Technical Memo 11: Algae and Organic Matter Modifications to RMA-11v41

Date: 9/22/04

Summary

This technical memo describes recent changes to the representation of organic matter in RMA-11v41. With these changes, the program has been modified to represent organic matter (including algae) more along the lines of CE-QUAL-W2. This new representation redefines algal decay to include death and respiration as two separate processes, incorporates a compartment for organic matter, and treats biochemical oxygen demand (BOD) as an independent form of organic matter.

Previously, algal death and respiration in RMA-11 were lumped into a single process referred to as "respiration." In this new version, RMA-11-OM2, algae now respire and die in separate processes. Respiration consumes oxygen and produces ammonia (NH3) and orthophosphate (PO4). Mortality produces organic matter. To better approximate the fate of organic matter in the water column, organic-N and organic-P compartments found in the old version of RMA-11 have been eliminated and an organic matter (OM) compartment has been added in their place. BOD, traditionally a measure of organic matter in wastewater, is now represented as a separate form of organic matter, not just an oxygen demand.

In this new representation, decaying organic matter consumes oxygen and produces NH3 and PO4. Similarly, BOD decay also consumes oxygen and produces NH3 and PO4. As before, bed algae are modeled as attached algae – nutrients, oxygen, and organic matter are exchanged between attached algae and the water column.

Background

The RMA-11 and CE-QUAL-W2 water quality models have been linked for our studies in the Klamath basin. While both models represent water quality well, they represent it differently, especially with respect to organic matter. In general, CEQUAL-W2 represents organic matter in a more complex way than RMA-11. These two different representations of organic matter create problems when the models are linked.

In its prior development, RMA-11 has followed the modeling structure of the QUAL2 models (Brown and Barnwell, 1987), using a simple representation of algae dynamics and representing organic matter in separate organic-N (Org N) and organic-P (Org-P) compartments. The original RMA-11 represents algal decay, as does QUAL2, as a single "respiration" process that consumes oxygen and produces Org-N and Org-P. In that representation, BOD is simply an oxygen demand, carbonaceous oxygen demand is exerted by decay of algae and BOD, and nutrients are produced by decay of Org-N and Org-P.

In CE-QUAL-W2, organic matter is modeled in more detail (only generally described here). Algal decay is represented by three processes: respiration, mortality, and excretion. Respiration simply consumes oxygen and produces nutrients. But mortality and excretion produce organic matter, which consumes oxygen as it decays to nutrients. In the CE-QUAL-W2 representation, BOD is modeled as a separate form of organic matter. Its decay consumes oxygen and produces nutrients.

Modifications

The RMA-11 model has been modified to make it more compatible with CE-QUAL-W2. In this new version of the model, organic matter is handled much in the same way as it is handled in CE-QUAL-W2. The organic N and organic P compartments found in earlier versions of RMA-11 have been eliminated. In the new version of RMA-11, algae decay into organic matter, and BOD, instead of just representing an oxygen demand, now represents a form of organic matter. Except for bed algae (which are modeled as attached algae), bed constituents have not been changed. Now, just like water-column algae, bed algae decay to water-column OM and respire to produce water-column NH3 and PO4 while consuming water-column DO. Schematics showing the way that organic matter is handled in the original RMA-11 and in RMA-11-OM2 are presented in Figure 1 and Figure 2, respectively.

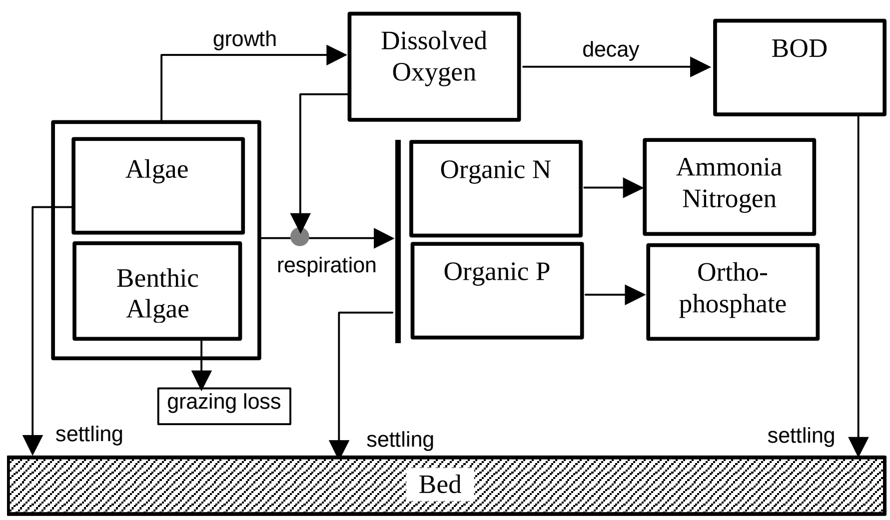

Figure 1. Schematic of organic matter modeling in original RMA-11

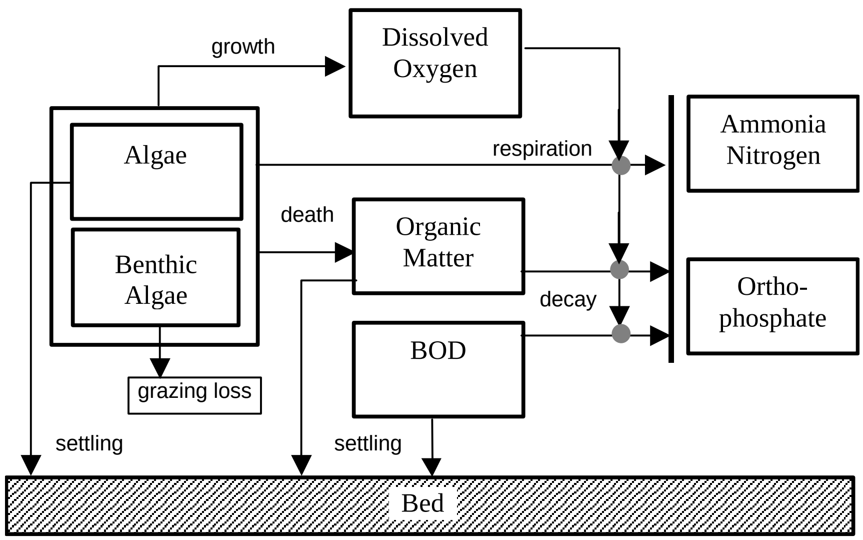

Figure 2. Schematic of organic matter modeling in new RMA-11-OM2

Some differences in the way that the models simulate organic matter remain. For simplicity, there is no distinction between dissolved and particulate or labile and refractory organic matter in the new RMA-11 model. Except for the details of partitioning organic matter, the two systems of modeling organic matter are essentially equivalent.

Model Interaction

RMA-11 to CE-QUAL-W2 transfer

Transferring output from the new version of RMA-11 to the CE-QUAL-W2 model is straightforward. In RMA-11, all organic matter is represented either by algae, BOD, or a general "organic matter" component. These water quality constituents are transferred directly into analogous W2 constituents. In both models, the BOD compartment represents CBODu. General "organic matter" from RMA-11 can be partitioned into dissolved, particulate, labile, and refractory forms depending on information available to justify such partitioning. A simple partitioning would assume the particulate fraction used in W2 modeling (APOM) and a labile fraction of unity.

Algae (W2)= Algae (RMA-11)

BOD (W2)= BOD (RMA-11)

LDOM (W2)= (1-APOM)*OM (RMA-11)

LPOM (W2)= APOM*OM (RMA-11)

RDOM (W2)= 0.0

RPOM (W2)= 0.0

CE-QUAL-W2 to RMA-11 transfer

Transfer from CE-QUAL-W2 to RMA-11 is similarly straightforward. The W2 simulated BOD should be used and not the “derived constituent” CBODu because the derived constituent includes algae and organic matter oxygen demands.

Algae (RMA-11)= Algae (W2)

BOD (RMA-11)= BOD (W2)

OM (RMA-11)= LDOM (W2) +LPOM (W2) +RDOM (W2) +RPOM (W2)

External Loading

External loading to both models must be made with consideration to appropriate constituents. Both models simulate BOD as CBODu. Therefore, if BOD5 (a commonly reported measure of CBOD) is used to specify a boundary forcing function, it must be converted to CBODu with an appropriate factor (e.g. 1.85). In RMA-11, this conversion is made before specifying boundary concentrations. CE-QUAL-W2 will make the conversion with a user-specified factor.

Both models simulate algae, BOD, and organic matter separately, so it is important to distinguish between these forms of organic material when specifying boundary concentrations. Reported values of BOD always contain living (algae) and non-living (organic matter) fractions, and care must be taken so as not to “double count” organic matter input. In general, the BOD compartment is used to specifically describe waste discharge (e.g., sewage treatment discharge) that will be tracked throughout a simulation while the algae and organic matter compartments are used to describe loadings from the natural environment.

Version

This new version of RMA-11 is based on a version that had its most recent modifications on 5-8-03 and 10-20-03 to correct bed constituent restart-file reading and implement minimum bed concentrations. The original source for all modifications is version 1.0 of RMA-11B dated 10-23-02.

Input changes

To accommodate changes to the model, organic matter is specified in place of organic N in input files, and mortality rates for algae are appended to element-variable data. To switch on OM modeling, a value of “4” should be given on Line type 3 (ID: “TYPE”) in the water quality control file (*.rm4). Org-N (previously indicated by a “4” on “TYPE”) and org-P (an “8” on “TYPE”) are disabled, though nothing will be hurt by specifying an “8” on “TYPE”.

Global temperature coefficients for organic matter are read in from Line type 10 (ID: “NITRO ”), where corresponding values for organic N used to be read. Algae mortality rate (1/day) is appended to variable element data for algae (Line type 25; “ALGAE “; columns 49-56) and bed algae (Line type 25a; “BALGAE “; columns 73-80). Variable element data for organic matter are specified in line type 26 (ID: “OM “) and include decay rate (1/day), settling rate (1/day), and Michaelis Menton coefficient for low DO inhibition of oxidation (mg/l).

Code changes

Following are code changes made to RMA-11B to create RMA 11-OM2.

BLK11.COM

Add global variables LOM and LBOM (not used). Rate coefficient matrix already dimensioned as RCOEF(NQL,8,MMAT) in BLK11.COM, so adding mortality in RCOEF(LALG,6,K1P(K)) is OK. Bed rate coefficient matrix dimensioned as BCOEF(NQL,9,MMAT) in BLK11.COM, so adding mortality in RCOEF(LBALG,9,K1P(K)) is OK.

```
      COMMON /BLK7/ IDOS,WTEMP(MNP),QTITLE,ICONST(NQL),IBCNST(NQL),
     + -a bunch of variables-
     + ,LOM,LBOM
```

DEFAULTS.FOR

Add mortality rates to RCOEF and BCOEF matrices. Set default rate.

```
RCOEF(LALG,6,K1P(K))= 0.10/86400. !algae mortality rate 1/DAY;         AEB JUN04
BCOEF(LBALG,9,K1P(K))= 0.10/86400. !bed algae mortality rate 1/DAY     AEB JUL04

IF(LOM .GT. 0) THEN                !replace ORGN with OM, add M-M      AEB JUL04
  RCOEF(LOM,1,K1P(K))= 0.25/86400. !OM conversion rate 1/DAY           AEB JUL04
  RCOEF(LOM,2,K1P(K))= 0.10/86400. !OM settling rate M/DAY             AEB JUL04
  RCOEF(LOM,3,K1P(K))= 0.10/86400. !M-M coefficient for low DO MG/L    AEB JUL04
ENDIF

IF(LBOM .GT. 0) THEN                                       !AEB JUL04  Not used.
 BCOEF(LBOM,1,K1P(K))= 0.25/86400. ! bed OM conversion rate 1/DAY AEB JUL04
ENDIF
```

INCON.FOR

Initialize LOM. Replace ORG-N with OM in assigning contstiuent array index. Eliminate ORG-P. Update echo check for algae mortality and organic matter.

```
-initialize LOM
  LOM   = 0                                                         !AEB JUL04

-disable org-N and org-P, assign OM to “4” in place of org-N
CAEB JUL04  Add OM in place of Org-N
        ELSEIF( ICONST(I).EQ.4 ) THEN
          LOM   = I                                                 !AEB JUL04
          CLABL(I) ='     OM '                                      !AEB JUL04
CAEB JUL04  Org-N not modeled
C        ELSEIF( ICONST(I).EQ.4 ) THEN
C          LORGN   = I
C          CLABL(I) ='   ORGN '
CAEB JUL04  Org-P not modeled
C        ELSEIF( ICONST(I).EQ.8 ) THEN
C          LORGP = I
C          CLABL(I) ='   ORGP '

-Default global echo.  Replace ORGN with OM in echo check.
      IF(LOM .NE. 0  .OR.  LNH3 .NE. 0  .OR.  LNO2 .NE. 0  .OR.       !AEB JUL04
     +    LNO3 .NE. 0) THEN
```

```
        IF(IDFC(3) .EQ. 0)
     +   WRITE(LOUT,2022) ALP(5),ALP(6),(THET(K),K=4,8),KNINH
      ENDIF

-Element variables echo check
CAEB JUN04 Increase to 6 for mortality rate
      IF(NAMEC(1:5) .EQ. 'ALGAE') THEN
             WRITE(LOUT,2051) (TRCOEF(J),J=1,6)                     !AEB JUN04
CAEB JUN04 Increase to 9 for mortality rate
          ELSEIF(NAMEC(1:6) .EQ. 'BALGAE') THEN
            WRITE(LOUT,3051) (TRCOEF(J),J=1,9)                      !AEB JUL04
CAEB JUN04 Replace ORG-N with OM.  Add coeff for M-M.
          ELSEIF(NAMEC(1:5) .EQ. 'OM   ') THEN
            WRITE(LOUT,2052) (TRCOEF(J),J=1,3)                      !AEB JUN04

-Element default values
CAEB JUN04 Increase coeffs to 6 for mortality rate
      IF(LALG .GT. 0  .AND.  IDFC(2) .EQ. 0) THEN
        WRITE(LOUT,2051) (RCOEF(LALG,J,K1P(1))*86400.,J=1,6)        !AEB JUL04
      ENDIF
CAEB JUL04 Add mortality
      IF(LBALG .GT. 0  .AND.  IDFB(2) .EQ. 0) THEN
        WRITE(LOUT,3051) (BCOEF(LBALG,J,K1P(1))*86400.,J=1,5)
     +                  ,(BCOEF(LBALG,J,K1P(1)),J=6,7)
     +                  , BCOEF(LBALG,8,K1P(1))*86400.
     +                  , BCOEF(LBALG,9,K1P(1))*86400.              !AEB JUL04
       ENDIF
CAEB JUL04 Replace ORGN with OM
      IF(LOM .GT. 0  .AND.  IDFC(3) .EQ. 0) THEN                    !AEB JUL04
        WRITE(LOUT,2052) (RCOEF(LOM,J,K1P(1))*86400.,J=1,3)         !AEB JUL04
      ENDIF

-Formats
 2022 FORMAT(/15x,' GLOBAL ORGANIC MATTER AND NITROGEN RATES'//       !AEB JUL04
     +   10X,'O2 UPTAKE PER UNIT NH3 OXYDATION',t50,f10.4,3x,'(gm O per
     +gm NH3)'/
     +   10X,'O2 UPTAKE PER UNIT NO2 OXYDATION',t50,f10.4,3x,'(gm O per
     +gm NO2)'/
     +   10X,'TEMP COEF FOR ORG MATTER DECAY',T50,F10.4/              !AEB JUL04
     +   10X,'TEMP COEF FOR ORG MATTER SETTLING',T50,F10.4/           !AEB JUL04
     +   10X,'TEMP COEF FOR AMMONIA DECAY',T50,F10.4/
     +   10X,'TEMP COEF FOR AMMONIA BENTHIC SOURCES',T50,F10.4/
     +   10X,'TEMP COEF FOR NITRITE DECAY',T50,F10.4/
     +   10X,'1ST ORDER NITRIFICATION INHIBITION COEF',t50,f10.4)
 2051 FORMAT(10X,'MAXIMUM ALGAE GROWTH RATE ',T50,F10.4,'   (1/DAY)'/
     +       10X,'ALGAE RESPIRATION RATE ',T50,F10.4,'   (1/DAY)'/
     +       10X,'ALGAE SETTLING RATE',T50,F10.4,'   (M/DAY)'/
     +       10X,'LIMIT ON ALGAE GROWTH RATE',T50,F10.4,'   (1/DAY)'/
     +       10X,'LIMIT ON ALGAE RESP. RATE',T50,F10.4,'   (1/DAY)'/
     +       10X,'ALGAE MORTALITY RATE ',T50,F10.4,'   (1/DAY)'/)     !AEB JUN04

2052 FORMAT(10X,'ORG MATTER DECAY RATE',T50,F10.4,'   (1/DAY)'/       !AEB JUL04
     +       10X,'ORG MATTER SETTLING RATE',T50,F10.4,'   (M/DAY)')   !AEB JUL04
     +       10X,'OM MICHAELIS-MENTON COEF',T50,F10.4,'   (M/DAY)')   !AEB JUL04
3051 FORMAT(/10X,'RATES FOR BED ALGAE',/
     +       10X,'ALGAE GROWTH RATE ',T50,F10.4,'   (1/DAY)'/
     +       10X,'ALGAE RESPIRATION RATE ',T50,F10.4,'   (1/DAY)'/
     +       10X,'ALGAE GRAZ. MORT. RATE ',T50,F10.4,'   (1/DAY)'/
     +       10X,'LIMIT ON ALGAE GROWTH RATE',T50,F10.4,'   (1/DAY)'/
     +       10X,'LIMIT ON ALGAE RESP. RATE',T50,F10.4,'   (1/DAY)'/
     +       10X,'CRIT SHEAR STRESS INCR EROS',T50,F10.4,'   (N/M2)'/
     +       10X,'CRIT SHEAR STRESS MASS EROS',T50,F10.4,'   (N/M2)'/
     +       10X,'ERODIBILTY CONST. INCR EROS',T50,F10.4,'   (/DAY)'
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```
     +       10X,'ALGAE MORTALITY RATE',T50,F10.4,'   (1/DAY)'        !AEB JUL04
     +     /)
```

MKALG.FOR

Add mortality, "AMORT." Make temperature adjustment same as respiration. Allow respiration to decay to NH3 and PO4. Let mortality produce organic matter. Eliminate ORG-N and ORG-P.

```
CAEB JUN04   Calculate respiration and mortality
        RESP = RCOEF(ICON,2,MAT)
        AMORT = RCOEF(ICON,6,MAT)                                     !AEB JUN04

CAEB JUN04  Add mortality to temperature correction
        AMORT = AMORT * THET(2)**(T(LTEMP)-20)                        !AEB JUN04

CAEB JUN04  Add mortality to rate terms
      RSLT = RSLT + GRW - RESP - AMORT – SET                          !AEB JUN04
      GRATE(ICON) = GRATE(ICON) + RSLT

CAEB JUL04 Disable ORG-N
C      If ORG-N is simulated, algae respiration is source of ORG-N
CAEB      IF( LORGN.GT.0) THEN
CAEB        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
CAEB          SRCSNK(LORGN) = SRCSNK(LORGN) +ALP(1)*RESP*T(ICON)
CAEB        ENDIF
CAEB      ENDIF

CAEB JUL04  If ORG MATTER is simulated, algae mortality is source of OM
      IF( LOM.GT.0) THEN                                              !AEB JUL04
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
          SRCSNK(LOM) = SRCSNK(LOM) + AMORT*T(ICON)                   !AEB JUL04
        ENDIF
      ENDIF

CAEB JUN04  If NH3 is simulated, growth demands NH3 and respiration is a source
      IF( LNH3 .GT. 0  .AND.  LNO3 .EQ. 0) THEN
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
          SRCSNK(LNH3) = SRCSNK(LNH3) + ALP(1)*(RESP - GRW)*T(ICON)   !AEB JUN04
        ENDIF
      ELSEIF( LNH3 .GT. 0  .AND.  LNO3 .GT. 0) THEN
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
          if(t(lnh3) + t(lno3) .gt. 0.) then
            FACTOR = PREFN*T(LNH3)/(PREFN*T(LNH3)+(1-PREFN)*T(LNO3))
          else
            factor=0.
          endif
          SRCSNK(LNH3) = SRCSNK(LNH3)
     +                   +ALP(1)*(RESP - FACTOR*GRW)*T(ICON)          !AEB JUN04
          SRCSNK(LNO3) = SRCSNK(LNO3) - (1.-FACTOR)*ALP(1)*GRW*T(ICON)
        ENDIF
      ENDIF

CAEB JUL04 Disable ORG-P
C      If ORG-P is simulated, algae respiration is source of ORG-P
CAEB      IF( LORGP.GT.0) THEN
CAEB        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
CAEB          SRCSNK(LORGP) = SRCSNK(LORGP)+ ALP(2)*RESP*T(ICON)
CAEB        ENDIF
CAEB      ENDIF

CAEB JUN04 If PO4 is simulated, growth demands PO4 and respiration is source
          SRCSNK(LPO4) = SRCSNK(LPO4) + ALP(2)*(RESP-GRW)*T(ICON)     !AEB JUN04
```

```
CAEB JUN04 No change. If DO is simulated, algae growth is source and
respiration a sink
          SRCSNK(LDO) = SRCSNK(LDO)+(ALP(3)*GRW-ALP(4)*RESP)*T(ICON)
```

MKRATES.FOR

Replace call to MKORGN with call to MKOM (a new routine, see below).

```
C      Loop through each node and constituent included in the simulation
C      and call the appropriate subroutine to calc source/sink
C        1 - Arbitrary Non-Conservative:
C        2 - BOD:
C        3 - DO:
C        4 - Organic matter:                                          !AEB JUL04
C        5 - NH3:
C        6 - N02:
C        7 - NO3:
C        8 - Org-P:
C        9 - PO4:
C       10 - Algae:
C       11 - Temperature:

     ELSE IF(ICONST(I).EQ.4 ) THEN
       CALL MKOM(I,T,D,MAT,VSET,IETP)        !Replace MKORGN with MKOM AEB JUL04
```

MKOXY.FOR:MKBOD

Add NH3 and PO4 decay products for BOD.

```
C   If NH3 is simulated, BOD decay (convert to OM) is source of NH3   !AEB JUL04
      IF( LNH3 .GT. 0) THEN                                           !AEB JUL04
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN                       !AEB JUL04
          SRCSNK(LNH3) = SRCSNK(LNH3) + ALP(1)*XK*T(ICON)/ALP(4)      !AEB JUL04
        ENDIF                                                         !AEB JUL04
      ENDIF                                                           !AEB JUL04

C   If PO4 is simulated, BOD decay (convert to OM) is source of PO4   !AEB JUL04
      IF( LPO4.GT.0) THEN                                             !AEB JUL04
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN                       !AEB JUL04
          SRCSNK(LPO4) = SRCSNK(LPO4) + ALP(2)*XK*T(ICON)/ALP(4)      !AEB JUL04
        ENDIF                                                         !AEB JUL04
      ENDIF                                                           !AEB JUL04
```

MKOM.FOR

Based on newly modified subroutine MKBOD (including settling) except:
-different temperature dependency coefficients
-do not use ALP(4) to convert oxygen demand to OM for SRCSNK NH3 and PO4
-use ALP(4) to convert decay to oxygen demand for SRCSNK DO

```
      SUBROUTINE MKOM(ICON,T,D,MAT,VSET,IETP)                         !AEB JUL04
C      If NH3 is simulated, OM decay is source of NH3
      IF( LNH3 .GT. 0) THEN
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
          SRCSNK(LNH3) = SRCSNK(LNH3) + ALP(1)*XK*T(ICON)             !AEB JUL04
        ENDIF
      ENDIF
C      If PO4 is simulated, OM decay is source of PO4                 !AEB JUL04
      IF( LPO4.GT.0) THEN                                             !AEB JUL04
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN                       !AEB JUL04
          SRCSNK(LPO4) = SRCSNK(LPO4) + ALP(2)*XK * T(ICON)           !AEB JUL04
        ENDIF                                                         !AEB JUL04
      ENDIF                                                           !AEB JUL04
```

```
CAEB JUL04  If DO is simulated, OM decay is a sink for DO (Use O2 uptake/algae
respired)
      IF( LDO.GT.0) THEN
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
          SRCSNK(LDO) = SRCSNK(LDO)-ALP(4)*XK * T(ICON)               !AEB JUL04
        ENDIF
      ENDIF
```

MKBALG.FOR

Change “AMORT” to “GRAZE.” Modify similar to MKALG. Add mortality, “BAMORT.” Make temperature adjustment same as respiration. Allow respirtion to decay to water-column NH3 and PO4. Let death and erosion produce water-column organic matter. Eliminate ORG-N and ORG-P. SRCSNK equations are similar to those of MKALG except that terms are divided by depth, D, and bed algae erosion is a source of OM.

```
CAEB ALP1 IS GAUSS-PT BED ALGAE LOSS TO EROSION?
CAEB ABLP(1) IS NITROGEN FRACTION OF BED ALGAE
CAEB ABLP(2) IS PHOSPHORUS FRACTION OF BED ALGAE
CAEB ABLP(3) IS OXYGEN FROM BED ALGAE GROWTH
CAEB ABLP(4) IS OXYGEN FROM BED ALGAE RESPIRATION
```

-Rename grazing and add mortality

```
      GRAZE= BCOEF(ICON,3,MAT)                 !AEB JUL04. Change AMORT to GRAZE
      BAMORT= BCOEF(ICON,9,MAT)                                       !AEB JUL04
      GRAZE= GRAZE* BTHET(2)**(T(LTEMP)-20.)                          !AEB JUL04
      BAMORT = BAMORT * BTHET(2)**(T(LTEMP)-20.)                      !AEB JUL04

      RSLT = RSLT + (GRW - RESP - GRAZE - BAMORT)                     !AEB JUL04
```

-Use respiration rate limit for both respiration and mortality.

```
      IF(BCOEF(ICON,5,MAT) .GT. 0.) THEN
        IF(RESP .GT. BCOEF(ICON,5,MAT)) RESP=BCOEF(ICON,5,MAT)
        IF(BAMORT .GT. BCOEF(ICON,5,MAT)) BAMORT=BCOEF(ICON,5,MAT)    !AEB JUL04
      ENDIF

CAEB JUL04 Disable ORG-N
C      If ORG-N is simulated, algae respiration is source of ORG-N
CAEB       IF( LORGN.GT.0) THEN
CAEB        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
CAEB          SRCSNK(LORGN) = SRCSNK(LORGN) +
CAEB     +     ABLP(1)*(RESP*TB(ICON)+ALP1)/D
CAEB        ENDIF
CAEB       ENDIF
CAEB   If OM is simulated, algae mortality and erosion are sources of OM
       IF( LOM.GT.0) THEN
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
          SRCSNK(LOM) = SRCSNK(LOM) + (BAMORT*TB(ICON)+ALP1)/D        !AEB JUL04
        ENDIF
       ENDIF

CAEB JUL04  If NH3 is simulated, algae growth demands NH3 and respiration is a
source
       IF( LNH3 .GT. 0  .AND.  LNO3 .EQ. 0) THEN
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
          SRCSNK(LNH3) = SRCSNK(LNH3) + ABLP(1)*(RESP-GRW)*TB(ICON)/D !AEB JUL04
        ENDIF
       ELSEIF( LNH3 .GT. 0  .AND.  LNO3 .GT. 0) THEN
         IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
          SRCSNK(LNH3) = SRCSNK(LNH3)
     +                   + ABLP(1)*(RESP-FACTOR*GRW)*TB(ICON)/D       !AEB JUL04
```

```
          SRCSNK(LNO3) = SRCSNK(LNO3)-ABLP(1)*(1.-FACTOR)*GRW*TB(ICON)/D
         ENDIF
       ENDIF

CAEB JUL04 If PO4 is simulated, algae growth demands PO4 and respiration is
source
       IF( LPO4.GT.0) THEN
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
          SRCSNK(LPO4) = SRCSNK(LPO4) + ABLP(2)*(RESP-GRW)*TB(ICON)/D !AEB JUL04
        ENDIF
       ENDIF

CAEB JUL04  If DO is simulated, algae growth is source and respiration a sink.
Algae loss to erosion is not a sink.
       IF( LDO.GT.0) THEN
        IF(IETP .EQ. 3  .OR.  IETP .EQ. 4) THEN
          SRCSNK(LDO) =SRCSNK(LDO)
     +           +((ABLP(3)*GRW-ABLP(4)*RESP)*TB(ICON))/D             !AEB JUL04
        ENDIF
       ENDIF
```