PORTLAND HARBOR SUPERFUND SITE DISCOUNTED SERVICE ACRE YEARS (DSAYS)

John Marshall / March 20, 2023

Calculation Logic Review and Testing

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Habitat Evaluation Procedure (HEP)/Habitat Equivalency Analysis (HEA)

Habitat Evaluation Procedure (HEP) is a methodology developed by the U.S. Fish and Wildlife Service (USFWS) to evaluate a habitat suitability index (HSI) ranging from 0 to 1.0 (0 means no habitat value and 1.0 means a full properly functioning habitat condition) using specific key habitat characteristics necessary to support the life-cycle requirements of selected habitat indicator species (Raleigh, R.F., W.J. Miller, P.C. Nelson 1986). While HEP generally selects several key indicator species, collectively considered as a habitat guild, apparently in the case of the Portland Harbor Superfund Site, only one habitat indicator species was used, Chinook Salmon (Figure 1) to calculate mitigation banking credits and debits.

Figure 1. Juvenile Chinook Salmon.

Figure 2 provides examples of how different variables[1] can be used collectively in estimating a habitat's final evaluated habitat score in the field. These habitat evaluations can be done both pre-disturbance and post disturbance and then the differences can be used to gauge the magnitude of the disturbance and to help quantify the amount of recovery needed for the habitat to be in a full properly functioning condition again. Likewise, these habitat suitability index models can also be applied both pre-restoration and post restoration at restoration and / or mitigation projects in order to help quantify the recovery goals and objectives and later during subsequent monitoring to help judge recovery successes vs failures.

[1] These variable graphs should not be interpreted as direct measures of habitat function but rather as key surrogate indicators of habitat function.

HEP evaluations can also be used in creating a currency for mitigation and conservation banking transactions in the form of credits (generated by restoration actions) sold to off-set the impacts of debits (generated by adverse impacts to habitat). At the Portland Harbor Superfund Site, a variation of HEP was initially planned to be merged with another habitat evaluation methodology developed by the National Oceanic and Atmospheric Administration (NOAA) called Habitat Equivalency Analysis (HEA). HEA is a service-to-service based scaling method to

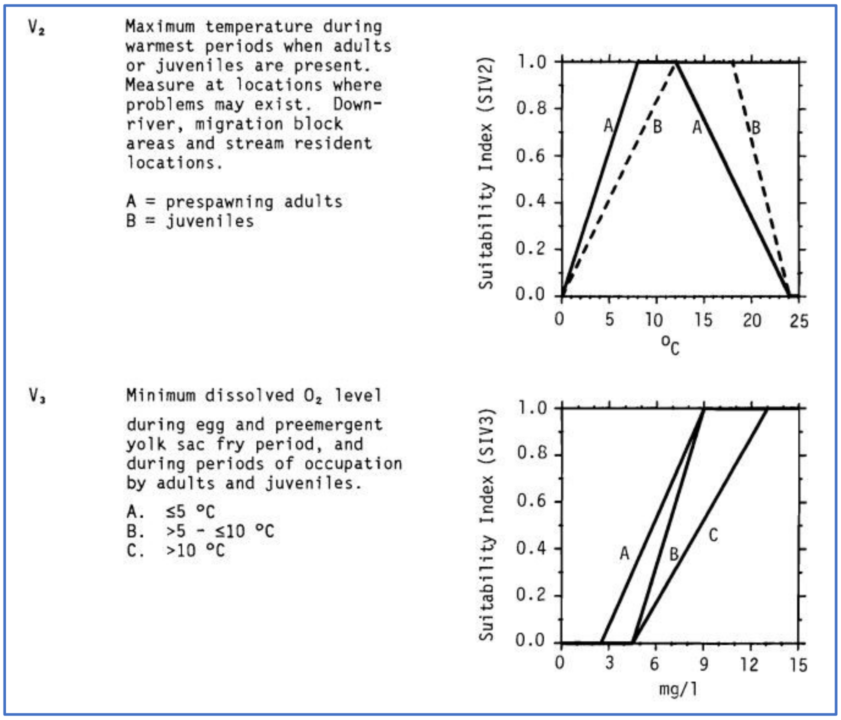


Figure 2. Habitat Evaluation Procedure (HEP) Habitat Suitability Index Graphs.

calculate the amount of restoration necessary to off-set or compensate habitat damages from hazardous substances. It initially employs a HEP or '*HEP like*' habitat ranking scale, but instead of just comparing pre and post disturbance and / or restoration conditions, it also recognizes habitat remediation is rarely if ever instantaneous. Rather it is generally a continuous and gradual process over time. To account for the loss of functional habitat during the recovery period and for the potential risks associated with a successful recovery outcome, HEA uses an amortization technique to track the rate and amount of recovery over given time periods. This methodology also inherently invokes a time loss interest penalty (TLIP) that automatically calculates additional remediation debits that will require credits to be generated in order to help off-set the period of time when habitat functional services are effectively unavailable to the key indicator species (NOAA 2006).

Discounted Service Acre Years (DSAYs)

HEA is currently being used by the Portland Harbor Superfund mitigation and conservation banks (banks) to help offset habitat impacts from decades of dumping of hazardous materials

Table 1. Relative Chinook Salmon Lower Willamette Habitat Values

Habitat	Habitat Characteristics	Function Hab. Val	Yrs Until Full Function
Upland	forested, in hist. floodplain, >200 ft from ACM*	0.65	50
	forested, outside historic floodplain	0.15	40 (80% in 10 yrs)
	vegetated, grass/shrub outside floodplain	0.1	5
	vegetated, invasive spp. outside floodplain	0.05	--
	forested along tributary into Willamette	0.15	40
	forested and part of the historic floodplain	0.3	40
	vegetated, grass/shrub in historic floodplain	0.2	5
	vegetated, invasive spp in historic floodplain	0.1	--
	unvegetated/paved/buildings	0	--
Riparian	naturally vegetated forest, <200 ft from ACM	0.5	40** (80% in 10 yrs)
	and in the historic floodplain	0.65	50
	naturally vegetated, grass/shrub	0.2	5
	and associated with historic flood plain	0.35	5
	invasive species	0.1	3
Active channel margin	Sloped (<5:1 or 11°), unarmored and vegetated	1	3
	Sloped (>5:1 or 11°), unarmored and vegetated	0.2	3
	sloped (<5:1), unarmored and unvegetated	0.8	3
	sloped (<5:1), bio-engineered	0.4	3
	sloped (>5:1), bio-engineered	0.2	3
	riprapped	0.1	1
	sheetpile	0	--
	pilings (1 per 100 sq ft)	half value of margin type	
	covered structures over channel margins	max of 0.1	--
Main Channel	shallow water, gravel and finer substrates	1	1
	shallow water, natural rock outcrop	1	1
	shallow water with riprap or concrete	0.1	1
	shallow water with covering structures	0.1	--
	shallow water with pilings (1 per 100 sq ft)	0.5	1
	deep water with natural substrates	0.1	1
	deep water with artificial substrates	0.05	1
Off Channel	"Cold" water tributary	1	1
	"Warm" water tributary	0.9	1
	side channel	1	1
	alcove or slough with tributary	1	1
	alcove or slough without tributary	0.8	1
	embayment (cove) with tributary	1	1
	embayment (cove) without tributary	0.8***	1

*--ACM = Active Channel Margin
**--this time adequate for juvenile chinook because of flood protection.
***--around 0.6 further upstream

Figure 3. Delphi Determined Functional Habitat Values.

generally in the area between River Mile-1 and River Mile-12 on the Willamette River. The credits and debits these banks are using are measured in discounted-service-acre-years (DSAYs). One DSAY represents the habitat value of ecosystem services provided by one acre of fully functioning habitat for one year.

Functional Habitat Value Scale and Portland Harbor Superfund Site Years to Full Function (1, 3, 5, 10, 30, 40, 50, 100, 300)[2]

The bank HEA applications deviated from the HEP model informed habitat ranking and instead used a best professional judgement process conducted collectively by a select committee of experts who systematically ranked an inventory of habitat types associated with use by Chinook salmon during their migrations through the Portland Harbor (Trustee Council 2009). This technique, commonly known as a Delphi method, is used relatively frequently by natural resource regulators and managers when developing regulatory tools. The select committee also provided habitat element associated time frames they considered reasonable for achieving a full state of recovery (Figure 3).

Delta HEA vs Annual Return Dividend for Calculating DSAYs

To better understand how the banks calculated their respective DSAY allotments, I employed an Excel spreadsheet (Figure 4) to enter data extracted from the Mitigation Bank Prospectus for Linnton Mill, one of the banks,[3] and information and data from various other related documents found in both text and tables. Using the spreadsheet allowed me to reproduce the DSAY amounts derived for the bank as shown in the Prospectus. A pivotal operation necessary to calculate DSAYs requires finding the differences between the post-disturbance

DSAYs - Discounted-Service-Acre-Years
A – Habitat Acres
TRS – Total Recovered Services Value Score
DS – Damaged Services Value Score
ARS – Annual Recovered Services Value Score
DR – Discount Rate aka Recovery Rate
PV – Present Value
PV_1 = (TRS – DS) / DR (Logic Alternative Now Used by Banks)
PV_2 = (ARS – DS) / DR (Logic Alternative Suggested for Use by Banks)
DSAYs = PV x A x 1-year

Figure 4. Delta HEA/Discount Rate vs Annual Return/Discount Rate DSAYs.

HEA habitat scores and the anticipated full habitat recovery scores for each of the stratified habitat types (Cowardin, L.M.,V. Carter, F.C. Golet, E.T. LaRoe 1979), termed here as delta

[2] Time periods in black are provided by Trustee Council and time periods in red were added by the author to assist in broadening the perspective of the overall analysis.
[3] Determining how HEA DSAYs have been derived at the Portland Harbor mitigation and restoration banks has entailed a great deal of detective work involving formal agency information requests, reading through multiple documents, and generally patching together a method interpreted from multiple disparate sources.

HEA. Delta HEA was then divided by a HEA discount rate of about 3%. These results were then multiplied by their respective acreages and totaled to find the final amount of ~ 318 DSAYs (PV_1 in Figure 4, top table Figure 5, and Figure 7). This number of DSAYs is over 26 times greater than the 12-acres purportedly supporting them. Logic seemed to suggest that if the range of DSAY value is between 0 and 1, and if all 12 acres were fully functioning, then the most the present value (PV) could possibly be is: 12 x 1 = 12 DSAYs. My work with conservation easement endowments allowed me to recognize that the arithmetic used to calculate Portland Harbor mitigation bank DSAYs was very similar to capitalization operations that divide annual rates of return by the accepted discount rates to find present values. I tried using annual rates of return instead of delta HEA as a dividend in the spreadsheet and found it yielded about 10 DSAYs (PV_2 in Figure 4, bottom table in Figure 5, and Figure 6). This appeared to me to be a more justifiable result for DSAY present value than the results provided by the Portland Harbor mitigation bank sponsors and the Trustee Council.

At this point, I requested clarification from NOAA chair of the Trustee Council regarding the logic behind the arithmetic discussed above. They declined to provide it at the time I asked for it and they denied my request to speak to the NOAA HEA expert on this topic. To-date and to the best of my knowledge, while there have been several general conversations and one general semi-formal presentation, there have been no specific responses targeting my request for a clarification of NOAA's explanation on why they use delta HEA instead of annual return as dividends for their present value DSAY calculations.

My takeaway from these general responses was that the Portland Harbor mitigation bank sponsors may believe their mitigation bank restoration actions should be rewarded as if they constitute some sort of semi-perpetuity ecosystem service credit factory that reaches fully functioning condition in one year and then begins adding function at a rate of 100% / year for each subsequent year over a time period of about 30-years. At first glance this logic may seem somehow plausible. After all if we debit against time periods from which habitat function is lost, why shouldn't we credit habitat function for time periods after it is regained?

A closer evaluation should however consider that our understanding of habitat functional loss and gain over extended periods of time is limited. There are many dynamic ecosystem specific variables in the mix at any given site and subsequently inherent uncertainty surrounding both the degradation and the recovery of any given habitat type and associated interdependent species (Watts et al 2020). Given the complexity and the risks associated with successful habitat recovery, it is probably wise to consider the likelihood and rate of success to be habitat type dependent. Perhaps more importantly, we should assume fast functional recovery to be the exception rather than the rule. Under this convention, it is reasonable to assume any habitat restoration action will likely require years if not decades or centuries to off-set past habitat functional degradation before it can ever be considered to have achieved a net gain. Putting this another way, it will be a very long time before we should be considering a future amortized delta HEA as the annual contribution to habitat function on any given habitat restoration site.

Testing Theory for Discounting Services on Specific Locations Over Time

Remaining skeptical of the Portland Harbor mitigation bank DSAY calculation methods, I reasoned plugging the delta HEA into various amortization scenarios (Figures 8 through 27) with different time frames and HEA discount rates[4] might provide some useful insights. I used three questions to help guide my amortization test scenarios:

1. What recovery time periods are anticipated at the banks?
2. What is the HEA discount rate that banks are currently using?
3. How would I have to manipulate the above two variables to achieve similar DSAY amounts as those derived in the Linnton Mill Mitigation and Conservation Bank Prospectus?
4. What, if any, insights could be derived from the nature of the manipulations required in item 3 above?

Recovery time periods were provided in Figure 3 and the discount rate was derived from text and tables in various Portland Harbor mitigation and conservation bank documents.

As testing began per questions 3 and 4, a theory began to coalesce to help to explain what DSAYs acquired through HEA amortization arithmetic may actually represent in the real world. The HEA amortization sequence reflects the beginning of the recovery sequence and the overall state at that point in the process is nearly a complete loss of habitat function. Next, as its name implies, the Time Lost Interest Penalty (TLIP) exacts a toll on the rate of recovery. A way in which this could be used to represent real world circumstances is that very difficult to replace natural resources will likely take a considerable amount of time to recover (Industrial Economics, Inc. 2018). Longer periods of recovery time accumulate a greater amount of cumulative 'interest debt' (loss of habitat functionality over time) relative to the 'principal debt' (initial habitat loss from impact). HEA was specifically designed to address this time loss habitat functionality as debt (NOAA 2006), not credit as indirectly implied in the Linnton Mitigation Bank Instrument (Grette Associates LLC. 2021). In fact, the HEA method prescribes that the ratio of interest debt + principal debt over principal debt should be used as a debit multiplier (NOAA 2006) under the logic that if commensurately more acreage is dedicated to recovery than that acreage for which damage is being compensated, then there is a higher confidence time loss habitat functions will be adequately off-set and be effectively replaced. This aligns well with a precautionary principle surrounding long-term habitat functional loss vs the risks and uncertainty of habitat functional recovery into the indefinite future.

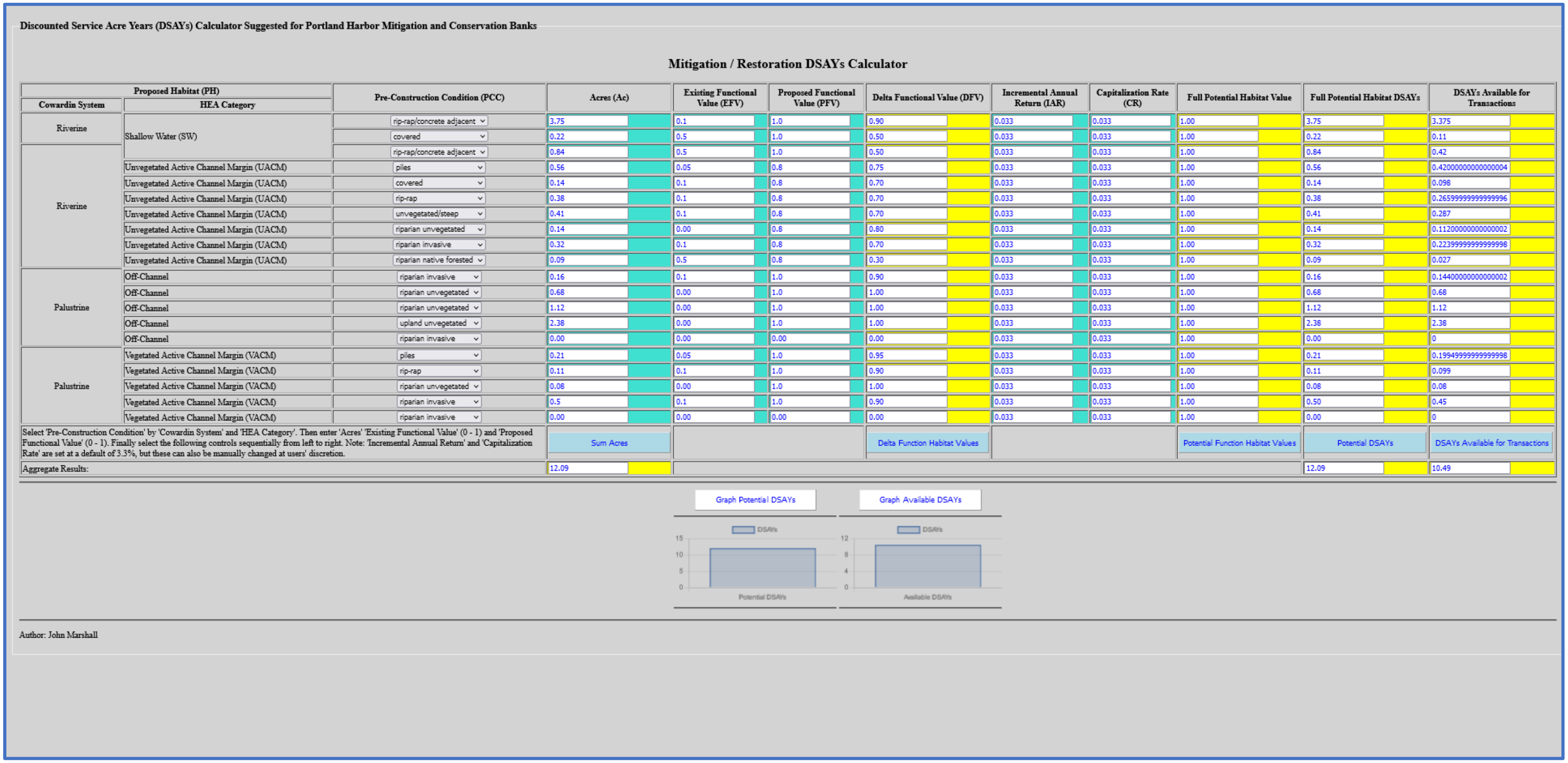
[4] Also coined here as 'Time Lost Interest Penalty' or as annual rate of return.

Proposed	Habitat	Pre-construction Condition	Acres	Existing Functional Value	Proposed Functional Value *	Delta Value	Incremental	HEA DISCOUNT Rate **	DV/DR	(DV/DR) * Acres	(DV/DR) * Ac by Cowardin Class	DV * A	
Cowardin Class	HEA Category					(DV)	Annual Value (AV)	(DR)					Incremental Annual Value
		Shallow Water riprap/concrete adjacent	3.75	0.1	1	0.9	0.033	0.032727	27.5	103.1		3.375	30x = 1
Riverine	Shallow Water	Shallow Water covered	0.22	0.5	1	0.5	0.033	0.032727	15.3	3.4		0.11	30x/30 = 1/30
		Shallow Water Gravel/rock, degraded	0.84	0.5	1	0.5	0.033	0.032727	15.3	12.8		0.42	x = 1/30
		ACM piles	0.56	0.05	0.8	0.75	0.033	0.032727	22.9	12.8		0.42	x = 0.033
		ACM covered	0.14	0.1	0.8	0.7	0.033	0.032727	21.4	3.0		0.098	
		ACM riprap	0.38	0.1	0.8	0.7	0.033	0.032727	21.4	8.1		0.266	
	ACM	ACM unvegetated/steep	0.41	0.1	0.8	0.7	0.033	0.032727	21.4	8.8	188.3	0.287	
	Unvegetated	Riparian unvegetated	0.14	0	0.8	0.8	0.033	0.032727	24.4	3.4		0.112	Alternative A
		Riparian invasive	0.32	0.1	0.8	0.7	0.033	0.032727	21.4	6.8		0.224	
		Riparian native forested	0.09	0.5	0.8	0.3	0.033	0.032727	9.2	0.8		0.027	This alternative divides
		Riparian invasive	0.16	0.1	1	0.9	0.033	0.032727	27.5	4.4		0.144	Delta V by HEA Discount
	Off-Channel	Riparian unvegetated	0.68	0	1	1	0.033	0.032727	30.6	20.8		0.68	Rate
		Riparian unvegetated	1.12	0	1	1	0.033	0.032727	30.6	34.2		1.12	
		Upland unvegetated	2.38	0	1	1	0.033	0.032727	30.6	72.7		2.38	
Palustrine		ACM piles	0.21	0.05	1	0.95	0.033	0.032727	29.0	6.1	132.3	0.1995	
	ACM	ACM riprap	0.11	0.1	1	0.9	0.033	0.032727	27.5	3.0		0.099	
	Vegetated	Riparian unvegetated	0.08	0	1	1	0.033	0.032727	30.6	2.4		0.08	
		Riparian invasive vegetated	0.5	0.1	1	0.9	0.033	0.032727	27.5	13.8		0.45	Mitigation Ratio (C/A)
		Sum Acres	12.09							Sum Credits aka DSAYs	321	10	26.51582155
												317.9242	

Proposed	Habitat	Pre-construction Condition	Acres	Existing Functional Value	Proposed Functional Value *	Delta Value	Incremental	HEA DISCOUNT Rate **	AV/DR	(AV/DR) * Acres	(AV/DR) * Ac by Cowardin Class	DV * A	
Cowardin Class	HEA Category					(DV)	Annual Value (AV)	(DR)					
		Shallow Water riprap/concrete adjacent	3.75	0.1	1	0.9	0.033	0.032727	1.0	3.8		3.375	
Riverine	Shallow Water	Shallow Water covered	0.22	0.5	1	0.5	0.033	0.032727	1.0	0.2		0.11	
		Shallow Water Gravel/rock, degraded	0.84	0.5	1	0.5	0.033	0.032727	1.0	0.8		0.42	
		ACM piles	0.56	0.05	0.8	0.75	0.033	0.032727	1.0	0.6		0.42	
		ACM covered	0.14	0.1	0.8	0.7	0.033	0.032727	1.0	0.1		0.098	
		ACM riprap	0.38	0.1	0.8	0.7	0.033	0.032727	1.0	0.4		0.266	Alternative B
	ACM	ACM unvegetated/steep	0.41	0.1	0.8	0.7	0.033	0.032727	1.0	0.4	7.8	0.287	
	Unvegetated	Riparian unvegetated	0.14	0	0.8	0.8	0.033	0.032727	1.0	0.1		0.112	This alternative divides
		Riparian invasive	0.32	0.1	0.8	0.7	0.033	0.032727	1.0	0.3		0.224	Incremental Annual V
		Riparian native forested	0.09	0.5	0.8	0.3	0.033	0.032727	1.0	0.1		0.027	by HEA Discount Rate
		Riparian invasive	0.16	0.1	1	0.9	0.033	0.032727	1.0	0.2		0.144	
	Off-Channel	Riparian unvegetated	0.68	0	1	1	0.033	0.032727	1.0	0.7		0.68	
		Riparian unvegetated	1.12	0	1	1	0.033	0.032727	1.0	1.1		1.12	
		Upland unvegetated	2.38	0	1	1	0.033	0.032727	1.0	2.4		2.38	
Palustrine		ACM piles	0.21	0.05	1	0.95	0.033	0.032727	1.0	0.2	4.4	0.1995	
	ACM	ACM riprap	0.11	0.1	1	0.9	0.033	0.032727	1.0	0.1		0.099	
	Vegetated	Riparian unvegetated	0.08	0	1	1	0.033	0.032727	1.0	0.1		0.08	
		Riparian invasive vegetated	0.5	0.1	1	0.9	0.033	0.032727	1.0	0.5		0.45	Alt A/ Alt B
		Sum Acres	12.09							Sum Credits aka DSAYs	12	10	26.29646339

... ALT_DSAYs HEA_B HEA_E HEA_G HEA_F HEA_N HEA_O HEA_I HEA_J HEA_L HEA_M HEA_K HEA_H HEA_C HEA_D

Figure 5. Delta HEA vs Annual Return HEA Derived DSAYs (Linnton Mill Mitigation Bank HEA Credits (DSAY) Example Calculations and Open Questions to Regulatory Agencies Tab ALT_DSAYs).



Discounted Service Acre Years (DSAYs) Calculator Suggested for Portland Harbor Mitigation and Conservation Banks

Mitigation / Restoration DSAYs Calculator

Proposed Habitat (PH): Cowardin System	Proposed Habitat (PH): HEA Category	Pre-Construction Condition (PCC)	Acres (Ac)	Existing Functional Value (EFV)	Proposed Functional Value (PFV)	Delta Functional Value (DFV)	Incremental Annual Return (IAR)	Capitalization Rate (CR)	Full Potential Habitat Value	Full Potential Habitat DSAYs	DSAYs Available for Transactions
Riverine	Shallow Water (SW)	rip-rap/concrete adjacent	3.75	0.1	1.0	0.90	0.033	0.033	1.00	3.75	3.375
Riverine	Shallow Water (SW)	covered	0.22	0.5	1.0	0.50	0.033	0.033	1.00	0.22	0.11
Riverine	Shallow Water (SW)	rip-rap/concrete adjacent	0.84	0.5	1.0	0.50	0.033	0.033	1.00	0.84	0.42
Riverine	Unvegetated Active Channel Margin (UACM)	piles	0.56	0.05	0.8	0.75	0.033	0.033	1.00	0.56	0.42000000000000004
Riverine	Unvegetated Active Channel Margin (UACM)	covered	0.14	0.1	0.8	0.70	0.033	0.033	1.00	0.14	0.098
Riverine	Unvegetated Active Channel Margin (UACM)	rip-rap	0.38	0.1	0.8	0.70	0.033	0.033	1.00	0.38	0.26599999999999996
Riverine	Unvegetated Active Channel Margin (UACM)	unvegetated/steep	0.41	0.1	0.8	0.70	0.033	0.033	1.00	0.41	0.287
Riverine	Unvegetated Active Channel Margin (UACM)	riparian unvegetated	0.14	0.00	0.8	0.80	0.033	0.033	1.00	0.14	0.11200000000000002
Riverine	Unvegetated Active Channel Margin (UACM)	riparian invasive	0.32	0.1	0.8	0.70	0.033	0.033	1.00	0.32	0.22399999999999998
Riverine	Unvegetated Active Channel Margin (UACM)	riparian native forested	0.09	0.5	0.8	0.30	0.033	0.033	1.00	0.09	0.027
Palustrine	Off-Channel	riparian invasive	0.16	0.1	1.0	0.90	0.033	0.033	1.00	0.16	0.14400000000000002
Palustrine	Off-Channel	riparian unvegetated	0.68	0.00	1.0	1.00	0.033	0.033	1.00	0.68	0.68
Palustrine	Off-Channel	riparian unvegetated	1.12	0.00	1.0	1.00	0.033	0.033	1.00	1.12	1.12
Palustrine	Off-Channel	upland unvegetated	2.38	0.00	1.0	1.00	0.033	0.033	1.00	2.38	2.38
Palustrine	Off-Channel	riparian invasive	0.00	0.00	0.00	0.00	0.033	0.033	1.00	0.00	0
Palustrine	Vegetated Active Channel Margin (VACM)	piles	0.21	0.05	1.0	0.95	0.033	0.033	1.00	0.21	0.19949999999999998
Palustrine	Vegetated Active Channel Margin (VACM)	rip-rap	0.11	0.1	1.0	0.90	0.033	0.033	1.00	0.11	0.099
Palustrine	Vegetated Active Channel Margin (VACM)	riparian unvegetated	0.08	0.00	1.0	1.00	0.033	0.033	1.00	0.08	0.08
Palustrine	Vegetated Active Channel Margin (VACM)	riparian invasive	0.5	0.1	1.0	0.90	0.033	0.033	1.00	0.50	0.45
Palustrine	Vegetated Active Channel Margin (VACM)	riparian invasive	0.00	0.00	0.00	0.00	0.033	0.033	1.00	0.00	0
Select 'Pre-Construction Condition' by 'Cowardin System' and 'HEA Category'. Then enter 'Acres' 'Existing Functional Value' (0 - 1) and 'Proposed Functional Value' (0 - 1). Finally select the following controls sequentially from left to right. Note: 'Incremental Annual Return' and 'Capitalization Rate' are set at a default of 3.3%, but these can also be manually changed at users' discretion.			Sum Acres			Delta Function Habitat Values			Potential Function Habitat Values	Potential DSAYs	DSAYs Available for Transactions
Aggregate Results:			12.09							12.09	10.49

Figure 6. DSAYs Calculator Results Using Annual Return / Rate of Annual Return (https://www.mitigationcreditdebit.com/EcoServCalculator.html).

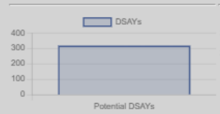
Discounted Service Acre Years (DSAYs) Calculator Suggested for Portland Harbor Mitigation and Conservation Banks

Mitigation / Restoration DSAYs Calculator

Proposed Habitat (PH) Cowardin System	Proposed Habitat (PH) HEA Category	Pre-Construction Condition (PCC)	Acres (Ac)	Existing Functional Value (EFV)	Proposed Functional Value (PFV)	Delta Functional Value (DFV)	Incremental Annual Return (IAR)	Capitalization Rate (CR)	Full Potential Habitat Value	Full Potential Habitat DSAYs	DSAYs Available for Transactions
Riverine	Shallow Water (SW)	rip-rap/concrete adjacent	3.75	0.1	1.0	0.90	0.90	0.033	27.27	102.26	92.034
Riverine	Shallow Water (SW)	covered	0.22	0.5	1.0	0.50	0.50	0.033	15.15	3.33	1.665
		gravel/rock degraded	0.84	0.5	1.0	0.50	0.50	0.033	15.15	12.73	6.365
	Unvegetated Active Channel Margin (UACM)	piles	0.56	0.05	0.8	0.75	0.75	0.033	22.73	12.73	9.5475
	Unvegetated Active Channel Margin (UACM)	covered	0.14	0.1	0.8	0.70	0.70	0.033	21.21	2.97	2.079
	Unvegetated Active Channel Margin (UACM)	rip-rap	0.38	0.1	0.8	0.70	0.70	0.033	21.21	8.06	5.642
	Unvegetated Active Channel Margin (UACM)	unvegetated/steep	0.41	0.1	0.8	0.70	0.70	0.033	21.21	8.70	6.089999999999999
	Unvegetated Active Channel Margin (UACM)	riparian unvegetated	0.14	0.00	0.8	0.80	0.80	0.033	24.24	3.39	2.712
	Unvegetated Active Channel Margin (UACM)	riparian invasive	0.32	0.1	0.8	0.70	0.70	0.033	21.21	6.79	4.753
	Unvegetated Active Channel Margin (UACM)	riparian native forested	0.09	0.5	0.8	0.30	0.30	0.033	9.09	0.82	0.24599999999999997
Palustrine	Off-Channel	riparian invasive	0.16	0.1	1.0	0.90	0.90	0.033	27.27	4.36	3.9240000000000004
	Off-Channel	riparian unvegetated	0.68	0.00	1.0	1.00	1.00	0.033	30.30	20.60	20.6
	Off-Channel	riparian unvegetated	1.12	0.00	1.0	1.00	1.00	0.033	30.30	33.94	33.94
	Off-Channel	upland unvegetated	2.38	0.00	1.0	1.00	1.00	0.033	30.30	72.11	72.11
	Off-Channel	riparian invasive	0.00	0.00	0.00	0.00	0.033	0.033	1.00	0.00	0
Palustrine	Vegetated Active Channel Margin (VACM)	piles	0.21	0.05	1.0	0.95	0.95	0.033	28.79	6.05	5.7475
	Vegetated Active Channel Margin (VACM)	rip-rap	0.11	0.1	1.0	0.90	0.90	0.033	27.27	3.00	2.7
	Vegetated Active Channel Margin (VACM)	riparian unvegetated	0.08	0.00	1.0	1.00	1.00	0.033	30.30	2.42	2.42
	Vegetated Active Channel Margin (VACM)	riparian invasive	0.5	0.1	1.0	0.90	0.90	0.033	27.27	13.63	12.267000000000001
	Vegetated Active Channel Margin (VACM)	riparian invasive	0.00	0.00	0.00	0.00	0.033	0.033	1.00	0.00	0
Select 'Pre-Construction Condition' by 'Cowardin System' and 'HEA Category'. Then enter 'Acres' 'Existing Functional Value' (0 - 1) and 'Proposed Functional Value' (0 - 1). Finally select the following controls sequentially from left to right. Note: 'Incremental Annual Return' and 'Capitalization Rate' are set at a default of 3.3%, but these can also be manually changed at users' discretion.			Sum Acres			Delta Function Habitat Values			Potential Function Habitat Values	Potential DSAYs	DSAYs Available for Transactions
Aggregate Results:			12.09							317.90	284.84

Graph Potential DSAYs

Graph Available DSAYs



Reset

Author: John Marshall

Figure 7. DSAYs Calculator Results Using Delta HEA / Rate of Annual Return (https://www.mitigationcreditdebit.com/EcoServCalculator.html).

Amortization of Functional Losses in DSAYs (3% TLIP) - 1 Years of Natural Resource Damage Assessment (Linnton Mill Mitigation Bank HEA Credits (DSAY) Example Calculations and Open Questions to Regulatory Agencies- Tab HEA_M).

Functional Loss	Time Loss Interest Penalty (TLIP)	Amortization Period (years)	Monthly Recovery (MR)	Total Recovery (TR) + TLIP
10.0	3.00%	1	0.84694	10.16

PFV = present functional value (pre-disturbance or after full recovery)

MR = monthly recovery

i = time loss function interest rate penalty

n = total number of months for full recovery to occur

$$PFV = \frac{R[1-(1+i)^{-n}]}{i} = \frac{0.84694 * [1-(1+0.0025)^{-12}]}{0.0025} = 0.84694 * 0.085966 / 0.0025 = 10.0$$

Solve R:

$$MR = \frac{PV * i}{[1-(1+i)^{-n}]} = \frac{10.0 * 0.0025}{[1-(1+0.0025)^{-12}]} = \frac{0.0250}{0.029518} = 0.84694$$

TR + TLIP = 0.84694 * 12 = 10.16

PFV = 10.0

i = 3.00% / 12 / 100 = 0.0025 n = 1 * 12 = 12

Mitigation Ratio: 1.016:1.00

Figure 8. Test 1a Amortization of Functional Losses in DSAYs.

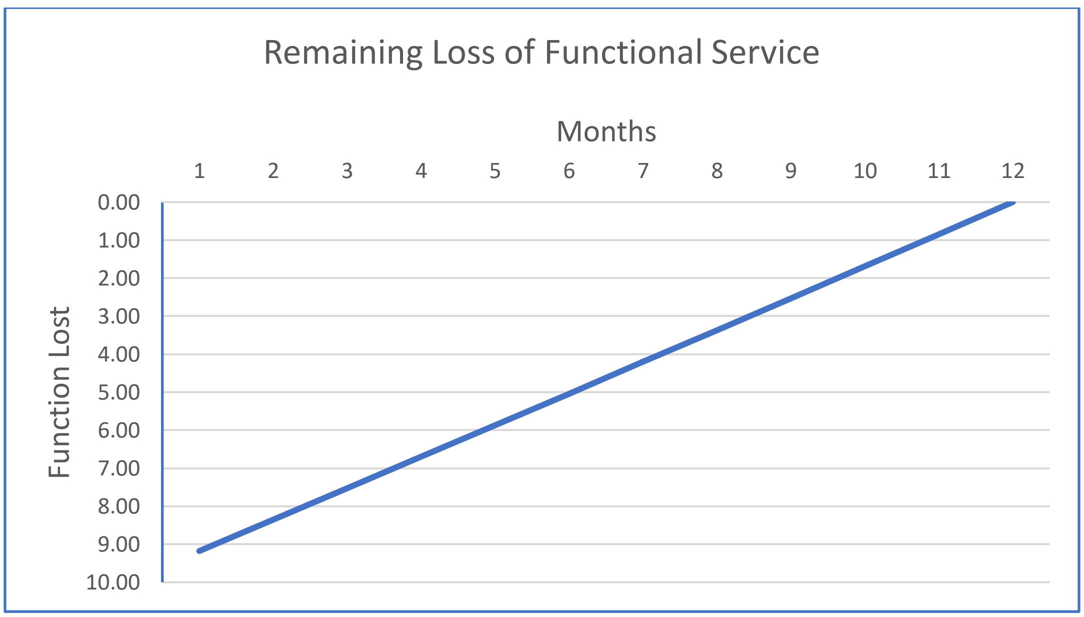


Figure 9. Test 1b Amortization of Functional Losses in DSAYs.

Amortization of Functional Losses in DSAYs (3% TLIP) - 3 Years of Natural Resource Damage Assessment (Linnton Mill Mitigation Bank HEA Credits (DSAY) Example Calculations and Open Questions to Regulatory Agencies - Tab HEA_K).

Functional Loss	Time Loss Interest Penalty (TLIP)	Amortization Period (years)	Monthly Recovery (MR)	Total Recovery (TR) + TLIP
10.0	3.00%	3	0.2908	10.46

PFV = present functional value (pre-disturbance or after full recovery)

MR = monthly recovery

i = time loss function interest rate penalty

n = total number of months for full recovery to occur

$$PFV = \frac{R[1-(1+i)^{-n}]}{i} = \frac{0.2908 * [1-(1+0.0025)^{-36}]}{0.0025} = 0.2908 * 0.085966/\ 0.0025 = 10.0$$

Solve R:

$$MR = \frac{PV * i}{[1-(1+i)^{-n}]} = \frac{10.0 * 0.0025}{[1-(1+0.0025)^{-36}]} = \frac{0.0250}{0.0859661627} = 0.2908$$

TR + TLIP = 0.2908 * 36 = 10.46

PFV = 10.0

i = 3.00% / 12 / 100 = 0.0025 n = 3 * 12 = 36

Mitigation Ratio: 1.04:1.00

Figure 10. Test 2a Amortization of Functional Losses in DSAYs.

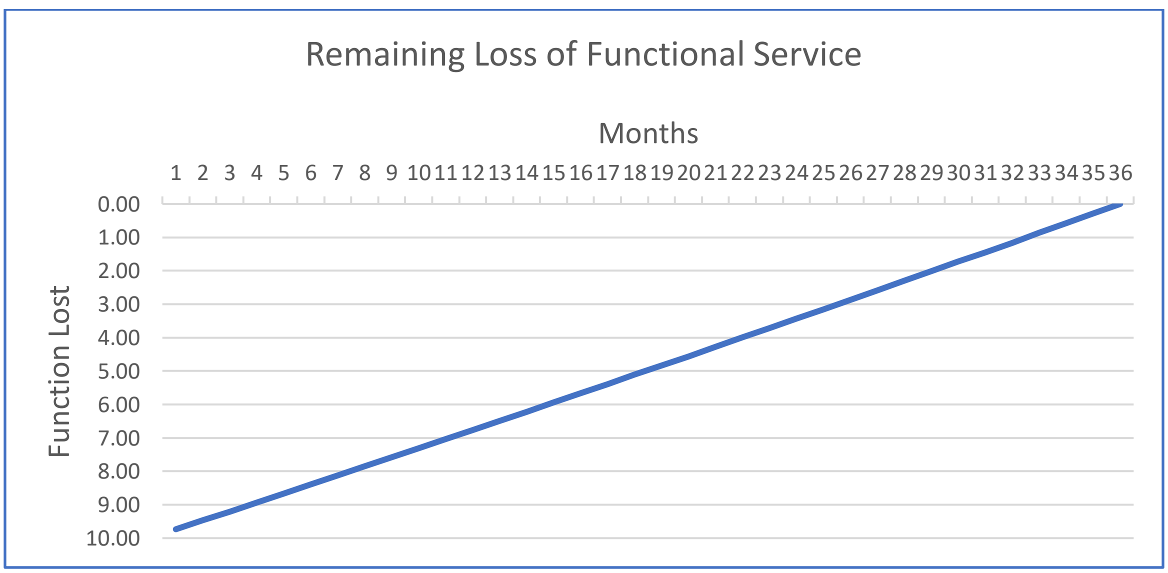


Figure 11. Test 2b Amortization of Functional Losses in DSAYs.

Amortization of Functional Losses in DSAYs (3% TLIP) - 5 Years of Natural Resource Damage Assessment (Linnton Mill Mitigation Bank HEA Credits (DSAY) Example Calculations and Open Questions to Regulatory Agencies - Tab HEA_L).

Functional Loss	Time Loss Interest Penalty (TLIP)	Amortization Period (years)	Monthly Recovery (MR)	Total Recovery (TR) + TLIP
10.0	3.00%	5	0.17968	10.78

PFV = present functional value (pre-disturbance or after full recovery)

MR = monthly recovery

i = time loss function interest rate penalty

n = total number of months for full recovery to occur

$$PFV = \frac{R[1 - (1 + i)^{-n}]}{i} = \frac{0.17968 * [1 - (1 + 0.0025)^{-60}]}{0.002} = 0.17968 * 0.085966 / 0.0025 = 10.0$$

Solve R:

$$MR = \frac{PV * i}{[1 - (1 + i)^{-n}]} = \frac{10.0 * 0.0025}{[1 - (1 + 0.0025)^{-60}]} = \frac{0.0250}{0.1391308942} = 0.17968$$

TR + TLIP = 0.17968 * 60 = 10.78

PFV = 10.0

i = 3.00% / 12 / 100 = 0.0025 n = 5 * 12 = 60

Mitigation Ratio: 1.078:1.00

Figure 12. Test 3a Amortization of Functional Losses in DSAYs.

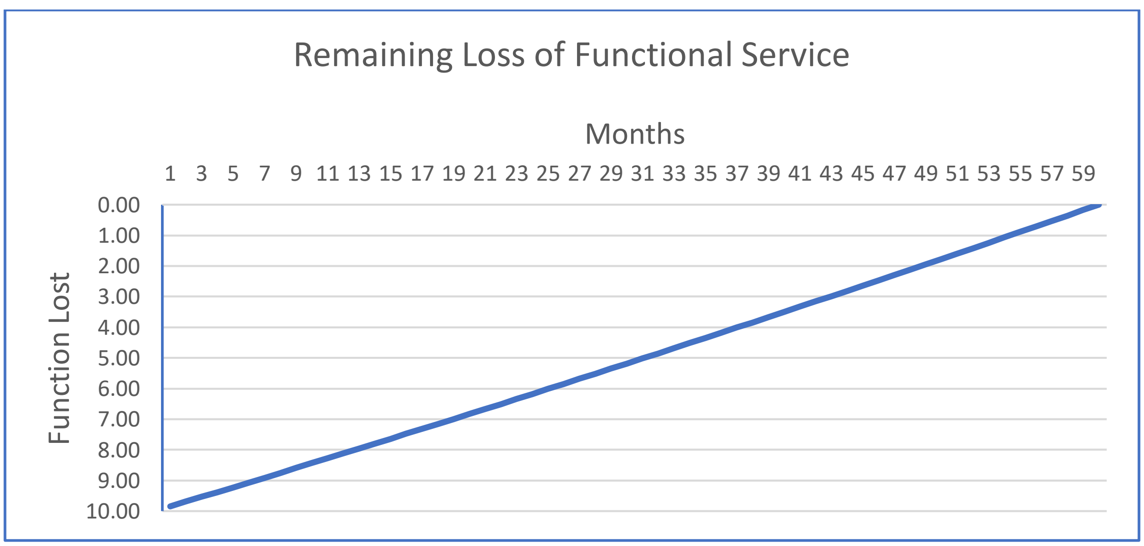


Figure 13. Test 3b Amortization of Functional Losses in DSAYs.

Amortization of Functional Losses in DSAYs (3% TLIP) - 10 Years of Natural Resource Damage Assessment (Linnton Mill Mitigation Bank HEA Credits (DSAY) Example Calculations and Open Questions to Regulatory Agencies - Tab HEA_J).

Functional Loss	Time Loss Interest Penalty (TLIP)	Amortization Period (years)	Monthly Recovery (MR)	Total Recovery (TR) + TLIP
10.0	3.00%	10	0.09656	11.59

PFV = present functional value (pre-disturbance or after full recovery)

MR = monthly recovery

i = time loss function interest rate penalty

n = total number of months for full recovery to occur

$$PFV = \frac{R[1 - (1 + i)^{-n}]}{i} = \frac{0.09656 * [1 - (1 + 0.0025)^{-120}]}{0.0025} = 0.09656 * 0.258904 / 0.0025 = 10.0$$

Solve R:

$$MR = \frac{PV * i}{[1 - (1 + i)^{-n}]} = \frac{10.0 * 0.0025}{[1 - (1 + 0.0025)^{-120}]} = \frac{0.0250}{0.2589} = 0.09656$$

TR + TLIP = 0.09656 * 120 = 11.59

PFV = 10.0

i = 3.00% / 12 / 100 = 0.0025 n = 10 * 12 = 120

Mitigation Ratio: 1.16:1.00

Figure 14. Test 4a Amortization of Functional Losses in DSAYs.

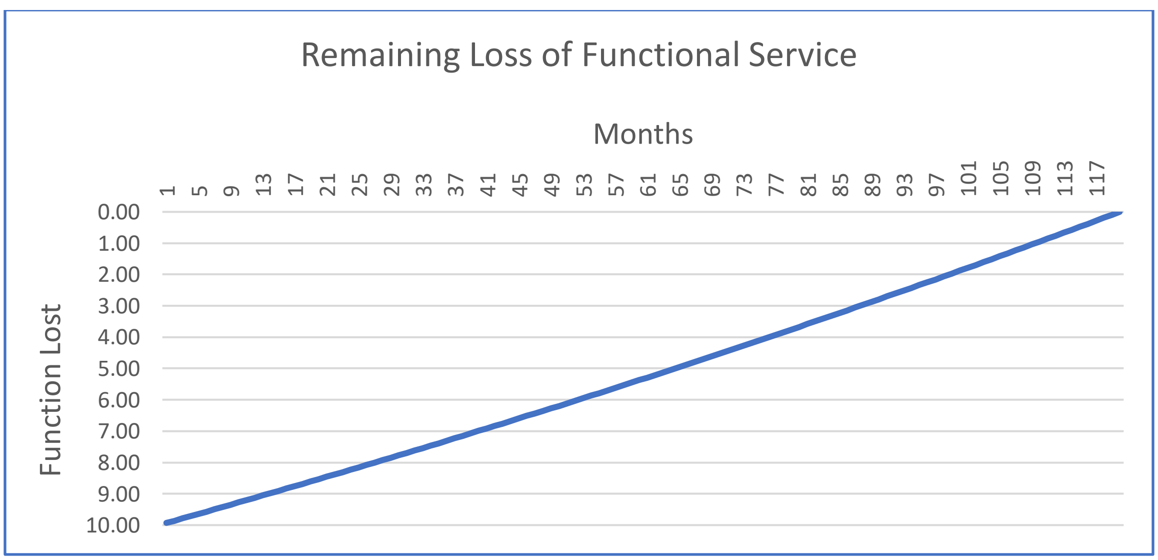


Figure 15. Test 4b Amortization of Functional Losses in DSAYs.

Amortization of Functional Losses in DSAYs (3% TLIP) - 30 Years of Natural Resource Damage Assessment (Linnton Mill Mitigation Bank HEA Credits (DSAY) Example Calculations and Open Questions to Regulatory Agencies - Tab HEA_F).

Functional Loss	Time Loss Interest Penalty (TLIP)	Amortization Period (years)	Monthly Recovery (MR)	Total Recovery (TR) + TLIP
10.0	3.00%	30	0.04216	15.18

PFV = present functional value (pre-disturbance or after full recovery)

MR = monthly recovery

i = time loss function interest rate penalty

n = total number of months for full recovery to occur

$$PFV = \frac{R[1-(1+i)^{-n}]}{i} = \frac{0.04216[1-(1+0.0025)^{-360}]}{0.0025} = .04216 * 0.5929 / 0.0025 = 10.0$$

Solve R:

$$MR = \frac{PV * i}{[1-(1+i)^{-n}]} = \frac{10.0 * 0.0025}{[1-(1+0.0025)^{-360}]} = \frac{0.0250}{0.5929} = 0.04216$$

TR + TLIP = 0.04216 * 360 = 15.18

PFV = 10.0

i = 3.00% / 12 / 100 = 0.0025 n = 30 * 12 = 360

Mitigation Ratio: 1.5:1.00

Figure 16. Test 5a Amortization of Functional Losses in DSAYs.

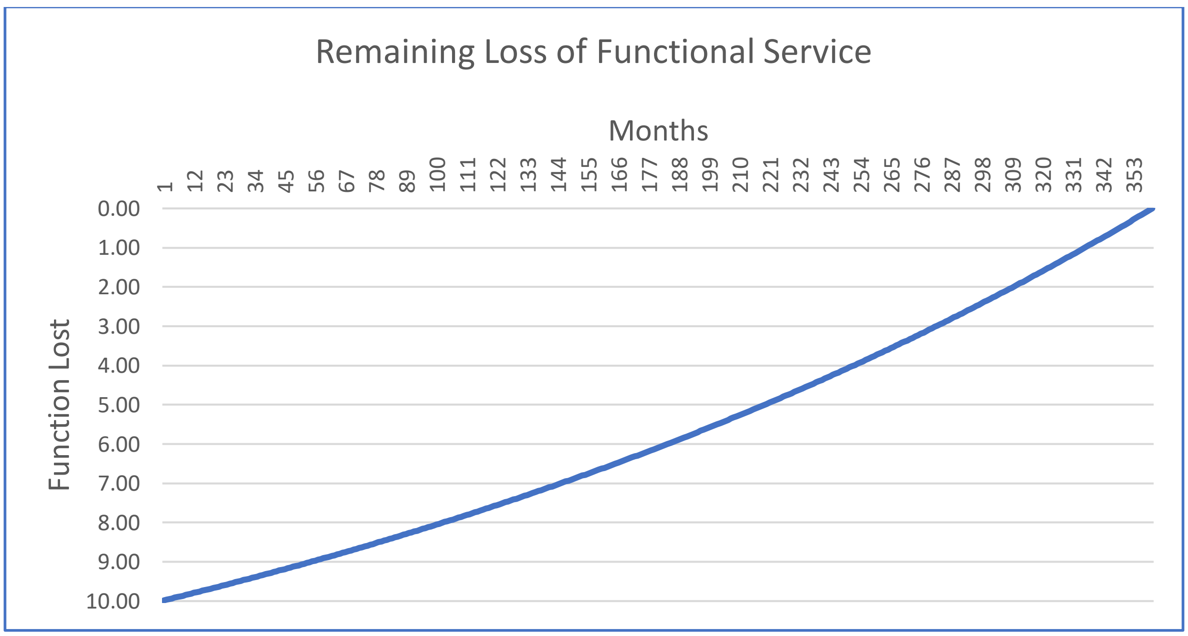


Figure 17. Test 5b Amortization of Functional Losses in DSAYs.

Amortization of Functional Losses in DSAYs (3% TLIP) - 40 Years of Natural Resource Damage Assessment ([Linnton Mill Mitigation Bank HEA Credits (DSAY) Example Calculations and Open Questions to Regulatory Agencies]() - Tab HEA_I).

Functional Loss	Time Loss Interest Penalty (TLIP)	Amortization Period (years)	Monthly Recovery (MR)	Total Recovery (TR) + TLIP
10.0	3.00%	40	0.03580	17.18

PFV = present functional value (pre-disturbance or after full recovery)

MR = monthly recovery

i = time loss function interest rate penalty

n = total number of months for full recovery to occur

$$PFV = \frac{R[1-(1+i)^{-n}]}{i} = \frac{0.03580 * [1-(1+0.0025)^{-480}]}{0.0025} = 0.03580 * 0.69835 / 0.0025 = 10.0$$

Solve R:

$$MR = \frac{PV * i}{[1-(1+i)^{-n}]} = \frac{10.0 * 0.0025}{[1-(1+0.0025)^{-480}]} = \frac{0.0250}{0.6983} = 0.03580$$

TR + TLIP = 0.03580 * 480 = 17.18

PFV = 10.0

i = 3.00% / 12 / 100 = 0.0025   n = 40 * 12 = 480

Mitigation Ratio: 1.7:1.00

Figure 18. Test 6a Amortization of Functional Losses in DSAYs.

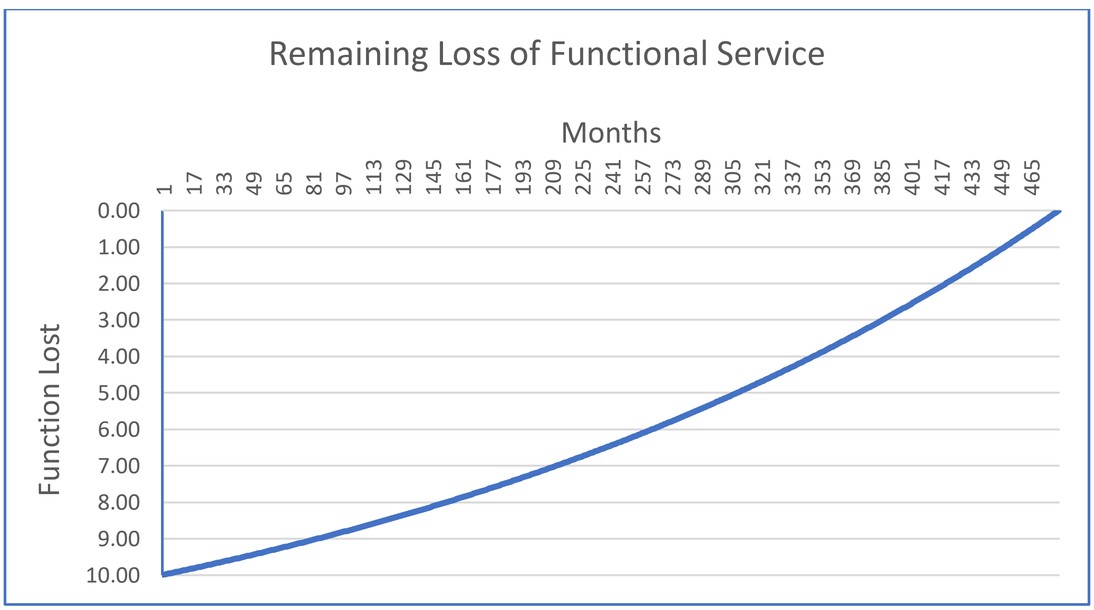


Figure 19. Test 6b Amortization of Functional Losses in DSAYs.

Amortization of Functional Losses in DSAYs (3% TLIP) - 100 Years of Natural Resource Damage Assessment ([Linnton Mill Mitigation Bank HEA Credits (DSAY) Example Calculations and Open Questions to Regulatory Agencies]() - Tab HEA_H).

Functional Loss	Time Loss Interest Penalty (TLIP)	Amortization Period (years)	Monthly Recovery (MR)	Total Recovery (TR) + TLIP
10.0	3.00%	100	0.02631	31.57

PFV = present functional value (pre-disturbance or after full recovery)

MR = monthly recovery

i = time loss function interest rate penalty

n = total number of months for full recovery to occur

$$PFV = \frac{R[1-(1+i)^{-n}]}{i} = \frac{0.02631\,[1-(1+0.0025)^{-1200}]}{0.0025} = 0.02631 * 0.95002 / 0.0025 = 10.0$$

Solve R:

$$MR = \frac{PV * i}{[1-(1+i)^{-n}]} = \frac{10.0 * 0.0025}{[1-(1+0.0025)^{-1200}]} = \frac{0.02500}{0.95002} = 0.02631$$

TR + TLIP = 0.02631 * 1200 = 31.57

PFV = 10.0

i = 3.00% / 12 / 100 = 0.0025 n = 100 * 12 = 1200

Mitigation Ratio: 31.57:10.00 = 3.16

Figure 20. Test 7a Amortization of Functional Losses in DSAYs.

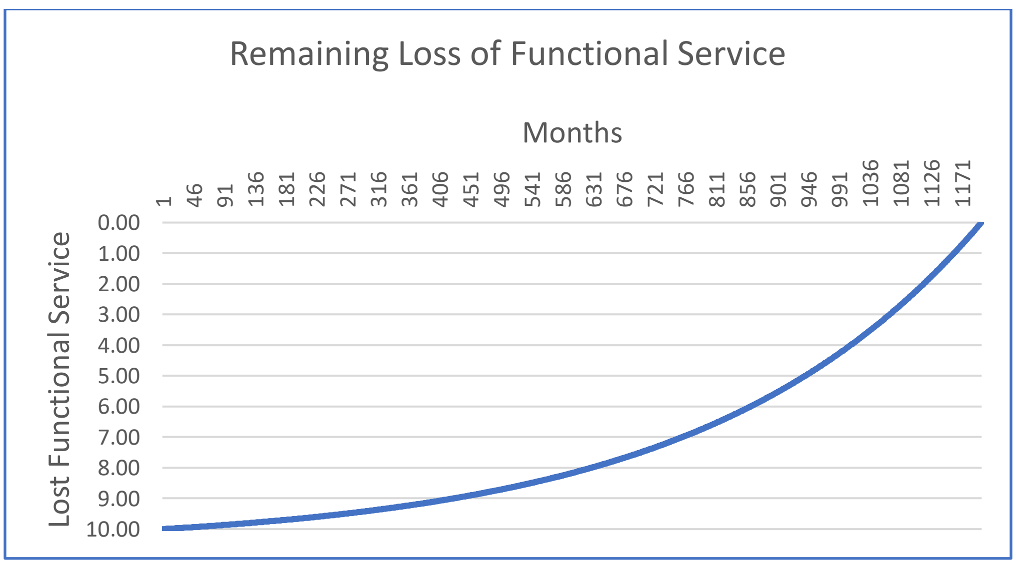


Figure 21. Test 7b Amortization of Functional Losses in DSAYs.

Amortization of Functional Losses in DSAYs (105.59% TLIP) - 30 Years of Natural Resource Damage Assessment (Linnton Mill Mitigation Bank HEA Credits (DSAY) Example Calculations and Open Questions to Regulatory Agencies - Tab HEA_G).

Functional Loss	Time Loss Interest Penalty (TLIP)	Amortization Period (years)	Monthly Recovery (MR)	Total Recovery (TR) + TLIP
10.0	105.59%	30	0.87998	316.79

PFV = present functional value (pre-disturbance or after full recovery)

MR = monthly recovery

i = time loss function interest rate penalty

n = total number of months for full recovery to occur

$$PFV = \frac{R[1-(1+i)^{-n}]}{i} = \frac{0.87998\ [1-(1+0.08799)^{-360}]}{0.08799} = .0.87998 * 0.9999 / 0.08799 = 10.0$$

Solve R:

$$MR = \frac{PV * i}{[1-(1+i)^{-n}]} = \frac{10.0 * 0.08799}{[1-(1+0.08799)^{-360}]} = \frac{0.8799}{0.9999} = 0.87998$$

TR + TLIP = 0.87998 * 360 = 316.79

PFV = 10.0

i = 105.59% / 12 / 100 = 0.08799 n = 30 * 12 = 360

Mitigation Ratio: 31.67:1.00

Figure 22. Test 8a Amortization of Functional Losses in DSAYs.

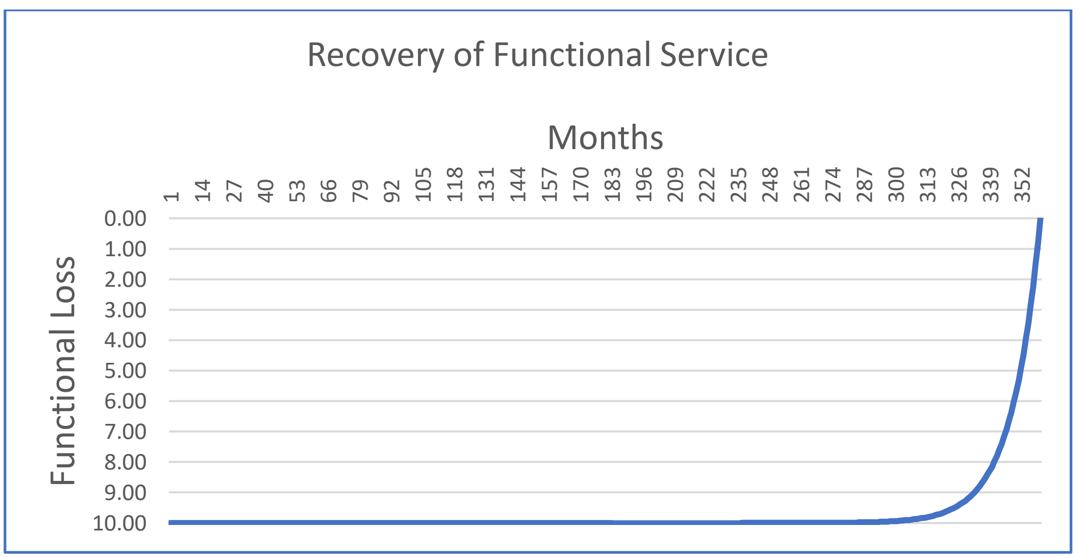


Figure 23. Test 8b Amortization of Functional Losses in DSAYs.

Amortization of Functional Losses in DSAYs (3% TLIP) - 300 Years of Natural Resource Damage Assessment (Linnton Mill Mitigation Bank HEA Credits (DSAY) Example Calculations and Open Questions to Regulatory Agencies - Tab HEA_N).

Functional Loss	Time Loss Interest Penalty (TLIP)	Amortization Period (years)	Monthly Recovery (MR)	Total Recovery (TR) + TLIP
10.0	3.00%	300	0.02500	90.01

PFV = present functional value (pre-disturbance or after full recovery)

MR = monthly recovery

i = time loss function interest rate penalty

n = total number of months for full recovery to occur

$$PFV = \frac{R[1-(1+i)^{-n}]}{i} = \frac{0.02500 * [1-(1+0.0025)^{-3600}]}{0.0025} = 0.02500 * 0.99987 / 0.0025 = 10.0$$

Solve R:

$$MR = \frac{PV * i}{[1-(1+i)^{-n}]} = \frac{10.0 * 0.0025}{[1-(1+0.0025)^{-3600}]} = \frac{0.02500}{0.99987} = 0.02500$$

TR + TLIP = 0.02500 * 3600 = 90.01

PFV = 10.0

i = 3.00% / 12 / 100 = 0.0025 n = 300 * 12 = 3600

Mitigation Ratio: 90.01:10.00 = 9.00:1.00

Figure 24. Test 9a Amortization of Functional Losses in DSAYs.

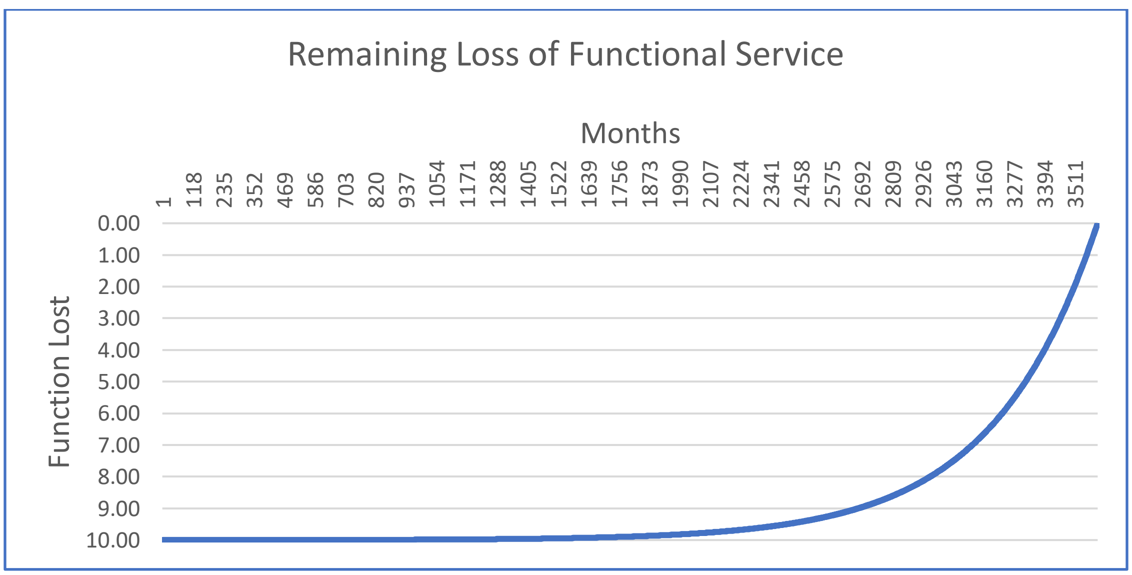


Figure 25. Test 9b Amortization of Functional Losses in DSAYs.

Amortization of Functional Losses in DSAYs (31.7% TLIP) - 100 Years of Natural Resource Damage Assessment (Linnton Mill Mitigation Bank HEA Credits (DSAY) Example Calculations and Open Questions to Regulatory Agencies - Tab HEA_O).

Functional Loss	Time Loss Interest Penalty (TLIP)	Amortization Period (years)	Monthly Recovery (MR)	Total Recovery (TR) + TLIP
10.0	31.70%	100	0.2640	316.8

PFV = present functional value (pre-disturbance or after full recovery)

MR = monthly recovery

i = time loss function interest rate penalty

n = total number of months for full recovery to occur

$$PFV = \frac{R[1-(1+i)^{-n}]}{i} = \frac{0.2640 * [1-(1+0.0264)^{-1200}]}{0.0264} = 0.2640 * 0.9999 / 0.0264 = 10.0$$

Solve R:

$$MR = \frac{PV * i}{[1-(1+i)^{-n}]} = \frac{10.0 * 0.0264}{[1-(1+0.0264)^{-1200}]} = \frac{0.264}{0.9999} = 0.2640$$

TR + TLIP = 0.2640 * 1200 = 316.8

PFV = 10.0

i = 31.7% / 12 / 100 = 0.0264   n = 100 * 12 = 1200

Mitigation Ratio: 316.8:10.00 = 31.7

Figure 26. Test 10a Amortization of Functional Losses in DSAYs.

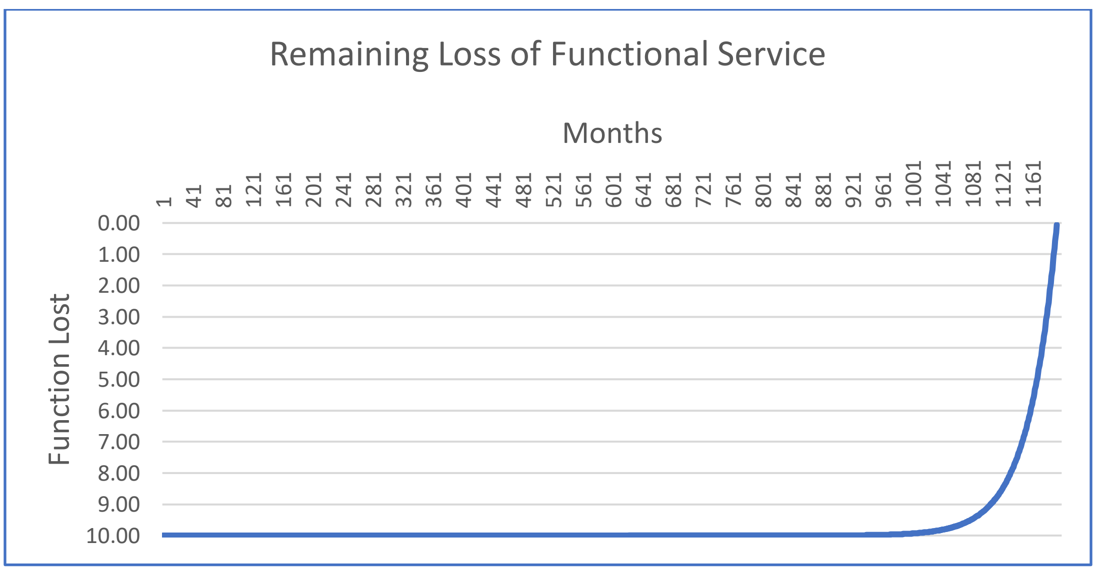


Figure 27. Test 10b Amortization of Functional Losses in DSAYs.

Conclusion

The present values calculated to derive for DSAYS for the Linnton Mill and other banks were obtained by dividing delta HEA by a discount rate of approximately 3%. Arithmetically, this has a high resemblance to operations real estate appraisers use to calculate the present value of real property:

To calculate the present value of the property, the investor divides the $10,500 net operating income by the capitalization rate of 3 percent for a present value or capitalized value of $350,000, since $10,500 / 0.03 = $350,000 (https://smallbusiness.chron.com/capitalized-value-method-35138.html).

The problem lies in the fact that delta HEA does not reflect the habitat function annual recovery, but rather the entire functional recovery over the entire life of the bank. It appears that the arithmetic used by the banks may treat this much larger figure as the annual accrual of function at their respective locations, thereby effectively artificially magnifying their true overall functional values about 30 times (Figure 28).

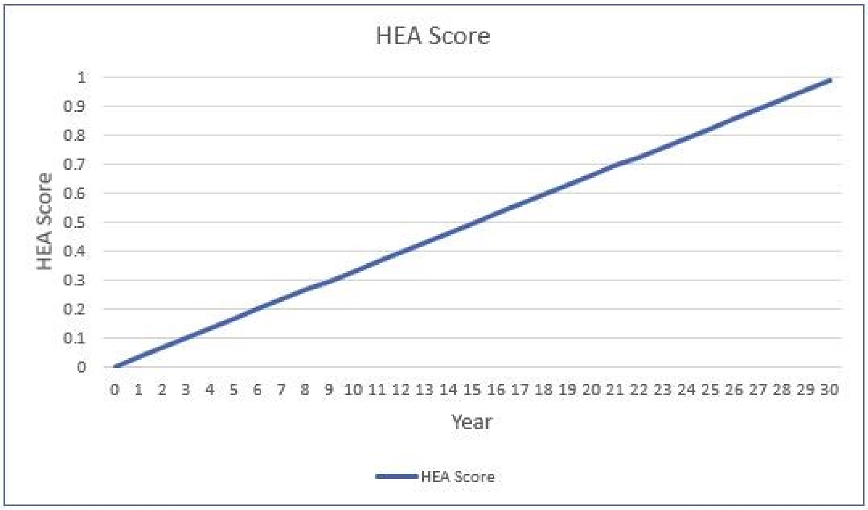
Two of the tests resulted in DSAY numbers similar to those derived in the Linnton Mitigation and Conservation Bank Prospectus, both with TLIPs far higher than 3%. The first had a TLIP over 105% over a 30-year recovery time (Figures 22 and 23) and the second had a TLIP over 31% over a 100-year recovery period (Figures 26 and 27). Direct interpretation of these tests suggests that in order to compensate for the amount of existing habitat function debt accrued in the Portland Harbor, banks would have to reach over 100% of potential habitat value annual accrual their first year and then continue that service for at least 30-years. Or they could be afforded about 1/30 of a credit for each acre undergoing restoration on their bank sites making it necessary to restore 30-acres of credit for every acre of debit in the Portland Harbor,[5] in effect the exact opposite of the credit (DSAYs) calculation currently under use by the banks that provide about 30-credits for each acre undergoing restoration. This suggests a serious flaw in the logic used to calculate DSAYs at the banks. The Trustee Council should investigate this further and their investigation finding results should be reported to the Portland Harbor stakeholders and to the general public.

Epilogue

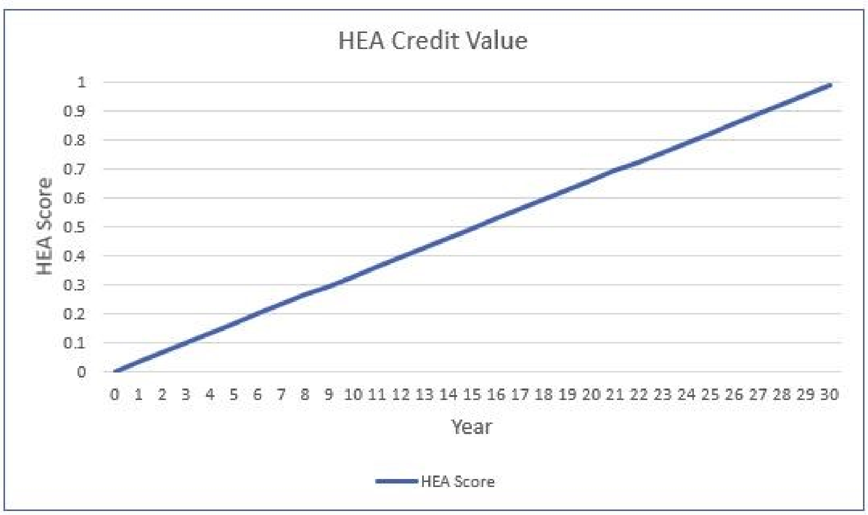
If the result of the investigation suggested above is that the alternative to the existing HEA DSAY calculation arithmetic logic provided in this paper's analysis is more defensible than the method currently used by the banks, then another body of logic relevant to subsequent mitigation ratios naturally emerges. It carries over with it the interpretation that the HEA TLIP or 'discount rate' reflects recovery of lost value over a specified time period and that this recovery rate

[5] Neither of these alternatives are practical to administer a mitigation banking program. They are stated here to illustrate the significant differences in the credit theories as evidenced by the two disparate arithmetic logic methods used to calculate credit contrasted and discussed in this paper.

satisfactorily represents the actual functional loss recovery the banks aspire to off-set, both from the standpoint of historical losses and from the standpoint of lag time to a future date of fully recovered function. Simply put, the ratio is a function of the interest debt plus the principal debt



AR = 0.033 DR[1] = 0.033 PV = AR / DR PV = 0.033/0.033[2] PV = 1 DSAY = PV * 1-Acre = 1



1 HEA Credit Value (DSAY) = $75,000.00 AR = $2,500.00 DR = 0.033

<u>Present Value (PV) Equals Annual Return (AR) Divided by Discount Rate (DR) Method</u>

PV = AR / DR	PV = 0.033/0.033	PV = 1	DSAY = 1 * 1-Acre = 1
PV = AR / DR	PV = $2,500 / .033	PV = $75,000.00	

<u>Present Value (PV) Equals Delta HEA (DH) Divided by Discount Rate (DR) Method[3]</u>

PV = DH / DR	PV = 1.0/0.033	PV = 30	DSAY = 30 * 1-Acre = 30
PV = DH / DR	PV = $75,000 / .033	PV = $2,250,000.00	

[1] Discount Rate (DR) is considered here as the equivalent of the Time Loss Interest Penalty (TLIP).
[2] More Precise Results Requires Expressing the DR Term to at Least the Sixth Decimal Place.
[3] This is the method used by the Portland Harbor Mitigation and Conservation Banks that is in question.

Figure 28. Comparison of Two DSAY Calculations Based on Different Arithmetic Logic.

over the principal debt. However, the ratios emerging out of the amortization tests are too severe to sustain a viable mitigation banking program in the Portland Harbor. Added to that realization is the fact that full ecological recovery of the Portland Harbor to pre-European settlement condition is not feasible in the 21st century. A lower benchmark for recovery is therefore justifiable as a compromise option.

It could be argued that the responsibility for off-setting (compensating) for historical losses lies with those responsible for the impacts, the polluters. And the responsibility for assuming the risk and time lag loss for achieving full recovery to an agreed upon 21st century benchmark lies with the mitigation bank sponsors. Splitting these responsibilities can be accomplished using effective mitigation ratios (https://www.mitigationcreditdebit.com/indexR.html).

However, there are at least several permutations of how the different burdens reflected in the effective ratios can be divided. Figure 29 displays six alternative cases, each with a different foundational logic and overall recovery result:

Case 1. There is an effective 1:1 ratio. For every 1-acre of mitigation, 1-acre of impact is compensated. The impact incurs full TLIP while mitigation receives reverse TLIP as a bonus for anticipated perpetuity future gain in function.

Case 2. There is an effective 3:1 ratio. For every 3-acres of mitigation, 1-acre of impact is compensated. The impact incurs full TLIP while mitigation remains TLIP neutral, no penalty and no bonus but receives credit for full recovery in advance.

Case 3. There is an effective 9:1 ratio. For every 9-acres of mitigation, 1-acre of impact is compensated. The impact incurs full TLIP while mitigation also incurs full TLIP for on-going time loss and risk for recovery still on-going.

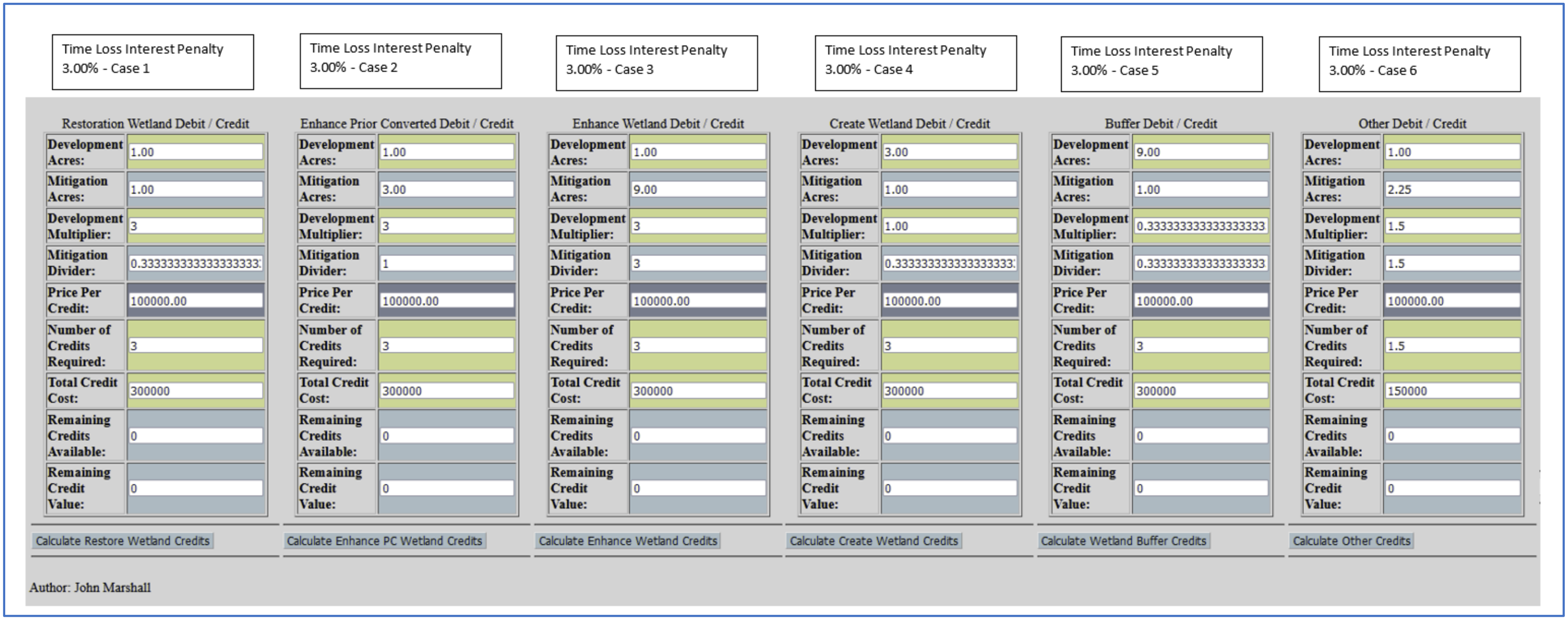
Case 4. There is an effective 1:3 ratio. For every 1-acre of mitigation, 3-acres of impact is compensated. The impact remains TLIP neutral while mitigation receives reverse TLIP as a bonus for anticipated perpetuity future gain in function.

Case 5. There is an effective 1:9 ratio. For every 1-acre of mitigation, 9- acres of impact is compensated. The impact and the mitigation receive reverse TLIPs as a bonus for anticipated perpetuity future gain in function.

Case 6. There is an effective 2.25:1 ratio. For every 2.25-acres of mitigation, 1- acre of impact is compensated. The impact and the mitigation share TLIP equally with moderate bonus for anticipated perpetuity future gain in function.

For meeting functional resource conservation recovery goals only Cases 1, 2, 3, and 6 would be acceptable, but Cases 2 and 3 would be the most desirable. While Case 3 is the best recovery alternative, and arguably the most defensible as representing actual natural function losses and likely risks associated with recovery, it is probably not practical from the perspectives of mitigation bank sponsors and regulators. After that, Case 2 would be the next best recovery alternative but mitigation bank sponsors would likely argue Case 1 is more cost effective for them to implement while still maintaining an effective 1:1 mitigation ratio. Case 6 might be viewed as a reasonable compromise between Cases 1 and 2.

It should be noted that in each of these scenarios there is this implied notion that weighted acreages can take on the role for compensating temporal losses of habitat functions along with the notion functional impacts have been accurately measured and represented in the arithmetic. Because of the state-of-the-art / science of measuring function is relatively still new and experimental (National Academy of Sciences 2001), and because the regulatory process itself favors coarse surrogate measures over direct functional analyses, neither can be empirically verified. This is why regulators have traditionally exercised a precautionary principle of no less than 1:1 mitigation ratios realizing even then, with properly enforced performance measures and on-going stewardship through adaptive management, net functional losses are still highly likely and full functional recovery remains elusive and highly unlikely.



	Time Loss Interest Penalty 3.00% - Case 1	Time Loss Interest Penalty 3.00% - Case 2	Time Loss Interest Penalty 3.00% - Case 3	Time Loss Interest Penalty 3.00% - Case 4	Time Loss Interest Penalty 3.00% - Case 5	Time Loss Interest Penalty 3.00% - Case 6
	Restoration Wetland Debit / Credit	Enhance Prior Converted Debit / Credit	Enhance Wetland Debit / Credit	Create Wetland Debit / Credit	Buffer Debit / Credit	Other Debit / Credit
Development Acres:	1.00	1.00	1.00	3.00	9.00	1.00
Mitigation Acres:	1.00	3.00	9.00	1.00	1.00	2.25
Development Multiplier:	3	3	3	1.00	0.333333333333333333	1.5
Mitigation Divider:	0.333333333333333333	1	3	0.333333333333333333	0.333333333333333333	1.5
Price Per Credit:	100000.00	100000.00	100000.00	100000.00	100000.00	100000.00
Number of Credits Required:	3	3	3	3	3	1.5
Total Credit Cost:	300000	300000	300000	300000	300000	150000
Remaining Credits Available:	0	0	0	0	0	0
Remaining Credit Value:	0	0	0	0	0	0
	Calculate Restore Wetland Credits	Calculate Enhance PC Wetland Credits	Calculate Enhance Wetland Credits	Calculate Create Wetland Credits	Calculate Wetland Buffer Credits	Calculate Other Credits

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Figure 29. Example Credit / Debit Transactions at 100-Year HEA Amortized Time Loss Interest Penalty of 3% as Discount Rates and Mitigation Ratios (https://www.mitigationcreditdebit.com/WVWMB_CDWorksheet.html).

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