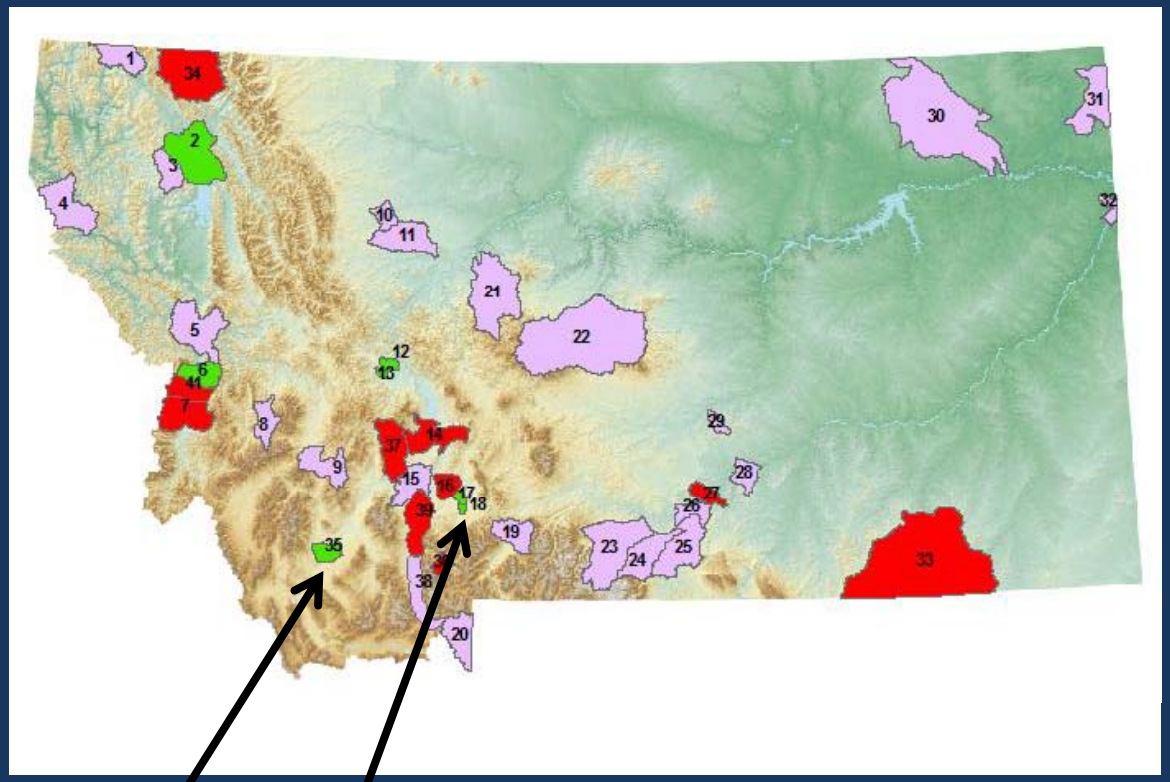
Ground Water Investigation Program (GWIP)

WPIC update March 6, 2012



Dillon

Gallatin Valley

Presented by MBMG
John Wheaton

Team Leaders for these projects:
Ginette Abdo
Tom Michalek

Focus today:

1. **Review on unconfined and confined aquifers and recharge**

2. **Valley-fill aquifer recharge by canal leakage**

Unconfined Aquifer

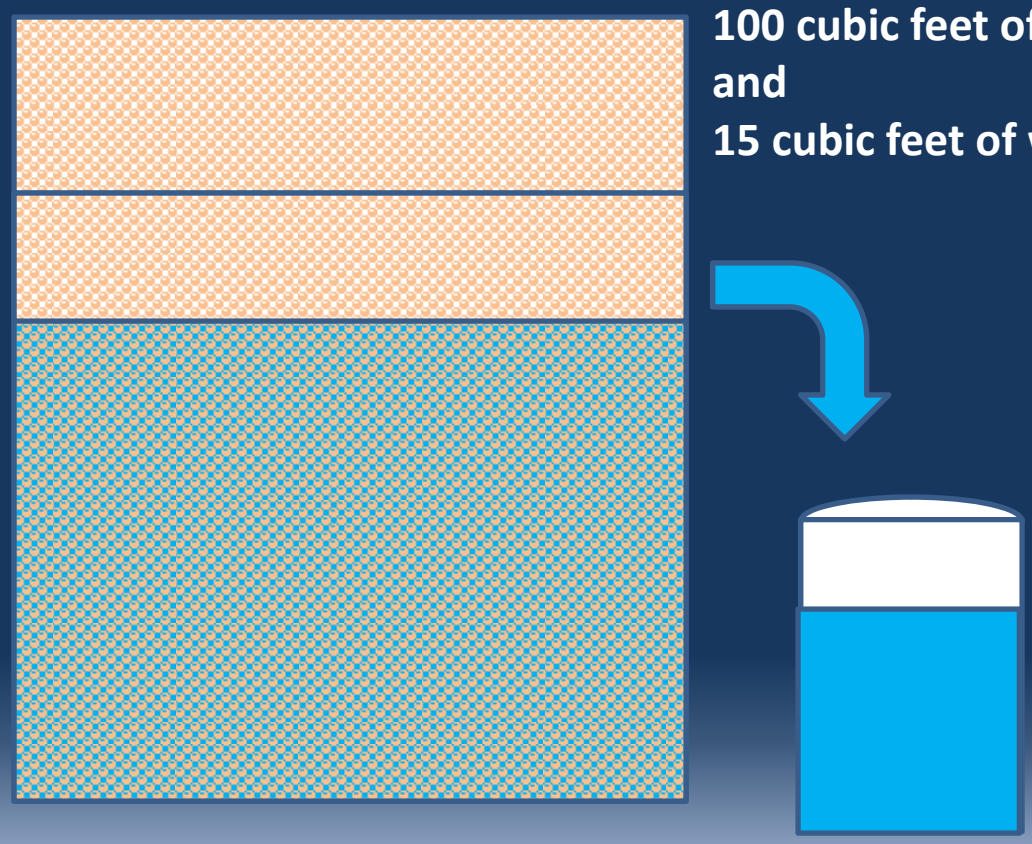
An aquifer in which there are no confining beds between the zone of saturation and the surface. The pore water pressure at the top surface is at atmospheric pressure (Fetter, 1980).

Water is released by draining water from the pores.

Unconfined Aquifer

Openings through overlying pores
allow local recharge

Land surface



100 cubic feet of aquifer is drained and
15 cubic feet of water are released.

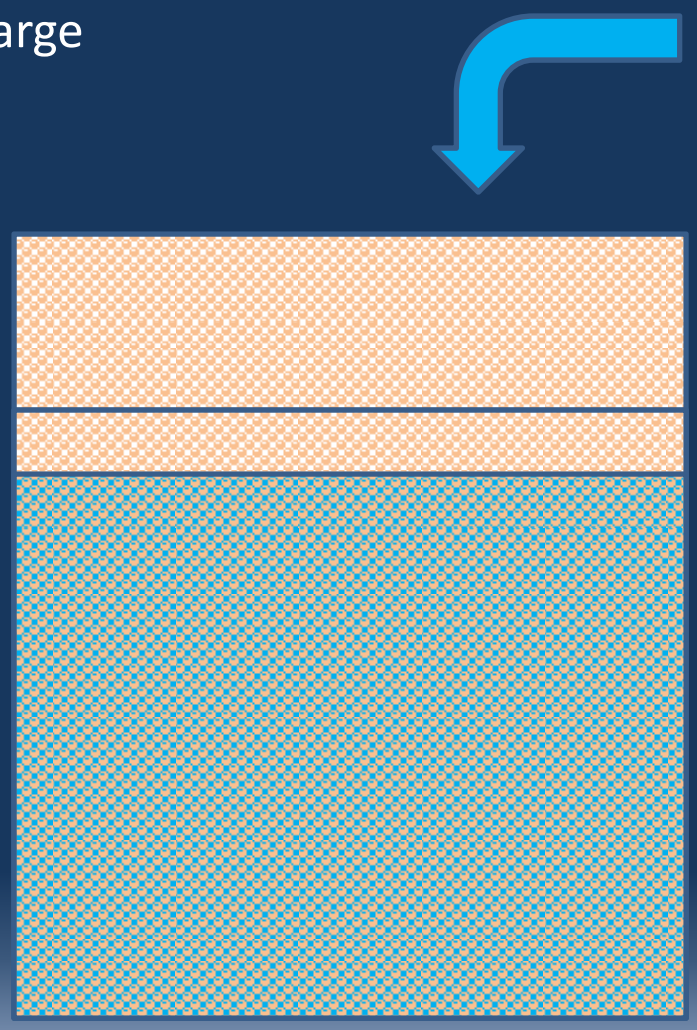
2% to 30% of the total aquifer volume is occupied by water

Unconfined Aquifer

Openings through overlying pores allow local recharge

1 inch of water infiltrating to the water table may raise the water level 6.7 inches.

Land surface



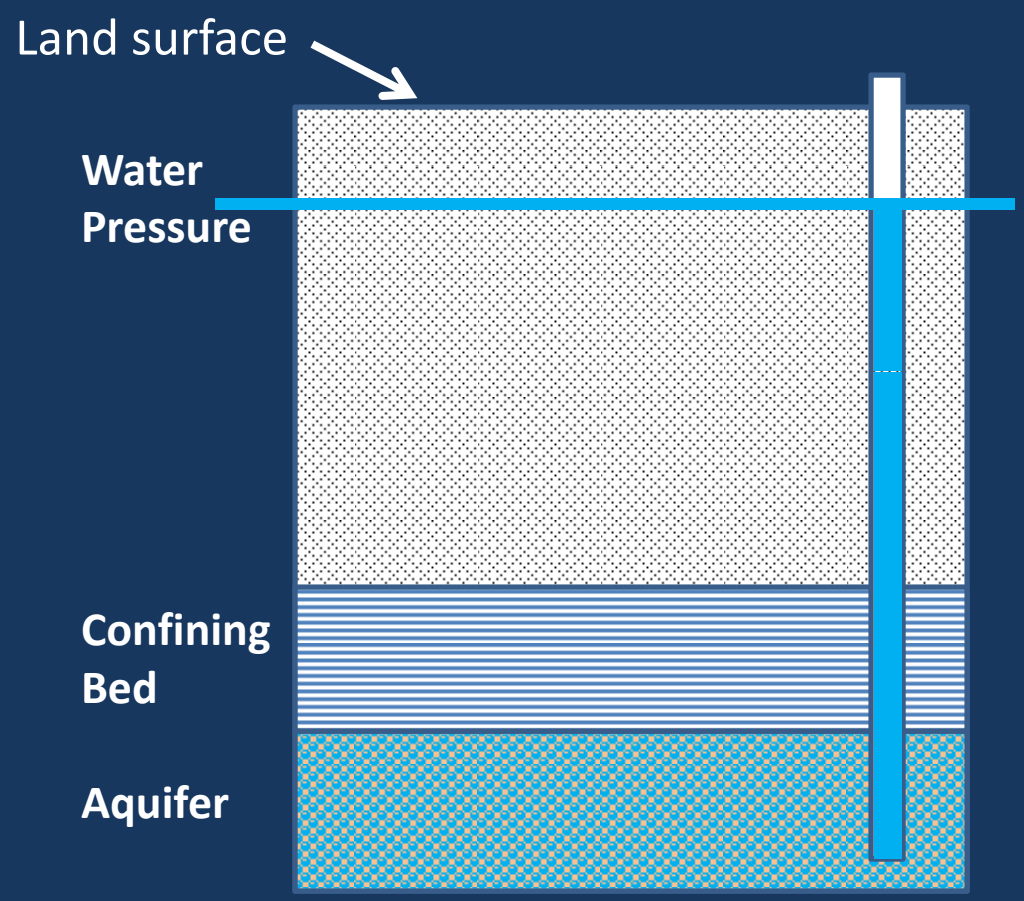
2% to 30% of the total aquifer volume is occupied by water

Confined Aquifer

An aquifer that is overlain by a confining bed. The confining bed has a significantly lower hydraulic conductivity than the aquifer (Fetter, 1980). The pore pressure is such that water will rise above the top of the aquifer in a tightly sealed well.

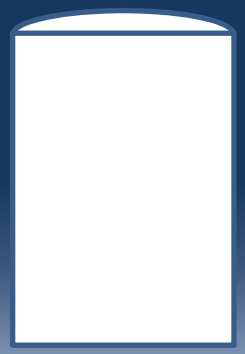
Water is released by compression of the mineral skeleton and by expansion of the water.

Confined Aquifer

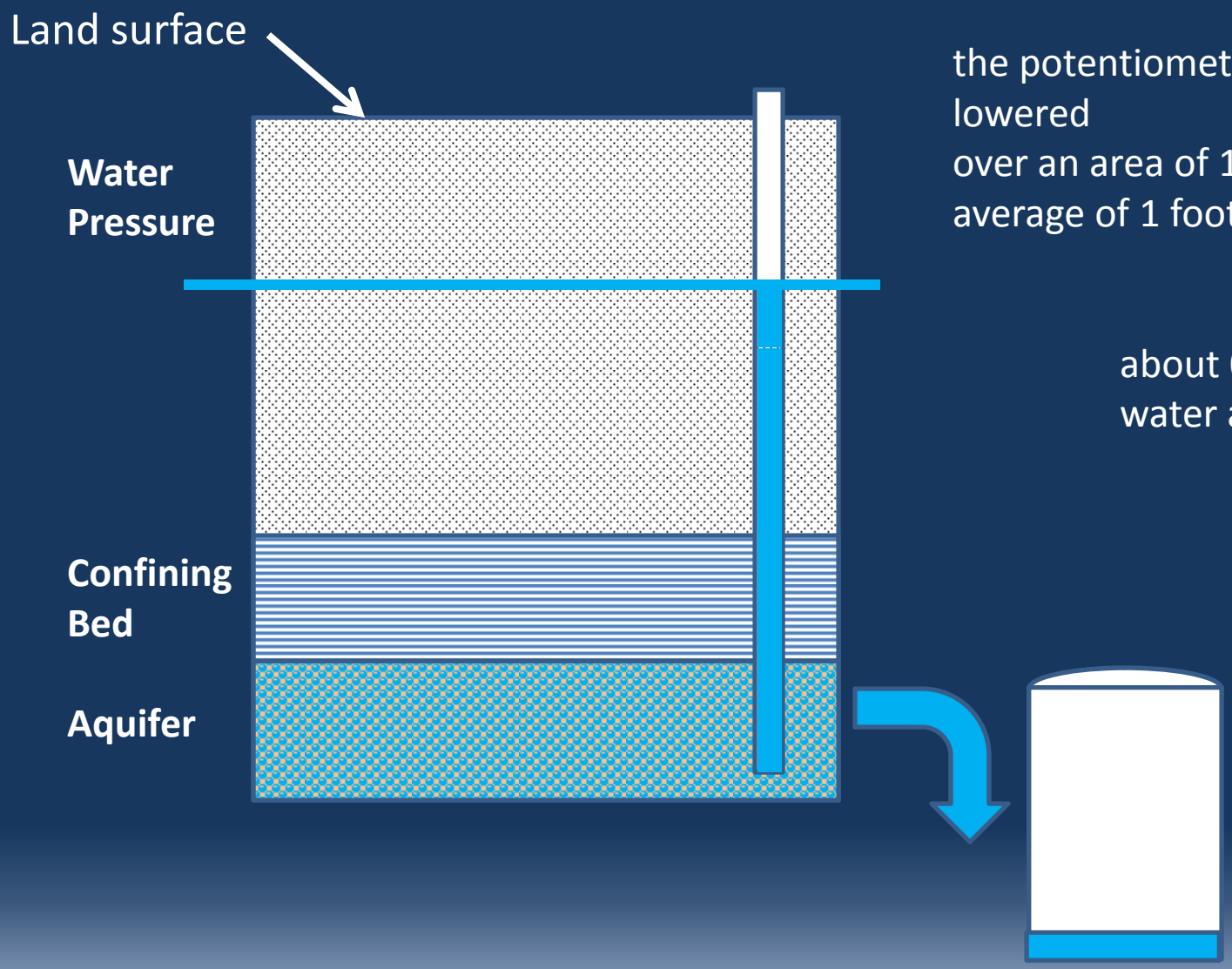


the potentiometric surface is lowered
over an area of 100 square feet an average of 1 foot

about 0.5 cubic feet of water are released.



Confined Aquifer



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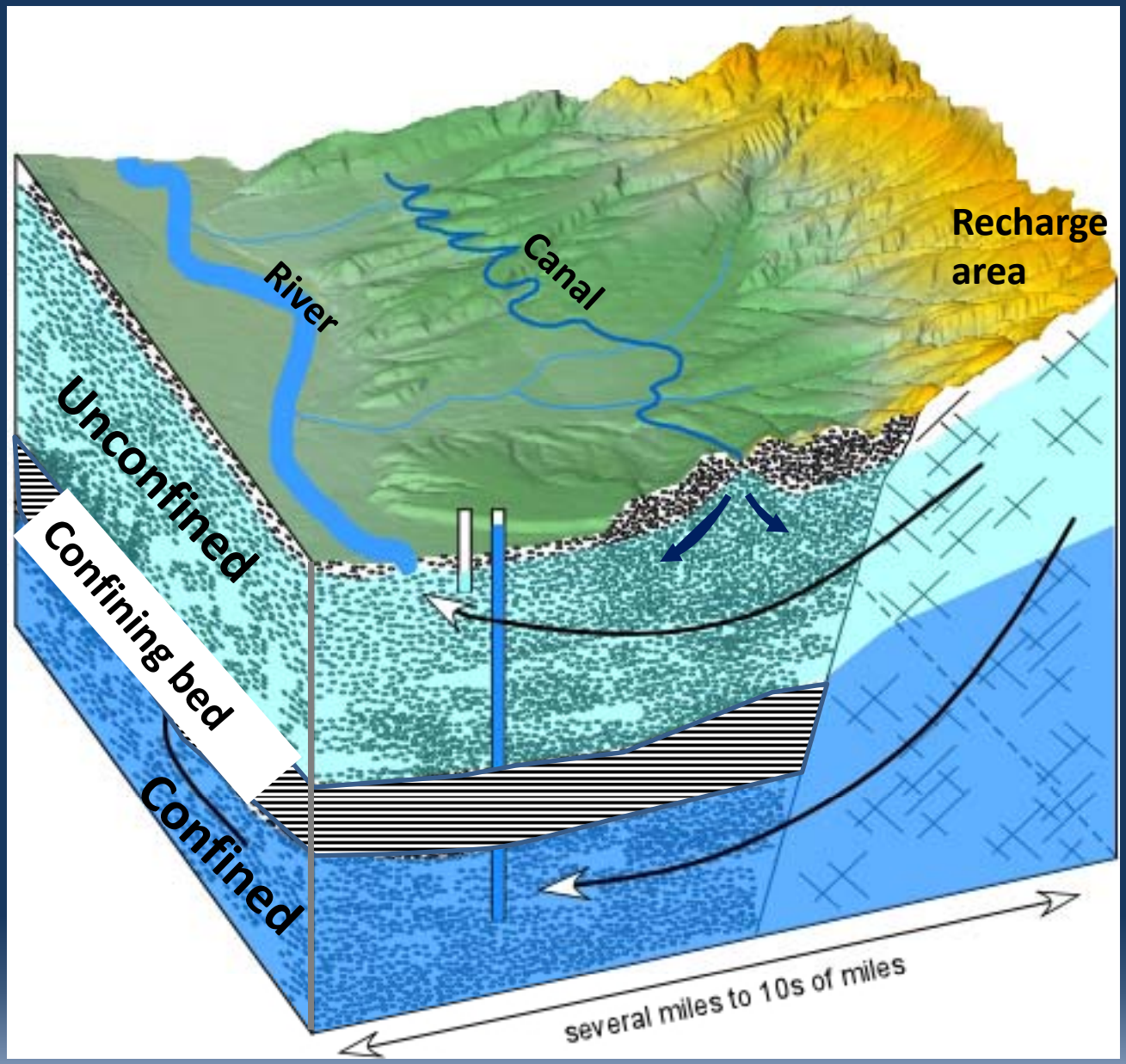
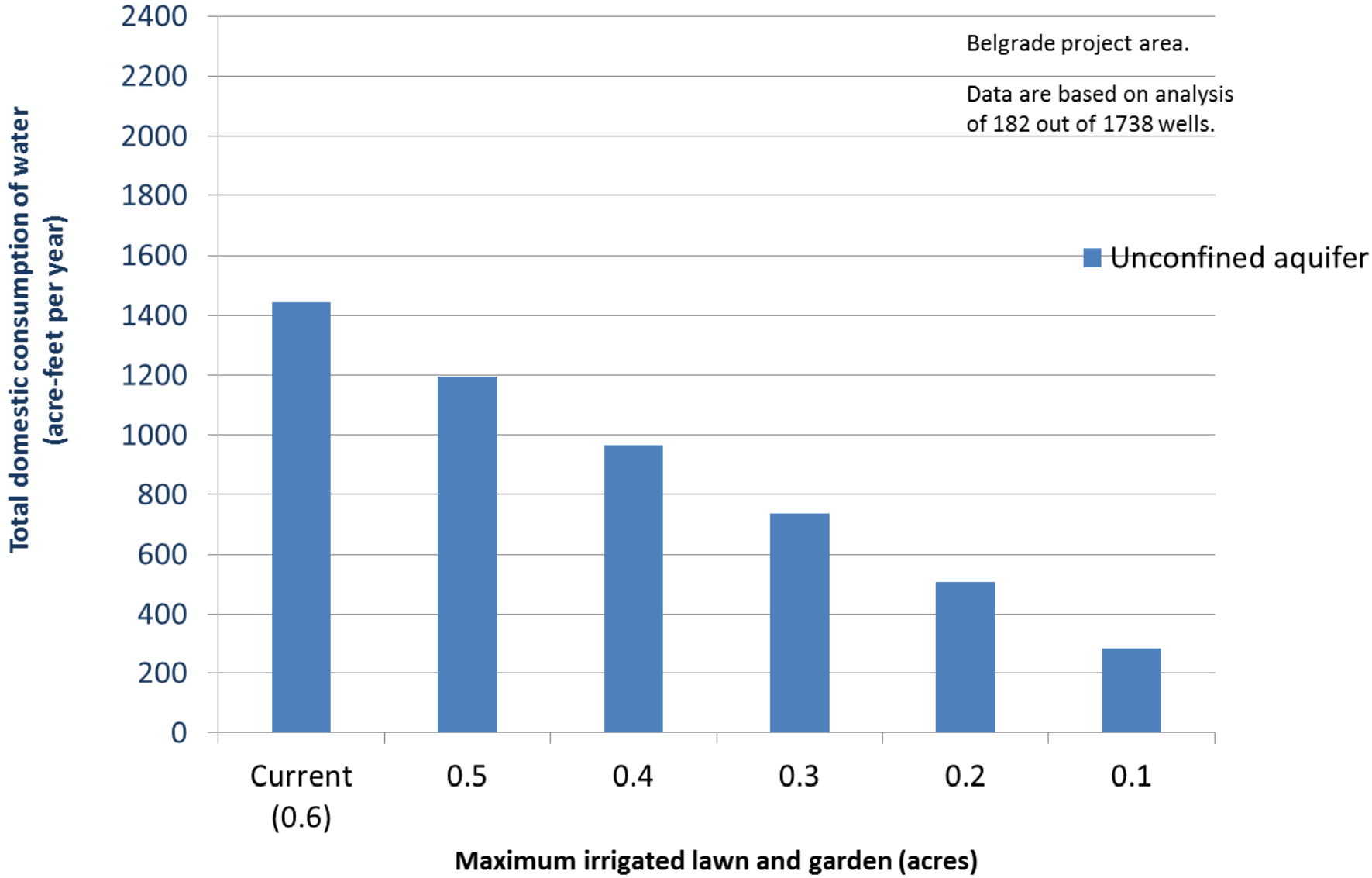

River
Canal
Recharge area
Unconfined
Confining bed
Confined
several miles to 10s of miles

Total annual water consumption for Belgrade study area
For lawn and garden and domestic use



Total annual water consumption for Belgrade study area
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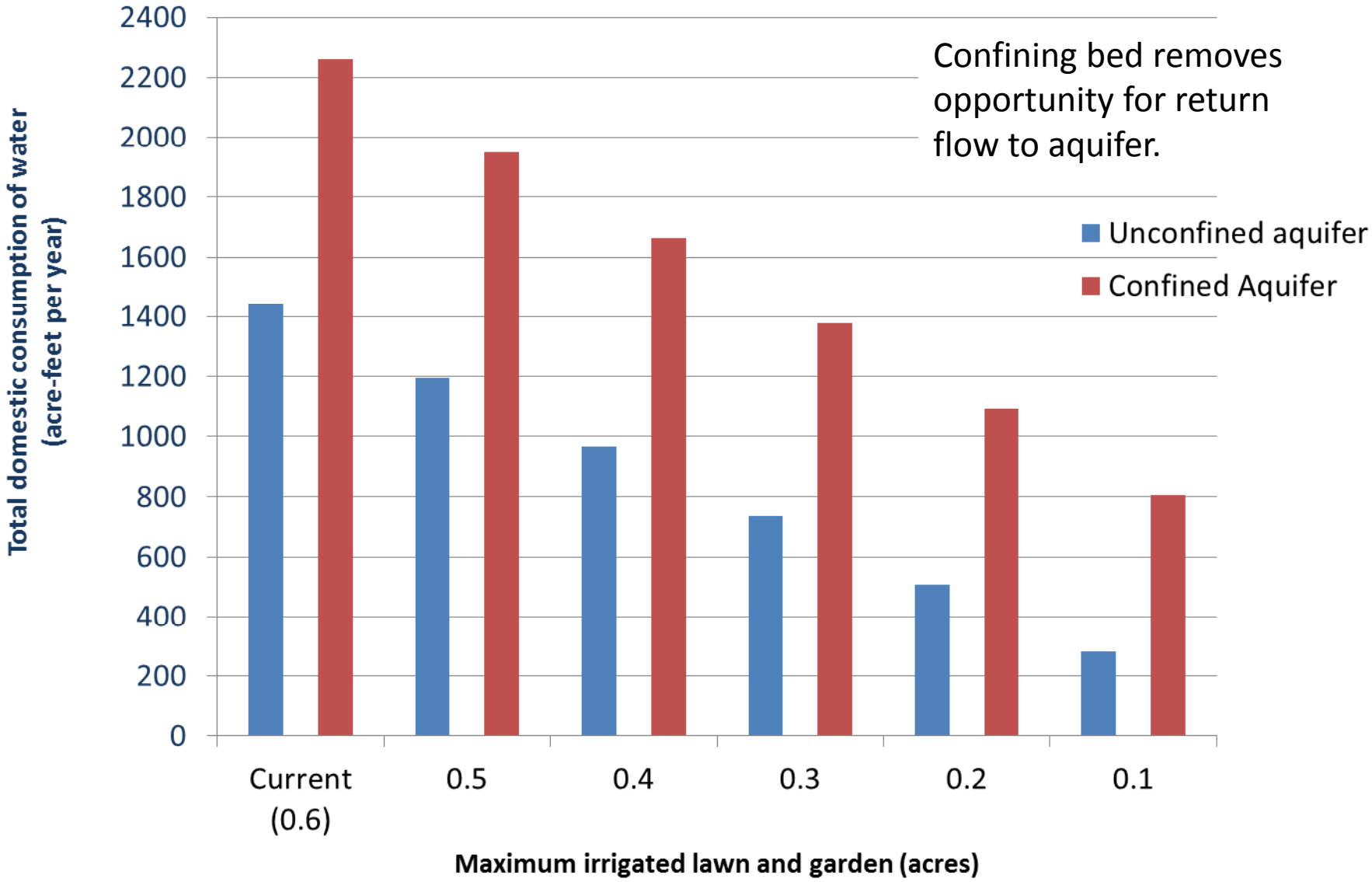
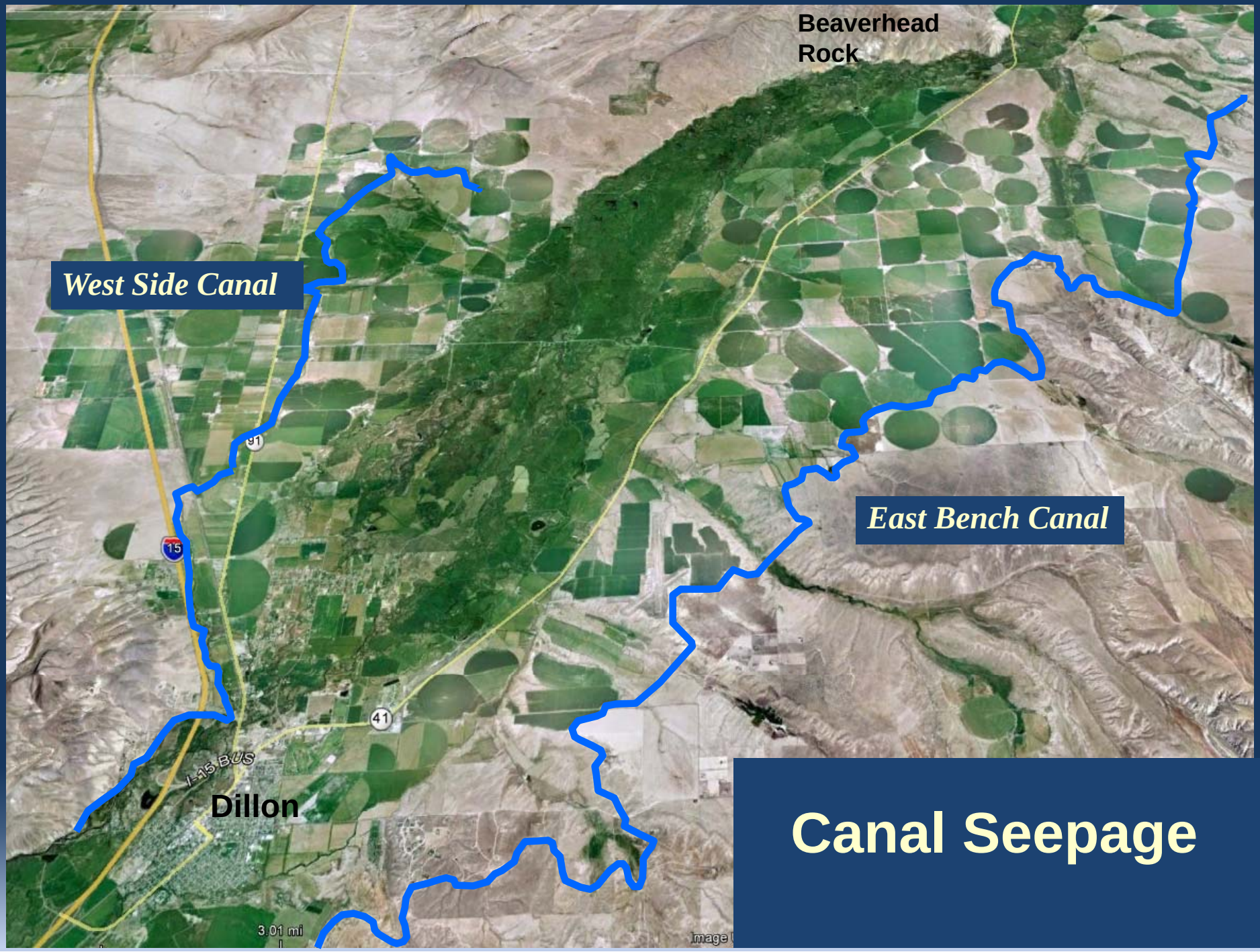


Ground Water Investigation Program
(GWIP)

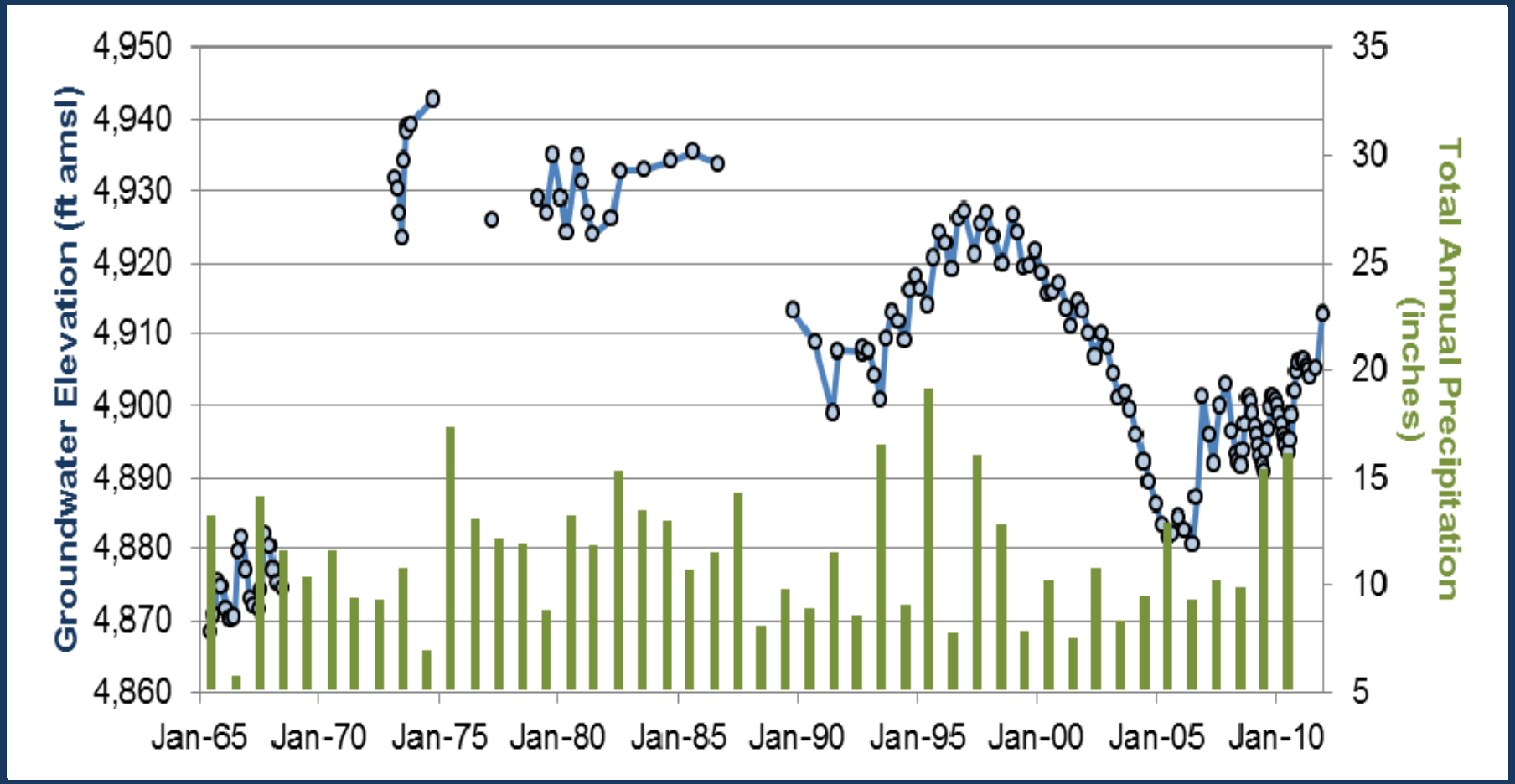
Next subject:

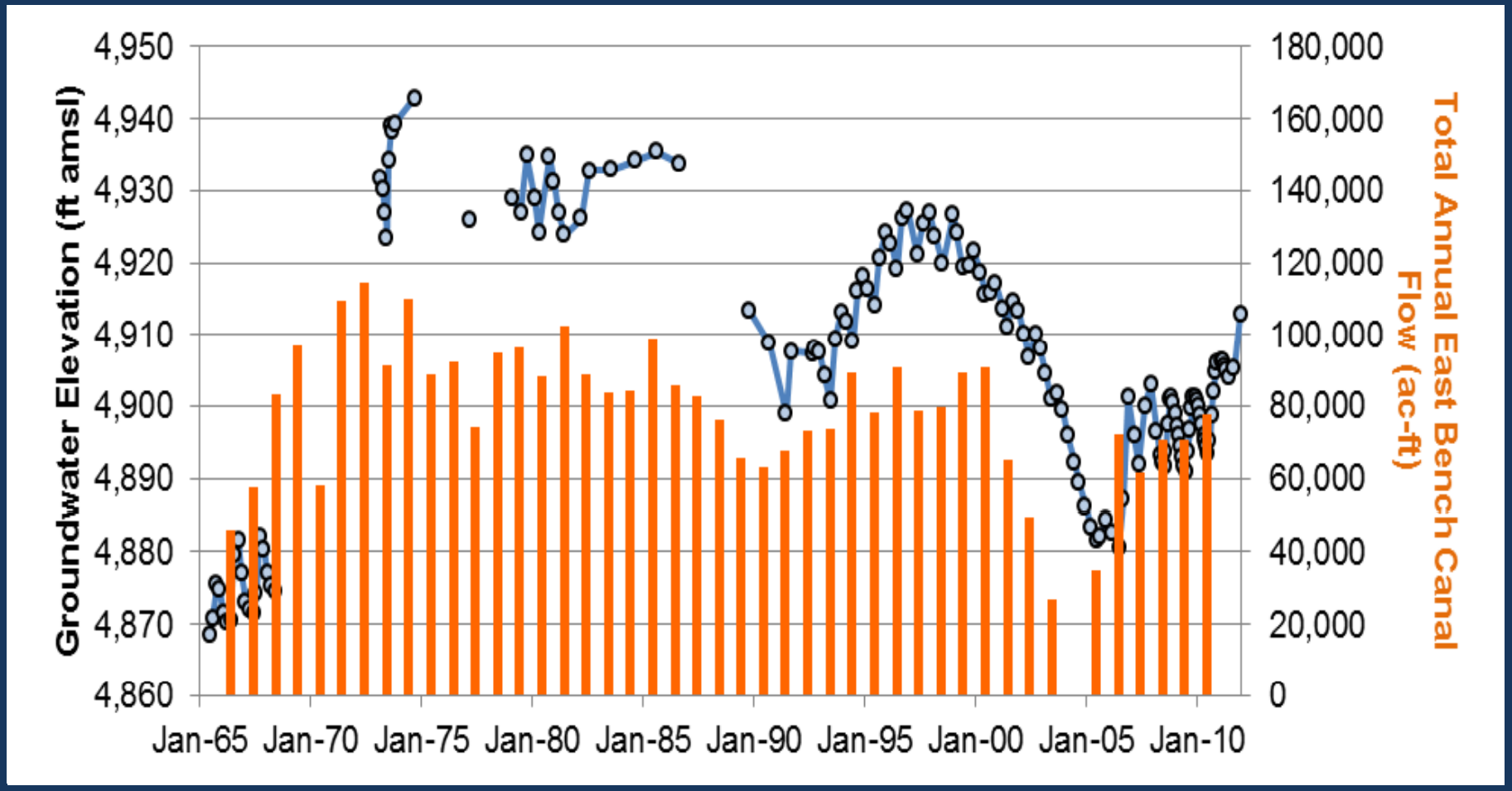
Unconfined aquifers and groundwater recharge from irrigation canals near Dillon

Ginette Abdo
Todd Myse
Julie Butler
Dean Snyder



Canal Seepage


Groundwater Elevation (ft amsl)
4,950
4,940
4,930
4,920
4,910
4,900
4,890
4,880
4,870
4,860
Total Annual Precipitation (inches)
35
30
25
20
15
10
5
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10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4,950
4,940
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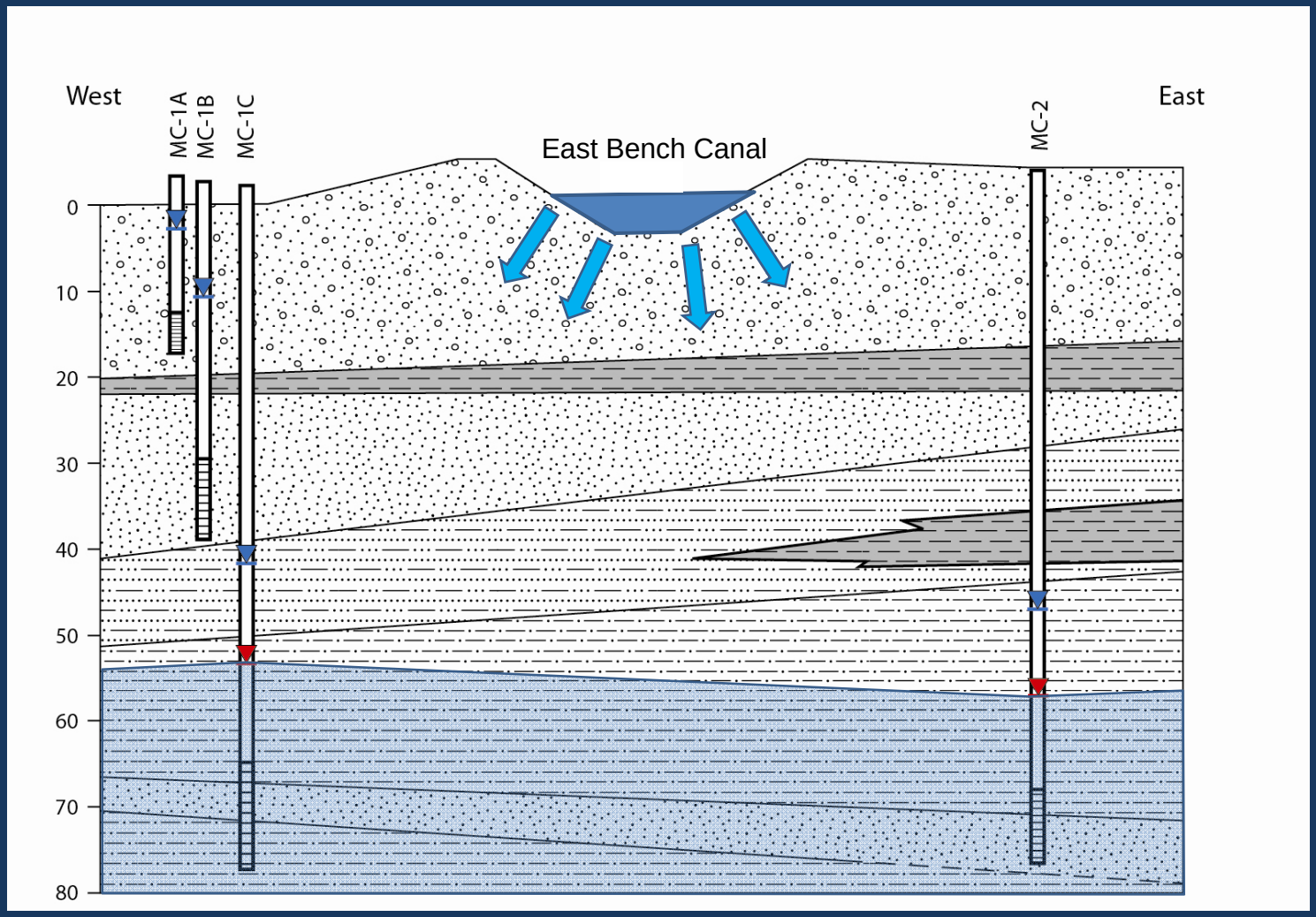
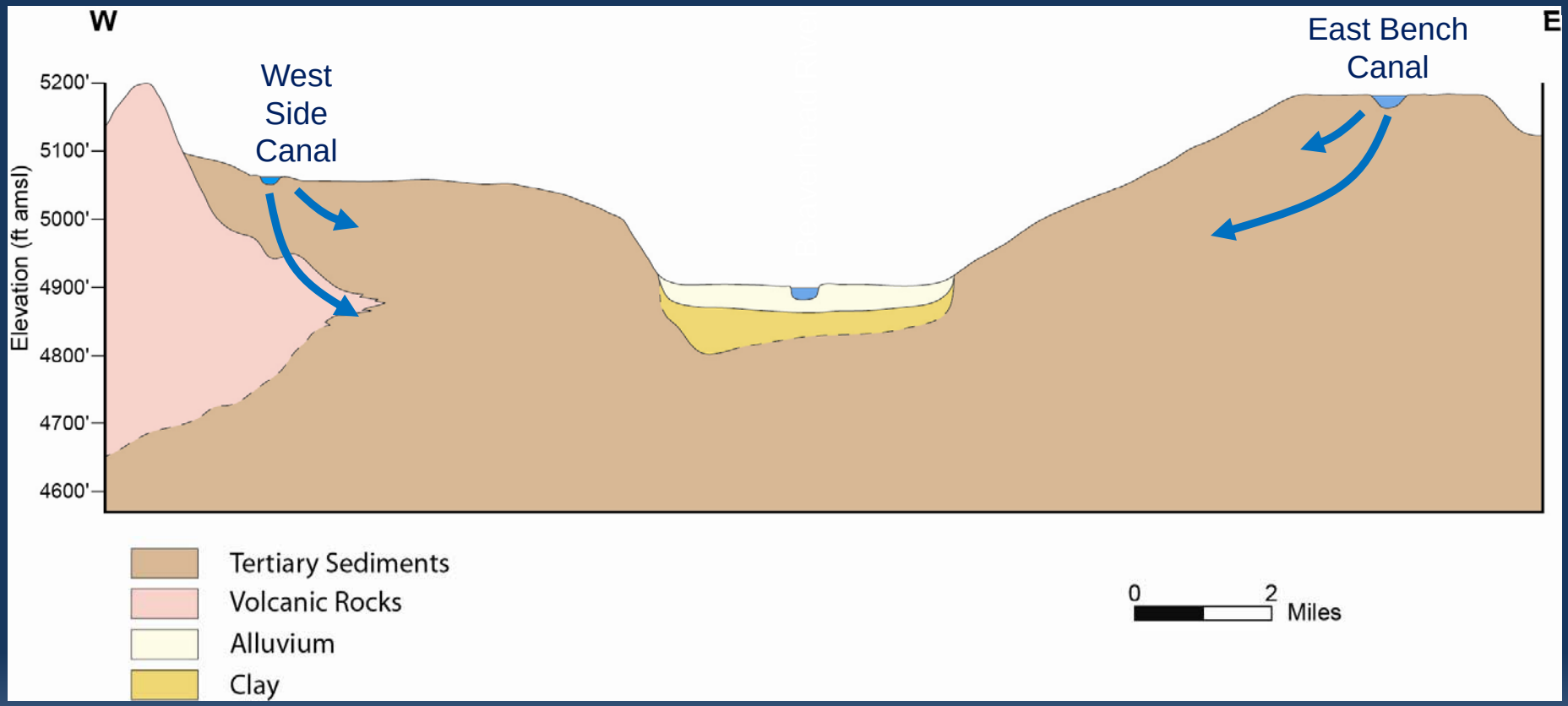
4,890
4,880
4,870
4,860
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Total Annual East Bench Canal Flow (ac-ft)


West
East
MC-1A
MC-1B
MC-1C
MC-2
East Bench Canal
0
10
20
30
40
50
60
70
80

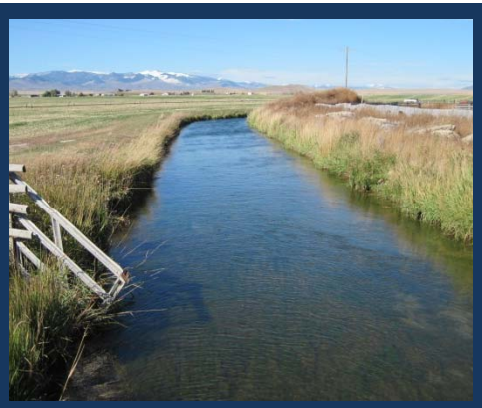
Groundwater Recharge from Canal Seepage
2010

Seepage Loss
5,900 ac-ft/yr

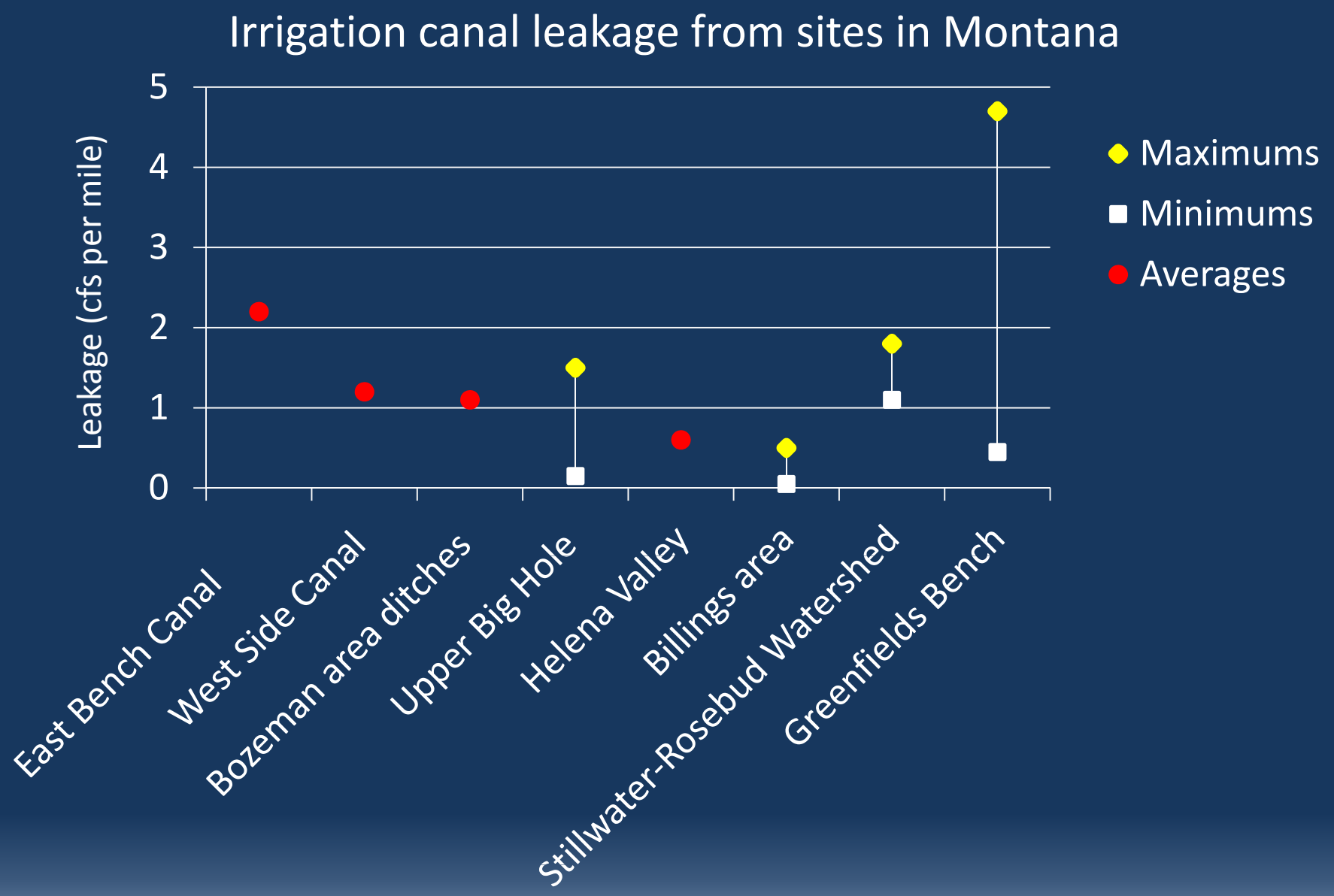
Seepage Loss
17,000 ac-ft/yr



Examples of Seepage Loses



• East Bench Canal	2.2 cfs/mile
• West Side Canal	1.2 cfs/mile
• Bozeman area ditches	1.1 cfs/mile
• Upper Big Hole	0.15-1.5 cfs/mile
• Helena Valley	0.6 cfs/mile
• Billings area	0.05-0.5 cfs/mile
• Stillwater-Rosebud Watershed	1.1-1.8 cfs/mile
• Greenfields Bench	0.45-4.7 cfs/mile


Irrigation canal leakage from sites in Montana
Leakage (cfs per mile)
5
4
3
2
1
0
East Bench Canal
West Side Canal
Bozeman area ditches
Upper Big Hole
Helena Valley
Billings area
Stillwater-Rosebud Watershed
Greenfields Bench
Maximums
Minimums
Averages

Ground Water Investigation Program
(G W I P)

Next subject:

Applying irrigation canal leakage over a large area

Refilling the western basins each year

Tom Michalek
Mary Sutherland
Bill Henne

Valley Fill Aquifers in Montana
Gallatin Valley as an example

Gallatin County

- ✓ Fastest growing county in the state; 32% increase in last census
- ✓ 10,000 more housing units
- ✓ 40% increase in water wells
- ✓ Irrigated acres decreased by 20% from 2002 to 2007
- ✓ Flood irrigation changing to sprinkler and pivot

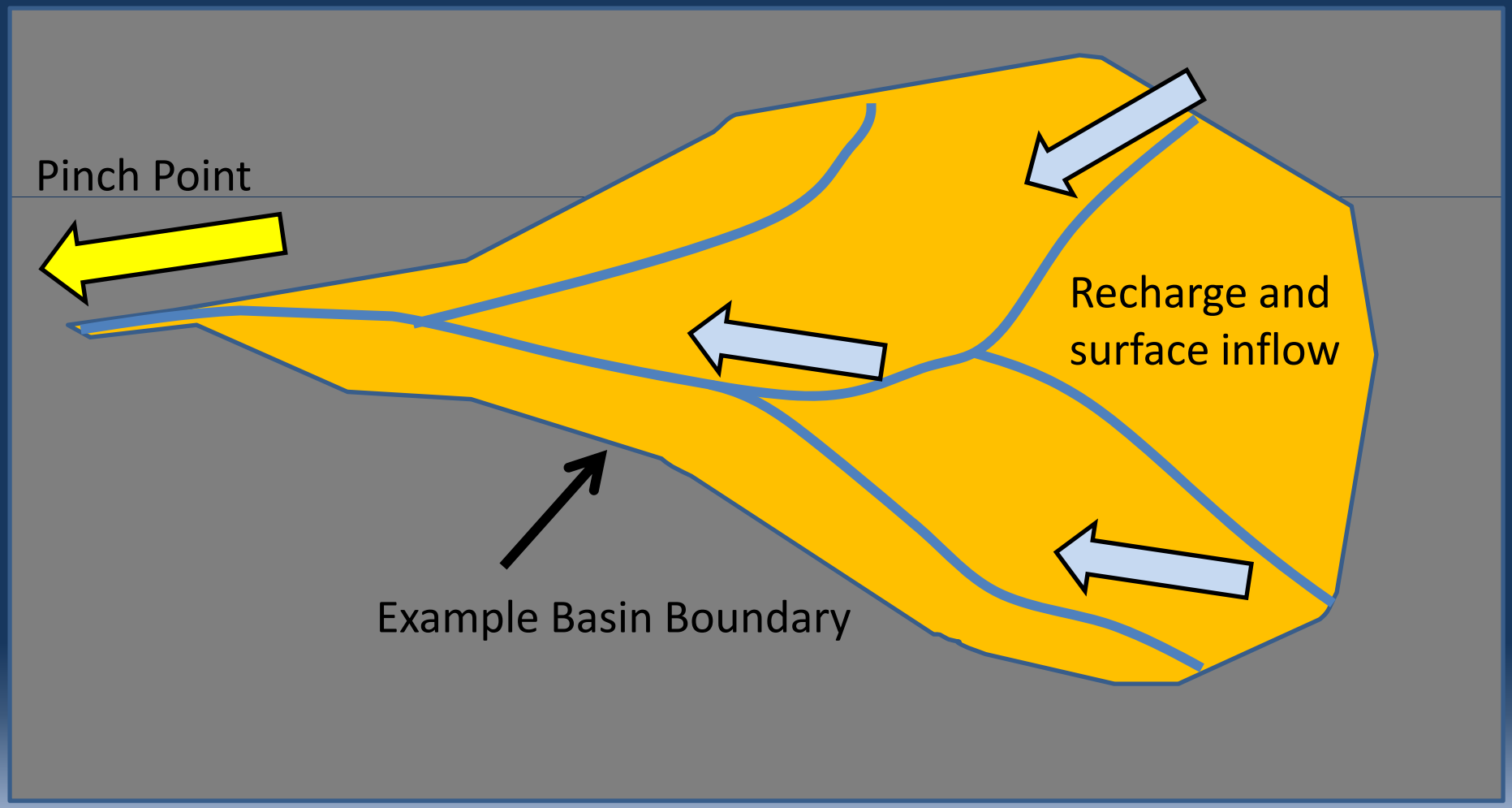
GWIP Questions:

What are the effects of these rapid changes?

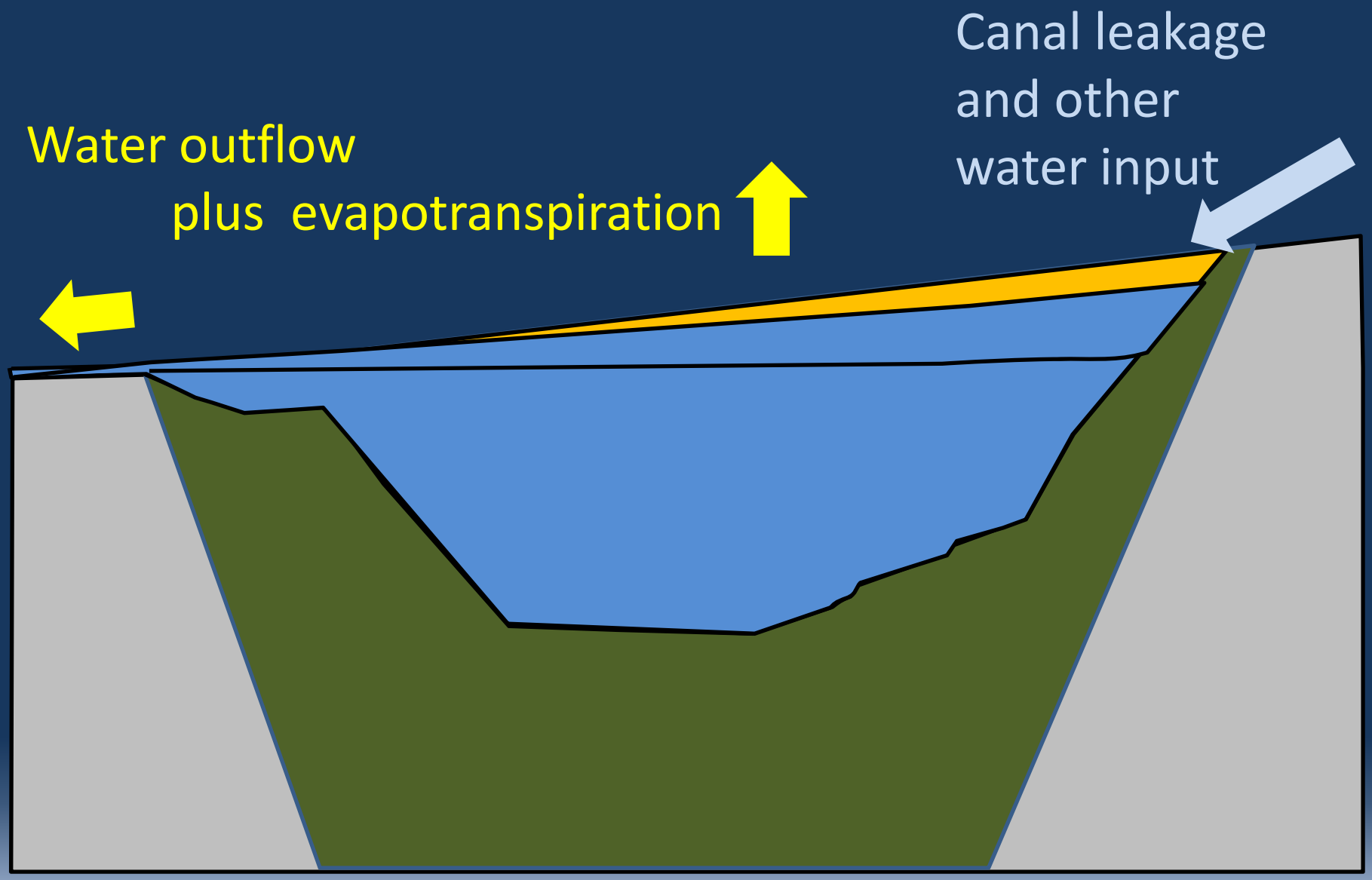
Can we manage future changes through understanding the hydrologic system?

Some valley fill aquifers:

Large basin, both groundwater and surface are forced through a restricted pinch point.



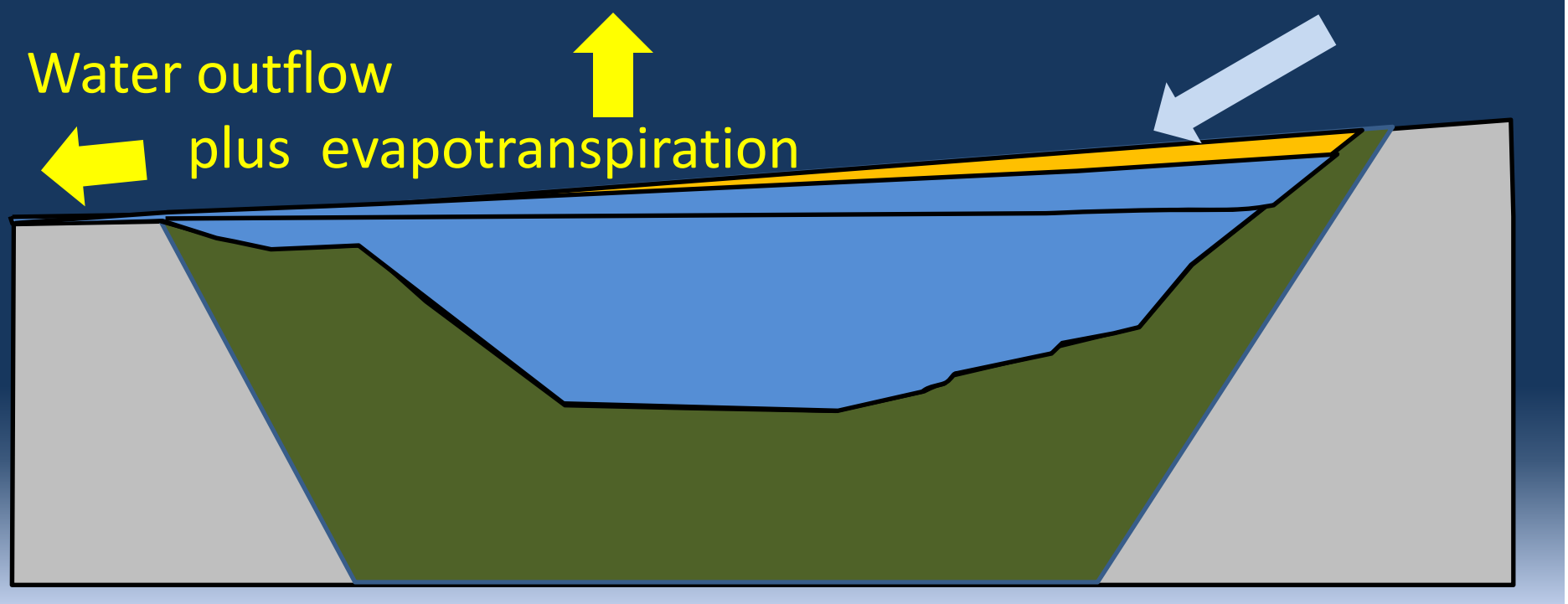
Valley fill aquifer - Annual basin recharge is controlled in large part by elevation of pinch point.

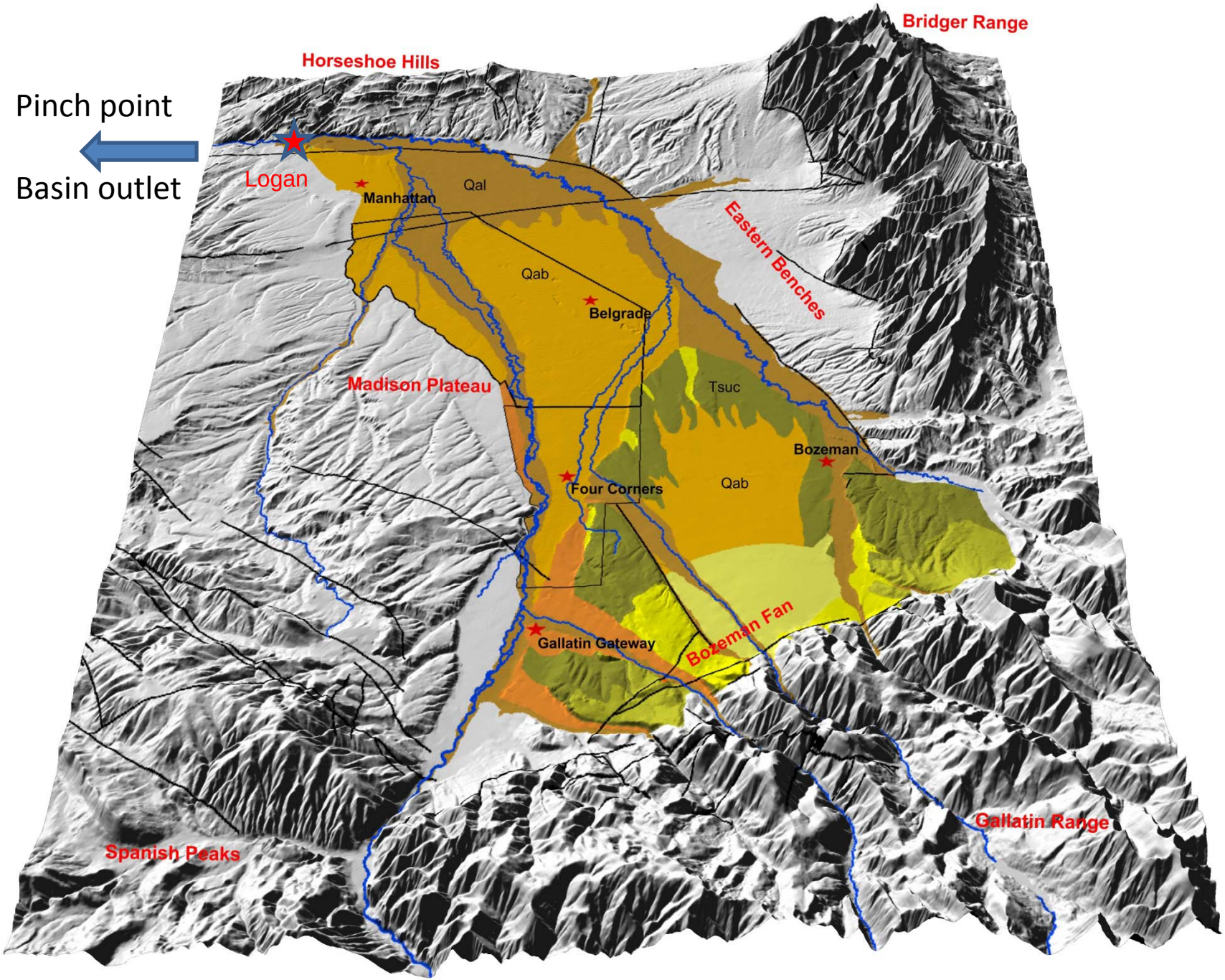


Groundwater level is the gradient (energy slope) moving water out of the basin.

It is a function of:

- elevation of pinch point (controls outflow level)
- amount of input
- loss within the basin (ET)



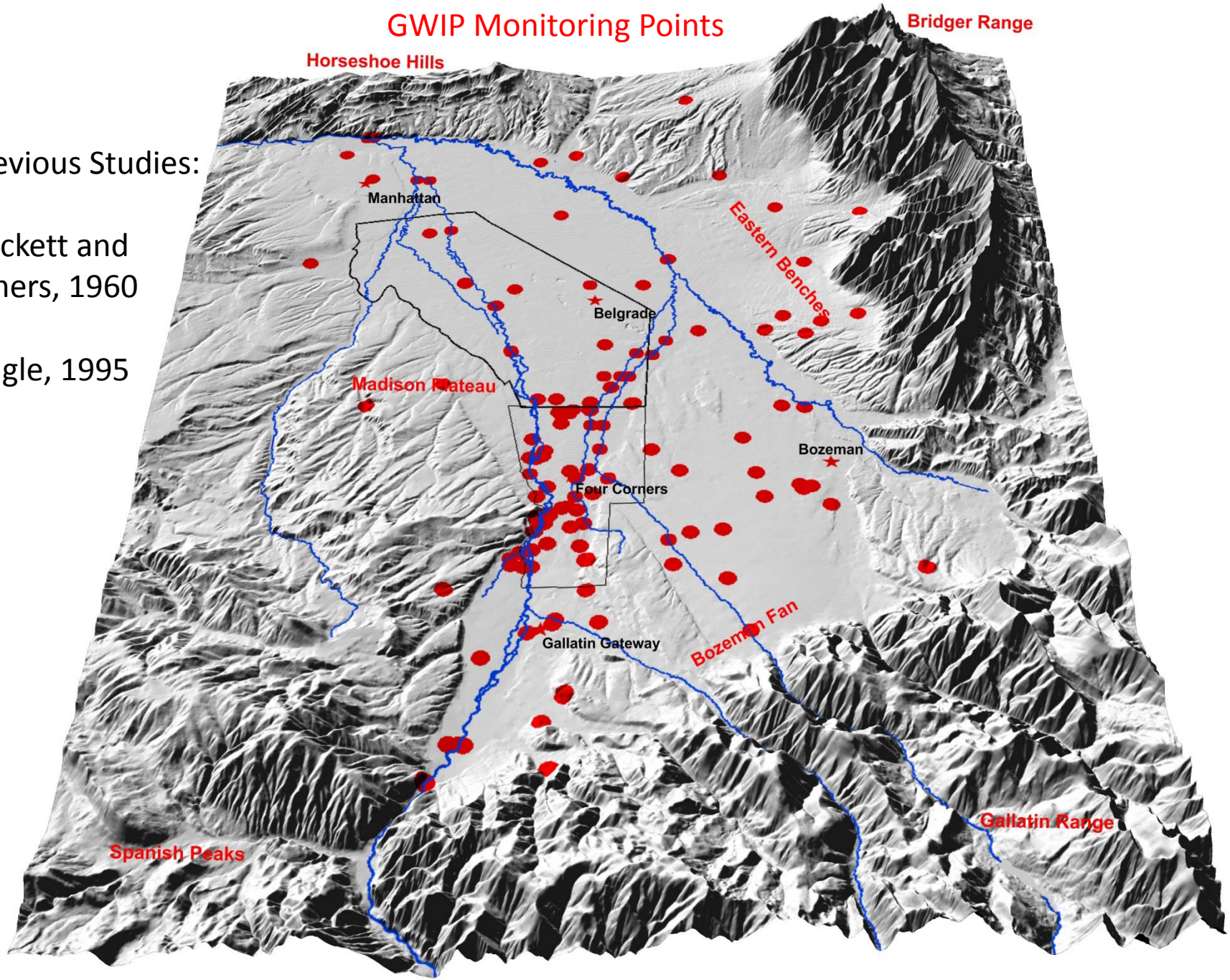

Pinch point
Basin outlet
Logan
Horseshoe Hills
Bridger Range
Manhattan
Qal
Qab
Belgrade
Eastern Benches
Madison Plateau
Tsuc
Bozeman
Four Corners
Qab
Gallatin Gateway
Bozeman Fan
Gallatin Range
Spanish Peaks

GWIP Monitoring Points

Previous Studies:

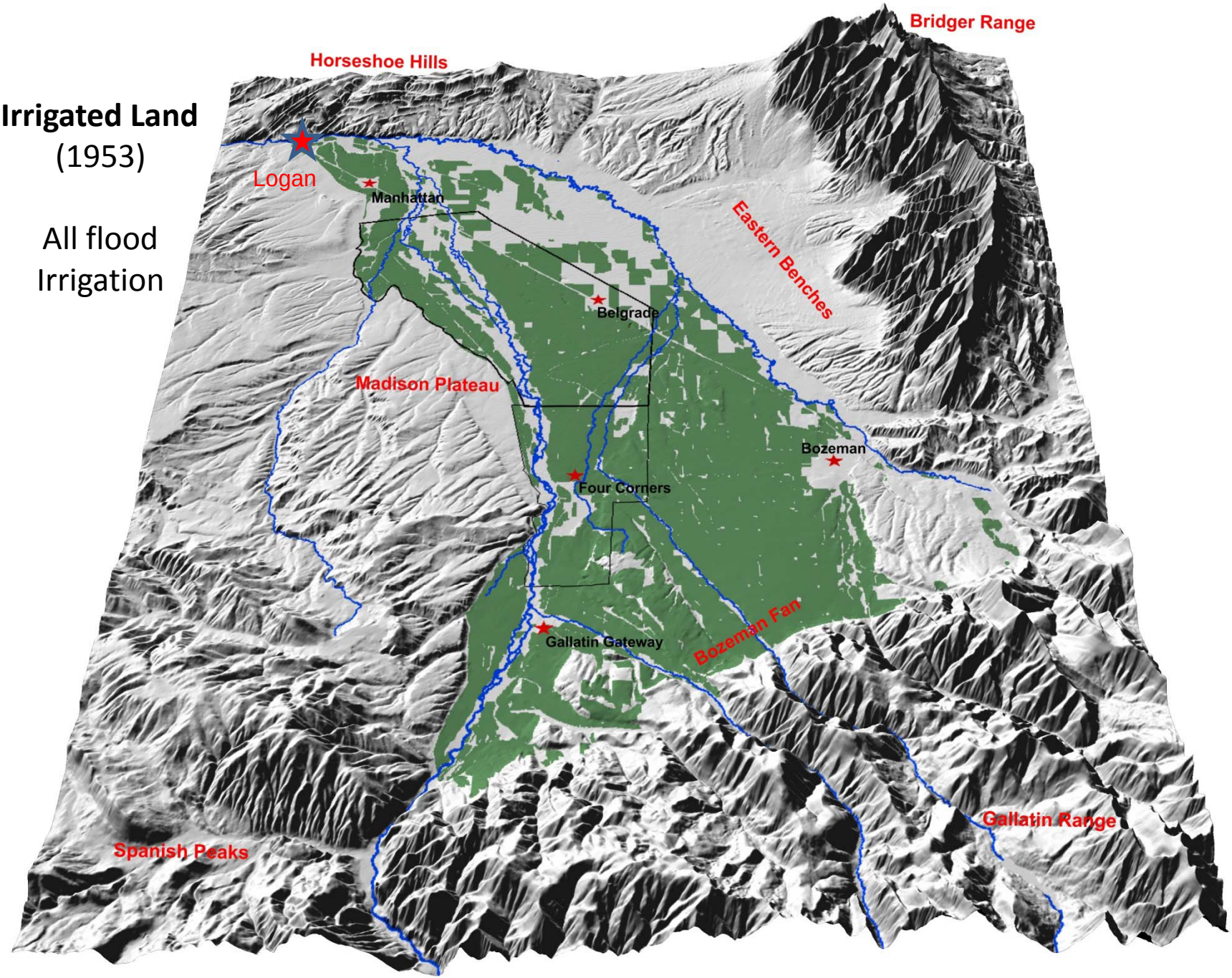
Hackett and others, 1960

Slagle, 1995

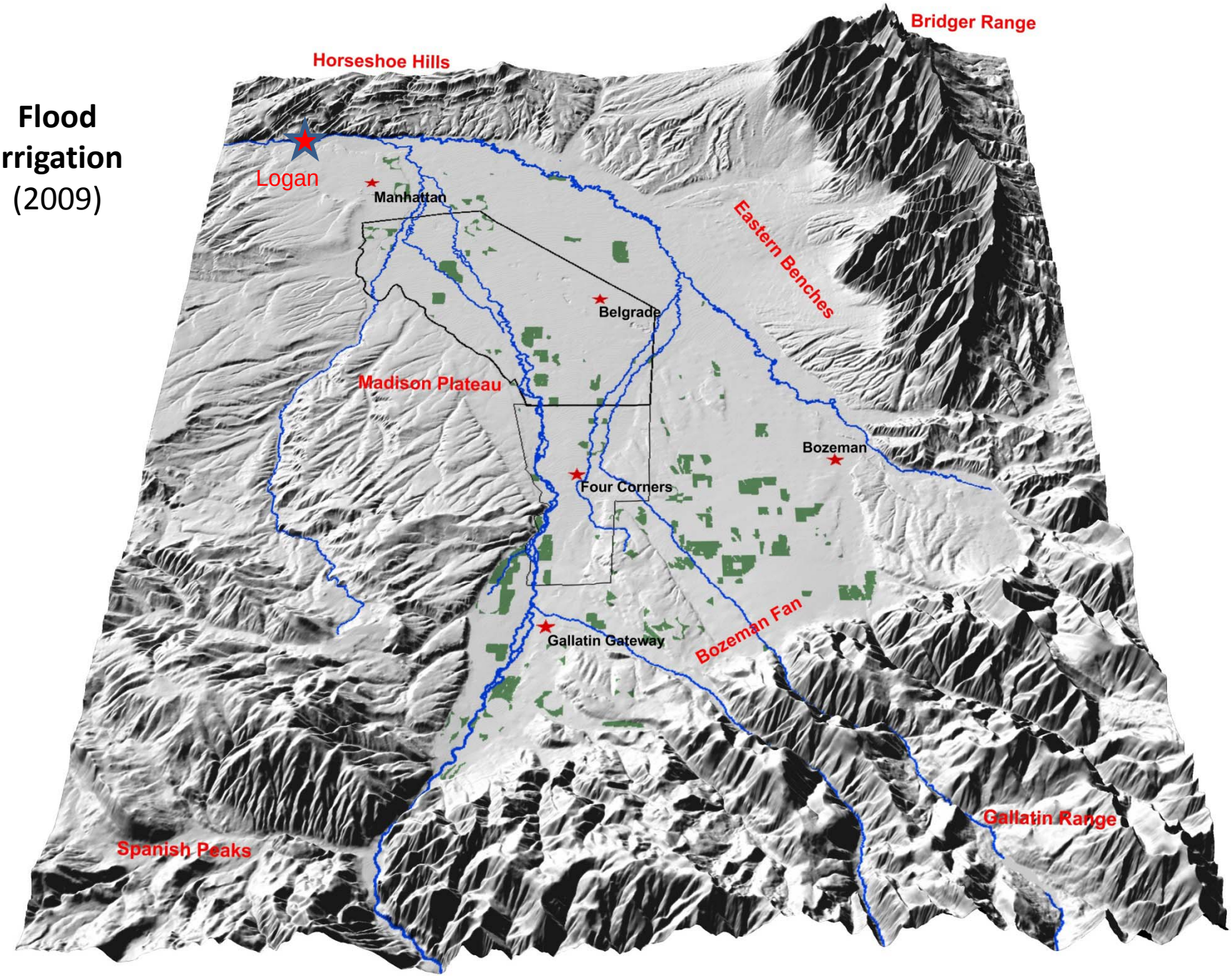


Irrigated Land
(1953)

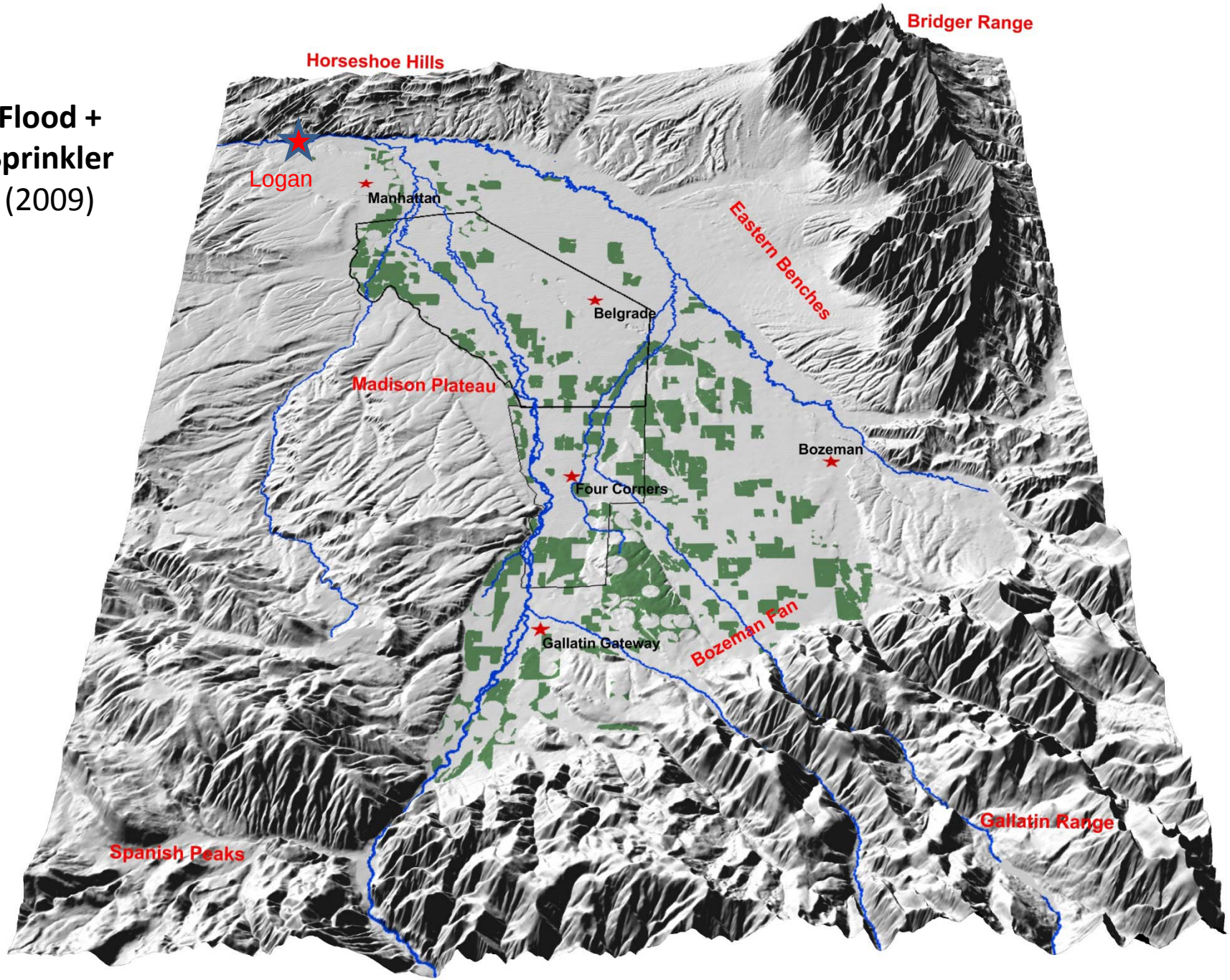
All flood
Irrigation



Flood Irrigation
(2009)

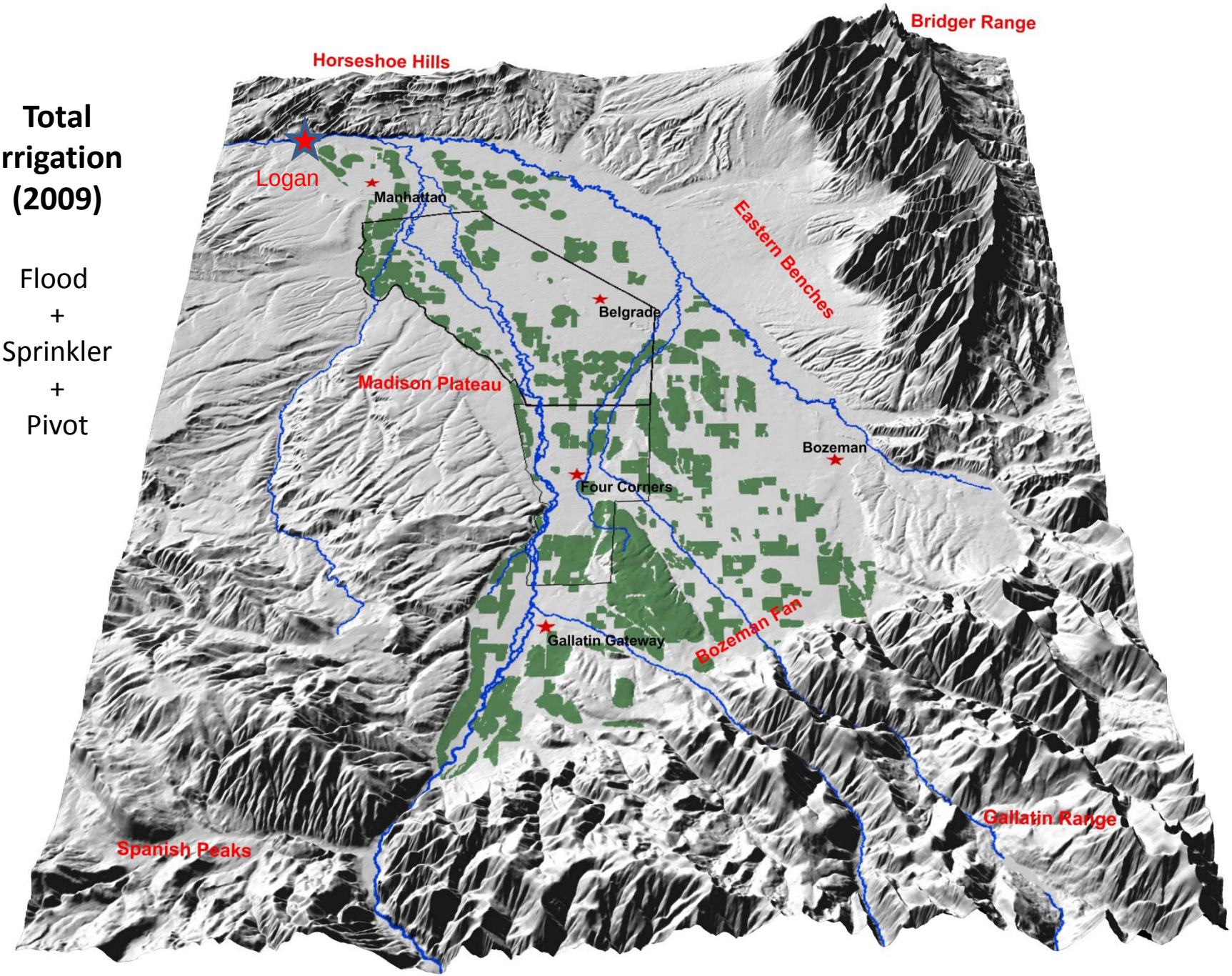


Flood + Sprinkler (2009)

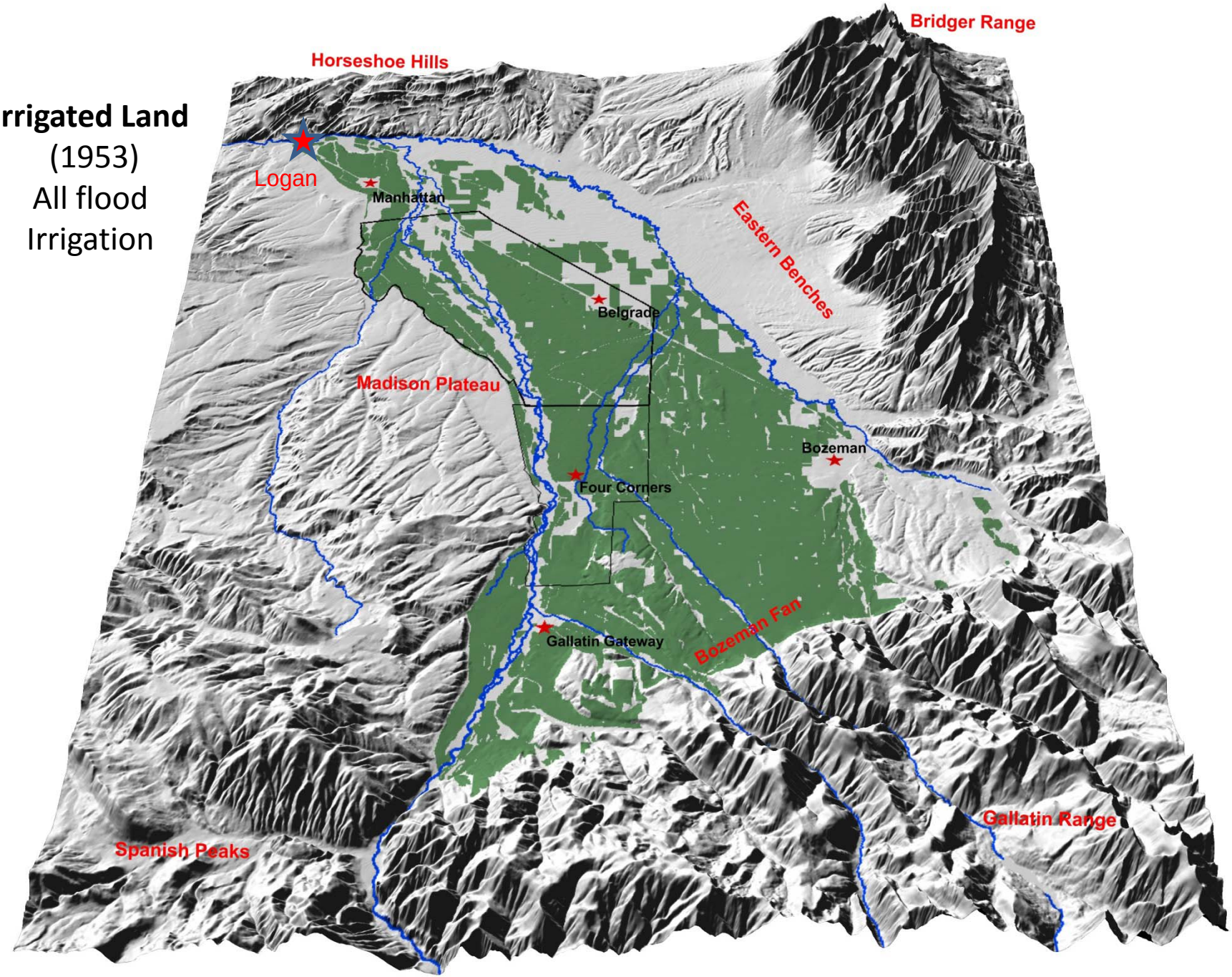


Total Irrigation (2009)

Flood
+
Sprinkler
+
Pivot

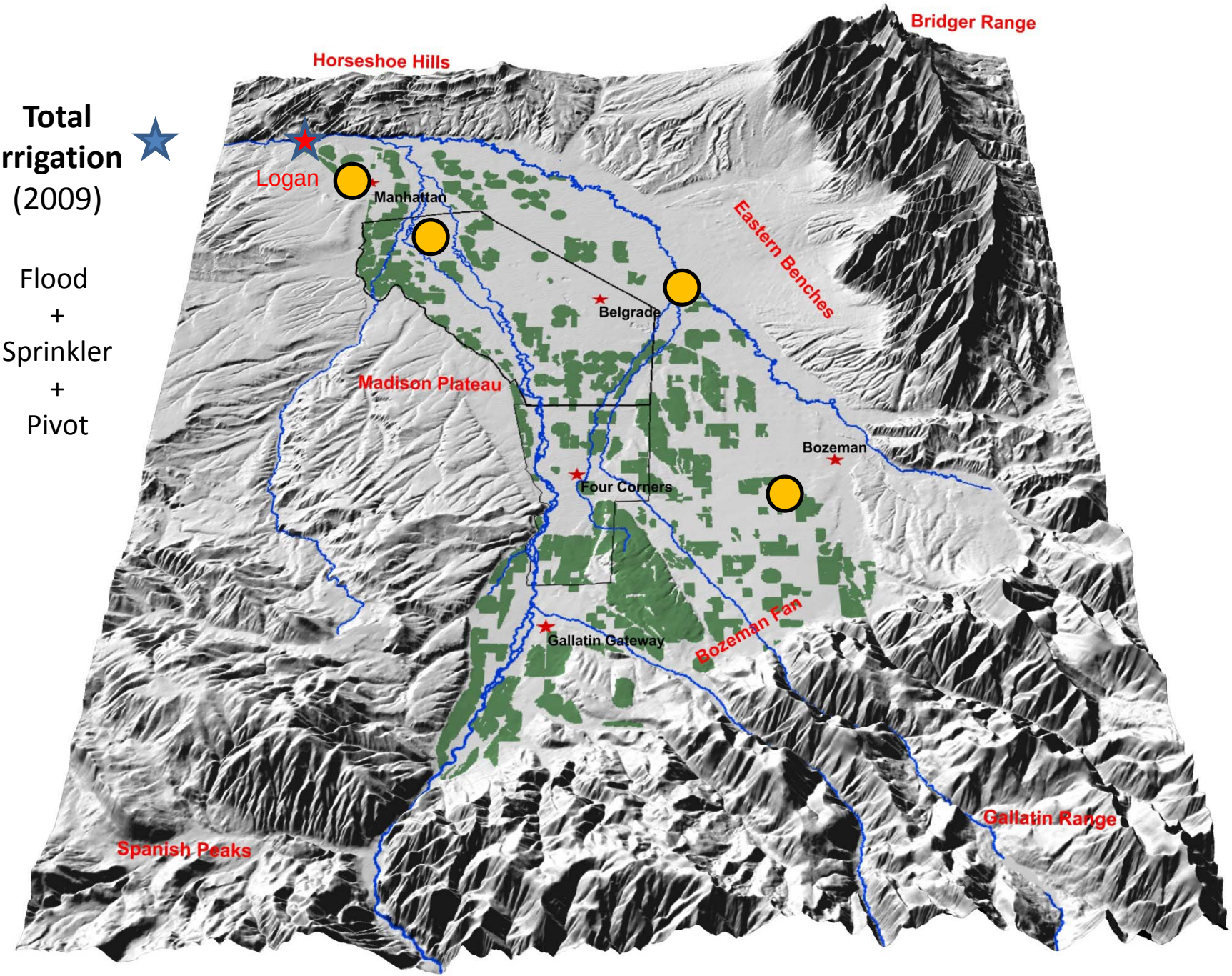


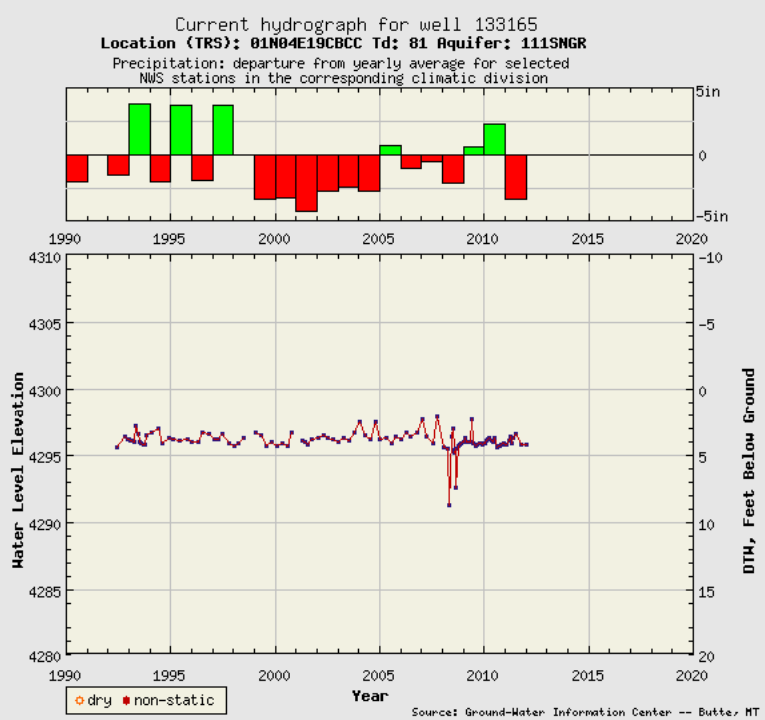
Irrigated Land
(1953)
All flood
Irrigation

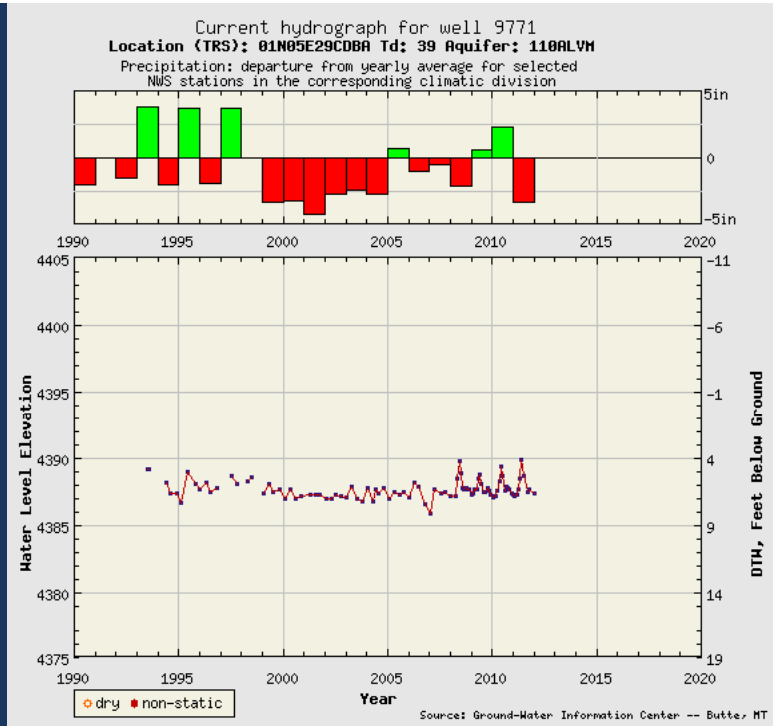


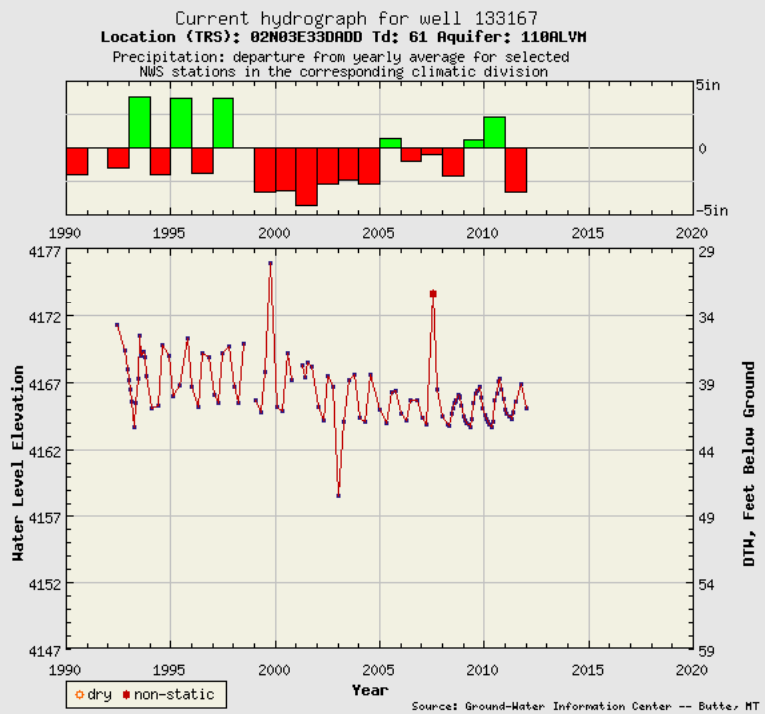
Total Irrigation (2009)

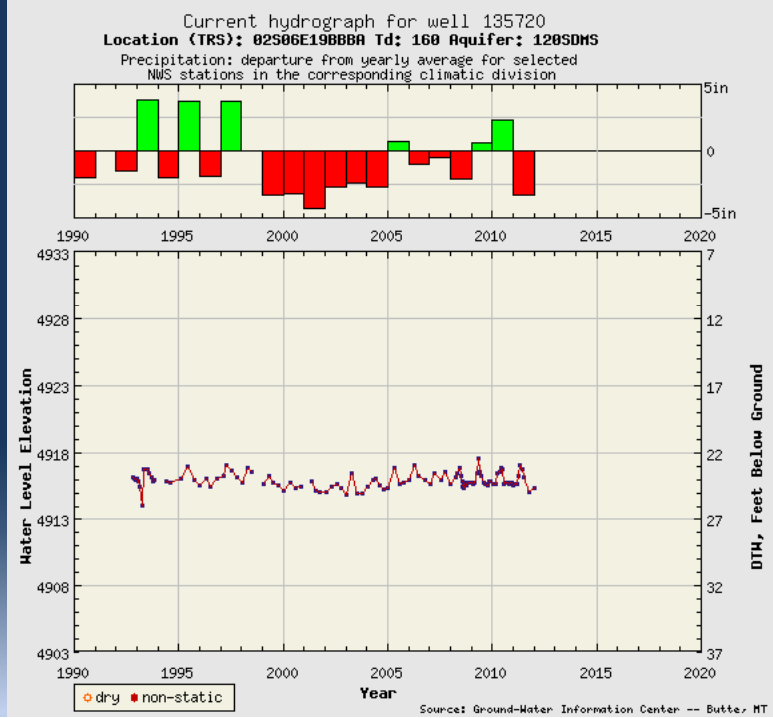
Flood
+
Sprinkler
+
Pivot




Current hydrograph for well 133165
Location (TRS): 01N04E19CBCC Td: 81 Aquifer: 111SNGR
Precipitation: departure from yearly average for selected NWS stations in the corresponding climatic division
5in
0
-5in
1990 1995 2000 2005 2010 2015 2020
Water Level Elevation
4310 4305 4300 4295 4290 4285 4280
DTW, Feet Below Ground
-10 -5 0 5 10 15 20
Year
dry non-static
Source: Ground-Water Information Center -- Butte, MT

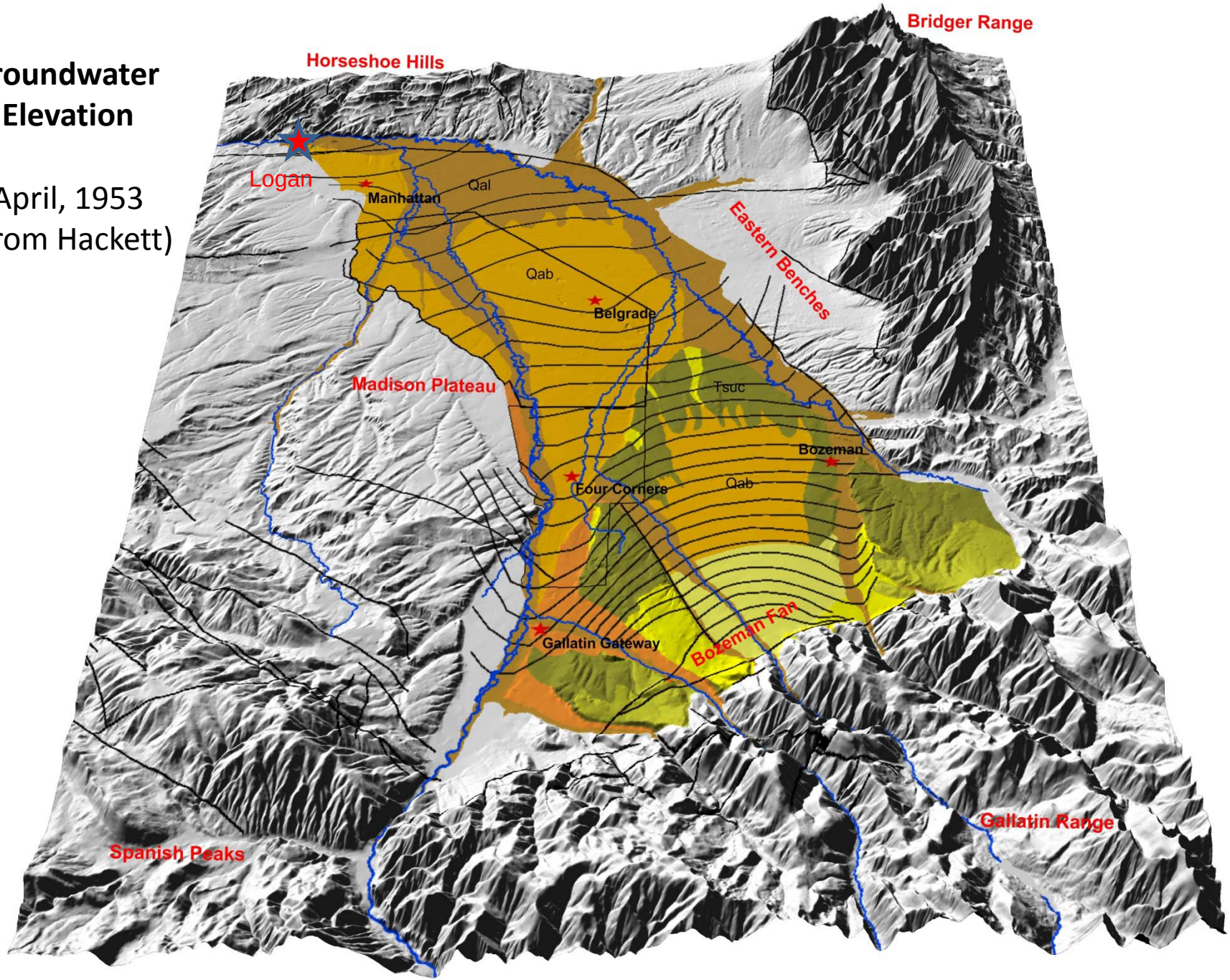

Current hydrograph for well 9771
Location (TRS): 01N05E29CDBA Td: 39 Aquifer: 110ALVM
Precipitation: departure from yearly average for selected NWS stations in the corresponding climatic division
5in
0
-5in
1990 1995 2000 2005 2010 2015 2020
Water Level Elevation
4405 4400 4395 4390 4385 4380 4375
DTW, Feet Below Ground
-11 -6 -1 4 9 14 19
Year
dry non-static
Source: Ground-Water Information Center -- Butte, MT


Current hydrograph for well 133167
Location (TRS): 02N03E33DADD Td: 61 Aquifer: 110ALVM
Precipitation: departure from yearly average for selected NWS stations in the corresponding climatic division
5in
0
-5in
1990 1995 2000 2005 2010 2015 2020
Water Level Elevation
4177 4172 4167 4162 4157 4152 4147
DTW, Feet Below Ground
29 34 39 44 49 54 59
Year
dry non-static
Source: Ground-Water Information Center -- Butte, MT


Current hydrograph for well 135720
Location (TRS): 02S06E19BBBA Td: 160 Aquifer: 120SDMS
Precipitation: departure from yearly average for selected NWS stations in the corresponding climatic division
5in
0
-5in
1990 1995 2000 2005 2010 2015 2020
Water Level Elevation
4933 4928 4923 4918 4913 4908 4903
DTW, Feet Below Ground
7 12 17 22 27 32 37
Year
dry non-static
Source: Ground-Water Information Center -- Butte, MT

Groundwater Elevation

April, 1953
(from Hackett)

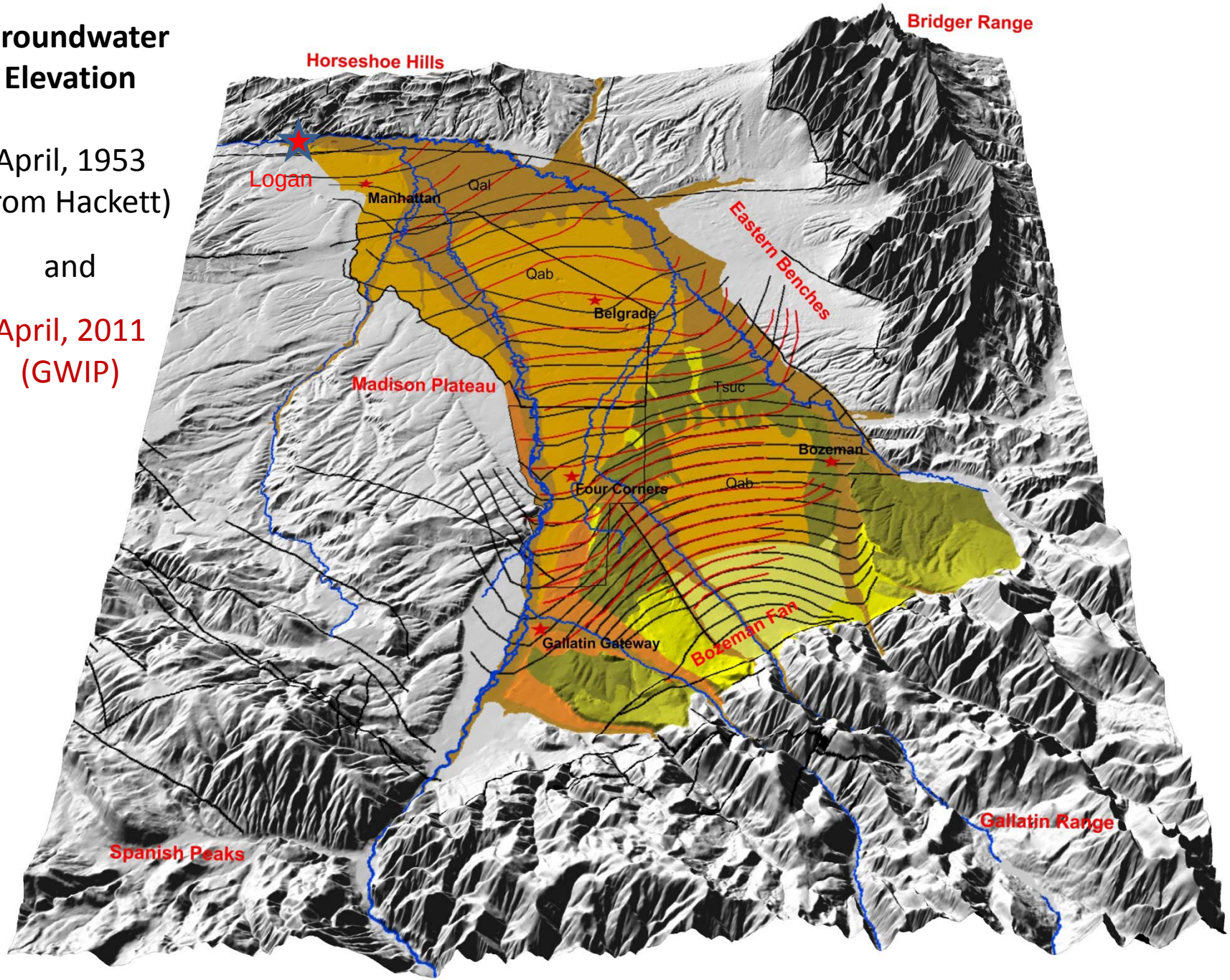


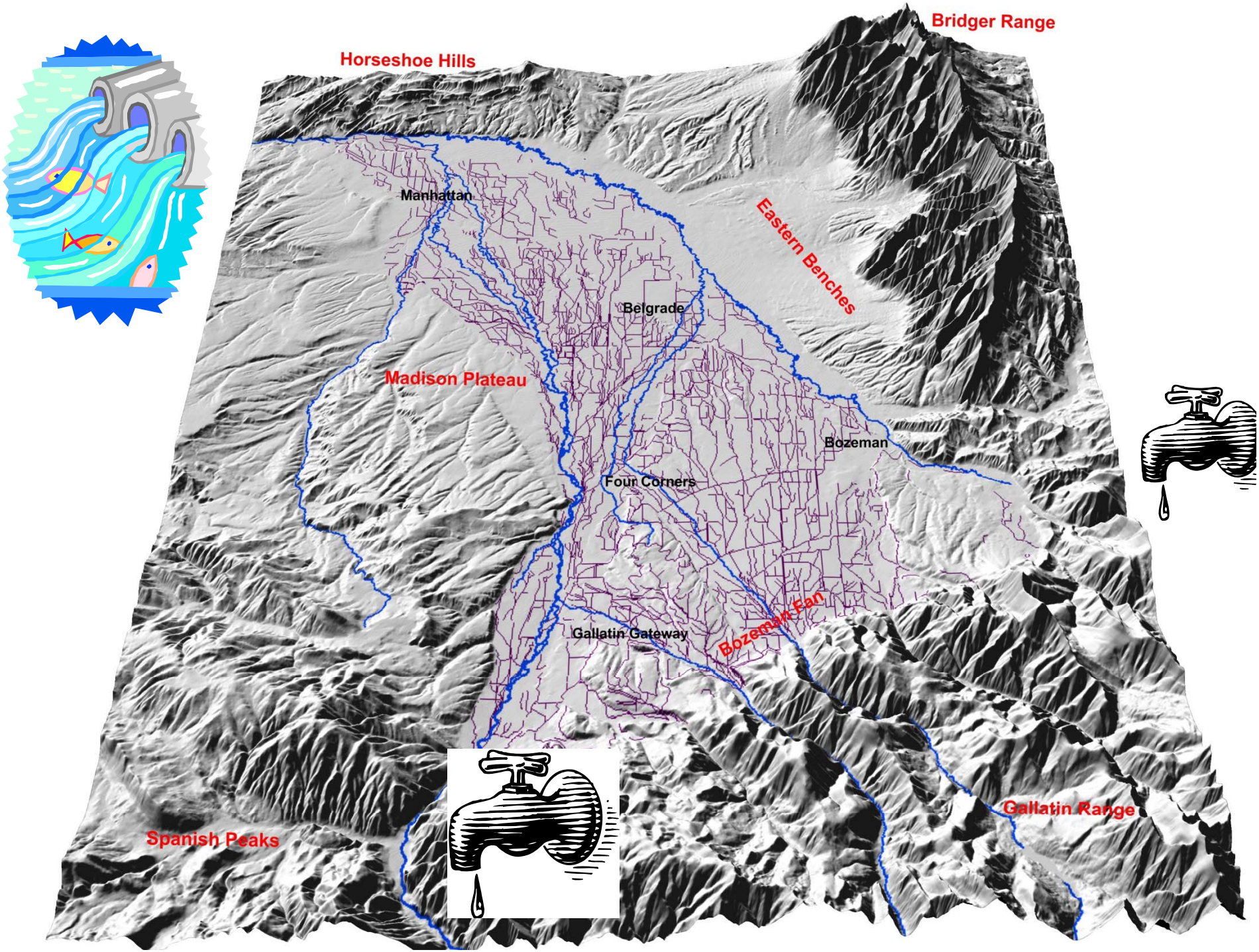
Groundwater Elevation

April, 1953
(from Hackett)

and

April, 2011
(GWIP)




Bridger Range
Horseshoe Hills
Manhattan
Eastern Benches
Belgrade
Madison Plateau
Bozeman
Four Corners
Bozeman Fan
Gallatin Gateway
Gallatin Range
Spanish Peaks

Conclusions:

An example of basin recharge from irrigation canals.

This was only one example from the many western Montana basins