Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 2:
REALM Update

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2 REALM Update

2.1 Introduction

The River, Estuary, and Land Model (REALM) project was introduced in last year's Annual Report (Ateljevich and Finch, 2003). The goal of REALM is to create a public model that offers performance and decision-making support that is not currently available in models. DWR's Delta Modeling Section believes that the technologies brought to the project by key partners will allow development of a model with capabilities that would otherwise be difficult to achieve.

2.2 Features

REALM will have features typical of current models, including 1-, 2-, and eventually 3D hydrodynamics, water quality transport, and particle tracking. The model will also include features necessary to solve important Bay/Delta questions, such as tidal or seasonal wetting and drying of areas, non-conservative constituents, wind effects, and particle tracking behavior.

To improve numerical accuracy and speed, REALM will use the computational infrastructure developed by Lawrence Berkeley National Laboratory (LBNL), one of our two key collaborators. REALM will use parallel processing, Adaptive Mesh Refinement (AMR), and embedded boundaries to improve accuracy and to concentrate computational effort in regions that are numerically difficult (for instance, with steep gradients) or pertinent to a study. These features are described in Ateljevich and Finch (2003).

REALM will also include systems analysis to make decision support, policy analysis, and real-time Delta management easier. REALM will provide:

- Model Steering: operating rules for boundary conditions and hydraulic devices that are managed adaptively (e.g. gates or pumps that are opened or closed depending on the state of the Delta such as water quality or stage values).

- Optimal control and data assimilation methods to make real-time control for O&M more accurate.

- Multi-objective analysis and visualization to let users see the tradeoffs between competing objectives, such as stage, exports, and water quality.

- Geographical Information System (GIS) for data storage and visualization.

The first release of REALM will have only a subset of all the features it is expected to eventually have. Feature priority will be driven by real-world problems and computational issues (see Section 2.5).

2.3 Status

In the past year, REALM has moved from a purely conceptual stage to the beginning stages of a working project. DWR staff worked on REALM in consultation with Lawrence Berkeley National Labratory (LBNL) and developed prototype 2D flow and transport solvers. These were applied to simplified test problems but the solver has yet to be applied to Delta geometry. Figure 2.1 illustrates the use of one of the LBNL computational techniques, AMR. This feature calculates the required grid density on-the-fly throughout the problem area by increasing the density where additional grid points are needed to maintain accuracy, and decreasing the density where possible to lessen computational demand. Other LBNL features available are embedded boundaries (allowing accurate description of natural boundaries in rectangular grids) and parallelization libraries.

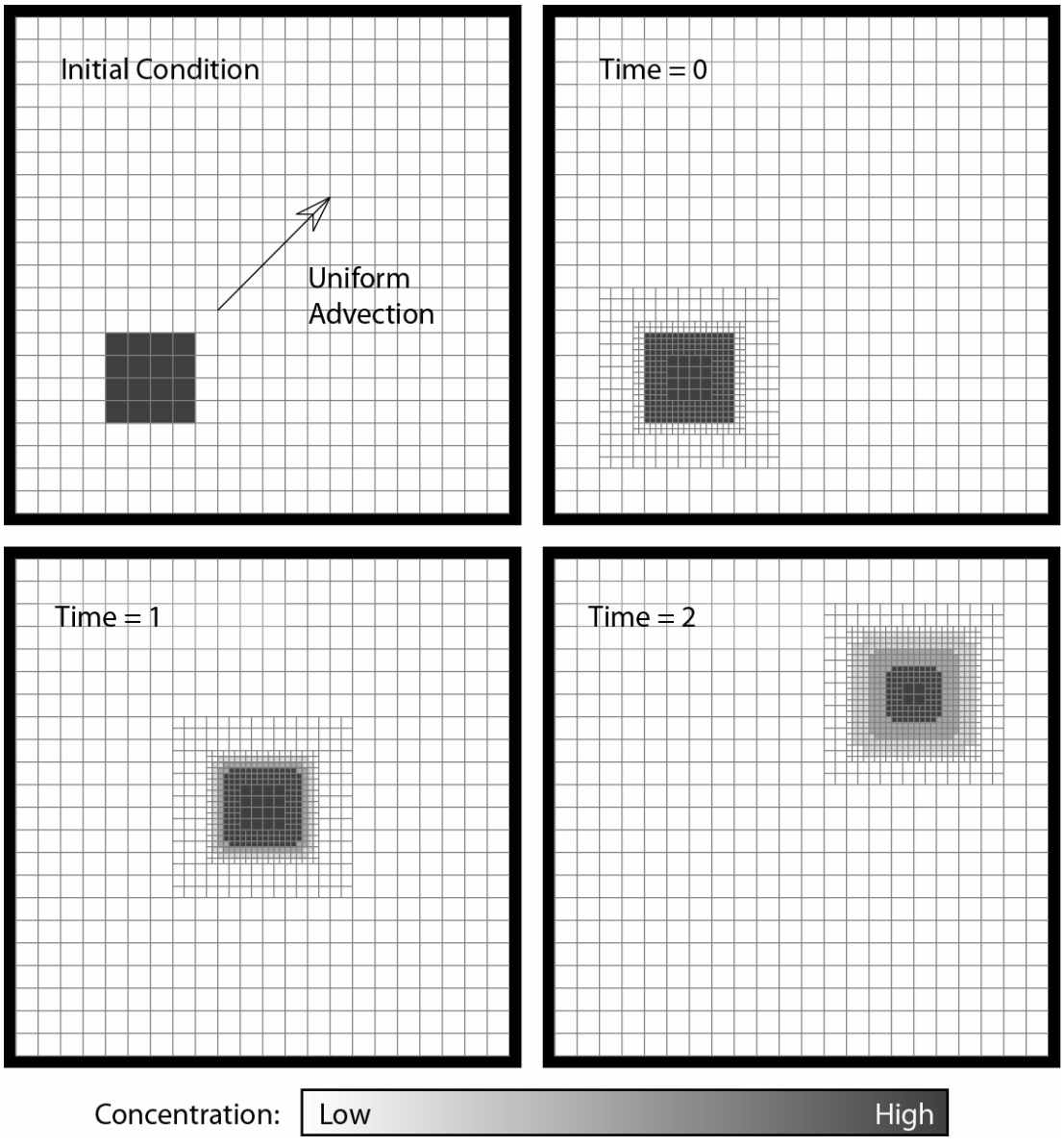

Figure 2.1: Advection in a Uniform Velocity Field, Showing Adaptive Mesh Refinement.

Expert outside help will be required in some areas. Contracts were initiated for a programmer, GIS assistance, and LBNL expertise. In December 2003 a contract programming expert was signed. A GIS contract was awarded in January 2004 to the Michael Thomas Group and work started in April 2004. A contract with LBNL is expected to be finalized for next Fiscal Year (2004-05).

Project meetings are held weekly to move the project from concept to design and address technical issues as they arise. Management meetings are held monthly to discuss and resolve administrative issues and review progress.

Some features planned for REALM have been tested using a new version of DSM2 as a test platform. This approach improves the functionality of our current Delta model and allows us to experiment and learn about proposed REALM features in a simpler environment. Features implemented in this manner in DSM2 include:

- Connection to a relational database for all non-time-varying data.
- A Graphical User Interface (GUI) to allow users to access and edit information in the database.
- New ways of implementing gates.
- Partial use of operating rules that are limited to hydrodynamic parameters such as stage and flow, and gate operations only.

2.4 Funding Scenarios

Three scenarios with different financial resources have been developed. All scenarios lead to a fully functional 1D-2D hydrodynamics and water quality model with GIS graphical support and particle tracking by the end of 2006. The model will include support for AMR, embedded boundaries and parallelization, and wetting and drying.

The scenarios differ in the timing and number of features offered. In the low and medium budget scenarios, it is possible to complete some advanced computational features such as 3D modeling and adjoint optimization capabilities, but not to package these features in a finished application within the 2006 planning horizon.

Table 2.1: Comparison of Deliverables near the End of 2006.

Features/Funding Levels	Low	Med	High
Calibrated model 1D-2D	Jul 2006	Mar 2006	Jan 2006
3D solver (no GUI)	Dec 2006	Aug 2006	May 2006
3D full application			Jul 2006
Optimization capability (adjoint)	Mar 2006	Dec 2005	Dec 2005
Multi-objective optimization with GUI	> 2 years	> 2 years	May 2006
Real-time data assimilation, no GUI (Kalman filter)	> 2 years	Jun 2006	Feb 2006
Real-time data assimilation application	> 2 years	> 2 years	Apr 2006
Automated calibration	> 2 years	> 2 years	Sep 2006
1D-2D technical docs	Minimal (usage only)	Minimal (usage only)	Full with tutorial (Jan 2006)
3D, particle, graphics documentation	> 2 years	> 2 years	Sep 2006

2.5 Feature Priority

- *Relevance*
  Features should solve problems of high benefit to the Department, SWP, Delta operations, and the State in general. The problems should be of enough importance to make solving them compelling.

- *Not solvable by other means*
  Features should solve problems that have not been solved yet, and the problems should be largely or entirely unsolvable with other means or tools. Or, other tools will only give approximate or qualitative solutions, when a REALM feature could provide a precise, quantitative solution which makes a substantial difference in benefit.

- *Ease of implementation*
  Features easy to implement, even though marginally useful, might be preferred over difficult implementations.

It was important to identify real-world problems that a REALM feature could solve. The following questions were posed to engineers, environmental scientists, and managers who have a history of direct involvement in solving Delta issues:

> *"What problems or questions in the Delta would you like to resolve, that you cannot because of limitations in current tools? What problems would you solve if tool limitations were not an issue?"*

Interview responses are available at:
http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/news/realmstatus032004.pdf

2.6 Reference

Ateljevich, E. and R. Finch. (2003). "Chapter 2: REALM." *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. 24th Annual Progress Report to the State Water Resources Control Board*. California Department of Water Resources, Bay-Delta Office. Sacramento, CA.

2.7 Website

Continuing updates concerning REALM can be found at:

http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/news/realm.cfm