodies in the watershed. Thus, it is important for any increases in impervious surfaces associated with new development in the watershed be minimized to the greatest extent possible. Several techniques are available to land planners to reduce the amount of impervious surfaces in new development. For example, planners can employ conservation design in residential areas. These design patterns cluster housing units together leaving more open space to buffer the impacts of the development. Subdivision designs should minimize street length in the housing layout and avoid cul-de-sacs without open centers. Residential street width should be also minimized. Although not always popular, shared driveways reduce pavement in residential areas as well. Porous pavement should be utilized in low traffic areas such as sidewalks. These are just of few of the possible alternatives for reducing the amount of impervious surfaces in a watershed.

In addition to limiting imperviousness, site planners should also consider means to reduce pollutants at their source or during their conveyance to a receiving waterbody. Many of the best management practices (BMPs) utilized in the newer commercial and residential developments, such as detention basins, treat stormwater volume and pollutants at the end of the line. Equal consideration should be given to practices that limit the creation or source of pollutants and practices that treat stormwater en route to an end-of-the-line treatment structure. For example, where site conditions allow, curb and gutter systems should be replaced with grassed shoulders and roadside swales to promote vegetative uptake of pollutants and infiltration of stormwater prior to its release in a detention basin or storm sewer. This would reduce both the amount of pollutants and volume of stormwater that the detention basin needs to treat. Curb and gutter systems do not provide any treatment of stormwater en route to the-end-of-the line structural BMP.

Reduction of pollutants at their source is especially important considering that many of the structural stormwater BMP have limitations on their pollutant removal capacity. Many stormwater BMPs report good pollutant removal efficiencies. Wet detention basins can remove close to 80% of the total suspended solid load to the basin. Unfortunately, over time the 20% that passes through may be sufficient to accelerate the degradation of sensitive ecosystems downstream of the BMP. In his examination of stormwater practices, Schueler (1996) identified the "irreducible" concentration of several typical stormwater pollutants discharged from various structural BMPs. For example, evidence from his study suggests that even under the best design and maintenance conditions, the total phosphorus concentration of water discharged from current stormwater BMPs (including stormwater BMP trains) is approximately 0.10 to 0.15 mg/L. These concentrations exceed the 0.03 mg/L threshold for the onset of nuisance algae blooms described in the water quality report that preceded this report. While there is some dilution when the stormwater discharge enters the lake reducing the total phosphorus concentration, over time continual discharge at this rate could accelerate the eutrophication of the Lake Louise.

Source reduction of pollutants includes strong erosion control efforts during construction activities. Sediment release from active construction sites can be several orders of magnitude greater than release from fully developed sites. The potential for release is even greater on highly erodible or potentially highly soils, which cover most of the Lake Louise watershed.

SUMMARY AND CONCLUSIONS

Shorewood Forest residents have cited poor water clarity, decreased lake depth, and nuisance growth of rooted plants and algae as their primary concerns with Lake Louise. Results of the water quality assessment conducted in the summer of 2003 indicate that the lake possesses elevated nutrient, particularly phosphorus, concentrations. The high nutrient concentrations are likely responsible for the observed algal blooms. The water quality assessment also validated the residents' concerns over the lake's water clarity. High sediment loading to the lake as well as re-suspension of bottom sediments by wind and boat action play a role in decreasing the lake's water clarity. The lake's eutrophic condition and natural morphometry create an ideal environment for the growth of nuisance rooted plant species such as Eurasian water milfoil.

Results of the watershed assessment showed that the Shorewood Forest residential subdivision occupies a large portion of the Lake Louise watershed. This gives residents significant influence in managing the landscape for improved water quality. Several management techniques can be implemented on individual properties, in the wooded ravines, and in the subdivision's common areas to reduce nutrient and sediment loading to the lake. At the request of the property owners association, the management techniques described in this report focus on lower cost techniques that are available to the lay person.

To help Shorewood Forest residents allocate limited financial resources, the following is a prioritization of the management techniques described in this report. Higher priority was given to management techniques that 1. address the critical problems identified during the water quality assessment portion of the project, 2. are inexpensive, and 3. can be implemented by one or a group of property owners.

Prioritized Recommendations:

1. Use only slow release, organic, phosphorus free fertilizers on residential lawns and common areas. This will eliminate one of the major sources of phosphorus to Lake Louise. Reducing the phosphorus load to the lake will be critical to reducing algae blooms and nuisance rooted plant growth. Phosphorus free fertilizers are becoming more available in many lawn and garden supply stores. At least, one company (Child's Play) offers lawn care service using a slow release, organic, phosphorus free fertilizer. Utilizing only slow release, organic, phosphorus free fertilizers is both inexpensive and within the control of Shorewood Forest residents.

2. Reduce the volume of stormwater leaving individual properties by disconnecting downspouts and installing rain gardens or rain barrels if necessary. This management action will decrease the runoff reaching the wooded ravines and streets. Runoff that reaches the wooded ravines adds to the erosion problem in the channels traversing the ravines. Runoff that reaches streets receives little to no treatment before reaching the lake. Reducing runoff from individual properties will therefore reduce nutrient and sediment loading to Lake Louise. Like using only slow release, organic, phosphorus free fertilizers, reducing the volume of stormwater leaving individual properties by disconnecting downspouts and installing rain gardens or rain barrels is inexpensive and within the control of Shorewood Forest residents.

3. Replace turf grass along waterways and the lake shoreline with a mix of native plant species to create a functioning natural buffer. These buffers will reduce nutrient and sediment loading to the lake by filtering runoff, increasing infiltration of runoff, reducing shoreline erosion, and deterring geese from taking up residence on the lake. While this management technique is more expensive than the preceding recommendations, it can be implemented by individual property owners. Additionally, if done properly, it is very effective in reducing pollutant loading since buffers reduce pollutant loads via several mechanisms.

4. Install check dams in the ravine channels. Check dams will help slow erosion in the ravine channels. These channels appear to be a major source of sediment to the lake. Preventing this erosion will help improve the lake's water clarity. The major cost of check dams is for the rock. Shorewood Forest residents, however, could install the check dams themselves, eliminating the cost of hiring a contractor to do the work. It is important to remember that check dams (new

and existing ones) must be cleaning once they are 60% full to ensure they are working effectively.

5. Keep the streets as clean as possible. This may mean individual residents will have to care for the portion of the street in front of their property. Continue to work with the local authority to improve the frequency and timing of organized street cleaning. Street and storm drain catch basin cleaning will primarily influence the lake's water clarity and lake depth since these management techniques focus on the removal of coarse sediment. Street cleaning typically does not have a large impact on reducing phosphorus loading to a lake.

The recommendations listed above should receive the highest priority as they will address the specific problems facing Lake Louise for the lowest cost. Other recommendations in the **Watershed Management** section should not be discarded however. They may be implemented with the understanding that they may not provide the same value as those recommendations listed above.

Shorewood Forest residents should continue to monitor the quality of their lake. This will allow the community to track the success of any management steps and help redirect management efforts when necessary. Lake monitoring can be completed by residents to reduce the cost associated with the monitoring. The Indiana Department of Environmental Management also has a volunteer lake monitoring program. Lake residents or users of any lake (regardless of whether the lake is public or private) can enroll in this program and gain the benefits of it. Enrollment in the Indiana Clean Lakes Volunteer Monitoring Program is highly recommended to the Shorewood Forest residents as a low cost way to monitor their lake and any progress they make in managing it.

Shorewood Forest residents must accept some of the natural limitations of Lake Louise when setting management goals. A large portion of Lake Louise is shallow, and shallow lakes tend to naturally support extensive rooted plant communities. Some rooted plants such as Eurasian water milfoil and curly leaf pondweed are not native to Indiana lakes and should be controlled to the extent possible. Native plants, however, are a natural part of functioning shallow lakes. Complete elimination of native plants should not be the goal of any management plan and is likely not possible.

Finally, Shorewood Forest residents should be aware that lake management is a long-term endeavor. Even though it is short, Lake Louise's historical pollutant loading will continue to affect the lake's current water quality. Additionally, lake systems often respond slowly to many watershed management efforts. Patience will be required. Shorewood Forest residents should, however, remain optimistic for attaining real improvement in Lake Louise's water quality. Shorewood Forest covers a large portion of the watershed, giving lake residents real control over their lake's future.

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APPENDIX 1:

ESTIMATION OF THE HYDRAULIC RESIDENCE TIME FOR LAKE LOUISE

Appendix 1: Estimation of the Hydraulic Residence Time for Lake Louise Shoreline.[1]

Parameter	Data
Watershed size (acres)	1363.6
Lake surface area (acres)	230
Lake volume (acre-ft)	1845.8
Primary runoff (feet/unit of land)[2]	0.974
Water Budget Summary	
Direct runoff to the lake (acre-ft/year)	1328.1
Direct precipitation (acre-ft/yr)[3]	690
Evaporation (acre-ft/yr)[4]	322.6
Discharge (acre-ft/yr)[5]	1695.4
Hydraulic residence time (yr)	1.1
Flushing rate (yr^{-1})	0.92

Notes:

1. See caveats in text of report.
2. Runoff is for the Little Calumet River at Porter, IN, which is the nearest gaged watershed, for 2000 (Stewart et al., 2000). This factor is multiplied by the watershed size to estimate the watershed runoff.
3. Precipitation is mean for 1951-1980. Standard normals are based on 30 years worth of data. The mean for 1951-1980 was multiplied by the lake surface area to yield an annual volumetric input of rain per year.
4. Evaporation is pan evaporation data for Valparaiso, IN in 2000. The National Oceanic and Atmospheric Administration (NOAA) determines evaporation rates at six sites in Indiana, one of which is located in Valparaiso. Annual evaporation from a 'standard pan' at the site averages 28.05 inches per year. Because evaporation from a standard pan is an overestimate of evaporation from a lake by about 40%, we estimated evaporation from Lake Louise at 16.83 inches per year. Multiplying this by the surface area of the lake yields an annual volumetric evaporation rate.
5. Discharge = (Direct runoff to the lake + Direct precipitation to the lake) – Evaporation

APPENDIX 2:

POSSIBLE SHORELINE BUFFER SPECIES LIST

Appendix 2: Possible Shoreline Buffer Species List.

Common Name	Botanical Name	Approximate Location*
Arrow Arum	*Peltandra virginica*	Shallow water/water's edge
Big Blue Stem	*Andropogon gerardii*	Varies/broad range
Black-Eyed Susan	*Rudbeckia hirta*	Drier soils
Blue Flag Iris	*Iris virginica shrevei*	Shallow water/water's edge
Blue Joint Grass	*Calamagrostis canadensis*	Wet to mesic soils
Bottle Gentian	*Gentiana andrewsii*	Mesic to dry soils
Butterfly Milkweed	*Asclepias tuberosa*	Mesic to dry soils
Chairmakers rush	*Scirpus pungens*	Shallow water/water's edge
Common Bur Reed	*Sparganium eurycarpum*	Shallow water/water's edge
Compass Plant	*Silphium laciniatum*	Varies/broad range
Cream Wild Indigo	*Baptisia leucophaea*	Mesic to dry soils
Culver's Root	*Veronicastrum virginianum*	Varies/broad range
Cup Plant	*Silphium perfoliatum*	Wet to mesic soils
Early Goldenrod	*Solidago juncea*	Wet to mesic soils
False Dragonhead	*Physostegia virginiana*	Wet to mesic soils
Goats Rue	*Tephrosia virginiana*	Varies/broad range
Golden Alexanders	*Zizia aurea*	Wet to mesic soils
Great Blue Lobelia	*Lobelia siphilitica*	Wet soils
Halberd-leaved Rose Mallow	*Hibiscus laevis*	Shallow water/water's edge
Hard-stemmed Bulrush	*Scirpus acutus*	Shallow water/water's edge
Heart-Leaved Meadow Parsnip	*Zizia aptera*	Mesic to dry soils
Heath Aster	*Aster ericoides*	Wet to mesic soils
Illinois Sensitive Plant	*Desmanthus illinoensis*	Mesic to dry soils
Illinois Tick Trefoil	*Desmodium illinoiense*	Varies/broad range
Indian Grass	*Sorghastrum nutans*	Varies/broad range
Ironweed	*Vernonia altissima*	Wet to mesic soils
Little Blue Stem	*Andropogon scoparius*	Varies/broad range
Marsh Blazing Star	*Liatris spicata*	Wet to mesic soils
New England Aster	*Aster novae-angliae*	Wet to mesic soils
New Jersey Tea	*Ceanothus americanus*	Varies/broad range
Old-Field Goldenrod	*Solidago nemoralis*	Mesic to dry soils
Partridge Pea	*Cassia fasciculata*	Varies/broad range
Pickerel Weed	*Pontederia cordata*	Shallow water/water's edge
Prairie Bergamot	*Monarda fistulosa*	Varies/broad range
Prairie Cinquefoil	*Potentilla arguta*	Mesic to dry soils
Prairie Cord Grass	*Spartina pectinata*	Wet to mesic soils
Prairie Coreopsis	*Coreopsis palmata*	Mesic to dry soils
Prairie Dock	*Silphium terebinthinaceum*	Varies/broad range
Prairie Switch Grass	*Panicum virgatum*	Varies/broad range
Prairie Wild Rye	*Elymus canadensis*	Varies/broad range
Purple Coneflower	*Echinacea purpurea*	Mesic to dry soils

Common Name	**Botanical Name**	**Approximate Location***
Rattlesnake Master	*Eryngium yuccifolium*	Varies/broad range
Rosin Weed	*Silphium integrifolium*	Varies/broad range
Rough Blazing Star	*Liatris aspera*	Mesic to dry soils
Round-Head Bush Clover	*Lespedeza capitata*	Varies/broad range
Rushes	*Juncus* spp.	Depends upon the species
Saw-Tooth Sunflower	*Helianthus grosseserratus*	Wet to mesic soils
Sedges	*Carex* spp.	Depends upon the species
Showy Goldenrod	*Solidago speciosa*	Mesic to dry soils
Side Oats Grama	*Bouteloua curtipendula*	Mesic to dry soils
Sky-Blue Aster	*Aster azureus*	Mesic to dry soils
Smooth Aster	*Aster laevis*	Mesic to dry soils
Sneezeweed	*Helenium autumnale*	Wet to mesic soils
Softsem Bulrush	*Scirpus validus creber*	Shallow water/water's edge
Spider-Wort	*Tradescantia ohiensis*	Wet to mesic soils
Stiff Goldenrod	*Solidago rigida*	Varies/broad range
Swamp Loosestrife	*Decodon verticillatus*	Shallow water/water's edge
Swamp Rose Mallow	*Hibiscus palustris*	Shallow water/water's edge
Sweet Black-Eyed Susan	*Rudbeckia subtomentosa*	Wet to mesic soils
Sweet Flag	*Acorus calamus*	Shallow water/water's edge
Tall Coreopsis	*Coreopsis tripteris*	Wet to mesic soils
Thimbleweed	*Anemone cylindrica*	Mesic to dry soils
Virginia Mountain Mint	*Pycnanthemum virginianum*	Varies/broad range
White Wild Indigo	*Baptisia leucantha*	Varies/broad range
Wild Lupine	*Lupinus perennis*	Mesic to dry soils
Wild Quinine	*Parthenium integrifolium*	Varies/broad range
Wrinkled Goldenrod	*Solidago rugosa*	Wet to mesic soils
Yellow Coneflower	*Ratibida pinnata*	Varies/broad range

* *These approximate locations are very general. Each species can have specific site conditions requirements (i.e. sun exposure, soil type, soil moisture). Consequently, site inspection should occur before determining an exact species list for a given site.*

APPENDIX 3:

GENERAL CONSTRUCTION DRAWINGS AND SPECIFICATIONS FOR ROCK CHECK DAMS

CHECK DAMS

Definition: A check dam is a small temporary dam constructed across a swale, gully, or drainageway.

Purpose: Check dams are intended to 'check' or reduce gully erosion. They are primarily temporary grade stabilization structures that can be used until the drainageway is permanently stabilized. Check dams reduce flow velocities, trap and store larger-sized sediment and provide stabilized drops. They should not be used in small streams. Check dams may be used if:

- the drainage area is less than 2 acres (0.8 ha);
- the drainage way is not a perennial stream.

Since these structures are located in watercourses, take special precautions to prevent erosion and sedimentation during construction of the structures. Permits to work in streams may be required from the local or state regulatory agencies.

Design Considerations: An engineered design is not required, however check dams must be constructed in a series to ensure proper function. Check dams are an expedient way to reduce gully erosion in the bottom of channels that will be stabilized or filled at a later date. However, it is usually better to line the channel or divert the flow to stabilize the channel than to install check dams. If these alternatives are not feasible, then check dams are very helpful. See Grass-Lined Channels and Structural Streambank Stabilization BMPs.

As with any gully treatment, the source of concentrated runoff, if any, should first be identified and treated, if possible. Treatments of runoff may include diversion, dissipation, dispersal or detainment.

Check dams can stabilize the grade of an active gully only if they are carefully constructed in a series, keyed into the bank and bottom sufficiently and maintained so that one failed check dam does not jeopardize the entire series.

Design Criteria: The following criteria shall be used when designing a check dam:

- Ensure that the drainage area is less than 2 acres (0.8 ha);
- The maximum height of the check dam center shall be 2 ft (0.6 m).
- The center of the check dam shall be 6 inches (0.2 m) lower than the outer edges.
- Construct the check dams in a series down the gully such that the maximum spacing between dams places the toe of the upstream dam at the same elevation as the top of the downstream dam (see detail).

ConstructionSpecifications:

- Obtain appropriate permits or approvals from local or state regulatory agencies.
- The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.
- Rock dams shall be constructed of 2-15 inch (51-381 mm) rock.
- Keep the center rock (spillway) section at least 6 inches (0.2 m) lower than the outer edges.
- Extend the abutments 18 inches (0.5 m) into the channel bank.
- Straw bales shall be placed in a single row, lengthwise, oriented perpendicular to the flow, with the ends of adjacent bales tightly abutting one another.
- Straw bale dams shall be extended such that the bottoms of the end bales are higher in elevation than the top of the middle bale

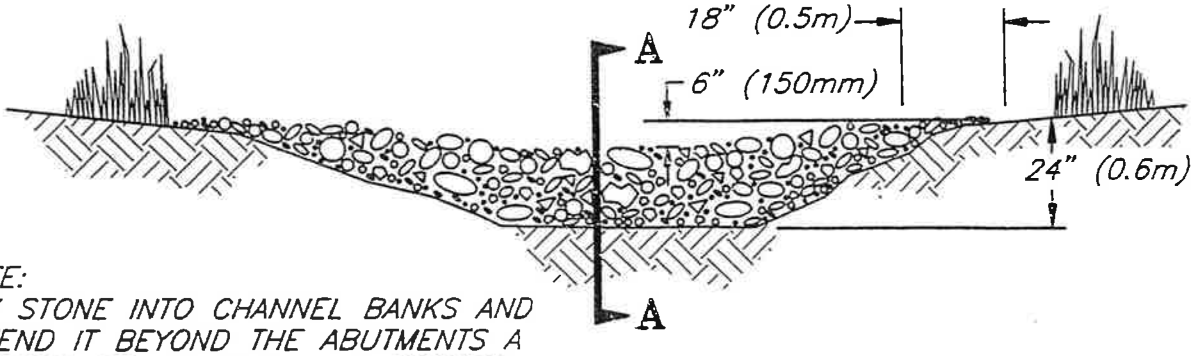
spillway to ensure that sediment-laden runoff will flow over the barrier, and not around it.

- Each straw bale shall be embedded in the soil a minimum of 4 inches (101 mm). Use straw, rocks, or filter fabric to fill any gaps between the bales and tamp the backfill material to prevent erosion under or around the bales. **Refer to Appendix - Geotextiles/Geosynthetics.**
- If the straw bales are wire bound, they should be oriented so the bindings are around the sides rather than along the top and bottom. Wire bindings that are placed in contact with the soil soon disintegrate and may allow the bale to fall apart.
- The straw bales shall be securely anchored in place by two wooden stakes or rebar driven through the bales. The first stake in each bale shall be driven toward the previously laid bale to force the bales tightly together. Drive the stakes at least 18 inches (0.5 m) into the ground. Proper staking is particularly important in channel flow applications.
- Construct an energy dissipator to reduce downstream erosion. See Energy Dissipator BMP.

Inspection and Maintenance:

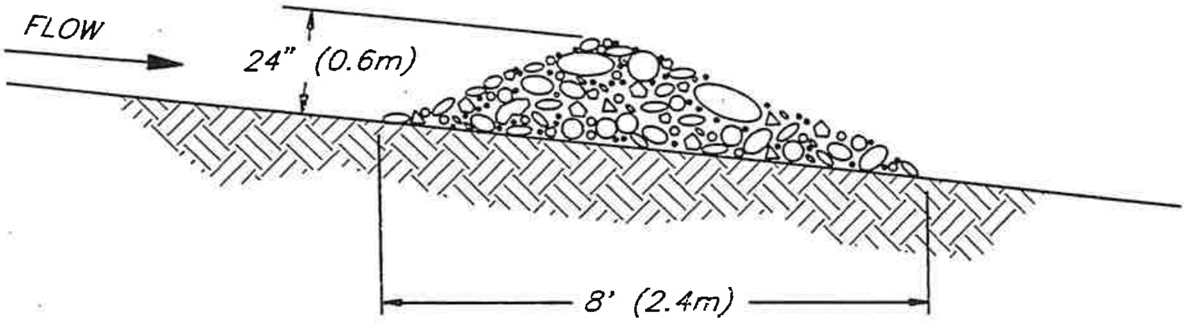
- The check dams shall be inspected for damage periodically during the winter and after each significant storm (1 inch (25 mm) in 24 hours) Prompt repairs shall be made to ensure that the dam is functioning properly. Any erosion caused by flows around the edges of the dam or under the structure shall be corrected immediately.
- Remove sediment from behind the dams when they become 60 percent full, or as needed. The removed sediment shall be deposited in an area that will not contribute sediment off-site and can be permanently stabilized.
- Remove checkdams and stakes when stabilization is complete.

Source: Association of Bay Area Governments, Manual of Standards for Erosion and Sediment Control Measures; John McCullah-CPESC; Goldman, Jackson, and Bursztynsky, Erosion and Sediment Control Handbook.



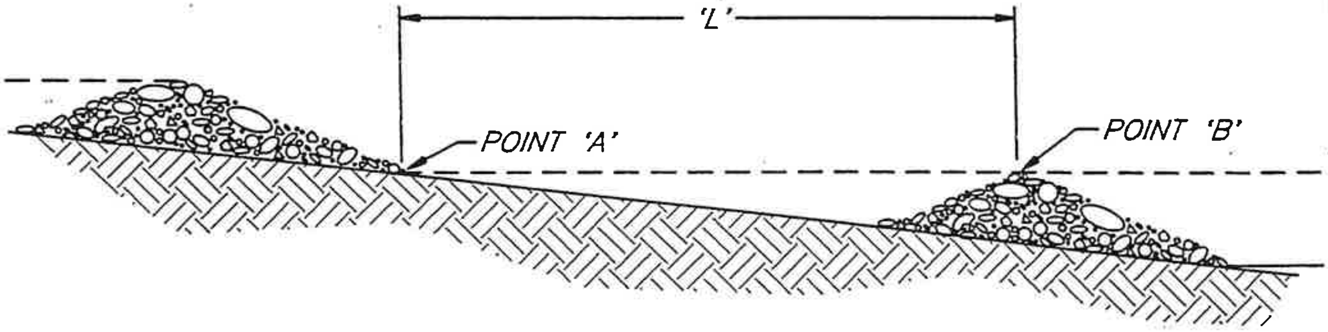
NOTE:
KEY STONE INTO CHANNEL BANKS AND EXTEND IT BEYOND THE ABUTMENTS A MINIMUM OF 18" (0.5m) TO PREVENT FLOW AROUND DAM.

VIEW LOOKING UPSTREAM



SECTION A – A

'L' = THE DISTANCE SUCH THAT POINTS 'A' AND 'B' ARE OF EQUAL ELEVATION.



SPACING BETWEEN CHECK DAMS

NOT TO SCALE

ROCK CHECK DAM

FILE: RCKCHKDM

Shorewood Forest Property Owners' Association

LAKE LOUISE
WATERSHED MANAGEMENT PLAN

May 1, 2009

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Table of Contents

Preface

This document comprises the Watershed Management Plan for the Lake Louise Watershed (hereinafter referred to as "the watershed"). It is intended to be a written guide for the restoration and preservation of the ecological health of the watershed. This plan is the outgrowth of the efforts of the Shorewood Forest Environmental Committee at the direction of the Shorewood Forest Property Owners Association Board of Directors (hereinafter referred to as "BOD").

The watershed is comprised of an area of 1,604 acres in Union Township, Porter County Indiana southwest of Valparaiso. It is roughly bounded by US 30 to the north, CR 100 North to the south, CR 500 West to the west and CR 350 West to the east. The watershed feeds Lake Louise that is a relatively shallow, 230-acre reservoir formed by impounding an unnamed tributary of Salt Creek. Lake Louise is the centerpiece of the Shorewood Forest residential subdivision, offering Shorewood Forest residents a place for fishing, boating, water-skiing, and swimming.

Mission Statement

The Lake Louise Watershed Management Plan (hereinafter referred to as "the plan") is intended to facilitate efforts to restore an environmentally and economically healthy watershed that benefits all who have a stake in it by meeting or exceeding state criteria for watersheds that feed lakes used for boating, swimming, and fishing. The plan will provide a series of actions intended to control both silt and nutrient pollution of the lake, control nuisance vegetation, prevent nuisance algal blooms, and maintain a healthy fishery.

Introduction

Lake Louise is a relatively shallow (maximum depth of approximately 25 feet) 230-acre reservoir located southwest of Valparaiso, Indiana. The lake was created by constructing a dam across a tributary to Salt Creek. Due to the landscape's topography, construction of the dam resulted in the formation of an irregularly shaped, multi-lobed reservoir. The majority of the Lake Louise Watershed lies within the boundaries of Shorewood Forest, a 900 lot upscale suburban, covenanted community within 3-6 miles of Valparaiso, Indiana. This reservoir is the centerpiece of Shorewood Forest residential subdivision, offering Shorewood Forest residents a place for fishing, boating, water-skiing, and swimming. Lake Louise also provides hours of quiet enjoyment for those who prefer to simply relax by its shores and watch the sun set. The community is governed by a Community Association, the Shorewood Forest Property Owners Association and member-elected Board of Directors. Control of the lake is in the hands of the Association. The remainder of the watershed is rapidly being developed as well and septic rural residential. The Property Owners' Association has commissioned several water quality studies over the years beginning in 1984-85. In addition three, one informal and two formal, bathymetric studies have been performed, most recently in 2005. The results of these studies will be discussed further under the concerns and solutions portion of this document.

Inventory of the Watershed

Map of Watershed

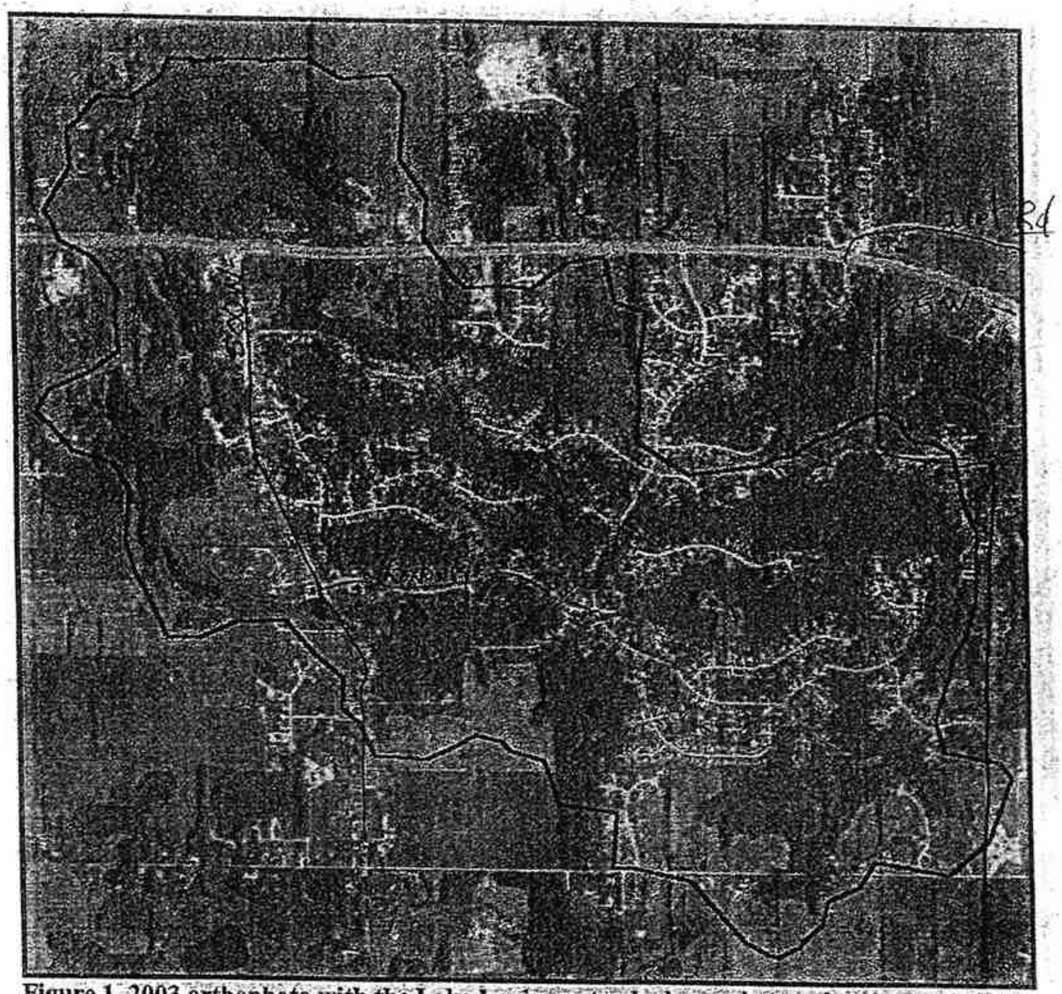


Figure 1. 2003 orthophoto with the Lake Louise watershed superimposed on it.

Physical Description

Table 1 presents some of the physical characteristics of Lake Louise and its watershed. Lake Louise is a medium to small sized reservoir with a surface area of approximately 230 acres. Lake Louise is fairly shallow with a mean depth of approximately 8 feet. This mean depth is based on bathymetric data presented in the 1990 study (Earth-Source, Inc., 1990) of the lake. A mean depth of 8 feet represents a 2-foot (20%) decrease in mean depth from a mean depth of 10 feet estimated from 1974 data. Like many reservoirs, Lake Louise's bathymetry varies considerably across its surface area. Its bays are generally less than 10 feet deep, with large portions of the bays less than 5 feet deep. In 1990, approximately 70% of the lake was less than 10 feet deep. The lake's deepest point is near its dam where the maximum depth extends to approximately 25 feet. The lake has a volume of approximately 1845 acre-ft.

Table 1. Physical characteristics of Lake Louise and its watershed

Physical Characteristic	
Lake Area	230 acres
Mean Depth	8 feet
Maximum Depth	25 feet
Lake Volume	1845 acre-ft
Watershed Area	1600 acres
Watershed Area to Lake Area Ratio	7:1
Estimated Hydraulic Residence Time	Approximately 1 year

Understanding the shallow nature of Lake Louise's is important for setting expectations' regarding the lake's primary productivity levels (i.e. the amount of rooted plant and algae growth). Shallow lakes have the capacity to support more rooted plants than deeper lakes. In shallow lakes, there is still sufficient sunlight to support plant growth at the bottom of the lake, particularly if the lake is only 10 deep as is the case with Lake Louise. Most aquatic plant species common to Indiana grow to depths greater than 10 feet. Given the shallow nature of Lake Louise's bays, one should expect rooted plants to cover a fairly large portion of these bays.

Lake Louise's 1600-acre watershed extends to the north, south, and west of the lake (Figure 1). The lake's watershed is relatively small compared to the size of the Lake Louise. The result is a watershed area to lake area ratio of approximately 7:1. This means that for every acre of water in Lake Louise, seven acres of land drain to it. Lake Louise's watershed area to lake area ratio is more typical of glacial lakes than reservoirs. Many glacial lakes have watershed area to lake area ratios on the order of 10-50:1, whereas reservoirs have watershed area to lake area ratios near 300:1 (Vant, 1987). Watershed area to lake area ratios can affect the chemical and biological characteristics of a lake. For example, lakes with large watersheds have the potential to receive greater quantities of pollutants (sediments, nutrients, pesticides, etc.) from runoff than lakes with smaller watershed. For lakes with large watershed-area to lake area ratios, watershed activities can potentially exert a greater influence on the health of the lake than lakes possessing small watershed area to lake area ratios. Conversely, for lakes with small watershed area to lake area ratios shoreline activities and internal lake processes may have a greater influence on the lake's health than lakes with large watershed area to lake area ratios.

Lake Louise's watershed area to lake area ratio is relatively small suggesting that in-lake processes and shoreline activities can have a significant affect on the lake's water quality. This is important in determining where management efforts should be focused. However, all storm runoff in the watershed is passed directly to the lake thereby increasing the effect of off-shore activities. Additionally Shorewood Forest residential subdivision composes a large portion of the watershed suggesting good management of this land is critical to improving water quality in the lake.

Geology and Topography

According to persons who lived in the area before development, there are several springs and small bogs throughout the watershed; however, the lake itself is primarily surface fed. The lobe of the lake commonly known as the Wexford Bay is reported to be partially spring fed, and the bottom contains an area of approximately 200 square feet which rises and falls over time. This area was described as marshland on the 1974 topographical survey as are several other areas of lake bottom. Examination of the 1974 topographical map of the area suggests that the lake was never very deep, especially in the lobes away from the dam.

Hydraulic residence time is a physical characteristic of Lake Louise and its watershed that should be considered when determining the direction management efforts to improve water quality in the lake. Hydraulic residence time refers to how long water stays in a lake before being replaced by fresh water from the lake's watershed or via direct precipitation. In lakes with long hydraulic residence times (i.e. several years), it is worthwhile to consider in-lake treatments to improve water quality. Because the water remains in the lake for extended periods, in-lake treatments tend to last several years on lakes with long hydraulic residence times. In contrast, lake managers of lakes with short residence times (i.e. several days up to a few months) should focus on watershed management techniques to improve water quality in these lakes. The water in lakes with short residence times is continually being replaced with new water from the watershed, so ensuring that the water entering lakes with short hydraulic residence times is clean is critical to ensuring good lake water quality.

Lake Louise has a hydraulic residence time of approximately one year. (Appendix 1 provides an explanation of the hydraulic residence time calculation for Lake Louise.) This means that, on average, water remains in the lake for approximately one year before it is replaced with new water from the watershed and/or atmosphere. A hydraulic residence time of one year is fairly long for reservoirs and is more typical of glacial lakes. It suggests Lake Louise's volume relative to its watershed size is greater than the lake volume to watershed area ratios for typical reservoirs. Lake Louise's relatively long hydraulic residence time also suggests that management efforts should focus on both in-lake processes and watershed processes.

It is important to note some caveats associated with the estimated hydraulic residence time for Lake Louise. Because there are no readily available, quantified estimates of groundwater movement into or out of Lake Louise, it was assumed that groundwater inputs to the lake equaled groundwater release from the lake. If groundwater inputs exceed groundwater outputs, Lake Louise would have a shorter hydraulic residence time than one year. The converse is true if groundwater outputs exceed groundwater inputs. Additionally, in calculating the hydraulic residence time estimate, Lake Louise was treated as a single basin. It is likely, however, that the bays have different individual residence times and these times differ from the residence time of the main portion of lake. Water likely flows slower through the bays and faster through the main portion of the lake, near the dam. This should also be considered when managing the lake's water quality.

Land Form and Slope

The Watershed is located on the southernmost portion of the Valparaiso Moraine which was formed by the retreat of the Wisconsin ice sheet. Before development the land area was about evenly split between Riparian and Mezic (dry) deciduous forest and meadowland/oak savanna. The area where the lake now lies was comprised of a series of stream-cut ravines, and small ponds formed by ephemeral streams which cut into the highly erodable soils of the moraine.

Soils

Soils in the watershed, and in particular their ability to erode or sustain certain land use practices, can impact the water quality of a lake. For example, highly erodible soils are, as their name implies, easily erodible. Soils that erode from the landscape are transported to waterways or water bodies where they impair water quality and often interfere with recreational uses by forming sediment deltas in the water bodies and spoiling the aesthetic beauty of the lake. In addition, such soils carry attached nutrients, which further impair water quality by fertilizing rooted plants and algae in the lake.

Figure 2 shows the soils covering the Lake Louise watershed and highlights the dominance of highly erodible and potentially highly erodible soils in the watershed. Most of the highly erodible soils in the watershed lie immediately adjacent to Lake Louise or along drainages that empty into the lake. Much of the remainder of the watershed is mapped in potentially erodible soils.
This suggests a large portion of the watershed is prone to erosion, potentially causing many of the problems noted above. It also emphasizes the need for good land management to curb erosion as much as possible.

The soils map of the watershed provides insight into the current condition of the lake. Long-time residents and scientific studies (Earth-Source, 1990) have noted a decrease in lake depth and volume. While current erosion from the landscape is likely continuing this decrease, the initial construction of homes along the Lakeshore may have played a big role in the observed decrease in lake depth and volume. The potential for soil erosion on active construction sites is often *several orders of magnitude* greater than the potential for soil erosion on active agricultural sites. This fact, coupled with the prevalence in highly erodible soils along Lake Louise, means a significant portion of the loss in lake depth and volume likely occurred during the construction of Shorewood Forest.

While is it beneficial to understand the consequence of historical actions on the lake's depth and volume, many of the areas mapped in highly erodible soils along Lake Louise are currently stabilized and covered with lawns or impervious surface. These areas no longer pose a threat to the lake's water quality (at least, in terms of the direct input of sediment).

Soils Map

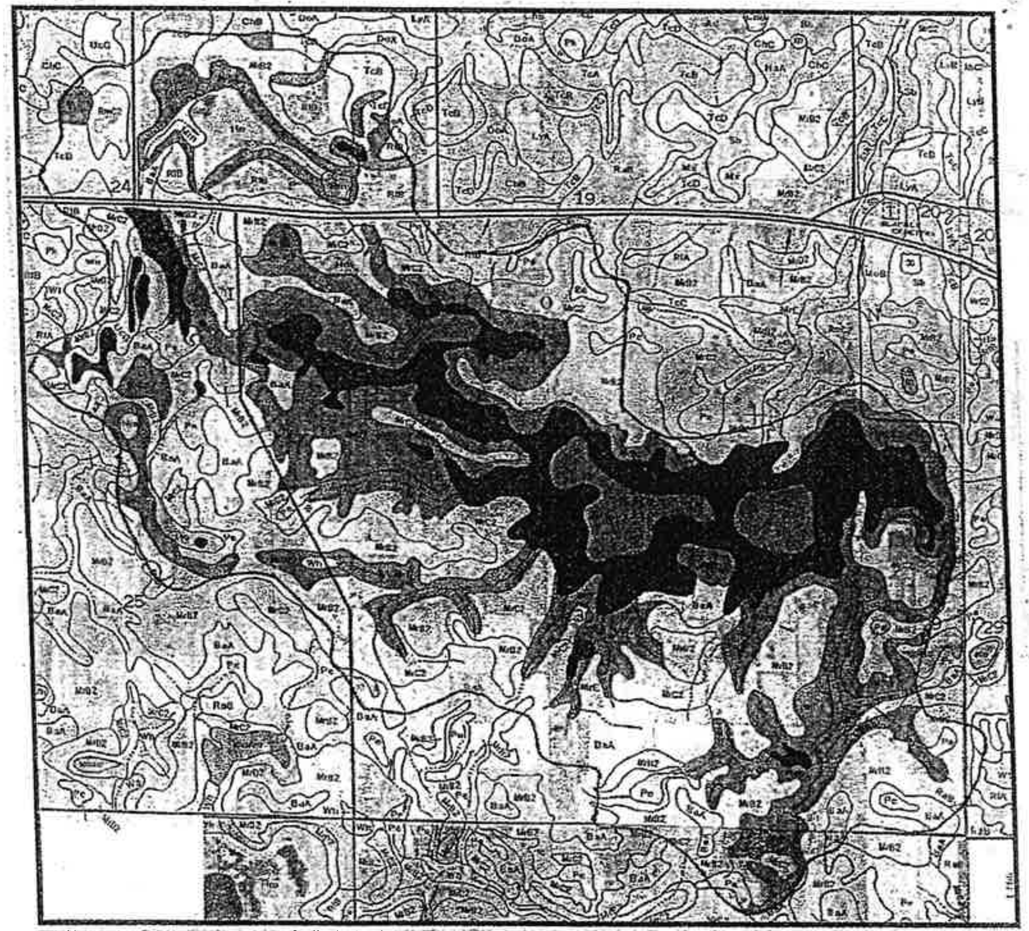


Figure 2. Soils covering the Lake Louise watershed. Highly erodible soils are shown in red; potentially highly erodible soils are shown in yellow.

Land Uses

Figure 3 and Table 1 present the land use in the Lake Louise watershed. (Land use data from the U.S. Geological Survey forms the basis of Figure 3.) Forested land and residential land use cover most of the watershed. Approximately 31% of the land draining to the lake is forested, while just over 29% of the land draining to the lake is used for residential purposes. Agricultural land and open fields (including fallow agricultural land and pastures) account for another third of the land use in the watershed. Wetlands cover approximately 6% of the watershed's landscape.

Land Use	**Watershed including Lake Louise**		**Watershed excluding Lake Louise**	
	Area (acres)	**Percent of Watershed**	**Area (acres)**	**Percent of Watershed**
Forest	428	26.7%	428	31.1%
Residential	400	24.9%	400	29.1%
Wetland	8 2	5.1 %	82	6.0%
Open water	241	15.0%	11	<1.0%
Agricultural	203	12.7%	203	14.8%
Pasture/grassland	250	15.6%	250	18.2%
Total	**1604**	**100.0%**	**1374**	**100%**

Table 1. Land use in the Lake Louise watershed.

Most of the residential land falls in the USGS's 'low intensity' residential category. According to the USGS's definition, low intensity residential areas consist largely of single family homes and impervious surface (driveways, sidewalks, roads, rooftops, etc.) cover 30-80% of the area. Using this definition and assuming that impervious surface covers about 50% of watershed's residential land (an estimate on the low side of the median), impervious surface covers approximately 15% of the watershed. This estimate of impervious surface coverage is above threshold at which the Center of Watershed Protection has found an associated decline in water quality.

Land Use Map

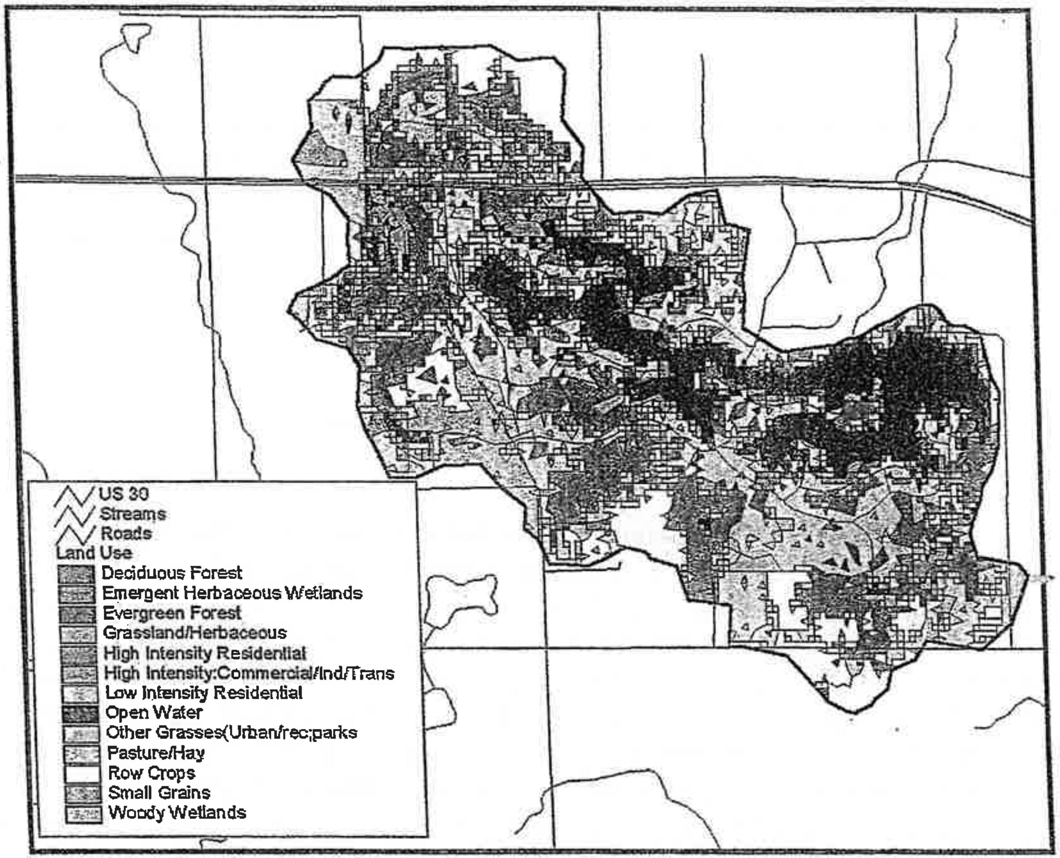


Figure 3. Land use in the Lake Louise watershed.

Chemical Use Patterns

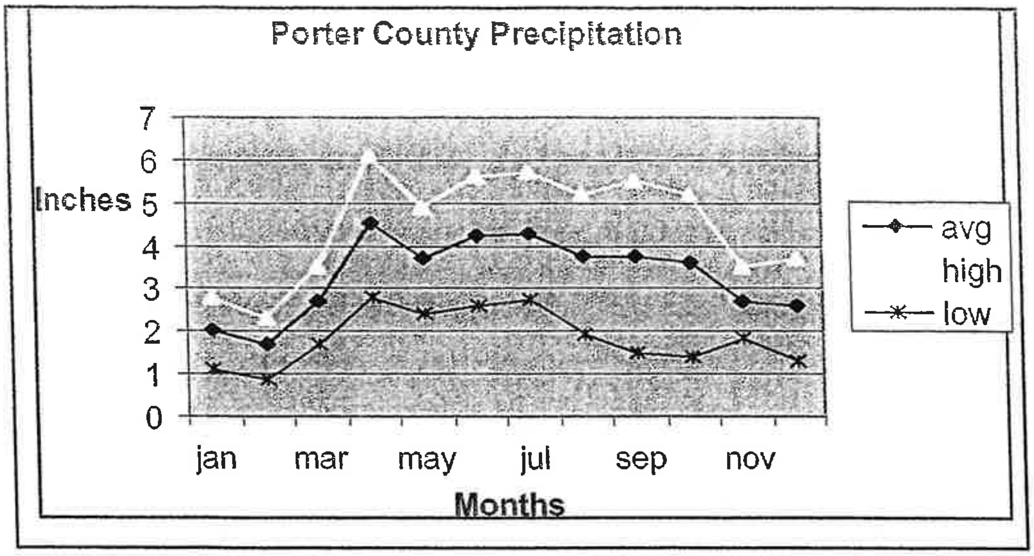
As more and more of the Watershed is converted to single family residential, chemical use in the watershed has changed from agricultural products to products used by commercial lawn care companies and individual homeowners. These chemicals consist of mostly inorganic fertilizers, fungicides, herbicides, and insecticides. In 2005 the Board of Directors passed a resolution urging the use of fertilizers not containing phosphorous and urging owners to leave untreated a 10-foot buffer along the street, driveways, pathways and drainage swales and for lake front owners, 10-15 feet of the lake.

Groundwater Resources

Prior to 2000, the subdivision drew its water from the Valparaiso aquifer which is located at approximately 3000 ft. The 37 lots which are well and septic access another, shallower aquifer located at between 100 and 150 ft. Since 2000, water for the subdivision other than the well and septic lots has been provided by Indiana American Water which draws from Lake Michigan.

Climate and Precipitation

The climate of the Lake Louise region is classified as temperate continental, which describes an area with warm summers and cool winters [IDNR, 1994]. The mean monthly temperature in summer, based on records from 1971-2000, ranges from 69 to 73° F. The mean monthly temperature in winter ranges from 22 to 28° F. The close proximity of Lake Michigan causes the vicinity to have increased amounts of snowfall in winter. The average yearly precipitation (rain, snow, sleet, and hail) in Porter County is approximately 40 inches. Precipitation is relatively constant throughout the year, as shown in the figure below. Approximately 70% of the rainfall is lost to evapotranspiration, leaving about 12 inches of surplus for the watershed's surface water and groundwater supply [IDNR, 1994]. The chart shows average monthly precipitation, and the 20% wettest and driest year expected.



Wildlife

Many dogs and cats live within the watershed but the only livestock currently located within the Watershed boundaries are ostriches and miniature horses, both on adjoining farms located west of County Road 500 W. There is, however, a wide diversity of wildlife living within the boundaries of the Watershed. These include rabbits, ground squirrels, chipmunks, three varieties of tree squirrels, moles, voles, deer, raccoons, beaver, red foxes, coyotes, opossums, skunks, bats, Great Canada Geese, wood ducks, mallards, great Blue Herons, red tailed hawks, kestrels, many species of song birds, turkey vultures, crows, snapping turtles, fresh water clams, crayfish, numerous fish species, both naturally introduced and stocked, and many others that have not yet been observed. Occasional visitors include eagles, loons, swans and sand hill cranes. There are no endangered species as far as is currently known but several threatened species, including a freshwater hydra and several land plants, can be found within the watershed. To date no biodiversity study has been undertaken; however some data on types of flora and fauna has been obtained by individual observation. It is clear from concerns expressed by the POA members that some species, particularly Canada geese, deer, moles, "chipmunks" and beaver are considered nuisances and may need to have their populations regulated in the near future.

Historical Information

Shorewood was first developed in 1974 as a HUD planned unit development with single family residential, multifamily, and commercial uses planned. Over the years all but approximately 4 acres (which lies outside the Watershed boundaries) have been rezoned single family residential. All but 37 of the lots have municipal utilities with water provided by Indiana-American Water and waste-water treatment provided by Shorewood Forest Utilities, Inc.

With the exception of a new section 29 being developed in the north central portion of the watershed, Shorewood Forest is "built out" and is experiencing new construction on the few remaining empty lots or in the form of teardowns of existing homes. The Architectural Control Committee, a committee appointed by the Board of Directors since 1999 and which acts as a neighborhood Plan Commission, has put in place erosion control best management practices for new and tear down construction which mirror those set forth in the Porter County Erosion Control Ordinance and Indiana Department of Environmental Management's Clean Water Act Phase II guidelines. Prior to that 1990, builders were not required to practice erosion control at their sites.

Dams

The dam which created Lake Louise is on the list of High Hazard dams maintained by the State. Inspection of the dam was turned over to the POA in early 2001. The dam and levy system are inspected every year by members of the POA staff and every other year by a licensed civil engineering firm.

Water Quality Issues

Problem Statement/Concerns

In response to rising levels of concern over the health of Lake Louise, the Board of Directors commissioned a Water Quality and Watershed assessment from J.F. New, Inc., an environmental consulting firm from Seymour Indiana. After the Board reviewed the resultant reports, they assigned to the Environmental Committee the task of preparing a draft watershed management plan for Lake Louise.

Discussions conducted with the Environmental Committee, Lake Committee, Board of Directors and Residents of Shorewood Forest on several occasions over the years culminating in a Neighborhood Meeting in April of 2007 produced the following concerns about the condition of Lake Louise and its watershed.

Association members expressed concern that:

1. Excessive submerged water plants during the late spring and summer prevent boaters and swimmers from enjoying the lake to the fullest.
2. Extensive algal blooms cause a loss in the esthetic appearance of the lake.
3. Water quality may be adversely affecting the fishery.
4. The lake has become shallow preventing some boaters from using their boats in certain areas of the lake.
5. Excessive erosion from the lake shore and ravines is polluting the lake.
6. Lake color and clarity is less than desired.
7. Concerns that road cinders, grass clippings, and leaves entering the lake at the storm drains are contributing or causing the reduction in perceived water quality.
8. Water quality of Lake Louise is worse than other area lakes.
9. Invasive species are taking over the lake or may take over the lake. Most commonly listed are zebra muscles and Eurasian water milfoil.
10. Large numbers of Hybrid Canada Geese resident in the watershed are causing pollution from their excrement.
11. Houses in the watershed which are on well and septic may pollute the lake if their septic systems are not maintained.
12. New development within the watershed is increasing storm water run off and storm water pollution leading to increased degradation of the lake.
13. The lake has high levels of nutrients in the water and sediments.

Further analysis of the concerns led to a priority list grouping the concerns into 5 priority groups.

Priority Grouping of Concerns

Priority 1:

#5 Excessive erosion from the lake shore and ravines are polluting the lake.

Priority 2:

#1 Excessive submerged water plants during the late spring and summer are keeping boaters and swimmers from enjoying the lake to the fullest.
#2 Extensive algal blooms cause a loss in the esthetic appearance of the lake.
#13 The lake has high levels of nutrients in the water and sediments.

Priority 3:

#4 The lake has become shallow preventing some boaters from using their boats in some parts of the lake.
#7 Concerns that road cinders, grass clippings, and leaves entering the lake at the storm drains are contributing or causing the reduction in perceived water quality.
#12 New development within the watershed is increasing storm water run off and storm water pollution leading to increased degradation of the lake.

Priority 4:

#3 Water quality may be adversely affecting the fishery.
#6 Lake color and clarity is less than desired.
#8 Water quality of Lake Louise is worse than other area lakes.
#10 Large numbers of Hybrid Canada Geese resident in the watershed are causing pollution from their excrement.
#11 Houses in the watershed which are on well and septic may pollute the lake if their septic systems are not maintained.

Priority 5:

9 Invasive species are taking over the lake or may take over the lake. Most commonly listed are zebra muscles and Eurasian water milfoil.

The Committee discerned that although a legitimate concern, the POA would be unable to affect concerns about additional development outside the borders of Shorewood Forest. The committee also recommended that concerns over the potential pollution of the lake from the well and septic lots is not within the scope of this plan at this time. Thus, 11 concerns remain to be addressed by the Committee and the Board. The remainder of this document will contain recommendations of best management practices applied to the remediation of the various concerns.

Residents believe that if we do not stop or reverse the further degradation of Lake Louise it will not be able to sustain the various recreational and aesthetic uses for which it was intended. This will lead to a decrease in the quality of lifestyle enjoyed by the residents of Shorewood Forest and a concurrent reduction in their property values.

Previous Water Quality Assessment

The results of the two studies were done by our consultants, J.F. New, and the study done in 1984, support the diminution of water quality within Lake Louise as compared to other Indiana lakes of similar size and characteristics. The water quality study found elevated total phosphorus and total Kjeldahl nitrogen concentrations. That is, the lake's water contained too much of the nutrients phosphorous and nitrogen. These nutrients support the growth of plants and algae. Lake Louise was found to be highly productive, "eutropic/hypereutropic (has large numbers of plants and many algae blooms).

The Watershed assessment showed evidence of a reduction in the lake depth over time caused by silt pollution from both point and non-point sources. This means that Lake Louise has grown shallower because fine silt has been carried into the lake from scour of the banks of the streams entering the lake and overland from unprotected or poorly protected soil both from undeveloped and developed lots, on the lake and away from the lake and from construction activities within the subdivision.

New made several suggestions for remediation of the lake and watershed. Some of these required action from individual property owners, some by the Community as a whole (i.e., by the Board) and some which might require the assistance of the County.

We will consider each of these suggestions in light of the priority assignments that have been made from the list of concerns.

Priority #1: Excessive erosion from the lake shore and ravines is polluting the lake.

New's suggestions:

1. Engineer the bottoms and banks of the ravines by adding check dams and other constructed devices to slow the passage of water in the ravine.
2. Slow down and reduce the amount of water entering these drainages by encouraging homeowners whose property adjoins the ravines to plant their property closest to the ravine with vegetation other than turf grass and reducing water flow off their property by using other methods of storm water management such as rain gardens and directing the water away from the portion draining into the ravines.
3. Planting the area adjacent to the ravine channels with native vegetation to stabilize the banks.
4. In the case of the Devon ravine, redirecting the storm water from Tremont Lane/Warrick Court into either the current wetland or into a constructed wet land on the other side of the pathway.

Steps already taken to address Priority 1 issues: The Board is currently involved in a long range (5-year) project to reconfigure the five major drainages—from west to east, the Roxbury, Atassi, Well commons, Westchester/Wilshire, and Devon—and Section 29, so as to slow down the speed of the water to enable the silt to drop out prior to entering the lake. After completion of this project, the Board may or may not attempt to alter the remaining minor drainages.

?riority #2: High levels of nutrients in the lake, excessive submerged plants during :he boating season and extensive algal blooms.

New's suggestions:

1. Reduce the quantity of phosphorous and nitrogen entering the lake in storm water by strongly recommending that owners to test their soil prior to beginning any fertilizer use or if that is not feasible, recommending the use of phosphorous free fertilizers except when starting a new lawn.
2. Request that owners use only the minimum quantity necessary to provide proper nutrition for their lawn and plantings.
3. Request that property owners or their lawn service companies leave an untreated buffer strip along the curb, driveway/walkways, lake and the edge of any natural drains.
4. Recommend that lakeshore owners plant their shoreline with a vegetative buffer at least 10 feet wide and 24" high.
5. Reduce the use of herbicides, fungicides and insecticides on landscapes by using only the minimum necessary amount and not applying any of these products prophilactically.
6. Reduce the amount of storm water leaving lots in the subdivision.
7. Reduce the amount of bottom scour and redistribution of nutrients into the water column caused by boating by managing the location of high speed boating and the number and size of boats on the lake.
8. Require owners with pets to remove pet waste from their lots frequently and dispose of it properly.

<u>Steps already taken to address Priority 2 issues:</u> The Board has passed resolutions strongly requesting all owners not use fertilizers containing phosphorous, leaving an untreated area at least 10 feet wide along the street, drains and driveways and leaving a buffer along the lake front which is not planted in turf grass. They have contacted the lawn maintenance companies doing business in Shorewood and asked them to do the same.

<u>Priority #3:</u> The lake has become shallow preventing some boaters from using their boats in some parts of the lake, causes may be road cinders and vegetation entering the lake via the storm drainage system and new developments causing increased silt and other pollutants in runoff from storms.

New's suggestions:

1. Keep streets as clean as possible.
2. Remove cinders from the curb areas as soon as possible after snow event has melted.
3. Prevent accumulated debris from entering the lake by requiring the removal of such debris from the road, preventing owners from dropping yard waste in the lake.
4. Prevent silt runoff from lots or in to storm drains by requiring owners and contractors to practice best practices for erosion control whenever soil is disturbed by construction or relandscaping.
5. Allow reintroduction of native water plants to the lake and <u>not</u> eradication of all plants when managing plant growth in the lake.

Steps already undertaken to address Priority 3 concerns: The Board has contracted with a street sweeping company to sweep the streets in Shorewood as necessary during the winter to reduce the amount of cinders entering the lake via storm drains. Porter County Highway department has retrofitted several storm drain catch basins with filters which are designed to trap much of the debris before it can enter the culverts, however, the County is not prepared to add more such filters, and finds it difficult to maintain them. The POA has determined that the filter experiment has been a failure and will not be extended. In addition, the Board has instituted a policy requiring homeowners to remove plant debris from the curbs adjacent to their lots on an ongoing basis and disallowing the disposal of yard waste into the storm drains or the lake. The Board is also pursuing installation of a second well near shore on the upstream side of the lake which it is hoped will add several inches of water to the lake when levels fall due to increased evaporation in dry years and between rain events.

The ACC/SFCC has received the new County ordinance (See Appendix) concerning erosion control and is intending to assist the County in enforcing it for new or additional construction on all lots in Shorewood Forest. The Landscape Committee and the Board are considering planting additional shoreline buffers on POA property in the near future.

Priority #4: Other impacts on water quality from waterfowl, well and septic properties are leading to further degradation and loss of fishery.

New's suggestions:

1. Monitor lake water for increases in nutrient load or e-coli which might indicate a failed septic tank is draining into the lake.
2. Slow down and reduce the amount of storm water leaving lots and entering the lake.
3. Continue to manage populations of geese residing full time on the lake.
4. Continue to monitor the health and appropriateness of the fishery.

Steps already taken to address Priority 4 concerns: The Board continues to obtain all the available Goose egg oiling permits it can in order to limit the number of geese who consider Lake Louise home. In addition, the Board conducted a fish survey in 2008 which indicated that the fishery remains healthy. The recommendations of the State Fisheries manager consulted by the Board in 2007 will be considered in further stocking activities.

Priority #5: Invasive species are taking over the lake or may take over the lake.

New's Suggestions:

1. Reintroduce native pond vegetation to Lake Louise while keeping a close eye on and take steps to prevent any reemergence of invasive plant species, especially curly leave pond weed, Eurasian water milfoil, purple loosestrife and Canary reed grass.
2. Encourage landscaping with native plant species to prevent escape of exotics into the environment.
3. Require all boats returning to Lake Louise from use in other State or private waters to be sterilized before they are put in the water.

Steps already undertaken to address Priority 5 concerns: The Board includes in the Boating rules sent to every owner in the spring instructions for sterilizing their boats before putting them into the waters of Lake Louise. They have instructed the POA maintenance staff to be on the lookout for loosestrife and canary reed grass and to remove it when found. In addition, the Board through its contract with Aquatic Control is attempting to reduce the quantity of chemicals put into the lake to the minimum necessary to prevent the spread of unwanted submerged and emergent vegetation during the summer growing season.

Implementation Program

SFPOA WATERSHED ACTION PLAN summary

PRIORITY #1

Excessive erosion from the lake shore and ravines is polluting the lake.

GOAL	METHOD	TIME FRAME	RESPONSIBILITY
1. Reduce silt pollution from major drainages by 60-80%.	1. Design and construct check damns, rills and other appropriate man made constructions in each stream.	By 2012	Work should be done by licensed engineer and construction company chosen by the SFPOA Board.*
	2. Plant stream banks and ravine edges with native, long-rooted plants and encourage appropriate vegetation in flood plains of streams.	By 2012	SFPOA staff, project designer, and owners of property along the drainage ways.
2. Reduce quantity of material entering the lake from storm drains by 50%.	Monitor curbs for silt, debris, and cinder build up. Inform County and schedule clean-out.	By 2012	Inspection: SFPOA staff;
3. Reduction of run-off from lots in Shorewood, especially those on the lake.	1. Owners of lots either on the lake or having a drainage ditch or swale within its boundaries are strongly encouraged to construct water gardens and redirect downspouts to same, especially those along the major drainages, into which rain or snow melt from roofs, driveways and walkways can be diverted. Other owners are encouraged to do so.	By 2012	All Shorewood Forest property owners and the SPOA Board and Staff.
	2. The Board should recommend installation of rain barrels on downspouts or rain chains (with French drains) on gutters on property which has insufficient vegetated area to install a rain garden of appropriate size.	By 2012	Individual homeowners and the SFPOA.
	3. Strongly urge owners of lake front lots and those through which any drainage stream flows to replace turf grass with a 10-15 foot buffer of long rooted plants along the lake front or stream or swale edge.	By 2012	Owners of lots adjoining the lake or drains and the SFPOA.
	4. The County requires installation of IDEM approved erosion control structures on all lots on which construction of any kind is being done, even landscaping projects, which result in the removal of the vegetative cover either before construction begins or within 3 days of the removal of the vegetative cover	By 2012	SFPOA Board, ACC and effected owners. Board and ACC to be sure that erosion control is part of the plans submitted for approval, and owners for construction.

PRIORITY #2

High levels of nutrients in the lake, excessive submerged plants during the boating season and extensive algal blooms.

GOAL	METHOD	TIME FRAME	RESPONSIBILITY
1. Reduce quantity of phosphorous and nitrogen entering the lake in storm water by encouraging owners to test their soil prior to beginning any fertilizer use or if that is not feasible, recommend the use of phosphorous free fertilizers except when starting a new lawn.	1. Education of residents through Shorelines and in development requirements for new construction. The POA to make test kits available.	Continual process.	Education by the SFEC and SFPOA Board, and acceptance and compliance by residents.
	2. Recommend that owners use only the minimum quantity necessary to provide proper nutrition for their lawn and plantings	Continual process.	Education by the SFEC and SFPOA Board, and acceptance and compliance by residents.
	3. Recommend that property owners or their lawn service companies leave an untreated buffer strip along the curb, driveway, walks, lake shore and the edge of any natural drains	Continual process.	Education by the SFEC and SFPOA Board, and acceptance and compliance by residents and lawn service companies.
	4. Recommend that lake shore owners plant their shore line with a vegetative buffer at least 10 feet wide and with species that grow at least 24" high.	Continual process.	Education by the SFEC and SFPOA Board, and acceptance and compliance by residents and landscape design and service companies.
2. Reduce the use of herbicides, fungicides and insecticides on landscapes by using only the minimum necessary amount and not applying any of these products prophilactically.	Education of residents through Shorelines and in development requirements for new construction. Education of local landscape service companies of SFPOA requirements.	Continual process.	Education by the SFEC and SFPOA Board, and acceptance and compliance by residents and landscape service companies.
3. Reduce the amount of storm water leaving lots in the subdivision.	See Priority #1.	Continual process.	Education by the SFEC and SFPOA Board, and acceptance and compliance by residents and landscape design and service companies.
4. Reduce the amount of bottom scour and redistribution of nutrients into the water column caused by boating by managing the location of high speed boating and the number and size of boats on the lake.	Education of residents through Shorelines and in annual boat license literature.	Continual process.	Education by the SFEC and SFPOA Board, and acceptance and compliance by residents.
5. Reduction of pet and animal waste in watershed.	Education of residents through Shorelines.	Continual process.	Education by the SFEC and SFPOA Board, and acceptance and compliance by residents.

PRIORITY #3

The lake has become shallow preventing some boaters from using their boats in some parts of the lake.

GOAL	METHOD	TIME FRAME	RESPONSIBILITY
Raise the water level of the lake.	Install a second well near the shore on the upstream side of the lake to pump water into the lake.	In progress.	SFPOA staff and project designer are responsible for the design, construction and maintenance of the second well.

PRIORITY #4

OTHER IMPACTS ON WATER QUALITY FROM WATERFOWL, WELL AND SEPTIC PROPERTIES ARE LEADING TO FURTHER DEGRADATION AND LOSS OF FISHERY.

GOAL	METHOD	TIME FRAME	RESPONSIBILITY
1. Reduce the geese reproduction rate.	The POA should obtain permits to find and spray their eggs with WD-40 or environmentally friendly oil..	Continual process.	Education by the SFEC and SFPOA Board, and acceptance and compliance by residents.
2. Removal of all goose waste from property and common areas.	See Priority #2, Goal #5.		
3. Insure the e-coli bacterium in the lake is at a safe level.	Areas around the lake where a failed septic system might drain into should be monitored for e-coli.	Continual process.	The Porter County Health Department, Shorewood Forest Property Owners Board Members and individual homeowners.
4. Encourage all homeowners to regularly check their septic systems.	Recommend the SFPOA Board Members pass a resolution requiring all homeowners with septic systems to provide the SFPOA with proof that their septic systems are in proper working order.	Continual process.	Shorewood Forest Property Owners Board Members and septic system homeowners.
5. Insure that the fish in Lake Louise are multiplying and the overall size and health of the fish are at a satisfactory level.	1. A fish survey should be done to determine the different kinds and size that are currently in our lake.	Survey completed, additional fish studies every five years.	Shorewood Forest Lake Committee Members and the Shorewood Forest Property Owners Board Members.
	2. Development of environmentally safe artificial fish concentrating structures and reefs to improve the feeding and breeding of fish.	Continual process.	Shorewood Forest Lake Committee Members and the Shorewood Forest Property Owners Board Members.
	3. Continuation of the fish stocking program to insure the right balance of predator, prey and sport fish with emphasis on the species that are most compatible with Lake Louise's environment and size.	Continual process.	Shorewood Forest Lake Committee Members and the Shorewood Forest Property Owners Board Members.

PRIORITY #5

Invasive species are taking over the lake or may take over the lake.

GOAL	METHOD	TIME FRAME	RESPONSIBILITY
1. Curtail the growth and development of invasive species with Lake Louise.	Instruct all boaters to clean and sanitize their boats before inserting them in the Lake.	Continual process.	Education by SFPOA Board as to what are the exotics. Have pictures and put these in the shorelines several times a year.
2. Encourage owners to plant native plants or non-invasive decorative species to prevent escape of exotics in the environment.	1. The SFPOA should educate residents of danger of having exotics in the lake system and as to what are the exotics.	Continual process.	Education by Pam Harris and Purdue University.
	2. Establish a recommendation program of Native Plants for Property Owners and for native pond vegetation.	Continual process	SFPOA
3. Develop a Launch Procedure and sign-in sheet that residents must sign each time they launch a boat to require that the boat be sterilized.	Property owners should sign in each time they put a boat into the lake.	Continual process.	Have the POA staff review the necessity of sterilizing boats when property owners get their yearly boat permit and also collect the daily Launch Sheets. Have the boat patrol make random inspections of incoming boats.

Action Plan Detail

Priority # 1: Excessive erosion from the lake shore and ravines is polluting the lake.

Goal # 1: Reduce silt pollution from major drainages by 60-80% by 2012.

Method #1: Design and construct check dams, rills and other appropriate man made constructions in each stream. Slowing the speed of water passing through the streams will prevent excessive scour and lead to drop-out of silt before it reaches the lake. Work should be done by a licensed engineer and construction company chosen by the SFPOA Board.* Circumstances permitting, one design project and one construction project will be done yearly until identified drainages are done. Turbidity measurements should be taken in spring after ice melt and in the fall at the outflow point of each of the five major identified ravines using the turbidity tube supplied by Hoosier Riverwatch. One measurement should be taken before construction commences. Members of the SFEC should work with the POA staff and create a written report to the Board and Committee annually so that a record can be maintained for review so that we can know if the method is working.

Method #2: Plant stream banks and ravine edges with native, long-rooted plants and encourage appropriate vegetation in flood plains of streams. Information on native plants, sources, and reasons for planting along drainage ways should be provided to owners by the SFEC. Native and deep rooted plants serve as barriers to runoff, and this slows the speed of water entering the lake reducing scour and so reduces silt pollution. SFPOA staff and owners of property along the drainage ways should do the planting at time of construction, or if, on the part of owners, as a retrofit of their landscaping. A written report of progress should be submitted to the Board and Committee annually to record progress for review.

Goal # 2: Reduce quantity of material entering the lake from storm drains 50% by 2012.

Method: Remove cinders and other debris from curbs before they enter the storm drains. Removal of large material before entrance to storm drains will reduce the amount of material in the basins and filters, allowing them to function longer between maintenance activities. Homeowners should be responsible for keeping leaf and grass clippings out of the gutters, drains, lake and vacant lots. Board should be responsible for arranging street sweeping of cinders and owners should be asked to sweep up cinders for disposal. The POA staff should be responsible for removing vegetative debris or silt from around storm drain grates and for clean up of gutters along common areas or lots maintained by the POA. Owners are encouraged clean storm drain covers which are located in front of their lots and to remove cinders between snows. Regular visual inspection by POA staff should be done at minimum twice a week and a report sent to the Board and Committee noting where cleaning was needed and any problems which need to be addressed so that owners can be notified. Responsibility: POA staff

Goal #3: Reduction of run-off from lots in Shorewood, especially those on the lake by 2012.

Method #1: Owners of lots either on the lake or having a drainage ditch or swale within its boundaries are strongly encouraged to construct water gardens and redirect downspouts to same, especially those along the major drainages, into which rain or snow melt from roofs, driveways and walkways can be diverted. Other owners are encouraged to do so. Using rain gardens has been shown to reduce the amount of water leaving lots and entering streams and other drains by slowing the movement of the water and allowing it to percolate into the soil rather than run off. Reducing the speed and volume of run off will reduce the quantity of silt and other debris carried in the water from entering storm drains and ditches. Homeowners, especially those with steeply sloped lots along the lake or having minor drains, are strongly urged to install this or another approved storm water retention device* within 2 years of adaptation of this document. In the case of drainage swales, the Covenants allow the Board to enforce maintenance of these in private yards. POA should install a sample garden at the clubhouse or an appropriate commons area within same time frame as a demonstration. Visual inspection of property by SFPOA staff or SFEC members should be conducted at end of 2 year completion date. The Board should be advised of progress

Method #2: The Board should recommend installation of rain barrels on downspouts or rain chains (with French drains) on gutters on property which has insufficient vegetated area to install a rain garden of appropriate size. Rain barrels have been proven to reduce the quantity of run off from lots. In addition, these storage devices collect rain water or snow melt which can then be used to water grass and other plants around the house or other buildings. The POA should install at least one rain barrel and one rain chain on clubhouse down spouts and gutters as a demonstration. Home owners should be strongly urged to install these devices. Down spouts must have a means of replacing barrels in the winter because water left in the barrels will freeze and crack the barrels. The SFPOA staff and SFEC members should visually inspect properties for compliance. The Board and Committee should be apprised of any owners who have failed, or do not wish to comply with request.

Method#3: Strongly urge owners of lake front lots and those through which any drainage stream flows to replace turf grass with a 10-15 foot buffer of long rooted plants along the lake front or stream or swale edge. Deep rooted plants have been shown to act as a filter and barrier for run off, thereby reducing the quantity and speed of this water causing it to loose much of the suspended solids which would otherwise reach the street or lake. These barriers have the added effect of minimizing goose penetration onto lots from the lake. The POA and effected owners should replace turf grass along their lake shores and drainages with deep rooted plants which extend at least 10 feet from the lake or drain unless there is insufficient area, in which case buffer is to be as wide as possible. The use of native plants is to be encouraged, but not required. Dense planting with tall (over 2 ft.) grasses or other perennials along the lakeshore should also be encouraged because these have been shown to discourage geese from coming ashore. The Board and Committee should make available to owners information on types of plants, sources, approximate cost, etc. Visual inspection should be conducted by SFPOA staff and members of the SFEC.

Method #4: The County requires installation of IDEM approved erosion control structures on all lots on which construction of any kind is being done, even landscaping projects, which result in the removal of the vegetative cover either before construction begins or within 3 days of the removal of the vegetative cover. The ACC should assist the County in enforcing these requirements. The IDEM requirements are attached as Appendix A. Construction on lots within Shorewood has resulted and will continue to result in excess silt and other debris entering the lake, especially from those lots along the shore. This has contributed substantially to the amount of silt now in the lake. Installation of best practices at the time such work begins will reduce silt pollution from these sources significantly. Additionally, as of 2006 all construction projects requiring a County permit must include an erosion control plan as part of their application. Said plan must comply with the new IDEM requirements. Board and ACC should be sure that erosion control is part of the plans submitted for approval, and owners for construction. All construction projects submitted for approval by the ACC should be accompanied by an erosion control plan either on the plot plan or via an attachment to the request. Landscape activity which does not require a permit is left to the honor of the effected owners. It is the responsibility of the effected owner to maintain these measures during all phases of the construction. Visual inspection of the job site should be made by a member of the ACC within 3 days of the start of construction, periodically during construction and within one day of any major rain event or snow melt, if possible. The POA staff should contact effected owners and require remediation if the site is found to be unprotected. In the event of lack of cooperation by the owner or contractor, the County should be contacted and an inspection requested. If the County shuts down the project, SFPOA staff should assist the County in monitoring the site for compliance.

*Maintenance of damns and ponds (i.e. periodic removal of silt build-up) to be done by POA staff or contractor chosen by the Board.

**Other approved methods include installation of retaining walls on steep slopes, creation of detention ponds, installation of drain fields, or use of permeable concrete or pavers in construction of driveways, sidewalks and patios. Design and installation of these devices is best left to professional engineers and contractors.

Priority #2: High levels of nutrients in the lake, excessive submerged plants during the boating season and extensive algal blooms.

Goal #1: Reduce quantity of phosphorous and nitrogen entering the lake in storm water by encouraging owners to test their soil prior to beginning any fertilizer use or if that is not feasible, recommend the use of phosphorous free fertilizers except when starting a new lawn.

Method #1: Education of residents through Shorelines and in development requirements for new construction. The POA should make test kits available. Reduction of fertilizer use reduces the amount of excess fertilizer available to run off into the lake and thus a reduction in nutrients available to plants and algae. The POA should insert instructions for testing in Shorelines and the website along with an insertion in the spring issues for reminders about the use of phosphorous free fertilizers.

Method #2: Recommend that owners use only the minimum quantity necessary to provide proper nutrition for their lawn and plantings.

Method #3: Recommend that property owners or their lawn service companies leave an untreated buffer strip along the curb, driveway, walks, lake shore and the edge of any natural drains.

Method #4: Recommend that lake shore owners plant their shore line with a vegetative buffer at least 10 feet wide and with species that grow at least 24" high. Less fertilizer in the water means less plant growth in the water. Vegetative buffer provides a filter strip along the lake to absorb nutrients prior to entrance into the lake. Additionally geese will not come ashore into such buffers. The POA should insert instructions for buffer designs in Shorelines along with an insertion in the spring issues for reminders about the benefits of shoreline vegetative buffers.

Goal #2: Reduce the use of herbicides, fungicides and insecticides on landscapes by using only the minimum necessary amount and not applying any of these products prophilactically.

Method: Education of residents through Shorelines and the website. Education of local landscape service companies of SFPOA requirements. Less use of herbicides, fungicides and insecticides in the water means fewer chemicals in the water, and a healthier recreational facility. Annual insertion of educational materials in Shorelines

Goal #3: Reduce the amount of storm water leaving lots in the subdivision.

Method: See Priority #1.

Goal #4: Reduce the amount of bottom scour and redistribution of nutrients into the water column caused by boating by managing the location of high speed boating and the number and size of boats on the lake.

Method: Education of residents through Shorelines and in annual boat license literature and strict enforcement of the speed rules. Less stirring of the lake bottom silt means nutrients contained in the silt will not be reintroduced into the lake water.

Goal #5: Reduction of pet and animal waste in watershed.

Method: Education of residents through Shorelines encouraging them to remove pet and animal waste from their yards and when they walk their dogs. Removal of animal waste from lots lowers the potential of e. coli and other diseases from entering the water. Additionally fecal matter is high in nitrogen which promotes plant growth.

Priority #3: The Lake has become shallow preventing some boaters from using their boats in some parts of the lake.

Goal: Raise the water level of the lake.

Method: Install a second well near the shore on the upstream side of the lake to pump water into the lake. Pumping water with a second well will add up to 12 inches of water to the lake when levels fall due to increased evaporation in dry years and between rain events. SFPOA staff and project designer should be responsible for the design, construction and maintenance of the second well. Monitor the lake's water level monthly to determine how much the pump should be run to maintain desired water levels.

PRIORITY # 4: Other impacts on water quality from waterfowl, well and septic properties are leading to further degradation and loss of fishery.

Goal #1: Reduce the geese reproduction rate.

Method: The POA should obtain permits to find and spray their eggs with WD-40 or environmentally friendly oil. This will prevent their eggs from hatching and help to keep the geese population from growing. The work should be done by DNR Staff after the maximum number of permits is obtained by the Shorewood Forest Property Owners Association Staff from the Indiana Department of Natural Resources. Most of the spraying should be done after obtaining permission from the homeowner to spray those eggs which are on their property. Spraying should be done every spring. Further action in this area should include making the community aware of the existing control and requesting the community identify the locations of the nesting geese for control applications.

Goal #2: Removal of all goose waste from property and common areas. See Priority #2, Goal #5.

Goal #3: Insure the e-coli a bacterium in the lake is at a safe level.

Method: Areas around the lake where a failed septic system might drain into should be monitored for e-coli. Excessive levels should be reported to the Porter County Health Department for inspection and action. Monitoring lake water in these areas for increases in e-coli will alert us to the possibility of contamination from failed septic fields and/or sewer breaks. Testing of water at the Roxbury stream, Lift Station Commons, Wexford Back Bay and Turtle Bay should be done along with pool and beach. The Shorewood Forest Maintenance Staff should inform the Board of any trouble spots and notify the Health Department.

Goal #4: Encourage all homeowners to regularly check their septic systems.

Method: Recommend that the Shorewood Forest Property Owners Board Members pass a resolution requesting all homeowners with septic systems to provide the Shorewood Forest Property Owners Board Members with proof that their septic systems are in proper working order. This will help to minimize a possible failure to their septic system and the damaging effect it could have on our lake. Homeowners should verify to the Shorewood Forest Property Owners Board Members that their septic systems are in good working order on a yearly basis. Owners should be educated as to the proper maintenance of their systems. Notification should be kept with lot records.

Goal #5: Insure that the fish in Lake Louise are multiplying and the overall size and health of the fish are at a satisfactory level.

Method #1: A fish survey should be done periodically to determine the different kinds and size that are currently in our lake. This will help keep our property values high by insuring that Lake Louise has an abundant and appropriate variety of fish to catch for our resident fisherman. A fish survey should be done by the Shorewood Forest Lake Committee every five to ten years to help revaluate the fish stocking program and insure the fish are adequately breeding and feeding.

Method #2: Development of environmentally safe artificial fish concentrating structures and reefs to improve the feeding and breeding of fish. Artificial structures such as these have been shown to promote spawning and survival of fish. Shorewood Forest Lake Committee Members and the Shorewood Forest Property Owners Board Members should monitor the effectiveness of these structures and adjust the number as needed. Shorewood Forest Lake Committee Members should keep the Shorewood Forest Property Owners Board Members informed of their progress and the impact it has on the fish.

Method #3: Continuation of the fish stocking program to insure the right balance of predator, prey and sport fish with emphasis on the species that are most compatible with Lake Louise's environment and size. Stocking should be done only in years when it can be demonstrated that the population of any one species is deteriorating. If the fish population is not balanced correctly, it could lead to a drop off of the fish population to where everything is catch and release and a lack of certain kinds of fish that fishermen look forward to catching. Fish stocking should continue to be evaluated on an annual basis. Shorewood Forest Lake Committee Members should keep the Shorewood Forest Property Owners Board Members informed of their progress and the impact it has on the fish.

Priority #5: **Invasive species are taking over the lake or may take over the lake.**

Goal #1: Curtail the growth and development of invasive species within Lake Louise.

Method: Instruct all boaters to clean and sanitize their boats before inserting them into Lake Louise. The SFEC should provide education materials for Boaters. Inspection records would make it possible to monitor the whole lake by sections to determine how different sections of the lake react over time and with treatment options that are undertaken in the future. Regular monitoring would record problem areas in the lake that are prone to infestation and keep a permanent records and treatment methods used each time with results of treatment.

Goal #2: Encourage Landowners to plant native plants or non-invasive decorative species to prevent escape of exotics into the environment.

Method #1: The SFPOA Board should educate residents of danger of having exotics in the lake system and as to what are the exotics. Native planting borders on the lots should help slow and stop spread of exotics. The Board should have pictures of exotics and put these in the shorelines several times a year.

Method #2: Establish a recommendation program of Native Plants for Property Owners and for native pond vegetation. The SFPOA should educate property owners of method, quantity, and cost to plant 10 foot boundary or to use these plants in their landscaping. The SFPOA should have handout literature that includes low cost plants that are available and sources for their purchase.

Goal #3: Develop a Launch Procedure and Sign-in Sheet that residents must sign each time they launch a boat to require that the boat be sterilized.

Method: Property owners should sign-in each time they put a boat into the lake. A waterproof sign area by the gate could have a notebook with sign-in sheets that could be collected daily by POA Maintenance. This would record who put boats into the lake. If all the residents were responsible and actually preformed sterilization, this should help insure that the lake remains free of invasive species from boats. The POA staff should review the necessity of sterilizing boats when property owners get their yearly boat permit. The boat patrol should make random inspections of incoming boats.

Recommendations for Review and Further Work

This document is an unfinished project on purpose, as it is important that the Watershed Plan be reviewed regularly to validate progress or lack thereof, add new technologies, discard methods that do not appear to be working and add others. As progress is made, other tasks need to be added to the Plan so that it becomes more comprehensive over time.

The Committee recommends, therefore, that the Plan methods and goals be reviewed every year for the first 2 years after adoption, and every 2 years from the third year on. A formal review should be undertaken in the 5th year after adoption and every 5 years thereafter. This review should include a repeat of the initial New study so that we can have an overall look at all the components from that study. A second fish study should also be undertaken at that time.

The issue of dredging the lake is one that we will have to address in the future. While we realize that dredging will need to be done at sometime in the future, it is the Committee's opinion that such a project will have a profound effect on the lake and the surrounding watershed; and, therefore, it is fiscally and scientifically irresponsible to undertake this task without first accomplishing the remediation of the major drains in the hope that this will reduce significantly the introduction of silt into the lake. The experience of Lake of the Four Seasons is a strong lesson. It is important that the environmental effects of dredging be taken into consideration before the decision is made. These effects include, but are not limited to, degradation of fishery, increased algal blooms and reduction in the total depth of the lake.

Because we believe it inevitable that lake dredging will become necessary, we recommend that the Board explore means to pay for such a project in advance, knowing that more than one funding source will be needed.

We recommend the Shorewood Forest Utility, Inc. examine the need for all septic system homeowners in the Lake Louise watershed to be connected to Shorewood Forest Utility, Inc. sewers. This will prevent homeowners with current septic systems from possibly polluting the lake when their system fails. As a part of this examination, the Shorewood Forest Utility, Inc. should contact septic system homeowners to determine the cost and feasibility of connecting to their sewer system. The Shorewood Forest Utility Board Members should keep the Shorewood Forest Property Owners Board Members and the community informed of their progress.

We also recommend that a Biodiversity and Wildlife Population Study be undertaken in the 5th year of the Plan. Should any threatened or endangered species be found, we may become eligible for a Fish and Wildlife Heritage Grant which is directed at private landowners and environmental groups.

Above all else it should be remembered that it took 30 years for our Watershed to reach the state it is in today, and it may very well take 30 years to fix it. Damage can occur in a day, but fixing it can take many years, so it is important for all stakeholders in the Lake Louise Watershed project to be patient, participate, and be diligent.

Appendices

ACRONYMS

ACC/SFCC Architectural Control Committee/Shorewood Forest Control Committee

BOD The Shorewood Forest Property Owners Association Board of Directors

EPA (USEPA) Environmental Protection Agency (US Environmental Protection Agency

IDEM Indiana Department of Environmental Management

IDNR/DNR Indiana Department of Natural Resources

NOAA National Oceanic and Atmospheric Administration

POA Property Owners Association

SFPOA Shorewood Forest Property Owners Association

SFEC Shorewood Forest Environmental Committee

USGS United States Geological Service

Definitions

1. **Algae bloom** An overabundance of aquatic algae (an aquatic plant with no true limbs or leaves) usually caused by excessive amounts of nitrogen and phosphorous in the water.

2. **Aquifer** An the extent of an underground area where water can be found.

3. **Bathymetric/Bathymetry** The measuring of the underwater topography of a body of water. The results of such a measurement are usually presented in the form of a map showing the contours of the bottom in terms of lines showing areas which are the same distance below the surface of the water body. Bathymetric study.

4. **Biomass** The weight of all biological matter.

5. **Carbon load** The net amount of carbon (usually in the form of carbon dioxide) produced by or as a result of the activities of a living organism. The definition of organism includes cities, towns, countries and industries as well as animals, plants and people.

6. **Check or coffer damn** A small damn made of rock, concrete or soil that impedes the flow of water in a stream or river.

7. **Detention pond** A manufactured wetland designed to hold water at a site indefinitely. Water can only leave a detention pond by evaporation or by filtering into the soil.

8. **Drain field** An area of ground, usually sloped, under which drain tiles are laid or which is used to percolate water such as a septic field.

9. **Ecology** The scientific study of relationships between plants, animals, insects, bacteria, with each other and the part of the world in which they live.

10. **Ecosystem** A system of interrelated organisms and their physical-chemical surroundings.

11. **Environment** The land, water, air, amount of light, chemical composition and physical characteristics of a particular spot on the earth.

12. **Epilimnion** The uppermost, warmest, well-mixed layer of a lake during stratification.

13. **Eutrophic** High concentrations of phosphorous and other nutrients, many microscopic and larger plants and loss of oxygen at depth cause a lake to be classified as eutrophic.

14. **Evapotransporation** The transportation of water molecules into the atmosphere caused by heating by the sun. Evaporation.

15. **Exotic** Introduced from abroad, not native.

16. **Hypereutrophic** Very eutrophic.

17. **Hypolimnion** The lower, cooler layer of a lake.

18. **Internal nutrient load** Nutrients released into the water by disturbance of the sediment in the bottom of the lake.

19. **Invasive species** Any plant or animal whose population spreads rapidly to the exclusion of other species. Examples of an invasive species are Kudsu vine, Japanese beetle, goldenrod.

20. **Limnology** The scientific study of the physical, chemical, geological and biological factors that affect lakes, reservoirs, streams and rivers.

21. **Littoral zone** That part of a lake or ocean extending from the shoreline to the greatest depth occupied by rooted plants.

22. **Mesotrophic** A condition between oligotrophic and eutrophic.

23. **Metalimnion** A layer of water within a lake where the water temperature changes very rapidly. It is between the top layer and bottom layer of water.

24. **Oligotrophic** Not enough organic matter is produced to reduce the oxygen concentration in the bottom of the lake. Usually described as having few floating or rooted plants and few animals.

25. **Organic matter** Molecules made by plants and animals which contain linked carbon atoms and other elements like hydrogen, oxygen and phosphorous.

26. **Pelagic zone** This is the open area of a lake from the edge of the littoral zone to the center of the lake.

27. **Phytoplankton** Microscopic algae and microbes that float freely in open water.

28. **Photic zone** That part of a lake which is lighted by the sun and in which photosynthesis can occur.

29. **Primary productivity** The rate at which algae and rooted plants covert light, water and carbon dioxide to sugar within their cells.

30. **Prophilactically** An action which is taken to prevent another action or result.

31. **Rain Barrel** A cylindrical container attached to a downspout in which rain water is captured. Rain barrels are usually no larger than 90 gallons.

32. **Rain Garden** A constructed wetland created to contain storm water on a lot which is planted with garden plants and is part of the landscaping of a building.

33. **Retention pond** A manufactured wetland designed to slow the passage of water from one area to another by temporarily impounding water. A rain garden is a retention pond.

34. **Riparian** The area of land from water's edge to the farthest point of land that includes the watershed of a stream or river or lake and the particular kinds of plants and animals that like to live there.

35. **Sediment** Bottom material in a lake that has been added after the lake's formation and consists of the remains of aquatic organisms, precipitation of dissolved chemicals and erosion of surrounds lands.

36. **Sediment trap** A pit, usually immediately before a check damn which acts as a catchment basin for sediment.

37. **Thermocline** A horizontal plane of water across a lake parallel to the surface and passing through the point of greatest temperature change. Thermoclines can be found in air as well and you may have felt one walking down a stair or hill.

38. Trophic state A measure of the "productivity" of a lake determined by the transparency, chlorophyll levels, phosphorus concentrations, amount of plants and the quantity of dissolved oxygen in a lake.

39. Watershed A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river or lake.

40. Wetland A wet of area of ground in which standing water is found. These areas need not have standing water in them all the time, but the soil is very wet and only plants which like to live in water can grow there. Examples are swamps, marshes, bogs, and lakes.

41. Zooplankton Microscopic animals that float freely in lake water.

County Ordinances

County Ordinances are maintained on file in the Shorewood Forest POA office.

Water Quality Test Results

The Water Quality Test results are maintained on CD in the Shorewood Forest POA office.

Native Trees for Great Lakes Region

(Approved for planting in Shorewood)

COMON NAME	SCIENTIFIC NAME
Eastern Redbud	*Cercis canadensis*
White service berry	*Amelarchier canadensis*
Downy service berry	*Amelanchier arborea*
Flowering Dogwood	*Cornus florida*
Wild Plum	*Prunus americana*
Sassafras	*Sassafras albidim*
Wahoo	*Euonymus adropurpurnus*
American linden (Basswood)	*Telia americana*
White Oak	*Quercus alba*
Bur oak	*Quercus macrocarpa*
Chestnut oak	*Q. prinus*
Shingle oak	*Q. imbricaria*
Pin oak	*Q. palustris*
Willow oak	*Q. phellos*
Scarlet oak	*Q. cacacirea*
Swamp oak	*Quercus tricolor*
Chincapin oak	*Q. muehlenbergis*
Black oak	*Q. velutrina*
Smoke tree	*Cotinus obovatus*
Hornbeam (Blue beech)	*Carpinas caroliniana*
Red buckeye	*Aesculus pavia*
Butternut	*Juglans cinercia*
Bitternut hickory	*Carya cordiformis*
Shagbark hickory	*Carya oruta*
Mockernut hickory	*C. tomentose*
Pignut hickory	*C. glabra*
Red maple (swamp maple)	*Acer rubrum*
Sugar maple	*Acer saccrum*
River birch	*Befula nigra*
Thornless hawthorn	*Crataegus crusgalli var.inermis*
Blue ash	*Fraxinus guadrangulata*
Kentucky coffee tree	*Gymnocladus dioica*
Witch-hazel	*Hamamelis verginiana*
Black tupelo	*Nyssa sylvatria*
Haphornbeam	*Ostrya virginiana*
Estern white pine	*Pinus stobus*
Quaking aspen	*Populus tremulordis*
Eastern arborvitae	*Thuya occidentalis*
Hemlock	*Thuya canadensis*
Blackhaw verbenum	*Vabernum pruniflora*

Some of the above trees can occur in shrub form as well as tree form. All are native to the Great Lakes mixed deciduous forest and should do well in Shorewood yards. Be sure to consult your nurseryman about soil and moisture conditions preferred by the trees before planting.

Shorewood Forest Construction Guidelines

Trees

Because it is in the best interests of the subdivision, individual property values (the presence of healthy trees on a lot have been demonstrated to raise the value of that lot by a minimum of $10,000), and the lake, the Shorewood Forest Board of Directors and the Architectural Control Committee have devised the following guidelines concerning trees.

1. As per the covenants, all developed lots within Shorewood Forest must have a minimum of **2 (two)** trees located within the "front yard". The "front yard" is defined as that area between the curb and the front elevation of the house and between the two 8' side set back lines. Porter County guidelines state that corner lots have 2 (two) front yards.
2. At the time of construction, permission will be granted for the removal of all trees of whatever size located within the footprint of the house, patio/decks and drive plus 15 feet in all directions. Trees within 10 and 15 feet of the footprint of the house must be replaced when final landscaping is done.
3. All trees remaining on the lot outside of this area must be protected by placing fencing (snow or silt) around the drip line of the tree (a line drawn on the ground corresponding to the furthest edge of the tree's canopy). No earth, construction debris, or equipment may be placed in or driven through this area.
4. Removal of any other trees 4" in diameter 4' above the ground may only be removed after approval of a tree removal request and issuance of a tree removal permit.

New Construction Guidelines

As a result of information received at a workshop/training conducted by the Water Quality division of IDEM on March 20, 2007, the Shorewood Forest Board of Directors and Architectural Control Committee strongly recommend that the following changes be made in the erosion control guidelines for all construction activities conducted within the platted boundaries of Shorewood Forest Subdivision. These include new construction, additions, or large scale landscaping jobs.

1. Before any construction can begin, and as part of the approval process, all trees which will be retained on the property must be clearly marked and protected with a barrier that extends in a circular fashion at the outer edge of the drip line of the canopy. No dirt shall be placed inside this perimeter, nor can the area be driven over by construction equipment. In addition, erosion prevention plans must be included with the application.
2. Gravel driveways **must** be installed before any other earthmoving or construction activities begin. These drives must extend from the curb to the building setback line and must consist of a fabric underlay and 6" of #2 stone. In the event that this is a "teardown", the original driveway must remain in place as long as possible and will serve in place of the gravel drive. **All deliveries made to the site or trucks or equipment must use this driveway. All construction vehicles must be parked on this drive or the street, on the same side as the construction site. Care must be taken that construction vehicles including workers personal vehicles do not block our roads or cause a hazard to other drivers.**
3. Vegetative buffers may be used as part of the erosion control plan, but may not be disturbed, driven over or otherwise damaged.
4. Temporary erosion control must be placed on all four sides of the lot.
5. Silt fence may be used as a final line of defense as long as it is installed and maintained properly. However, the Best Management Practice we would like to see is a combination of a. mulch, fabric or coconut fiber logs filled with mulch or filter material placed parallel to the curb or lot line. If the slope is greater than 1:12, multiple logs or runs of silt fence with overlapping ends will be required. **This protection must be placed on all four sides of the lot.**
6. Silt fence, if used, must be buried in a trench which is 4" wide and 4" deep on the off-street side of the curb and backfilled with compaction.
7. **Any and all dirt stockpiled on the site must be stabilized by the use of erosion blankets or additional silt fencing properly installed. Dirt piles must be seeded if the dirt will be stockpiled for more than 15 days. Steep and unvegetated hill sides should be similarly protected.**
8. Construction sites located close to storm drain inlets must provide a barrier at the inlet which will prevent silt laden water from entering the drain. Water cleaned of silt must still get through. All such filters are to be maintained regularly.
9. Lots which contain drainage swales must have installed check damns along the swale using staked hay bales. These should be installed every 20 feet and should be buried at least 4 inches below grade.
10. Streets must be cleaned of mud, dirt, or sand by close of work **every day.**
11. SWEPPP permits if required must be posted at the site along with the county building permit and contact information for all contractors and subcontractors.

12. For lake lots, a vegetated strip at least 10 ft. wide must be planted behind the log or silt fence before temporary erosion control materials are removed. Grass is not approved for this buffer. Along all other sides, and on all four sides of off-water lots, seed with mulch or other plants must be in place before temporary erosion control structures are removed. Dormant seeding (at twice the normal density) with mulch cover can be applied in the fall. The mulch will hold over the winter.
13. **All erosion control structures must be maintained at all times. Failure to do so may result in a mandatory work stoppage until it is fixed. Driving over any erosion control structure other than the gravel drive is also not allowed.**

According to IDEM, compost (and leaf litter) may be used on flat ground as an erosion control blanket.

In addition, concrete washout activities may only be conducted at the site of the Utility plant. Concrete washout water may cause fish kills because of high pH.

Installation of Silt Fencing

Step 1. At the location at which the silt fence is to be installed, a trench is dug which is 4 inches wide and 4 inches deep.

Step 2. Stakes to support the silt fence are to be installed in the trench so that the silt fence when attached is against the curb if installed along the road, or on the down-slope side of the trench if anywhere else on the lot.

Step 3. Heavy duty silt fence material is to be attached to the stakes using heavy duty staples or nails. The material should be drawn taught between stakes and extend into the trench the full distance to the bottom. Extra material can be folded so as to lie along the bottom of the trench if desired.

Step 4. Soil is to be back filled along the trench so that the fabric is covered with 4 inches of compacted soil.

This fencing must not be driven over or removed until the ground behind it has been stabilized by planting with grass or other plants, or covered with mulch or landscaping stones. If the fence is knocked down or torn, it must be replaced according to the same procedure listed above.

Construction Guidelines for Hay Bales

Hay bale check damns are to be laid in such a manner that they form a "smile" with the "arrow" in the direction of expected flow.

Procedure for installing hay bales:

1. A trench is dug 4 inches deep and as wide as the narrow edge of the bales at the location in which the bale is to be laid.

2. Hay bales are placed in the trenches.

3. Metal stakes or pieces of rebar long enough to penetrate the ground and extend at least 4 inches above the hay bales are to be driven into the bales and into the ground.

Permanent Erosion Control for Lots with Lake Frontage

1. There is no single solution to prevent shoreline erosion.

2. Shoreline erosion is only a major problem on those lots fronting the fast water area, especially the far eastern shoreline and Deer Island, and lots with steep slopes which continue into the lake or abut narrow channels.

3. Permanent controls must be developed on a lot by lot basis. These measures include, but are not limited to the following:

    a. On lots in the fast water area.
        i. If the shoreline-to lake bottom grade is shallow (i.e. 1/12), cladding the shoreline with landscape cloth and stones from two feet above the high water line to 2 ft below, or laying stones in mortar may be done. In addition at least 1 to 1 ½ feet of emergent plants are to be planted in the lake side of the stones.
        ii. On Deer Island where the lake bottom drops off quickly to deep water, stones in mortar with rebar tiebacks or properly constructed sea walls may be used.
        iii. Use of seawalls in narrow channels is to be discouraged as they simply intensify the problem on the other side. Therefore, erosion controls in channels will be the same as for fast water, except that for shallow or moderate slopes, the planting of a buffer 10-15 feet wide along the shore including both land and emergent plants is to be used.
        iv. Lots in the no-wake area not along narrow channels which have steep slopes must install the plant buffer with a series of water slowing devices such are retaining walls, rain gardens and drain fields up slope from the lake.
        v. All other lots must plant a 10-15 foot buffer along their shoreline including both land and emergent plants.

4. In all cases, species of plants which are considered invasive, such as spatterdock, purple loostrife, yellow lotus, and any others on the State "hit list" may not be included in the plantings. Turf grass is not considered a sufficient barrier. Native plants are encouraged because or their low maintenance characteristics, but non-native plants may be used.

Permanent Erosion Control for Lots Abutting a Stream Canyon

Lots which include or abut one of the inflow streams are required to install permanent erosion control. This can take the form of:

1. A planted buffer containing plants other than turf grass 10-15 feet from the stream will be established.
2. If the stream bank is part of a canyon, the sides of the canyon are to be stabilized using retaining walls or ground cover mixed with taller plants, and by reducing the amount and speed of runoff using rain barrels, rain gardens or drain fields.
3. If the lot fully contains the stream, check dams in the stream bed are to be used along with 1 and 2 above.

JF News Reports

JF News reports are maintained on file at the Shorewood Forest POA office.

Budget Estimate for the Plan

Item	1 yr amount	Budget 2008	5 yr total
Ravines	$100,000	$60,000	$400,000
Shoreline plants*	10,000	0	30,000
Submerged plants*	5,000	0	15,000
Street sweeping	5,000	5000	25,000
Rain barrel	300	0	300
Rain chain	400	0	400
Rain garden plants*	2000	0	2000
Soil test kits	2688	0	13,440
Education mat.	300	0	1500
New pumps	35,000	0	35000
Elect. to run	16000	?	80,000
Fish study	2575	2575	5200
Fish hab.	300	0	900
Oil for eggs	10	?	50
E-coli tests*	600	3000	3000
Water Qual test**	1000	1000	5000
Redo New	0	0	30,000
Total	$170,785	$71,575	$641,790

*not a specific line item, but may be included in the total of a line item

**cost of student participation under business good will or contributions also included as part of the lake treatment line item

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LAKE LOUISE DAM

IEAP

INCIDENT AND EMERGENCY ACTION PLAN

NATIONAL INVENTORY OF DAMS NO. IN00247

IDNR DAM NO. (64-8)
VALPARAISO, INDIANA

SHOREWOOD FOREST PROPERTY OWNERS ASSOCIATION

Copy No. ___________
Revision No. 0
July, 2016

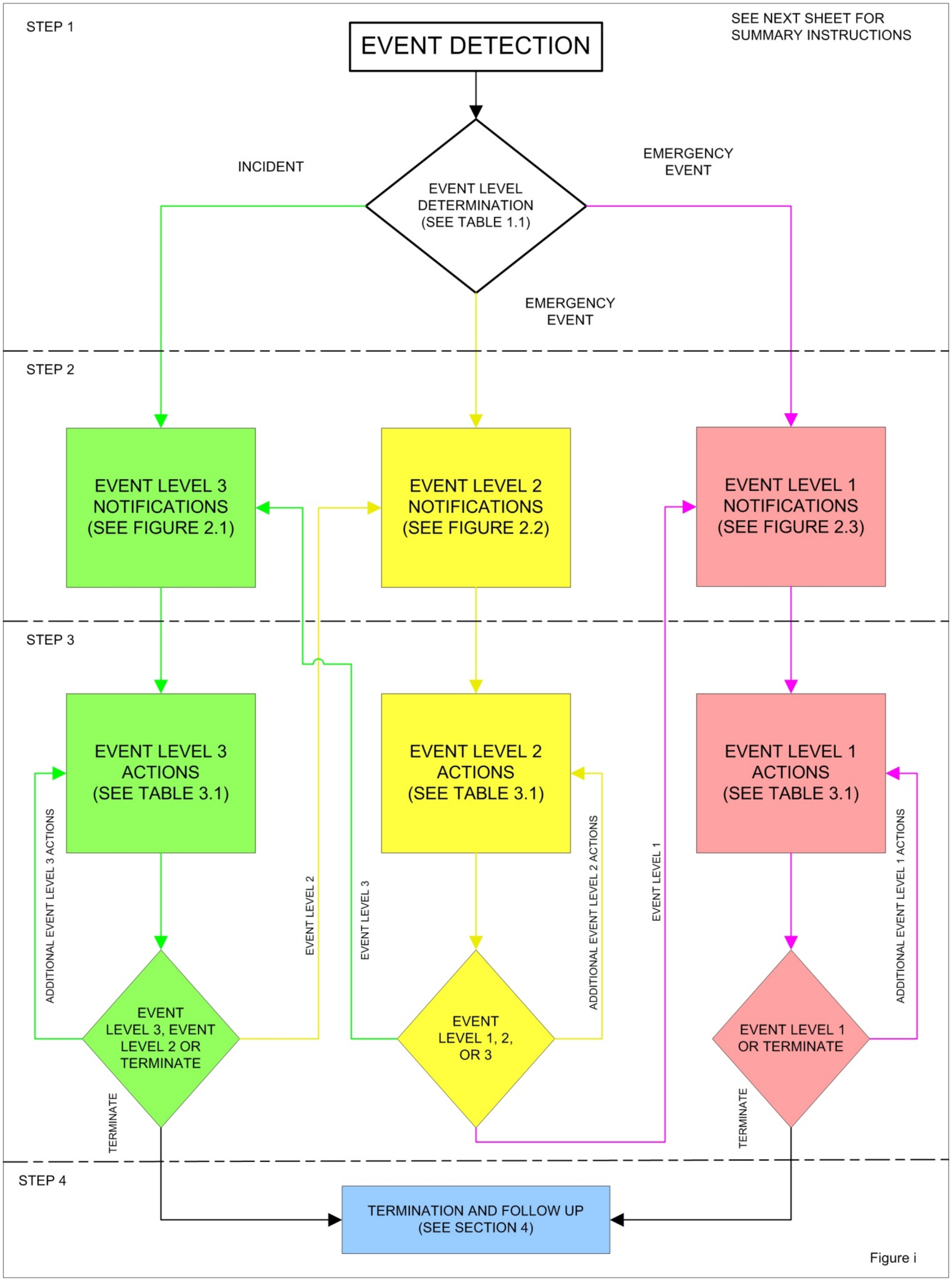
STEP 1
EVENT DETECTION
SEE NEXT SHEET FOR SUMMARY INSTRUCTIONS
INCIDENT
EVENT LEVEL DETERMINATION (SEE TABLE 1.1)
EMERGENCY EVENT
EMERGENCY EVENT
STEP 2
EVENT LEVEL 3 NOTIFICATIONS (SEE FIGURE 2.1)
EVENT LEVEL 2 NOTIFICATIONS (SEE FIGURE 2.2)
EVENT LEVEL 1 NOTIFICATIONS (SEE FIGURE 2.3)
STEP 3
EVENT LEVEL 3 ACTIONS (SEE TABLE 3.1)
EVENT LEVEL 2 ACTIONS (SEE TABLE 3.1)
EVENT LEVEL 1 ACTIONS (SEE TABLE 3.1)
ADDITIONAL EVENT LEVEL 3 ACTIONS
EVENT LEVEL 2
EVENT LEVEL 3
ADDITIONAL EVENT LEVEL 2 ACTIONS
EVENT LEVEL 1
ADDITIONAL EVENT LEVEL 1 ACTIONS
EVENT LEVEL 3, EVENT LEVEL 2 OR TERMINATE
EVENT LEVEL 1, 2, OR 3
EVENT LEVEL 1 OR TERMINATE
TERMINATE
TERMINATE
STEP 4
TERMINATION AND FOLLOW UP (SEE SECTION 4)

Figure i

SUMMARY OF IEAP PROCESS

There are four steps that must be followed anytime an incident or emergency event is detected at the Lake Louise Dam. The steps are:

Step 1: Event Detection and Level Determination
Step 2: Notification and Communication
Step 3: Expected Actions
Step 4: Termination and Follow-up

Incidents and emergency events are defined in Section 1.2.1 of this Incident and Emergency Action Plan (IEAP). The specific actions required for each step will depend on the severity of the situation as defined during Step 1. The actions required for each step of the IEAP are summarized graphically on the IEAP Flow Chart (Figure i) and are described in the corresponding IEAP Section. A summary of each step is provided below.

Step 1 - Event Detection and Level Determination

During the initial step, an incident or emergency event is detected at the dam and classified by the IEAP Coordinator into one of the following event levels:

Event Level 3: Incident, slowly developing
Event Level 2: Emergency Event, rapidly developing
Event Level 1: Emergency Event, imminent dam failure or flash flooding

Information to help the IEAP Coordinator determine which of the above event levels is applicable is provided in Section 1 of this IEAP.

Step 2 - Notification and Communication

After the event level has been determined, notifications are made in accordance with the appropriate notification flow charts provided in Section 2 of this IEAP.

Step 3 - Expected Actions

After the initial notifications are made, the IEAP Coordinator should refer to Table 3.1 and confer with the Assigned Engineer to develop and execute appropriate preventive actions. During this step of the IEAP, there is a continuous process of taking actions, assessing the status of the situation, and keeping others informed through communication channels established during the initial notifications. The IEAP may go through multiple event levels during Steps 2 and 3 as the situation either improves or worsens.

Step 4 - Termination and Follow-up

Once the event has ended or been resolved, termination and follow-up procedures should be followed as outlined in Section 4 of this IEAP. IEAP operations can only be terminated after completing operations under Event Level 3 or 1. If Event Level 2 is declared, the operations must be designated Event Level 3 or 1 before terminating the IEAP operations.

APPROVAL AND ACCEPTANCE

The undersigned states that he/she has read the following document and understands the contents of it, and that all the statements contained in the document are true and correct, to the best of his/her knowledge and belief.

IEAP Coordinator's Approval and Acceptance:

(Signature)

(Printed Name)

(Title)

(Date)

Assigned Engineer's Approval and Acceptance:

(Signature)

(Printed Name)

(Title)

(Date)

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PRIVACY STATEMENT

Current Federal and State regulations allow the collection of pertinent information for emergency preparedness. The purpose of this collection is for the creation of an emergency roster for the emergency agencies and the Shorewood Forest Property Owners Association, which will be used in case of an incident or emergency event at the Lake Louise Dam. This information is subject to the provision of the applicable Federal and State privacy acts and regulations.

ACKNOWLEDGEMENTS

This document was prepared for the Shorewood Forest Property Owners Association by Lawson-Fisher Associates P.C. (LFA). LFA acknowledges using resources from the Indiana Department of Natural Resources (IDNR) and methodology from Christopher B. Burke Engineering, LLC (CBBEL). The estimated flood inundation map as seen in Figure 5.3 used this methodology.

PURPOSE

The purpose of this IEAP is to reduce the risk of human life loss and injury during an incident or emergency event at the Lake Louise Dam. The Dam is rated as a High Hazard structure due to the potential for loss of life and property if the dam were to fail. There is no warning system, auxiliary power, or instrumentation. According to past Dam Safety Inspections, there is a mechanical drawdown valve but it has never been operated. A secondary purpose of the IEAP is to minimize the potential for property damage during an incident or emergency event at the Lake Louise Dam. This includes damage to the dam itself as well as residences, businesses, agricultural land, roads, utilities, and other infrastructure downstream.

The dam is located in Shorewood Forest, a development by the Shorewood Corporation, in the central portion of Porter County approximately 4 miles west of Valparaiso, Indiana.

SCOPE

The Scope of the IEAP is limited to listing actions that the IEAP Coordinator will need to take to promptly and accurately inform several other parties of an ongoing or impending emergency. In addition, the Scope of the IEAP lists how to communicate the extent of possible flooding downstream of the dam caused by an event. The response plan to assist emergency first responders (police, fire, and the Emergency Management Agency) carry out their warning or evacuation duties are not usually addressed in the IEAP.

IEAP ANNUAL REVIEW AND PERIODIC TEST

This IEAP document will require an annual review and update, to stay current. A periodic test of the IEAP procedures is also required every five (5) years to ensure continued effectiveness. For annual review and periodic test procedures, reference Appendix D.

REVISIONS

For revision procedures, reference Appendix D.

Revision No.	Date	Revisions Made
0	July, 2016	IEAP published in IDNR 2012 format.

Revised pages inserted in this IEAP by

(Signature)

(Printed Name)

(Date)

SECTION 1 – EVENT DETECTION AND LEVEL DETERMINATION

SECTION 1.
EVENT DETECTION AND LEVEL DETERMINATION

This section of the Incident and Emergency Action Plan (IEAP) describes the first step that must be followed whenever an incident or emergency event is detected at the Lake Louise Dam. This section also describes event detection and information to assist the IEAP Coordinator in determining the appropriate level for the event.

1.1 Event Detection

Incidents or emergency events may be detected by:

- Observations at or near the dam by property owners or the public.
- Forewarning of conditions (severe weather) which may cause an incident or emergency event at the dam.
- Earthquakes felt or reported in the vicinity of the dam.

After any incident or emergency event is detected and reported to the IEAP Coordinator, the IEAP Coordinator is responsible for determining the level of the event. If the Porter County Police Department receives a 911 call regarding observations of an incident or emergency event at the dam, the dispatcher shall first contact the IEAP Coordinator. The IEAP Coordinator shall determine the appropriate event level (as defined in Section 1.2.2) and advise the dispatcher of the event level.

1.2 Event Level Determination

1.2.1 Incidents and Emergency Events

An incident is defined as a slowly developing event, which is not normally encountered in the routine operation of the dam and reservoir, or necessitates a variation from the Standard Operating Procedures. Such events are more common than emergency conditions and can offer more time to conduct preplanned responses to the slowly developing situation. If addressed in a timely manner, such events can often be prevented from progressing. An incident requires operations in accordance with Event Level 3 of this IEAP.

An emergency event is defined as a developing event that is of a serious nature, demands immediate attention and may endanger the dam, persons, or property. An emergency event requires immediate operations in accordance with Event Level 2 or 1 of this IEAP.

1.2.2 Level Determination

The IEAP Coordinator shall be responsible for defining incidents or emergency events as one of the three following event levels:

Event Level 3 - This is an incident that is defined as an unusual, slowly developing situation that may endanger the structural integrity of the dam if the situation should get worse or conditions cannot be controlled in time. The situation should be closely monitored by the IEAP Coordinator and attended by the appropriate engineering and operations staff. However, notification to emergency coordination agencies should still be provided as a precautionary measure. For the

Lake Louise Dam during an Event Level 3 the Porter County Emergency Management Agency (EMA) should be contacted as the emergency coordination agency. In addition, the Assigned Engineer and the Indiana Department of Natural Resources (IDNR) should be notified of the situation.

Event Level 2 - This is an emergency event that is defined as rapidly developing and could quickly lead to dam failure and flash flooding downstream of the dam. The IEAP Coordinator should contact the 911 Dispatch Center and the Porter County EMA to prepare to evacuate downstream of the Lake Louise Dam. The IDNR and Assigned Engineer should also be notified and can help coordinate the emergency agencies to prepare for evacuation. The local police and fire departments should also help give warnings and assist with evacuation efforts.

Event Level 1 - This is an emergency event that is defined as imminent dam failure or flash flooding downstream of the dam. The IEAP Coordinator should contact the 911 Dispatch Center and the Porter County EMA to immediately evacuate downstream of the dam. In addition, the Assigned Engineer and local police and fire departments can assist with the evacuations downstream of the Lake Louise Dam. The police departments can assist to complete road closures and give flash flood warning to the residents. With the help of the Porter County EMA, the Porter County Sheriff Department can also visually check on the residents immediately downstream of the Lake Louise Dam who possibly didn’t hear any of the warnings. The Valparaiso Fire Department and other surrounding fire departments should also provide assistance with warnings, emergency equipment, and other required resources in the case of rescue operations.

1.2.3 Level Determination Guidance

Table 1.1 shall be used as a guide for determining the appropriate event level. This table attempts to be all inclusive, however, an event or condition may arise that is not covered in this table. In the circumstance of multiple events occurring at the dam with conflicting event levels, always designate the higher event level as the governing event level.

1.2.4 Roles, Responsibilities, and Authority

IEAP Coordinator – The IEAP Coordinator shall function as the Incident Commander during any of the three event levels of operation described in this IEAP. The IEAP Coordinator has the authority to take the necessary actions described in this IEAP and should consult with the Assigned Engineer before initiating notifications described in this IEAP, if time permits.

The IEAP Coordinator is responsible for providing initial, timely, and accurate notifications to the 911 Dispatch Center and the Porter County EMA after an Event Level 2 or 1 has been determined. The IEAP Coordinator is also responsible for providing subsequent updates of the situation to the the Assigned Engineer, Porter County Sheriff Department and IDNR to assist in making timely and accurate decisions regarding warning and evacuation responsibilities.

Once an Event Level 2 or 1 is terminated, the IEAP Coordinator is responsible for preparing an accurate summary of the field observation and activities of the event.

911 Dispatch Center – This is the local emergency management agency that will start the coordination and preparation to evacuate downstream of the dam, as well as the implementation of the evacuation itself.

Porter County Emergency Management Agency (EMA) – The EMA is primarily responsible for giving warnings to residents located in the projected flood inundation areas and can assist in the coordination of emergency agencies. The EMA can also assist the Porter County Sheriff Department and other local police and fire departments with communicating warnings or evacuations. The EMA is also responsible for making notifications to the Indiana Department of Homeland Security (IDHS).

Valparaiso Fire Department – Local emergency department responsible for assisting with emergency warnings and helping local police departments. If necessary, they can also contact other local fire departments near the projected flood zone.

Indiana Department of Homeland Security & Emergency Operations Center (IDHS-EOC) – Responsible for coordinating efforts at the state level and notifying state agencies.

Porter County Sheriff's Department – The Porter County Sheriff's Department is responsible for carrying out warnings and evacuations of populations at risk downstream of the dam. If not done so already, the Sheriff's Department shall notify other local police departments such as the Valparaiso Police Department, and follow the notification flow chart for the corresponding Event Level.

Indiana Department of Transportation (INDOT) / Porter County Highway Department – INDOT and the Porter County Highway Department will be responsible for assisting with signage and road closures due to flooding or potential flooding.

Red Cross – The Red Cross is responsible for assisting with evacuation or providing temporary shelter for residents who will be in need.

Shorewood Forest Property Owners Association – The Shorewood Forest Property Owners Association are responsible for assisting the Valparaiso Police Department in carrying out warnings and evacuations of populations at risk downstream of dam.

TABLE 1.1 – EVENT LEVEL DETERMINATION GUIDANCE

TABLE 1.1
EVENT LEVEL DETERMINATION GUIDANCE

Event	Observation	Event Level
Flooding	Reservoir water surface greater than Elevation 723.5 feet (NGVD29). This is approximately 1.5 feet below the top of the dam	3
	Reservoir water surface greater than Elevation 724.0 feet (NGVD29). This is 1.0 foot below the top of the dam.	2
	Reservoir water surface is equal to or greater than 724.5 feet (NGVD 29). This is approximately 0.5 foot below the top of the dam.	1
Earthquake	Magnitude of 5.0 or greater earthquake felt or reported within 50 miles of dam.	3
	Earthquake resulting in visible damage to the dam or appurtenant structures.	2
	Earthquake resulting in uncontrolled release of water from the dam.	1
Seepage	Observation of any new seepage areas in the dam or appurtenant structures.	3
	Observation of new seepage areas with cloudy discharge, visibly increasing in flow rate, or flow rates greater than 1 gpm.	2
	Uncontrolled discharge from seepage areas with flow rates greater than 3 gpm.	1
Cracking	New cracks observed in the dam greater than 1/4-inch wide without seepage or new cracks observed in concrete appurtenant structures greater than 1/4-inch wide.	3
	New cracks in the dam or appurtenant structures with seepage flowing through the crack.	2
Movement	Movement of the dam or appurtenant structures greater than 3/4 of an inch.	3
	New or significant movement of the dam or appurtenant structures, or movement greater than 1.5 inches.	2
Overtopping	Reservoir water surface elevation greater than Elevation 725.0 feet NGVD29 (dam crest) and rising, dam failure is imminent.	1
Sabotage	Sabotage at the dam that is not likely to lead to dam failure.	3
	Sabotage or demonstration that may result in dam failure.	2
	Sabotage or demonstration that has caused imminent dam failure.	1

SECTION 2 – NOTIFICATION AND COMMUNICATION

SECTION 2.
NOTIFICATION AND COMMUNICATION

This section of the IEAP describes the appropriate notifications that should be made after the IEAP Coordinator has determined the event level as an Event Level 3, 2, or 1. This section also outlines the communication systems that are available for making notifications as well as a Public Affairs Plan with sample media release and a list of media contacts. Notifications should be made in accordance with the appropriate Notification Flow Chart.

2.1 Communication Systems

Communication between all parties involved shall be completed by the IEAP Coordinator. All communication shall be completed by telephone unless stated otherwise by the IEAP Coordinator.

2.2 Pre-scripted Messages

The following pre-scripted messages may be used as a guide to communicate the status of an event.

Event Level 3

- This is the IEAP Coordinator. I am making this call in accordance with the Lake Louise Dam IEAP.
- An incident has been detected at the Lake Louise Dam.
- The IEAP has been activated, currently at an Incident Level 3.
- If a problem occurs, **flooding along Salt Creek Tributary is possible**. In addition to the Salt Creek Tributary flooding, adjacent tributaries could also be inundated. It is recommended that a **Flood Advisory** be put into effect for low-lying areas downstream of the Lake Louise Dam.
- The situation is being monitored to determine if any evacuation warnings are necessary.
- Coordination for the duration of the event will occur at ….(*state the address of facility)*
- We will keep you apprised of the situation. The best telephone number to reach me during this event is … (*state the best number to reach you*).

Event Level 2

- This is the IEAP Coordinator. I am making this call in accordance with the Lake Louise Dam IEAP.
- Problems have occurred with the Lake Louise Dam.
- The IEAP has been activated, currently at the Emergency Level 2.
- Flooding along Salt Creek downstream of the Lake Louise Dam is possible.
- **Prepare to evacuate** downstream of the Lake Louise Dam. Most of the projected inundation is directly north, but also includes adjacent tributaries to the Salt Creek Tributary. The inundation is projected to flow towards Interstate 30 and State Highways 130 and 149. These roads could be impassable due to flood waters rushing over the surface of the roads. It is possible if a major breach event at the dam occurs, portions of South Haven could be flooded. Areas east and southeast of the dam are also susceptible to inundation, from minor tributaries that flow south of Interstate 30. It is recommended that a **Flash Flood Watch** be put into effect for low-lying areas downstream of the Lake Louise Dam, including the town of South Haven.
- Coordination for the duration of the event will occur at ….(*state the address of facility)*

- We will keep you apprised of the situation. The best telephone number to reach me during this event is … (*state the best number to reach you*).

<u>Event Level 1</u>

- This is the IEAP Coordinator. I am making this call in accordance with the Lake Louise Dam IEAP.
- Failure of the Lake Louise Dam is imminent.
- The IEAP has been activated, currently at the highest Emergency Level 1.
- Flooding along the Salt Creek Tributary will occur.
- **Immediately evacuate** along the Salt Creek Tributary. It is highly recommended that a **Flash Flood Warning** be put into effect for low-lying areas downstream of the Dam, including the town of South Haven. **Evacuate** if you are presently located near Interstate 30, north of Lake Louise, or near State Route 130 between Tower Road and County Road 375. **Evacuate** if you are near State Route 149, St. Clair Road, West 500 Road, West 700 Road, or Lincoln Highway. These roads consist of the more major roads but there are several other minor roads that could be impassable from an emergency breach of the dam.
- Coordination for the duration of the event will occur at ….(*state the address of facility)*
- We will keep you apprised of the situation. The best telephone number to reach me during this event is … (*state the best number to reach you*).

2.3 Public Affairs Plan

In the event of an incident or an emergency condition, the Porter County Emergency Management Agency (EMA) will be alerted and briefed on the situation. The Porter County (EMA) will prepare and deliver a message for public release based on the existing conditions and information from the IEAP Coordinator.

Preparation of warning messages should begin as soon as their potential need is apparent so that they can be issued promptly upon the determination of a Level 2 or Level 1 event. Where time is available for its preparation, the initial message should contain all pertinent information. However, in some cases, an emergency condition may be declared with little or no advance notice. The following example messages provide a model for the first announcements in such cases for Event Levels 2 and 1. Subsequent announcements should provide additional details.

<u>Announcement for Possible Dam Failure Problem (Event Level 2)</u>

THE (*<u>agency</u>*) ANNOUNCED AT (*<u>time</u>*) TODAY THAT AN EMERGENCY CONDITION EXISTED AROUND THE LAKE LOUISE DAM DUE TO (*<u>general description of problem</u>*).

THE SPOKESPERSON EMPHASIZED ALTHOUGH THERE IS NO IMMEDIATE DANGER OF THE DAM FAILING, THERE IS NO DRAWDOWN STRUCTURE AT THE DAM. AS A PRECAUTIONARY MEASURE LOW LYING AREAS DOWNSTREAM OF THE DAM, INCLUDING THE EASTERN SECTOR OF SOUTH HAVEN SHOULD **PREPARE TO EVACUATE**. AREAS INCLUDE EAST AND WEST OF THE SALT CREEK TRIBUTARY NORTH OF THE DAM AND INTERSTATE 30 NORTH OF LAKE LOUISE. ADDITIONAL AREAS INCLUDE STATE ROUTE 130 IN BETWEEN TOWER ROAD AND COUNTY ROAD 375. **PREPARE TO EVACUATE** IF YOU ARE PRESENTLY DOWNSTREAM OF THE LAKE LOUISE DAM NEAR STATE ROUTE 149, ST. CLAIR ROAD, WEST 500 ROAD, 600 NORTH ROAD, WEST 700 ROAD, OR LINCOLN HIGHWAY.

ADDITIONAL INFORMATION WILL BE RELEASED AS PROMPTLY AS POSSIBLE.

Announcement for Possible Dam Failure Imminent or in Progress (Event Level 1)

URGENT, URGENT: THE (*agency*) ANNOUNCED AT (*time*) TODAY THAT AN EMERGENCY CONDITION EXISTED AROUND THE LAKE LOUISE DAM DUE TO (*general description of problem*).

ATTEMPTS TO SAVE THE DAM ARE UNDERWAY BUT THEIR SUCCESS CANNOT BE DETERMINED AS OF YET.

LOW LYING AREAS DOWNSTREAM OF THE DAM, INCLUDING THE EASTERN SECTOR OF SOUTH HAVEN SHOULD EVACUATE TO HIGH GROUND **IMMEDIATELY!**

OTHER AREAS INCLUDE EAST AND WEST OF THE SALT CREEK TRIBUTARY NORTH OF THE DAM AND INTERSTATE 30 NORTH OF LAKE LOUISE. ADDITIONAL AREAS INCLUDE STATE ROUTE 130 IN BETWEEN TOWER ROAD AND COUNTY ROAD 375. IF YOU ARE PRESENTLY NEAR STATE ROUTE 149, ST. CLAIR ROAD, WEST 500 ROAD, WEST 875 ROAD, WEST 900 ROAD, WEST 850 ROAD, WEST 700 ROAD, OR LINCOLN HIGHWAY, EVACUATE TO HIGH GROUND **IMMEDIATELY!**

AREAS CLOSER TO THE DAM WILL BE FLOODED SOONER. THESE ROADS COULD BE INUNDATED AND POSSIBLY IMPASSIBLE DURING AND AFTER A DAM BREACH.

ADDITIONAL INFORMATION WILL BE RELEASED AS PROMPTLY AS POSSIBLE.

Media Contacts

The National Weather Service will be the primary source through which emergency announcements are released to the news media. Contact the National Weather Service and issue a Flash Flood Watch for a Level 2 event and a Flash Flood Warning for a Level 1 event.

NATIONAL WEATHER SERVICE (24-hour telephone number):	(317) 856-0367 (317) 856-0368

The following radio and television stations will be contacted if the National Weather Service cannot be reached. They are considered to be the ones that would provide coverage of the area downstream of the Lake Louise Dam. They can provide an early alert and pertinent information regarding the current dam situation.

Television Stations

WYIN-Lakeshore Public Media
Phone: (219) 756-5656

WNDU
Front Desk: (574) 284-3000
Newsroom: (574) 284-3016

WSBT
Breaking News: (574) 247-6397
Newsroom: (574) 233-3141

Fox 28
Switchboard: (574) 679-9758
Newsroom: (574) 679-4545

WJYS
Phone: (219) 933-8888

Radio Stations

WVUR
Phone: (219) 464-5383

WVLP-LP
Phone: (219) 476-9000

WLJE
Phone: (219) 462-4880

WITW-LP
Phone: (219) 476-9489

Local Newspapers

The Times
Phone: (219) 462-5151

Chesterton Tribune
Phone: (219) 926-1131

FIGURE 2.1 – NOTIFICATION FLOW CHART, EVENT LEVEL 3

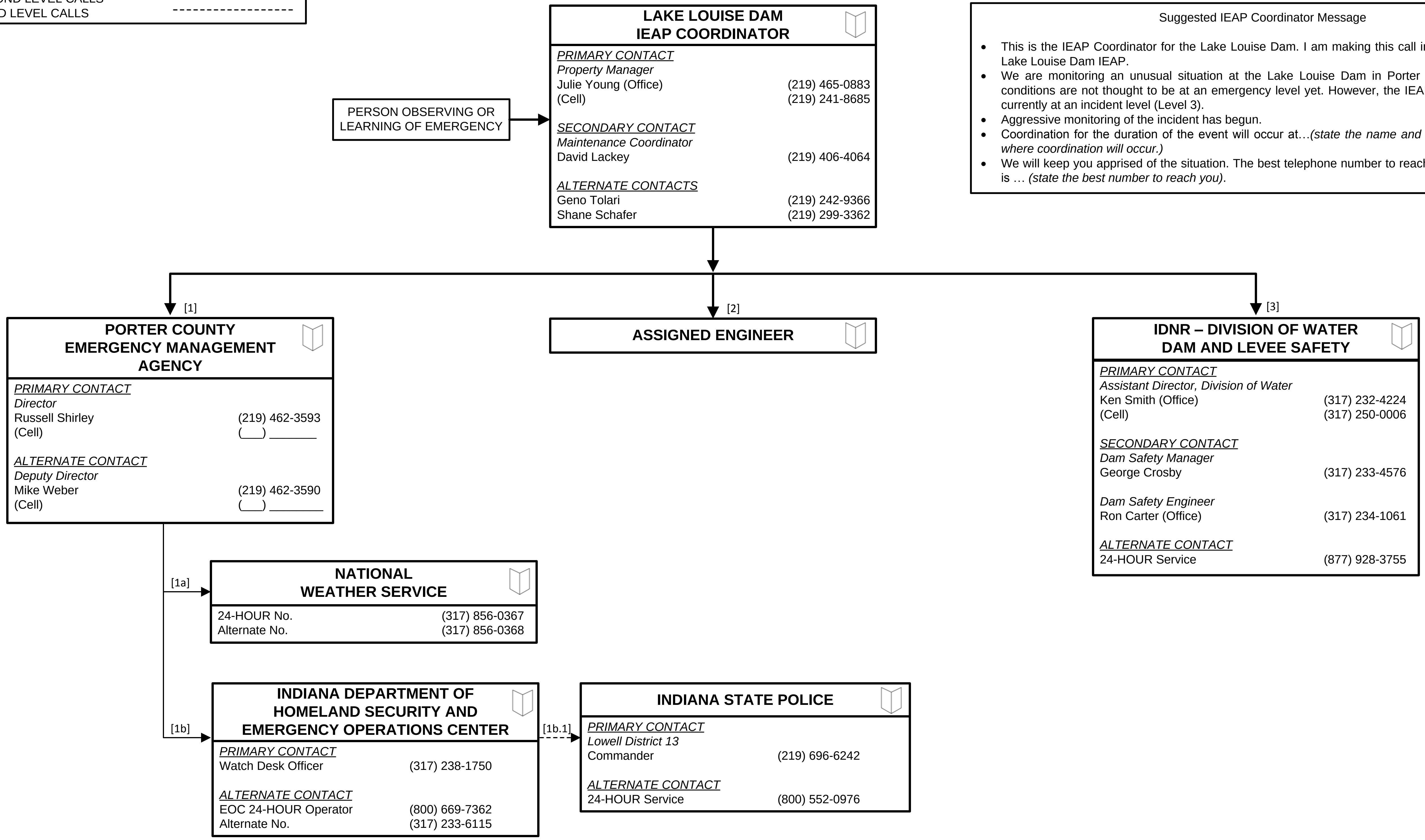
NOTE:
1) [#a, b, c, and d] DENOTES SUGGESTED SEQUENCE
2) [R1a] DENOTES REDUNDANCY SEQUENCE

LEGEND:

CALLS BY IEAP COORDINATOR	━━━━
SECOND LEVEL CALLS	────
THIRD LEVEL CALLS	- - - -

EVENT LEVEL 3 NOTIFICATION

INCIDENT, SLOWLY DEVELOPING



PERSON OBSERVING OR LEARNING OF EMERGENCY

LAKE LOUISE DAM IEAP COORDINATOR

PRIMARY CONTACT
Property Manager

Julie Young (Office)	(219) 465-0883
(Cell)	(219) 241-8685

SECONDARY CONTACT
Maintenance Coordinator

David Lackey	(219) 406-4064

ALTERNATE CONTACTS

Geno Tolari	(219) 242-9366
Shane Schafer	(219) 299-3362

Suggested IEAP Coordinator Message

- This is the IEAP Coordinator for the Lake Louise Dam. I am making this call in accordance with the Lake Louise Dam IEAP.
- We are monitoring an unusual situation at the Lake Louise Dam in Porter County, Indiana. The conditions are not thought to be at an emergency level yet. However, the IEAP has been activated, currently at an incident level (Level 3).
- Aggressive monitoring of the incident has begun.
- Coordination for the duration of the event will occur at…*(state the name and address of the facility where coordination will occur.)*
- We will keep you apprised of the situation. The best telephone number to reach me during this event is … *(state the best number to reach you)*.

[1]

PORTER COUNTY EMERGENCY MANAGEMENT AGENCY

PRIMARY CONTACT
Director

Russell Shirley	(219) 462-3593
(Cell)	(___) _______

ALTERNATE CONTACT
Deputy Director

Mike Weber	(219) 462-3590
(Cell)	(___) ________

[2]

ASSIGNED ENGINEER

[3]

IDNR – DIVISION OF WATER DAM AND LEVEE SAFETY

PRIMARY CONTACT
Assistant Director, Division of Water

Ken Smith (Office)	(317) 232-4224
(Cell)	(317) 250-0006

SECONDARY CONTACT
Dam Safety Manager

George Crosby	(317) 233-4576

Dam Safety Engineer

Ron Carter (Office)	(317) 234-1061

ALTERNATE CONTACT

24-HOUR Service	(877) 928-3755

[1a]

NATIONAL WEATHER SERVICE

24-HOUR No.	(317) 856-0367
Alternate No.	(317) 856-0368

[1b]

INDIANA DEPARTMENT OF HOMELAND SECURITY AND EMERGENCY OPERATIONS CENTER

PRIMARY CONTACT

Watch Desk Officer	(317) 238-1750

ALTERNATE CONTACT

EOC 24-HOUR Operator	(800) 669-7362
Alternate No.	(317) 233-6115

[1b.1]

INDIANA STATE POLICE

PRIMARY CONTACT
Lowell District 13

Commander	(219) 696-6242

ALTERNATE CONTACT

24-HOUR Service	(800) 552-0976

NOTE: Make Notifications on this sheet and then fold it back.

= Received Copy of IEAP

LAKE LOUISE DAM INCIDENT AND EMERGENCY ACTION PLAN	**NOTIFICATION FLOW CHART FOR EVENT LEVEL 3**	
	JULY 2016	FIGURE 2.1

FIGURE 2.2 – NOTIFICATION FLOW CHART, EVENT LEVEL 2

NOTE:
1) [#a, b, c, and d] DENOTES SUGGESTED SEQUENCE
2) [R1a] DENOTES REDUNDANCY SEQUENCE

LEGEND:

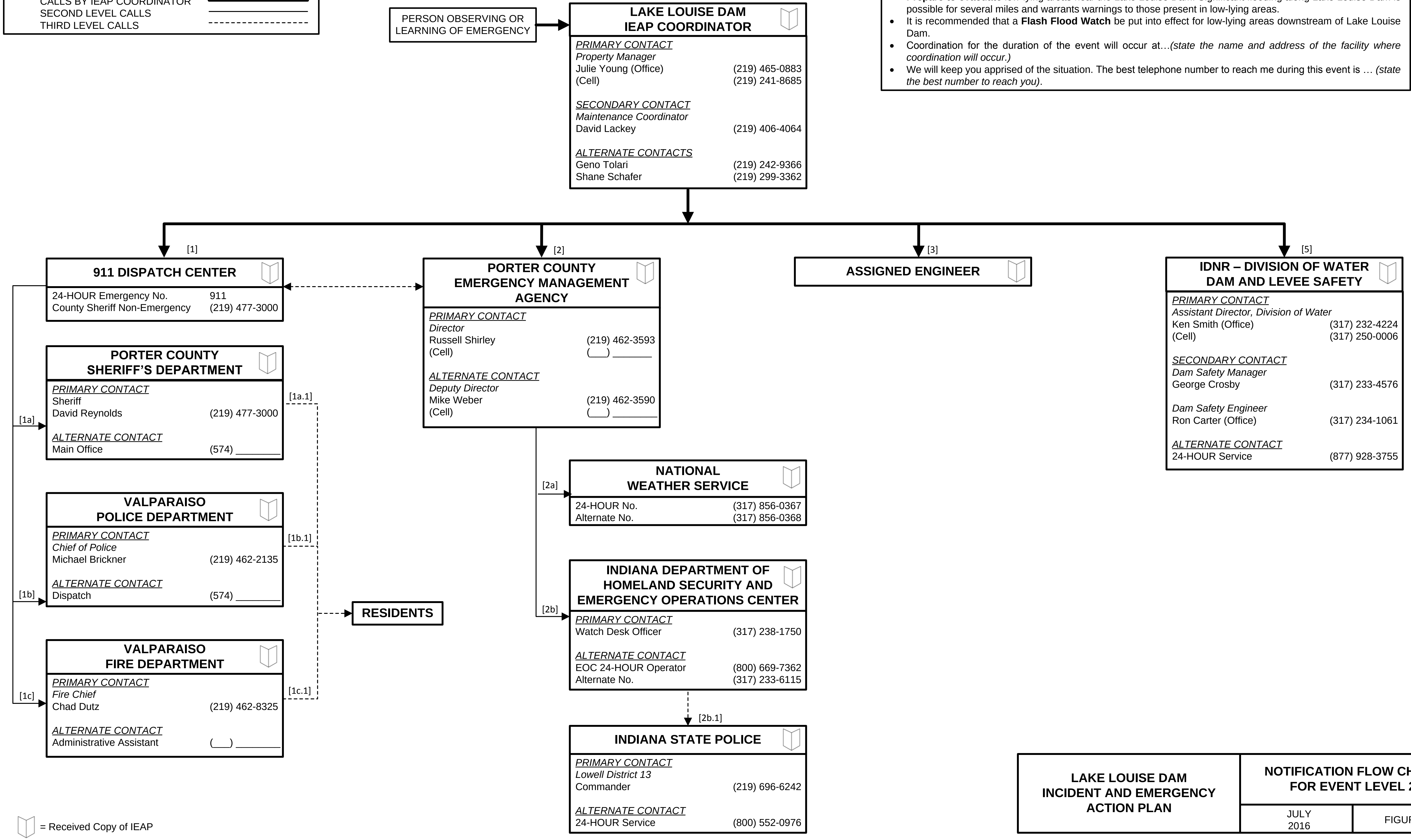
CALLS BY IEAP COORDINATOR	━━━━
SECOND LEVEL CALLS	────
THIRD LEVEL CALLS	- - - -

EVENT LEVEL 2 NOTIFICATION

EMERGENCY EVENT, RAPIDLY DEVELOPING

Suggested IEAP Coordinator Message

- This is the IEAP Coordinator for Lake Louise Dam. I am making this call in accordance with the Lake Louise Dam IEAP.
- Problems have occurred with Lake Louise Dam in Porter County.
- The IEAP has been activated, currently at emergency level (Level 2).
- Flooding along Salt Creek and Slat Creek Tributary is possible.
- **Prepare to evacuate** low-lying areas near the Lake Louise Dam. Significant flooding along Lake Louise Dam is possible for several miles and warrants warnings to those present in low-lying areas.
- It is recommended that a **Flash Flood Watch** be put into effect for low-lying areas downstream of Lake Louise Dam.
- Coordination for the duration of the event will occur at…*(state the name and address of the facility where coordination will occur.)*
- We will keep you apprised of the situation. The best telephone number to reach me during this event is … *(state the best number to reach you)*.



PERSON OBSERVING OR LEARNING OF EMERGENCY

LAKE LOUISE DAM IEAP COORDINATOR

PRIMARY CONTACT
Property Manager
Julie Young (Office) (219) 465-0883
(Cell) (219) 241-8685

SECONDARY CONTACT
Maintenance Coordinator
David Lackey (219) 406-4064

ALTERNATE CONTACTS
Geno Tolari (219) 242-9366
Shane Schafer (219) 299-3362

[1] **911 DISPATCH CENTER**

24-HOUR Emergency No. 911
County Sheriff Non-Emergency (219) 477-3000

[1a] **PORTER COUNTY SHERIFF'S DEPARTMENT**

PRIMARY CONTACT
Sheriff
David Reynolds (219) 477-3000

ALTERNATE CONTACT
Main Office (574) ________

[1b] **VALPARAISO POLICE DEPARTMENT**

PRIMARY CONTACT
Chief of Police
Michael Brickner (219) 462-2135

ALTERNATE CONTACT
Dispatch (574) ________

[1c] **VALPARAISO FIRE DEPARTMENT**

PRIMARY CONTACT
Fire Chief
Chad Dutz (219) 462-8325

ALTERNATE CONTACT
Administrative Assistant (___) ________

[1a.1] [1b.1] [1c.1] **RESIDENTS**

[2] **PORTER COUNTY EMERGENCY MANAGEMENT AGENCY**

PRIMARY CONTACT
Director
Russell Shirley (219) 462-3593
(Cell) (___) _______

ALTERNATE CONTACT
Deputy Director
Mike Weber (219) 462-3590
(Cell) (___) ________

[2a] **NATIONAL WEATHER SERVICE**

24-HOUR No. (317) 856-0367
Alternate No. (317) 856-0368

[2b] **INDIANA DEPARTMENT OF HOMELAND SECURITY AND EMERGENCY OPERATIONS CENTER**

PRIMARY CONTACT
Watch Desk Officer (317) 238-1750

ALTERNATE CONTACT
EOC 24-HOUR Operator (800) 669-7362
Alternate No. (317) 233-6115

[2b.1] **INDIANA STATE POLICE**

PRIMARY CONTACT
Lowell District 13
Commander (219) 696-6242

ALTERNATE CONTACT
24-HOUR Service (800) 552-0976

[3] **ASSIGNED ENGINEER**

[5] **IDNR – DIVISION OF WATER DAM AND LEVEE SAFETY**

PRIMARY CONTACT
Assistant Director, Division of Water
Ken Smith (Office) (317) 232-4224
(Cell) (317) 250-0006

SECONDARY CONTACT
Dam Safety Manager
George Crosby (317) 233-4576

Dam Safety Engineer
Ron Carter (Office) (317) 234-1061

ALTERNATE CONTACT
24-HOUR Service (877) 928-3755

📖 = Received Copy of IEAP

NOTE: Make Notifications on this sheet and then fold it back.

LAKE LOUISE DAM INCIDENT AND EMERGENCY ACTION PLAN	NOTIFICATION FLOW CHART FOR EVENT LEVEL 2	
	JULY 2016	FIGURE 2.2

FIGURE 2.3 – NOTIFICATION FLOW CHART, EVENT LEVEL 1

NOTE:
1) [#a, b, c, and d] DENOTES SUGGESTED SEQUENCE
2) [R1a] DENOTES REDUNDANCY SEQUENCE

LEGEND:

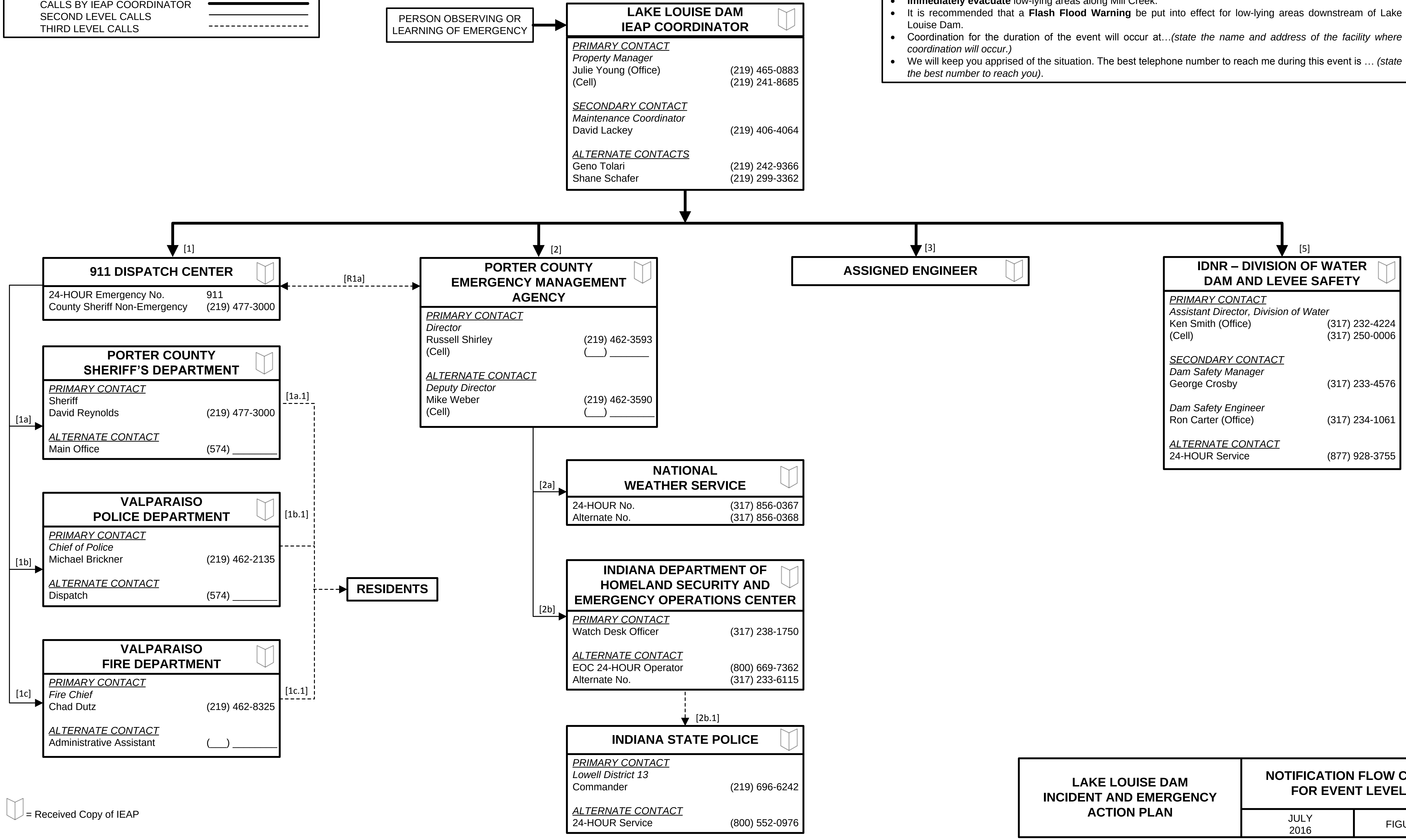
CALLS BY IEAP COORDINATOR	━━━━
SECOND LEVEL CALLS	────
THIRD LEVEL CALLS	- - - -

EVENT LEVEL 1 NOTIFICATION

EMERGENCY EVENT, IMMINENT DAM FAILURE

Suggested IEAP Coordinator Message

- This is the IEAP Coordinator for Lake Louise Dam. I am making this call in accordance with the Lake Louise Dam IEAP.
- Problems have occurred with Lake Louise Dam in Porter County.
- The IEAP has been activated, currently at emergency level (Level 1).
- Flooding along Salt Creek and Salt Creek Tributary will occur.
- **Immediately evacuate** low-lying areas along Mill Creek.
- It is recommended that a **Flash Flood Warning** be put into effect for low-lying areas downstream of Lake Louise Dam.
- Coordination for the duration of the event will occur at…*(state the name and address of the facility where coordination will occur.)*
- We will keep you apprised of the situation. The best telephone number to reach me during this event is … *(state the best number to reach you)*.



PERSON OBSERVING OR LEARNING OF EMERGENCY

LAKE LOUISE DAM IEAP COORDINATOR

PRIMARY CONTACT	
Property Manager	
Julie Young (Office)	(219) 465-0883
(Cell)	(219) 241-8685
SECONDARY CONTACT	
Maintenance Coordinator	
David Lackey	(219) 406-4064
ALTERNATE CONTACTS	
Geno Tolari	(219) 242-9366
Shane Schafer	(219) 299-3362

911 DISPATCH CENTER

24-HOUR Emergency No.	911
County Sheriff Non-Emergency	(219) 477-3000

PORTER COUNTY SHERIFF'S DEPARTMENT

PRIMARY CONTACT	
Sheriff	
David Reynolds	(219) 477-3000
ALTERNATE CONTACT	
Main Office	(574) ________

VALPARAISO POLICE DEPARTMENT

PRIMARY CONTACT	
Chief of Police	
Michael Brickner	(219) 462-2135
ALTERNATE CONTACT	
Dispatch	(574) ________

VALPARAISO FIRE DEPARTMENT

PRIMARY CONTACT	
Fire Chief	
Chad Dutz	(219) 462-8325
ALTERNATE CONTACT	
Administrative Assistant	(___) ________

RESIDENTS

PORTER COUNTY EMERGENCY MANAGEMENT AGENCY

PRIMARY CONTACT	
Director	
Russell Shirley	(219) 462-3593
(Cell)	(___) ________
ALTERNATE CONTACT	
Deputy Director	
Mike Weber	(219) 462-3590
(Cell)	(___) ________

NATIONAL WEATHER SERVICE

24-HOUR No.	(317) 856-0367
Alternate No.	(317) 856-0368

INDIANA DEPARTMENT OF HOMELAND SECURITY AND EMERGENCY OPERATIONS CENTER

PRIMARY CONTACT	
Watch Desk Officer	(317) 238-1750
ALTERNATE CONTACT	
EOC 24-HOUR Operator	(800) 669-7362
Alternate No.	(317) 233-6115

INDIANA STATE POLICE

PRIMARY CONTACT	
Lowell District 13	
Commander	(219) 696-6242
ALTERNATE CONTACT	
24-HOUR Service	(800) 552-0976

ASSIGNED ENGINEER

IDNR – DIVISION OF WATER DAM AND LEVEE SAFETY

PRIMARY CONTACT	
Assistant Director, Division of Water	
Ken Smith (Office)	(317) 232-4224
(Cell)	(317) 250-0006
SECONDARY CONTACT	
Dam Safety Manager	
George Crosby	(317) 233-4576
Dam Safety Engineer	
Ron Carter (Office)	(317) 234-1061
ALTERNATE CONTACT	
24-HOUR Service	(877) 928-3755

🕮 = Received Copy of IEAP

NOTE: Make Notifications on this sheet and then fold it back.

LAKE LOUISE DAM INCIDENT AND EMERGENCY ACTION PLAN	NOTIFICATION FLOW CHART FOR EVENT LEVEL 1	
	JULY 2016	FIGURE 2.3

SECTION 3 – EXPECTED ACTIONS

TABLE 3.1 – ACTION DATA SHEET INDEX

SECTION 3.
EXPECTED ACTIONS

3.1 Action Data Sheets

After the IEAP Coordinator has determined the event level and has made the appropriate notifications, the IEAP Coordinator shall take action, using the Action Data Sheets as a guide. Table 3.1 is an index of the Action Data Sheets.

The Action Data Sheets should be reviewed with the Assigned Engineer when possible and as time permits. If an event is not covered, adapt an Action Data Sheet of a similar event and event level. If resources described in the Action Data Sheets are not available, adapt with the available resources.

Table 3.1
Action Data Sheet Index

Event	Event Level	Action Data Sheet
Flooding	3	A3
	2	A2
	1	A1
Earthquake	3	B3
	2	B2
	1	B1
Seepage	3	C3
	2	C2
	1	C1
Cracking	3	D3
	2	D2
Movement	3	E3
	2	E2
Overtopping	1	F1
Sabotage	3	J3
	2	J2
	1	J1

Note: G-Series through I-Series Action Data Sheet (Gate Failure, Block Gates, and Instrument Failure) are not applicable for the Lake Louise Dam.

EVENT: **FLOODING**

LEVEL: 3 (incident, slowly developing)

Sheet

A3

RECOMMENDED ACTIONS

Time/Date Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.1 have been made.

B. Have staff members monitor flood conditions in the reservoir and report back to the IEAP Coordinator periodically or if conditions change significantly. If necessary, coordinate with the Assigned Engineer to possibly activate the drawdown valve.

C. Have staff members inspect the dam, spillway, and embankments. If possible look for any indications of piping, seepage, erosion, or cracking. Carefully inspect the retaining wall sections on the downstream side of the spillway.

D. If possible, have staff members record the reservoir level in relation to the dam crest or another fixed point daily.

E. Have staff members monitor conditions downstream from the dam.

F. Record all information, observations, and actions on an Event Log Form (Form 3.1).

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or other preventative instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions daily, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event can be terminated (e.g., inflows are decreasing; reservoir is below Elevation 723.5 feet (NGVD29), which is 1.5 feet below the dam crest).

B) The event remains at the current Event Level 3 (e.g. reservoir levels have not changed significantly, or in between 723.5 feet (NGVD29) and 724.0 feet (NGVD29)).

C) The event warrants escalation to Event Level 2 (e.g. reservoir levels have or will soon exceed elevation 724.0 feet (NGVD29) which is 1 foot below the dam crest).

Based on this determination, follow the appropriate actions below.

A) TERMINATION	B) EVENT LEVEL 3	C) EVENT LEVEL 2
Go to **Termination and Follow-up** (Section 4)	Continue recommended actions on this sheet	Go to **Event Level 2 or Event Level 1 Notification Chart**

EVENT: **FLOODING**

LEVEL: 2 (emergency event, rapidly developing)

Sheet

A2

RECOMMENDED ACTIONS

Time/Date
Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.2 have been made.
B. Send a trained staff member, with designated equipment, to the dam to monitor conditions and report back to the IEAP Coordinator.
C. Have staff members monitor flood conditions in the reservoir and report back to the IEAP Coordinator periodically or if conditions change significantly. If necessary, coordinate with the Assigned Engineer to possibly activate the drawdown valve.
D. Have staff members inspect the crest, embankments, and spillway. In particular, check for any signs of increased seepage or erosion.
E. Record all information, observations, and actions on an Event Log Form (Form 3.1).

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or other preventative instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions twice a day, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event warrants downgrade to Event Level 3 (e.g. inflows are decreasing, reservoir is below elevation 723.5 feet (NGVD29), which is 1.5 feet below the dam crest). All contacts on Event Level 2 Notification Flow Chart shall be notified of the downgrade from Event Level 2 to Event Level 3.
B) The event remains at the current Event Level 2 (e.g. reservoir levels have not changed significantly, or in between 724.0 feet (NGVD29) and 724.5 feet (NGVD29)).
C) The event warrants escalation to Event Level 1 (e.g. reservoir levels have or will soon exceed elevation 724.5 feet (NGVD29), which is 0.5 foot below the dam crest).

Based on this determination, follow the appropriate actions below.

A) EVENT LEVEL 3	**B) EVENT LEVEL 2**	**C) EVENT LEVEL 1**
Go to **Event Level 3 Notification Chart**	Continue recommended actions on this sheet	Go to **Event Level 1 Notification Chart**

EVENT: **FLOODING**

LEVEL: 1 (emergency event, imminent dam failure or flash flooding)

Sheet

A1

RECOMMENDED ACTIONS

Time/Date
Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.3 have been made.

B. Send staff, with designated equipment, to the dam to observe and continuously monitor conditions at the dam from **HIGH GROUND**, and try to inspect upstream and downstream of the spillway. Use the Emergency Access Site Map in Section 5. Observers should report back to the IEAP Coordinator periodically, and inform the Assigned Engineer immediately when conditions change. If possible, document with photographs, videotape, and document the times of any key events.

C. Record all information, observations, and actions on an Event Log Form (Form 3.1).

D. Establish a means to keep in frequent contact with the Assigned Engineer until Event Level 1 is terminated.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or other preventative instructions as appropriate.

EVALUATION / DECISION

Evaluate the situation as events progress, or whenever conditions change. Determine whether:

A) The event remains at the current Event Level 1 (e.g. reservoir level has not changed significantly or at elevation 724.5 feet (NGVD29) or higher).

B) The event can be terminated.

Based on this determination, follow the appropriate actions below.

A) EVENT LEVEL 1	**B) TERMINATED**	
Continue recommended actions on this sheet	Go to **Termination and Follow-up** (Section 4)	

EVENT: **Earthquake**

LEVEL: 3 (incident, slowly developing)

Sheet

B3

RECOMMENDED ACTIONS

Time/Date <u>Completed</u>

IEAP Coordinator:

A. Make sure notifications on Figure 2.1 have been made.
B. Send a trained staff member, with designated equipment, to the dam to monitor flood conditions in the reservoir and report back to the IEAP Coordinator.
C. Have staff members inspect the dam embankment and the dam spillway. In particular, carefully check the downstream chute retaining wall sections of the spillway, since there has been wall joint separation and misalignment in the past. **IF AN INCREASE IN SEEPAGE, EROSION, OR CRACKING IS OBSERVED, REFER TO TABLE 1.1 FOR GUIDANCE IN DETERMINING THE APPROPRIATE EVENT LEVEL.**
D. If possible, have staff members record the reservoir level in relation to the dam crest or another fixed point daily or more frequently, if required.
E. Have staff members monitor conditions downstream from the dam.
F. Record all information, observations, and actions on an Event Log Form (Form 3.1).
G. Contact the Assigned Engineer to report the latest observations and conditions. If conditions change significantly, contact the Assigned Engineer or designee immediately.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or other preventative instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions daily, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event can be terminated.
B) The event remains at the current Event Level 3.
C) The event warrants escalation to Event Level 2 or 1. (e.g. visible damage to the dam or appurtenant structures)

Based on this determination, follow the appropriate actions below.

A) TERMINATION	B) EVENT LEVEL 3	C) EVENT LEVEL 2
Go to **Termination and Follow-up** (Section 4)	Continue recommended actions on this sheet	Go to **Event Level 2 or Event Level 1 Notification Chart**

EVENT: **Earthquake**

LEVEL: 2 (emergency event, rapidly developing)

Sheet

B2

RECOMMENDED ACTIONS

Time/Date Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.2 have been made.

B. Send a trained staff member, with designated equipment to the dam, to monitor conditions and report back to the IEAP Coordinator.

C. Have staff members inspect the dam embankment and main spillway. Use the Emergency Access Site Map in Section 5. In particular, carefully check the downstream chute retaining wall sections of the spillway, since there has been wall joint separation and misalignment in the past. Check for any debris along the spillway chute walls and stilling basin, remove if applicable. **IF AN INCREASE IN SEEPAGE, EROSION, OR CRACKING IS OBSERVED, REFER TO TABLE 1.1 FOR GUIDANCE IN DETERMINING THE APPROPRIATE EVENT LEVEL.**

D. If possible, have staff members record the reservoir level in relation to the dam crest or another fixed point daily or more frequently, if required.

E. Record all information, observations, and actions on an Event Log Form (Form 3.1).

F. Contact the Assigned Engineer daily to report the latest observations and conditions. If conditions change significantly, contact the Assigned Engineer immediately.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions twice a day, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event warrants downgrade to Event Level 3. All contacts on Event Level 2 Notification Flow Chart shall be notified of downgrade from Event Level 2 to Event Level 3.

B) The event remains at the current Event Level 2.

C) The event warrants escalation to Event Level 1.

Based on this determination, follow the appropriate actions below.

A) EVENT LEVEL 3	B) EVENT LEVEL 2	C) EVENT LEVEL 1
Go to **Event Level 3 Notification Chart**	Continue recommended actions on this sheet	Go to **Event Level 1 Notification Chart**

EVENT: **Earthquake**

LEVEL: 1 (emergency event, imminent dam failure or flash flooding)

Sheet

B1

RECOMMENDED ACTIONS

Time/Date Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.3 have been made.

B. Send staff, with designated equipment, to the dam to observe and continuously monitor conditions at the dam from **HIGH GROUND**. Attempt to inspect the spillway from the upstream and downstream sides. Use the Emergency Access Site Map in Section 5. Observers should report back to the IEAP Coordinator periodically, and inform the Assigned Engineer immediately when conditions change. If possible, document with photographs, videotape, and the times of any key events.

C. Record all information, observations, and actions on an Event Log Form (Form 3.1).

D. Establish a means of communication to keep in contact with the Assigned Engineer until Event Level 1 is terminated.

Assigned Engineer:

A. Review all pertinent information in order to recommend appropriate actions to the IEAP Coordinator. If necessary, contact local emergency contractors and/or other individuals that may be able to assist in monitoring the situation.

EVALUATION / DECISION

Evaluate the situation as events progress, or whenever conditions change. Determine whether:

A) The event remains at the current Event Level 1.

B) The event can be terminated.

Based on this determination, follow the appropriate actions below.

A) EVENT LEVEL 1	**B) TERMINATED**	
Continue recommended actions on this sheet	Go to **Termination and Follow-up** (Section 4)	

EVENT: **Seepage** LEVEL: 3 (incident, slowly developing)	Sheet **C3**

RECOMMENDED ACTIONS

Time/Date Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.1 have been made.
B. Send a trained staff member, with designated equipment, to the dam to locate and quantify the new seepage areas and report back to the IEAP Coordinator.
C. Have staff members monitor the new seepage areas daily, for at least one week, and report back to the IEAP Coordinator periodically or if conditions change significantly.
D. Have staff members inspect the dam and appurtenant structures. In particular, carefully check the downstream chute retaining wall sections of the spillway since there has been wall joint separation and misalignment in the past. Pay close attention to the downstream slope of the East embankment as wet areas have been found in prior safety inspections. Check for any debris along the spillway chute walls and stilling basin, remove if applicable. **IF ADDITIONAL SEEPAGE, CRACKING, OR EROSION OCCURS, REFER TO TABLE 1.1 FOR GUIDANCE IN DETERMINING THE APPROPRIATE LEVEL FOR THE NEW CONDITION AND RECOMMENDED ACTIONS.**
E. Check to see if there is any vegetation along the spillway crest that was removed or blown over.
F. If possible, have staff members record the reservoir level in relation to the dam crest or another fixed point daily, or more frequently, if required.
G. Have staff members monitor conditions downstream from the dam.
H. Record all information, observations, and actions on an Event Log Form (Form 3.1).

Assigned Engineer:

A) Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions daily, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event can be terminated.
B) The event remains at the current Event Level 3.
C) The event warrants escalation to Event Level 2 or 1.

Based on this determination, follow the appropriate actions below.

A) TERMINATION	B) EVENT LEVEL 3	C) EVENT LEVEL 2
Go to **Termination and Follow-up** (Section 4)	Continue recommended actions on this sheet	Go to **Event Level 2 or Event Level 1 Notification Chart**

EVENT: **Seepage**

LEVEL: 2 (emergency event, rapidly developing)

Sheet

C2

RECOMMENDED ACTIONS

Time/Date
Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.2 have been made.

B. Have staff members monitor the new seepage areas daily, for at least one week, and report back to the IEAP Coordinator periodically or if conditions change significantly.

C. Have staff members inspect the dam spillway and embankments. In particular, carefully check the downstream chute retaining wall sections of the spillway, since there has been wall joint separation and misalignment in the past. Pay close attention to the downstream slope of the East embankment, as wet areas have been found in prior safety inspections. Check for any debris along the spillway chute walls and stilling basin, remove if applicable. **IF ADDITIONAL SEEPAGE, CRACKING, OR EROSION OCCURS, REFER TO TABLE 1.1 FOR GUIDANCE IN DETERMINING THE APPROPRIATE LEVEL FOR THE NEW CONDITION AND RECOMMENDED ACTIONS.**

D. Check to see if there is any vegetation along the spillway crest that was removed or blown over.

E. If possible, have staff members record the reservoir level in relation to the dam crest or another fixed point, hourly.

F. Record all information, observations, and actions on an Event Log Form (Form 3.1).

G. Contact the Assigned Engineer daily, to report the latest observations and conditions. If conditions change significantly, contact the Assigned Engineer immediately.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions twice a day, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event warrants downgrade to Event Level 3. All contacts on Event Level 2 Notification Flow Chart shall be notified of downgrade from Event Level 2 to Event Level 3.

B) The event remains at the current Event Level 2 (e.g. any observation of new seepage areas with cloudy discharge, visibly increasing in flow rate, or flow rates of 1 gpm or less).

C) The event warrants escalation to Event Level 1 (e.g. any observation of uncontrolled flow of greater than 3 gpm).

Based on this determination, follow the appropriate actions below.

A) EVENT LEVEL 3	B) EVENT LEVEL 2	C) EVENT LEVEL 1
Go to **Event Level 3 Notification Chart**	Continue recommended actions on this sheet	Go to **Event Level 1 Notification Chart**

EVENT: **Seepage**

LEVEL: 1 (emergency event, imminent dam failure or flash flooding)

Sheet

C1

RECOMMENDED ACTIONS

Time/Date Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.3 have been made.

B. Send staff, with designated equipment, to the dam to observe and continuously monitor conditions at the dam from **HIGH GROUND**. Use the Emergency Access Site Map in Section 5. Observers should report back to the IEAP Coordinator periodically. Inform the Assigned Engineer immediately when conditions change. If possible, document with photographs, videotape, and the times of any key events.

C. Record all information, observations, and actions on an Event Log Form (Form 3.1).

D. Establish a means to keep in frequent contact with the Assigned Engineer until Event Level 1 is terminated.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate the situation as events progress, or whenever conditions change. Determine whether:

A) The event remains at the current Event Level 1.

B) The event can be terminated.

Based on this determination, follow the appropriate actions below.

A) EVENT LEVEL 1	B) TERMINATED	
Continue recommended actions on this sheet	Go to **Termination and Follow-up** (Section 4)	

EVENT: **Cracking**

LEVEL: 3 (incident, slowly developing)

Sheet

D3

RECOMMENDED ACTIONS

Time/Date
Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.1 have been made.

B. Send a trained staff member, with designated equipment, to the dam to locate and quantify the cracking and report back to the IEAP Coordinator.

C. Have staff members monitor the cracking daily and report back to the IEAP Coordinator periodically, or if conditions change significantly. If possible, inspect the main spillway and embankments. In particular, carefully check the downstream chute retaining wall sections of the spillway since there has been wall joint separation and misalignment in the past. **IF ADDITIONAL SEEPAGE, CRACKING, OR EROSION OCCURS, REFER TO TABLE 1.1 FOR GUIDANCE IN DETERMINING THE APPROPRIATE LEVEL FOR THE NEW CONDITION AND RECOMMENDED ACTIONS.**

D. Record all information, observations, and actions on an Event Log Form (Form 3.1).

E. Contact the Assigned Engineer daily, to report the latest observations and conditions. If conditions change significantly, contact the Engineer immediately.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions at least daily, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event can be terminated.

B) The event remains at the current Event Level 3 (e.g. new cracks observed in the dam greater than 1/4-inch wide without seepage or new cracks observed in concrete appurtenant structures greater than 1/4-inch wide).

C) The event warrants escalation to Event Level 2 (e.g. new cracks in the dam or appurtenant structures with seepage flowing through the cracks).

Based on this determination, follow the appropriate actions below.

A) TERMINATION	**B) EVENT LEVEL 3**	**C) EVENT LEVEL 2**
Go to **Termination and Follow-up** (Section 4)	Continue recommended actions on this sheet	Go to **Event Level 2 or Event Level 1 Notification Chart**

EVENT: **Cracking**

LEVEL: 2 (emergency event, rapidly developing)

Sheet

D2

RECOMMENDED ACTIONS

Time/Date
Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.2 have been made.

B. Send a trained staff member, with designated equipment, to the dam to locate and quantify the cracking and report back to the IEAP Coordinator.

C. Have staff members monitor the cracking daily and report back to the IEAP Coordinator periodically or if conditions change significantly. Have staff members inspect the dam spillway and the embankments. In particular, carefully check the downstream chute retaining wall sections of the spillway since there has been wall joint separation and misalignment in the past. **IF ADDITIONAL SEEPAGE, CRACKING, OR EROSION OCCURS, REFER TO TABLE 1.1 FOR GUIDANCE IN DETERMINING THE APPROPRIATE LEVEL FOR THE NEW CONDITION AND RECOMMENDED ACTIONS.**

D. If possible, have staff members record the reservoir level in relation to the dam crest or another fixed point hourly.

E. Record all information, observations, and actions on an Event Log Form (Form 3.1).

F. Contact the Assigned Engineer daily to report the latest observations and conditions. If conditions change significantly, contact the Assigned Engineer immediately.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions twice a day, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event warrants downgrade to Event Level 3 (e.g. no more seepage through the cracks). All contacts on Event Level 2 Notification Flow Chart shall be notified of downgrade from Event Level 2 to Event Level 3.

B) The event remains at the current Event Level 2 (e.g. new cracks in the dam or appurtenant structures with seepage flowing through the cracks).

C) The event warrants escalation to Event Level 1 (DAM IS FAILING).

Based on this determination, follow the appropriate actions below.

A) EVENT LEVEL 3	**B) EVENT LEVEL 2**	**C) EVENT LEVEL 1**
Go to **Event Level 3 Notification Chart**	Continue recommended actions on this sheet	Go to **Event Level 1 Notification Chart**

EVENT: (**Movement**)

LEVEL: 3 (incident, slowly developing)

Sheet

E3

RECOMMENDED ACTIONS

IEAP Coordinator:

Time/Date Completed

A. Make sure notifications on Figure 2.1 have been made.

B. Mark the movement area and if necessary, survey the movement area.

C. Have staff members inspect the dam and appurtenant structures. If possible, inspect the main spillway, reservoir area, and the embankments. In particular, carefully check the downstream chute retaining wall sections of the spillway, since there has been wall joint separation and misalignment in the past. **IF ADDITIONAL SEEPAGE, CRACKING, OR EROSION OCCURS, REFER TO TABLE 1.1 FOR GUIDANCE IN DETERMINING THE APPROPRIATE LEVEL FOR THE NEW CONDITION AND RECOMMENDED ACTIONS.**

D. If possible, have staff members record the reservoir level in relation to the dam crest or another fixed point daily.

E. Have staff members monitor conditions downstream from the dam.

F. Record all information, observations, and actions on an Event Log Form (Form 3.1).

G. Contact the Assigned Engineer daily to report the latest observations and conditions. If conditions change significantly, contact the Assigned Engineer immediately.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions daily, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event can be terminated.

B) The event remains at the current Event Level 3 (e.g. movement of the dam or appurtenant structures greater than an inch).

C) The event warrants escalation to Event Level 2 (e.g. movement of the dam or appurtenant structures of 3 inches or greater).

Based on this determination, follow the appropriate actions below.

A) TERMINATION	B) EVENT LEVEL 3	C) EVENT LEVEL 2
Go to **Termination and Follow-up** (Section 4)	Continue recommended actions on this sheet	Go to **Event Level 2 or Event Level 1 Notification Chart**

EVENT: **Movement**

LEVEL: 2 (emergency event, rapidly developing)

Sheet

E2

RECOMMENDED ACTIONS

Time/Date Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.2 have been made.
B. Mark the movement area and if necessary, survey the movement area.
C. Have staff members inspect the dam spillway and embankments. Determine if the embankments have moved and note which direction. In particular, carefully check the downstream chute retaining wall sections of the spillway, since there has been wall joint separation and misalignment in the past. **IF ADDITIONAL SEEPAGE, CRACKING, OR EROSION OCCURS, REFER TO TABLE 1.1 FOR GUIDANCE IN DETERMINING THE APPROPRIATE LEVEL FOR THE NEW CONDITION AND RECOMMENDED ACTIONS.**
D. If possible, have staff members record the reservoir level in relation to the dam crest or another fixed point hourly.
E. Have staff members monitor conditions downstream from the dam.
F. Record all information, observations, and actions on an Event Log Form (Form 3.1).
G. Contact the Assigned Engineer daily to report the latest observations and conditions. If conditions change significantly, contact the Assigned Engineer immediately.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions at least twice daily, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event warrants downgrade to Event Level 3. All contacts on Event Level 2 Notification Flow Chart shall be notified of downgrade from Event Level 2 to Event Level 3.
B) The event remains at the current Event Level 2.
C) The event warrants escalation to Event Level 1 (DAM IS FAILING).

Based on this determination, follow the appropriate actions below.

A) EVENT LEVEL 3	B) EVENT LEVEL 2	C) EVENT LEVEL 1
Go to **Event Level 3 Notification Chart**	Continue recommended actions on this sheet	Go to **Event Level 1 Notification Chart**

EVENT: **Overtopping** LEVEL: 1 (emergency event, imminent dam failure or flash flooding)	Sheet **F1**

RECOMMENDED ACTIONS

Time/Date Completed

IEAP Coordinator:

A. Make sure notifications on Figure 2.3 have been made.

B. Send trained staff members, with designated equipment, to the dam to monitor conditions continuously **FROM HIGH GROUND.** Staff members should report back to the IEAP Coordinator periodically or if situation changes significantly. Use the Emergency Access Site Map in Section 5.

C. If possible, staff members should document the situation with photographs, videotape, and the times of any key events.

D. Record all information, observations, and actions on an Event Log Form (Form 3.1).

E. Establish a means to keep in frequent contact with the Assigned Engineer until Event Level 1 is terminated.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate the situation as events progress, or whenever conditions change. Determine whether:

A) The event remains at the current Event Level 1.

B) The event can be terminated.

Based on this determination, follow the appropriate actions below.

A) EVENT LEVEL 1	B) TERMINATED	
Continue recommended actions on this sheet	Go to **Termination and Follow-up** (Section 4)	

EVENT: **Sabotage**

LEVEL: 3 (incident, slowly developing)

Sheet

J3

RECOMMENDED ACTIONS

Time/Date Completed

IEAP Coordinator:

A. Contact the Police Department directly.
B. Follow Police Department's standard operating procedures for sabotage of a property.
C. Make sure notifications on Figure 2.1 have been made.
D. If possible, develop a plan to mitigate additional damage to the dam or appurtenant structures with the assistance of the Assigned Engineer.
E. Record all information, observations, and actions on an Event Log Form (Form 3.1).
F. Contact the Assigned Engineer hourly to report the latest situations and conditions. If conditions change significantly, contact the Assigned Engineer.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions daily, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event can be terminated.
B) The event remains at the current Event Level 3.
C) The event warrants escalation to Event Level 2.

Based on this determination, follow the appropriate actions below.

A) TERMINATION	**B) EVENT LEVEL 3**	**C) EVENT LEVEL 2**
Go to **Termination and Follow-up** (Section 4)	Continue recommended actions on this sheet	Go to **Event Level 2 or Event Level 1 Notification Chart**

EVENT: **Sabotage**

LEVEL: 2 (emergency event, rapidly developing)

Sheet

J2

RECOMMENDED ACTIONS

Time/Date
Completed

IEAP Coordinator:

A. Contact the Police Department directly.
B. Make sure notifications on Figure 2.2 have been made.
C. Follow the instructions from the Police Department or the Emergency Agency Official.
D. Record all information, observations, and actions on an Event Log Form (Form 3.1).
E. Contact the Assigned Engineer daily to report the latest observations and conditions. If conditions change significantly, contact the Assigned Engineer immediately.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate conditions twice a day, or whenever conditions change significantly. Using Table 1.1 and Table 3.1, determine whether:

A) The event warrants downgrade to Event Level 3. All contacts on Event Level 2 Notification Flow Chart shall be notified of downgrade from Event Level 2 to Event Level 3.
B) The event remains at the current Event Level 2.
C) The event warrants escalation to Event Level 1.

Based on this determination, follow the appropriate actions below.

A) EVENT LEVEL 3	B) EVENT LEVEL 2	C) EVENT LEVEL 1
Go to **Event Level 3 Notification Chart**	Continue recommended actions on this sheet	Go to **Event Level 1 Notification Chart**

EVENT: **Sabotage**

LEVEL: 1 (emergency event, imminent dam failure or flash flooding)

Sheet

J1

RECOMMENDED ACTIONS

Time/Date Completed

IEAP Coordinator:

A. Notify the Police Department directly.
B. Make sure notifications on Figure 2.3 have been made.
C. Send trained staff members, with designated equipment, to the dam to monitor conditions continuously **FROM HIGH GROUND** and report back to the IEAP Coordinator periodically or if situation changes significantly. Use the Emergency Access Site Map in Section 5.
D. If possible, staff members should document the situation with photographs, videotape, and the times of any key events.
E. Record all information, observations, and actions on an Event Log Form (Form 3.1).
F. Establish a means to keep in frequent contact with the Assigned Engineer until Event Level 1 is terminated.

Assigned Engineer:

A. Review pertinent information from the IEAP Coordinator and recommend additional monitoring or preventive instructions as appropriate.

EVALUATION / DECISION

Evaluate the situation as events progress, or whenever conditions change. Determine whether:

A) The event remains at the current Event Level 1.
B) The event can be terminated.

Based on this determination, follow the appropriate actions below.

A) EVENT LEVEL 1	**B) TERMINATED**	
Continue recommended actions on this sheet	Go to **Termination and Follow-up** (Section 4)	

3.2 Locally Available Equipment, Labor, and Materials

Locally available resources include:

Sand and Gravel Supply:

Whitcomb Trucking, Inc.
4105 Montdale Park Drive
Valparaiso, IN 46383
Phone: (219) 465-3066

Pumping Supplier:

Xylem
7615 New York Street
Indianapolis, IN 46214
Phone: (317) 273-4470
Cell: (317) 677-3962 (Lucas Gibson)
Cell: (317) 677-4852 (David Gut)

Diving Contractors:

Collins Engineers, Inc.
123 North Wacker Drive
Chicago, IL 60606
Phone: (312) 704-9300
24-Hour Emergency: (877) 346-3234

Heavy Equipment Service and Rental:

Hertz Equipment Rental
6611 Shepherd Avenue
Portage, IN 46368
Phone: (219) 787-8448

Miscellaneous Resources:

INDOT-LaPorte District
315 East Boyd Boulevard
LaPorte, IN 46350
24-Hour Dispatch: (855) 464-6368

Helicopter Service:

Goshen Helicopter, Inc.
17836 County Road 24
Goshen, IN 46528
Cell: (574) 320-5975

Sun Aero Helicopters, Inc.
19500 Burnham Avenue
Lynwood, IL 60411
Phone: (708) 895-8958

Construction Contractor:

G.E. Marshall
1351 Joliet
Valparaiso, IN 46385
Phone: (219) 462-3415

Martin and Sons
508 East Indiana
Kouts, IN 46347
Phone: (219) 766-2274

H.G. Underground
1355 East State Road 2
LaPorte, IN 46350
Phone: (219) 362-7242

3.3 Incident or Emergency Event Log

Use the Incident or Emergency Event Log (Form 3.1) on next page to record actions and events during an Incident or Emergency Event and the time that the action or event occurred. A copy of this form is also provided in the inside pocket of the front cover of binder for use during an active event.

FORM 3.1 – INCIDENT OR EMERGENCY EVENT LOG

FORM 3.1
INCIDENT OR EMERGENCY EVENT LOG

YOU ARE (CIRCLE ONE): IEAP Coordinator / IDNR-DOW Director / On-Call Engineer / Sheriff / EMA / Other ________________

DETECTION

When did you detect/get notified of the event?
How did you detect/get notified of the event?

LEVEL DETERMINATION

What initial level has the IEAP Coordinator assigned to the event?

ACTIONS AND EVENT PROGRESSION

Date	Time	Action/Event Progression	Taken By

ACTIONS AND EVENT PROGRESSION (continued)

Date	Time	Action/Event Progression	Taken By

SECTION 4 –TERMINATION AND FOLLOW-UP

SECTION 4
TERMINATION AND FOLLOW-UP

Once IEAP operations have begun under Event Level 3, 2, or 1, the IEAP operations must eventually be terminated and follow-up procedures completed. As shown on Figure i, for dam scenarios with all three event levels, IEAP operations can only be terminated after completing operations under Event Level 3 or 1. If Event Level 2 is declared, the operations must be designated Event Level 3 or 1 before terminating the IEAP operations.

4.1 Termination Responsibilities

The IEAP Coordinator is responsible for terminating the IEAP operations and relaying the decision to all parties involved. It is then the responsibility of each person to notify the same contacts that he or she notified during the original event notification process to inform those people that the event has been terminated (see Figure 2.1 through 2.3).

4.2 Follow-up

Event Level 3 – After the IEAP Coordinator has terminated IEAP operations under Event Level 3, the IEAP Coordinator will schedule a meeting with the Assigned Engineer, Property Owners Association, Porter County Emergency Management Agency (EMA), IDNR staff, and others involved. The call should be scheduled and completed as soon as possible after the Event Level 3 was terminated. The objective of the conference call is to review the IEAP and identify effective IEAP procedures that were followed and to identify other potential areas where the IEAP could be improved. The IEAP Coordinator will maintain the final revised IEAP document and make any necessary changes.

Event Level 2 or 1 – After the IEAP Coordinator has terminated the IEAP operations under Event 2 or 1, they will complete a Serious Accident or Incident Form within four (4) weeks of the date that the IEAP operations were terminated. This will be in addition to activities for Event Level 3.

Event That Has Caused Loss of Life, Injury or Property Damage – The IEAP Coordinator or designee will organize an immediate assessment of loss after an event that has caused loss of life, injury, or property damage. After completion of the IEAP Coordinator’s debriefing report (described below), the IEAP Coordinator will consider revisions to the IEAP document, if appropriate.

After the IEAP Coordinator has terminated IEAP operations under Event Level 2 or 1, the IEAP Coordinator shall schedule and hold a follow-up meeting within four (4) weeks of the date that the IEAP operations were terminated. The meeting shall be chaired by the IEAP Coordinator. As a minimum, the Assigned Engineer, Property Owners Association, Porter County EMA, IDNR, and representatives from various emergency response agencies shall attend the meeting.

The objectives of the follow-up meeting are to: 1) review the IEAP operations and the IEAP document; 2) identify effective IEAP procedures that were followed; 3) identify potential areas where the IEAP or other emergency operations could be improved; 4) review the loss assessment, if applicable. The IEAP Coordinator will follow-up with a debriefing report that describes the event, the IEAP Operations, and termination activities. The debriefing report shall include a list of suggested improvements and revisions to the IEAP and other emergency operations. The debriefing report shall be completed within four (4) weeks of the follow-up meeting and inserted into Appendix C, Past IEAP Activity. IEAP changes, if warranted, shall be completed within eight (8) weeks of the follow-up meeting.

SECTION 5 – MAPS, FIGURES AND SUPPORTING DATA

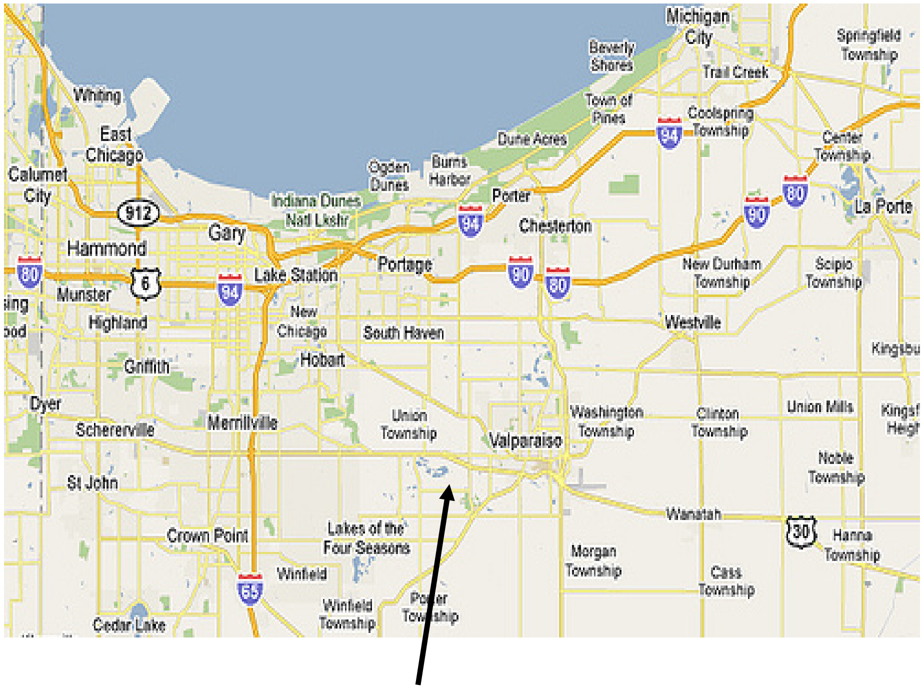
SECTION 5
MAPS, FIGURES AND SUPPORTING DATA

FIGURE 5.1 – LOCATION MAP AND VICINITY MAP

PORTER COUNTY

SOURCE: INDIANA MAP
GIS DATA

STATE MAP



LAKE LOUISE DAM

LFA

LAKE LOUISE DAM
INCIDENT AND EMERGENCY ACTION PLAN

LOCATION AND VICINITY MAP

JULY, 2016

FIGURE 5.1

FIGURE 5.2 – EMERGENCY SITE ACCESS ROUTE MAP

From Valparaiso: Head west on Lincoln Highway (Inst. 30) and turn left (south) on County Road 375. Stay on County Road 375 for close to 0.4 Miles and turn right on Deer Ridge Road (west). Stay on Deer Ridge Road for close to 0.18 miles. There is an empty lot to the right and the dam should be visible to the west.

LFA

LAKE LOUISE DAM
INCIDENT AND EMERGENCY ACTION PLAN

EMERGENCY SITE ACCESS ROUTE MAP

JULY, 2016

FIGURE 5.2

FIGURE 5.3 – ESTIMATED DAM FAILURE FLOOD INUNDATION MAPS

The Federal Emergency Management Agency's Flood Hazard (Zone AE and A) areas are not available for the Lake Louise Dam Breach area and therefore are not shown on these estimated dam failure flood inundation figures.

*Buildings within or near inundation area based on 2013 Aerial Photography.

NOTE: Not all vulnerable buildings may be shown. Buildings within additional evacuation areas due to access limitations are not labeled.

LEGEND

- 〰 Salt Creek Tributary and Salt Creek
- ▪▪▪ Additional Warning
- ▢ Approximate Town/City Limits
- ▢ Indiana Counties
- ▨ Lake Louise
- 🟥 Approximate Dam Failure Inundation Area (Lake Louise Dam)
- 🟩 Lake Louise Dam

NOTE TO USER:

The dam failure flood inundation area shown on this map represents the hazard area due to a potential failure of the Lake Louise Dam only and does not reflect flooding that may be possible due to multiple dam failures. Preparation of this map is not intended to reflect on the safety or integrity of the dam. Buildings and clusters of buildings as well as additional warning and evacuation areas due to access limitations were determined based on 2013 aerial photography. Not all vulnerable buildings may be shown.

Because of the method, procedures, and assumptions used to develop the dam failure flood inundation area, the limits of flooding shown should be considered approximate and should be used only as a guideline for establishing warning and evacuation zones. The inundation limits are very approximate and should be updated through a more detailed study. Additional flooding may be possible outside of the limits shown. Actual inundation areas will depend on actual failure conditions and may differ from areas shown on the map. Due to this uncertainty, the entire population in the floodplain valley below the Lake Louise Dam (including areas that may have limited or no access) must be evacuated in the event of an emergency, regardless of whether such areas are shown within the inundation limits or not.

Aerial Photography: IndianaMap Framework Data
(indianamap.org)
Porter County - 2013
Marshall County - 2013

LFA
LAWSON-FISHER ASSOCIATES P.C.
525 W WASHINGTON AVENUE
SOUTH BEND, INDIANA 46601
PH. (574) 234-3167

PROJECT:	LAKE LOUISE DAM INCIDENT AND EMERGENCY ACTION PLAN	PROJECT NO. 201443.00	SCALE 1'=2000'
TITLE:	ESTIMATED DAM FAILURE FLOOD INUNDATION MAP LAKE LOUISE DAM (64-8)		DATE: 10/2014 FIGURE A SHEET 1 OF 3

The Federal Emergency Management Agency's Flood Hazard (Zone AE and A) areas are not available for the Lake Louise Dam Breach area and therefore are not shown on these estimated dam failure flood inundation figures.

*Buildings within or near inundation area based on 2013 Aerial Photography.

NOTE: Not all vulnerable buildings may be shown. Buildings within additional evacuation areas due to access limitations are not labeled.

LEGEND

- ⌂ Apparent Buildings
- → Breach Wave Flow Direction
- → Backwater Flow
- ～ Salt Creek Tributary and Salt Creek
- ▪▪▪ Additional Warning
- ▪▪▪ Matchline
- ▭ Approximate Town/City Limits
- ▭ Indiana Counties
- 🟦 Lake Louise
- 🟥 Approximate Dam Failure Inundation Area (Lake Louise Dam)
- 🟩 Lake Louise Dam

LAKE LOUISE (SHOWN AT MAXIMUM POOL ELEV. PLUS 1-FOOT OF OVERTOPPING 726.0 FT. NGVD88)

ADDITIONAL AREA TO BE WARNED/EVACUATED DUE TO LIMITED OR NO ACCESS DURING A POTENTIAL DAM BREACH EVENT (TYPICAL)

NOTE: NUMEROUS BUILDINGS IN AND NEAR DAM FAILURE INUNDATION AREA ARE WITHIN THE DAM FAILURE FLOOD INUNDATION AREA OR HAVE ACCESS LIMITATIONS BUT ARE NOT LABELED

NOTE TO USER:

The dam failure flood inundation area shown on this map represents the hazard area due to a potential failure of the Lake Louise Dam only and does not reflect flooding that may be possible due to multiple dam failures. Preparation of this map is not intended to reflect on the safety or integrity of the dam. Buildings and clusters of buildings as well as additional warning and evacuation areas due to access limitations were determined based on 2013 aerial photography. Not all vulnerable buildings may be shown.

Because of the method, procedures, and assumptions used to develop the dam failure flood inundation area, the limits of flooding shown should be considered approximate and should be used only as a guideline for establishing warning and evacuation zones. The inundation limits are very approximate and should be updated through a more detailed study. Additional flooding may be possible outside of the limits shown. Actual inundation areas will depend on actual failure conditions and may differ from areas shown on the map. Due to this uncertainty, the entire population in the floodplain valley below the Lake Louise Dam (including areas that may have limited or no access) must be evacuated in the event of an emergency, regardless of whether such areas are shown within the inundation limits or not.

Aerial Photography: IndianaMap Framework Data (indianamap.org)
Porter County - 2013
Marshall County - 2013

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525 W WASHINGTON AVENUE
SOUTH BEND, INDIANA 46601
PH. (574) 234-3167

PROJECT: LAKE LOUISE DAM INCIDENT AND EMERGENCY ACTION PLAN

PROJECT NO. 201443.00

SCALE 1"=1000'

DATE: 10/2014

TITLE: ESTIMATED DAM FAILURE FLOOD INUNDATION MAP LAKE LOUISE DAM (64-8)

FIGURE B
SHEET 2 OF 3

NOTE TO USER:

The dam failure flood inundation area shown on this map represents the hazard area due to a potential failure of the Lake Louise Dam only and does not reflect flooding that may be possible due to multiple dam failures. Preparation of this map is not intended to reflect on the safety or integrity of the dam. Buildings and clusters of buildings as well as additional warning and evacuation areas due to access limitations were determined based on 2013 aerial photography. Not all vulnerable buildings may be shown.

Because of the method, procedures, and assumptions used to develop the dam failure flood inundation area, the limits of flooding shown should be considered approximate and should be used only as a guideline for establishing warning and evacuation zones. The inundation limits are very approximate and should be updated through a more detailed study. Additional flooding may be possible outside of the limits shown. Actual inundation areas will depend on actual failure conditions and may differ from areas shown on the map. Due to this uncertainty, the entire population in the floodplain valley below the Lake Louise Dam (including areas that may have limited or no access) must be evacuated in the event of an emergency, regardless of whether such areas are shown within the inundation limits or not.

NOTE: NUMEROUS BUILDINGS IN AND NEAR DAM FAILURE INUNDATION AREA HAVE ACCESS LIMITATIONS BUT ARE NOT LABELED

LIMITS OF FLOODING NOT DETERMINED BEYOND THIS POINT. ADDITIONAL FLOODING IS POSSIBLE

NOTE: NUMEROUS BUILDINGS IN AND NEAR DAM FAILURE INUNDATION AREA HAVE ACCESS LIMITATIONS BUT ARE NOT LABELED

NOTE: NUMEROUS BUILDINGS IN AND NEAR DAM FAILURE INUNDATION AREA HAVE ACCESS LIMITATIONS BUT ARE NOT LABELED

ADDITIONAL AREA TO BE WARNED/EVACUATED DUE TO LIMITED OR NO ACCESS DURING A POTENTIAL DAM BREACH EVENT (TYPICAL)

The Federal Emergency Management Agency's Flood Hazard (Zone AE and A) areas are not available for the Lake Louise Dam Breach area and therefore are not shown on these estimated dam failure flood inundation figures.

*Buildings within or near inundation area based on 2013 Aerial Photography.

NOTE: Not all vulnerable buildings may be shown. Buildings within additional evacuation areas due to access limitations are not labeled.

LEGEND

⌂	Apparent Buildings
➝	Breach Wave Flow Direction
➝	Backwater Flow
∿	Salt Creek Tributary and Salt Creek
┅	Additional Warning
┅	Matchline
▭	Approximate Town/City Limits
▭	Indiana Counties
▨	Lake Louise
▨	Approximate Dam Failure Inundation Area (Lake Louise Dam)
🟩	Lake Louise Dam

NOTE: NUMEROUS BUILDINGS IN AND NEAR DAM FAILURE INUNDATION AREA HAVE ACCESS LIMITATIONS BUT ARE NOT LABELED

LIMITS OF FLOODING NOT DETERMINED BEYOND THIS POINT. ADDITIONAL FLOODING IS POSSIBLE

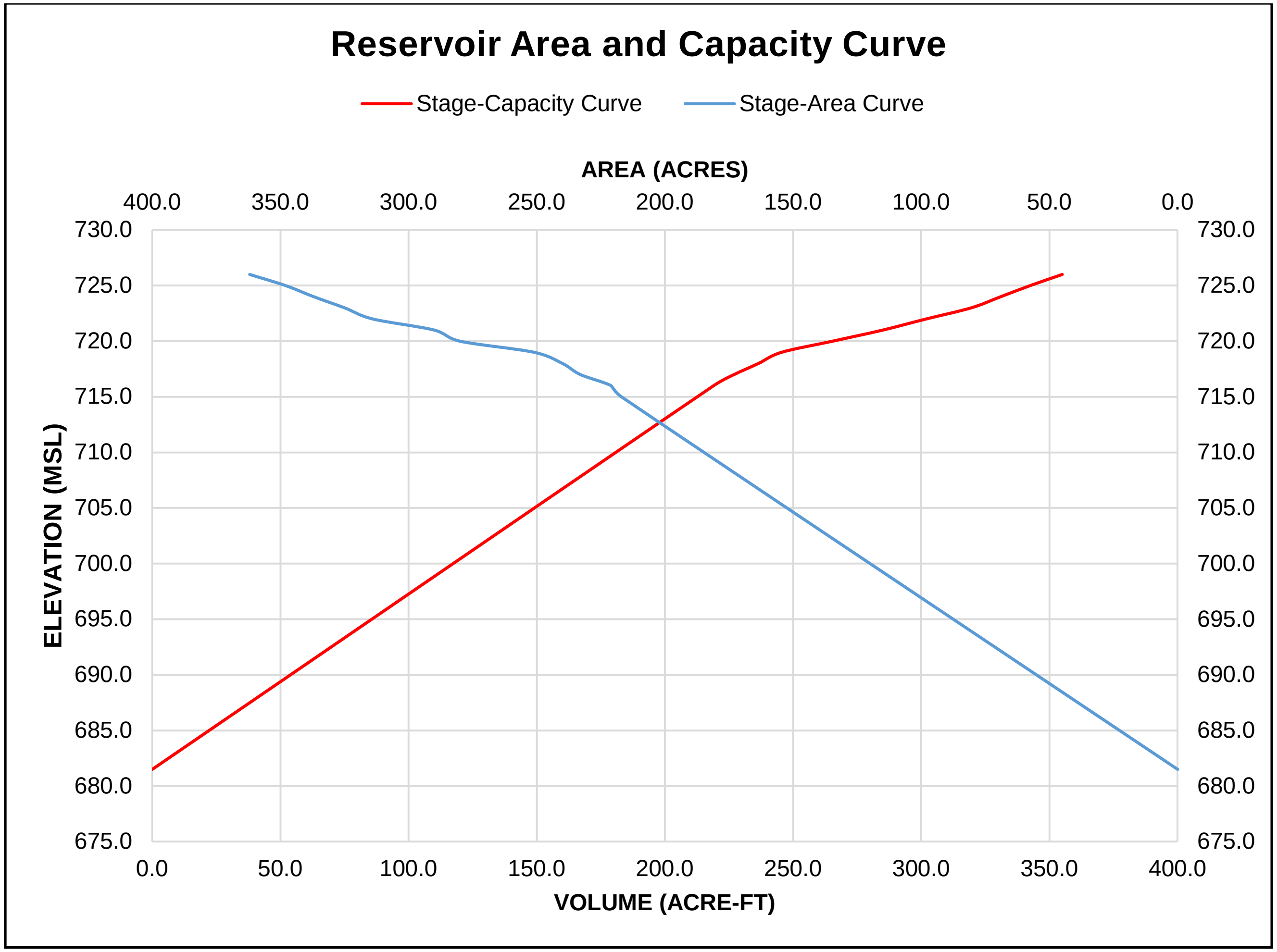
ADDITIONAL AREA TO BE WARNED/EVACUATED DUE TO LIMITED OR NO ACCESS DURING A POTENTIAL DAM BREACH EVENT (TYPICAL)

Aerial Photography: IndianaMap Framework Data
(indianamap.org)
Porter County - 2013
Marshall County - 2013

LFA
LAWSON-FISHER ASSOCIATES P.C.
525 W WASHINGTON AVENUE
SOUTH BEND, INDIANA 46601
PH. (574) 234-3167

PROJECT:	**LAKE LOUISE DAM INCIDENT AND EMERGENCY ACTION PLAN**	**PROJECT NO.** **201443.00**	**SCALE** **1'=1000'**
			DATE: 10/2014
TITLE:	**ESTIMATED DAM FAILURE FLOOD INUNDATION MAP LAKE LOUISE DAM (64-8)**		**FIGURE C SHEET 3 OF 3**

FIGURE 5.4 – RESERVOIR AREA CAPACITY CURVE



LFA

LAKE LOUISE DAM
INCIDENT AND EMERGENCY ACTION PLAN

RESERVOIR AREA AND CAPACITY CURVE

JULY, 2016

FIGURE 5.4

FIGURE 5.5 – SPILLWAY RATING CURVE

Figure 5.5 – Spillway Rating Curve not available.

FIGURE 5.6 – ANNOTATED SITE PICTURES

LAKE LOUISE DAM SITE PICTURES

Photograph 1: Looking east at the entrance of the Principal Spillway Chute

Photograph 2: Looking northeast along the Principal Spillway Chute

LFA	LAKE LOUISE DAM INCIDENT AND EMERGENCY ACTION PLAN	SITE PICTURES
		JULY, 2016
		FIGURE 5.6

LAKE LOUISE DAM SITE PICTURES

Photograph 3: Looking downstream of the Principal Spillway

Photograph 4: Looking along the crest of the West Embankment

LFA	**LAKE LOUISE DAM** **INCIDENT AND EMERGENCY ACTION PLAN**	**SITE PICTURES**
		JULY, 2016 | **FIGURE 5.6**

FIGURE 5.7 – SCHEMATIC PLAN OF THE DAM

LFA

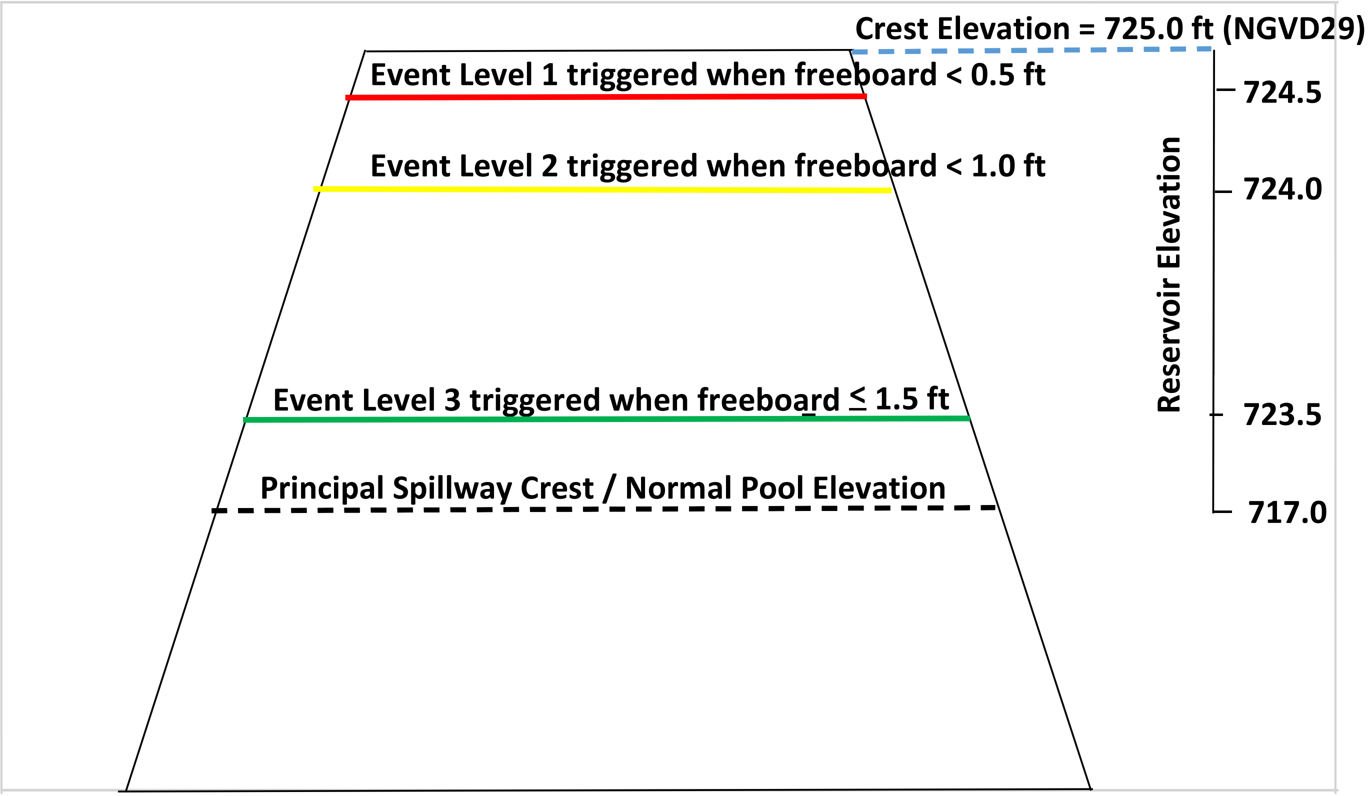
LAKE LOUISE DAM
INCIDENT AND EMERGENCY ACTION PLAN

SCHEMATIC PLAN OF THE DAM

JULY, 2016

FIGURE 5.7

FIGURE 5.8 – FLOOD EVENT LEVEL ILLUSTRATION DIAGRAM



LFA

LAKE LOUISE DAM
INCIDENT AND EMERGENCY ACTION PLAN

FLOOD EVENT LEVEL DETERMINATION ILLUSTRATION

JULY, 2016

FIGURE 5.8

APPENDIX A – WARNING AND EVACUATION

APPENDIX A
WARNING AND EVACUATION

This appendix is available for inserting local warning and evacuation plans developed by IDNR or others.

APPENDIX B – INUNDATION MAP DOCUMENTATION

APPENDIX B
INUNDATION MAP DOCUMENTATION

INUNDATION AREA

The estimated flood dam failure flood inundation map provided in Figure 5.3 shows the approximate hazard area that could be affected from the failure of the Lake Louise Dam. The dam breach inundation mapping area extents along Salt Creek Tributary to Salt Creek. State Road 30 will also be inundated along with the area southeast of the dam along the creek.

The approximate flood area from the dam breach was determined using a simplified methodology developed by the Indiana Department of Natural Resources (IDNR) and Christopher B. Burke Engineering (CBBEL). The technique was utilized to estimate peak discharge values during a dam breach. The simplified technique utilizes the Froehlich Equation to compute the maximum breach discharge at a particular site. Discharge values typically decrease from the peak value as the breach flood wave travels downstream away from the dam. Flood wave attenuation was estimated using the method in the Dam Break Inundation Analysis published by Washington State Department of Ecology (2007). The technique was developed from evaluating multiple channel slopes and cross section configurations using an unsteady flow U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) model for various volumes of water controlled by a dam to develop downstream flood wave attenuation curves. The water surface elevation at the downstream end the streamline was checked with the 100-year profile elevations from the 1981 Flood Insurance Studies for the City of Portage, Indiana. The water surface elevation at the downstream were much higher than the Federal Emergency Management Agency's 100-year elevation. Therefore, the streamline was extended north to the Indiana Toll Road 80 to allow for attenuation.

The approximate dam failure flood inundation mapping was performed only to determine the general limits of a potential failure of the Lake Louise Dam for notification purposes. The terrain in the vicinity downstream of the dam is such that flood waters could potentially flow into areas beyond what is mapped. This type of scenario is beyond the limits of the one-dimensional steady-flow model used in this approach. Actual flooding conditions will also depend on actual failure conditions during the flood emergency and may differ from the areas shown on the map.

EMERGENCY EVACUATION PLANNING ZONES

Emergency evacuation planning zones are specific segments or portions of dam-failure flood inundation areas downstream from the Lake Louise Dam that:

1. Define the potential area of impact resulting from each type and/or severity of event.
2. Allow response personnel to prioritize evacuation activities for the populations at risk in terms of distance downstream from the dam and flood wave travel times.

Local response organizations should define appropriate emergency evacuation planning zones and appropriate evacuation centers in emergency operations appendices specific to the Lake Louise Dam.

APPENDIX C – PAST IEAP ACTIVITY

APPENDIX C
PAST IEAP ACTIVITY

This Appendix is the placeholder for copies of past IEAP activity reports, Annual Review Verification Statements that must be completed after the annual review is performed, and Periodic Test Memos to be included after periodic tests have been performed.

APPENDIX D – IEAP REVIEW AND REVISION

APPENDIX D
IEAP REVIEW AND REVISION

IEAP Annual Review

The IEAP Coordinator will review the Incident and Emergency Action Plan (IEAP) annually. The IEAP Annual Review will include:

- The IEAP Coordinator will call all of the contacts on the notification charts in the IEAP to verify the phone numbers and persons are current and accurate.
- The IEAP Coordinator will call the locally available resources to verify the phone numbers, addresses and services are current.
- The IEAP Coordinator will verify the persons contacted that he or she understands his or her responsibilities as described.
- Considering the IEAP Annual Review, events of the past year regarding the dam, and the IEAP Periodic Test Summary Memorandum, when applicable, the IEAP Coordinator will revise the IEAP document, if appropriate.
- The IEAP Coordinator will complete an IEAP Annual Review Verification Statement. An IEAP Annual Review Verification Statement master copy is included in this appendix.

IEAP Periodic Test

The IEAP Coordinator will perform a Periodic Test of the IEAP every five (5) years.

The test will consist of a meeting that includes a table-top exercise conducted at the Lake Louise Dam and organized by the IEAP Coordinator. Attendance should include the Shorewood Forest Property Owners Association, Assigned Engineer, IDNR staff members, a representative from Porter County EMA, and Valparaiso Police Department. Other organizations are encouraged to participate, at the discretion of the IEAP Coordinator.

The table-top exercise will include a scenario of an incident, or emergency event at the dam. The scenario will be developed by the Assigned Engineer prior to the exercise. The participants will discuss their responses and actions to address the particular scenario. The facilitator will control discussion and help develop reasonable responses throughout the scenario. The table-top exercise will be recorded in an Event Log just like a real event.

After the table-top exercise, the five (5) sections of the IEAP will be reviewed and discussed. Other emergency procedures or operating procedures can be discussed further. After the review, the IEAP Coordinator can improve the IEAP, if warranted.

Revision

The IEAP Coordinator holds the master IEAP and is responsible for all revisions.

When revisions occur the IEAP Coordinator will ensure that the revised pages and a revised Revisions page are provided to all the document holders. The document holders are responsible for revising their outdated copy of the respective document(s) whenever revisions are received.

Each page (including the outdated Revisions page) shall be removed and replaced with the revised pages. Outdated pages shall be immediately discarded to avoid any confusion with the revisions. The individual who removes outdated pages and replaces them with the revised pages shall sign and date the accompanying revised Revision page. It is important that the documents are revised immediately upon receipt of revisions. Check the outdated Revisions page to ensure that all of the revisions to date have been inserted in this document.

FORM D.1
IEAP ANNUAL REVIEW VERIFICA. TION STATEMENT

Name of Dam: Lake Louise

Date of Drill: _____________

A. The current IEAP is on hand and all revisions have been inserted.
B. The emergency procedures observed during the drill were in accordance with the IEAP.
C. The readiness evaluated in the drill was acceptable.
D. The communications network is correct and was verified.
E. The training of personnel is sufficient and acceptable.
F. The IEAP Annual Review procedures were followed.

Additional Comments: ____

____

_______________________________ _______________________________
(individual responsible for conducting IEAP Annual Review) Date

____
(printed name)

_______________________________ _______________________________
(IEAP Coordinator) Date

____
(printed name)

APPENDIX E – IEAP DISTRIBUTION

APPENDIX E
IEAP DISTRIBUTION

	IEAP Copy No.
Shorewood Forest Property Owners Association 410 Shorewood Ct. Valparaiso, IN 46385 Phone: (219) 465-0883	1
Porter County Emergency Management Agency 117 N. 2nd St. Goshen, IN 46526 Phone: (219) 462-8654	2
Porter County Sheriff's Department 26861 County Road 26 Elkhart, IN 46517 Phone: (219) 477-3000	3
City of Valparaiso Police Department 355 Washington St. Valparaiso, IN 46383 Phone: (219) 462-2135	4
City of Valparaiso Fire Department 205 Indiana Ave Valparaiso, IN 46383 Phone: (219) 462-8325	5
Indiana Department of Natural Resources (IDNR) – Dam and Levee Safety 402 W. Washington St. Room W264 Indianapolis, IN 46204 Phone: (317) 232-4160	6
Indiana Department of Homeland Security and Emergency Operations Center 302 W. Washington St. Room W046 Indianapolis, IN 46204 Phone: (317) 232-8380	7
Indiana State Police 1550 181st Ave. Lowell, IN 46356 Phone: (219) 696-6242	8
National Weather Service 6900 W. Hanna Ave. Indianapolis, IN 46241 Phone: (317)856-0367	9
Assigned Engineer	10

APPENDIX F – SUPPLEMENTARY INFORMATION

APPENDIX F
SUPPLEMENTARY INFORMATION

This appendix contains background information and pertinent data, and is also the place holder for any other key supplementary information such as emergency materials, service contracts, and any other relevant material for the Lake Louise Dam and other similar information that may be placed in this appendix by individual plan holders for quick reference during an event.

PERTINENT DATA[1]

A. GENERAL	
Name of Dam	Lake Louise Dam
Name of Reservoir	Lake Louise
Owner	Shorewood Forest Property Owners Association
County	Porter
River or Stream	Un-named Tributary Salt Creek
Watershed Basin	Grand & Little Calumet
National Inventory of Dams Number	IN00247
Hazard Potential Classification	High
Required Spillway Capacity (% PMF Design Flood)	100%
Year Constructed	1974
Legal Description (of Dam)	Lake Louise Dam
Latitude	41° 27.3' N
Longitude	87° 8.6' W
B. DAM	
Type	Earthen
Crest Elevation (ft., NGVD 1929)	725
Crest Width (feet)	12
Crest Length (feet)	420
Embankment Height (feet)	45
Upstream Slope	3:1 (H:V)
Downstream Slope	3:1 (H:V)
C. SPILLWAY SYSTEM	
1. Principal Spillway	
Type	Concrete crest
Control Sill Elevation (ft., NGVD 29)	717
Dimensions	40'' wide x 50'' long
Freeboard above Control Sill Elevation (feet)	8.0
Discharge during Design Storm (cfs)	2,600
Terminal Structure	NA

Note: Data obtained from 1980 Phase I Inspection Report by CMT, and 2014 Dam Safety Inspection Report by Nagai Professional Engineering Services.

PERTINENT DATA (CONT'D)

2. Emergency Spillway	
Type	NA
Control Sill Elevation (ft, NAVD 1988)	NA
Length of Control Section (feet)	NA
Freeboard above Control Sill Elevation (feet)	NA
Discharge during Design Storm (cfs)	NA
Terminal Structure	NA
3. Combined Spillway	
Total Spillway Discharge Capacity (cfs)	2,600
Freeboard at Peak of Design Flood (feet)	1.5
D. OUTLET WORKS (Drawdown Facility)	
Type	Drawdown
Dimensions	36" x 42"
Control Structure (valve, gate, stoplogs, etc.)	Sluice Gate
Inlet / Outlet Inverts (ft, NGVD 29)	707' (Inlet)
Discharge Capacity at Normal Pool (cfs)	NA
E. RESERVOIR	
Normal Pool Elevation (Feet)	717.0
Reservoir Area at Normal Pool (Acres)	230
Estimated Storage at Normal Pool (Acre-feet)	1980
Reservoir Area at Top of Dam (Acres)	350
Estimated Storage at Top of Dam (Acre-feet)	4700
F. DRAINAGE BASIN	
Drainage Area (square miles)	2.56
Description	Crops, deciduous forest, open space, grasslands, and developed residential areas.

NOTES: 1- Data obtained from 1980 Phase I Inspection Report by CMT, and 2014 Dam Safety Inspection Report by Nagai Professional Engineering Services.

APPENDIX G - GLOSSARY

APPENDIX G
GLOSSARY

Abutment. The undisturbed natural material of the valley side against which the dam is constructed. The left and right abutments are defined as being on the right and left side of an observer looking downstream.

Acre-Foot. A term used in measuring the volume of water that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet.

Appurtenant structure. A structure necessary for the operation of a dam such as outlets, trash racks, valves, spillways, power plants, tunnels, etc.

Breach. An eroded opening through a dam that drains the reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional opening that allows uncontrolled discharge from the reservoir.

Channel. A general term for any natural or artificial watercourse.

Conduit. A closed channel to convey water through, around, or under a dam.

Culvert. A closed channel to convey water.

Crest of Dam. Top of dam.

Cross section. A sectional view of a dam formed by passing a plane through the dam perpendicular to the axis.

Dam. A barrier constructed across a watercourse for the purpose of impounding or diverting water.

a. Embankment dam. Any dam constructed of excavated natural materials or of industrial waste materials.
b. Concrete dam. Any dam constructed of concrete materials.

Dam failure. The uncontrolled release of reservoir contents.

Drain, toe. A system of pipe and/or pervious material along the downstream toe of a dam used to collect seepage from the foundation and embankment and convey it to a free outlet.

Drainage area. The area that drains to a particular point on a river or stream.

Drawdown. The difference between a water level and a lower water level in a reservoir within a particular time. Used as a verb, it is the lowering of the water surface due to release of water from the reservoir.

IEAP Operations. All actions taken by the dam owner and other involved agencies to address an incident or emergency event.

Earthquake. A sudden motion or trembling in the earth caused by the abrupt release of accumulated stress along a fault.

Incident and Emergency Action Plan (IEAP). A comprehensive, single-source document providing accurate and current instructions intended to help dam owners/operators save lives, minimize property damage, and minimize environmental impacts caused by large releases from a dam, dam failure, or other events that present hazardous conditions.

Emergency Event. An event which takes place or a condition which develops that is of a serious nature that may endanger the dam, or endanger persons or property, and demands immediate attention.

Filter (filter zone). A band of granular material graded (either naturally or by selection) so as to allow seepage through or within the layers while preventing the migration of material from adjacent zones.

Flood. A temporary rise in water levels resulting in inundation of areas not normally covered by water; may be expressed in terms of probability of exceedance per year such as one percent chance flood or expressed as a fraction of the probable maximum flood of other reference flood. Some related terms are:

a. Flood, Inflow Design (IDF). That flood used in the design of a safe dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

b. Flood, Probable Maximum (PMF). The largest flood reasonably expected at a point on a stream because of a probable maximum storm and favorable runoff conditions.

Freeboard. Vertical distance between a stated water level and the top of dam.

Gate. A movable, watertight barrier for the control of water.

a. Outlet gate. A gate controlling the flow of water through a reservoir outlet.

b. Slide gate (sluice gate). A gate that can be opened or closed by sliding in supporting guides.

Height, hydraulic. The vertical distance between the maximum design water level and the lowest point in the original streambed.

Height, structural. The vertical distance between the lowest point on the dam crest and the lowest point of the excavated foundation.

Hydrograph, breach or dam failure. A flood hydrograph resulting from a dam breach.

Hydrograph, flood. A graphical representation of the flood discharge with respect to time for a particular point on a stream or river.

Hydrograph, unit. A hydrograph with a volume of one inch of runoff resulting from a storm of a specified duration and aerial distribution. Hydrographs from other storms of the same duration and distribution are assumed to have the same time base but with ordinates of flow in proportion to the runoff volumes.

Incident. An unusual event which takes place, or a condition which is slowly developing, that is not normally encountered in the routine operation of the dam and reservoir, or necessitates a variation from the operating procedures. Such events are more common that emergency conditions and often offer time to conduct preplanned responses to the slowly developing situation. If addressed in a timely manner, such events can often be prevented from progressing into a much worse event.

Incident Command System (ICS). A management system designed to control personnel, equipment, supplies, and communications at the scene of an incident or emergency event. An Incident Command System is typically deployed at the beginning of an event until the management of the on- scene operations are no longer needed. The structure of the Incident Command System can be expanded or contracted depending on the changing needs of the event. The Incident Command System allows agencies of all kinds to effectively communicate using common terminology.

Incident Commander. The Incident Commander is the highest ranking official available at the scene of an incident or emergency event. All personnel involved in the operating procedures of the dam or emergency operations should be trained in the fundamentals of ICS.

Instrumentation. An arrangement of devices installed into or near dams (i.e., piezometer, inclinometer, strain gage, survey points, etc.) that provide measurements that can be used to evaluate performance parameters of a structure.

Intake. Any structure in a reservoir, dam or river for the purpose of directing water into a conduit, tunnel, canal or pipeline.

Inundation map. A map delineating the area that would be submerged by a particular flood event.

Length of dam. The length along the top of the dam between contact abutments. This also includes the spillway, power plants, navigation lock, fish pass, etc., where these form part of the length of the dam. If detached from the dam, these structures should not be included.

Outlet. An opening through which water can be discharged.

Parapet wall. A wall built along the top of a dam (upstream or downstream edge) used for safety of vehicles and pedestrians, to prevent overtopping caused by wave runup, or ornamentation.

Phreatic surface. The free surface of water seeping at atmospheric pressure through soil or rock.

Piezometer. An instrument for measuring pressure head.

Piping. The progressive development of internal erosion by seepage appearing downstream as a hole or seam discharging water containing soil particles.

Probability. The likelihood of an event occurring within a given period of time.

Probable Maximum Flood (PMF). The maximum runoff condition resulting from the most severe combination of hydrologic and meteorological conditions that are considered reasonably possible for the drainage basin under study.

Probable Maximum Precipitation (PMP). Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location.

Public Information Officer (PIO). A Property staff member designated by the *(IEAP Coordinator)*. During IEAP operations, the PIO will be the contact person at the Property for the media, and will keep the media informed of the IEAP operations.

Relief Wells. A line of vertical wells or boreholes to facilitate drainage of the foundation and abutments and to reduce water pressure.

Reservoir. A body of water impounded by a dam and in which water can be stored.

Reservoir surface area. The area covered by a reservoir when filled to a specified level.

Riprap. A layer of stone, precast blocks, bags of cement or other suitable material, generally placed on the upstream slopes of an embankment or along a watercourse as protection against wave action, erosion, or scour. It consists of pieces of relatively large size as distinguished from a gravel blanket.

Seepage. Flow or movement of water through a dam, its foundation, or its abutments.

Slope. Inclination from the horizontal, measured as the ratio of horizontal units to corresponding vertical units.

Spillway. A structure over or through which flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means such as gates, it is considered a controlled spillway. If the elevation of the spillway crest is the only control, it is considered an uncontrolled spillway.

Spillway channel. An 'open channel or closed conduit conveying water from the spillway inlet downstream.

Spillway crest. The lowest level at which water can flow over or through the spillway.

Spillway, chute. An inclined channel, usually separate from the dam, to convey reservoir overflow into the natural channel below the dam or into an adjacent natural drainage channel.

Standing Operating Procedures (SOP). A comprehensive, single-source document providing accurate and current instructions for normal operation, maintenance, monitoring, and inspection of a dam and appurtenant features.

Stoplogs. Timbers or steel beams placed on top of each other with their ends held in guides on each side of a channel or conduit so as to provide a cheaper or more easily handled means of temporary closure than a bulkhead gate.

Storage. The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel. Definitions of specific types of storage in reservoirs are:

a. Dead Storage. The reservoir volume between the invert of the lowest intake and the reservoir bottom.

b. Active Storage. The reservoir volume between the normal reservoir water surface elevation and the invert of the lowest intake.

c. Flood Storage. The reservoir volume between the crest of the dam and the normal reservoir water surface elevation.