Stream Mitigation Model

Examples for Mitigation Category 1 and 2 Streams

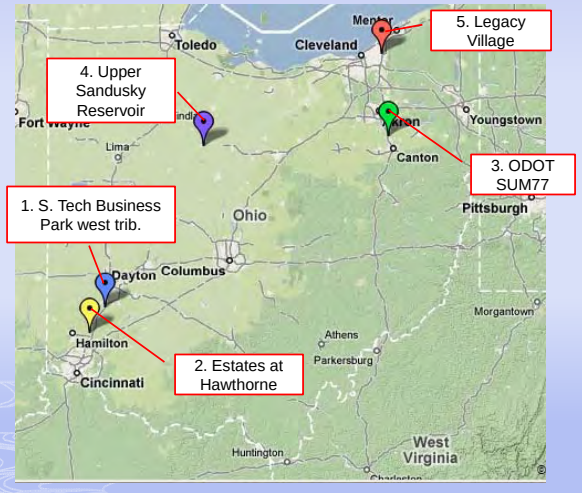
Preface

- Five example sites are presented from Ohio
- Each site is an approved stream mitigation site that served as an on-site stream relocation or replacement project
- All sites fall into Mitigation Category 1 or 2 based upon the draft stream mitigation rules
- Each site has been assessed for channel and flood prone area by Ohio DNR Division of Soil and Water Conservation staff
  - Data and site photos used in this analysis were provided courtesy of ODNR
- Comparisons are made regarding outcomes from the proposed standards within the revised Ohio EPA stream mitigation protocol
- Examples of improvements to the original designs with respect to the mitigation model are also provided

Preface

- Notes regarding stream mitigation protocol evaluation:
  - Habitat criteria do not apply for the stream segments used in these examples
  - Woody riparian buffer criteria also do not apply
  - Mitigation target based upon provision of sufficient flood prone area at or below 2 x D_{max} to protect downstream water quality
    - D_{max} = the maximum depth at a riffle at the bankfull stage
    - Minimum acreage required for credit is assumed to be adjusted flood prone acres equal to 30% of the streamway target
  - Data is presented for the flood prone areas inundated or saturated at three elevations: 2.0 x D_{max}, at 1.5 x D_{max}, and at the bankfull stage
  - The outcome for the adjusted flood prone area is also provided for the existing condition and an enhanced design for the site

Site Locations



Site 1 South Tech Business Center
Ohio EPA 401 ID: 034301
ACOE ID: (L) 199800240

Site 1 South Tech Business Center

- "West Tributary" site.
- Project approved in June 1999.
- 2,300 foot stream relocation with 25 foot buffer on each side of the stream.
- Drainage area = 288 acres.
- HHEI score = 59 (Class II PHWH)
  - falls into Mitigation Category 2

Site 1 South Tech Business Center

Belt width is equal to 74% of the streamway target.

Flood prone width ($2 * D_{max}$) is only 24% of the streamway target.

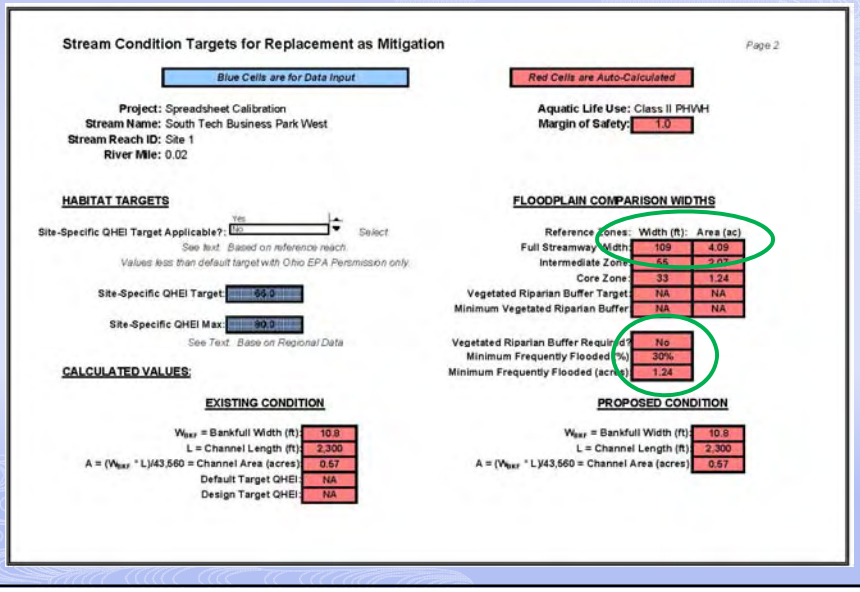
Note the entrenchment of the stream channel.

Photos courtesy ODNR

Site 1 South Tech Business Center

Current Conditions – Site Cross Section

Site 1. South Tech Business Park



Stream Condition Targets for Replacement as Mitigation

Page 2

Blue Cells are for Data Input

Red Cells are Auto-Calculated

Project: Spreadsheet Calibration
Stream Name: South Tech Business Park West
Stream Reach ID: Site 1
River Mile: 0.02

Aquatic Life Use: Class II PHWH
Margin of Safety: 1.0

HABITAT TARGETS

Site-Specific QHEI Target Applicable?: No (Yes) — Select

See text. Based on reference reach.

Values less than default target with Ohio EPA Permission only.

Site-Specific QHEI Target: 66.0

Site-Specific QHEI Max: 90.0

See Text. Base on Regional Data

CALCULATED VALUES:

EXISTING CONDITION

W_{BKF} = Bankfull Width (ft):	10.8
L = Channel Length (ft):	2,300
A = (W_{BKF} * L)/43,560 = Channel Area (acres):	0.57
Default Target QHEI:	NA
Design Target QHEI:	NA

FLOODPLAIN COMPARISON WIDTHS

Reference Zones:	Width (ft):	Area (ac)
Full Streamway Width:	109	4.09
Intermediate Zone:	55	2.07
Core Zone:	33	1.24
Vegetated Riparian Buffer Target:	NA	NA
Minimum Vegetated Riparian Buffer:	NA	NA

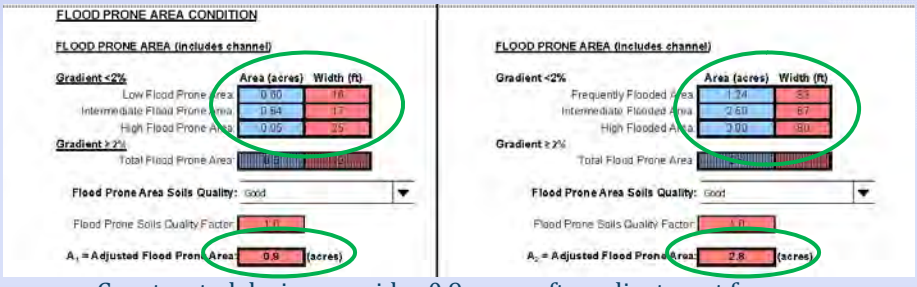
Vegetated Riparian Buffer Required?	No
Minimum Frequently Flooded (%)	30%
Minimum Frequently Flooded (acres)	1.24

PROPOSED CONDITION

W_{BKF} = Bankfull Width (ft):	10.8
L = Channel Length (ft):	2,300
A = (W_{BKF} * L)/43,560 = Channel Area (acres):	0.57

Site 1. South Tech Business Park

Constructed Design | **Alternative Using Same Footprint**



FLOOD PRONE AREA CONDITION

FLOOD PRONE AREA (includes channel)

Gradient <2%

	Area (acres)	Width (ft)
Low Flood Prone Area	0.00	16
Intermediate Flood Prone Area	0.84	17
High Flood Prone Area	0.05	25

Gradient ≥ 2%

Total Flood Prone Area

Flood Prone Area Soils Quality: Good

Flood Prone Soils Quality Factor: 1.0

A_1 = Adjusted Flood Prone Area: 0.9 (acres)

FLOOD PRONE AREA (includes channel)

Gradient <2%

	Area (acres)	Width (ft)
Frequently Flooded Area	1.24	33
Intermediate Flooded Area	2.60	67
High Flooded Area	0.00	80

Gradient ≥ 2%

Total Flood Prone Area

Flood Prone Area Soils Quality: Good

Flood Prone Soils Quality Factor: 1.0

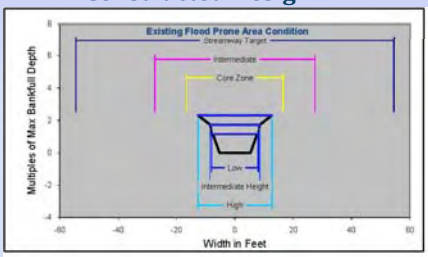
A_2 = Adjusted Flood Prone Area: 2.8 (acres)

- Constructed design provides 0.9 acres after adjustment for elevation and proximity to the stream.
- Constructed design = 22% of the streamway target (4.1 acres).
  - The minimum for mitigation credit is 1.2 acres (30% of target) for the site.
- An alternative design within the same land area would provide flood prone acreage equivalent to 68% of the target (2.8 acres)

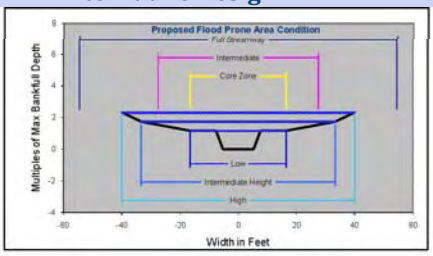
Site 1. South Tech Business Park

Stream Mitigation Model Output:

Constructed Design



Alternative Design



Project: Spreadsheet Calibration
Stream Name: South Tech Business Park West
Stream Reach ID: Site 1
River Mile: 0.02

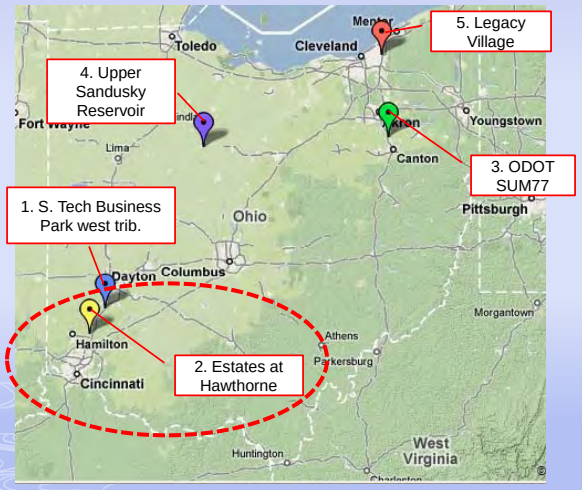
Note:

- Constructed design would not receive credit under the new stream mitigation protocol

Site 1 South Tech Business Center West Tributary

- Summary
  - Land set aside as stream "buffer" is not connected with the stream except under very high flow conditions.
  - Mitigation model guidelines would not have been met for the project.
  - Stream mitigation model informed design could have provided over 3 times the functional flood prone area for the site with no additional buffer acreage.

Site 2 Estates at Hawthorne
Ohio EPA 401 ID: 052228
ACOE ID: (L) 200500113

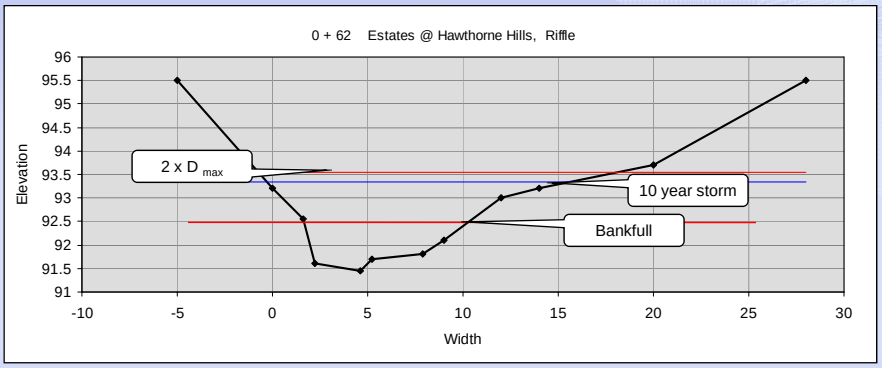


Site 2 Estates at Hawthorne

- Created channel constructed in 2006
- 850 foot reach of intermittent stream
- 2 stage channel design with 60 foot total width
- Drainage area = 54.4 acres
- Assumed to be Class II PHWH
  - Mitigation Category 2

Rod is at 2 x D_{max} and is equal to 30% Target Width

Site 2 Estates at Hawthorne



Note that the 10 year storm is carried within the flood prone width of the channel

Site 2 Estates at Hawthorne

Stream Condition Targets for Replacement as Mitigation

Page 2

Blue Cells are for Data Input

Red Cells are Auto-Calculated

Project: Spreadsheet Calibration
Stream Name: Estates at Hawthorne Hills ATF
Stream Reach ID: Site 1
River Mile: 0

Aquatic Life Use: Class I PHWH
Margin of Safety: 1.0

HABITAT TARGETS

Site-Specific QHEI Target Applicable?: No (Yes) — Select

See text. Based on reference reach.
Values less than default target with Ohio EPA Permission only.

Site-Specific QHEI Target: 65.0

Site-Specific QHEI Max: 90.0

See Text. Base on Regional Data

FLOODPLAIN COMPARISON WIDTHS

	Width (ft)	Area (ac)
Reference Zones:		
Full Streamway Width:	58	1.07
Intermediate Zone:	29	0.54
Core Zone:	18	0.34
Vegetated Riparian Buffer Target:	NA	NA
Minimum Vegetated Riparian Buffer:	NA	NA

Vegetated Riparian Buffer Required?	No
Minimum Frequently Flooded (%)	30%
Minimum Frequently Flooded (acres)	0.34

CALCULATED VALUES:

EXISTING CONDITION

W_{BKF} = Bankfull Width (ft):	5.8
L = Channel Length (ft):	850
A = (W_{BKF} * L)/43,560 = Channel Area (acres):	0.11
Default Target QHEI:	NA
Design Target QHEI:	NA

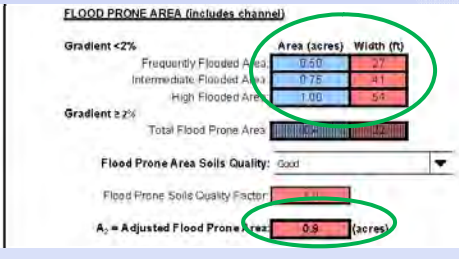
PROPOSED CONDITION

W_{BKF} = Bankfull Width (ft):	5.8
L = Channel Length (ft):	850
A = (W_{BKF} * L)/43,560 = Channel Area (acres):	0.11

Site 2. Estates at Hawthorne

Constructed Design

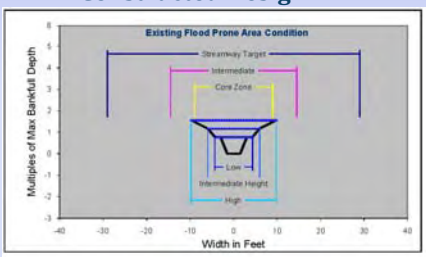
Alternative Using Same Footprint



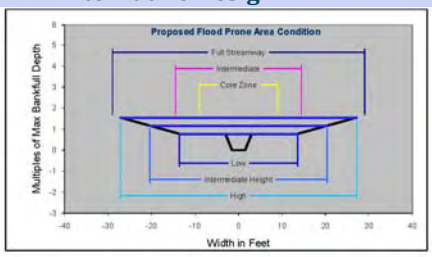
- Constructed design provides 0.3 acres after adjustment for elevation and proximity to the stream.
- Constructed design = 30% of the streamway target (1.1 acres)
  - Note : acreages rounded to nearest 0.1 acres
- An alternative design within the same land area would provide flood prone acreage equivalent to 80% of the target (0.9 acres)

Site 2. Estates at Hawthorne

Stream Mitigation Model Output:
Constructed Design



Alternative Design



Project: Spreadsheet Calibration
Stream Name: Estates at Hawthorne Hills ATF
Stream Reach ID: Site 1
River Mile: 0

Note:

- Constructed design is at the minimum threshold to receive credit under the new stream mitigation protocol

Site 2. Estates at Hawthorne

- Summary
  - The constructed channel meets the minimum design criteria for Mitigation Category 2 replacement (30% of streamway target)
  - Note sediment deposition within the bankfull channel and lack of bank erosion.
  - Function could have been enhanced by providing a wider flood prone area (0.9 acres vs. 0.3 acres)

Site 3 ODOT SUM-77-20.502
Ohio EPA 401 ID: 033874
ACOE ID: (H)200000142

Site 3 ODOT SUM-77-20.502

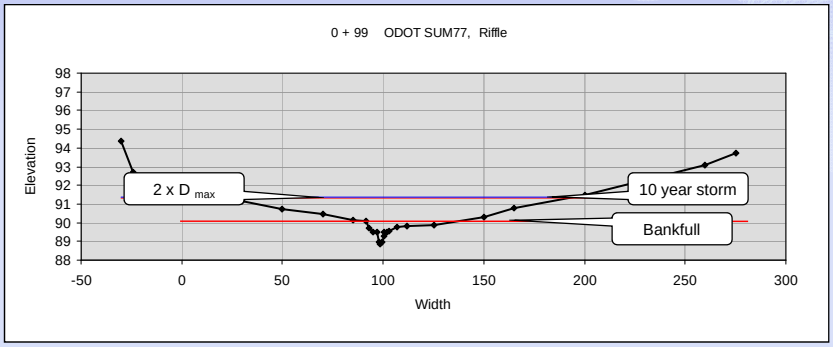
- Constructed in 2006
- 1,000 ft constructed 2 stage channel
  - Design includes riffles and sinuosity
- HHEI score = 56
- Class II PHWH, Mitigation Category 2

Site 3 ODOT SUM-77-20.502

Current condition

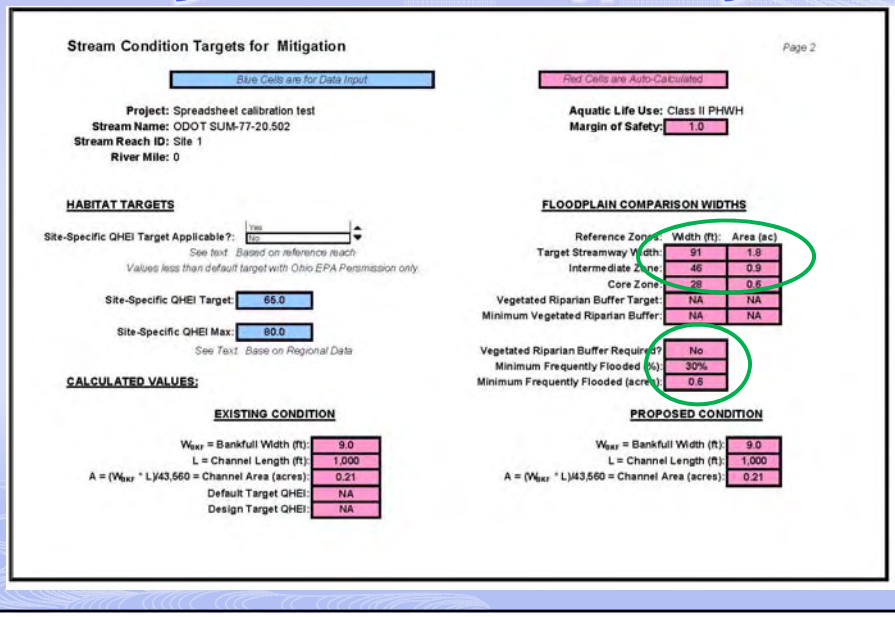
Constructed Streamway

Site 3 ODOT SUM-77-20.502



- Notes:
  - The 10 year storm is carried within the flood prone width of the channel
  - The flood prone width is equivalent to 58% of the site

Site 3 ODOT SUM-77-20.502



Stream Condition Targets for Mitigation

Page 2

Blue Cells are for Data Input

Red Cells are Auto-Calculated

Project: Spreadsheet calibration test
Stream Name: ODOT SUM-77-20.502
Stream Reach ID: Site 1
River Mile: 0

Aquatic Life Use: Class II PHWH
Margin of Safety: 1.0

HABITAT TARGETS

Site-Specific QHEI Target Applicable?: No

See text Based on reference reach
Values less than default target with Ohio EPA Permission only

Site-Specific QHEI Target: 65.0

Site-Specific QHEI Max: 80.0

See Text Base on Regional Data

FLOODPLAIN COMPARISON WIDTHS

	Width (ft):	Area (ac)
Reference Zones:		
Target Streamway Width:	91	1.8
Intermediate Zone:	46	0.9
Core Zone:	28	0.6
Vegetated Riparian Buffer Target:	NA	NA
Minimum Vegetated Riparian Buffer:	NA	NA

Vegetated Riparian Buffer Required?	No
Minimum Frequently Flooded (%):	30%
Minimum Frequently Flooded (acres):	0.6

CALCULATED VALUES:

EXISTING CONDITION

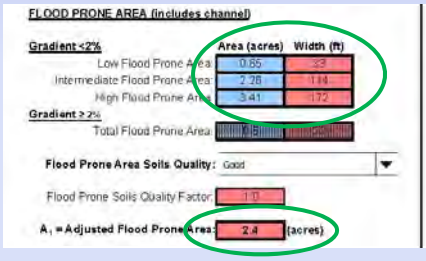
W_{BKF} = Bankfull Width (ft):	9.0
L = Channel Length (ft):	1,000
A = (W_{BKF} * L)/43,560 = Channel Area (acres):	0.21
Default Target QHEI:	NA
Design Target QHEI:	NA

PROPOSED CONDITION

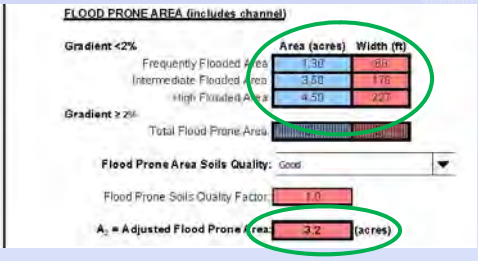
W_{BKF} = Bankfull Width (ft):	9.0
L = Channel Length (ft):	1,000
A = (W_{BKF} * L)/43,560 = Channel Area (acres):	0.21

Site 3 ODOT SUM-77-20.502

Constructed Design



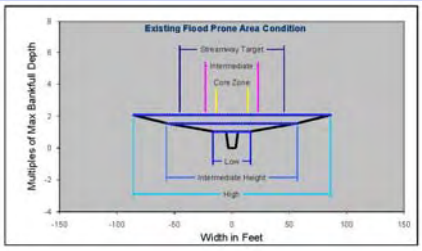
Alternative Using Same Footprint



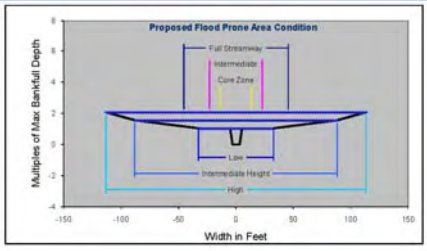
- Constructed design provides 2.4 acres after adjustment for elevation and proximity to the stream. Equivalent to 71% of the actual flood prone area (demonstrates adjustment for lateral distance and elevation)
- Constructed design = 133% of the streamway target (1.8 acres)
  - Note : acreages rounded to nearest 0.1 acres
- An alternative design within the same land area would provide flood prone acreage equivalent to 178% of the target (3.2 acres)

Site 3 ODOT SUM-77-20.502

Stream Mitigation Model Output:
Constructed Design



Alternative Design



Project: Spreadsheet Calibration
Stream Name: ODOT SUM-77-20.502
Stream Reach ID: Site 1
River Mile: 0

Notes:

- Constructed design is at 133% of the streamway target.
- Alternate design presented to indicate additional water quality benefit from using more of the available area for flood storage. The flood prone area could be enlarged an additional 33% within the same site footprint (3.2 acres vs. 2.4 acres)

Site 3 ODOT SUM-77-20.502

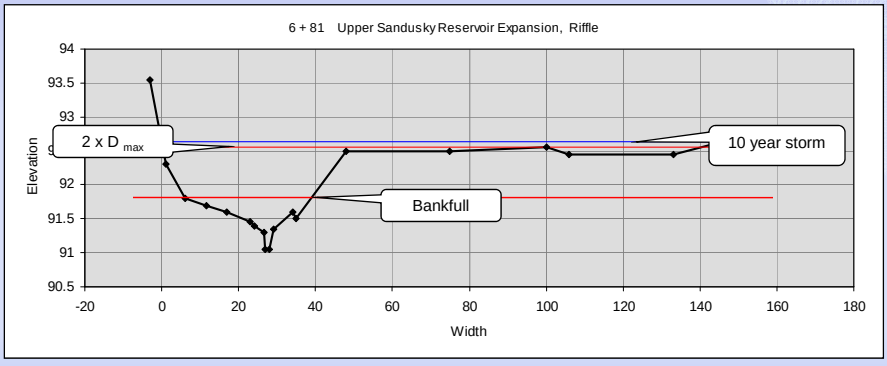
- Summary
  - The flood prone width provided in the constructed design exceeds the target streamway width. Project would meet the goals of the draft mitigation rule
  - Soil characteristics may limit the success of riparian vegetation establishment
    - Note soil quality information was not available fo rhtis analysis
  - Additional water quality benefit could have been realized with an enhanced design

Site 4 Upper Sandusky Reservoir Expansion
Ohio EPA 401 ID: 010532
ACOE ID: (B)2000-01678(2)

Site 4 Upper Sandusky Reservoir Expansion

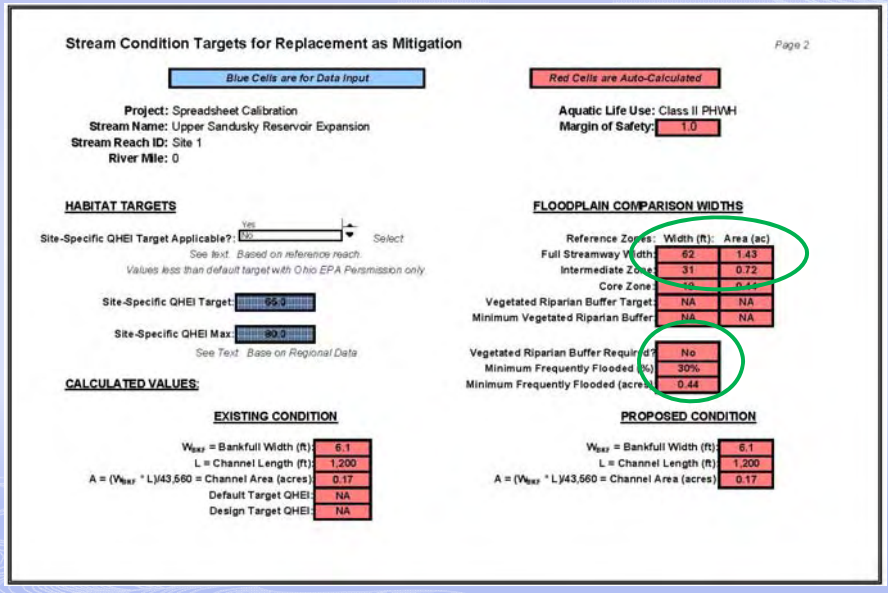
- 1,200 feet of constructed channel to mitigate for 300 feet of impact
- Drainage area = 64 acres
- HHEI score = 59
  - Class II PHWH
  - Mitigation Category 2
- Constructed in 2002

Site 4 Upper Sandusky Reservoir Expansion



- Notes:
  - The streamway is 240% of the target and the entire flood prone width is inundated by the 10 year storm
  - 45% of the site is inundated by the 2 year storm

Site 4 Upper Sandusky Reservoir Expansion



Stream Condition Targets for Replacement as Mitigation

Page 2

Blue Cells are for Data Input

Red Cells are Auto-Calculated

Project: Spreadsheet Calibration
Stream Name: Upper Sandusky Reservoir Expansion
Stream Reach ID: Site 1
River Mile: 0

Aquatic Life Use: Class II PHWH
Margin of Safety: 1.0

HABITAT TARGETS

Site-Specific QHEI Target Applicable?: Yes — Select

See text. Based on reference reach.

Values less than default target with Ohio EPA Permission only

Site-Specific QHEI Target: 65.0

Site-Specific QHEI Max: 80.0

See Text. Base on Regional Data

FLOODPLAIN COMPARISON WIDTHS

Reference Zones:	Width (ft):	Area (ac)
Full Streamway Width:	62	1.43
Intermediate Zone:	31	0.72
Core Zone:		
Vegetated Riparian Buffer Target:	NA	NA
Minimum Vegetated Riparian Buffer:	NA	NA

Vegetated Riparian Buffer Required? No
Minimum Frequently Flooded (%) 30%
Minimum Frequently Flooded (acres) 0.44

CALCULATED VALUES:

EXISTING CONDITION

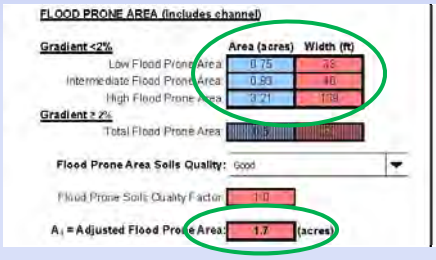
W_{BKF} = Bankfull Width (ft): 6.1
L = Channel Length (ft): 1,200
A = (W_{BKF} * L)/43,560 = Channel Area (acres): 0.17
Default Target QHEI: NA
Design Target QHEI: NA

PROPOSED CONDITION

W_{BKF} = Bankfull Width (ft): 6.1
L = Channel Length (ft): 1,200
A = (W_{BKF} * L)/43,560 = Channel Area (acres): 0.17

Site 4 Upper Sandusky Reservoir Expansion

Constructed Design



FLOOD PRONE AREA (includes channel)

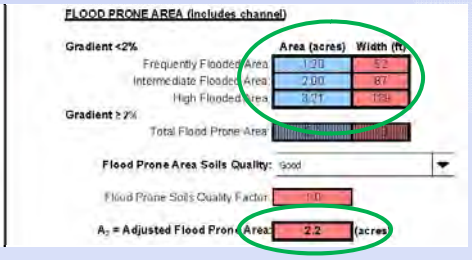
Gradient <2%	Area (acres)	Width (ft)
Low Flood Prone Area	0.75	38
Intermediate Flood Prone Area	0.93	80
High Flood Prone Area	3.21	139
Gradient ≥ 2%		
Total Flood Prone Area	4.9	215

Flood Prone Area Soils Quality: Good

Flood Prone Soils Quality Factor: 1.0

A_1 = Adjusted Flood Prone Area: 1.7 (acres)

Alternative Using Same Footprint



FLOOD PRONE AREA (includes channel)

Gradient <2%	Area (acres)	Width (ft)
Frequently Flooded Area	1.20	52
Intermediate Flooded Area	2.00	87
High Flooded Area	3.21	139
Gradient ≥ 2%		
Total Flood Prone Area	6.4	278

Flood Prone Area Soils Quality: Good

Flood Prone Soils Quality Factor: 1.0

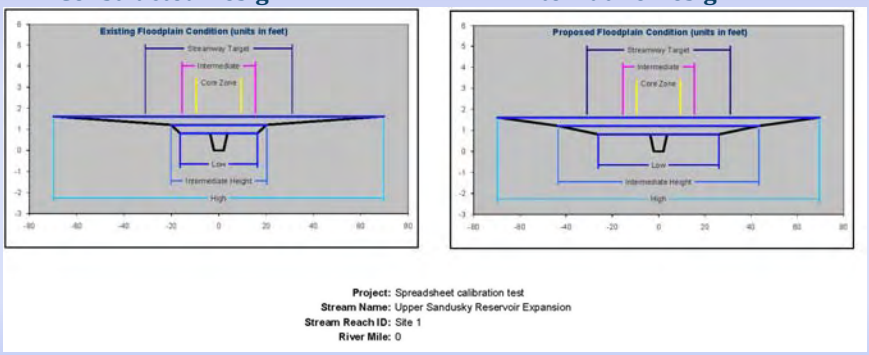
A_2 = Adjusted Flood Prone Area: 2.2 (acres)

- Constructed design provides 1.7 acres after adjustment for elevation and proximity to the stream. Equivalent to 53% of the actual flood prone area (demonstrates adjustment for lateral distance and elevation)
- Constructed design = 121% of the streamway target (1.4 acres)
  - Note : acreages rounded to nearest 0.1 acres
- An alternative design within the same land area would provide flood prone acreage equivalent to 157% of the target (2.2 acres)

Site 4 Upper Sandusky Reservoir Expansion

Stream Mitigation Model Output:

Constructed Design **Alternative Design**



Notes:

- Constructed design is at 121% of the streamway target.
- Alternate design presented to indicate additional water quality benefit from using more of the available area for flood storage. The flood prone area could be enlarged an additional 29% within the same site footprint (2.2 acres vs. 1.7 acres)

Site 4 Upper Sandusky Reservoir Expansion

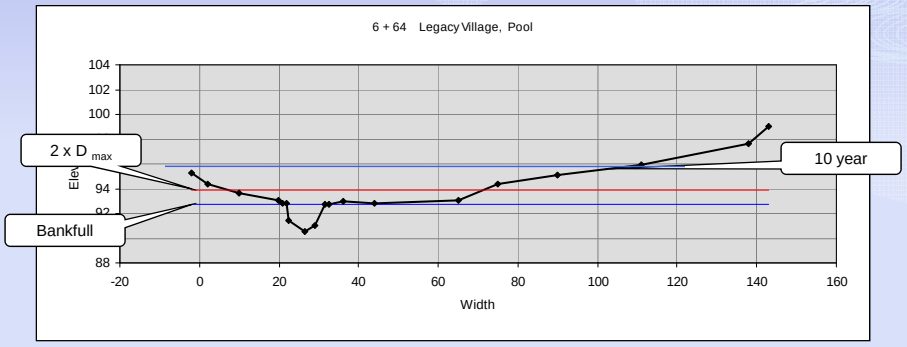
- Summary
  - Constructed design meets the criteria for credit under the draft mitigation rule
  - Flood prone benefit could be significantly improved by increasing the effective flood prone area
    - This example: could increase the adjusted flood prone area at least 30% within the same footprint (2.2 acres vs. 1.7 acres)

Site 5 Legacy Village Development
Ohio EPA 401 ID: 010231
ACOE ID: (B) 2000-01699(3)

Site 5 Legacy Village Development

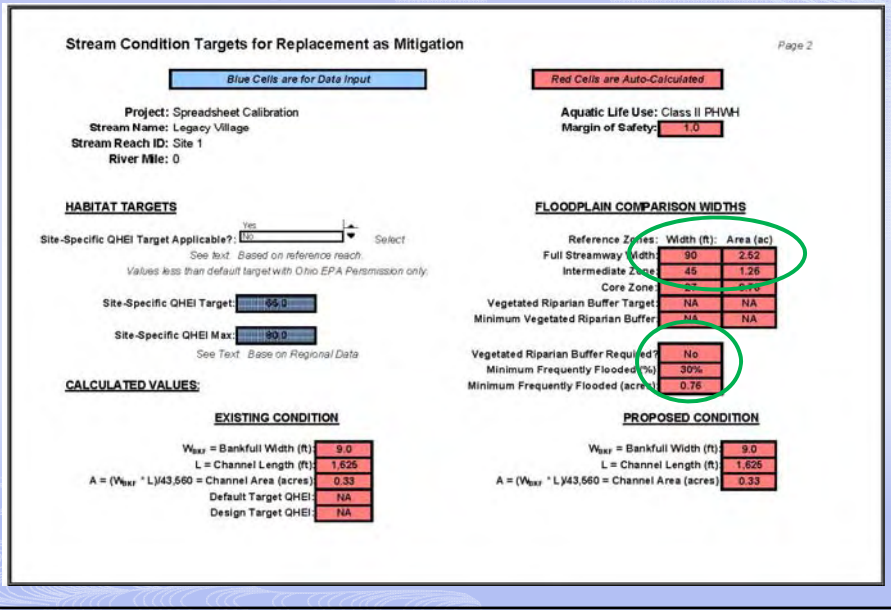
- Constructed in 2005
- Created 1,625 ft of new stream channel with an expanded floodplain
- Replaced existing man-made, partially culverted concrete flume
- Drainage area = 175 acres
- HHEI score = 56
  - Class II PHWH
  - Mitigation Category 2

Site 5 Legacy Village Development



- Notes:
  - The area inundated at bankfull stage is 50% of the streamway target
  - The flood prone area is 70% of the streamway target
  - However, the area of the protected site is 150% of the target streamway

Site 5 Legacy Village Development



Stream Condition Targets for Replacement as Mitigation Page 2

Blue Cells are for Data Input | Red Cells are Auto-Calculated

Project: Spreadsheet Calibration
Stream Name: Legacy Village
Stream Reach ID: Site 1
River Mile: 0

Aquatic Life Use: Class II PHWH
Margin of Safety: 1.0

HABITAT TARGETS

Site-Specific QHEI Target Applicable?: No (Yes) Select
See text. Based on reference reach.
Values less than default target with Ohio EPA Permission only.

Site-Specific QHEI Target: 65.0
Site-Specific QHEI Max: 80.0
See Text. Base on Regional Data

FLOODPLAIN COMPARISON WIDTHS

Reference Zones:	Width (ft):	Area (ac)
Full Streamway Width:	90	2.52
Intermediate Zone:	45	1.26
Core Zone:		
Vegetated Riparian Buffer Target:	NA	NA
Minimum Vegetated Riparian Buffer:	NA	NA

Vegetated Riparian Buffer Required? No
Minimum Frequently Flooded (%) 30%
Minimum Frequently Flooded (acres) 0.76

CALCULATED VALUES:

EXISTING CONDITION

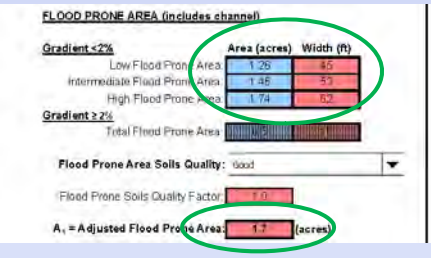
W_{BKF} = Bankfull Width (ft):	9.0
L = Channel Length (ft):	1,625
A = (W_{BKF} * L)/43,560 = Channel Area (acres)	0.33
Default Target QHEI:	NA
Design Target QHEI:	NA

PROPOSED CONDITION

W_{BKF} = Bankfull Width (ft):	9.0
L = Channel Length (ft):	1,625
A = (W_{BKF} * L)/43,560 = Channel Area (acres)	0.33

Site 5 Legacy Village Development

Constructed Design

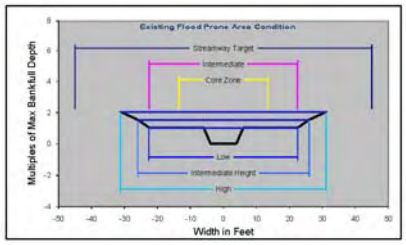


Alternative Using Same Footprint

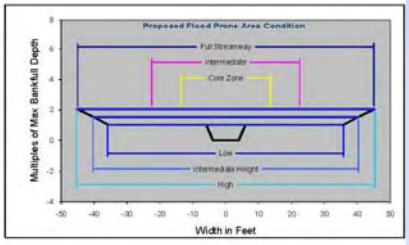
- Constructed design provides 1.7 acres after adjustment for elevation and proximity to the stream.
- Constructed design = 68% of the streamway target (2.5 acres) and would meet the criteria for mitigation credit
  - Note : acreages rounded to nearest 0.1 acres
- An alternative design within the same land area would provide flood prone acreage equivalent to 96% of the target (2.4 acres)

Site 5 Legacy Village Development

Stream Mitigation Model Output:
Constructed Design



Alternative Design



Project: Spreadsheet Calibration
Stream Name: Legacy Village
Stream Reach ID: Site 1
River Mile: 0

Notes:

- Constructed design is at 68% of the streamway target.
- Alternate design presented to indicate additional water quality benefit from using more of the available area for flood storage. The flood prone area could be enlarged an additional 41% within the same site footprint (2.4 acres vs. 1.7 acres)

Site 5 Legacy Village Development

- Summary
  - Constructed design meets the criteria for credit under the draft mitigation rule
  - Note well adjusted, vegetated riparian area
  - Flood prone benefit could be significantly improved by increasing the effective flood prone area
    - This example: could increase the adjusted flood prone area at least 41% within the same footprint (24 acres vs. 1.7 acres)

Conclusions

- The flood prone area model used in the proposed protocol can accurately predict and measure outcomes with respect to project design
- The approach utilized in the model has been used successfully at numerous sites throughout the state
- The model can be used to inform design alternatives that can provide additional water quality benefit during the antidegradation review process.