Appendix A

Habitat Suitability Criteria

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HSC sources and references for the Wilder, Bellows Falls and Vernon projects.

Species	Life Stage	Variable	Original Source	Identified Source	Note:
American Shad	Juvenile	Velocity	Stier and Crance, 1985	Stier and Crance, 1985	
		Depth	Stier and Crance, 1985	Excelon, 2012 (Conowingo IFIM)	Based on Greene et al. 2009
		Substrate	Stier and Crance, 1985	Stier and Crance, 1985	Not Stier and Crance 1985, source?
	Adult	Velocity	Stier and Crance, 1985	Stier and Crance, 1985	
		Depth	Stier and Crance, 1985	Stier and Crance, 1985	
		Substrate	Stier and Crance, 1985	Stier and Crance, 1985	Not Stier and Crance 1985, source?
	Spawning	Velocity	Stier and Crance, 1985	Hightower et al., 2012	Modified based on review of data
		Depth	Stier and Crance, 1985	Hightower et al., 2012	Used original Stier and Crance, 1985 endpoint of 50 feet.
		Substrate	Stier and Crance, 1985	Stier and Crance, 1985	
Walleye	Fry	Velocity	McMahon et al., 1984	McMahon et al., 1984	
		Depth	McMahon et al., 1984	McMahon et al., 1984	
		Substrate	McMahon et al., 1984	McMahon et al., 1984	
	Juvenile	Velocity	McMahon et al., 1984	McMahon et al., 1984	
		Depth	McMahon et al., 1984	McMahon et al., 1984	
		Substrate	McMahon et al., 1984	McMahon et al., 1984	
	Adult	Velocity	McMahon et al., 1984	McMahon et al., 1984	
		Depth	McMahon et al., 1984	McMahon et al., 1984	
		Substrate	McMahon et al., 1984	McMahon et al., 1984	
	Spawning/ Incubation	Velocity	McMahon et al., 1984	Bozek et al., 2011	Based on reanalysis of Bozek et al., 2011
		Depth	McMahon et al., 1984	Bozek et al., 2011	From Turners Falls project
		Substrate	McMahon et al., 1984	McMahon et al., 1984	
Fallfish	Fry	Velocity	NA	Gomez and Sullivan, 2007	Velocity and depth based on brook trout fry and juvenile HSC curves developed as part of a Delphi Process for the Deerfield River.
		Depth	NA	Gomez and Sullivan, 2007	
		Substrate	NA	Gomez and Sullivan, 2007	
	Juvenile	Velocity	NA	Gomez and Sullivan, 2007	
		Depth	NA	Gomez and Sullivan, 2007	
		Substrate	NA	Gomez and Sullivan, 2007	
	Adult	Velocity	None identified	Gomez and Sullivan, 2007	Developed in consultation with the New York Department of Environmental Conservation
		Depth	None identified	Gomez and Sullivan, 2007	
		Substrate	None identified	Gomez and Sullivan, 2007	
	Spawning/ Incubation	Velocity	None identified	Gomez and Sullivan, 2007	
		Depth	None identified	Gomez and Sullivan, 2007	
		Substrate	None identified	Gomez and Sullivan, 2007	

Species	Life Stage	Variable	Original Source	Identified Source	Note:
Longnose dace	Fry	Velocity	USGS HSC Library	Gomez and Sullivan, 2007	
		Depth	USGS HSC Library	Gomez and Sullivan, 2007	
		Substrate	USGS HSC Library	Gomez and Sullivan, 2007	
	Juvenile	Velocity	USGS HSC Library	Gomez and Sullivan, 2000	Modified by Vermont Department of Fish and Wildlife
		Depth	USGS HSC Library	Gomez and Sullivan, 2000	
		Substrate	USGS HSC Library	Gomez and Sullivan, 2000	
	Adult	Velocity	USGS HSC Library	Gomez and Sullivan, 2000	
		Depth	USGS HSC Library	Gomez and Sullivan, 2000	
		Substrate	USGS HSC Library	Gomez and Sullivan, 2007	
White sucker	Fry	Velocity	Twomey et al., 1984	Twomey et al., 1984	
		Depth	Twomey et al., 1984	Twomey et al., 1984	
		Substrate	Twomey et al., 1984	Twomey et al., 1984	
	Juvenile/Adult	Velocity	Twomey et al., 1984	Twomey et al., 1984	
		Depth	Twomey et al., 1984	Twomey et al., 1984	
		Substrate	Twomey et al., 1984	Twomey et al., 1984	
	Spawning/ Incubation	Velocity	Twomey et al., 1984	Twomey et al., 1984	
		Depth	Twomey et al., 1984	Twomey et al., 1984	
		Substrate	Twomey et al., 1984	Gomez and Sullivan, 2007	Modified from original source
Tessellated darter	Adult	Velocity	Warner et al. 2006	Warner et al. 2006 & Aadland and Kuitunen 2006	Modified by VTDFW-2015
		Depth	Warner et al. 2006		
		Substrate	Aadland and Kuitunen 2006	Aadland and Kuitunen 2006	Jhonny darter as surrogate
Sea lamprey	Spawning	Velocity	Kynard and Horgan, 2013	Kynard and Horgan, 2013	Modified by FWS based on Yergeau, 1983 (depth and substrate); Depth modified by NAI Feb. 2017
		Depth	Kynard and Horgan, 2013	Kynard and Horgan, 2013	
		Substrate	Kynard and Horgan, 2013	Kynard and Horgan, 2013	
Smallmouth bass	Fry	Velocity	NA	Leonard et al., 1986	HSC source for this project
		Depth	NA	Leonard et al., 1986	HSC source for this project
		Substrate	NA	Leonard et al., 1986	HSC source for this project
	Juvenile	Velocity	NA	Groshens and Orth, 1994	HSC source for this project
		Depth	NA	Leonard et al., 1986	HSC source for this project
		Substrate	NA	Leonard et al., 1986	HSC source for this project
	Adult	Velocity	NA	Groshens and Orth, 1994	HSC source for this project
		Depth	NA	Leonard et al., 1986	HSC source for this project
		Substrate	NA	Leonard et al., 1986	HSC source for this project
	Spawning	Velocity	NA	Allen, 1996	HSC source for this project
		Depth	NA	Edwards et al., 1983	HSC source for this project
		Substrate	NA	Allen, 1996	HSC source for this project
Macro-invetebrates	nymphs	Velocity	Unknown	Gomez and Sullivan, 2000	VTDFW modified
		Depth	Unknown	Gomez and Sullivan, 2000	NMPC curve
		Substrate	Unknown	Gomez and Sullivan, 2000	

Species	Variable	Original Source	Identified Source	Note:
Dwarf Wedgemussel	Velocity	Normandeau &Biodrawverity 2016	Normandeau &Biodrawverity 2016	Delphi process
	Depth	Normandeau &Biodrawverity 2016	Normandeau &Biodrawverity 2016	
	Substrate	Normandeau &Biodrawverity 2016	Normandeau &Biodrawverity 2016	
	Shear Velocity	Normandeau &Biodrawverity 2016	Normandeau &Biodrawverity 2016	
	Bed Shear Stress	Normandeau &Biodrawverity 2016	Normandeau &Biodrawverity 2016	
	Relative Shear Stress	Normandeau &Biodrawverity 2016	Normandeau &Biodrawverity 2016	
	Benthic Velocity	Normandeau &Biodrawverity 2016	Normandeau &Biodrawverity 2016	
Co-occurring Mussels	Velocity	Normandeau &Biodrawverity 2017	Normandeau &Biodrawverity 2017	
	Depth	Normandeau &Biodrawverity 2017	Normandeau &Biodrawverity 2017	
	Substrate	Normandeau &Biodrawverity 2017	Normandeau &Biodrawverity 2017	
	Bed Shear Stress	Normandeau &Biodrawverity 2017	Normandeau &Biodrawverity 2017	
	Relative Shear Stress	Normandeau &Biodrawverity 2017	Normandeau &Biodrawverity 2017	
	Benthic Velocity	Normandeau &Biodrawverity 2017	Normandeau &Biodrawverity 2017	

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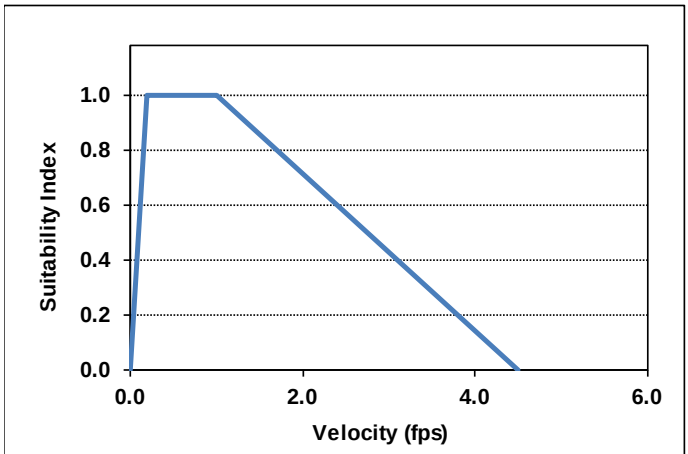
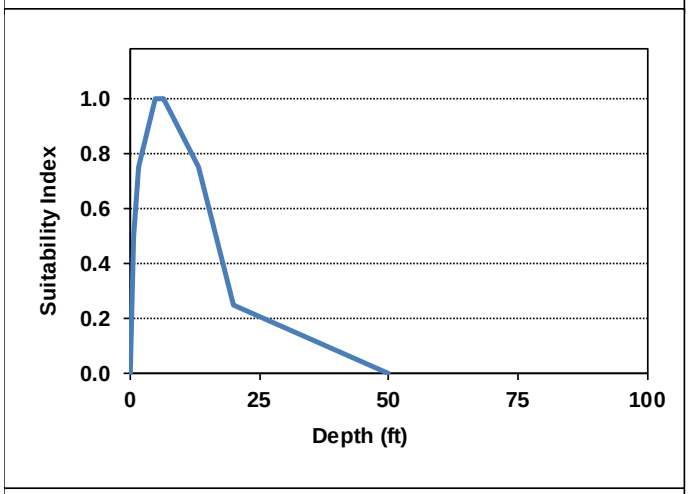
American Shad Juvenile



Source:

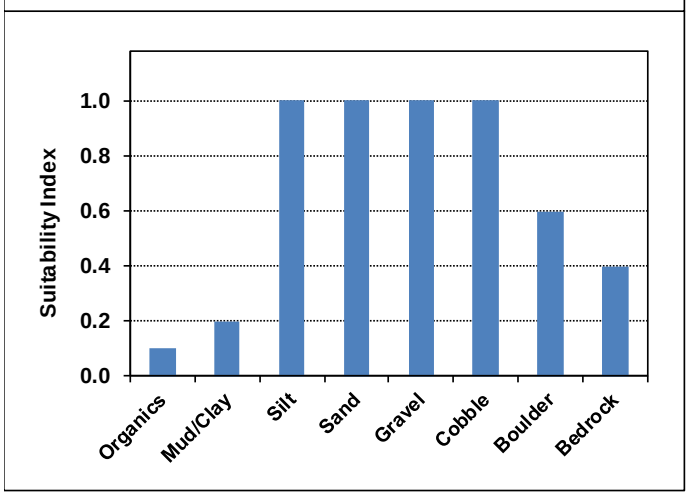
Stier and Crance, 1985

Velocity (ft/s)	SI
0.00	0.00
0.20	1.00
1.00	1.00
4.50	0.00



Greene et al., 2009

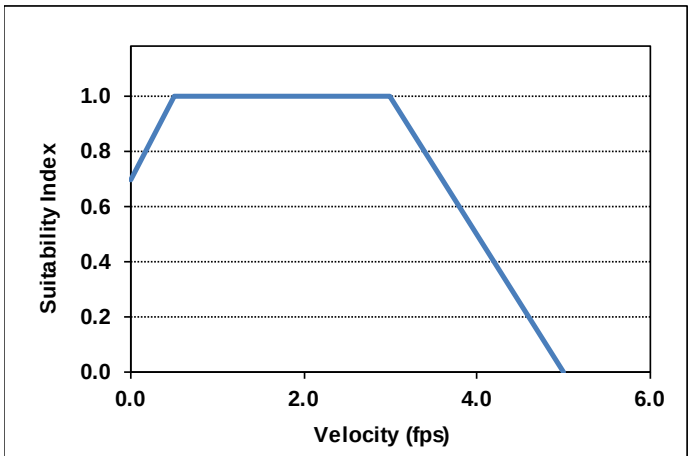
Depth (ft)	SI
0.00	0.00
0.66	0.50
1.50	0.75
4.90	1.00
6.60	1.00
13.20	0.75
20.00	0.25
50.00	0.00



Conowingo IFIM

Substrate	SI
Organics	0.10
Mud/Clay	0.20
Silt	1.00
Sand	1.00
Gravel	1.00
Cobble	1.00
Boulder	0.60
Bedrock	0.40

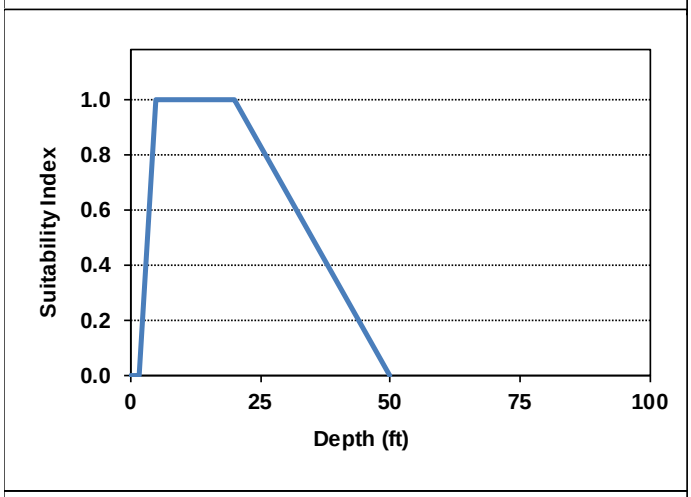
American Shad Adult



Source:

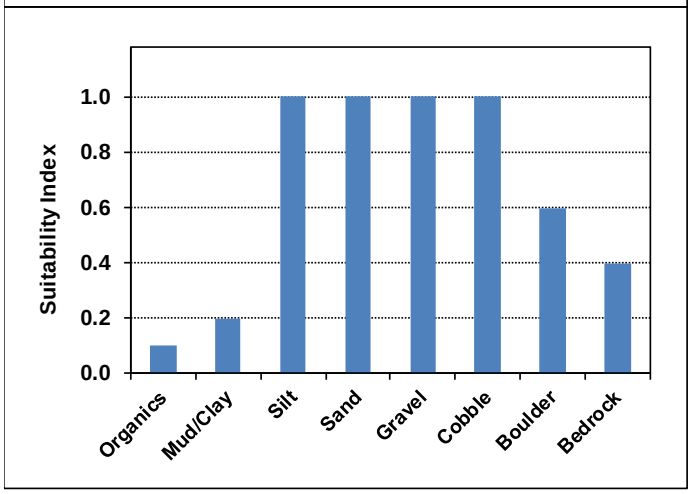
Stier and Crance, 1985

Velocity (ft/s)	SI
0.00	0.70
0.50	1.00
3.00	1.00
5.00	0.00



Stier and Crance, 1985

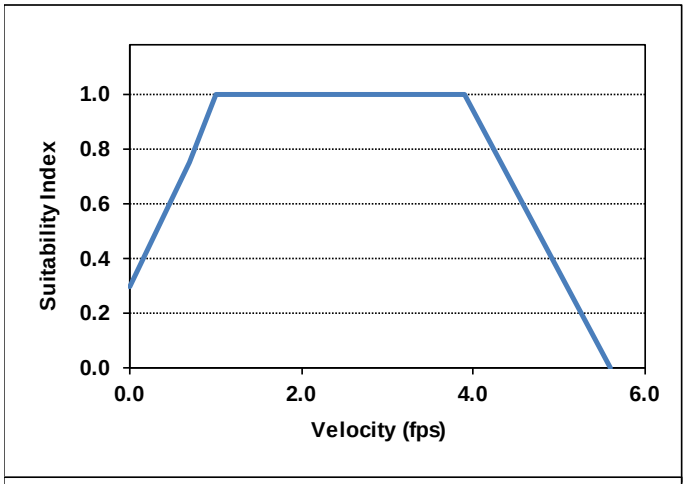
Depth (ft)	SI
0.00	0.00
1.50	0.00
5.00	1.00
20.00	1.00
50.00	0.00



Conowingo IFIM

Substrate	SI
Organics	0.10
Mud/Clay	0.20
Silt	1.00
Sand	1.00
Gravel	1.00
Cobble	1.00
Boulder	0.60
Bedrock	0.40

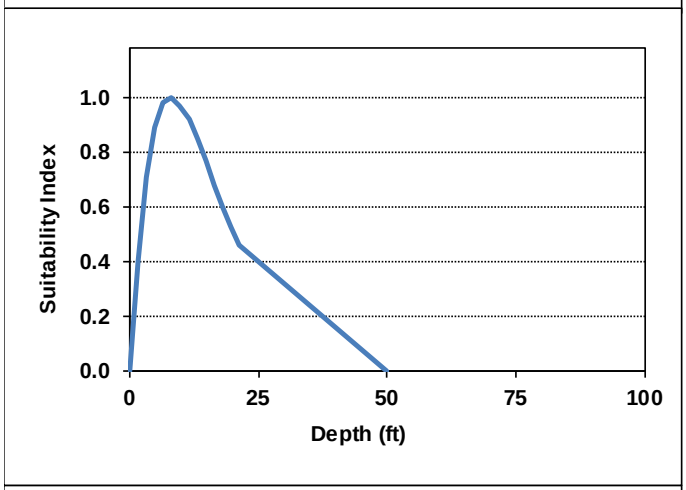
American Shad Spawning



Source:

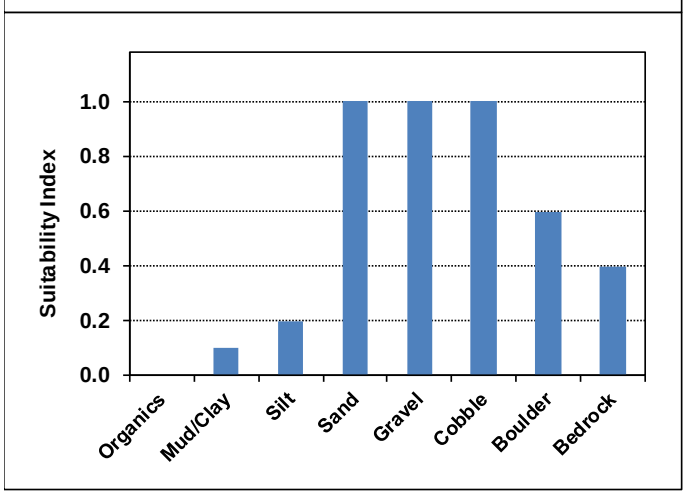
Velocity based on data from Hightower et al., 2012

Velocity (ft/s)	SI
0.00	0.30
0.70	0.75
1.00	1.00
3.00	1.00
3.90	1.00
5.60	0.00



Hightower et al., 2012 and Stier and Crance, 1985

Depth (ft)	SI
0.00	0.00
1.60	0.40
3.30	0.71
4.90	0.89
6.60	0.98
8.20	1.00
9.80	0.97
11.50	0.92
13.10	0.85
14.80	0.77
16.40	0.68
18.00	0.60
19.70	0.53
21.30	0.46
50.00	0.00

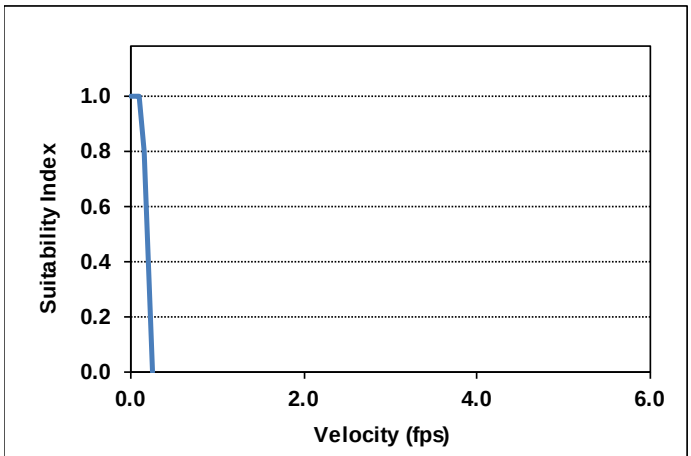


Stier and Crance, 1985

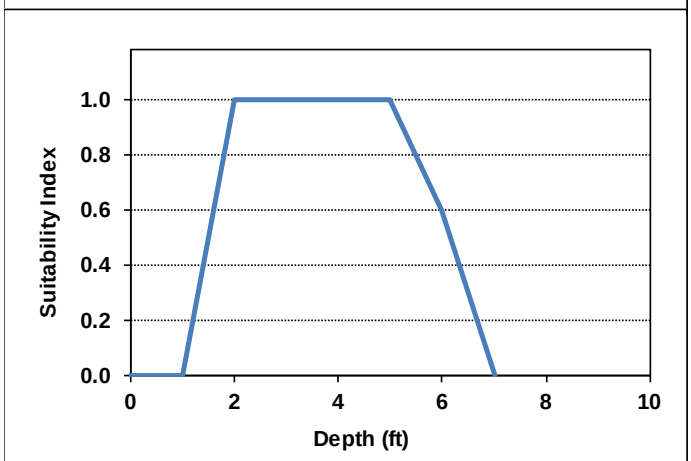
Substrate	SI
Organics	0.00
Mud/Clay	0.10
Silt	0.20
Sand	1.00
Gravel	1.00
Cobble	1.00
Boulder	0.60
Bedrock	0.40

Walleye Fry

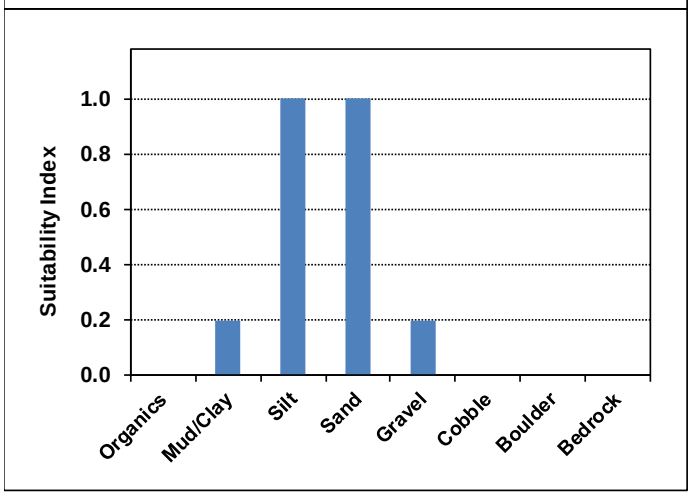
Source:
McMahon et al., 1984



Velocity (ft/s)	SI
0.00	1.00
0.10	1.00
0.15	0.80
0.25	0.00
2.00	0.00



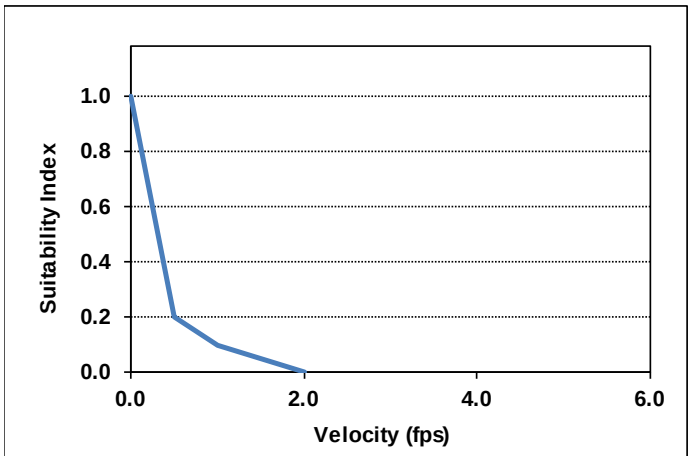
Depth (ft)	SI
0.00	0.00
1.00	0.00
2.00	1.00
5.00	1.00
6.00	0.60
7.00	0.00



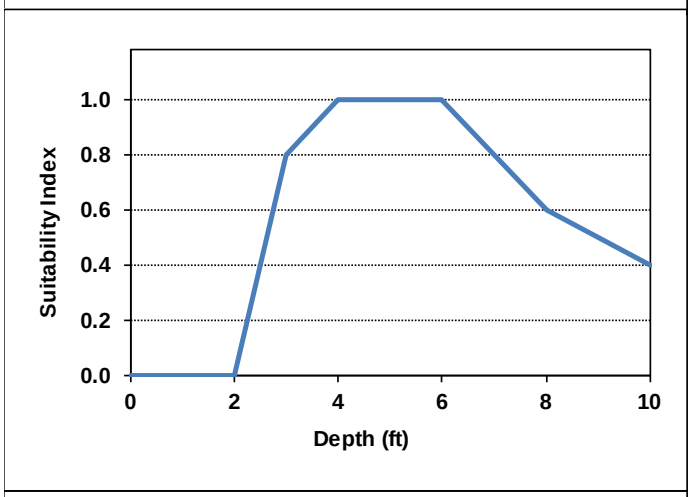
Substrate	SI
Organics	0.00
Mud/Clay	0.20
Silt	1.00
Sand	1.00
Gravel	0.20
Cobble	0.00
Boulder	0.00
Bedrock	0.00

Walleye Juvenile

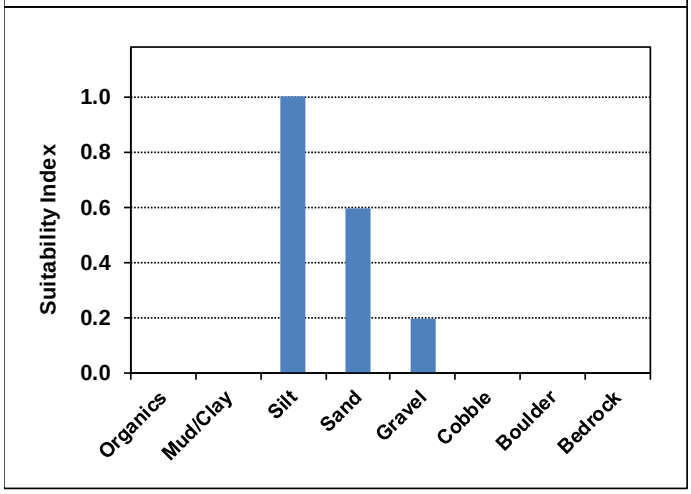
Source:
McMahon et al., 1984



Velocity (ft/s)	SI
0.00	1.00
0.50	0.20
1.00	0.10
2.00	0.00



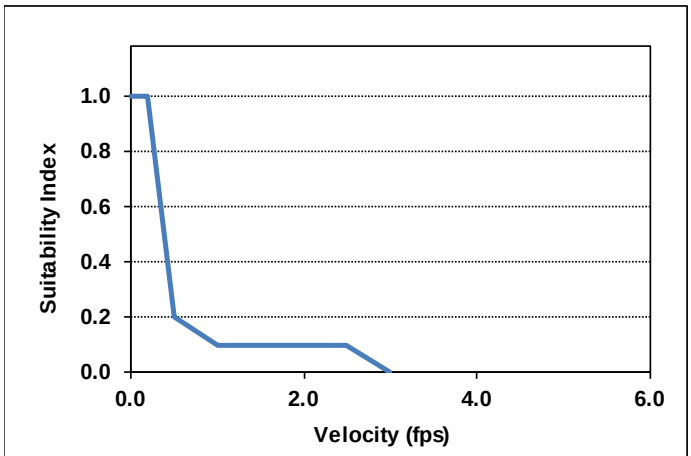
Depth (ft)	SI
0.00	0.00
2.00	0.00
3.00	0.80
4.00	1.00
6.00	1.00
8.00	0.60
10.00	0.40
50.00	0.40



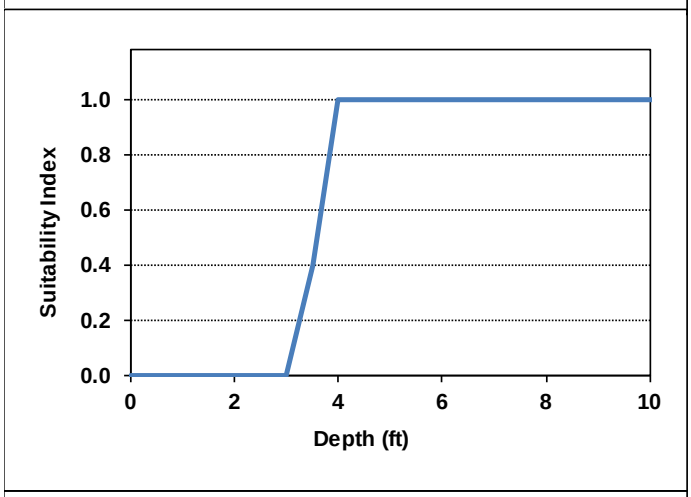
Substrate	SI
Organics	0.00
Mud/Clay	0.00
Silt	1.00
Sand	0.60
Gravel	0.20
Cobble	0.00
Boulder	0.00
Bedrock	0.00

Walleye Adult

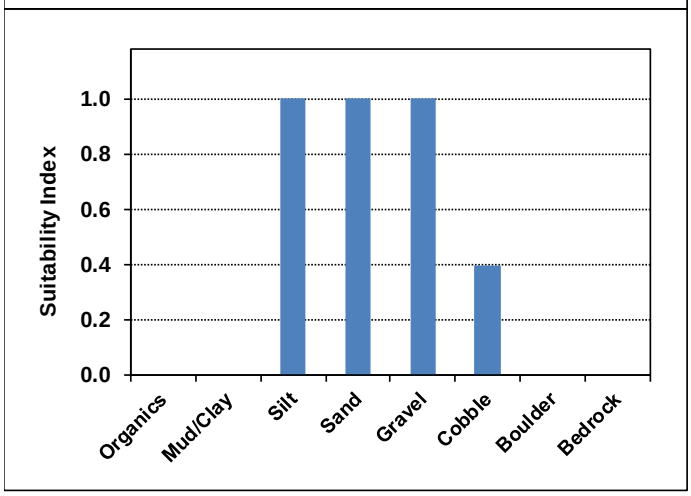
Source:
McMahon et al., 1984



Velocity (ft/s)	SI
0.00	1.00
0.20	1.00
0.50	0.20
1.00	0.10
2.50	0.10
3.00	0.00

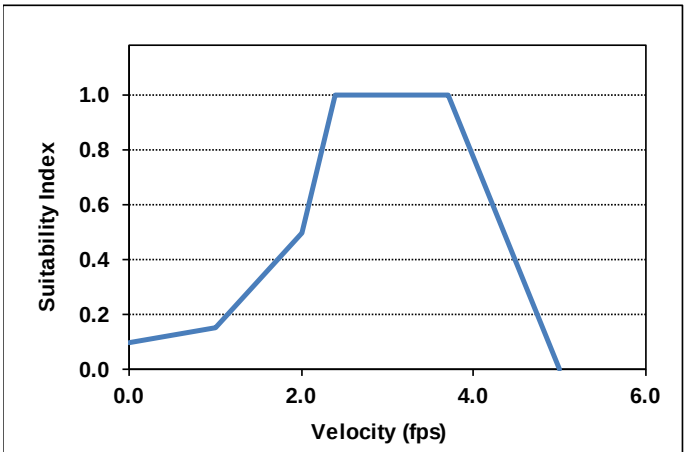


Depth (ft)	SI
0.00	0.00
3.00	0.00
3.50	0.40
4.00	1.00
50.00	1.00



Substrate	SI
Organics	0.00
Mud/Clay	0.00
Silt	1.00
Sand	1.00
Gravel	1.00
Cobble	0.40
Boulder	0.00
Bedrock	0.00

Walleye Spawning & Incubation

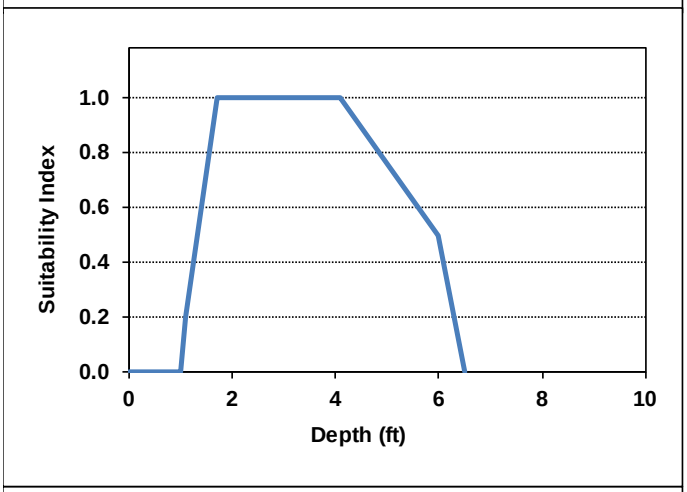


Source:

Based on Bozek et al., 2011

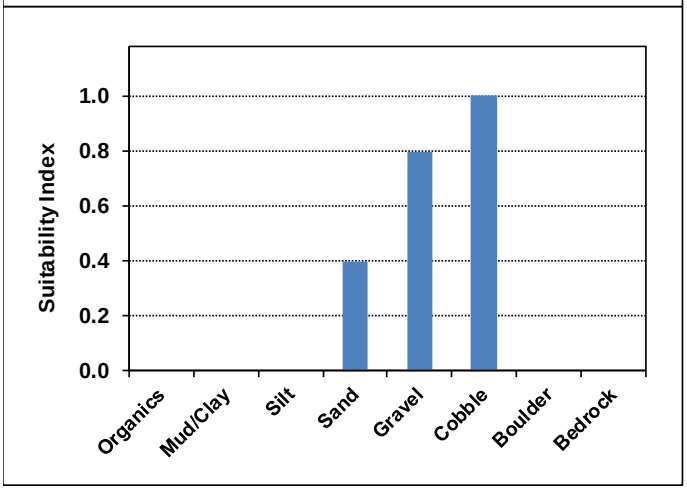
Velocity (ft/s)	SI
0.00	0.10
1.00	0.15
2.00	0.50
2.40	1.00
3.70	1.00
5.00	0.00

endpoint hypothetical



Turners Falls based on Bozek et al., 2011

Depth (ft)	SI
0.00	0.00
1.00	0.00
1.10	0.20
1.70	1.00
4.10	1.00
6.00	0.50
6.50	0.00



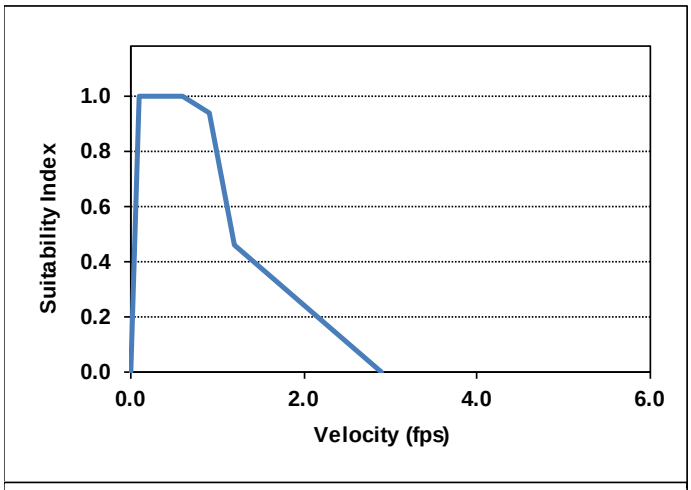
McMahon et al., 1984

Substrate	SI
Organics	0.00
Mud/Clay	0.00
Silt	0.00
Sand	0.40
Gravel	0.80
Cobble	1.00
Boulder	0.00
Bedrock	0.00

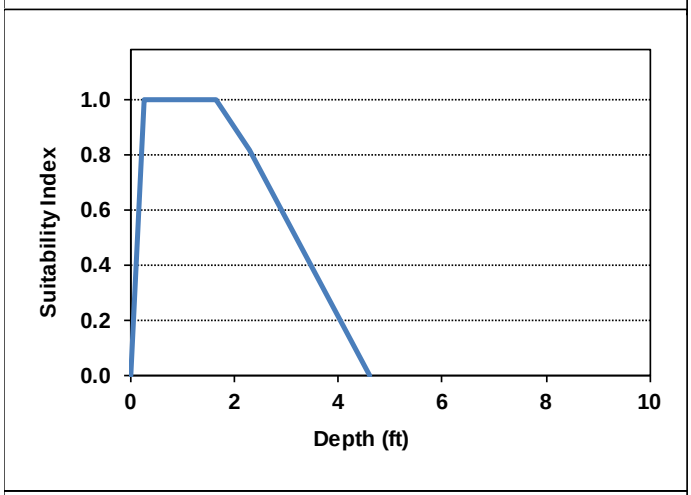
Fallfish Fry

Velocity and depth from brook trout fry curves (Deerfield River)
Substrate developed by Charles Ritzi

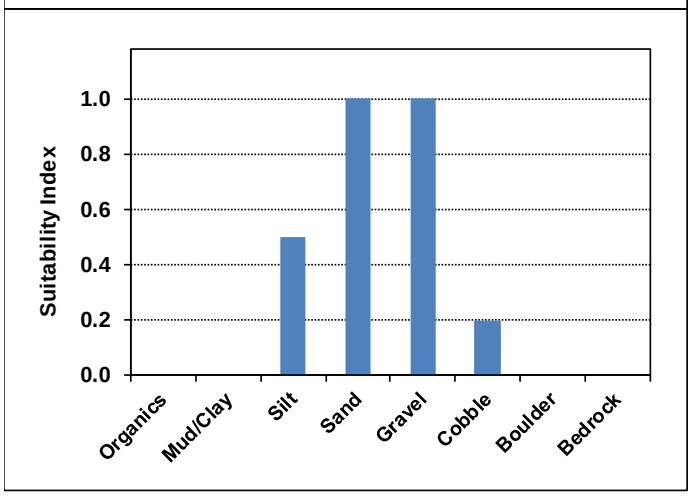
Source:
Gomez and Sullivan, 2007



Velocity (ft/s)	SI
0.00	0.00
0.10	1.00
0.60	1.00
0.90	0.94
1.20	0.46
2.90	0.00



Depth (ft)	SI
0.00	0.00
0.25	1.00
1.65	1.00
2.30	0.82
4.60	0.00
100.00	0.00

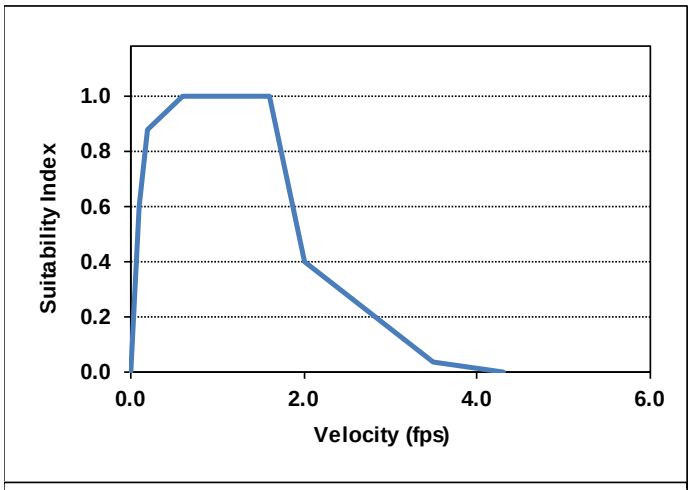


Substrate	SI
Organics	0.00
Mud/Clay	0.00
Silt	0.50
Sand	1.00
Gravel	1.00
Cobble	0.20
Boulder	0.00
Bedrock	0.00

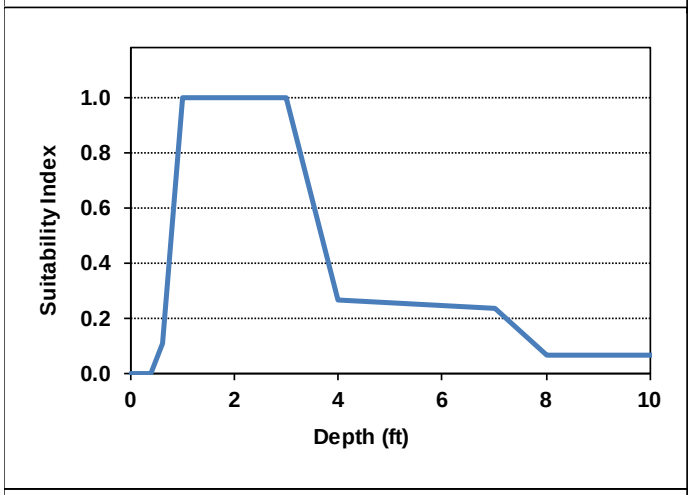
Fallfish Juvenile

Velocity and depth from brook trout fry curves (Deerfield River)
Substrate developed by Charles Ritzi

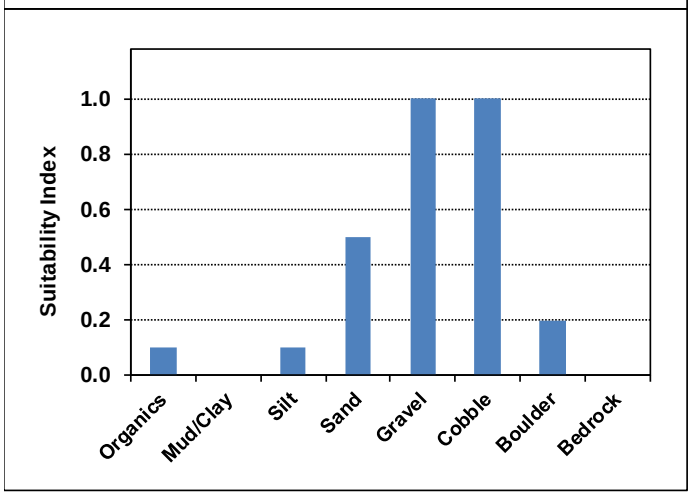
Source:
Gomez and Sullivan, 2007



Velocity (ft/s)	SI
0.00	0.00
0.10	0.60
0.20	0.88
0.60	1.00
1.60	1.00
2.00	0.40
3.50	0.04
4.30	0.00



Depth (ft)	SI
0.00	0.00
0.40	0.00
0.60	0.11
1.00	1.00
3.00	1.00
4.00	0.27
7.00	0.24
8.00	0.07
20.00	0.07
100.00	0.07

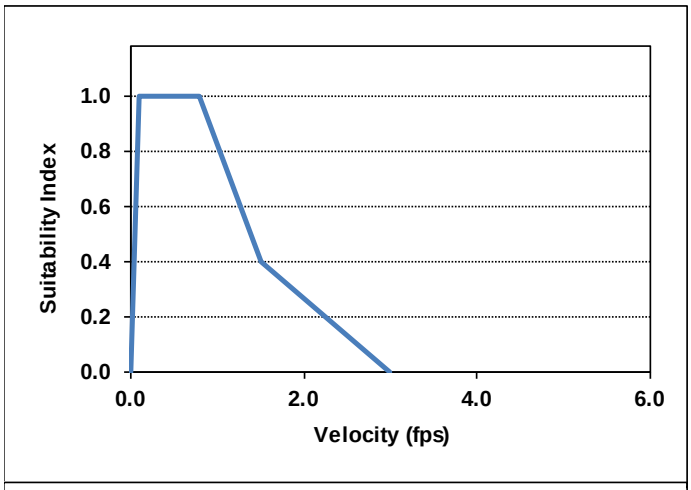


Substrate	SI
Organics	0.10
Mud/Clay	0.00
Silt	0.10
Sand	0.50
Gravel	1.00
Cobble	1.00
Boulder	0.20
Bedrock	0.00

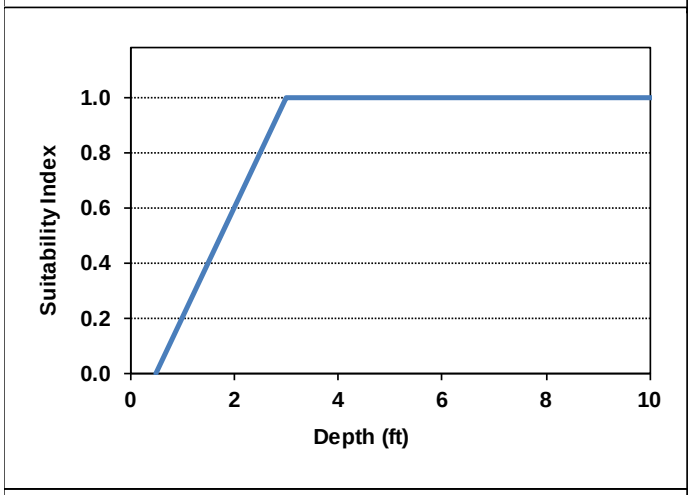
Fallfish Adult

Developed from consultation with NYSDEC
(New York Dept. of Environmental Conservation)

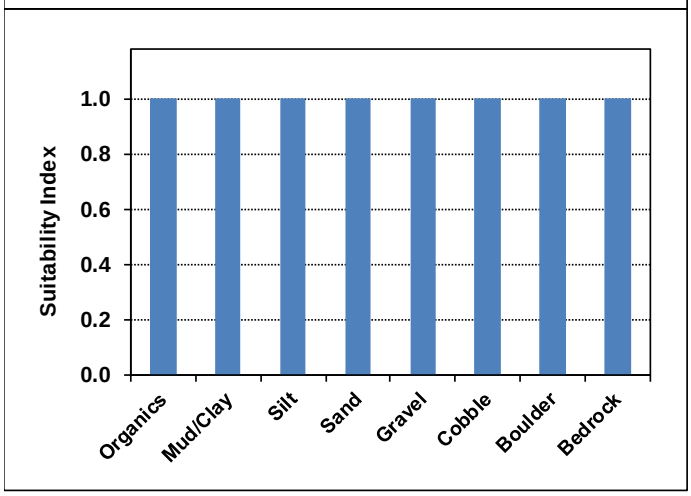
Source:
Gomez and Sullivan, 2007



Velocity (ft/s)	SI
0.00	0.00
0.10	1.00
0.80	1.00
1.50	0.40
3.00	0.00



Depth (ft)	SI
0.00	0.00
0.50	0.00
3.00	1.00
100.00	1.00

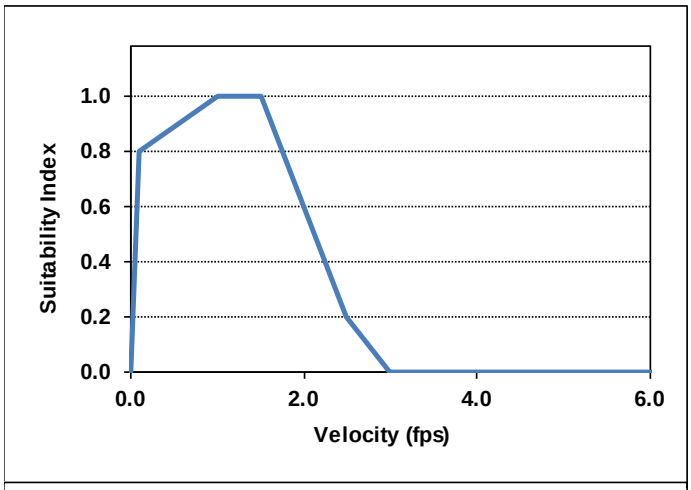


Substrate	SI
Organics	1.00
Mud/Clay	1.00
Silt	1.00
Sand	1.00
Gravel	1.00
Cobble	1.00
Boulder	1.00
Bedrock	1.00

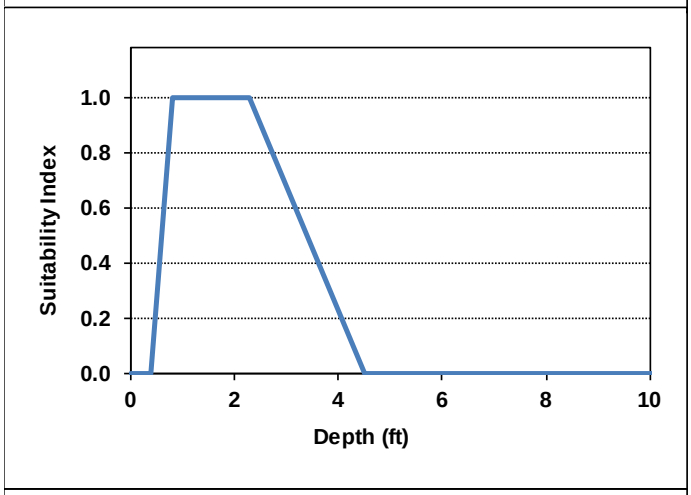
Fallfish Spawning & Incubation

Developed from consultation with NYSDEC
(New York Dept. of Environmental Conservation)

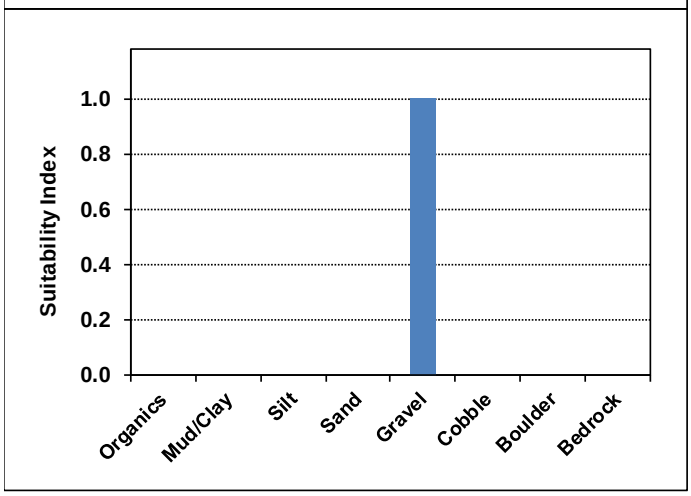
Source:
Gomez and Sullivan, 2007



Velocity (ft/s)	SI
0.00	0.00
0.10	0.80
1.00	1.00
1.50	1.00
2.50	0.20
3.00	0.00
100.00	0.00



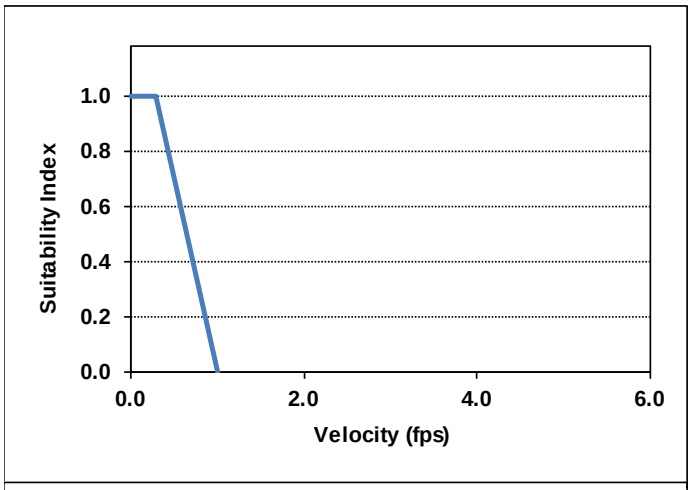
Depth (ft)	SI
0.00	0.00
0.40	0.00
0.80	1.00
2.30	1.00
4.50	0.00
100.00	0.00



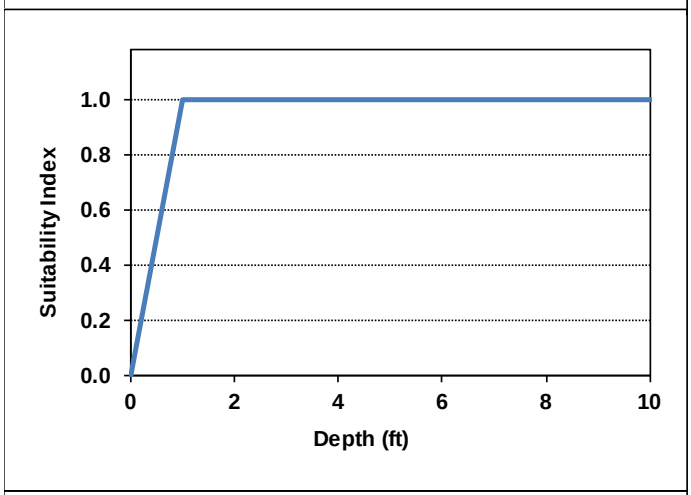
Substrate	SI
Organics	0.00
Mud/Clay	0.00
Silt	0.00
Sand	0.00
Gravel	1.00
Cobble	0.00
Boulder	0.00
Bedrock	0.00

White Sucker Fry

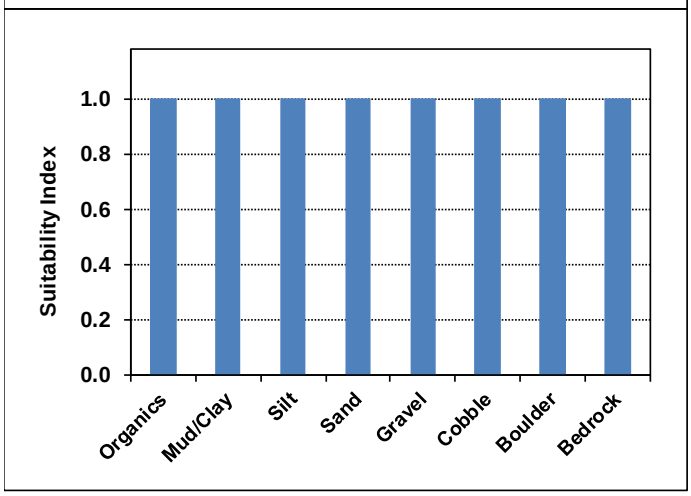
Source:
Twomey et al., 1984



Velocity (ft/s)	SI
0.00	1.00
0.30	1.00
1.00	0.00



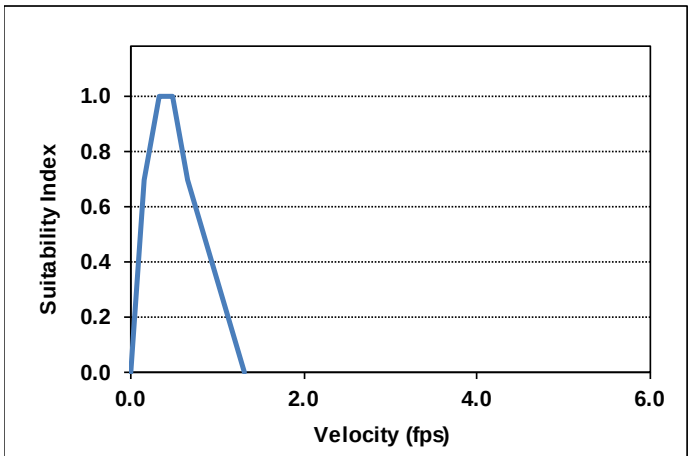
Depth (ft)	SI
0.00	0.00
1.00	1.00
100.00	1.00



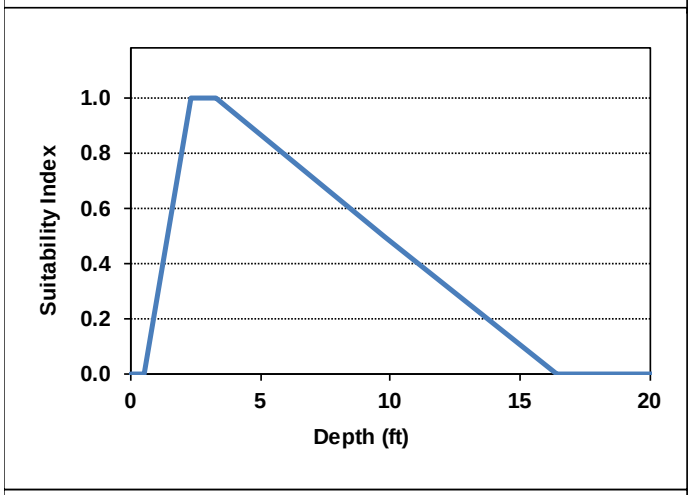
Substrate	SI
Organics	1.00
Mud/Clay	1.00
Silt	1.00
Sand	1.00
Gravel	1.00
Cobble	1.00
Boulder	1.00
Bedrock	1.00

White Sucker Adult/Juvenile

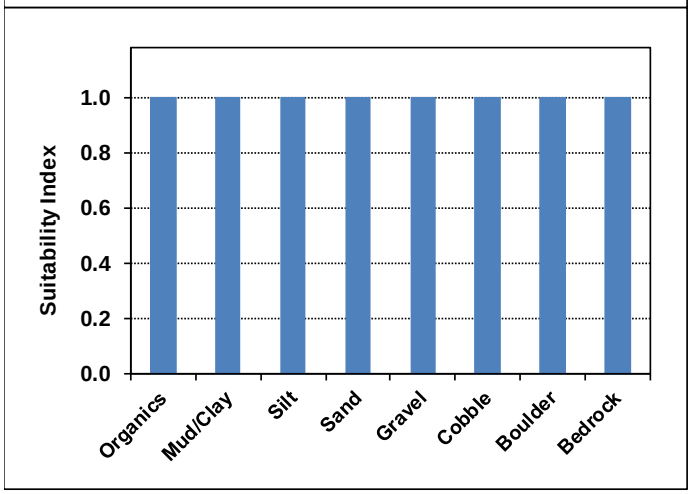
Source:
Twomey et al., 1984



Velocity (ft/s)	SI
0.00	0.00
0.16	0.70
0.33	1.00
0.49	1.00
0.66	0.70
1.31	0.00



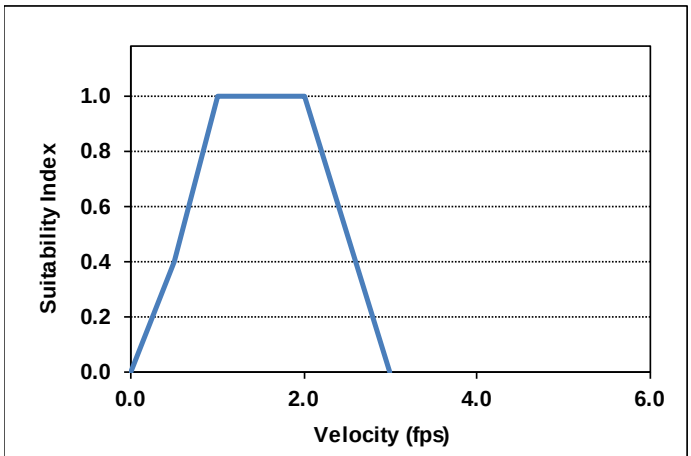
Depth (ft)	SI
0.00	0.00
0.50	0.00
2.30	1.00
3.30	1.00
9.80	0.50
16.40	0.00
100.00	0.00



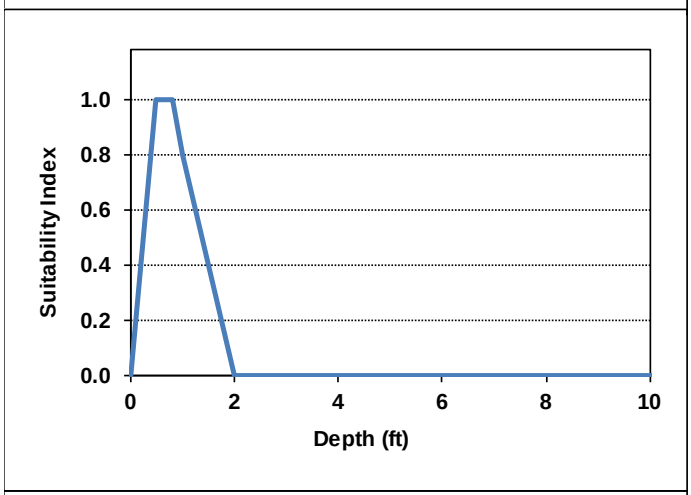
Substrate	SI
Organics	1.00
Mud/Clay	1.00
Silt	1.00
Sand	1.00
Gravel	1.00
Cobble	1.00
Boulder	1.00
Bedrock	1.00

White Sucker Spawning & Incubation

Source:
Twomey et al., 1984

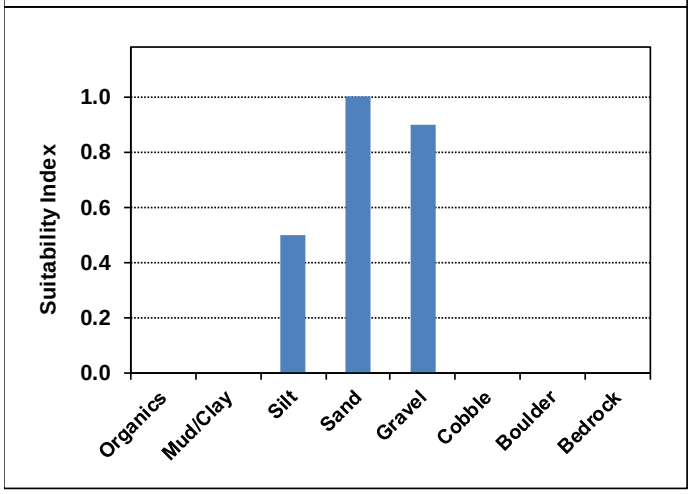


Velocity (ft/s)	SI
0.00	0.00
0.50	0.40
1.00	1.00
2.00	1.00
3.00	0.00



Depth (ft)	SI
0.00	0.00
0.50	1.00
0.80	1.00
1.00	0.80
2.00	0.00
100.00	0.00

Substrate Source:
Gomez and Sullivan, 2007

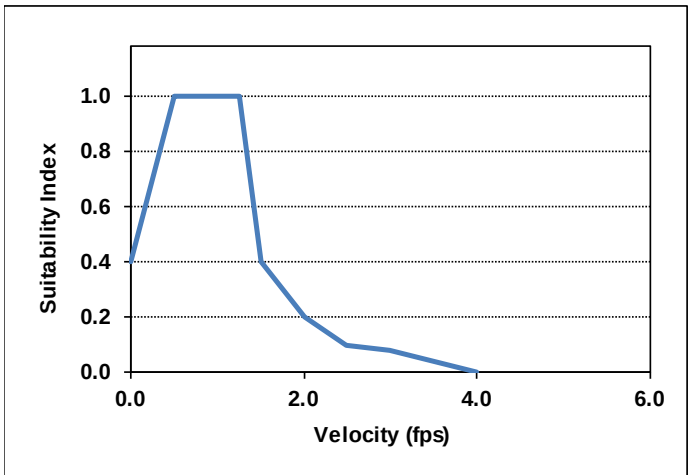


Substrate	SI
Organics	0.00
Mud/Clay	0.00
Silt	0.50
Sand	1.00
Gravel	0.90
Cobble	0.00
Boulder	0.00
Bedrock	0.00

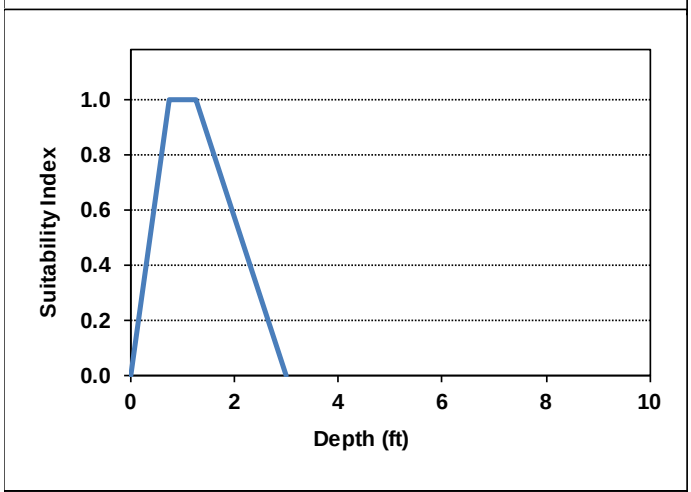
Longnose Dace Fry

Original curve identified as from USFWS HSC library
Modified by VDFW for the Lamoille River IFS (Gomez and Sullivan, 2000)

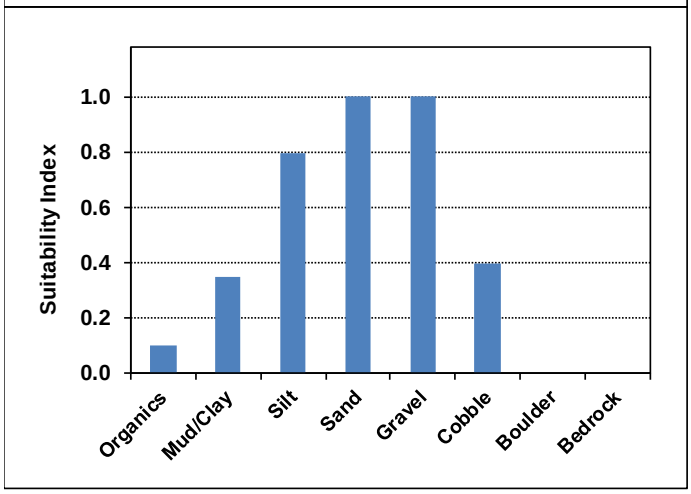
Source:
Gomez and Sullivan, 2007



Velocity (ft/s)	SI
0.00	0.40
0.50	1.00
1.25	1.00
1.50	0.40
2.00	0.20
2.50	0.10
3.00	0.08
4.00	0.00



Depth (ft)	SI
0.00	0.00
0.75	1.00
1.25	1.00
3.00	0.00

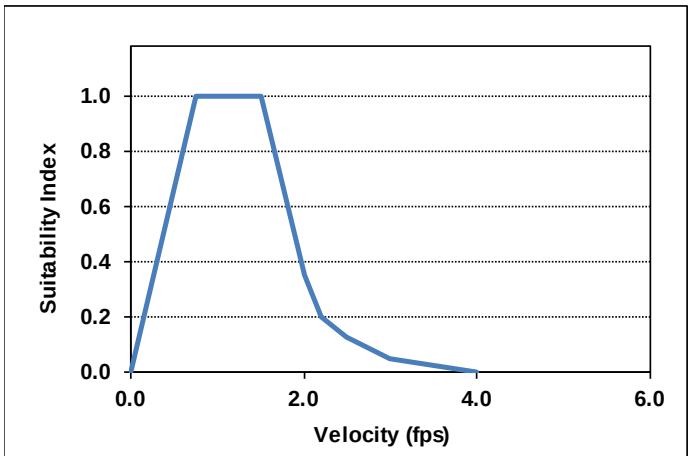


Substrate	SI
Organics	0.10
Mud/Clay	0.35
Silt	0.80
Sand	1.00
Gravel	1.00
Cobble	0.40
Boulder	0.00
Bedrock	0.00

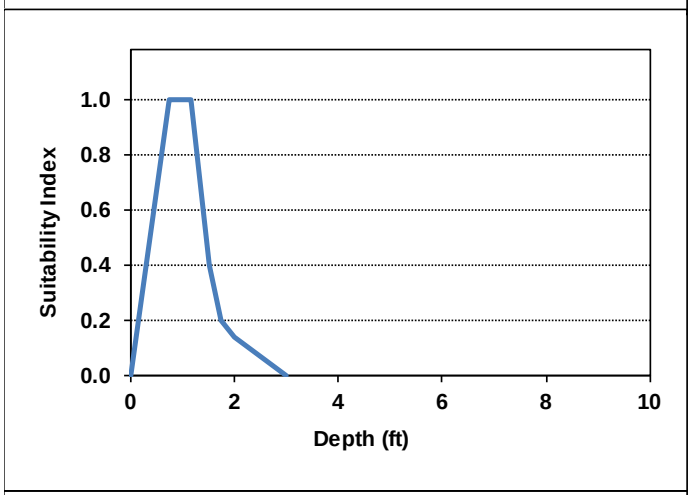
Longnose Dace Juvenile

Original curve identified as from USFWS HSC library
Modified by VDFW for the Lamoille River IFS (Gomez and Sullivan, 2000)

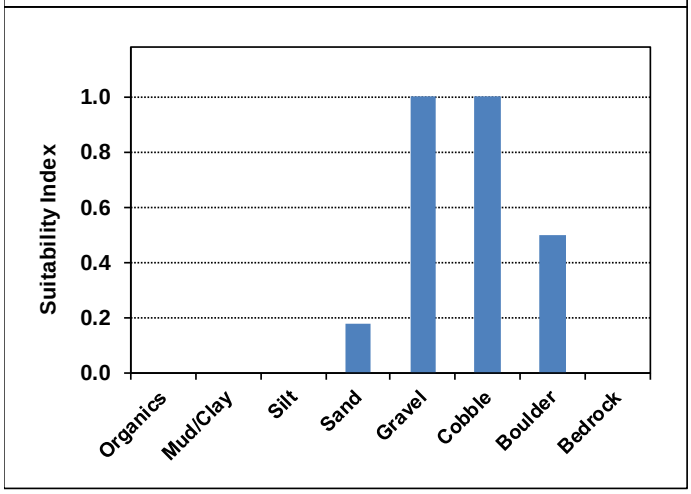
Source:
Gomez and Sullivan, 2000



Velocity (ft/s)	SI
0.00	0.00
0.75	1.00
1.50	1.00
2.00	0.35
2.20	0.20
2.50	0.13
3.00	0.05
4.00	0.00



Depth (ft)	SI
0.00	0.00
0.75	1.00
1.15	1.00
1.50	0.40
1.75	0.20
2.00	0.14
3.00	0.00

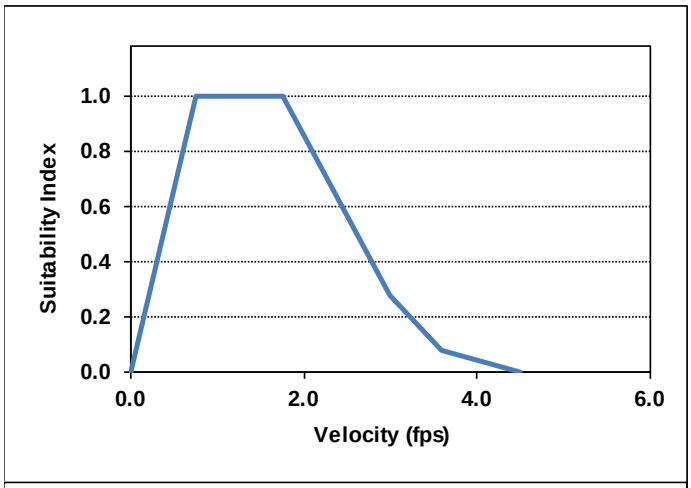


Substrate	SI
Organics	0.00
Mud/Clay	0.00
Silt	0.00
Sand	0.18
Gravel	1.00
Cobble	1.00
Boulder	0.50
Bedrock	0.00

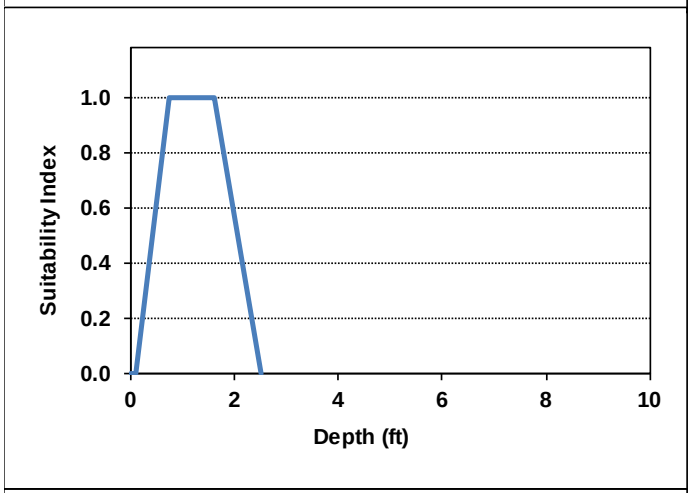
Longnose Dace Adult

Original curve identified as from USGS HSC library
Modified by VDFW for the Lamoille River IFS (Gomez and Sullivan, 2000)

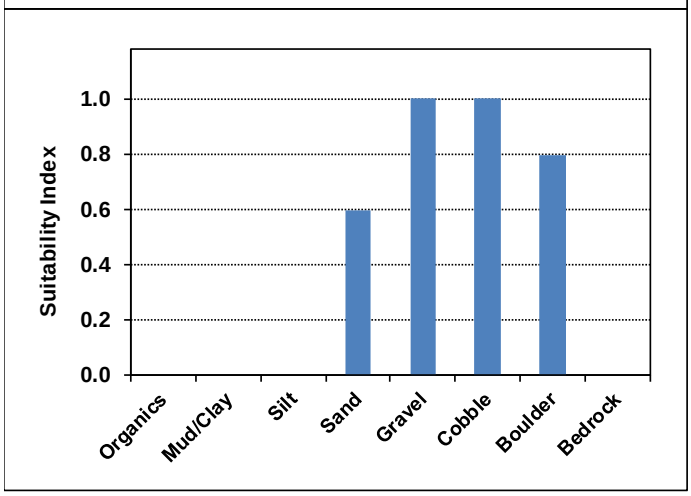
Source:
Gomez and Sullivan, 2000



Velocity (ft/s)	SI
0.00	0.00
0.75	1.00
1.75	1.00
3.00	0.28
3.60	0.08
4.50	0.00



Depth (ft)	SI
0.00	0.00
0.10	0.00
0.75	1.00
1.60	1.00
2.50	0.00



Substrate	SI
Organics	0.00
Mud/Clay	0.00
Silt	0.00
Sand	0.60
Gravel	1.00
Cobble	1.00
Boulder	0.80
Bedrock	0.00

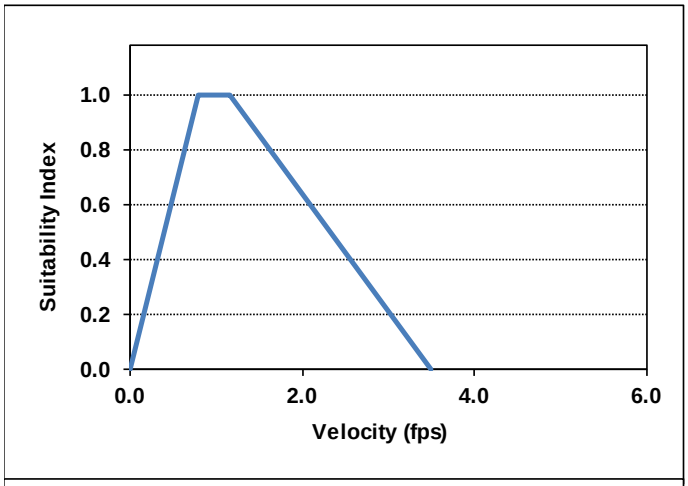
Tessellated Darter Adult

Modified by VDFW (2015) using sources

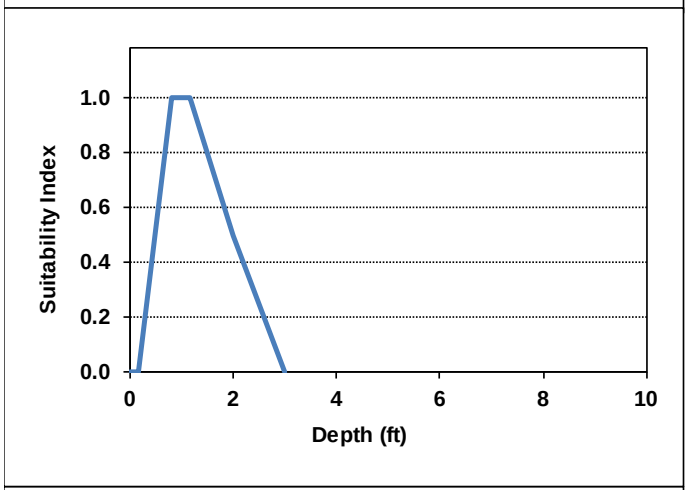
Source:

Warner et al. 2006,

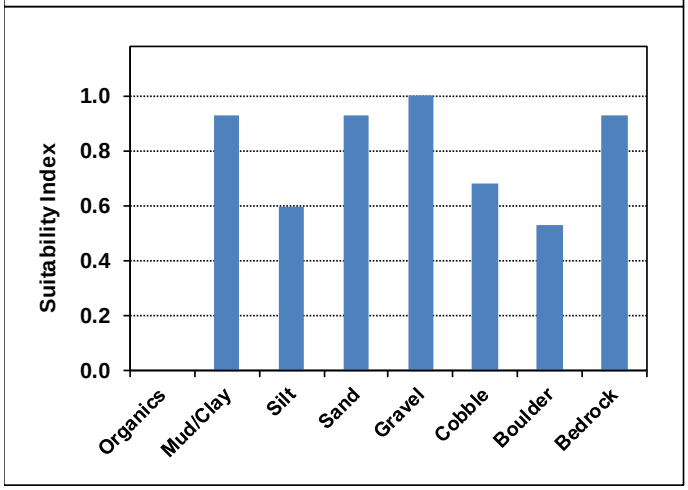
Aadland and Kuitunen 2006



Velocity (ft/s)	SI
0.00	0.00
0.80	1.00
1.15	1.00
3.50	0.00



Depth (ft)	SI
0.00	0.00
0.16	0.00
0.80	1.00
1.15	1.00
2.00	0.50
3.00	0.00



Substrate Source: Aadland and Kuitunen, 2006

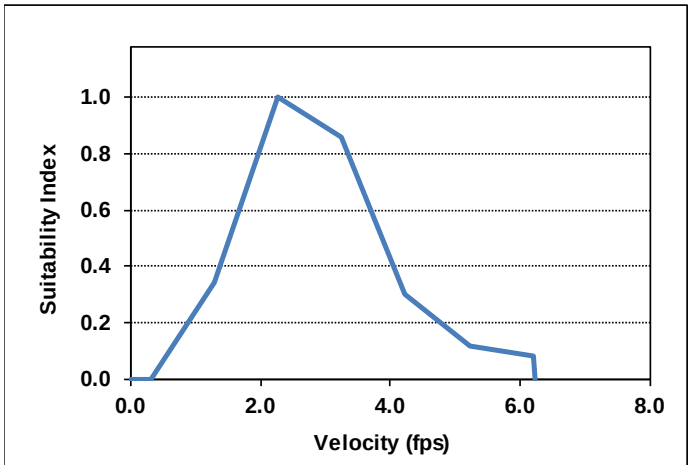
Johnny Darter- Surrogate for Tessellated Darter

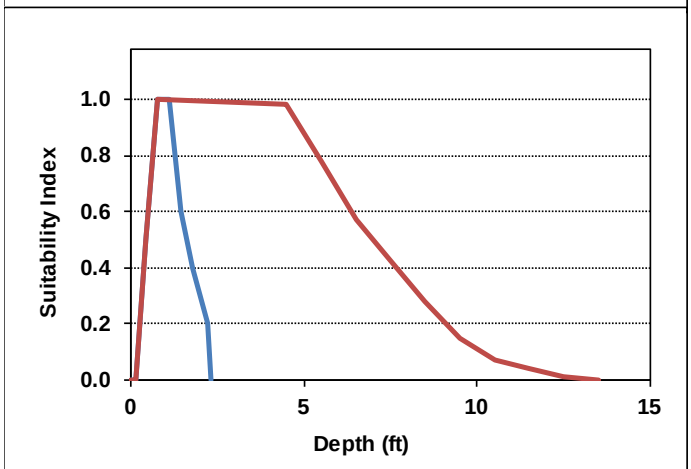
(PPL Bell Bend 2012)

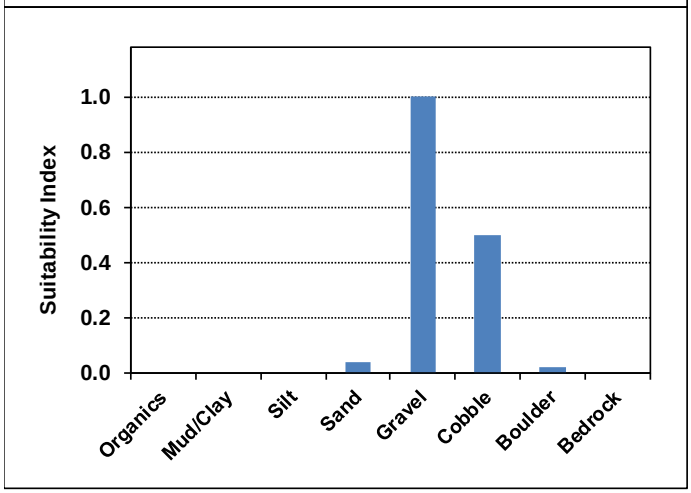
Substrate	SI
Organics	0.00
Mud/Clay	0.93
Silt	0.60
Sand	0.93
Gravel	1.00
Cobble	0.68
Boulder	0.53
Bedrock	0.93

Sea Lamprey Spawning & Incubation

Modified by USFWS (2014) based on Yergeau 1983 (depth and substrate)







Source:

Kynard and Horgan, 2013

Yergeau, 1983

Velocity (ft/s)	SI
0.00	0.00
0.30	0.00
1.28	0.34
2.26	1.00
3.25	0.86
4.23	0.30
5.22	0.12
6.20	0.08
6.23	0.00

Depth (ft)	SI
0.00	0.00
0.13	0.00
0.46	0.50
0.79	1.00
1.12	1.00
1.44	0.60
1.77	0.40
2.20	0.20
2.30	0.00

Modified by NAI

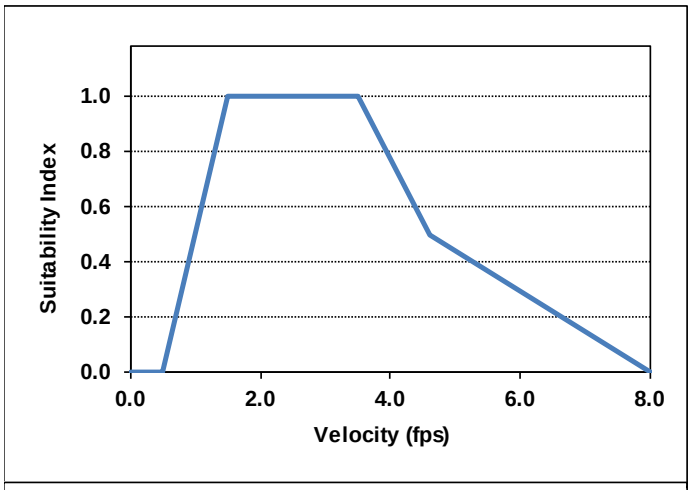
Depth (ft)	SI
0.00	0.00
0.13	0.00
0.46	0.50
0.79	1.00
4.50	0.98
5.50	0.78
6.50	0.57
7.50	0.43
8.50	0.28
9.50	0.15
10.50	0.07
11.50	0.04
12.50	0.01
13.50	0.00

Substrate	SI
Organics	0.00
Mud/Clay	0.00
Silt	0.00
Sand	0.04
Gravel	1.00
Cobble	0.50
Boulder	0.02
Bedrock	0.00

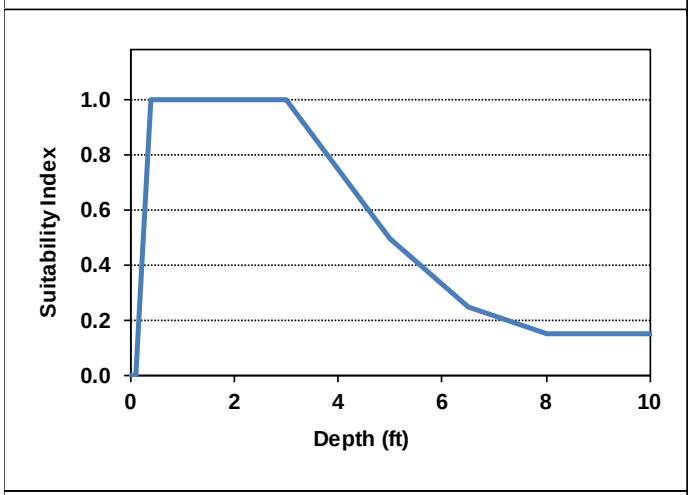
Macroinvertebrates

Source:

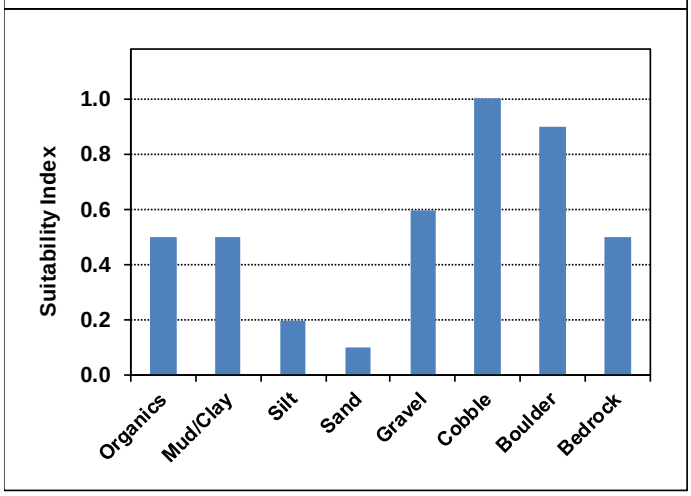
Gomez and Sullivan, 2000



Velocity (ft/s)	SI
0.00	0.00
0.50	0.00
1.50	1.00
3.50	1.00
4.60	0.50
8.00	0.00



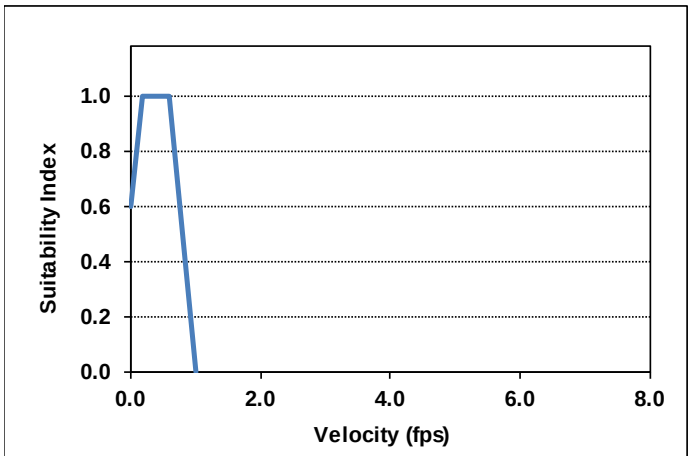
Depth (ft)	SI
0.00	0.00
0.10	0.00
0.40	1.00
3.00	1.00
5.00	0.50
6.50	0.25
8.00	0.15
10.00	0.15
100.00	0.00



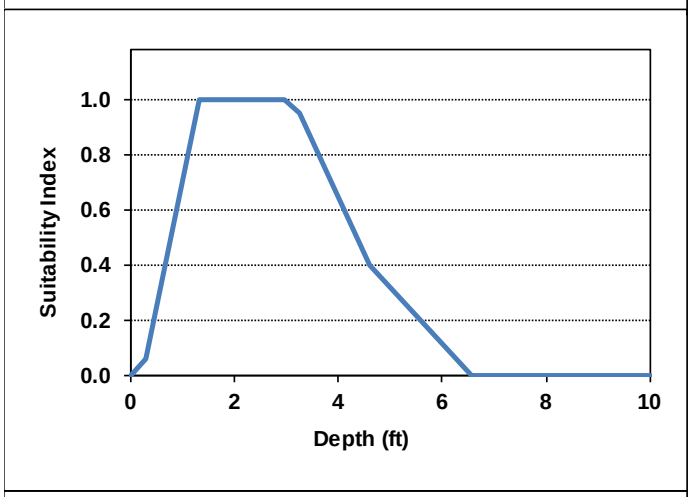
Substrate	SI
Organics	0.50
Mud/Clay	0.50
Silt	0.20
Sand	0.10
Gravel	0.60
Cobble	1.00
Boulder	0.90
Bedrock	0.50

Smallmouth Bass Fry

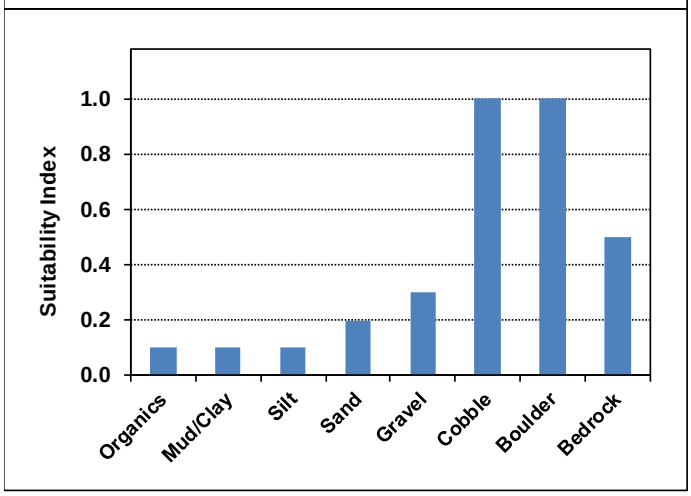
Source:
Leonard et al, 1986



Velocity (ft/s)	SI
0.00	0.60
0.19	1.00
0.59	1.00
1.00	0.00

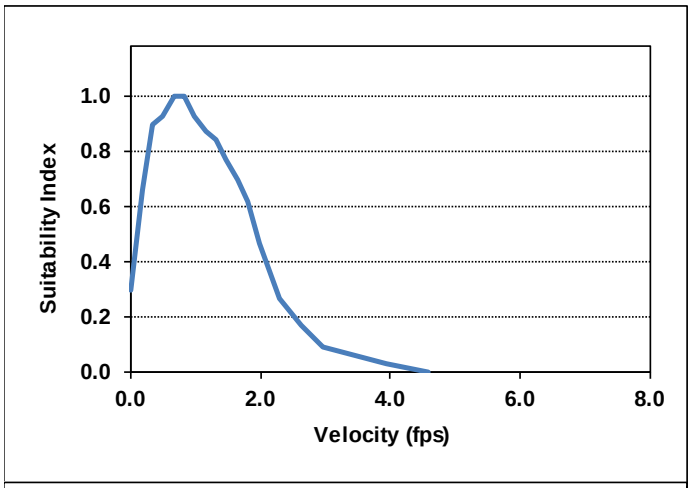


Depth (ft)	SI
0.00	0.00
0.28	0.06
1.31	1.00
2.95	1.00
3.25	0.95
4.59	0.40
6.56	0.00
10.00	0.00



Substrate	SI
Organics	0.10
Mud/Clay	0.10
Silt	0.10
Sand	0.20
Gravel	0.30
Cobble	1.00
Boulder	1.00
Bedrock	0.50

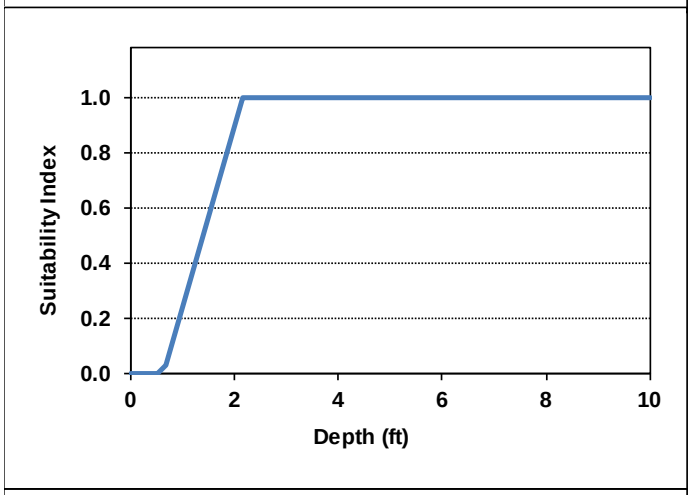
Smallmouth Bass Juvenile



Source:

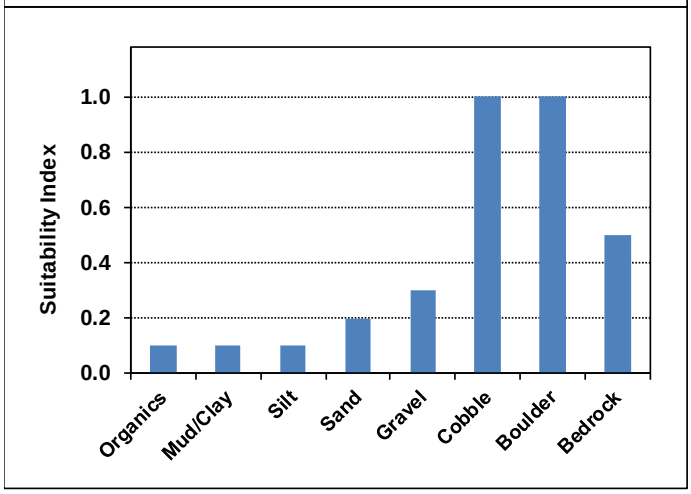
Groshens and Orth 1994

Velocity (ft/s)	SI
0.00	0.30
0.17	0.66
0.33	0.90
0.50	0.93
0.66	1.00
0.83	1.00
0.98	0.93
1.15	0.87
1.31	0.84
1.47	0.77
1.64	0.70
1.81	0.62
1.98	0.47
2.30	0.27
2.62	0.17
2.95	0.09
3.94	0.03
4.59	0.00



Leonard et al, 1986

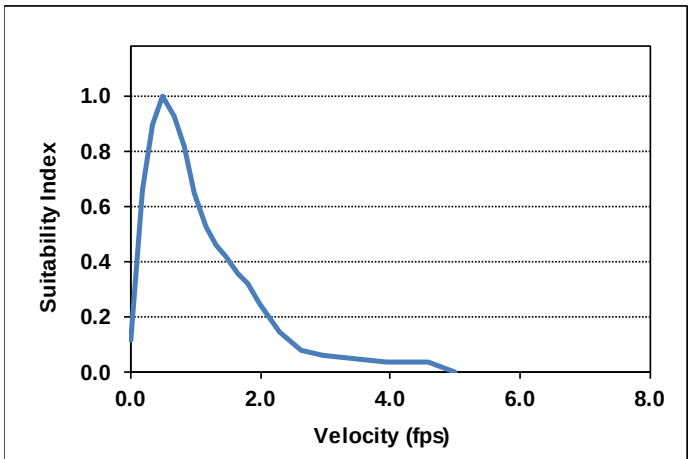
Depth (ft)	SI
0.00	0.00
0.52	0.00
0.67	0.03
2.15	1.00
10.00	1.00



Leonard et al, 1986

Substrate	SI
Organics	0.10
Mud/Clay	0.10
Silt	0.10
Sand	0.20
Gravel	0.30
Cobble	1.00
Boulder	1.00
Bedrock	0.50

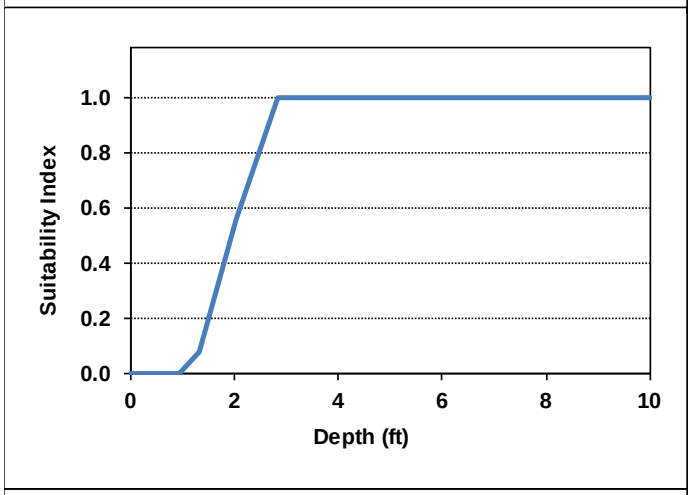
Smallmouth Bass Adult



Source:

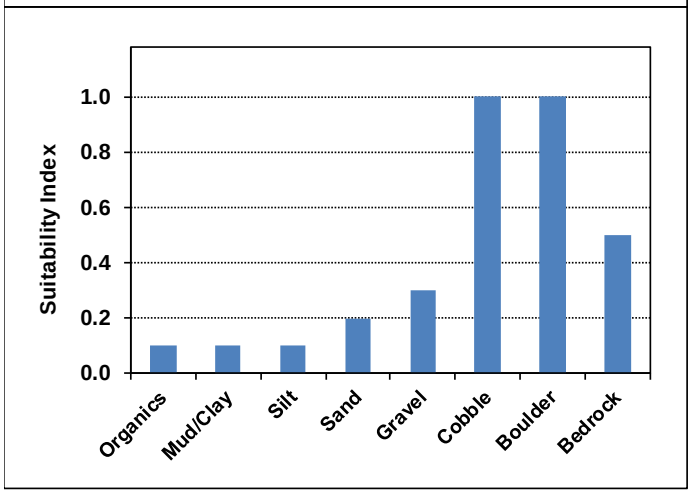
Groshens and Orth 1994

Velocity (ft/s)	SI
0.00	0.12
0.17	0.66
0.33	0.90
0.50	1.00
0.66	0.93
0.83	0.82
0.98	0.65
1.15	0.53
1.31	0.46
1.47	0.42
1.64	0.36
1.81	0.32
1.98	0.25
2.30	0.15
2.62	0.08
2.95	0.06
3.94	0.04
4.59	0.04
5.00	0.00



Leonard et al, 1986

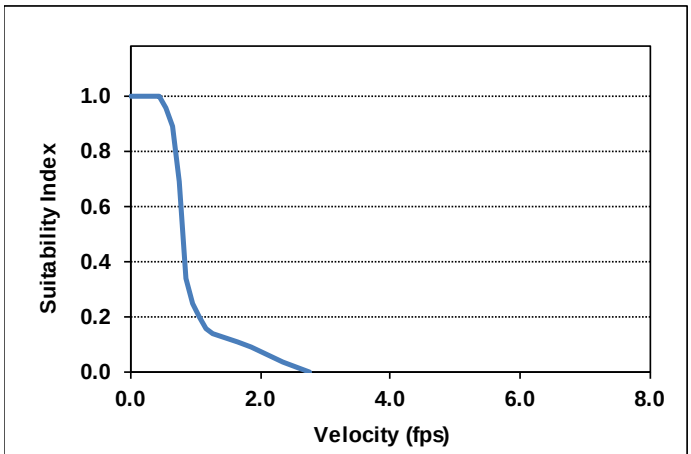
Depth (ft)	SI
0.00	0.00
0.92	0.00
1.31	0.08
2.03	0.56
2.82	1.00
6.00	1.00
10.00	1.00

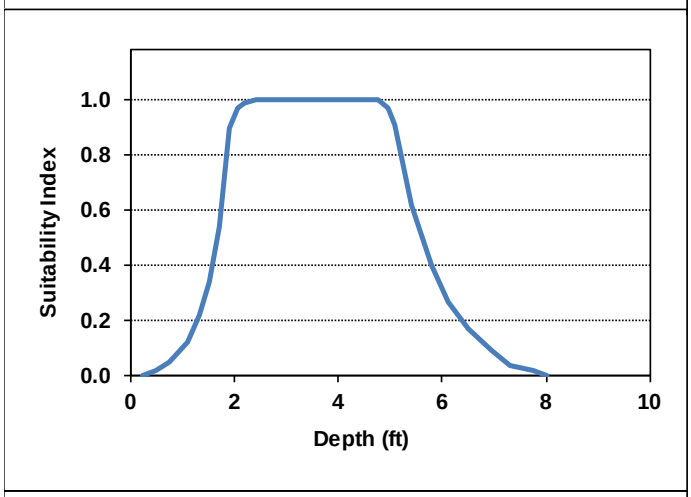


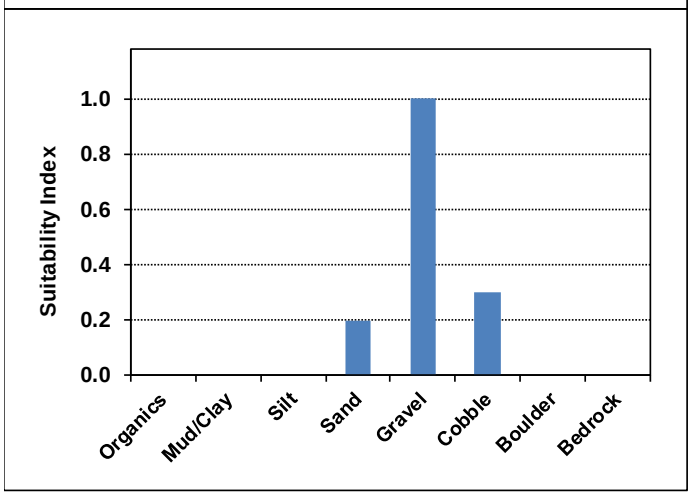
Leonard et al, 1986

Substrate	SI
Organics	0.10
Mud/Clay	0.10
Silt	0.10
Sand	0.20
Gravel	0.30
Cobble	1.00
Boulder	1.00
Bedrock	0.50

Smallmouth Bass Spawning







Source:

Allen, 1996

Velocity (ft/s)	SI
0.00	1.00
0.45	1.00
0.55	0.96
0.65	0.89
0.75	0.69
0.85	0.34
0.95	0.25
1.05	0.20
1.15	0.16
1.25	0.14
1.65	0.11
1.85	0.09
2.35	0.04
2.55	0.02
2.75	0.00

Edwards et al., 1983

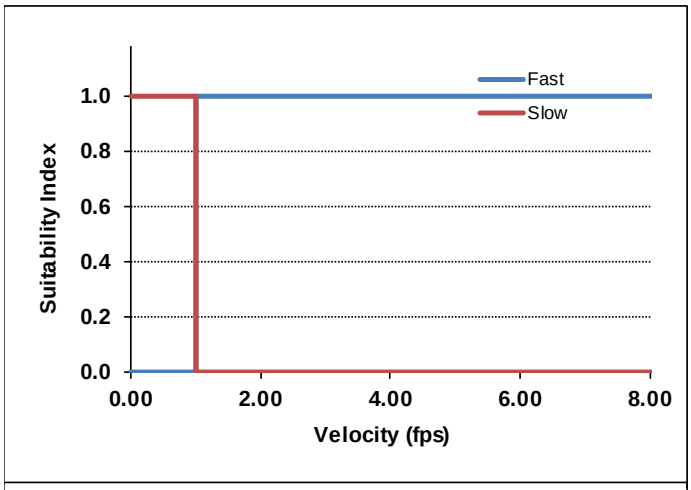
Depth (ft)	SI
0.22	0.00
0.50	0.02
0.74	0.05
1.10	0.12
1.32	0.22
1.53	0.34
1.70	0.54
1.90	0.90
2.05	0.97
2.18	0.99
2.40	1.00
4.75	1.00
4.95	0.97
5.10	0.91
5.40	0.62
5.80	0.40
6.10	0.27
6.50	0.17
6.95	0.09
7.30	0.04
7.75	0.02
8.00	0.00

Allen, 1996

Substrate	SI
Organics	0.00
Mud/Clay	0.00
Silt	0.00
Sand	0.20
Gravel	1.00
Cobble	0.30
Boulder	0.00
Bedrock	0.00

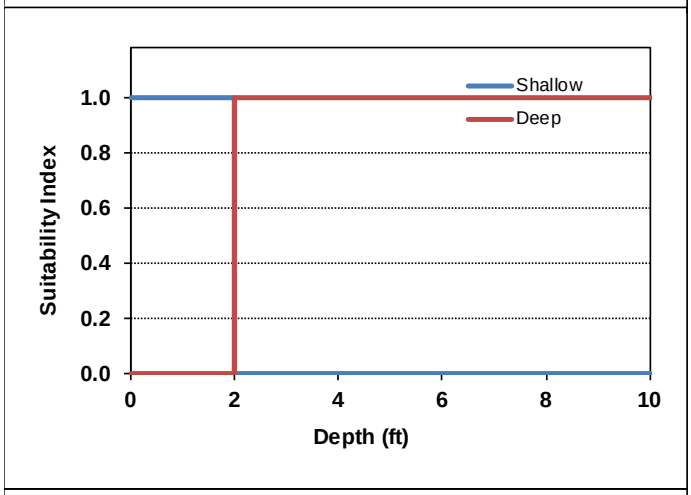
Generalized Habitat Criteria (GHC)

Source:
VDFW



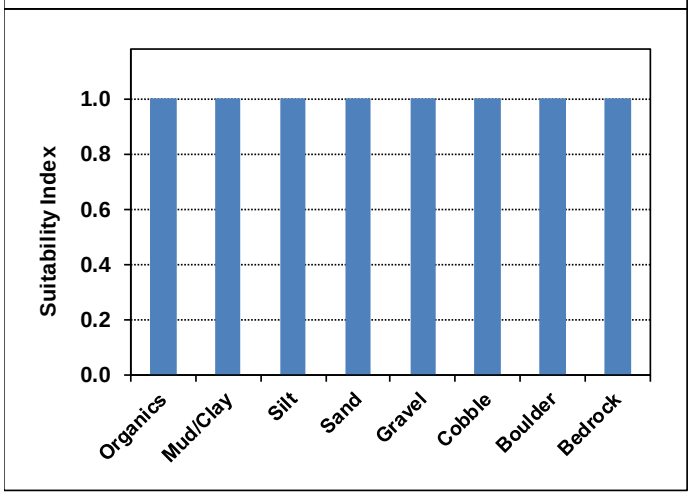
Fast Velocity (ft/s)	SI
0.00	0.00
1.00	0.00
1.01	1.00
10.00	1.00

Slow Velocity (ft/s)	SI
0.00	1.00
1.00	1.00
1.01	0.00
10.00	0.00



Shallow Depth (ft)	SI
0.00	1.00
2.00	1.00
2.01	0.00
10.00	0.00

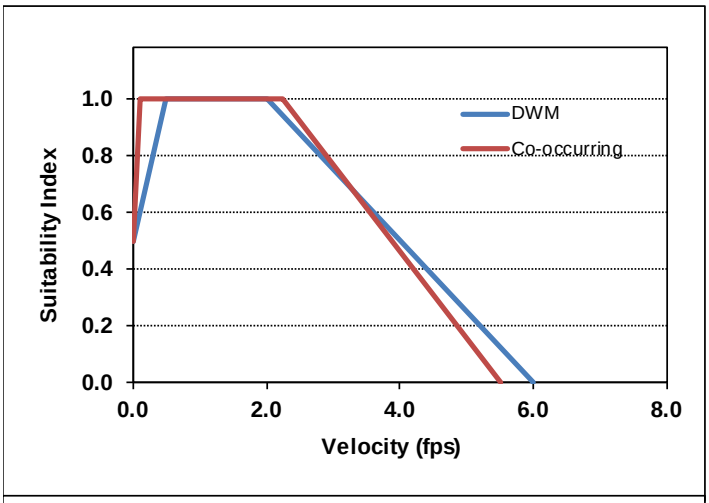
Deep Depth (ft)	SI
0.00	0.00
2.00	0.00
2.01	1.00
100.00	1.00



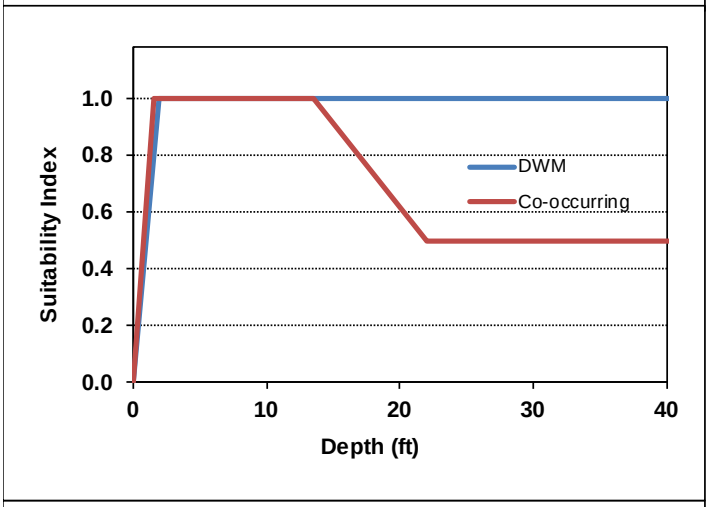
Substrate	SI
Organics	1.00
Mud/Clay	1.00
Silt	1.00
Sand	1.00
Gravel	1.00
Cobble	1.00
Boulder	1.00
Bedrock	1.00

Mussels - Dwarf Wedgemussel (DWM) Co-Occurring

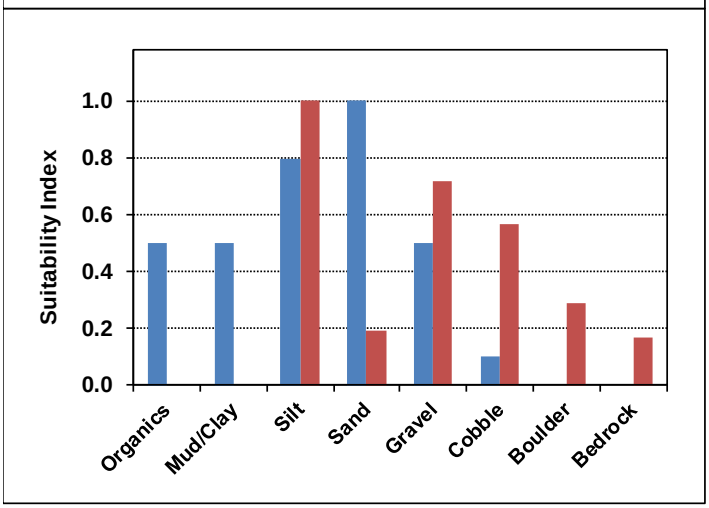
Source: DWM — Normandeau and Biodrawversity 2016; Co-0ccurring — Normandeau and Biodrawversity 2017



DWM		Co-occurring	
MCV (ft/s)	SI	MCV (ft/s)	SI
0.00	0.50	0.00	0.50
0.50	1.00	0.10	1.00
2.00	1.00	2.25	1.00
6.00	0.00	5.50	0.00



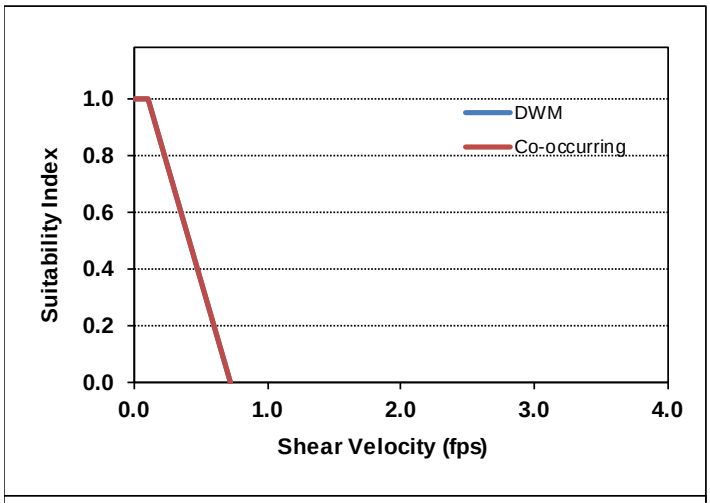
DWM		Co-occurring	
Depth (ft)	SI	Depth (ft)	SI
0.00	0.00	0.00	0.00
2.00	1.00	1.50	1.00
40.00	1.00	13.50	1.00
100.00	1.00	22.00	0.50
		30.00	0.50
		100	0.5



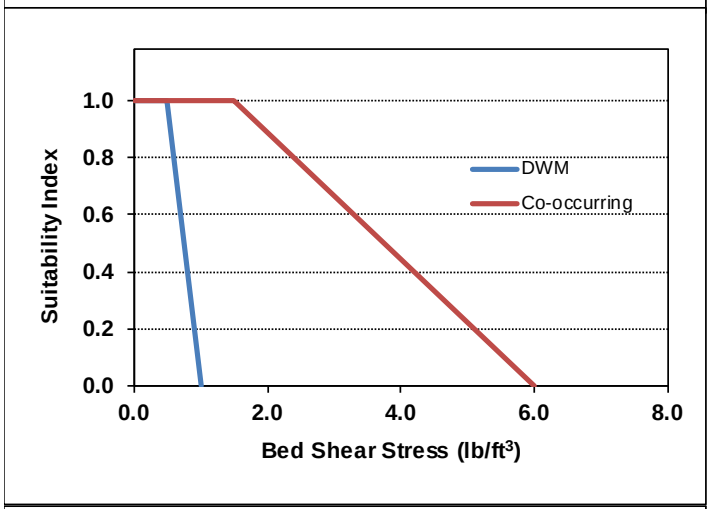
DWM		Co-occurring	
Substrate	SI	Substrate	SI
Organics	0.50	Organics	0.00
Mud/Clay	0.50	Mud/Clay	0.00
Silt	0.80	Silt	1.00
Sand	1.00	Sand	0.19
Gravel	0.50	Gravel	0.72
Cobble	0.10	Cobble	0.57
Boulder	0.00	Boulder	0.29
Bedrock	0.00	Bedrock	0.17

Mussels - Dwarf Wedgemussel (DWM) Co-Occurring

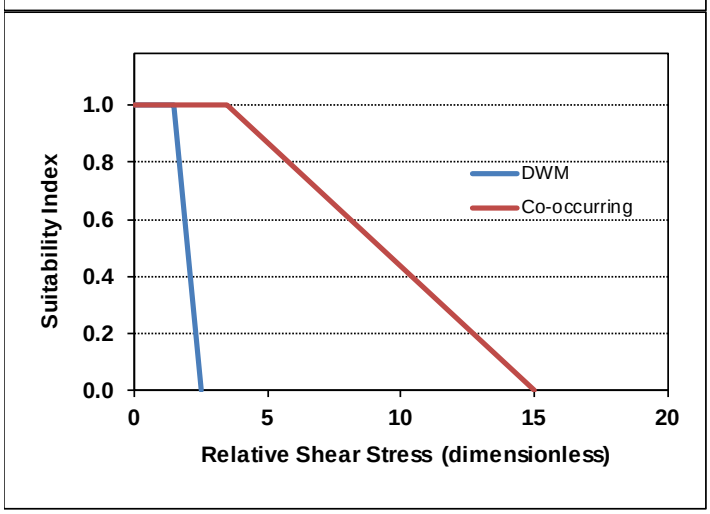
Source: DWM — Normandeau and Biodrawversity 2016; Co-0ccurring — Normandeau and Biodrawversity 2017



DWM		Co-occurring	
Velocity (ft/s)	SI	Velocity (ft/s)	SI
0.00	1.00	0.00	1.00
0.10	1.00	0.10	1.00
0.72	0.00	0.72	0.00



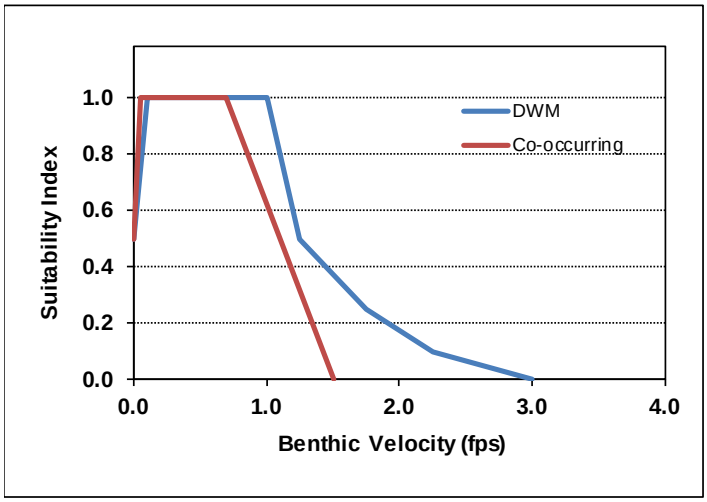
DWM		Co-occurring	
SS (lb/ft^3)	SI	SS (lb/ft^3)	SI
0.00	1.00	0.00	1.00
0.50	1.00	1.50	1.00
1.00	0.00	6.00	0.00



DWM		Co-occurring	
RSS	SI	RSS	SI
0	1.00	0	1.00
1.5	1.00	3.5	1.00
2.5	0.00	15	0.00

Mussels - Dwarf Wedgemussel (DWM) Co-Occurring

Source: DWM — Normandeau and Biodrawversity 2016; Co-0ccurring — Normandeau and Biodrawversity 2017



DWM		Co-occurring	
Velocity (ft/s)	SI	Velocity (ft/s)	SI
0.00	0.50	0.00	0.50
0.10	1.00	0.05	1.00
1.00	1.00	0.70	1.00
1.25	0.50	1.50	0.00
1.75	0.25		
2.25	0.10		
3.00	0.00		

Literature Cited:

Aadland, L.P., C.M. Cook, M.T. Negus, H.G. Drewes, and C.S. Anderson. 1991. Microhabitat preferences of selected stream fishes and a community-oriented approach to instream flow assessments. Section of Fisheries, Investigational Report. Minnesota Department of Natural Resources, Division of Fish and Wildlife. St Paul, Minnesota. 142pp.

Aadland, L.P., and A. Kuitunen. 2006. Habitat suitability criteria for stream fishes and mussels of Minnesota. Minnesota Department of Natural Resources, Ecological Services Division, Fergus Falls and St. Paul, MN. 167pp.

Allen, M.A. 1996. Equal area line-transect sampling for smallmouth bass habitat suitability criteria in the Susquehanna River, Pennsylvania. Pages B119-132 in M. LeClerc, C. Herve, S. Valentin, A. Boudreault, and Y. Cote, editors. Ecohydraulics 2000: Second international symposium on habitat hydraulics. Institut National de la Recherche Scientifique-Eau, Quebec, Canada

Bozek, M.A., T. J. Haxton, and J. K. Raabe. 2011. Walleye and sauger habitat. Pp 133-197, in Biology, management, and culture of walleye and sauger, B. A. Barton, editor. 570 pages, American Fisheries Society, June 2011.

Edwards, E.A., G. Gebhart, and O.E. Maughan. 1983. Habitat suitability information: smallmouth bass. USDI, Fish and Wildlife Service FWS/OBS-82/10.36. 47p.

Exelon. 2012. Updated study report. Instream flow habitat assessment below Conowingo Dam, RSP 3.16, Conowingo Hydroelectric Project, FERC Project No. 405. Prepared by Gomez and Sullivan Engineers and Normandeau Associates.

Greene, K. E., Zimmerman, J. L., Laney, R. W., & Thomas-Blate, J. C. 2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Habitat Management Series No.9. Washington, D.C: Atlantic States Marine Fisheries Commission.

Gomez and Sullivan Engineers. 2000. Lamoille River Hydroelectric Project, FERC Project No. 2205. Instream flow and habitat study report. Prepared for Central Vermont Public Service Corp.

Gomez and Sullivan Engineers, P.C. 2007. Glendale Hydroelectric Project FERC Project No. 2801. Final Report Bypass reach aquatic habitat and instream flow study.

Groshens, T.P., and D.J. Orth. 1994. Transferability of habitat suitability criteria for smallmouth bass, Micropterus dolomieu. Rivers 4:194-212.

Hightower, J.E., J.E. Harris, J.K. Raabe, P. Brownell, and C.A. Drew. 2012. A Bayesian spawning habitat suitability model for American shad in Southeastern United States rivers. Journal of Fish and Wildlife Management

Kynard B. and M. Horgan. 2013. Habitat suitability index for sea lamprey redds. Unpublished manuscript. 5 pp.

Layzer, J.B. 1974. Spawning Sites and Behavior of American Shad, Alosa sapidissima (Wilson), in the Connecticut River between Holyoke and Turners Falls, Massachusetts, 1972. Master of Science Thesis. University of Massachusetts, Amherst, Massachusetts.

Leonard, P.M., D.J. Orth, and C.J. Goudreau. 1986. Development of a method for recommending instream flows for fishes in the Upper James River, Virginia. Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, Blacksburg, VA. 122pp.

McMahon, T.E., J.W. Terrell, and P.C. Nelson. 1984. Habitat suitability information: walleye. United States Fish and Wildlife Service FWS/OBS-82/10.56. 43p.

Normandeau Associates, Inc. (Normandeau) and Biodrawversity. 2017. ILP Study 24– Dwarf Wedgemussel and Co-Occurring Mussel Study, Development of Habitat Suitability Criteria for Co-Occcurring Mussels. Prepared for TransCanada Hydro Northeast Inc. Draft, 2017.

Normandeau Associates, Inc. (Normandeau) and Biodrawversity. 2016. ILP Study 24– Dwarf Wedgemussel and Co-Occurring Mussel Study, Development of Delphi Habitat Suitability Criteria. Prepared for TransCanada Hydro Northeast Inc. May 26, 2016.

Steir, D.J. and J.H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. U.S. Fish and Wildlife Service Biological Report 82(10.88). 34pp.

Twomey, K.A., K.L. Williamson, and P.C. Nelson. 1984. Habitat suitability index models and instream flow suitability curves: white sucker. United States Fish and Wildlife Service FWS/OBS-82/10.64. 56pp.

Warner, G.S., F.L. Ogden, A.C. Bagtzoglou, and P. Paraciewicz. 2006. Long-term impact analysis of the University of Connecticut's Fenton River water supply wills on the habitat of the Fenton River. Report prepared by the University of Connecticut Departments of Natural Resources Management and Engineering and Civil and Environmental Engineering. March 7, 2006. 172pp.

Yergeau, K.M. 1983. Population demography, riverine movement and spawning habitat of the sea lamprey, Petromyzon marinus, in the Connecticut River. M.Sc. thesis. University of Massachusetts, Amherst, Massachusetts. 634 pp.