



Dye Tracer Studies

In order to determine patterns of lake circulation and mixing, on April 7-8, and again on August 4-5, 1999, slug-injection **dye tracer studies** were run at Deep Hollow Lake near Sidon, Mississippi by Doug Shields, Scott Knight, and other personnel from USDA-ARS National Sedimentation Laboratory assisted by collaborating agencies.

Dye was introduced to the north end of the lake in April and to the south end in August. There was no precipitation during either dye study. Wind speeds were estimated at 5 to 10 mph from the south on April 7 and 10 to 15 mph from the southwest on April 8. Winds were calm on August 4 and 5.



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- Inflow was generated by pumping wells and transmitting the groundwater to a ephemeral channels. Flow was maintained at a near-constant levels for the duration of each test. Measurements of flow rate were conducted by the Mississippi District of the U.S. Geological Survey. Hydrographs derived from data provided by that agency are shown in later slides.
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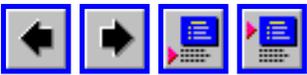
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- In both dye studies, two gallons of Rhodamine B dye (10% stock solution, about 800 g active ingredient, total) were mixed with about six gallons of water.
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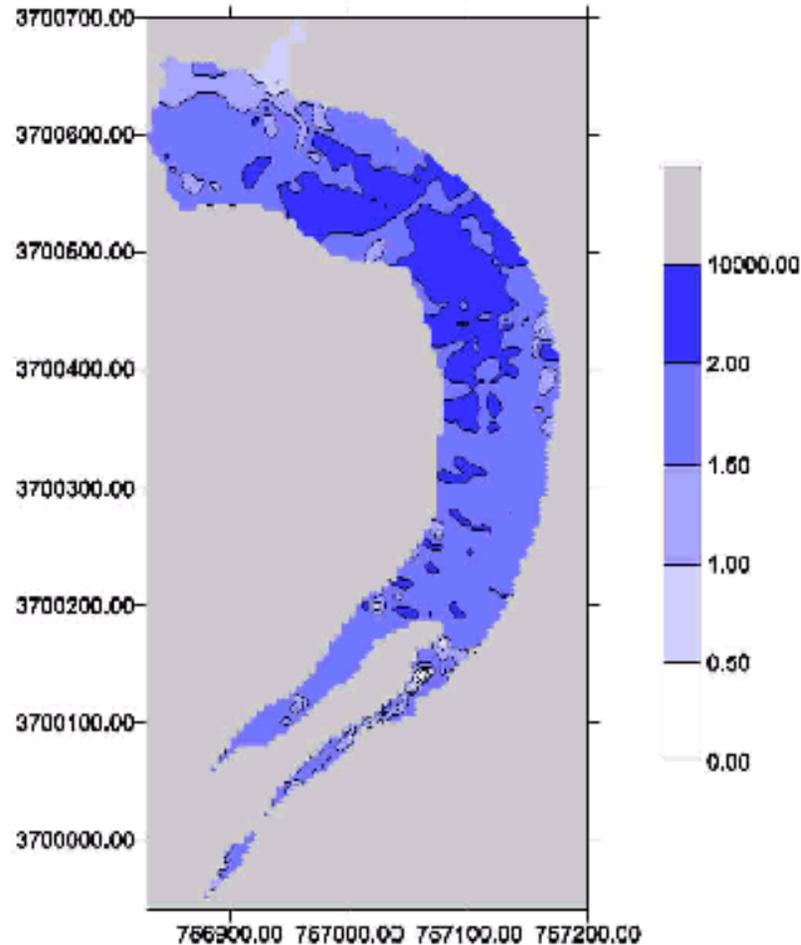
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- The dye solution was instantaneously injected to the lake inflow at 1115 hours on April 7 and at 1200 hours on August 4.
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- Visible plums moved down the ephemeral channels and reached the lake within 30 minutes.
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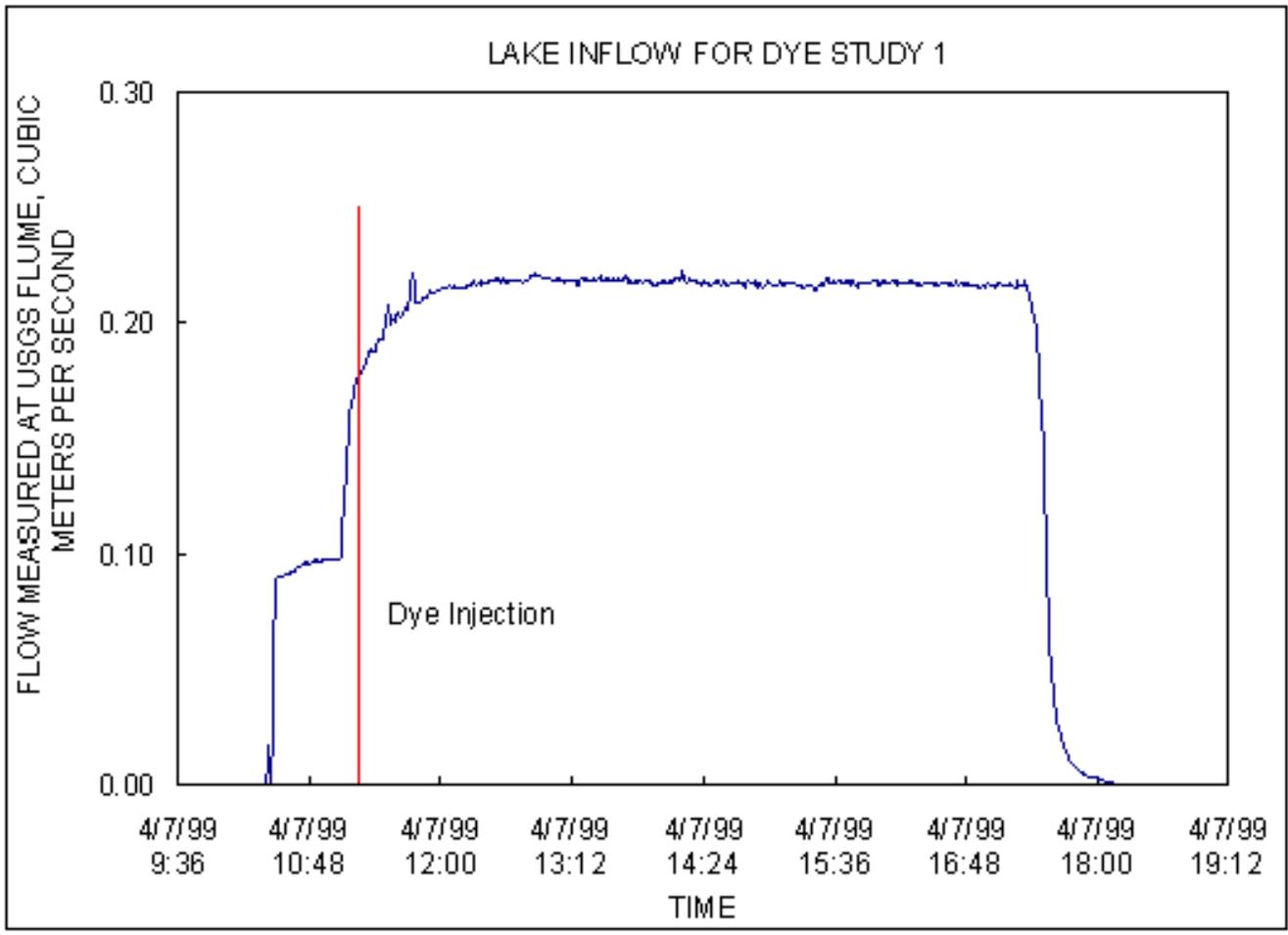
**MISSISSIPPI DELTA MSEA. DEEP HOLLOW LAKE.
WATER DEPTH, M. APRIL 7 & 8, 1999 AND
AUGUST 4 & 5, 1999.
ALL DEPTHS CORRECTED TO LAKE STAGE = 5.3 FT.**



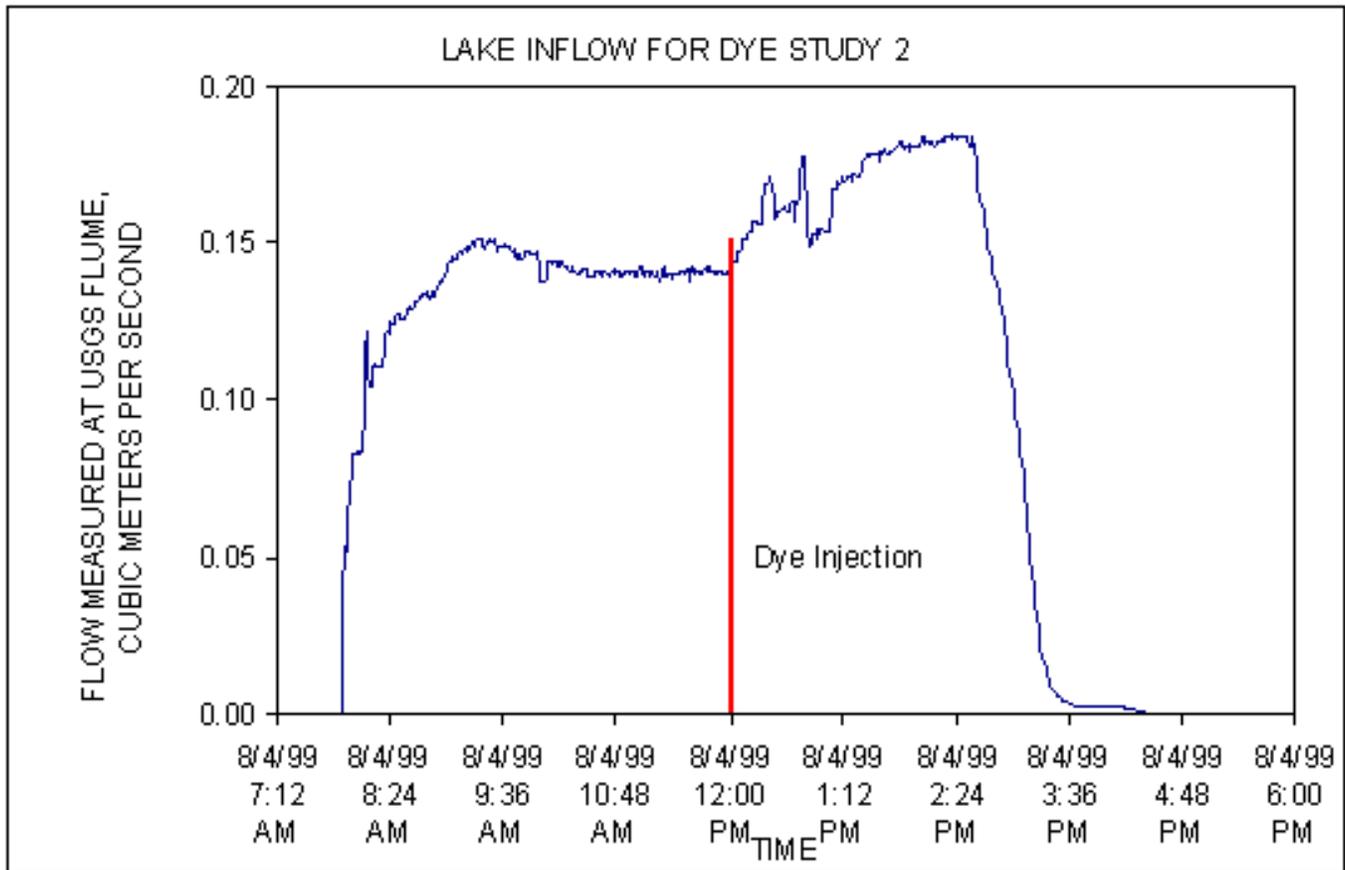
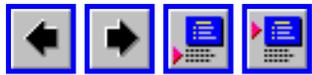
- This map was generated during this study using an echosounder coupled with the differential GPS. Water depths are shown in meters and the x- and y-axis are labeled in Universal Transverse Mercator coordinates in meters. Deep Hollow Lake has featureless bed topography, which is typical of very old oxbow lakes. For the April test, water depth averaged 2.0 m (6 ft) while in August, mean depth was 1.3 m (4 ft). In April, lake surface area was 74,390 m² (~19 acres) and the volume was 147,396 m³. In fact, lake surface area was likely about 10 percent larger, and mean depth somewhat smaller because we could not access extremely shallow areas, which were often covered by flooded shrubby vegetation, for echosounder mapping.



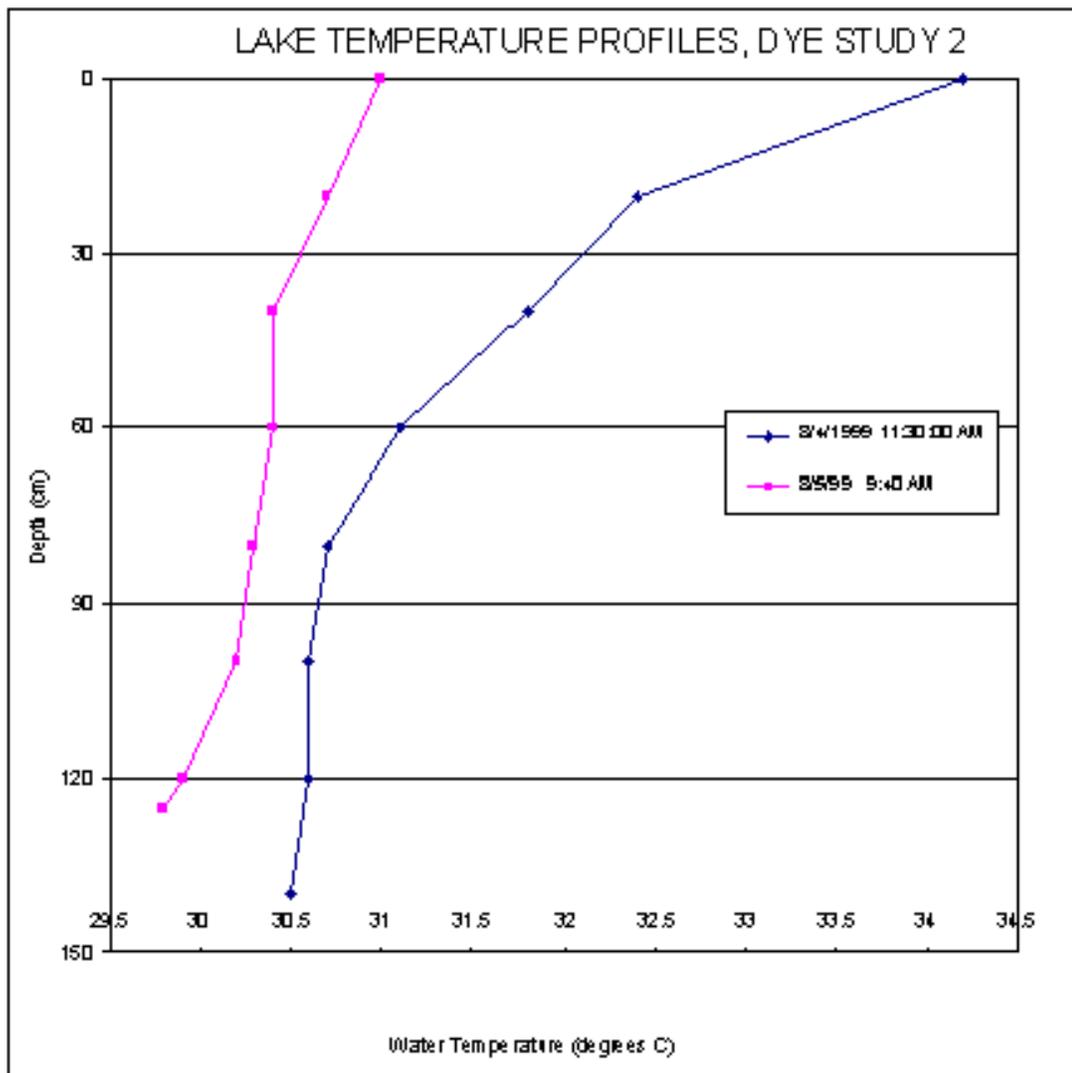
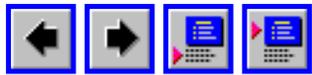
A Turner Model 10 AU fluorometer was mounted on a small boat with a differential GPS and operated in flow-through mode to obtain maps of dye concentration at selected times during the first 26 hr after injection. The fluorometer was fed using a garden hose attached to a small pump and a rigid PVC pipe mounted as to maintain constant depth below surface. Inflow depth was selected by collecting vertical profile of dye concentration prior to sampling and setting sampling depth for maximum concentration. All mapping done on April 7 represents a depth of 50 cm below the surface, while a depth of 125 cm was sampled on April 8. A depth of 80 cm was used for dye mapping for both August 4 and 5.



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- For the first test, inflow occurred between 1025 and 1745 hours on April 7. Mean flow rate for this period was 0.2 m³/s , and total flow volume was 5,165 m³. Lake stage was about 5.5 ft on April 7 and 5.3 ft on April 8. Inflow temperature was measured with a mercury thermometer and was 20 deg C, which was about 8 degrees cooler than the lake surface.



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- For the second test, inflow occurred between 0750 and 1630 hours on August 4. Mean flow rate for this period was 0.13 m³/s, and total flow volume was 3,878 m³. Lake stage, read from the staff gage near the main boat ramp was 3.4 ft both days, or about 2 ft lower than for the April dye study. Inflow temperature was estimated to be about 23 deg C based on minimum temperatures measured by the fluorometer, which was 7 to 11 deg C cooler than the lake surface.
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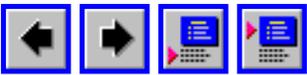


- A major difference between the two dye studies was that the lake was warmer and exhibited weak stratification during midday periods of the second study. Temperature profiles measured at the center of the lake are shown. Temperature profiles were collected at the same point on both days. They indicate that the lower part of the lake (below about 60 cm depth) had a nearly constant temperature of about 30 C, but upper layers warmed considerably during the day.

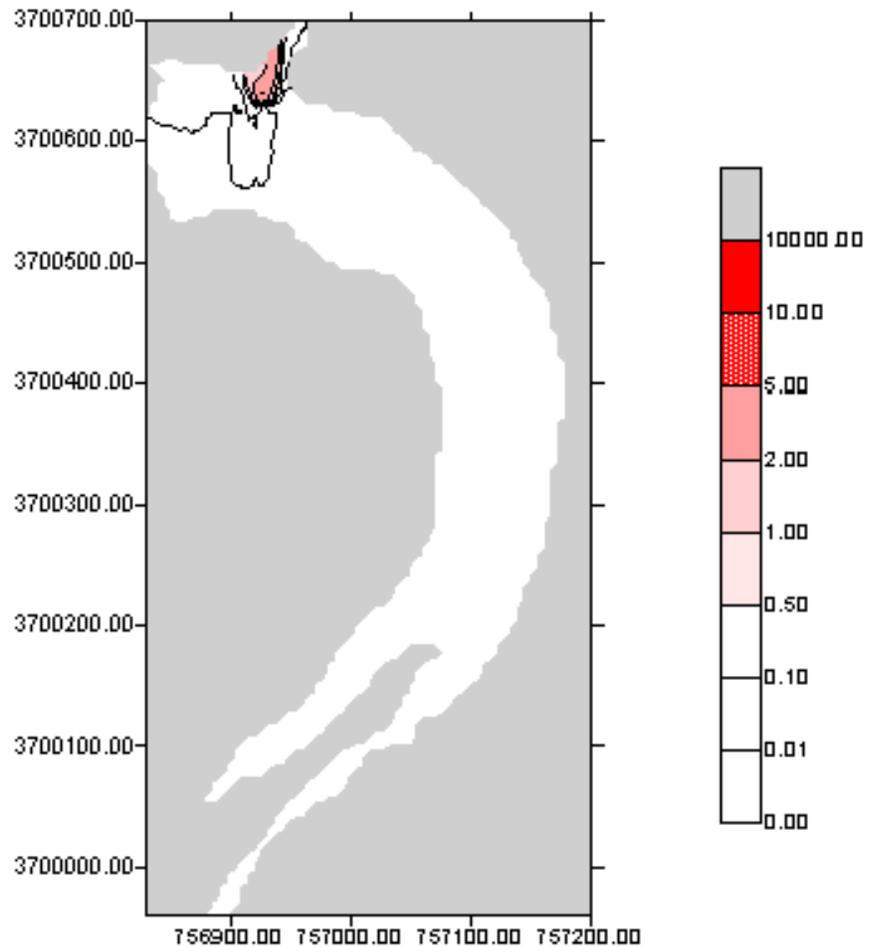
Descriptive Statistics for Dye Tracer Tests, Deep Hollow Lake, Mississippi, 1999

DATE STUDY	NOMINAL TIME AFTER INJECTION MIN	NO OF MEASUREMENTS	START TIME	END TIME	MEAN TIME	MEAN TIME AFTER INJECTION	MIN TEMP, DEG C	MEAN TEMP, DEG C	MAX TEMP, DEG C	MIN CONC, PPM	MEAN CONC, PPM	MAX CONC, PPM
April 7-8	30	151	11:43:46	11:51:22	11:47:34	0:31:48	23.8	24.1	23.8	0.0	0.1	Off scale
April 7-8	90	427	12:47:18	13:11:03	12:59:35	1:43:49	23.8	24.4	25.5	0.0	1.3	151
April 7-8	180	239	14:13:52	14:29:31	14:21:01	3:05:15	25.1	25.8	27.0	0.0	0.6	29
April 7-8	300	402	15:49:42	16:15:00	16:02:24	4:46:38	25.0	26.2	28.6	0.0	0.3	7
April 7-8	1900	1631	12:19:00	13:58:40	13:10:08	2:5:54	21.4	24.3	24.8	0.0	6.9	39
Aug 4-5	60	239	12:40:49	13:10:26	12:55:38	0:55:38	24.6	30.9	33.1	0.0	0.9	Off scale
Aug 4-5	160	385	13:38:43	15:33:43	14:36:13	2:36:13	24.7	32.1	35.2	0.0	14.4	Off scale
Aug 4-5	260	441	15:59:08	16:45:29	16:22:18	4:22:18	31.7	34.3	37.2	0.0	2.9	18
Aug 4-5	1400	913	10:03:18	11:10:46	10:37:02	22:37:02	30.1	31.4	33.9	0.1	4.4	8

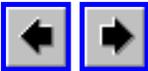
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- Basic data for both dye studies are shown in this table. Following slides illustrate a series of dye concentration maps at each indicated sampling time.
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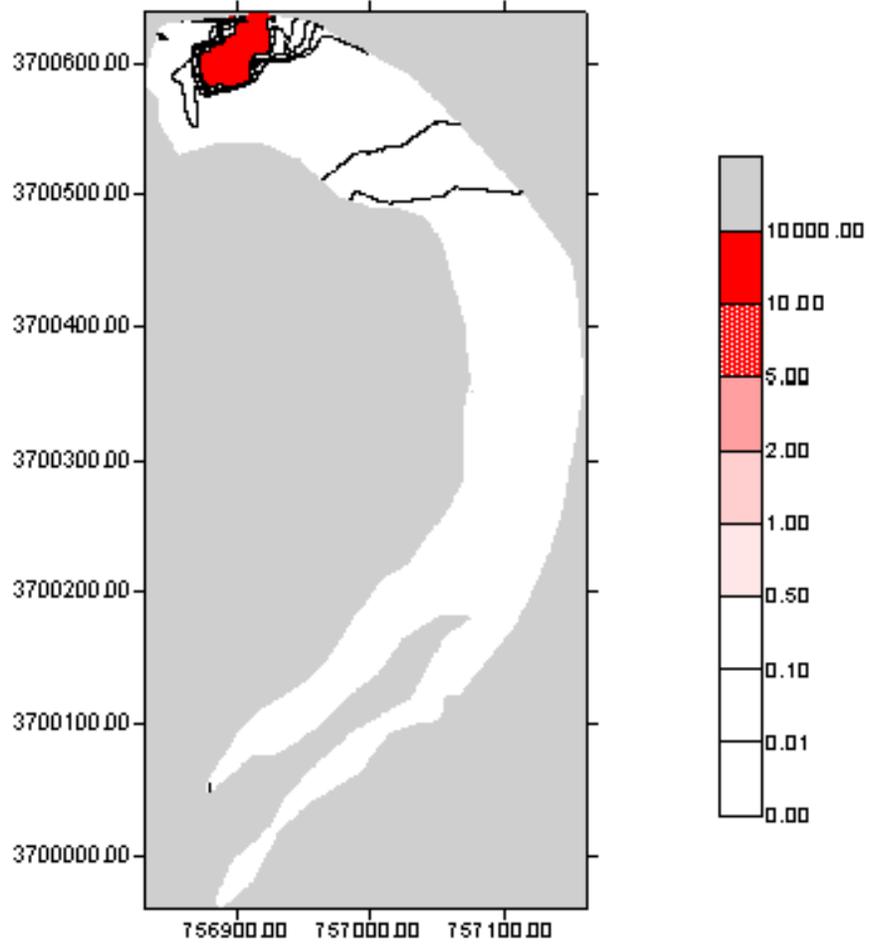
**MISSISSIPPI DELTA MSEA. DEEP HOLLOW LAKE. 4/7/99
DYE CONCENTRATIONS IN PPB AT A DEPTH OF 50 CM
BELOW SURFACE, T = 30 MIN AFTER INJECTION.**

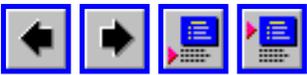


- Contour maps of dye concentration are shown in ppb, and the x- and y-axis are labeled in Universal Transverse Mercator coordinates in meters (datum NAD27 CONUS, Zone 15, False easting 500,000 m).
 - Dye concentrations recorded at $t = 30$ min in the April dye study were low because the plume at that point was very compact, and centroid concentrations were above the measurable range.
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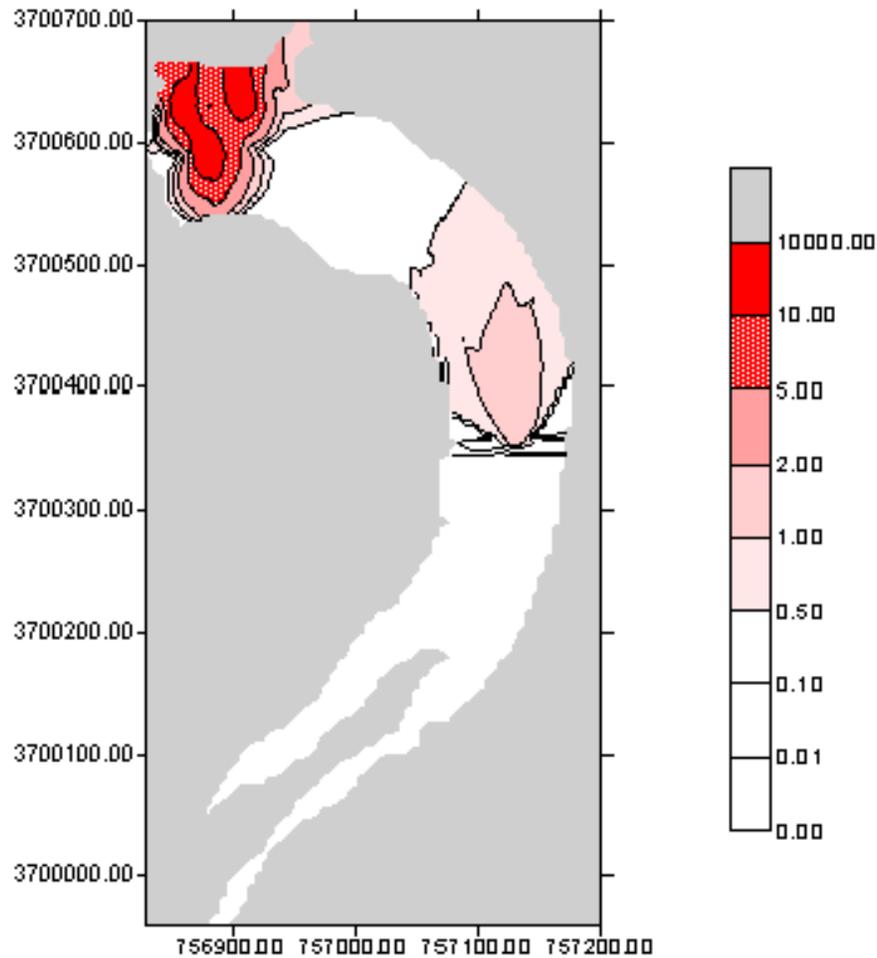


**MISSISSIPPI DELTA MSEA. DEEP HOLLOW LAKE. 4/7/99
DYE CONCENTRATIONS IN PPB AT A DEPTH OF 50 CM
BELOW SURFACE, T = 90 MIN AFTER INJECTION.**

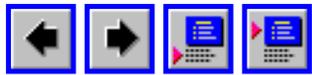




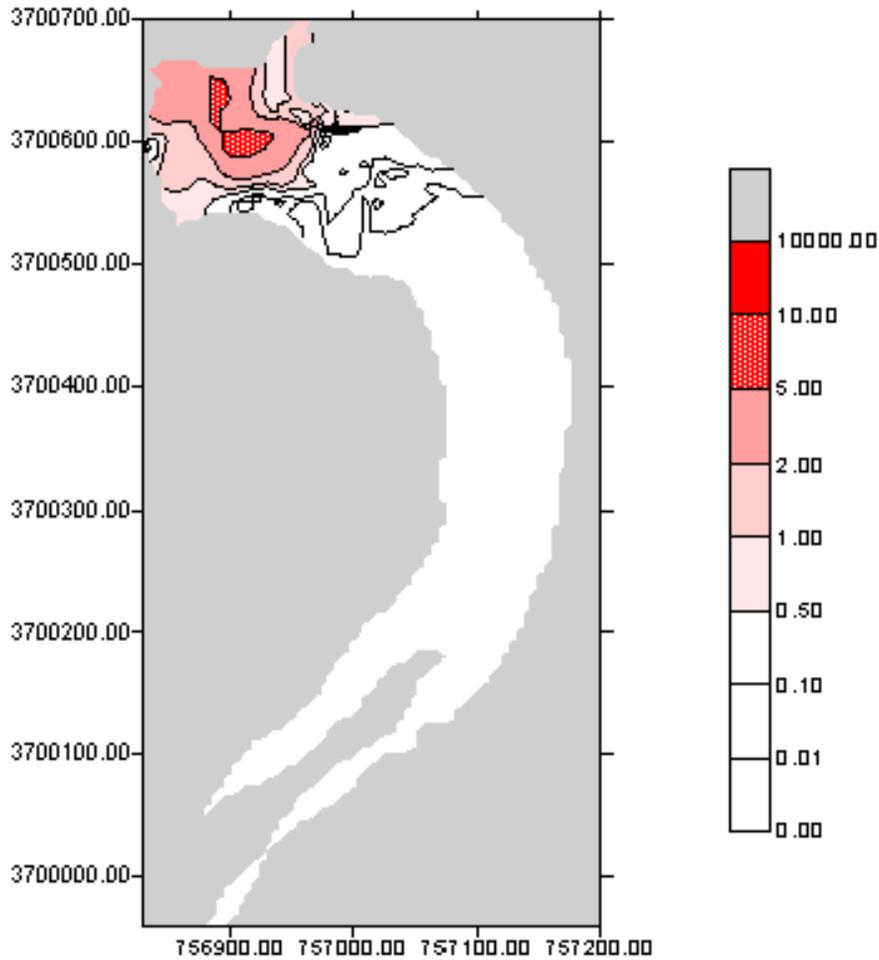
**MISSISSIPPI DELTA MSEA. DEEP HOLLOW LAKE. 4/7/99
DYE CONCENTRATIONS IN PPB AT A DEPTH OF 50 CM
BELOW SURFACE, T = 180 MIN AFTER INJECTION.**



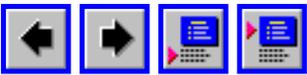
- Wind-induced mixing was the primary influence on dye dispersion. Wind shear on the surface of the lake forced surface layers toward the inflow point and resulted in an opposite movement of lower layers to the west and south. This movement is shown on the dye maps.



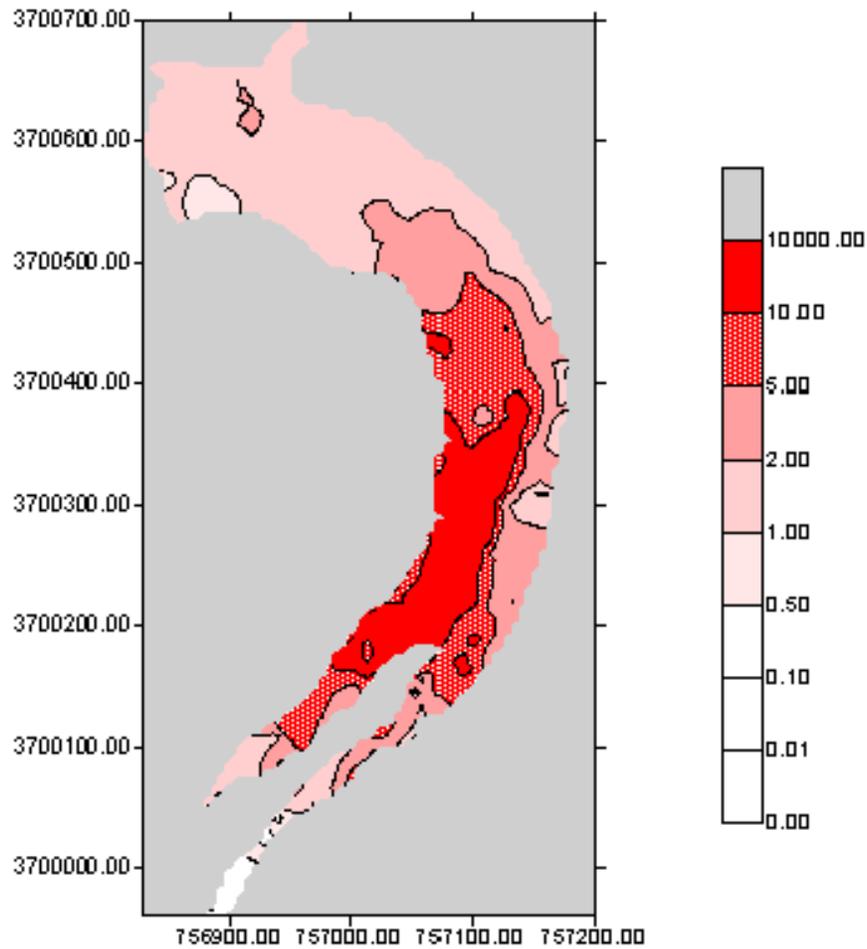
**MISSISSIPPI DELTA MSEA. DEEP HOLLOW LAKE. 4/7/99
DYE CONCENTRATIONS IN PPB AT A DEPTH OF 50 CM
BELOW SURFACE, T = 300 MIN AFTER INJECTION.**



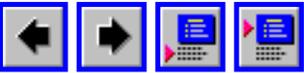
- Concentrations at $t = 300$ min are low relative to maps for previous and subsequent times evidently because the plume sank beneath 50 cm depth.



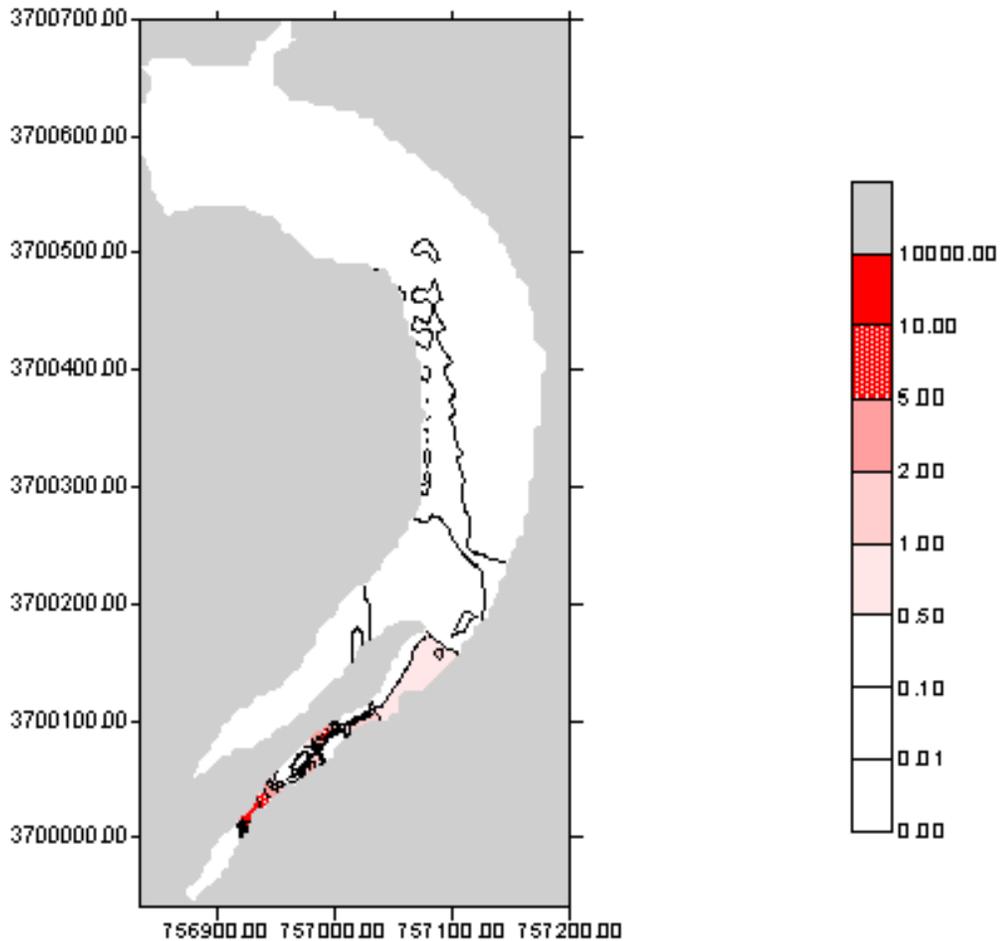
**MISSISSIPPI DELTA MSEA. DEEP HOLLOW LAKE. 4/8/99
DYE CONCENTRATIONS IN PPB AT A DEPTH OF 125 CM
BELOW SURFACE, T = 1500 MIN AFTER INJECTION.**



- The next day (T=1500 min) the dye had dispersed and the highest concentrations at the measurement depth were located at the opposite end of the lake from the point of introduction.
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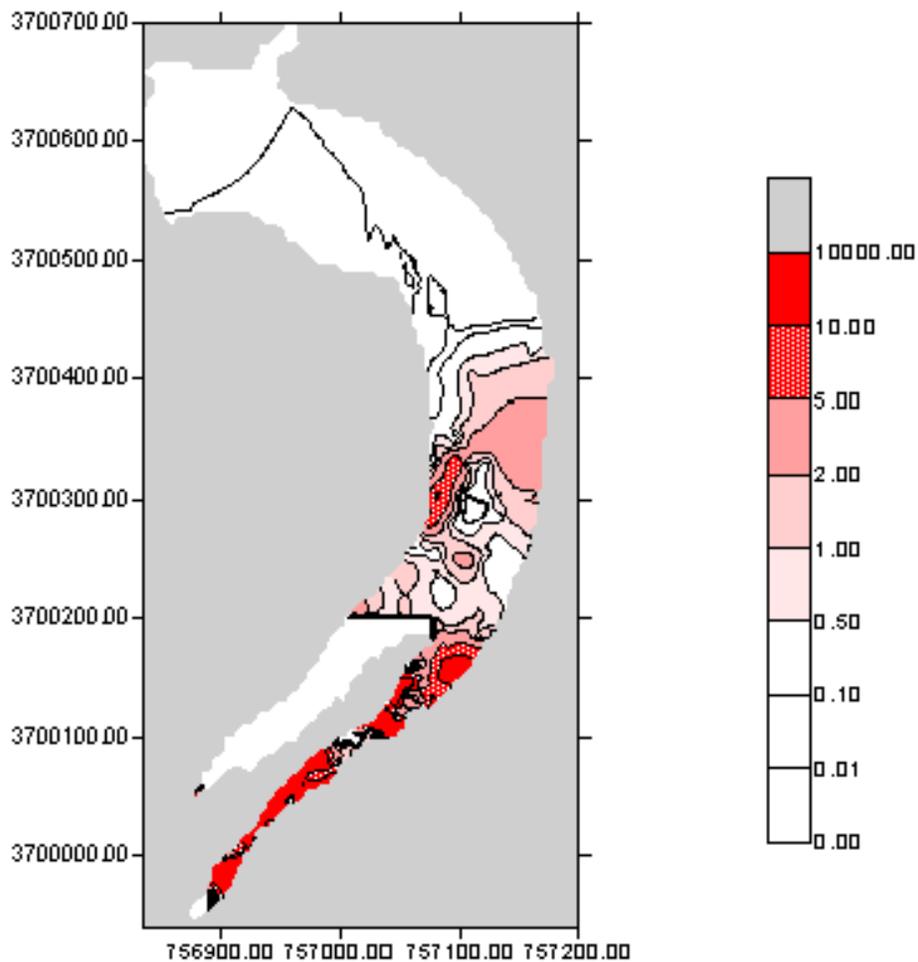
**MISSISSIPPI DELTA MSEA. DEEP HOLLOW LAKE. 8/4/99
DYE CONCENTRATIONS IN PPB AT A DEPTH OF 80 CM
BELOW SURFACE, T = 60 MIN AFTER INJECTION.**



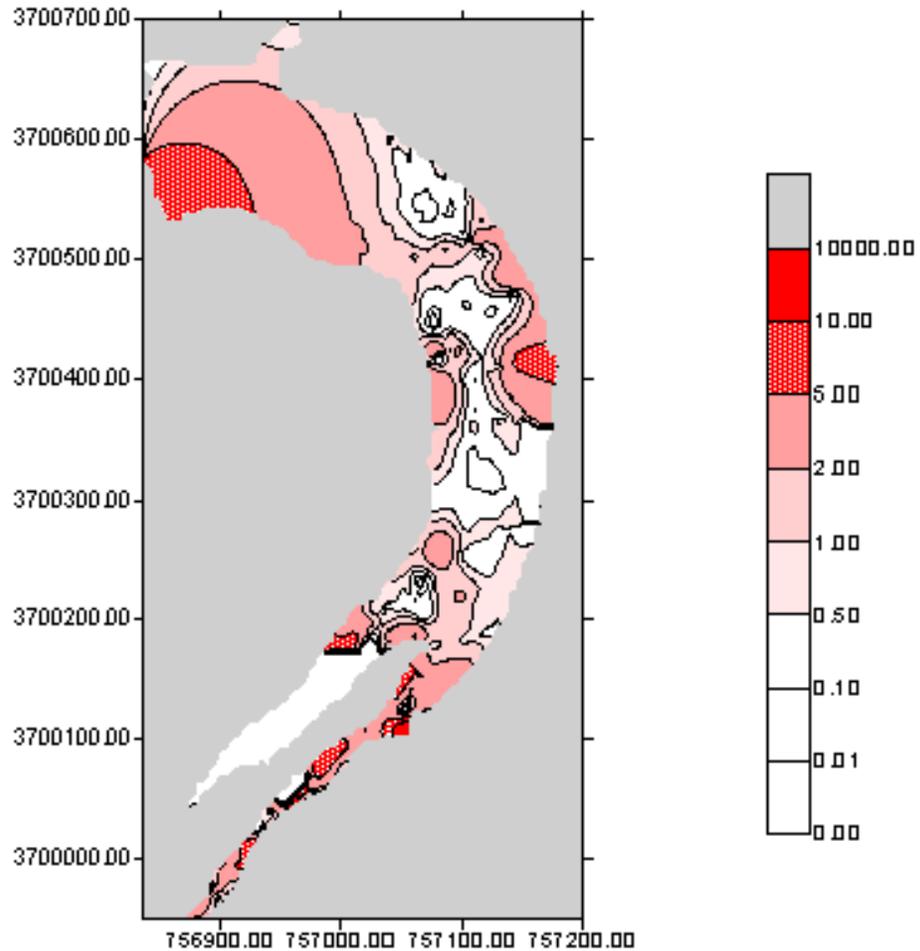
- In a fashion similar to the first study, short-term ($t = 60$ min) mapped concentrations appear low because the dye cloud was very compact, and when it was encountered, concentrations exceeded about 200 ppb, which was above the measurable range.



**MISSISSIPPI DELTA MSEA. DEEP HOLLOW LAKE. 8/4/99
DYE CONCENTRATIONS IN PPB AT A DEPTH OF 80 CM
BELOW SURFACE, T = 160 MIN AFTER INJECTION.**

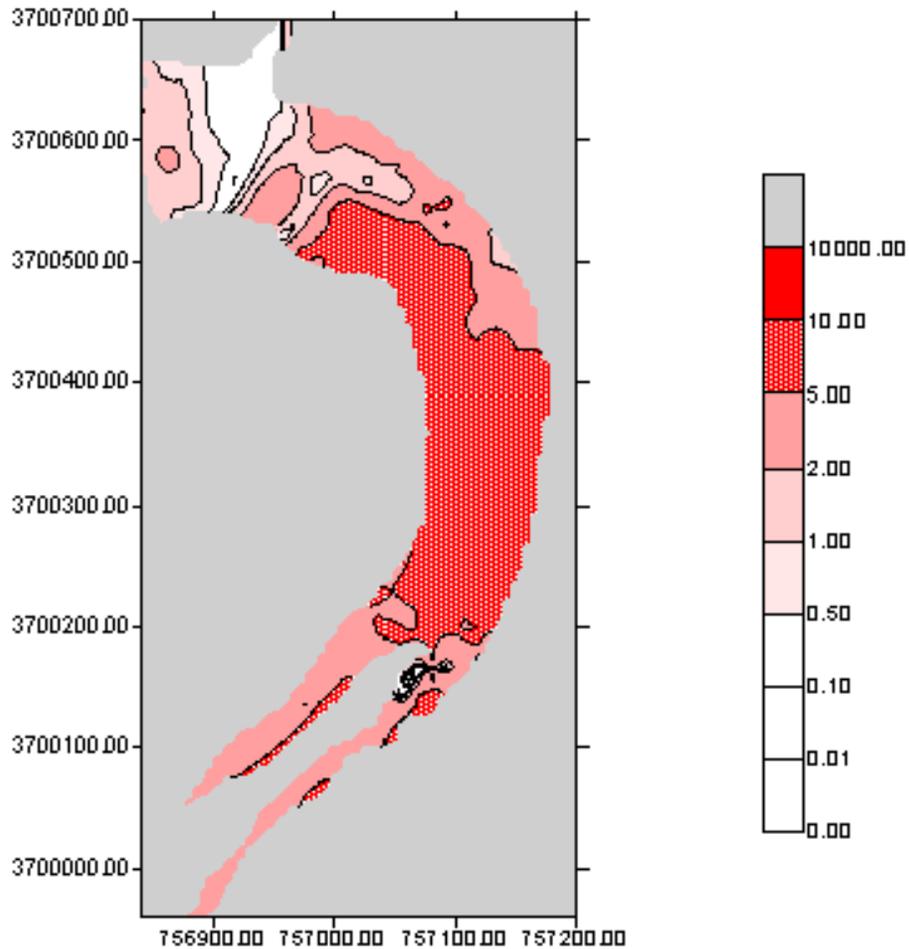


**MISSISSIPPI DELTA MSEA. DEEP HOLLOW LAKE. 8/4/99
DYE CONCENTRATIONS IN PPB AT A DEPTH OF 80 CM
BELOW SURFACE, T = 260 MIN AFTER INJECTION.**



- Despite the relatively low inflow rate and the lack of wind-induced mixing, significant concentrations of dye reached the northern end (opposite the injection point) within 260 min.

**MISSISSIPPI DELTA MSEA. DEEP HOLLOW LAKE. 8/5/99
DYE CONCENTRATIONS IN PPB AT A DEPTH OF 80 CM
BELOW SURFACE, T = 1400 MIN AFTER INJECTION.**



- In both dye studies, the dye cloud had moved well into the middle section of the lake on the second day, and occupied the cooler, lower layer of water below about 50 cm depth.