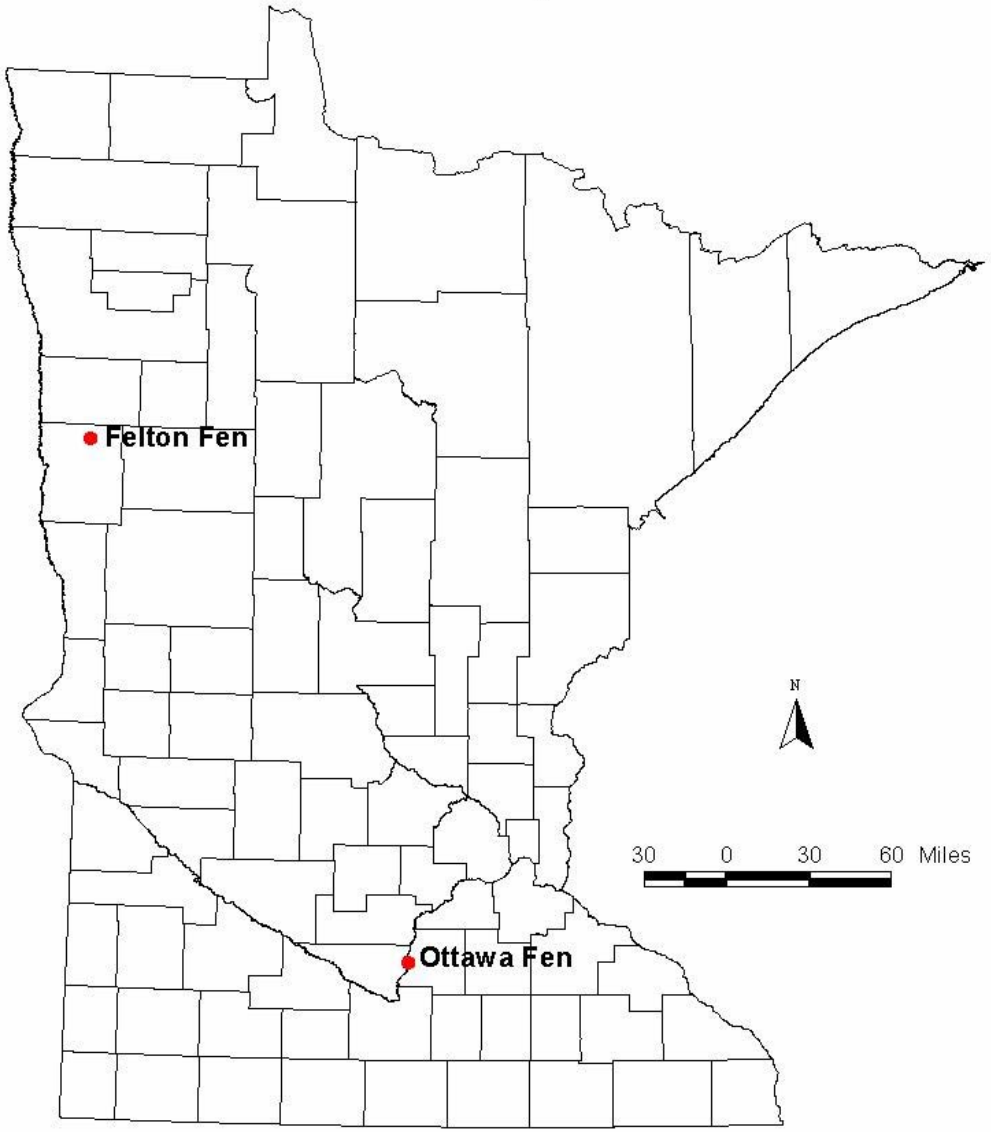
Fens at the Brink

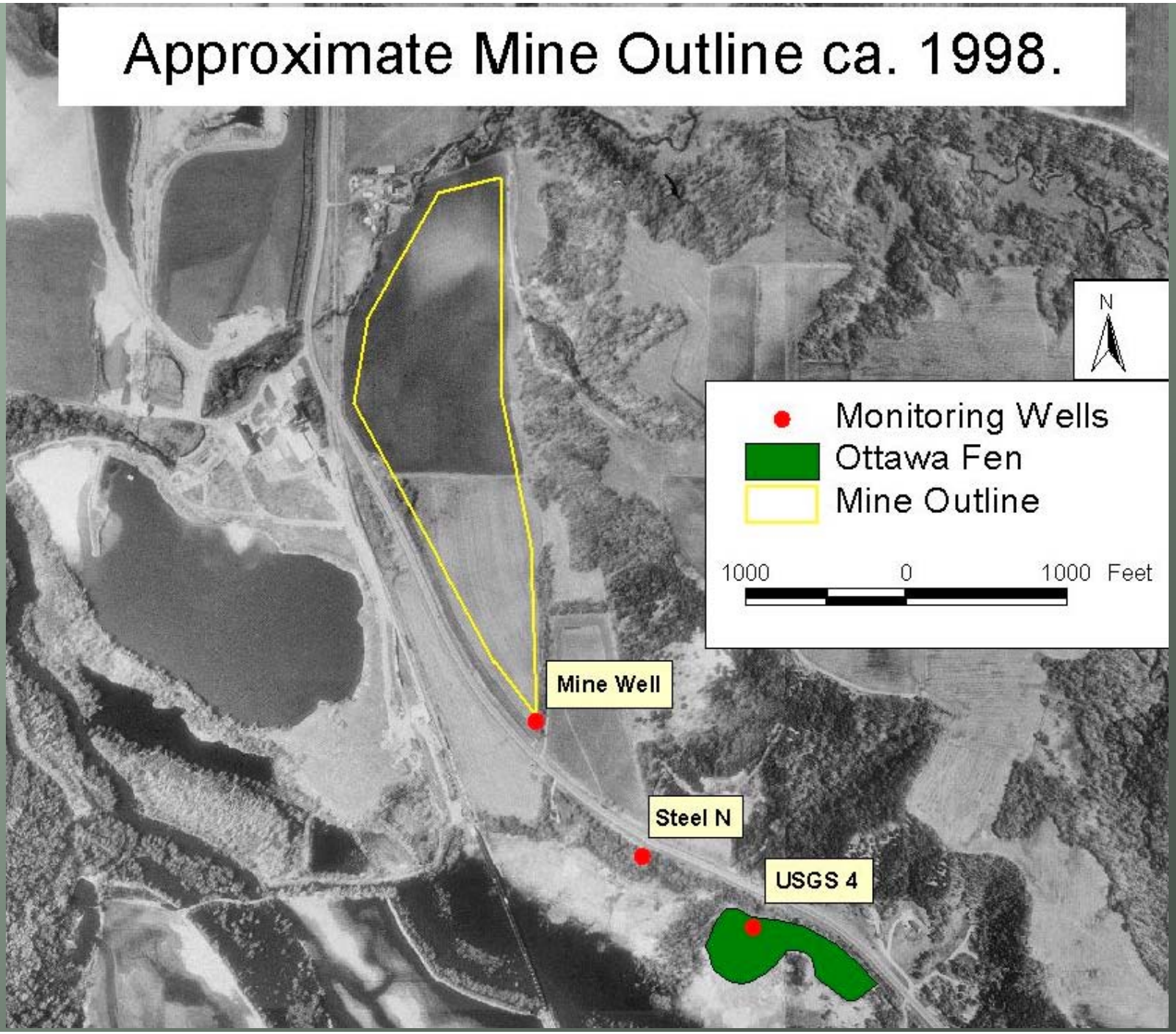
Case Studies of Sand and Gravel Mining *vs*. Calcareous Fens.

Case Study Sites



Ottawa Fen

Unorthodox Mitigation Used in Effort to Save Rare Wetland.


Approximate Mine Outline ca. 1998.
N
Monitoring Wells
Ottawa Fen
Mine Outline
1000
0
1000 Feet
Mine Well
Steel N
USGS 4

Hydrogeologic Modeling

- Model Assumptions
  - The layer mined and the fen were separated by a confining unit
  - Sump elevation of 740’
  - Pumping 1100 GPM
- Predicted Effects
  - Some head loss beneath the fen

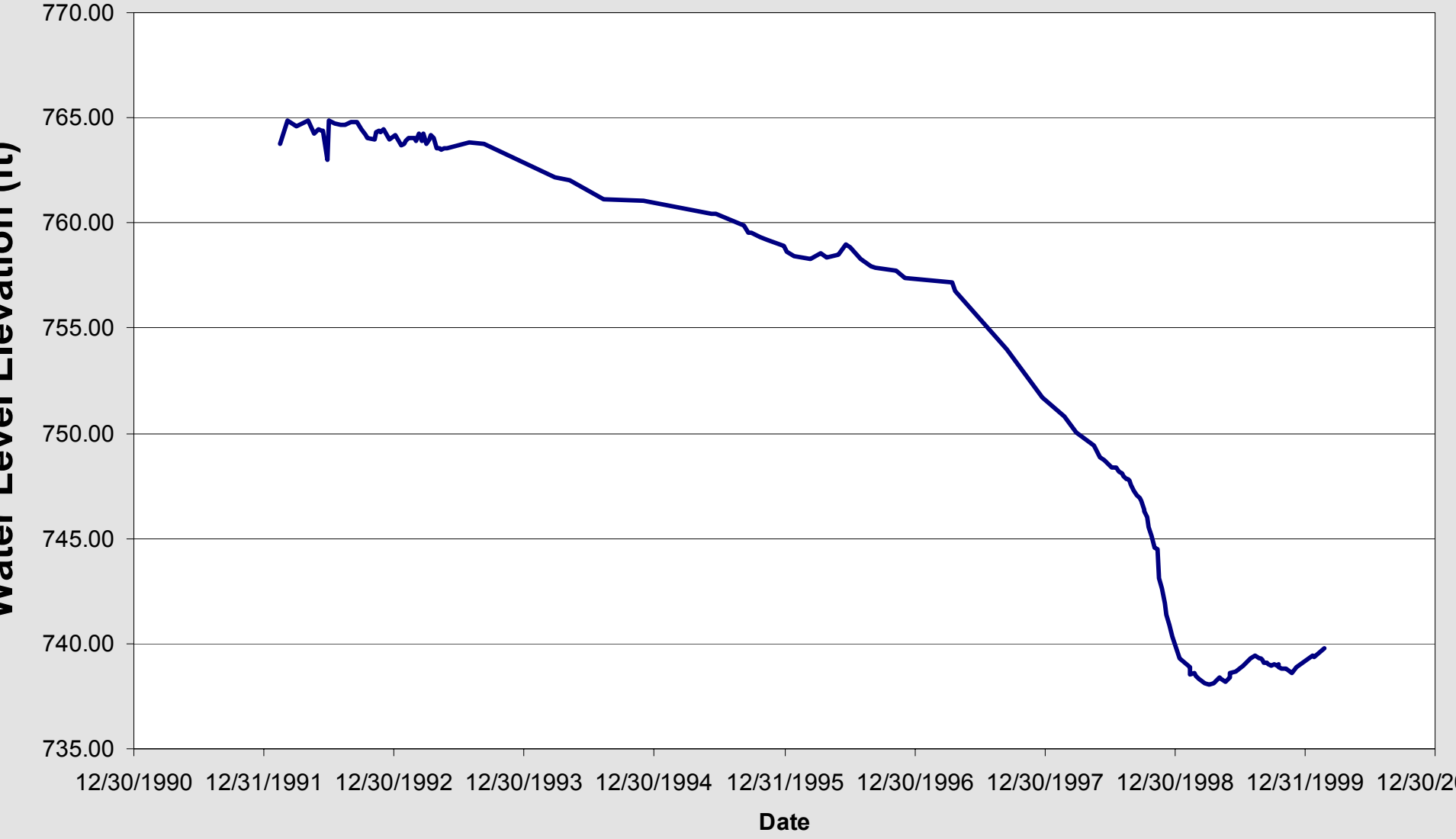
Model Weaknesses

- Mined material below confining unit
- Actual sump elevation of 688’

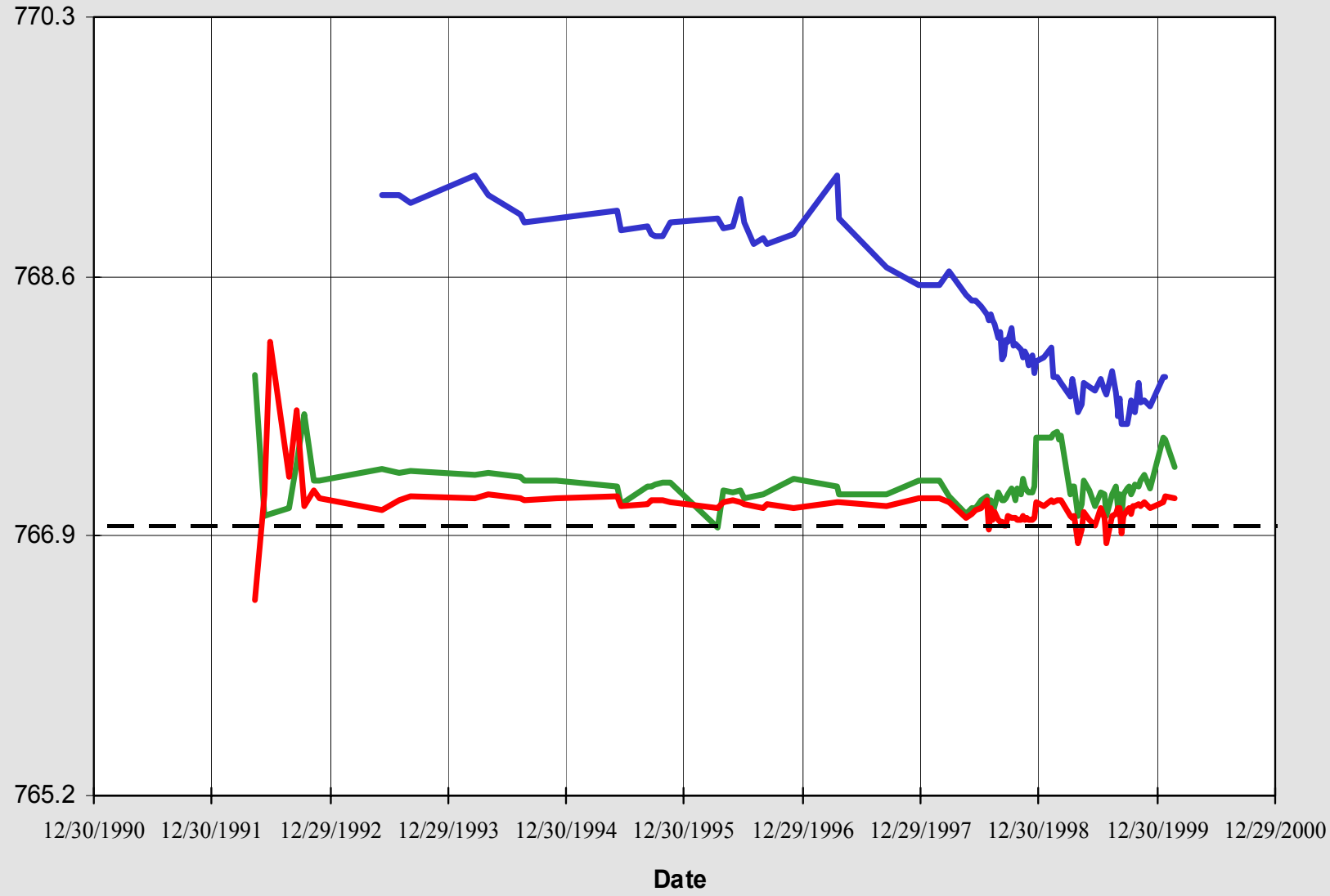
DNR Response

- DNR modeling
- Require monitoring wells

Ottawa Mine Well



Ottawa Fen Well Nest



Impacts to the Fen

- Head loss as of 9/28/99
  - 769.14 - 767.69 = 1.45’
    - (1.45 / 2.16) * 100% = 67%

Mitigation - A Last Resort!

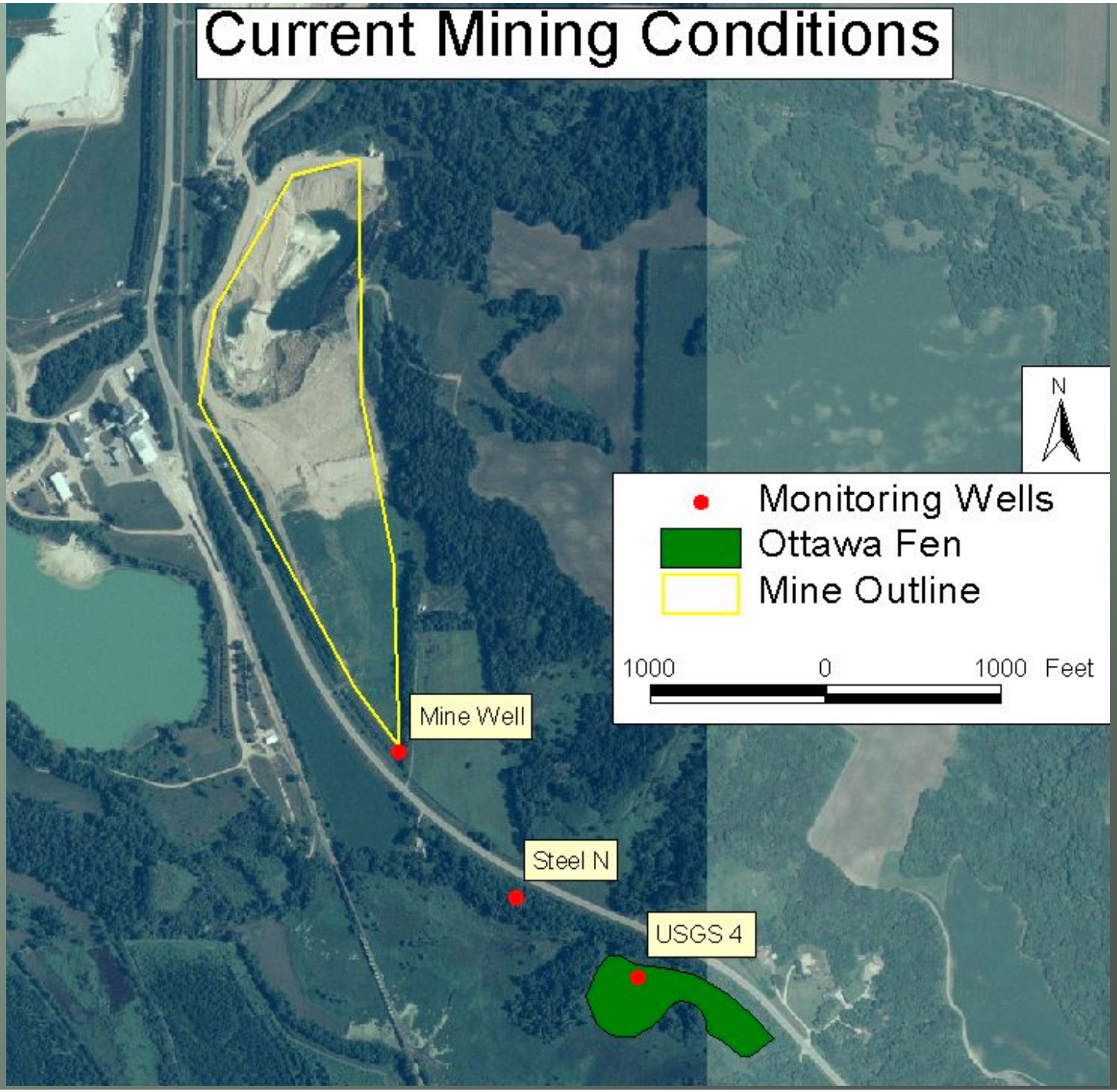
- Unavoidable impact of an essential project
- Approved (DNR) management plan
- Mitigation can be very expensive
- Peat soils are vulnerable: compaction, decomposition = subsidence

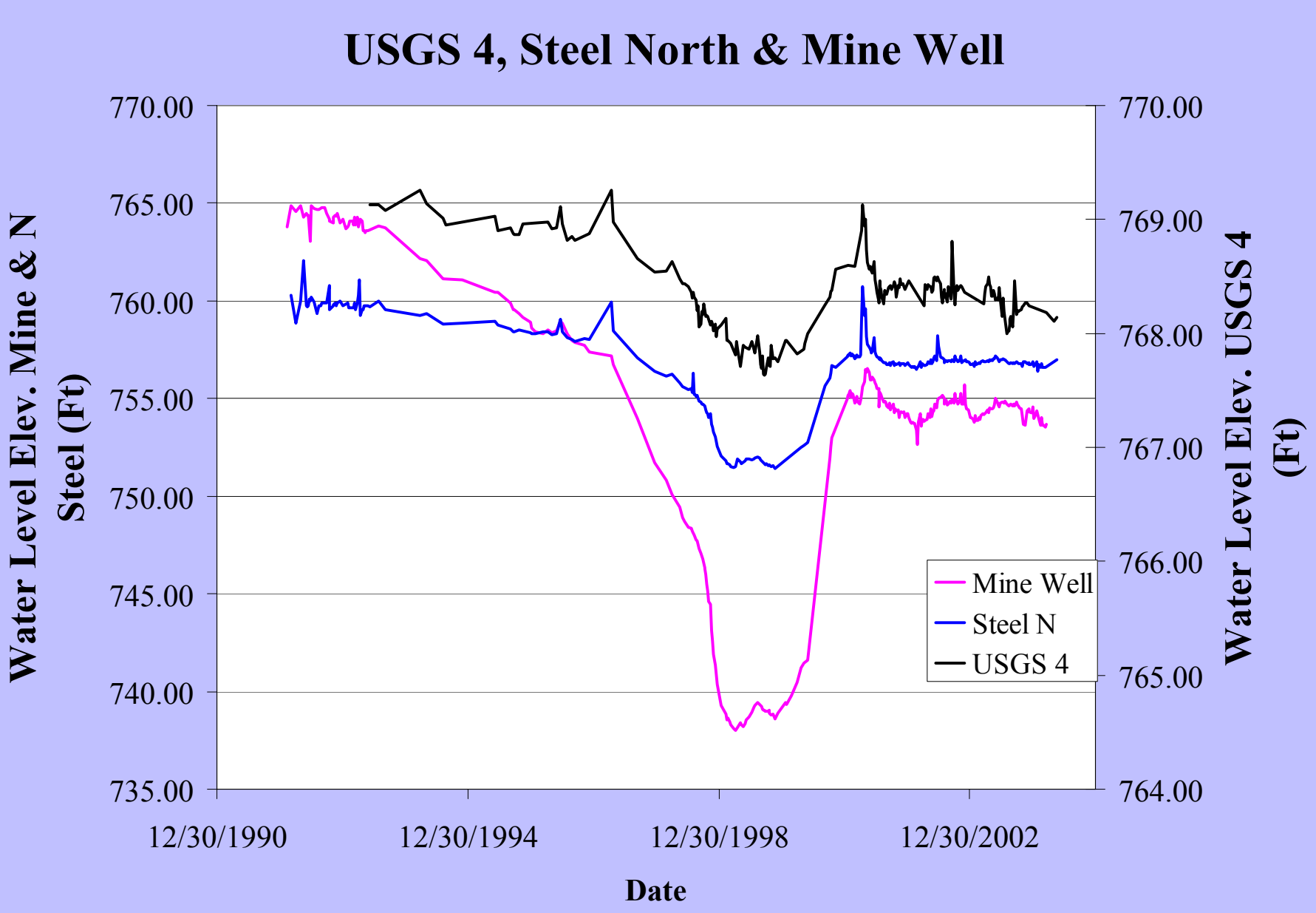
Irrigation

- Why implemented
- Early efforts
- Eventual solution
- Pitfalls

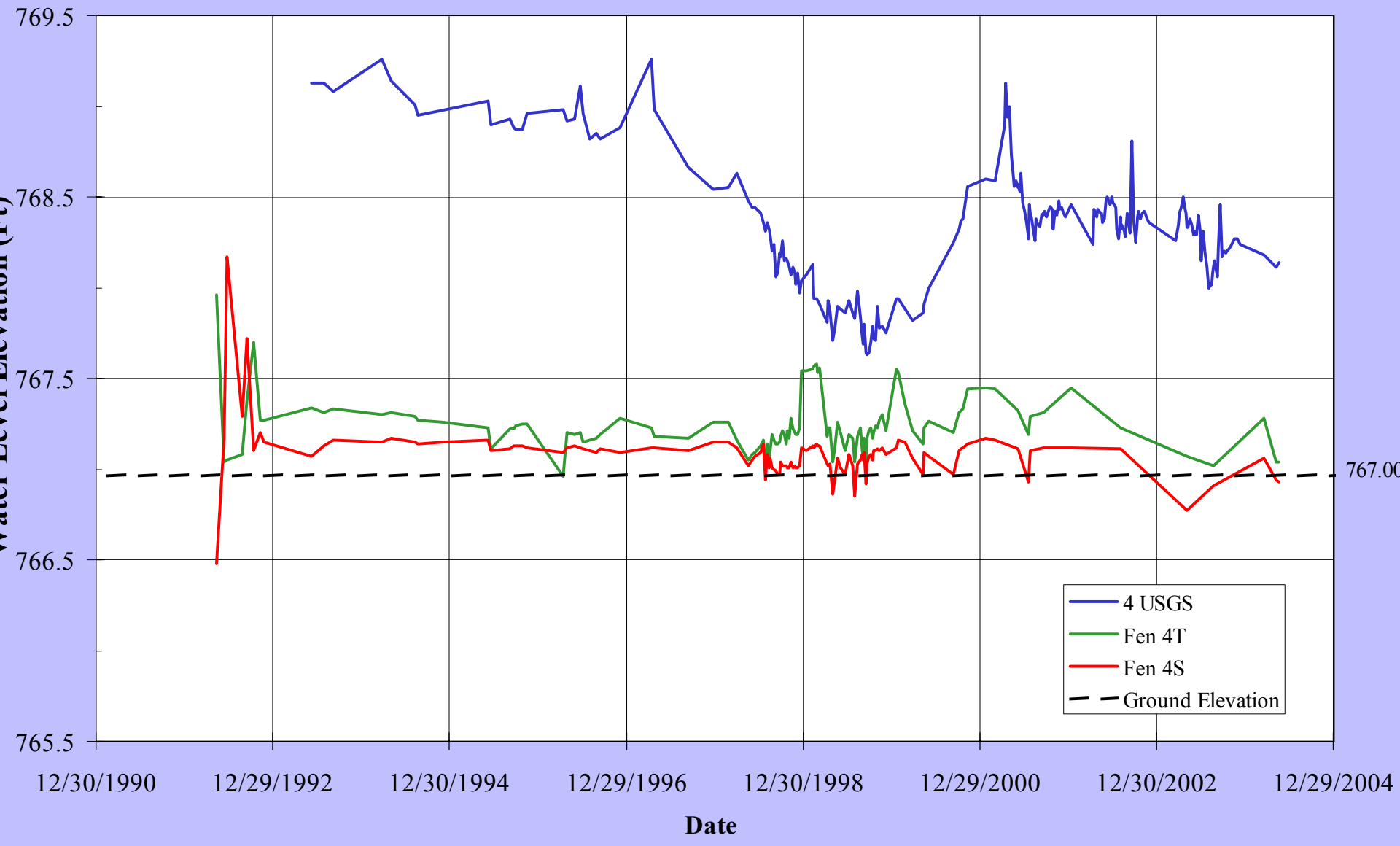
Possible Solutions

- Accelerated end date
- Backfilling


Current Mining Conditions
N
Monitoring Wells
Ottawa Fen
Mine Outline
1000
0
1000 Feet
Mine Well
Steel N
USGS 4


USGS 4, Steel North & Mine Well
Water Level Elev. Mine & N Steel (Ft)
Water Level Elev. USGS 4 (Ft)
770.00
765.00
760.00
755.00
750.00
745.00
740.00
735.00
770.00
769.00
768.00
767.00
766.00
765.00
764.00
12/30/1990
12/30/1994
12/30/1998
12/30/2002
Date
Mine Well
Steel N
USGS 4

Ottawa Fen - Nest 4 Wells



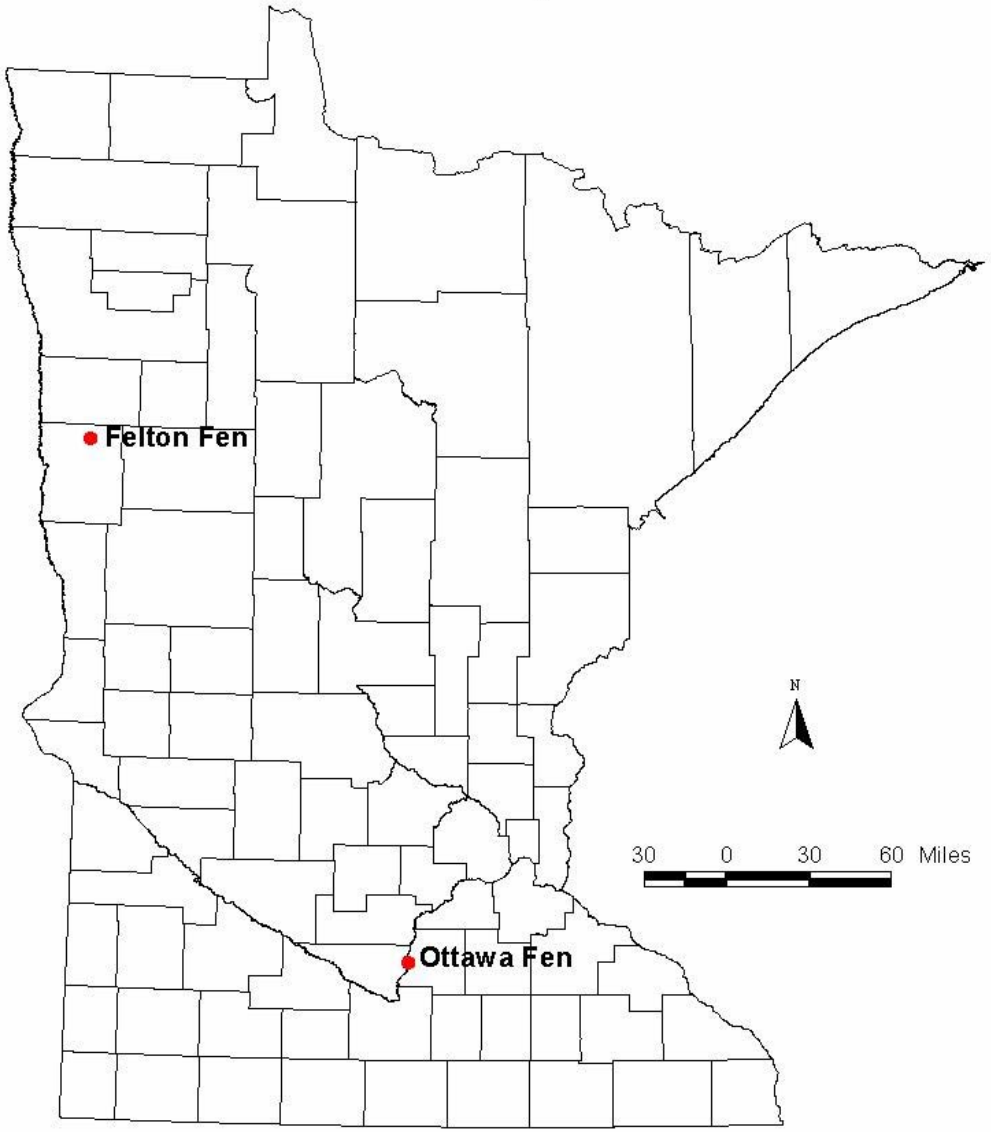
Impacts to the Fen

- Head loss as of 5/18/04
  - 769.14 - 768.11 = 1.03’
    - (1.03 / 2.16) * 100% = 48%

Summary

- Modeling
- Monitoring
- Long-term solutions
- Recovery?

Case Study Sites



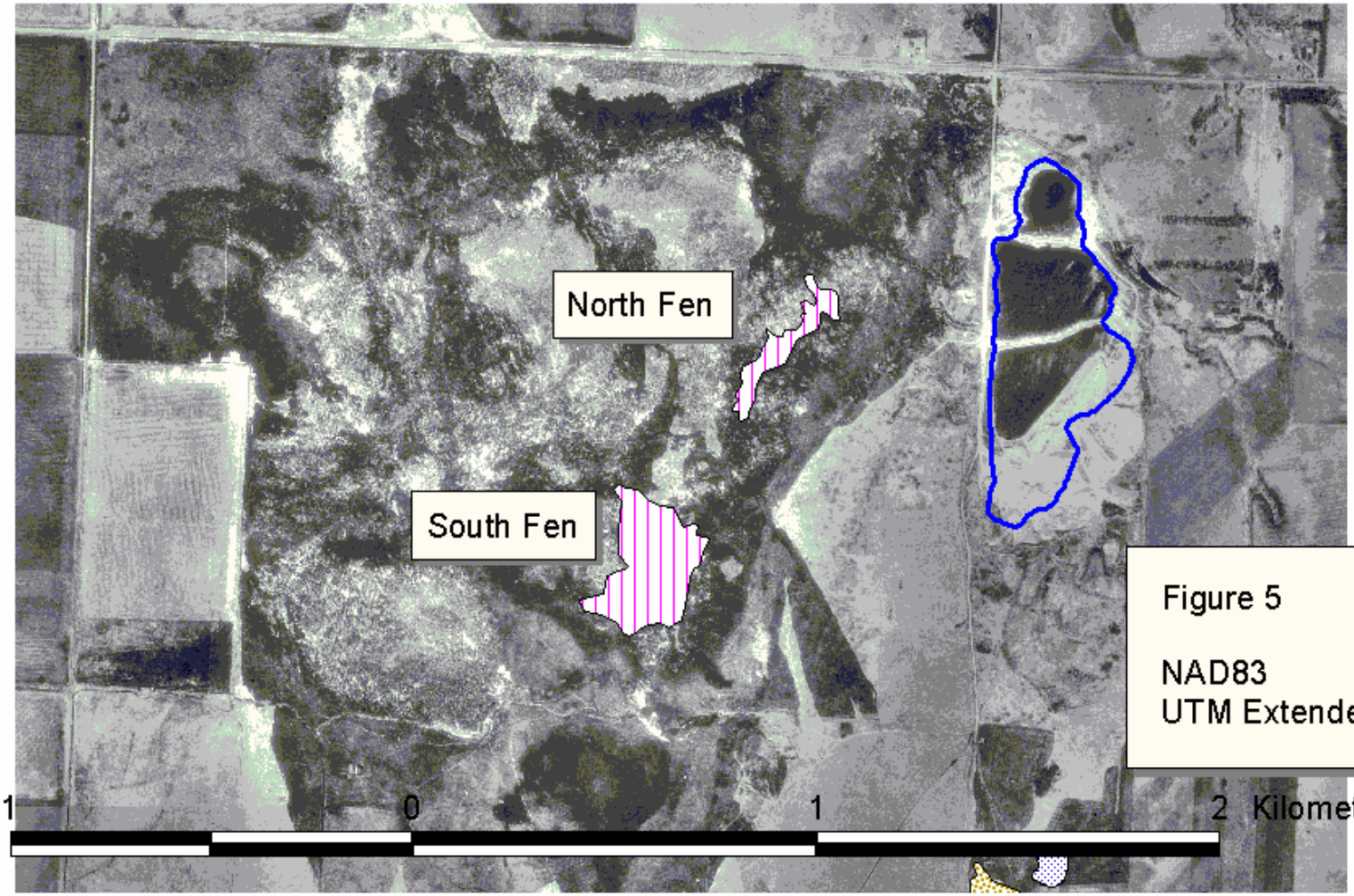
Felton Fen

A Conflict in Natural Resources Management.

Background

- In 1959 mining started on a state trust fund parcel under a State of Minnesota lease.

Felton Prairie Fen Air Photo

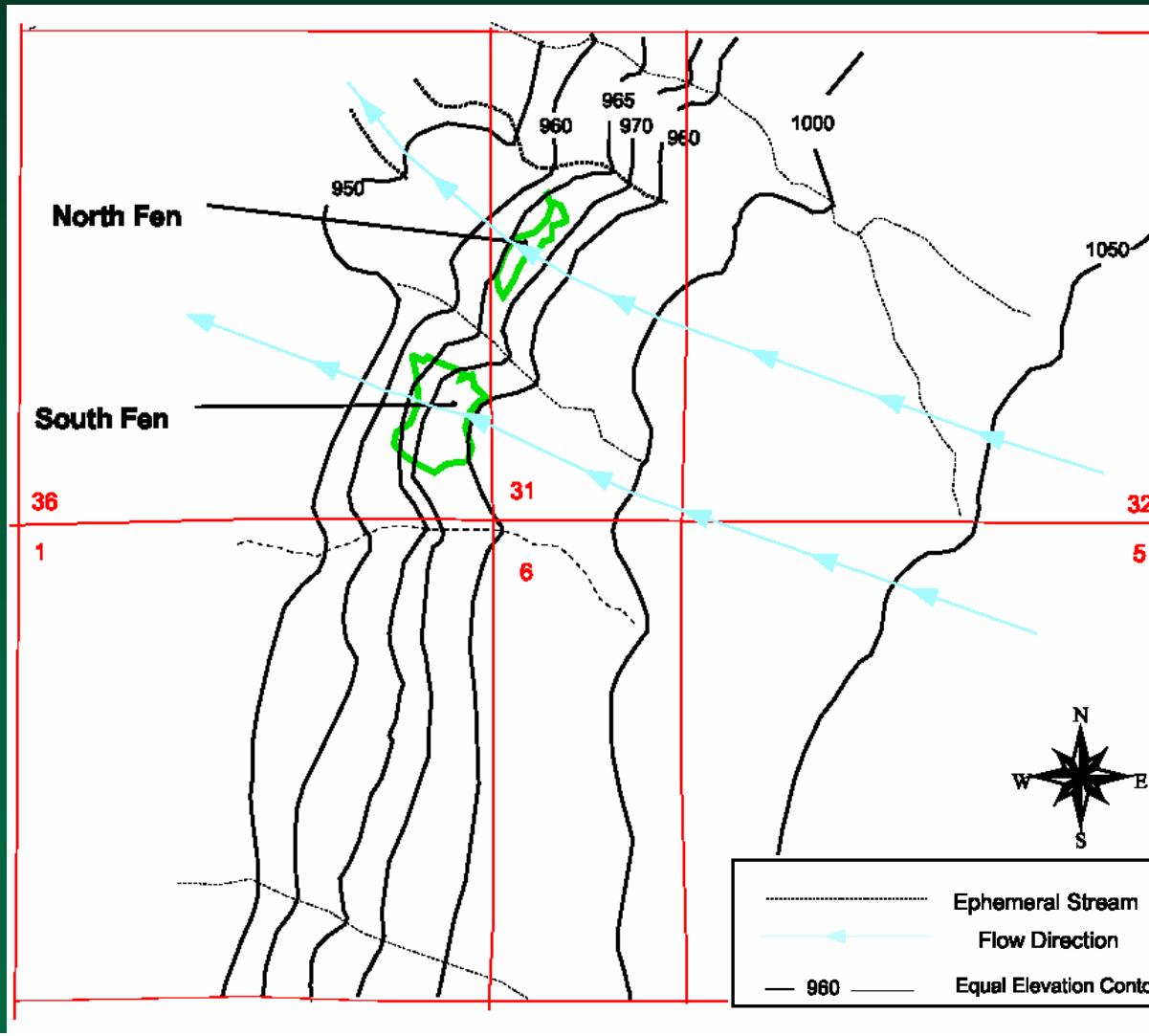


Area of Conflict.

- Significant sand and gravel resources on the site
- Rare calcareous fens
- High quality remnant native prairie

Premining Conditions

- Ground water flow east to west
- Perpendicular to topography
- Extensive native prairie



Site Studies

- DNR Waters hydrologic study
- DNR Minerals LCMR rotosonic study

DNR Waters Study

- Beginning 1995, because of concerns over the health of the calcareous fens, DNR Division of Waters begins a hydrologic investigation of the fens downgradient of the gravel pit.

Felton Prairie Fen Well Locations

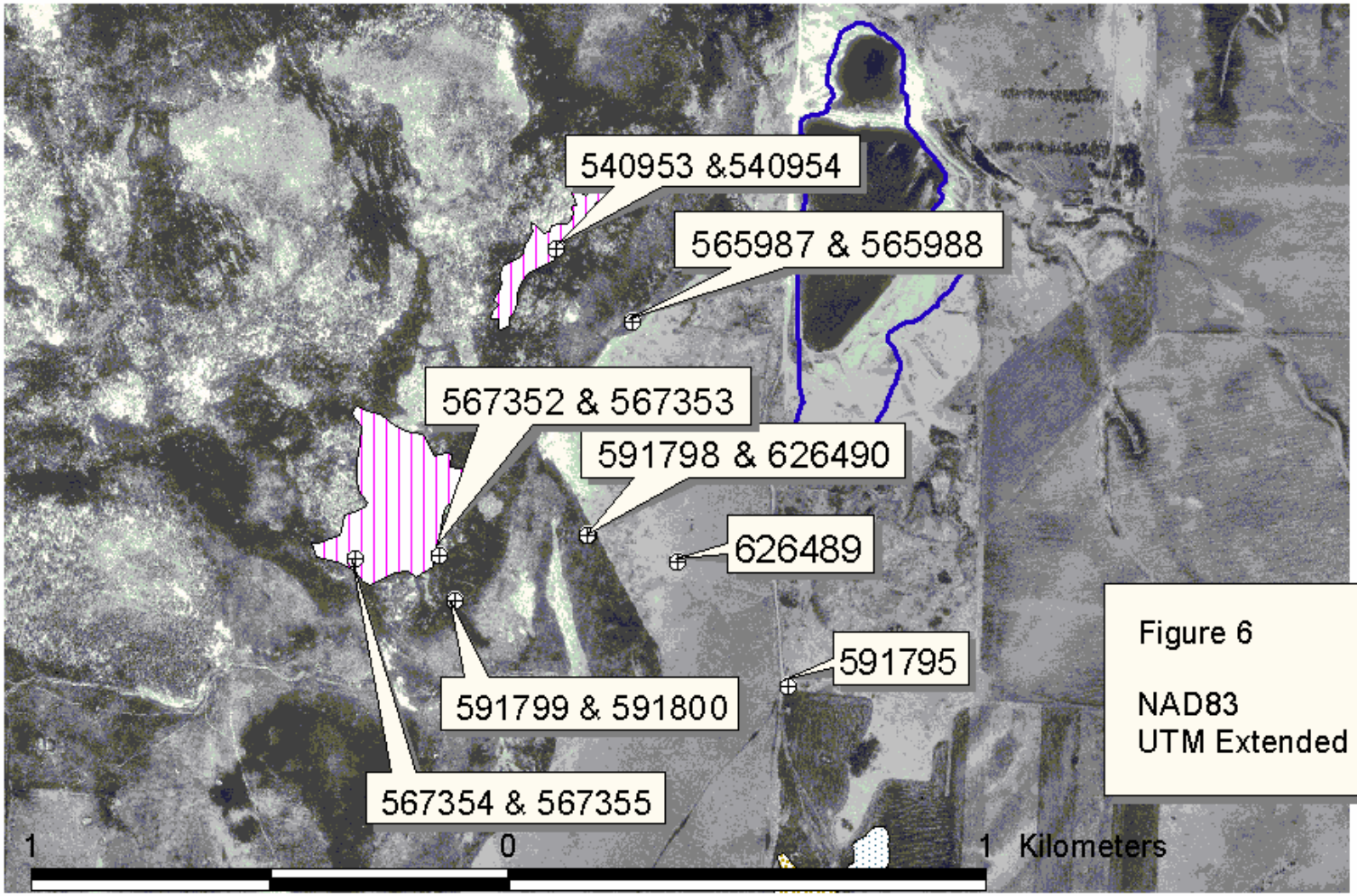


Figure 6

NAD83
UTM Extended zone 15

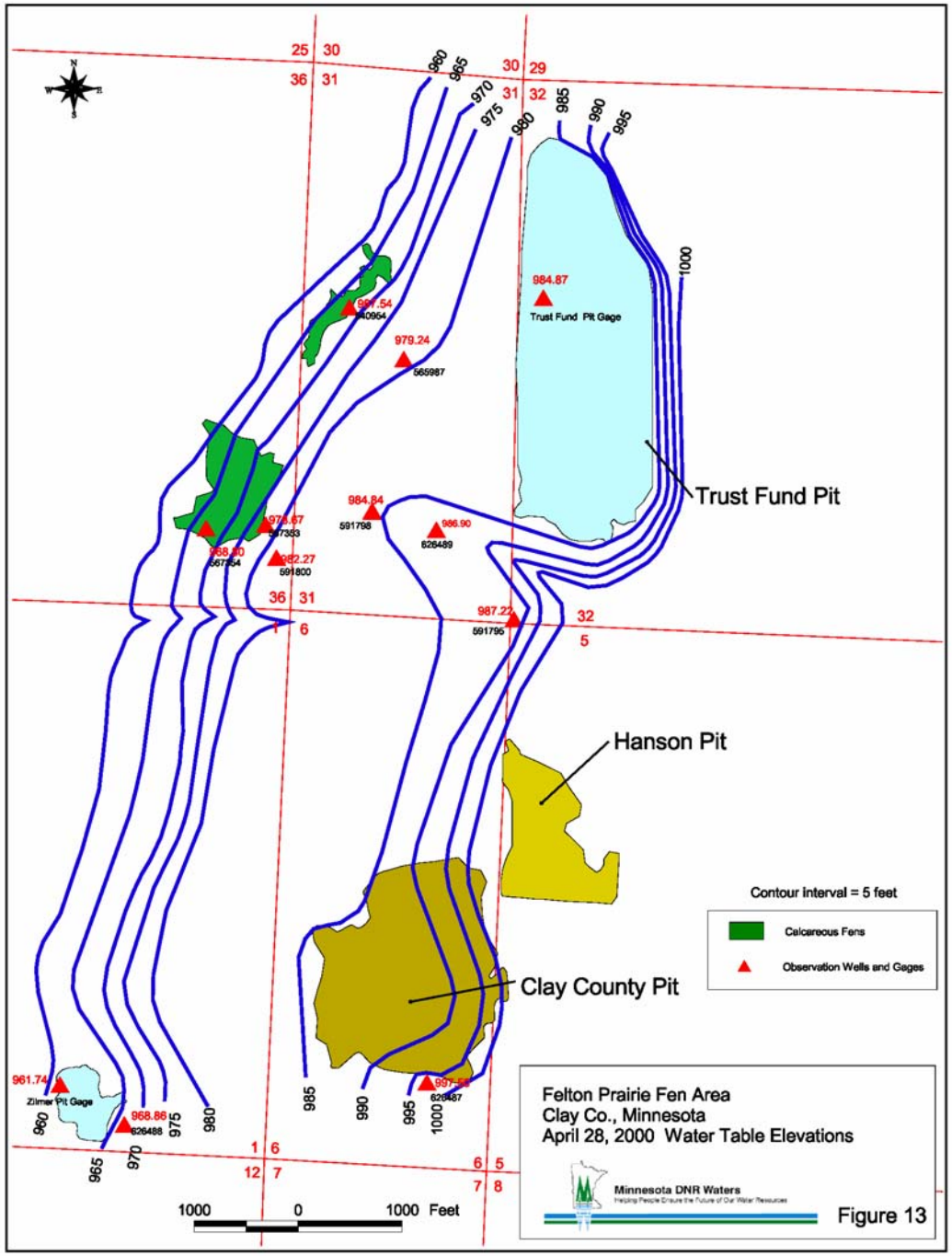
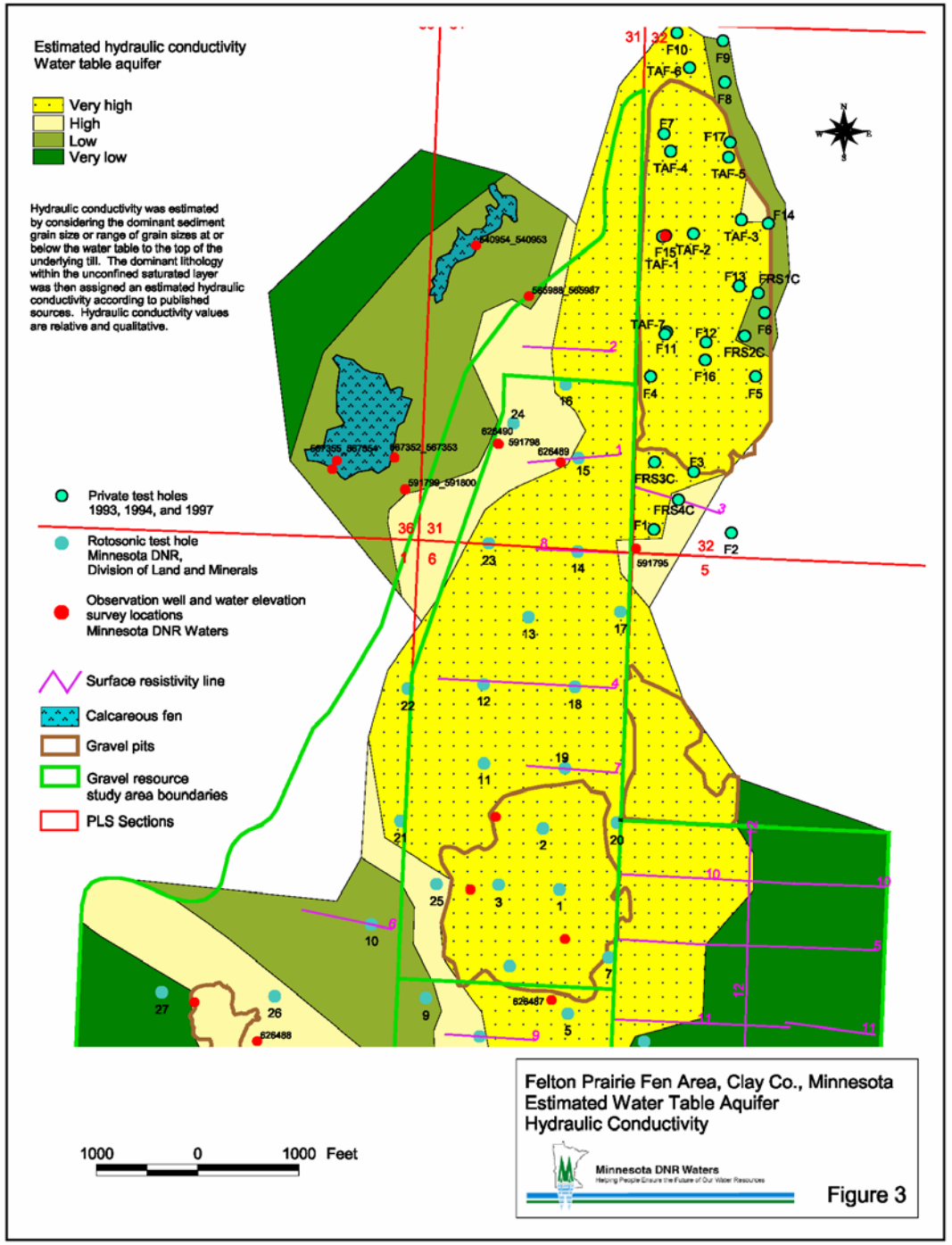
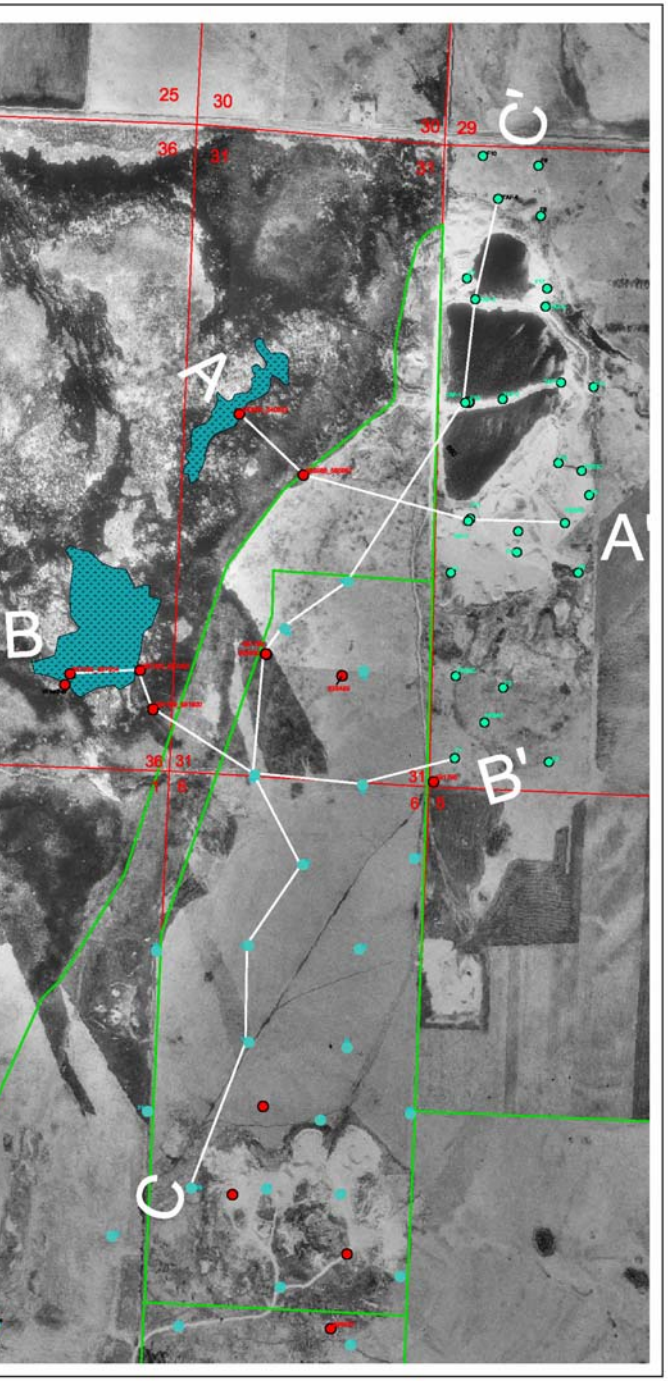

984.87
Trust Fund Pit Gage
Trust Fund Pit
Hanson Pit
Clay County Pit
Contour interval = 5 feet
Calcareous Fens
Observation Wells and Gages
Felton Prairie Fen Area
Clay Co., Minnesota
April 28, 2000 Water Table Elevations
Minnesota DNR Waters
1000 0 1000 Feet

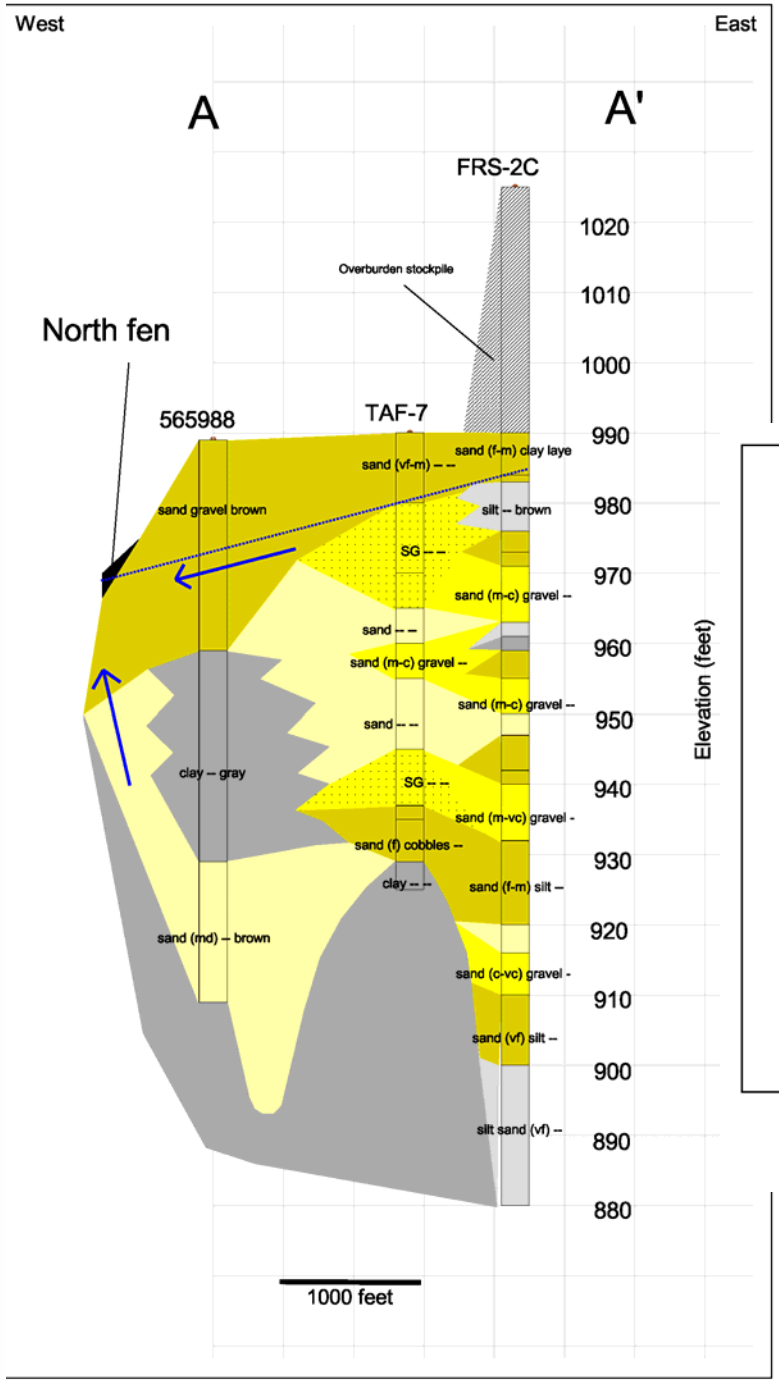
Figure 13

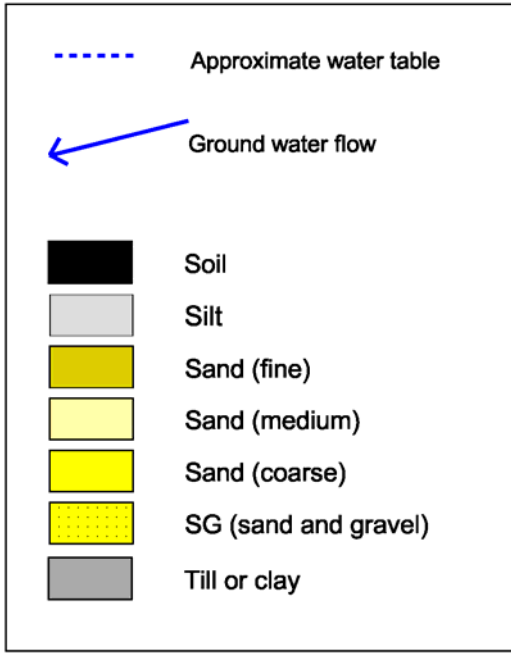
DNR Minerals Study

- LCMR funded rotosonic drilling to evaluate mineral potential in unmined areas of the site
- Coordinated with DNR Waters geophysical work


Estimated hydraulic conductivity
Water table aquifer
Very high
High
Low
Very low
Hydraulic conductivity was estimated by considering the dominant sediment grain size or range of grain sizes at or below the water table to the top of the underlying till. The dominant lithology within the unconfined saturated layer was then assigned an estimated hydraulic conductivity according to published sources. Hydraulic conductivity values are relative and qualitative.
Private test holes 1993, 1994, and 1997
Rotosonic test hole Minnesota DNR, Division of Land and Minerals
Observation well and water elevation survey locations Minnesota DNR Waters
Surface resistivity line
Calcareous fen
Gravel pits
Gravel resource study area boundaries
PLS Sections
1000 0 1000 Feet
Felton Prairie Fen Area, Clay Co., Minnesota
Estimated Water Table Aquifer
Hydraulic Conductivity
Minnesota DNR Waters
Figure 3



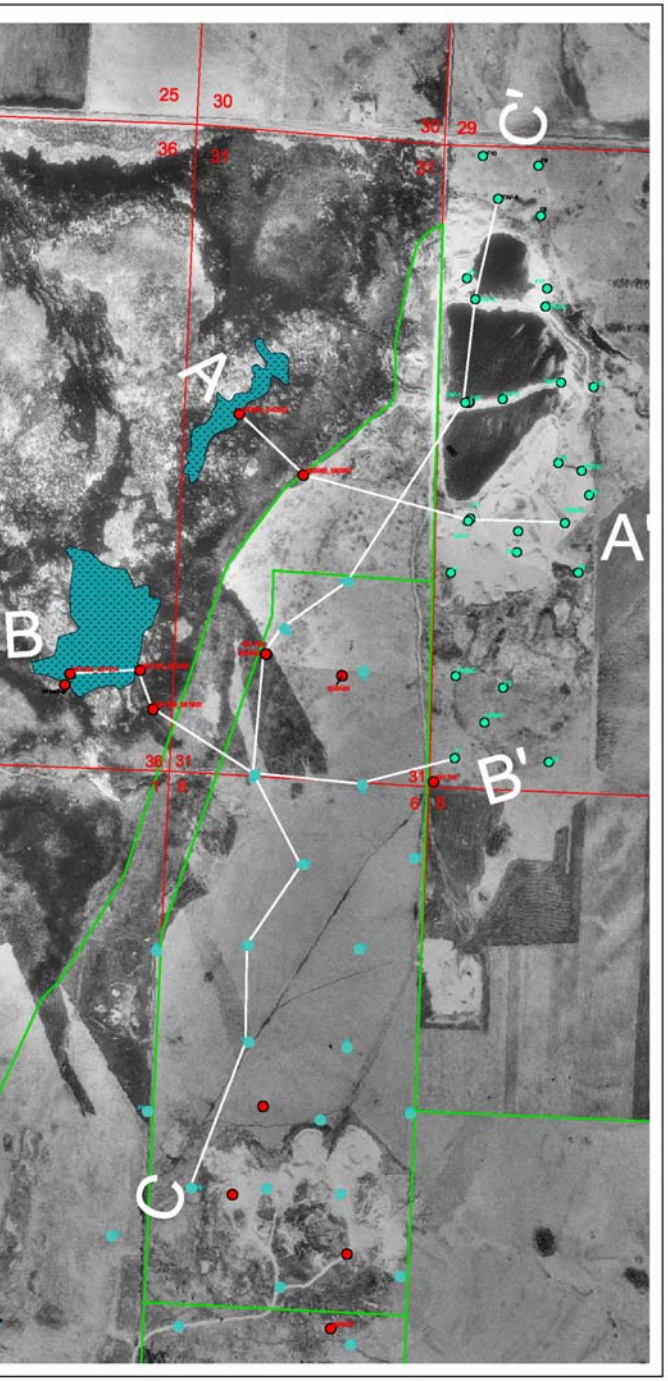




Vertical Exageration = 50X

Minnesota DNR Waters
Helping People Ensure the Future of Our Water Resour

d:/Clay/Felton/Felton.apr, Xseclayout
Jim Berg 2/01



West

East

B

B'

South fen

F-1

DNR-14

DNR-23

591800

567353

567355

1020

1010

1000

990

980

970

960

950

940

930

920

910

900

sand (f) -- --

S&G silty brn

Sand (f) clean brn

sand (m-c) gravel --

S&G clean gry

SG -- --

S&G clean brn

peat -- black

sand (vf) -- --

sand (f) -- gray

clay -- --

Cobbley S&G silty gr

sand (vc) gravel --

sand (vc) gravel --

Till -- drk gry

Sandy Till silty gry

Till -- drk gry

1000 feet

Approximate water table

Ground water flow

Soil

Silt

Sand (fine)

Sand (medium)

Sand (coarse)

SG (sand and gravel)

Till or clay

Vertical Exageration = 50X

Minnesota DNR Waters

Helping People Ensure the Future of Our Water Resour

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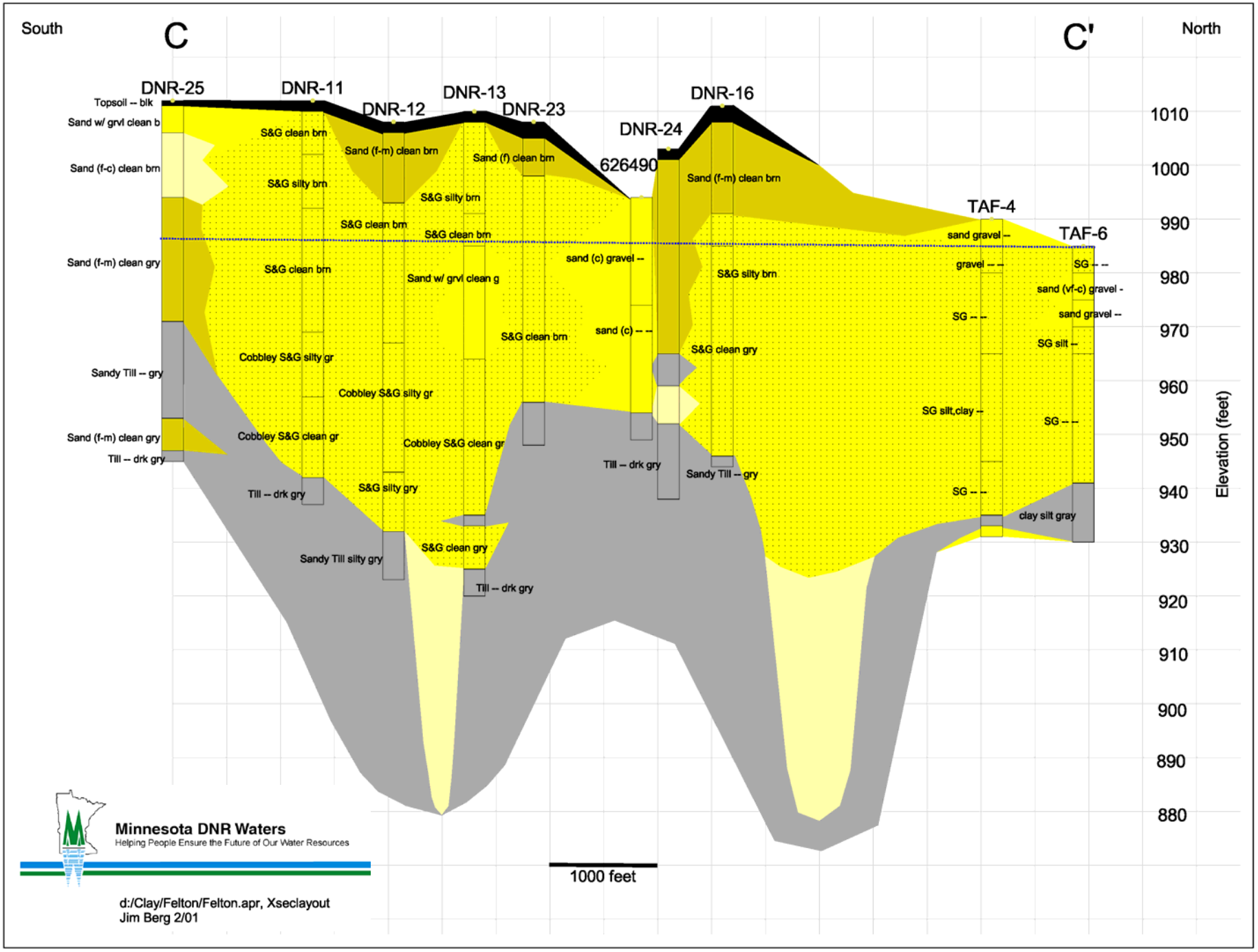
Jim Berg 2/01


South
C
C'
North
DNR-25
DNR-11
DNR-12
DNR-13
DNR-23
DNR-24
626490
DNR-16
TAF-4
TAF-6
Topsoil -- blk
Sand w/ grvl clean b
Sand (f-c) clean brn
Sand (f-m) clean gry
Sandy Till -- gry
Sand (f-m) clean gry
Till -- drk gry
S&G clean brn
S&G silty brn
S&G clean brn
Cobbley S&G silty gr
Cobbley S&G clean gr
Till -- drk gry
Sandy Till silty gry
Sand (f-m) clean brn
S&G silty brn
S&G clean brn
Sand w/ grvl clean g
Cobbley S&G silty gr
Cobbley S&G clean gr
S&G silty gry
S&G clean gry
Till -- drk gry
Sand (f) clean brn
S&G clean brn
Till -- drk gry
sand (c) gravel --
sand (c) -- --
Sand (f-m) clean brn
S&G silty brn
S&G clean gry
Sandy Till -- gry
sand gravel --
gravel -- --
SG -- --
SG silt,clay --
SG -- --
clay silt gray
SG -- --
sand (vf-c) gravel -
sand gravel --
SG silt --
1010
1000
990
980
970
960
950
940
930
920
910
900
890
880
Elevation (feet)
1000 feet
Minnesota DNR Waters
Helping People Ensure the Future of Our Water Resources
d:/Clay/Felton/Felton.apr, Xseclayout
Jim Berg 2/01

Modeling Efforts

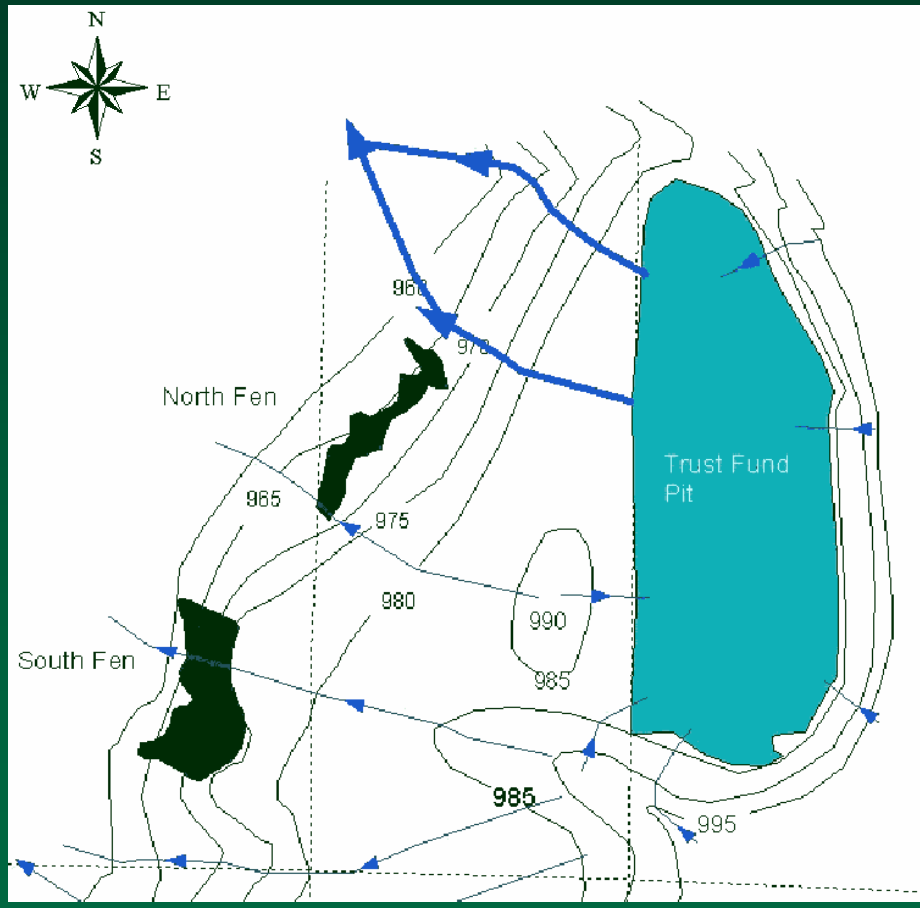
- Computer modeling
  - Geology too complex for existing models
  - Failed to recreate existing conditions
- Traditional flow net modeling

Impacts

- Water level decrease of 15 feet
- Increased gradient between pit and county ditch to 100’/Mile
- Water level decrease beneath the fen.
- Change in vegetation

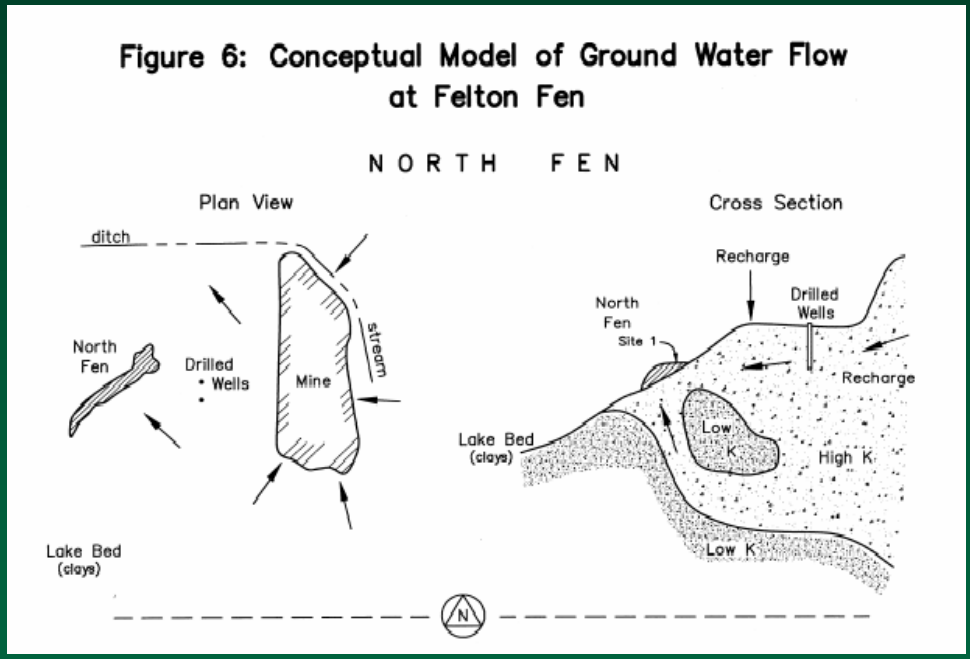
Effects of Mining

- Radial flow along south and west edge.
- Water level contours pulled to the east.
- Removed a large portion of the North Fen recharge area.



Conceptual Model

- Fen fed by both near-surface and deeper ground water



Mitigation Efforts

- Limit further mining on State Trust Fund property
- Limit spatial extent of additional gravel pits
- Backfill portions of the State Trust Fund pit

Summary

- Most heavily studied site in northern Minnesota.
- Effects on local ground water resources.
- Effects on calcareous fens.
- Difficulty of managing these areas.