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Accelerated Basin De-inventory Modeling

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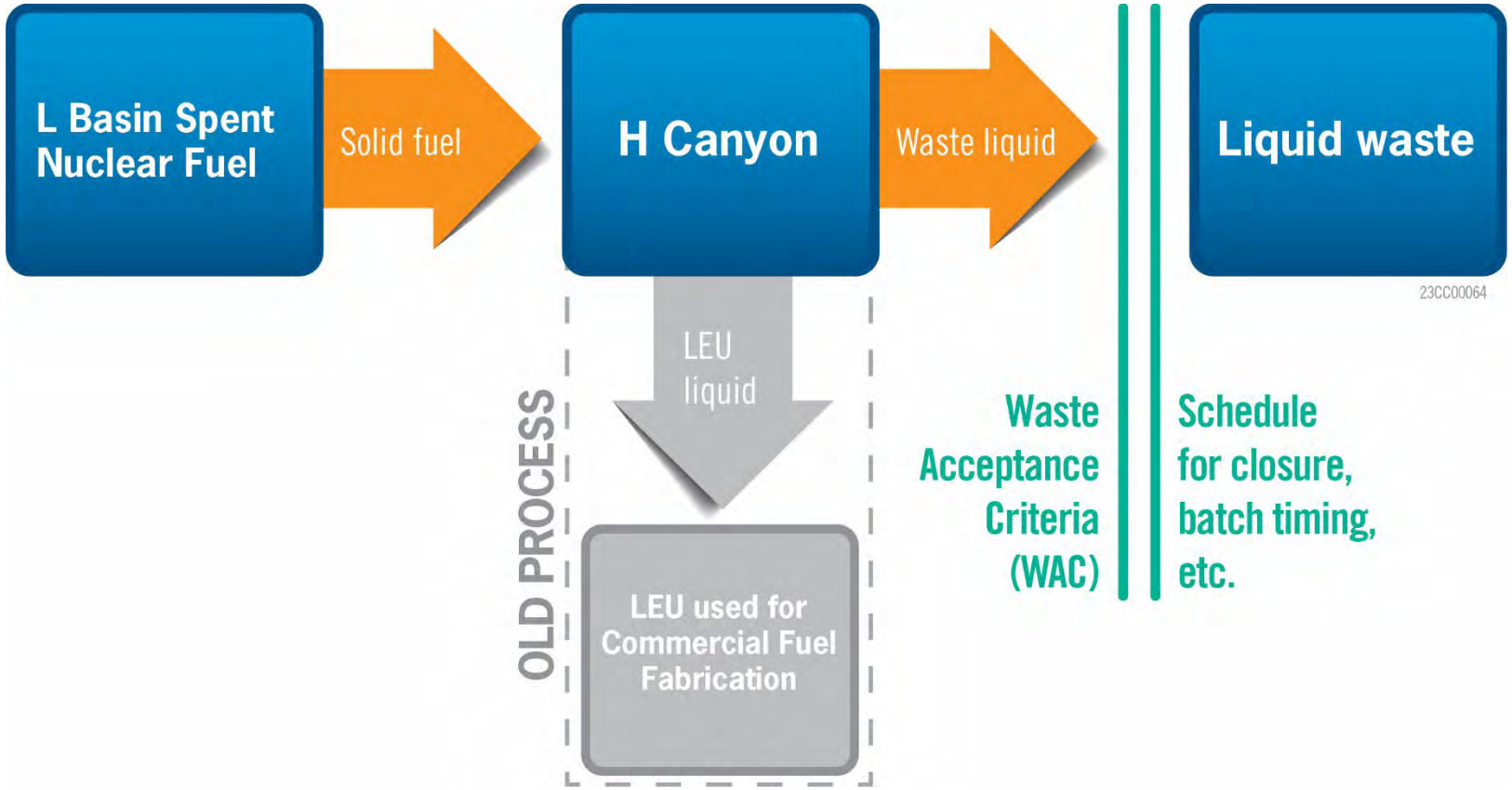
Background: Material flow in ABD system is complex



While the physical process for dispositioning legacy fuel as waste is simpler (not as many steps), the requirements are much more complex. This presents a daunting logistical and planning challenge.

Spent Nuclear Fuel — How much variety can there be?

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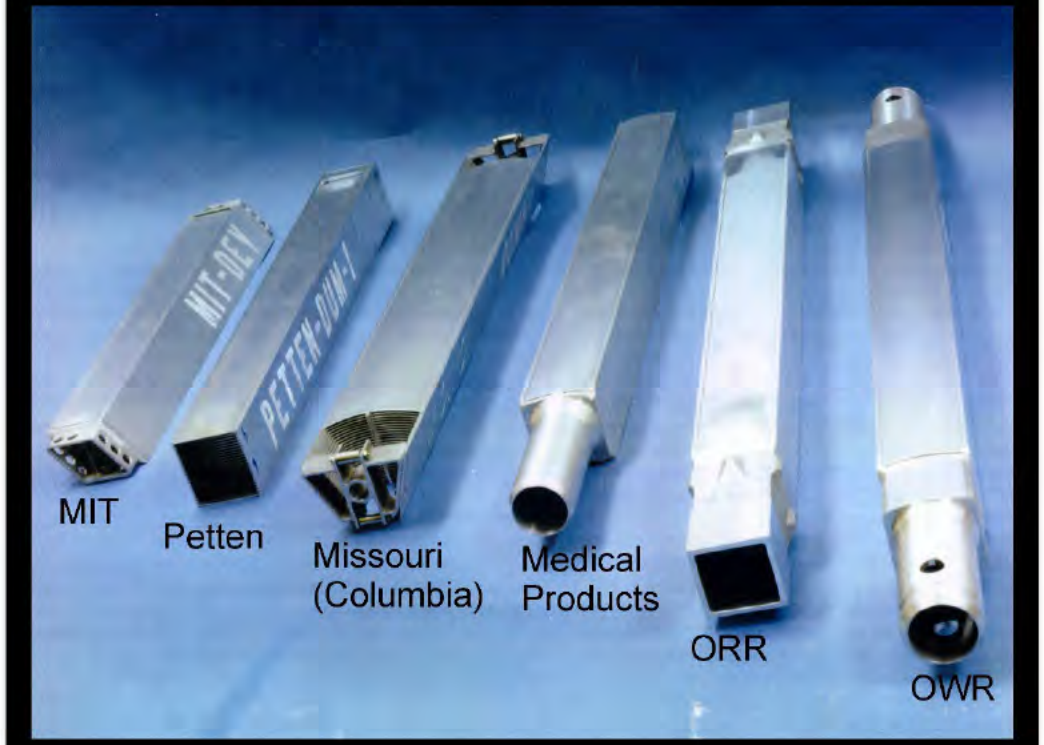
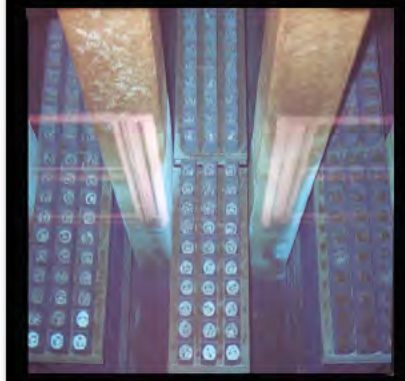
Fuel Variety - MTR





L Bundles in L Basin

HFIR Core being charged

Looking in the basin, many round fuel bundles look very similar. However, inside the bundles is a vast array of fuel compositions, shapes and sizes. Each bundle has its own unique characteristics, which must be considered when making the recipe.

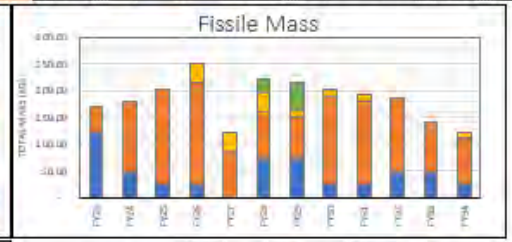
It's just going to waste. How hard can it be?

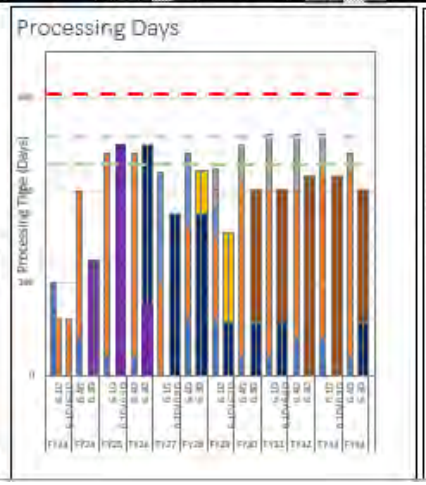
- **Types of items that must be tracked and balanced**
  - Total amount of uranium, plutonium, non-radioactive components: How much tea?
  - Concentration of components: How sweet is the tea?
  - How much of each type of uranium and plutonium (isotopes): What type of sugar (turbinado, cane, high fructose)?
  - How much poison to limit the uranium and plutonium reactivity: How much lemon to counteract the sweetness?
  - How the material was packaged and "clad": What containers were used to hold the tea and sugar?
  - The history (reactor, age, etc.) of items: What country of origin and process has been used to make the sugar?

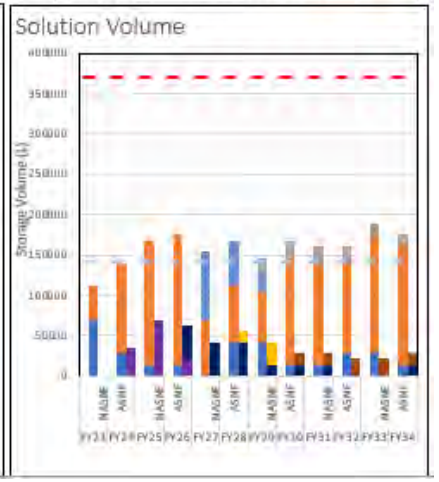
There are complex chemistry requirements that must be balanced in order to ensure a compliant waste stream can be achieved, now and years from now. Success in making the right recipe is in the details!

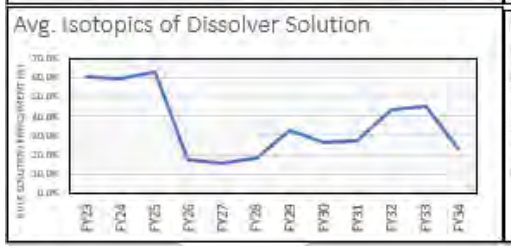
Planning for chemistry: High-level modeling

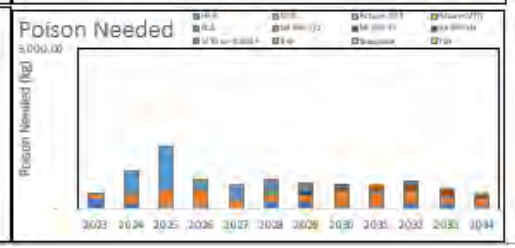
	Total 6.4D Eq.	HFIR	Total 6.4D Eq.	MTR	Total 6.4D Eq.	NASNF G1/2	Total 6.4D Eq.	NASNF G3a	Total 6.4D Eq.	NASNF G3b	Total 6.4D Eq.	FCA	Total 6.4D Eq.	1CU	Fissile Discard	MTR w	RHF	Slowpoke	TSR	HFBR	Targets	Kodak	Yavoi	Y12	TTR	Mound	PNNL	Other	Total 6.4D Eq.
Reset	166	Balance: (1) 6.4D eq.	22	Balance: (18.5) 6.4D eq	93.5	Balance: (0) 6.4D eq.	13	Balance: (0.1) 6.4D eq.	3	Balance: (-0.3) 6.4D eq.	6	Balance: (0) 6.4D eq.	9	Balance: (1) kg	213	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	19.5
FY2	8		5		3		0		0				0		0														0
FY2	12.5		2		8		0		0		0		2.5		100														0
FY2	17		1		11		0		0				5		113														0
FY2	16.5		1		11		3		0				1.5		0														0
FY2	14		0		5		3		0				0			6													6
FY2	16		3		5		3		1		0		0			4													4
FY2	13.5		3		4.5		1		2				0			##	1												3
FY3	14		1		9.5		1		0		1		0							.5									1.5
FY3	13.5		1		9		1		0		1		0										1						1.5
FY3	13		2		8		0		0		1.5		0											1					1.5
FY3	14		2		9.5		0		0		1.5		0																1
FY3	14		1		10		1		0		1		0								1								1









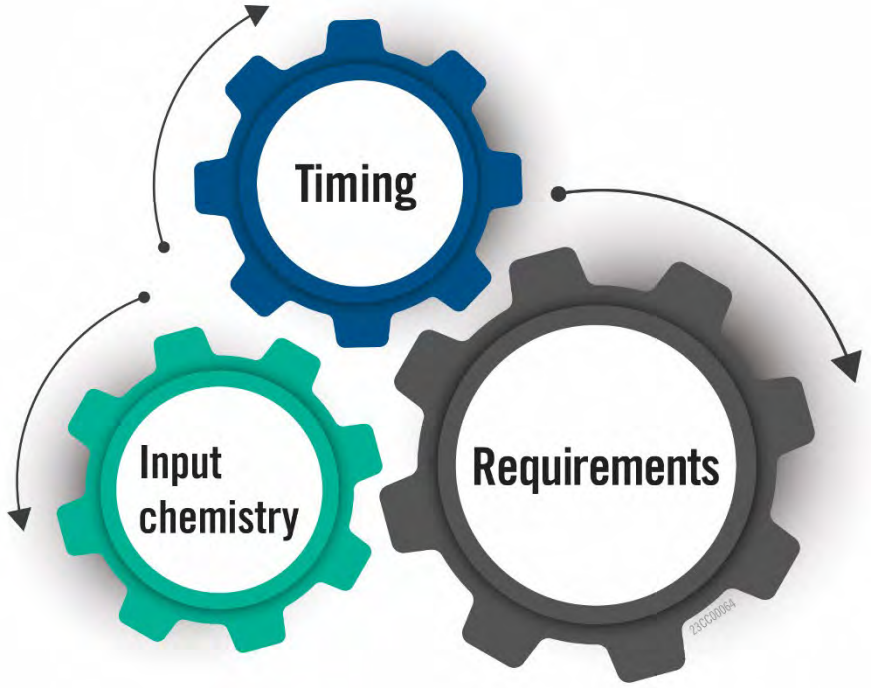


Once the chemistry is right: How to get it to LW?

- As if making the right recipe wasn't hard enough, there are limitations on WHEN a certain recipe can be delivered to the Tank Farm.
  - Each recipe is specified as part of a "sludge batch."
  - The limits on the sludge batch affect the recipe preparation.
  - Each sludge batch has a transfer window, and significant planning is involved to integrate the two facilities.

The chemistry plus the sludge timing dictate how fast H Canyon will need to run each year.

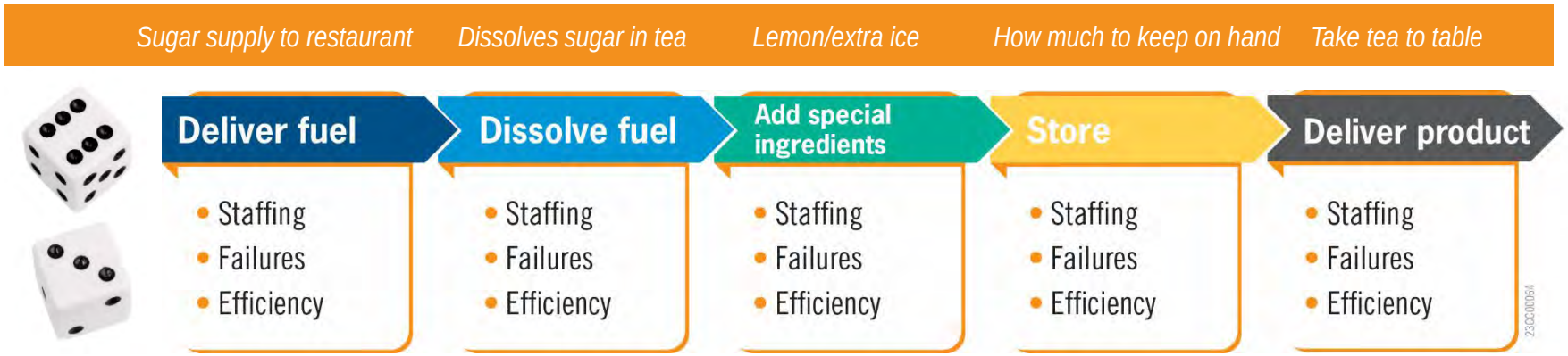
A **sludge batch** is a batch of well-characterized sludge that the tank farm has combined out of their waste vessels and prepared for vitrification in glass. This is done in batches to ensure the sludge meets all of the downstream stringent requirements for glass quality and eventual disposal.



Chemistry + schedule = throughput requirements

- Fuel travels through many process “stations” as it moves from L Basin to Liquid Waste.
- Each of these stations is affected by staffing, efficiency, outages, equipment capability and other factors.
- H Canyon uses what is called a “discrete event model” to simulate fuel moving through each of these stations, one by one.

Sweet tea analogy



Discrete event modeling, a method used to understand how processes behave and to predict outcomes, can:

- break down individual steps and simulate success and failures in each step
- be used to predict events years out

Lifecycle prediction

Year 1

Deliver fuel	Dissolve fuel	Add special ingredients	Store	Deliver product
• Staffing • Failures • Efficiency	• Staffing • Failures • Efficiency	• Staffing • Failures • Efficiency	• Staffing • Failures • Efficiency	• Staffing • Failures • Efficiency

Year 2-10

Deliver fuel	Dissolve fuel	Add special ingredients	Store	Deliver product
• Staffing • Failures • Efficiency	• Staffing • Failures • Efficiency	• Staffing • Failures • Efficiency	• Staffing • Failures • Efficiency	• Staffing • Failures • Efficiency

The simulation can be used to predict events many years out. Prediction for success in the out years, helps decide what fuel to process TODAY. These decisions can either save years or add years to the lifecycle. IT'S IMPORTANT to PLAN AHEAD!

Example output from discrete event model

Home

Throughput Summary - 15 Years

Batches Completed (6.4D equiv.)

HFIR	MTR
41	127.00
FCA	NASNF
9.00	22.50

6.4D Dissolutions
110
6.1D Diss (6.4 equiv.)
55
6.3D Diss (6.4 equiv.)
31.50

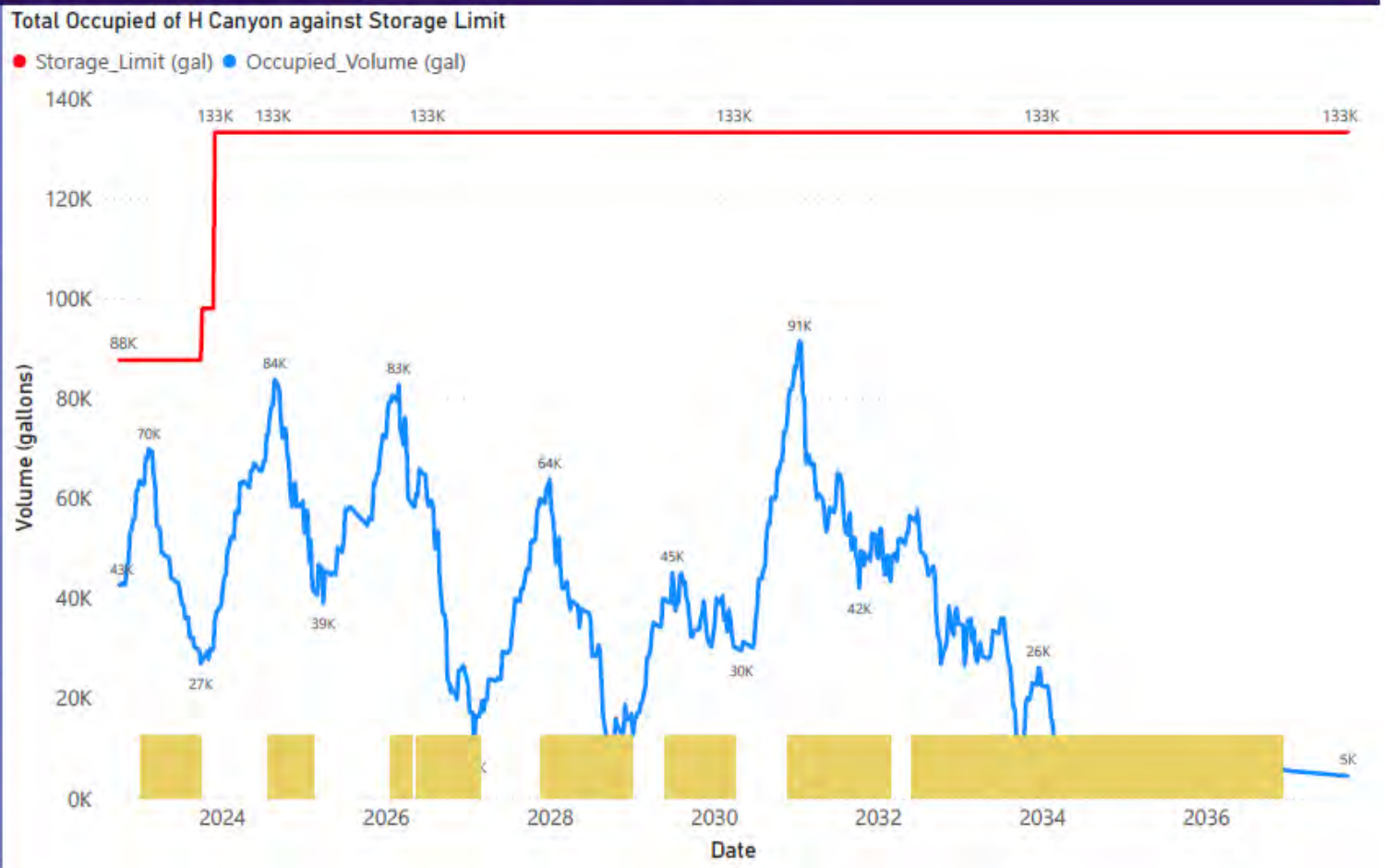
Batches Discarded

HFIR*	MTR*
47.10	133.90

*Chemical additions have been subtracted from this calculation resulting in a more pessimistic result.

FCA**	NASNF**
9.10	24.60

**Can be slightly higher than fuel dissolved due to jet dilutions and the minimum contents in Tank 7.4.

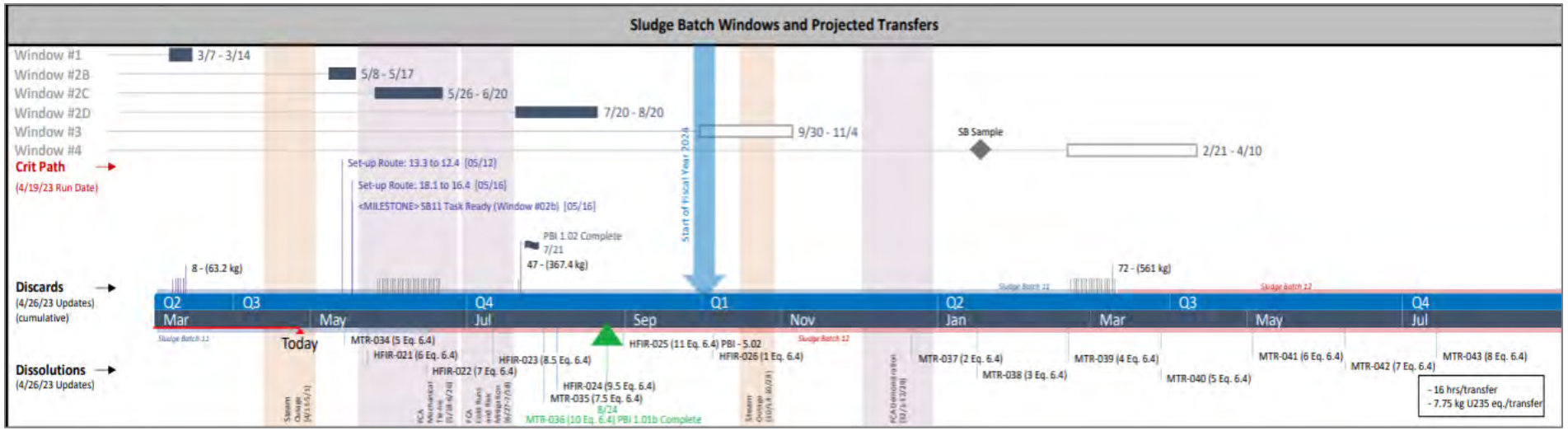


What does all this modeling mean?

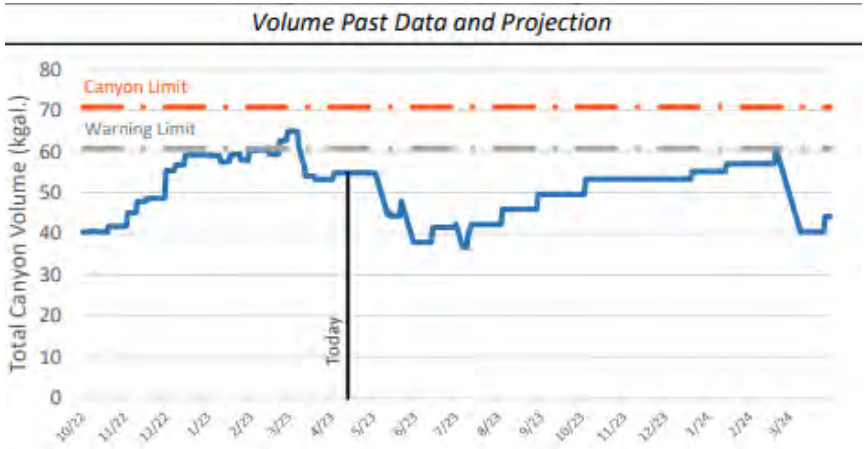
- Model predictions help SRNS and DOE set goals and measure success.
  - How many dissolutions should we be doing per year?
  - What operational risks should we be concerned about and how could they affect mission success ?
    - *What can we do to prevent or minimize the risks? (Staffing, equipment investment)*
- What regulatory limitations are challenging to the mission?
  - Fissile loading in glass
  - Poison requirements
- Can Capital Investment reduce risks or accelerate the mission?
  - New storage tanks
  - Faster processes

In the complex ABD system, modeling is critical to avoid unnecessary costs.

Execution and monitoring success



After using the planning tools and discrete event modeling to plan the mission and lock in near-term operational goals, modeling can assist in executing the mission.

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