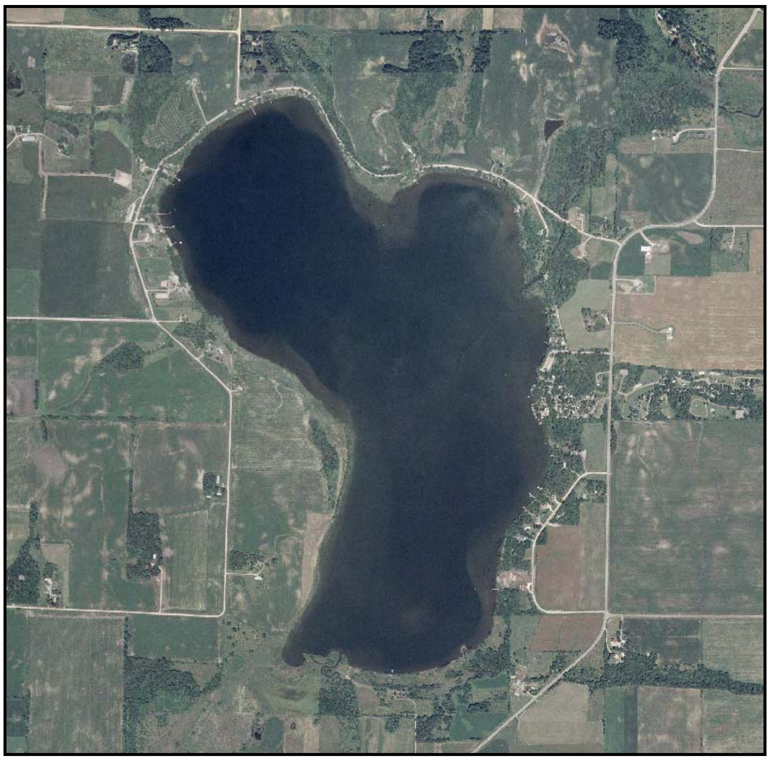
# Cokato Lake (86-263)
## Wright County

# Hydrologic Investigation



DNR Waters

**April 14, 2005**

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### Problem Statement

In recent years, heavy rainfall has caused high lake level conditions on Cokato Lake. Members of the lake association feel that high water problems will continue due to recent culvert changes within the watershed, and continued growth within the city of Cokato. The lake association would like the Department to improve the outlet to accommodate the increase in water coming into the lake. The existing outlet structure, which is owned by the DNR Division of Fisheries, was constructed in 1965.

The Surface Water Unit within DNR Waters was requested to conduct a hydrologic evaluation of Cokato Lake and its watershed, with an emphasis on the specific concerns raised by the lake association.

Cokato Lake is located in southwestern Wright County, approximately two miles north of the city of Cokato. Cokato Lake outlets directly to the North Fork Crow River, which is slightly more than a mile downstream of the lake outlet – as the crow flies.

### Background Information

Watershed: Cokato Lake, 582 acres in size, has a total watershed area of 29,300 acres (Figure 1). The corresponding watershed to lake area ratio is 50:1. Three larger lakes are located within the Cokato Lake watershed, including Smith, Shakopee and Byron Lakes. The total area tributary to those three lakes is 4,870 acres, or 9.1% of the total watershed area of Cokato Lake. The amount of runoff contributed by these three subwatersheds to Cokato Lake would be expected to be relatively minor, compared to the remainder of the watershed. Excluding those three subwatersheds, the "direct" watershed of Cokato Lake is 24,400 acres; the corresponding watershed to lake area ratio using this value is still a very high 42:1.

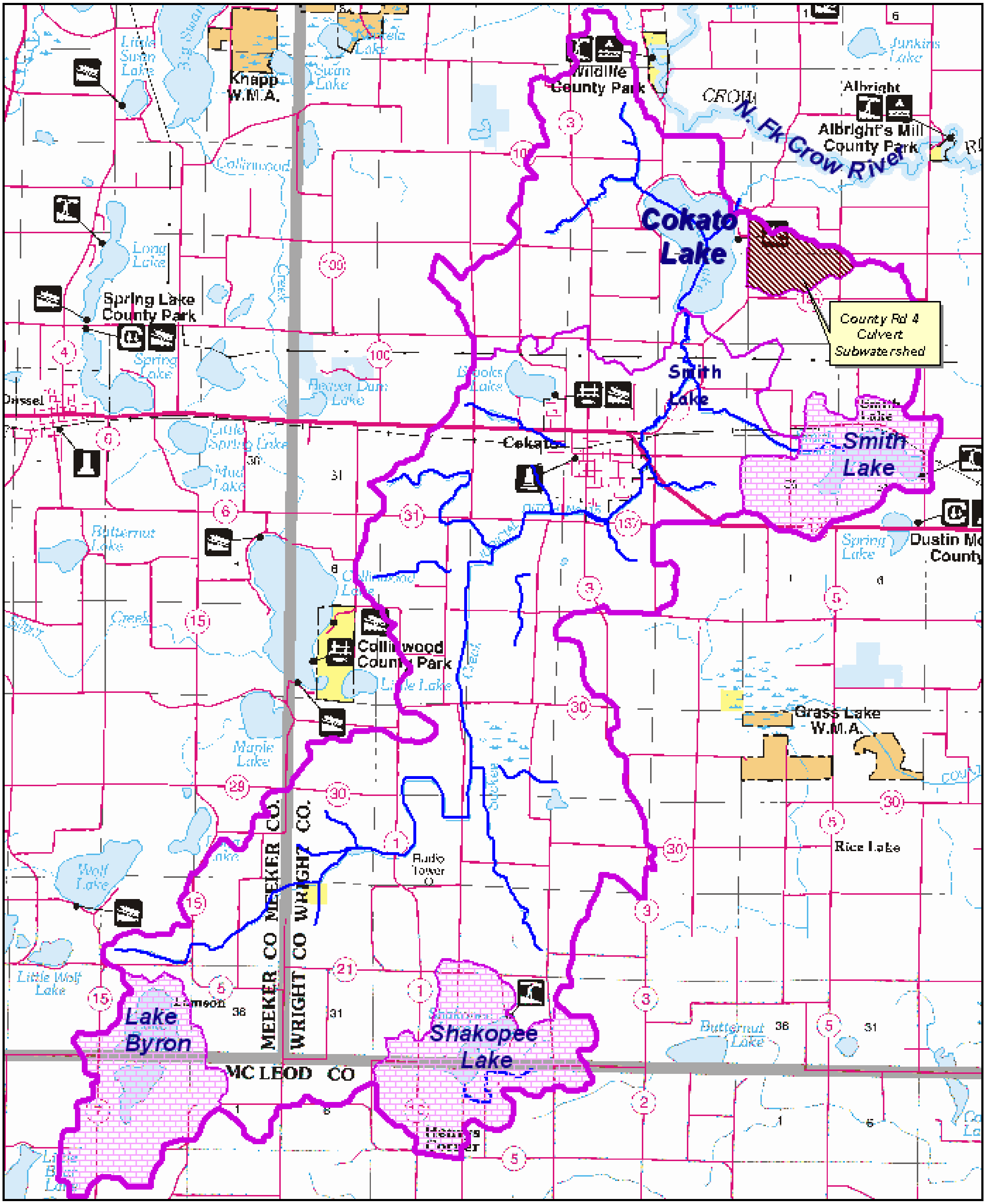


Figure 1: Cokato Lake Watershed

Soils: The Wright County Soil Survey, published by the then Soil Conservation Service, indicates that the general soil association within the Cokato Lake watershed is the Lester-Hayden-Peat Association. This soil association is the largest in Wright County and is generally described as consisting of "….rolling areas. Slopes are generally short and irregular. Peat bogs and marshes occur. The association includes many large and small lakes." Both the Lester and Hayden soils are generally well drained and have a loam surface layer and clay loam subsoil. Peat soils are found in most of the depressions.

Land cover: A land cover map, based on early-1990s aerial photographs, and tabulated percentages for the Cokato Lake watershed are shown below (Figure 2).

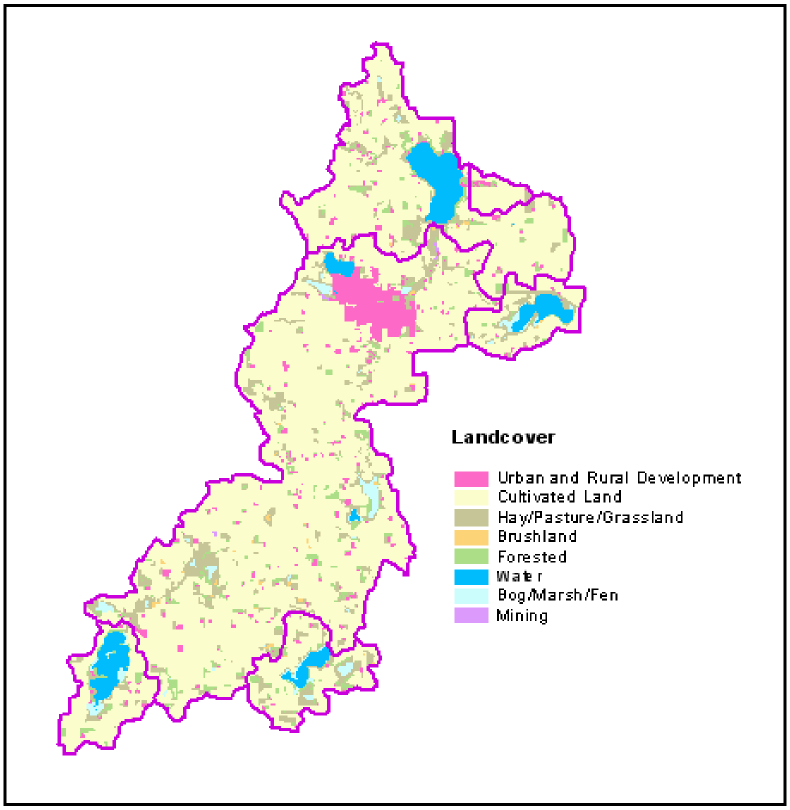


Figure 2. Land Cover

| | Acres | Percent |
|---|---|---|
| Urban and Rural Development | 1466 | 5.0 |
| Cultivated Land | 22,254 | 76.0 |
| Hay/Pasture/Grassland | 2514 | 8.6 |
| Brushland | 77 | 0.3 |
| Forested | 1155 | 3.9 |
| Water | 1362 | 4.7 |
| Bog/Marsh/Fen | 447 | 1.5 |
| Mining | 20 | 0.1 |

Three quarters of the land within the Cokato Lake watershed is in agricultural production. Considerable agricultural drainage improvements have occurred within the watershed. Much of Sucker Creek, the primary tributary to Cokato Lake, was channelized with the establishment of Joint County Ditch No. 15. Additional private drainage activity has also occurred, both open ditch and subsurface drains. Surface drainage improvements in particular will tend to increase both the volume and rate at which runoff reaches Cokato Lake.

**Recorded Lake Levels**

Figure 3a is a plot of all available recorded lake levels for Cokato Lake. The Ordinary High Water (OHW) level and the runout elevation (lowest point on the crest of the outlet dam) are also shown on this graph. The total range of recorded lake levels is 2.7 feet. Unfortunately, water levels were not recorded during recent highwater events. However, two highwater marks from the summer of 2002 flood were recently surveyed (970.7 and 970.9). The lake levels reached in 2002 far exceeded the recorded range of lake levels.

(All elevations in this report reference feet above mean sea level – 1929 adjustment.)

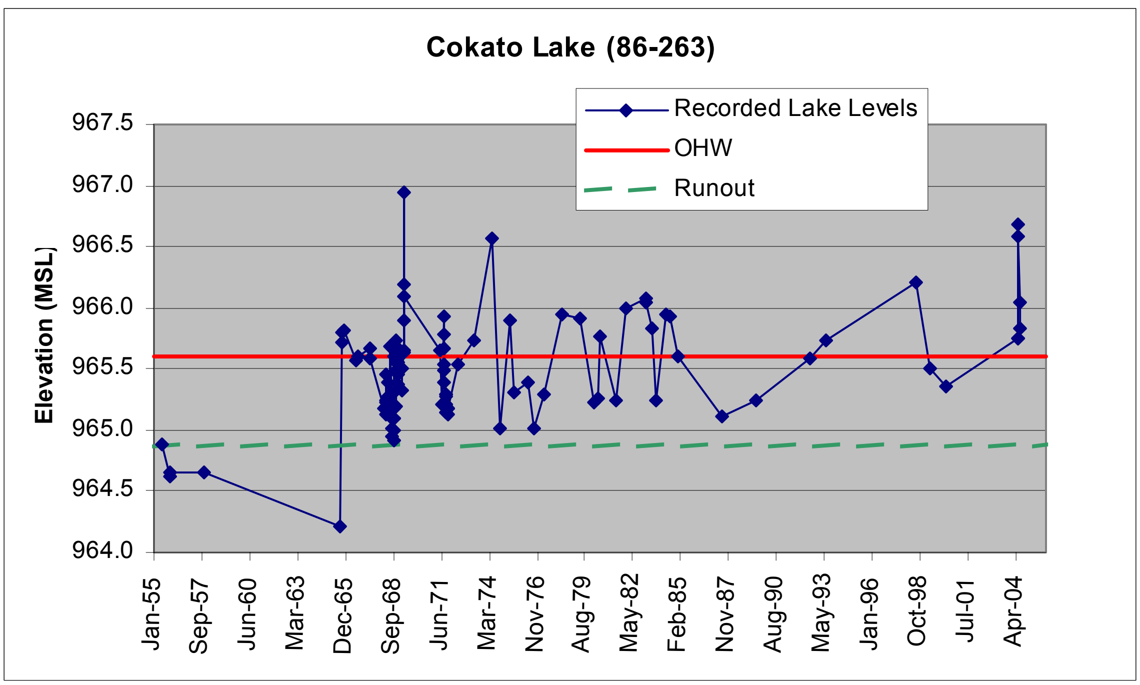


Figure 3a. Recorded Lake Levels

A lake level gage was re-installed on Cokato Lake during the spring of 2004. Only a handful of readings have been obtained to-date. But the current gage reader did capture the lake level response following a 2.5” June rainfall event. As shown in Figure 3b, Cokato Lake rose 0.94 feet and receded to pre-storm levels within three weeks.

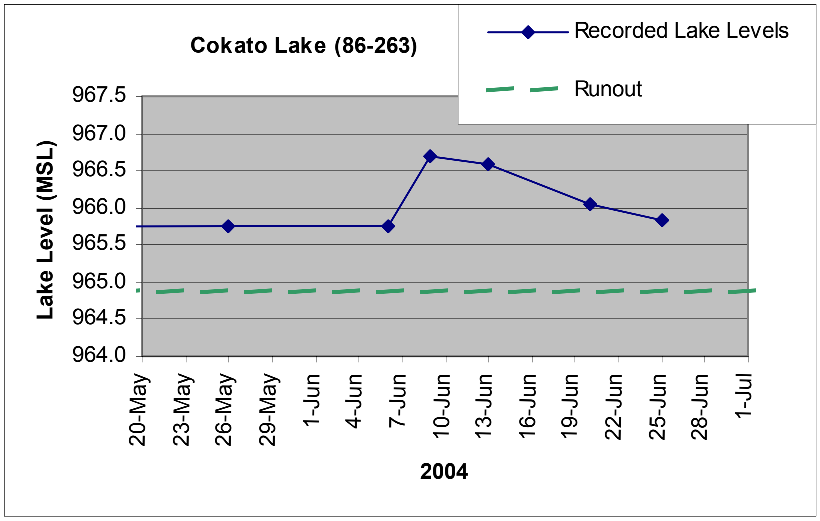


Figure 3b. June 2004 recorded lake levels.

**Recent rainfall**

Central Minnesota, including Wright County has received its share of heavy rainfall during the last few years. Three significant summer rainstorm events affected Wright County during 2002 and 2003. A summary of these storms including a map showing rainfall totals may be found at the DNR Climatology Office website: http://www.climate.umn.edu/doc/flashflood.htm. An excerpt for the June 2002 event is included as Figure 4. Refer back to Figure 1 to help locate Cokato Lake and its watershed.

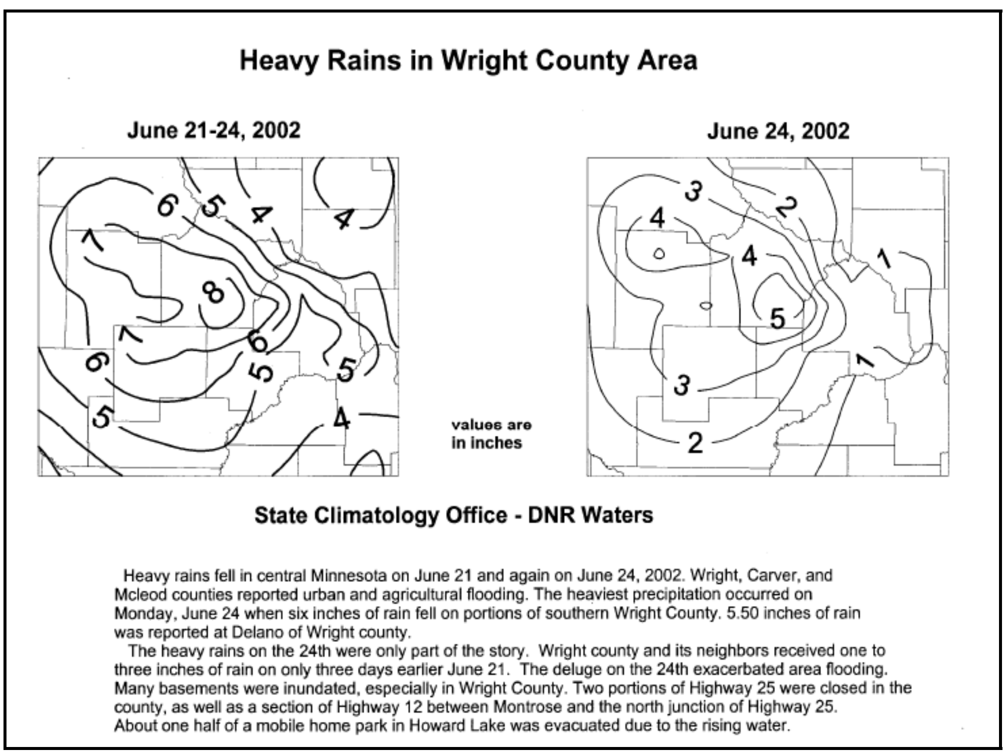


Figure 4. Heavy June 2002 Rainfall.

## Hydraulic and Hydrologic Analyses

Commonly used hydraulic and hydrologic engineering analytical techniques were used as part of this study. Two computer simulation models developed by the U.S. Army Corps of Engineers were instrumental in this study – HEC-RAS and HEC-HMS. HEC-RAS (Hydrologic Engineering Center – River Analysis System) was used to compute flow and water levels over the outlet dam and downstream channel. HEC-HMS (- Hydrologic Modeling System) was used to compute the rate and volume of runoff entering Cokato Lake and then "routing" that inflow through Cokato Lake and its outlet. Summaries of the results of these analyses are incorporated into the following discussion.

## Outlet

A lake's outlet, including dam and downstream channel, is a primary factor to evaluate when dealing with lake levels concerns. The outlet controls the rate at which water can leave a given lake. The outlet has no control on the amount of water entering a lake. A recent photo of the Cokato Lake dam is shown below.


Figure 5. Cokato Lake Dam

A DNR Waters field crew completed a survey of the Cokato Lake outlet channel, including the $25^{th}$ Street and County Road 4 culverts on March 2, 2005. These data provided the basis for developing an HEC-RAS model for the Cokato Lake outlet.

The key product of this model is the relationship of how outflow from Cokato Lake varies with changing lake levels. This relationship was first developed for existing conditions. The simulation results confirm that the dam does control outflow during lower flow conditions. As lake levels, and therefore outflow increases, the downstream channel becomes the primary control (beginning at a flow rate of approximately 500 cubic feet per second). The culvert under 25th Street SW does restrict outflow from Cokato Lake during high flow conditions.

Two alternatives to increase outflow were evaluated using the HEC-RAS model. The first alternative assumed that the higher portions of the outlet dam were lowered approximately eight inches to the elevation of the existing low "notch." When the photograph in Figure 6 was taken, the lake level was below high portions of the dam crest and water was only flowing through the low notch in the dam. The 2nd alternative assumed that a second culvert (w/ same dimensions) was added to 25th St. SW crossing, without any modification to the existing dam. The computed lake level – outflow rating curve for existing conditions and the two alternatives is shown as Figure 6.

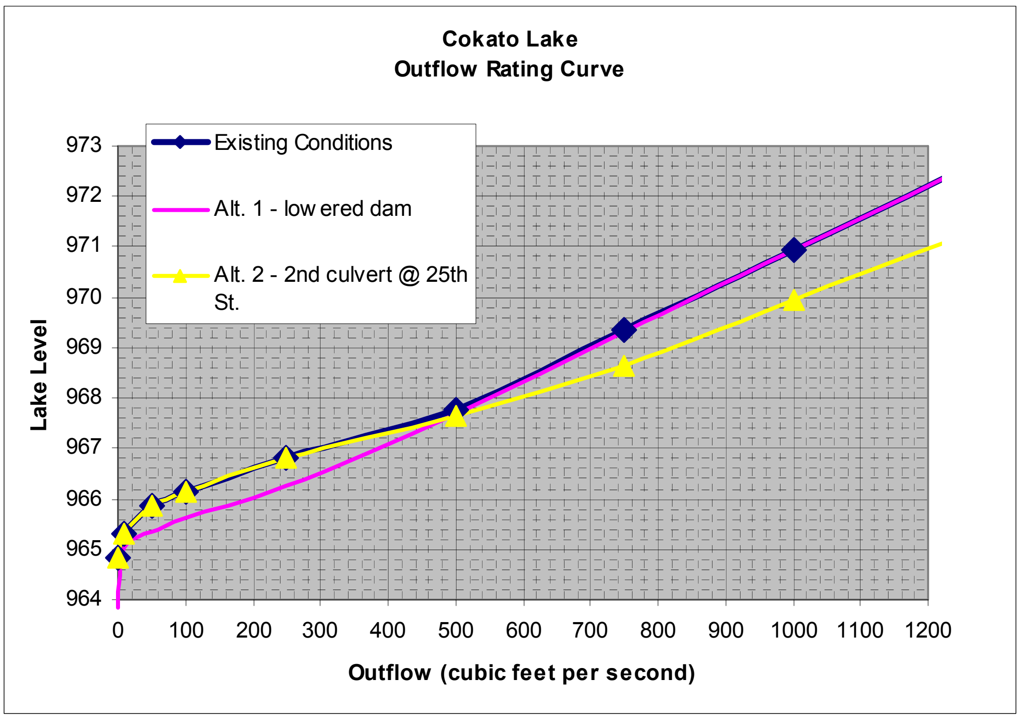


Figure 6. Outflow Rating Curve

The next step is to determine how the "improved" outflow conditions will affect lake levels on Cokato Lake, which required the use of the 2nd Corps of Engineers' computer simulation model (HEC-HMS). The HEC-HMS model parameters were first estimated using the recorded rainfall and lake level data for June 2004. The parameters were then adjusted for the summer of 2002 event, such that the computed peak lake level essentially matched the surveyed highwater mark (970.7 / 971.0). Once the HEC-HMS model was "calibrated" to the 2002 event, the model was rerun using the two alternative outflow rating curves shown in Figure 7. The results are tabulated below:

**Cokato Lake**
Computed Lake Levels -
Existing Conditions and Two Outlet Alternatives

| | Starting Lake Level | Peak Lake Level | Lake Level "Bounce" |
|---|---|---|---|
| Existing Conditions | 965.31 | 970.89 | 5.58 ft. |
| Alt. 1: lower entire dam crest to elevation of the low notch | 965.02 | 970.71 | 5.69 |
| Alt. 2: add 2nd culvert at 25th Street SW | 965.31 | 970.62 | 5.31 |

**Development within the City of Cokato**

The city of Cokato comprises approximately five percent of the total watershed of Cokato Lake. Aerial photographs from the early 1990s and 2003 were reviewed to identify instances of newer development within the city. Commercial expansion along the U.S. Highway 12 corridor appears to be the primary activity that would be expected increase runoff to Cokato Lake. There has also been new residential development, primarily in the southeast quadrant of the city. The increased amount of imperious surface – roads, driveways and rooftops of the residential development - would also tend to increase runoff, but to a lesser extent than commercial development.

Figure 7 includes both aerial photographs. The red boxes highlight those areas of the city interpreted to be newer commercial development, including parking lots. The yellow boxes indicate areas of new residential development. The total area of each development type are as follows:

| | | |
|---|---|---|
| Commercial development: | 61.0 acres; | 0.25% of the direct watershed |
| Residential development: | 36.2 acres; | 0.15% of the direct watershed |

The HEC-HMS model was used to gain a sense of the impact on peak lake levels due to the expanding urban development with the city of Cokato. The model parameter used to compute the amount of runoff was adjusted to account for an additional 100 acres of urban development. With the assumption of additional runoff from the City of Cokato, the computed peak lake level for the summer of 2002 event increased by 0.02 feet.

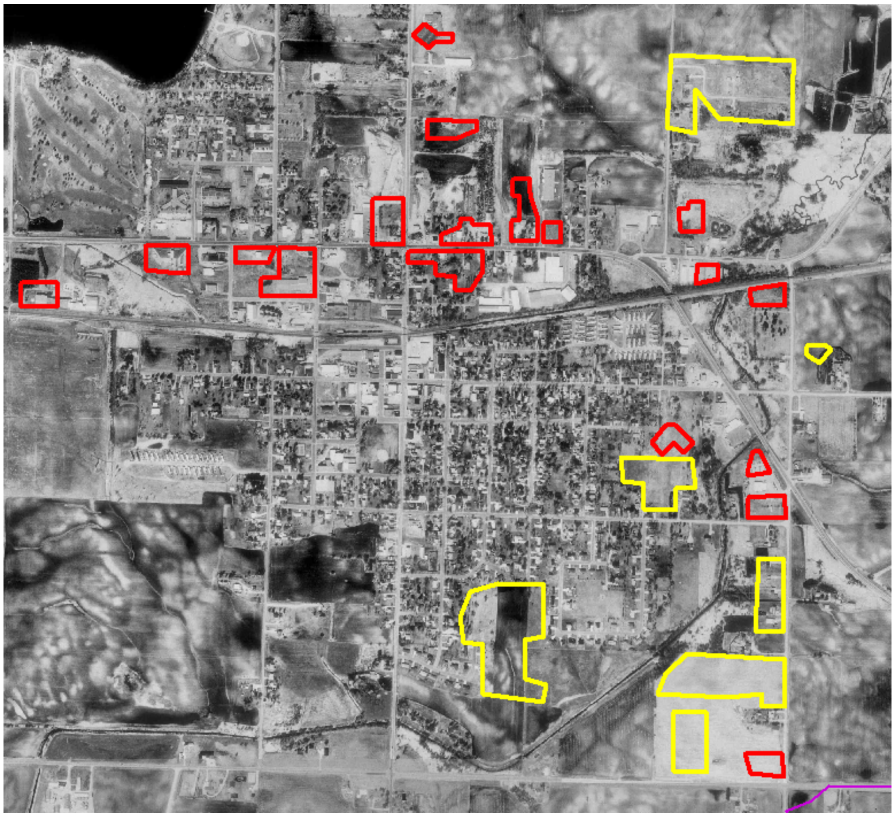
Figure 7a – early 1990s aerial photograph

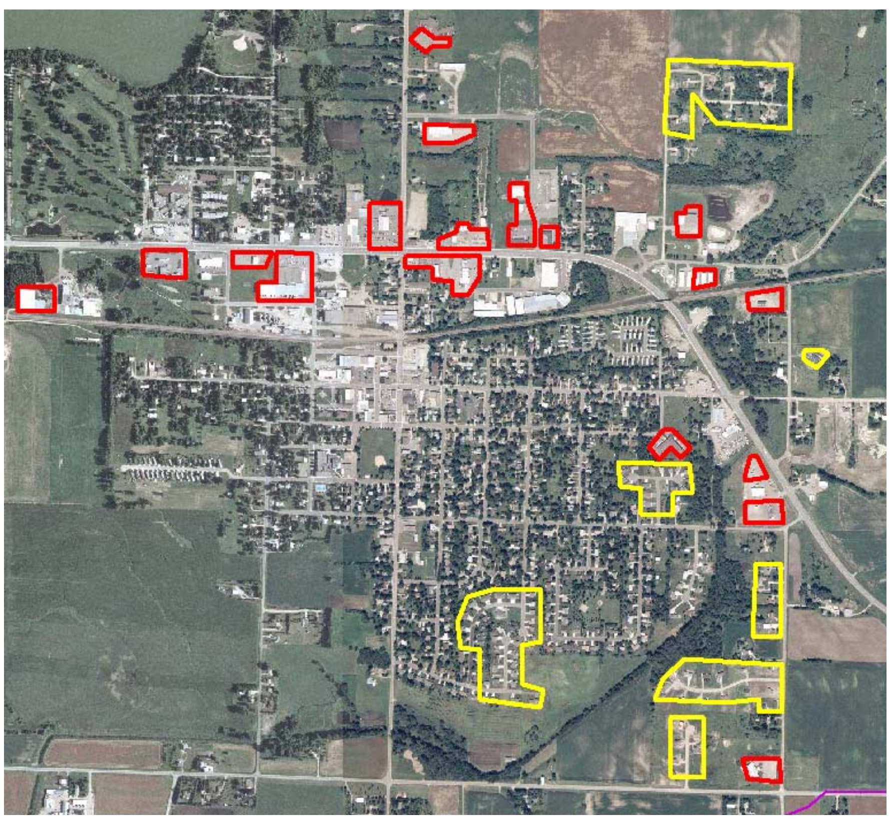
Figure 7b – 2003 aerial photograph

## County Road 4 Culvert

Another issue raised by the lake association was the new County Road 4 culvert, immediately east of Cokato Lake. The portion of the Cokato Lake watershed draining through this culvert is highlighted on Figure 1. This subwatershed represents 1.6% of the direct watershed to Cokato Lake.

This author understands that an older set of 3 – 24" diameter culverts at this road crossing were recently replaced by Wright County with a single 48" culvert. A very simple comparison is to look at the total cross sectional area – 9.4 square feet (old) vs. 12.6 square feet (new). While not a true measure of the respective hydraulic capacity, this comparison would suggest that the new culvert has approximately one-third more capacity than the old culvert crossing.

The change in culvert will not increase the total volume of runoff reaching Cokato Lake for a given storm event. But the larger culvert will affect the timing. Due to their close proximity to the lake, the old set of culverts to would have had to store water for several days in order serve as an effective flood damage reduction measure (refer back to Figure 3b). The culvert change would be expected to change the runoff timing by a matter of several hours, not the days required to effect a measurable change in lake levels.

## Conclusions

- **The very large watershed to lake area ratio is the overriding factor causing periodic high levels on Cokato Lake.**
- Lowering the crest of the outlet dam would result in lower peak lake levels, but the total lake level "bounce" would remain essentially the same. A lower dam crest would also result in lower lake levels during normal to dry climatic conditions.
- The existing culvert under the 25$^{th}$ St. NW does restrict outflow during flood conditions. However, doubling the capacity the hydraulic capacity of the road crossing reduced the peak simulated lake level for the 2002 event by less than 2 inches.
- Neither the new development within the city of Cokato, nor the new culvert on County Road 4 measurably increased flooding conditions on Cokato Lake. The extensive drainage network throughout the watershed has likely had a far greater impact.
- No one person, agency or action is to blame for the high lake levels experienced on Cokato Lake during the last few years, nor are there easy solutions to minimizing future high lake levels. A comprehensive program to identify, evaluate and implement a wide variety of measures to slow down and reduce runoff from throughout the entire watershed is the only realistic option to achieving a measurable benefit.

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