Irrigation Canals and Groundwater

- ✓ Alters hydrographs
- ✓ Water storage
- ✓ Changes timing of flow
- ✓ Delivers aquifer recharge

Main Ditch, near Poulson, circa 1916

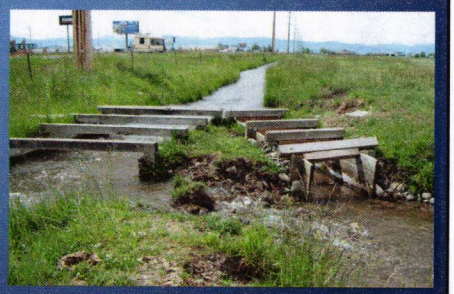
Ginette Abdo
Montana Bureau of Mines and Geology
Presented to:
Water Policy Interim Committee
Helena January, 2016

Contributions from :
Groundwater Investigation Program Staff
Groundwater Assessment Program

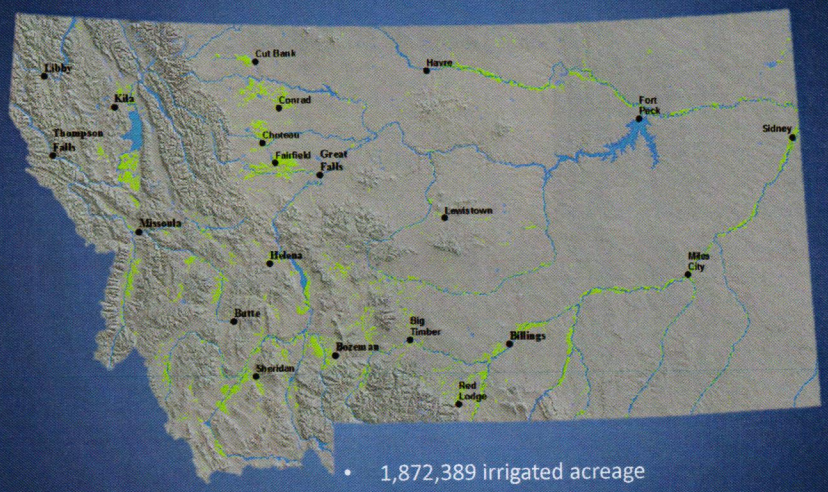
MBMG
Montana Bureau of Mines and Geology

Major points

- ✓ Dynamics of canal seepage
- ✓ Potential impacts of leakage
- ✓ Variability in leakage rates
- ✓ Extensive canal network
- ✓ Management implications of leakage



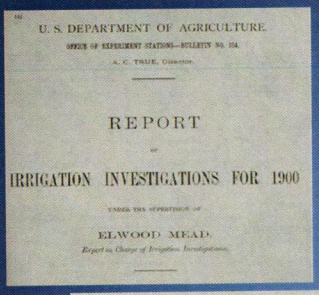
Irrigated acreage in Montana



- 1,872,389 irrigated acreage
- 2% of total acreage is irrigated
- About 3% of irrigation is from groundwater and 97% is from surface water

Farm and Ranch Survey 2013

Measuring canal leakage 1900



U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 104.

A. C. TRUE, Director.

REPORT

OF

IRRIGATION INVESTIGATIONS FOR 1900

UNDER THE SUPERVISION OF

ELWOOD MEAD,

Expert in Charge of Irrigation Investigations.

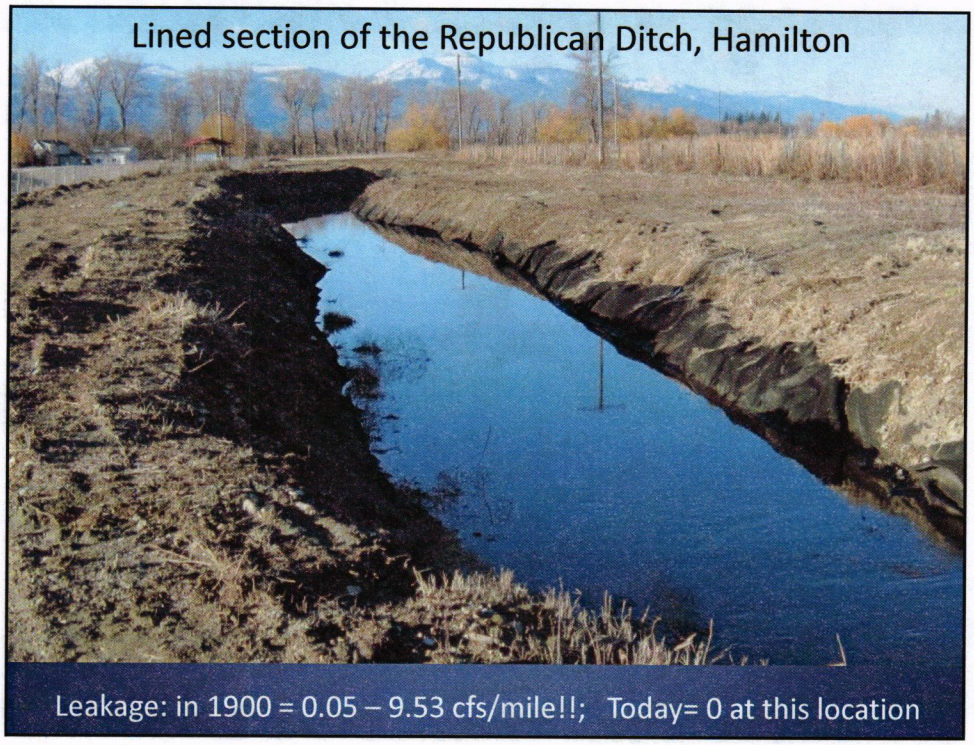
Range of Loss: 0.29 % to 6.6 %

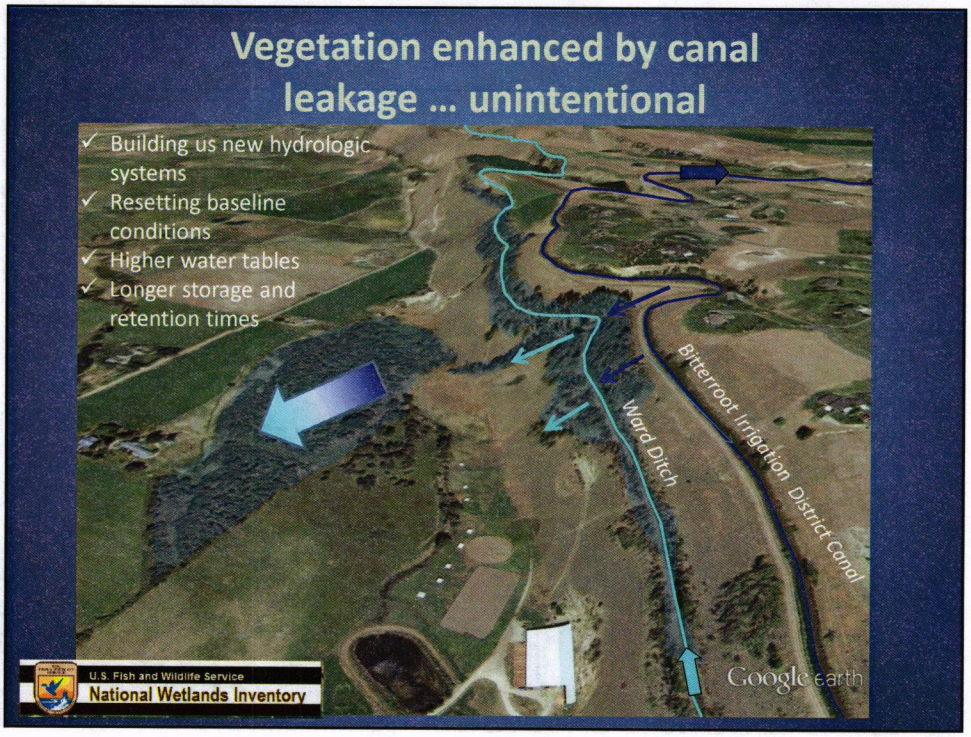
Average losses by seepage and evaporation.

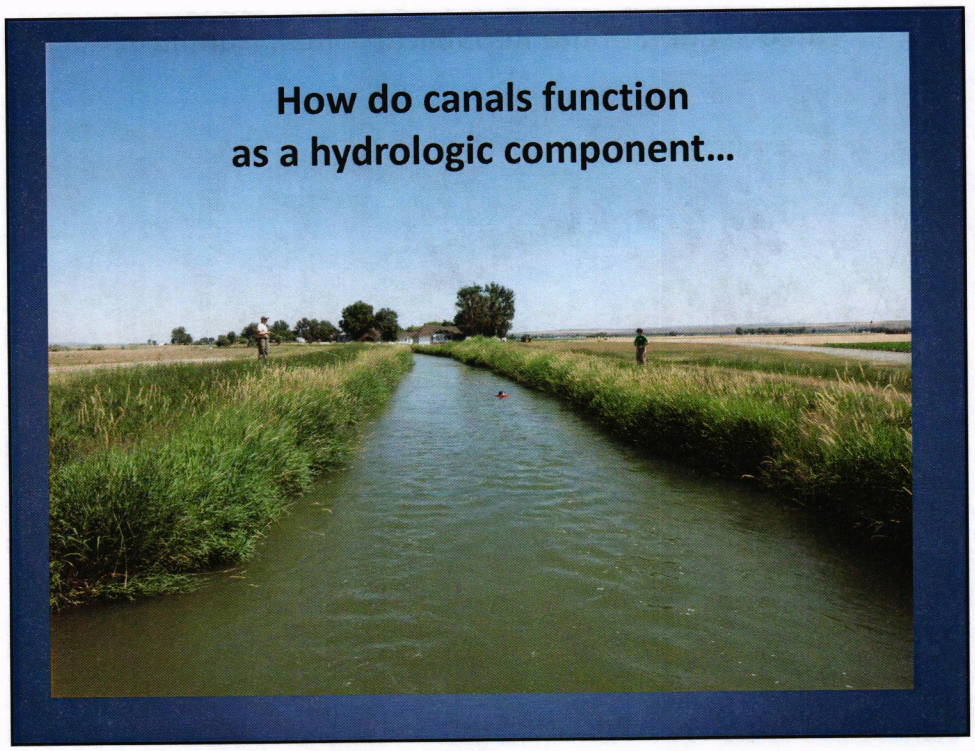
Canal.	Rate of loss per mile.
	Per cent.
West line of Bear River Canal, Utah	1.11
East Jordan Canal, Utah	3.84
Arizona and Consolidated canals, Arizona	.48
Logan and Richmond Canal, Utah, 1899	3.17
Logan and Richmond Canal, Utah, 1900	6.17
Logan, Hyde Park, and Smithfield Canal, Utah, 1899	3.85
Logan, Hyde Park, and Smithfield Canal, Utah, 1900	6.60
Canal No. 2, Wheatland, Wyo., July, 1900	1.00
Canal No. 2, Wheatland, Wyo., August, 1900	.29
West Gallatin Canal, Montana	.87
Farmers' Canal, Montana	1.65
Middle Creek Canal, Montana	1.85
Big Ditch, Montana	1.16
Republican Canal, Montana	2.53
Mean	2.47

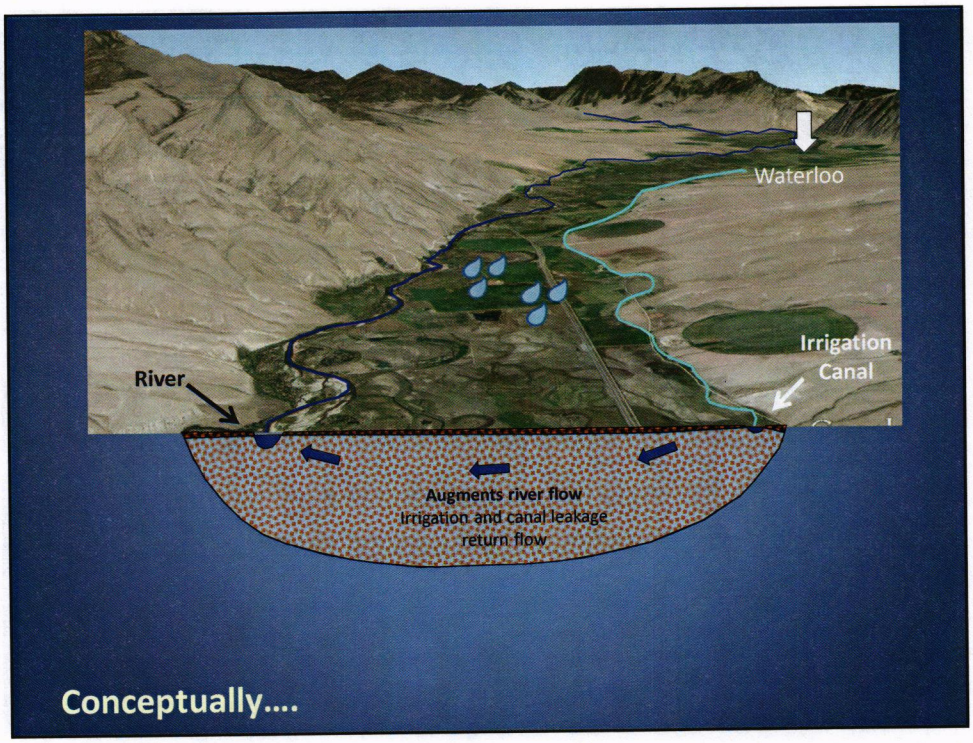
2.53% in 1900

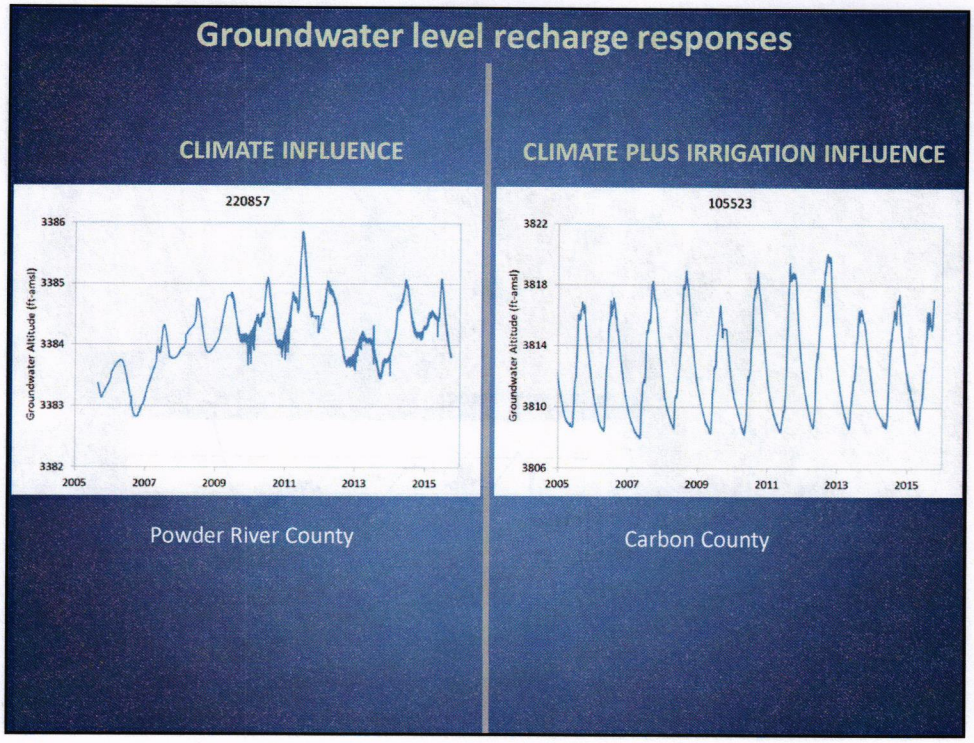
Report of Irrigation Investigations for 1900
U.S. Department of Agriculture

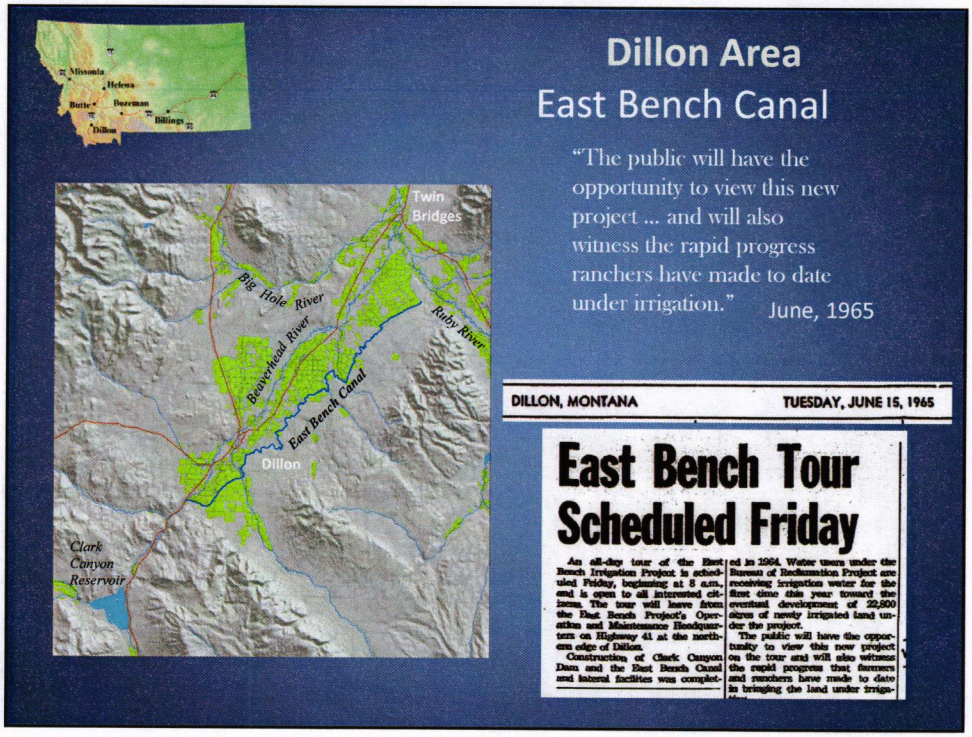

Lined section of the Republican Ditch, Hamilton
Leakage: in 1900 = 0.05 – 9.53 cfs/mile!!; Today= 0 at this location

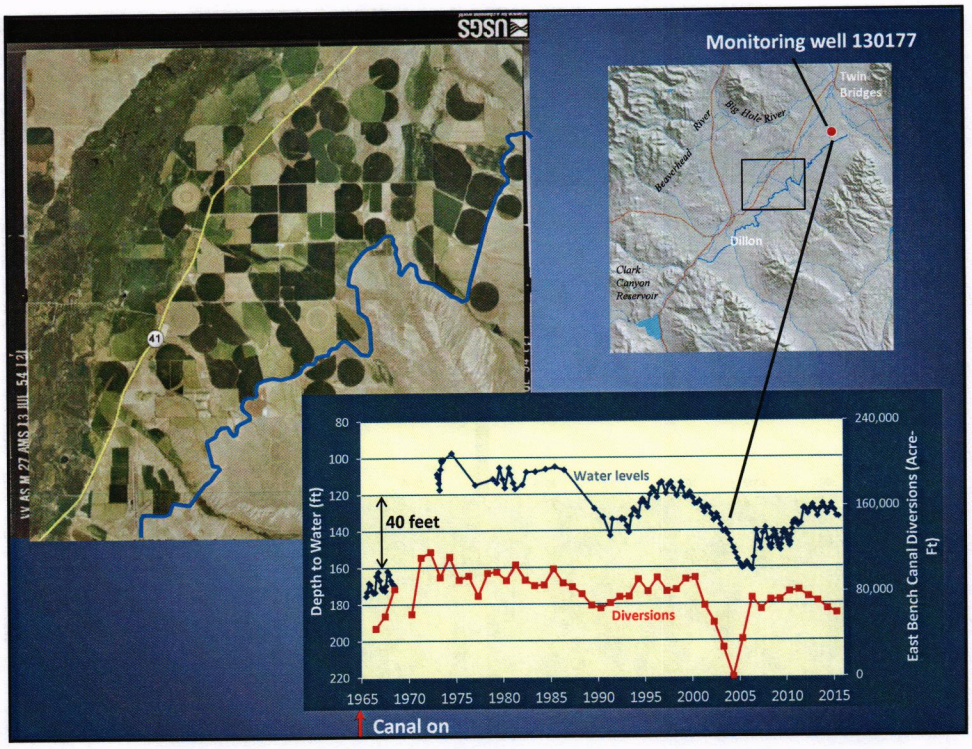

Vegetation enhanced by canal leakage ... unintentional
✓ Building us new hydrologic systems
✓ Resetting baseline conditions
✓ Higher water tables
✓ Longer storage and retention times
Bitterroot Irrigation District Canal
Ward Ditch
U.S. Fish and Wildlife Service
National Wetlands Inventory
Google earth

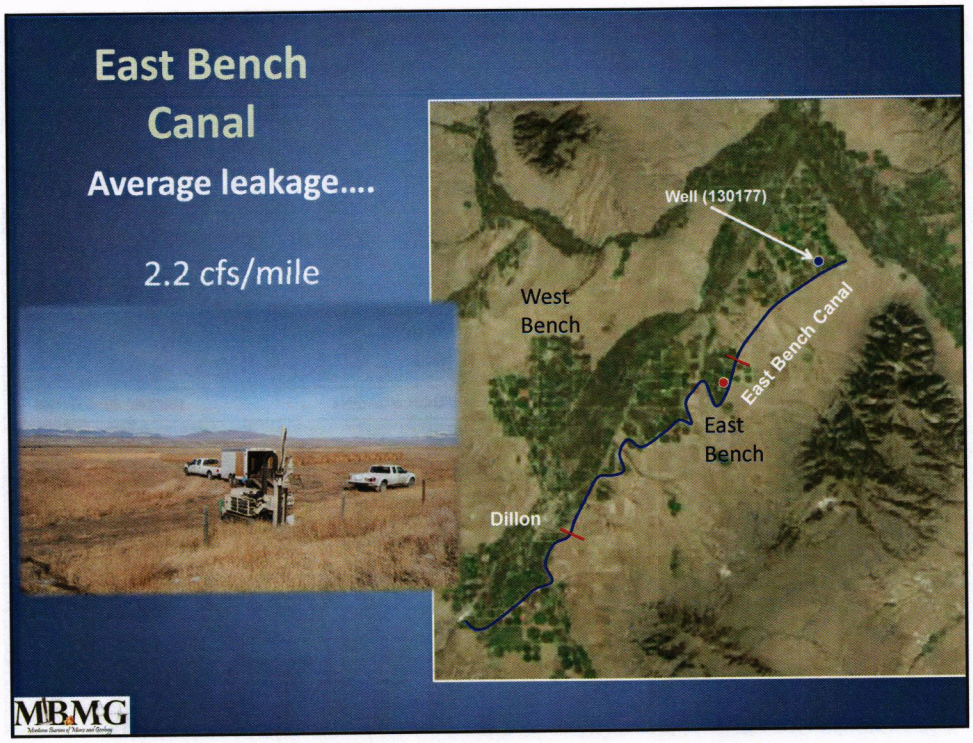

How do canals function
as a hydrologic component...

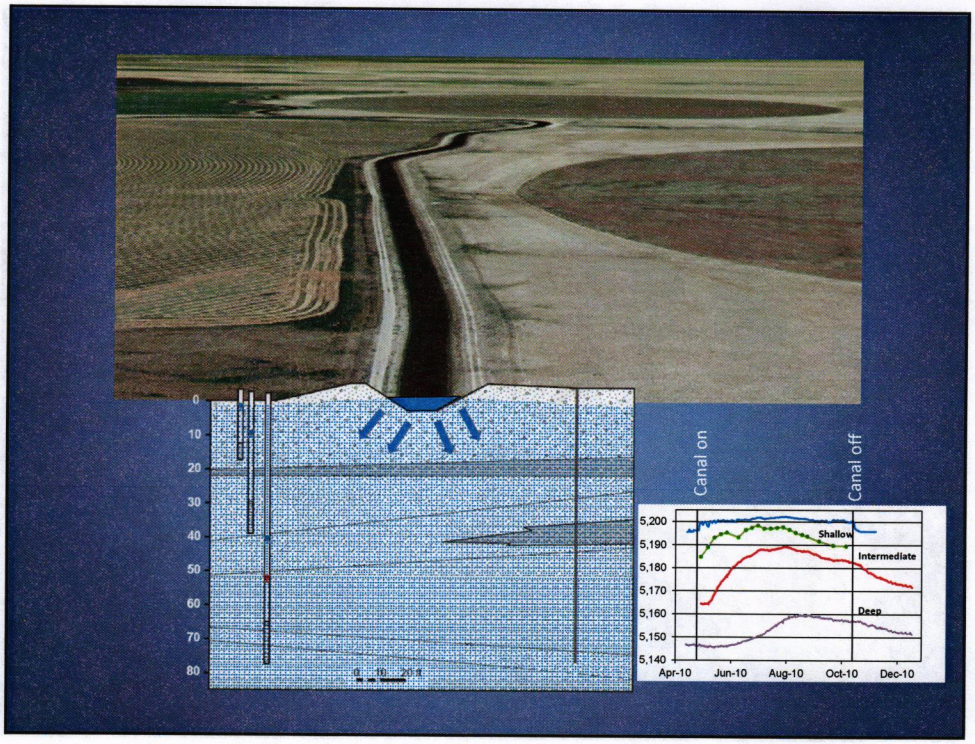

Waterloo
Irrigation
Canal
River
Augments river flow
Irrigation and canal leakage
return flow
Conceptually....

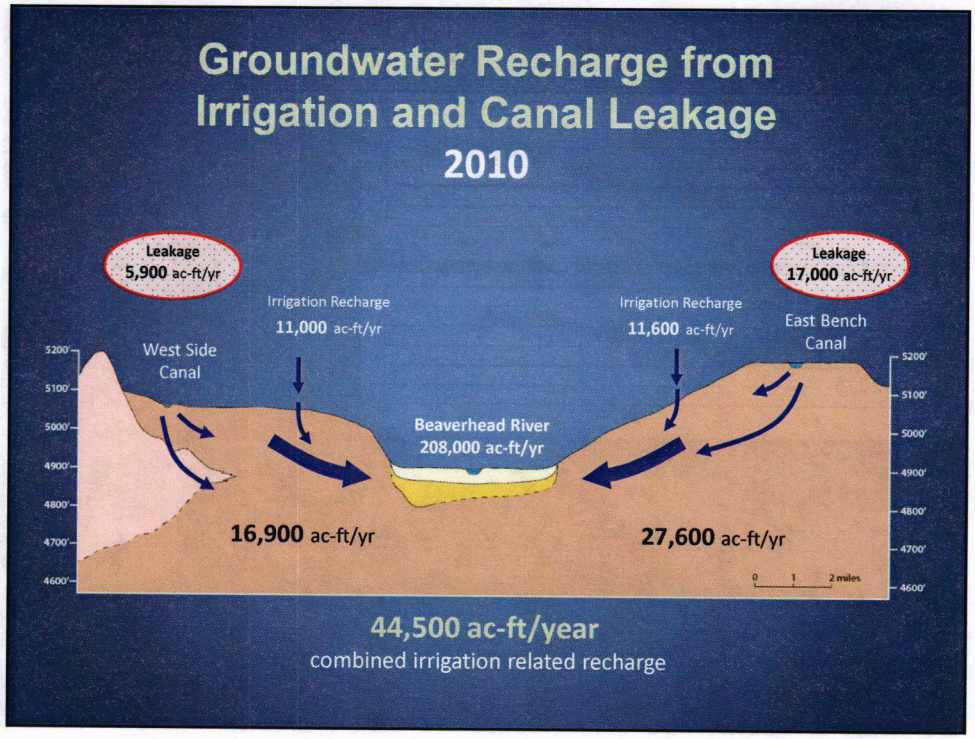

Groundwater level recharge responses
CLIMATE INFLUENCE
CLIMATE PLUS IRRIGATION INFLUENCE
220857
105523
Groundwater Altitude (ft-amsl)
3386
3385
3384
3383
3382
3822
3818
3814
3810
3806
2005
2007
2009
2011
2013
2015
Powder River County
Carbon County


Missoula
Helena
Butte
Bozeman
Billings
Dillon
Twin Bridges
Big Hole River
Beaverhead River
Ruby River
East Bench Canal
Dillon
Clark Canyon Reservoir
Dillon Area
East Bench Canal
"The public will have the opportunity to view this new project ... and will also witness the rapid progress ranchers have made to date under irrigation." June, 1965
DILLON, MONTANA TUESDAY, JUNE 15, 1965
East Bench Tour Scheduled Friday
An all-day tour of the East Bench Irrigation Project is scheduled Friday, beginning at 9 a.m. and is open to all interested citizens. The tour will leave from the East Bench Project's Operation and Maintenance Headquarters on Highway 41 at the northern edge of Dillon.
Construction of Clark Canyon Dam and the East Bench Canal and lateral facilities was completed in 1964. Water users under the Bureau of Reclamation Project are receiving irrigation water for the first time this year toward the eventual development of 22,800 acres of newly irrigated land under the project.
The public will have the opportunity to view this new project on the tour and will also witness the rapid progress that farmers and ranchers have made to date in bringing the land under irriga-

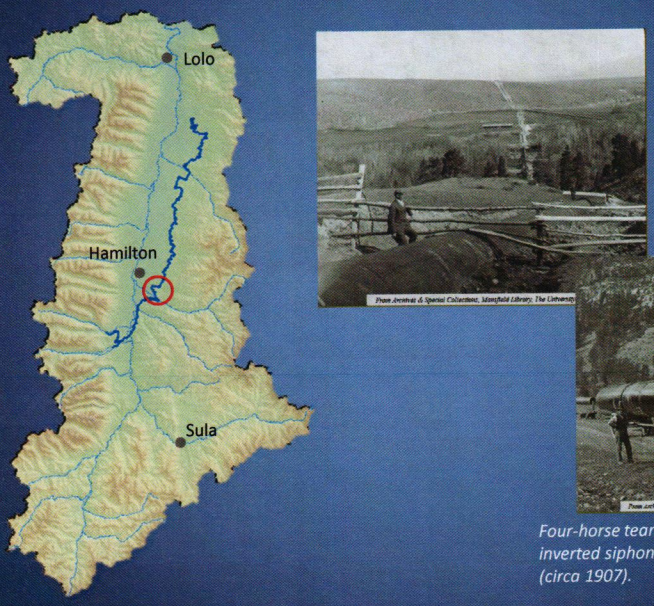

USGS
Monitoring well 130177
Twin Bridges
Big Hole River
Beaverhead River
Dillon
Clark Canyon Reservoir
41
Depth to Water (ft)
80
100
120
140
160
180
200
220
Water levels
40 feet
Diversions
240,000
160,000
80,000
0
East Bench Canal Diversions (Acre-Ft)
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015
Canal on


East Bench Canal
Average leakage....
2.2 cfs/mile
Well (130177)
West Bench
East Bench Canal
East Bench
Dillon
MBMG

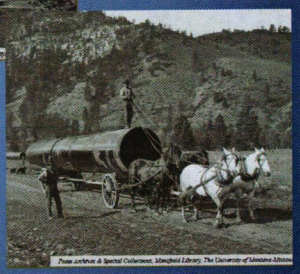

0
10
20
30
40
50
60
70
80
Canal on
Canal off
5,200
5,190
5,180
5,170
5,160
5,150
5,140
Shallow
Intermediate
Deep
Apr-10
Jun-10
Aug-10
Oct-10
Dec-10


Groundwater Recharge from Irrigation and Canal Leakage
2010
Leakage 5,900 ac-ft/yr
Irrigation Recharge 11,000 ac-ft/yr
Irrigation Recharge 11,600 ac-ft/yr
Leakage 17,000 ac-ft/yr
West Side Canal
East Bench Canal
Beaverhead River 208,000 ac-ft/yr
16,900 ac-ft/yr
27,600 ac-ft/yr
5200'
5100'
5000'
4900'
4800'
4700'
4600'
0 1 2 miles
44,500 ac-ft/year
combined irrigation related recharge

The Big Ditch and the McIntosh Red Apples - 1907

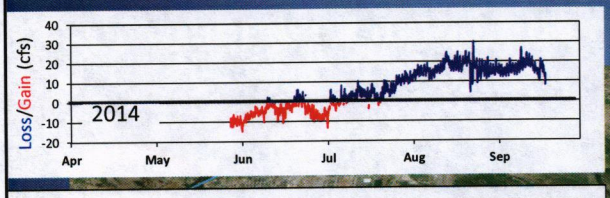


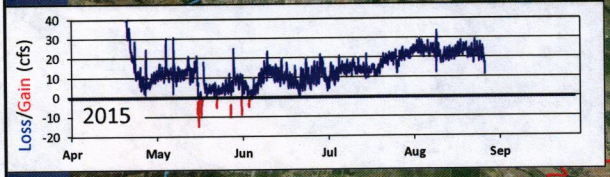
View of the 'Big Ditch' an irrigation project in the Bitterroot Valley (circa 1907). U of M, Mansfield Library



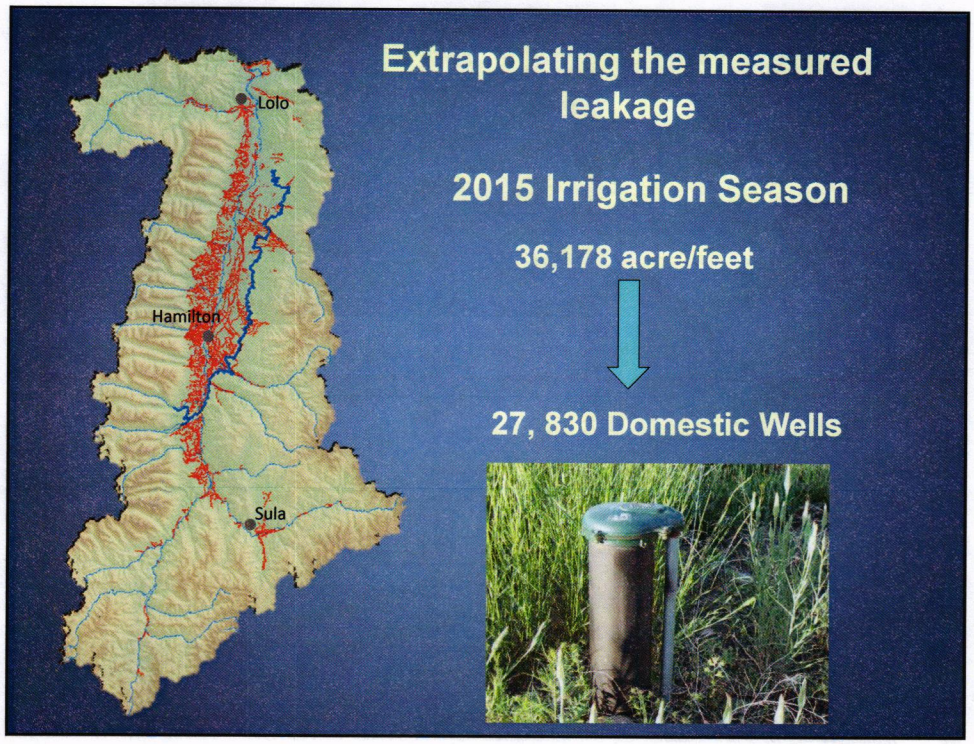
Four-horse team hauling steel pipe for inverted siphon across the Bitterroot River (circa 1907). U of M, Mansfield Library

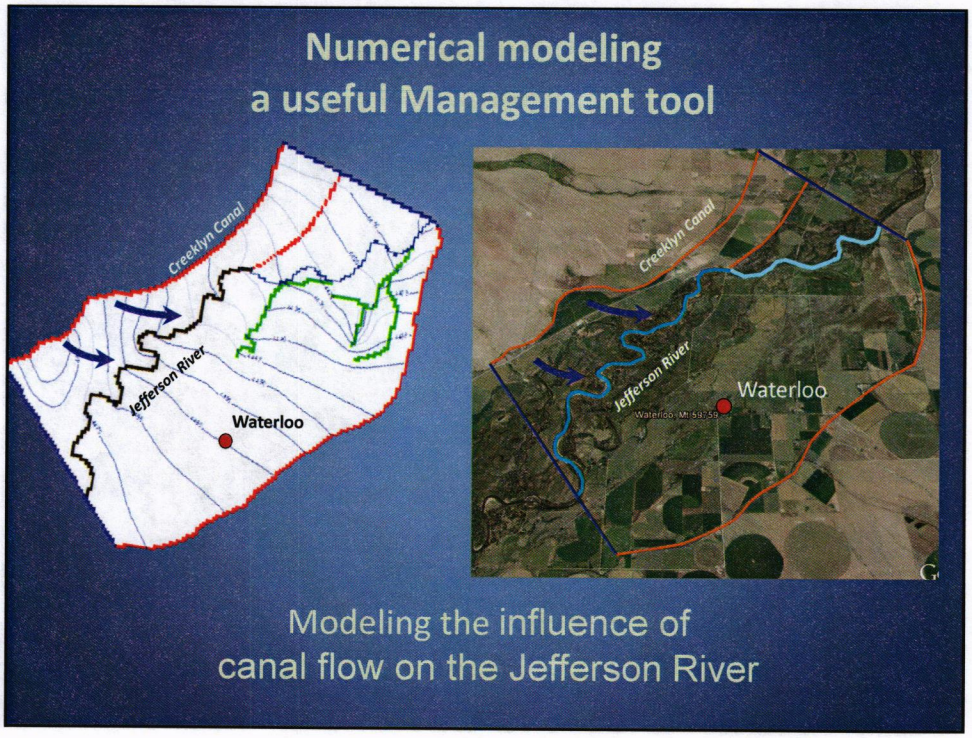
Bitterroot Irrigation District Canal (BRID)

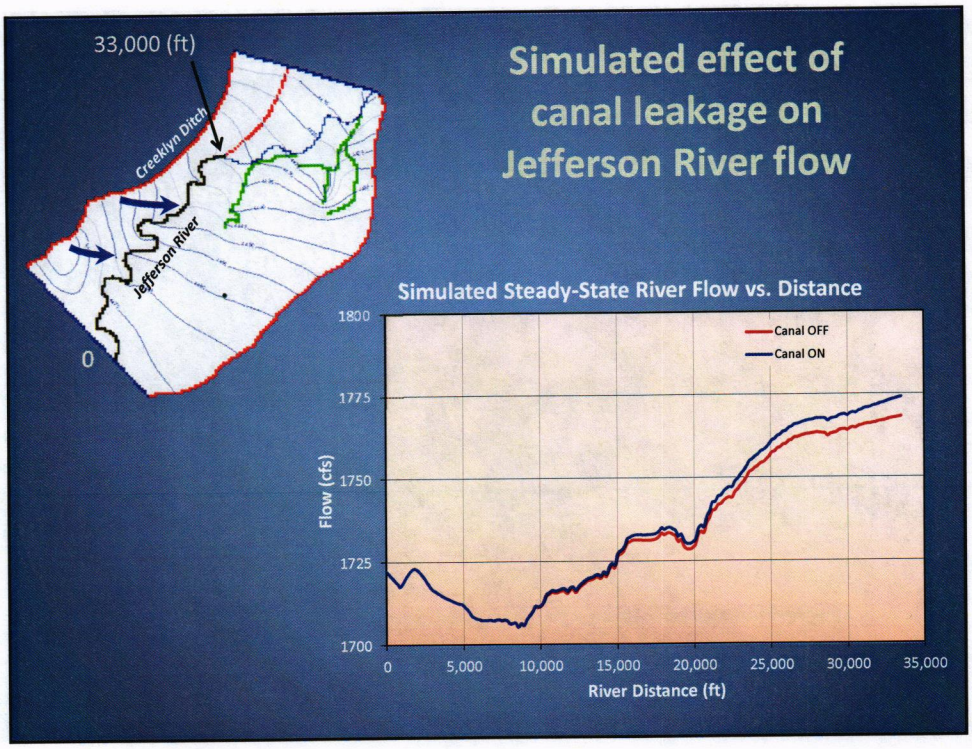




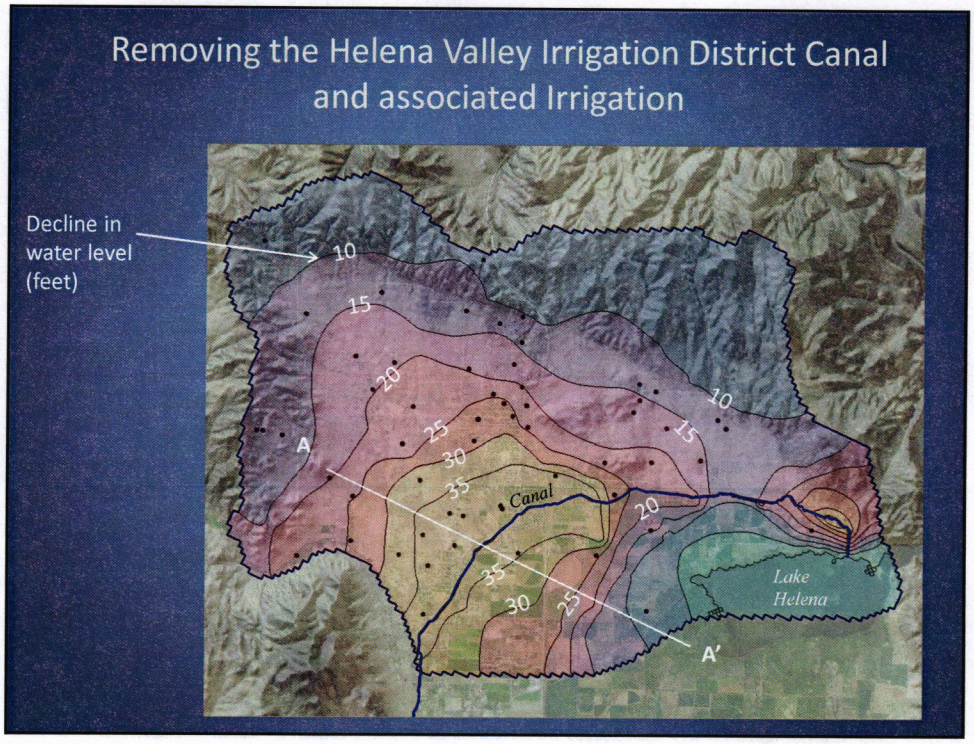
5.8 miles
Average loss
0 – 3.9 cfs/mile loss

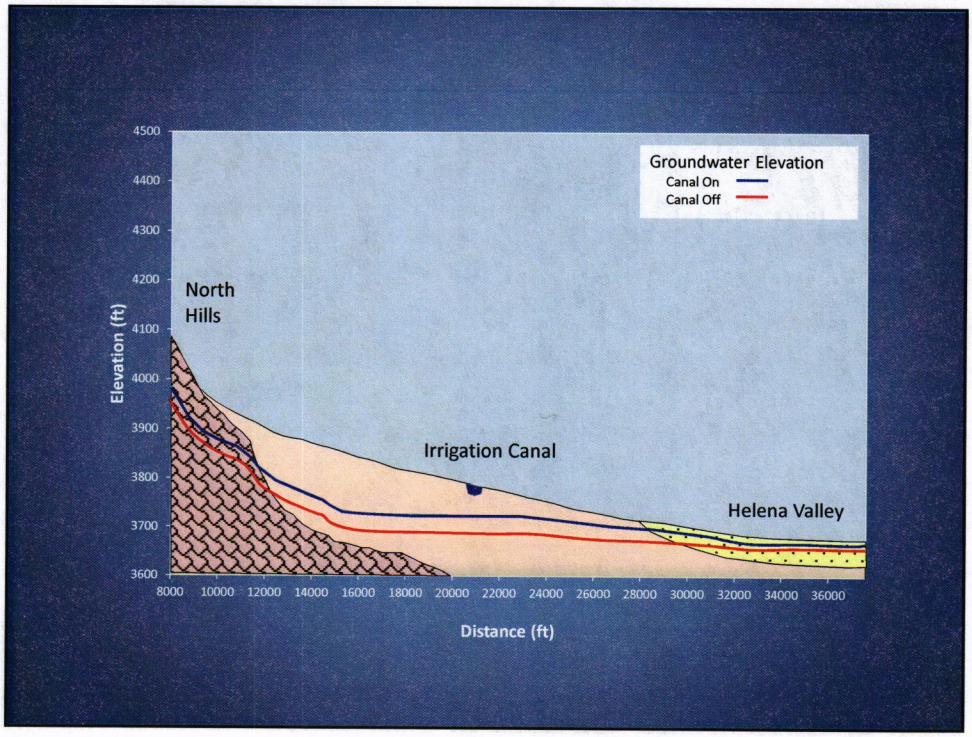

Extrapolating the measured leakage
2015 Irrigation Season
36,178 acre/feet
27, 830 Domestic Wells
Lolo
Hamilton
Sula

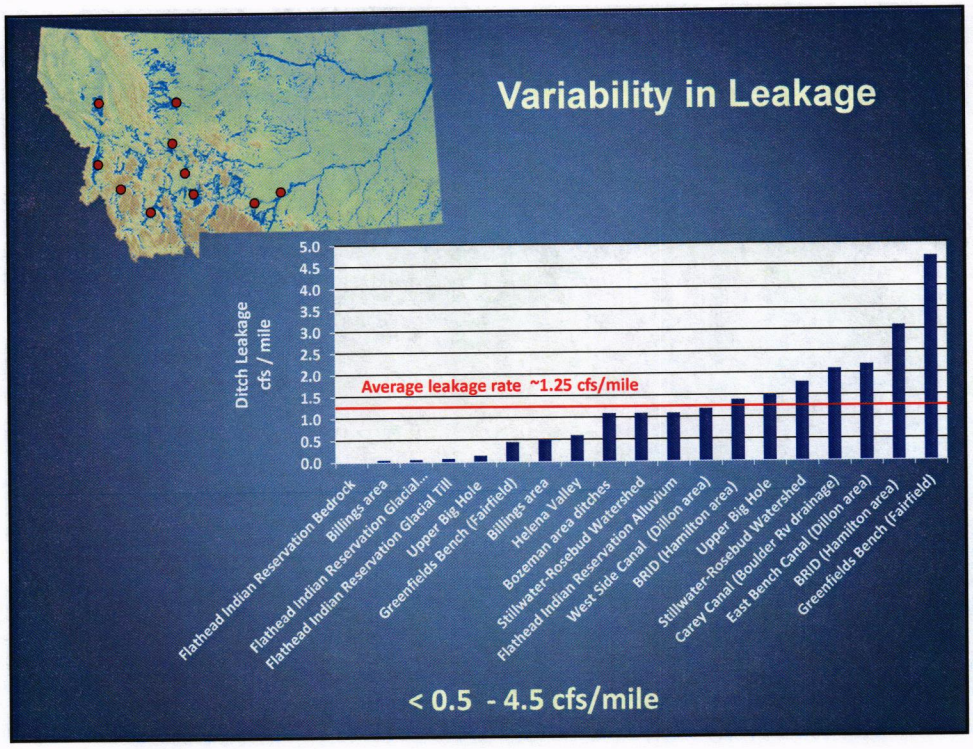

Numerical modeling
a useful Management tool
Creeklyn Canal
Jefferson River
Waterloo
Modeling the influence of
canal flow on the Jefferson River

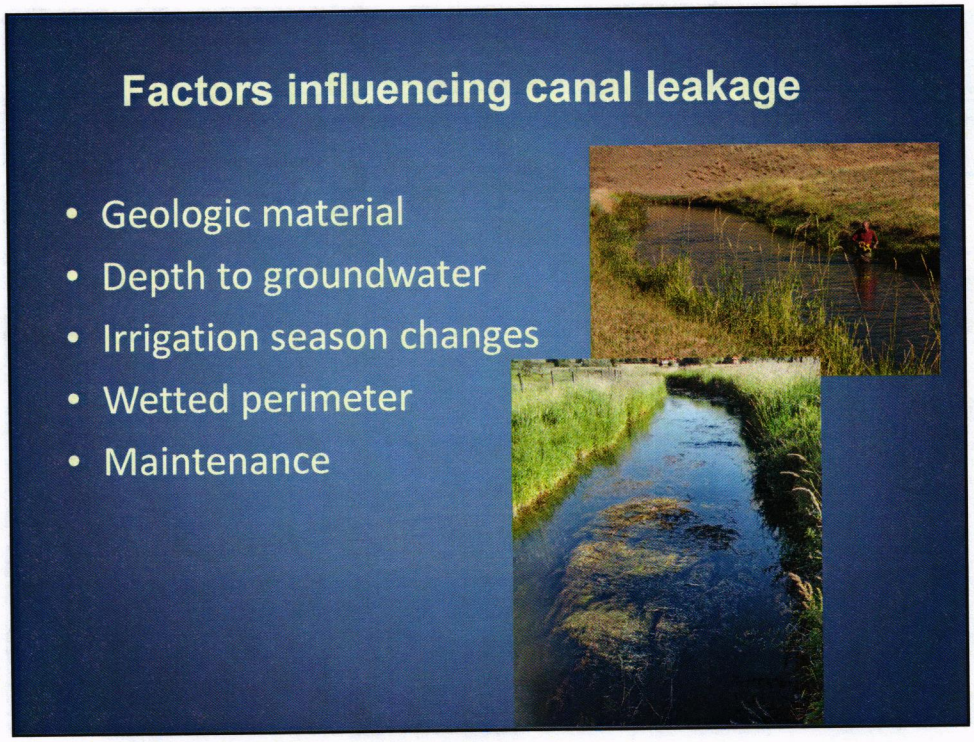

33,000 (ft)
Creeklyn Ditch
Jefferson River
0
Simulated effect of canal leakage on Jefferson River flow
Simulated Steady-State River Flow vs. Distance
Canal OFF
Canal ON
Flow (cfs)
1800
1775
1750
1725
1700
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
River Distance (ft)

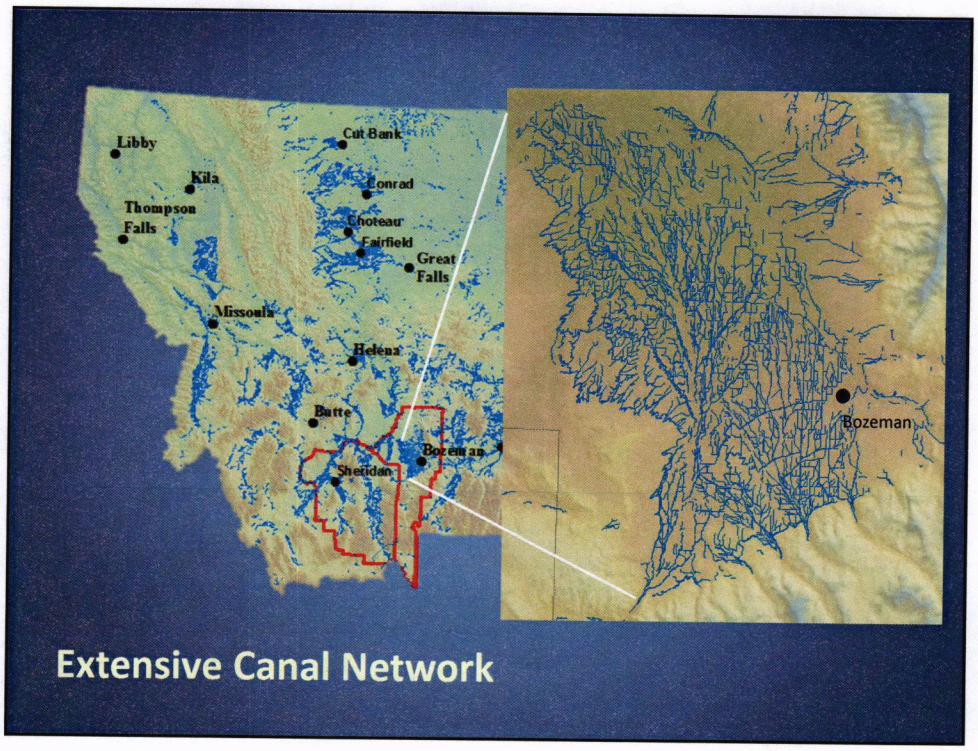

North Hills
Ground Water Investigation Program
North Hills GWIP Investigation
Helena Valley Irrigation Canal
Lake Helena
Hauser Lake
Helena
0
2

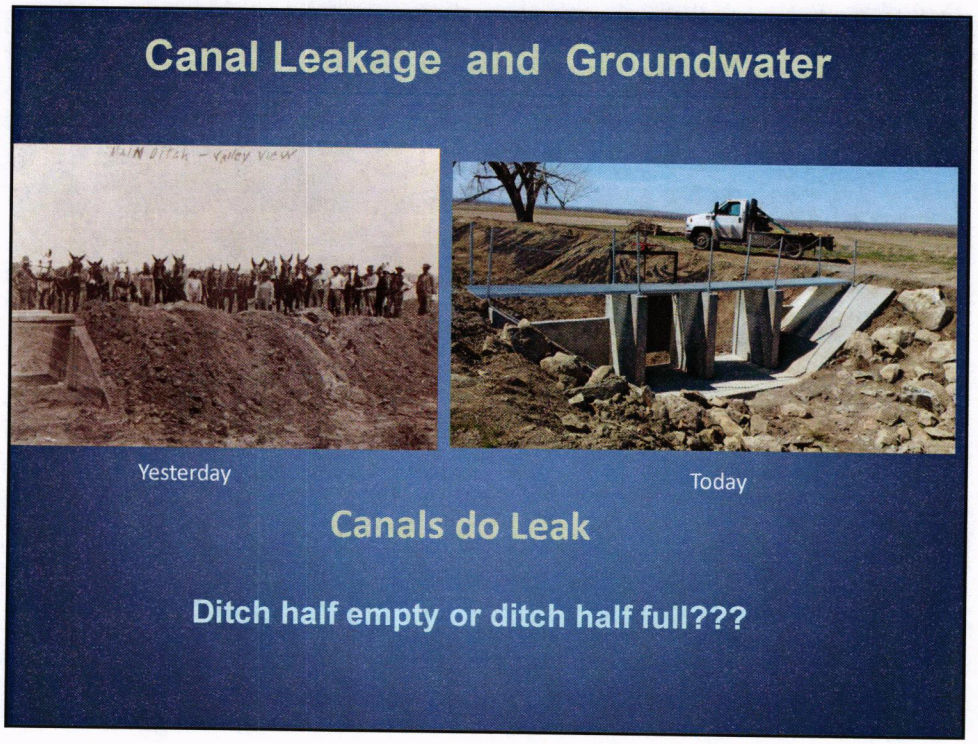

Removing the Helena Valley Irrigation District Canal and associated Irrigation
Decline in water level (feet)
10
15
20
25
30
35
A
A'
Canal
Lake Helena


Groundwater Elevation
Canal On
Canal Off
North Hills
Irrigation Canal
Helena Valley
Elevation (ft)
Distance (ft)
4500
4400
4300
4200
4100
4000
3900
3800
3700
3600
8000 10000 12000 14000 16000 18000 20000 22000 24000 26000 28000 30000 32000 34000 36000


Variability in Leakage
Ditch Leakage cfs / mile
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Average leakage rate ~1.25 cfs/mile
Flathead Indian Reservation Bedrock
Billings area
Flathead Indian Reservation Glacial...
Flathead Indian Reservation Glacial Till
Upper Big Hole
Greenfields Bench (Fairfield)
Billings area
Helena Valley
Bozeman area ditches
Stillwater-Rosebud Watershed
Flathead Indian Reservation Alluvium
West Side Canal (Dillon area)
BRID (Hamilton area)
Upper Big Hole
Stillwater-Rosebud Watershed
Carey Canal (Boulder Rv drainage)
East Bench Canal (Dillon area)
BRID (Hamilton area)
Greenfields Bench (Fairfield)
< 0.5 - 4.5 cfs/mile

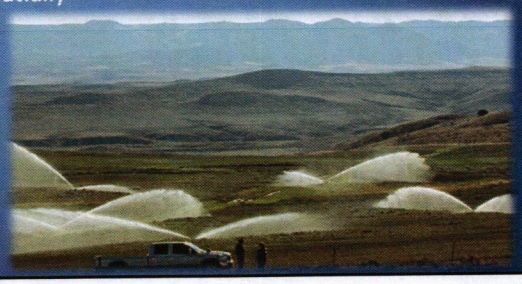

Factors influencing canal leakage
• Geologic material
• Depth to groundwater
• Irrigation season changes
• Wetted perimeter
• Maintenance


Libby
Kila
Thompson Falls
Missoula
Cut Bank
Conrad
Choteau
Fairfield
Great Falls
Helena
Butte
Bozeman
Sheridan
Bozeman
Extensive Canal Network


Canal Leakage and Groundwater
Yesterday
Today
Canals do Leak
Ditch half empty or ditch half full???

Major points

- ✓ Dynamics of canal seepage
  - Leakage has been ongoing
- ✓ Leakage implications
  - Raise groundwater levels and increase groundwater recharge
  - Augment stream flow in the late season
- ✓ Variability in leakage rates
  - NOT 'one size fits all'
  - Varies temporally and spatially
- ✓ Extensive canal network
  - Many, many thousands of miles

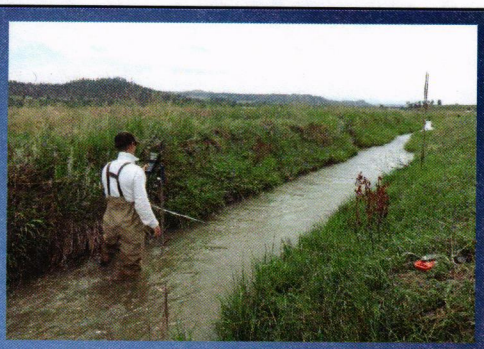


Water Management and Canal Leakage

Raising the possibility of Managed Artificial Recharge

- ✓ Artificial recharge through managed canal leakage is possible in some areas but not universal
- ✓ Candidate areas must have available storage capacity
- ✓ Appropriate aquifer properties - transmissivity
- ✓ Modeling is essential to predict changes to the hydrogeology

Challenges



- ✓ Physical vs. Legally available water
- ✓ Water use planning is holistic - changing application methods, conveyance efficiency, point of use, all affect other parts of the hydrologic system.
- ✓ Land use change - can reduce irrigation infrastructure and reduce recharge, altering the status quo