Conclusions and Recommendations

The results of this mixing zone / dilution credit study show that the Yountville WWRF effluent plume mixes to 12:1 dilution into the Napa River within a maximum distance of 200 ft downstream of Outfall E-1 under various critical minimum-dilution discharge conditions. Normal discharge conditions, providing greater than 100:1 river-to-effluent flow ratio, would result in mixing zones of commensurately smaller areas.

Allowing a regulatory mixing zone for Yountville WWRF discharges to the Napa River is acceptable because the mixing zone complies with the conditions in the SIP. Therefore, Yountville should be limited to a minimum river-to-effluent flow ratio of 40:1 and granted a dilution credit of D=12, which would be applied to WQBEL calculations during the new NPDES permit.

In the broader context of the Napa River, monitoring data collected downstream of Yountville Outfall E-1 do not exceed applicable water quality objectives. Furthermore, if the Yountville WWRF maintains a minimum river-to-effluent flow ratio of 40:1 at Outfall E-1, the minimum permitted dilution of all municipal wastewater discharges combined (with St. Helena's 25:1 and Calistoga's 10:1 river-to-effluent flow ratios) would still be at least 12:1 downstream of Outfall E-1 and over 30:1 downstream where saltwater objectives apply. Typical river-to-effluent flow ratios would be 95:1 downstream of Outfall E-1 and 264:1 at Napa.

References

Arizona (1992) Title 18. Environmental Quality Chapter 11. Department of Environmental Quality Water Quality Standards; Article 1. Water Quality Standards for Surface Waters R18-11-114. Mixing Zones. Online at http://lists.azdeq.gov/environ/water/standards/download/ SWQ_Standards-1-09-unofficial.pdf.

ATSDR http://www.atsdr.cdc.gov/. In: Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services.

Bouwer, E.J., B.E. Rittmann, and P.L. McCarty (1981) "Anaerobic degradation of halogenated 1- and 2-carbon organic compounds." *Environ. Sci. Technol.* 15: 596-599.

Chu, W., and Chan, K.H. (2000) "The prediction of partitioning coefficients for chemicals causing environmental concern." *Science of the Total Environment* 248: 1-10.

Colorado Department of Public Health and Environment (2002). "Colorado Mixing Zone Implementation Guidance." Water Quality Control Division, April, 64 pp.

EPA (1991a). "Assessment and control of bioconcentratable contaminants in surface waters." Office of Water Regulations and Standards, Washington, DC.

EPA (1991b). "Technical support document for water quality-based toxics control." Office of Water Regulations and Standards, Washington, DC.

EPA Region VIII (1995). "Mixing Zones and Dilution Policy." September, 111 pp.

Fischer, H.B., E.J. List, C.Y. Koh, J. Imberger, and N.H. Brooks (1979). *Mixing in Inland and Coastal Waters*. Academic Press, New York.

Hazardous Substances Data Bank (HSDB) http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. United States National Library of Medicide, TOXNET Toxicology Data Network. Accessed 9/4/08.

Jirka, G.H. (2007). "Buoyant Surface Discharges into Water Bodies. II: Jet Integral Model", *J. Hydr. Engr.*, 133(9):1021-1036.

Jirka, G.H., R.L. Doneker, and S.W. Hinton (1996). *User's Manual for CORMIX: A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters*. Cooperative Agreement No. CX824847-01-0. USEPA Office of Sci. & Techn. 152 pp.

Jones, G.R., J.D. Nash, R.L. Doneker, and G.H. Jirka (2007). "Surface Discharges into Water Bodies. I: Flow Classification and Prediction Methodology", *J. Hydr. Engr.*, 133(9):1010-1020.

Kaczmar, S.W. (1984) "Volatilization rates of selected haloforms from aqueous environments" *Environ. Toxicol. Chem.* **3**: 31-35.

Kilpatrick, F.A., and E.D. Cobb (1985). "Measurement of discharge using tracers." *Techniques of Water-Resources Investigations of the USGS*. Book 3, Chapter A16, Appendix B, 63 pp.

Los Angeles Regional Water Quality Control Board (1994). "Basin Plan, Ch. 4 Strategic Planning and Implementation." June 13. 69 pp.

Lyman, W.J., W.F. Reehl, and D.H. Rosenblatt (1990) *Handbook of Chemical Property Estimation Methods, Environmental Behavior of Organic Compounds*. Washington, DC: American Chemical Society.

Mabey, W. (1981) Aquatic Fate Process Data for Organic Priority Pollutants USEPA-440/4-81-014. In: USEPA.

Mabey, W., and Mill, T. (1978) *J. Phys. Chem. Ref. Data* 7: 383-415.

State Water Resources Control Board (SWRCB) (2005). Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California. CA Environmental Protection Agency. 64 pp. Available on-line at http://www.swrcb.ca.gov/water_issues/programs/state_implementation_policy/docs/final.pdf.

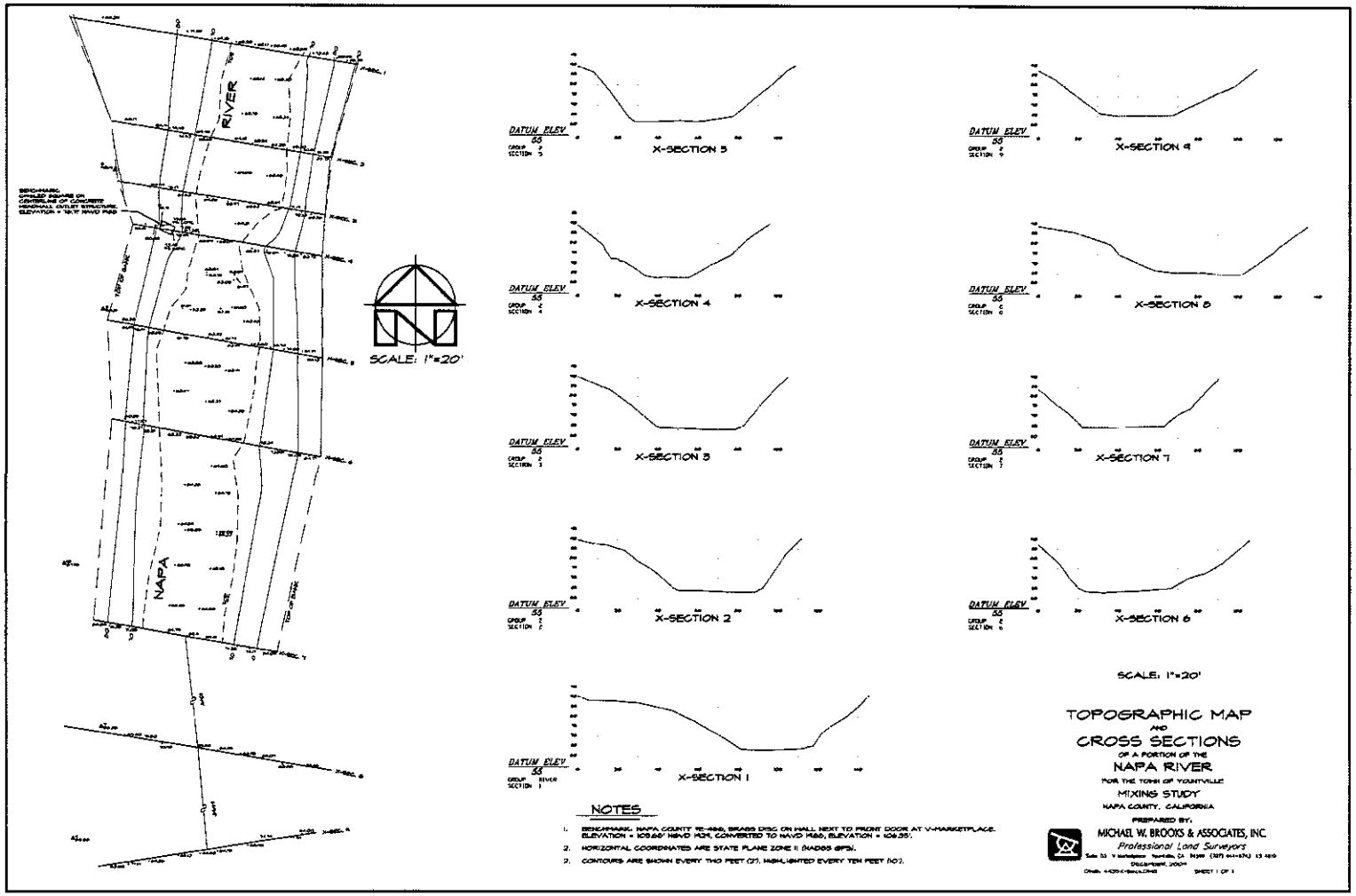
Staudinger, J., and P. Roberts (1996) "A critical review of Henry's law constants for environmental applications." *Crit. Rev. Environ. Sci. Technol.*, 26, 205-297

Tabak, H. (1981) *J. Water Poll. Control Fed.* 53: 1503-1518.

United States Environmental Protection Agency (USEPA) (1991). *Technical Support Document for Water Quality-based Toxics Control*. EPA/505/2-90-001. 145 pp.

Utah Division of Water Quality (2000). "Mixing Zone Implementation Procedure." March 17, 11 pp.

Appendix A. Napa River Survey Results



Appendix B. Example CORMIX Output File

```
CORMIX3 PREDICTION FILE:
3333333333333333333333333333333333333333333333333333333333333333333333333333333333
                        CORMIX MIXING ZONE EXPERT SYSTEM
                 Subsystem CORMIX3:   Buoyant Surface Discharges
                          CORMIX Version 6.0GT
                       HYDRO3 Version 6.0.0.0 October 2009
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   Yountville WWRF
 Design case:       simulations
 FILE NAME:         C:\...iles\CORMIX 6.0\StephenM\Yountville\scenarios.prd
 Time stamp:        Tue Jan 26 13:01:27 2010

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     12.31  AS    =     11.26  QA    =      2.06  ICHREG= 2
 HA    =      0.91  HD    =      0.91
 UA    =      0.183 F     =      0.099 USTAR =0.2035E-01
 UW    =      0.000 UWSTAR=0.0000E+00
 Uniform density environment
 STRCND=  U         RHOAM =  999.1011

DISCHARGE PARAMETERS (metric units)
 BANK  =  RIGHT     DISTB =      0.00  Configuration: flush_discharge
 SIGMA =     80.00  HDO   =      0.91  SLOPE =    0.00 deg.
 Rectangular channel geometry:
 B0    =      0.610 H0    =      0.122 A0    =0.7432E-01  AR    =      0.200
 U0    =      1.120 Q0    =      0.083       =0.8324E-01
 RHO0  =  998.4258  DRHO0 =0.6753E+00  GP0   =0.6628E-02
 C0    =0.1000E+03  CUNITS=  mg/l
 IPOLL =  1         KS    =0.0000E+00  KD    =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.8324E-01  M0    =0.9324E-01  J0    =0.5518E-03
 Associated length scales (meters)
 LQ    =      0.27  LM    =      7.18  Lm    =      1.67  Lb    =      0.09

NON-DIMENSIONAL PARAMETERS
 FR0   =     26.35  FRCH  =     39.40  R     =      6.12

FLOW CLASSIFICATION
 3333333333333333333333333333333333333333
 3  Flow class (CORMIX3)      =    SA1    3
 3  Applicable layer depth HS =     0.91  3
 3333333333333333333333333333333333333333

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.1000E+03  CUNITS=  mg/l
 NTOX  =  0
 NSTD  =  0
 REGMZ =  0
 XINT  =    304.80  XMAX  =    304.80

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the WATER SURFACE and at center of discharge
      channel/outlet:      0.00 m  from the RIGHT bank/shore.
    X-axis points downstream
    Y-axis points to left as seen by an observer looking downstream
    Z-axis points vertically upward (in CORMIX3, all values Z = 0.00)
```

```
NSTEP =  20 display intervals per module
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD301: DISCHARGE MODULE

 Efflux conditions:
       X        Y        Z        S        C        BV       BH        TT
     0.00     0.00     0.00      1.0 0.100E+03   0.12     0.30 .00000E+00

END OF MOD301: DISCHARGE MODULE
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN MOD302: ZONE OF FLOW ESTABLISHMENT

  Control volume inflow:
       X        Y        Z        S        C        BV       BH        TT
     0.00     0.00     0.00      1.0 0.100E+03   0.12     0.30 .00000E+00

 Profile definitions:
   BV = Gaussian 1/e (37%) vertical thickness
   BH = Gaussian 1/e (37%) horizontal half-width, normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction efects, if any)
   TT = Cumulative travel time

  Control volume outflow:                                  SIGMAE=     77.18
       X        Y        Z        S        C        BV       BH        TT
     0.17     0.73     0.00      1.0 0.100E+03   0.19     0.36 .66604E+00
 Cumulative travel time =           0.6660 sec

END OF MOD302: ZONE OF FLOW ESTABLISHMENT
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BEGIN CORSURF (MOD310): BUOYANT SURFACE JET - NEAR-FIELD REGION

 Surface jet in deep crossflow with shoreline-attachment.

 Profile definitions:
   BV = Gaussian 1/e (37%) vertical thickness
   BH = Gaussian 1/e (37%) horizontal half-width, normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction efects, if any)
   TT = Cumulative travel time

       X        Y        Z        S        C        BV       BH        TT
     0.17     0.73     0.00      1.0 0.100E+03   0.19     0.36 .66604E+00
     1.68     3.25     0.00      3.1 0.318E+02   0.48     0.92 .55628E+01
     3.90     4.71     0.00      5.1 0.197E+02   0.66     1.25 .13253E+02
     6.39     5.68     0.00      6.6 0.152E+02   0.77     1.47 .22855E+02
     8.98     6.35     0.00      7.7 0.130E+02   0.83     1.64 .33435E+02
    11.60     6.84     0.00      8.5 0.118E+02   0.84     1.81 .44542E+02
    14.25     7.18     0.00      9.1 0.110E+02   0.84     1.96 .55947E+02
    16.91     7.41     0.00      9.5 0.105E+02   0.82     2.11 .67528E+02
    19.58     7.54     0.00      9.8 0.102E+02   0.79     2.25 .79212E+02
  Maximum lateral extent of recirculation bubble.
    22.25     7.58     0.00     10.1 0.995E+01   0.77     2.39 .90954E+02
    24.92     7.54     0.00     10.3 0.973E+01   0.74     2.52 .10273E+03
    27.59     7.42     0.00     10.5 0.948E+01   0.73     2.66 .11454E+03
    30.26     7.23     0.00     10.8 0.923E+01   0.71     2.79 .12639E+03
    32.92     6.98     0.00     11.2 0.896E+01   0.70     2.91 .13829E+03
    35.57     6.66     0.00     11.5 0.869E+01   0.70     3.04 .15022E+03
    38.21     6.28     0.00     11.9 0.843E+01   0.69     3.16 .16219E+03
    40.85     5.85     0.00     12.2 0.817E+01   0.69     3.29 .17420E+03
```

```
    43.48     5.38     0.00     12.6 0.791E+01   0.69     3.41 .18626E+03
    46.10     4.85     0.00     13.0 0.766E+01   0.69     3.53 .19836E+03
    48.71     4.29     0.00     13.5 0.742E+01   0.69     3.65 .21050E+03
    51.31     3.69     0.00     13.9 0.719E+01   0.70     3.77 .22269E+03
 End of RECIRCULATION BUBBLE for shoreline-attached jet motion.
   Dilution in recirculation bubble =   19.5
   Corresponding concentration      =    0.513E+01
 Cumulative travel time =         222.6907 sec

END OF CORSURF (MOD310): BUOYANT SURFACE JET - NEAR-FIELD REGION
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **
-------------------------------------------------------------------------------

 The initial plume WIDTH/THICKNESS VALUE in the next far-field module will be
  CORRECTED by a factor  1.08 to conserve the mass flux in the far-field!

 Some bank/shore interaction occurs at end of near-field.

 In the next prediction module, the jet/plume centerline will be set
   to follow the bank/shore.
-------------------------------------------------------------------------------
BEGIN MOD341: BUOYANT AMBIENT SPREADING

 Plume is ATTACHED to RIGHT bank/shore.
   Plume width is now determined from RIGHT bank/shore.

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally from bank/shoreline
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
       X        Y        Z        S        C       BV       BH        TT
    51.31     0.00     0.00     13.9 0.719E+01   0.75     8.12 .22269E+03
    52.21    -0.00     0.00     14.0 0.712E+01   0.74     8.35 .22743E+03
    53.12    -0.00     0.00     14.2 0.705E+01   0.72     8.58 .23217E+03
    54.02    -0.00     0.00     14.3 0.699E+01   0.71     8.81 .23692E+03
    54.92    -0.00     0.00     14.4 0.692E+01   0.70     9.03 .24166E+03
    55.82    -0.00     0.00     14.6 0.686E+01   0.69     9.25 .24640E+03
    56.73    -0.00     0.00     14.7 0.680E+01   0.68     9.47 .25114E+03
    57.63    -0.00     0.00     14.8 0.674E+01   0.67     9.69 .25588E+03
    58.53    -0.00     0.00     15.0 0.668E+01   0.66     9.90 .26062E+03
    59.43    -0.00     0.00     15.1 0.662E+01   0.65    10.12 .26537E+03
    60.33    -0.00     0.00     15.2 0.656E+01   0.65    10.33 .27011E+03
    61.24    -0.00     0.00     15.4 0.651E+01   0.64    10.53 .27485E+03
    62.14    -0.00     0.00     15.5 0.645E+01   0.63    10.74 .27959E+03
    63.04    -0.00     0.00     15.6 0.639E+01   0.63    10.94 .28433E+03
    63.94    -0.00     0.00     15.8 0.634E+01   0.62    11.14 .28907E+03
    64.85    -0.00     0.00     15.9 0.629E+01   0.61    11.34 .29382E+03
    65.75    -0.00     0.00     16.0 0.623E+01   0.61    11.54 .29856E+03
    66.65    -0.00     0.00     16.2 0.618E+01   0.60    11.74 .30330E+03
    67.55    -0.00     0.00     16.3 0.613E+01   0.60    11.93 .30804E+03
    68.45    -0.00     0.00     16.5 0.607E+01   0.59    12.12 .31278E+03
    69.36    -0.00     0.00     16.6 0.602E+01   0.59    12.31 .31752E+03
 Cumulative travel time =         317.5240 sec
 Plume is LATERALLY FULLY MIXED at the end of the buoyant spreading regime.

END OF MOD341: BUOYANT AMBIENT SPREADING
-------------------------------------------------------------------------------
```

```
-----------------------------------------------------------------------------
BEGIN MOD361: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)    = 0.372E-02 m^2/s
  Horizontal diffusivity (initial value) = 0.931E-02 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to water depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction efects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
       X        Y        Z        S        C        BV       BH        TT
    69.36     0.00     0.00     16.6 0.602E+01   0.59    12.31 .31752E+03
    81.13    -0.00     0.00     17.1 0.585E+01   0.61    12.31 .37939E+03
    92.90    -0.00     0.00     17.6 0.569E+01   0.62    12.31 .44126E+03
   104.67    -0.00     0.00     18.1 0.552E+01   0.64    12.31 .50313E+03
   116.44    -0.00     0.00     18.7 0.536E+01   0.66    12.31 .56500E+03
   128.22    -0.00     0.00     19.3 0.519E+01   0.68    12.31 .62687E+03
   139.99    -0.00     0.00     19.9 0.503E+01   0.71    12.31 .68875E+03
   151.76    -0.00     0.00     20.5 0.488E+01   0.73    12.31 .75062E+03
   163.53    -0.00     0.00     21.2 0.472E+01   0.75    12.31 .81249E+03
   175.31    -0.00     0.00     21.9 0.456E+01   0.78    12.31 .87436E+03
   187.08    -0.00     0.00     22.7 0.441E+01   0.81    12.31 .93623E+03
   198.85    -0.00     0.00     23.5 0.426E+01   0.83    12.31 .99810E+03
   210.62    -0.00     0.00     24.3 0.412E+01   0.86    12.31 .10600E+04
   222.39    -0.00     0.00     25.2 0.397E+01   0.89    12.31 .11218E+04
 Plume interacts with BOTTOM.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
   234.17    -0.00     0.00     25.7 0.389E+01   0.91    12.31 .11837E+04
 Effluent is FULLY MIXED over the entire channel cross-section.
 Except for possible far-field decay or reaction processes, there are
   NO FURTHER CHANGES with downstream direction.
   245.94    -0.00     0.00     25.7 0.389E+01   0.91    12.31 .12456E+04
   257.71    -0.00     0.00     25.7 0.389E+01   0.91    12.31 .13074E+04
   269.48    -0.00     0.00     25.7 0.389E+01   0.91    12.31 .13693E+04
   281.26    -0.00     0.00     25.7 0.389E+01   0.91    12.31 .14312E+04
   293.03    -0.00     0.00     25.7 0.389E+01   0.91    12.31 .14931E+04
   304.80    -0.00     0.00     25.7 0.389E+01   0.91    12.31 .15549E+04
 Cumulative travel time =        1554.9277 sec

 Simulation limit based on maximum specified distance =    304.80 m.
   This is the REGION OF INTEREST limitation.

END OF MOD361: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
CORMIX3: Buoyant Surface Discharges                    End of Prediction File
3333333333333333333333333333333333333333333333333333333333333333333333333333
```