SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
W239 N1812 ROCKWOOD DRIVE • PO BOX 1607 • WAUKESHA, WI 53187-1607 • TELEPHONE (262) 547-6721
FAX (262) 547-1103

Serving the Counties of: KENOSHA
MILWAUKEE
OZAUKEE
RACINE
WALWORTH
WASHINGTON
WAUKESHA

SEWRPC Staff Memorandum

BIG CEDAR LAKE WATERSHED LAND USE AND POLLUTANT LOADING UPDATE

June 24, 2020

Big Cedar Lake (the Lake), located in central Washington County, is the largest lake in the County and lies near the headwaters of the Cedar Creek watershed. Protecting the Lake's water quality to enhance its recreational and ecological potential are very important to the Lake user community. Several organizations, including the Cedar Lakes Conservation Foundation (CLCF), the Big Cedar Lake Property Owners Association, the Big Cedar Lake Protection and Rehabilitation District (BCLPRD), and the Town of West Bend, have expressed interest in gathering updated information on changes within the Lake's watershed and pollutant loading to the Lake. In an email and attached letter on January 2nd, 2020 (see Appendix A) the District asked Southeastern Wisconsin Regional Planning Commission (Commission) staff to update the land use and nonpoint source pollutant load information presented in the Commission's Memorandum Report Number 137, *A Water Quality Protection and Stormwater Management Plan for Big Cedar Lake* hereafter referred to as MR 137.[1] This staff memorandum, prepared in response to that request, should be considered as an amendment to the aforementioned plan and part of the ongoing commitment of the Big Cedar Lake Protection and Rehabilitation District, the Towns of Polk and West Bend, and Washington County to sound planning with respect to this Lake. This memorandum provides information that can help interested parties understand changes in watershed land use and nonpoint source pollutant loading to the Lake since 1995. This memorandum also describes ongoing efforts to reduce pollutant loads and guides future stormwater management planning among the 20 subbasins draining to Big Cedar Lake (Map 1).

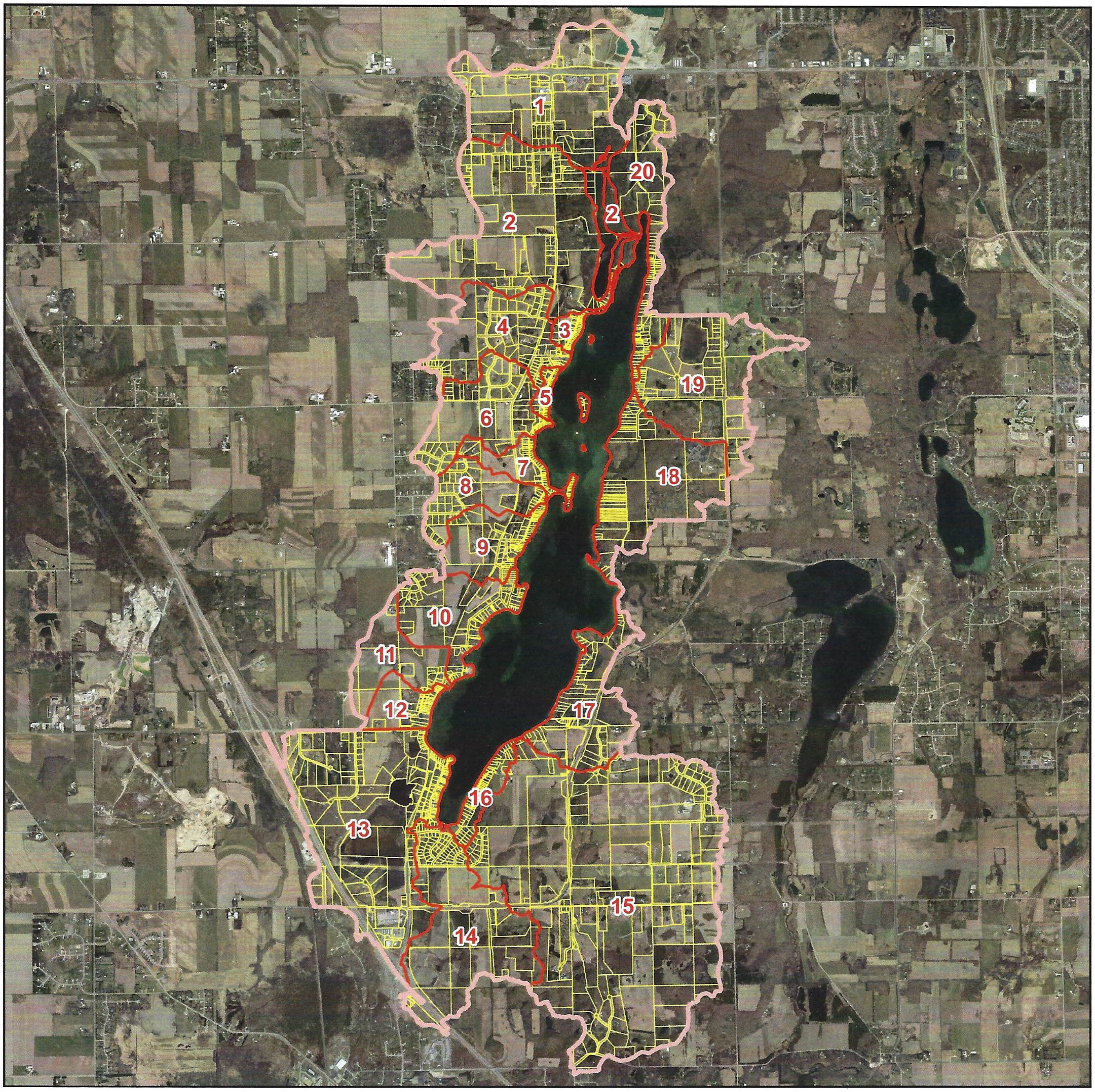
WATERSHED DEFINITION AND AREA

In this staff memorandum, the term "watershed" describes the drainage area that contributes surface water runoff to Big Cedar Lake as well as the Lake itself. Unless otherwise specified, reported acreages for the contributing watershed do not include the open surface water acreage of Big Cedar Lake itself, but the inclusion of Gilbert Lake in the contributing watershed can vary. MR 137 includes Gilbert Lake as part of Big Cedar Lake's contributing area while the updated 2020 Commission land use inventory data do not, as Big Cedar Lake and Gilbert Lake are essentially treated as a combined waterbody in the 2020 land use data.

The total drainage area of Big Cedar Lake, including the surface area of Big Cedar Lake and Gilbert Lake, is reported as 6,641 acres in MR 137. The drainage area tributary to Big Cedar Lake (including the 44-acre Gilbert Lake) is reported as 5,709 acres while the surface water of Big Cedar Lake is 932 acres. The combined surface water acreage of Big Cedar and Gilbert Lakes in the 2020 land use inventory is 1,001 acres due to differences in how land uses were classified and mapped between 1995 and 2020. These differences are described in greater detail in the "Land Use" section.

[1] *SEWRPC Memorandum Report No. 137,* A Water Quality Protection and Stormwater Management Plan for Big Cedar Lake, Washington County, Wisconsin, Vol. 1 Inventory Findings, Water Quality Analyses, Recommended Management Measures, *August 2001; and, SEWRPC Memorandum Report No. 137,* A Water Quality Protection and Stormwater Management Plan for Big Cedar Lake, Washington County, Wisconsin, Vol. 2 Stormwater Management Plans for Three Pilot Subbasins, *August 2001.*

Map 1
Big Cedar Lake Watershed and Subbasins: 1995 Watershed Boundaries



BIG CEDAR LAKE WATERSHED BOUNDARY

SUBBASIN BOUNDARY

16 SUBBASIN REFERNCE NUMBER

PARCEL BOUNDARY

N

0 0.25 0.5 0.75 1 Miles

Source: SEWRPC

In the process of preparing this staff memorandum, the Lake watershed and subbasin boundaries were reviewed and revised to account for hydrologic changes within the watershed since the publication of MR 137. This memorandum will refer to the updated watershed delineation as the "revised watershed." Subbasins 13 and 19 were determined to have areas that do not drain to Big Cedar Lake and thus these areas within these subbasins were removed from the revised watershed. Consequently, the revised 2020 watershed, including Big Cedar and Gilbert Lakes, has a total area of 6,273 acres. Revision of the watershed and subbasin boundaries is described in greater detail in the "Updated Subbasins, Pollutant Loads, and Pollutant Load Reduction Goals" section.

LAND USE

Prior to European settlement, the watershed's vegetation was dominated by maple-basswood-red oak forest. Additional vegetation communities included nearly 500 acres of beech-maple forest in the northwestern corner, a 32 acre strip of lowland hardwoods near the southern end of the watershed, as well as approximately 168 combined acres of conifer swamp found southwest of Mueller Lake, along the eastern shore of Gilbert Lake, and at the Lake outlet to Cedar Creek. Following European settlement in the mid-1800s, most lands in the watershed were converted throughout the 19th and 20th centuries into predominantly agricultural and residential uses.

1995 Land Use

The 1995 land use data reported in Table 5 of MR 137 indicates that 3,056 acres were occupied by agricultural uses or were vacant, 746 acres were occupied by residential uses, and 2,360 acres were occupied by wetland, woodland, or surface water (including the acreages of Gilbert Lake and Big Cedar Lake). All other land uses combined occupied 476 acres. Agricultural and vacant lands were the most dominant land use in Subbasin 6, 8, 11, 12, and 15. Subbasin 15, which at 1,392 acres is substantially larger than the other subbasins, had the highest total acreage in agricultural use or vacant, totaling 995 acres. Residential uses were most dominant in Subbasins 3, 5, and 16, with Subbasin 15 also having the highest total acreage of residential lands at 88.8 acres. Combined wetlands and woodlands were the most dominant in Subbasin 18, while Subbasin 13 had the highest total combined acreage at 231 acres.

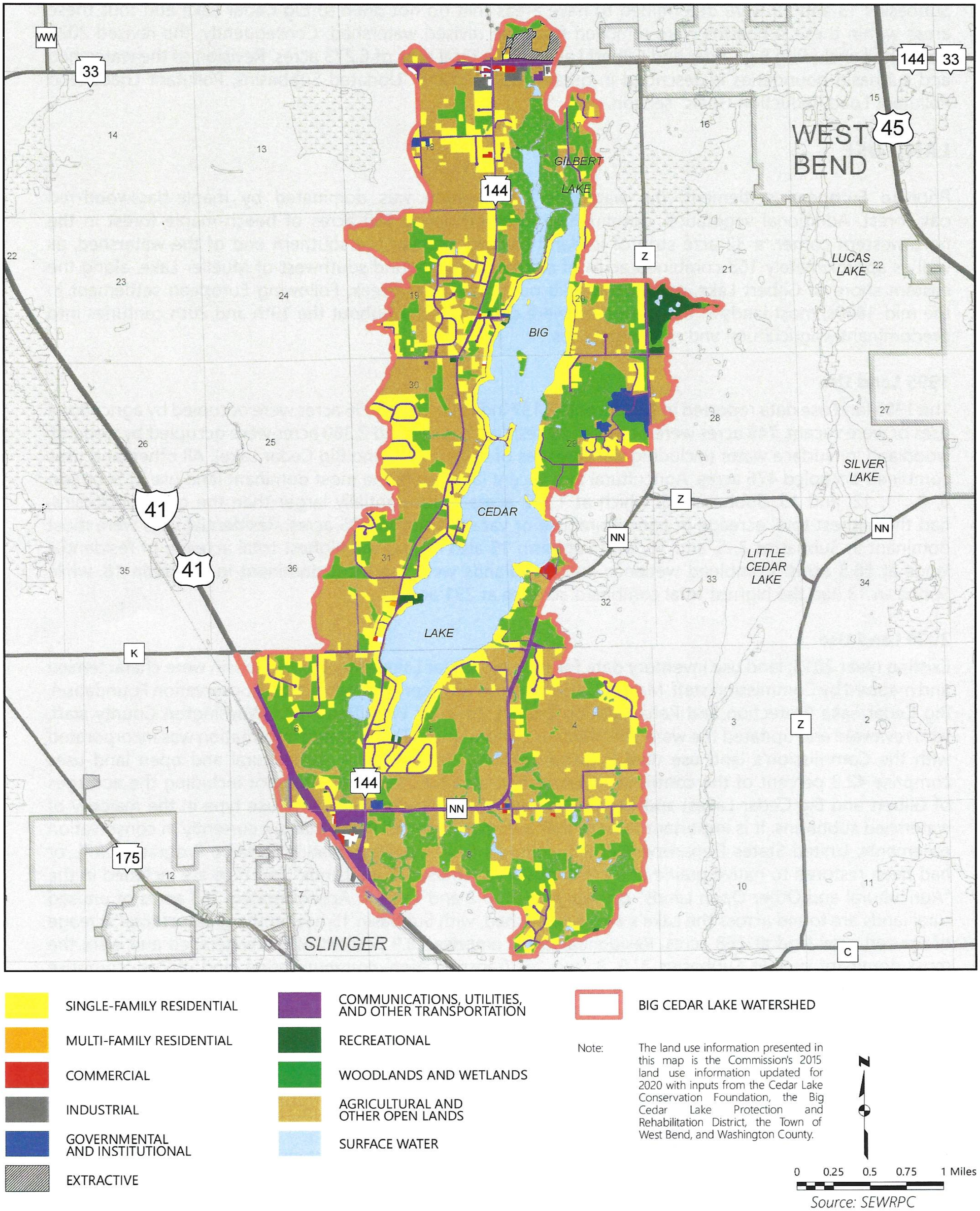
2020 Land Use

Existing (year 2015) land use inventory data for each Big Cedar Lake watershed subbasin were characterized and mapped by Commission staff. Maps of 2015 land use were sent to Cedar Lakes Conservation Foundation, Big Cedar Lake Protection and Rehabilitation District, Town of West Bend, and Washington County staff, who reviewed and updated the watershed land use information. This updated information was incorporated with the Commission's land use data to produce Map 2 and Table 1. Agricultural and open land uses comprise 42.3 percent of the contributing watershed area (i.e., the watershed not including the acreages of Gilbert and Big Cedar Lakes) and these uses were the most dominant land use type in the majority of watershed subbasins. It is important to note that previously farmed lands that are currently in conservation easements, United States Department of Agriculture's (USDA's) Conservation Reserve Program (CRP), or had been restored to native prairie and are considered "Unused Rural Lands" and thus are included in the "Agricultural and Other Open Lands" category on Map 2 and Table 1. Approximately 763 acres of unused rural lands are found across the Lake's entire watershed, with Subbasin 15 having the greatest total acreage of unused rural land at 268 acres. Residential uses comprise 18.9 percent of the watershed and were the most dominant uses in Subbasins 3, 5, 8, and 16. Transportation, communication, and utilities comprise 7.9 percent of the watershed and are evenly distributed across all the subbasins. All other urban land uses combined comprise less than three percent of the watershed. Woodlands comprise 19.1 percent of the watershed and were the most dominant land use in Subbasins 13, 17, 18, and 20, while wetlands comprise another 8.0 percent. Surface waters, not including Big Cedar Lake and Gilbert Lake, comprise 0.8 percent of the watershed.

Changes in Land Use Mapping and Classification

It is important to recognize that land use mapping and classification has substantially changed since the 1995 land use inventory was conducted and then discussed in MR 137. Consequently, it is difficult to provide an exact accounting of the differences in watershed land use between these dates. The most significant of these changes include: 1) the digitization of the land use inventory in 2000 to match real property boundaries,

Map 2
Land Uses in the Big Cedar Lake Watershed Current as of 2020



Source: SEWRPC

Table 1
Big Cedar Lake Watershed Generalized Land Use by Subbasin: 2020

	Big Cedar Lake Water Subbasin																			
Land Use Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Agricultural and Open Lands	168.4	312.5	5.7	90.1	3.3	95.2	32.0	48.6	64.6	61.3	91.4	42.3	131.4	163.2	814.5	11.7	58.0	31.5	119.3	38.9
Commercial	5.6	1.2	--	0.3	0.2	--	--	--	--	--	--	0.6	2.6	--	1.3	--	4.9	--	--	--
Extractive	33.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Governmental and Institutional	--	3.8	0.1	0.7	--	--	--	--	--	--	--	--	0.9	1.1	1.7	--	--	24.0	1.1	--
Industrial	15.3	--	--	--	--	0.3	--	--	--	--	--	--	6.9	--	--	--	--	--	0.3	0.3
Recreational	0.3	0.0	--	0.9	--	--	--	--	--	4.8	0.1	--	1.3	1.3	1.1	0.1	--	0.2	55.8	--
Residential	34.2	86.9	18.9	66.2	12.7	62.4	23.4	55.7	41.6	60.3	12.8	16.4	120.3	44.4	166.8	30.9	49.2	72.1	38.3	49.6
Transportation, Communication, and Utilities	41.3	23.8	1.4	21.9	1.5	18.6	4.8	8.5	8.1	17.3	5.1	7.3	113.2	32.1	53.0	3.2	24.5	26.0	23.0	10.6
Water	2.3	2.0	--	1.6	--	0.1	0.2	0.3	--	--	--	--	14.0	2.8	14.3	--	--	0.7	4.6	1.1
Wetlands	41.8	76.2	4.1	0.6	--	2.4	--	4.1	--	1.2	--	--	97.7	52.3	70.2	--	14.9	19.7	29.6	35.1
Woodlands	36.2	52.0	4.9	43.6	0.6	25.4	5.5	8.1	15.6	45.1	20.7	5.3	138.8	83.3	268.9	8.4	61.8	141.4	55.8	54.3
Total	378.8	558.4	35.0	225.8	18.3	204.5	66.0	125.3	129.8	190.0	130.0	71.9	627.0	380.5	1,391.8	54.3	213.1	315.6	328.0	190.0

Note: This land use includes the updated information provided by staff from the Cedar Lakes Conservation Foundation, Big Cedar Lake Protection and Rehabilitation District, and Washington County.

Source: CLCF, BCLPRD, Washington County, and SEWRPC

2) completion of the Wisconsin Wetland Inventory in 2005 provided greater accuracy and precision for wetland areas and consequently increased total reported wetland acreages, and 3) reclassification of "Lands Under Development" and "Vacant Lands" into different land use groups. These changes are explained in greater detail below.

The digitization of land use mapping, including matching uses to real property boundaries, increased the precision of the land use inventory and made it more usable to public agencies and private interests throughout Southeastern Wisconsin. As a result of the change, however, land use inventory data from the year 2000 and onward are not strictly comparable with data from the 1995 and prior inventories. The most significant effect of this change was to increase the transportation, communication, and utilities category, due to the use of expanded estimated right-of-ways compared to earlier inventories. This land use category increased by 90.7 acres between 1995 and 2020 land use for the Lake watershed. However, it is difficult to determine exactly how much of this increase is due to road construction compared to the change described above. Additionally, the change to match real property boundaries also resulted in a slight shifting of total acreages between the subbasins of the Big Cedar Lake watershed for 2020 compared to the 1995 subbasin acreages. The total acreage of the watershed was unaffected by this change. The change to match real boundaries also required the redelineation of all waterbodies in the Region. Consequently, Gilbert Lake and Big Cedar Lake were combined into essentially one waterbody with a total area of 1,001 acres (955 acres for Big Cedar Lake and 46 acres for Gilbert Lake).

As part of the Wisconsin Department of Natural Resources (WDNR) Wisconsin Wetland Inventory, beginning in the year 2005, wetlands were mapped to a much finer scale and greater level of detail (more wetland categories) than in prior inventories. This change increased the accuracy and precision of wetland mapping throughout Southeastern Wisconsin. As a result of the change, however, year 2015 wetland inventory data are not directly comparable with data from the year 2000 and prior inventories. Lands classified as wetlands increased by 67.9 acres for the Lake watershed between the 1995 and 2020 land uses, with some of this increase likely due to an increase in the number of wetlands, farmed wetlands reverting to wetlands due to inactivity/abandonment of agricultural cultivation activities, and expanded boundaries within pre-existing wetland areas. However, wetland acreage decreased in Subbasins 4, 7, and 13, potentially related to residential housing and roadway construction.

The 1995 generalized land use inventory includes the categories of "Lands Under Development" and "Vacant Lands." The "Lands Under Development" category has since been split into the Residential; Commercial; Industrial; Communication, Utilities, and Other Transportation; Governmental and Institutional; and Recreational classifications depending on the intent for development. Similarly, the "Vacant Lands" classification was split into unused rural and unused urban lands, which are categorized under "Agricultural and Open Lands" on Table 1 and Map 2. Within the Big Cedar Lake watershed, over 517 acres were classified as "Vacant Lands" in the 1995 land use while 10.4 acres were classified as "Lands Under Development." The 2020 land use classification identified no lands that would have been classified as "Lands Under Development" while 768 acres would have been classified as "Vacant Lands" using the 1995 land use category protocol.

Differences Between 1995 and 2020 Land Use

Considering the classification and mapping changes described above, the Big Cedar Lake watershed has undergone a shift from cultivated agricultural lands towards more residential development and unused rural land. Between 1995 and 2020, the acreage of cultivated land decreased from 2,261 to 1,164 acres, a 51.4 percent decrease. During this same time period, the acreages of residential land use increased from 745 to 1,063 acres (a 29.9 percent increase) while unused rural land use increased from 512 to 763 acres (a 32.9 percent increase). Hence, not more than 30 percent of the loss in cultivated lands appears associated with residential development throughout the watershed. As described previously, "unused rural lands" include conservation easements, native prairie, and CRP so this shift may reflect increased use of these conservation practices within the watershed. An increase in woodland acreages from 832 to 1,068 acres may also reflect conservation practices and expanding forestland associated with agricultural land abandonment. Aside from the aforementioned change in the wetlands and transportation, communication, and utilities categories, only slight changes are noted in the remaining land use categories since 1995.

POLLUTANT LOADING

Actual and perceived water quality issues are generally high priority concerns to lake and stream resource managers, residents, and waterbody users. Excessive pollutants entering the Lake from various sources could degrade water quality over time. The most prevalent pollutants entering waterbodies include sediment and nutrients, both of which have natural sources and sources that are attributable to human activity. Sediment and nutrient loads can greatly increase when humans disturb land cover and runoff patterns through activities such as tilling and construction, both of which typically loosen soil, increase runoff and in turn allow soil to more easily erode and eventually enter streams and lakes. Phosphorus is a key nutrient for aquatic plants and algae, with the availability of phosphorus often limiting their growth and abundance. On the other hand, excessive phosphorus concentrations promote heavy algal growth, which leads to reduced water clarity and dissolved oxygen concentrations that do not adequately support healthy and desirable aquatic life. Sources of phosphorus can vary across a watershed. Fertilizers, animal manure, and phosphorus adhering to eroded soil particles are dominant phosphorus sources in rural areas. Stormwater collection and conveyance systems and onsite wastewater treatment systems contribute much of the phosphorus delivered to waterbodies from urban areas.

1995 Pollutant Loading

In MR 137, Commission staff utilized the unit area load (UAL) model to model pollutant loads to Big Cedar Lake based on the 1995 land use data. The UAL model estimates total pollutant loading to the Lake using land use information and a range of loading rates for different types of land uses. Table 2 shows the modeled annual total phosphorus and sediment loads (pounds and tons per year, respectively) and loading rates (pounds and tons per acre per year, respectively) using 1995 land use information from the contributing watershed, i.e., not including loading directly to the Lake surface. The 1995 modeled pollutant loading indicated that 669 tons of suspended sediment, 2,400 pounds of total phosphorus, 45.8 pounds of copper, 176.3 pounds of zinc, and 0.49 pounds of cadmium enter the Lake from nonpoint sources annually.[2] The estimates reported in MR 137 include 250 pounds of phosphorus contributed by precipitation and dry atmospheric fallout over the Lake surface but contributions from these sources were not calculated for the other pollutants. Subbasin 15, the largest and most rural subbasin, had the largest loads of phosphorus and sediment (see Table 2). Subbasin 1, which had the most acreage in commercial and industrial uses, had the highest heavy metal loads. Point source pollutant loads, such as discharge from industrial and municipal wastewater treatment plants, are not found within the watershed. Therefore, nonpoint source loads are the sole pollutant contributor to the Lake.

In MR 137, Commission staff used the Wisconsin Lake Modeling Suite (WiLMS) model created by WDNR with hydrologic and morphometric information, including lake size, volume, mean depth, and residence time, to estimate phosphorus loading and in-lake phosphorus concentrations via the Vollenweider-type Organization for Economic Cooperation and Development (OECD) phosphorus budget model. Agreement between the modeled and observed in-lake phosphorus concentrations, which ranged between 6 to 69 micrograms per liter (ug/l), led to the confirmation that the estimated pollutant loading was reasonable.

2020 Pollutant Loading

Commission staff used the updated 2020 land use inventory as input data for the UAL model to estimate present-day pollutant loads in the Big Cedar Lake watershed. The modeled annual total phosphorus and sediment loads and loading rates using 2020 land use data from the contributing watershed, i.e., not including pollutant loading directly to the surface of Big Cedar Lake or Gilbert Lake, are shown in Table 2. The UAL model estimates that 534 tons of sediment, 2,071 pounds of total phosphorus, 30 pounds of copper, 171 pounds of zinc, and 1.2 pounds of cadmium are delivered to Big Cedar Lake, including atmospheric deposits to the Lake surface, under updated 2020 land use conditions. Map 3 illustrates phosphorus loading estimated by the UAL model for each watershed subbasin. UAL model output indicates that Subbasins 2, 11, and 12 have the highest phosphorus and sediment loading per acre (see Figures 1 and 2). Subbasins 2 and 15, which are large subbasins dominated by agricultural and residential uses, contribute the greatest amount of total phosphorus and sediment to the Lake (see Figures 3 and 4). In contrast, Subbasin 20 had the lowest annual phosphorus (0.1 pounds per acre) and sediment (0.01 tons per acre) loading rates.

---

[2] *MR 137 reports an annual total phosphorus load of 2,340 pounds in the text, but the subbasin totals in Table 6 of MR 137 combined with the 250 pounds of phosphorus contributed to the Lake surface total 2,400 pounds.*

Table 2
Big Cedar Lake Watershed Phosphorus and Sediment Loading by Subbasin: 1995 Versus 2020

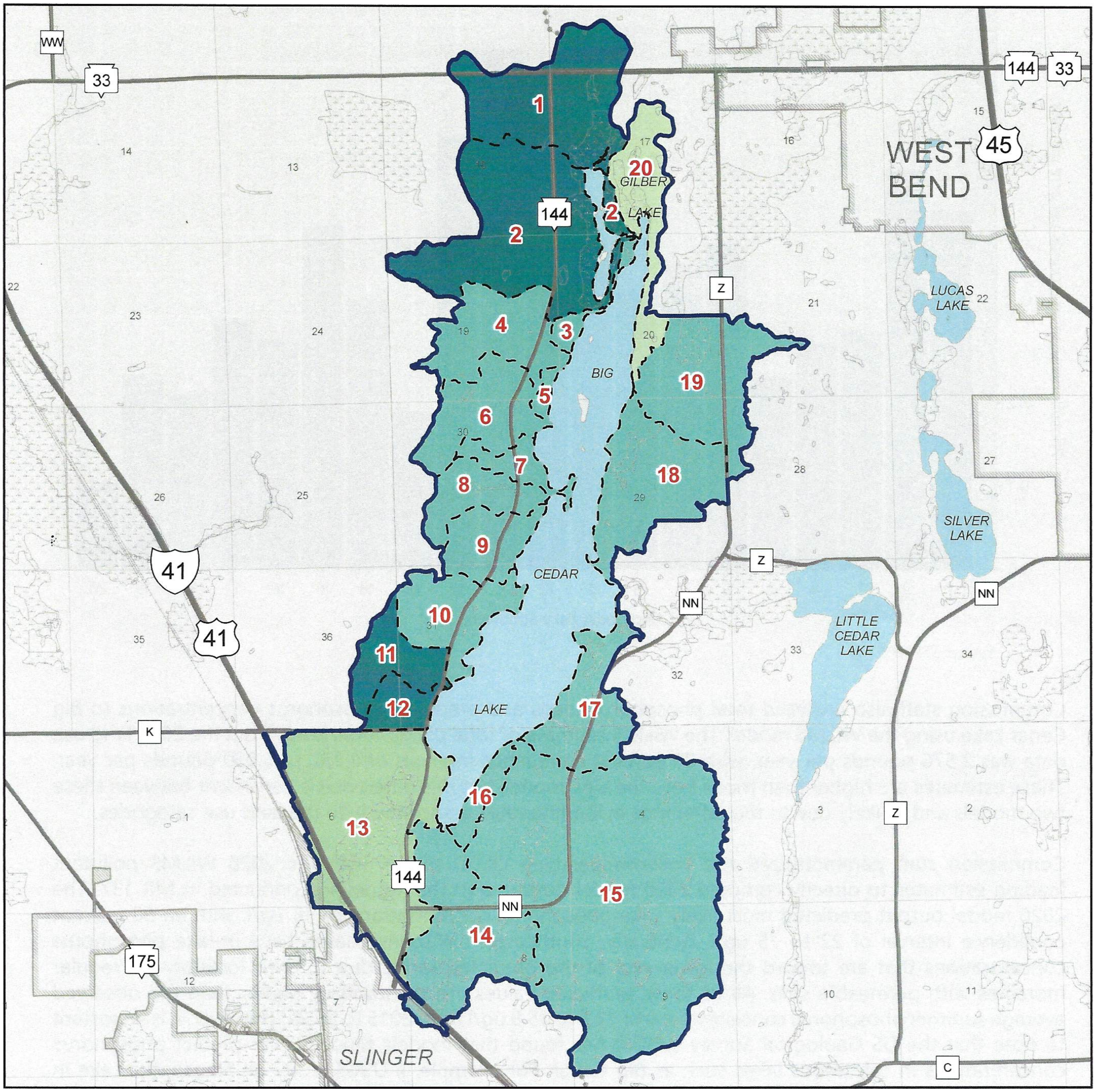
		Big Cedar Lake Watershed Subbasin																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total[a]
Subbasin Area (Acres)	1995	379.1	561.4	36.0	226.0	19.2	204.4	70.6	125.3	130.5	188.2	129.9	71.5	627.3	380.8	1,392	58.1	221.7	314.7	327.8	191.8	5,656
	2020	378.8	558.4	35.0	225.8	18.3	204.4	66.0	125.3	129.8	189.0	130.0	71.9	627.0	380.5	1,392	54.3	213.1	315.6	328.0	190.0	5,633
	Difference	-0.3	-2.9	-1.0	-0.2	-0.9	0	-4.6	0	-0.7	0.8	0.1	0.4	-0.3	-0.3	0	-3.8	-8.6	0.9	0.2	-1.8	-23
Total Phosphorus Loading (lbs/year)	1995	181.0	242.2	7.2	100.0	4.6	104.0	25.0	64.1	47.7	65.6	66.1	38.1	152.0	175.0	589.0	15.9	62.7	60.7	102.0	46.5	2,149
	2020	163.6	266.3	10.0	60.8	4.2	79.1	24.0	41.5	46.1	67.1	80.3	36.9	118.0	122.1	568.2	14.7	63.5	77.3	76.4	19.9	1,940
	Difference	-17.4	24.1	2.8	-39.2	-0.4	-24.9	-1	-22.6	-1.6	-1.5	14.2	-1.2	-34	-52.9	-20.8	-1.2	0.8	16.6	-25.6	-26.6	-212
Phosphorus Loading Rate (lbs/acre/year)	1995	0.48	0.43	0.20	0.44	0.24	0.51	0.35	0.51	0.37	0.35	0.51	0.53	0.24	0.46	0.42	0.27	0.28	0.19	0.31	0.24	0.37
	2020	0.43	0.48	0.29	0.27	0.23	0.39	0.36	0.33	0.36	0.36	0.62	0.51	0.19	0.32	0.41	0.27	0.30	0.24	0.23	0.10	0.33
	Difference	-0.05	0.05	0.09	-0.17	-0.01	-0.12	0.01	-0.18	-0.01	0.01	0.11	-0.02	-0.05	-0.14	-0.01	0.00	0.02	0.05	-0.08	-0.14	-0.03
Sediment Loading (tons/year)	1995	62.6	78.0	2.5	31.2	1.7	36.4	8.6	23.7	19.7	20.0	21.7	11.6	32.5	40.0	209.2	3.8	18.2	8.2	27.0	12.8	669.4
	2020	41.8	64.4	2.0	12.1	0.7	17.7	5.4	8.2	10.0	14.6	20.3	9.0	26.1	28.5	134.7	2.5	14.6	12.6	13.1	1.8	440.1
	Difference	-20.8	-13.5	-0.5	-19.1	-1.0	-18.7	-3.3	-15.4	-9.7	-5.4	-1.4	-2.5	-6.4	-11.5	-74.5	-1.3	-3.5	4.4	-13.9	-11.0	-229.3
Sediment Loading Rate (tons/acre/year)	1995	0.17	0.14	0.07	0.14	0.09	0.18	0.12	0.19	0.15	0.11	0.17	0.16	0.05	0.11	0.15	0.07	0.08	0.03	0.08	0.07	0.12
	2020	0.11	0.12	0.06	0.05	0.04	0.09	0.08	0.07	0.08	0.08	0.16	0.13	0.04	0.07	0.10	0.05	0.07	0.04	0.04	0.01	0.07
	Difference	-0.06	-0.02	-0.01	-0.09	-0.05	-0.09	-0.04	-0.12	-0.07	-0.03	-0.01	-0.03	-0.01	-0.04	-0.05	-0.02	-0.01	0.01	-0.04	-0.06	-0.05

Note: The difference is calculated as the 2020 pollutant loads subtracted by the 1995 pollutant loads. Thus, negative numbers indicate lower modeled pollutant loading in 2020 than in 1995. Note that modeled differences reflect both changes in how the Commission's land use is mapped and classified as well as actual land use change within the watershed. Additionally, this Table does not include phosphorus or sediment contributed to the Lake via atmospheric deposition onto the Lake surface or contributed by islands within the Lake.

[a] *This column indicates the row sum for the Subbasin Area, Total Phosphorus Loading, and Sediment Loading categories while it indicates the row average for the Phosphorus Loading Rate and Sediment Loading Rate categories.*

Source: SEWRPC

Map 3
Modeled Average Annual Nonpoint Total Phosphorus (TP) Loading Among Subbasins Within the Big Cedar Lake Watershed: 1995 Watershed Boundaries



TP (LBS/ACRE/YEAR)

0.03 - 0.10

0.11 - 0.20

0.21 - 0.40

0.41 - 0.60

BIG CEDAR LAKE WATERSHED

BIG CEDAR LAKE WATERSHED SUBBASINS

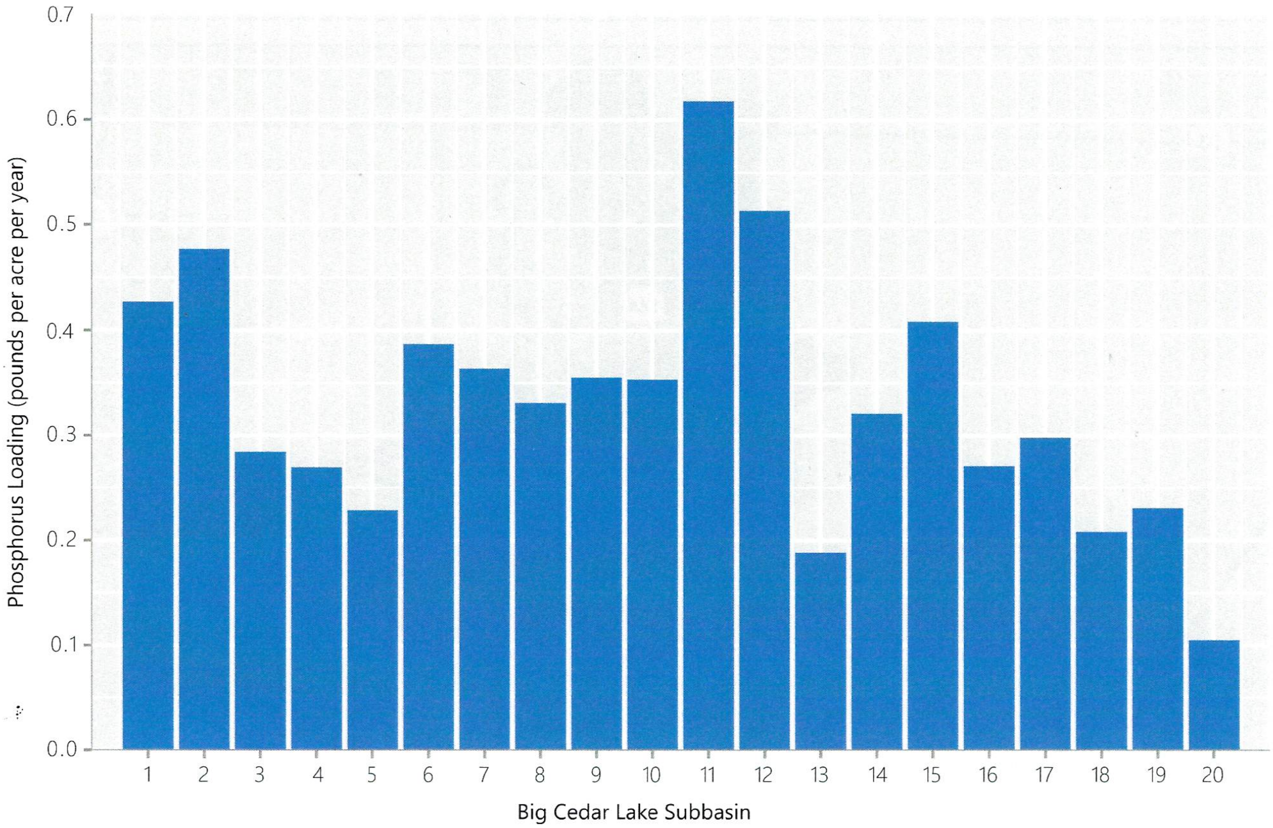
Note: The illustrated phosphorus loading rates represent the average phosphorus loading rate per acre for each subbasin from the Commission's Unit Area Loading (UAL) model.

N

0 0.25 0.5 0.75 1 Miles

Source: SEWRPC

Figure 1
2020 Big Cedar Lake Watershed Modeled Phosphorus Loading per Acre



Source: SEWRPC

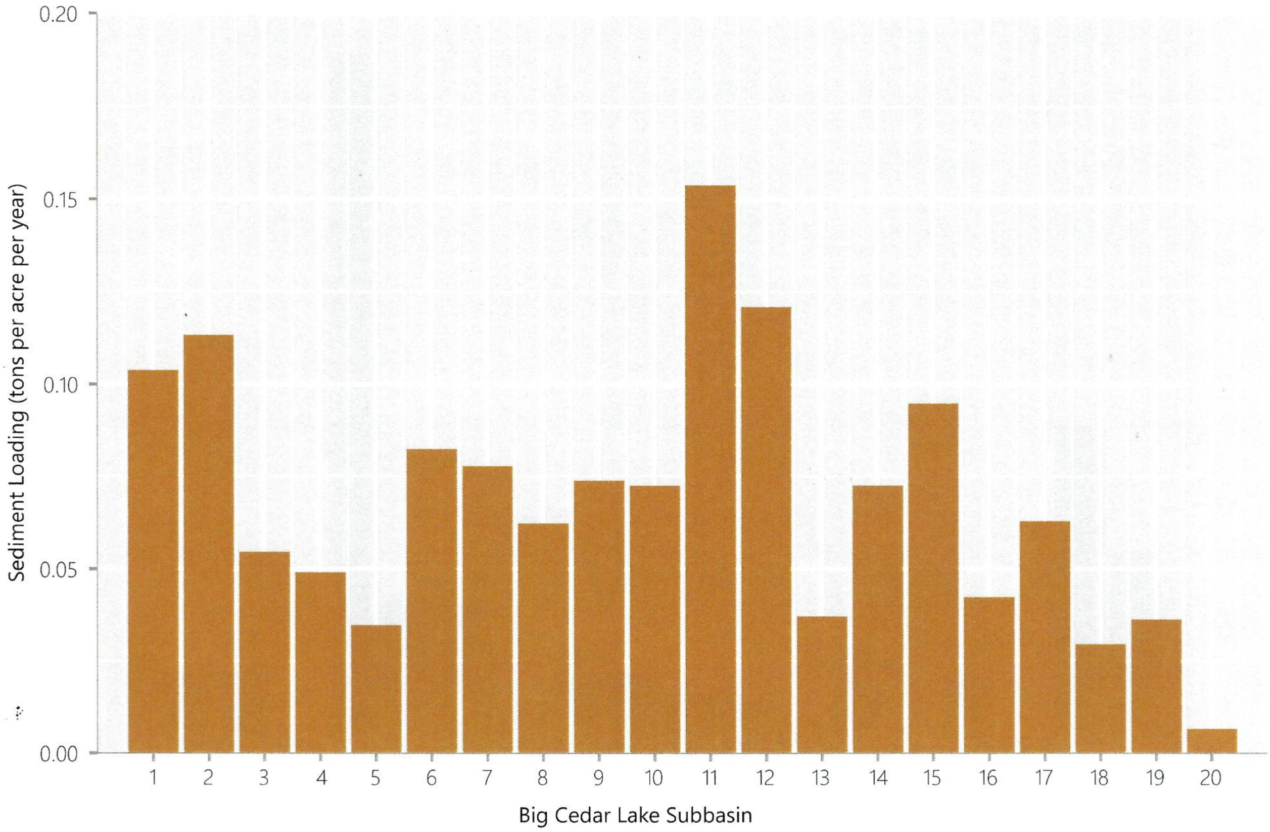
Commission staff also analyzed total phosphorus loads and predicted phosphorus concentrations to Big Cedar Lake using the WiLMS model. The WiLMS estimate of total phosphorus loads from the 2020 land use data was 2,576 pounds per year, with 80 percent confidence intervals of 1,332 to 5,950 pounds per year. These estimates are higher than those from the UAL model, but this difference is consistent between these two models and is likely due to the difference in loading rates associated with the land use categories.

Commission staff parameterized the Vollenweider-type OECD model with the 2020 WiLMS pollutant loading estimates to directly compare 2020 model output with the modeling conducted in MR 137. The 2020 model output predicted most likely Lake phosphorus concentrations of 38 ug/l, with an 80 percent confidence interval of 22 to 75 ug/l. Generally, Southeastern Wisconsin lakes have in-lake phosphorus concentrations that are toward the lower end of the predicted range due to their location in irregular moraines with permeable soils. All of these predicted values are substantially higher than the observed average summer phosphorus concentrations of 12.8 to 15.8 ug/l from 2015 to 2020.[3] However, it is important to note that the US Geological Survey (USGS) has found that models tend to over-predict phosphorus concentrations in calcareous lakes such as Big Cedar. For example, a USGS study on Nagawicka Lake in Waukesha County found that the predicted concentrations from the WiLMS lake models consistently over predicted phosphorus by a factor of 2.2.[4] The USGS authors attributed this discrepancy as likely due to the co-precipitation of phosphorus with calcite and the sequestration of phosphorus in deep sediments that occurs in calcareous lakes. Accounting for this over prediction using the WiLMS "low" estimate results in a phosphorus concentration of 10 ug/l, which is closer to but lower than the observed Lake values.

[3] *For more information on Big Cedar water quality monitoring, see the Narrative Reports at the following link: dnr.wi.gov/lakes/waterquality/Station.aspx?id=673206.*

[4] *Herbert S. Garn, Dale M. Robertson, William J. Rose, Gerald L. Goddard, and Judy A. Horwatich., Water Quality, Hydrology, and Response to Changes in Phosphorus Loading of Nagawicka Lake, a Calcareous Lake in Waukesha County, Wisconsin, U. S. Geological Survey, Scientific Investigations Report 2005-5273, 2006, pubs.usgs.gov/sir/2006/5273/.*

Figure 2
2020 Big Cedar Lake Watershed Modeled Sediment Loading per Acre



Source: SEWRPC

Commission staff also used the UAL loading rate of 2,071 pounds per year as an input to the Vollenweider-type OECD model to compare predicted lake phosphorus concentrations with observed concentrations. The most likely predicted lake phosphorus concentration was 31 ug/l, with an 80 percent confidence interval of 18 to 63 ug/l. Applying the 2.2 over prediction factor to the most likely predicted value results in a value of 14.1, which is within the range observed between 2015 and 2020. Consequently, these Lake concentration results would indicate that the actual phosphorus loading rate may be closer to the UAL estimate of 2,071 pounds per year than the WiLMS estimate of 2,576 pounds per year. The UAL loading estimates were thus used for the comparison between 1995 and 2020 pollutant loading with the Big Cedar Lake watershed.

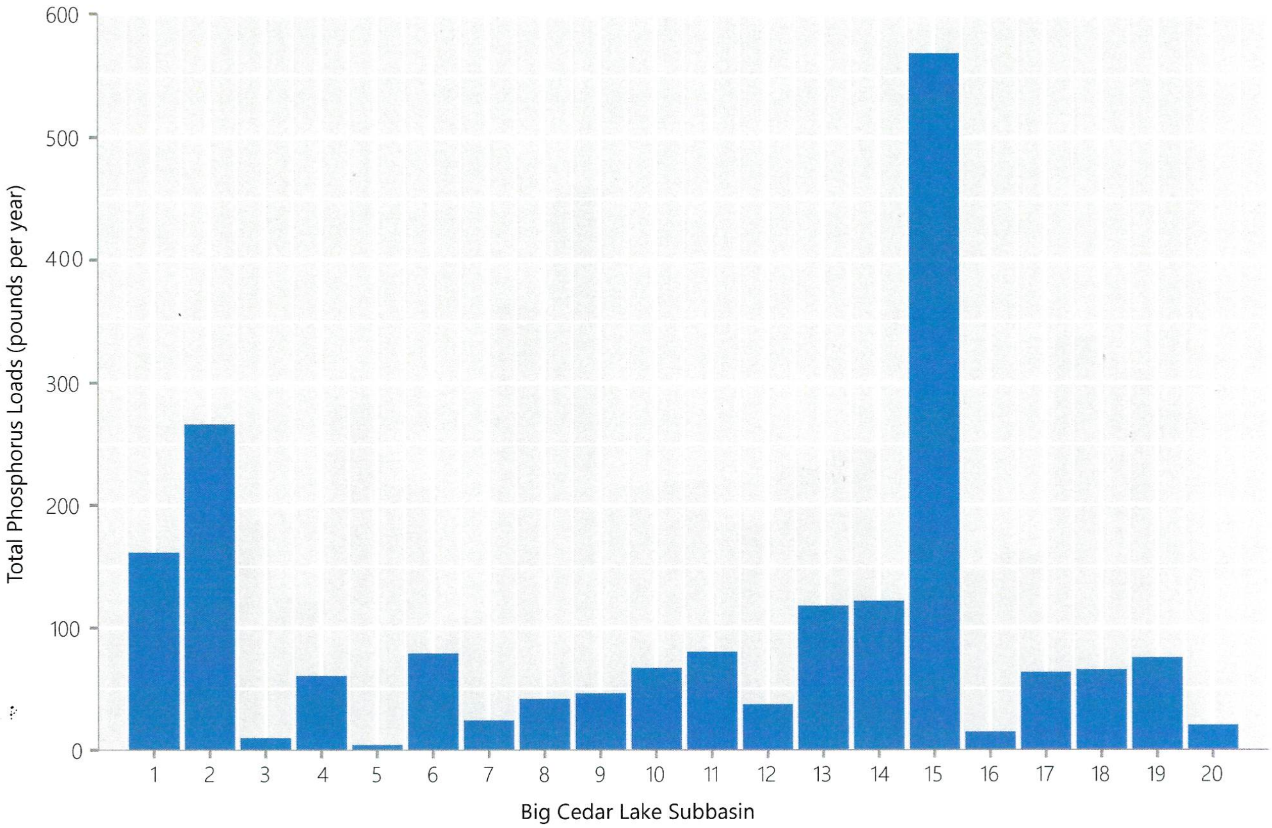
Changes in Pollutant Loading

Since the UAL pollutant loading model is based on the Commission's land use information, the same changes in land use mapping that affected comparisons between the 1995 and 2020 land use data also affect comparison of watershed pollutant loading. As an added effect, there are different land use categories used for the UAL model with the 2020 land use data compared with the 1995 land use data, in part due to the land use classification changes described above. Thus, the differences described are provided with the caveat that these differences may not be entirely attributed to actual changes in pollutant loading as changes in land use classification and pollutant load modeling are also incorporated.

MR 137 estimated annual loadings of 669 tons of sediment and 2,400 pounds of total phosphorus to the Lake from its contributing watershed.[5] Comparing the 1995 annual loadings from MR 137 to the 2020 UAL loading indicates that modeled annual sediment loading has decreased by 229 tons of sediment (a 20 percent decrease) while phosphorus loading decreased 400 pounds (a 14 percent decrease). These load reductions are consistent with the shifting watershed land uses from intensive agricultural use to fewer intensive uses, such as conservation easements, CRP, woodland, and prairie. More land classified as

[5] *SEWRPC MR 137, 2001*, op. cit.

Figure 3
2020 Big Cedar Lake Watershed Modeled Total Phosphorus Loads by Subbasin



Source: SEWRPC

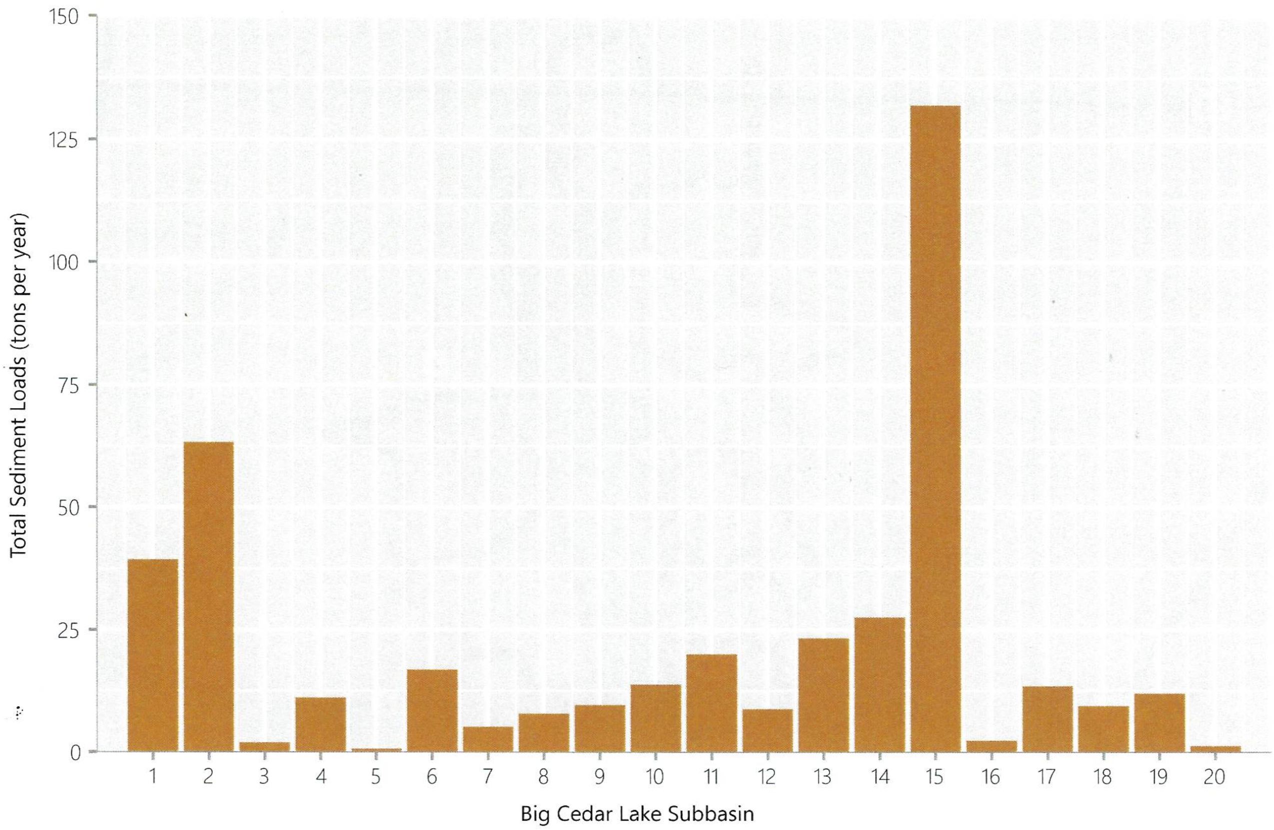
wetlands following the Wisconsin Wetland Inventory update also likely contributed to reduced modeled phosphorus and sediment loading. As shown in Table 2, modeled sediment loading has decreased in every subbasin except Subbasin 18, while phosphorus loading has decreased in every subbasin except Subbasins 2, 3, 11, 17, and 18. Subbasins 2 and 18, where phosphorus loading increased the most, had slight declines in woodland acreage between 1995 and 2020, while agricultural and residential land use acreages increased. Changes in phosphorus loading in Subbasins 3, 11, and 17 were negligible and may be attributed to the aforementioned differences in Commission land use mapping rather than actual land use changes in the watershed.

Watershed loading of copper and zinc decreased by 16 and 5 pounds, respectively, between 1995 and 2020. Cadmium loading increased from 0.49 to 1.2 pounds during this time period. Loading of these metals is generally contributed by urban and transportation land uses. Changes in land use mapping and classification, particularly to roadside areas, are likely having a greater influence on the metals load modeling than the small changes in urban land uses that actually occurred within the watershed.

UPDATED SUBBASINS, POLLUTANT LOADS, AND LOAD REDUCTION GOALS

Given the significant improvements in available topographical information since 1995 and hydrologic changes within the watershed, the Commission has revised the boundaries of the Big Cedar Lake watershed and Subbasins 1, 13, and 19 as well as identified significant internally drained areas (see Map 4). Internally draining areas are still considered part of the watershed, but they do not contribute to surface water runoff to Big Cedar Lake. These revisions, discussed in the following paragraphs, decreased the total watershed area by 368 acres. The revised boundaries better reflect the current hydrology of the watershed and thus are a more accurate framework for evaluating land use and pollutant loading information than the boundaries presented in MR 137. Updated land use and pollutant loading information using these revised boundaries is presented later in this section.

Figure 4
2020 Big Cedar Lake Watershed Modeled Watershed Total Sediment Loads by Subbasin



Source: SEWRPC

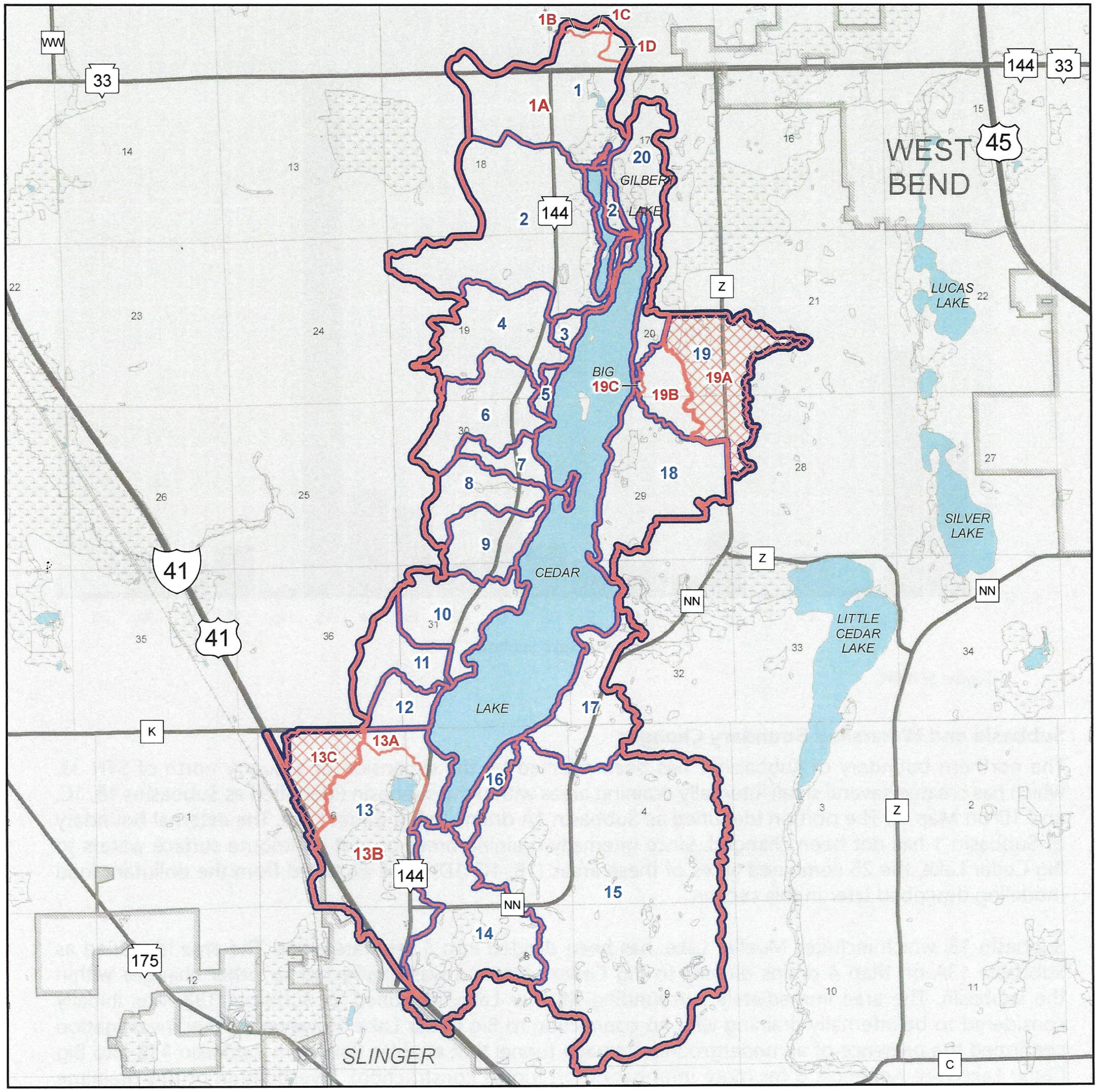
Subbasin and Watershed Boundary Changes

The northern boundary of Subbasin 1 has been affected by the expansion of a quarry north of STH 33, which has created several small internally draining areas within the subbasin (identified as Subbasins 1B, 1C, and 1D on Map 4). The portion identified as Subbasin 1A drains to Big Cedar Lake. The external boundary of Subbasin 1 has not been changed. Since internally draining areas do not contribute surface waters to Big Cedar Lake, the 26 combined acres of these areas (1B, 1C, 1D) were excluded from the pollutant load modeling described later in this section.

Subbasin 13, which includes Mueller Lake, has been divided into 3 separate areas. The area identified as Subbasin 13A on Map 4 drains directly to Big Cedar Lake and was unaffected by other changes within the subbasin. The area immediately surrounding Mueller Lake, identified as Subbasin 13B, was initially considered to be internally draining with no connection to Big Cedar Lake. However, further investigation confirmed the presence of an underground drainage tunnel that enables flow from Subbasin 13B into Big Cedar Lake (see Appendix B for more information on tunnel construction). Investigation of this drainage tunnel to assess its condition and confirm its inlet and outlet would be warranted for a future study. Subbasin 13C was determined to drain through a culvert under IH 41 towards the East Branch of the Rock River. Consequently, Subbasin 13C (126 acres) was removed from the Big Cedar Lake watershed.

MR 137 indicated the area identified as Subbasin 19B on Map 4 was internally draining while the area denoted as Subbasin 19A was recommended to be removed from the Big Cedar Lake watershed, as that area was determined to drain into the Washington Creek subwatershed. During the preparation of this staff memorandum, Subbasin 19B was found to discharge into Big Cedar Lake via a pond outlet drain (see Figure 5) and therefore it is no longer considered to be internally draining. Additionally, Subbasin 19B increased by five acres to account for home construction along Century Hills Court that altered local drainage pathways. The MR 137 recommendation that the area marked as Subbasin 19A should be excluded from the Big Cedar Lake drainage area and included in the Washington Creek subwatershed was accounted

Map 4
Big Cedar Lake Watershed and Subbasins: 1995 and Revised 2020 Watershed Boundaries



REVISED DATA

- BIG CEDAR LAKE WATERSHED BOUNDARY
- SUBBASIN BOUNDARY
- REMOVED SUBBASIN
- 13A SUBBASIN REFERENCE NUMBER

1995 DATA

- BIG CEDAR LAKE WATERSHED BOUNDARY
- SUBBASIN BOUNDARY
- 16 SUBBASIN REFERENCE NUMBER

N

0 0.25 0.5 0.75 1 Miles

Source: SEWRPC

Figure 5
Subbasin 19B Drainage Path and Outlet to Big Cedar Lake

Note: The orange arrow in the top image indicates the flow path from sub-basin 19B to Big Cedar Lake. The bottom image is a picture of the outlet drain into Big Cedar Lake at the end of this path. Aerial imagery in the top image is from 2015.

Source: SEWRPC

for in this revision. Consequently, the revised Subbasin 19 and watershed boundaries reflect the removal of Subbasin 19A (242 acres). The area identified as Subbasin 19C on Map 4 drains directly to Big Cedar Lake and was unaffected by other changes in Subbasin 19.

Updated Land Use and Pollutant Loading

The 2020 land use inventory with the revised subbasin and watershed boundaries, including internally drained areas but excluding the surface area of Big Cedar Lake, Gilbert Lake, and islands within Big Cedar Lake, is presented in Table 3. Through this revision, 368 acres were removed from the watershed in Subbasins 13 and 19 while another 26 acres of the watershed were recognized as internally draining and thus did not contribute to the watershed pollutant load modeling. Agricultural, residential, and woodland land uses were the largest decreases with the removal of 126 acres from Subbasin 13. Subbasin 19, which decreased in area from 328 to 86 acres, saw significant declines in every land use category including total removal of government and institutional, recreational, and wetland land uses. It is important to recognize that these declines do not indicate a change in the land use of these areas, but instead that these areas are no longer considered part of the Big Cedar Lake watershed.

The updated pollutant loading information for each subbasin is presented in Table 4. Using the 2020 land use within the revised watershed boundaries, including pollutant loading directly to the Lake surface, total UAL-modeled phosphorus and sediment loading decreased to 1,991 pounds per year and 520 tons per year, respectively, while WiLMS-modeled total phosphorus loading decreased to 2,462 pounds per year. These decreases are attributed to the smaller watershed size and recognition of internally drained areas that do not contribute pollutant loads to Big Cedar Lake in Subbasins 1, 13, and 19. Subbasins 1, 13, and 19 had decreased total phosphorus and sediment loads, but Subbasins 1 and 13 had slight increases in their total phosphorus and sediment loading per acre (see Map 5). Using the UAL-modeled total phosphorus loading as input for the Vollenweider-type OECD model resulted in predicted lake phosphorus concentrations of 17 ug/l using the "low" scenario. These concentrations are near the observed concentrations of 12.8 to 15.8 ug/l within the Lake.

Cadmium, copper, and zinc loading decreased to 1.0, 25.5, and 154.4 pounds per year, respectively, with the revised watershed boundaries. These decreases reflect the removal of extractive, residential, and transportation land uses from the contributing watershed with the removal of acres in Subbasins 13 and 19 and the designation of internally draining acres in Subbasin 1.

A summary of the total pollutant loads for the 1995, 2020, and revised 2020 land use and watersheds is presented in Table 5. Apart from a slight increase in cadmium loading, pollutant loading has decreased across the watershed between 1995 and the revised 2020 land use and watershed boundaries. As previously discussed, this decrease likely reflects actual changes in land use, including increased acreage of lands in conservation practices, as well as changes to the Commission's land use mapping and pollutant loading model application. Table 5 also indicates the subbasins with the highest total loading and the highest loading per acre for the revised 2020 land use and watershed. Subbasin 15 had the highest total loading for phosphorus and sediment while Subbasin 11 had the highest loading per acre of these pollutants. Subbasin 13 had the highest total loading and loading per acre for cadmium, copper, and zinc. This updated land use and pollutant loading should be used for future pollutant load reduction and conservation planning efforts as it best reflects the current conditions in the watershed.

Load Reduction Goals

As part of the Milwaukee River Basin, the Big Cedar Lake watershed is addressed in the Milwaukee River TMDL that was approved in 2018.[6] This TMDL addresses impairments such as oxygen depletion, excessive algae growth, reduced populations of submerged aquatic vegetation, water clarity problems, and degraded habitat resulting from high concentrations of total phosphorus (TP) and total suspended solids (TSS). It is important to note that although Big Cedar Lake is not listed as impaired, it does discharge into Cedar Creek, which has been listed as impaired since 2014. The TMDL established annual baseline nonpoint source loads

---

[6] *CDM Smith, On Behalf of: Wisconsin Department of Natural Resources and Milwaukee Metropolitan Sewerage District,* Final Report: Total Maximum Daily Loads for Total Phosphorus, Total Suspended Solids, and Fecal Coliform in the Milwaukee River Basin, Wisconsin, *Prepared for: U.S. Environmental Protection Agency Region 5, March 2018. See website at dnr.wi.gov/topic/TMDLs/Milwaukee.*

Table 3
Generalized Land Use for Revised Big Cedar Lake Watershed and Subbasin Boundaries: 2020

	Big Cedar Lake Water Subbasin																			
Land Use Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Agricultural and Open Lands	168.4	312.5	5.7	90.1	3.3	95.2	32.0	48.6	64.6	61.3	91.4	42.3	105.1	163.2	814.5	11.7	58.0	31.5	48.3	38.9
Commercial	5.6	1.2	--	0.3	0.2	--	--	--	--	--	--	0.6	2.5	--	1.3	--	4.9	--	--	--
Extractive	33.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Governmental and Institutional	--	3.8	0.1	0.7	--	--	--	--	--	--	--	--	0.9	1.1	1.7	--	--	24.0	--	--
Industrial	15.3	--	--	--	--	0.3	--	--	--	--	--	--	6.9	--	--	--	--	--	0.3	0.3
Recreational	0.3	0.0	--	0.9	--	--	--	--	--	4.8	0.1	--	1.3	1.3	1.1	0.1	--	0.2	--	--
Residential	34.2	86.9	18.9	66.2	12.7	62.4	23.4	55.7	41.6	60.3	12.8	16.4	90.0	44.4	166.8	30.9	49.2	72.1	8.4	49.6
Transportation, Communication, and Utilities	41.3	23.8	1.4	21.9	1.5	18.6	4.8	8.5	8.1	17.3	5.1	7.3	85.8	32.1	53.0	3.2	24.5	26.0	4.8	10.6
Water	2.3	2.0	--	1.6	--	0.1	0.2	0.3	--	--	--	--	14.0	2.8	14.3	--	--	0.7	1.6	1.1
Wetlands	41.8	76.2	4.1	0.6	--	2.4	--	4.1	--	1.2	--	--	97.7	52.3	70.2	--	14.9	19.7	--	35.1
Woodlands	36.2	52.0	4.9	43.6	0.6	25.4	5.5	8.1	15.6	45.1	20.7	5.3	96.9	83.3	268.9	8.4	61.8	141.4	22.6	54.3
Total	378.8	558.4	35.0	225.8	18.3	204.5	66.0	125.3	129.8	190.0	130.0	71.9	501.1	380.5	1,391.8	54.3	213.1	315.6	85.7	190.0

Note: This land use table includes the same updated land use information presented in Table 1 but for the revised watershed and subbasin boundaries. Only Subbasins 13 and 19 had areas removed following the watershed boundary revisions.

Source: CLCF, BCLPRD, Washington County, and SEWRPC

Table 4
Total Phosphorus and Sediment Loading for Revised Big Cedar Lake Watershed and Subbasin Boundaries: 2020

		Big Cedar Lake Watershed Subbasin																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total[a]
Contributing Subbasin Area (Acres)[b]	2020	378.8	558.4	35.0	225.8	18.3	204.4	66.0	125.3	129.8	189.0	130.0	71.9	627.0	380.5	1,392	54.3	213.1	315.6	328.0	190.0	5,633
	Revised	352.7	558.4	35.0	225.8	18.3	204.4	66.0	125.3	129.8	189.0	130.0	71.9	501.1	380.5	1,392	54.3	213.1	315.6	85.7	190.0	5,239
	Difference	-26.1	0	0	0	0	0	0	0	0	0	0	0	-125.9	0	0	0	0	0	-242.3	0	-394
Total Phosphorus Loading (lbs/year)	2020	163.6	266.3	10.0	60.8	4.2	79.1	24.0	41.5	46.1	67.1	80.3	36.9	118.0	122.1	568.2	14.7	63.5	77.3	76.4	19.9	1,940
	Revised	161.3	266.3	10.0	60.8	4.2	79.1	24.0	41.5	46.1	67.1	80.3	36.9	103.4	122.1	568.2	14.7	63.5	77.3	10.8	19.9	1,858
	Difference	-2.3	0	0	0	0	0	0	0	0	0	0	0	-14.6	0	0	0	0	0	-65.6	0	-83
Phosphorus Loading Rate (lbs/acre/year)	2020	0.43	0.48	0.29	0.27	0.23	0.39	0.36	0.33	0.36	0.36	0.62	0.51	0.19	0.32	0.41	0.27	0.30	0.24	0.23	0.10	0.33
	Revised	0.46	0.48	0.29	0.27	0.23	0.39	0.36	0.33	0.36	0.36	0.62	0.51	0.21	0.32	0.41	0.27	0.30	0.24	0.13	0.10	0.33
	Difference	0.03	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	-0.10	0	0
Sediment Loading (tons/year)	2020	41.8	64.4	2.0	12.1	0.7	17.7	5.4	8.2	10.0	14.6	20.3	9.0	26.1	28.5	134.7	2.5	14.6	12.6	13.1	1.8	440
	Revised	41.7	64.4	2.0	12.1	0.7	17.7	5.4	8.2	10.0	14.6	20.3	9.0	23.8	28.5	134.7	2.5	14.6	12.6	1.2	1.8	426
	Difference	-0.1	0	0	0	0	0	0	0	0	0	0	0	-2.3	0	0	0	0	0	-11.9	0	-14
Sediment Loading Rate (tons/acre/year)	2020	0.11	0.12	0.06	0.05	0.04	0.09	0.08	0.07	0.08	0.08	0.16	0.13	0.04	0.07	0.10	0.05	0.07	0.04	0.04	0.01	0.07
	Revised	0.12	0.12	0.06	0.05	0.04	0.09	0.08	0.07	0.08	0.08	0.16	0.13	0.05	0.07	0.10	0.05	0.07	0.04	0.01	0.01	0.07
	Difference	0.01	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	-0.03	0	0

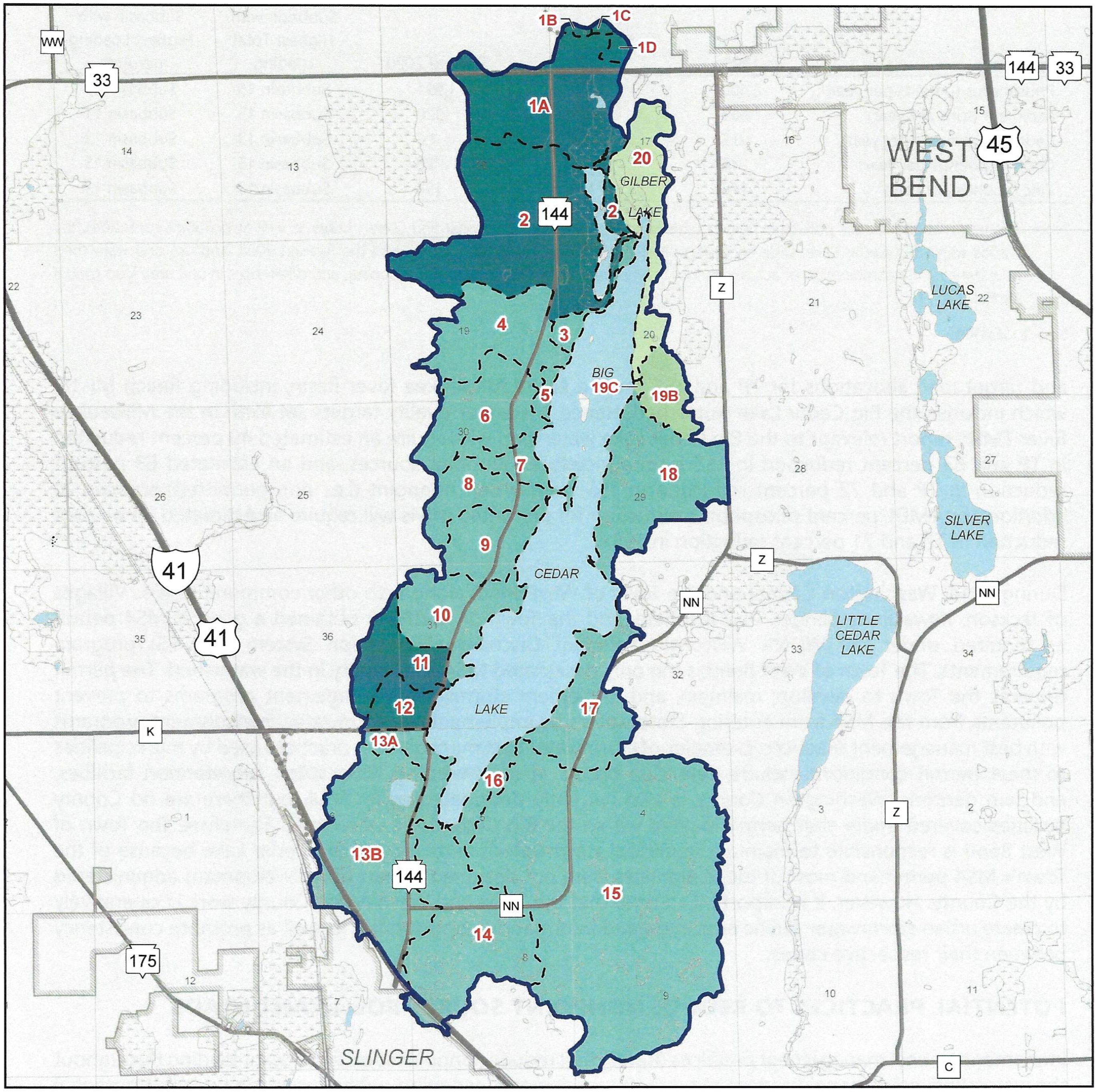
Note: The Difference is calculated as the revised watershed pollutant loads (revised) subtracted by the 2020 pollutant loads using the MR 137 watershed (2020). Thus, negative numbers indicate lower modeled pollutant loading in the revised watershed. Subbasins 1, 13, and 19 were the only subbasins affected by the boundary revisions.

[a] *This column indicates the row sum for the Contributing Subbasin Area, Total Phosphorus Loading, and Sediment Loading categories. It indicates the row average for the Phosphorus Loading Rate and Sediment Loading Rate categories.*

[b] *Contributing Subbasin Area does not include acreages that were designated as internally draining with the revised 2020 watershed boundary.*

Source: SEWRPC

Map 5
Modeled Average Annual Nonpoint Total Phosphorus (TP) Loading Among Subbasins Within the Revised 2020 Big Cedar Lake Watershed Boundaries



TP (LBS/ACRE/YEAR)

- 0.03 - 0.10
- 0.11 - 0.20
- 0.21 - 0.40
- 0.41 - 0.60

BIG CEDAR LAKE WATERSHED

BIG CEDAR LAKE WATERSHED SUBBASINS

Note: The illustrated phosphorus loading rates represent the average phosphorus loading rate per acre for each subbasin from the Commission's Unit Area Loading (UAL) model.

0 0.25 0.5 0.75 1 Miles

Source: SEWRPC

Table 5
Pollutant Loading Summary for Revised Big Cedar Lake Watershed and Subbasin Boundaries

Pollutant	Land Use and Watershed Boundaries 1995	2020	Revised 2020	Loading from Revised 2020 Watershed Boundaries: Subbasin with Highest Total Loading	Subbasin with Highest Loading per Acre
Phosphorus (pounds per year)	2,400	2,071	1,991	Subbasin 15	Subbasin 11
Sediment (tons per year)	669	534	520	Subbasin 15	Subbasin 11
Cadmium (pounds per year)	0.5	1.2	1.0	Subbasin 13	Subbasin 13
Copper (pounds per year)	46	30	26	Subbasin 13	Subbasin 13
Zinc (pounds per year)	176	171	154	Subbasin 13	Subbasin 13

Note: This information includes pollutants loaded directly to the surface of Big Cedar and Gilbert Lakes as well as pollutant contributed by islands within Big Cedar Lake. Differences in pollutant loading between 1995, 2020, and the Revised 2020 land use and watershed boundaries are a combination of actual changes in land use, differences in land use mapping, and differences in unit area load model application.

Source: SEWRPC

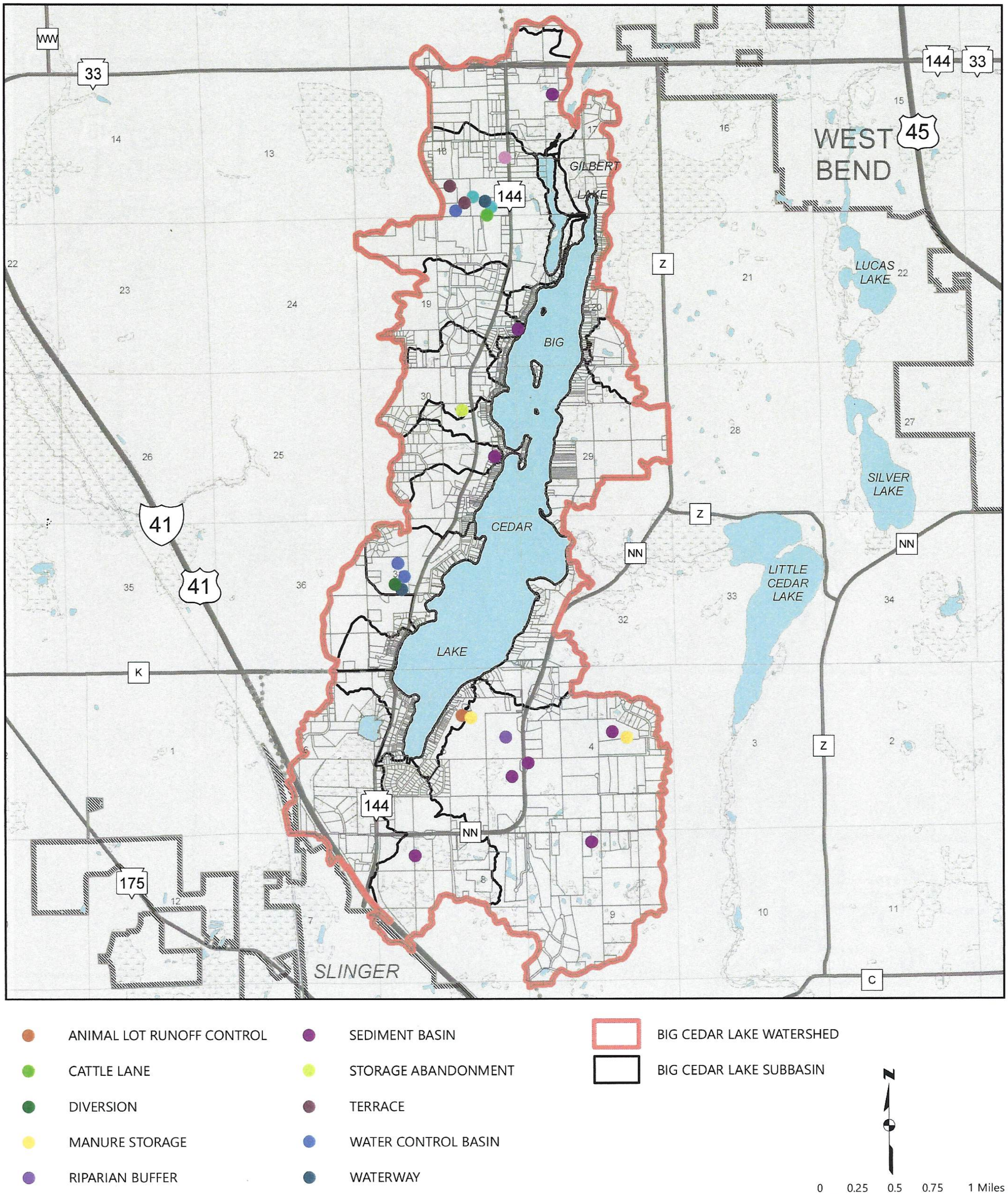
and target load allocations for TP and TSS for the entire Milwaukee River Basin, including Reach MI-18, which includes the Big Cedar Lake watershed. Hence, the water quality targets set forth in the Milwaukee River TMDL report relevant to the Big Cedar Lake watershed will require an estimated 40 percent reduction in TP and 63 percent reduction in TSS from agricultural nonpoint sources, and an estimated 69 percent reduction in TP and 72 percent reduction in TSS from urban nonpoint (i.e., non-permitted) sources. In addition, the TMDL percent phosphorus reduction for permitted MS4s will require an estimated 68 percent reduction in TP and 71 percent reduction in TSS.

During 2014, Washington County and the Town of West Bend, along with other communities (i.e., Villages of Jackson, Kewaskum, Slinger, and Richfield, and the Town of Hartford) obtained a general MS4 permit as required under the WDNR Wisconsin Pollutant Discharge Elimination System (WPDES) program requirements. The Town of West Bend is the only designated MS4 community in the watershed. The permit requires the Town to develop, maintain, and implement stormwater management programs to prevent pollutants from the MS4 from entering State waters by implementing stormwater management programs with best management practices. Examples of stormwater best management practices used by municipalities to meet permit conditions include detention basins, street sweeping, filter strips, bioretention facilities, and rain gardens. Washington County is also currently designated as an MS4, but there are no County facilities covered under that permit located within the Big Cedar Lake watershed. Therefore, the Town of West Bend is responsible to maintain municipal stormwater ponds around Big Cedar Lake because of the Town's MS4 permit and most of those practices were not designed as part of a development administered by the County. However, it is important to note that the Town and Washington County work cooperatively to create urban stormwater public education and information opportunities as well as promote consistency between their respective codes.

POTENTIAL PRACTICES TO REDUCE NONPOINT SOURCE POLLUTANT LOADS

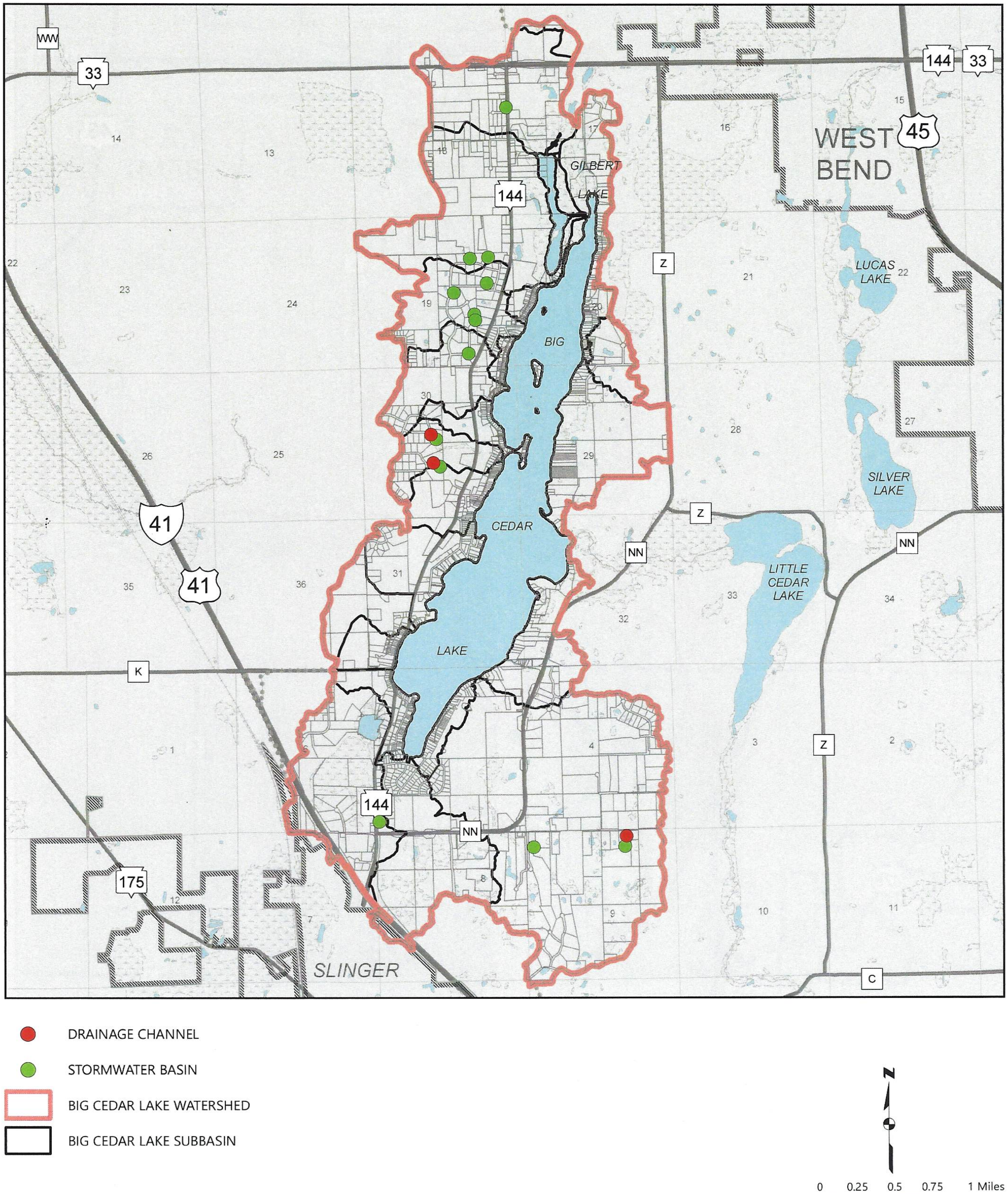
Implementing best management practices (BMPs) that reduce nonpoint source pollutant loading throughout the watershed, educational programming, and broadening/deepening public support have great potential for protecting the health of Big Cedar Lake. Strong partnerships that adopt programmatic approaches meaningfully contribute to long-lasting pollutant reduction. Reducing nonpoint sources of phosphorus and sediment from agricultural land uses in the Big Cedar Laker watershed is a major priority for the BCLPRD, the CLCF, and other organizations involved in improving water quality, including the Town of West Bend and Washington County. These organizations have supported BMP implementation in the form of conservation practices (see Map 6) and stormwater management practices (see Map 7) across the watershed. These conservation practices include efforts to reduce pollutant loading specifically from animal operations, such as cattle lanes and manure storage, as well as practices that reduce loading from other agricultural and residential land uses, such as riparian buffers and sediment basins. These practices are most abundant in heavily agricultural Subbasins 2 and 15. Thirteen stormwater basins and three drainage channels have also

Map 6
Soil Conservation Practices in the Big Cedar Lake Revised Watershed Current as of 2020



Source: Washington County and SEWRPC

Map 7
Stormwater Management Practices in the Big Cedar Lake Revised Watershed Current as of 2020



Source: Washington County and SEWRPC

been constructed within the watershed to mitigate pollutant loads delivered to the Lake with stormwater runoff. In addition to these practices, the CLCF has also been implementing conservation easements and establishing prairie vegetation in undeveloped parcels across the Big Cedar Lake watershed.[7] Continued support of BMP implementation, along with education and outreach efforts about reducing nonpoint source pollution, will help protect the hydrological and ecological integrity of Big Cedar Lake.

Several recommendations from MR 137 are still relevant, and recent developments of the Milwaukee River TMDL and WPDES programs have helped to establish target load reduction goals for permitted and non-permitted nonpoint source loads in the Big Cedar Lake watershed area as summarized above. In addition, based upon the pollutant load assessment summarized above and the percent load reduction goals from agricultural and urban nonpoint sources, significant opportunities remain to meet or exceed pollutant load reduction goals in this watershed. Hence, in addition to the recommendations laid out in the MR 137, it is further recommended that the BCLPRD continue to collaborate with partners to improve existing stormwater management practices and establish new BMPs to help achieve or exceed the percent nonpoint source reduction goals for urban and agricultural areas draining to Big Cedar Lake. Examples of these additional concepts are provided below.

Urban Areas

Plan and Educate Stakeholders in Collaboration with Local Municipalities

The BCLPRD should consider working with the Town of West Bend and Washington County's stormwater management program for EPA and NR 216 stormwater permit requirements. The BCLPRD should strive to meet or exceed requirements of their respective WPDES MS4 Permits by improving existing BMPs and/or to develop information and education opportunities (e.g., training workshops and/or demonstration projects).

Enhance Existing and Planned Stormwater Management Infrastructure

Stormwater runoff quality can often be improved by retrofitting current infrastructure. This is often most conveniently done when existing infrastructure needs repair or replacement. For example, straight roadside ditches and swales that feed directly into a waterbody can be regraded to gently and gradually disperse water into vegetated upland and wetland areas. This change helps trap sediment and nutrients that would previously have been discharged directly into the Lake or streams leading to the Lake.

Runoff speed and stormwater volume should be reduced whenever possible. Runoff should be detained and/or infiltrated when practical. Many opportunities exist to achieve this goal. While few are large in scale, widespread application of small-scale practices can have profound results. For example, widespread adoption of environmentally friendly residential stormwater practices could significantly alter stormwater runoff patterns and quality. A simple example includes revamping roadside runoff patterns to reduce direct runoff into waterbodies. Ditch turnouts and ditch checks are examples of practices that can help public and private roadway managers to achieve this goal. Example design guidance is provided in Appendix C. Roadway practices obviously require active participation by the Town of West Bend, private road owners, and adjacent landowners.

Reduce Pollutant Loads from Residential Areas

Residential areas, especially waterfront properties, can contribute appreciable pollutant loads to lakes and streams. Not only are waterfront properties commonly densely populated and heavily influenced by human activity, their location reduces the chance that pollutants emanating from these areas can be intercepted before entering waterbodies. While many residential activities can contribute sediment, nutrients, and other pollutants to waterbodies, privately owned wastewater treatment systems (POWTS), winter deicing, and landscaping activities are perhaps the most common examples.

As most of the watershed is not within a sewer service area, POWTS may be an important ongoing contributor to Big Cedar Lake's overall ongoing pollutant load. The dense road network in portions of the watershed may also be a significant source of sediment and other pollutants to the Lake. Creating ditch turnouts and ditch checks as well as diverting runoff from impervious surfaces (e.g., driveways, rooftops) into heavily vegetated areas can help mitigate these pollutant loads. In addition to these actions, reducing the mass of

[7] *For more information on CLCF properties, see www.conservecedarlakes.org/wp-content/uploads/2020/04/2019-August-Large-CLCF-Map-with-parcel-numbers-and-OWLT-colors-NO-LOGO-2.pdf.*

chloride-based road deicing salt applied to roadways, driveways, and walks can help reduce chloride loads to the Lake.[8]

Intensely "manicured" landscapes, an aesthetic favored by many property owners, often utilize more fertilizer and pesticides on a per-acre basis than agricultural lands. Given that many of the Region's waterbodies are ringed by residential properties, and that runoff from these properties often drains directly to waterbodies, the collective load to lakes and streams can by quite high. Furthermore, some property owners burn leaves and brush near the water's edge allowing nutrients contained in ash to easily enter waterbodies. Actions that can help alleviate these loads include the following examples.

- Establish or enhance shoreline buffers
- Direct Lake-direct runoff through buffers and rain gardens
- Encourage stormwater infiltration through appropriate lawn care
- Avoid pollutant leaks and spills in and around homes
- Prohibit burning and disposal of yard waste near lake and stream shorelines
- Minimize chloride-based deicer use

Communicating best management practices and engaging in a campaign to encourage their use (e.g., offering to pick up grass clipping or leaves) will incrementally reduce water quality problems. Mitigating residential area pollutant loads is a high priority, especially given the direct impact that shoreline residents, who have a vested interest in Lake health, can have on Big Cedar Lake's water quality.

Agricultural Areas

Collaborate with Producer-Led Groups

Producer-led watershed groups are a relatively recent innovation that has greatly enhanced the ability to enhance sustainable agriculture and allied conservation practices in Wisconsin. Producer-led groups sponsor programs that endeavor to improve soil health, water quality, and farm profitability by a variety of means, including the following examples.

- Recruiting producers to apply for and install low-cost conservation BMPs to improve soil and water quality
- Providing education and outreach (field days, workshops, tours) to area producers about the principles of soil health, soil improvement practices and water quality improvement conservation practices
- Improving the image of agriculture by showcasing various local leadership, outreach activities, farm and/or field signs and being active in the community promoting good farming practices.

Many producer-led groups are now present in Wisconsin, including the Cedar Creek watershed. Cedar Creek Farmers is a very active producer-led group in the Cedar Creek watershed within Washington County.[9]

The BCLPRD and/or other interested organizations are encouraged to actively participate in producer-led initiatives. Some conservation-themed organizations actively support local producer-led groups by offering financial and logistical support to the initiative. Examples of financial support include stipends to offset

---

[8] *Pavement deicing activities can be made more efficient in several ways, reducing the amount of salt applied during a winter season. Many organizations, including the Commission, are studying the impact of chloride on the environment and methods that can be taken to reduce the effect of road deicing on water quality. Sources of information abound on the internet. For example, the WDNR discusses road deicing at the following URL: dnr.wi.gov/wnrmag/2010/02/salt.htm.*

[9] *More information about the Cedar Creek Farmers producer-led group may be found at the following URL: www.co.washington.wi.us/default.iml?mdl=print_detail.mdl&DetailID=1224.*

tuition and fees associated with key educational events, purchasing key equipment which is often a barrier to initiating soil health practices and leasing this equipment to producers, and offering subsidies to help offset the cost of conservation practices.

Sponsor Grant Applications

The BCLPRD, county, and/or other local units of government may apply for grants from WDNR to control NPS pollution and meet the TMDL load allocation. The WDNR supports NPS pollution abatement by administering and providing cost-sharing grants to fund BMPs through various grant programs, including, but not limited to:[10]

- The Targeted Runoff Management Grant Program
- The Notice of Discharge Grant Program
- The Urban Nonpoint Source & Storm Water Management Grant Program
- The Lake Planning Grant Program
- The Lake Protection Grant Program
- The River Planning & Protection Grant Program

---

[10] *CDM Smith, March 2018, (see section 7.2.4.2 WDNR Cost-Sharing Grant Programs for more details) Op. cit.*

APPENDICES

APPENDIX A

REQUEST LETTER FROM BIG CEDAR LAKE PROTECTION AND REHABILITATION DISTRICT FOR PLAN UPDATE

12/16/19
Laura Herrick
Chief Environmental Engineer
SEWRPC
W239 N1812 Rockwood Dr.
Waukesha, WI. 53187-1607

Ms. Herrick

We understand that you have been in communication with the Big Cedar Lake Property Owners Association. The discussion has centered around an update the *Water Quality and Stormwater Plan for Big Cedar Lake.* Also known as MR 137.

The Big Cedar Lake Protection and Rehabilitation District is requesting that the plan be reviewed and updated for the twenty subbasins as detailed in the 2001 report.

It is understood that this work is done at no cost to the PRD.

Please keep the PRD and the BCLPOA periodically informed of your progress.
If there is any additional data needed to complete the report please let us know. We may be able to provide.

Thank You,

BCLPRD

12/16/19
Laura Herrick
Chief Environmental Engineer
SEWRPC
W239 N1812 Rockwood Dr.
Waukesha, WI. 53187-1607

Ms. Herrick

We understand that you have been in communication with the Big Cedar Lake Property Owners Association. The discussion has centered around an update the *Water Quality and Stormwater Plan for Big Cedar Lake.* Also known as MR 137.

The Big Cedar Lake Protection and Rehabilitation District is requesting that the plan be reviewed and updated for the twenty subbasins as detailed in the 2001 report.

It is understood that this work is done at no cost to the PRD.

Please keep the PRD and the BCLPOA periodically informed of your progress.
If there is any additional data needed to complete the report please let us know. We may be able to provide.

Thank You,

BCLPRD

NEWS ARTICLE ON MUELLER LAKE DRAINAGE TUNNEL

APPENDIX B

Source: Don Kosterman, West Bend News Vol. 199, No. 130, June 2nd, 1973.

History of Polk Tunnel Cloudy

BY DON KOSTERMAN
News Staff Writer

A manmade drain tunnel, approximately three-quarters of a tile long, links two Washington County lakes and apparently spans some 100 years of county history, going back further than most memories can relate.

The tunnel slips quietly under State 144 between Mueller's Lake and the southern end of Big Cedar Lake and is unknown to all but the residents under whose land it passes and a few nearby oldtimers.

There are three manholes which emerge from the drain tunnel to the surface and they lead some 18 feet to the drain below, the circumference of which is not known. What is known is that the tunnel links the two lakes and allows excess water from Mueller's Lake drain off into Cedar Lake.

The existence of the drain came to light recently when land belonging to the estate of William Jaeschke, which borders Cedar Lake, was sold to Raymond Geiger. The land had three cottages on it and was to be parceled for sale.

A check with the register of deeds for the county by George Nehrbass, Town of Polk clerk, revealed that there was an easement through the land for the drain. At an appeals board meeting more information was brought out about the tunnel and the lots were drawn up to keep 50 feet from the drain with construction or sewage.

The lots are along Highland Park Drive, south of the Sandy Beach Resort, and the five original non-conforming lots were divided into three because of the tunnel's passage below.

The history of the drain is not documented in any records as yet found but the story, collaborated by a number of residents, is an interesting one.

The drain tunnel is said to have been dug and constructed by hand around the 1870s to drain water from the Mueller Lake area. The job was reported done by the Soo Line which had a track going through the area to the Cedar Lake Station. High water in the spring caused the train problems so control of the lake's level was sought.

Labor for the project was provided by prisoners brought up daily by rail from Milwaukee who dug in the 18 foot deep, three-quarter mile long tunnel, placing the manholes along the way. The manholes themselves represent quite a job as they are brick laid with metal rungs up their sides.

Cedar Lake Station was located on what is now the southwest corner of State 144 and County NN and it had served the various hotels situated around Big Cedar Lake.

Since the tunnel was placed, the level of Mueller's Lake has remained relatively constant and in spring water can be seen rushing into Big Cedar Lake from the outlet below the lake's surface. Another provision provided for when the tunnel was placed, according to residents, was that the farmer using the field through which the tumel passed could use the manholes to draw up water for his stock.

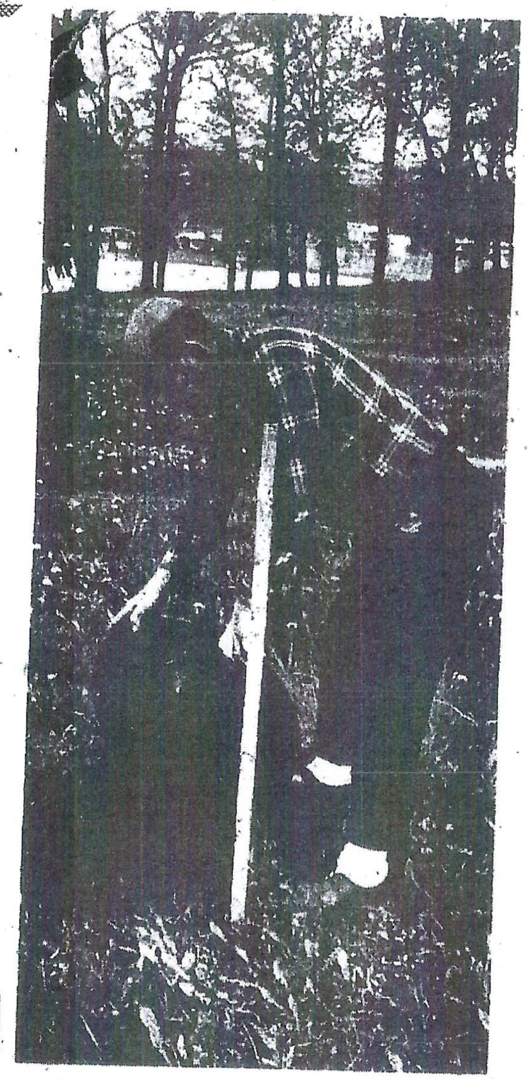
More Pictures On Page Seven

Today a water tower stands over one of the manholes and Jonathan Schultz uses a pump to draw water for plants in his garden. The 1,000 gal. tank stands over a drain tunnel about which he knows only hand-me-down information.

Another story about the tunnel has it that originally no Northern Pikes were caught in Big Cedar, but only in Mueller's Lake. After the tunnel they evidently found their way into the much larger body of water.

West Bend News

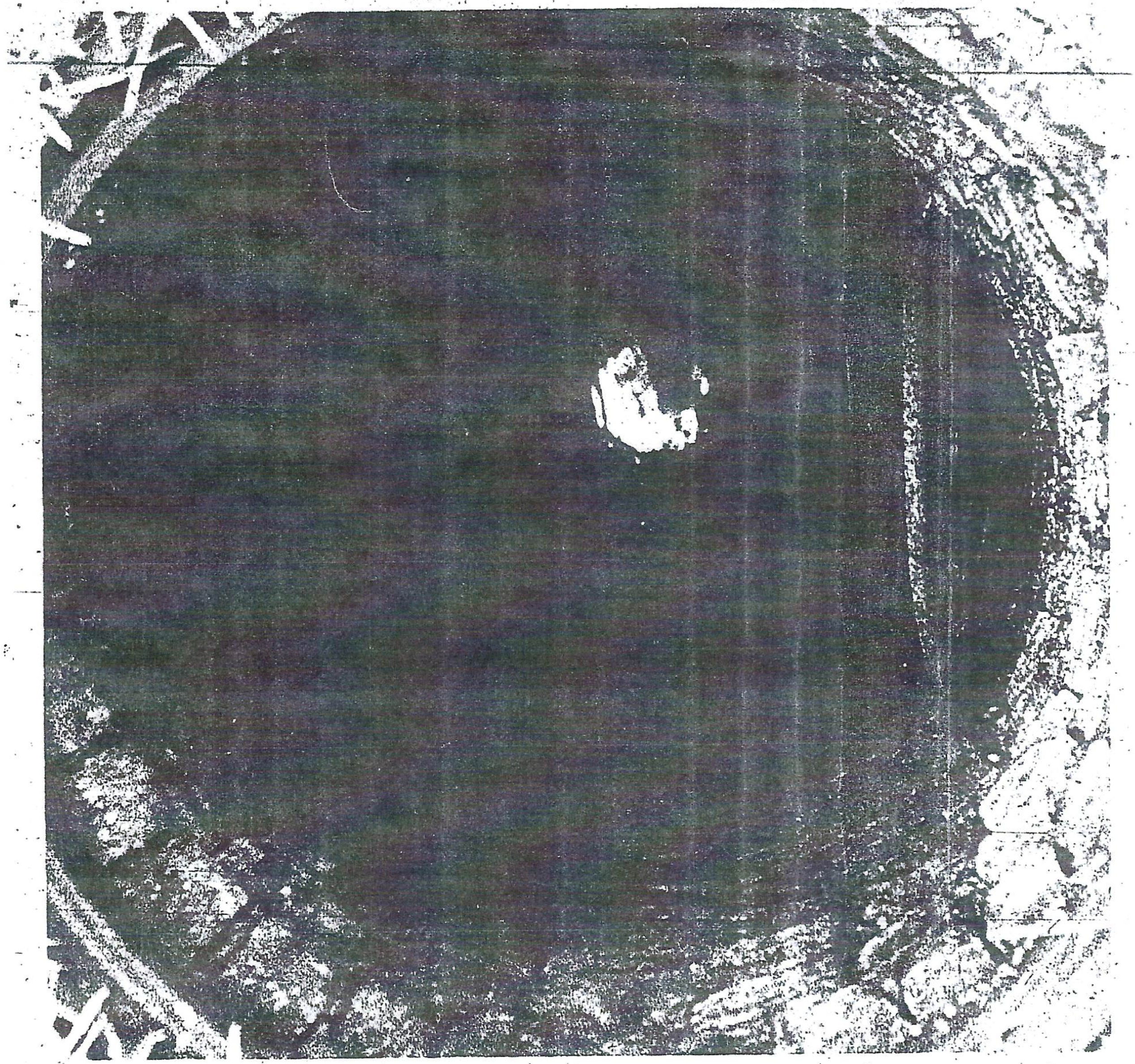
VOL. 119, NO. 130 Saturday, June 2, 1973, 14 Pages 10 CENTS



Town of Polk clerk, George Nehrbass, opens a manhole cover on the drain. Cedar Lake is in the background.

— News Staff Photo

June 2, 1973 THE WEST BEND NEWS



Looking down some 18 feet into one of the manholes shows water passing between the two lakes. The manholes are carefully laid in brick, complete with iron rungs leading down to the drain.

History of Polk Tunnel Cloudy

BY DON KOSTERMAN
News Staff Writer

A manmade drain tunnel, approximately three-quarters of a tile long, links two Washington County lakes and apparently spans some 100 years of county history, going back further than most memories can relate.

The tunnel slips quietly under State 144 between Mueller's Lake and the southern end of Big Cedar Lake and is unknown to all but the residents under whose land it passes and a few nearby oldtimers.

There are three manholes which emerge from the drain tunnel to the surface and they lead some 18 feet to the drain below, the circumference of which is not known. What is known is that the tunnel links the two lakes and allows excess water from Mueller's Lake drain off into Cedar Lake.

The existence of the drain came to light recently when land belonging to the estate of William Jaeschke, which borders Cedar Lake, was sold to Raymond Geiger. The land had three cottages on it and was to be parceled for sale.

A check with the register of deeds for the county by George Nehrbass, Town of Polk clerk, revealed that there was an easement through the land for the drain. At an appeals board meeting more information was brought out about the tunnel and the lots were drawn up to keep 50 feet from the drain with construction or sewage.

The lots are along Highland Park Drive, south of the Sandy Beach Resort, and the five original non-conforming lots were divided into three because of the tunnel's passage below.

The history of the drain is not documented in any records as yet found but the story, collaborated by a number of residents, is an interesting one.

The drain tunnel is said to have been dug and constructed by hand around the 1870s to drain water from the Mueller Lake area. The job was reported done by the Soo Line which had a track going through the area to the Cedar Lake Station. High water in the spring caused the train problems so control of the lake's level was sought.

Labor for the project was provided by prisoners brought up daily by rail from Milwaukee who dug in the 18 foot deep, three-quarter mile long tunnel, placing the manholes along the way. The manholes themselves represent quite a job as they are brick laid with metal rungs up their sides.

Cedar Lake Station was located on what is now the southwest corner of State 144 and County NN and it had served the various hotels situated around Big Cedar Lake.

Since the tunnel was placed, the level of Mueller's Lake has remained relatively constant and in spring water can be seen rushing into Big Cedar Lake from the outlet below the lake's surface. Another provision provided for when the tunnel was placed, according to residents, was that the farmer using the field through which the tunnel passed could use the manholes to draw up water for his stock.

More Pictures On Page Seven

Today a water tower stands over one of the manholes and Jonathan Schultz uses a pump to draw water for plants in his garden. The 1,000 gal. tank stands over a drain tunnel about which he knows only hand-me-down information.

Another story about the tunnel has it that originally no Northern Pikes were caught in Big Cedar, but only in Mueller's Lake. After the tunnel they evidently found their way into the much larger body of water.

West Bend News

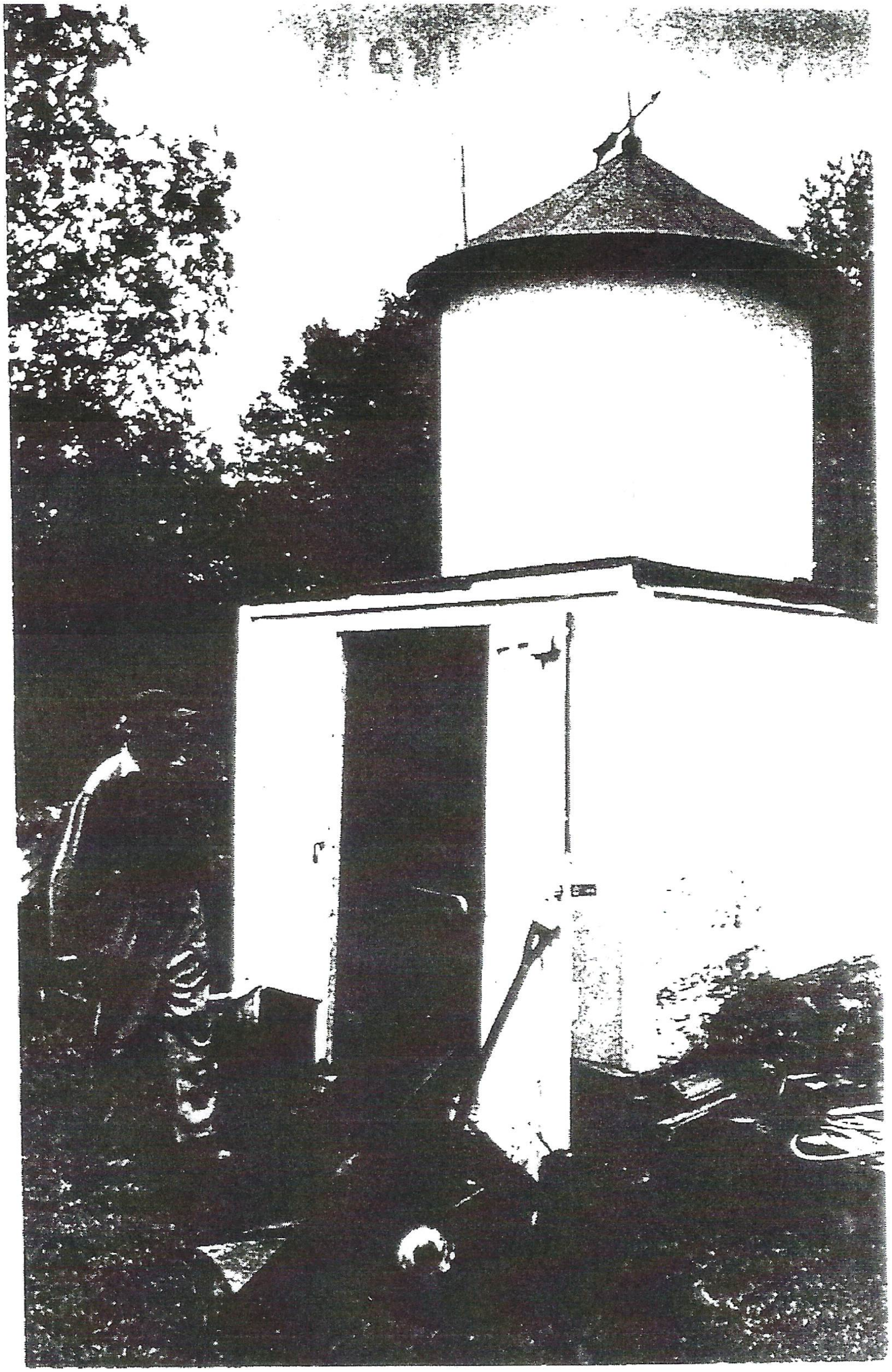
VOL. 119, NO. 130 Saturday, June 2, 1973, 14 Pages 10 CENTS

Town of Polk clerk, George Nehrbass, opens a manhole cover on the drain. Cedar Lake is in the background.

—News Staff Photo

eller's Lake lies west of County 144 near the southern tip of Big Cedar Lake and is the source of a
n tunnel which leads to Big Cedar. The presence of the tunnel came up at a recent meeting of
the Town of Polk appeals board, but little is known of its origin.

—Staff Photos by Dan Kosterman



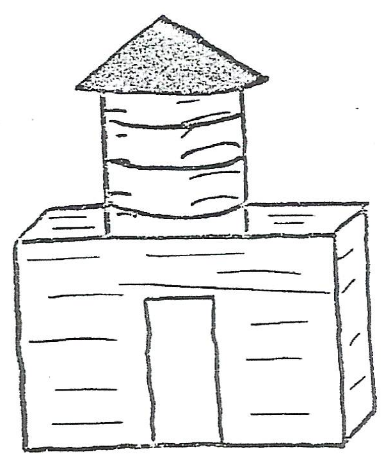
Jonathan Schultz checks out a water tower built over one of the manholes from which water is now pumped for nearby gardens.

called Gilbert's Lake because land contiguous to it was donated to the Wisconsin Conservation Department around 1923 by the Gilbert family. Cedar Lakes shoreline is almost all upland with only a small marsh area at the Gilbert's Lake stream.

LAKE STATISTICS

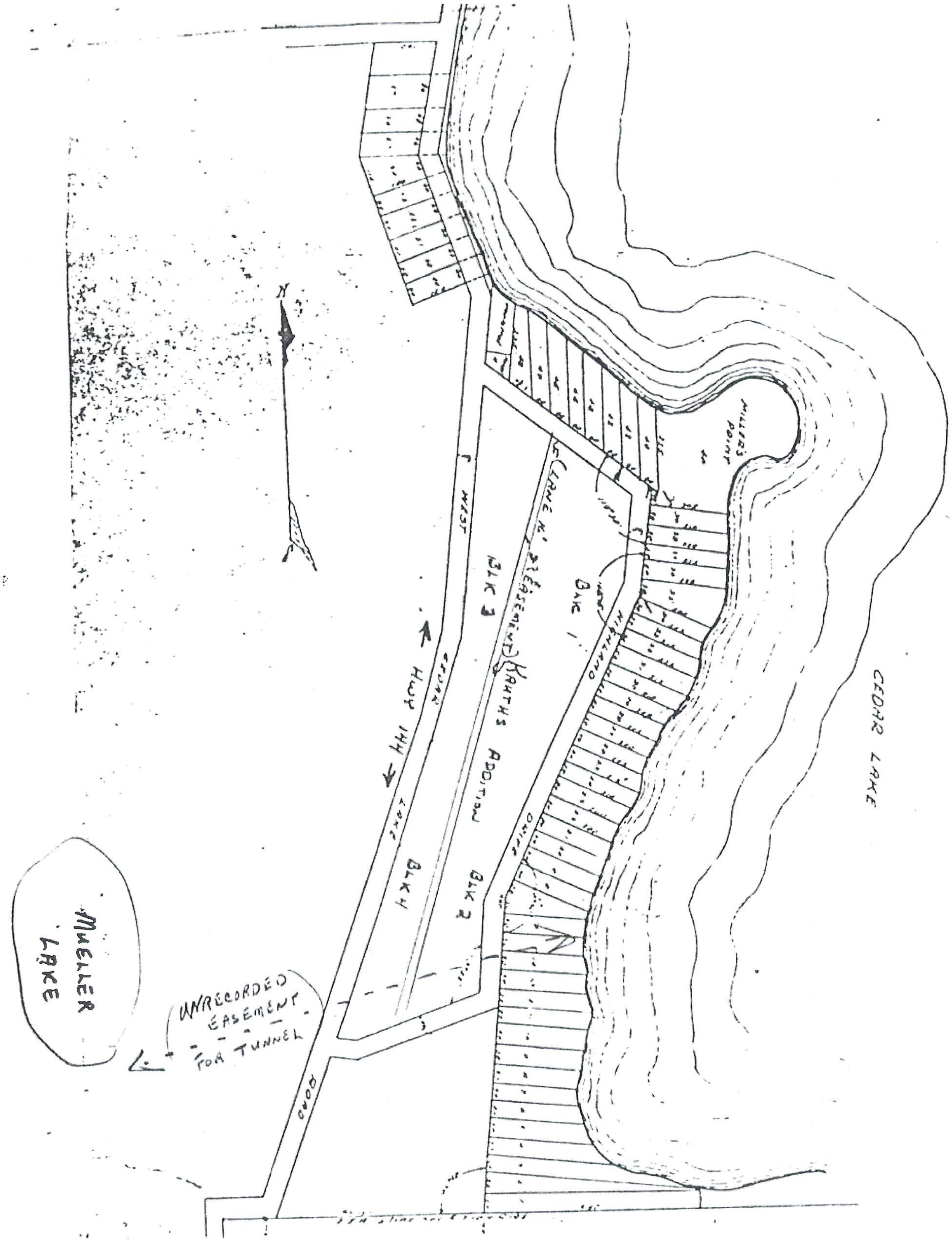
WATER AREA	932 ACRES
MAXIMUM DEPTH	105 FEET
UNDER THREE FEET	7%
OVER TWENTY FEET	47%
MEAN DEPTH	34 FEET
MAXIMUM LENGTH	3.80 MILES
MAXIMUM WIDTH	0.64 MILES
SHORELINE	10.2 MILES, WITHOUT ISLANDS
SHORELINE	11.0 MILES, WITH ISLANDS
VOLUME	31,983 ACRE FEET

The lake drains through Cedar Creek into Little Cedar Lake to the east. Cedar Creek leaves the lake in the north east corner of Timmer's Bay. At this exit point there is a low-point dam that helps govern the lakes water level. Operating levels of the lake were established by the Railroad Commission of Wisconsin back in 1931. The elevations (called benchmarks) were set on posts near the dam with bronze tablets to clarify the information. The maximum elevation is 90.75 feet and the minimum elevation was listed at 89.59 feet. Water enters the lake from Gilbert's Lake and there are springs in the lake itself. On the south west end of the lake an underground stream enters from what is known as Mueller's Pond. The stream runs under the garden property of Jonathan Schultz as well as Hwy. 144 and a few other properties. Mr. Schultz uses water from the stream for his garden by way of an interesting water tower arrangement.

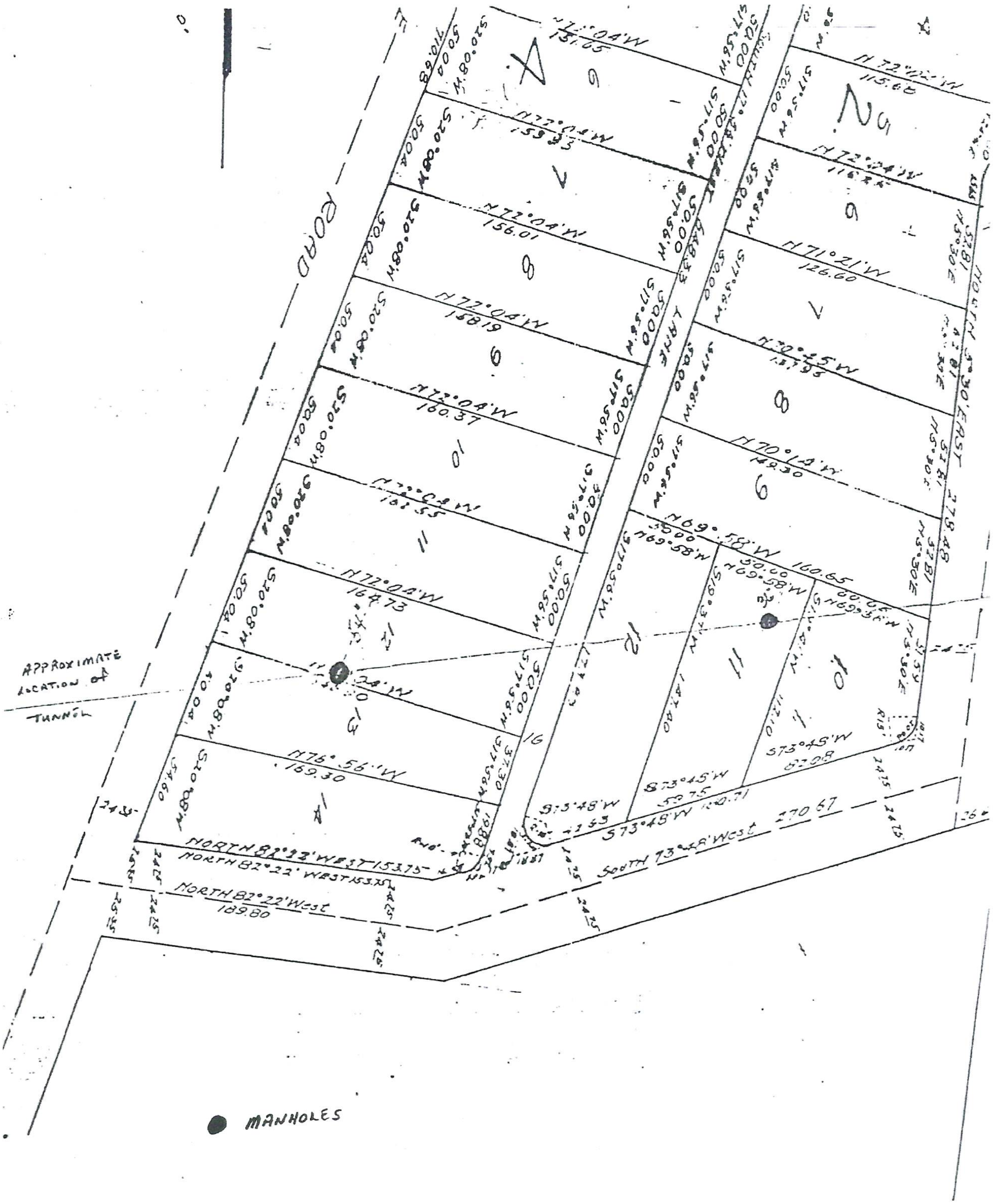


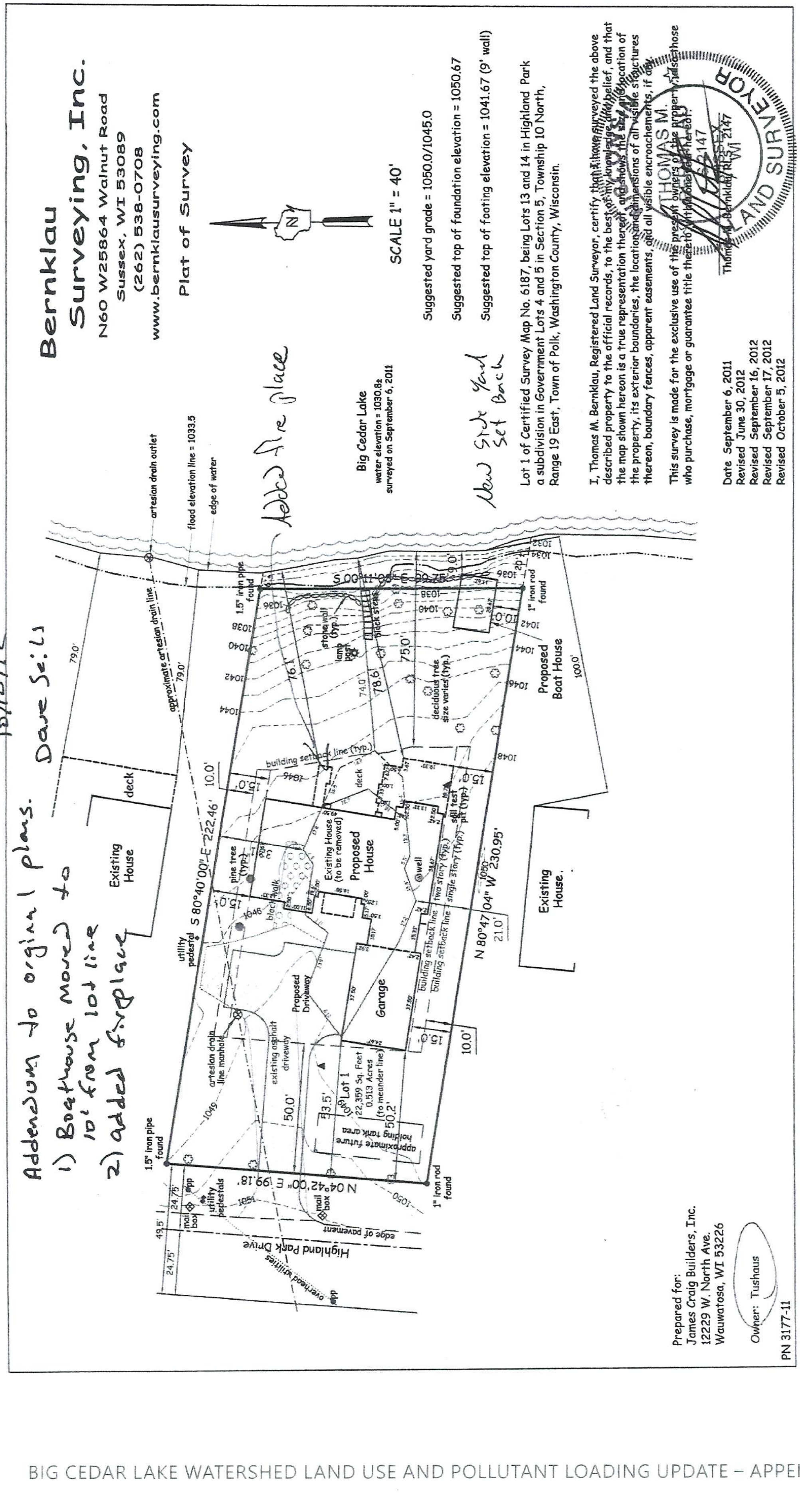
SCHULTZ'S WATER TOWER

Approximate Location of Mueller Lake Drainage Tunnel



Source: BCLPRD and SEWRPC


ROAD
APPROXIMATE LOCATION of TUNNEL
MANHOLES
NORTH 82°22' WEST 153.75
NORTH 82°22' West
189.80
South 73°48' West 270.67
N 69°58' W 160.65
N 72°04' W
156.01
N 72°04' W
158.19
N 72°04' W
160.37
N 72°04' W
164.73
N 76°56' W
169.30
N 71°21' W
126.60
N 70°14' W
NORTH 5°30' EAST 278.48
S 73°45' W
82.08


Bernklau Surveying, Inc.
N60 W25864 Walnut Road
Sussex, WI 53089
(262) 538-0708
www.bernklausurveying.com
Plat of Survey
N
SCALE 1" = 40'
Suggested yard grade = 1050.0/1045.0
Suggested top of foundation elevation = 1050.67
Suggested top of footing elevation = 1041.67 (9' wall)
Lot 1 of Certified Survey Map No. 6187, being Lots 13 and 14 in Highland Park a subdivision in Government Lots 4 and 5 in Section 5, Township 10 North, Range 19 East, Town of Polk, Washington County, Wisconsin.
This survey is made for the exclusive use of the present owners of the property, and those who purchase, mortgage or guarantee title thereto within one year hereof.
Date September 6, 2011
Revised June 30, 2012
Revised September 16, 2012
Revised September 17, 2012
Revised October 5, 2012
Big Cedar Lake
water elevation = 1030.8±
surveyed on September 6, 2011
artesian drain outlet
flood elevation line = 1033.5
edge of water
approximate artesian drain line
Existing House
Proposed House
Existing House (to be removed)
Garage
Proposed Driveway
Proposed Boat House
deck
building setback line (typ.)
S 80°40'00" E 222.46'
N 80°47'04" W 230.95'
S 00°11'05" E 99.75'
N 04°42'00" E 99.18'
Lot 1
22,359 Sq. Feet
0.513 Acres
(to meander line)
approximate future holding tank area
existing asphalt driveway
artesian drain line manhole
utility pedestal
1.5" iron pipe found
1" iron rod found
Highland Park Drive
edge of pavement
overhead utilities
mail box
utility pedestals
Prepared for:
James Craig Builders, Inc.
12229 W. North Ave.
Wauwatosa, WI 53226
Owner: Tushaus
PN 3177-11
Addendum to original plans.
1) Boathouse moved to 10' from lot line
2) added fireplace
10/2/12
Dave Seils
Added fire place
New State Yard Set Back
THOMAS M. BERNKLAU S-2147 SUSSEX, WI LAND SURVEYOR

APPENDIX C

DITCH CHECK/CHECK DAM AND DITCH TURNOUT MANAGEMENT PRACTICES

Source: State of California, Department of Transportation, Check Dams, Section 4, Storm Water Quality Handbooks, Project Planning and Design Guide, Construction Site Best Management Practices (BMPs) Manual, Storm Water Pollution Prevention Plan (SWPPP) and Water Pollution Control Program (WPCP) Preparation Manual, March 2003, www.dot.ca.gov/hq/construc/stormwater/SC-04.pdf

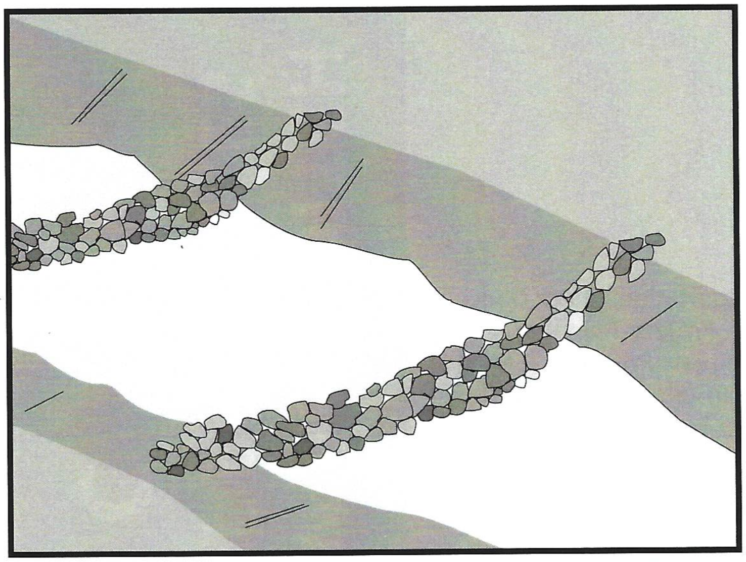
Part of the Conservation Practices for Homeowners Factsheet Series, available at:

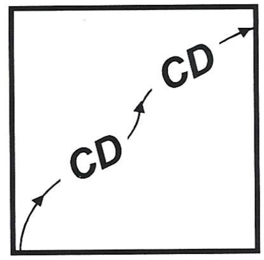
Maine DEP (800.452.1942)
www.maine.gov/dep/blwq/docwatershed/materials.htm

Portland Water District (207.774.5961)
www.pwd.org/news/publications.php
www.pwd.org/sites/default/files/turnouts.pdf

Check Dams

SC-4





Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ● Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

Check dams reduce scour and channel erosion by reducing flow velocity and encouraging sediment settlement. A check dam is a small device constructed of rock, gravel bags, sandbags, fiber rolls, or other proprietary product placed across a natural or man-made channel or drainage ditch.

Appropriate Applications

- Check dams may be installed:
  - In small open channels that drain 4 ha (10 ac) or less.
  - In steep channels where storm water runoff velocities exceed 1.5 m/s (4.9 ft/sec).
  - During the establishment of grass linings in drainage ditches or channels.
  - In temporary ditches where the short length of service does not warrant establishment of erosion-resistant linings.
- This BMP may be implemented on a project-by-project basis with other BMPs when determined necessary and feasible by the Resident Engineer (RE).

Limitations

- Not to be used in live streams.
- Not appropriate in channels that drain areas greater than 4 ha (10 ac).
- Not to be placed in channels that are already grass lined unless erosion is expected, as installation may damage vegetation.
- Require extensive maintenance following high velocity flows.
- Promotes sediment trapping, which can be re-suspended during subsequent storms or removal of the check dam.

Standards and Specifications

- Not to be constructed from straw bales or silt fence.
- Check dams shall be placed at a distance and height to allow small pools to form behind them. Install the first check dam approximately 5 meters (16 ft) from the outfall device and at regular intervals based on slope gradient and soil type.
- For multiple check dam installation, backwater from downstream check dam shall reach the toe of the upstream dam.
- High flows (typically a 2-year storm or larger) shall safely flow over the check dam without an increase in upstream flooding or damage to the check dam.
- Where grass is used to line ditches, check dams shall be removed when grass has matured sufficiently to protect the ditch or swale.
- Rock shall be placed individually by hand or by mechanical methods (no dumping of rock) to achieve complete ditch or swale coverage.
- Fiber rolls may be used as check dams if approved by the RE or the Construction NPDES Coordinator. Refer to SC-5 "Fiber Rolls."
- Gravel bags may be used as check dams with the following specifications:

Materials

- ***Bag Material:*** Bags shall be either polypropylene, polyethylene or polyamide woven fabric, minimum unit weight 135 g/m2 (four ounces per square yard), mullen burst strength exceeding 2,070 kPa (300 psi) in conformance with the requirements in ASTM designation D3786, and ultraviolet stability exceeding 70% in conformance with the requirements in ASTM designation D4355.
- ***Bag Size:*** Each gravel-filled bag shall have a length of 450 mm (18 in), width of 300 mm (12 in), thickness of 75 mm (3 in), and mass of approximately 15 kg (33 lb). Bag dimensions are nominal, and may vary based on locally available materials. Alternative bag sizes shall be submitted to the RE for approval prior to deployment.
- ***Fill Material:*** Fill material shall be between 10 mm and 20 mm (0.4 and 0.8 inch) in diameter, and shall be clean and free from clay balls, organic matter, and other deleterious materials. The opening of gravel-filled bags shall be secured such that gravel does not escape. Gravel-filled bags shall be between 13 kg and 22 kg (28 and 48 lb) in mass. Fill material is subject to approval by the RE.

Installation

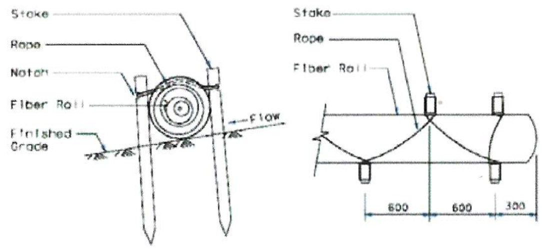
- Install along a level contour.
- Tightly abut bags and stack gravel bags using a pyramid approach.

Gravel bags shall not be stacked any higher than 1 meter (3.2 ft).

– Upper rows of gravel bags shall overlap joints in lower rows.

Maintenance and Inspection

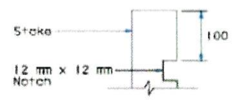
- Inspect check dams after each significant rainfall event. Repair damage as needed or as required by the RE.
- Remove sediment when depth reaches one-third of the check dam height.
- Remove accumulated sediment prior to permanent seeding or soil stabilization.
- Remove check dam and accumulated sediment when check dams are no longer needed or when required by the RE.
- Removed sediment shall be incorporated in the project at locations designated by the RE or disposed of outside the highway right-of-way in conformance with the Standard Specifications.



SECTION

PLAN

STAKING AND LASHING DETAIL



ELEVATION

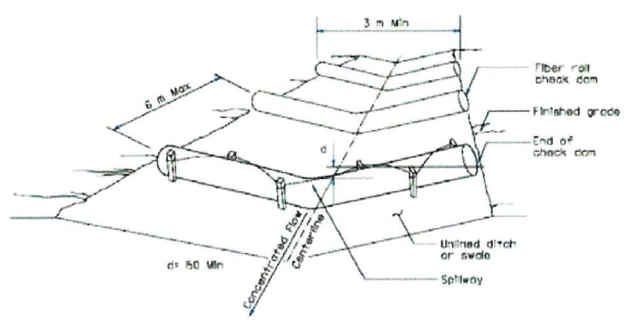
NOTCH DETAIL

SECTION

TEMPORARY CHECK DAM (TYPE 2)

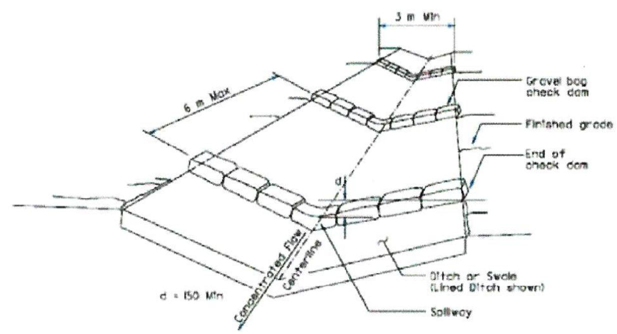
NOTE

1. Spillway depth 'd' shall be maintained to prevent flanking of concentrated flow around the ends of check dam.



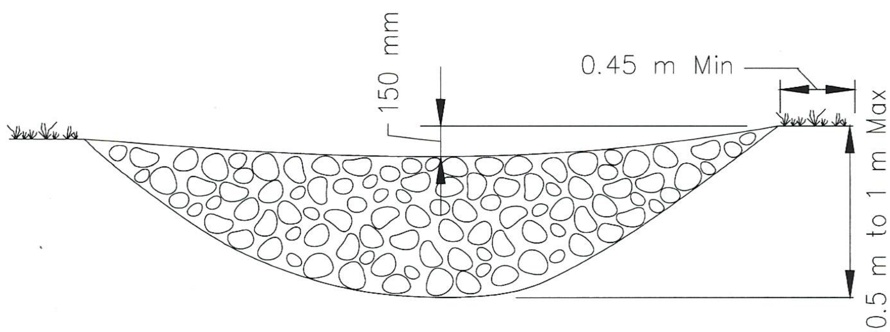
PERSPECTIVE

TEMPORARY CHECK DAM (TYPE 1)

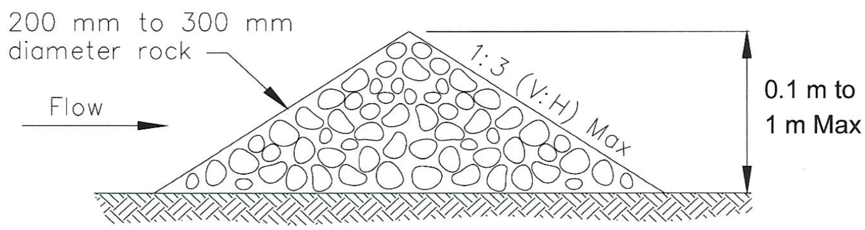


PERSPECTIVE

TEMPORARY CHECK DAM (TYPE 2)



ELEVATION



TYPICAL ROCK CHECK DAM SECTION

ROCK CHECK DAM

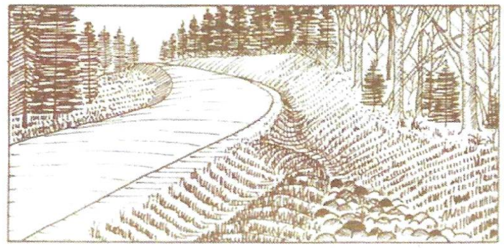
NOT TO SCALE

TURNOUTS

~diverting water off roads and driveways~

Portland Water District

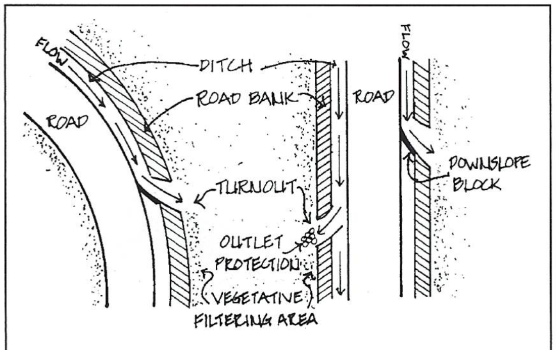
Purpose: Any camp road, even properly constructed ones, alter natural drainage patterns. On camp roads, the biggest concern is to get water off the road surface as quickly as possible. When surface water is not drained off the road, it can lead to washouts, muddy conditions, and potholes.



Turnouts return stormwater runoff as sheet flow to natural drainage areas. Often turnouts are simply extensions of ditches that redirect water into the woods and disperse runoff before it can cause erosion. Turnouts reduce the speed of runoff, allowing soil particles to settle out instead of being transported to a stream, river, or lake. Water and nutrients can then be filtered and absorbed by the surrounding vegetation.

Installation: Turnouts are used to direct water away from the road into a vegetated buffer area, and can be constructed on paved or gravel roads with or without ditches. Turnouts can be the width of a backhoe bucket, a bulldozer blade, or a handheld shovel. Turnouts should intersect the ditch at the same depth, and gently slope down and away from the road.

As it is easier to disperse smaller volumes of water at a time, turnouts should be constructed as often as possible. Ideally, turnouts should be placed every 50 feet. Utilize the natural contours of the land and install turnouts frequently enough to prevent large volumes of runoff from accumulating along the side of the road. Turnouts should be placed closer on steeper slopes. However, check with abutting property owners to ensure this water will not adversely impact their property.



DETAIL - TURNOUTS

Turnouts should be stabilized so as not to create additional soil erosion. The turnout can be seeded and stabilized with hay mulch or erosion control blankets. Alternately, on steeper slopes or areas receiving greater flow, 3"-6" angular stone rip-rap placed over non-woven getotextile fabric can be used to line the structure.

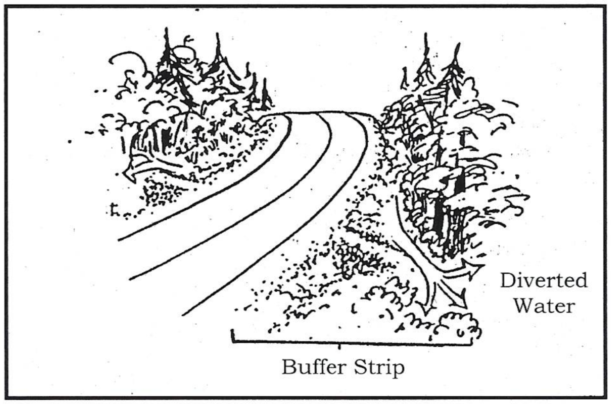
The turnout should have a flared end section that is level and lined with rock to spread out the flow. This level-lip spreader or rock dam converts the concentrated, channeled flow into slower, sheet flow just before it discharges into the vegetated area.

Most importantly, do NOT outlet turnouts into existing stream channels or drainage ways!

Materials: No special tools or equipment are required to construct turnouts. A backhoe, FrontRunner, or even a shovel can be used to build a turnout.

As with ditches, turnouts must be stabilized to keep from causing further erosion problems as they discharge stormwater away from the road. Turnouts with less than a 5% slope can be seeded with a conservation mix and mulched with hay or an erosion control blanket until the seed germinates. On steeper slopes, secure non-woven geotextile fabric on the soil and cover with 3"-6" stone rip-rap.

Care needs to be taken on the outlet of the structure. It is vital that the channeled water be spread out and slowed so it does not erode the neighboring land. Turnouts should have a flared end section that is level and lined with rock to spread out the flow. Use 4"-6" crushed, angular stone for the outlet.



Maintenance: Because the turnout may have a secondary function as a small sediment trap, maintenance is critical to ensure excessive sedimentation from storm events does not fill the structure and render it nonfunctional.

Check turnouts during and after large storm events for erosion or accumulation of debris. Any turnout will fill with sediment over time, and it is critical to remove this material for the structure to function properly. Confirm that water flows evenly into the vegetation, and does not form an erosive channel. Shift stone, as needed, to stop any channelized flow.

Have a post-storm plan in place for checking for damage and determining maintenance needs.

Part of the ***Conservation Practices for Homeowners*** Factsheet Series, available at:
Maine DEP (800.452.1942); http://www.maine.gov/dep/blwq/docwatershed/materials.htm
Portland Water District (207.774.5961); http://www.pwd.org/news/publications.php

May 2006 DEPLW0786