Impacts of Feed Composition and Recycle on Hanford Low-Activity Waste Glass Mass

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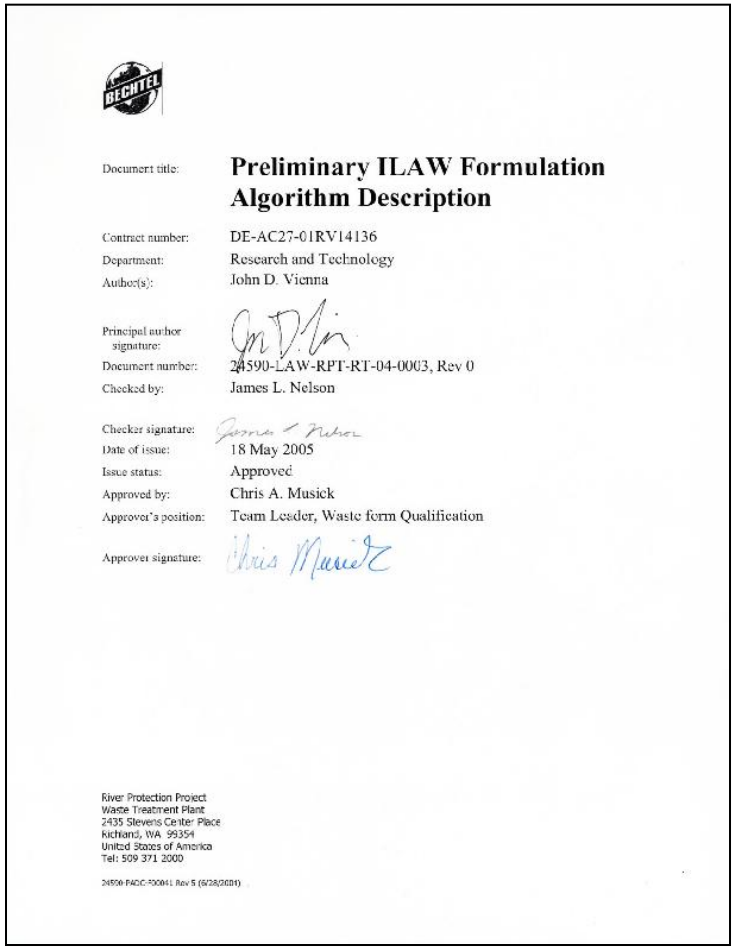
LAW Glass Loading Limits

- WTP baseline (LAW Glass Formulation Algorithm)
  - low uncertainty → thoroughly tested
  - accounts for Na, S, Cl, F, Cr, K, and P impacts
  - conservative loading
- Advanced silicate formulation
  - higher uncertainty than baseline
  - currently accounts for Na and S impacts
  - impacts of other components not specifically tested, but, one can evaluate maxima from testing as a lower bound



BECHTEL

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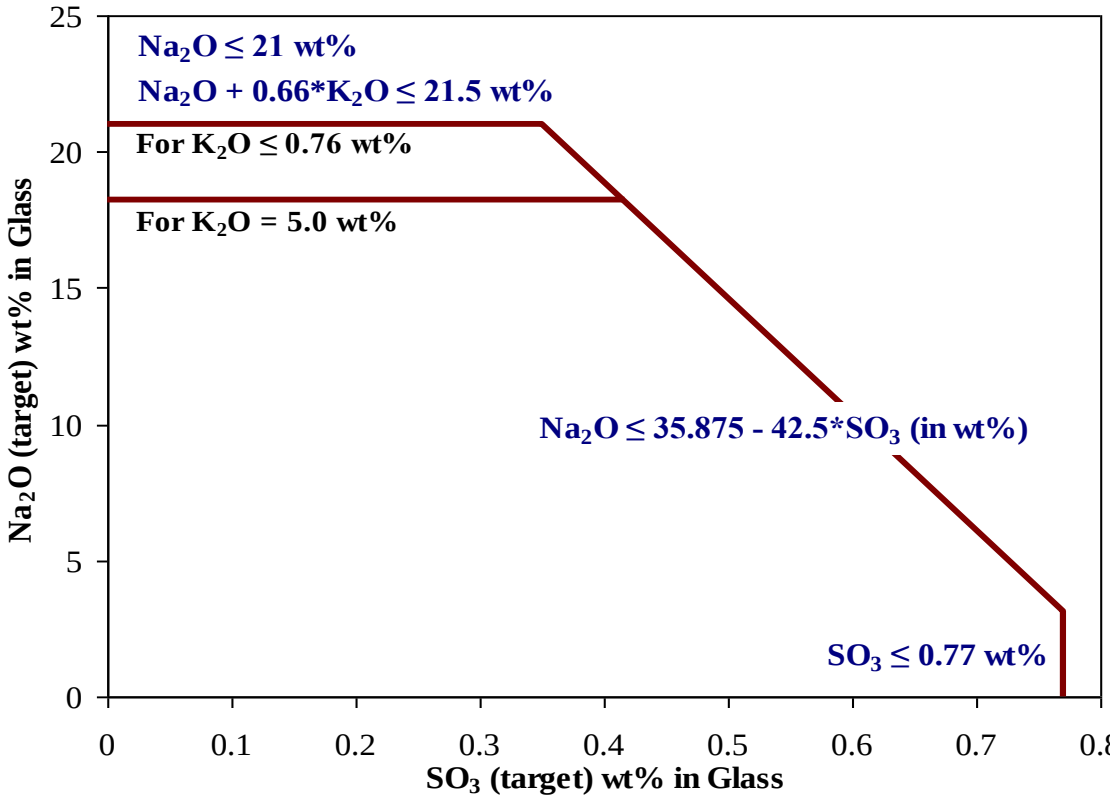
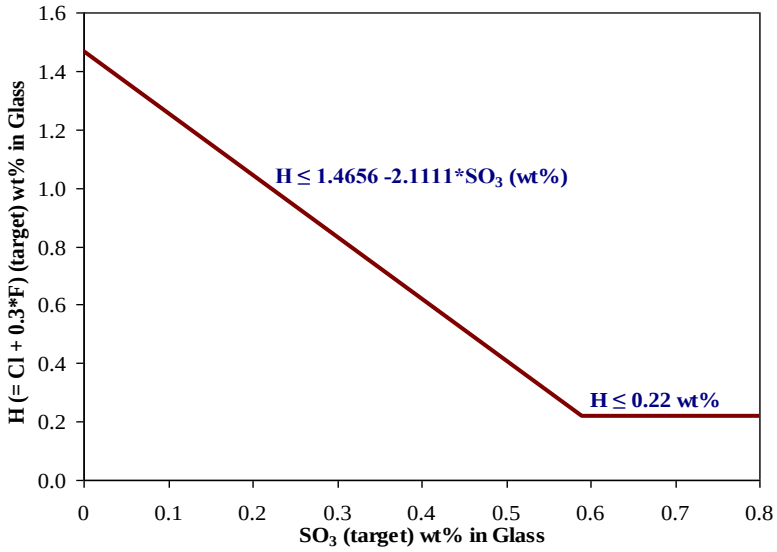
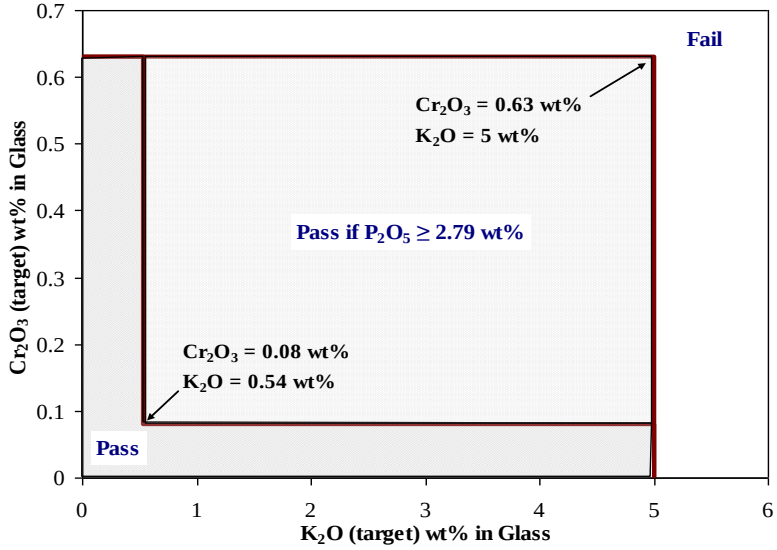
WTP Baseline Glass Formulation







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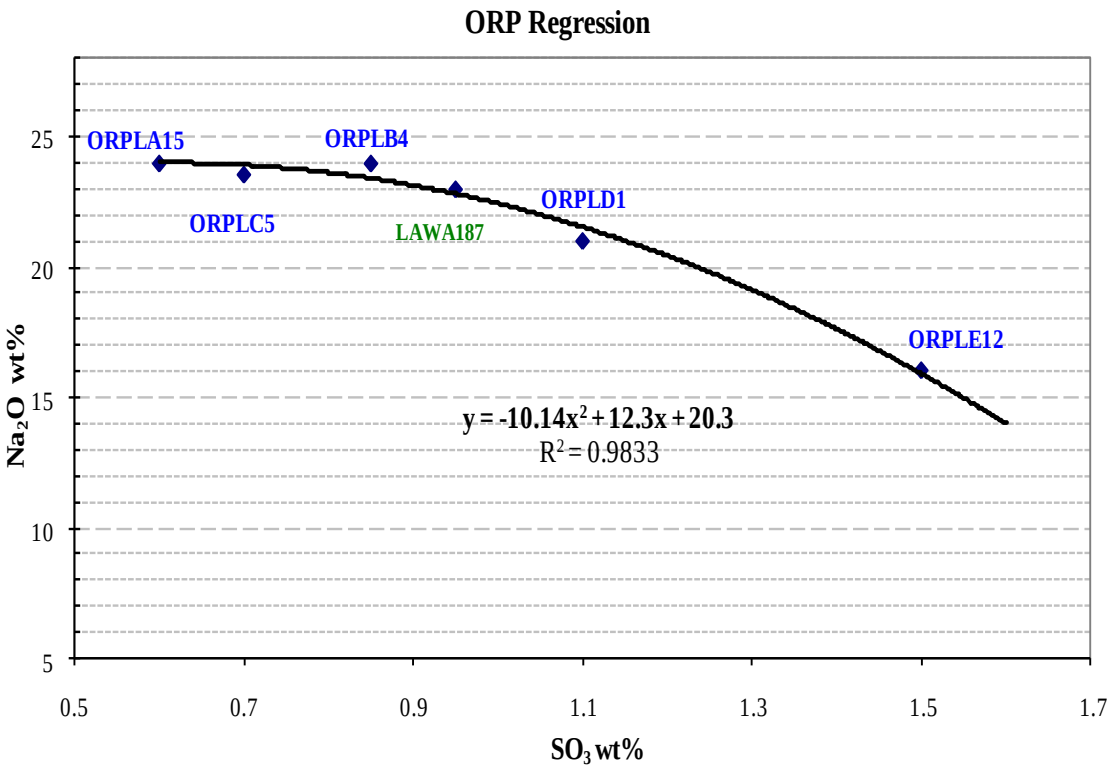
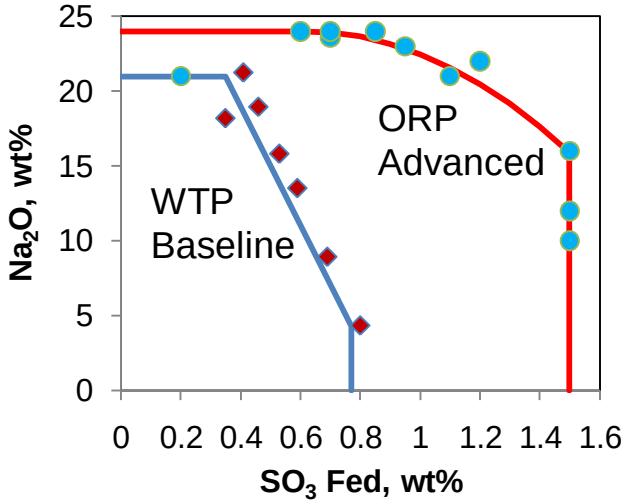
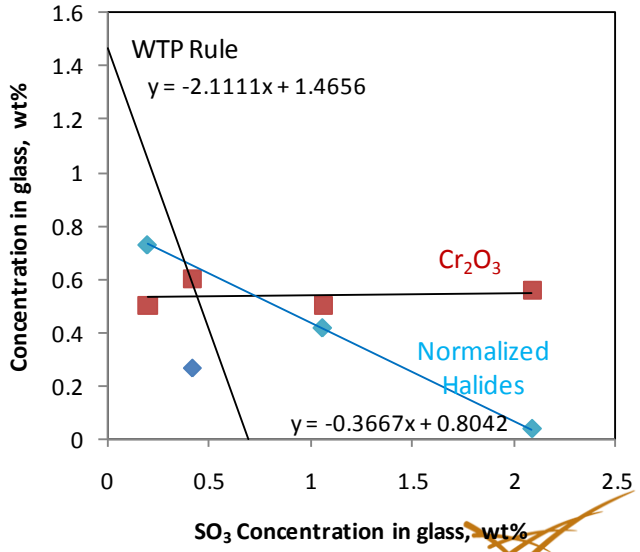
ORP Advanced Silicate Glass Formulation



Data points from scaled melter tests





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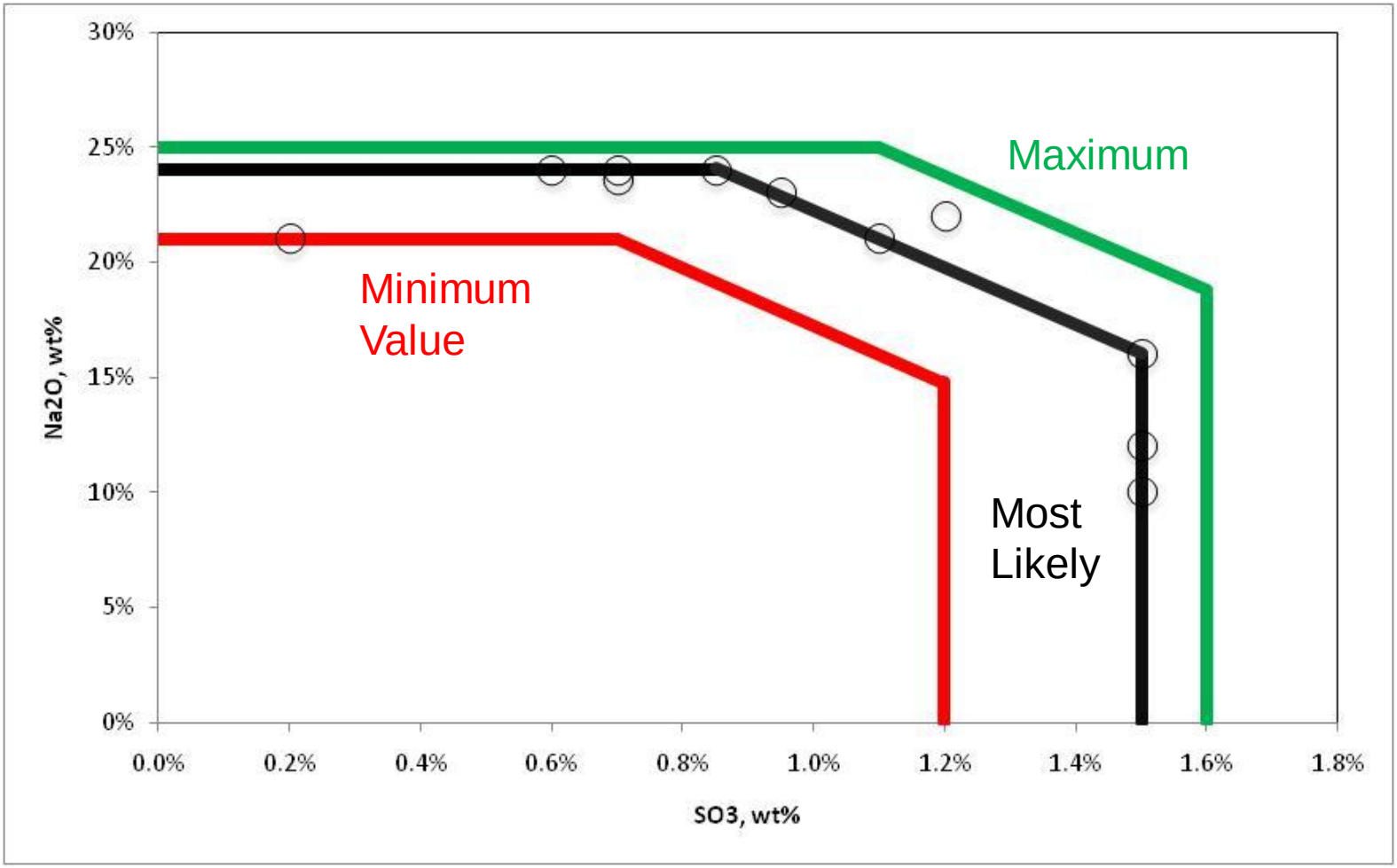
Glass Formulation Uncertainty



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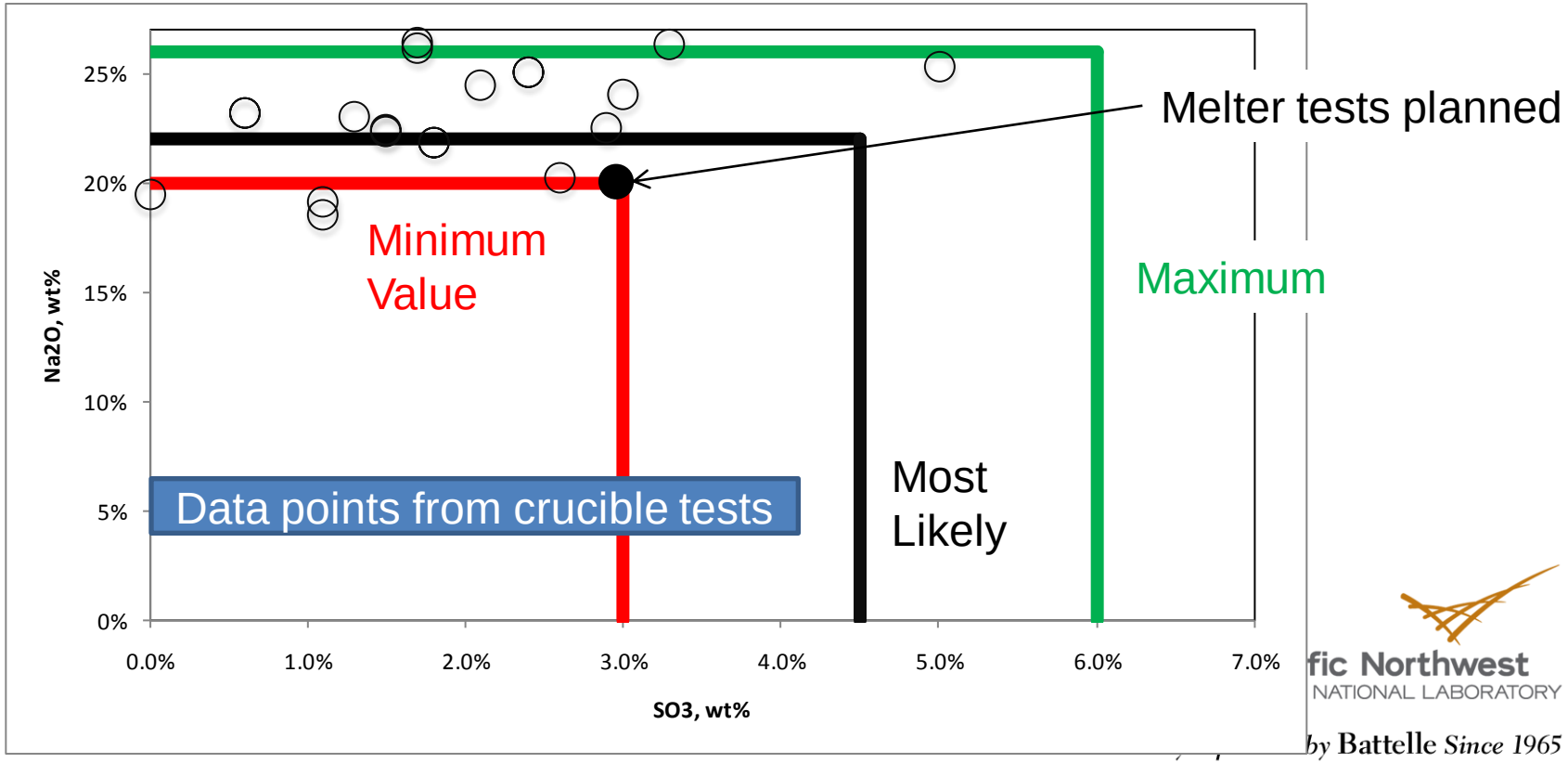
Phosphate Glass Loading Estimates

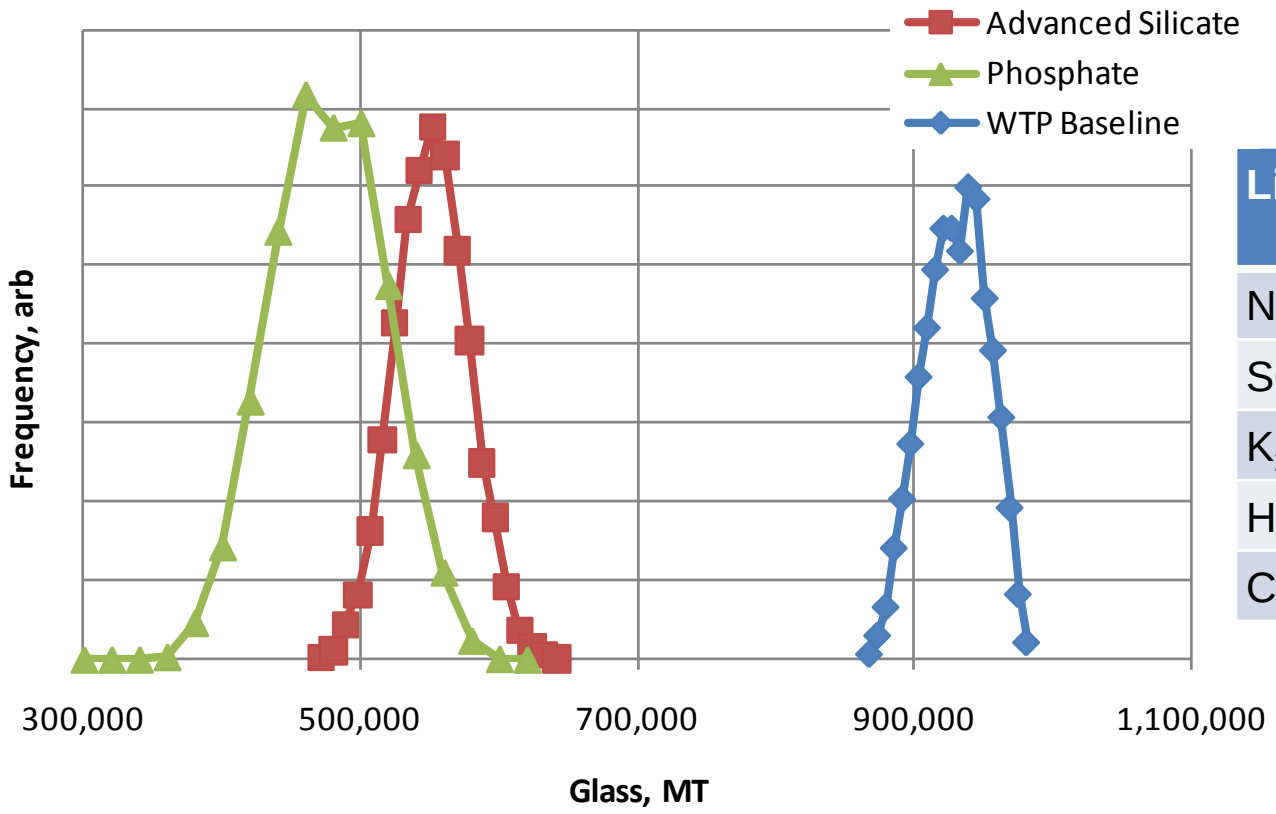
- Insufficient data to refine loading estimates, however, based on preliminary assessments:
  - 20 wt% ≤ Na_2O ≤ 26 wt% → most likely 22 wt%
  - 3 wt% ≤ SO_3 ≤ 6 wt% → most likely 4.5 wt%
  - No halide, phosphate, or chromate limits



Waste Loading Calculations

- Start with Hanford Tank Waste Optimization Simulator (HTWOS) estimates of LAW
  - SP4 Planning Case-3.0-8.4r0-2009-03-30-at-20-02-39
  - 78,000 MT Na, 5.31 MT SO_4, 1.4 MT Tc
- Vary uncertain parameters:
  - Na inventory 60,000 to 90,000 MT Na (constant relative reduction)
  - Advanced glass formulation rules (Na_2O, SO_3, halides, Cr_2O_3)
  - Iron phosphate glass formulation rules (Na_2O and SO_3 loading)
- Calculate glass mass for each “realization”
  - Monte Carlo with 5,000 realization
  - generate glass mass, process time, canister count, etc. probability distributions

Results – Glass Mass and Limits



Limit	WTP glass	Adv SiO_2	$FePO_4$ Glass
Na_2O	9%	35%	99%
SO_3	87%	48%	1%
K_2O	1%	0%	0%
Hal	1%	9%	0%
Cr_2O_3	1%	1%	0%

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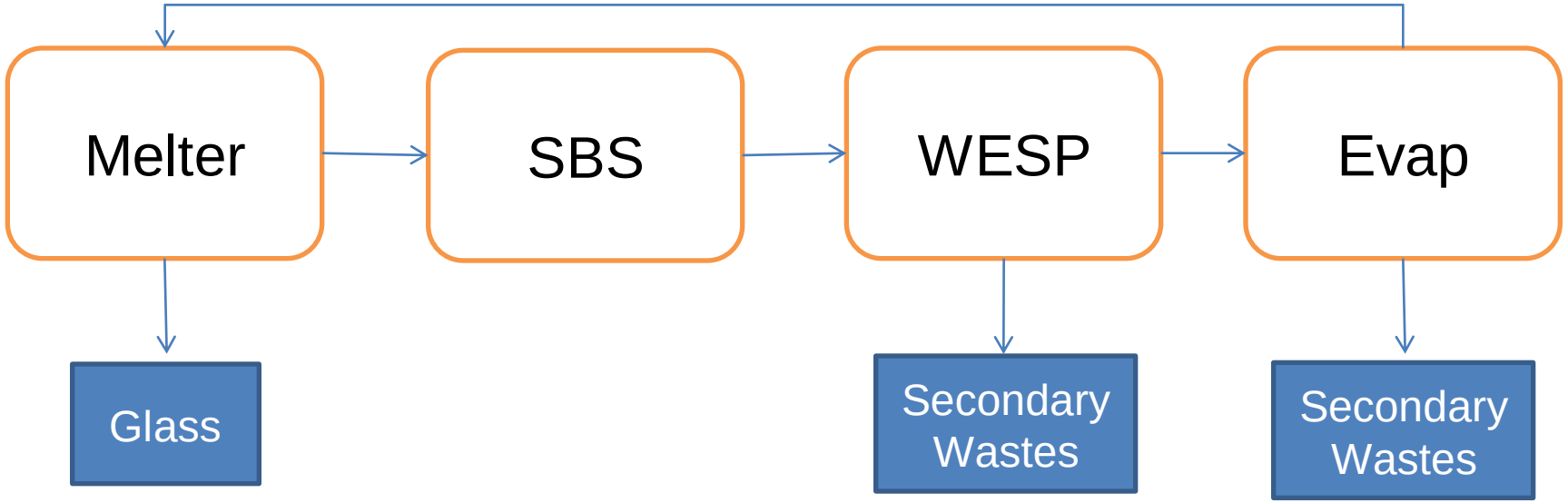
Recycle Impacts

- Concentration in melter feed will become incoming concentration over the sum of purges at steady state
- Only significant purges are glass and secondary wastes (recycled salts from HLW typically go to LAW)

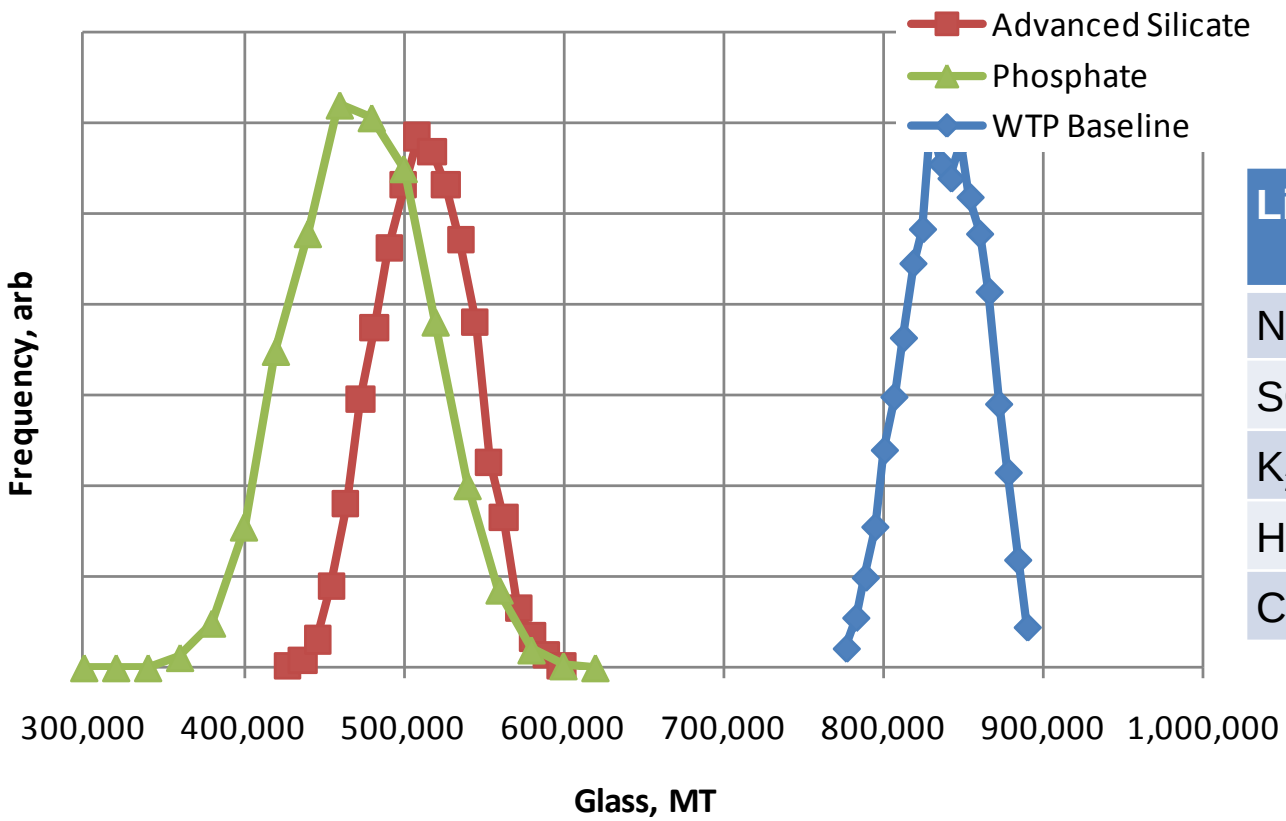


Recycle Stream Impacts on Waste Loading

- More volatile components concentrate in the melter feed (see % of input feed table)
- Some components have highly variable retentions in glass
  - Cs, I, S for examples for which feed composition and melter operation significantly impact the splits
- These concentrations were manually removed from feeds to calculate impacts on glass volumes
- Note: Glass formulations for no recycle schemes would undoubtedly be developed to improve waste loadings that wasn't accounted for here

Ele	Conc
Al	100.0
Cl	191%
Cr	104.0%
Cs	~111%
F	132%
I	~234%
K	103.4%
Na	100.7%
P	100.5%
S	~118%
Tc	254%

Results – Glass Mass and Limits – No Recycle



Limit	WTP glass	Adv SiO_2	$FePO_4$ Glass
Na_2O	12%	44%	99%
SO_3	84%	51%	1%
K_2O	1%	0%	0%
Hal	0%	2%	0%
Cr_2O_3	1%	1%	0%

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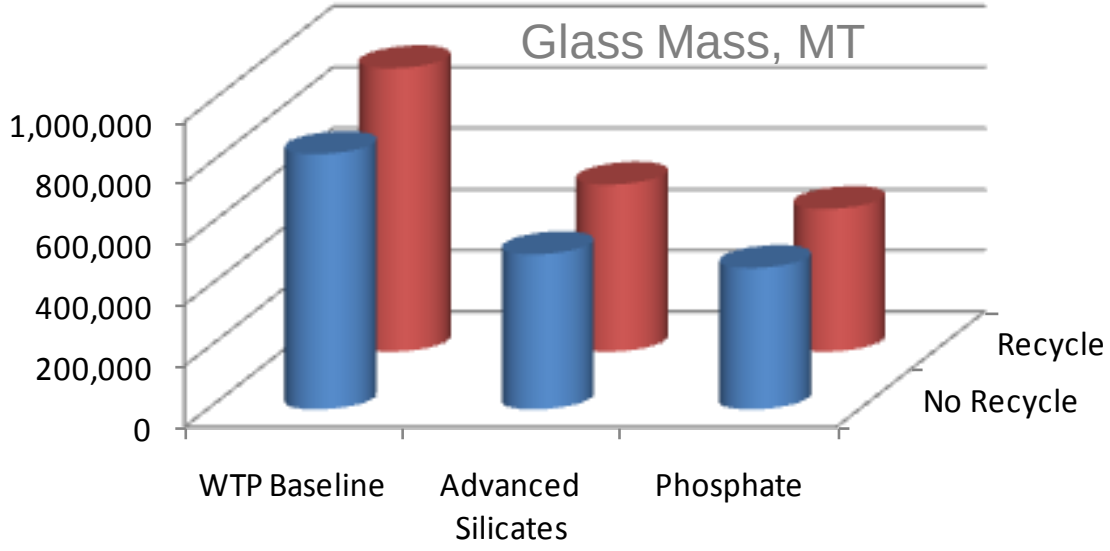
Results – Glass Mass

Formulation	Recycle	Glass mass, MT
WTP Baseline	Yes	928,000 ± 46,500
WTP Baseline	No	836,000 ± 48,000
Advanced	Yes	547,000 ± 52,000
Advanced	No	508,500 ± 57,000
Phosphate	Yes	467,500 ± 82,000
Phosphate	No	463,000 ± 80,500



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Results – Process Time/Capacity

Formulation	Recycle	Time, Single LAW Plant (y)	Time, 40% 1st LAW, 60% 2nd LAW (y)	Capacity, 2nd LAW for 27 y (MT/d)
WTP Baseline	Yes	121 ± 9	48	113
WTP Baseline	No	109 ± 9	44	100
Advanced	Yes	55 ± 9	22	51
Advanced	No	51 ± 8	20	46
Phosphate	Yes	48 ± 13	19	40
Phosphate	No	48 ± 13	19	39

A Note on Risks

- To facilitate calculations, a number of simplifying assumptions were made. These assumptions should be recognized in light of the risks they present.
- Waste composition
  - the waste compositions taken from a preliminary system plan rev. 4 HTWOS run that was not thoroughly analyzed
  - the potential for inaccurate conclusions stem from the relative amounts of Na:S:Cl:F:Cr:P and the absolute amount of Na
  - the calculations will be repeated using an ORP reference waste stream that was thoroughly reviewed
- Advanced silicate glass
  - reliable glass property models currently do not extend to this composition region and the tolerance to S, Cl, F, P, and Cr have not been quantified
  - as these glasses are further developed, these assumptions can be checked

A Note on Risks, cont.

- Iron phosphate glass
  - the state of development of iron phosphate glasses is immature compared to silicate glass development
  - several potential issues have been raised with $FePO_4$ glass:
    - corrosion of melter construction materials
    - impacts of off-gases on process and equipment
    - melting rate
    - durability of quenched and slow cooled glass
    - size of processing envelope

    these issues are being addressed systematically in an on-going research project
  - only one cold-crucible melter test was performed with $FePO_4$ waste glasses and significantly less crucible studies
  - no information is available for the volatility of key chemical and radioactive elements

Summary and Conclusions

- Advanced silicate formulations reduce glass by ~40 rel% and phosphate glass reduce glass by a further 15 rel%
- Breaking the recycle loop reduces glass by 7 to 10 rel%
  - lower impact for advanced silicates
  - no impact for phosphate glass
- Different waste estimates generate different impacts
  - higher (S, Cl, F):Na ratio wastes yield higher impacts of recycle
  - vitrifying only Na would not yield any significant recycle impact
- Real risks to estimates of glass volume and process time should be considered. Some of those factors were accounted for, but, not all of them due to lack of numerical representation.