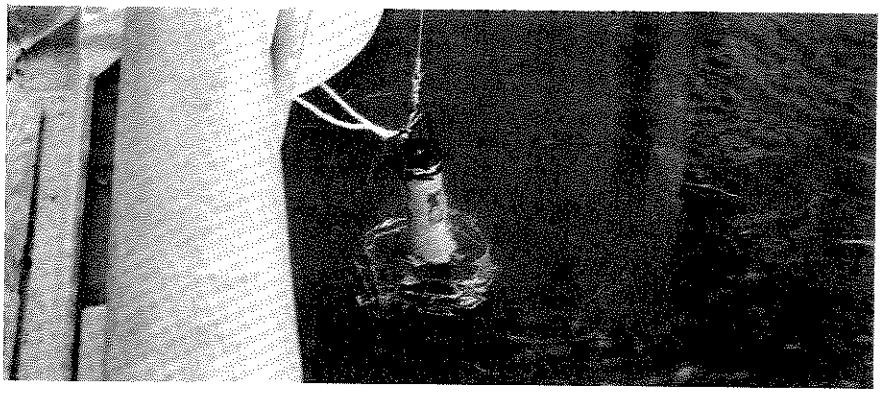

INITIAL DILUTION

A variety of numerical simulation models, employing a number of different conceptual approaches, have been developed to assist in estimating the initial dilutions of sewage effluent achieved at ocean outfalls. The predictions of these models have been tested against one another and against the observations in physical simulation model studies, but direct comparisons with actual ocean outfall discharges are sparse.

SCCWRP worked with the U.S. Environmental Protection Agency (EPA) in summer 1986 in a joint study of initial dilutions achieved at the Encina outfall (off Carlsbad, Calif.). The purpose of the study was to obtain measurements of the initial dilution and of the synoptic characteristics of the receiving waters, to test the validity of the various numerical simulation models.

Physicist and oceanographer Terry Hendricks and other SCCWRP staff obtained initial dilution measurements by tracking Rhodamine-WT dye in the plume or wastefield near the Encina outfall. The dye was injected into the effluent stream at the treatment plant (Figure 1).

Working for the most part within 100 to 200 meters of the outfall, Hendricks and his associates determined the spatial characteristics and dye concentrations of the plume by "profiling" the water column at a number of stations, using a submerged pumping system from which water samples were fed into a continuous-flow fluorometer. The pump's depth and local water temperature and salinity were monitored using a CTD (conductivity-temperature-depth) package. It took about 8 hours to sample all stations; profiling the water column required about 45 minutes at each station. Ambient currents were monitored using a mooring with four current meters; also, drogues were deployed to provide a "real-time" estimate of flow speed and direction. In addition, a tracking vessel profiled the water around the perimeter of the study area to provide information about receiving water conditions.

Average dilutions (Table 1) were computed from the ratio between dye concentrations at the time of injection and the average concentration within the plume (or within the wastefield, depending on sample location). This computation is an average both in time (at a constant depth) and space (over all depths within the plume or wastefield). The lowest dilution observed was approximately 289:1; the highest, about 1782:1.

All the dilutions were primarily a function of position within the plume or wastefield.

At the completion of the initial dilution process, the initial dilution was approximately 590:1. The average speed of the ocean currents during the study was 9.3 cm/sec. This is approximately the median current speed for this area, and was sufficiently strong (Froude number = 0.73) to produce an enhancement in the initial dilution and affect the trajectory and shape of the plume.

The initial dilution process was completed approximately 62 meters downstream from the outfall. At the ZID boundary (46m downstream), the dilution was approximately 440:1. The lower edge of the plume or wastefield was in contact with the ocean bottom for a distance of 100-

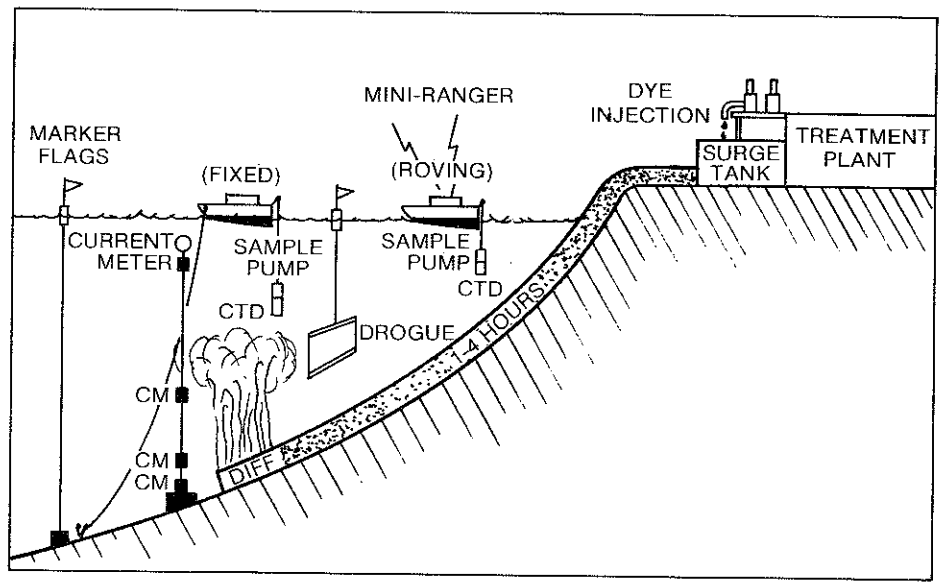

Figure 1. Study elements - Encina initial dilution study, June, 1986

120 meters downstream, and the maximum thickness of the wastefield occurred between 60 and 90 meters downstream (with an estimated value of 22-26 meters).

By 440 meters downstream, the wastefield elevation above the ocean bottom was still the same at the completion of initial dilution (11m); there was only a slight increase in the dilution (15 percent). However, there was a 3-fold change in wastefield thickness (22m − 8m) associated with the dynamic collapse of the wastefield.

The density structure of the ocean and the ocean currents were relatively constant (e.g. 9.3 ± 2.3 cm/sec) during the course of the experiment and representative of "typical" conditions. The discharge rate was also quite constant (25.3 ± 2.2 MGD), although considerably higher than the daily average discharge rate (17.3 MGD). Thus these measurements are indicative of initial dilutions generally occurring at this outfall area. Additional studies will be required to discern the characteristics of the initial dilution process for less common conditions, such as during ocean currents with speeds less than 4-5 cm/sec.

Sta #	X(m)*	Q (MGD)	V (cm/sec)**	AVG DILU	WFLD ELEV (m)	WFLD THICKNESS (m)
6	32	25.7	8.6	289	3.3	10
8	44	22.5	7.2	358	7.2	17
(2)	(61)	(20.4)	(11.2)	(1782)	-	-
4	92	28.9	9.8	540	10.6	22
7	109	23.5	8.8	570	9.8	18
(5)	109	(26.8)	(10.2)	(721)	(12.3)	(18)
3	122	25.3	11.8	741	10.3	16
9	440	23.6	8.9	680	11.7	8

( ) Indicates stations near edge of wastefield.

* Longshore distance downstream from diffuser.

* * Across-diffuser component - except for station 5 all cross-shore velocites were less than 2 cm/sec.

Table 1. *Initial Dil. Summary*

The dilution observations appear to be in generally good agreement with preliminary hindcast estimates using EPA numerical simulation models of the process. The entrainment rate of dilution water into the plume does, however, appear to occur at a greater rate than incorporated into the models, resulting in a reduced height of rise for the plume. This conclusion is, however, dependent on the final results of the numerical model simulations being carried out by the EPA (Newport, OR).