Short-term Monitoring of Dissolved Oxygen and Salinity Concentrations in the Mill River

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Prepared for Regional Water Authority

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Introduction

A short-term monitoring effort was conducted on August 1, 2000 to evaluate dissolved oxygen and salinity concentrations over a full tidal cycle in the Mill River. An original objective of the monitoring was to determine the effects of low flow on dissolved oxygen (DO) and salinity concentrations in the river during summer conditions. However when the monitoring was conducted, heavy rains preceding the field effort created unusually high seasonal flows. Thus the results of the monitoring reflect higher flow rates than typically occur in August.

Dissolved Oxygen and Salinity Monitoring

The water quality monitoring was conducted by two field teams, one from CH2M Hill (2-persons by boat) and one from the Regional Water Authority (RWA) on foot with assistance from an additional CH2M HILL crew member during afternoon measurements. DO and salinity concentrations were measured with two hand-held, in-situ meters (a YSI Model 95 and a Hydrolab Quanta), which were calibrated simultaneously prior to the surveys to ensure comparability of the results. Five surveys of DO and salinity concentrations in the Mill River, from the dam to the tidal gates, were conducted from approximately 7:00 am to 8:00 pm on August 1, 2000 (Table 1). Measurements were also taken at one additional station, next to the power generating plant downstream of the tidal gates. However, this station was not included in all five surveys because insufficient time was available to return to this station during each survey.

Dissolved oxygen, salinity, conductivity, temperature, and water level change were measured at a total of 20 stations along the river (Figure 1), from Station #0 (in Lake Whitney, just up stream of the dam) to Station #18 (down stream of the tidal gates at the Quinnipiac Energy power generating plant). One additional station was added during the course of the third survey, when the stake marking Station #14 was underwater and could not be located. The additional station was labeled #14B and was located between Stations 13 and 14, approximately equidistant from both.

Stations #5 through #16 were marked by stakes driven into the riverbed near shore, while water quality measurements were recorded from mid-channel abreast of the stakes. Five rounds of measurements were collected between Station #5 and Station #18. Water quality measurements were collected at each location from the surface (6 inches depth), mid-depth, and within one foot of the river bottom. At locations exceeding 5 to 6 feet depth, additional measurements were taken at 2.5-foot intervals.

The low tide for New Haven, CT on August 1, 2000 was at 6:47 am, and the high tide occurred at 12:57 pm. There is generally about a 2-hour lag time between high tide in the harbor and its maximum depth in the Mill River in the vicinity of the footbridge.

Table 1. Dissolved Oxygen/Salinity Surveys Completed on Mill River on August 1, 2000 (Stations downstream of footbridge)

Survey #	Start Time	Finish Time	Station #18 Time	Number of Stations
1	0712 (Station #15)	0909 (Station #5)	0950	13
2	1025 (Station #17)	1156Station #5)	1310	13
3	1400 (Station #17)	1607 (Station #5)	Not measured	13
4	1628 (Station #17)	1726 (Station #12)	Not measured	7
5	1824 (Station #17)	1925 (Station #5)	2004	9

Note: Stations 0 through 4 were surveyed simultaneously at closely corresponding time intervals during each survey.

In addition to the August 1 survey, limited monitoring was conducted by RWA on July 3 and July 5. The methods used were the same as those described above for stations 0 through 4 (i.e. measurement using hydrolab at stations reached by wading) These data are also presented in this report.

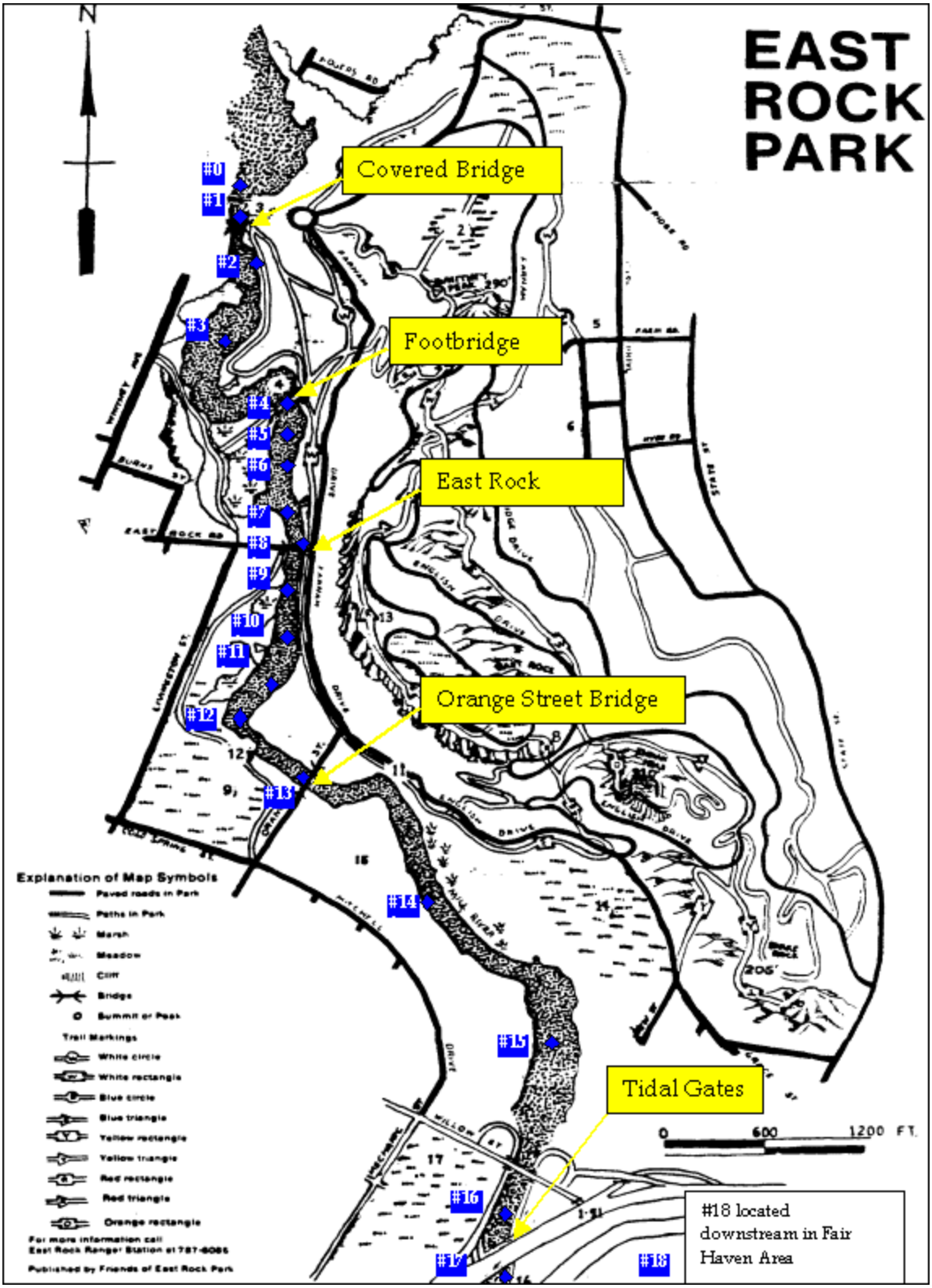
Results of Dissolved Oxygen Monitoring

The results of the DO monitoring revealed a steady decrease in DO concentrations with increasing distance downstream of the Lake Whitney dam (Figure 2). Figure 2 shows DO

concentrations as measured at mid-depth for each sampling location. The DO concentrations measured at the surface and near bottom were generally similar for each location and are presented with the full data set in Appendix A.

Under most conditions, the data show an immediate increase in DO in the plunge pool directly below the dam spillway due to aeration. During the July 25 survey the lake water was super saturated (approximately 12 mg/l) and the DO actually decreased as the water spilled over the dam. Although there was sometimes a minor increase in DO through the steep gradient (and therefore relatively fast flowing) section of the river (about 1500 feet immediately below the dam), DO generally decreased substantially with increasing distance downstream. Below Orange Street the DO drops precipitously. A minor DO spike was observed directly downstream of the tide gates during outgoing tide conditions due to the turbulence and high velocity through the tide gates. A difference of 15 inches was measured in water levels at the tide gates, resulting in substantial hydraulic head and turbulent flow on the downstream side of the tide gates during the outgoing tide. Conversely, the opposite trend in DO was measured on the incoming tide, where a substantial increase in DO was observed on the upstream side of the tide gates. This effect most likely occurs from the turbulence and boiling of water that is created by the hydraulic head difference that builds up when the tide changes.

Figure 1: Locations Sampled during the Dissolved Oxygen/Salinity Monitoring on the Mill River:



The data showed low DO water was pushed upstream with the incoming tide to about the area of Station #14 (Figure 1), which was located about 800 ft downstream of the Orange Street

Bridge. The data showed that the tide did not affect DO concentrations upstream of this vicinity.

Data were also collected by RWA on July 3 and July 25, 2000 on high and low tides respectively. These data are included in Figure 1 to compare the effect of varying flow rates on DO concentrations. On July 3 the flow rate at the spillway was estimated at 66.3 million gallons per day (mgd), and on July 25 the flow rate was estimated at 46.7 mgd. In contrast, on August 1, the flow rate was 122 mgd, which was approximately twice as high as it was on July 3, and three times as high as it was on July 25.

The variation in flow rates within the range of 46 to 66 mgd appeared to have little effect on DO concentrations in the Mill River. The DO concentrations between the dam and the tide gates ranged from approximately 5 to 9 mg/L, with the majority of the readings falling in the 7 to 9 mg/L range. Some of the observed variation was undoubtedly caused by the increased oxygen production from photosynthesis, during daylight hours.

The decrease in DO concentrations downstream of the Orange Street Bridge suggests that an increased biological oxygen demand was placed on the system at and below this stretch. The source of the increased oxygen demand is unknown but the rains the preceeded the monitoring event could have contributed storm water runoff and combined sewage load to the system.

Results of Salinity Monitoring

The results of the salinity monitoring revealed that the heavy flows during the August 1 monitoring suppressed the upstream migration of a salt wedge during high tide (Figure 3). Very little variation in salinity concentrations were observed upstream of the tide gates on August 1. In contrast, on July 3, the salinity concentrations were slightly higher upstream of the tide gates.

During the peak high tide on August 1, 2000 the salt wedge only extend approximately to the area of the river near Station #15. This contrasts sharply with the results of previous monitoring during very low flow conditions, when the salt wedge extended upstream as far as the area between East Rock Bridge and the Footbridge. Thus, the very heavy flow present on August 1, 2000 appeared to suppress the intrusion of the salt wedge upstream to a great extent.

Figure 2. Dissolved Oxygen Concentrations in the Mill River:

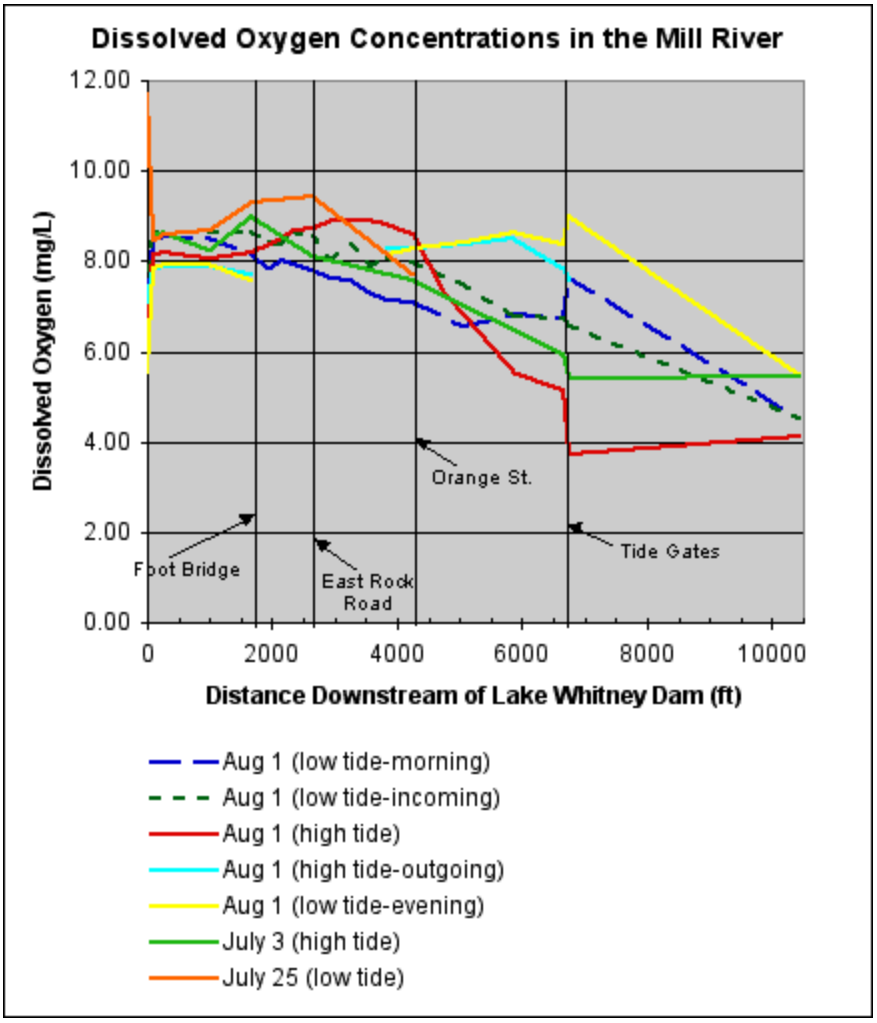
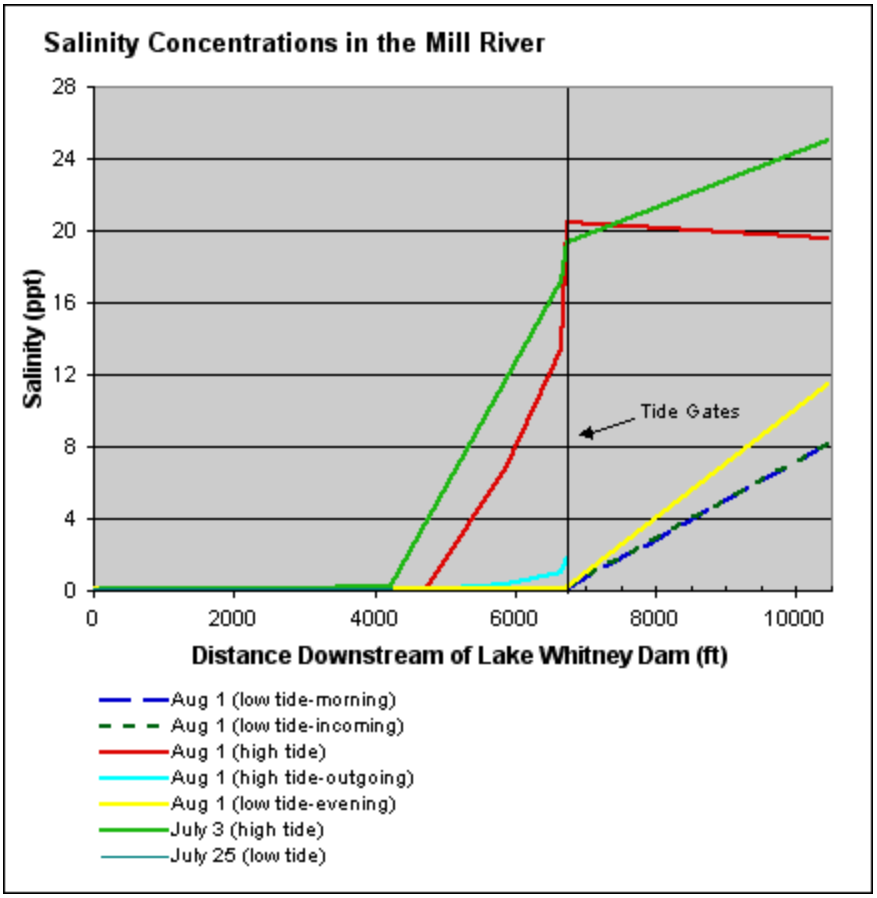


Figure 3. Salinity Concentrations in the Mill River:


Salinity Concentrations in the Mill River
Salinity (ppt)
28
24
20
16
12
8
4
0
0
2000
4000
6000
8000
10000
Distance Downstream of Lake Whitney Dam (ft)
Tide Gates
Aug 1 (low tide-morning)
Aug 1 (low tide-incoming)
Aug 1 (high tide)
Aug 1 (high tide-outgoing)
Aug 1 (low tide-evening)
July 3 (high tide)
July 25 (low tide)