# WEST GALLATIN RIVER DETAILED FLOODPLAIN STUDY

***"No Drought About It, The Flood Will Come"***

Presenter:
Mark Franchi, PE, CFM,

Morrison Maierle

Presentation to Cover:

A. West Gallatin River hydrologic update.
B. West Gallatin River hydraulic update.
C. Identification of split flow reaches.
D. Hydraulic model cross section development.
E. Hydraulic model structure crossings.
F. Split flow worst case scenarios and flow optimization.
G. Floodway analysis.
H. FEMA accepted floodplain work maps.
I. Detailed floodplain study is to update:
   - 1979 hydraulic modeling,
   - 2011 DFIRM mapping.

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Manhattan

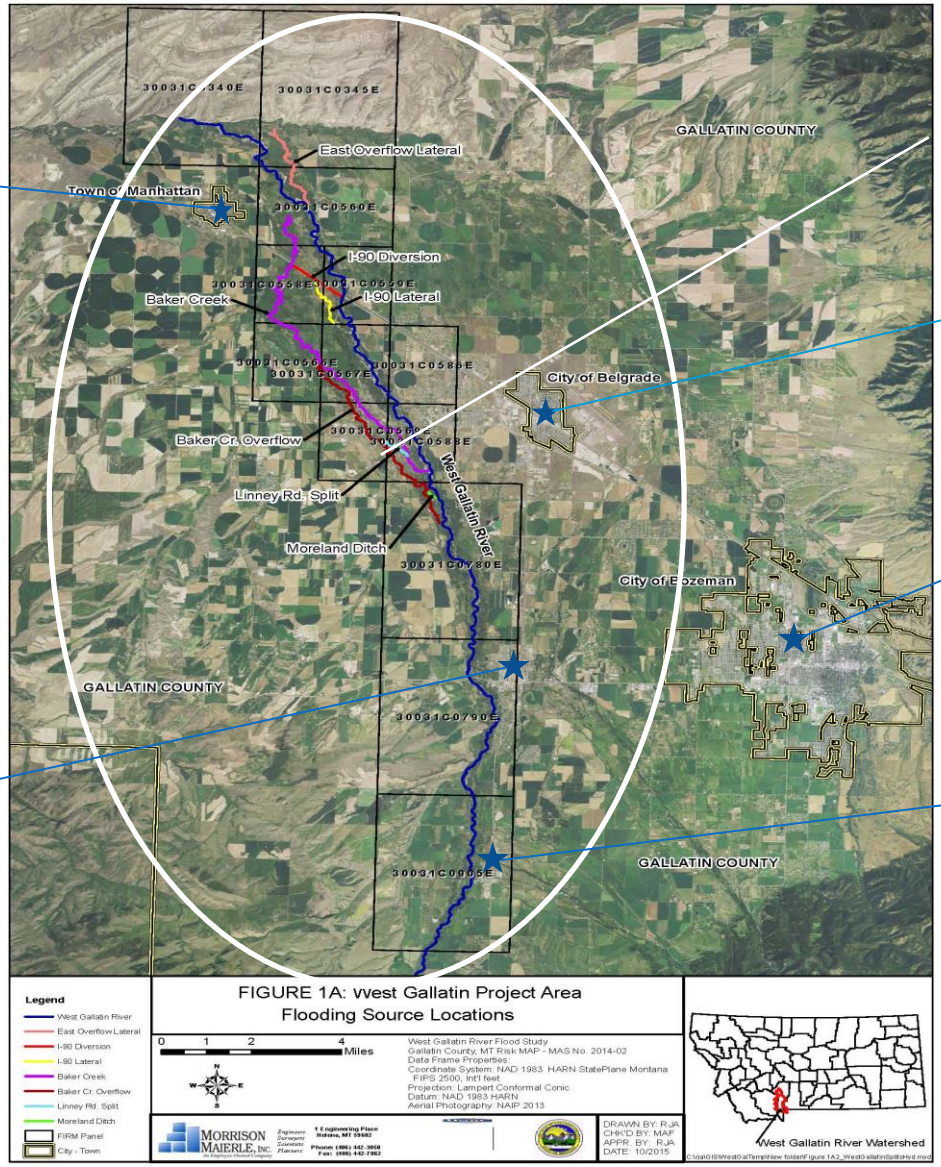
Study Area

Belgrade

Bozeman

Four Corners

Gallatin Gateway



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## Hydrologic Update:

- Flood frequency analysis following USGS Bulletin 17B at two active stream gage locations for the most current period of record.
  1. Upstream gage is near Gallatin Gateway, MT *(USGS Gage #06043500).*
  2. Downstream gage at Logan, MT *(USGS Gage #06052500).*
- Effective hydrologic analysis used only the Gallatin Gateway gage data and calculated flow change locations with USGS one-gage transfer equation.
- Update analysis used USGS PeakFQ computer program for log-Pearson Type III flood frequency analysis at the two gage locations.
- Update used USGS two-gage linear interpolation logarithmic method to calculate peak flow rates at the confluence of East Gallatin River.

### Updated Flow Rates:

| Location | Drainage Area (Square Miles) | Annual Chance Peak Flow Rates (cfs) | | | | |
|---|---|---|---|---|---|---|
| | | 10% | 2% | 1% | 1% plus | 0.2% |
| Confluence with East Gallatin River | 1,099.8 | 7,664 *(8,850)* | 9,535 *(11,400)* | 10,269 *(12,350)* | 10,937 *(n/a)* | 11,859 *(14,800)* |
| | | *(effective peak flow rates)* | | | | |

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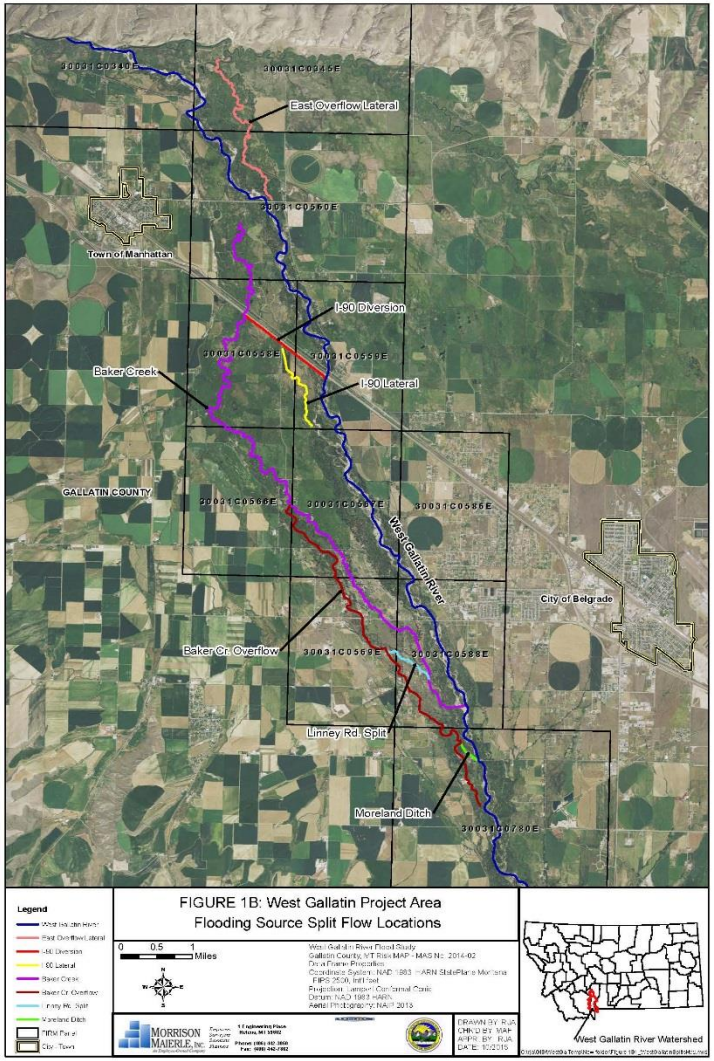
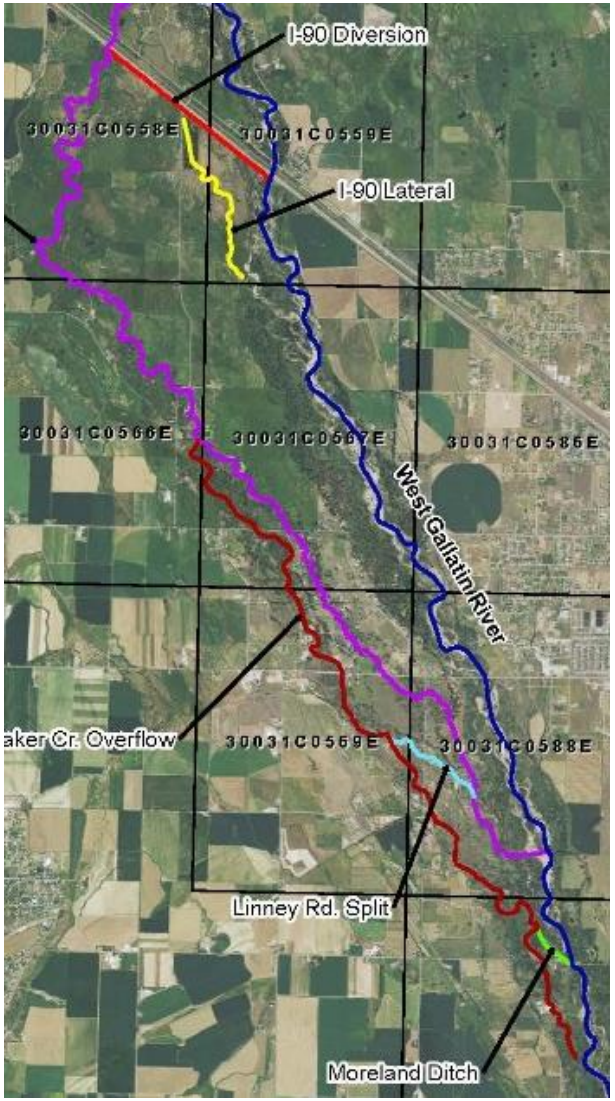
## Hydraulic Update:

- 1D modeling with HEC-RAS, Version 4.1.0 computer program.
- Cross section geometry based on:
- a) 2013 LiDAR survey by Photo Science, Inc.
- b) 2013 bathymetric survey by Gaston Engineering & Surveying.
- Cross section placement is at bathymetric survey and hydraulic structure locations.
- Split flow and secondary flow path modeling is at flow junctions and overbank overtopping locations.
- Four worst case scenarios were analyzed to model split flow reaches:
- HEC-RAS flow optimization routine utilized for each worst case scenario.
- Iterative flow optimization was necessary to calibrate WSE's at flow junctions and overbank overtopping locations.
- Utilized of HEC-GeoRAS and ArcMap GIS computer programs for floodplain work map preparation.




| Channel Reach: | Length (RM): |
|---|---|
| 1. West Gallatin River: | 30.4 |
| 2. Baker Creek: | 11.5 |
| 3. Baker Creek Overflow: | 6.3 |
| 4. East Overflow Lateral: | 3.1 |
| 5. I-90 Diversion: | 1.5 |
| 6. I-90 Lateral: | 1.4 |
| 7. Linney Rd. Split: | 0.7 |
| 8. Moreland Ditch: | 0.3 |




## Split Flow Reaches:

1. Baker Creek
2. Baker Creek Overflow
3. East Overflow Lateral (North of I-90)
4. I-90 Diversion
5. I-90 Lateral
6. Linney Rd. Split
7. Moreland Ditch

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## Summary of Channel Reaches:

| Channel Reach | Length (RM) | HEC-RAS X-Sections |
|---|---|---|
| **1. West Gallatin River:** | **30.4** | **355** |
| **2. Baker Creek:** | **11.5** | **147** |
| **3. Baker Creek Overflow:** | **6.3** | **83** |
| **4. East Overflow Lateral:** | **3.1** | **27** |
| **5. I-90 Diversion:** | **1.5** | **20** |
| **6. I-90 Lateral:** | **1.4** | **16** |
| **7. Linney Rd. Split:** | **0.7** | **19** |
| **8. Moreland Ditch:** | **0.3** | **9** |
| Total: | 55.2 | 676 |

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## Summary of Hydraulic Structures:

| Structure Type | Priority | | | Total |
|---|---|---|---|---|
| | High | Medium | Low | |
| Bridge | 33 | 2 | 2 | 37 |
| Culvert | 22 | 4 | 25 | 51 |
| Diversion | 2 | 8 | 3 | 13 |
| Headgate | 4 | 2 | 3 | 9 |
| Pedestrian Bridge | 7 | 6 | 5 | 18 |
| Private Bridge | 19 | 8 | 12 | 39 |
| Railroad Bridge | 3 | 0 | 0 | 3 |
| Turnout | 0 | 0 | 2 | 2 |
| Total | 90 | 30 | 52 | 172 |

## High Priority Bridge Structures:

I-90 Bridge Crossings

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## High Priority Bridge Structures:

MRL Railroad

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## Medium Priority Structures:

Stage Coach Trail Road

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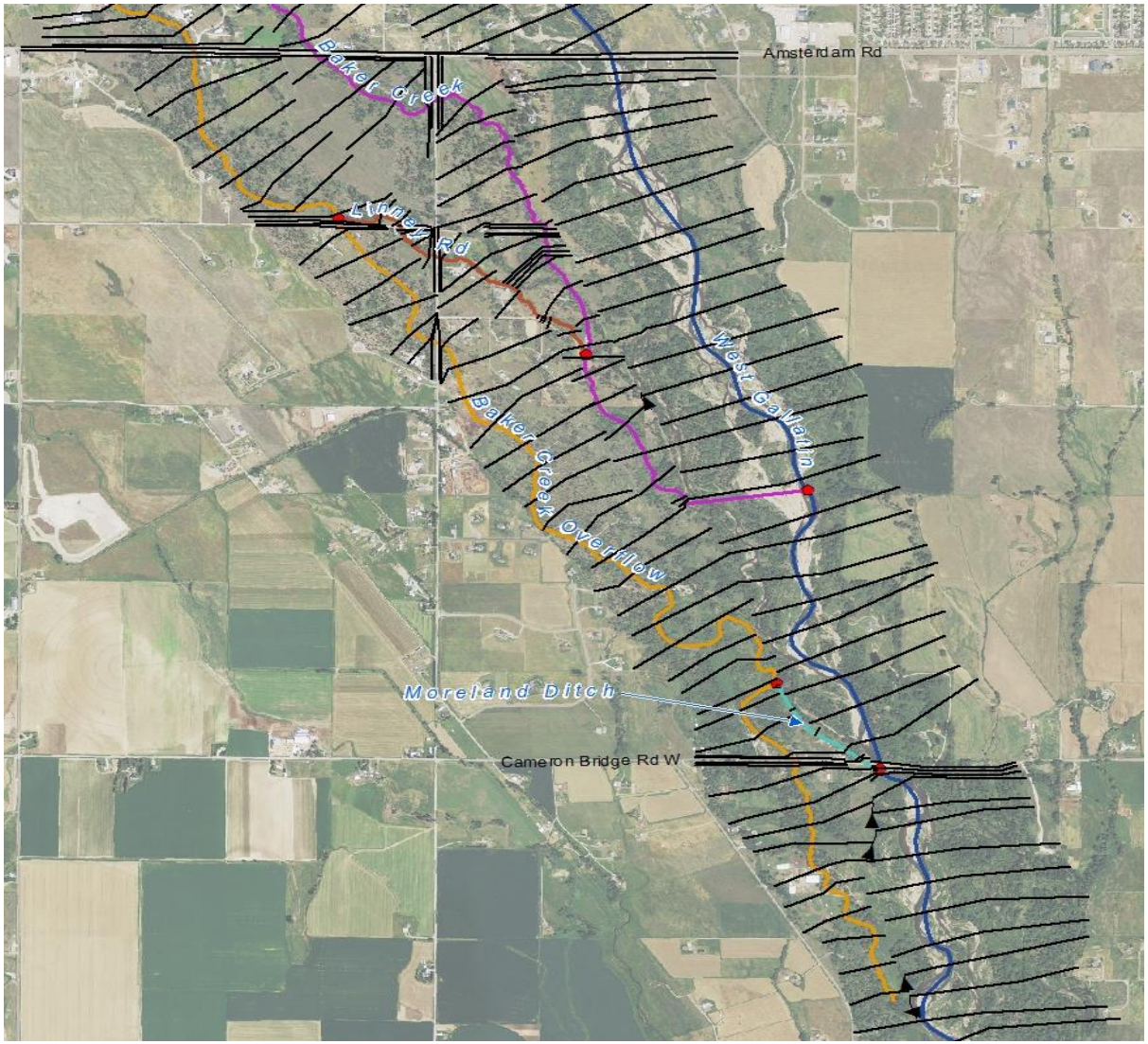
## Low Priority Structures:

Private Pedestrian Crossing

# Segment of HEC-RAS Model:



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## Worst Case Split Flow Scenario Analysis:

1. Structure condition to create maximum flow regime for each split flow reach.
2. Separate HEC-RAS plan for each worst case scenario.
3. Determine BFE's to delineate floodplains for each split flow reach.
4. Four worst case scenarios are:

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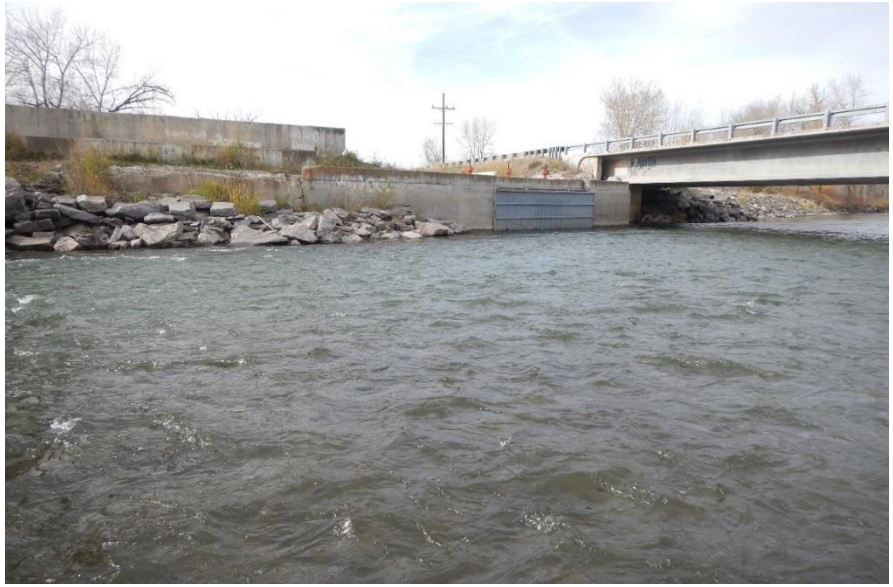
## Worst Case Scenario #1:

West Gallatin River flows highest when:
Moreland Ditch and Baker Creek south diversion gates fully closed during a flood event.



Moreland Ditch Diversion Structure

Baker Creek South Diversion

## Worst Case Scenario #2:

Upstream reach of Baker Creek flows highest when:

Baker Creek south and north diversion structures fail during a flood event.

Baker Creek South Diversion Structure

Baker Creek North Diversion Structure

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## Worst Case Scenario #3:

Baker Creek Overflow channel flows highest when:

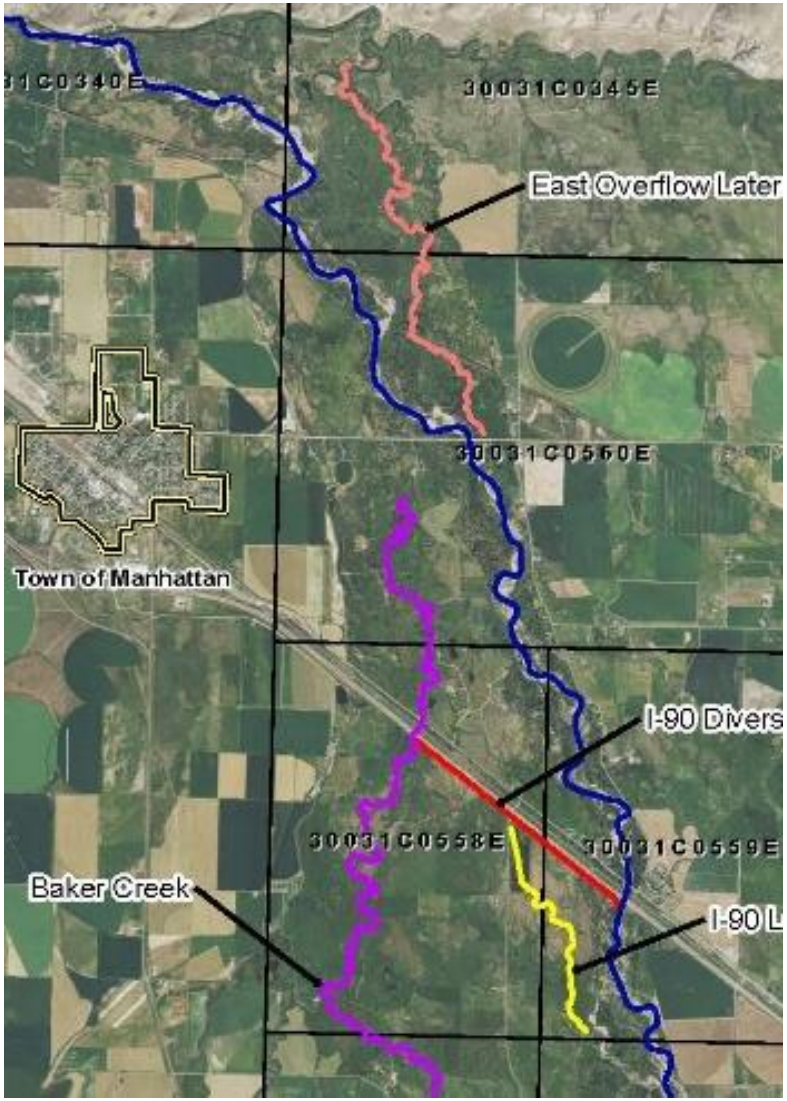
Moreland Ditch diversion structure gates fully open during a flood event.

Moreland Ditch Diversion Structure

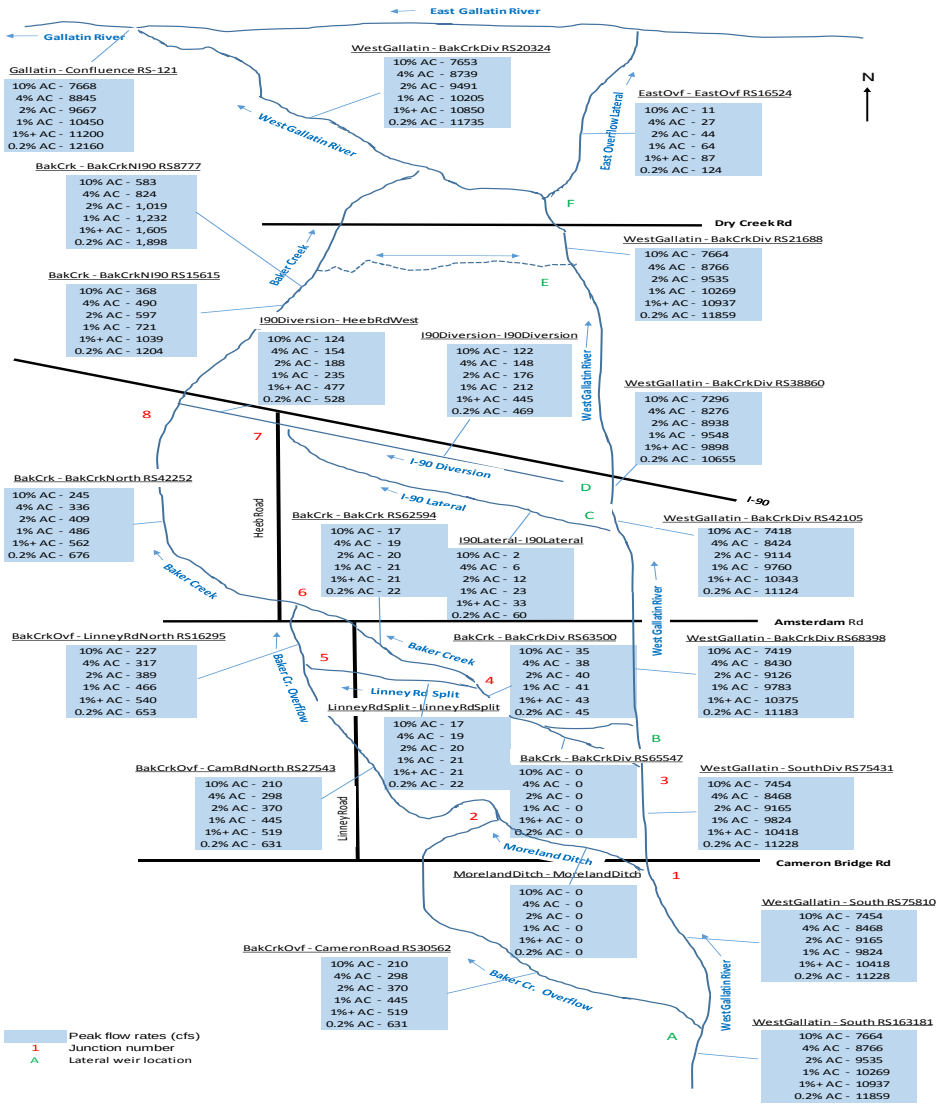
## Worst Case Scenario #4:

Downstream reach Baker Creek flows highest when:

- I-90 Diversion structure fails.
- Flow routed along I-90 Diversion channel.
- Flows discharged to Baker Creek.



# Split Flow Tracking Diagram For Each Scenario:



# Split Flow Tracking Spreadsheet For Each Scenario:

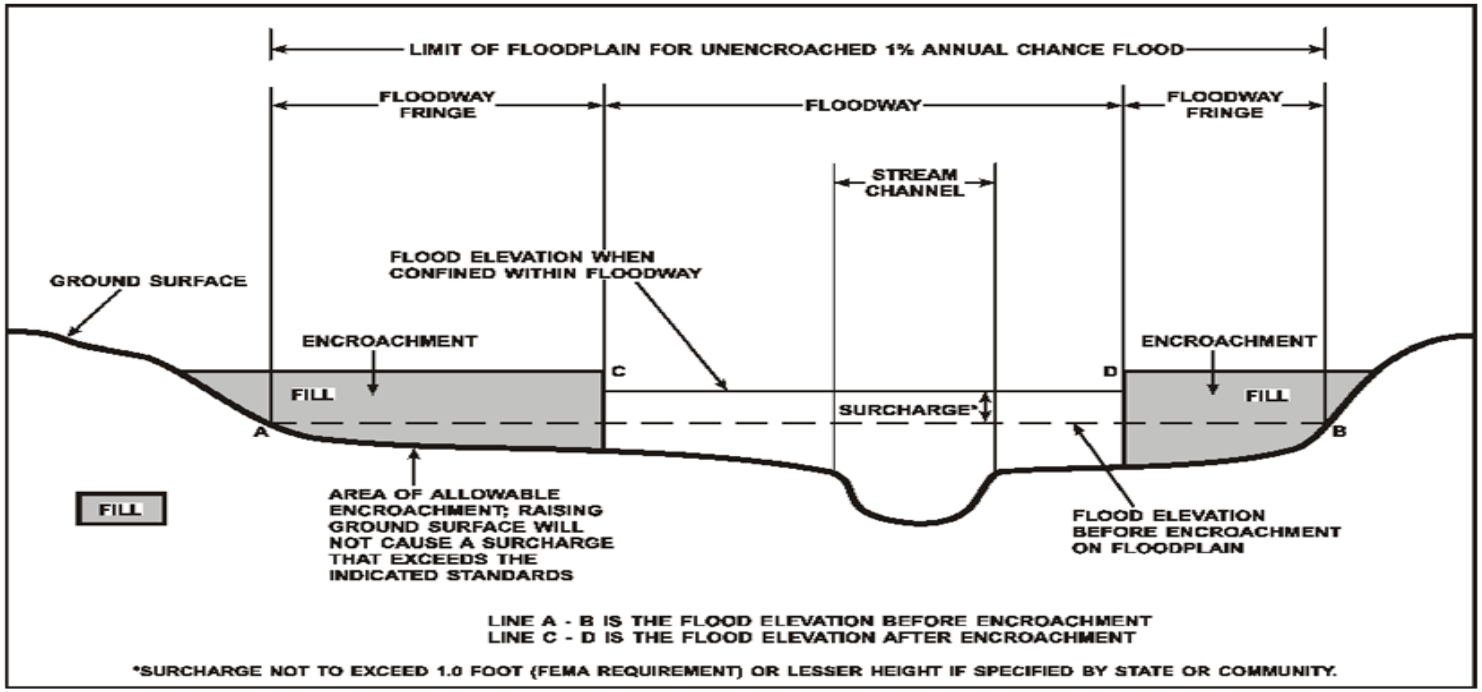
| River | Reach | River Sta | Recurrence Interval Flow (cfs) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 10% AC | 4% AC | 2% AC | 1% AC | 1% AC+ | 0.2% AC |
| BakCrk | BakCrkDiv | 65547 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0 |
| | BakCrkDiv | 63500 | 35 | 38 | 40 | 41 | 43 | 45 |
| | BakCrk | 62594 | 17 | 19 | 20 | 21 | 21 | 22 |
| | BakCrkNorth | 42252 | 245 | 336 | 409 | 486 | 562 | 676 |
| | BakCrkNI90 | 15615 | 368 | 490 | 597 | 721 | 1039 | 1204 |
| | BakCrkNI90 | 8777 | 484 | 661 | 811 | 976 | 1318 | 1538 |
| | BakCrkNI90 | 4991 | 583 | 824 | 1019 | 1232 | 1605 | 1898 |
| BakCrkOvf | CameronRoad | 33456 | 24 | 49 | 70 | 92 | 112 | 142 |
| | CameronRoad | 32965 | 158 | 221 | 269 | 316 | 359 | 421 |
| | CameronRoad | 31012 | 158 | 221 | 270 | 318 | 364 | 428 |
| | CameronRoad | 30562 | 210 | 298 | 370 | 445 | 519 | 631 |
| | CamRdNorth | 27543 | 210 | 298 | 370 | 445 | 519 | 631 |
| | LinneyRdNorth | 16295 | 227 | 317 | 389 | 466 | 540 | 653 |
| EastOvf | EastOvf | 16524 | 11 | 27 | 44 | 64 | 87 | 124 |
| I90Diversion | I90Diversion | 7829 | 122 | 148 | 176 | 212 | 445 | 469 |
| | HeebRdWest | 3667 | 124 | 154 | 188 | 235 | 477 | 528 |
| I90Lateral | I90Lateral | 7615 | 2 | 6 | 12 | 23 | 33 | 60 |
| LinneyRdSplit | LinneyRdSplit | 4181 | 17 | 19 | 20 | 21 | 21 | 22 |
| MorelandDitch | MorelandDitch | 1870 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| WestGallatin | South | 163181 | 7664 | 8766 | 9535 | 10269 | 10937 | 11859 |
| | South | 79310 | 7640 | 8717 | 9465 | 10177 | 10825 | 11717 |
| | South | 78758 | 7506 | 8545 | 9266 | 9953 | 10578 | 11438 |
| | South | 76476 | 7506 | 8545 | 9265 | 9951 | 10573 | 11431 |
| | South | 75810 | 7454 | 8468 | 9165 | 9824 | 10418 | 11228 |
| | SouthDiv | 75431 | 7454 | 8468 | 9165 | 9824 | 10418 | 11228 |
| | BakCrkDiv | 70410 | 7454 | 8468 | 9165 | 9824 | 10418 | 11228 |
| | BakCrkDiv | 68398 | 7419 | 8430 | 9126 | 9783 | 10375 | 11183 |
| | BakCrkDiv | 42105 | 7418 | 8424 | 9114 | 9760 | 10343 | 11124 |
| | BakCrkDiv | 38860 | 7296 | 8276 | 8938 | 9548 | 9898 | 10655 |
| | BakCrkDiv | 26546 | 7181 | 8105 | 8724 | 9293 | 9619 | 10321 |
| | BakCrkDiv | 24752 | 7081 | 7942 | 8516 | 9037 | 9332 | 9961 |
| | BakCrkDiv | 21688 | 7664 | 8766 | 9535 | 10269 | 10937 | 11859 |
| | BakCrkDiv | 20324 | 7653 | 8739 | 9491 | 10205 | 10850 | 11735 |
| Gallatin | BakCrkDiv | -121 | 7668 | 8845 | 9667 | 10450 | 11200 | 12160 |

**Lateral Weir Flow Data Summary Table**

| River | Reach | River Sta | Recurrence Interval Flow (cfs) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 10% AC | 4% AC | 2% AC | 1% AC | 1% AC+ | 0.2% AC |
| WestGallatin | South A | 79491 | 24 | 49 | 70 | 92 | 112 | 142 |
| | South A | 78957 | 134 | 172 | 199 | 225 | 248 | 279 |
| | South A | 76760 | 0 | 0 | 1 | 2 | 4 | 8 |
| | South A | 76300 | 51 | 77 | 100 | 127 | 155 | 202 |
| | BakCrkDiv B | 68639 | 35 | 38 | 40 | 41 | 43 | 45 |
| | I90Lat C | 42754 | 2 | 6 | 12 | 23 | 33 | 60 |
| | I90Div D | 39077 | 122 | 148 | 176 | 212 | 445 | 469 |
| | BakCrkConflu E | 26545 | 115 | 172 | 214 | 255 | 279 | 334 |
| | BakCrkConflu E | 24751 | 99 | 162 | 208 | 257 | 287 | 360 |
| | EastOvf F | 20706 | 11 | 27 | 44 | 64 | 87 | 124 |

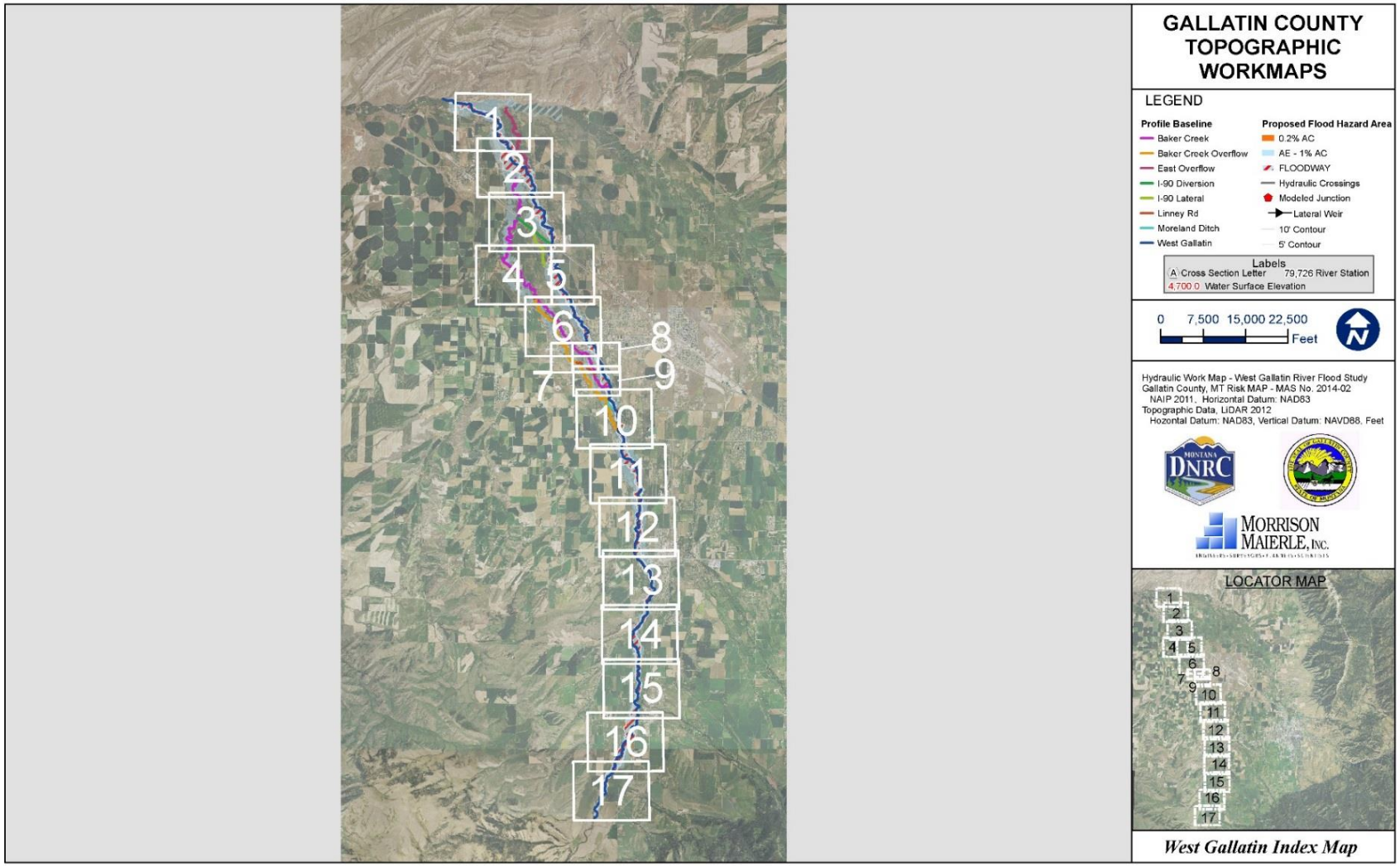
Flow rates optimized with HEC-RAS model

# 1% Annual Chance Floodway:

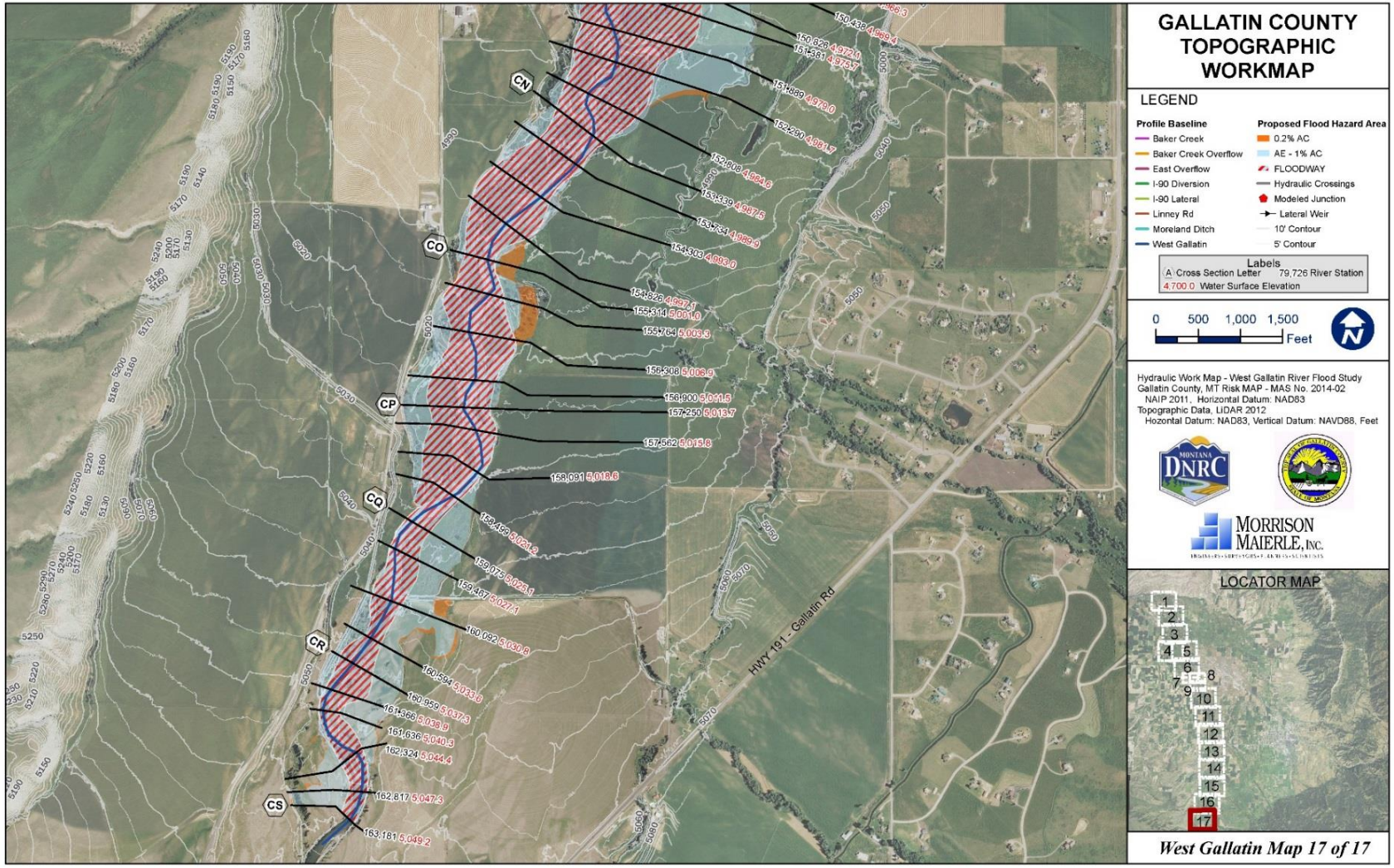



- Montana has a 0.5-foot maximum surcharge standard versus Federal one-foot maximum surcharge.
- No floodway in split flow reaches of West Gallatin River since difference in WSE's for full flow rate versus reduced split flow rate is less than 0.5-feet.
- Following work maps show floodplain and floodway delineations for the West Gallatin River.

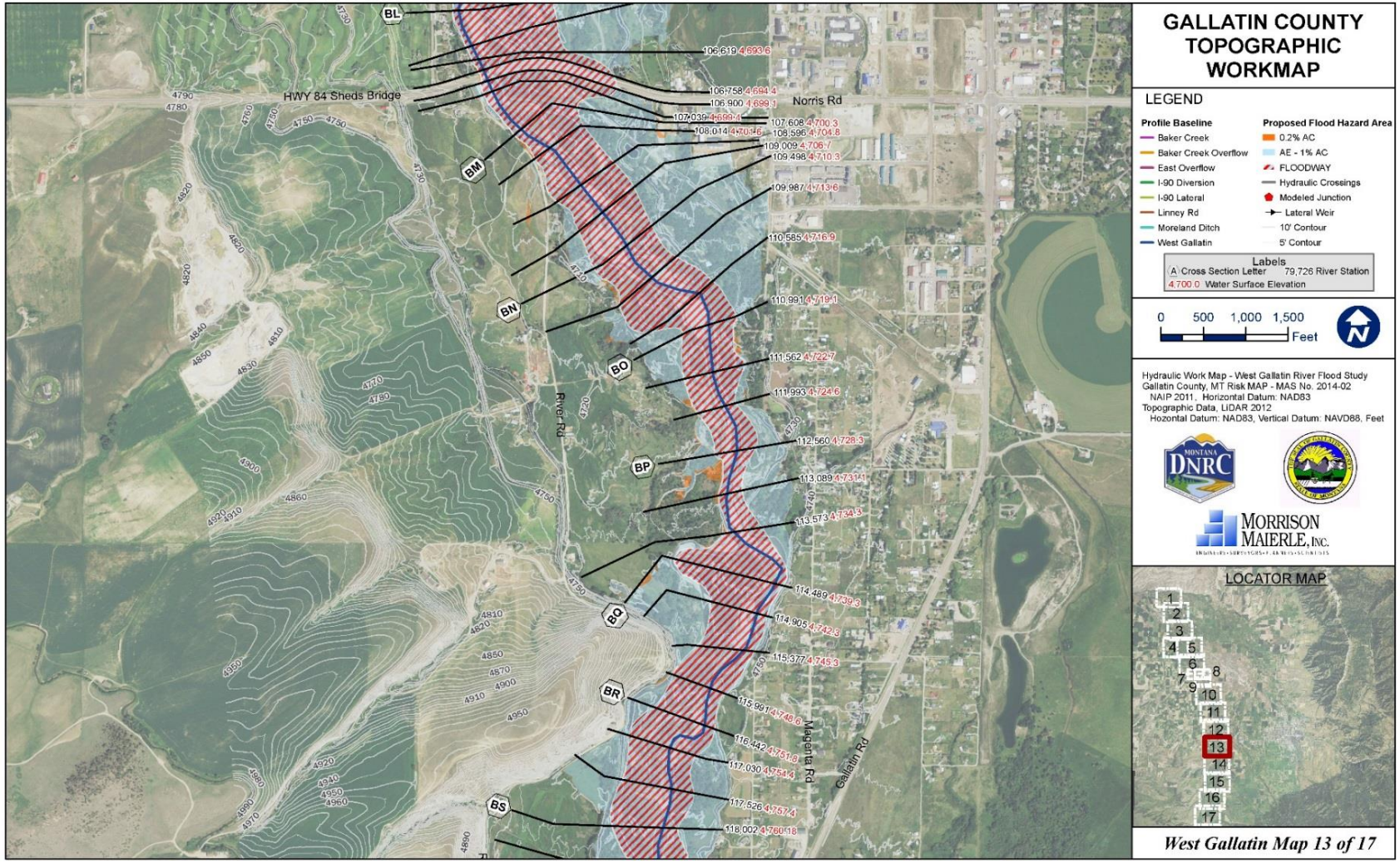
# Floodplain Work Map Index:



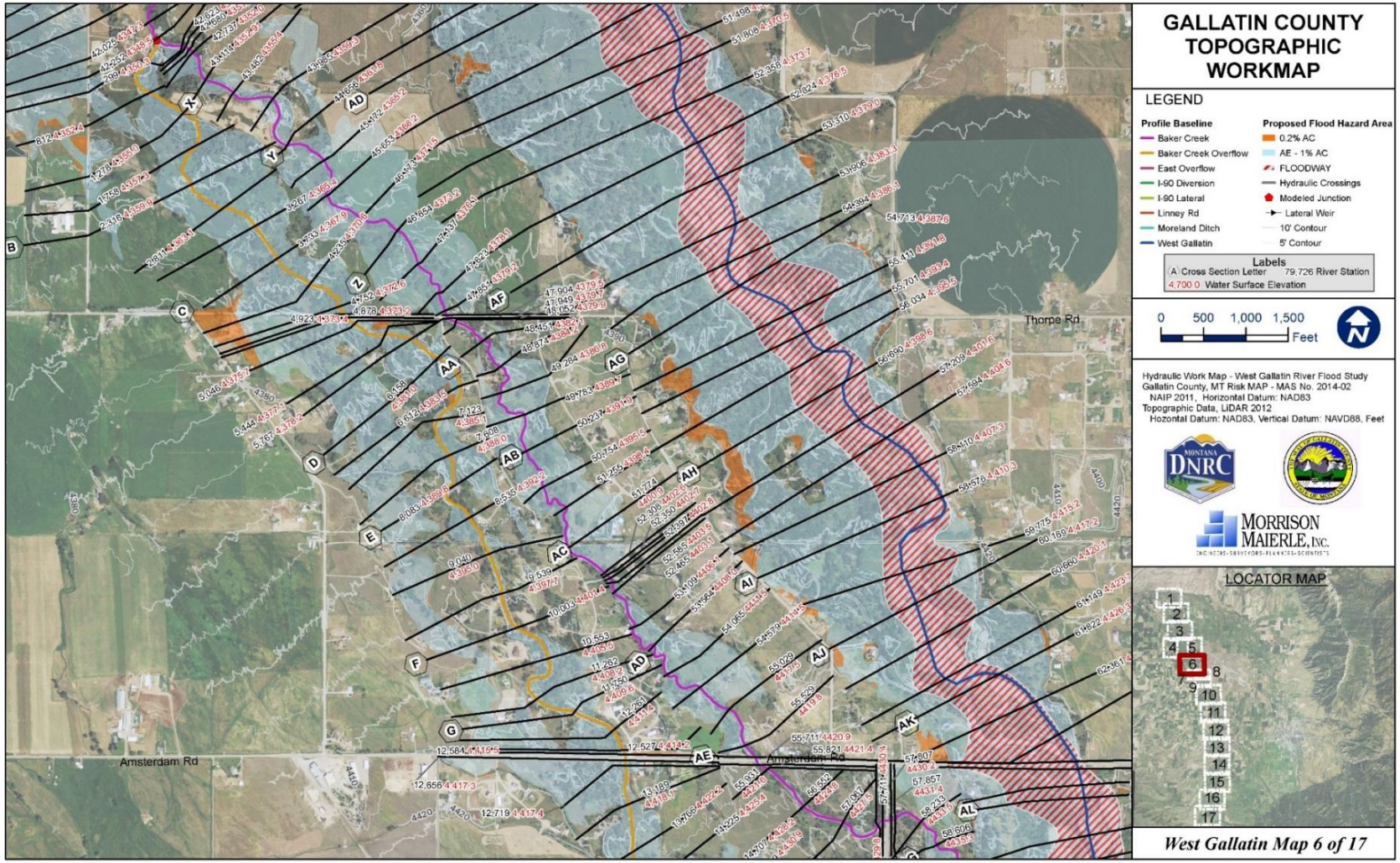
# Floodplain Work Map 17 of 17



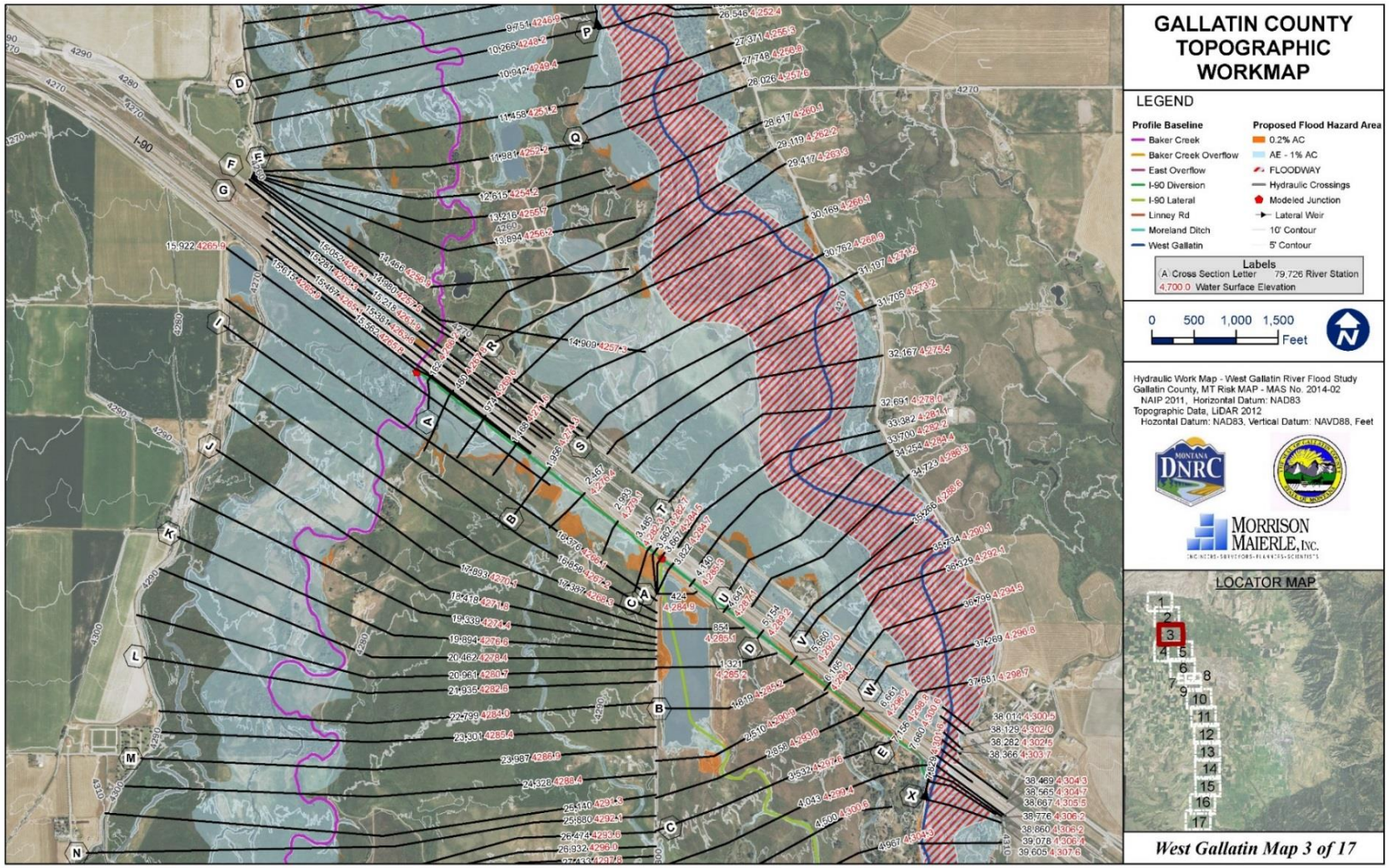
# Floodplain Work Map 13 of 17



# Floodplain Work Map 6 of 17

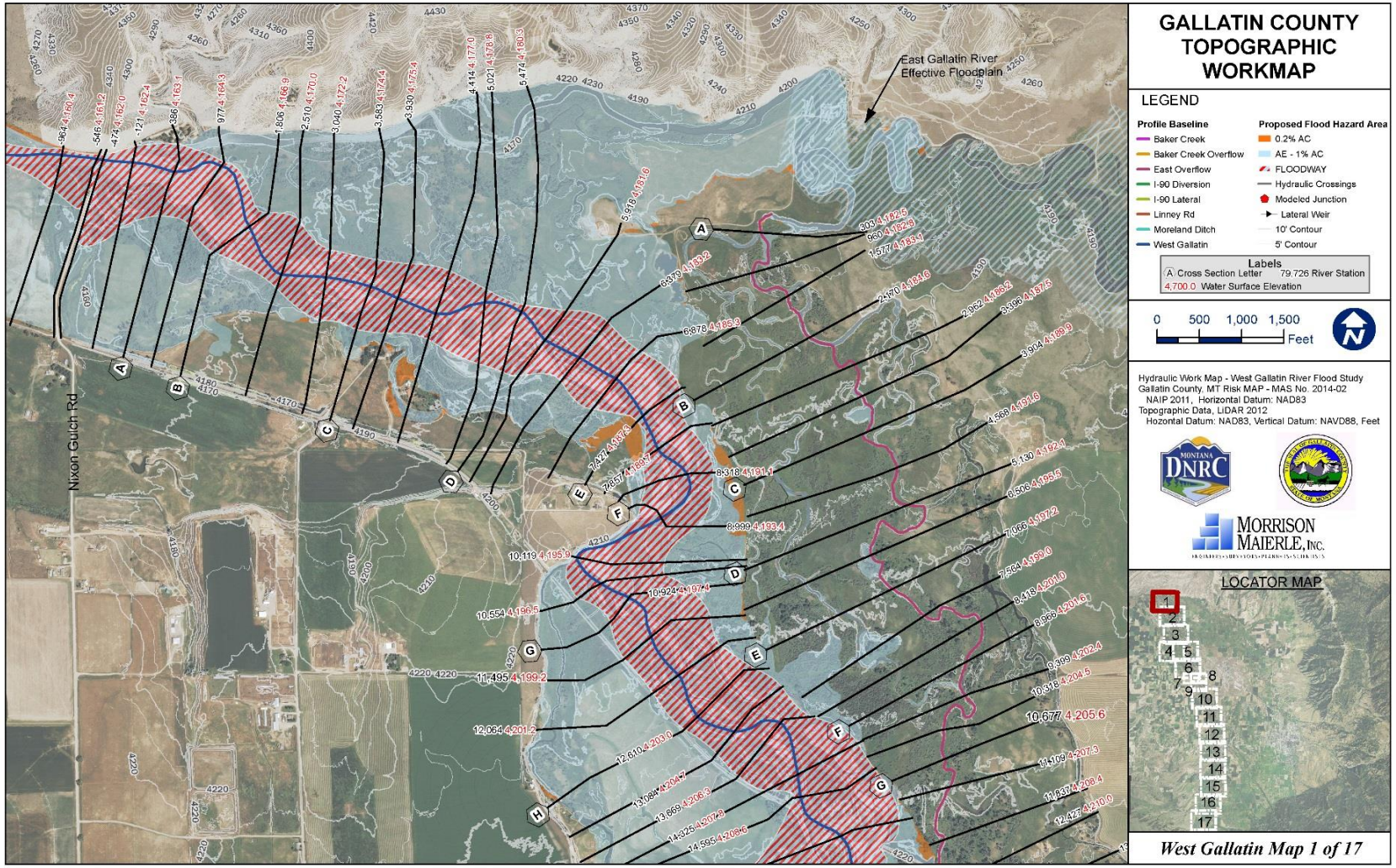


# Floodplain Work Map 3 of 17:




West Gallatin River Detailed Floodplain Study

# Floodplain Work Map 1 of 17:




West Gallatin River Detailed Floodplain Study

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## Summary of Floodplain Update Changes:

**Mapping Area (acres):**

| SFHA (1% AC) | | Floodway (1% AC) | |
|---|---|---|---|
| Increased | 2,012 acres | Increased | 1,600 acres |
| Decreased | 1,569 acres | Decreased | 2,850 acres |
| Net | **+443 acres** | Net | **− 1,250 acres** |
| | *(increase)* | | *(decrease)* |

**Structures (each):**

| SFHA (1% AC) | | Floodway (1% AC) | |
|---|---|---|---|
| Added | 50 structures | Added | 10 structures |
| Removed | 65 structures | Removed | 47 structures |
| Net | **-15 structures** | Net | **− 37 structures** |
| | *(decrease)* | | *(decrease)* |

## West Gallatin River Floodplain Summary:

- Study update has achieved FEMA's independent review and acceptance.
- Preliminary FIRM's to be released to public in September 2016.
- Preliminary FIRM's to be presented at future community meetings.
- Will be a 90-day public review and appeal period.
- Final acceptance of the study will occur after the 90-day appeal period.
- FEMA will then publish and issue effective FIRM's.

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## MMI Floodplain Project Team:

- Russ Anderson, PE, CFM: Project Manager and Hydrology Update.
- Mark Franchi, PE, CFM: Task Manager Hydraulic Modeling & Reports.
- Kristyn Mayernik, PE: Task Manager Work Map Preparation.
- Luke Carlson, PE: Hydraulic Model Setup & GIS Implementation.
- Matt Barnes, PE: Hydraulic Structure Survey.
- Jeff Roe, PLS: Hydraulic Structure Survey.
- Ken Salo, PE: Principal-In-Charge and QA/QC Manager.

# Questions?

**Thank you,**
Mark Franchi, PE, CFM

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engineers ▪ surveyors ▪ planners ▪ scientists