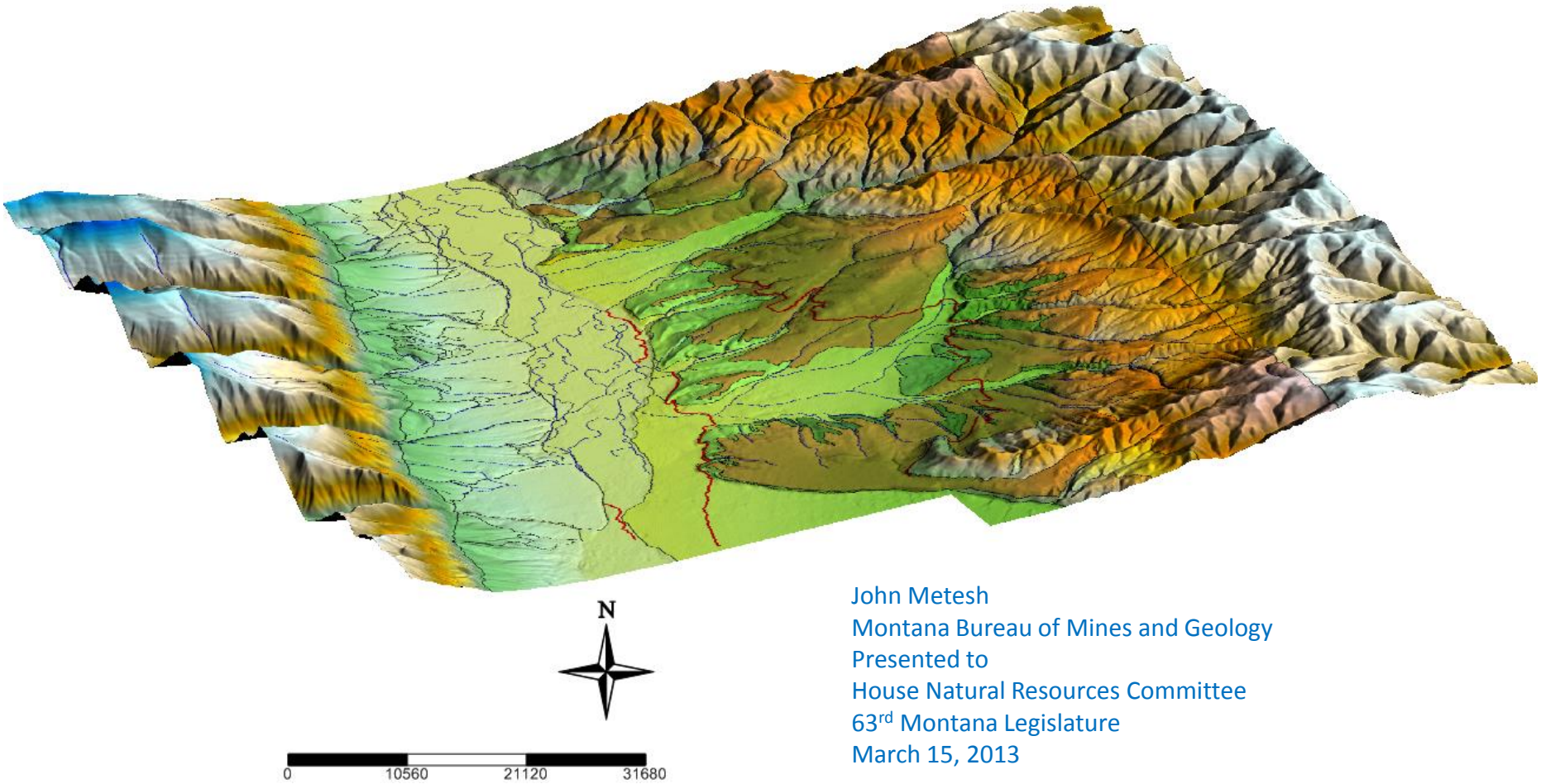
Stream Depletion Zones
the hydrologic perspective



John Metesh
Montana Bureau of Mines and Geology
Presented to
House Natural Resources Committee
63rd Montana Legislature
March 15, 2013

Some ground rules…

Stream Depletion results from pumping groundwater until the groundwater discharge to the stream is reduced and/or flow from the stream to groundwater is induced. Both conditions reduce stream discharge.

Stream Depletion is independent of stream discharge

same effect whether 1000 cfs or 10 cfs

Unless, of course, you dry up the stream

Stream Depletion is independent of well interference

it is both cumulative and additive

1 well pumping 500 gpm

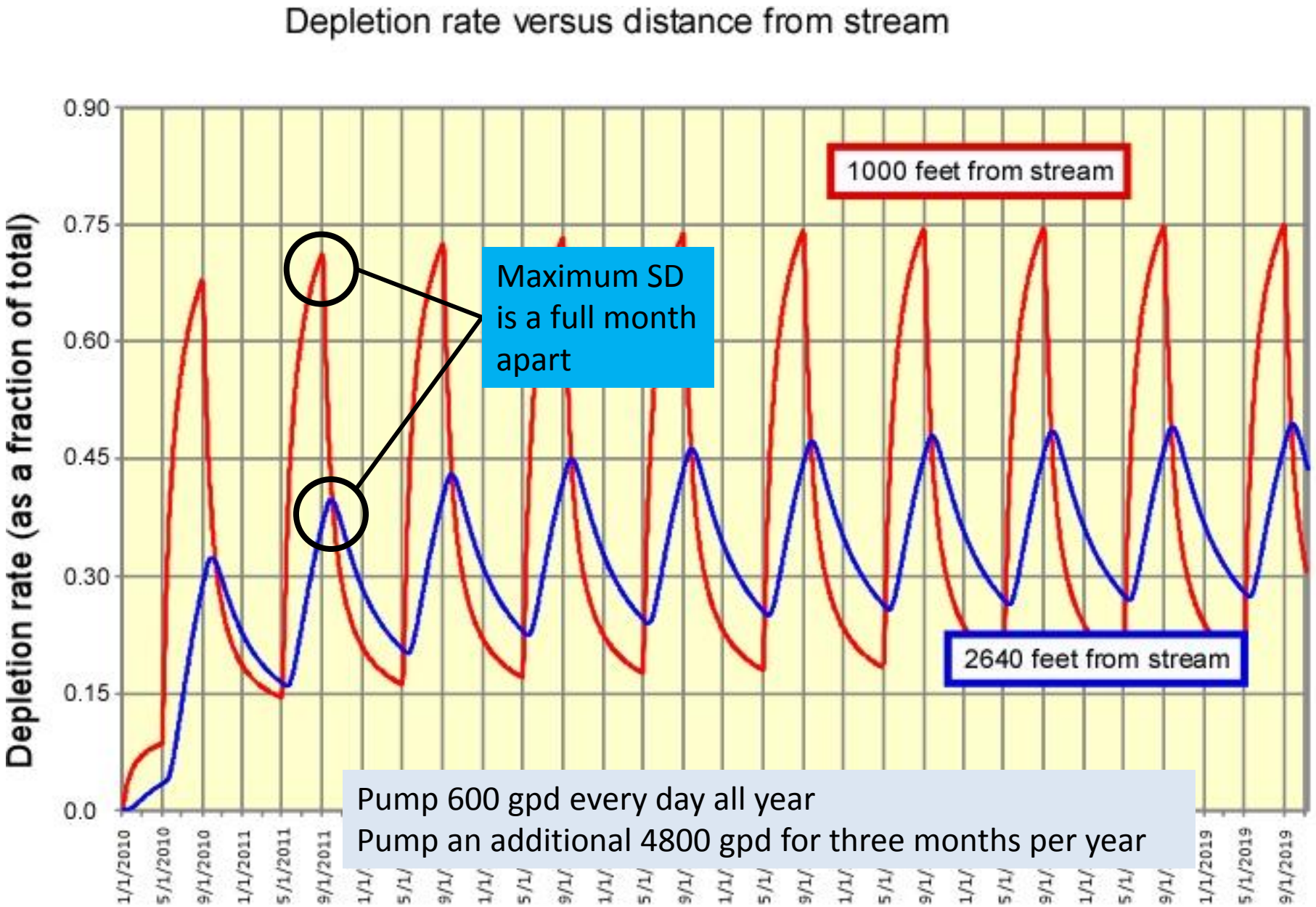
has the same effect as

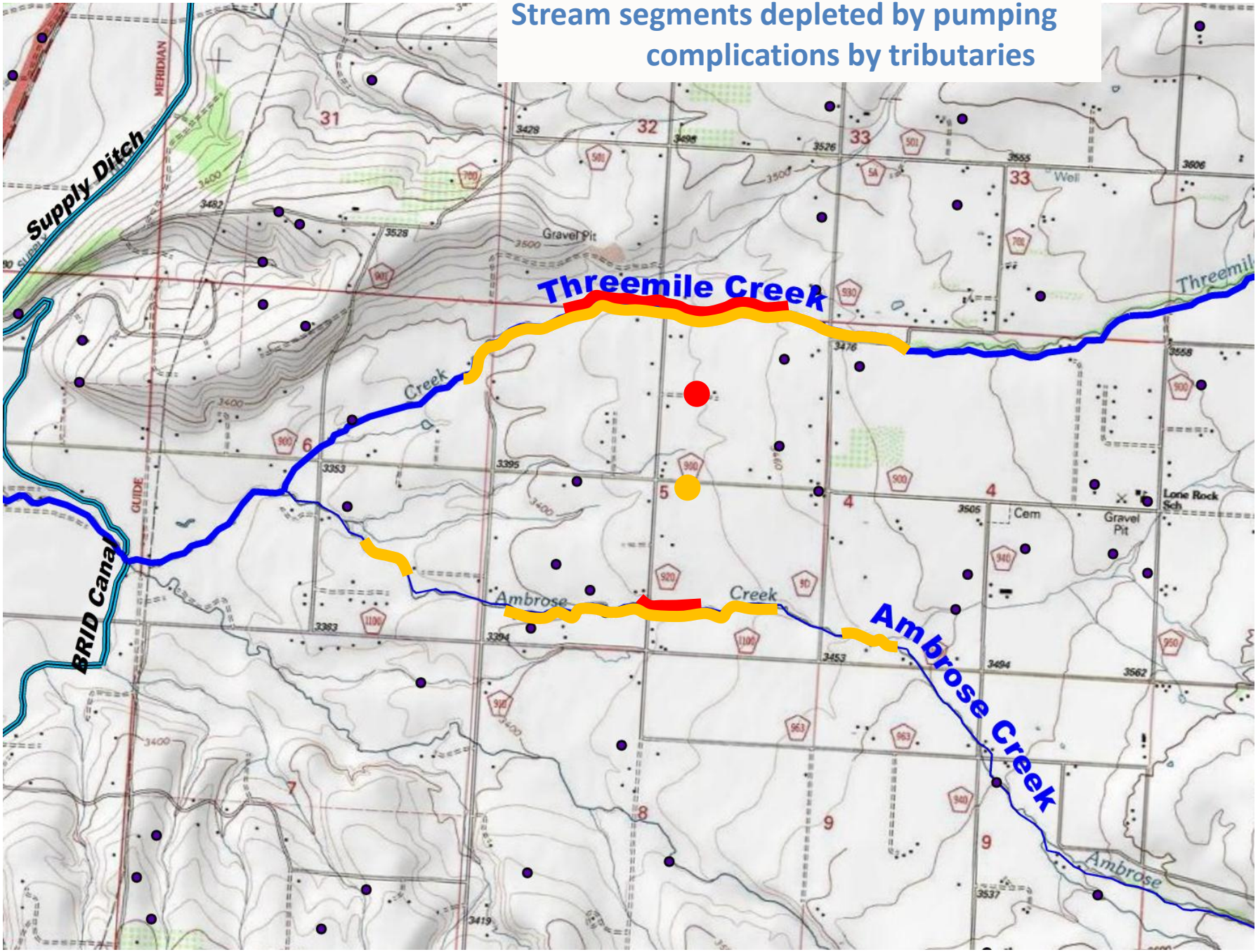
50 wells pumping 10 gpm

Depletion does not stop when pumping stops

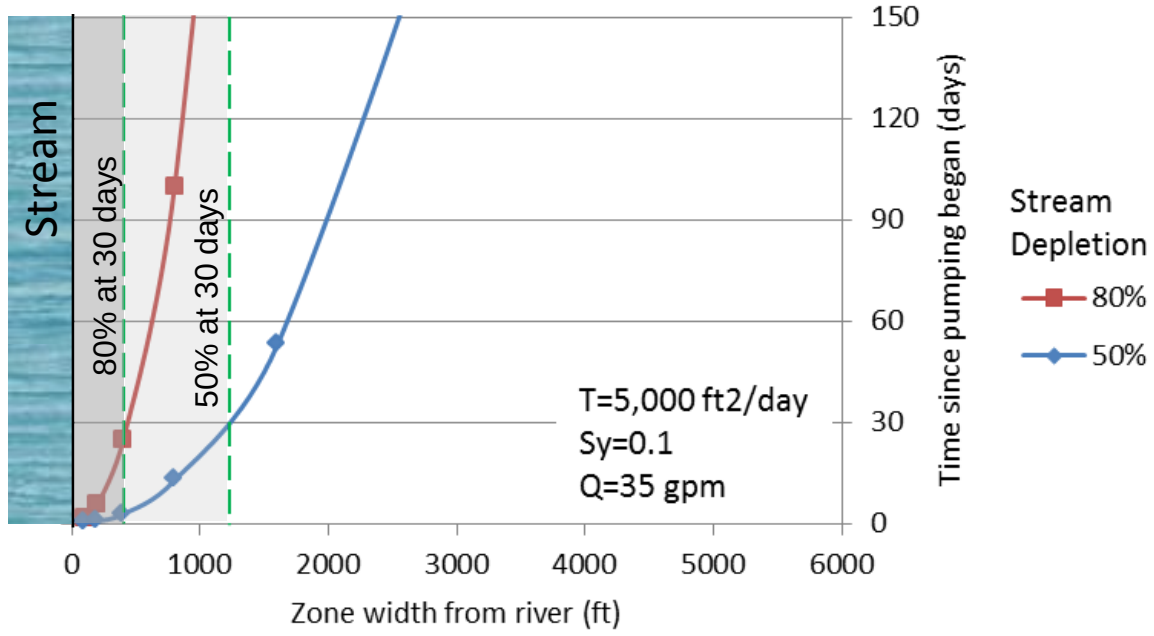
Stream Depletion is independent of distance from the well(s) to the stream

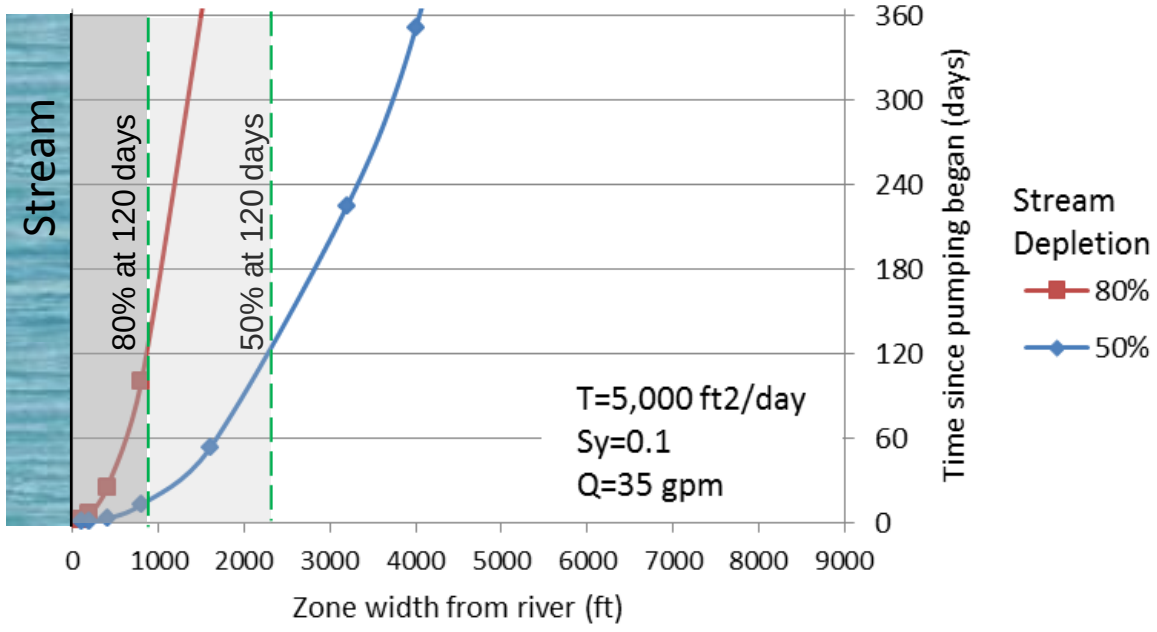
*BUT the **RATE** of depletion **IS** dependent on distance*


Depletion rate versus distance from stream
Depletion rate (as a fraction of total)
0.90
0.75
0.60
0.45
0.30
0.15
0.0
1000 feet from stream
2640 feet from stream
Maximum SD is a full month apart
Pump 600 gpd every day all year
Pump an additional 4800 gpd for three months per year
1/1/2010
5/1/2010
9/1/2010
1/1/2011
5/1/2011
9/1/2011
1/1/2019
5/1/2019
9/1/2019


Stream segments depleted by pumping complications by tributaries
Supply Ditch
BRID Canal
Threemile Creek
Ambrose Creek
Ambrose Creek
Gravel Pit
Gravel Pit
Cem
Lone Rock Sch
Well
MERIDIAN
GUIDE

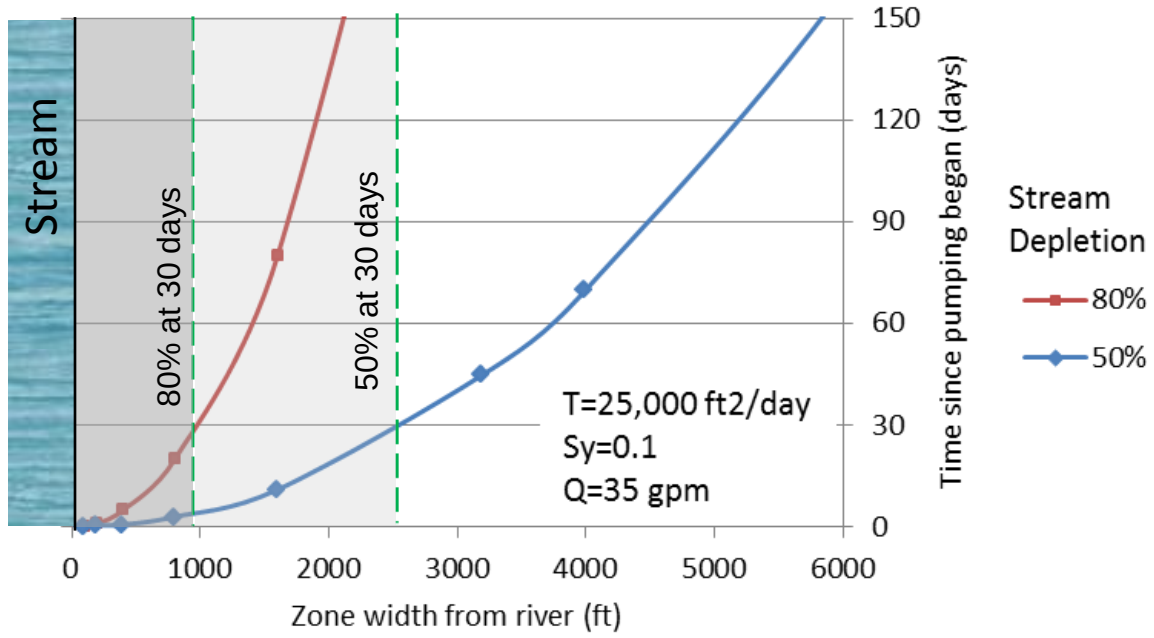
Moderately productive alluvial aquifer
Transmissivity = 5,000 ft^2/day

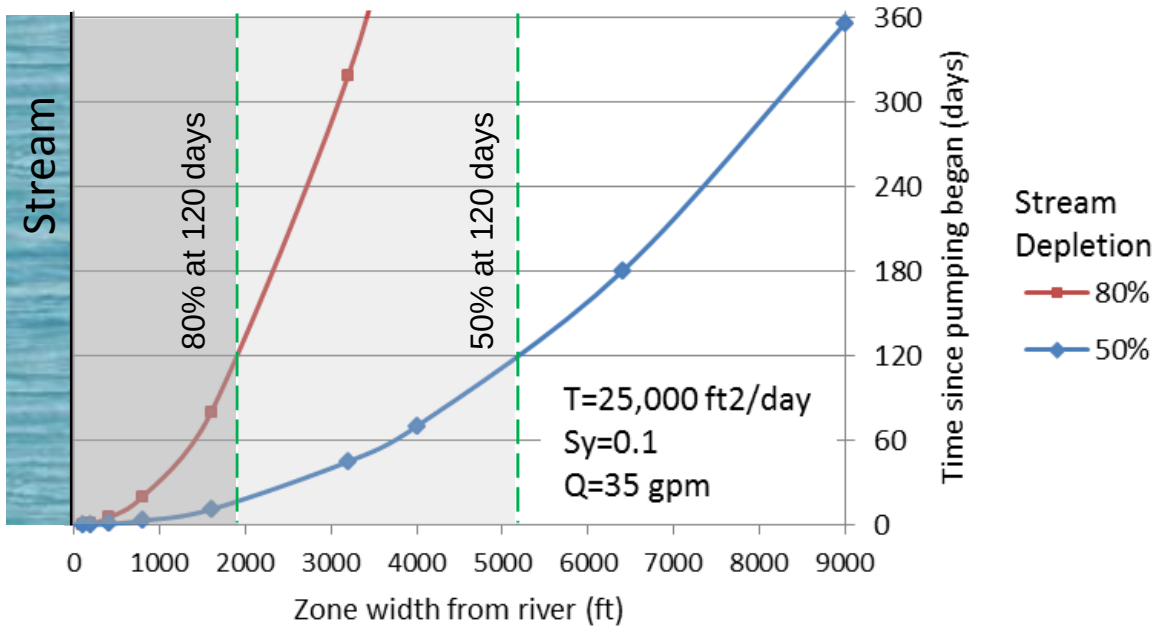




Textbook example based on the "Colorado Model" (WPM Software, 2001; based on Schroeder, 1987). See model documentation for assumptions and limitations.

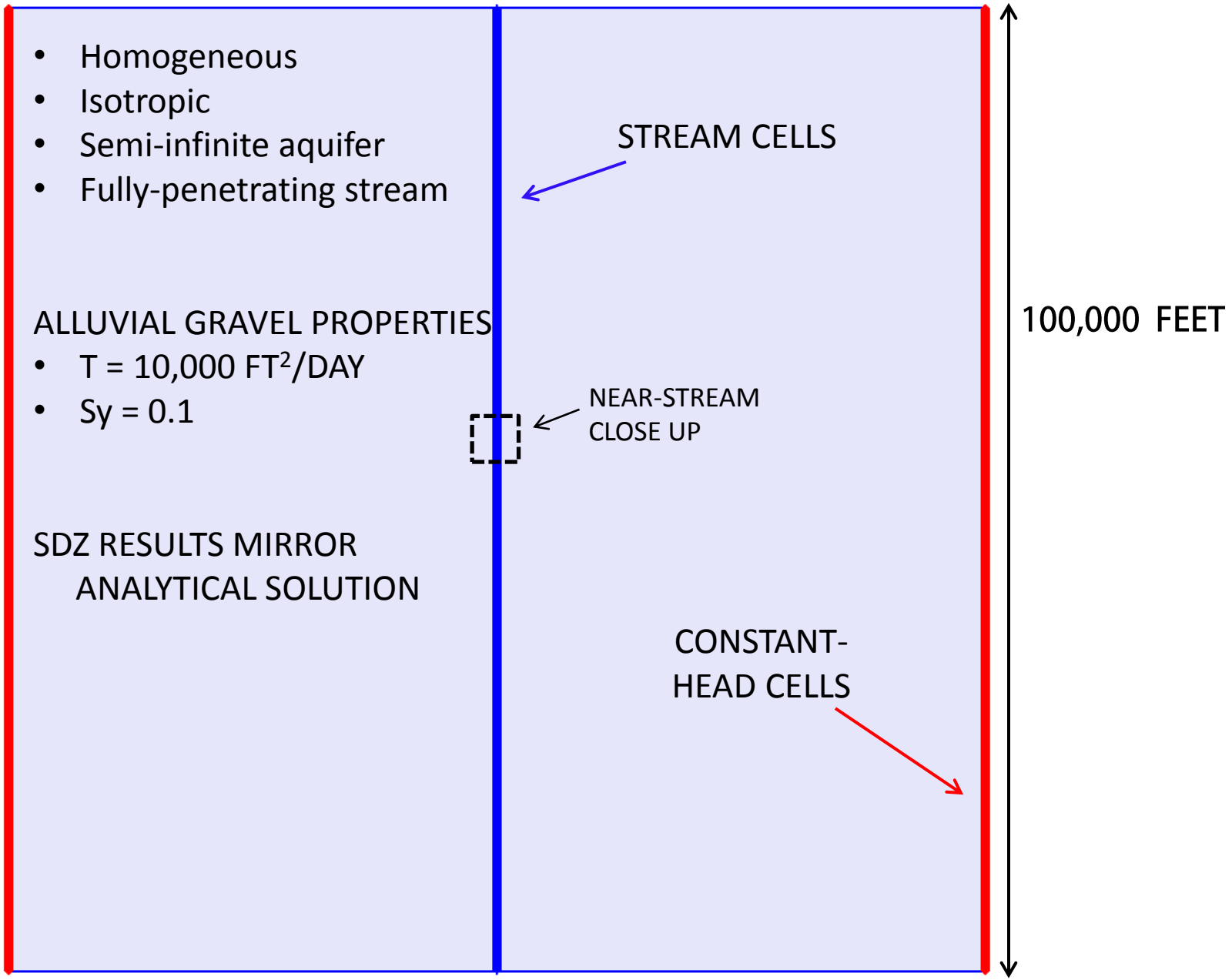
Highly productive alluvial aquifer
Transmissivity = 25,000 ft^2/day



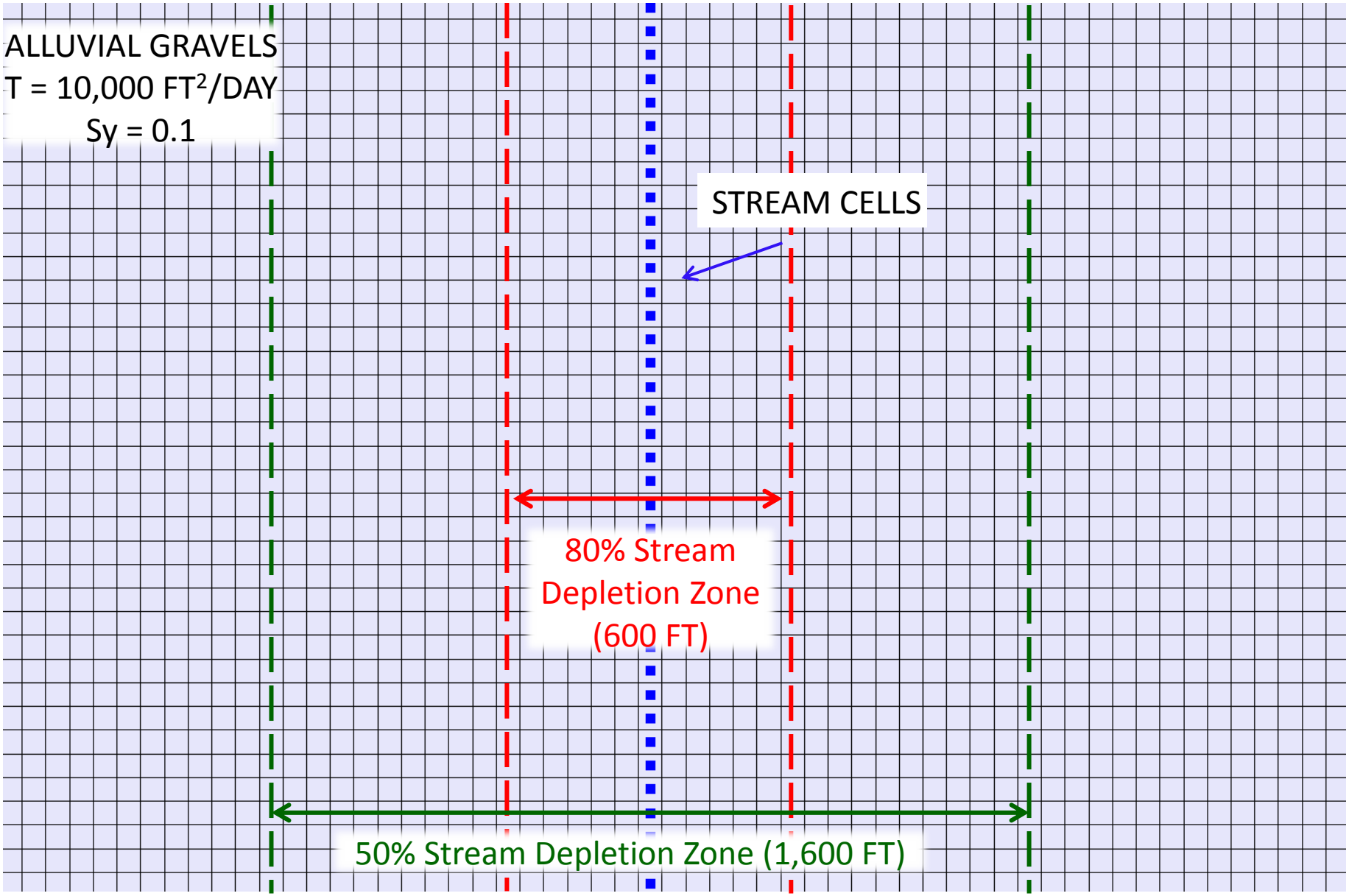


Textbook example based on the "Colorado Model" (WPM Software, 2001; based on Schroeder, 1987). See model documentation for assumptions and limitations.

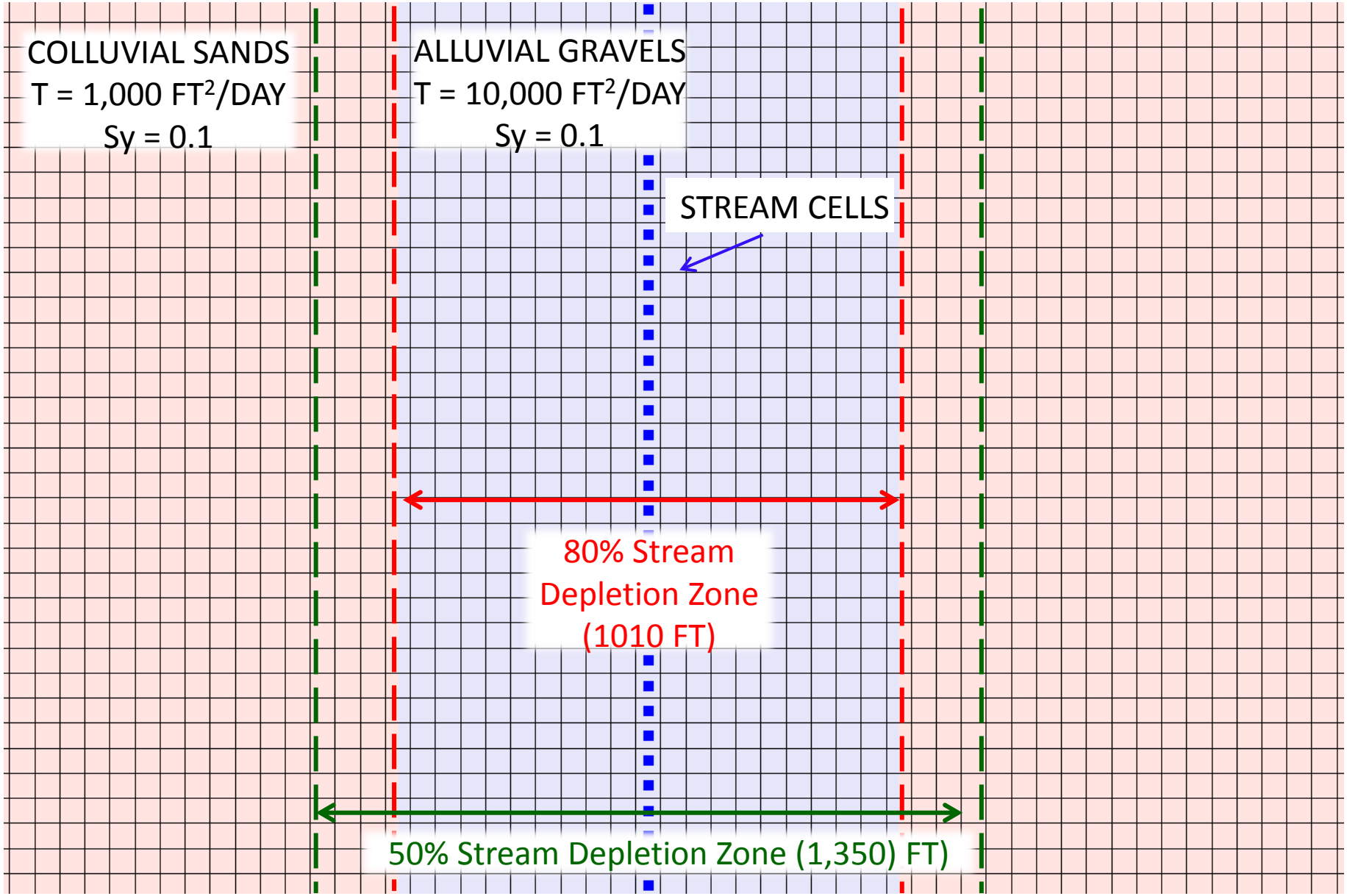
"SANDBOX" MODFLOW MODEL

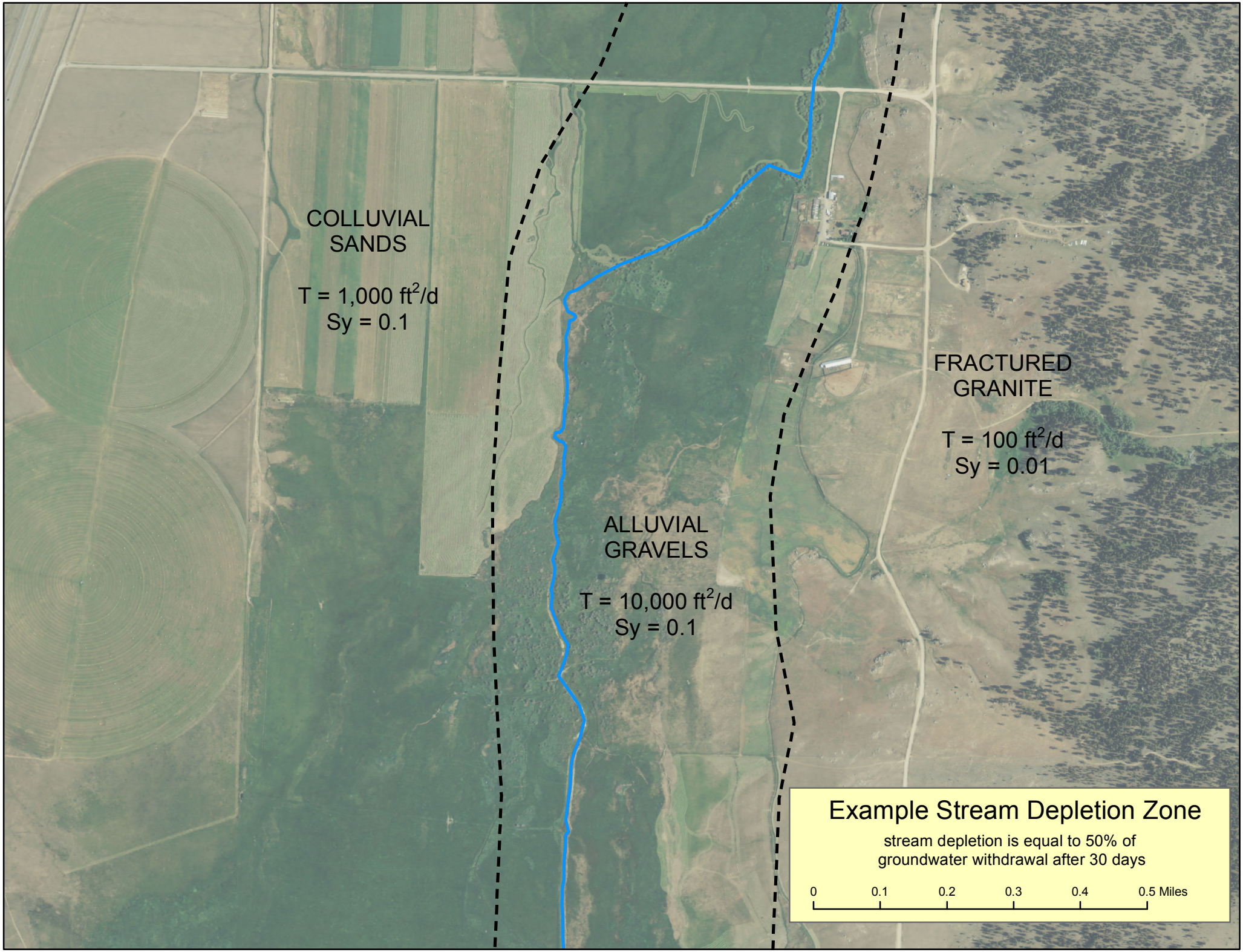


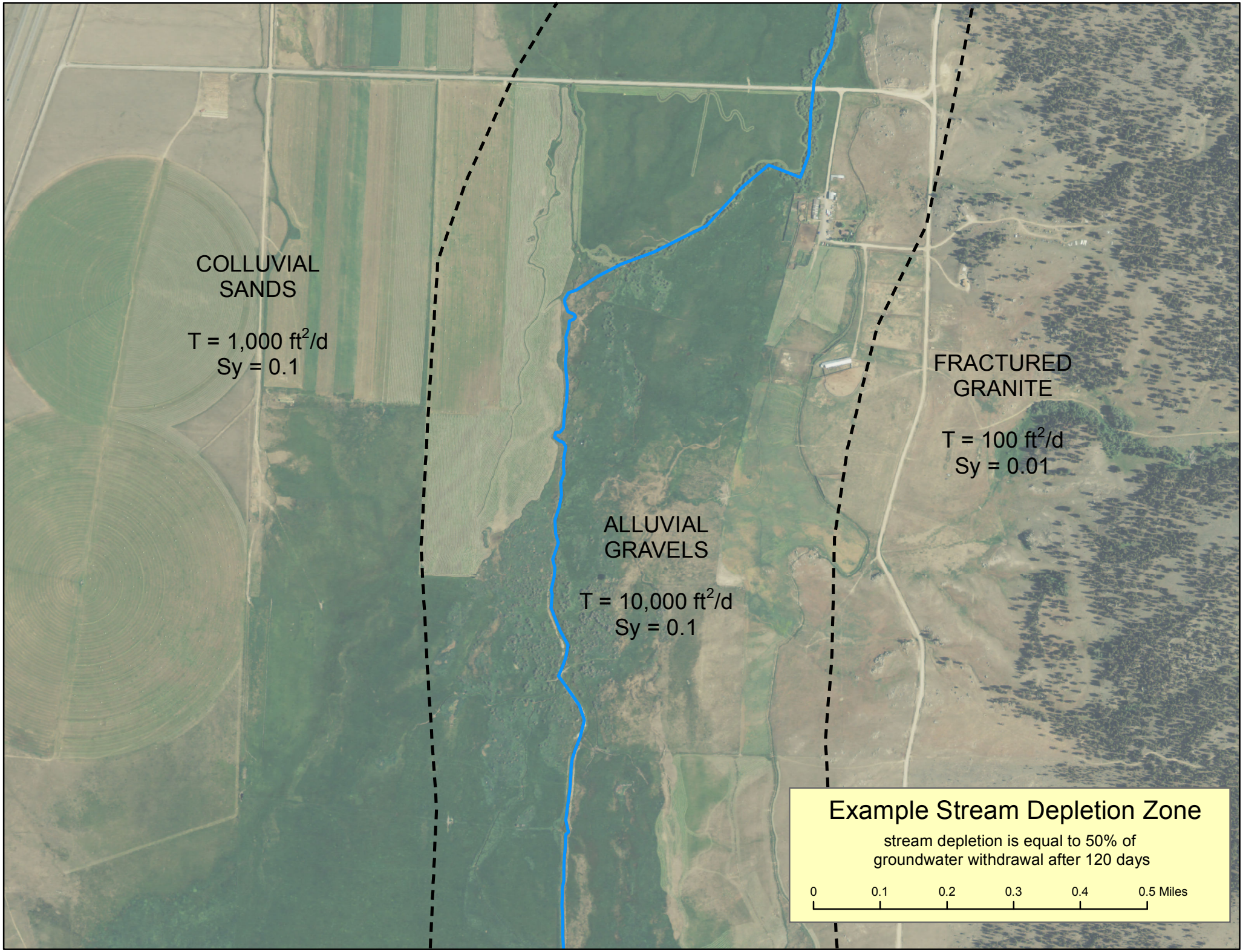
STREAM DEPLETION ZONES AFTER 30 DAYS OF PUMPING AT 35 GPM IN A HOMOGENEOUS AQUIFER

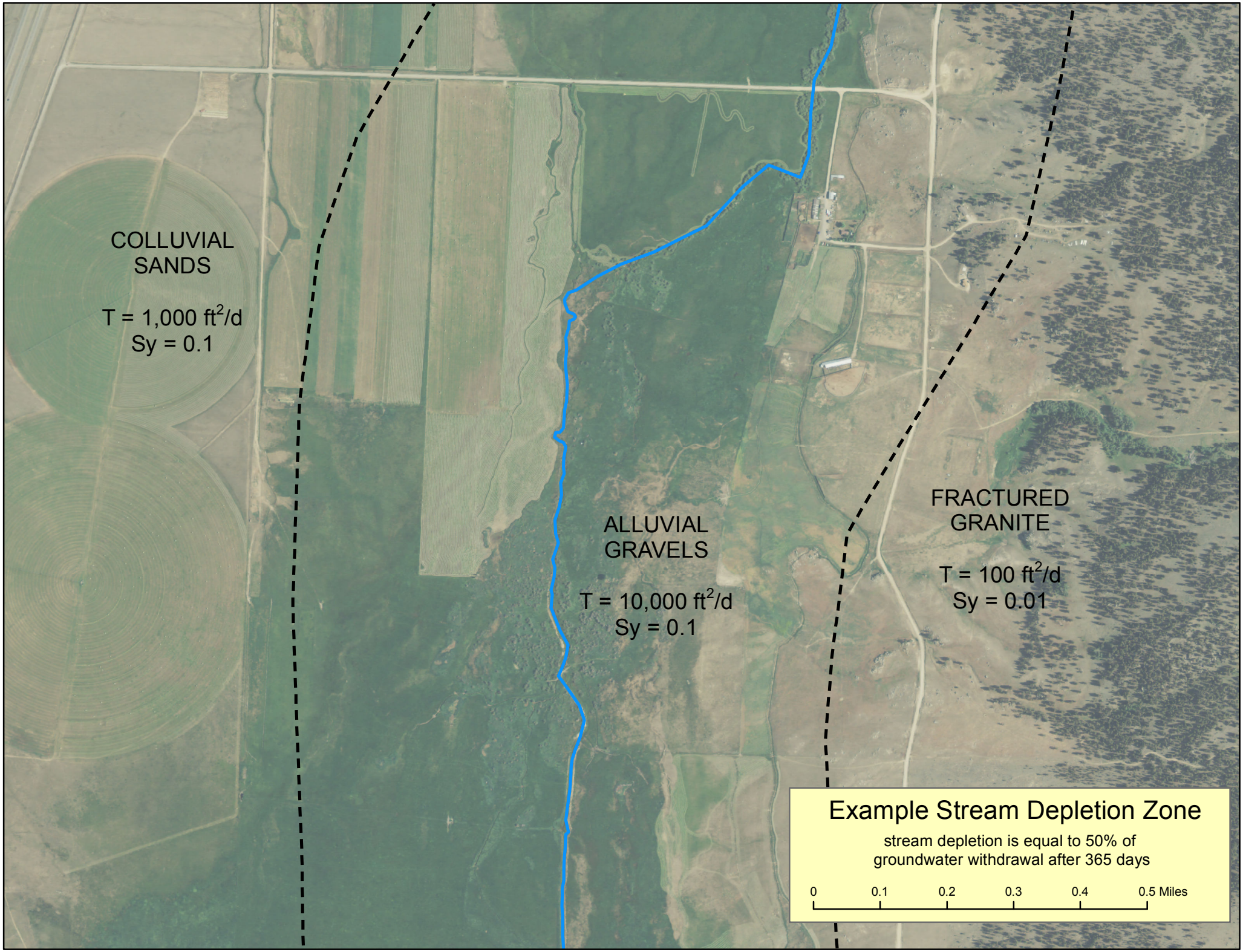


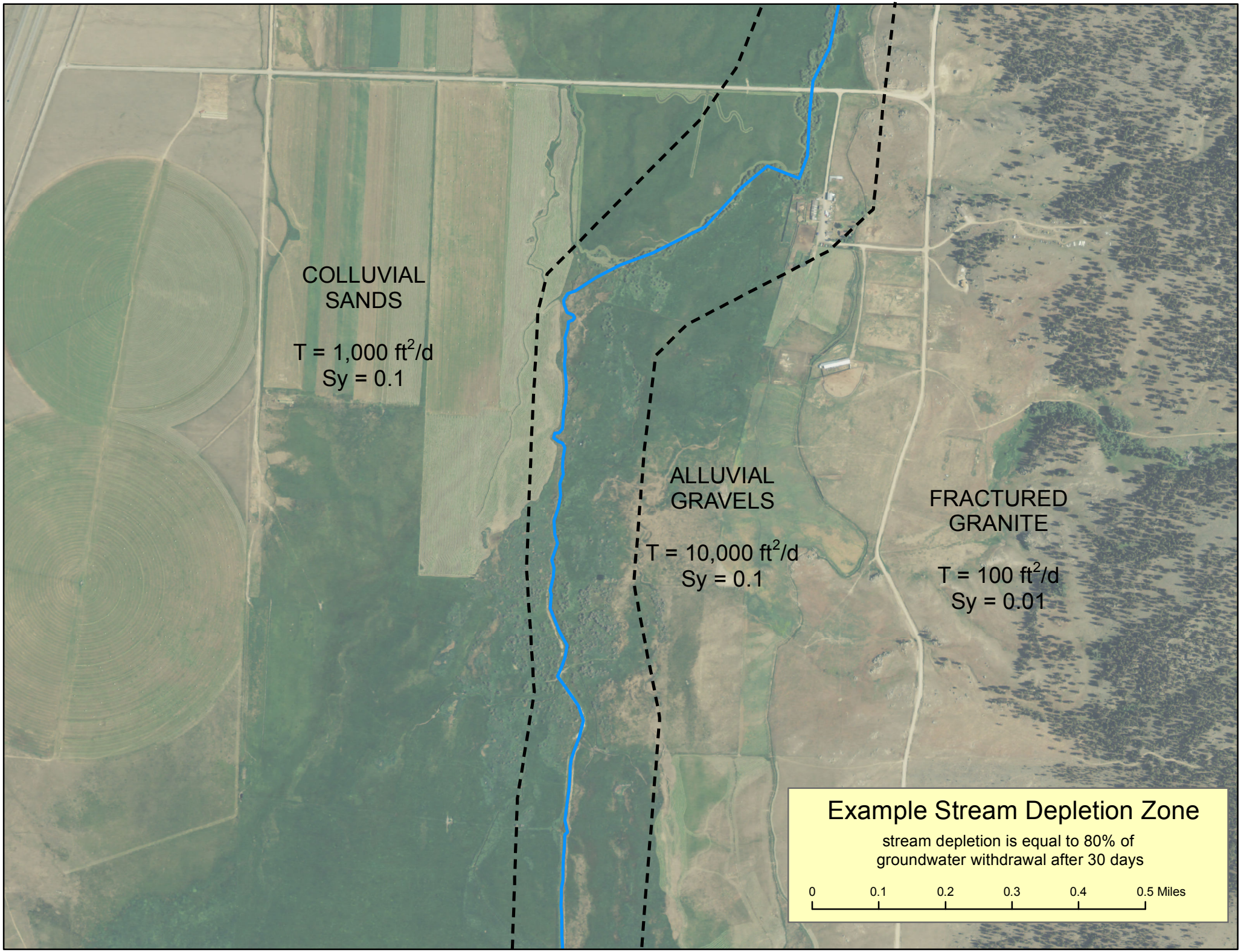
STREAM DEPLETION ZONES AFTER 30 DAYS OF PUMPING AT 35 GPM IN A (SIMPLIFIED) HETEROGENEOUS AQUIFER

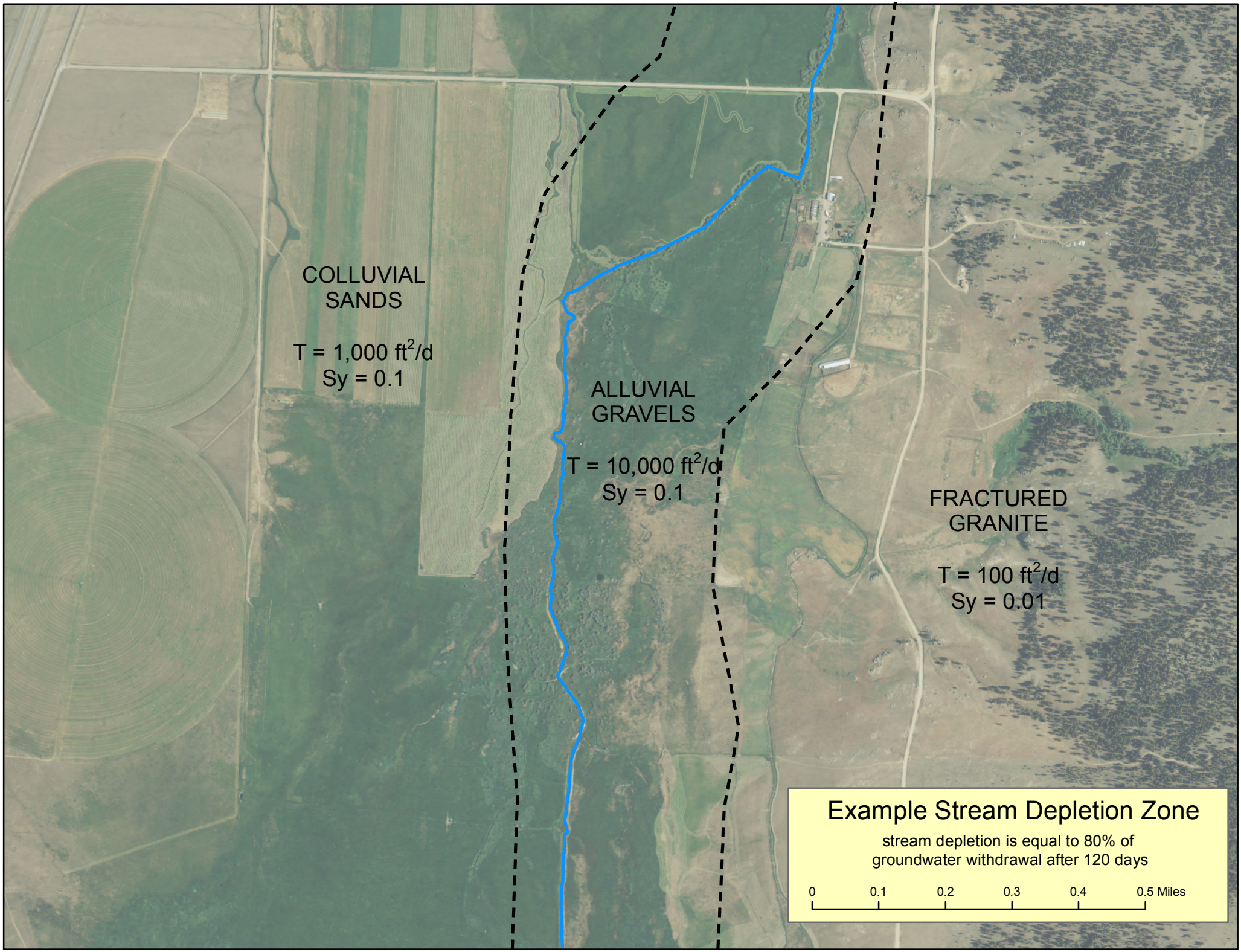


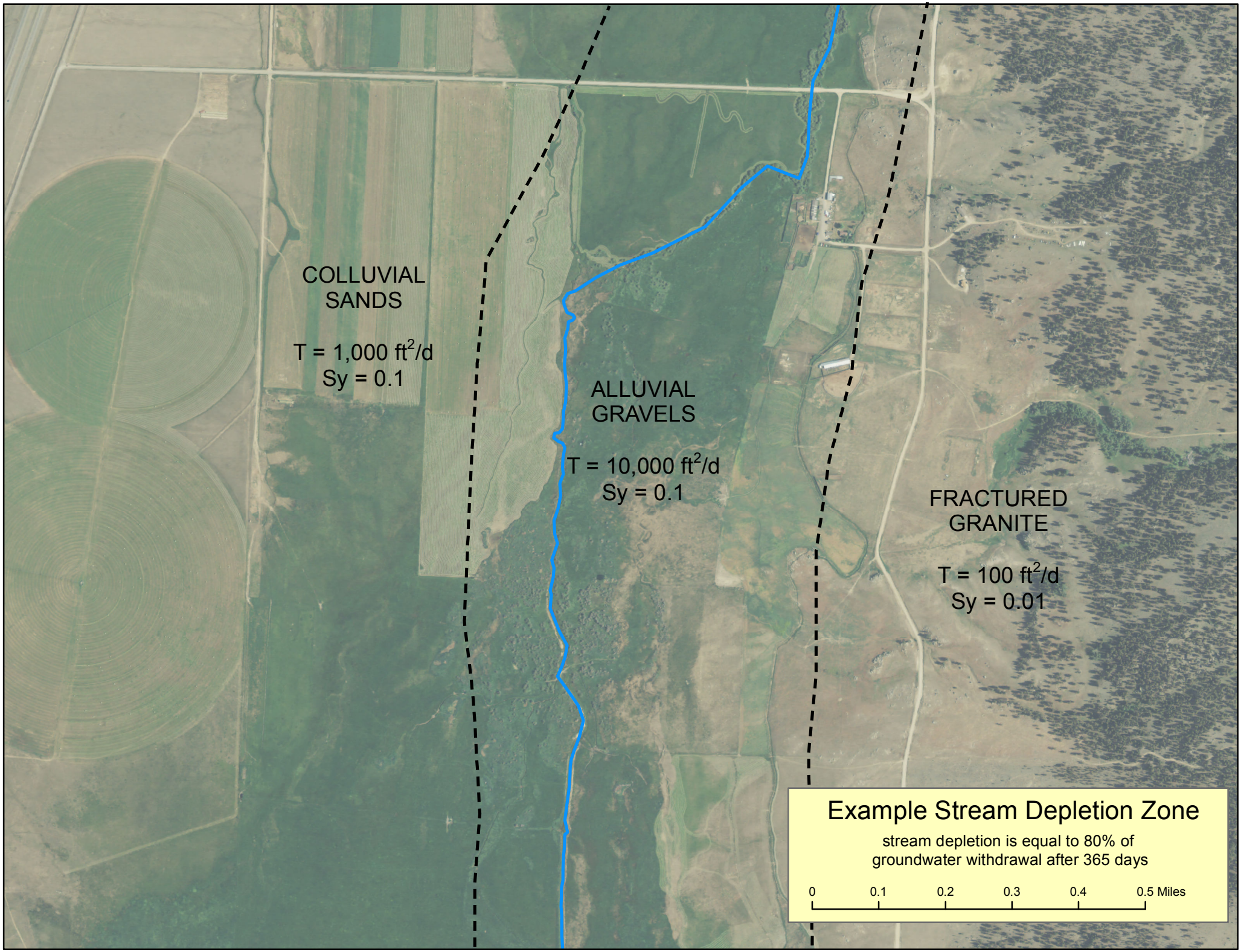

COLLUVIAL
SANDS
T = 1,000 ft²/d
Sy = 0.1
ALLUVIAL
GRAVELS
T = 10,000 ft²/d
Sy = 0.1
FRACTURED
GRANITE
T = 100 ft²/d
Sy = 0.01
Example Stream Depletion Zone
stream depletion is equal to 50% of
groundwater withdrawal after 30 days
0
0.1
0.2
0.3
0.4
0.5 Miles


COLLUVIAL
SANDS
T = 1,000 ft²/d
Sy = 0.1
ALLUVIAL
GRAVELS
T = 10,000 ft²/d
Sy = 0.1
FRACTURED
GRANITE
T = 100 ft²/d
Sy = 0.01
Example Stream Depletion Zone
stream depletion is equal to 50% of
groundwater withdrawal after 120 days
0
0.1
0.2
0.3
0.4
0.5 Miles


COLLUVIAL
SANDS
T = 1,000 ft²/d
Sy = 0.1
ALLUVIAL
GRAVELS
T = 10,000 ft²/d
Sy = 0.1
FRACTURED
GRANITE
T = 100 ft²/d
Sy = 0.01
Example Stream Depletion Zone
stream depletion is equal to 50% of
groundwater withdrawal after 365 days
0
0.1
0.2
0.3
0.4
0.5 Miles


COLLUVIAL
SANDS
T = 1,000 ft²/d
Sy = 0.1
ALLUVIAL
GRAVELS
T = 10,000 ft²/d
Sy = 0.1
FRACTURED
GRANITE
T = 100 ft²/d
Sy = 0.01
Example Stream Depletion Zone
stream depletion is equal to 80% of
groundwater withdrawal after 30 days
0
0.1
0.2
0.3
0.4
0.5 Miles


COLLUVIAL
SANDS
T = 1,000 ft²/d
Sy = 0.1
ALLUVIAL
GRAVELS
T = 10,000 ft²/d
Sy = 0.1
FRACTURED
GRANITE
T = 100 ft²/d
Sy = 0.01
Example Stream Depletion Zone
stream depletion is equal to 80% of
groundwater withdrawal after 120 days
0
0.1
0.2
0.3
0.4
0.5 Miles


COLLUVIAL
SANDS
T = 1,000 ft²/d
Sy = 0.1
ALLUVIAL
GRAVELS
T = 10,000 ft²/d
Sy = 0.1
FRACTURED
GRANITE
T = 100 ft²/d
Sy = 0.01
Example Stream Depletion Zone
stream depletion is equal to 80% of
groundwater withdrawal after 365 days
0
0.1
0.2
0.3
0.4
0.5 Miles

Complications

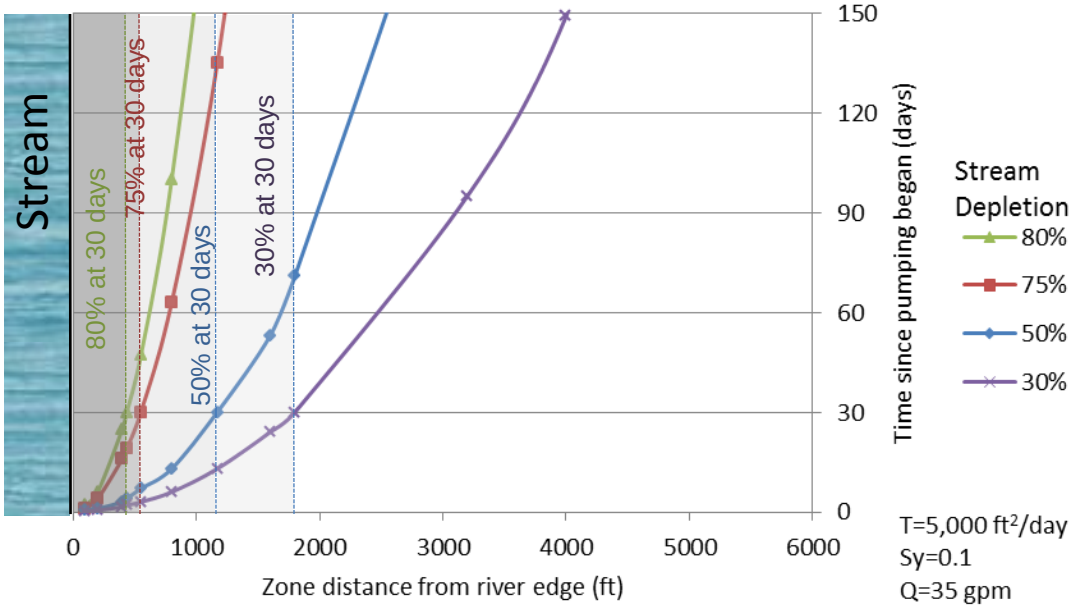
- Some hydrogeologic conditions can be quite complicated: more data, more complex models may be needed.
  e.g. Eightmile Creek basin

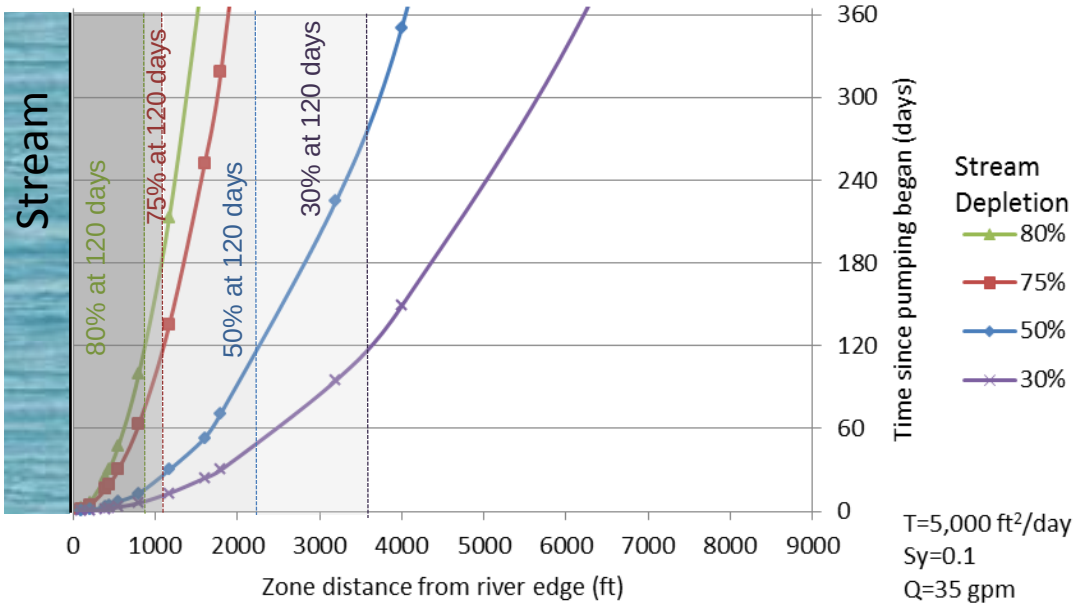
- Multiple tributaries can result in overlapping zones

- Aquifer conditions can change dramatically with depth
  e.g. Flathead Lake basin, lower Beaverhead River basin

- Cumulative error in establishing zone line can be significant (but, can be defined)
  aquifer test data and analyses
  subsurface mapping of lithology
  model method

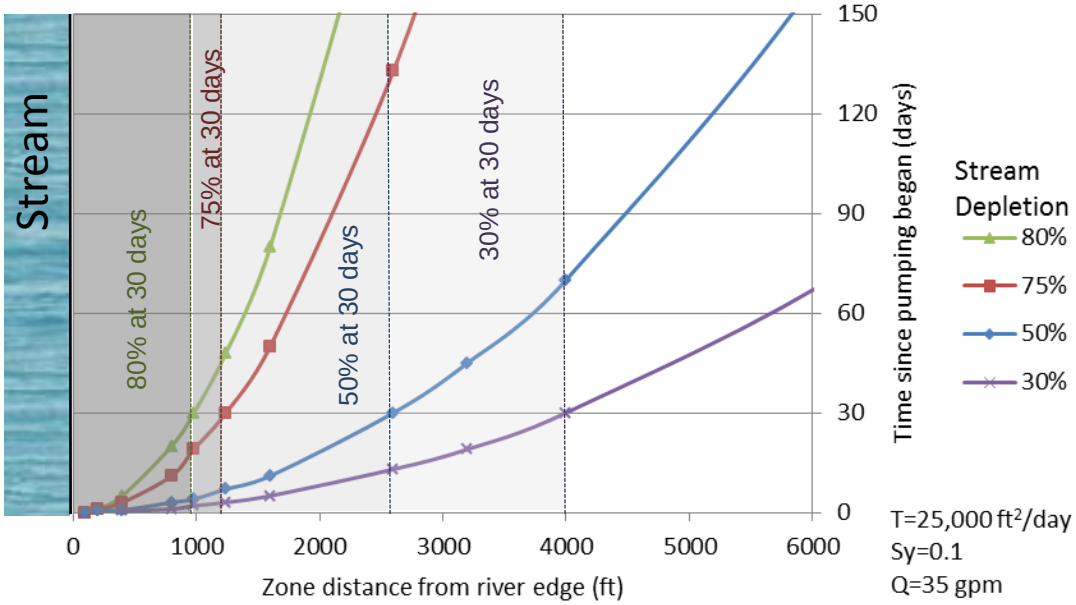
Moderately productive alluvial aquifer
Transmissivity = 5,000 ft²/day

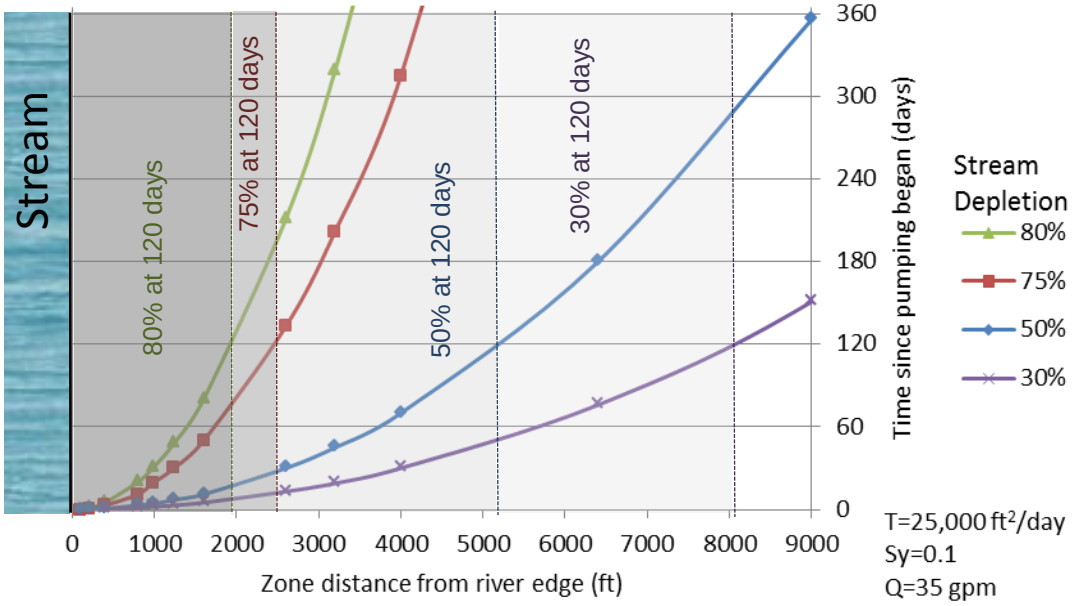




Textbook example based on the "Colorado Model" (WPM Software, 2001; based on Schroeder, 1987). See model documentation for assumptions and limitations.

Highly productive alluvial aquifer
Transmissivity = 25,000 ft²/day





Textbook example based on the "Colorado Model" (WPM Software, 2001; based on Schroeder, 1987). See model documentation for assumptions and limitations.