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

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Chapter 5
Particle Filter for DSM2-PTM

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5 Particle Filter for DSM2-PTM

5.1 Introduction

The intent of this study is to develop a PTM module feature which simulates directing/blocking particles without affecting flows.

One of the major applications of this particle filter is to simulate fish screens and non-physical barriers, which could prevent fish from entering an area. Another application is to provide an option to keep fish from entering agricultural diversions, seepage to groundwater, and water transfer facilities.

5.2 Filter Algorithm

In DSM2-PTM, model grids are configured as waterbodies connected at nodes. The designed filter is only for modifying particle movement at nodes, which represent the waterbody junctions in the real world.

Therefore, this filter must have two major functions:

- Redirect particles exiting nodes from the default flow-split ratio;
- Block particles entering nodes.

The designed filter is the combination of the two functions described above; it has both functions activated from its upstream and downstream sides. Therefore, as particles flow back and forth due to tides, they could meet different functions of the filter when passing through from different flow directions. Programming details are in Appendix B.

5.2.1 Filter after a Node

PTM uses flow ratios to direct particles into different branch waterbodies (channel, reservoir, transfer, and boundary) at nodes (junctions). This filter is programmed as a readjustment factor to modify this function, i.e. the new split ratio is based on $flow * filter\_operation$. Figure 5-1 shows an example of this algorithm.

In the case without the filter particles are split based on the branch flow ratios, e.g.

$$flow_1 : flow_2 = 50:50 = 1:1$$

This case results in half the particles in each branch (Figure 5-1, top graphic).

In the case with a filter, the new split ratio would be recalculated with the filter operation, a fraction between zero and one: zero means totally-block; one means 100% passing; values in between will readjust the split ratio, e.g.

$$\left(flow_1 * filter_{1_{op}}\right) : (flow_2) = (50 * 0.25) : (50) = 1:4$$

This case partially blocks particles entering the filtered branch, and directs 80% of the particles to the unfiltered branch (Figure 5-1, bottom graphic).

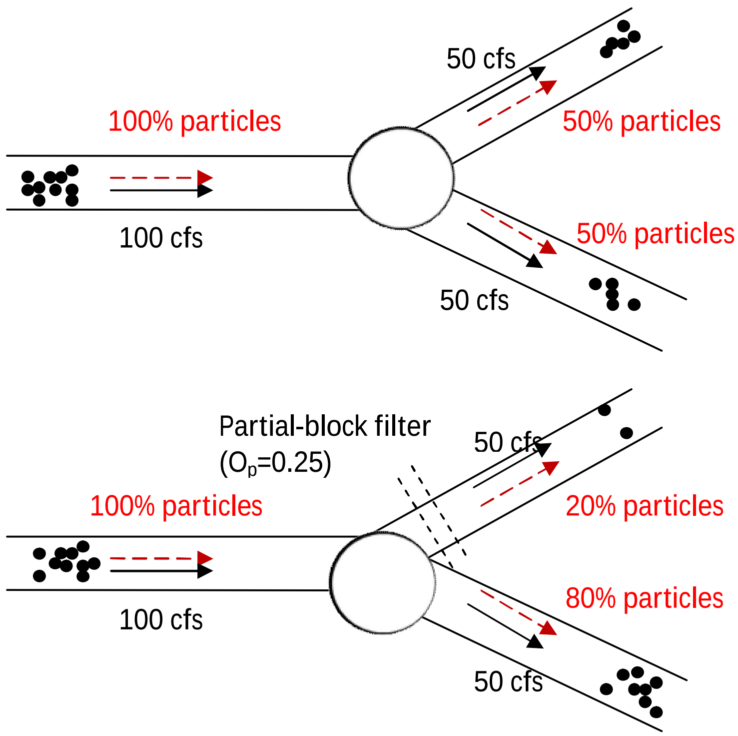

Figure 5-1 Flow and particle fluxes at two equal-branch junctions, with a partially-block filter set on one branch (Solid arrows depict flow; dashed arrows depict particle fluxes). The particle amount in the plot is for illustration only, and is not the actual amount.

When this algorithm is applied to channels without branches, the filter will block particles when its value is zero, and totally pass with all the other values (Figure 5-2).

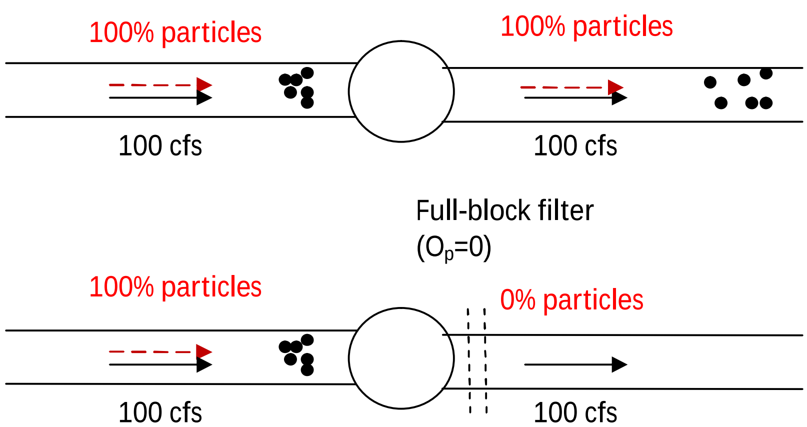

Figure 5-2 Flow and particle fluxes without and with a full-block filter set after the particle-entering node (Solid arrows depict flow; dashed arrows depict particle fluxes).

Reservoir, transfer, and boundary share the same algorithm for filter after a node. Since DSM2-PTM has two steps for particles transferring from reservoirs to channels (or transfers), this filter algorithm only functions at the 2nd step. Figure 5-3 shows an example of this case:

- Particles first determine which node they flow to, based on the ratio of flow*time step/reservoir

$$flow_1 * \text{time step / reservoir volume} \qquad \text{(Miller, 2002)}$$

- Particles then utilize adjusted flow ratios (same as described in the previous paragraphs) to split, if there are multiple channels (or transfers), i.e. filters after one node won't affect particles' ability to move to other nodes of the same reservoir.

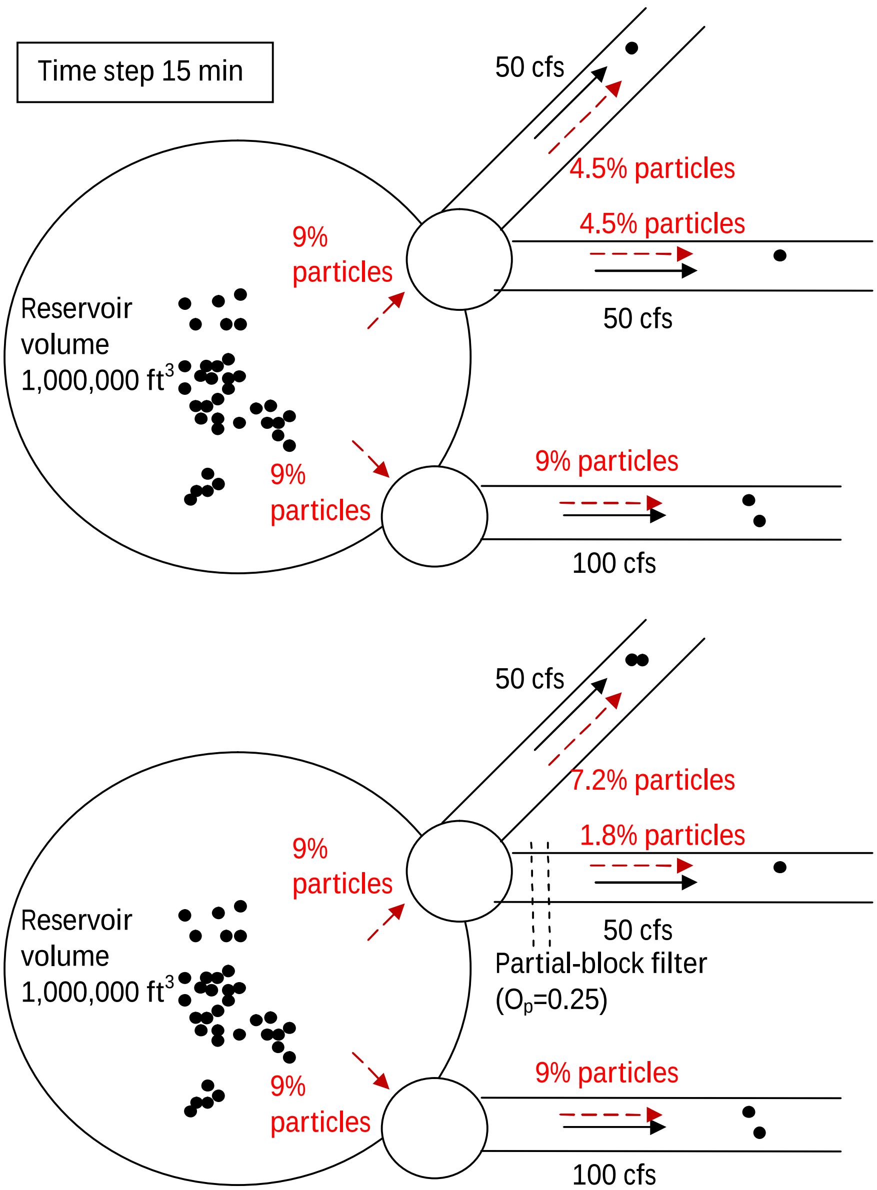

Figure 5-3 Flow and particle fluxes w/o and with a partial-block filter set after the particle-entering node in grid with reservoir (Solid arrows depict flow; dashed arrows depict particle fluxes).

5.2.2 Filter before a Node

A filter with operation 0 would also serve as a block for particles entering a node. A filter with all the other operations (>0 and <=1) would behave as no-filter condition, i.e. totally pass. Figure 5-4 shows an example of this algorithm at channels. Reservoir, transfer, and boundary have the same application with this function.

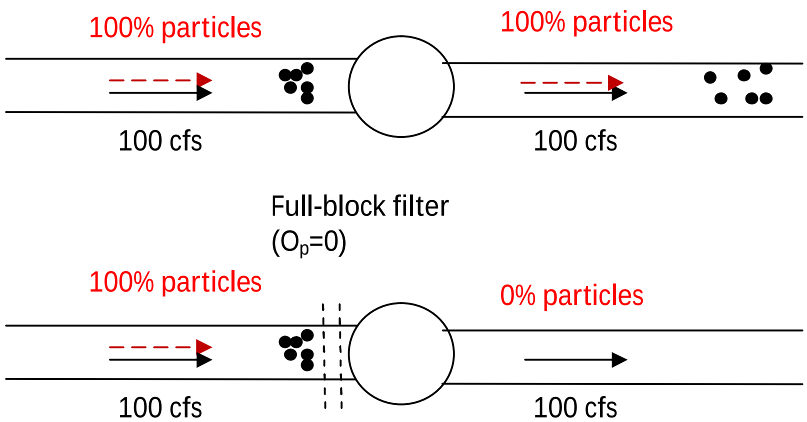

Figure 5-4 Flow and particle fluxes w/o and with a full-block filter set before the particle-entering node (Solid arrows depict flow; dashed arrows depict particle fluxes).

5.3 Filter Input Table

There are two filter input text tables used to control the filters described here.

- "PARTICLE_FILTER" is for normal filters located at DSM2 grid nodes.
- "PARTICLE_RES_FILTER" is for filters operating at special reservoirs (e.g., Clifton Court Forebay in the standard Delta grid) which directly connect to source flows. In this case, implicit nodes are generated during the DSM2-PTM grid initialization process, and are assigned to the filters.

As mentioned in the previous section, a filter is assigned to a DSM2 grid node (or reservoir as the special case), and one neighbor waterbody specified as the control side. The waterbody could be any type of waterbody in the PTM module: channel, reservoir, boundary (source flow, stage boundary), and transfer. These are defined under entries NODE and WATERBODY.

FILE and PATH are entries for filter operation:

- Constant filters are defined with FILE: constant; PATH: a real number between 0 and 1
- Time-varying filters are defined with FILE: location on computer + DSS filename, which allows relative location; PATH: DSS pathname
- Filter value should be a real number between 0 and 1

Following are two samples of these two input tables. Details and explanations are in Appendix A.

```
PARTICLE_FILTER
NAME    NODE WATERBODY  FILLIN FILE           PATH
280_357  280   chan:357      last    ./Filter_OP_NF.dss /HIST/280_357/FILTER_OP//IR-DECADE/DWR/
END

PARTICLE_RES_FILTER
NAME     RES_NAME   WATERBODY  FILLIN FILE      PATH
div_bbid  clifton_court qext:div_bbid last ./filterOp.dss /HIST/CLFC_DIV/FILTER_OP//IR-DECADE/DWR/
END
```

Table 5-1 Table Identifiers and their respective descriptions in filter input text blocks

Identifier	Field Descriptions
NAME	Name assigned to the particle filter
NODE	The ID of the node to which the filter is assigned
WATERBODY	The type and ID of the waterbody to which the filter is attached, separated by a colon (:)
FILLIN	Method for filling in data if the time step of the assigned series is greater than the time step of the model. See FILLIN types (http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2/definitions/fillin.html).
FILE	DSS or text file in which data are stored. Enter the word constant to assign a constant value to the input (the value will be entered in the next column).
PATH	The path within the text or DSS file of the time series data. If the constant keyword was used in the Input File column, enter the value here. The stored variable is the particle passing efficiency, a floating-point number value between 0 and 1; 0:block; 1:pass.
RES_NAME	The name of the reservoir to which the filter is applied

5.4 Summary

The PTM filter is designed to change the particle flux without affecting flows. This filter feature is configured in the DSM2 text input system:

- Its location can be specified with a combination of nodes and waterbodies in the DSM2 grid.
- Filter operation can be constant or time-varying (DSS format), and can have a partial passing efficiency for junction split decision.

Validation tests were conducted to ensure the programming meets the design purpose. Please see test details in Appendix C and other PTM test chapters in this report (Zhou, 2013) (Zhou & Nam, 2013).

5.5 Acknowledgements

We thank Nicky Sandhu, Tara Smith, Min Yu, and Xiaochun Wang for their help in the study initial discussion and report revision.

5.6 References

Miller, A. (2002). Chapter 2, Particle Tracking Model Verification and Calibration. *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh, 23rd Annual Progress Report* .

Zhou, Y. (2013). Chapter 7, DSM2-PTM Standard Test Suite Design and Automation. *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh, 34th Annual Progress Report* .

Zhou, Y., & Nam, K. (2013). Chapter 6, DSM2-PTM Improvements. *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh, 34th Annual Progress Report* .

5.7 Appendices

Note: All appendices are stored in DWR Bay-Delta Office DSM2 User Group website.

http://baydeltaoffice.water.ca.gov/downloads/DSM2_Users_Group/PTM_filter/

Appendix A: Input Table Design for DSM2-PTM Particle Filter

http://baydeltaoffice.water.ca.gov/downloads/DSM2_Users_Group/PTM_filter/AppA_input_table.docx

Appendix B: Programming Details for DSM2-PTM Particle Filter

http://baydeltaoffice.water.ca.gov/downloads/DSM2_Users_Group/PTM_filter /AppB_coding.docx

Appendix C: Validation Test for DSM2-PTM Filter Design

http://baydeltaoffice.water.ca.gov/downloads/DSM2_Users_Group/PTM_filter /AppC_test.docx