Appendix C. Code Modifications

Several modifications were made to the version 3.12 CE-QUAL-W2 model code beyond those already documented by Sullivan and others (2007) and Sullivan and Rounds (2006). The original Detroit Lake version 3.12 model published by Sullivan and others (2007) included a USGS-coded blending subroutine that allowed the model to select two outlets from among several potential outlets and set the percentage of the total release rate in each outlet in order to meet a user-supplied downstream temperature target time series. In this study, several additional modifications were made to the model code:

- The DOWNSTREAM_WITHDRAWAL and LATERAL_WITHDRAWAL subroutines were updated to make the velocity profile equations similar to those used in CE-QUAL-W2 version 3.6. The LATERAL_WITHDRAWAL subroutine also was modified to allow both "point" and "line" withdrawals, using equations from the DOWNSTREAM_WITHDRAWAL subroutine.

- The blending subroutine was modified to iteratively set the outlet release rates when two outlets are used; up to five iterations are performed. In the original blending subroutine, the temperature released from each outlet was estimated as the temperature in the reservoir at the elevation of the outlet, but that estimate did not always match well with the actual temperature released through the outlet because water from many layers is drawn into the outlet as specified by the model's selective withdrawal algorithm. Because the amount of water that comes from various layers depends on the release rate for that outlet, this procedure had to be iterative in order to be accurate.

  In this iterative process, an initial estimate of the release rates is made and then refined in a loop. The loop is exited early if the current and previous release rates for each outlet are within 1 percent. If all five iterations are performed and the current and previous results are still not within 1 percent, then a message is written to the model warning file. This code modification greatly improved the accuracy of the blending subroutine.

- Two new inputs were added to the model control file to allow withdrawals (in addition to structures) to have the characteristics of a line sink or a point sink and to specify the width of the line sink. The WD SINK card is located in the control file just after the WD TYPE card; accepted inputs are either LINE or POINT. The WD WIDTH card follows, to include the width of any line sinks that are specified for withdrawals.

- For floating outlets, the original blending algorithm assumed that all floating outlets, and all sliding-gate outlets that were located at their upper limit near the water surface, were positioned at a depth of 1.5 m below the water surface. The introduction of a new withdrawal depth variable allows the user to set the depth of each floating or sliding-gate outlet relative to the water surface. This new WD FLOAT card is located just after the WD WIDTH card in the control file.

- A new input variable (MINFRAC) was added for use with the blending subroutine to allow the user to specify a minimum outlet flow rate or a minimum fraction of the total release rate for a particular group of withdrawals. This input variable does not affect the choice of outlets. If a user specifies more than three withdrawals in any one withdrawal group, this factor is not used to determine which two of the available withdrawals are selected for blending the releases and, therefore, this constraint will not necessarily be honored.

  When not active, this new MINFRAC variable is set to 0.0. When used to set a minimum fraction of the total withdrawal, it is set to a positive value less than or equal to 1.0. To set a minimum flow rate in cubic meters per second, the MINFRAC input is set by the user to a negative number where the minimum flow rate is equal to the absolute value of MINFRAC. The negative sign is used to tell the model that this is a minimum flow rate rather than a minimum fraction of the total flow. The model ensures that MINFRAC is not larger than 1.0. This new user input is provided on a new WD MINFR card that is located just after the WD GROUP card in the model control file.

  Note that the minimum flow specification should work well as long as the withdrawn flows do not change between the times that the blending subroutine is called. If the withdrawal flow rates change more frequently than the subroutine is called, then this code does not guarantee that the minimum specified flows are met. Often, the blending subroutine may only be called once or a few times per day so that dam operators do not have to frequently change gate positions.

- Lastly, a withdrawal priority setting was added as a user-specified input so that if more than one minimum flow constraint was specified within a withdrawal group, the code can try to honor each constraint according to the specified outlet priority. A lower code

specifies a higher priority; therefore, a priority input of 1 is a higher priority than a priority input of 2. Specified minimum flow criteria will not necessarily be met if the outlet has a lower priority (higher priority number). The priority setting does not affect the choice of which two outlets are selected from among a group of more than two withdrawals in a group.

After honoring the priority level, the blending subroutine makes an attempt to meet any other fractional flow or minimum flow criteria. However, if a greater total flow or total fractional flow is requested relative to what can be provided, a compromise will be made and it is possible that neither minimum flow constraint will be honored.

In cases when the water column is isothermal and no minimum flow criteria are set, the priority setting is used to route all of the outflow to the outlet with the higher priority (lower priority setting).

The new inputs to the model control file described in this section above might look like the snippet of a control file example as reproduced here for a system with three withdrawals:

```
WD TYPE    WDTYPE    WDTYPE    WDTYPE    WDTYPE    WDTYPE    WDTYPE    WDTYPE    WDTYPE   WDTYPE
             FIXED     FIXED     FIXED

WD SINK    WDSINK    WDSINK    WDSINK    WDSINK    WDSINK    WDSINK    WDSINK    WDSINK   WDSINK
              LINE      LINE      LINE

WD WIDTH       WWD       WWD       WWD       WWD       WWD       WWD       WWD       WWD      WWD
               6.8       4.0        25

WD FLOAT   WDEPTH    WDEPTH    WDEPTH    WDEPTH    WDEPTH    WDEPTH    WDEPTH    WDEPTH   WDEPTH
                 0         0         0

WD GROUP     WDGRP     WDGRP     WDGRP     WDGRP     WDGRP     WDGRP     WDGRP     WDGRP    WDGRP
                 1         1         2

WD MINFR  MINFRAC   MINFRAC   MINFRAC   MINFRAC   MINFRAC   MINFRAC   MINFRAC   MINFRAC  MINFRAC
               0.4         0         0

WD PRIOR  WDPRIOR   WDPRIOR   WDPRIOR   WDPRIOR   WDPRIOR   WDPRIOR   WDPRIOR   WDPRIOR  WDPRIOR
                 1         2         3
```

The modified model source code is available online at the project website: http://or.water.usgs.gov/santiam/detroit_lake/ in the Downloads section of that page.