Exhibit Brentwood-113

Using Particle Tracking to Indicate Delta Residence Time

California Department of Water Resources   Bay-Delta Office   Modeling Support Branch   Delta Modeling Section

Step 1

Simulate Delta Hydrodynamics

For the Pelagic Organism Decline study, historical Delta conditions were simulated with DSM2 HYDRO, but hydrology and project operations generated by planning studies could also be used.

DSM2 HYDRO INPUTS

Delta Exports/Diversions (daily average)
- Banks Pumping Plant
- Tracy Pumping Plant
- Contra Costa Canal
- North Bay Aquaduct

Delta Inflow (daily average)
- Sacramento River
- San Joaquin River
- Yolo Bypass
- Cosumnes River
- Mokelumne River
- Calaveras River

Delta Consumptive Use (monthly)

Martinez Tide (15-minute)

Barrier Installations/Operations
- South Delta Agriculture Barriers
- Old River at Head Fish Barrier

Gate Operations
- Clifton Court Forebay Intake Gates
- Suisun Marsh Salinity Control Gate
- Delta Cross Channel Gates

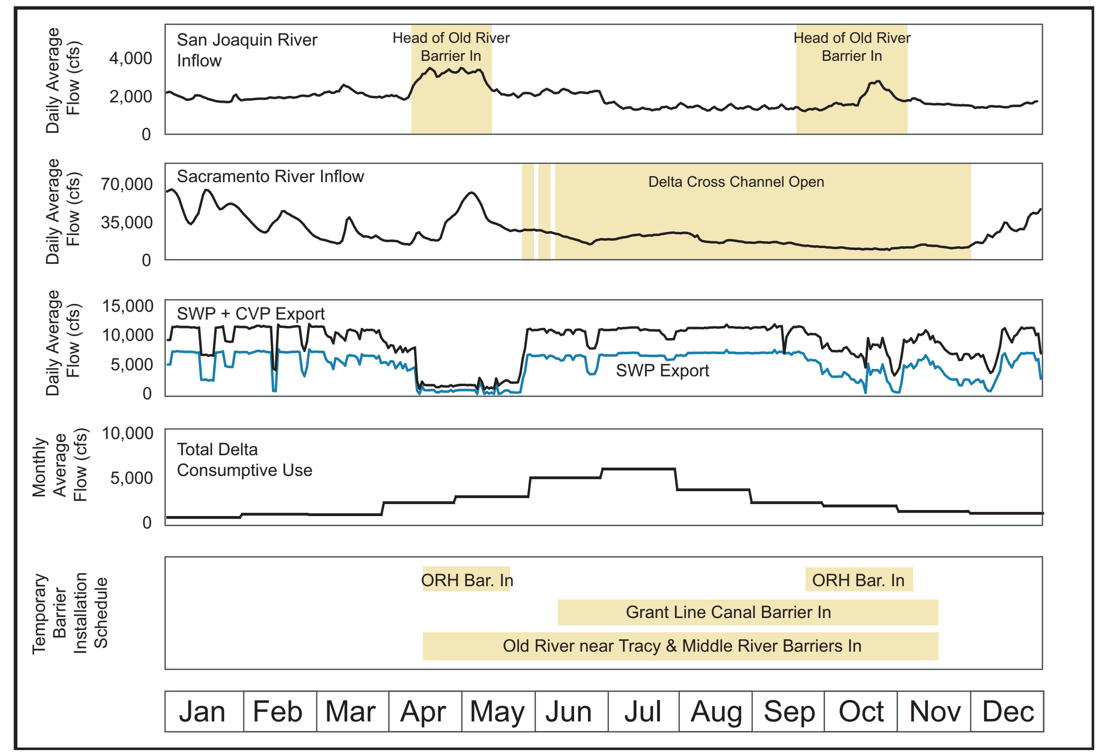
DSM2 HYDRO OUTPUTS

Binary File
- Input for the particle tracking model

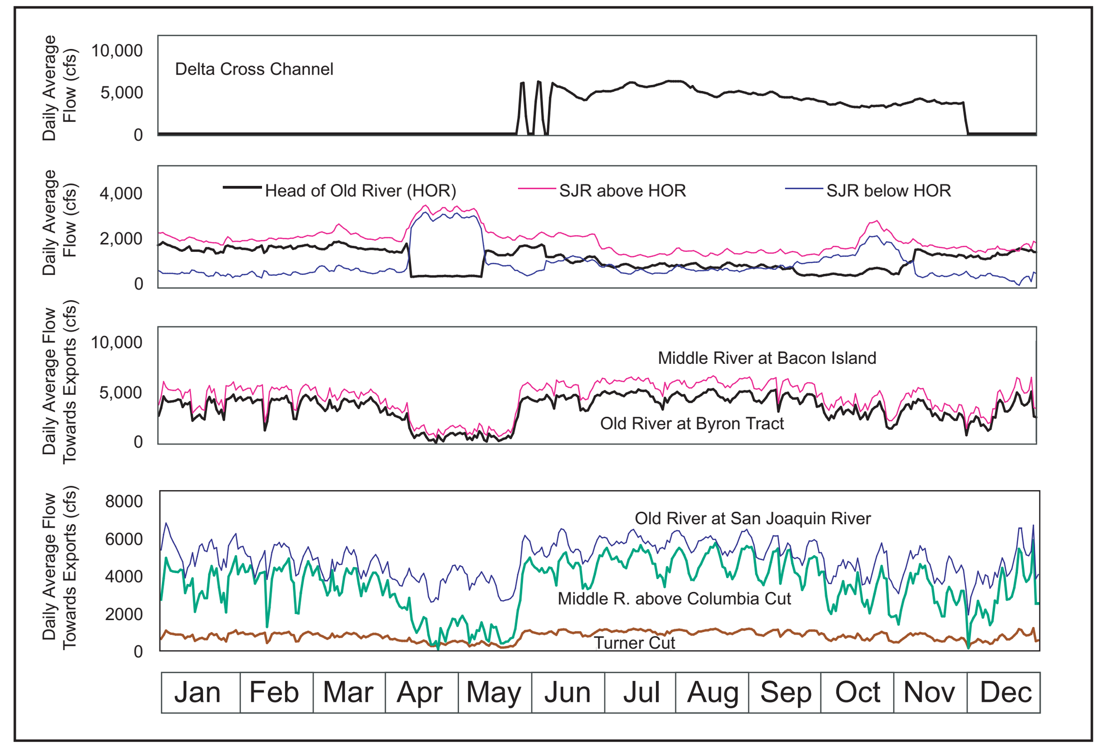
DSS File
- Stages, velocity, flow at user-specified locations (15-minute)

Simulation of Historical 2003 Hydrodynamics

Sample Input



Sample Output: Daily Average Flows



Step 2

Determine Residence Time Referenced to a Single Day

Residence time defined

For this study, residence time was defined as the time taken for a specified percent of injected particles to leave or be removed from Delta channels in a specified region. The residence time then varies daily with Delta hydrodynamics, the percent of particles removed criterion, the region specified, and the location(s) of the injections.

As defined, the residence time depends upon:
- Delta hydrodynamics
- the location(s) of the injections
- the region specified
- the percent of particles removed criterion

Example: Determining the Residence Time for:
- June 15, 2003 injection
- Vernalis injection site
- Region specified: the Delta to Chipps Island
- Percent of particles criteria: 25%, 50%, and 75% removed

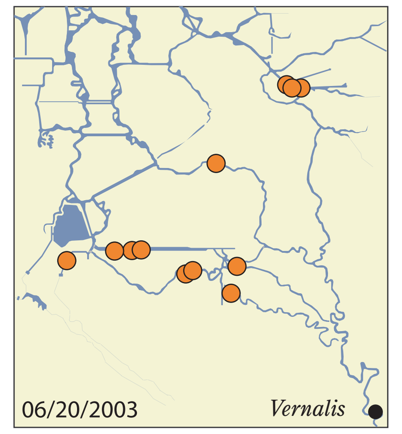
Example: Residence Time for Particles Injected at Vernalis on June 15, 2003

June 15, 2003
Injection of Particles

Particle Fate	
Entrained by CVP	0 %
Entrained by SWP	0 %
Move past Chipps	0 %
Onto Delta Islands	0 %
In Contra Costa Canal	0 %
Not in Delta in channels	0 %

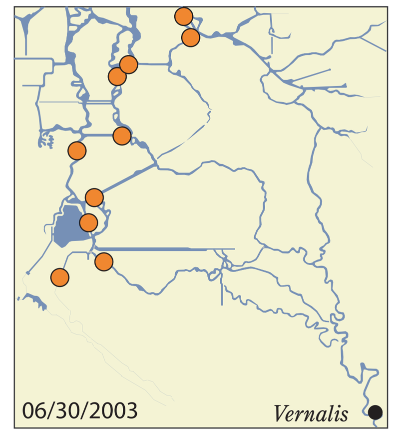
June 20, 2003
5 Days after injection

Particle Fate	
Entrained by CVP	9 %
Entrained by SWP	<1 %
Move past Chipps	<1 %
Onto Delta Islands	12 %
In Contra Costa Canal	<1 %
Not in Delta in channels	21 %



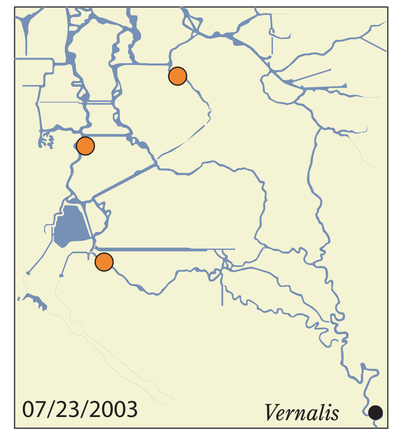
June 30, 2003
15 Days after injection

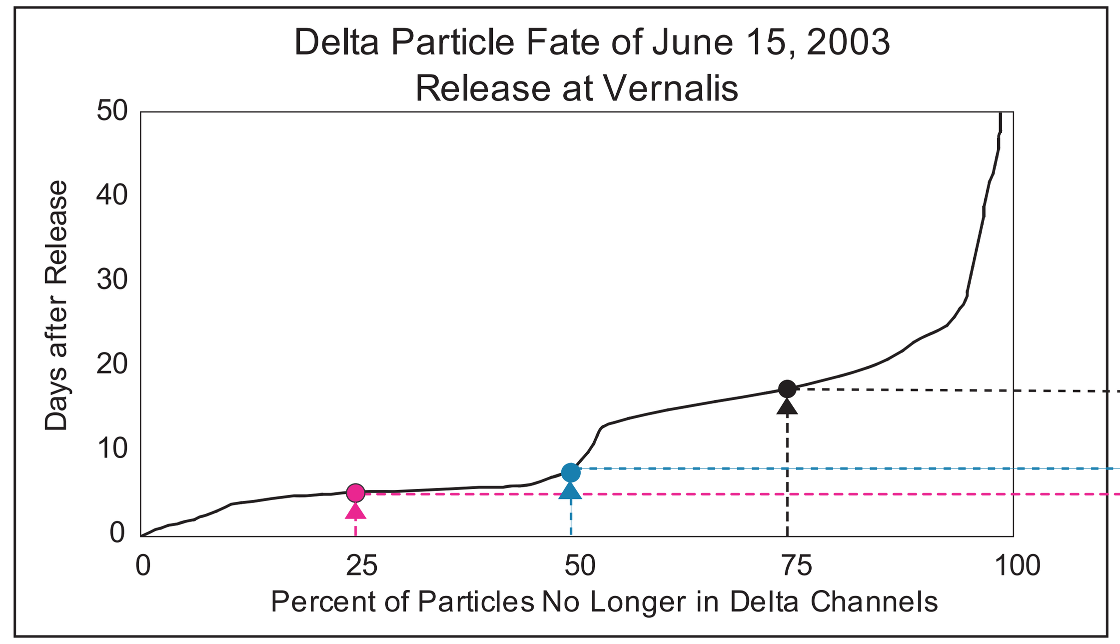
Particle Fate	
Entrained by CVP	38 %
Entrained by SWP	1 %
Move past Chipps	<1 %
Onto Delta Islands	22 %
In Contra Costa Canal	<1 %
Not in Delta in channels	61%



July 23, 2003
38 Days after injection

Particle Fate	
Entrained by CVP	51 %
Entrained by SWP	18 %
Move past Chipps	<1 %
Onto Delta Islands	28 %
In Contra Costa Canal	<1 %
Not in Delta in channels	97%





This example shows the particle fate, expressed as the percent of injected particles no longer in Delta channels, for a Vernalis particle injection on June 15, 2003. Residence time is estimated to be 5, 9, and 18 days for 25, 50, and 75% level of particle removal.

To create this graph for the entire Delta region on a given day, particles are released at a location such as Vernalis or Freeport and a time series of particle fate by percent of total injection as they leave the Delta channels is generated.

Possible fates other than remaining in the Delta channels are:
- Passing Chipps Island
- Exiting via SWP and CVP exports
- Exiting via agricultural diversions
- Exiting via Contra Costa diversions

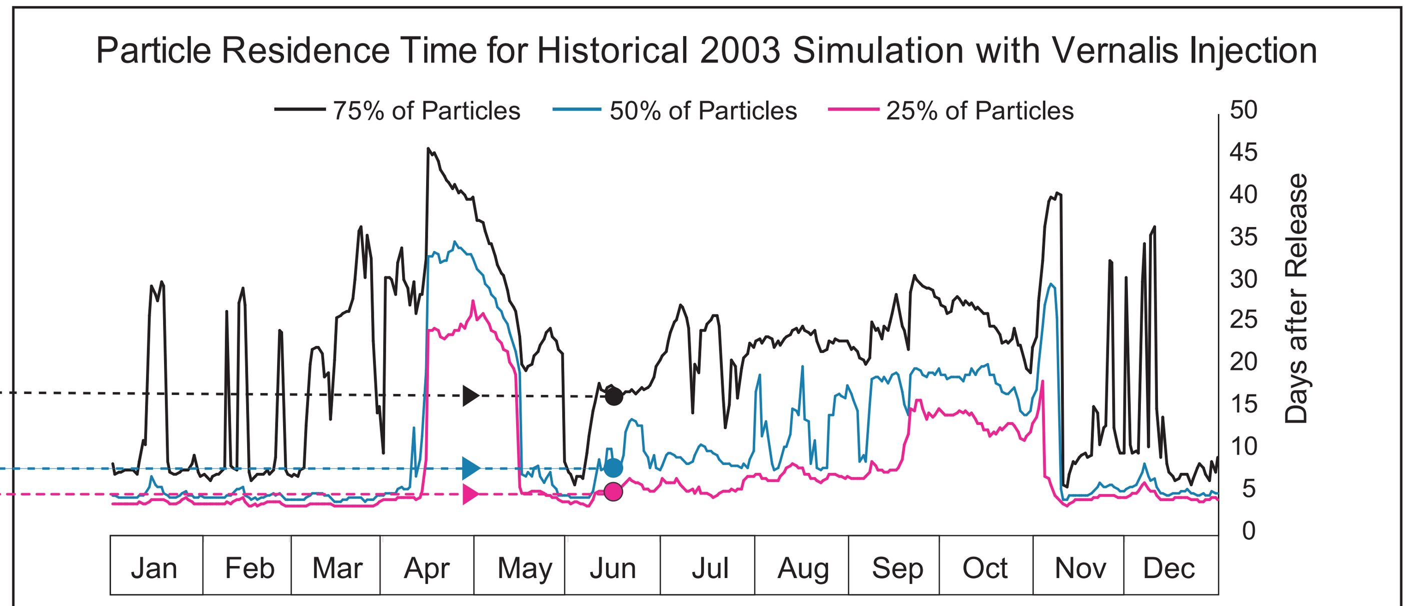
The time series of these fates, excluding particles remaining in the Delta, are then summed to derive a net fate time series. This is shown in the chart above. From this, the time for 25, 50, and 75% of released particles to have a fate out of the Delta can be determined. This process is repeated for each day in order to produce a year-long time series of residence time (as shown in step 3). Particle tracking simulation duration for a given particle release to ensure at least 75% of particles have left the Delta channels ranges from a few days to over 90.

Step 3

Generate Time Series of Residence Times

Python scripts are used to automate multiple PTM simulations. In our example we constructed PTM runs starting on consecutive days, each running until >95% of the particles had a fate. From the regional fate time series (one from each PTM run) one can construct a time series index of regional fate for a given percent of the particles. We constructed three Delta fate time series of 25, 50, and 75% particle fate for each injection day. The figure below illustrates the three indices for 2003. The example shows how three data points originate from one of many time series of regional particle fate. Each day's data is from a separate PTM simulation.

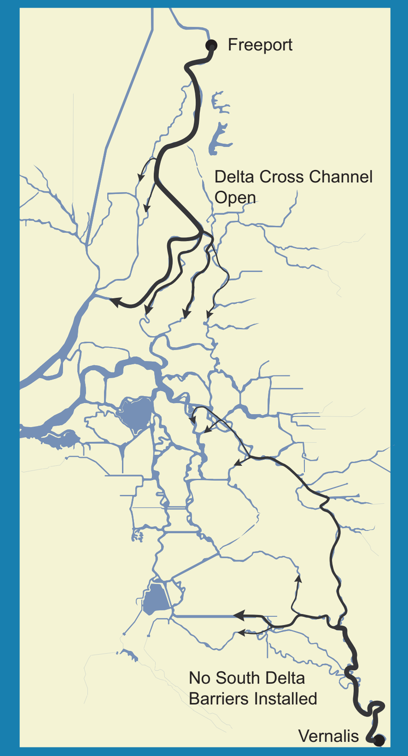
Example: Results of Daily Injections for the Entire 2003



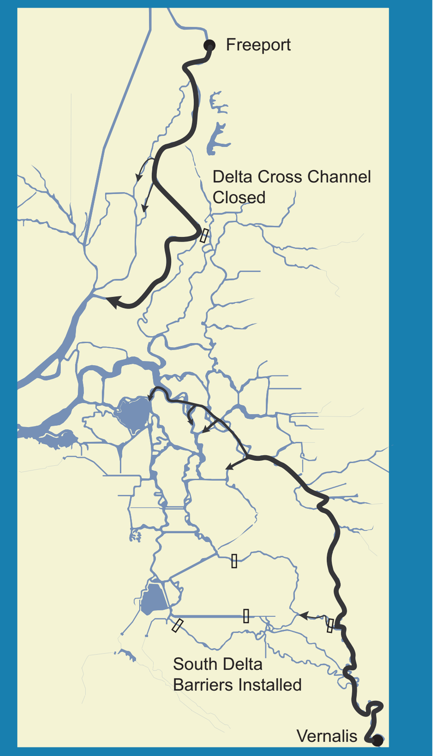
Three one-year time series have been assembled from 365 PTM simulations. The values for June 15, 2003 as shown are from the June 15, 2003 particle injection simulation (the results of which are shown in the graph to the left).

Relating Residence Time Index to Delta Hydrodynamics

The indices reflect the hydrodynamics of the Delta which in turn reflect the boundary tide, Delta inflows and exports and barrier operations. Particles are introduced at strategic locations and simulation of advection and dispersion provide quasi three-dimensional representations of moving water parcels. Residence time is generally lengthened with lower inflows to the Delta and barrier operations which result in more circuitous travel paths. Residence time for particles introduced at Freeport depends primarily upon Sacramento River inflow and operation of the Delta Cross Channel. Residence time for particles introduced at Vernalis depends primarily upon San Joaquin River inflow, SWP and CVP pumping, and South Delta barrier installation / operation.



Relatively Longer Residence Times for Freeport Injection but Shorter Residence Times for Vernalis Injection

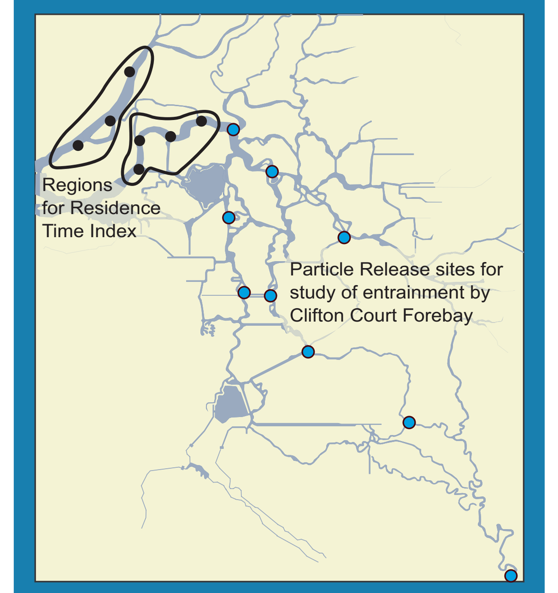


Relatively Shorter Residence Times for Freeport Injection but Longer Residence Times for Vernalis Injection

Other Applications of the PTM Simulations

To aid the Pelagic Organism Decline Hydrology and Project Operations Satellite Team's analysis of trends in Delta hydrodynamics, DWR Delta Modeling staff also used DWR's Particle Tracking Model to develop time series of indices of residence times for specific regions in the Delta. Two regions were of particular interest: the lower Sacramento River surrounding Decker Island and the lower San Joaquin River from downstream of the Mokelumne River to Jersey Point.

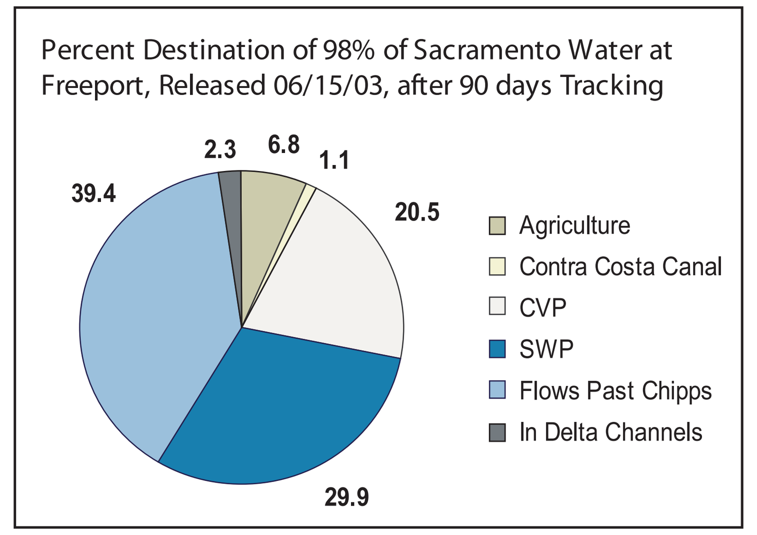
Regional Residence Time



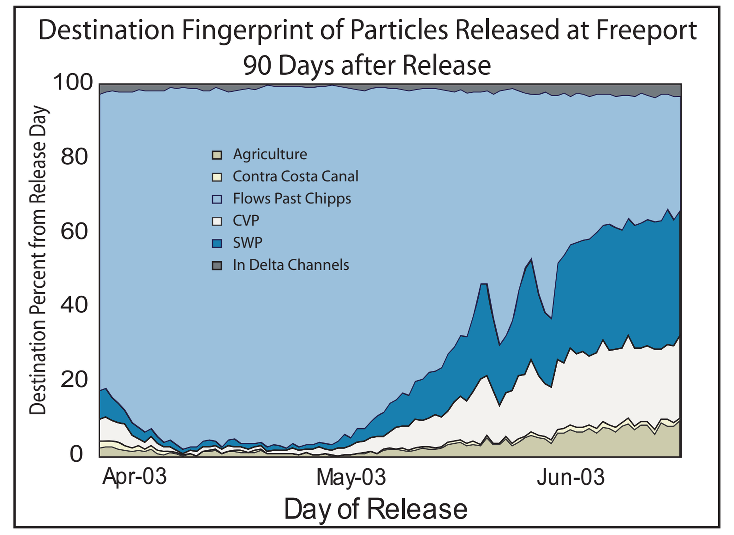
Daily SWP Entrainment Potential

To help analysis of fish salvage data at Skinner Fish facility, the Particle Tracking Model was run with particles released daily for historical 2005 hydrodynamic conditions at eight locations in the Delta to determine what percent of particles eventually ended up in Clifton Court Forebay. These simulations indicate potential for entrainment by date and location.

A destination fingerprint can be estimated to determine where a source water will flow. Below is a one day example and a time series example of destination percentages associated with release days. The release can be made anywhere in the modeled system. This helps us better understand the effects of a release location and timing into the Delta water ways.

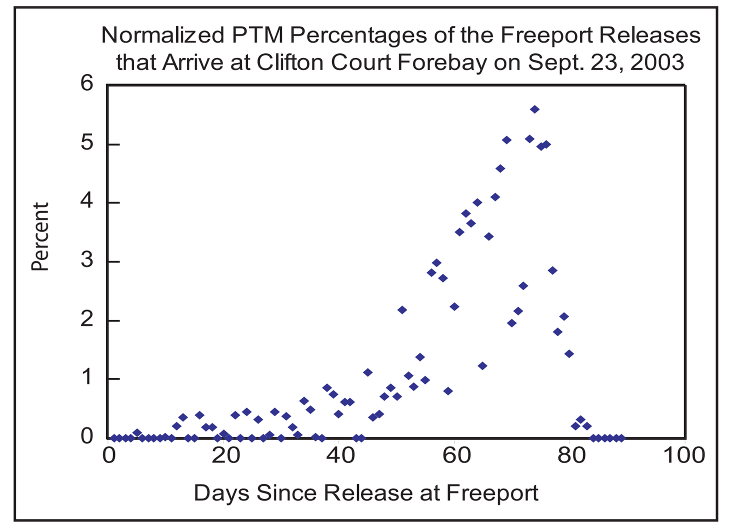


Example of a one day destination fingerprint for Sacramento River passing Freeport



Example of a time series destination fingerprint for Sacramento River passing Freeport

For a specific location and time PTM can indicate the water sources, quantity of each source water, and the times each source water originated. For example the graph to the right shows for a given date (e.g. Sept. 23, 2003), the portion of water in Clifton Court Forebay that once passed by Freeport and when this occurred. This technique may be useful when analyzing a location's peak constituent concentration to estimate where the source may have originated and when it was introduced to the system.



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This poster was prepared by Jim Wilde with assistance from Michael Mierzwa and Bob Suits, Delta Modeling Section, DWR
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