TMDL
For Temperature in
Ken's Lake, Utah

Prepared by
Utah Department of Environmental Quality/Division of Water Quality

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Waterbody ID	**Ken's Lake**
Location	**San Juan County, Utah** **HUC # 14030005**
Pollutants of Concern	**Temperature**
Impaired Beneficial Uses	**Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.**
Loading Assessment	**Temperature impairment is a result of natural causes. The energy input is a direct result of heating by the sun.**
Defined Targets/Endpoints	**Petition for delisting based on analysis.**
Implementation Strategy	**Incorporate site-specific standard for temperature as per target/endpoint description.**
This document is identified as a TMDL for Ken's Lake and is officially submitted to the U.S. EPA to act upon and approve as a TMDL.	

I. Introduction

Ken's Lake is an off-stream reservoir at the foot of the west slopes of the La Sal Mountains in southeastern Utah. The impoundment is approximately 10 miles south of Moab (see Figure 1) and is part of the Mill Creek Watershed. The valley is a long graben, where the underlying rocks have dropped below the surrounding terrain. It is an arid redrock desert. Water is brought into the lake via the Sheley Diversion Tunnel from Mill Creek. The Grand County Water Conservancy District initiated development of Ken's Lake in 1979. The lake was developed to serve the agricultural irrigation needs of residents of Moab's Spanish Valley. The reservoir includes a dam that is 95 feet high and 4,050 feet long. Nearly 900,000 cubic yards of earth were needed to complete the dam, which is designed to hold 2,610 acre-feet of water. The reservoir has a surface area of 35 hectares/86 acres, is 2,690 feet long, 1,400 feet wide and has a maximum depth of 70 feet.

The sole perennial inflow to Ken's Lake is the canal from the Sheley Diversion. Outflow is to a pressurized irrigation system, which provides water to irrigated acreage in Spanish Valley. Vegetation in the surrounding area is sparse and predominantly shrub and grassland.

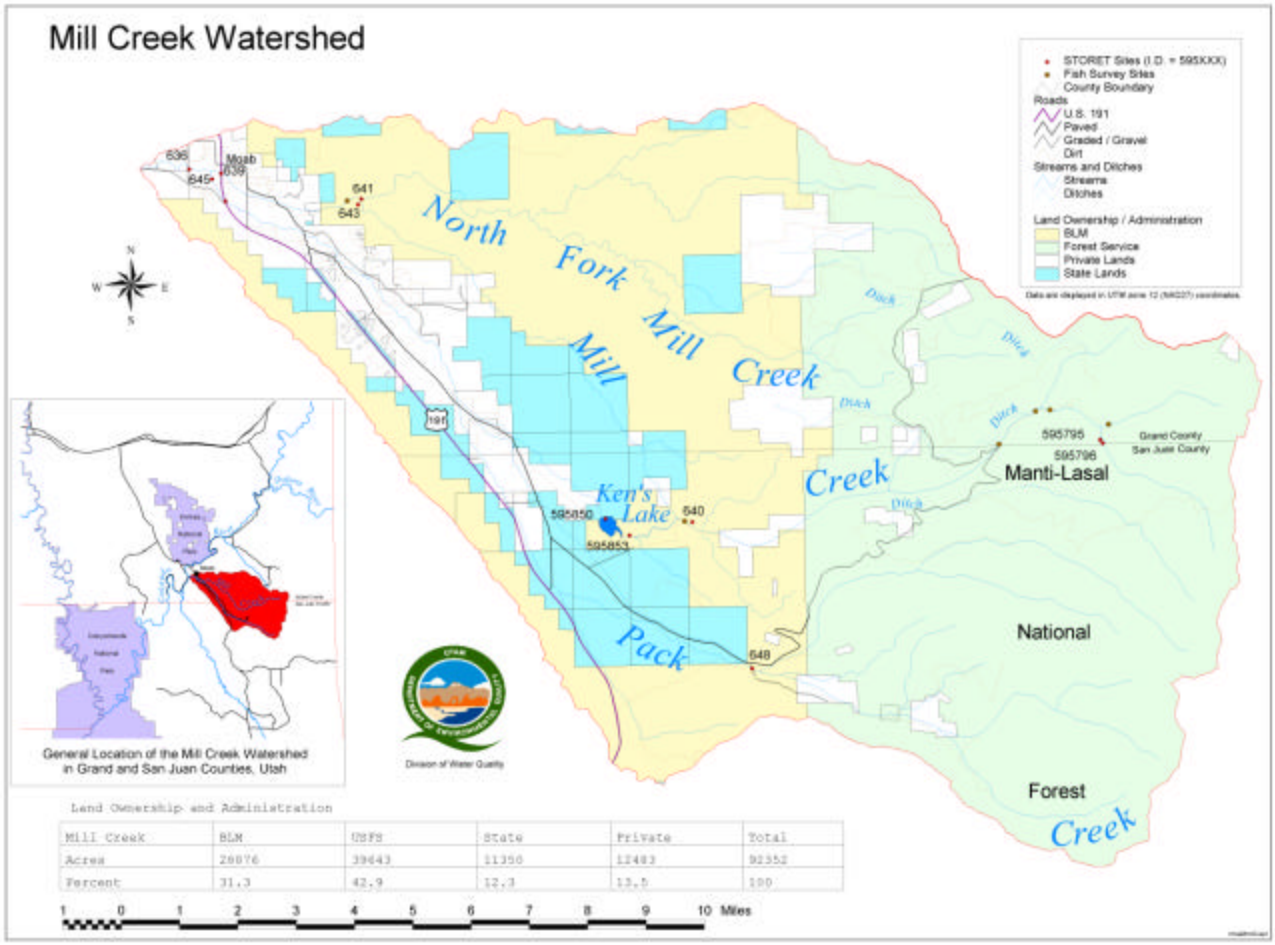


Figure 1 - Mill Creek Watershed

The reservoir contains populations of largemouth bass, green sunfish, channel catfish, brown trout, and rainbow trout. These species provide a valuable recreation resource for residents and visitors of the Moab area. Approximately 11,000 catchable-size rainbow trout are stocked annually by UDWR. The Utah Division of Wildlife Resources feels that this water is appropriately designated as a coldwater trout fishery, but is managed as such on a seasonal rather than year-round basis. UDWR recognizes

that summer water temperatures are too high for stocked fish to survive year-round. Stocking of these fish is split between spring and fall seasons when rainbow trout survival and catchability by anglers are highest. Summer water temperatures are not favorable for a trout fishery. Grand Water and Sewer Service Agency is legally required by the BLM to maintain a minimum pool of at least 400 acre-feet of water in the reservoir for fishery purposes.

II. Water Quality Standards

The Utah Division of Water Quality (DWQ) has assessed and classified the beneficial uses of Ken's Lake. The assessments were made using Utah's water quality standards. The water quality numeric standard for temperature in Class 3A fisheries is 20 degrees Celsius. Ken's Lake was found to exceed this standard periodically from June thru September.

Table 1 - Pollutant of impairment & designated uses

Waterbody	**Impairment**	**Beneficial Use Classes** (Impaired class shown in **bold**)
Ken's Lake	Temperature	2B, **3A**, 4

Table 2 - Description of Beneficial Use Classification in Utah

BENEFICIAL USE CLASSIFICATIONS FOR WATER IN THE STATE OF UTAH
Protected for recreational use and aesthetics.
Class 2B - Protected for secondary contact recreation such as boating, wading, or similar uses.
Protected for use by aquatic wildlife.
Class 3A - Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.
Class 4 - Protected for agricultural uses including irrigation of crops and stockwatering.

III. Water Quality Targets/Endpoints

The state will develop a site-specific standard for temperature in Ken's Lake or reclassify the lake as a warm water fishery (3B), based on information in this TMDL study as identified in table 3.

Table 3 - Recommended site-specific temperature standard

Time Period	**Temperature not to be exceeded**
October 1st – May 31st	20 degrees Celsius
June 1st – September 30th	Site specific standard

IV. TMDL

Water quality in Ken's Lake will meet state standards or site-specific criteria for it's designated beneficial uses.

V. Significant Sources

Ken's Lake is supplied with water through a diversion tunnel and travels approximately 1 mile from the Sheley diversion to the lake. Thermal impairment is a direct result of heating by the sun. The only other important sources of cooling or heating are evaporative cooling from wind, sensible heat loss or conduction and inflow of the diversion stream. Most light entering Ken's Lake is converted directly to heat. In this southern Utah region the annual change in the heat content of the reservoir closely reflects the seasonal pattern of temperature (see figure 2). Although shading by vegetation is very important in streams it is not in most lakes and is not a factor, nor feasible, on Ken's Lake an irrigation impoundment. The inflow water temperatures meet Utah Water Quality Standards.

VI. Technical Analysis

Heat cycles give a total accounting of the gain and loss of heat by the system during a specified time period. A square centimeter of lake surface is a convenient unit since heat transfer is expressed in terms of area. Thus units have been converted to calories per square centimeter. The length of the water column considered is taken as the average depth of the lake during the critical period. The heat income and losses from the lake surface vary with time of day but can generally be expressed as:

$$\mathbf{S = R_n - E - H - Q}$$

Where:

S = storage rate of heat in the lake.

$\mathbf{R_n}$ = net radiation from weather station in Grand Junction, CO. approximately 70 miles from Moab (see tables 4).

E = (evaporation - approximately 540 calories/gram) heat lost by evaporation, dependant on wind, surface temperature and air vapor pressure. Ken's Lake evaporation equals approximately 137 acre-feet annually (see tables 4).

H = (sensible heat transfer), which is roughly equal to conduction. Based on figure 2, minimum temperature for Moab in summer rarely drops below 20 degrees C indicating that sensible heat transfer would predominantly be from the air to the water.

Q = (advective heat inputs and outputs) due to inflow and outflow of streams. Water inflow from the Shelley Diversion has been measured (by field team) ranging from 15 degrees in early June to 19 degrees in August (see table 5).

Month	Solar Radiation KWh/m^2/day	Solar Radiation Calories/cm^2/day	Solar Radiation Calories/day to Ken's Lake	Evaporation from Ken's Lake (Acre-feet)
June	8.1	696.92	2,426,396,672,000	42.92
July	7.3	628.10	2,186,792,960,000	38.28
August	6.5	559.26	1,947,119,616,000	34.80

Table 4 - Solar Radiation & Evaporation

Based on the above information it is clear that the temperature in Ken's Lake will continue to exceed the state's 20 degree Celsius standard during the summer months. Trout survival is not expected during the July 1st – September 15th period. The Division of Wildlife Resources (UDWR) feel that a sufficient portion of the water column to maintain a coldwater fishery in Ken's Lake is a minimum band of at least 10 vertical feet that stays below 20 C. According to UDWR to achieve suitable temperatures for trout during summer would require a reservoir depth (at the deepest point) of; approximately 16 ft in late June, 27 ft in mid-July, 34 ft in late July, and 41 ft in late August. Given that the primary purpose of the reservoir is irrigation, these water levels are unrealistic.

Month	Average lake storage at months end (Acre-feet)	Average inflow to Ken's Lake (Acre-feet)	Percent of storage attributed to inflow	Average temperature of inflow (degrees C)
June	2117	978	46 %	15
July	1625	457	28 %	18
August	1146	360	31 %	19

Table 5 - Ken's Lake storage & inflow

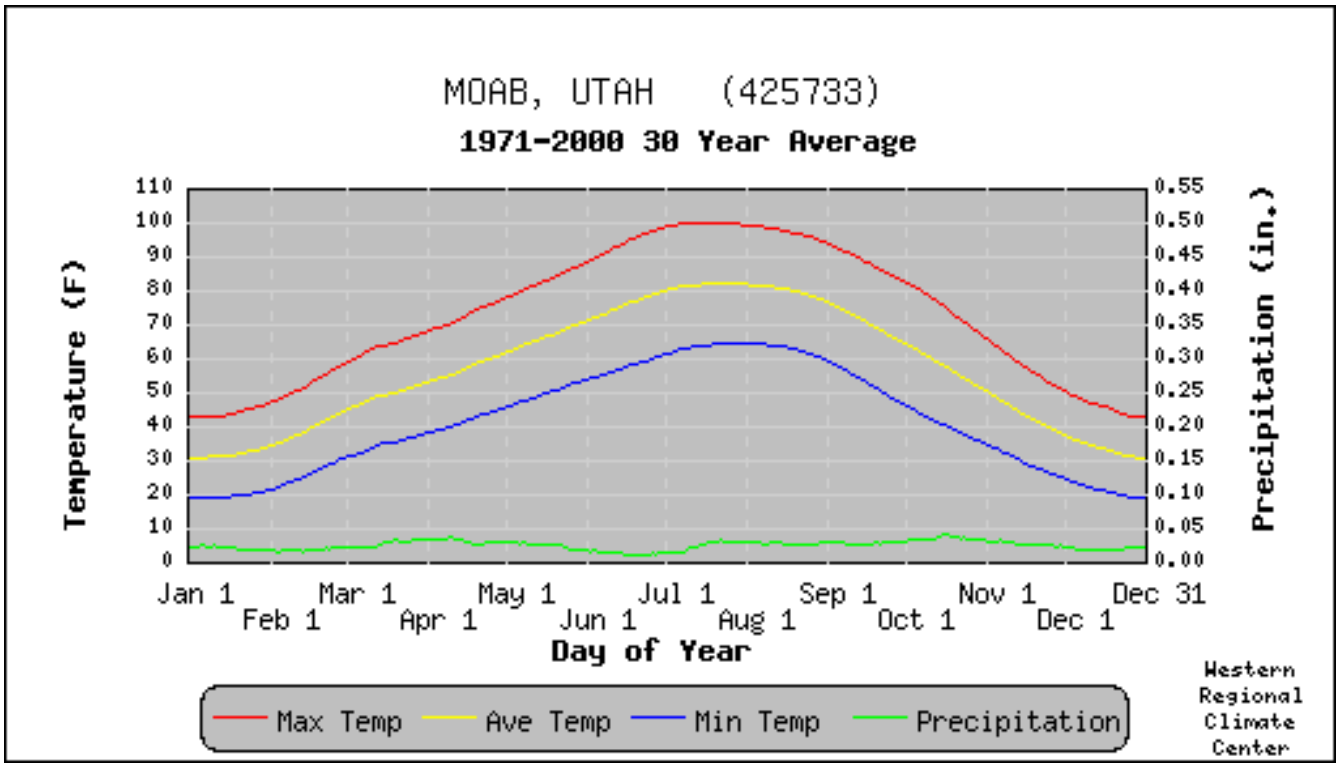


Figure 2 - Moab, Utah (425733) 1971-2000 Monthly Climate Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	44.2	52.7	64.0	72.9	83.2	94.1	99.8	97.4	88.6	74.9	56.1	46.0	73.0
Average Min. Temperature (F)	19.9	26.1	34.8	41.9	49.9	57.6	63.7	63.0	53.2	40.5	28.7	21.4	41.9
Average Total Precipitation (in.)	0.66	0.57	0.87	0.95	0.80	0.43	0.79	0.89	0.86	1.12	0.83	0.66	9.42

Table 6 – Moab, Utah (425733) 1971-2000 Monthly Climate Summary

Month	Net Calories/day to Ken's Lake (radiation-evaporation)	Potential daily temperature increase (degrees C)	Potential monthly temperature increase (degrees C)	Average lake temperature first day of the month (degrees C)
June	1,473,330,022,633	0.46	13.73	13.2
July	1,336,760,338,962	0.42	12.87	19.3
August	1,174,363,055,020	0.36	11.31	21.4

Table 7 - Heating in Ken's Lake

Table 7 shows the potential temperature increase in Ken's Lake on a monthly and daily basis. Although wind speed and cloud cover do serve to further reduce the water temperature. It is obvious that a shallow irrigation impoundment in this Southern Utah climate cannot be expected to maintain a temperature below 20 degrees Celsius.

The change in temperature from late spring to summer can be seen in figures 4 through 13. These figures show how the temperature is adequate in late May and early June and then becomes impaired by August. The dissolved oxygen profiles are also shown. In spite of the high temperatures the dissolved oxygen levels are adequate for fish.

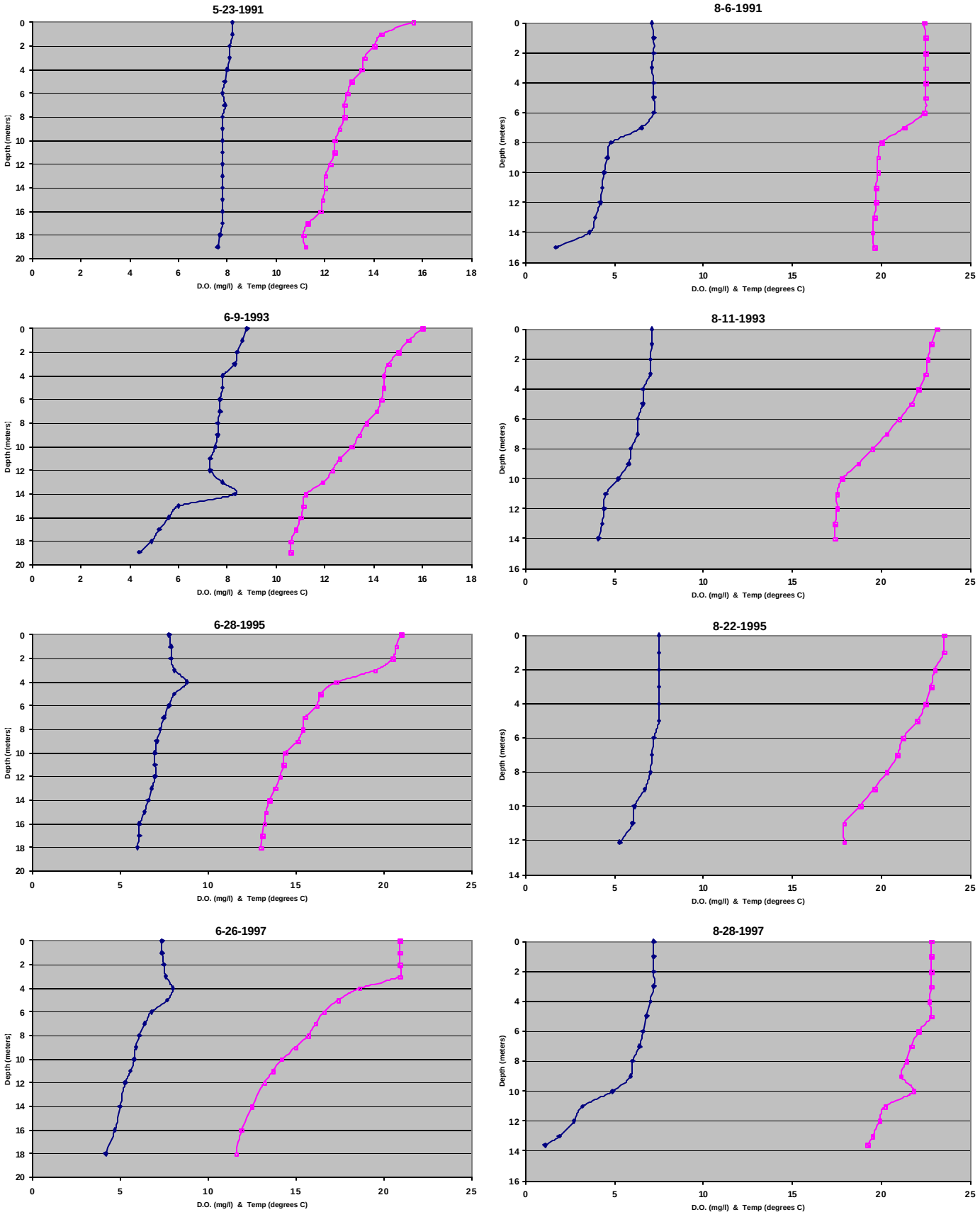
VII. Margin of Safety

The reservoir and inflow will continue to be monitored to assure compliance with state standards. With new information or data the TMDL may be reevaluated based upon data obtained. Riparian improvements along the inflow channel will provide an additional margin of safety.

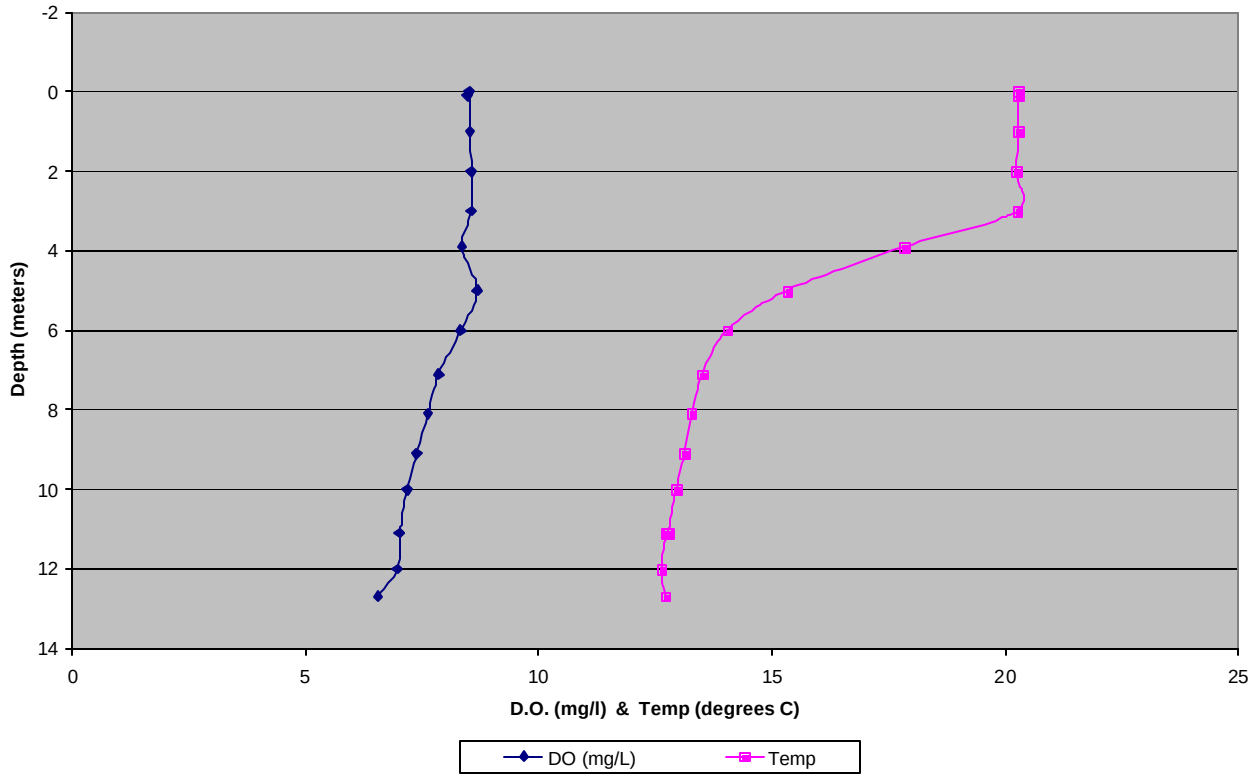
VIII. Allocation of Load

Based on the technical analysis performed Ken's Lake is unable to meet the current state water quality standard for temperature (20 degrees Celsius). Radiation inputs during the summer months will continue to cause temperatures to rise above 20 degrees Celsius. Because the only thermal input causing a temperature increase is naturally occurring, no allocation can be made.

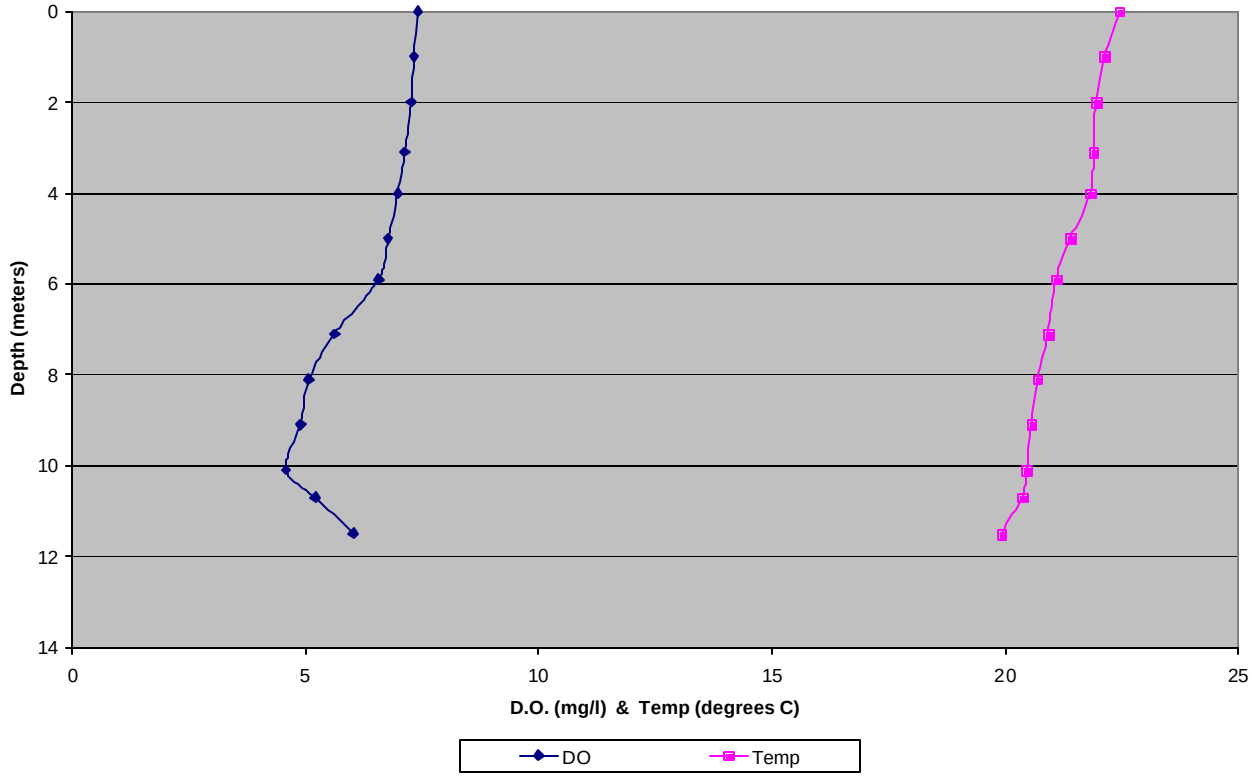
Figures 4-13 Ken's Lake Temperature & Dissolved Oxygen Profiles



Ken's Lake Profile 6-12-2001



Ken's Lake Profile 8-14-2001



Public Participation

Information concerning Ken's Lake has been distributed throughout the community. A brochure was developed to help people understand TMDL's. A public meeting and open house were held to explain the assessment and recommendations to those interested.

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