Appendix D

Attachment 1 – Destratification of Lake Mead

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Memorandum

Date: 3/28/2006

Re: Incomplete Destratification of Lake Mead

Project No: S014004.1

Introduction

The purpose of this memorandum is to clarify results of the Lake Mead modeling with respect to the fact that Lake Mead may not completely destratify every winter. Results are presented from refined ELCOM simulations that indicate the original modeling conclusions do *not* change as a result of an incomplete destratification. In particular, the modeling indicates that there is *no* accumulation of effluent when it is discharged into the hypolimnion through a diffuser at Boulder Islands (BI) in the years when the lake does not destratify in the winter. As discussed below, this is mainly a result of the effluent being significantly warmer and thus less dense than the ambient reservoir water.

ELCOM Refinement

Previous ELCOM/CAEDYM simulations were performed for the years 1999 through 2003 (Lake Mead ELCOM/CAEDYM Modeling, November 17, 2005 [Modeling Report]). Of those years, Lake Mead did not completely destratify in 2000 and 2003 (LaBounty & Burns, 2005). This is apparent in Figure 4.7 of the Modeling Report, where measured and simulated temperature profiles are shown. On 2/15/00 and 2/11/03 the measured data indicate the presence of weak thermoclines. The original ELCOM simulation for these years *does* predict incomplete destratification and the existence of the 2000 and 2003 winter thermoclines. However, the locations of the predicted weak thermoclines are, respectively, approximately 200 ft and 100 ft deeper than measured.

The 2003 ELCOM simulation has subsequently been refined to better capture the depth of the weak winter thermocline. This was achieved by reducing the bulk wind mixing and stress coefficients and slightly adjusting the vertical distribution of The Narrows inflow from late 2002 through early 2003. **Figure 1** plots temperature profiles from the refined simulation together with measured data from November 2002 through June 2003. The agreement between the new modeling results and the measured temperature profiles is good. In particular, the modeling results capture well the weak thermoclines in January, February, and March.

BI Alternative Simulations

Three new simulations of the BI diffuser operation using the ECP (ELCOM/CAEDYM/PLUMES) code with the modified boundary conditions (as described above) were carried out to represent operations from the beginning of 2002 through the spring of 2003. The initial (on 1/1/2002) water surface elevations (WSEL) considered were 1,178 ft, 1,100 ft, and 1,000 ft.

Figure 2 plots the concentration of effluent tracer along a cross-section from the Las Vegas Wash (LVW) through the diffuser to Hoover Dam on a typical winter day (February 1) in 2003 for the simulation with an initial WSEL of 1,178 ft. Contours of perchlorate (entering from the LVW) and temperature are also shown. It is clear that the effluent rises *above* the diffuser, which is at an elevation of 880 ft, approximately 220 ft above the lowest point in Boulder Basin. The effluent does not sink, which is a result of the effluent temperature being warmer than the ambient lake temperature (even though the effluent has a slightly higher salinity than the ambient water, the effluent is positively buoyant due to the temperature difference). The vast majority of effluent tracer is located above the elevation of the lower Hoover Dam outlets, indicating that a build up of effluent constituents deep in the hypolimnion will not occur.

Figure 3 plots contours of effluent tracer as a function of elevation and time for the first three months of 2003 at Hoover Dam (1,178 ft WSEL). At all times the effluent is mixed and diluted, and remains mostly between 900 ft and 1,000 ft elevations, approximately 240 to 340 ft above the lowest point of the reservoir. The bottom of the hypolimnion is not impacted.

Figures 4 and **5** are similar to **Figures 2** and **3**, respectively, except that the initial WSEL is 1,100 ft. The results are much the same as when the initial WSEL is 1,178 ft, although there is more mixing of the effluent into the epilimnion as a result of the shallower insertion depth. Again, the base of the hypolimnion is not significantly impacted by the effluent. In fact, **Figure 5** shows the predicted concentrations of effluent tracer at the base of the hypolimnion near Hoover Dam *decrease* with time when the lake remains weakly stratified in the winter.

Figures 6 and **7** are similar to **Figures 4** and **5**, respectively, except that the initial WSEL is 1,000 ft. The effluent is now usually mixed completely throughout the epilimnion. The base of the hypolimnion is not significantly impacted by the effluent, and the concentrations of effluent tracer at the base of the hypolimnion near Hoover Dam *decrease* with time when the lake remains weakly stratified in the winter.

At all three lake levels considered, the modeling indicates that there is *no* accumulation of effluent when it is discharged into the hypolimnion through a diffuser at BI in years when the lake does not destratify in the winter. This is mainly a result of the discharged effluent being significantly warmer and thus less dense than the ambient reservoir water. Thus, in winter, the effluent rises well

above the diffuser, located at elevation 880 ft (approximately 220 ft above the lowest point in the reservoir), and is diluted with ambient lake water. The majority of the effluent remains above the elevation of the diffuser.

References

"Lake Mead ELCOM/CAEDYM Modeling" [Modeling Report], *Flow Science Incorporated*, November 17, 2005.

LaBounty, J.F. and N.M. Burns, 2005. "Characterization of Boulder Basin, Lake Mead, Nevada-Arizona, USA – Based on Analysis of 34 Limnological Parameters". *Lake and Reserv. Manage.* 21(3):277-307.

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Comparison of Measured and Simulated Temperature Profiles at Station CR346.4
(November 2002 - June 2003)

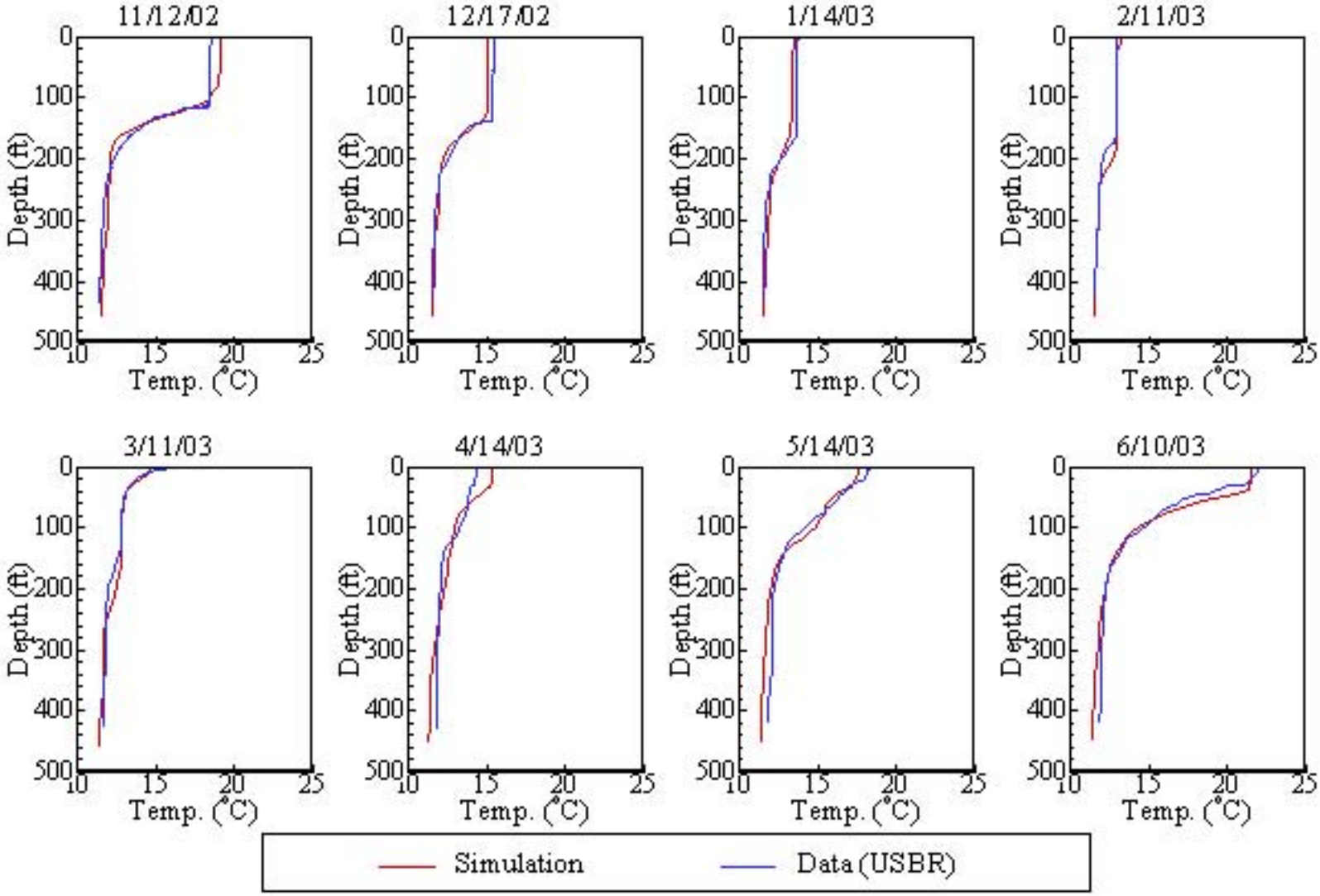

Figure 1

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Boulder Islands Diffuser, Initial WSEL = 1,178 ft

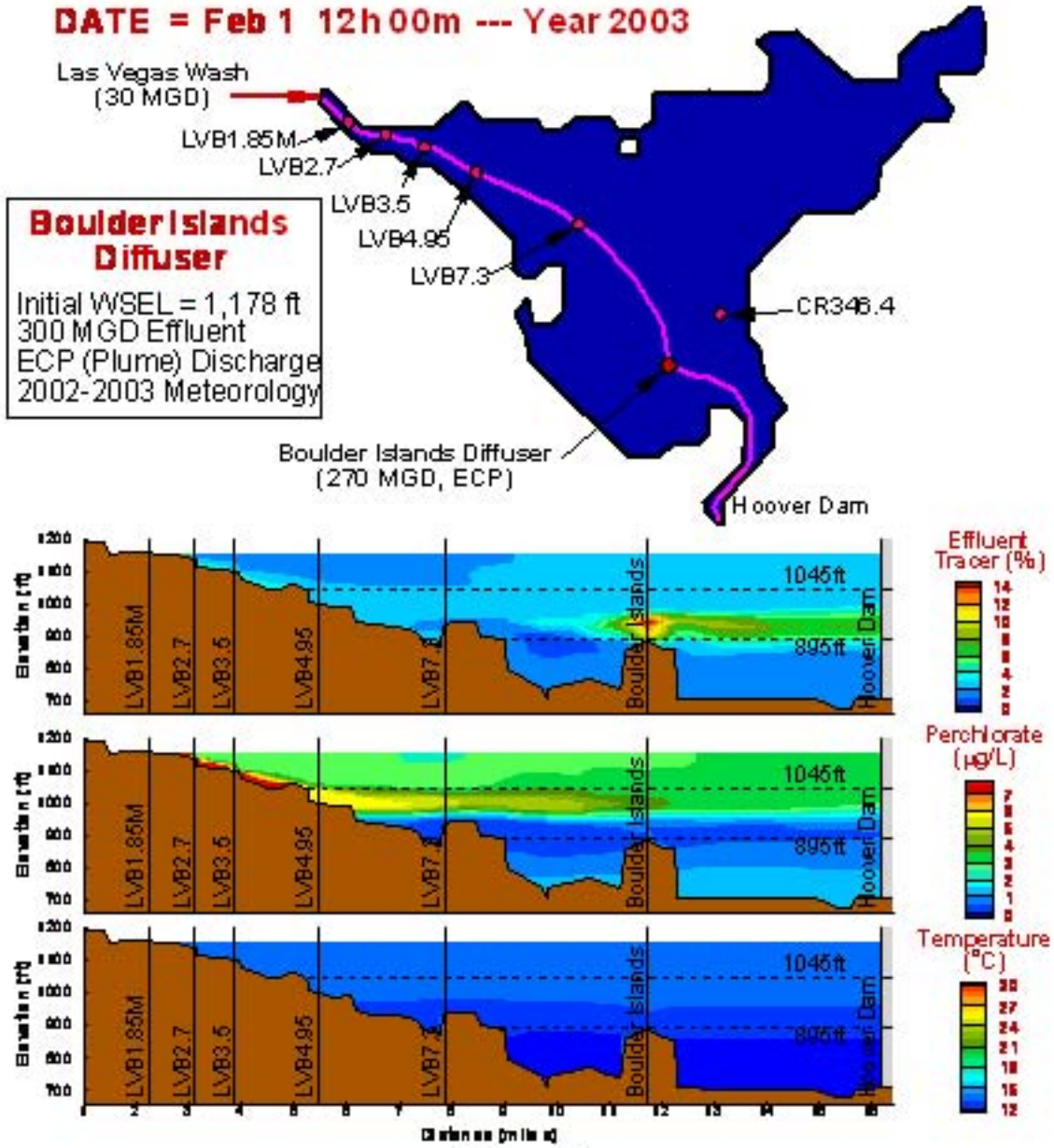

Figure 2

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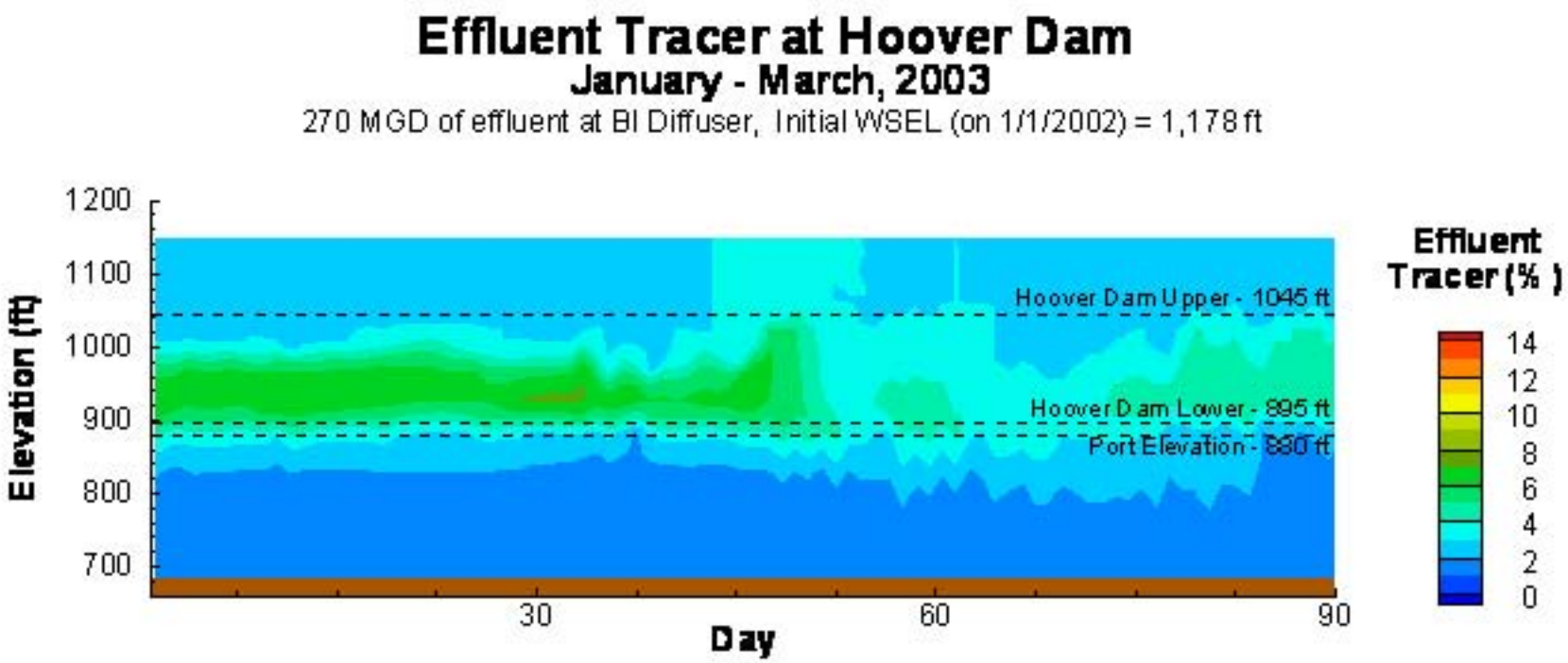

Figure 3

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Boulder Islands Diffuser, Initial WSEL = 1,100 ft

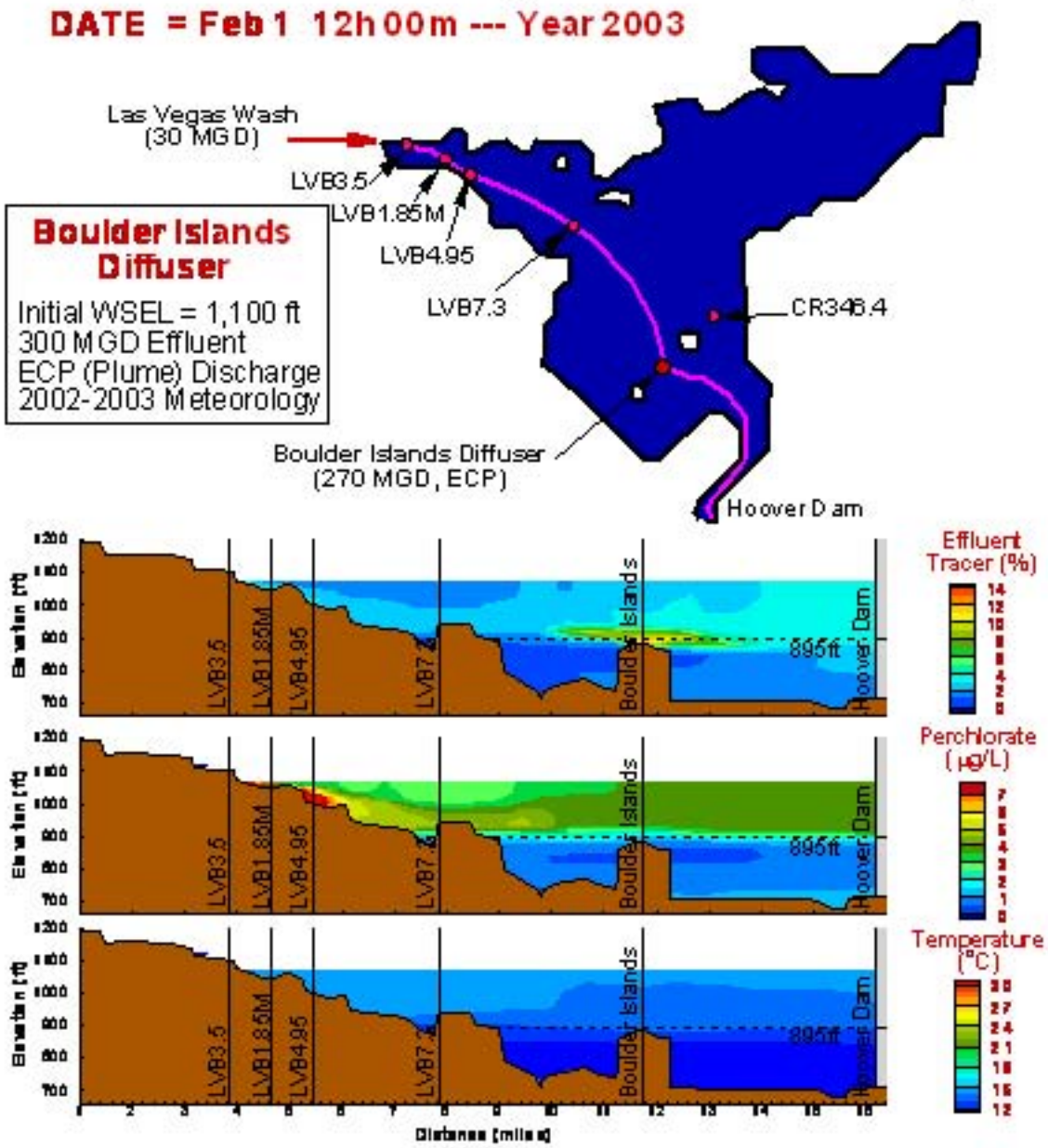

Figure 4

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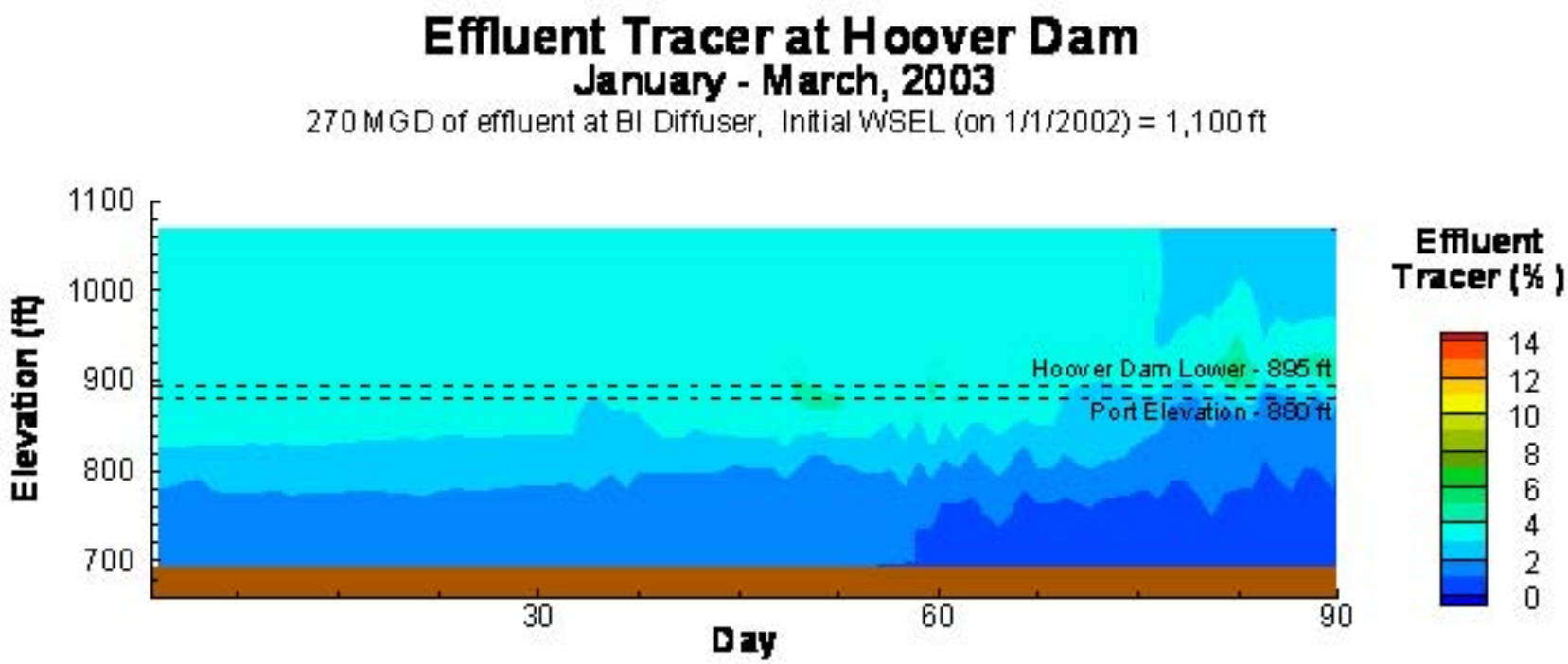

Figure 5

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Boulder Islands Diffuser, Initial WSEL = 1,000 ft

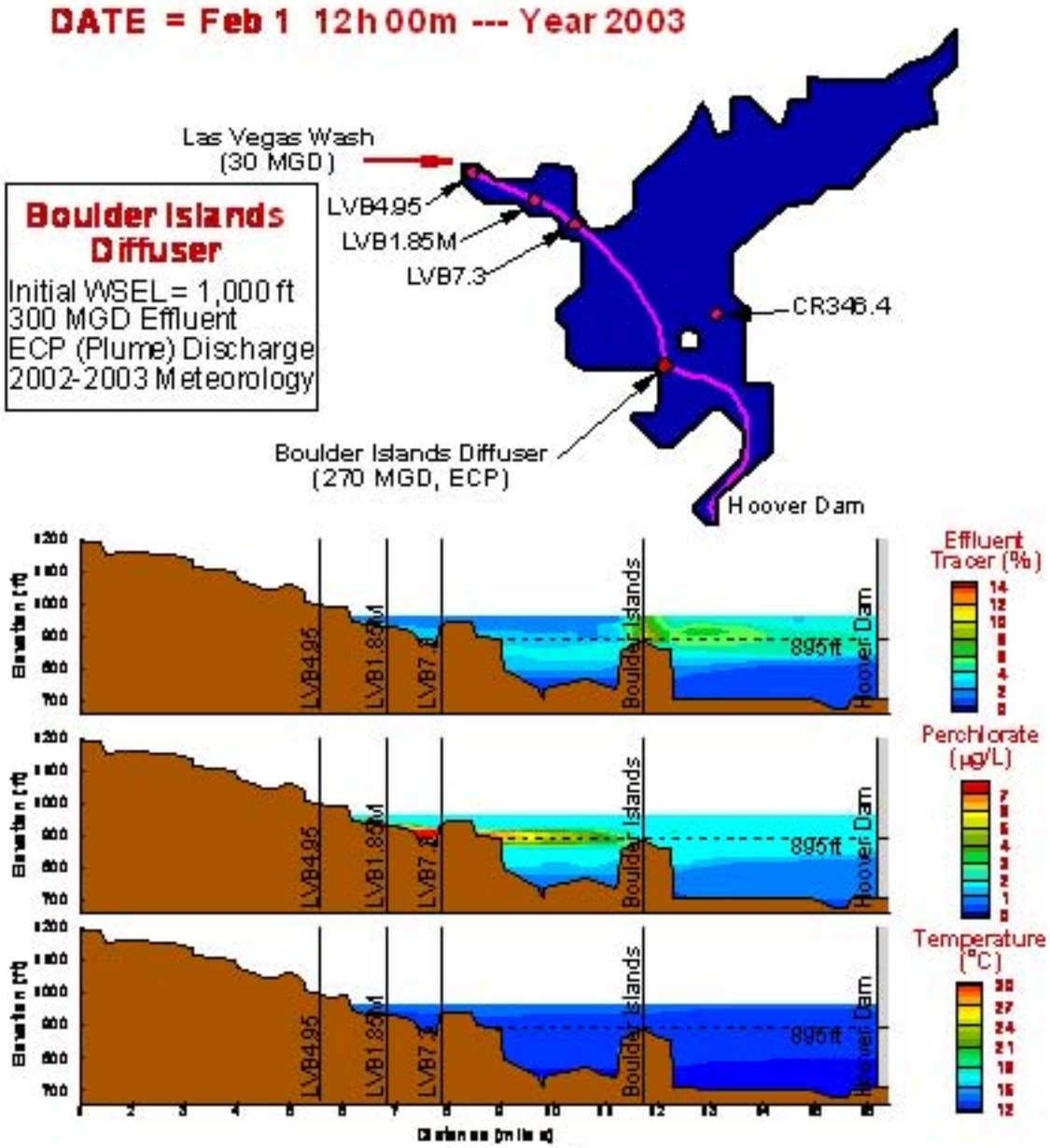

Figure 6

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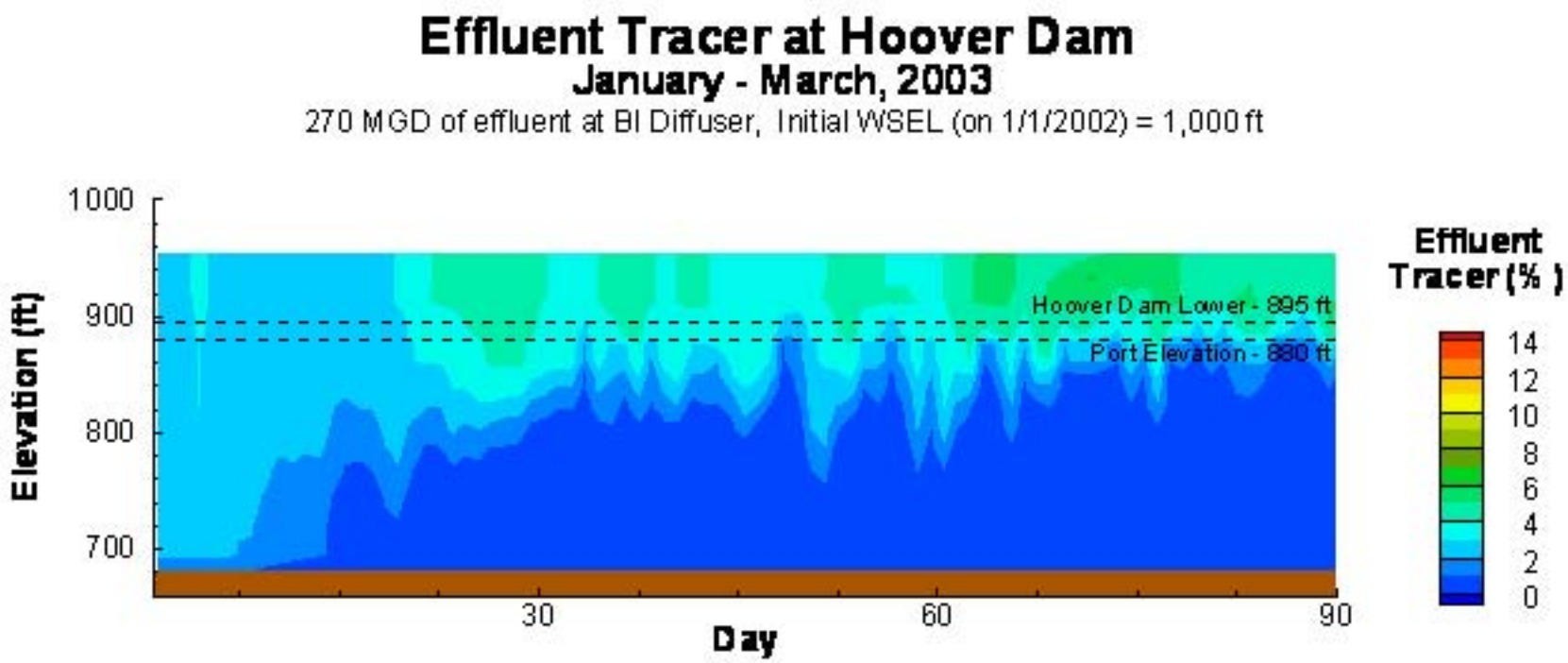

Figure 7

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