LATE COMMENT

EFT
Ecological Flows Tool

The Ecological Flows Tool (EFT) is a database-centered decision support system for linking flow to changes in the physical habitats for multiple species of concern. EFT works by integrating a range of representative functional ecological response indicators with key physical variables obtained from widely used hydrologic models. EFT transparently relates multiple attributes of the flow regime to multiple species' life-history needs, contributing to an effective understanding of flow and non-flow restoration actions on focal species and their habitats. The hallmark of the EFT approach is integration and clear communication of multiple ecological trade-offs associated with different water operation alternatives.

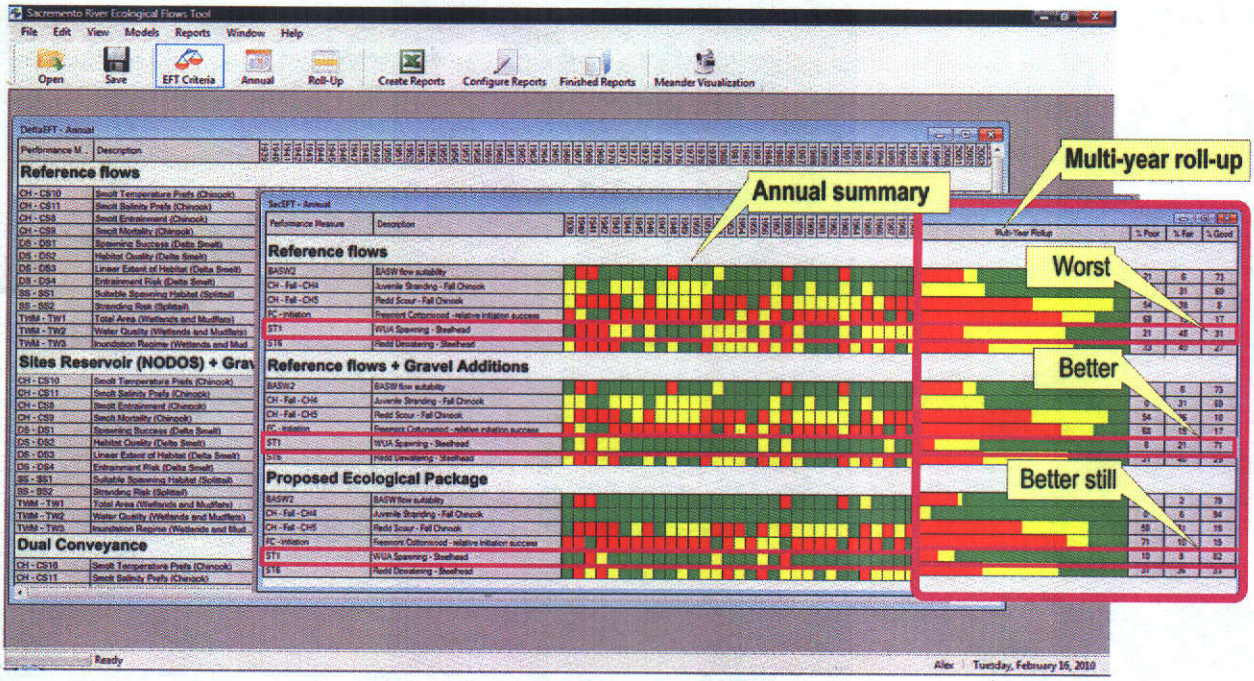

Figure 1. Example of annual and multi-year roll-up traffic light indicator ratings.

Multiple focal species & indicators

In all, EFT includes conceptual models for eleven (11) species and twenty-four (24) causally-reasoned performance indicators. EFT performance indicators are based on a mixture of process-based ecological functions and empirical relationships between flow, habitats and focal species response. EFT's representative ecological indicators capture the essence of existing conceptual models and are driven by widely used physical models for flow, stage, salinity, and water temperature. Intuitive output interfaces allow cross-walking of ecological consequences over policy alternatives.

SacEFT focal species & habitats

Steelhead
(Oncorhynchus mykiss)

Chinook Salmon
(Oncorhynchus tshawytscha)

Green Sturgeon
(Acipenser medirostris)

Bank Swallow
(Riparia riparia)

Western Pond Turtle *(Clemmys marmorata)*
Proxy: Large Woody Debris Recruitment

Fremont Cottonwood
(Populus fremontii)

DeltaEFT focal species & habitats

Steelhead
(Oncorhynchus mykiss)

Chinook Salmon
(Oncorhynchus tshawytscha)

Delta Smelt
(Hypomesus transpacificus)

Splittail
(Pogonichthys macrolepidotus)

Tidal Wetlands

Invasive deterrence
(E. Densa, Corbicula, Corbula)

	Focal Species & Habitats	Performance Measures
Sacramento River	Fremont cottonwood (FC)	FC1 – Successful Fremont cottonwood initiation FC2 – Cottonwood seedling scour.
	Bank swallow (BASW)	BASW1 – Habitat potential/suitability BASW2 – Risk of nest inundation and bank sloughing during nesting
	Western pond turtle	LWD1 – Index of old vegetation recruited to the Sacramento River mainstem.
	Green sturgeon (GS)	GS1 – Egg-to-larvae survival
	Chinook salmon, Steelhead trout (CS)	CS1 – Area of suitable spawning habitat (ft2) CS3 – Egg-to-fry survival (proportion) CS5 – Redd scour risk CS6 – Redd dewatering (proportion) CS2 – Area of suitable rearing habitat (ft2) CS4 – Juvenile stranding (index)

	Focal Species & Habitats	Performance Measures
Delta Ecoregion	Chinook & Steelhead (CS)	CS7 – Smolt weight gain in alt. migration corridors CS9 – smolt mortality index as a function of passage time (negatively correlated with CS7) CS10 – smolt temperature preference index (departures from optimum v. weight gain)
	Delta smelt (DS)	DS1 – spawning success index DS2 – index of habitat suitability DS4 – entrainment risk (index)
	Splittail (SS)	SS1 – proportion of maximum potential spawning habitat (index)
	Fresh / brackish tidal wetlands (TW)	TW1 – brackish wetland area TW2 – freshwater wetland area
	Invasive species deterrence (ID)	ID1 – Brazilian waterweed suppression ID2 (Corbula), ID3 (Corbicula) – invasive clam larvae and recruit suppression

EFT is structured as an 'ecological plug-in' to existing models that are commonly used for water planning in the Central Valley. Rather than reinventing models, EFT utilizes output data sets from daily disaggregations of CALSIM, DSM2 and other models that are used to investigate water delivery and other standards set for the

CVP and SWP water system. EFT utilizes these data and adds ecological calculations to evaluate effects on multiple ecosystem targets.

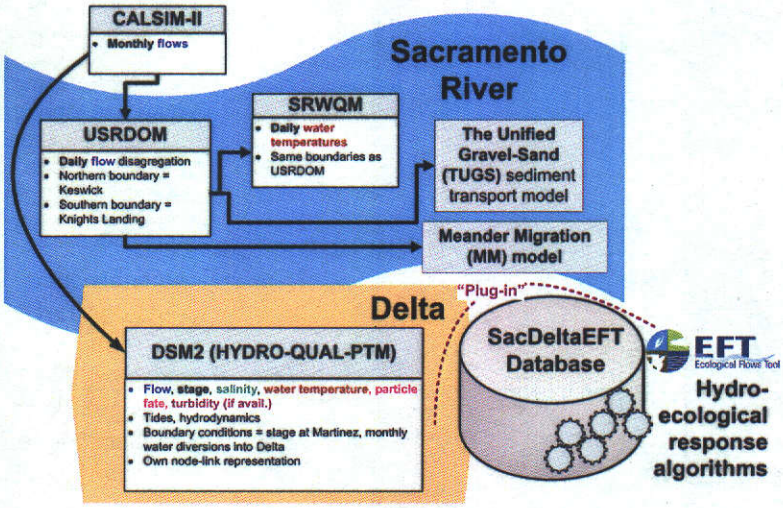

Figure 2. EFT hydrologic foundation. Note: physical models used in DeltaEFT are not necessarily limited to those shown here. Where it is feasible and practical to obtain outputs at a daily resolution for multi-decadal simulations, other models can be "swapped in" if they are deemed a better representation of the physical variables of interest.

Extensive scientific understanding about the Sacramento River and Delta ecosystem's likely response to flows has been developed over the past twenty years. Prior to EFT, much of this important information existed in a multitude of separate reports, independent conceptual models, and unconnected modeling tools. EFT has synthesized much of this disparate information, linking ecological submodels to existing physical planning models, providing a major advance in the region's capabilities for assessing ecological trade-offs.

EFT was not developed in a vacuum. The functional relationships and indicators that are encapsulated into the decision support tool represent the collective thoughts of more than seventy (70) scientists from state and federal agencies, consulting firms, and research institutions that have participated in our workshops or that wrote primary papers on which the relationships are based.

In addition to integrating disparate sources of information, a challenge overcome by EFT's design was translating information into easily understandable results for managers. Practical synthesis and integration is challenging when considering multiple ecological targets, complex physical models, and multiple audiences (i.e., high level managers as well as technical level staff). In keeping with the design principle of making it easy for non-specialists to understand the model's results, EFT creates output that can span the range from high-overview to daily and location specific detail. The output interface makes extensive use of a "traffic light" paradigm that juxtaposes performance measure (PM) results and scenarios to provide an intuitive overview of whether a given year's PMs are healthy (**green**), of some concern (**yellow**), or of serious concern/poor (**red**).

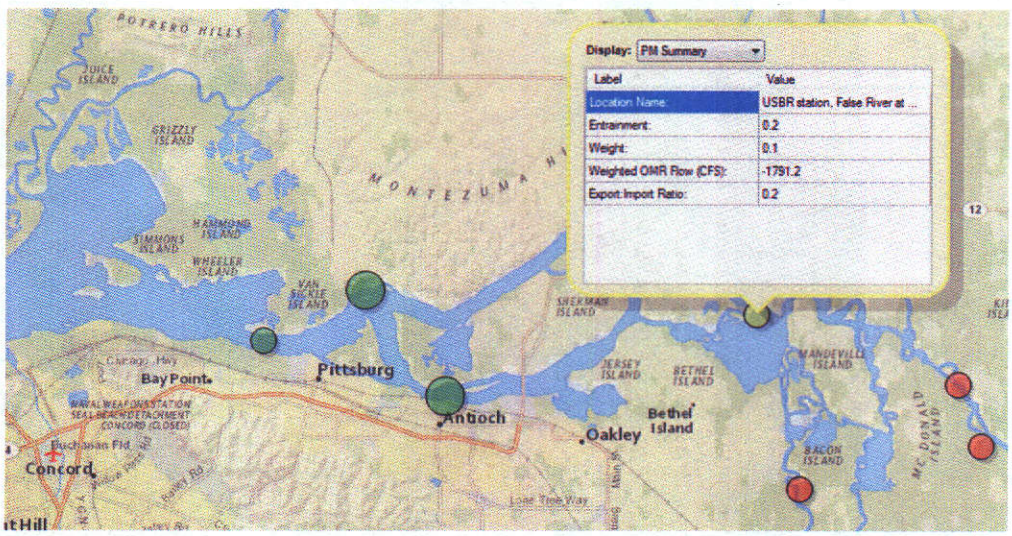

Figure 3. Example of map-based output information for DS4: Index of risk of entrainment.

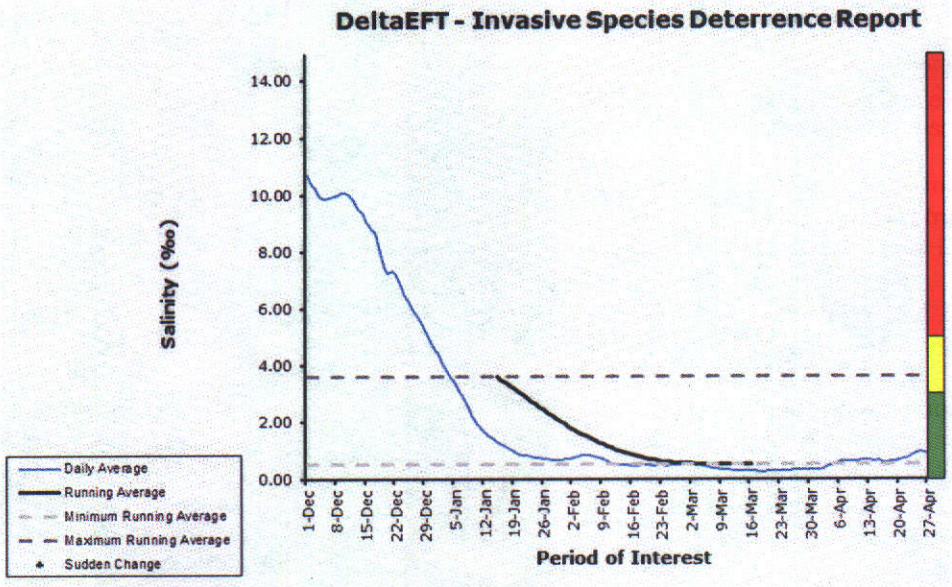

Figure 4. Example of Excel output graph information for ID2: Brackish water invasive overbite clam suppression.

EFT's output interface and reports for trade off analyses make it clear how actions implemented for the benefit of one area or focal species may affect (both positive and negative) another area or focal species. For example, we can show how altering Sacramento River flows to meet export pumping schedules in the Delta affects focal species' performance measures both in the Sacramento River and the Delta.

One of the biggest challenges in the practical development of ecological flow regime guidelines is the wide range of objectives, focal species and habitat types that need to be considered. EFT has brought into focus how these various objectives cannot all be simultaneously met. In nature, conditions often benefit one target or species to the potential detriment of another in any given year. Fortunately, flow characteristics that benefit the various ecological targets investigated are usually required on a periodic basis and not every single year. EFT studies simplify communication of these trade-offs, and catalyze definition of state-dependent management practices that promote the development of needed flexibility in the water management system.

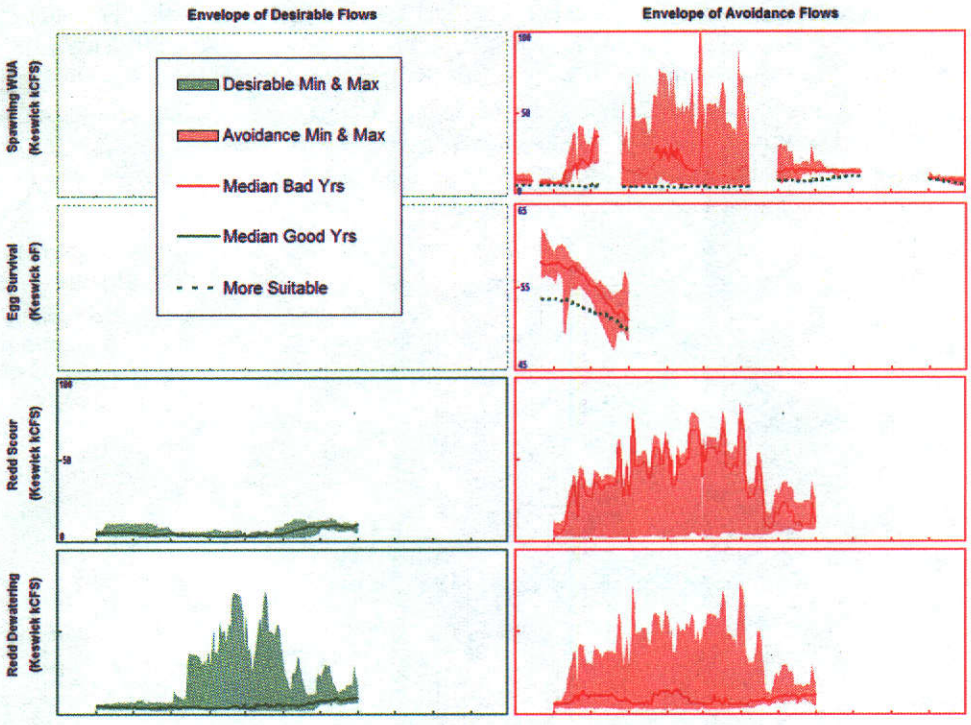

Figure 5. Develop ecological flow regime guidelines.

EFT focal species submodels are integrated and centered around a single SQL Server relational database. The software's Graphical User Interface, Model Controller & Analysis Engine, and Excel Reporting Service connect to and interact with this central database. Users may perform Sacramento River (SacEFT) or Delta (DeltaEFT) effects analyses separately or in conjunction with one another. Users can chose which management scenarios to evaluate, what range of years to display, and which ecological indicators they wish to evaluate.

Strengths

Ecological effects analyses informed by EFT have the following strengths:

1. **More representative**: multiple focal species & habitats.
2. **Rapid scenario comparison**: trade-offs in one framework.
3. **Eco-regions linked: Sacramento & Delta.**
4. Broad **synthesis of science & advice** of experts.
5. Ability to **evaluate multiple actions** (gravel, channel migration, floodplain activation, conveyance, operations).
6. **Intuitive outputs simplify communication**.
7. **Speed / agility** – EFT effects analyses can be run in "days" and "weeks" (rather than months/years).
8. **Plug-in** to any hydrodynamic / water quality model.
9. **Extensible**. Improve/add performance indicators as science evolves. Design anticipates being refined over time.
10. **"Goldilocks" level of detail.** Not as data hungry & assumption rich as life-cycle models.

Software

EFT Reader software is publically available and free to download at: http://essa.com/tools/eft/download. The EFT Reader links with a centralized copy of the EFT database located on a remote server. The public EFT Reader database currently contains a suite of fully configured scenarios, derived from the Sacramento River Ecological Flows Study and from test scenarios supplied by DWR and project partners. Future versions of the EFT Reader database will include results for simulations based on other effects analysis investigations, as they move into the public domain.

EFT was developed between 2004 and 2012 with funding from the CalFed Ecosystem Restoration Program, Packard Foundation, The Nature Conservancy and ESSA Technologies.

Additional information

- http://essa.com/tools/eft
- http://www.dfg.ca.gov/ERP/signature_sacriverecoflows.asp
- http://www.conservationgateway.org/Files/Pages/nature-conservancy-and-en.aspx

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