Simulation Results

CORMIX was applied to simulate the mixing zone of effluent from the Yountville's Outfall E-1 into the Napa River. Predicted distances tend to be conservative in that they do not account for major irregularities in the actual (as opposed to the simulated) channel that would reduce the time and distance to mixing.

MODEL CALIBRATION

Conditions measured during the tracer study (see section "Tracer Study" above) were simulated in CORMIX to calibrate representative parameters. The only calibration terms were effluent discharge depth and channel depth. These terms were uncertain because of the rocky, cascading effluent outfall and significant change in river water depth.

Simulation results for calibrated conditions are presented in **Figure 9**. The effluent plume mixes initially within 75 feet downstream. At this point, the plume has 11:1 dilution and spreads 23 ft across the channel owing to lateral momentum. The plume centerline reaches the far bank at 175 feet downstream. The plume mixes completely *across* the channel approximately 215 feet downstream of the outfall and then also vertically by 290 feet downstream. Simulation results are plotted along with tracer study measurements on the topograph map of the mixing zone study reach in **Figure 10**. These results are consistent with the field measurements and observations of dye, indicating that the model is well calibrated.

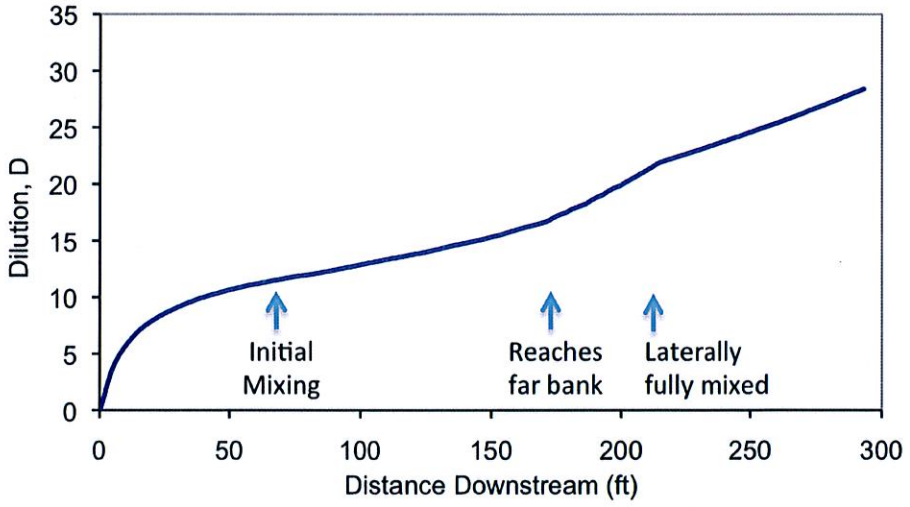

Figure 9. CORMIX calibration results for Yountville Outfall E-1, confirming near-field dilution measurements from the tracer study.

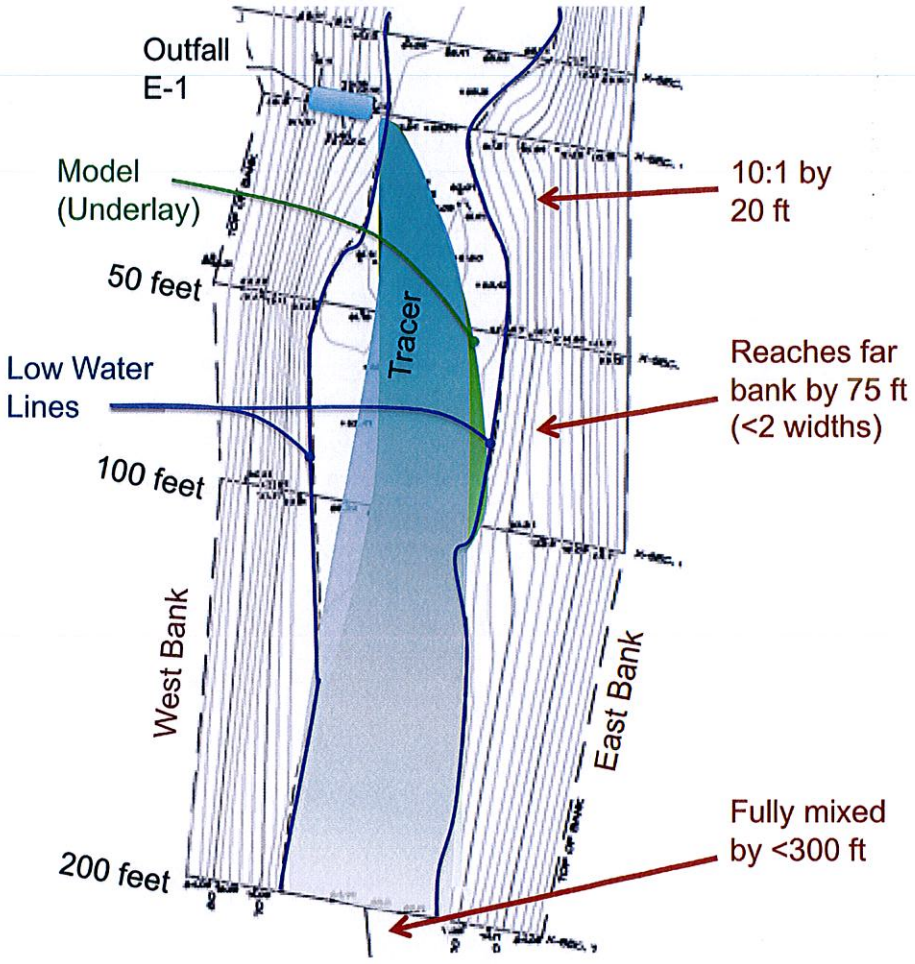

Figure 10. Tracer study measurements (blue) overlaying CORMIX results (green) for calibrated conditions. The topographic map of the channel encompasses the reach 20 feet upstream and 200 feet downstream.

MODEL SIMULATIONS

Based on the CORMIX input values presented in Tables 1 and 2 above, CORMIX results for each scenario are summarized in this section. An example output file, for the first row in Table 2 above, is presented in **Appendix B**. Values in **Table 5** indicate the CORMIX-predicted downstream extent of the mixing zone under each critical discharge scenario, each of which is at the minimum river-to-effluent flow ratio of 40:1. The regulatory mixing zone extends less than 200 ft downstream of Outfall E-1 under all critical conditions.

Table 5. Length of mixing zone predicted by CORMIX for each simulated scenario of critical discharge conditions.

Applicable Objectives	Future Critical Flow Rates (MGD)			CORMIX MZ Lengths (ft)		Plume Characteristics @ D=12	
	Basis	Effluent	River[1]	D=12	Fully Mixed (D=40)	Travel Time (min)	Width (ft)
Acute	Maximum daily average	1.9	75	184	820	4	10
	Minimum daily average	0.26	10	128	719	6	26
Chronic	Maximum four-day average	1.6	63	131	919	3	23
	Minimum four-day average	0.29	12	108	623	5	26
Human Health	Long-term average	0.54	22	184	492	6	16

[1] Calculated at 40:1 dilution from effluent flow rate.

In all simulations, the warmer effluent is less dense than the cooler ambient water. Consequently, CORMIX results indicate that the effluent plume is buoyant, tending to float on the river water surface after initially plunging from the bank discharge point, then mix downward by turbulent mixing. CORMIX indicates that the plume migrates across the channel prior to complete vertical mixing, owing to its initial momentum. Benthic organisms will not be exposed to effluent in the near-field. But regardless, travel time from the outfall to the edge of the D=12 regulatory mixing zone is only 3-6 minutes for the various acute mixing scenarios.

The plume mixes to at least 12:1 (D=12) within 185 feet downstream under critical acute conditions and within approximately 130 feet under critical chronic conditions. For critical human health conditions, which do not apply directly to an intermittent seasonal discharge, the D=12 regulatory mixing zone extends approximately 185 feet downstream.

The plume becomes *fully* mixed approximately 490-920 ft downstream under critical conditions. These distances are longer than measured during the tracer study primarily because the normally greater temperature (read: density) difference inhibits vertical mixing. Nonetheless, this length is still much shorter than the distance to the downstream ambient monitoring station (see Figures 1 and 2 above). There are no known drinking water intakes in the approximately 15 miles of river downstream of the outfall.

Effluent discharged under minimum flow scenarios enters a narrower, more quiescent channel, which allows greater initial momentum-induced lateral mixing (Effect #1). However, less river turbulence under these conditions reduces turbulent mixing (Effects #2 and #3).

COMPARISON TO THRESHOLDS SET ELSEWHERE

Several references for delineating regulatory mixing zones are provided above in section "Conditions for Sizing a Mixing Zone". The regulatory mixing zone lengths estimated based on those criteria are summarized for comparison in **Table 6**. One incongruity in Yountville WWRF's case is that greater dilution is needed for the ammonia acute criterion than for any chronic criterion. The regulatory mixing zone length of 200 feet proposed for Yountville is well within the range of thresholds applied in other southwestern states.

Table 6. Regulatory mixing zone lengths based on criteria applied elsewhere.

Applicable Objectives	Basis	Mixing Zone Lengths (in feet) According to Other Criteria							
		LA RWQCB (1994)	Arizona (1992)		CO (2002)		Utah (2000)		
		250 ft d/s	500 m d/s	50% of XS	CCC<6 x width2	CMC=.1-.25CCC	CCC< 2500	CMC< 0.5w	t < 15 min
Acute	Maximum daily average	250	1640	410	N/A	92-230	N/A	410	681
	Minimum daily average			359		62-156		359	261
Chronic	Maximum four-day average			459	9927	N/A	2500	N/A	N/A
	Minimum four-day average			312	9318		2500		
Human Health	Long-term average			246	N/A		N/A		

LEGEND:
"N/A" = the criteria do not apply to the scenario in that row
CMC = Criteria Maximum Concentration, relevant for the acute mixing zone
CMC = Criteria Maximum Concentration, relevant for the acute mixing zone
"N/A" = Criteria does not apply to that objective
"d/s" = downstream
"t" = Residence time of drifting material in the mixing zone
"w" = channel width