Chapter 20

CONCLUSIONS

Contents

The sequence of benchmark test problems has provided an appropriate framework for a rational evaluation of the capabilities of the three models.

- Some of the problems were designed to evaluate model response in focussed situations that are common elements of typical Bay-Delta applications.
- Others were designed to stretch the response envelope, anticipating potential future applications.

Problems have been identified with all three models. Some were fixed in revised submissions. Others remain.

Models of this nature are sophisticated in concept, demanding in code implementation, and complicated in application. The identification of problems in such detailed testing was expected, but nonetheless disappointing for such mature codes.

Good numerical modeling practice should routinely include a sequence of benchmark tests of this nature.

It may be that many, if not all, of the problems identified are eventually attributable to some unfamiliarity with

- the context of the benchmark tests,
- the specific data reporting format and/or
- the shear volume of data predictions that were generated.

That itself is an important reminder that there is no substitute for

- careful analysis,
- experienced modelers, and
- continuing review.

Summary comments follow.

20.1 Contra Costa Water District

Participation Files H1 through H5 were received in December 1998. Files H8 through H11 were received in August 2000. CCW did not respond to all of the mass transport problems.

H1 Expected response.

H2 Expected response.

H3 Response is close to that expected. Poor resolution of stage boundary conditions forces a spurious stepped response.

H4 Response has many elements that are visually credible. Significant numerical precision error identified in upland Reach CD.

H5 Visually credible response. But numerical precision problem (see H4) must remain.

H6 Visually credible response. MOC algorithm appears to filter any shorter wave responses.

H7 Visually credible response.

H8 Visually credible response.

H9 Visually credible response. Problems identified in H4 have been resolved.

H10 Perhaps a credible response, but only if the stepped Q response pattern is a data reporting error.

H11 No solution for problems as defined. Solution could only be obtained for a very much smaller space and time step, suggesting a fundamental difficulty with the CCW code. H11 solution presented is credible.

M1 Did not contribute.

M2 Did not contribute.

M3 Did not contribute.

M4 Did not contribute.

20.2 Department of Water Resources

Participation DWR contributed to all of the problems. However, it seems that the DWR model lacked the flexibility to respond to the problems as defined. All were changed in some manner, some significantly. No data file was provided in the required standard format, and there was some inconsistency in the format of the data files that were provided.

Files H1 through H5 were received in September 1998, revised in October 1999, and revised again in March 2000. Files M1, M2 and M4 were received in September 1998, revised in October 1999, and revised again in March 2000. An incomplete contribution for M3 was received in September 1998; it was never revised. Files H6 through H8 were received in October 1999, and revised in March 2000. Files H9 through H11 were received in August 2000, and revised twice that month.

H1 Expected response.

H2 Expected response for disturbance propagation. Problem changed to avoid evaluation of open boundary conditions.

H3 Expected response.

H4 Expected response.

H5 Visually credible response.

H6 Visually credible response. But either gate code or box algorithm appear to heavily filter any shorter wave responses.

H7 Visually credible response. See H6 observation about filtering of shorter wave responses.

H8 Visually credible response.

H9 Visually credible response.

H10 Visually credible response.

H11 Almost credible response. Apparent difficulty with upstream Q boundary condition.

M1 Credible response.

M2 Credible response.

M3 Adopted algorithm for dispersive transport has compromised an otherwise excellent contaminant transport model.

M4 Trends correct, but credibility uncertain.

20.3 Resource Management Associates

Participation RMA were the only group that responded to all problems. Files H1 through H6 were received in September 1997, revised in February 2000, and revised again in August 2000. Files M1 through M4 were received in September 1997, and revised in August 2000. Files H6 through H8 were received in February 2000. Files H9 through H11 were received in August 2000.

H1 Expected response.

H2 Expected η response, but distributed discontinuities in Q response. Also, momentum is not conserved. RMA argue that these are known, and controllable, difficulties that can be traced to differing spatial resolution of η and Q in their Finite Element algorithm.

H3 Expected response.

H4 Expected response, but small residual oscillations may suggest a less than adequate numerical algorithm.

H5 Visually credible response.

H6 Visually credible response.

H7 Visually credible response.

H8 Visually credible response.

H9 Visually credible response.

H10 Visually credible response.

H11 Almost credible response. Apparent difficulty with upstream Q boundary condition.

M1 Expected response.

M2 Expected response, but beyond resolution of the RMA Eulerian algorithm.

M3 Visually credible response.

M4 Visually credible response.

20.4 Summary

For the hydrodynamic (H series) tests, all three participant models have eventually managed to demonstrate acceptable performance.

Initial responses from CCW were the most credible. Some problems were identified, and CCW did not submit any revisions.

Initial responses from DWR and RMA had a number of problems. Both these codes are mature, and have been used in practice for many years. In addition, the results were prepared and presented by the current maintainers of these codes. These responses were revised, and continuing difficulties were identified. The results includes in this report come mostly from the third attempt.

That it took mostly three attempts to get it right needs to be highlighted. As suggested previously, some of these difficulties might be attributable to some unfamiliarity with the context of the benchmark tests, with the specific data reporting format and/or with the shear volume of data predictions that were generated. But not all.

The very positive experience of the review of the review needs also to be highlighted. Successful hydrodynamic modeling demands a simultaneous mastery of physical and numerical processes, and of their interaction. Neither modeler nor reviewer has a claim to infallibility. And both should be subject to review. Every even mildly negative review comment was challenged. Many were resolved, as a result of the review of the review.

There are two inescapable conclusions:

1. all three codes are potentially viable models for unsteady, gradually varied flow in river and estuary systems, but

2. no code should be accepted without **extensive** and **independent** review.

For the salinity transport (M series) tests, there was complete participation only from RMA. Their code performed as expected, but not without some revision. The lack of complete participation from CCW and DWR was disappointing, especially as their advective transport algorithms are theoretically superior to the RMA code.

DWR did contribute to the M1 and M2 tests, where the excellent performance of their advective transport algorithm was demonstrated. However, the DWR dispersive transport did not have the physical credibility to successfully complete the M3 and M4 tests.

20.5 Automatic Review is Essential

An extensive and independent review should be a routine and automatic part of any numerical model study. Without such review, the credibility of model predictions is uncertain. On the experience of this study, it must be assumed that the credibility of un-reviewed model predictions is compromised.

Review needs to be **automatic**. It should not be left as an afterthought. It should be arranged, funded and committed as an integral part of any model study.

Review needs to be **independent**. The reviewer(s) need to be demonstratably independent. They need not be acceptable to the initial modelers. Suitable reviewers might be academic researchers or commercial competitors.

Review needs to be **extensive**. A cursory read of a report is unlikely to be satisfactory. The experience of the present study was that a number of difficulties would not have been identified without detailed analyses of the actual numbers.

Finally, there needs to be a review of the review. The authors of the numerical model study should be invited to **respond** to the review comments, and their response should be included in the review document.

20.6 Documentation

Numerical model documentation that is both

- in a standardized form, and
- current

is an essential description of any credible numerical code.

The IAHR-sponsored *Guidelines for documenting the validity of computational modelling software* (Dee et al. 1994) should be followed as a standardized form for model documentation.

The BDMF should host on-line version of this documentation, and require that hard copies be deposited with the University of California's Water Resources Center Archives.

REFERENCES

Dee, D., J. Cunge, G. Labadie, A. R. Mateo, M. Mathiesen, R. Price, M. Santos, and R. Warren (1994). *Guidelines for documenting the validity of computational modelling software.* IAHR/AIRH, Delft, The Netherlands.