DESIGN AND HYDRAULIC ANALYSIS

OF

PROPOSED SANDY LAKE OUTLET

AND DOWNSTREAM AREAS

BALDWIN TOWNSHIP

SHERBURNE COUNTY, MINNESOTA

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota, Statute Sections 326.02 to 326.16.

Tedd W. Mattke, P.E.	May 7, 1986	15612
	DATE	REG. NO.

MATEFFY ENGINEERING & ASSOCIATES, INC.
663 Old Highway 8
New Brighton, Minnesota 55112-7767

BACKGROUND

Sandy Lake is a 70 acre land-locked lake located just west of the Sherburne County - Isanti County line. Over the past several years, the water table in the area has been rising due to higher-than-normal precipitation levels. With no otlet, Sandy Lake has risen to the point that it threatens homes constructed on the lake.

Baldwin Township asked the Army Corps of Engineers to construct an outlet to the lake. The outlet could drain into an existing drainageway located just southeast of the lake which drains into Blue Lake, located 1 mile to the southeast. The Army Corps of Engineers did not begin the project as promptly as Baldwin Township would like, so certain unnamed persons constructed an outlet on their own initiative, without acquiring the necessary permits. The illicit outlet was reported by an anonymous person the the Minnesota Department of Natural Resources (DNR) who subsequently required the inactivation of the outlet pending acquisition of the required permits.

In May 1986, Mateffy Engineering was engaged to analyze the impact of the proposed outlet, initiate the permit process, and design an outlet that meets the standards required by the Minnesota Department of Natural Resources.

METHODS

Survey data of the illicit outlet was obtained from Mr. Dale Homuth, Regional Hydrologist at the St. Cloud office of the DNR. Additional survey field data was collected at the illicit outlet, and downstream structures (two culverts prior to Blue Lake and the Blue Lake outlet.) A sketch of the illicit outlet is shown in Figure 1.

Hydraulic computations were made to determine the discharge capacity of the illicit outlet, and to evaluate the impact of that additional discharge downstream. These computations are shown in the appendix.

RESULTS OF HYDRAULIC ANALYSIS

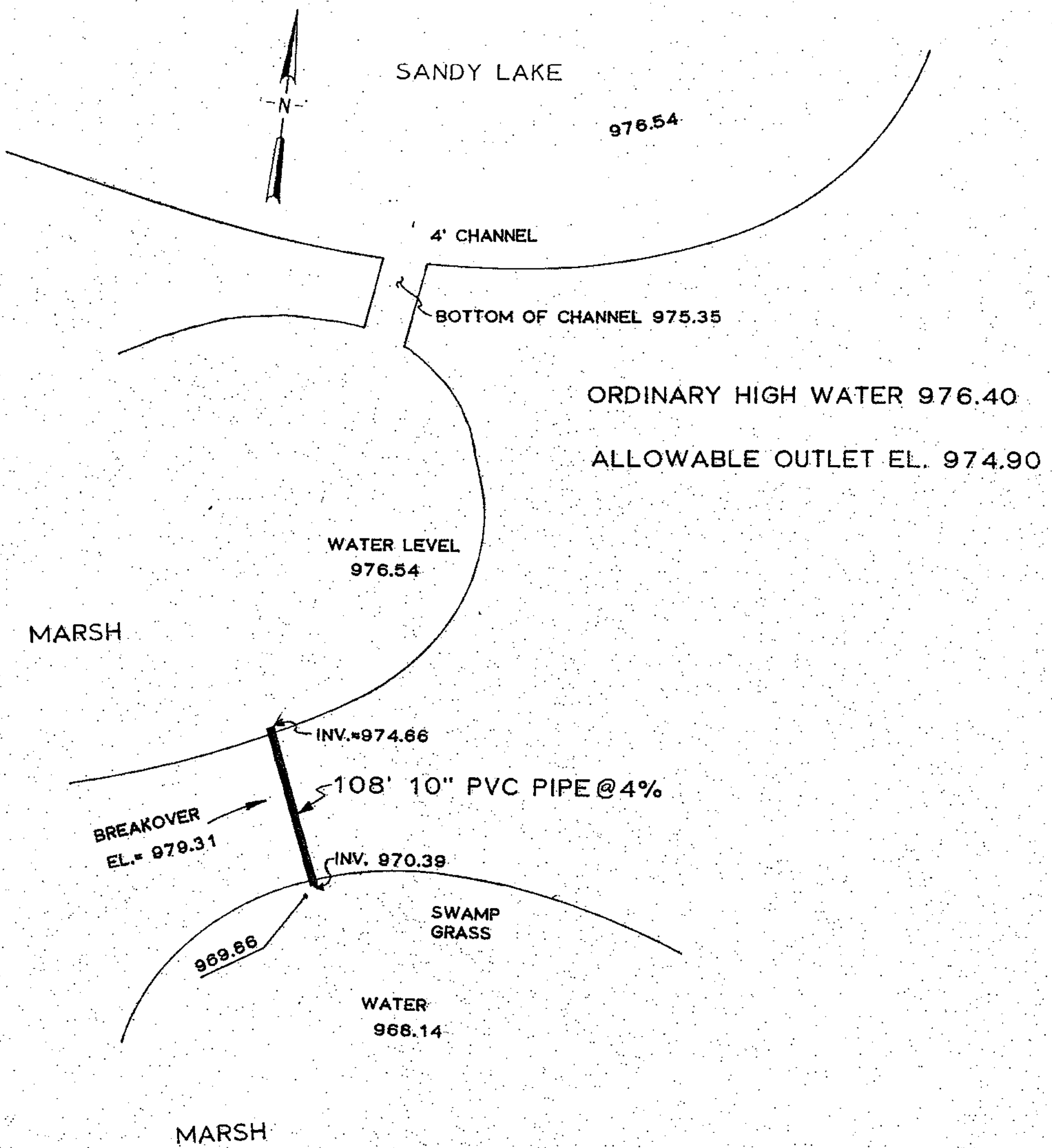
Figure 2 shows the location of the illicit outlet, and the other structures analyzed in this study. From a hydraulic viewpoint, the illicit outlet is a fairly good design. The discharge through the outlet during approximately seven days of operation was approximately 3 cubic feet per second (cfs.). This quantity was enough to lower the lake level six inches in seven days. The location of the outlet is acceptable since the outlet drains into the lake's natural drainageway (where the water would go if the lake level rose high enough.)

The water quality of Sandy Lake is quite high since it is a fairly deep lake and has a relatively small drainage area. Consequently, the overflow water (going out through the outlet) would be of high quality.

The impact on flood levels in the drainageway downstream was found to be very minor. At the 24 inch culvert under the county road, the effect would be less than two inches. Further downstream, just prior to Blue Lake, the effect would be less than 1/2 inch. Finally, the effect on the level of Blue Lake would be less than 1/2 inch. It should be noted that the effects of storage and the timing of discharges have not been included in the analysis. If these effects were included, the calculated impact of the proposed Sandy Lake outlet would be considerably smaller than the numbers indicated above. Consequently, the impact of the proposed Sandy Lake outlet on downstream flood levels is considered insignificant or negligible.

The effect of increased erosion potential downstream was also investigated. It was found that, due to increased normal depth, erosion potential in the waterway during flooding would tend to decrease. The only places where there would be a tendency toward increased erosion would be at the culverts where velocities would increase slightly. At those locations, it was found that the increased erosion potential would be negligible.

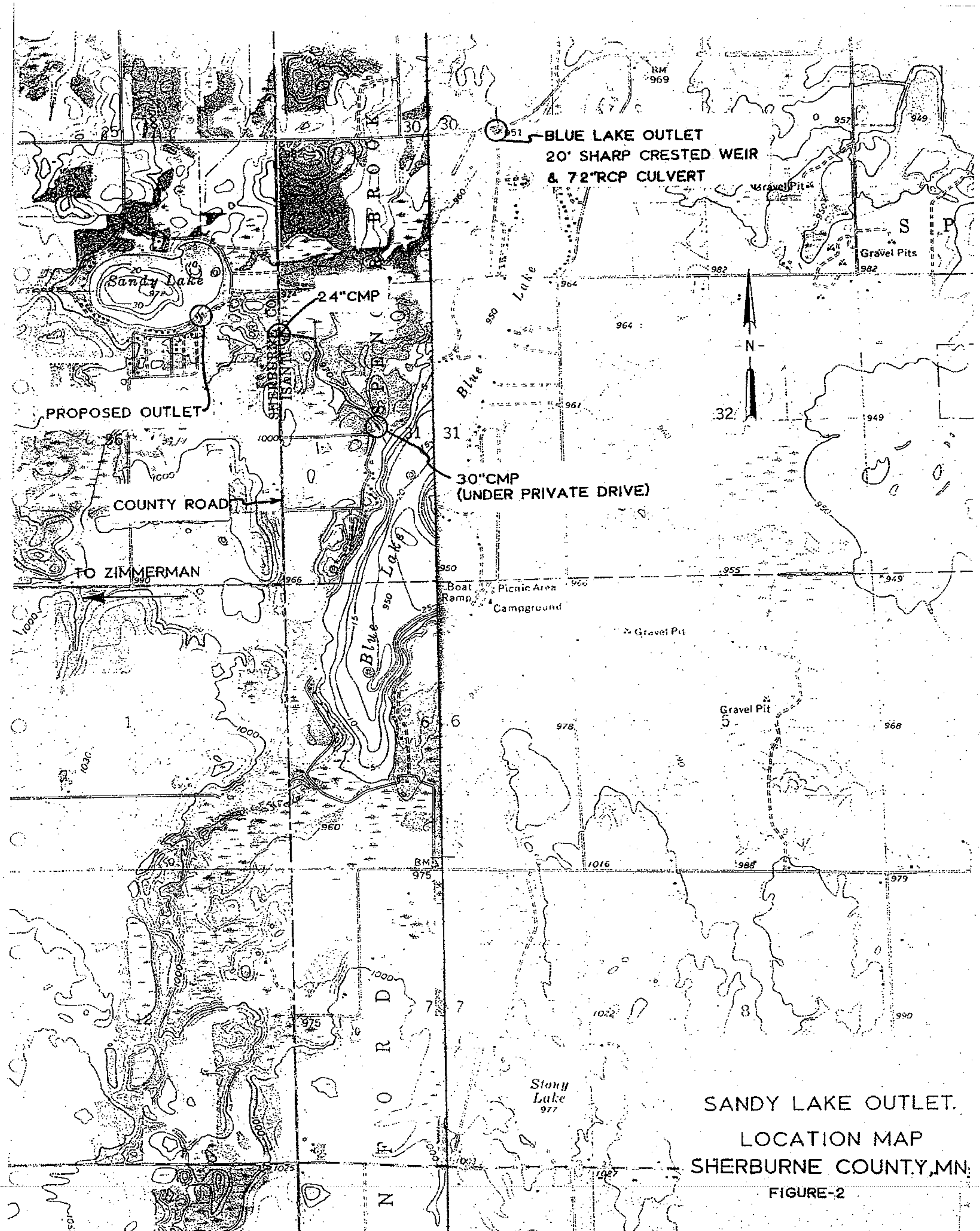
Because Blue Lake has a high proportion of rough fish, while Sandy Lake is nearly void of them, the potential for rough fish migration up the outlet pipe was investigated. Velocities in the pipe were approximately 5.5 feet per second when the pipe was flowing full. Carp can swim against such a current, although the narrow diameter of the pipe could make the effective velocity many times that number to a good-sized carp. For that reason and to reduce maintenance problems and the chance of accidents, the proposed inlet structure has a fish barrier/child-proof grate to prevent upstream movement of rough fish into Sandy Lake. The proposed outlet is shown in Figure 3.



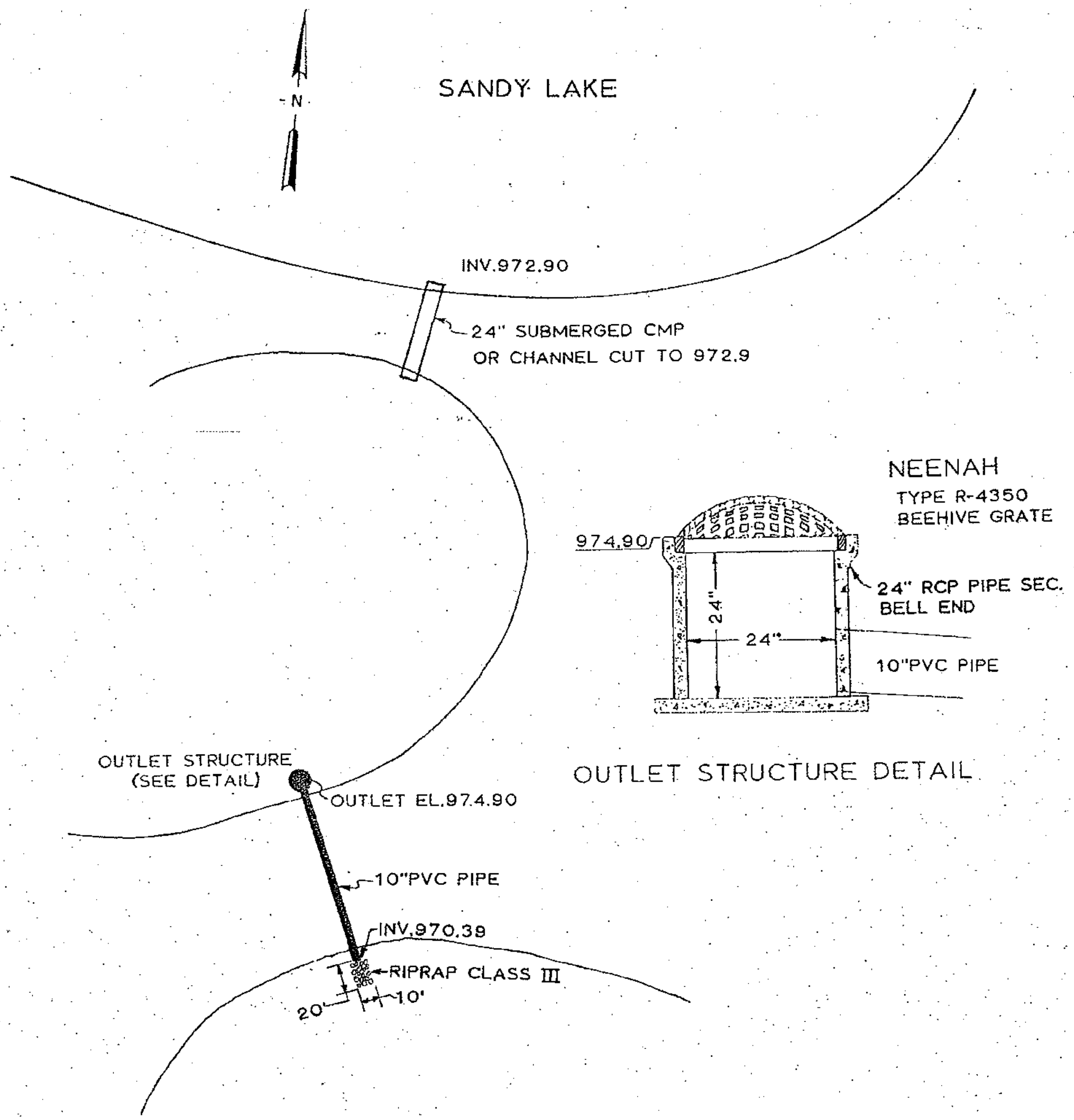
SANDY LAKE

ILLICIT OUTLET

FIGURE-1



SANDY LAKE OUTLET.
LOCATION MAP
SHERBURNE COUNTY, MN.
FIGURE-2



SANDY LAKE

PROPOSED OUTLET PLAN

FIGURE-3

APPENDIX

APPENDIX

A. EXISTING OUTLET PIPE CAPACITY

When first installed, lake dropped 6" in 7 days, or approximately 1"/day.

$$\frac{1\text{"/day}}{12\text{"/ft}} \times 70 \text{ acres} \times \frac{43560 \text{ ft}^2\text{/acre}}{3600\text{sec/hr} \times 24\text{hrs/day}} = \boxed{2.94 \text{ cfs}}$$

Use 3cfs

B. FIRST CULVERT DOWNSTREAM OF SANDY LAKE (Under County Road)

24" CMP @ 1.1%
Capacity of Pipe at breakover = 65 cfs
Capacity of Pipe flowing full = 27 cfs

Check difference in elevation of backwater due to 3 cfs additional flow.

1.1% x 46' = .51' difference before
30 cfs in 24" pipe = 1.5% slope of hydraulic grade
1.5% x 46' = .69' head loss after adding 3 cfs

.69' - .51' = .18'

= **[2 inches]** difference

C. SECOND CULVERT (Last Culvert before Blue Lake under private drive)

30" CMP @ 1%

Capacity of Pipe at breakdown = 145 cfs
Capacity of Pipe flowing full = 45 cfs

Check difference in elevation of backwater due to 3 cfs additional flow

1% x 24' = .24' difference before
48 cfs in 30" pipe = 1.15% slope of hydraulic grade
1.15 x 24 = .28' head loss after adding 3cfs

.28' - .24' = .04' = **[1/2"]** difference

D. BLUE LAKE OUTLET

20 feet weir structure, with 72" RCP outlet culvert behind

72" RCP had capacity (flowing full) of ~ 500 cfs.

add 3 cfs and elevation would rise by .001' ~ **1/64 inch**

If weir is flowing at 1', capacity is:

$$g = C_W\, 2/3\, \sqrt{64.4}\ (1)^{3/2}(20) \quad \text{where} \quad C_W \sim .61$$

$$= \boxed{65 \text{ cfs}}$$

Add 3 cfs $\therefore$ $H^{3/2} = 68/65$

$$H = 1.03' \therefore \text{rise} = .o3' = \boxed{.36"}$$

E. CALCULATE EROSION POTENTIAL CAUSED BY ADDITIONAL FLOW

3200 feet from County Road to Blue Lake - Elevation change is approximately 10' (from USGS map).

Channel Slope = **0.31%**

Assume Channel width averages 8 feet.
Calculate Normal depth, assuming rectangular channel:

Q = 27 crs   q = 3.38 cfs/ft

$$\text{Critical depth} = \sqrt[3]{\frac{(3.38)^2}{32.2}} = \boxed{.71'}$$

Mannings Formula

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

$$27 = \frac{1.49}{.04}\ 8\ (d) \left(\frac{8 + 2d}{8d}\right)^{2/3} (.0031)^{1/2}$$

$$1.63 = d \left(\frac{8+2d}{8d}\right)^{2/3} \qquad \boxed{d = 2'}$$

$\therefore$ Subcritical Flow

$$\text{Velocity} = \frac{3.38}{2} = \boxed{1.69 \text{ fps}}$$

Add 3 cfs:

$Q = 30$ cfs $\quad q = 3.75$ cfs/ft

$$1.81 = d\left(\frac{8 + 2d}{8d}\right)^{2/3} \qquad d = 2.4'$$

$$\text{Velocity} = \frac{3.75}{2.4} = \boxed{1.56 \text{ fps}}$$

RESULT: Additional flow would tend to decrease average flow velocity and increase depth of flow.

NOTE: This would tend to reduce erosion potential in drainageway, but could increase erosion at inadequate structures. Since the additional flow would have only very minor impacts on the two water levels and discharges at the two structures, the erosion potential caused by the additional flow from Sandy Lake would be immeasurable.