Appendix A
Hydrology and Hydraulics

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Introduction and Location of Site

Lake Lou Yaeger is utilized by the City of Litchfield Water Treatment Facility as a water supply and as a recreation facility for the surrounding communities. The Lake encompasses approximately 1,300-1,400 acres and is approximately 8 miles long and 0.5 miles at its widest. Water elevation is controlled by a concrete spillway with an overtopping elevation of 591.5 ft and a winter drawdown elevation of 587.5 ft.

An annual drawdown of the lake is performed. This drawdown, which typically begins during late fall, provides extra storage volume for late winter and spring runoff. The drawdown is performed with the outlet conduit that is located about 700 feet toward the east of the center of the principal spillway and about 100 feet upstream of the center of the dam. The goal of the drawdown of the lake is to lower its elevation about four feet below the elevation of the principal spillway. Data for the drawdown during late 2014 into early 2015 shows that it commenced on 20 November 2014. The lake reached its lowest level of about four feet below the elevation of the principal spillway by early February 2015. Some fluctuations of the lake elevation occurred during the drawdown as the result of runoff from precipitation.

The main focus of this project was at the upper or northern end of the lake where the effects of sedimentation are most noticeable and where possible measures could be taken to counter sedimentation without impacting other uses of the lake. The upper end of Lake Lou Yaeger is fed by three main tributaries: Blue Grass Creek, Shoal Creek, and Shop Creek (formally Shoal Creek No 2 and consisting of 3 parts, Shop Creek, Five Mile Lake and Threemile Creek). Shop Creek flows into Five Mile Lake, an existing retention feature located approximately 1.4 miles upstream from Lake Lou Yaeger. Threemile Creek flows into the lower end of Five Mile Lake and is the portion of the waterway between Five Mile Lake and Lake Lou Yaeger. However, for this study's purposes, calculations were based on Shop Creek, Five Mile Lake and Threemile Creek as one waterway and listed as Shop Creek. Five Mile Lake was constructed in 1966, the same year as Lake Lou Yaeger, but is considered effectively full at this time and is no longer functioning as a sediment retention basin. The relationships of these three watersheds, as well as their sizes can be seen in Figure 1 and Table 2, respectively.

Four possible measures were analyzed to reduce sedimentation at the lake. These measures involved building a rock berm with a top elevation one half foot below the spillway crest elevation. This would allow water to flow over the berm at the lakes design elevation and encourage sediment to deposit before entering the lower portion of the lake. These measures were all located at the upper end of the lake and are laid out in the below map. Berm #1 is located at the narrowest part of the lake and could possible take advantage of a private roadways and power company right-of-way that is already cleared for construction access from the East side of the lake. Berm #1A is located slightly upstream and across the main lake body but avoids isolating some existing camping locations and takes advantage of easier construction access along the West side of the lake. Berm #2 would cross the western finger of the lake that is fed by Shop Creek and could utilize the same construction access as Berm #1A. Berm #3 is across the eastern finger of the lake and is fed by Shoal and Blue Grass Creeks but does not have easily identifiable construction access.

All four sites were analyzed for projected sedimentation rates and wetland creation acreage. Early calculations showed that Berms #2 and #3 were not practical alternatives due to existing depths upstream of the Berms being insufficient to support long term sediment retention and short project lives.

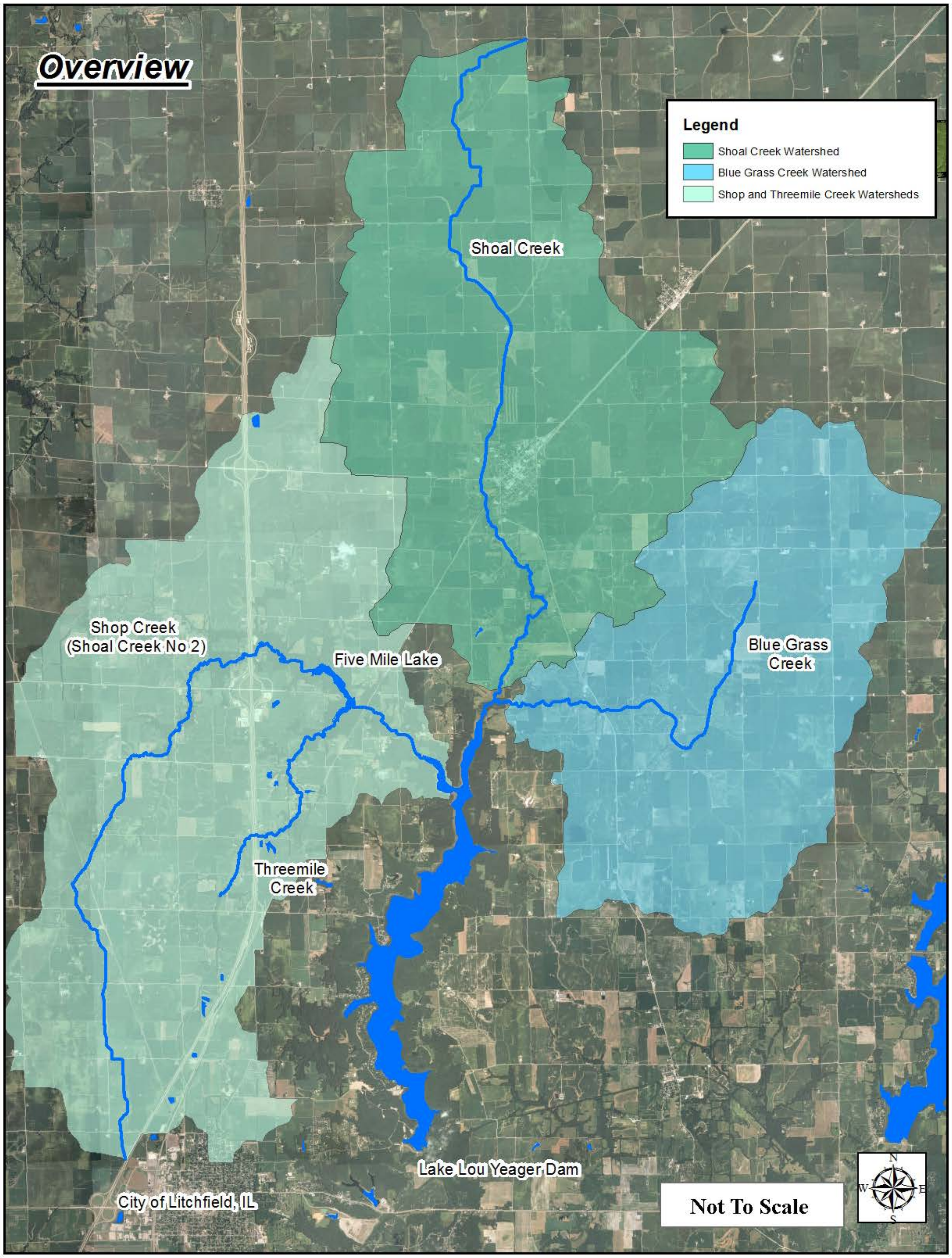

Figure 1: Lake Lou Yaeger and the tributaries and watersheds at the upper end of the lake.

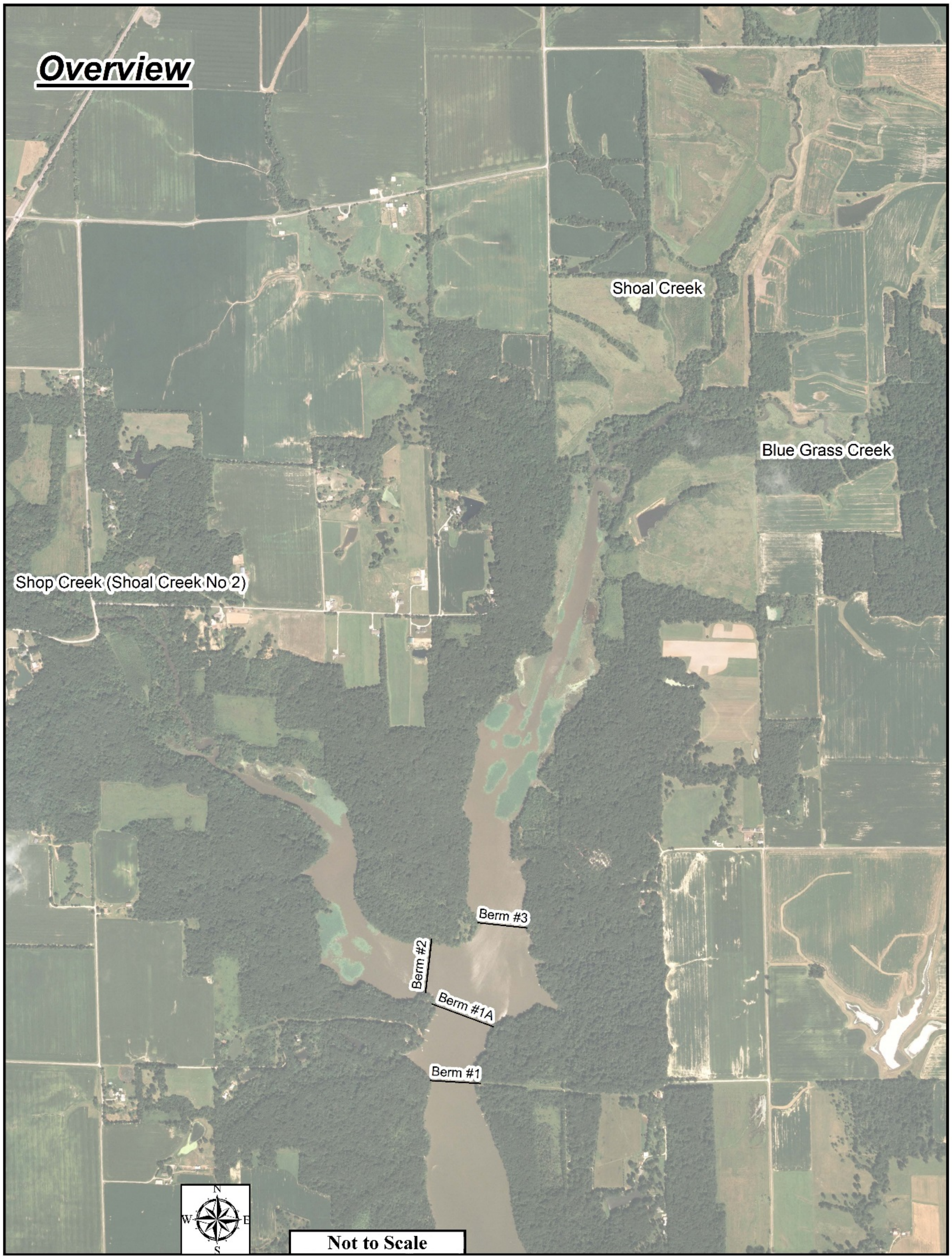

Figure 2: The upper or northern end of Lake Lou Yaeger showing tributaries and locations of Berms #1 - #3

Sediment Inflow to the Lake

Various methods were considered for determining sediment inflow to the lake. Sediment data was not collected on West Fork Shoal Creek, the northern-most major tributary of the lake. This type of data was also not collected on two western major tributaries of the lake, Threemile Branch and Shop Creek. Since field-collected sediment data was not available, the possibility of calculating sediment inflow to the lake was considered. There are several empirical approaches for the estimation of erosion. Empirical approaches are derived from, or are guided by, experience or experiment. They are provable or verifiable by experience or experiment. Two of the commonly used empirical approaches are the Universal Soil Loss Equation and the Revised Universal Soil Loss Equation. The application of these two equations requires vast knowledge of the watersheds of interest. That knowledge was not available within the St. Louis District (MVS), so it was decided to request the assistance of the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS).

Several individuals in the Hillsboro, Illinois, office of the USDA NRCS were contacted and a meeting was held with these individuals at their office by project team members. The USDA NRCS in Hillsboro contacted the USDA NRCS office in Springfield, Illinois, and personnel in the Springfield office were able to provide assistance with the calculation of average annual sediment yield for portions of the lake's watershed. The USDA NRCS requested Geographic Information System information for the watersheds for which average annual sediment yield was needed (namely, shapefiles of the watersheds). Shapefiles for two watersheds was provided. The first of these watersheds was that of Bluegrass Creek, a tributary of the lake on its eastern side. Bluegrass Creek enters West Fork Shoal Creek near the upper end of the lake. The second watershed was that of West Fork Shoal Creek down to near its confluence with Bluegrass Creek. West Fork Shoal Creek enters the lake at its upper end.

A report on average annual sediment yield was produced by USDA NRCS that had separate sections for Bluegrass Creek and West Fork Shoal Creek. The USDA NRCS sediment production report is given below in APPENDIX A-1. Information from this report was used for the sedimentation analysis that was developed for this project.

After information was acquired from the USDA NRCS on average annual sediment yield for the watersheds mentioned previously, assistance was again requested of the USDA NRCS with the calculation of average annual sediment yield for another tributary watershed of the lake. This tributary was Threemile Branch, which enters the western-most arm of the two arms of the lake at its upstream end. The USDA NRCS was not able to provide assistance for Threemile Branch. Therefore, sedimentation data given in a report that was completed previously (Lake Lou Yaeger Restoration Plan - Final Report, January 1995) was used for the sedimentation analysis that was developed for Threemile Branch. This report that was completed in January 1995 was prepared by Crawford, Murphy and Tilly, Inc. (Springfield, Illinois), as a Clean Lakes Program Phase 1 Diagnostic and Feasibility Study.

Steady-Flow Hydraulic Modeling

Steady-flow hydraulic modeling of the lake was developed primarily for the purpose of determining the effects of the proposed in-lake berm upon water-surface elevations upstream of it. Citizens that live near the lake have expressed interest in the potential for the berm to produce induced flooding, which could affect their properties. The steady-flow hydraulic modeling provides a method to determine if induced flooding occurs as the result of the proposed berm, and thus a means to address the concerns of the citizens.

A report obtained from the MVS electronic files was reviewed to determine reasonable flow rates to use for the steady-flow hydraulic modeling. This report was an inspection report from the National Dam Safety Program and is entitled "Kaskaskia River Basin, Lake Lou Yaeger Dam, Montgomery County, Illinois, Inventory Number 00693, Inspection Report, National Dam Safety Program, May 1980 (Department of the Army, Chicago District, Corps of Engineers). This report identified the peak inflow rate for the flood event having a one percent chance of occurring in any given year (i.e., the so-called 100-year flood event) as 10,100 cubic feet per second (cfs). This report also has project information, engineering data, hydrology and hydraulics data, engineering drawings, visual inspection information and pictures.

However, another short report obtained from the MVS electronic files was written in April 1999 following a review of the May 1980 report. The April 1999 report contained data taken from hydrologic modeling performed with the legacy USACE computer program HEC-1. Runoff from the rainfall event having a one percent chance of occurring in any given year was calculated for five different rainfall durations (12, 18, 24, 48 and 72 hours). Peak inflow rates to the lake were given for each of these five simulations in the report, as well as peak outflow rates. The highest peak inflow rate to the lake calculated for these five simulations was about 20,300 cfs.

Based upon the information obtained for the two reports described above, eight flow rates up to and including 20,000 cfs were used in the steady-flow hydraulic modeling of the lake. It was desired to simulate a wide range of flow rates to assess the possibility of induced flooding as the result of the proposed in-lake berm. In developing the hydraulic modeling, it was assumed that each of the eight flow rates that were simulated were occurring throughout the entire lake.

An electronic representation of topography and bathymetry data for the lake and its immediate vicinity was used in the Geographic Information Systems computer program ArcMap 10.0 to develop cross sections of the lake. The cross sections (which are drawn approximately perpendicular to the direction of water flow) depict the varying elevations of the bottom of the lake, the shoreline and adjacent land. These cross sections were then transferred to the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) computer program for the calculation of steady-flow water-surface profiles for the lake. The cross sections and two proposed locations for in-lake berms are shown in Figure 3. The cross sections are drawn in black and the proposed locations for in-lake berms are dawn in gray.

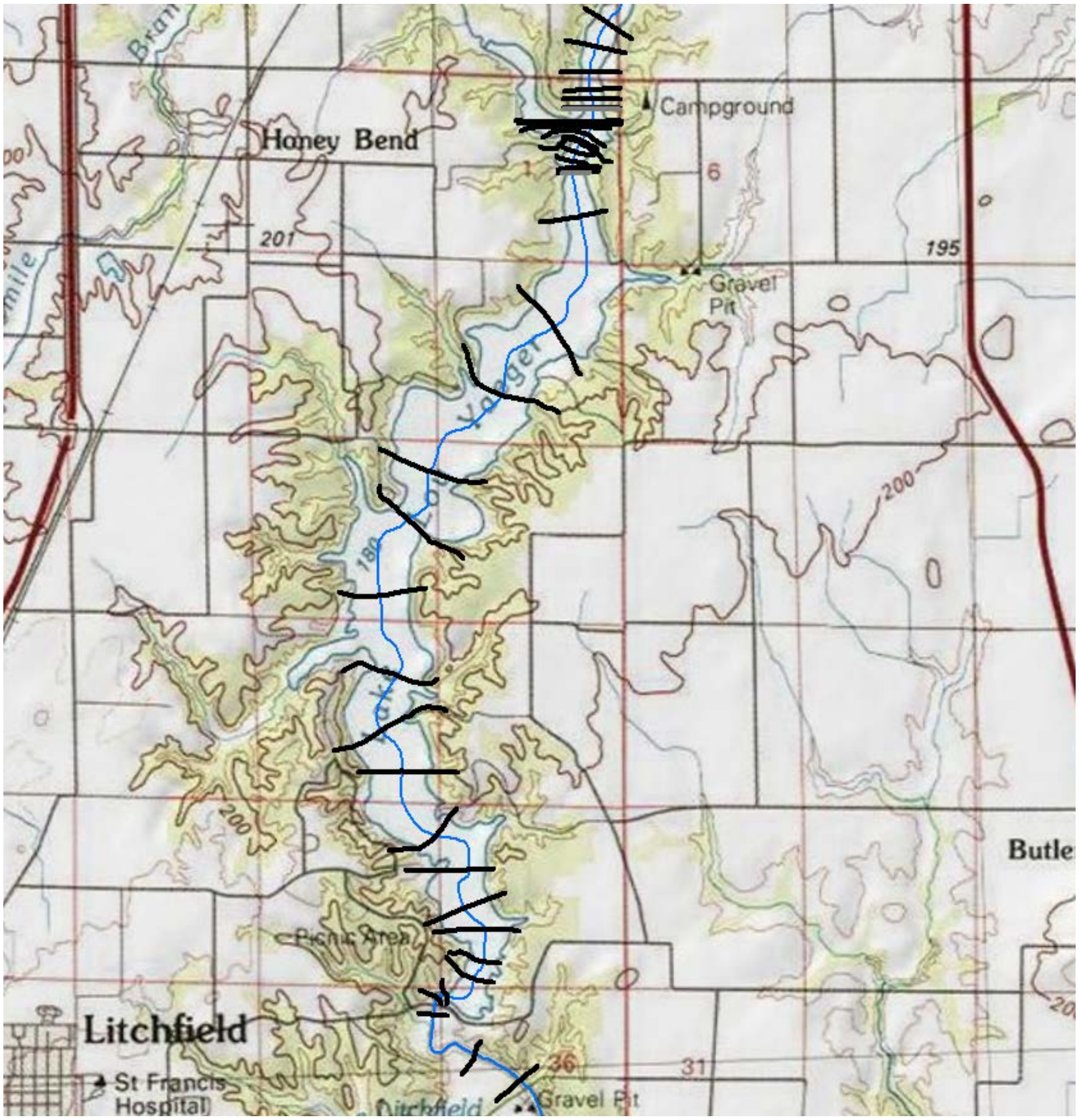

Figure 3. Cross Sections and Two Proposed Locations for In-lake Berms.

Eight flow rates (1,000; 5,000; 7,500; 10,000; 12,500; 15,000; 17,500 and 20,000 cfs) for the lake were simulated with the steady-flow computer model. In addition to the cross sections, the model includes depictions of the lake's dam and the proposed in-lake berm. The depictions of the dam and the berm are similar to that of a cross section in that the varying elevations of the structure (either dam or berm), the shoreline and the adjacent land are depicted at the locations of the dam and berm. The depictions of the dam and the berm are drawn approximately perpendicular to the direction of water flow, as are the cross sections. The depiction of the dam includes the uncontrolled spillway, which has a crest elevation of 591.0 feet (referenced to the North American Vertical Datum of 1988 (NAVD88). The depiction of the berm has a crest elevation of 590.5 feet NAVD88, one-half foot below the lake's uncontrolled spillway crest elevation. The geometric data that depicts the lake and its immediate vicinity (cross sections, dam, and proposed in-lake berm) is contained in a set of data known as a plan in the computer program HEC-RAS. In this plan, it was assumed that no sediment had accumulated upstream of the proposed in-lake berm.

A second plan was developed with the computer program HEC-RAS. This plan was a duplication of the first plan that was developed except that the proposed in-lake berm was removed from it. Thus, two plans (one containing the berm and one without it) were available for simulations of the eight flow rates that were described above. The lake water-surface profiles produced in simulations with the two plans were compared to determine if induced flooding was produced by the proposed in-lake berm.

The steady-flow hydraulic modeling for both plans included cross sections of the lake from the dam upstream to the proposed in-lake berm, and cross sections that extended slightly over 1,650 feet upstream of the proposed in-lake berm. There were 10 cross sections of the lake upstream of the proposed berm. The computed water-surface elevation of the lake at each of these 10 cross sections was compared for the two plans for each of the eight flow rates discussed above, yielding 80 comparisons of water-surface elevations. These comparisons showed that the largest increase in the water-surface elevation at any of the 10 cross sections for any of the eight flow rates was 0.02 feet.

Upon completion of the modeling and water-surface elevation comparisons that have been described above, it was decided to take the analysis one step further. A third plan was developed that was based upon the assumption that sediment had accumulated upstream of the proposed in-lake berm up to the crest elevation of the berm. In this plan, modifications were made to all 10 cross sections upstream of the berm to reflect the assumption that sediment had accumulated up to the crest elevation of the berm. For this plan that assumed sediment accumulation had occurred and the plan that assumed no sediment accumulation, the same comparisons of water-surface elevations upstream of the berm were made as described in the previous paragraph. These comparisons showed that the largest increase in the water-surface elevation at any of the 10 cross sections for any of the eight flow rates was 0.26 feet.

Water Flow Velocity at the In-Lake Berm

The velocity of water flow at the in-lake berm is a factor in the selection of the size of rock to use for construction of the berm. The steady-flow hydraulic modeling that was developed for the lake was used to determine average flow velocities at the in-lake berm and at the closest lake cross section upstream of the berm. In the steady-flow hydraulic modeling, it was assumed that one flow rate was occurring throughout the entire lake for each simulation that was performed. The flow rates that were simulated were based upon information in two dam safety reports for the lake. Information taken from the reports showed that the peak inflow rate to the lake for the one-percent-chance flood event in any given year (the so-called "100-year event") is about 20,300 cfs. Flow rates from 20,000 cfs down to 1,000 cfs were modeled. Also, the reports showed that the Probable Maximum Flood (PMF) peak inflow rate to the lake is about 100,050 cfs. The PMF was also modeled, as well as half of the PMF.

Average flow velocity data calculated from steady-flow hydraulic modeling is given in Table 1. The flow areas given in Table 1 represent conditions just after construction of the in-lake berm and prior to any sediment accumulation upstream of the berm. Based upon the flow velocity data in Table 1, it was decided to use a design flow velocity of 10 feet per second.

Table 1: Average Flow Velocity Data Calculated from Steady-Flow Hydraulic Modeling.

	River Station 45952.00 feet in Hydraulic Modeling		River Station 45976.18 feet in Hydraulic Modeling	
Flow Rate Through Lake (cubic feet per second)	Weir Flow Area at In-Lake Berm (square feet)	Average Flow Velocity at In-Lake Berm (feet per second)	Flow Area at Cross Section (square feet)	Average Flow Velocity at Cross Section (feet per second)
1,000	983.8	1.0	2929.8	0.3
5,000	2310.2	2.2	4244.6	1.2
7,500	2924.7	2.6	4849.8	1.6
10,000	3475.0	2.9	5390.1	1.9
12,500	3976.3	3.1	5881.5	2.1
15,000	4448.0	3.4	6342.3	2.4
17,500	4890.0	3.6	6773.4	2.6
20,000	5310.6	3.8	7183.7	2.8
50,025 (0.5 PMF)	9760.2	5.1	11491.4	4.4
100,050 (1.0 PMF)	15710.8	6.4	17221.3	5.8

If work on this project is approved to move to the Plans and Specifications phase, it is recommended that unsteady-flow hydraulic modeling be developed to determine the flow velocities at the in-lake berm. A flood event should be modeled that has an inflow hydrograph with a rapidly rising ascension side, with the initial lake elevation being that of the normal annual winter drawdown. This approach to the modeling would simulate a significant flood event entering the lake while the lake is at its lowest annual elevation, thus resulting in relatively high flow velocities at the in-lake berm.

Sedimentation Conditions of Alternatives of Lake Lou Yaeger

Current sedimentation conditions of Lake Lou Yaeger were determined using the 2011 hydrosurvey, a pre-1964 topographic survey, (NRCS) average annual sediment yield values for both Blue Grass Creek and the Upper West Fork of Shoal Creek watersheds, and average annual sediment yield value for Shop Creek from the “Restoration Plan for Lake Lou Yaeger” (January 1995). Based upon historical aerial photography from Google Earth, the upper (northern) section of Lake Lou Yaeger has been relatively shallow over the last decade. Figure 4 is an aerial photo of the lake in March of 2005. At the time the lake was in winter draw down, exposing the shallow mud bars and creek like channels.

Figure 4: Aerial photo of upper Lake Lou Yaeger during winter drawdown.

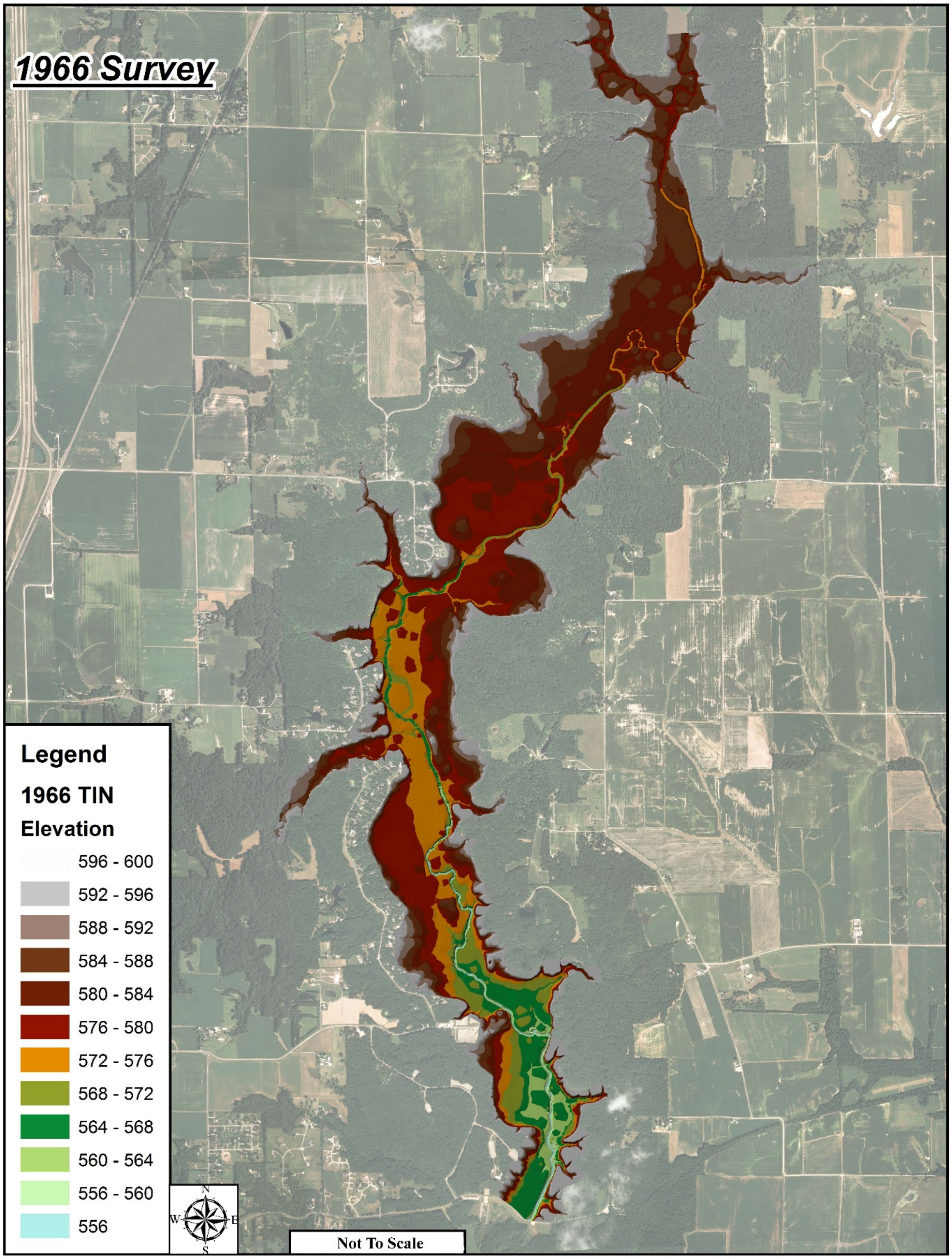

Figure 5: Pre-1964 Survey of the Lake Lou Yaeger basin before the reservoir was filled

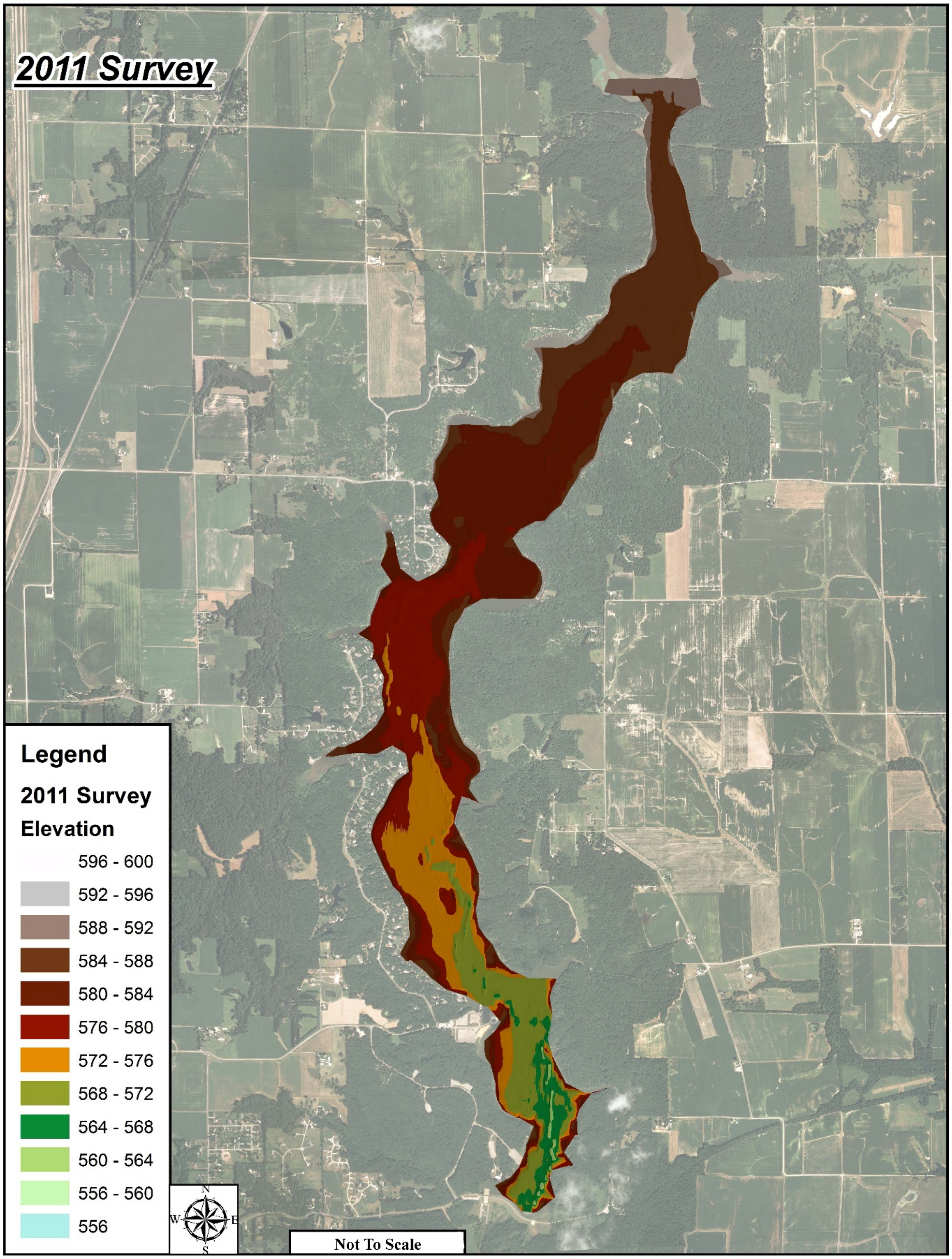

Figure 6: 2011 Bathymetric survey

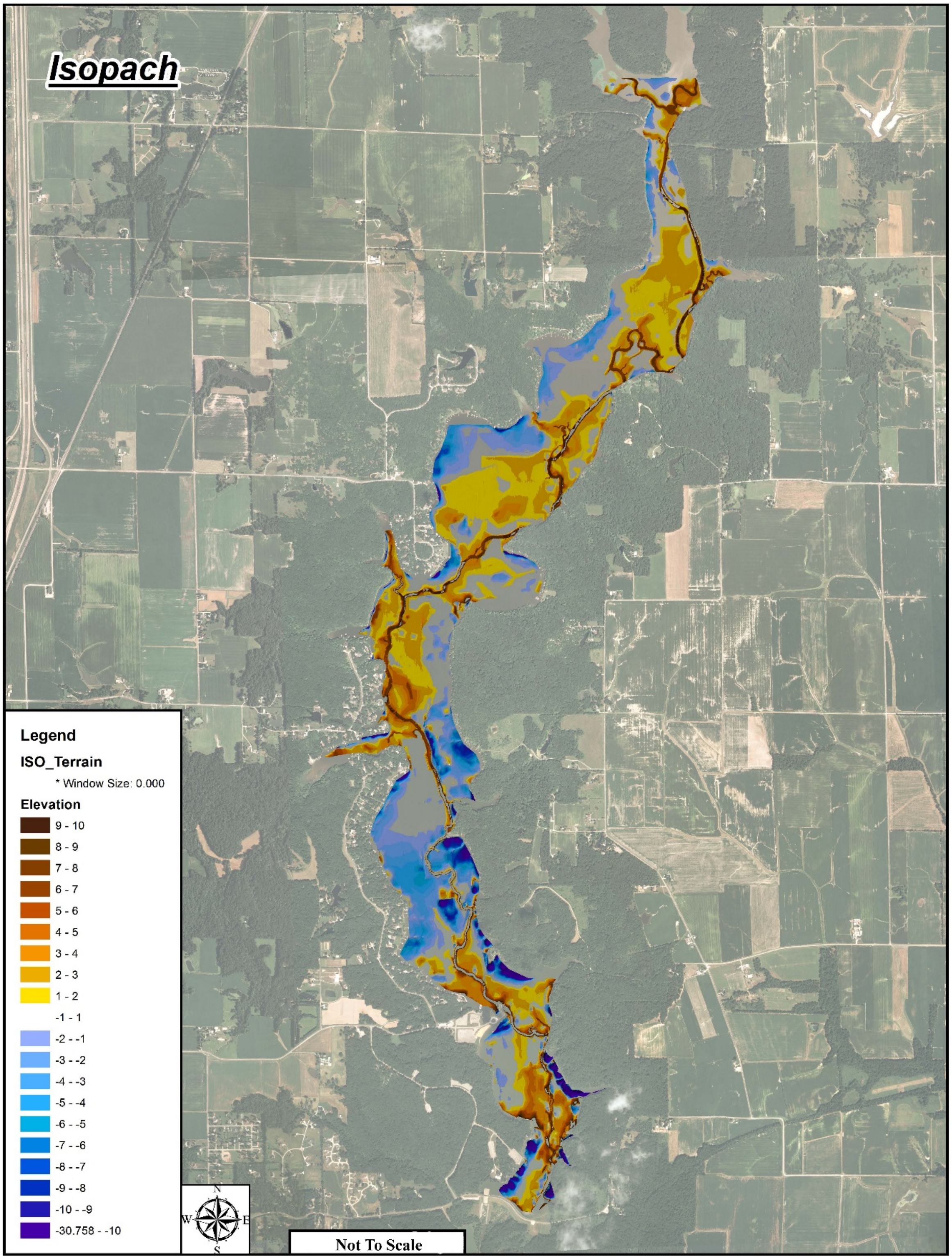

Figure 7: Isopach analysis comparing the pre-1964 and 2011 surveys. A positive number (yellow to brown) indicates an increase in bed elevation, a negative number (blue to purple) indicates a decrease in bed elevation.

The inflow of sediment for Shop Creek, formerly Shoal Creek No. 2, was referenced from the “Restoration Plan for Lake Lou Yaeger” section 1.9.2 under *Eroded Soils*. The value referenced from the report was 3.67 tons/acre/year. The inflows of sediment for Shoal Creek and Blue Grass Creek were referenced from the NRSC via email communication. For Blue Grass Creek, the value was 34,960 tons/year. For Shoal Creek, the value was 51,510 tons/year. These values were communicated to USACE in tons/year.

Table 2: The areas of the respective watersheds that were analyzed.

Watershed name	Area (acres)	Tons of clay
Shoal Creek	19756	51510
Blue grass creek	15188	34960
Shop creek	24448	89724.16

These numbers were generated from the assumption that the sediment was mostly of the clay variety. Clay was assumed as the primary sediment falling out of suspension due to section 1.2.1 in the “Restoration Plan for Lake Lou Yaeger” and visual inspection.

An Isopach analysis, as seen in Figures 5, 6 and7, which is the comparison of 2 surveys, was done to generate a sedimentation volume between Figure 6, the 2011 hydrosurvey and Figure 5, the pre-1964 topographic map (which was digitized in Arc-GIS). The pre-1964 topographic map (Figure 5) was a survey from before Lake Lou Yaeger was created. Through different conversion factors, a range was developed for the yearly sedimentation rate. The values were between 70.9 acre ft/year and 73.5 acre ft/year. The sediment inflow from these three tributaries was also roughly lower then what the “Restoration Plan for Lake Lou Yaeger” has in section 1.10.41 under *Reduction in Volume at Lake Lou Yaeger*. Therefore a ratio adjustment must be made in order to get an accurate sedimentation rate.

Table 3: The Restoration Plan for Lake Lou Yaeger report and Isopach values pertaining to the whole lake.

	Isopach	Report from 1995
Sedimentation Rate (acre ft/yr)	16.2	175.0

Conversion Ratio:

$$\frac{16.2}{175.0} = \frac{X}{70.9\ or\ 73.5}$$

This conversion ratio is used to scale the yearly inflow of sediment to what we have seen in the difference between the survey data. This was needed because the majority of the sediment inflow from these creeks passes through the site without settling out.

This yielded the corrected sedimentation range values of 6.56 to 6.79 (acre ft/yr).

From here sites 1, 1A, 2, and 3 were each run using parameters unique to their own structure placement. Sites 2 and 3 were eliminated early due to sedimentation causing a short project life. All analysis beyond this point were only completed on sites 1 and 1A.

Normal moving water surface for this section of the lake was assumed to be 591.5 ft NAVD. Volumes were found at the Lake's maximum pooled water surface (elevation 591.0 ft NAVD) and at the structure height, 1 foot below normal water moving surface (elevation 590.5 ft NAVD)

Table 4: Storage volumes

BERM #1

590.5 [NAVD]

Storage volume (acre-ft)	Area (acre)	Storage Volume Parameter - Vs (in)
151.4	122.2	14.8

591.0 [NAVD]

Storage volume (acre-ft)
258.6

BERM #1A

590.5 [NAVD]

Storage volume (acre-ft)	Area (acre)	Storage Volume Parameter - Vs (in)
114.7	111.1	12.4

591.0 [NAVD]

Storage volume (acre-ft)
210.4

Between 1961 and 1990 the average annual rainfall for the Litchfield Illinois area was 38.69 inches. With this annual inflow value and the storage volume (Vs) calculated earlier, the sediment trap ratio could be determined for each of these alternatives. A Brune trap-efficiency curve was used in both alternatives to determine the sediment trap efficiency of each structure individually. This and the equations used above was referenced from Section 15.10 on page 828-829 in Hydrologic Analysis and Design 3rd Edition by Richard H. McCuen.

Table 5: Each alternative and their sediment capture effectiveness.

	Vs/Average Annual Inflow (Yr)	Sediment Trap Efficiency (%) (WS 590.5 NAVD)	Berm #1 sediment trap effectiveness (%) (WS 591.0 NAVD)
Berm #1 and US	0.38	0.88	0.61
Whole Lake (No Berm #1)	3.63		0.946

	Vs/Average Annual Inflow (Yr)	Sediment Trap Efficiency (%) (WS 590.5 NAVD)	Berm #1A sediment trap effectiveness (%) (WS 591.0 NAVD)
Berm #1A and US	0.32	0.875	0.47
Whole Lake (No Berm #1A)	3.63		0.946

Brune trap efficiency relationship curve graphs are located in the Index item number 2 at the end of this appendix. Since the average annual inflows are roughly close, one line will be provided on the attached graph.

Based upon these sediment trap percentages and the corrected sedimentation values mentioned earlier. The calculation is a simple division of volume behind stated alternative over the sedimentation value multiplied by the sediment trap efficiency.

$$Years\ until\ Terrestrial\ creation = \frac{Volume\ behind\ Berm}{(Sediment\ Trap\ Efficency) * (Corrected\ Sedimentation\ Rate)}$$

Table 6: Years until terrestrial for each alternative

Sedimentation rate After Berm (Acre ft/yr)	4.04	4.18
Years to fill in upstream of Berm #1	37.4	36.1

Sedimentation rate After Berm (Acre ft/yr)	3.13	3.24
Years to fill in upstream of Berm #1A	36.6	35.3

For each of these alternatives there was a without structure alternative. Each of these sediment rates were calculated by using the 2011 hydrosurvey and pre-1964 topographic survey. A volume was calculated within the area behind the berm and up to the elevation of the spillway crest of the dam downstream (591.0 ft NAVD). A difference of these two volumes was then calculated and divided by the time between the two surveys. This results in an annual average sedimentation rate currently and with no structures in place. Then, the same calculation is used to calculate the life of the area behind the berms with no structure added.

Table 7: Project life of the area behind the proposed berms with no structure added.

Berm 1 (No Structure)

Pre-1964			
Z (ELV) [NAVD]	Volume (ft^3)	Surface Area (sqft)	Average Depth (ft)
591.0	9183097.3	1689485.7	5.43

2011			
Z (ELV) [NAVD]	Volume (ft^3)	Surface Area (sqft)	Average Depth (ft)
591.0	5843894.8	1711240.3	3.41
2011 (ac-ft)	134.1		
Change (ft^3)	3339202.4		
Change per year (ac-ft)	1.70		

Sedimentation rate no Berm	1.70
Years to fill in NO BERM	151.8
Years to fill in NO BERM @ Berm #1 height	88.9

Berm 1A (No Structure)

Pre-1964			
Z (ELV) [NAVD]	Volume (ft^3)	Surface Area (sqft)	Average Depth (ft)
591.0	14222175.5	2572753.9	5.52

2011			
Z (ELV) [NAVD]	Volume (ft^3)	Surface Area (sqft)	Average Depth (ft)
591.0	6964787.2	2604245.7	2.67
2011 (ac-ft)	159.8		
Change (ft^3)	7257388.3		
Change per year (ac-ft)	3.70		

Sedimentation rate no Berm	3.70
Years to fill in NO BERM	56.8
Years to fill in NO BERM @ Berm #1A height	31.0

Each alternative was then evaluated at key times during the project life: 5 years, 25 years, and 50 years. All evaluation key times were evaluated both with and without structure (berm). All of the depths are average depths and should not reflect a constant depth of the lake.

Table 8: Key point evaluation values

Berm 1		
	With Berm	No Berm
0 year volume (acre ft)	258.66	
0 year average depth (ft)	2.12	
5 year volume (acre ft)	237.72	250.14
5 year average depth (ft)	1.94	2.05
25 year volume (acre ft)	154.00	216.07
25 year average depth (ft)	1.26	1.77
50 year volume (acre ft)	84.10	173.48
50 year average depth (ft)	0.69	1.42
Sedimentation rate (acre ft/yr)	4.19	1.70

Berm 1A		
	With Berm	No Berm
0 year volume (acre ft)	210.37	
0 year average depth (ft)	1.89	
5 year volume (acre ft)	194.15	191.86
5 year average depth (ft)	1.75	1.73
25 year volume (acre ft)	129.26	117.82
25 year average depth (ft)	1.16	1.06
50 year volume (acre ft)	41.28	25.26
50 year average depth (ft)	0.37	0.23
Sedimentation rate (acre ft/yr)	3.24	3.70

The area of the lake downstream of the berm was also evaluated at the same time interval for habitat purposes. The entire lake life is also calculated. These calculations are the same type of mathematical operation as done in the previous tables.

Table 9: The results of the evaluation downstream of the berm for both alternatives.

Whole Lake Sedimentation Analysis of BERM #1

No Berm

Area	Sed Rate
1,193.8	16.18

0 Yr Volume	5 Yr Volume	25 Yr Volume	50 Yr Volume
12,782	12,701	12,378	11,973

Total Life
790.1

0 Yr Avg Depth	5 Yr Avg Depth	25 Yr Avg Depth	50 Yr Avg Depth
10.7	10.6	10.4	10.0

With Berm

Area	Sed Rate
1,193.8	13.69

0 Yr Volume	5 Yr Volume	25 Yr Volume	50 Yr Volume
12,782	12,714	12,440	12,063

Total Life
796.6

0 Yr Avg Depth	5 Yr Avg Depth	25 Yr Avg Depth	50 Yr Avg Depth
10.7	10.6	10.4	10.1

Whole Lake Sedimentation Analysis of BERM #1A

No Berm

Area	Sed Rate
1206.4	16.2

0 Yr Volume	5 Yr Volume	25 Yr Volume	50 Yr Volume
12,826	12,745	12,422	12,017

Total Life
792.8

0 Yr Avg Depth	5 Yr Avg Depth	25 Yr Avg Depth	50 Yr Avg Depth
10.7	10.6	10.3	10.0

With Berm

Area	Sed Rate
1206.4	16.6

0 Yr Volume	5 Yr Volume	25 Yr Volume	50 Yr Volume
12,826	12,743	12,410	12,001

Total Life
791.8

0 Yr Avg Depth	5 Yr Avg Depth	25 Yr Avg Depth	50 Yr Avg Depth
10.7	10.6	10.3	9.9

These results show no significant life increase from either berm in regards to sedimentation of the entire lake however the berms do increase environmental benefits upstream of their construction. In addition, Berm 1A will not be effective on trapping any additional sediment beyond what is naturally occurring upstream of this location.

During this analysis some hydraulic assumptions were made due to lack of funds and data.

1. Due to poor data management, the 2011 hydrosurvey was merged with a recent small bankline LiDAR survey to obtain more coverage of the lake; however the date of the LiDAR is unknown. For simplicity, it was assumed to be 2011.
2. It was assumed that during sediment conveyance the water surface would be 1 foot above the structure in order to adequately assume a sediment trap efficiency percentage. During design phase water surface monitoring in the area would be suggested.
3. All depths are averaged and should not be used as uniform depths.
4. Volumes in this analysis should not reflect an adequate lake volumes. Some sections of the hydrosurvey were missing banklines and back water hallows. A future survey is suggested to obtain real volume measurement.
5. Two vertical datums were used in this report due to the fact that all of the surveys (with the exception of the small bankline LiDAR) are surveyed in NVGD. Spillway crest elevation is also measured in NVGD. Therefore sedimentation analysis was performed in the NVGD datum. Then converted to NAVD to display in this report.
6. Sediment load was assumed to be a variety clay.
7. It was assumed that all sediment that passes into Fivemile lake is transported downstream into Lake Lou Yaeger at the same rate as it arrives (Fivemile Lake is entirely filled and ineffective as a sediment trap)
8. It was assumed sediment loads from any other source besides these three creeks was Not Applicable.

<u>Index:</u>

1. APPENDIX A-1 – USDA NRCS SEDIMENT PRODUCTION REPORT.
2. APPENDIX A-2 – BRUNE TRAP EFFICIENCY RELATIONSHIP GRAPH

APPENDIX A-1 – USDA NRCS SEDIMENT PRODUCTION REPORT

Shoal and Bluegrass Creeks Sediment Production
February 2015

This report is a follow-up to a more complete field investigation conducted on the Lake Lou Yaeger watershed in September of 1999 by NRCS (Windhorn). That report used earlier data gathered by the engineering firm of Crawford, Murphy, and Tilly, Inc. (1995) and in report Illinois State Water Survey Sedimentation Survey of Lake Lou Yaeger in November of 1977. An earlier, partial erosion inventory, was completed by SCS (now NRCS) in the late 1970's. These reports were all intended to get a quantitative idea as to how much sediment was entering this lake and from what sources. This *current* report will address estimated sediment production and transport from the Shoal Creek tributary and the Bluegrass Creek tributary. Sediment retarding basins are being considered for both of these sites.

No additional field work was completed for this report. Erosion totals for sheet and rill erosion, ephemeral erosion, gully and stream bank erosion are listed in the reports above. The main emphasis in the current report was to "partition" the erosion and sediment totals to the above mentioned tributaries. *Always important to keep in mind that all of these totals are <u>average annual ESTIMATES</u> based on vegetation, soil, geology, and surface water flow characteristics. Some of these estimates can change dramatically from year to year based on weather conditions and flow patterns.*

Shoal Creek

Shoal Creek is about 19, 756 acres in size. It is the major tributary at the northern or head-waters area of the lake. All the totals on erosion and sedimentation are contained in the documents listed above. The same values were used to compute sediment delivery to the outlet end with some adjustments for individual types of erosion and their Sediment Delivery Rates. (SDR)

Shoal Creek had a total annual erosion rate of 87,075 tons. Of that total, 1% (1,100T) is attributed to stream bank erosion, 4% (3,400T) for gully erosion, 13% (10,800 T) to ephemeral erosion and the rest 82% (71,775 T) to sheet and rill erosion. Applying SDR rates to "convert" erosion into sediment, Shoal Creek produces about **51,510 tons of sediment** delivered to the outlet on an average annual basis. This figures to be **2.6 Tons** of sediment /Acre/Year delivered to the outlet of the creek.

Blue Grass Creek

Blue Grass Creek is about 15,188 acres in size and lies to the northeast side of Lake Lou Yaeger. As discussed above, the totals for erosion and sediment in this watershed came directly from the detailed report completed in 1999.

Blue Grass Creek had a total annual erosion rate of 60,000 T. One percent of that (500 T) is from stream bank erosion, 2% (1400 T) came from gully erosion, 11% (6,700 T) from ephemeral erosion, and 86% (51,400 T) from sheet and rill erosion. Applying the SDR rates to Blue Grass

Creek produces about **34,960 tons of sediment** delivered to the outlet on an average annual basis. This figures to be about **2.3 Tons** of sediment/ Acre/ Year delivered to the outlet.

Errata: The Sediment Delivery Rates (SDR) in the 1999 report used an SDR of 0.75 for all Sheet and Rill erosion rates. This value originated in the earlier engineering report by Crawford, Murphy and Tilley, Inc. when they applied it to their data. I believe the SDR of 0.75 gives an apparent transport rate and sediment volume that is excessive for the Sheet and Rill erosion on the 0-5% slopes in these watersheds. Therefore, the totals listed above were adjusted to a more appropriate rate of 0.55. Sediment delivery rates for an entire watershed of this size are a good first-order estimate, but never meant to be a highly repeatable quantitative value.

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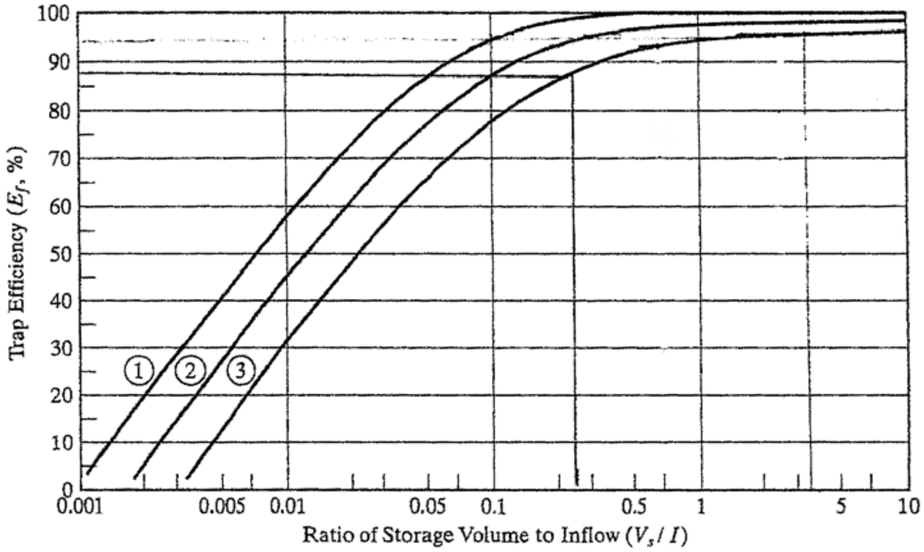
APPENDIX A-2 – BRUNE TRAP EFFICIENCY RELATIONSHIP GRAPH



Brune trap-efficiency relationship for (1) primary highly flocculated and coarse-grained sediments, (2) median-grained sediments, and (3) primarily colloidal and dispersed fine-grained sediments.