HLWYM HEmails

From: James Winterle
Sent: Monday, January 08, 2007 1:21 PM
To: 'CNWRA_Dirs_Managers'; Goodluck Ofoegbu; Luis Ibarra; Chandrika Manepally; Yi-Ming Pan; David Pickett; Roberto Pabalan; Osvaldo Pensado; 'Ron Janetzke'; James Mancillas; Hakan Basagaoglu
Cc: [redacted]
Subject: FW: ACTION: TPA Drift Degradation Scenario Approach
Attachments: DriftDeg_recommendation_02.ppt; parameters_1.wpd

Follow Up Flag: Follow up
Flag Status: Flagged

This message pertains to ENG1,2,3,4 and UZ2 ISI teams:

See meeting announcement below. I have reserved room A237 beginning at 2:30 pm tomorrow, January 9. This will be a chance to ask any clarifying questions related to proposed changes to the TPA code related to degraded drift processes. Recall that any requests for changes to the proposed approach and parameter values are needed by Jan. 12.
Osvaldo's presentation and proposed parameter values from last month are attached; we do not plan to repeat this presentation. Please forward to anyone else in your ISI team who you think should attend.

--Jim Winterle

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-----Original Message-----
From: Christopher Grossman [mailto:cjg2@nrc.gov]
Sent: Monday, January 08, 2007 10:47 AM
To: Osvaldo Pensado; Christopher Grossman; David Brooks; Mysore Nataraja; Randall Fedors; Sheena Whaley; Tae Ahn
Cc: Gordon Wittmeyer; James Winterle; Sitakanta Mohanty; Andy Campbell; Brittain Hill; Bret Leslie; Mahendra Shah; Timothy McCartin
Subject: Re: ACTION: TPA Drift Degradation Scenario Approach

Item Type: Appointment
Start Date: Tuesday, 9 Jan 2007, 03:30:00pm (Eastern Standard Time)
Duration: 1 Hour
Place: T-8 C5

Date: Tues. Jan 9, 2007
Time: 3:30 ET/2:30 CT
Location: NRC: T-8 C5

ACTION:
CNWRA - please provide a number to call.
ISI Leads - Please be sure your CNWRA counterparts are available, if necessary.

Purpose: On Dec. 18, Osvaldo Pensado presented the proposed approach for the drift degradation scenario modifications. At that time, we asked for feedback on the approach (attached) and associated parameter values (attached) from the ISI's connected to the drift degradation

scenario by Jan. 12. The purpose of this meeting is to facilitate discussion on the approach and clear up any remaining questions the ISI's may have.

Outcome: The TPA Code Team would like to begin receiving feedback from the ISI teams (for those ready to provide and discuss) and TPA Advisory Panel members on the parameter ranges and approach in a multidisciplinary setting to facilitate discussion. The TPA Code Team will be answering any outstanding questions/ambiguities ISI teams and TPA Advisory Panel Members may have.

Process: There will be no formal presentation of the approach as this was conducted earlier for all parties. Open Discussion of feedback and questions by all.

>>> Christopher Grossman 12/13/06 8:48 AM >>>
I've attached Osvaldo's proposed parameter ranges for the newly introduced parameters (*.wpd). I've also attached a previous presentation as background to understand the proposed approach and how these parameters fit into the approach (*.ppt). The presentation is only for information and contains some outdated material, but provides a general sense of our direction which will be elaborated on Monday.

ACTION: Be prepared to comment on the justification for parameters. We are looking for feedback on the range, distribution, and basis supporting them.

Date: Monday, December 18, 2006
Time: 2:00pm ET/1:00pm CT
Location: T-8 C5(NRC)/See J.Winterle

Bridge (3 lines): 1-800-638-8081
Passcode: 2893#
Note: If you plan to use the bridge, please let Bret Leslie know to ensure a sufficient # of lines.

Background: Drift Degradation was introduced to the TPA code in version 5.0 We are finalizing some of the approaches to better integrate the scenario with the affected modules in the TPA code to better model the key processes and uncertainties associated with drift degradation. Some of the key issues we are attempting to address involves the availability of water for release in failures not wholly dependent upon the presence of water (i.e., mechanical failures) and the integration of corrosion and mechanical processes.

Purpose: Brief affected ISI teams on the modifications planned for the TPA code to integrate the drift degradation scenario into the TPA code and better address key processes and uncertainties.

Action: NRC ISI leads should coordinate with CNWRA to ensure proper coverage.

Outcome: Affected ISI teams (ENG1, ENG2, ENG3, ENG4, UZ2) should have an understanding of (i) the rationale for the modifications (ii) the proposed new approach, (iii) key parameter ranges and associated bases.

The TPA development team is soliciting feedback from the ISI teams regarding the approach and the parameter distributions and justifications. We will be identifying points of contact for the feedback.

Process:
Introduction & Background - Winterle - 10 minutes
Presentation of Proposed Approach & Parameter Distributions - Pensado - 45 minutes Open Discussion - All - 30 minutes Closing & Identification of Action Items - Leslie - 5 minutes

Christopher J. Grossman
System Performance Analyst
Division of High-Level Waste Repository Safety
Office of Nuclear Material Safety and Safeguards
United States Nuclear Regulatory Commission
301-415-7658
cjg2@nrc.gov

Hearing Identifier: HLW_YuccaMountain_Hold_EX
Email Number: 737

Mail Envelope Properties (142c01c73351$b7aec400$a5c8a281)

Subject: FW: ACTION: TPA Drift Degradation Scenario Approach
Sent Date: 1/8/2007 1:20:46 PM
Received Date: 1/8/2007 1:20:53 PM
From: James Winterle

Created By: jwinterle@cnwra.swri.edu

Recipients:
[redacted]
Tracking Status: None
"'CNWRA_Dirs_Managers'" <CNWRA_Dirs_Managers@cnwra.swri.edu>
Tracking Status: None
"Goodluck Ofoegbu" <ofoegbu@cnwra.swri.edu>
Tracking Status: None
"Luis Ibarra" <libarra@cnwra.swri.edu>
Tracking Status: None
"Chandrika Manepally" <cmanepally@cnwra.swri.edu>
Tracking Status: None
"Yi-Ming Pan" <ypan@cnwra.swri.edu>
Tracking Status: None
"David Pickett" <dpickett@cnwra.swri.edu>
Tracking Status: None
"Roberto Pabalan" <rpabalan@cnwra.swri.edu>
Tracking Status: None
"Osvaldo Pensado" <opensado@cnwra.swri.edu>
Tracking Status: None
"'Ron Janetzke'" <rjanetzke@swri.edu>
Tracking Status: None
"James Mancillas" <jmancillas@cnwra.swri.edu>
Tracking Status: None
"Hakan Basagaoglu" <hbasagaoglu@cnwra.swri.edu>
Tracking Status: None

Post Office: cnwra.swri.edu

Files	**Size**	**Date & Time**
MESSAGE	5027	1/8/2007 1:20:53 PM
DriftDeg_recommendation_02.ppt	153152	
parameters_1.wpd	2460615	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received: Follow up

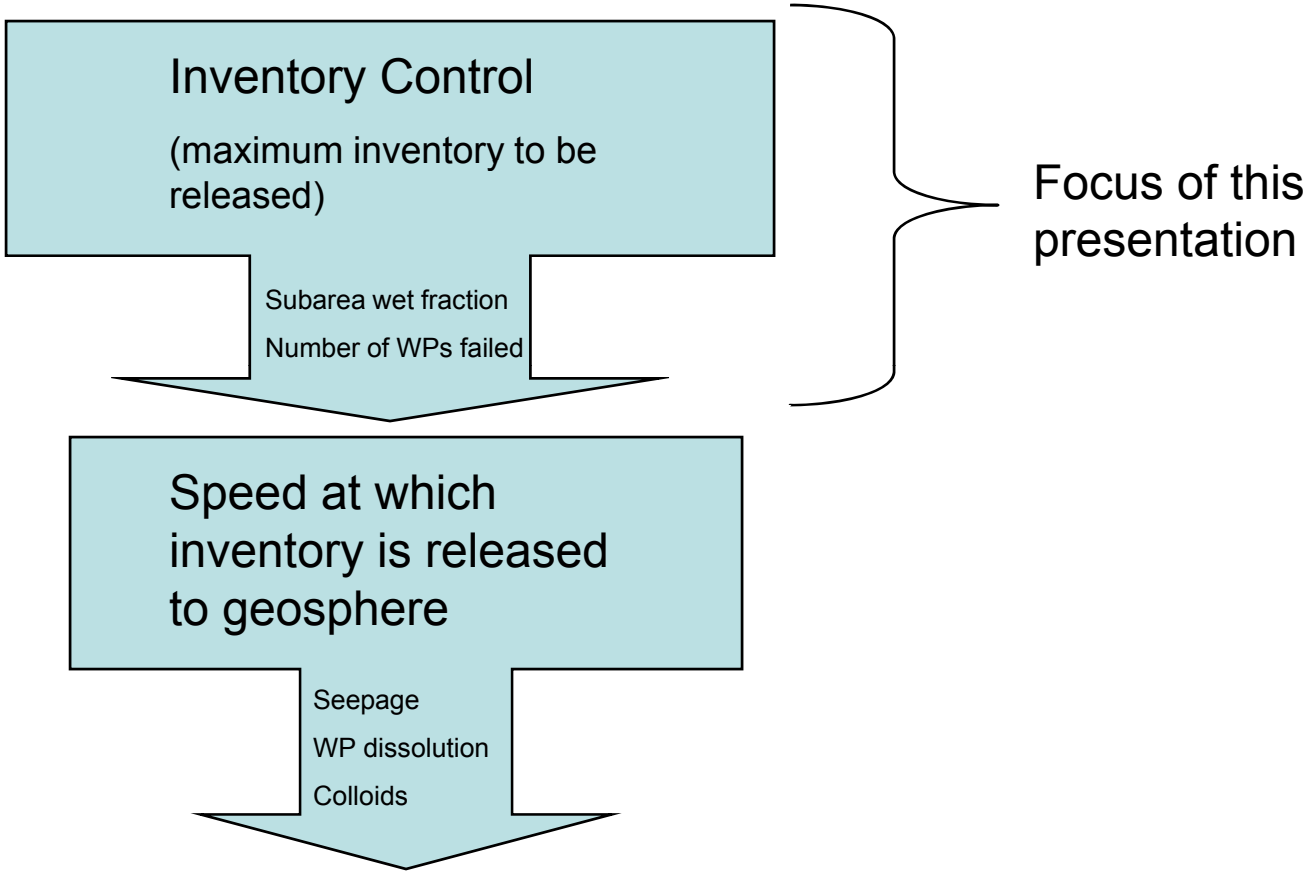
Recommendations on Drift Degradation Scenario

Osvaldo Pensado

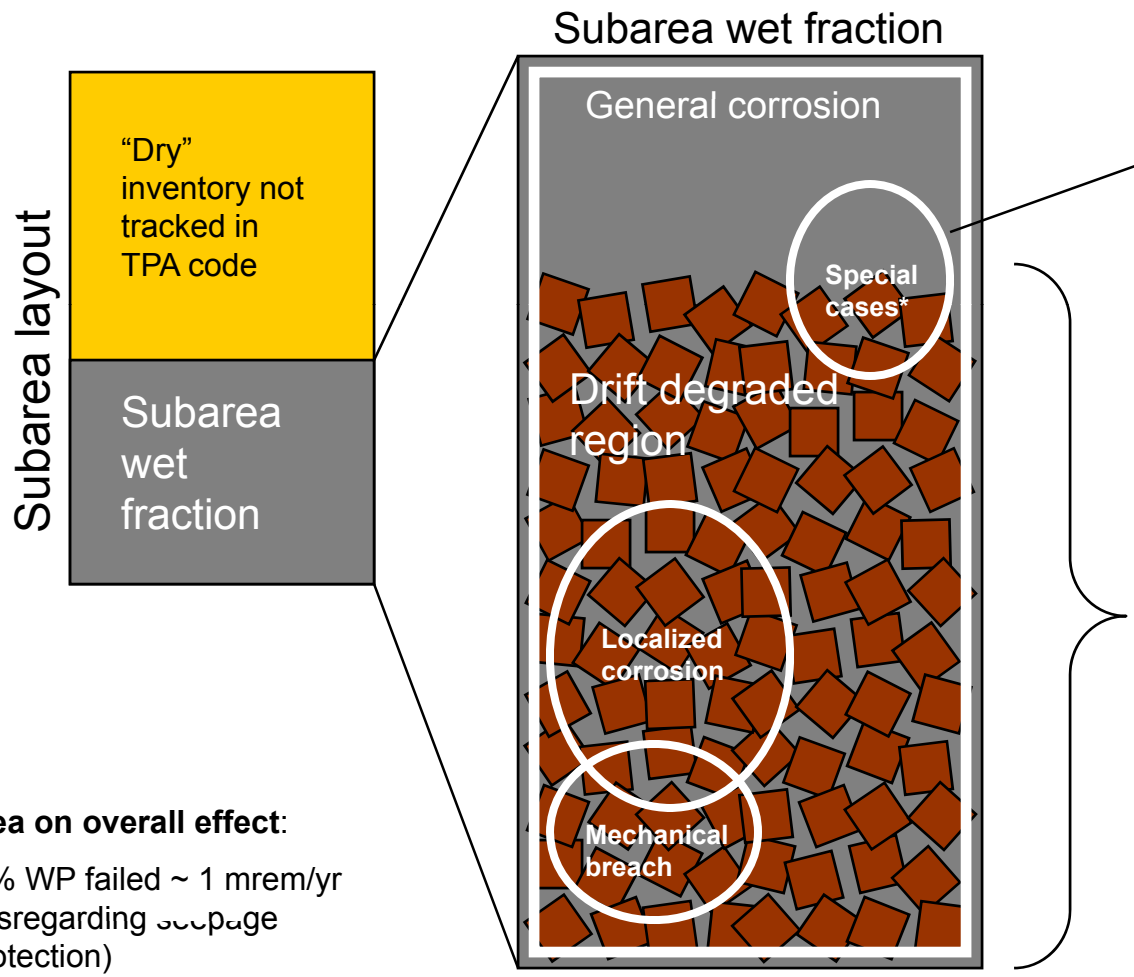
Contributors: J. Winterle, R. Rice, C. Grossman

November 7, 2006

TPA Code Approach



WP distribution by failure type in the subarea



Conservative to assume that the "special cases" set does not intercept the localized corrosion (LC) or mechanical breach sets

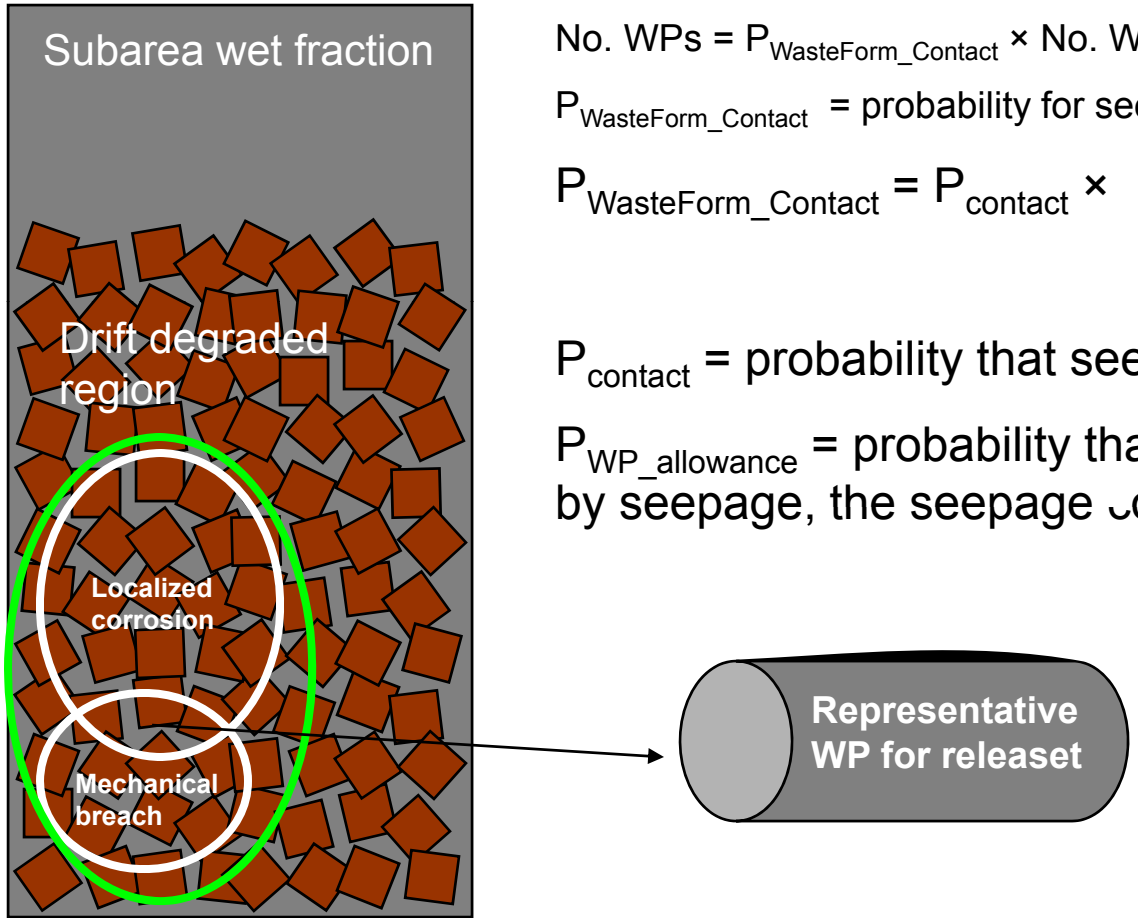
Originally, we considered that all WPs in the drift degraded region could experience localized corrosion or mechanical breaching. We want to move away from that representation.

Idea on overall effect:

1 % WP failed ~ 1 mrem/yr (disregarding seepage protection)

*Special cases: initially defective WPs, faulting, igneous

How many WPs can contribute to release?



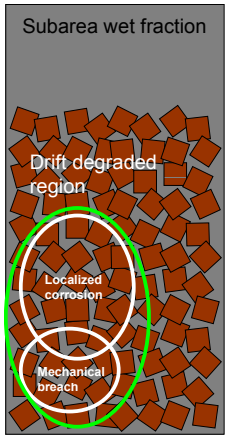
No. WPs = $P_{WasteForm_Contact}$ × No. WPs in subarea

$P_{WasteForm_Contact}$ = probability for seepage to contact waste forms

$$P_{WasteForm_Contact} = P_{contact} \times P_{WP_allowance}$$

$P_{contact}$ = probability that seepage contacts the WP

$P_{WP_allowance}$ = probability that, if the WP is contacted by seepage, the seepage contacts the waste forms



$P_{contact}$

$P_{contact}$ = probability that waste package is contacted by seepage

$P_{contact} = P_{Drift}\, P_{Rubble}\, P_{DSopening}\, P_{DSdrip_capture}$

P_{Drift} = fraction of drift colla¸ se alon¸ lon¸itudinal direction

~uniform[0.8, 1.0]

P_{Rubble} = probability for drip to go through rubble ~ 1.0

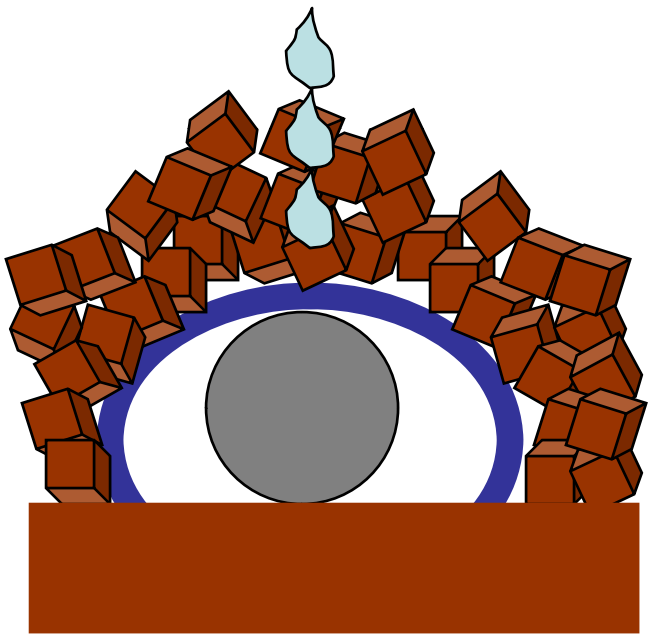
$P_{DSopening}$ = ¸ robabilit¸ for colla¸ se dri¸ shields to have o¸ enin¸s

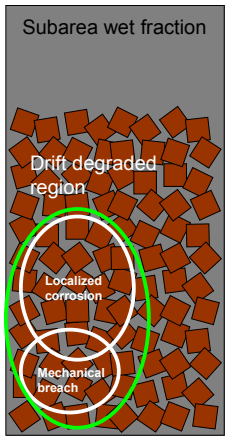
~1.0

$P_{DSdrip_capture}$ = probability for open drip shields to capture seepage

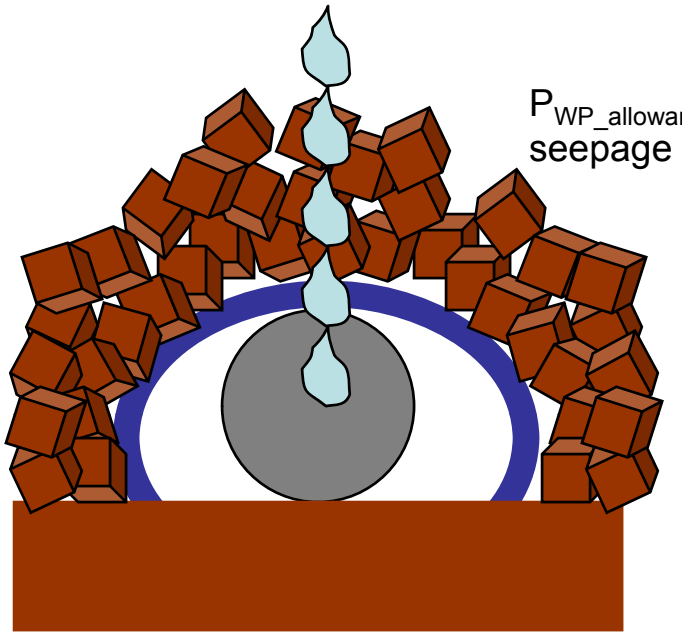
~ compromised or failed DS surface fraction

$P_{contact} \sim P_{Drift}\, P_{DSdrip_capture}$





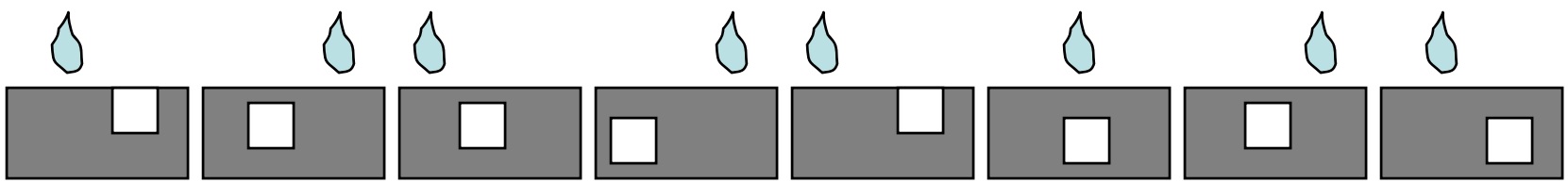
$P_{WP_allowance}$



$P_{WP_allowance}$ = probability that in WPs contacted by seepage, the seepage is captured by the failed WP area

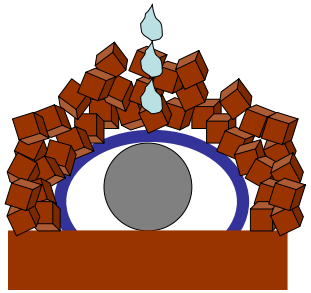
~ failed WP surface fraction

WP ensemble

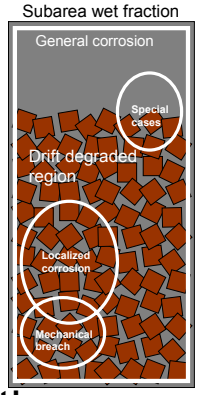


$P_{WP_allowance}$ is the probability that the seepage point is captured by the “window” on the waste package

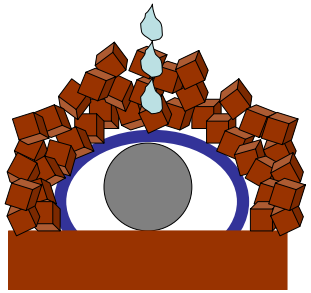
$P_{WP_allowance}$ should be function of the “window size”



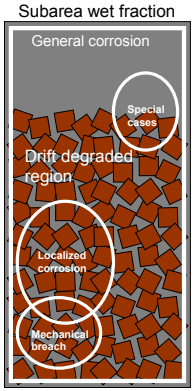
Notes on $P_{contact}$



- $P_{contact}$ = probability that waste package is contacted by seepage
- Should be a function of the failed DS surface fraction. This surface fraction is a function of time!
- Three value kinds of $P_{contact}$:
  - Initial defects, general corrosion, faulting, igneous WPs
    - Suggest $P_{contact}$=1
    - WPs could be located on a degraded drift or on a “pristine” drift. In the later case, those WPs could release radionuclides when DS fail by general corrosion. Not worth differentiating between WPs located on drift degraded or undegraded areas.
  - Localized corrosion
    - Compute as $P_{contact} = P_{Drift}\ P_{DSdrip_capture}$ (slide 1)
    - Uncertainty in $P_{contact}$ must account for the fact that $P_{DSdrip_capture}$ is a function of time. However, LC can only happen during the thermal pulse (past the thermal pulse there is no more LC WP failure). Need to account for size of DS opening during thermal pulse.
    - Propose $P_{DSdrip_capture}$ ~ initially compromised DS surface fraction by mechanical breaching

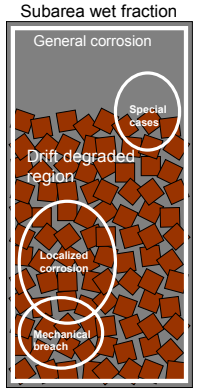


Notes on $P_{contact}$

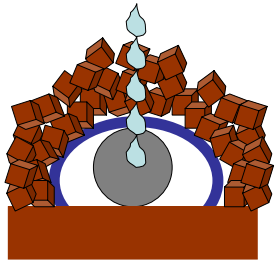


- Three value kinds of $P_{contact}$ (continued):
  - Mechanically breached WPs
    - Drip shields eventually fail by general corrosion, at that time, the probability that seepage may contact the waste packages is high (close to 100%)
    - Suggest $P_{DSdrip_capture}$ ~ uniform[0, 1] or Uniform[0.8, 1]

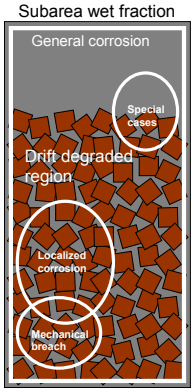
Notes on $P_{WP_allowance}$



- General corrosion, faulting, igneous
  - $P_{WP_allowance} = 1$
- Initially defective WPs
  - Could use $P_{WP_allowance}$ ~ fraction of initially compromised surface
  - Initially defective WPs could exhibit localized corrosion, mechanical breach, and general corrosion eventually; thus, good idea to use high value of $P_{WP_allowance}$
  - Small number of WPs already, with more decrease we will soon end with less than 1 WP failed in the entire repository
  - Conservative to use a high bound distribution ~ uniform[0.8, 1]
- Localized corrosion
  - Could be WP weld only, WP body only, or combination
  - Could use combined compromised WP surface to define $P_{WP_allowance}$
  - However, spatial location of seepage point is likely to coincide with failed surface, thus, suggest using $P_{WP_allowance}$ ~ uniform[0.8, 1]
  - Also failed area may grow with time and, eventually, all WPs fail by general corrosion
  - Good idea to use a high value of $P_{WP_allowance}$



Notes on $P_{WP_allowance}$ (cont'd)

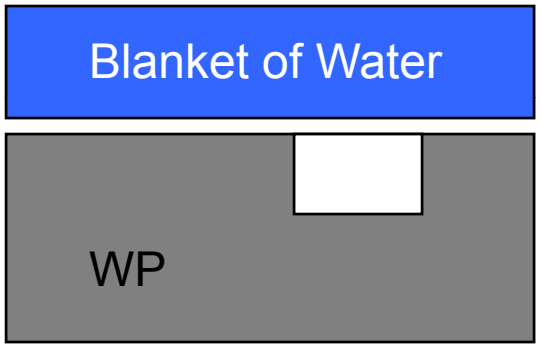


- Mechanically breached WPs
  - $P_{WP_allowance}$ ~ initially breached WP surface fraction
  - Mechanically breached WPs could also exhibit localized corrosion; however, breach tends to occur later in time when LC is not longer possible. Propose to ignore additional contribution to probability by localized corrosion, or slightly overestimate $P_{WP_allowance}$
  - Recall that we assume that mechanical breach can only occur in the first ~200,000 years (not sufficient time for WPs to fail by general corrosion)

Caveat on See¸ a˘e Factors

- Need to use carefully, to avoid double counting

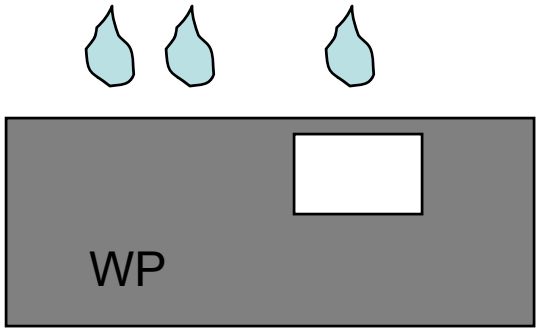
Old paradigm



Water available for release ~ proportional to compromised surface (size of window on WP).

All WPs get <u>some</u> water.

New paradigm



Water available for release is likely high fraction of **seepage points** contacting the WP. No significant reduction in seepage should occur.

<u>Some</u> WPs get water, but at higher rates than in the old paradigm

Concrete Proposal

	$P_{contact}$	$P_{WP_allowance}$
General corrosion, faulting, igneous	1	1
Initially defective	1	Uniform[0.8, 1]
Mechanical breach	P_{Drift} $P_{DSdrip_capture}$ = Uniform[0.8, 1] × Uniform[0.8, 1]	Initially breached WP surface fraction
Localized corrosion	P_{Drift} $P_{DSdrip_capture}$ = Uniform[0.8, 1] × Fraction of initially breached DS surface	Uniform[0.8, 1]

Insert 8 new parameters: 2 probabilities × 4 failure modes.

Combine general corrosion, faulting, igneous into one failure mode.

Compute the number of WPs contributing to release as

$$P_{contact} \times P_{WP_allowance} \times \text{No. WPs in subarea}$$

Idea on overall effect:

1 % WP failed ~ 1 mrem/yr (disregarding seepage protection)

Parameter	Distribution	Justification
Probability Parameters		
Probability_WPWaterContact_GC-Flt-Ig	1.0	Drip shield eventually fails by general corrosion (mean failure time ~ 30,000 years). High probability that compromised WPs will be eventually contacted by water.
Probability_WPWaterAllowance_GC-Flt-Ig	1.0	Assume extensive damage on WP by general corrosion, faulting, or igneous events
Probability_WPWaterContact_InitialDefects	1.0	Drip shield eventually fails by general corrosion (mean failure time ~ 30,000 years). High probability that compromised WPs will be eventually contacted by water.
Probability_WPWaterAllowance_InitialDefects	loguniform 10^{-3}, 0.1	Initially defective WPs can be affected by localized corrosion and mechanical damage. Thus, it is proposed to compute $P_{allowance}$ as a weighted average of the allowance values for LC and mechanically damages WPs. [1] Probability_WPWaterAllowance_InitialDefects = (1 – probability of LC – probability of mechanical failure) ε + (probability of LC) Probability_WPWaterAllowance_LC + (probability of mechanical failure) Probability_WPWaterAllowance_MechFail [2] probability of LC ~ 0.3 × Probability_WPWaterAllowance_LC × Probability_WPWaterContact_LC [3] probability of mechanical failure ~ 0.1 × Probability_WPWaterAllowance_MechFail × Probability_WPWaterContact_MechFail If ε = uniform(10^{-3}, 10^{-2}), then Eq. [1] spans from approximately from 10^{-3} to 0.1. The distribution for Probability_WPWaterAllowance_InitialDefects is a log-distribution. To keep consistency with other Probability distributions a loguniform distribution is proposed (to avoid implying that detailed information is available).
Probability_WPWaterContact_MechFail	1.0	Drip shield eventually fails by general corrosion (mean failure time ~ 30,000 years). High probability that compromised WPs will be eventually contacted by water.

Probability_WPWaterAllowance_MechFail	loguniform 10^{-3}, 1.0	ContactLengthSubarea_1[m]=normal{0.192, 0.808} Assume a 0.15-m flange and 5 ribs on the DS (all of them assumed to contact the WP). Thus, the total contact area is ~ {0.0288, 0.1212} m^2. Projected WP surface: (WPLength[m]=5.165; WPDiameter[m]=1.659) = 8.56874 m^2 Damaged fraction: {0.0168053, 0.0707222} The damaged fraction may be overestimated. On the other hand, it can be argued that seepage could run along the WP causing higher seepage capture. It is reasonable to lower the low bound by a factor of 10 and increase the upper bound by a factor of 10, and assume a log-uniform distribution. WPs could open with time, making more inventory available for release (there is a chance that WPs could open up with later seismic events increasing the size of the WP damaged area, and increase the "allowance" probability). Thus, an upper bound of 1 is reasonable.

Probability_WPWaterContact_LC	loguniform 10^{-4}, 10^{-2}	**Damaged DS surface** Assumed damage area on drip shield ~ 0.5 m^2 (strip 0.5-m wide and 1-m long) Projected DS surface: 2.75 m × 5.165 m = 14.2 m^2 Damaged projected fraction ~ 0.5/14 = 0.03 ~ 0.01 If the damaged area on the drip shield is in the form of cracks, then a 0.01 fraction is clearly an overestimation. **Probability that seepage will land on crevice areas appropriate for LC, p_c** Approximately 0.01 of the total surface is comprised of welds. There is a 3% probability that localized corrosion will happen on the body and welded areas. There is a 23% probability that LC will occur on welded areas only. If p is the probability that seepage lands in crevices, then the probability that seeps land on crevices with welds is 0.01 p, and on crevices without welds (1−0.01) p. p_c can be computed as a weighted average: $p_c = (0.23/0.26)\ 0.01\ p + (0.03/0.26)\ (1-0.01)\ p = 0.12\ p \sim 0.1\ p$ Multiplying the damaged DS surface times p_c: Probability_WPWaterContact_LC = 0.001 p It is reasonable to assume Probability_WPWaterContact_LC ~ loguniform[10^{-4}, 10^{-2}] The low end derives from assuming p=0.1. The upper recognizes that the drip shield could capture a higher proportion of seepage than the dictated by the damaged DS surface fraction. It is reasonable to emphasize lower values of the distribution; thus the selection of a log-distribution. Mean(loguniform[10^{-4}, 10^{-2}]) = 0.002 Interpretation: if drip shields collapse, only 2/1000 WPs will be contacted by seepage with the potential to induce localized corrosion.
Probability_WPWaterAllowance_LC	1.0	If localized corrosion occurs, it is because seepage contacts appropriate crevice regions. Thus, there is a high chance that such water may infiltrate the WP.
Seepage Factors		

InitialSeepageReductionFractionByMechFailedDS	Uniform 0.01, 0.1	Assumed damage area on drip shield ~ 0.5 m^2 (strip 0.5-m wide and 1-m long) Projected DS surface: 2.75 m × 5.165 m = 14.2 m^2 Damaged projected fraction ~ 0.5/14 = 0.03 Assume 5 seepage points impinging on the DS, fixed in space. Then, the probability that one of the seepage points will coincide with the opening on the DS is 5 × 0.03 ~ 0.1 A factor of 10 decrease, due to an smaller DS damaged area (likely to be in the form of cracks) is a reasonable assumption for a low bound on the distribution. It is considered that 0.1 upper bound value may be overestimated given that the damaged area on the DS may be much smaller. Probably assuming 5 seepage points per DS is also an overestimation. Mean(uniform[0.01, 0.1]) = 0.05 **Interpretation**: only 5 percent of the seepage impinging on damaged drip shields, infiltrates those.
DSSeepageProtectionDegradationRate[1/yr]	0.0	This parameters was proposed to allow for openings on the DS to grow (linearly) in time, capturing more and more seepage as time elapses. There is no information to propose a value for the degradation rate. This parameter is not too important if the parameter InitialSeepageReductionFractionByMechFailedDS is relatively large. Also, eventually the DS fails by general corrosion; at that time, it is assumed that 100% of the seepage infiltrates the DS. Thus, this parameter is not relevant for long-term simulations.
InitialSeepageReductionFractionByMechFailedWP	loguniform 0.01, 1.0	The breached DS area may be close to the breached area on the WP. As an extreme case, it is considered that all of the seepage impinging on the WP, infiltrates the WP (although this scenario appears unlikely). Since a correlation could exist between the impinging point of seepage on the WP and the location of the breached area on the WP, geometrical arguments to estimate parameter InitialSeepageReductionFractionByMechFailedWP are of limited value. A 0.01 and 1 bound values are (arbitrarily) assumed. A log-distribution is proposed, since it is considered that low-values are more likely than high values.

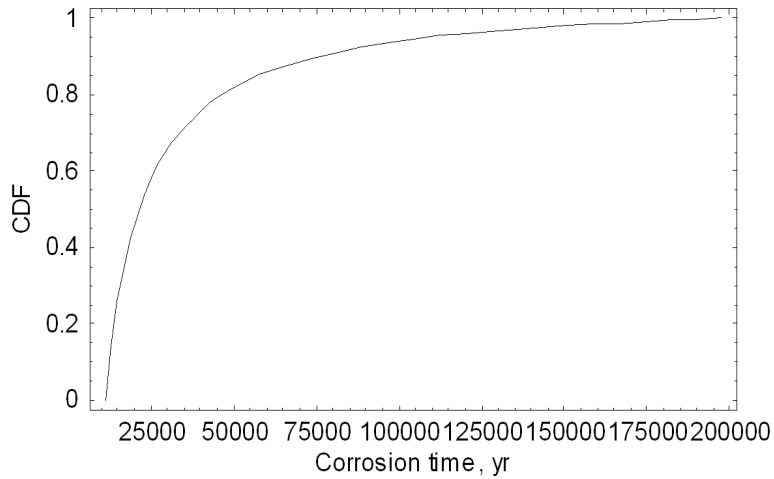
WPSeepageProtectionDegradationRate[1/yr]	0.0	This parameter is not important if InitialSeepageReductionFractionByMechFailedWP is sampled at high values. It is not clear the mechanism for which a mechanically breached WP could further open the WP as a function of time. Probably seismic events could lead to further opening, but it unknown the frequency of those events (are events with a recurrence rate of 10^{-3}/yr or higher sufficient to induce opening of initial fractures?). If we assume that only 10^{-4}/yr events could further open mechanically damaged waste packages; then, the following distributions could be used: 1 later event to induce complete opening: lognormal(4.2×10^{-6}, 0.006) 1/yr 2 later events for complete opening: lognormal(5.8×10^{-6}, 0.00066) 1/yr 3 later events for complete opening: lognormal(5.86×10^{-6}, 0.00025) 1/yr 4 later events for complete opening: lognormal(5.57×10^{-6}, 0.00014) 1/yr Mechanisms for gradual opening are entirely hypothetical. A zero value for the degradation rate is recommended.
InitialSeepageReductionFractionLC	loguniform 0.001, 0.1	It is uncertain the fraction of the seepage infiltrating the WP to the impinging on the WP. However, it appears that the fraction should be small, because of the following observations: 1) Localized corrosion is in the form of crevice corrosion. Crevices must be tight for crevice corrosion to propagate (opening of crevices causes arrest of localized corrosion). If crevices are tight, water will not flow freely but rather diffuse into the crevice area. 2) Pits in the crevice area are a few microns in diameter, and full with corrosion products, further restricting the flow of water. For those reasons, it is reasonable to assume that the infiltrated seepage is a small fraction (1/1000 or greater) of the seepage impinging on the waste package. It is not recommended to make the fraction smaller than 1/1000 as the advective release model implemented in the TPA code may cease to be meaningful (the advective release model is an appropriate description in the limit when there is a significant flow in and out of the WP). The upper bound of 0.1 is selected as a reasonable value. A log-distribution is proposed because it is considered that lower values are more likely.

WeldAdvectiveFraction[] **to be renamed as** InitialSeepageReductionFractionWeldLC	loguniform 0.001, 0.1	Propose to use the same distribution as InitialSeepageReductionFractionLC
InitialSeepageReductionFractionInitiallyDefWP	loguniform 0.001, 0.1	Propose to use the same distribution as InitialSeepageReductionFractionLC
InitialDefWPSeepageProtectionDegradationRate[1/yr]	0.0	Parameter added to enhance flexibility, defaulted at 0.0. No clear mechanism is envisioned by which initially defective WPs may open as time elapses.
Waste Form Dissolution		
FractionOfWPsWithDiffusionTilt[]	0.0	The net effect of this parameter is to eliminate diffusion from release computations.

WaterContactMode_Initial(0=BathTub,1=FlowThrough) WaterContactMode_Faulting(0=BathTub,1=FlowThrough) WaterContactMode_Volcanic(0=BathTub,1=FlowThrough) WaterContactMode_SeismicInterval1(0=BathTub,1=FlowThrough) WaterContactMode_SeismicInterval2(0=BathTub,1=FlowThrough) WaterContactMode_SeismicInterval3(0=BathTub,1=FlowThrough) WaterContactMode_SeismicInterval4(0=BathTub,1=FlowThrough) WaterContactMode_Corrosion(0=BathTub,1=FlowThrough)	1	Set flow-through as default water contact mode. Flow-through produces earlier releases of radionuclides in solution and in colloidal form compared to bathtub. In bathtub, advective and colloidal releases only occur after the bathtub overflow. Probably earlier releases could occur in the form of diffusion; however, existing diffusion model in TPA was not designed to address that scenario (existing model may overestimate diffusive releases). It is recommended to default the water contact mode to flow-through.

SFWettedFraction_Initial_X X=1, 2, ..., 10	loguniform 0.001, 0.1	Propose to use the same distribution as InitialSeepageReductionFractionInitiallyDefWP. **Propose using a rank correlation coefficient equal to 0.7**. The justification is that if seepage is significantly decreased, then only a small fraction of the waste form will be contacted by seepage. T. McCartin proposed to increase the SFWettedFraction when general corrosion fails WPs. This increase is not relevant, as the general corrosion WP source will shadow any previous releases. Thus, it is proposed to preserve the current approach of constant SFWettedFraction value. In the TPA code, the set of initially defective WPs is treated as a disjoint set of the LC WPs or mech WPs. Such an approach is conservative. Thus, there is no need to consider the scenario where initially defective WPs could also experience LC or mechanical breaching.
SFWettedFraction_FAULTO	uniform 0.0, 1.0	No change with respect to previous TPA code versions.
SFWettedFraction_VOLCANO	uniform 0.0, 1.0	No change with respect to previous TPA code versions.
SFWettedFraction_SEISMO1_X SFWettedFraction_SEISMO2_X X=1, 2, ..., 10	loguniform 0.01, 1	Propose to use the same distribution as InitialSeepageReductionFractionByMechFailedWP. Propose using a rank **correlation coefficient equal to 0.7.** The justification is that if seepage is significantly decreased, then only a small fraction of the waste form will be contacted by seepage. T. McCartin proposed to increase the SFWettedFraction when general corrosion fails WPs. This increase is not relevant, as the general corrosion WP source will shadow any previous releases. Thus, it is proposed to preserve the current approach of constant SFWettedFraction value. Mechanically failed WPs could also experience localized corrosion at earlier times than the time of mechanical breaching. Increases due to WP localized corrosion on the SFWettedFraction are negligible, because the probability that a WP is mechanically breached and also affected by localized corrosion and also capture water to mobilize the waste form is negligible.

SFWettedFraction_SEISMO3_X X=1, 2, ..., 10	uniform 0, 1	This parameter is not used. Consider removing.
SFWettedFraction_SEISMO4_X X=1, 2, ..., 10 To be renamed as SFWettedFraction_LC_X	loguniform 0.001, 0.1	Propose to use the same distribution as InitialSeepageReductionFractionLC. **Propose using a rank correlation coefficient equal to 0.7.** The justification is that if seepage is significantly decreased, then only a small fraction of the waste form will be contacted by seepage. T. McCartin proposed to increase the SFWettedFraction when general corrosion fails WPs. This increase is not relevant, as the general corrosion WP source will shadow any previous releases. Thus, it is proposed to preserve the current approach of constant SFWettedFraction value.
SFWettedFraction_Corrosion_X X=1, 2, ..., 10	uniform 0.0, 1.0	No change with respect to previous TPA code versions. This parameter will be applied to waste packages failed by general corrosion.
FuelRodHalfLength[m]	0.0	Value selected to allow for instantaneous unzipping. Alternatively, CladdingVelocityEnhancementFactor[] = 10^6. O. Pensado proposed to modify the cladding model to allow for gradual exposure of the WF. However, it is not clear the meaning of such a gradual exposure (the same exposure parameters would be used for all of the WP failure modes). Therefore, it is recommended to leave the cladding model as is, but make FuelRodHalfLength[m]=0.0 to allow for instantaneous unzipping (no credit for gradual exposure of the waste form).
FractionOfWPsWithDiffusionTilt[]	0.0	Setting this parameter as 0 causes de-activation of diffusive releases. The diffusion model, and its parameters, should be re-evaluated if activated.

Remove old parameters		Remove the following block from tpa.inp as it could cause confusion. Interval 4 is now used for localized corrosion. iconstant NumberOfSEISMOWPFailureIntervals 4 constant BeginningOfSEISMOWPFailureInterval1[yr] 0.0 constant BeginningOfSEISMOWPFailureInterval2[yr] 2000.0 constant BeginningOfSEISMOWPFailureInterval3[yr] 5000.0 constant BeginningOfSEISMOWPFailureInterval4[yr] 10000.0
Miscellaneous		
DefectiveFractionOfWPs/cell	loguniform 10^{-4}, 10^{-2}	Distribution in TPA 4.0: uniform[10^{-4}, 10^{-2}] . No clear justification on the distribution selection is available. Selection of "uniform" was arbitrary. The probability of the presence of waste packages sufficiently defective to allow immediate release as soon as contacted by water should be small given inspection procedures in place. Recommend replacing uniform by loguniform.
DripShieldCorrosionRate[m/yr]	uniform 7.6×10^{-8}, 1.32×10^{-6}	 Minimum: 11,400 years Maximum: 197,000 years Mean: 34,400 years

		Notes by X. He: Corrosion rates in the range of 4.3E-8 and 8.6E-8 m/yr are reported in CNWRA 2001-03 (Figure 4-7 and 4-9). Corrosion rates decreased with time. Blackwood et al. (1988) reported a maximum rate of 10-20E-6 m/yr for a pH = 1 acidified solution and < 1-2E-6 m/yr for pH ~ 2 solution. It is very unlikely to get solution with such low pH in Yucca Mountain Repository; thus, these data are ignored. In Metal's handbook, 9th Edition, Volume 13, the reported titanium grade 7 general corrosion rates in 62% CaCl2 at 150°C, 10% and 30% FeCl3, and saturated MgCl2 boiling solutions are nil (pp. 705-706). These solutions are very aggressive. DOE data including titanium grades 7 and 16 (General and Localized Corrosion of the Drip Shield. Rev. 2, 2004): 3.8E-8 m/yr to 3.2E-7 m/yr. For titanium grade 7 the corrosion rate is 3.8E-8 m/yr to 5.0E-8 m/yr Hua and Gordon (2004) reported the corrosion rate of titanium Grade 7 in BSW-12 at 60°C to 105 °C is 2.03E-7 to 6.6E-7 m/yr. For titanium grade 24/29 supports, Schutz (2003) reported that the general corrosion rate is 4-5 times of that of titanium grade 7. German data for titanium Grade 7 after 3.5 yrs exposure to Q-brine 90°C - 6E-8 m/yr 170°C - 4E-8 m/yr 200°C - 1.5E-7 m/yr Thus, based on the data in the literature, corrosion rate bounds of 3.8×10^{-8} and 6.6×10^{-7} m/yr were selected. Because corrosion happens in the underside of the drip shield, these bounds were multiplied by 2 and a uniform distribution was selected. An alternative is considering that the under and above drip shield corrosion rates are independent. The addition of two uniform distributions results in a triangular distribution: triangular[$2\times3.8\times10^{-8}$, $(66+3.8)\times10^{-8}$, $2\times6.6\times10^{-7}$] m/yr. The DS failure time for this distribution has a mean value of 26,000 years. Because selection of longer DS lifetimes is conservative with respect to mechanical breaching of the WP, a uniform distribution for the corrosion rate is preferred over a triangular distribution. **References**:

		Bechtel SAIC. General and Localized Corrosion of the Drip Shield. Rev. 2, 2004 Blackwood, D.J., L.M. Peter, and D.E. Williams. “Stability and Open Circuit Breakdown of the Passive Oxide Film on Titanium.” Electrochimica Acta, 33, pp. 1143-1149. 1988. Hua, F. and G. Gordon. “Corrosion Behavior of Alloy 22 and Ti Grade 7 in a Nuclear Waste Repository Environment.” Corrosion, Vol. 60. pp. 764-777. 2004. Schutz, R.W. “Platinum Group Metal Additions to Titanium: a Highly Effective Strategy for Enhancing Corrosion Resistance.” Corrosion. Vol. 59. pp. 1043-1057. 2003.