Endpointtool: An Excel®-Based Workbook for Hanford Tank Waste Treatment Planning

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ABSTRACT

The EndpointTool is a Microsoft Excel®-based workbook with a set of macros and worksheets for the evaluation of Hanford Site tank treatment scenarios. This tool enables the user to determine bottlenecks in processes and storage and address regulatory issues. It also provides an avenue to evaluate new technologies, as well as changes in existing technologies and their impact to the current baseline. The EndpointTool tracks 46 radionuclides, 52 species, and 10 properties for each event. Seventeen different processes are modeled, each with its own worksheet that describes that process, has its assumptions, qualifications, and calculations, and holds the historical results of each process event. This enables the user to not only look at the big picture, but to evaluate process parameters such as flowrates, sizing, etc.

The user composes an event that is a combination of a sender tank, a process tank, and a receiver tank. Each event involves one of the processes and each process can have up to a total of 81 assumptions and 180 qualifications. The starting point for all tank inventories is the Hanford tank Best-Basis Inventory (BBI). Each tank comprises up to three phases: saltcake, sludge, and supernatant. Each of these BBI phases has an insoluble solids fraction that was derived from the embedded solubility model.

Each composed event must meet a set of qualifications that are dependent on the process, as well as whether the sender tank has any inventory, whether the receiver tank has sufficient space, etc. For example, supernatant events are limited to a maximum solids specified in its assumptions, usually 5 wt%. Above this solids contents, a slurry transfer must be used. Once a qualified event is added to the EventList, the inventories of involved tanks are updated in a status worksheet and the results of that event appear in the timeline and metrics charts.

Although the EndpointTool is not a true dynamic model, it provides a useful desktop capability for quite complex process sequences. While only schedule and variances are presently performed, a cost module is in development.

INTRODUCTION

One of the more complex issues facing planners for Hanford tank waste disposition is the difficulty in evaluating the impact of changing scenarios. These changing scenarios are a result of changes in tank waste inventories, budgets, processes, etc. To date, much of the Hanford Site planning basis has been performed by Hanford Tank Waste Operations Simulator modeling(1) and the results of that modeling appear in various reports cited therein. However, there is a need for a more user-friendly tool that can be used by a more universal community, which would permit broader planning.

In particular, many analysts are keenly interested in comparing the impact of a new process (e.g., fractional crystallization) on the overall performance of a scenario without that process. Such comparisons can then be used to gauge the efficacy of a new technology or approach. Given the widespread use of Excel as a planning tool, it is beneficial to have Excel as the platform for the EndpointTool. Thus, user-created and user-saved tank waste treatment scenarios can be easily distributed and shared among many different users.

METHODOLOGY

The EndpointTool permits a user to design a series of tank waste treatments with appropriate constraints. Basically, a user submits a list of process events and the EndpointTool schedules each event given the constraints imposed by process and tank space availability. An Event is a combination of a Sender tank, a Process tank, and a Receiver tank as shown in Fig. 1. The Receiver tank receives the main product for a given process, while other product streams associated with a given process are assigned to Queues. Queues are simply out-of-system "tanks" for holding material that can then be moved to other tanks or processes by later Events. In addition, there are a number of Queues assigned to hold final products, such as immobilized High-Level Waste glass.

The starting point for all tank inventories is the BBI, queried July 2007. Each tank comprises up to three phases: saltcake, sludge, and supernatant. Each of these BBI phases has an insoluble solids fraction that was derived from a simple solubility model(2) that was applied to the set of all BBI supernatants.

Composed Events must meet a set of Qualifications (see Table 1) that are dependent on the process, as well as whether the Sender tank has any inventory, whether the Receiver tank has sufficient space, etc. For example, supernatant Events (suXfer's) are limited to a maximum solids specified in its assumptions, usually 5 wt%. Above this solids content, a slurry transfer (slXfer) must be used. Table 2 shows EndpointTool's species and properties, which comprise a larger set than the BBI provides. Thus, EndpointTool will accommodate additional information if it becomes available.

Once a qualified Event is added to the EventList, the inventories of involved tanks are updated in a Status worksheet and the results of that Event appear in the timeline and metrics charts. The user inputs the information shown in Table 3 shaded cells and then executes the AddEvent macro.

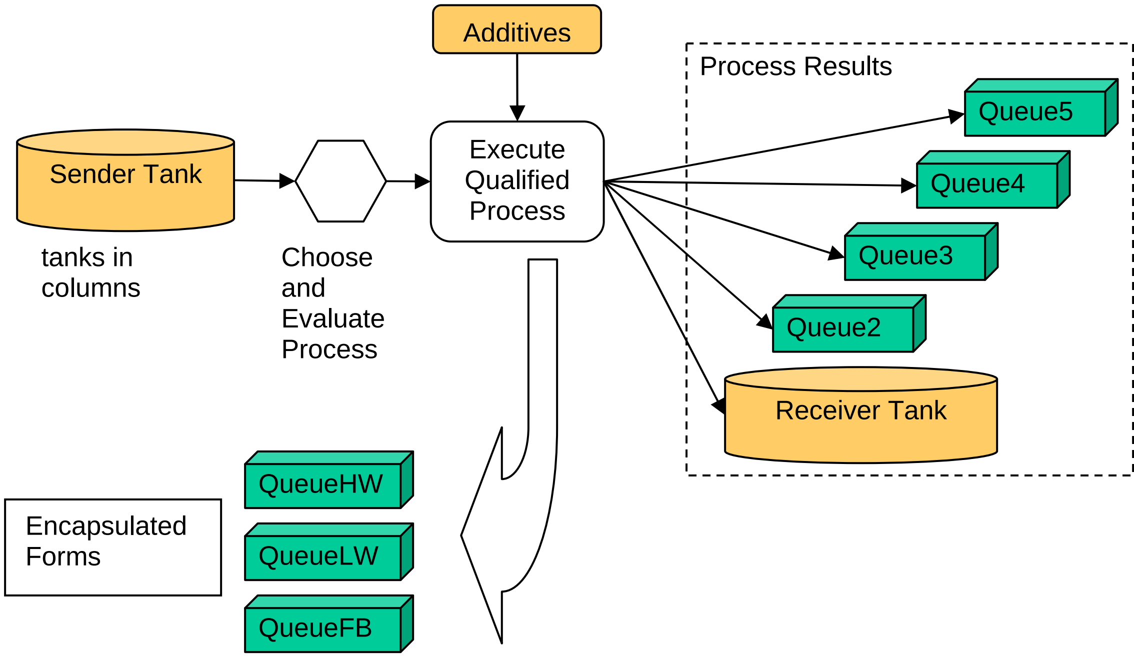

Figure 1. Schematic showing the EndpointTool Event logic

Table 1. List of processes, assumptions, and qualifications for the EndpointTool.

Process	Process Description	Assumptions	Qualifications
suXfer	Supernatant transfer	6	39
slXfer	Slurry transfer	6	40
dryXfer(E&W)	Allows transfers without constraints	7	38
Filtration	Produces permeate with specified residual solids and retentate with the balance of solids	9	5
CsIX	Performs Cs ion separation into two streams: diluate and eluate	12	5
CausticWash	Caustic Wash is essentially a Filtration with additives that dissolve specified amount of Al and other species	13	7
iLAWvit	LAW vitrification by WTP	7	12
iHLWvit	HLW vitrification by WTP	7	10
iFBSR(E&W)	LAW by Fluidized Bed Steam Reformer	7	12
iBulkVit	LAW by Bulk Vitrification	7	12
iCeramic	LAW by other ceramic or hydroceramic process	Not done yet	—
oxLeach	Oxidative leach is filtration with additives	Not done yet	—
FracCryst	Fractional Crystallization creates new specified solids and then filters	Not done yet	—
SelLeach	Selective leach redissolves specified solids and then filters	Not done yet	—
SrTruDecon	Strontium/TRU Decontamination forms solids by additive with Sr and TRU and then Filters.	Not done yet	

Table 2. List of species, radionuclides and properties tracked by EndpointTool. Note that the number of species available in the BBI is less than those shown.

Item Tracked	No.	Description
Species	52	Na+, Ag+, Al+3, As+5, B+3, Ba+2, Be+2, Bi+3, Ca+2, Cd+2, Ce+3, Co+3, Cr(TOTAL), Cs+, Cu+2, Fe+3, Hg+2, K+, La+3, Li+, Mg+2, Mn+4, Mo+6, Nd+3, Ni+2, Pb+2, Pr+3, Rb+, Sb+5, Se+6, Si+4, Sr+2, Ta+5, Te+6, Ti+4, Tl+3, TOC, V+5, W+6, Y+3, Zn+2, Zr+4, OH-, Cl-, CN-, CO3-2, F-, NO2-, NO3-, PO4-3, SO4-2, C2O4-2
Radionuclides	46	3-H, 14-C, 59-Ni, 63-Ni, 60-Co, 79-Se, 90-Sr, 90-Y, 93-Zr, 93m-Nb, 99-Tc, 106-Ru, 113m-Cd, 125-Sb, 126-Sn, 129-I, 134-Cs, 137-Cs, 137m-Ba, 151-Sm, 152-Eu, 154-Eu, 155-Eu, 226-Ra, 228-Ra, 227-Ac, 231-Pa, 229-Th, 232-Th, 232-U, 233-U, 234-U, 235-U, 236-U, 238-U, U(TOTAL) kg, 237-Np, 238-Pu, 239-Pu, 240-Pu, 241-Pu, 242-Pu, 241-Am, 243-Am, 242-Cm, 243-Cm, 244-Cm
Properties	10	wt% H20, dry mass (kg), Density (kg/m3), original volume, Total mass, Total volume, Oxides Mass, Solids wt% (insoluble), Solids wt% (total), Solids vol%

Table 3. Example of event Sender, Receiver, Process, and volume (in kgal = 1,000 gal) selection. User adjusts only shaded cells.

Event #150		**Total**	**Saltcake**	**Sludge**	**Supernatant**
Sender	241-BX-105	71.85	24.83	42.27	4.76
Process→	slXfer	71.85	24.83	42.27	4.76
Phase Frac.	Total	1	1	1	1
Receiver	241-SY-103	0.0	0.00	0.00	0.0
sendAfter	241-BX-105	0.00	0.00	0.00	0.00
recAfter	241-SY-103	298.94	0.00	266.97	31.96
		kgal			

If a process Qualification fails, the pass/fail flag goes FALSE. Clicking the pass/fail flag hyperlinks (actually QualInfo macro) to the particular qualification that has failed for that process. The Process Monitors and Qualification shown are a part of a Process worksheet. For example, a numeric error will turn the “error?” flag TRUE and red and a tank overfill will set that flag TRUE.

Table 4. Example of event Monitors and Qualifications for the Event in Table 3.

Monitors					
	Frac	**NxDate**	**EvDays**	**EndDate**	**Empty**
241-BX-105	1	2008.5	3.3	2008.5	FALSE
241-SY-103	—	—	—	—	—
before	**total Ci**	**total Na**	**total Ox**	free	free
241-BX-105	224,481	95,820	346,334	—	—
241-SY-103	164,511	249,400	411,822	—	—
after	**total Ci**	**total Na**	**total Ox**	free	free
241-BX-105	6,635	17,133	48,166	—	—
241-SY-103	382,357	328,087	709,990	—	—
Qualifications					
pass/fail	**error?**	**overfill**	**Cs DF**	**slwt%**	**Na M**
TRUE	—	—	37.8	47.35%	15.32
% limit	**% limit**	**% limit**	**0**	—	—
0%	0%	0%	0	—	—

Process Worksheets

There is a total of 17 process worksheets as described in Table 1. However, only two processes will be described here: suXfer and CausticWash. Each process worksheet has a similar layout and is linked to the main DoEvents worksheet. Selection of a process causes the compositions of the various standard streams to be directed to the calculations on that process worksheet.

A process worksheet comprises the compositions for the streams associated with that process, as well as the Assumptions and Qualifications that are defined by the user. Assumptions define the parameters of the process such as its rate and total operating efficiency (TOE), while Qualifications define the limits for the application of that process for the selected tank waste.

Process suXfer

This process models the basic supernatant transfer of waste from one tank to another tank or to a Queue. The suXfer conforms to a series of rules as shown in Table 5, with a corresponding set of Assumptions, Qualifications, and calculations. The suXfer process will also redefine phases. During an suXfer, all Saltcake phases are dissolved and all solids are moved into the slurry phase. There are more limitations on the amount of solids that are allowed; therefore, the slwt% limit is necessarily limited.

Table 5. List of rules for suXfer process.

No.	Description
1	All suXfer durations scale with sender not receiver volume.
2	suXfer process simulates a transfer of any one of su, sc, and sl or a proportionate amount of each with a Total transfer.
3	If +water is TRUE, the transfer also adds water to dilute to the target Na molarity in assumptions.
4	Sender su insoluble solids go to Rec sl.
5	Sender sa insoluble solids go to Rec sl, balance of Sender sa goes to Rec su.
6	Sender sl all goes to Rec sl.
7	All insoluble solids in Sender su and sc go to Rec sl.
8	All remaining Sender sc goes to Rec su. Thus, suXfer zeros sc phase.
9	This simulates sedimentation and completely zeros sa, saltcake.
10	The process days needed for the given processing are returned according to the process rate and TOE.
11	Thus the suXfer also simulates a sedimentation of insoluble solids by transferring the insolubles to the sl phase.

The user can modify the suXfer process assumptions shown in Table 6. Each process sheet shows a list of assumptions that have to do with the rate, TOE, whether dilution water will be added, the starting date for the process, and whether more than one process can be concurrent or simultaneous. Then the particular process, in this case suXfer, has an additional assumption limiting solids amounts or specifying a target SpG. Thus, the suXfer can dilute or concentrate the waster during transfer.

Table 6. List of suXfer process assumptions.

Description	Value	Units	Comment
Process rate	100	gal/min	Apply TOE for actual rate.
TOE	20%	%	Includes set up and shut down.
+ water	TRUE	—	This selects whether process will automatically add water.
Online date	2008.75	year	—
Concurrent	1	—	Number of concurrent events allowed.
sl limit	5%	wt%	Product1 slurry solids amount.
SpG target	1.47	g/cm^3	If set, SpG target overrides Na max thereby diluting/concentrating.

Process CausticWash

CausticWash simulates the dissolution of aluminum hydroxide by means of added NaOH followed by filtration. Filtration (see Fig. 2) is based on the cross-flow filtration of slurry waste (solids carried in liquids) to partition a stream into two fractions: retentate and permeate. The retentate fraction carries the majority of the solids (specified by assumptions) and results in a sludge phase in the Sender tank.

Permeate is the low solids fraction and that ends up in the receiver tank. Note that this emulates any number of filtration schemes including a settle-decant operation. However, it is necessary to specify different solids partitioning for different desired simulations.

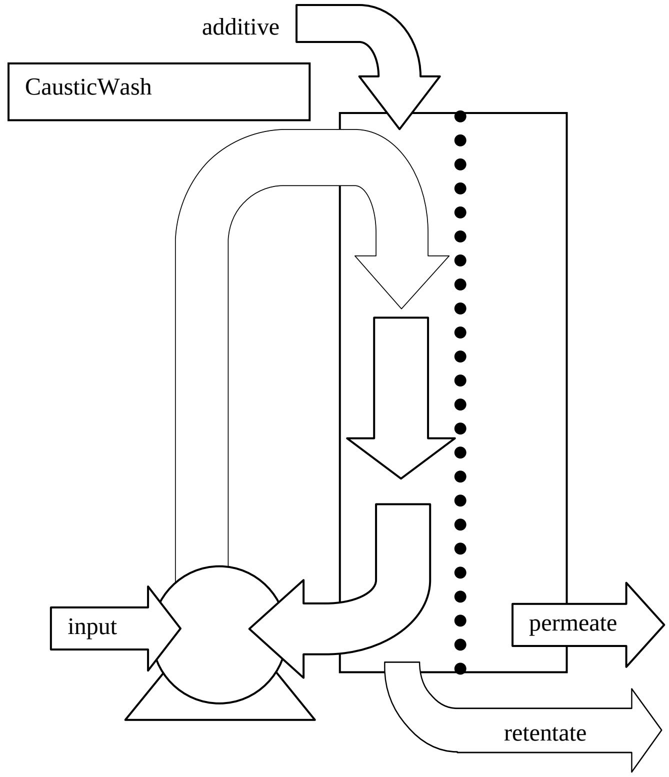

Figure 2. Schematic of CausticWash process

Table 7. CausticWash Rules.

No.	Description
1	CausticWash process simulates dissolution of solids and separation into two streams: permeate (prod1) and retentate (prod2).
2	A certain percent of liquids carries over to the solids and vice versa. The final retentate is then diluted with water to reach the solids wt% target. Permeate is not diluted. This dilution is only done if the +water = TRUE.
3	The process days needed for the given processing are returned according to the process rate and TOE.
4	Solids volume is calculated based on oxides densities listed for the solids amounts. Oxide densities are those on the Assumptions sheet.

Table 8. CausticWash process assumptions.

Description	Value	Units	Comment
Process rate	10	gal/min	Instantaneous rate of process. xTOE to get actual rate.
TOE	80%	%	Total operating efficiency for process.
+water	TRUE	—	This selects whether process will automatically add or subtract water.
Online date	2010	year	Starting date for process.
Concurrent	1	—	Number of concurrent events allowed.
su carryover to sl	4.0%	%	Product2 liquids carryover.
sl carryover to su	0	%	Product1 liquid solids residue.
sl target	18%	wt%	Product2 slurry solids amount.
sl target		vol%	Solids volume percent.
Na demand	5.1	MT/MT Al	Need NaOH to scale with Al removed.
Al% removed	90%	%	Percent of Al partitioned to permeate.
Cr% removed	90%	%	Percent of Cr partitioned to permeate.
Na% removed	0%	%	Percent of solids Na partitioned to permeate.

RESULTS AND DISCUSSION

The Event Timeline of a simple case is shown in Figure 3 for an early start of the iLAWvit process. The Event Timeline shows each process event as it is scheduled as a bar on the horizontal bar chart. Mouseover on each Event reveals the volume, Sender tank, and Receiver tank of the Event, while Event antecedents and decendents are shown by selection of "ShowLink" option.

In this way, a particular scenario can be laid out and then subsequently examined in detail. Various metrics (curies disposed, waste volume processed, water evaporated, etc.), can be plotted or exported in a variety of different ways. One can track phosphate or chromium or any other species across any number of events. Figure 3 shows a plot of the amount of iLAW Na that has been encapsulated as a function of time.

It is important to begin a scenario with a list of desired outcomes such as "Meet 2018 TPA Milestones" or "Empty C Farm First." Given a list of outcomes, one then devises a strategy for meeting those outcomes. Given the often multiple paths possible that achieve any given set of outcomes, that strategy can often be very flexible. For example, one could decide to process SST waste at 1.5 times DST waste, hold 4 Mgal DST in reserve, or retrieve East Area waste at 1.5 times West Area waste.

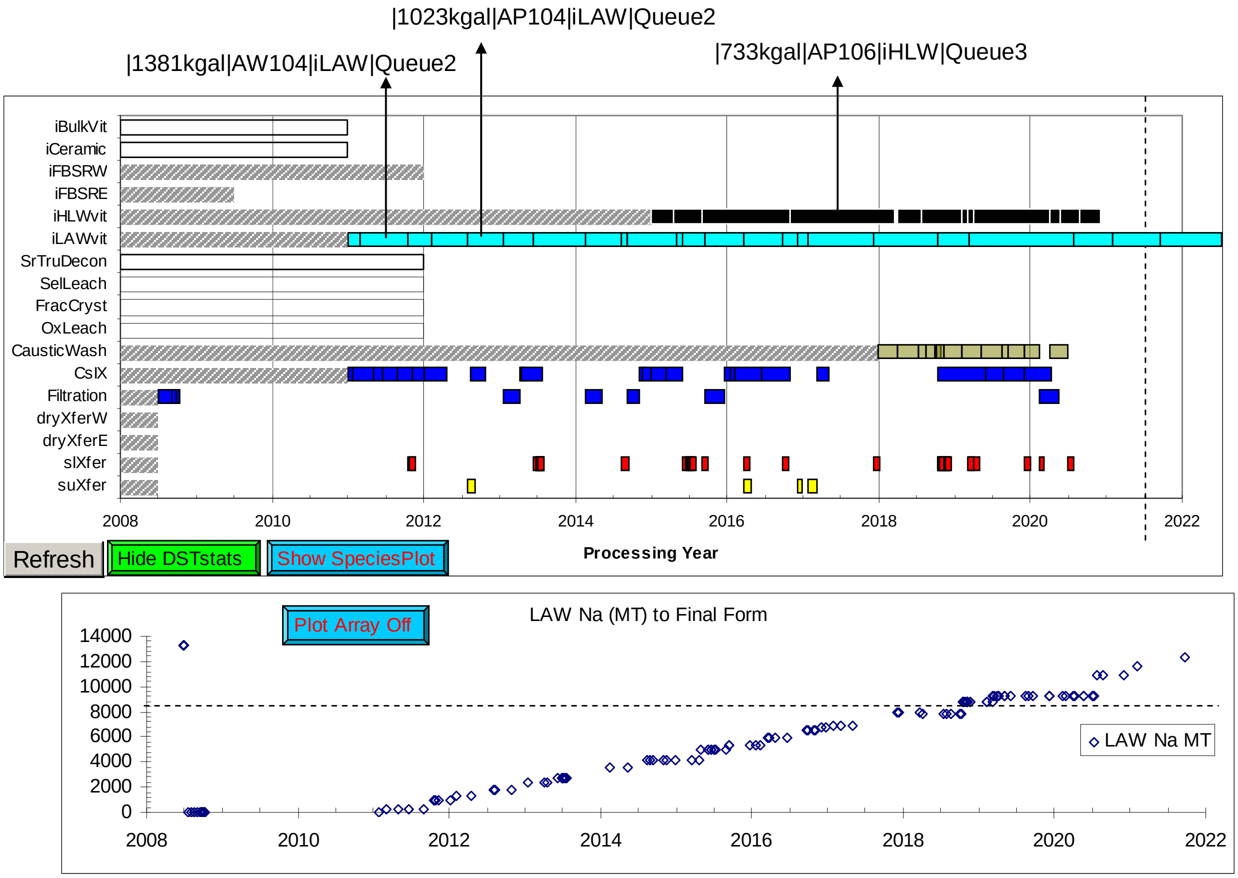

Figure 3. Timeline showing process Events for a case where the iLAWvit process would start early along with the metric plot for the MT of LAW Na created

SUMMARY

The EndpointTool is a powerful Excel-based planning resource. It is portable and test runs have shown that about 600 Events can effectively represent the processing of all of Hanford tank waste. Since each Event takes approximately 3 seconds to run on a 1.8 GHz CPU with 512 MB ram, a complete run only takes approximately 30 minutes.

As a result, extensive scenario planning and process optimization is possible with this tool. Moreover, EventList “scenarios” can be easily shared among users and scenario planning can then be distributed among a large number of users.

ACKNOWLEDGEMENTS

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