Environmental Programs

OVERVIEW OF CAMP EDWARDS F&T MODELING ACTIVITIES FOR DEMOLITION AREA 1

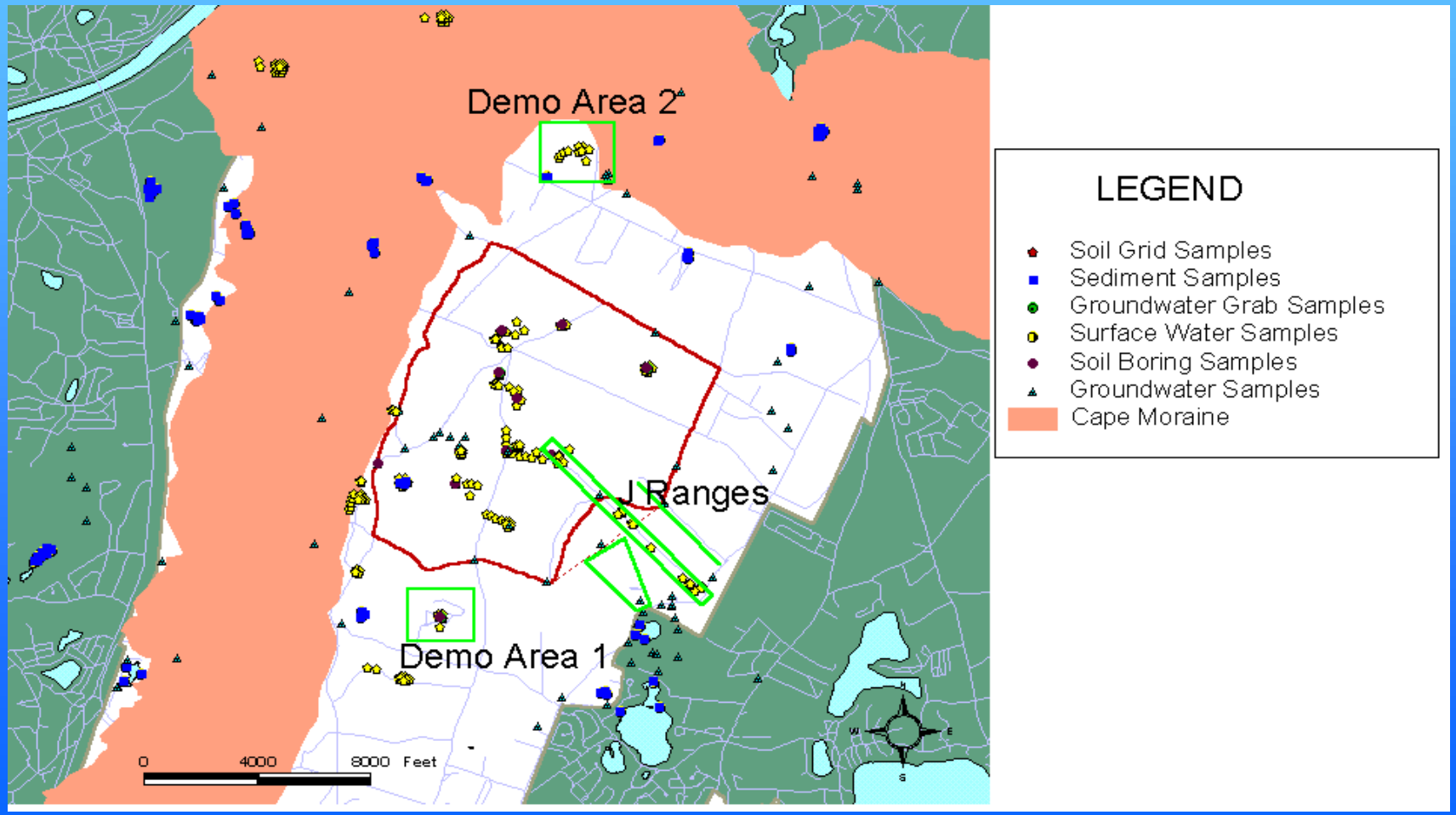
Jay Clausen, Diane Curry, Tod Monks, Jacob Zaidel (AMEC)

Presented to NGB, USGS, USEPA, MADEP, USACE & Jacobs Eng. on 8/28/01(IAGWSPO Contact Dave Hill, 508-968-5621).

HISTORICAL OVERVIEW

- Submitted Draft Model Selection Document - 07/22/99
- Submitted Final Model Selection Document - 05/16/00
- Modeling Summit w/AEC, WES, Jacobs, USGS, DEP, EPA - 09/19/00
- Submitted Draft Modeling Strategy Document - 03/26/01
- Modeling Meeting w/AEC, WES, Jacobs, USGS, DEP - 04/03/01
- Ongoing Modeling Meetings/Discussions w/USGS, WES, AEC, Jacobs

DEMO 1 LOCATION



MAJOR SOURCES OF INFORMATION

- USGS Regional Model, Reports, and Discussions
- AMEC/OGDEN Reports
- Jacobs Engineering Group Inc. Reports
- JPO/Water-Supply Reports
- MMR Related Technical Papers and Articles

MODELING OBJECTIVES

- Primary Objectives
  - Develop Sub-Regional F&T Model(s) for Demo 1 Using MODFLOW and MT3D in GMS
  - Calibrate F&T Model to Present Steady-State Conditions for RDX
  - Predict F&T of RDX from (Past to Present) and (Present to Future, i.e. 30 years)
  - Identify Present Impacts on Groundwater Flow and Contaminant Transport Due to Water-Supply Wells

MODELING OBJECTIVES (cont.)

- Related Tasks

  - Conduct Sensitivity Analysis to Quantify the Uncertainty in Calibrated Model(s) Caused by Uncertainty in the Estimates of Aquifer Parameters and Transport Parameters
  - Utilize Model for Assessing Remedial Options
  - Utilize Model for Engineering Design
  - Document Demo 1 Modeling Approach, Results, and Conclusions

MODEL CODES

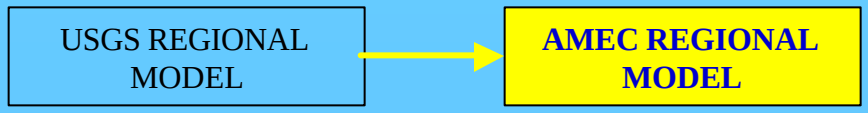
- MODFLOW (Flow)
- MT3D (Transport)

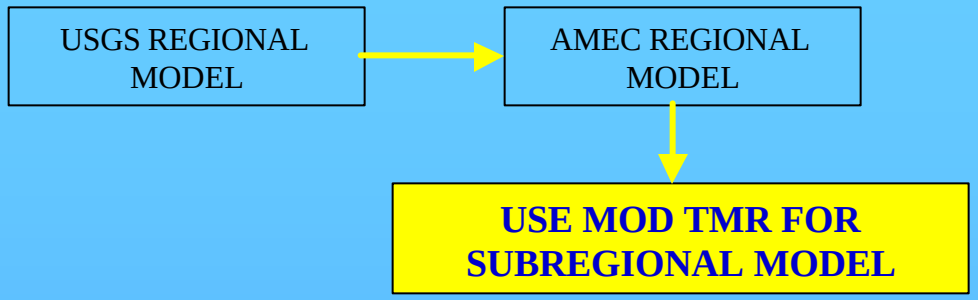
MODELING CHALLENGES

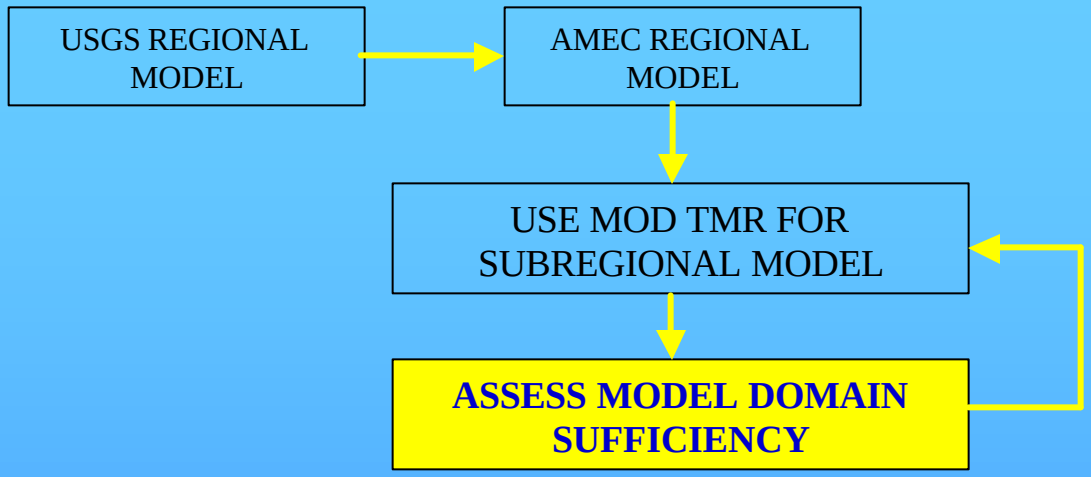
- Conversion From USGS Data Format to GMS Format Requirements
- Modifications of Regional USGS Model
- Development of Software Program to Facilitate Data Format Conversion From GMS to TECPLOT and GIS
- Transport Simulations (Three Models)
- Size of Subregional Model
  - Recompiled MODFLOW, MODPATH and MT3D Source Code
  - Upgrade of Computers
  - Development of FTP Site

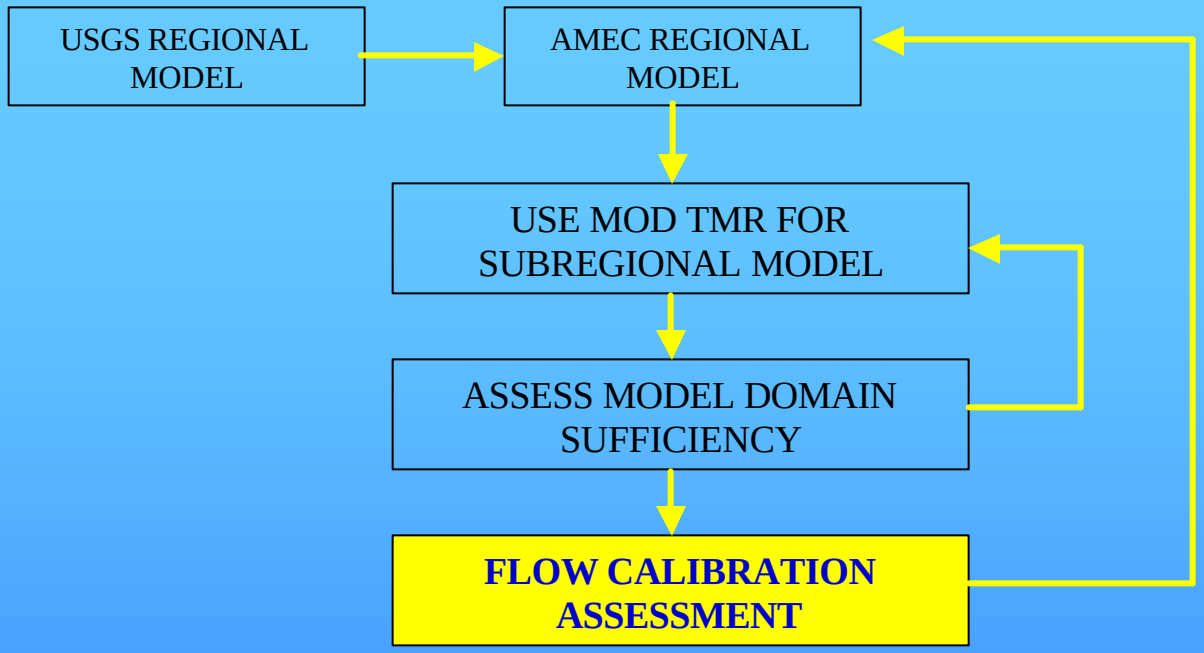
MODELING PROCESS

USGS REGIONAL MODEL


USGS REGIONAL MODEL
AMEC REGIONAL MODEL


USGS REGIONAL MODEL
AMEC REGIONAL MODEL
USE MOD TMR FOR SUBREGIONAL MODEL


USGS REGIONAL MODEL
AMEC REGIONAL MODEL
USE MOD TMR FOR SUBREGIONAL MODEL
ASSESS MODEL DOMAIN SUFFICIENCY


USGS REGIONAL MODEL
AMEC REGIONAL MODEL
USE MOD TMR FOR SUBREGIONAL MODEL
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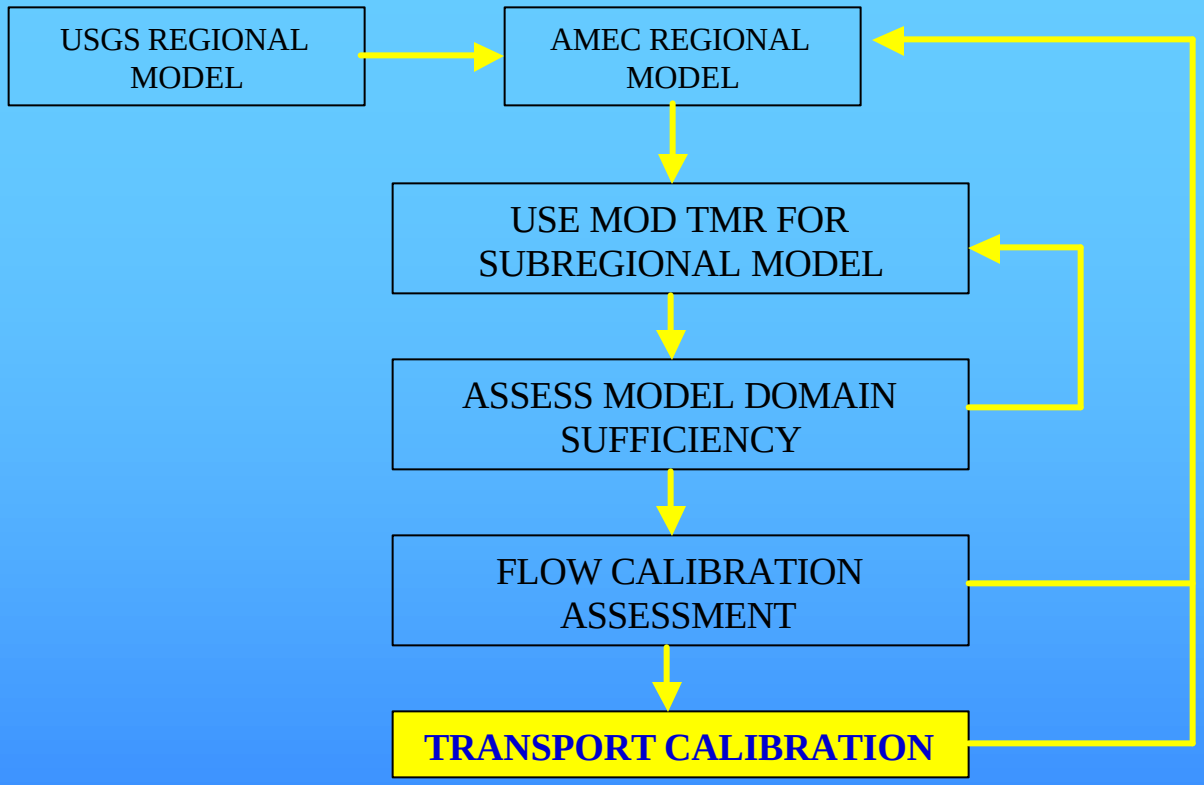
FLOW CALIBRATION ASSESSMENT


USGS REGIONAL MODEL
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USE MOD TMR FOR SUBREGIONAL MODEL
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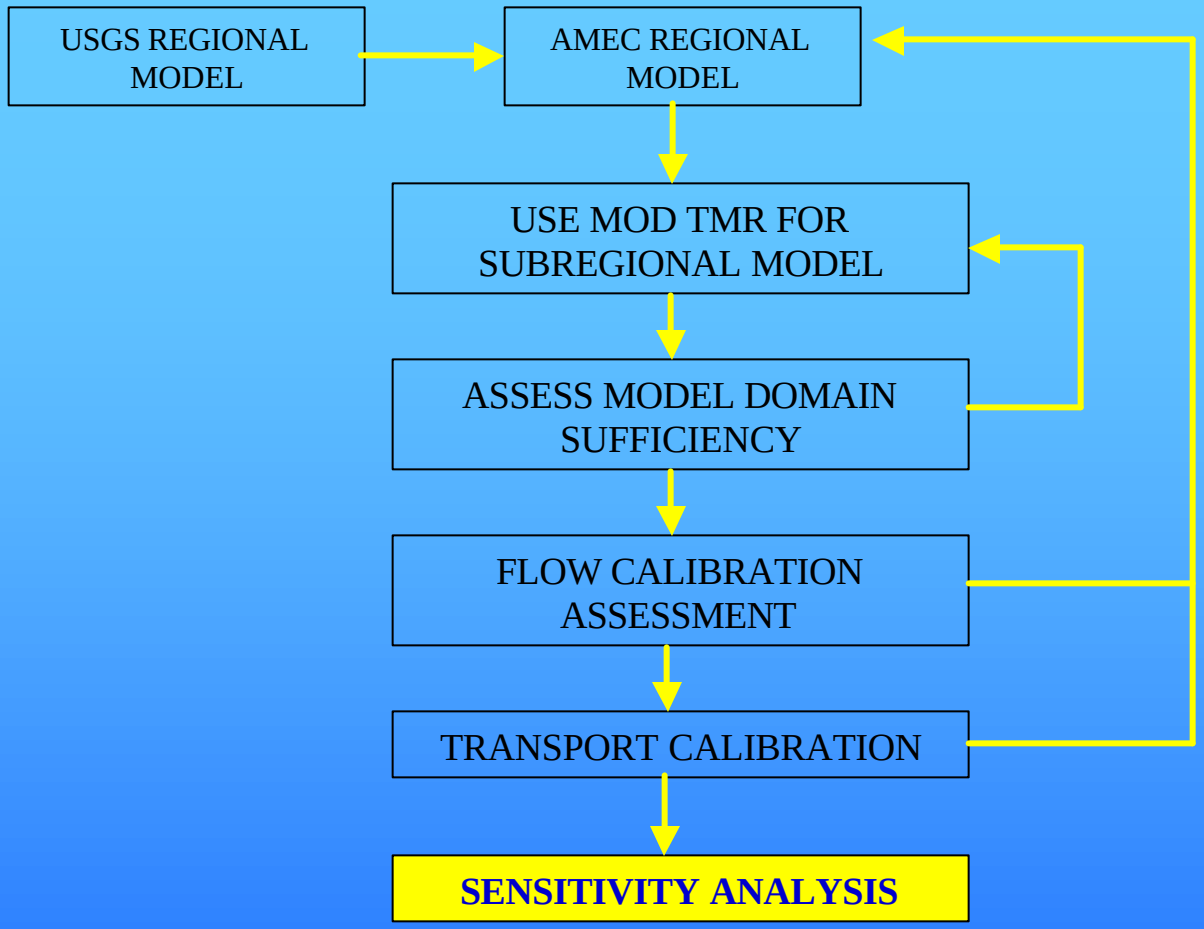
FLOW CALIBRATION ASSESSMENT
TRANSPORT CALIBRATION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AMEC REGIONAL MODEL
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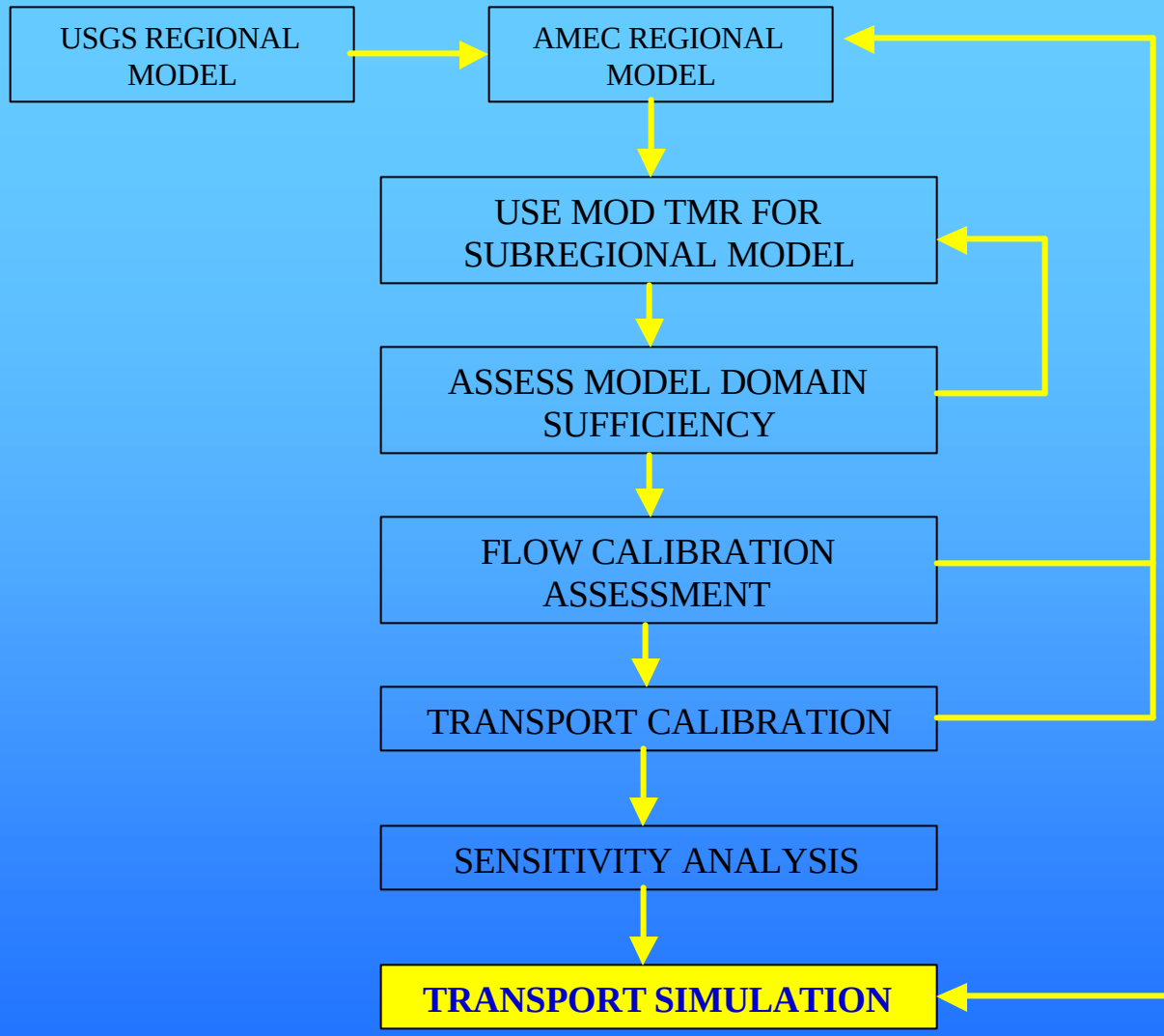
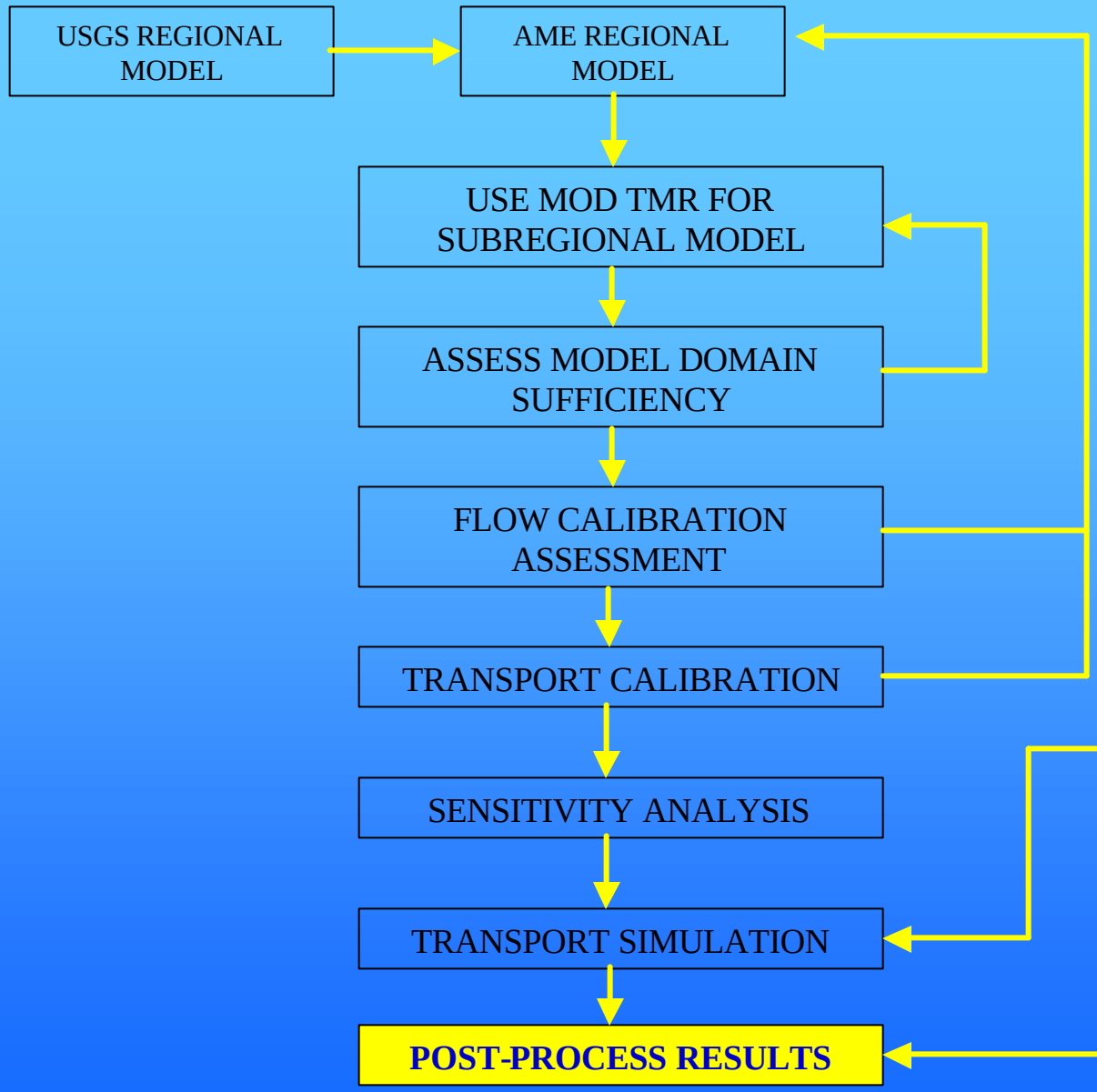
FLOW CALIBRATION ASSESSMENT
TRANSPORT CALIBRATION
SENSITIVITY ANALYSIS



Typical Processing Time

MODFLOW -	**2 HOURS**
MODPATH -	**10 MINUTES**
MT3D -	**24+ HOURS**



Typical Processing Time

MODFLOW -	2 HOURS
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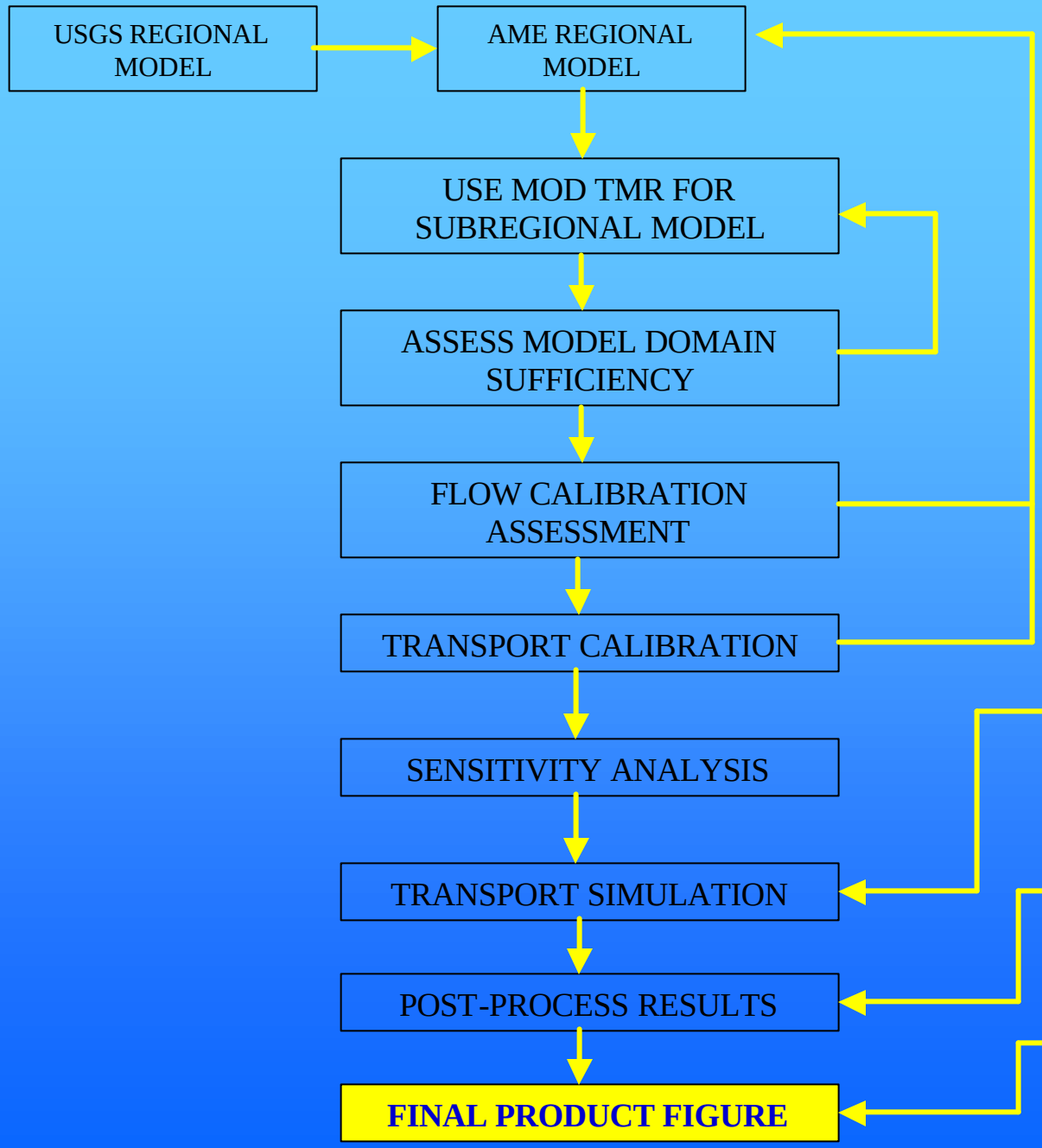
MT3D -	24+ HOURS

TEC PLOT -	**4 HOURS**
GIS - ARC INFO -	**4 HOURS**
3D ANALYST -	**4 HOURS**



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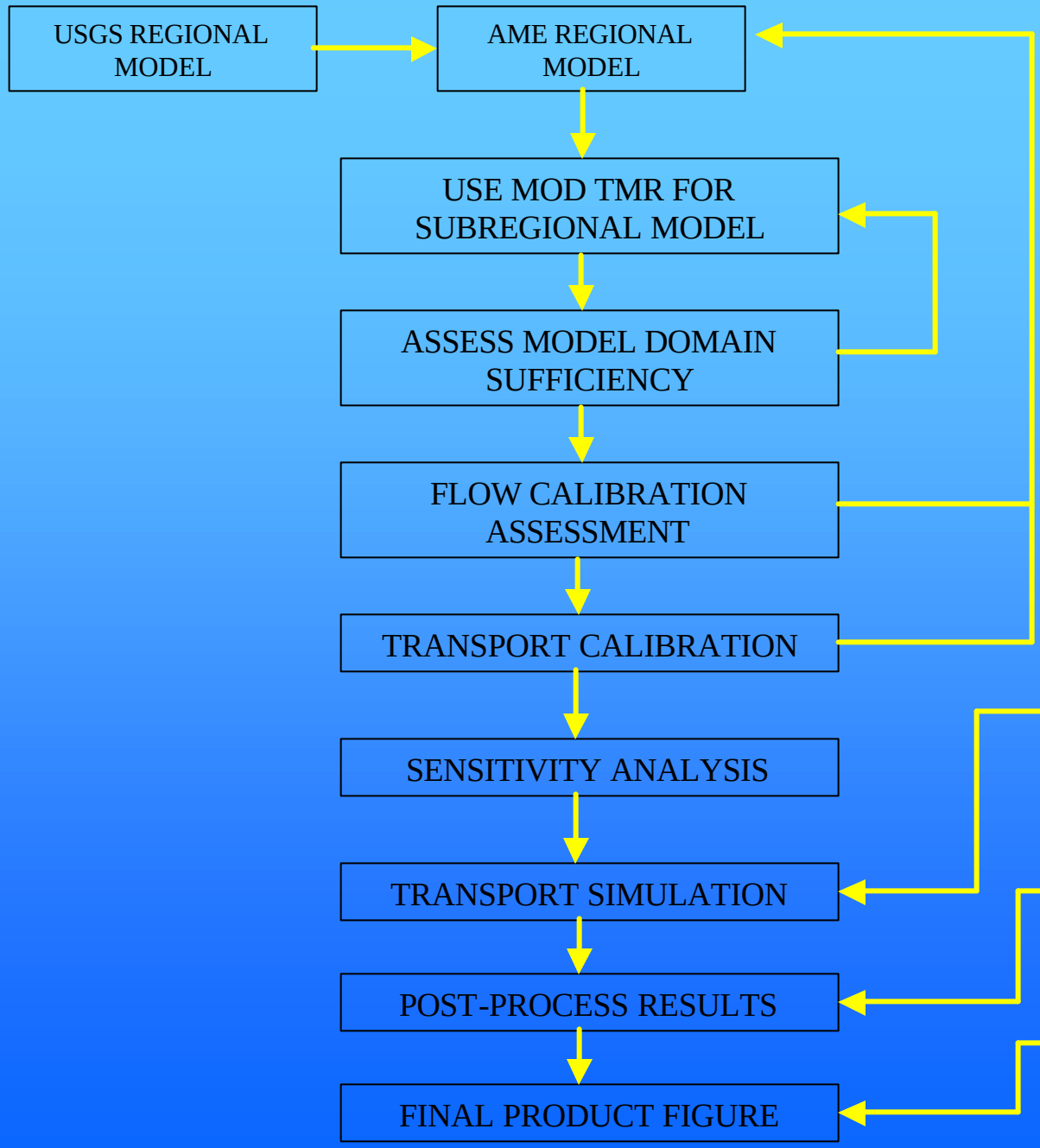

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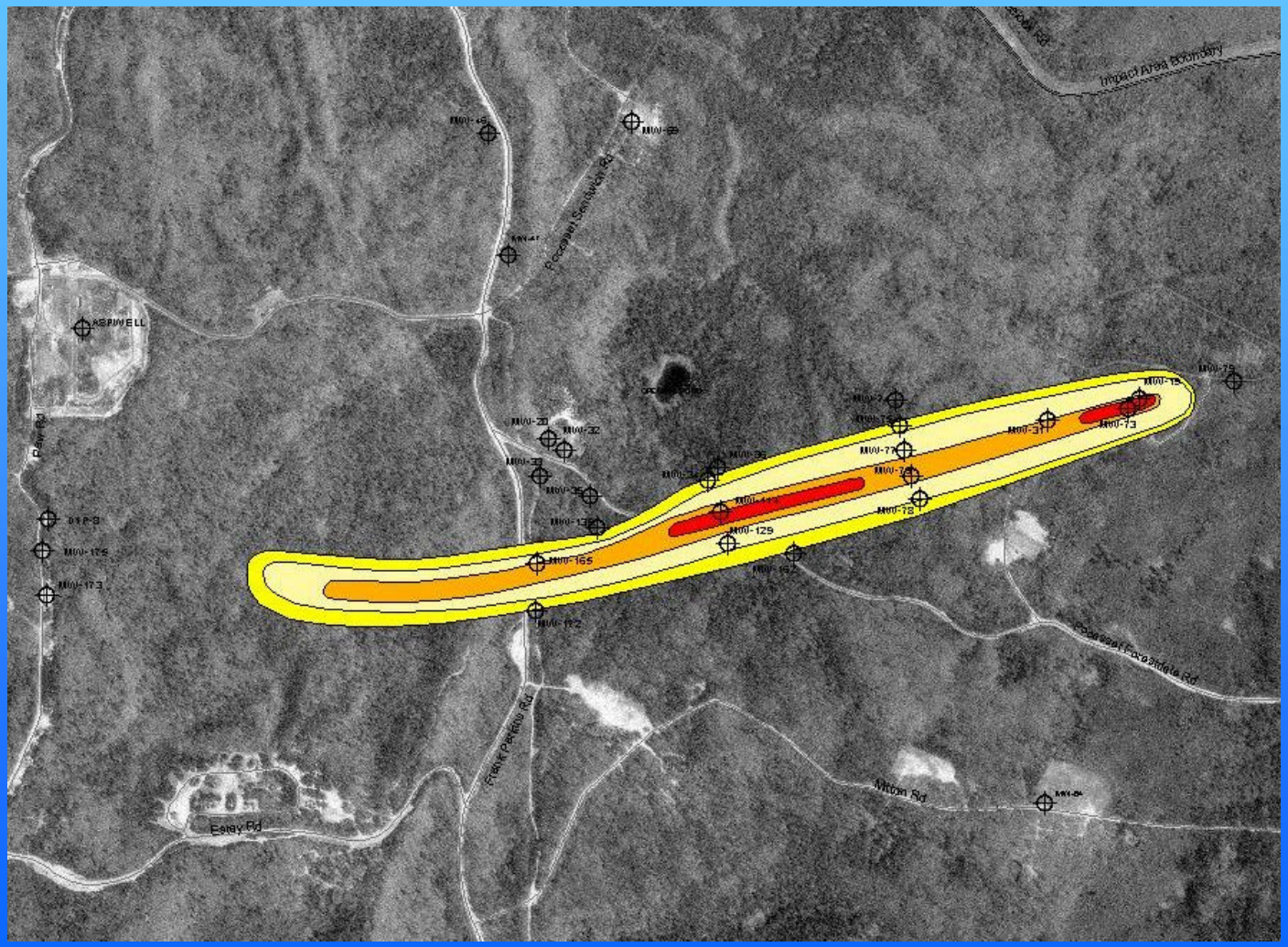
SATURATED ZONE MODELING SITE CONCEPTUAL MODEL

- Hydrogeologic Setting
- Present Extent of Contamination

SPECIFICS OF DEMO 1

- Downgradient (west) of Groundwater Mound
- Horizontal Flow Gradients Predominate
- Relatively High Hydraulic Conductivity Zone
- Downgradient Extraction System (Bourne WS)
- Flow Direction and Gradients Insensitive to Seasonal Fluctuations in Precipitation and Aquifer Recharge

RDX PLUME MAP



- 0.25 - 2 ug/L
- 2 - 50 ug/L
- 50 - 100 ug/L
- > 100 ug/L

SUMMARY OF REGIONAL MODEL MODIFICATIONS

Regional Model	Modifications	Importance for Demo 1 Area
MMR-6	Increased K-Values in Southern Half of BBM	High
MMR-7	Updated Depth to Rock in Central Impact Area, Demo 1 and J Ranges	Low
MMR-8	Improved Representation of the Snake, Weeks, Wakeby and Mashpee Ponds	Low

REGIONAL MODEL

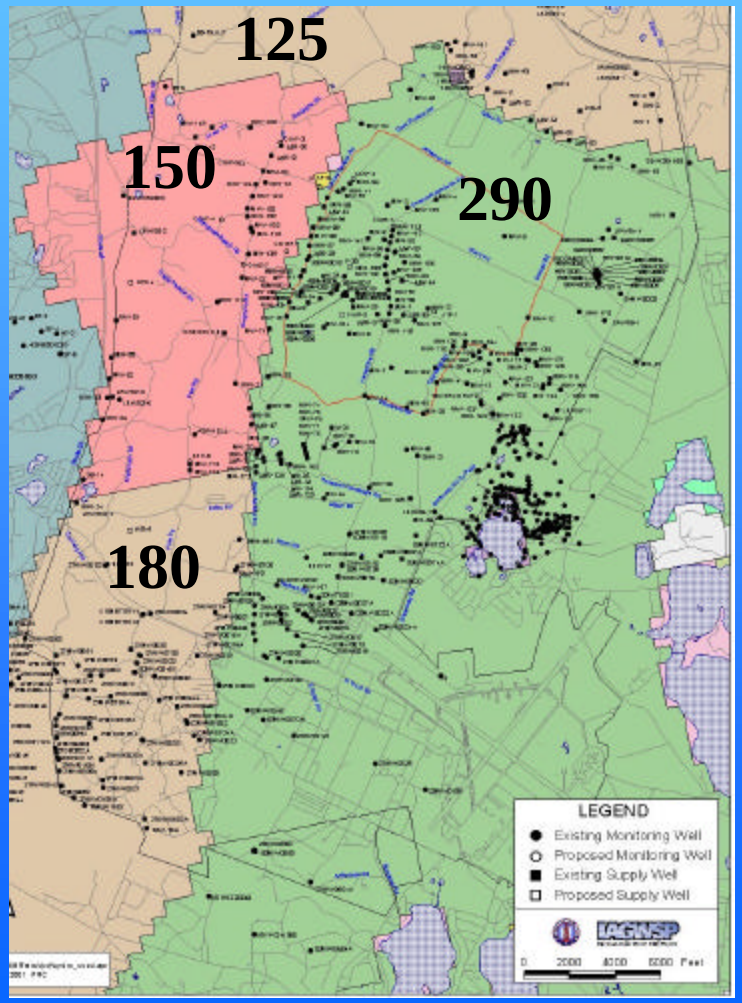
HYDRAULIC CONDUCTIVITY VALUES FOR DEMO 1 IN USGS MODEL

Model Layer	Elevation* (ft ngvd)	Range of K Values (ft/d)	K Values at Demo 1 (ft/d)
1	above 40	125 - 350	290
2	20 to 40	125 - 350	290
3	0 to 20	125 - 300	290
4	-20 to 0	100 - 290	290
5	-40 to -20	70 - 230	230
6	-60 to -40	70 - 230	230
7	-80 to -60	30 – 200	125
8	-100 to -80	10 - 125	70
9	-140 to -100	10 - 70	30
10	bedrock** to -140	10 - 70	30
11	NA	10 - 30	NA

*In the central portion; ** about -200 to -150 ft ngvd

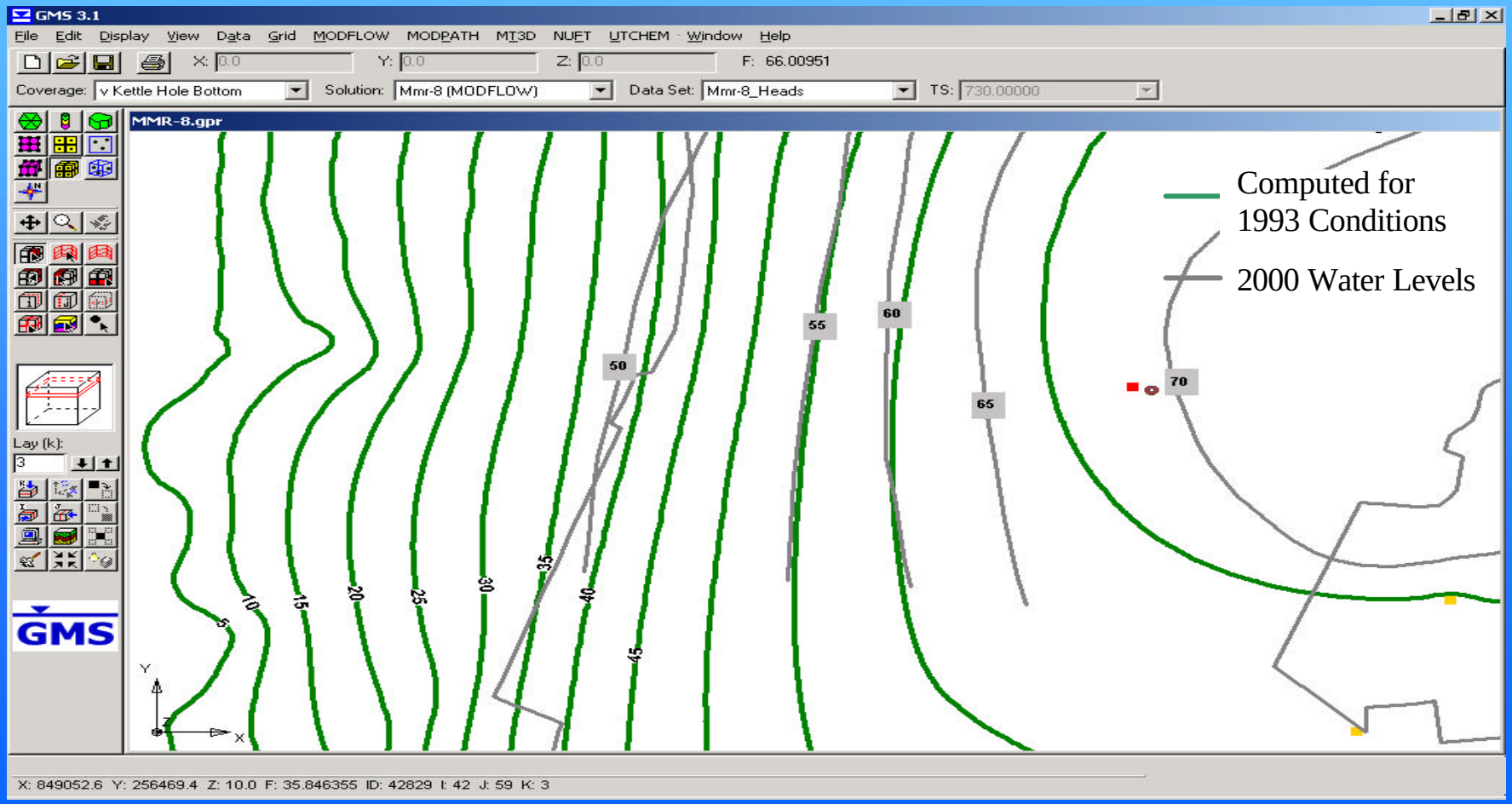
(based on USGS Regional Model)

DISTRIBUTION OF HYDRAULIC CONDUCTIVITY IN LAYER 1



(based on USGS Regional Model)

MEASURED 2000 WATER-LEVELS AND MODEL COMPUTED CONTOURS

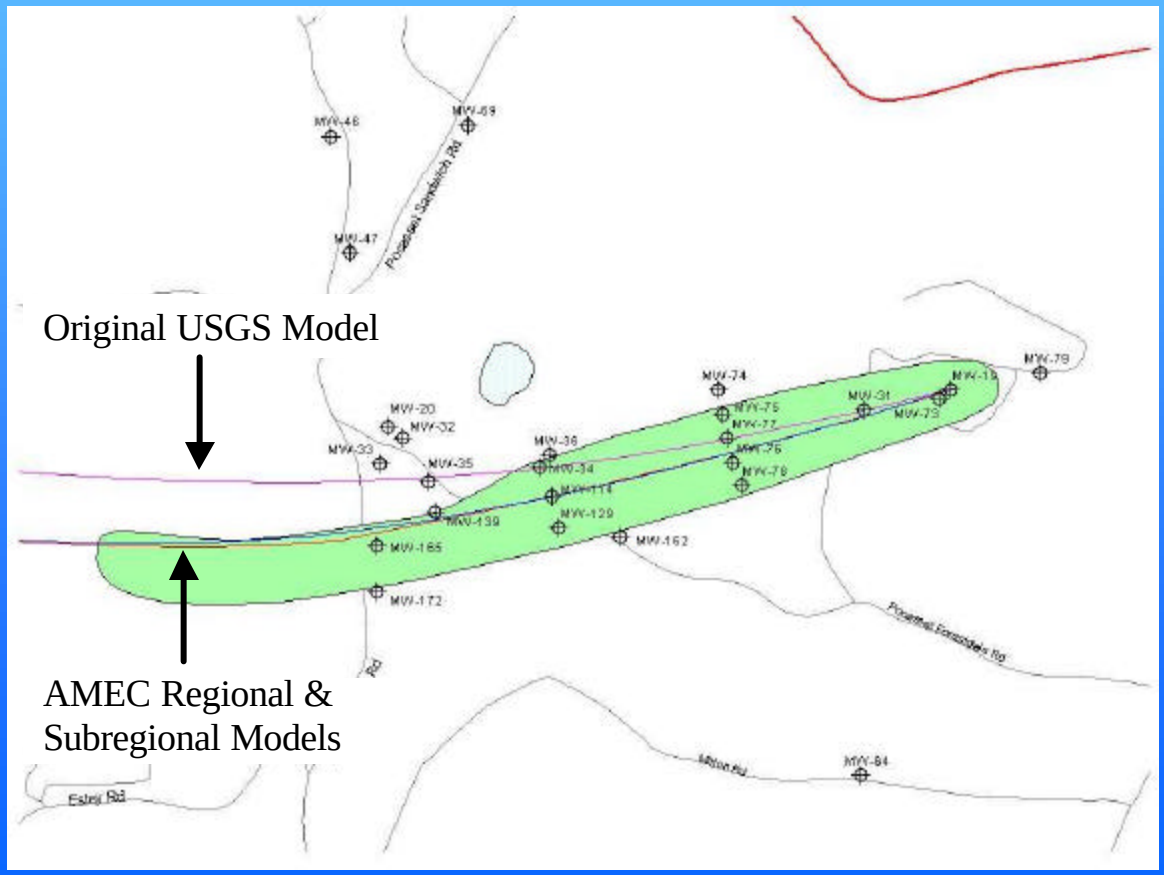


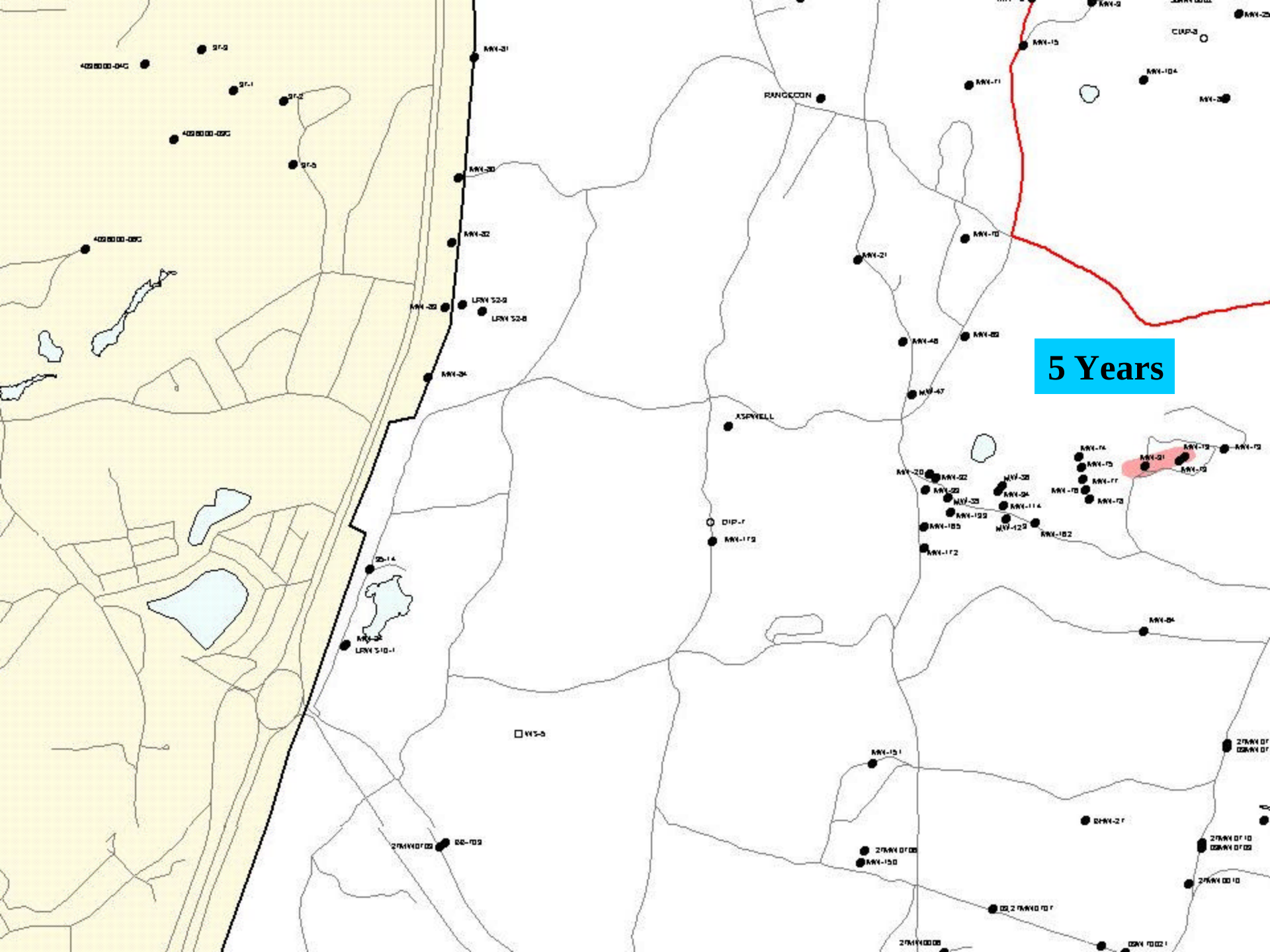
COMPARISON OF GRADIENTS

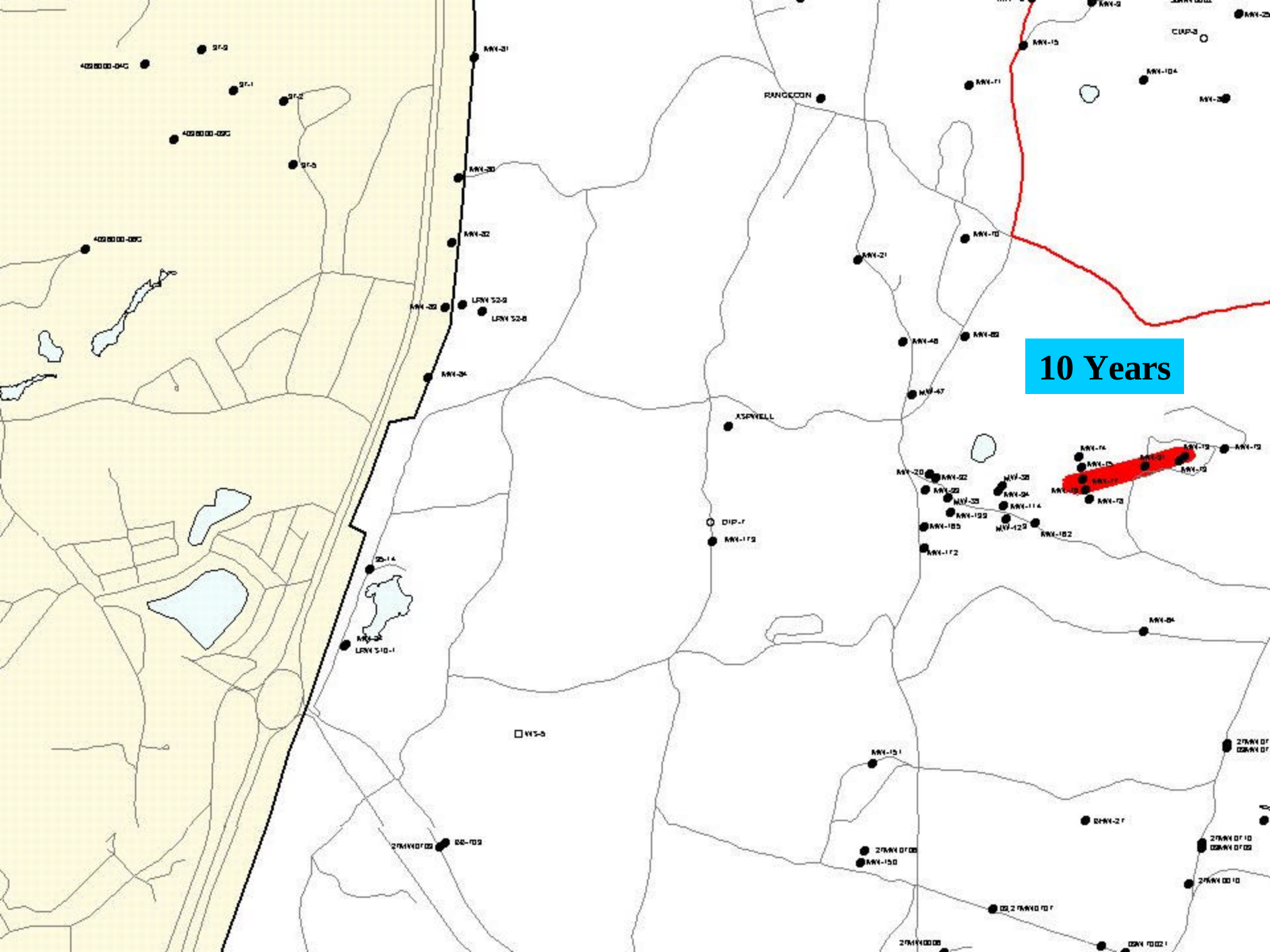
Gradients	Measured (2000)	Model Predicted*
Across the Plume Area	0.10%	0.08%
From Demo 1 to MMR Boundary	0.21%	0.27%

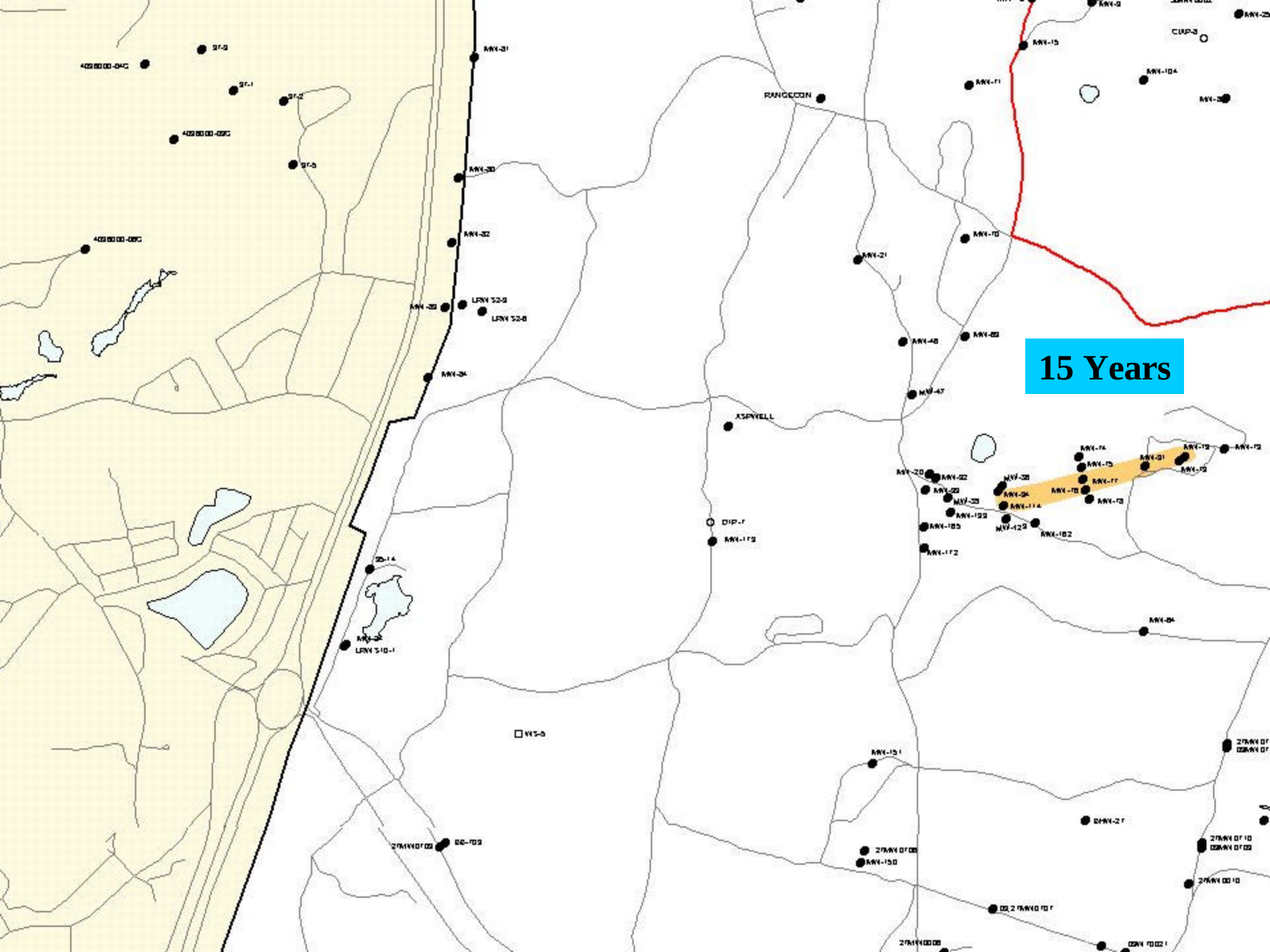
* Calibrated to 1993 water levels

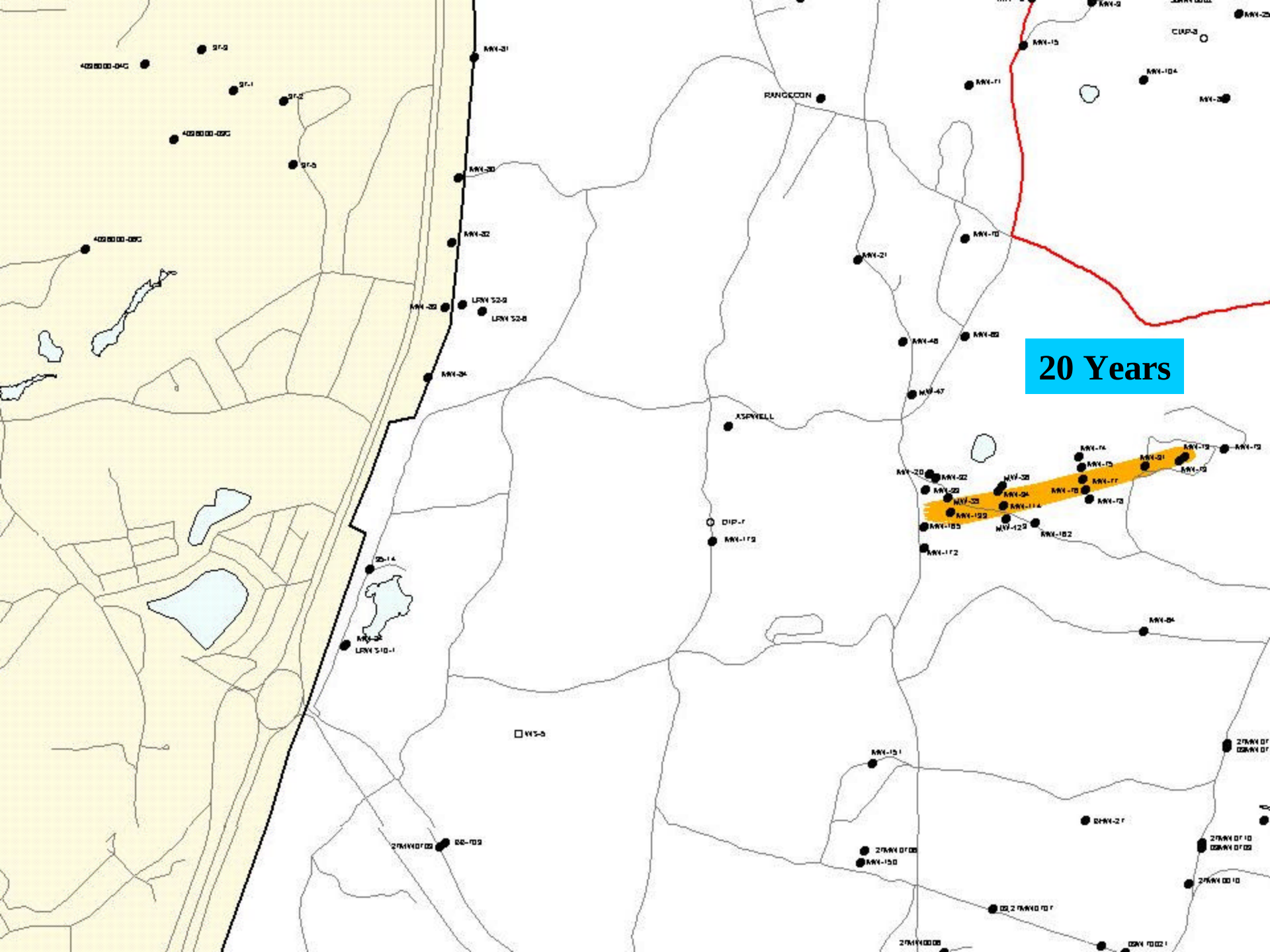
FLOW PATH PREDICIONS BETWEEN ORIGINAL USGS AND MODIFIED AMEC MODELS

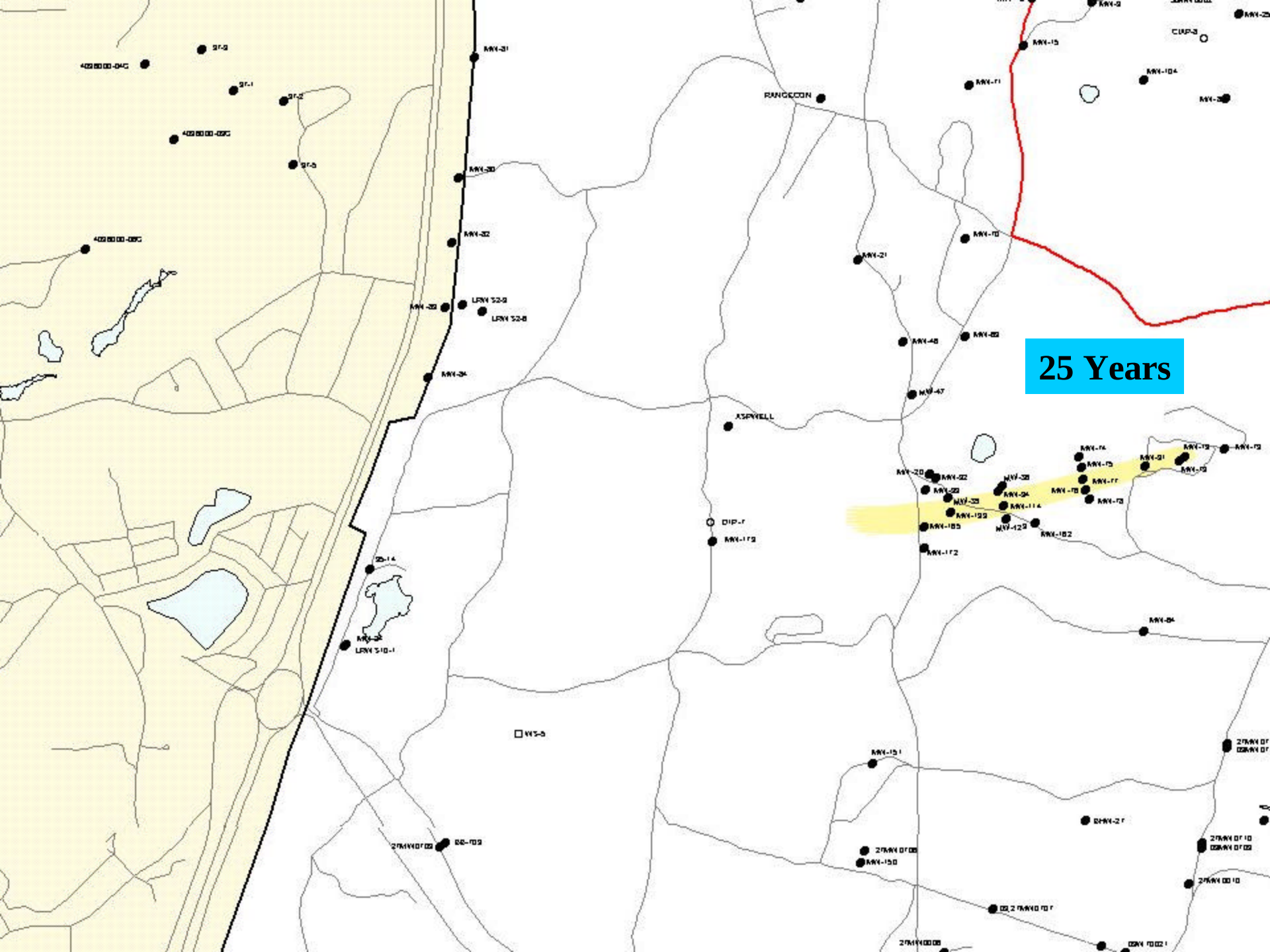


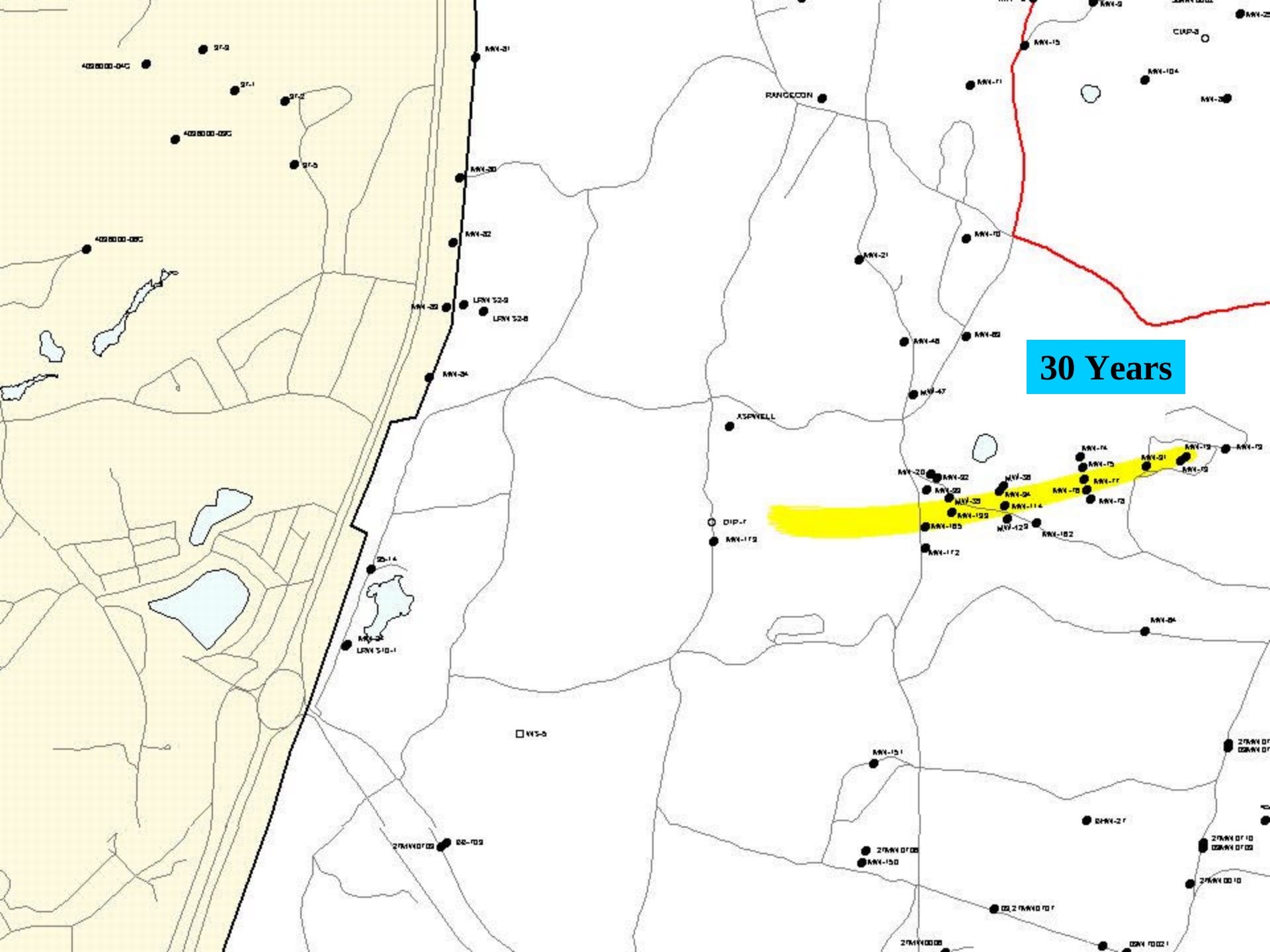

5 Years

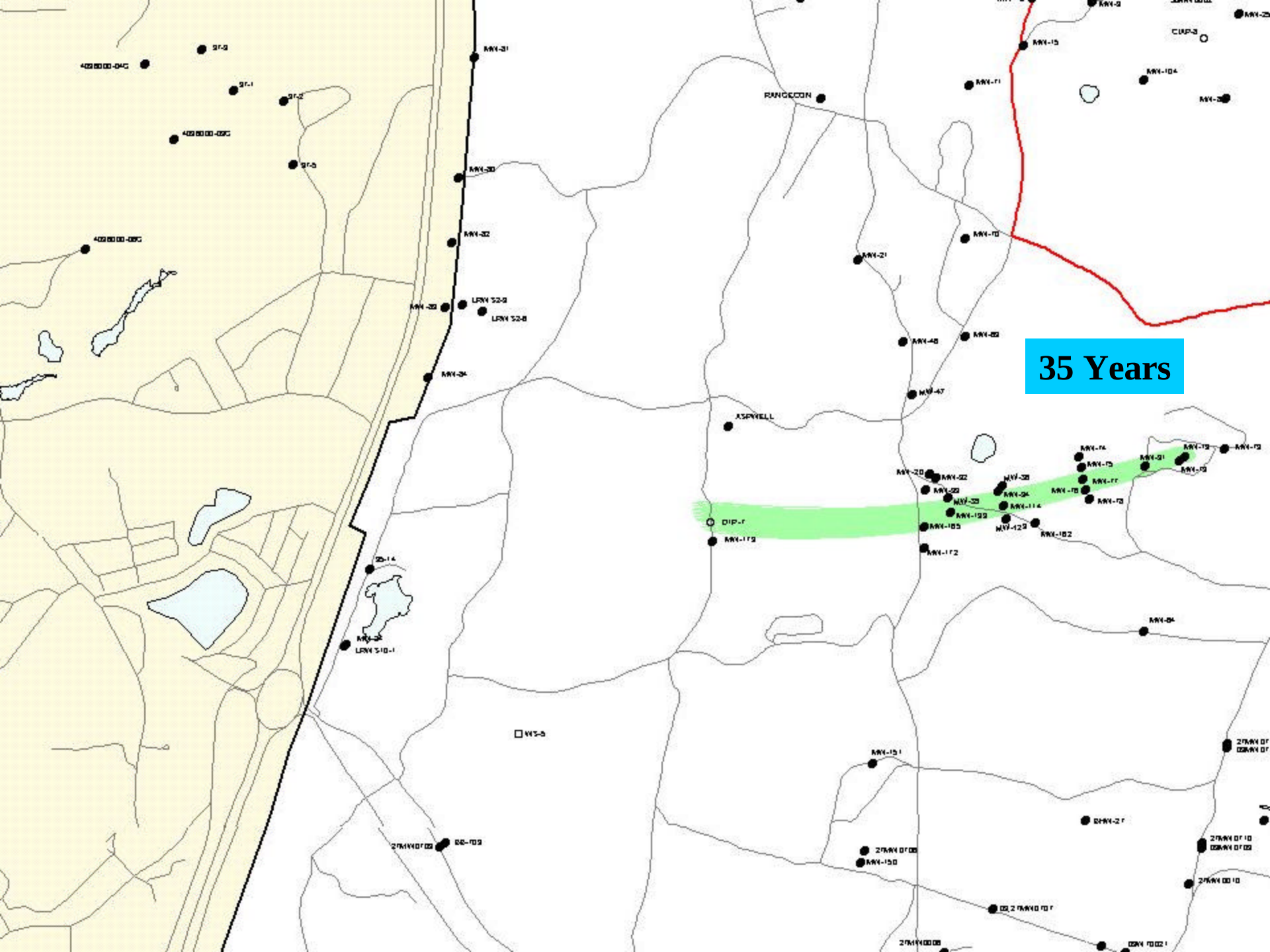

10 Years
RANGECOIN
ASPWELL
DIP-1
MW-5

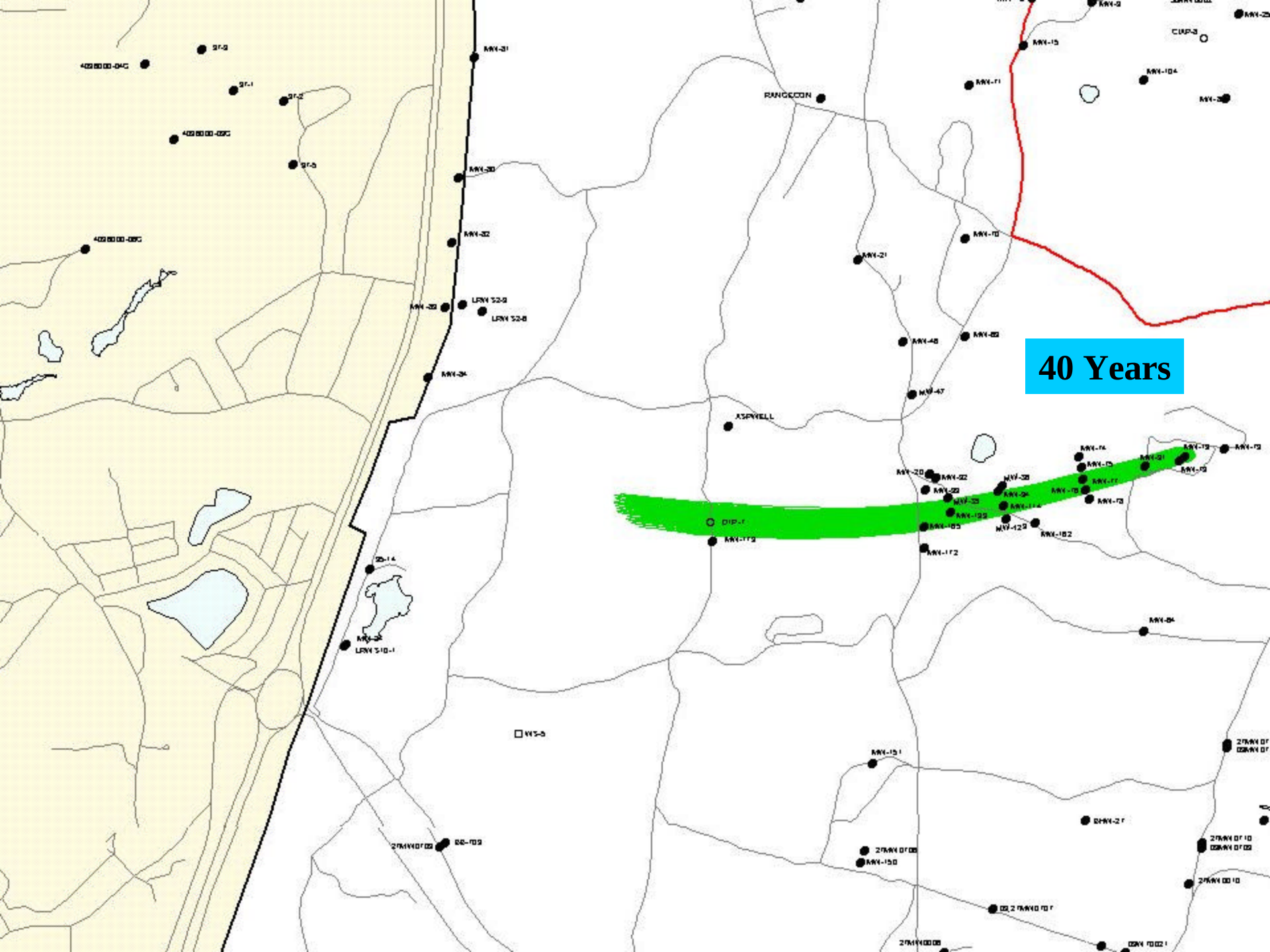

15 Years

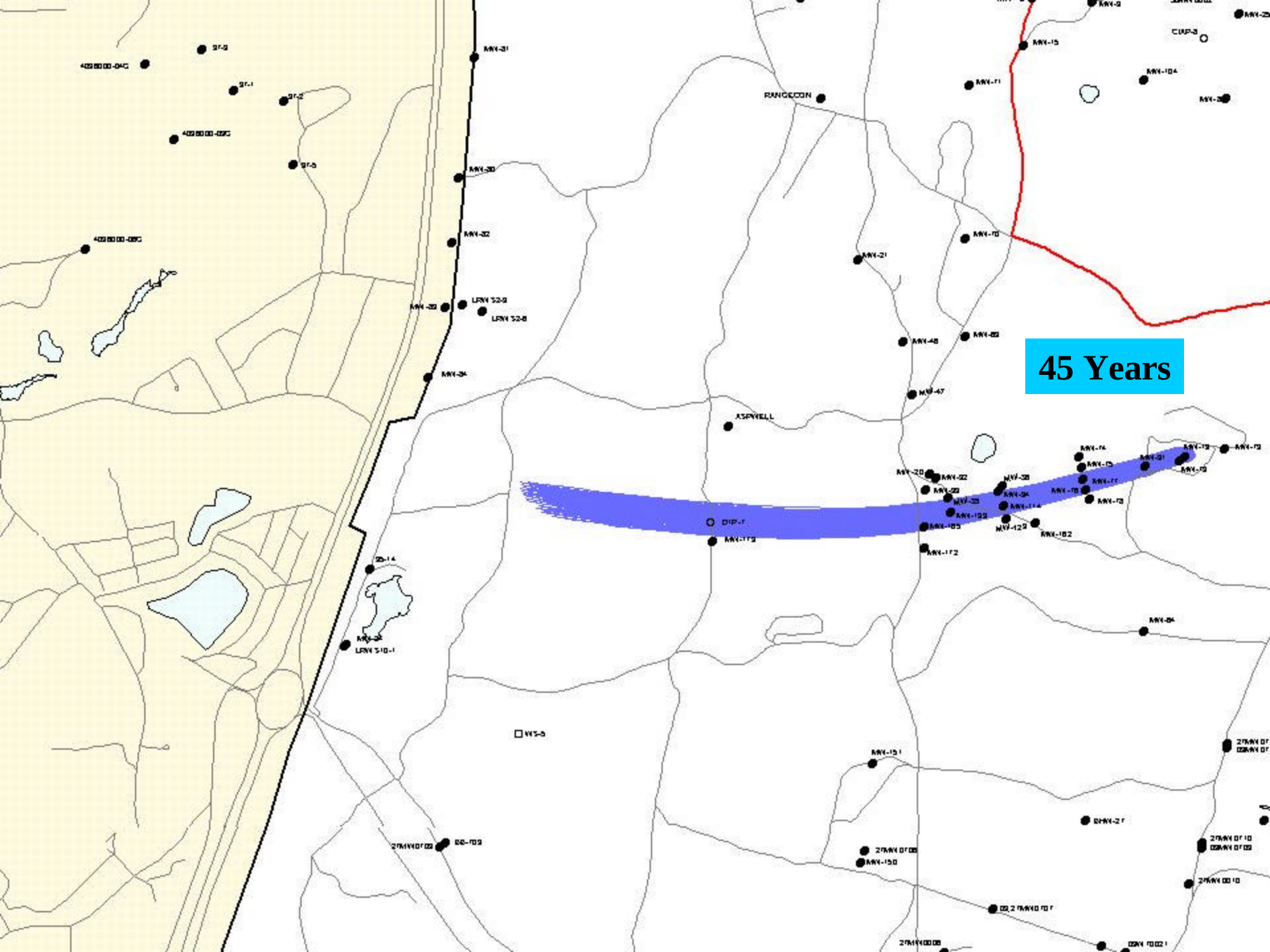

20 Years

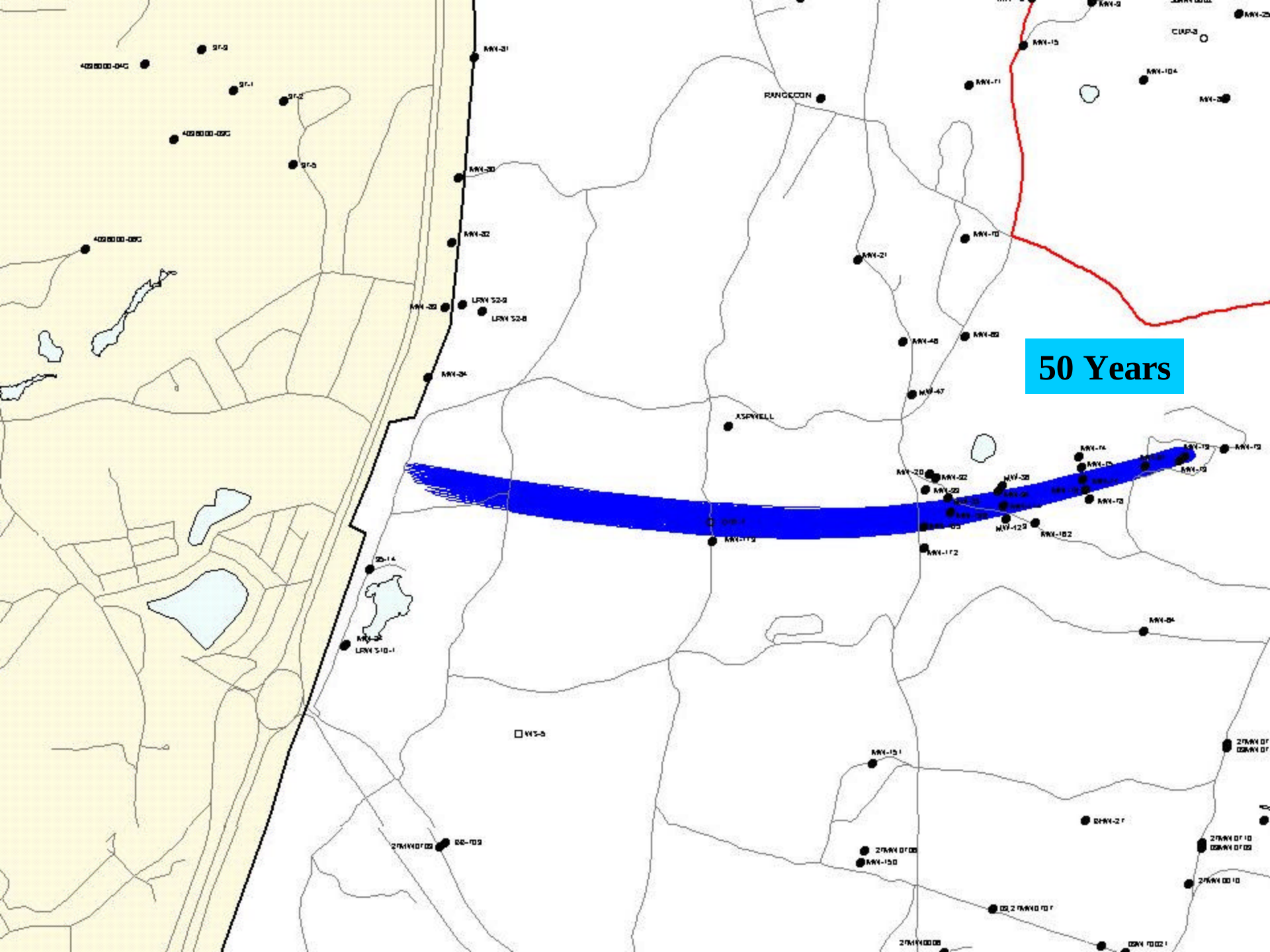

25 Years

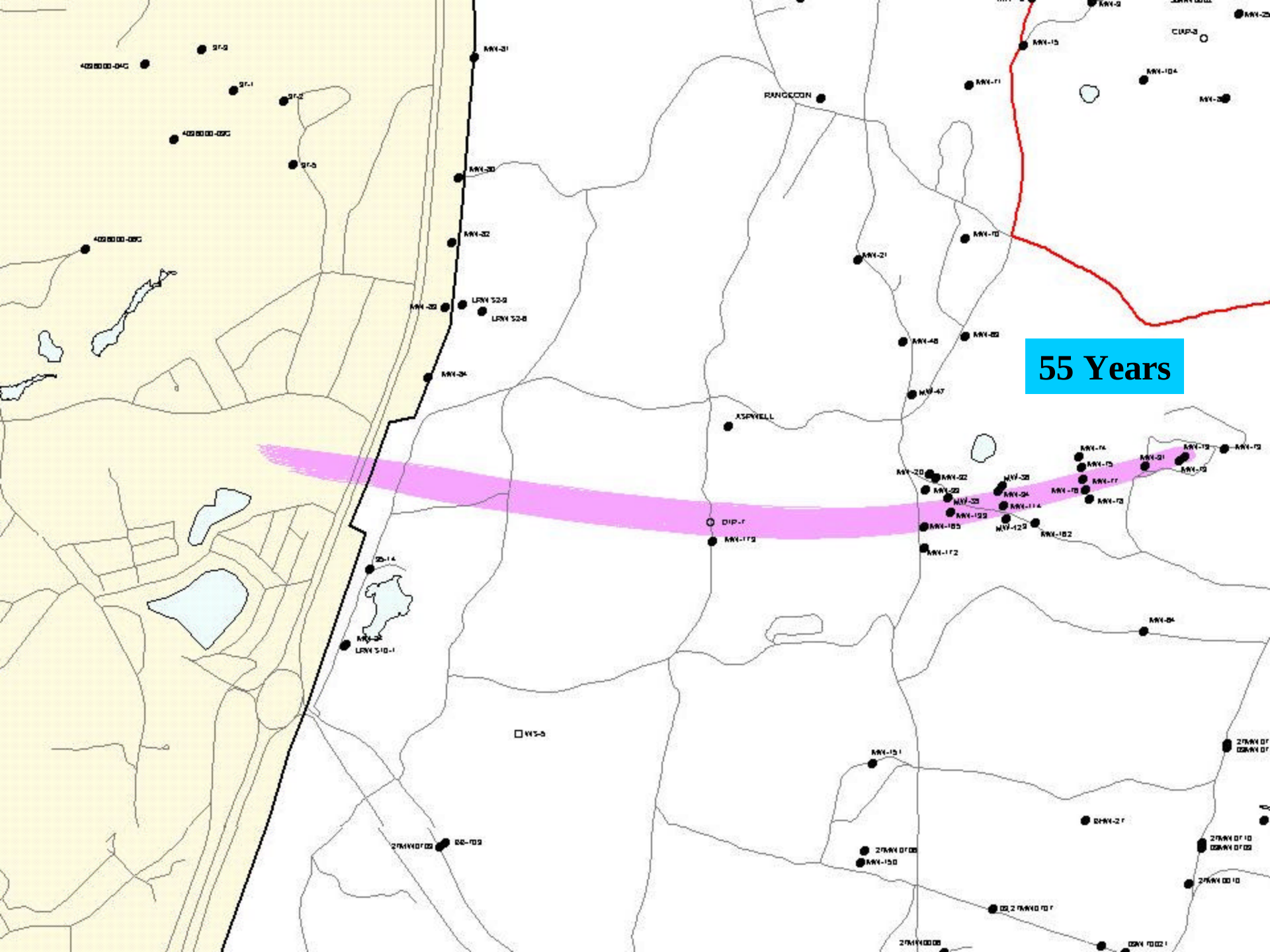

30 Years

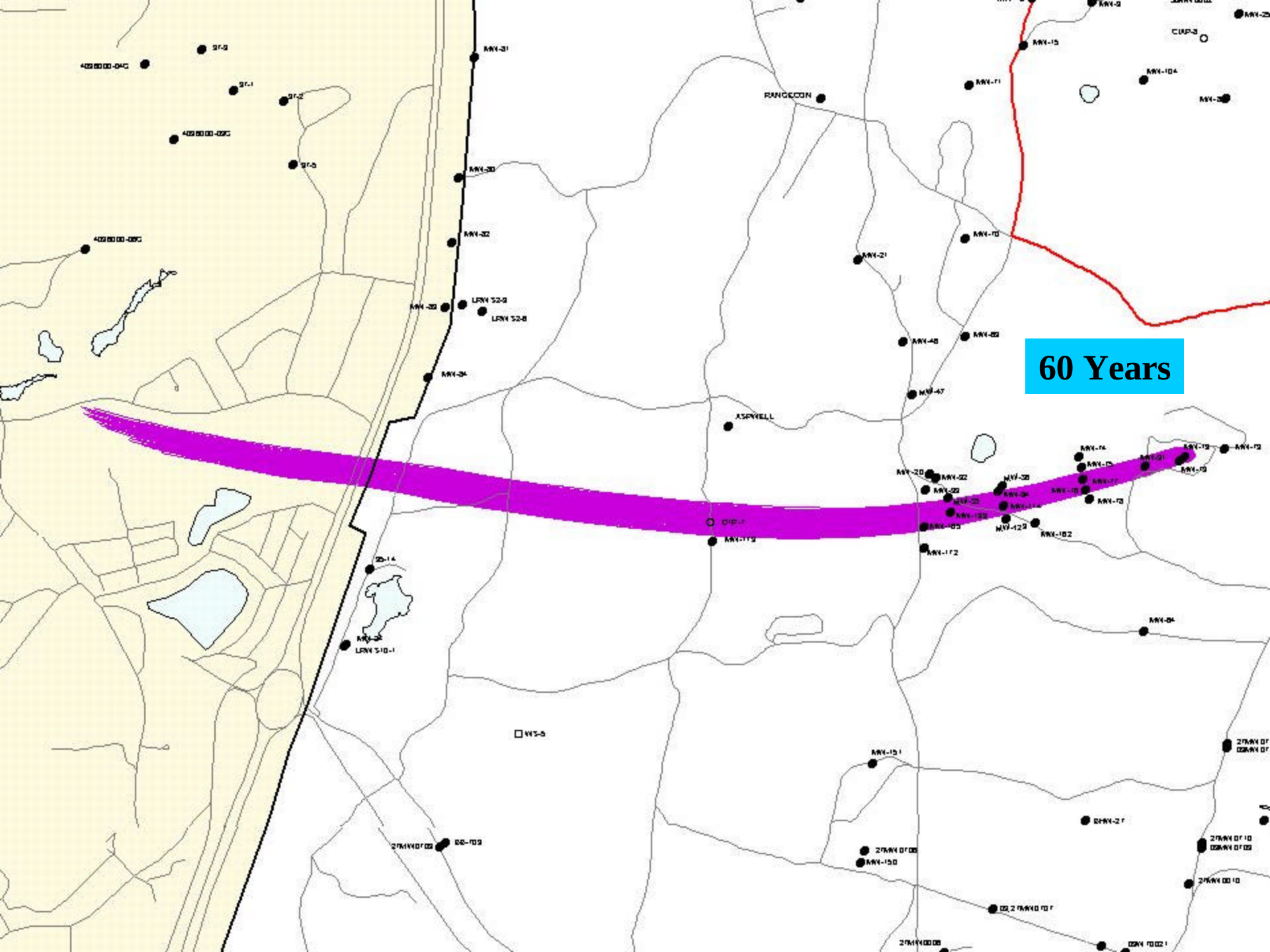

35 Years


40 Years

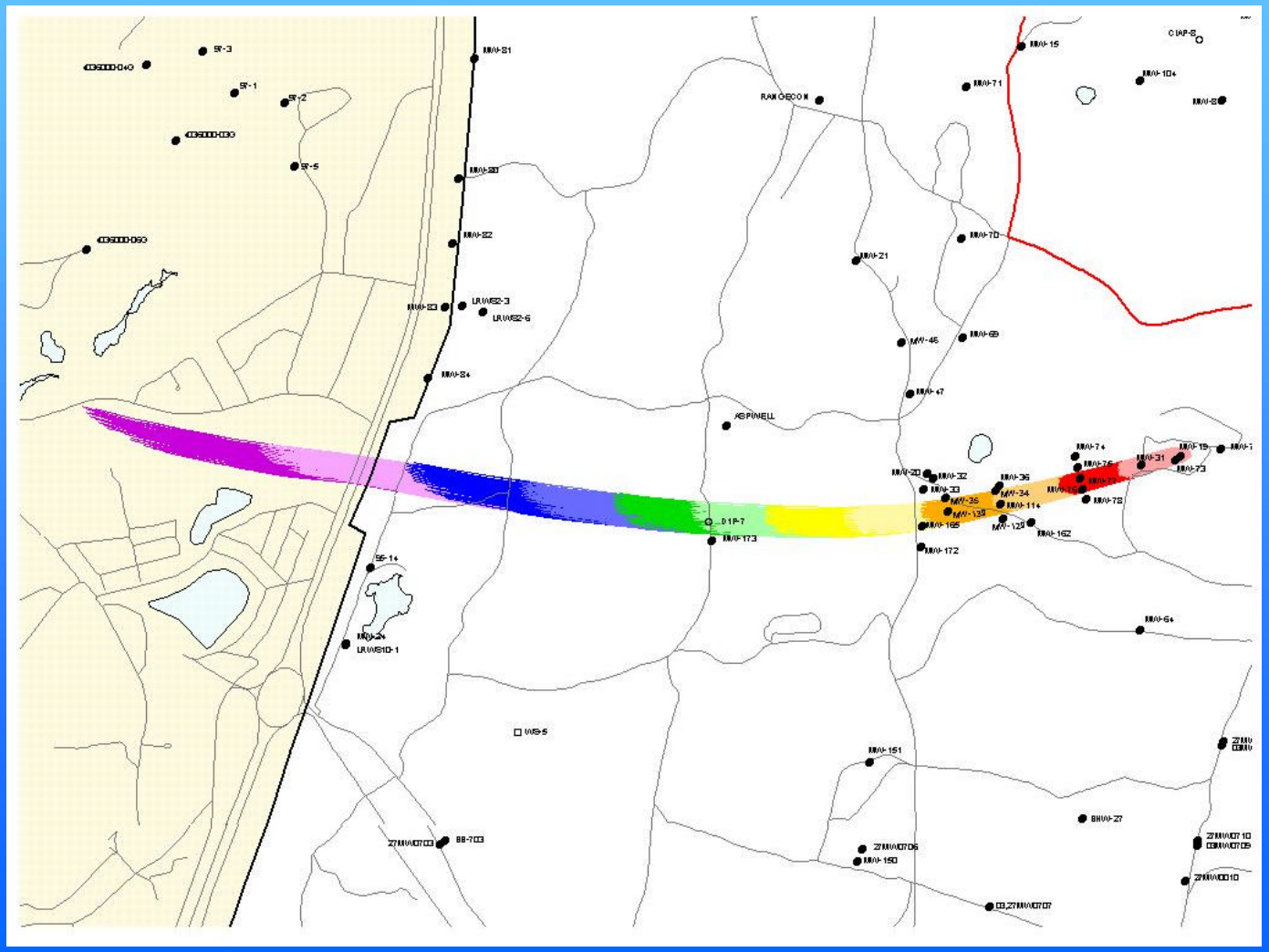

45 Years


50 Years


55 Years


60 Years

DEMO 1 PARTICLE TRACKS



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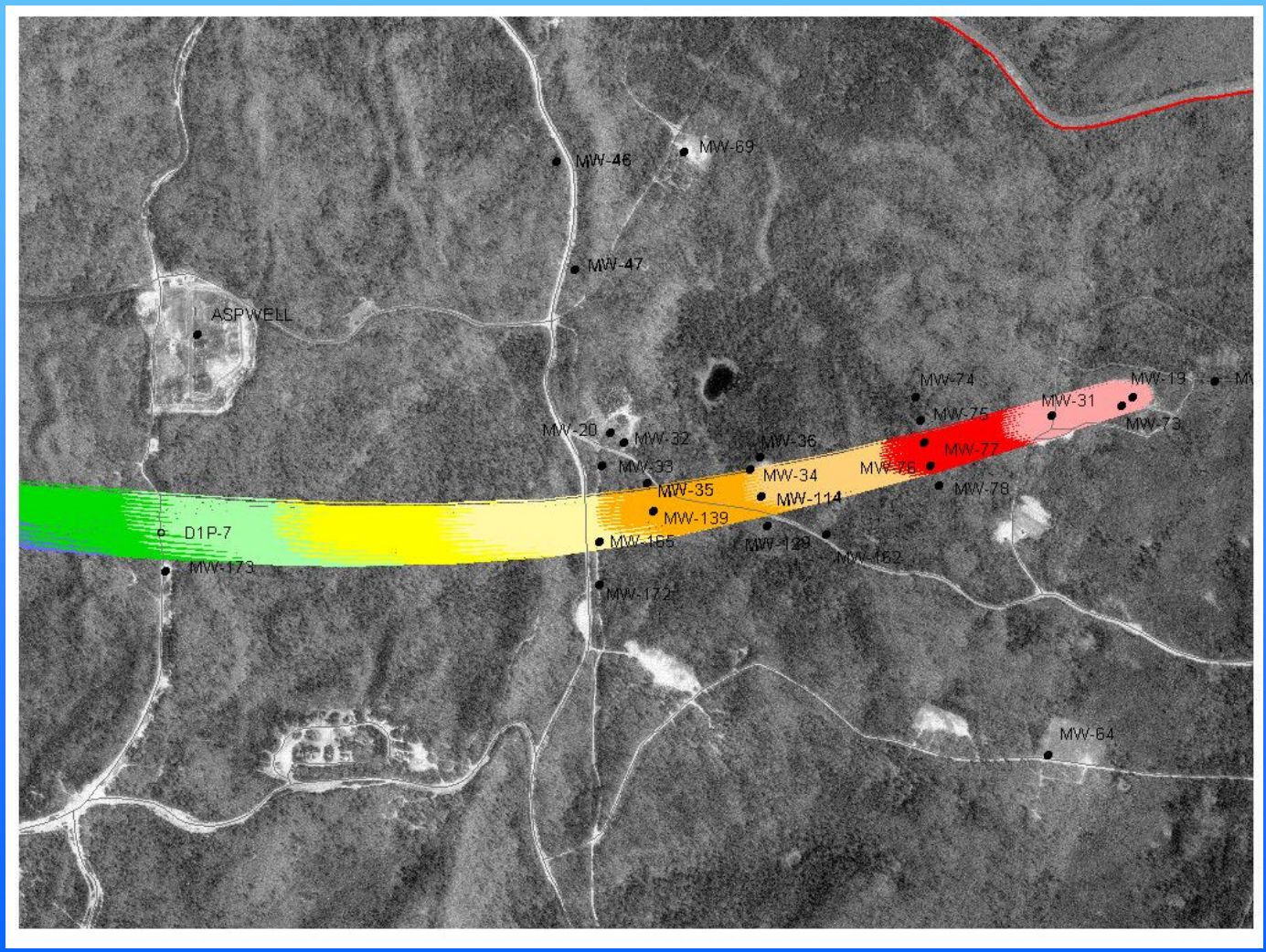
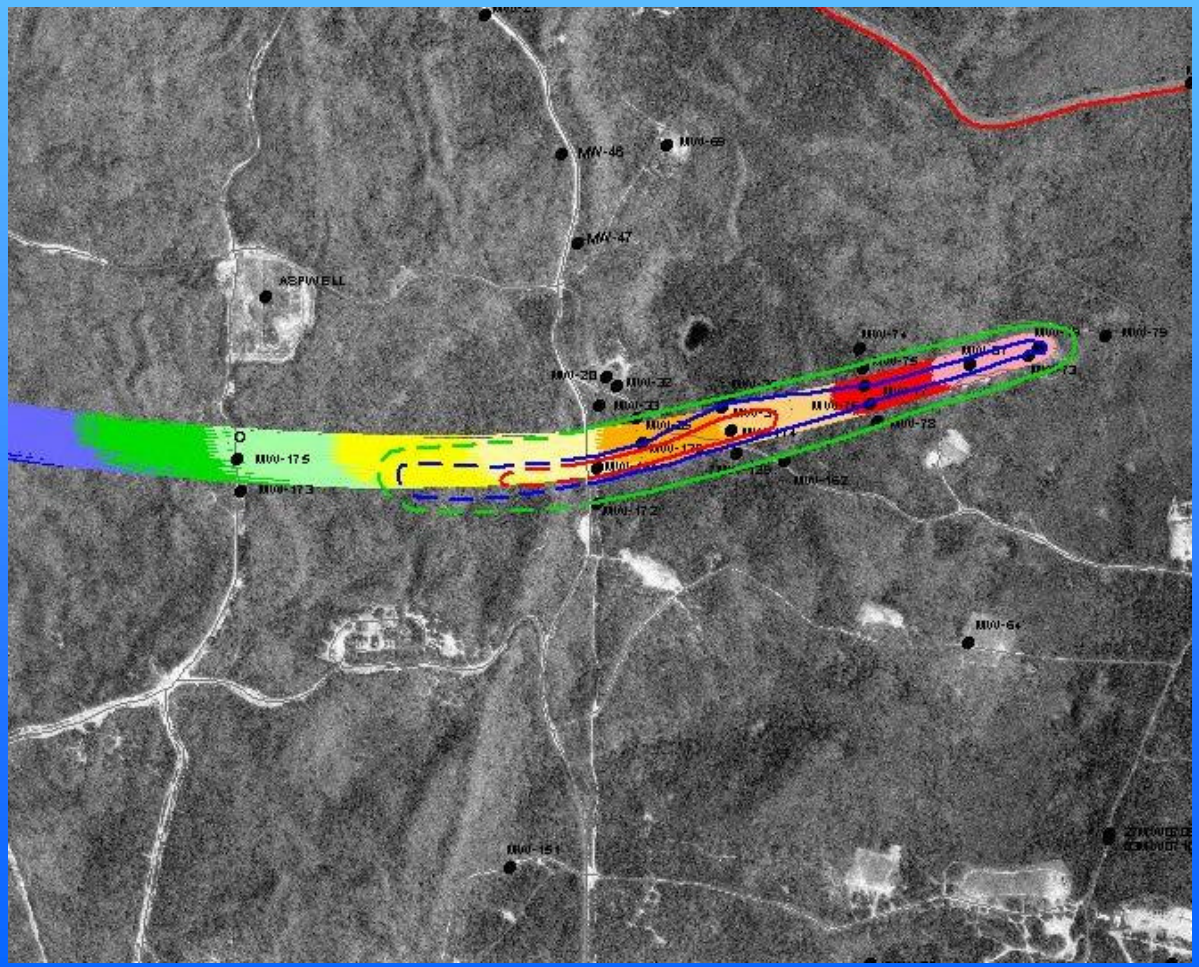


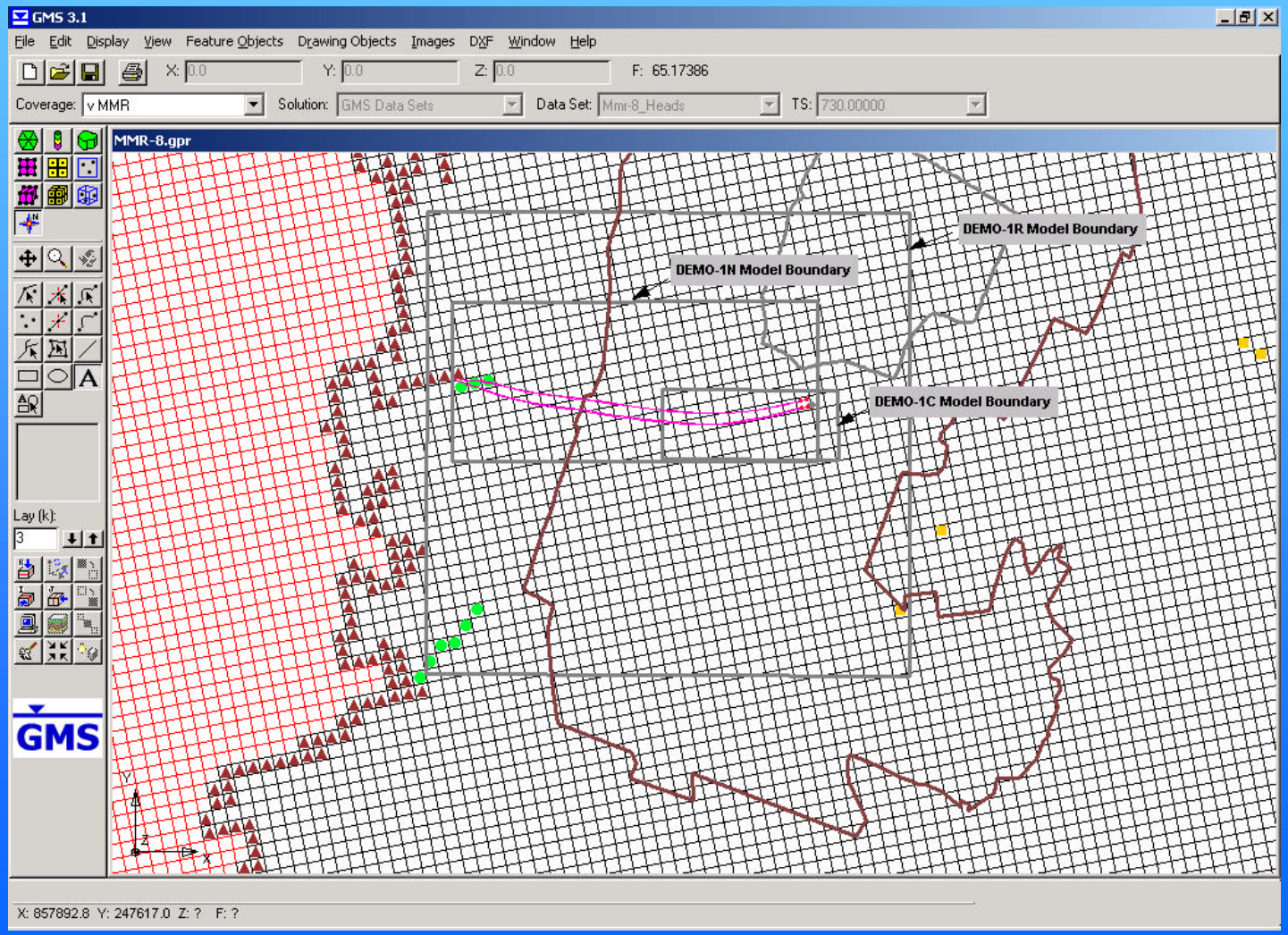
MODEL PREDICTED PARTICLE PATHS VS CURRENT PLUME CONFIGURATION



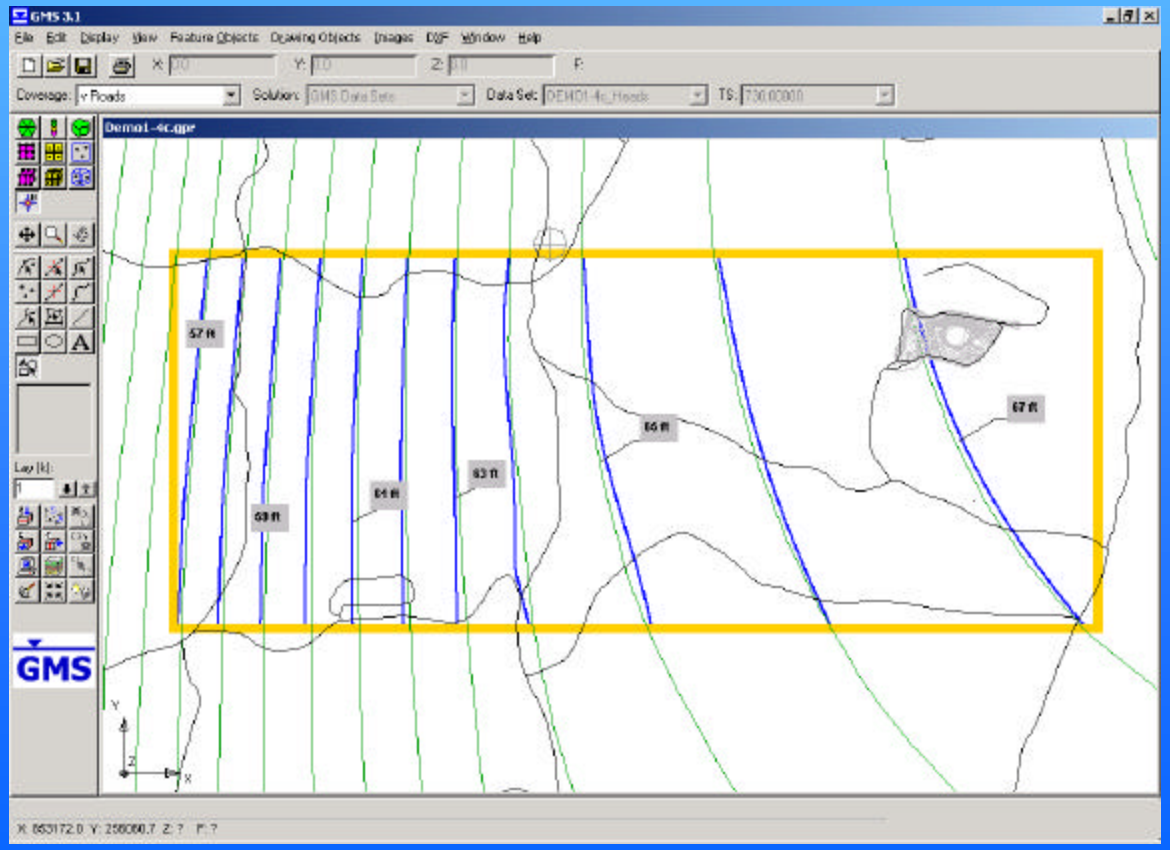
DEVELOPMENT OF DEMO 1 SUB-REGIONAL MODELS

- Demo 1-4C - Fate-and-Transport Calibration
- Demo 1-4N - No Action Scenario Analysis
- Demo 1-4R - Aquifer Remediation Scenario Analysis

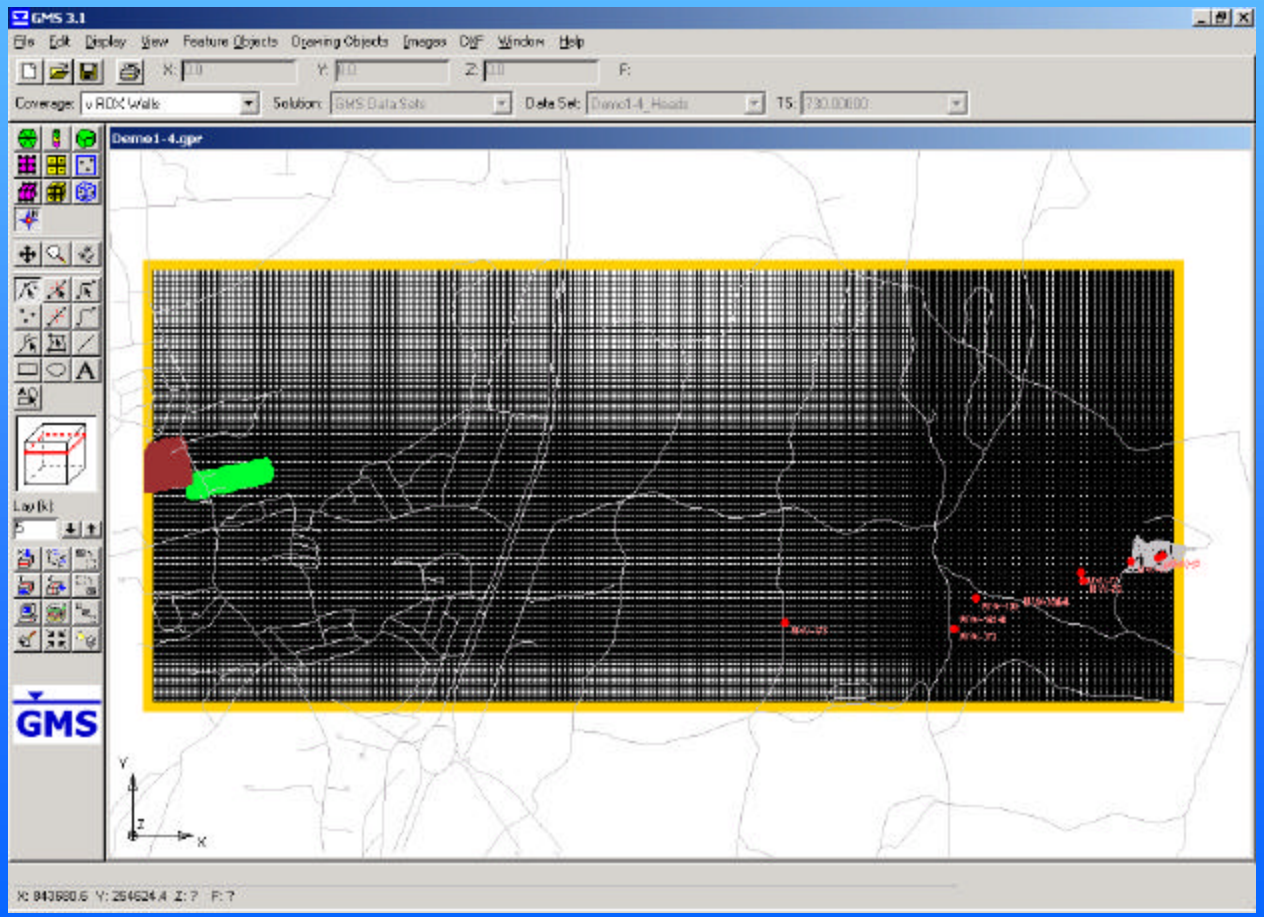
DEMO-1 SUB-REGIONAL MODELS



WATER-LEVEL CONTOUR COMPARISON BETWEEN REGIONAL AND SUB-REGIONAL FLOW MODELS



NUMERICAL GRID FOR SUB-REGIONAL "NO-ACTION" MODEL



SUMMARY OF EPA HELP MODEL RESULTS FOR DEMO 1 AREA

1. Run-off From the Slopes Constitutes About 12% - 17% of Total Precipitation;
2. Run-off Occurs Primarily in Winter and Spring Due to the Snow Melt and Rain During Frozen Soil Conditions;
3. Recharge Along the Slopes Was Predicted to Be Lower by 20% - 30% Compared With “No Run-off” Condition;
4. Recharge in the Depression Area Was Predicted to Be Increased by About 50% Due to the Surface Run-off From Slopes.

MAJOR F&T COMPONENTS

Component	Description	Effect on Solution	Expected Importance
Advection	Migration along flow path	Preserves concentration levels along flow paths	High
Dispersion	Spreading around center of mass	Smears concentration fronts	Low
Retardation	Sorption to solid phase	Slows front propagation	Medium
Degradation	Transformation into another chemical	Reduces concentration levels	Low
Leaching	Contaminant loading from unsaturated zone	Controls concentration levels in source area and total mass	High

TRANSPORT CALIBRATION TARGETS

- Total Mass of RDX in Aquifer
- Distribution of RDX Mass with Depth
- Width of RDX Plume
- Maximum Extent of RDX Plume
- Maximum Depth of RDX Plume
- Maximum RDX Concentration

TRANSPORT CALIBRATION SUMMARY

Parameter	Model Predicted	Observed/Estimated
Total Mass of Dissolved RDX (kg)	14	16
Width of RDX Plume (ft)	450	500
Length of RDX Plume (ft)	5,600	5,500
Depth of RDX Plume (ft bwt)	90	80
Maximum Concentration of RDX within Demo 1 (ug/L)	420	390

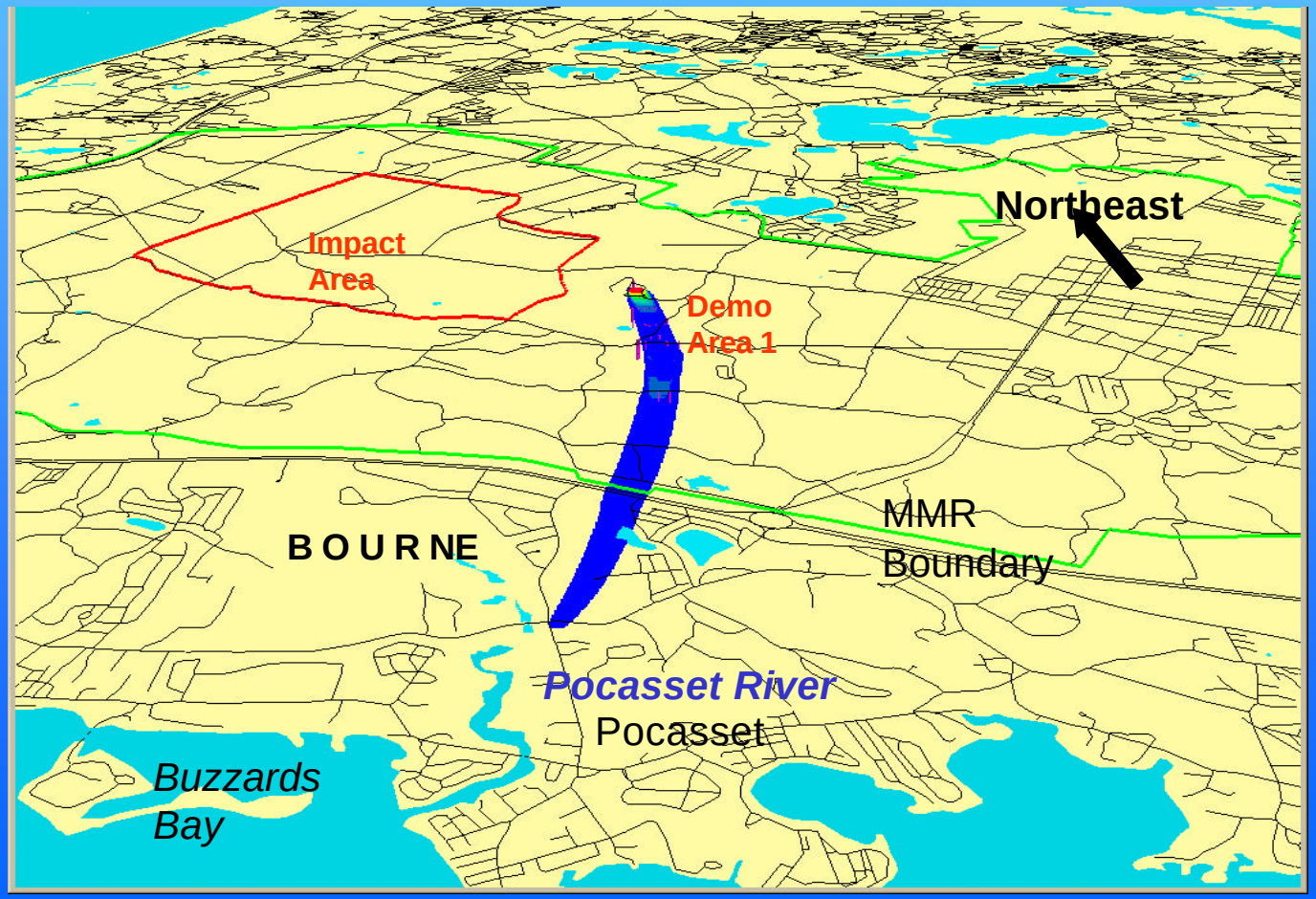
MAJOR CONCLUSION OF F&T DEMO 1 MODEL CALIBRATION

4. Calibration Suggests Source Release Started 20-30 Years Ago
5. RDX Sources Do Not Show Any Notable Sign of Depletion
6. Acceptable Calibration was Achieved Using the Reported Dispersivity Values (Garabedian et al., 1991), i.e. Longitudinal Dispersivity of 3 ft, Transverse Dispersivity of 0.06 ft and a Vertical Dispersivity of 0.005 ft

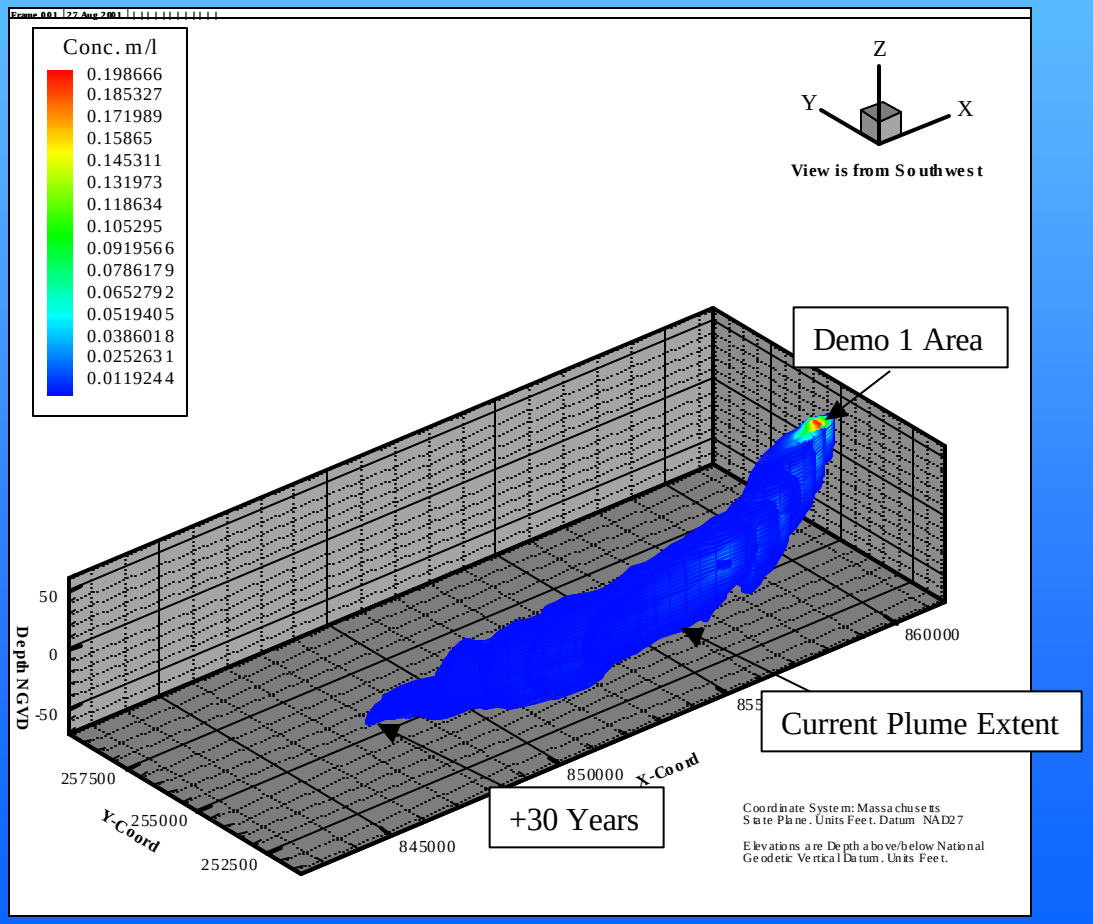
FLOW & TRANSPORT SIMULATIONS

- No Action Scenario
- Gradient Control - Single Extraction Well
- Gradient Control - Single Extraction Well with Discharge to Demo 1 Surface
- Plume Collapse - Five Extraction Wells
- Plume Collapse - Five Extraction Wells Discharge to Demo 1 Surface
- Plume Collapse - Five Extraction Wells with Reinjection
- Other Scenarios

RDX NO ACTION PROJECTION - 30 YEARS INTO FUTURE

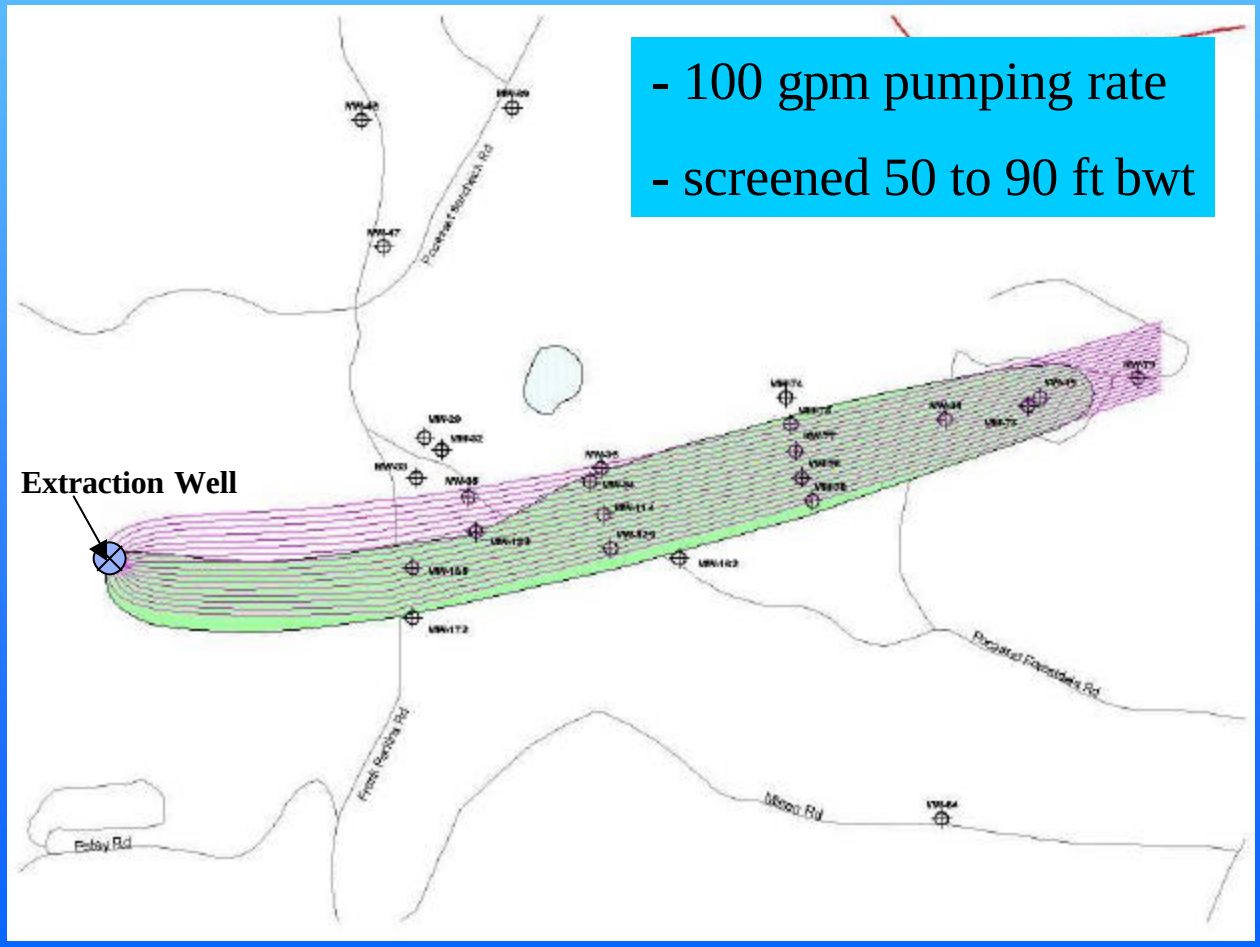


RDX PLUME - 30 YEAR PREDICTION

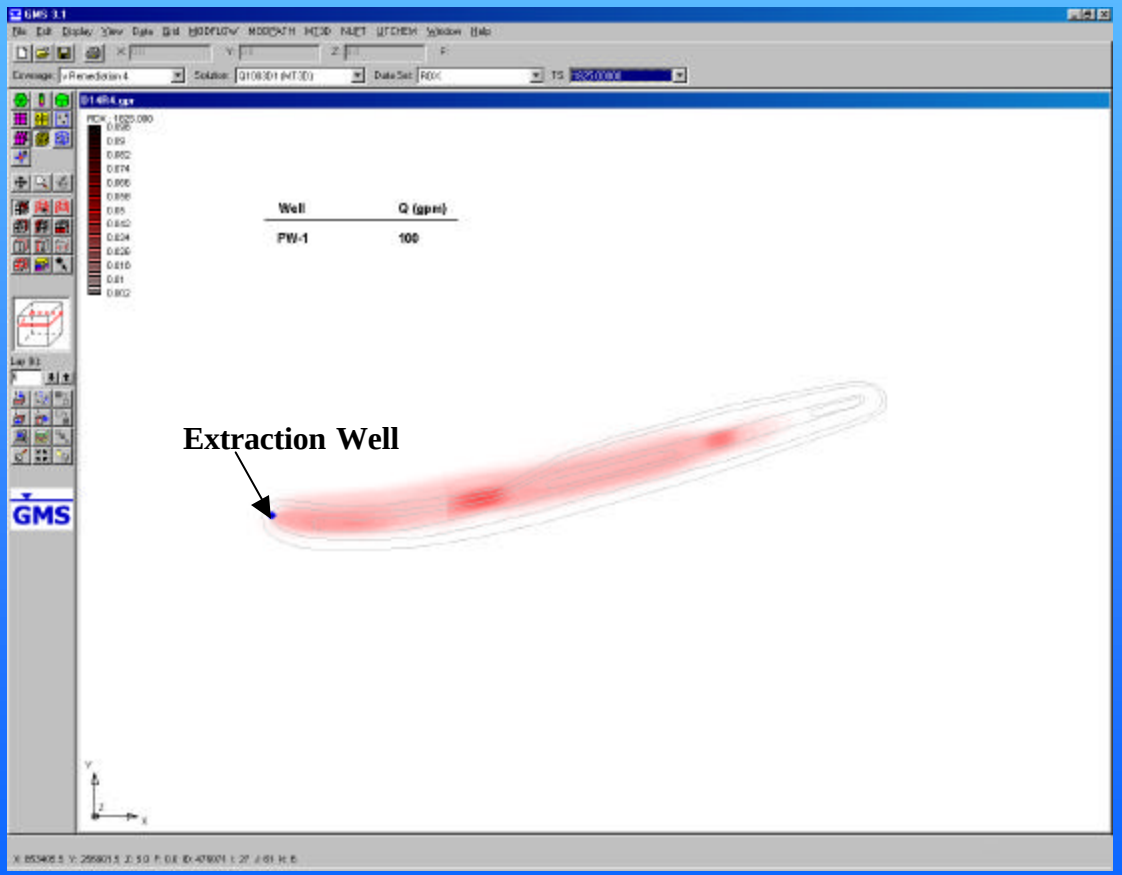


GRADIENT CONTROL - SINGLE EXTRACTION WELL

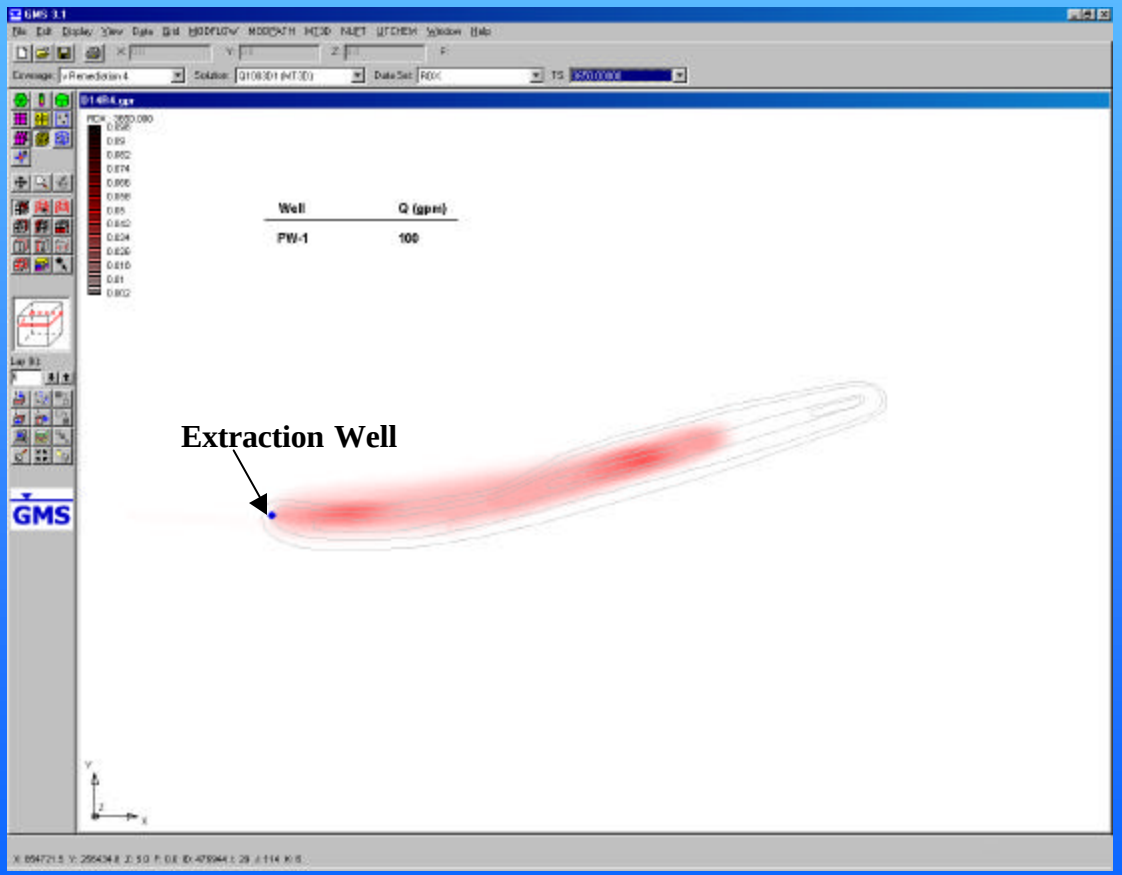
- 100 gpm pumping rate
- screened 50 to 90 ft bwt



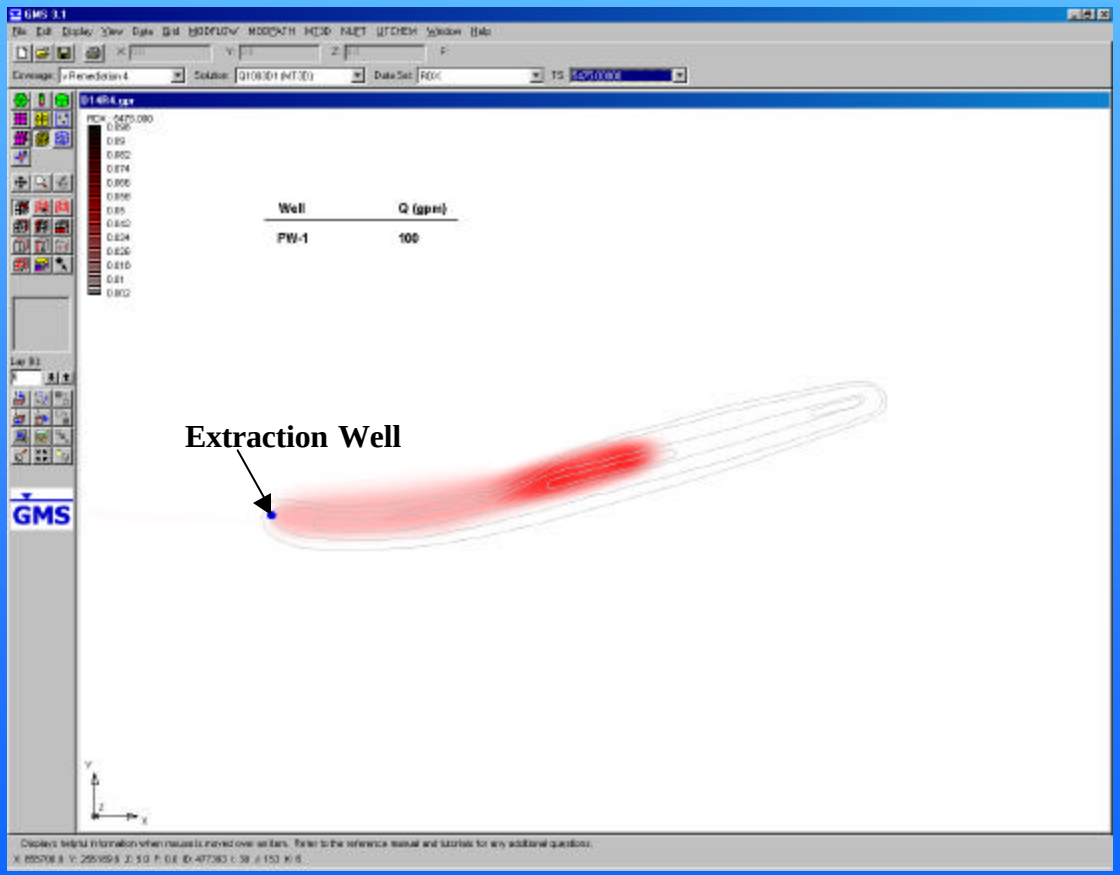
One extraction well T = +5 years



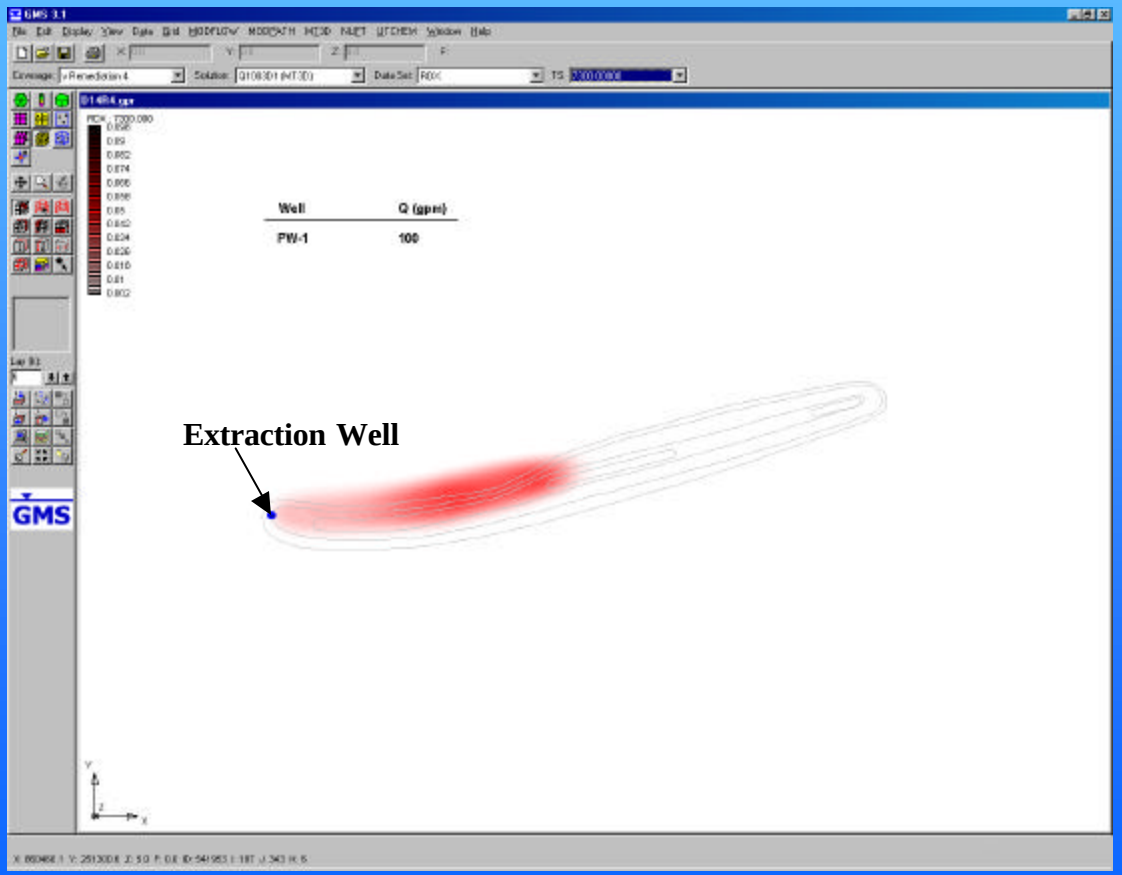
One extraction well T = +10 years



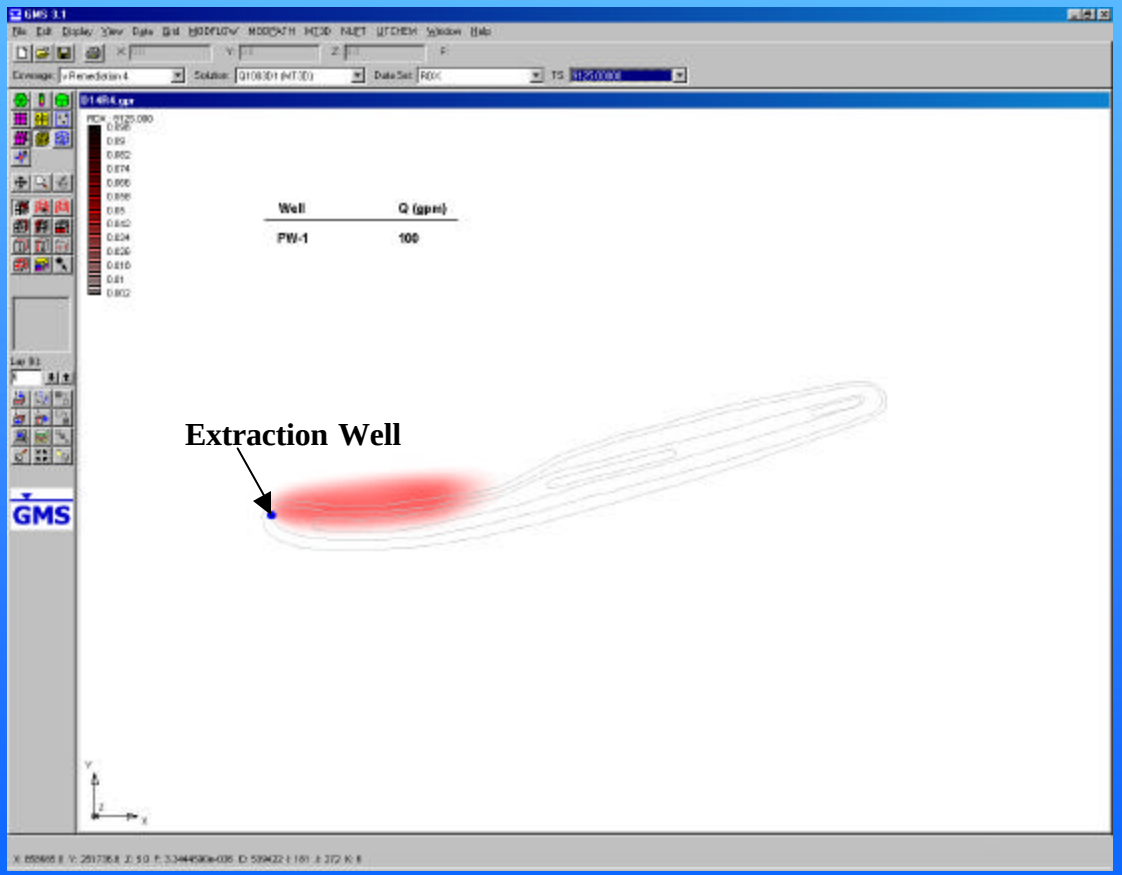
One extraction well T = +15 years



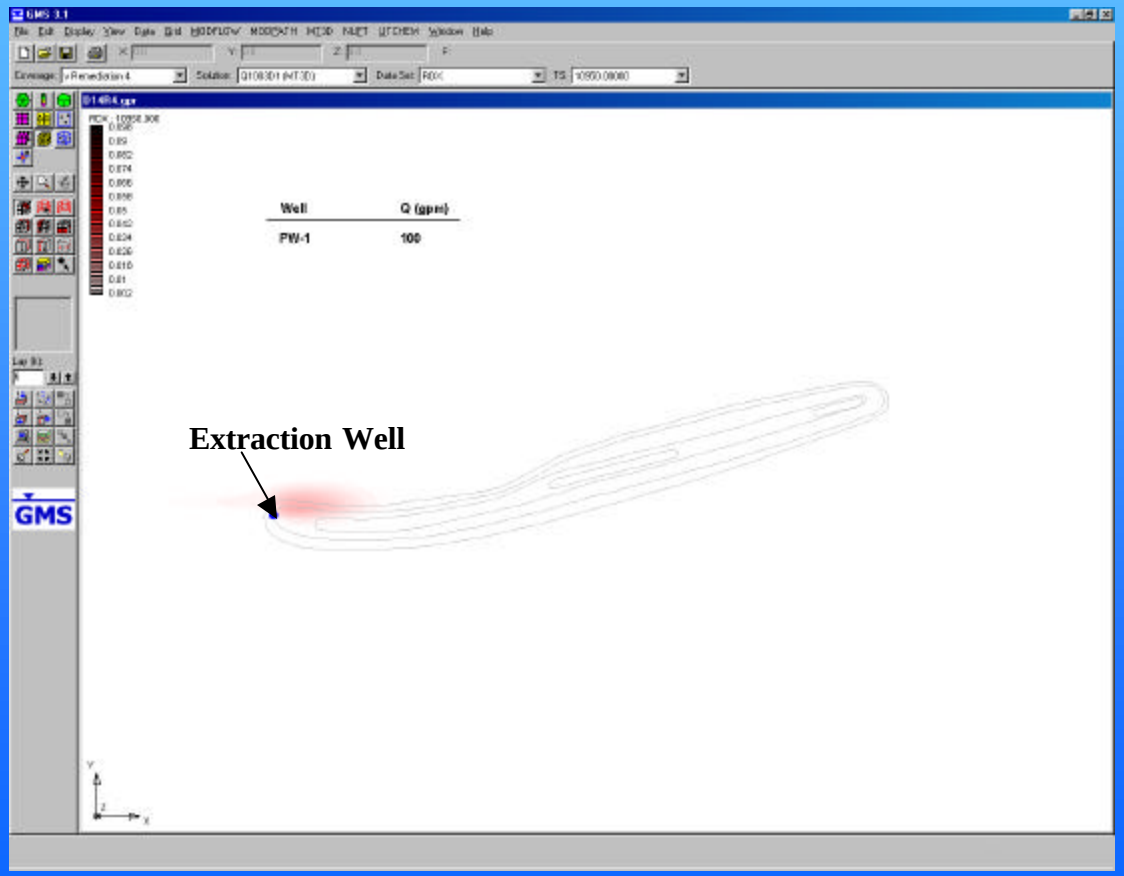
One extraction well T = +20 years



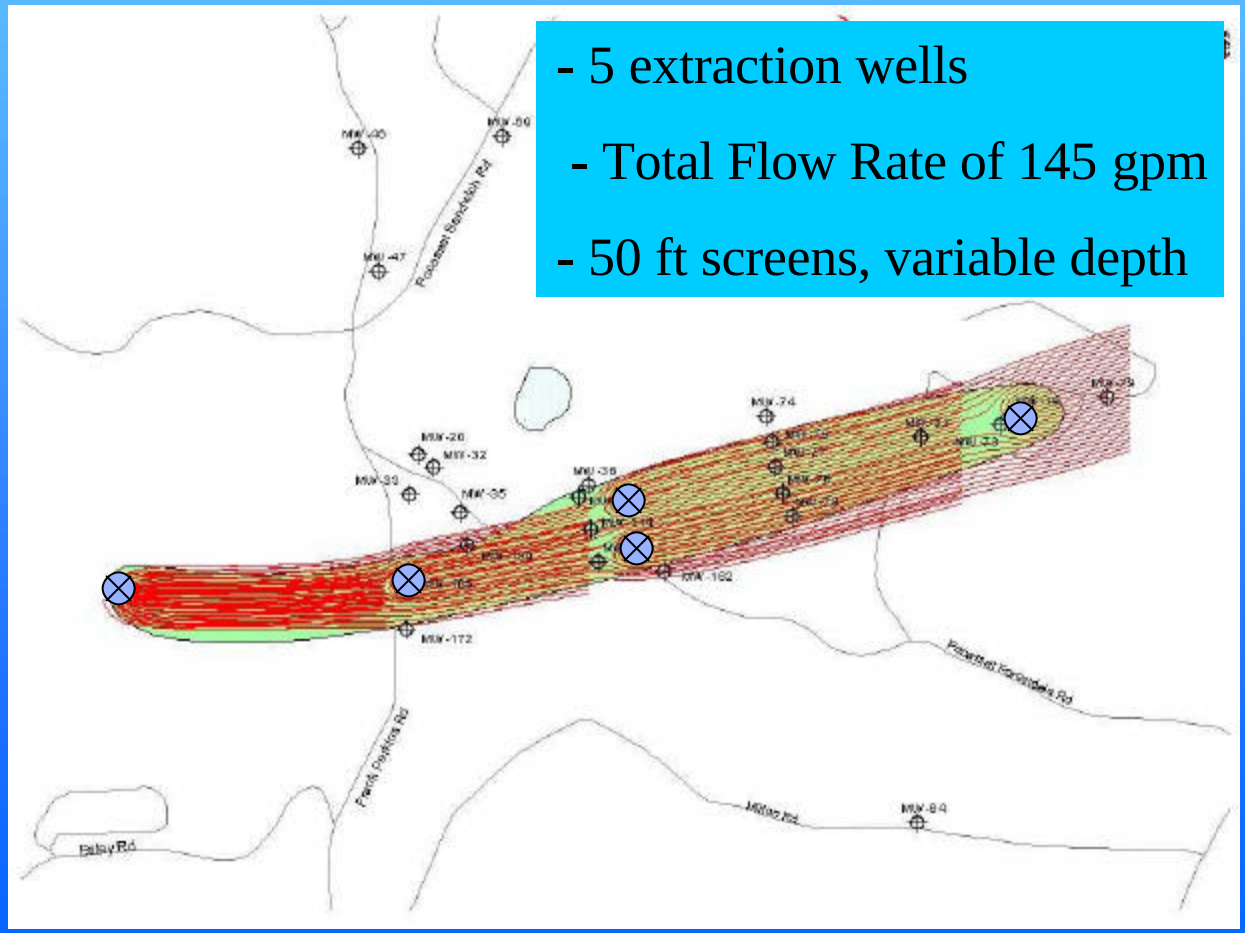
One extraction well T = +25 years



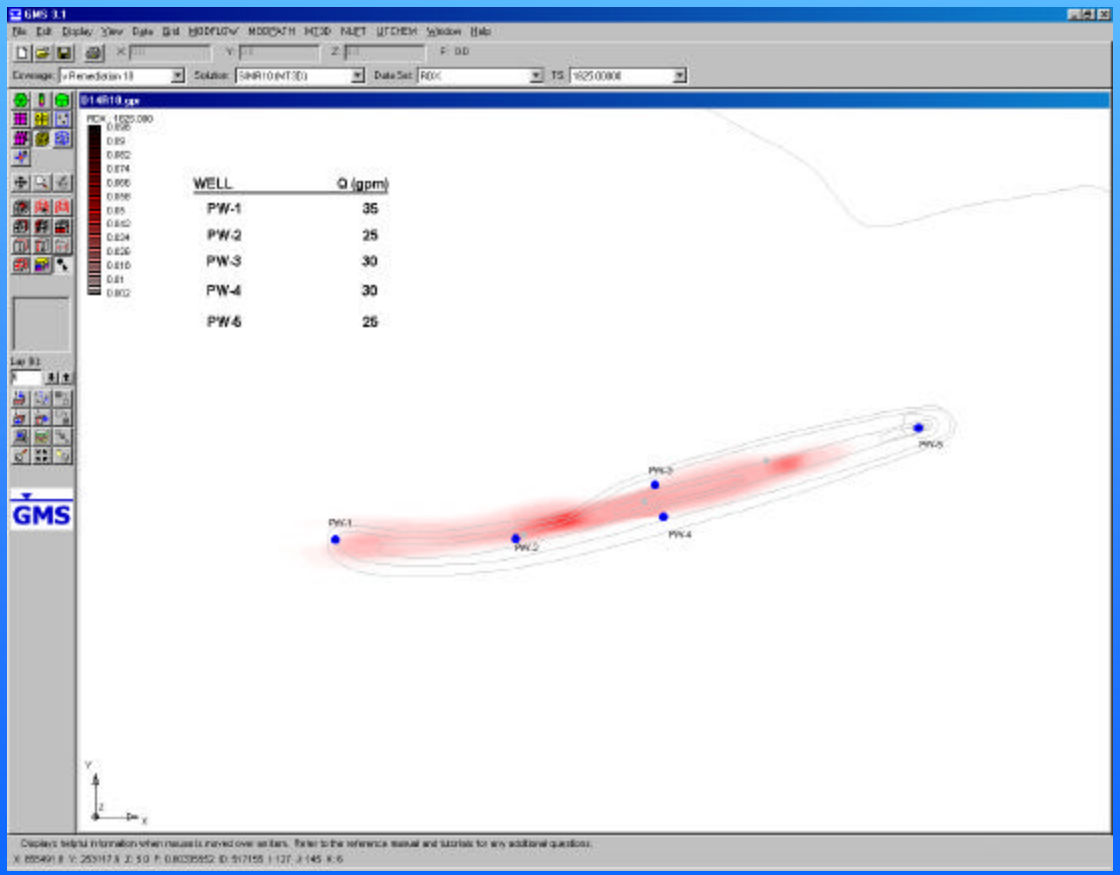
One extraction well T = +30 years



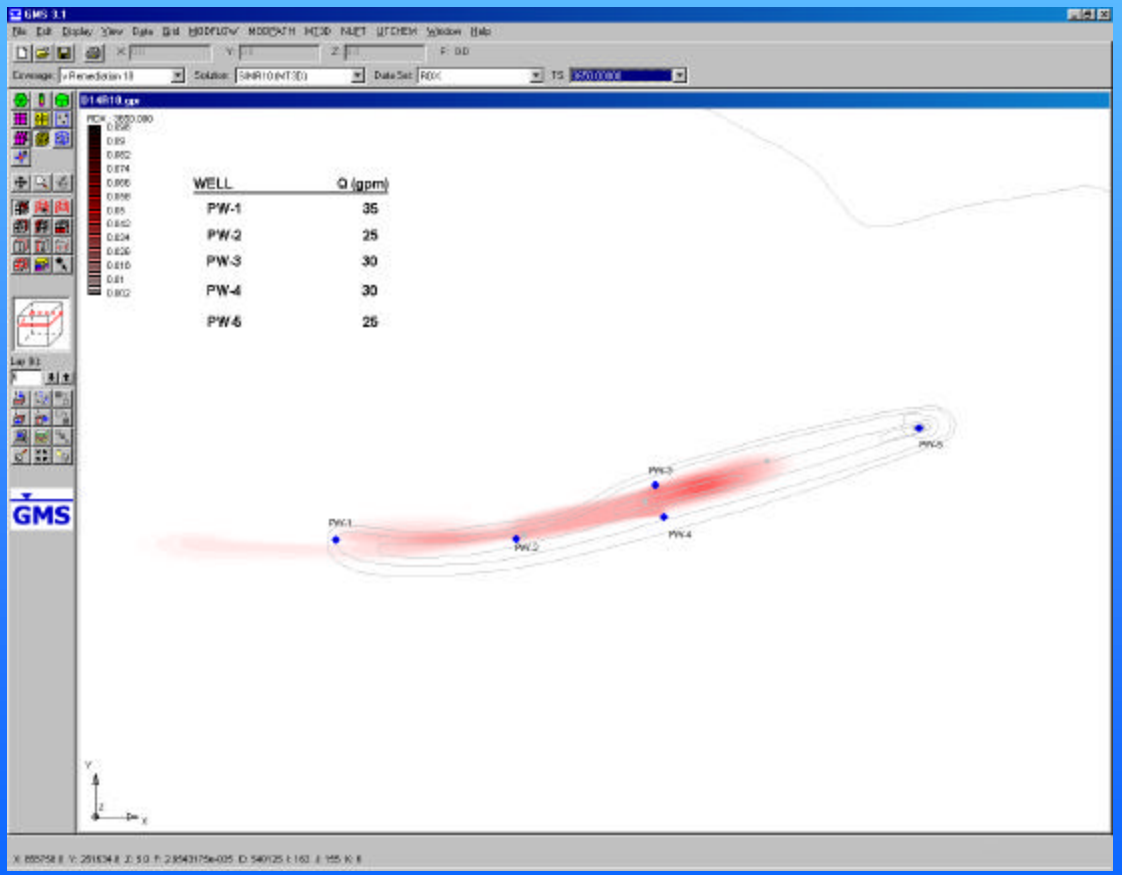
PLUME COLLAPSE - EXTRACTION ONLY



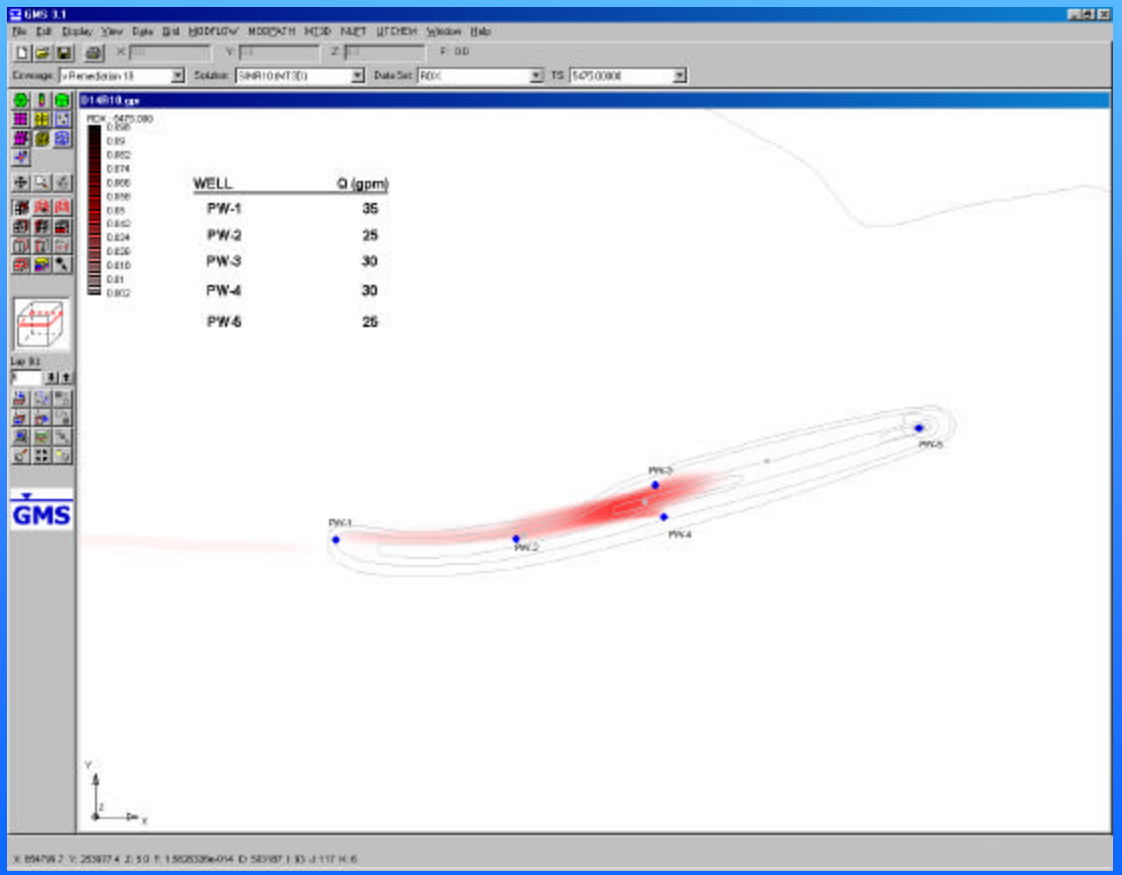
Five extraction wells T = +5 years



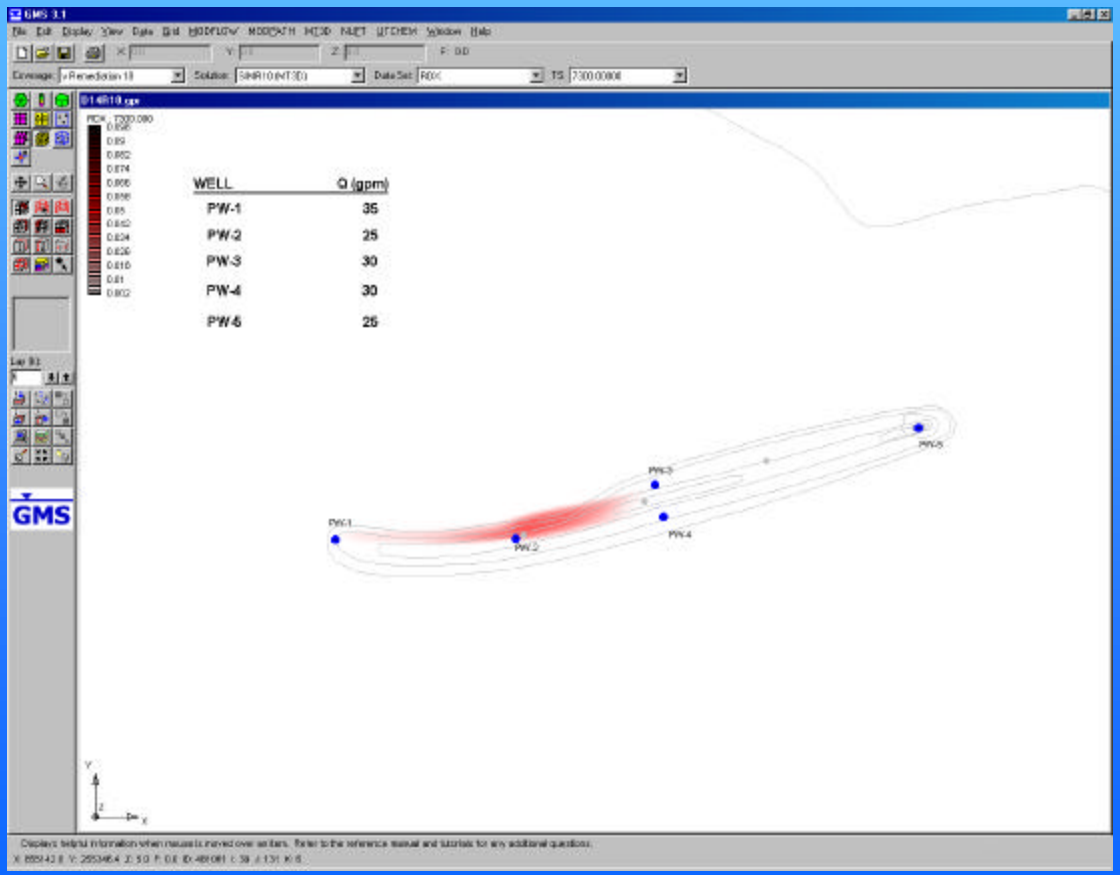
Five extraction wells T = +10 years



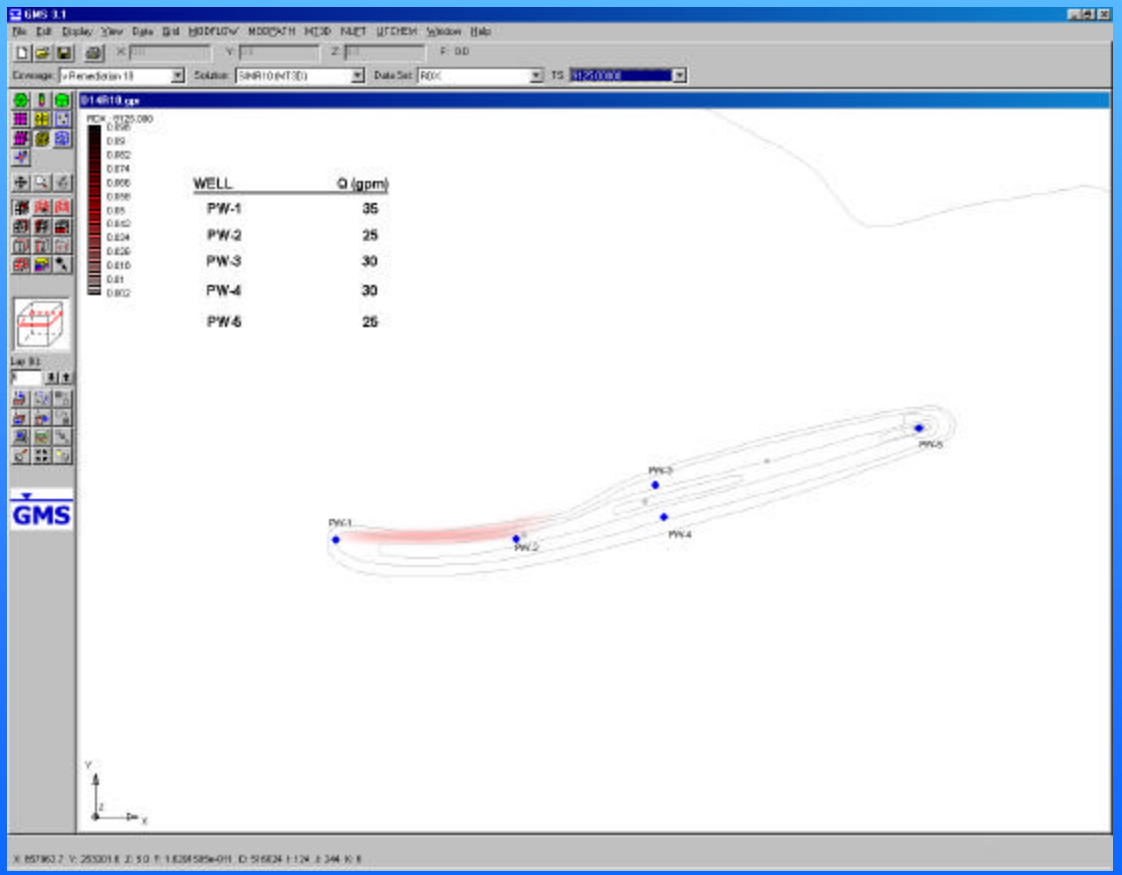
Five extraction wells T = +15 years



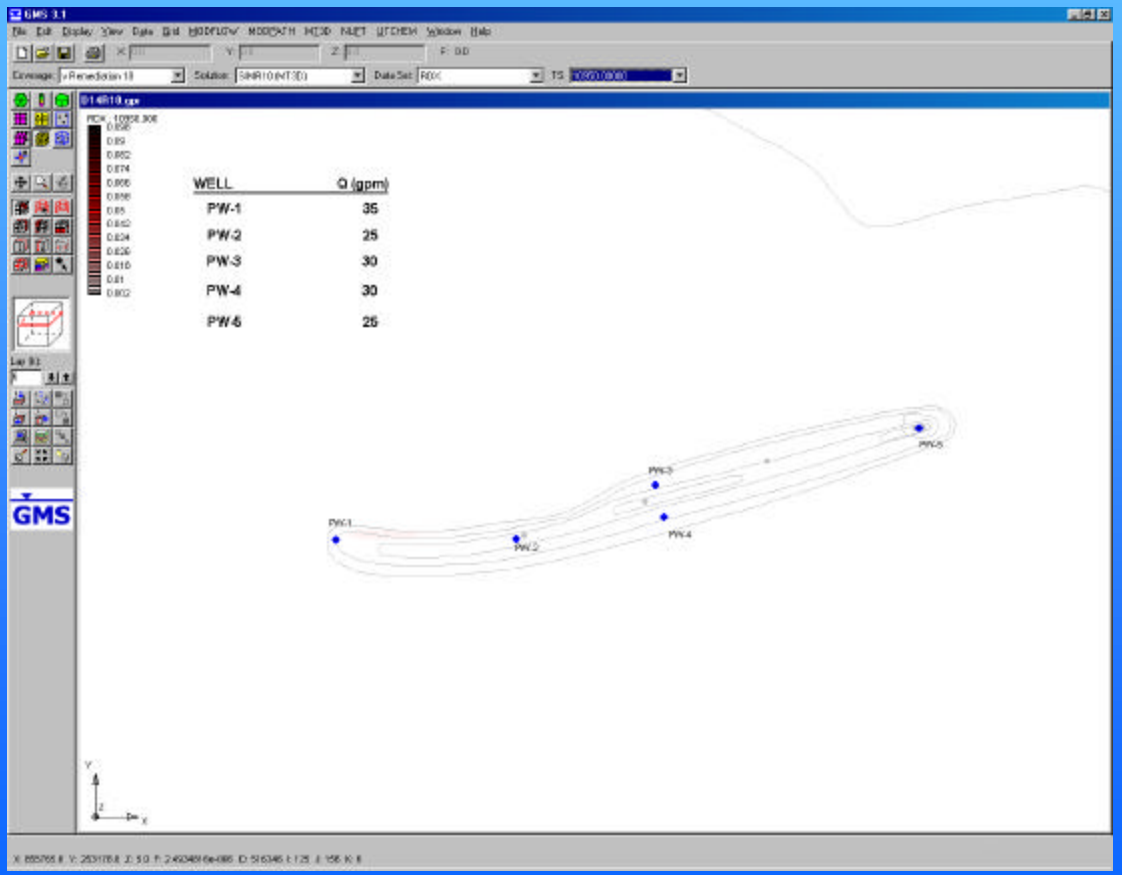
Five extraction wells T = +20 years

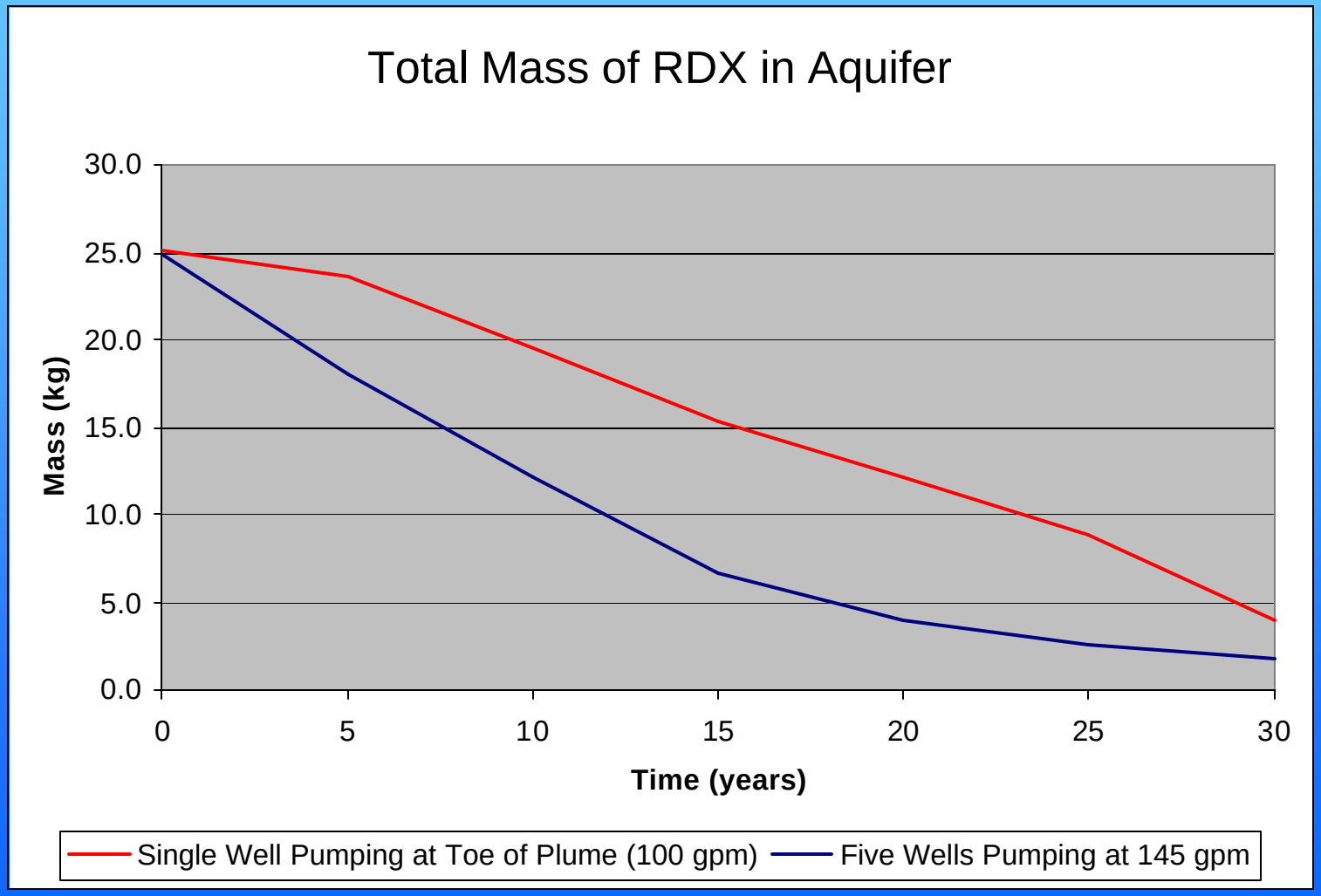


Five extraction wells T = +25 years

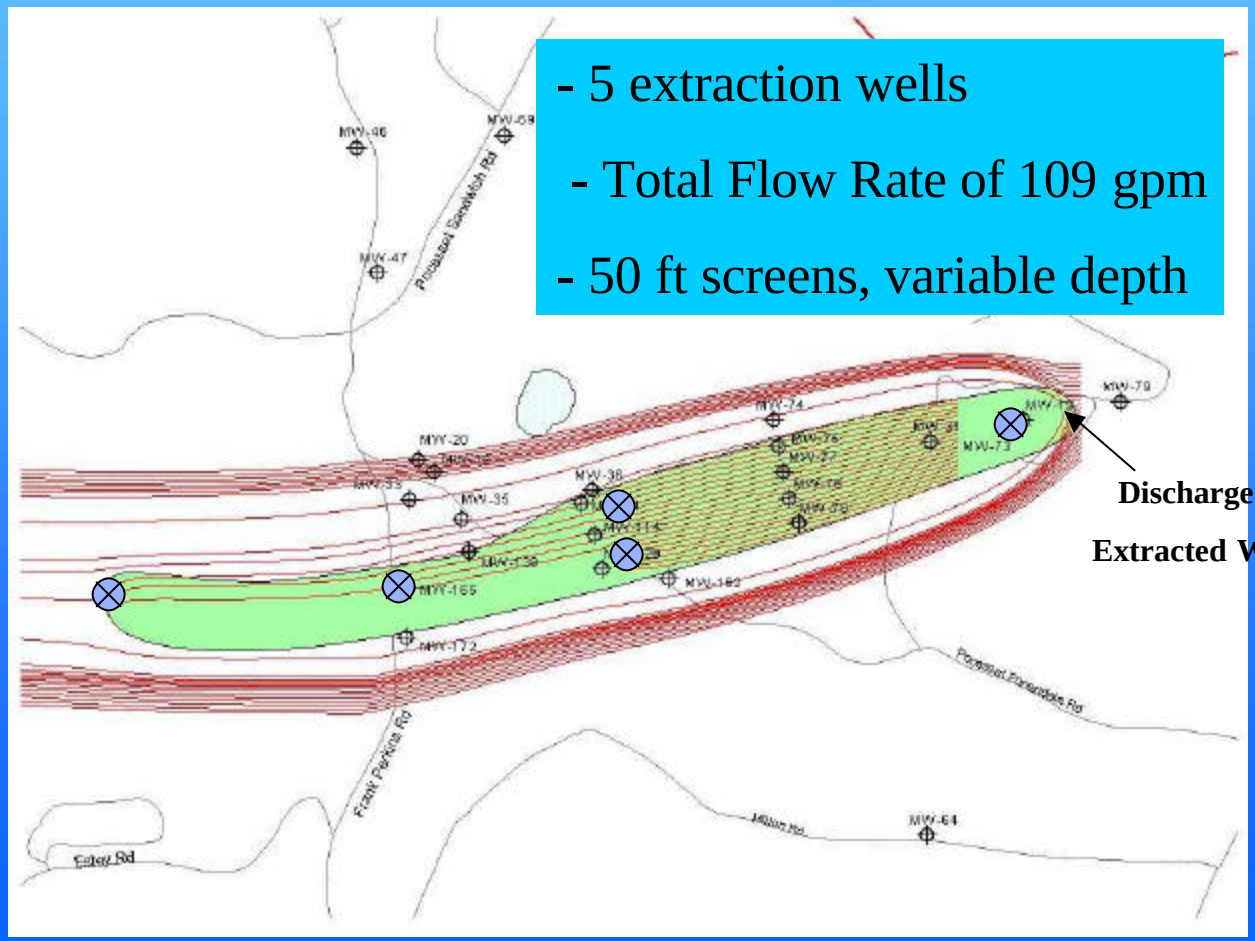


Five extraction wells T = +30 years



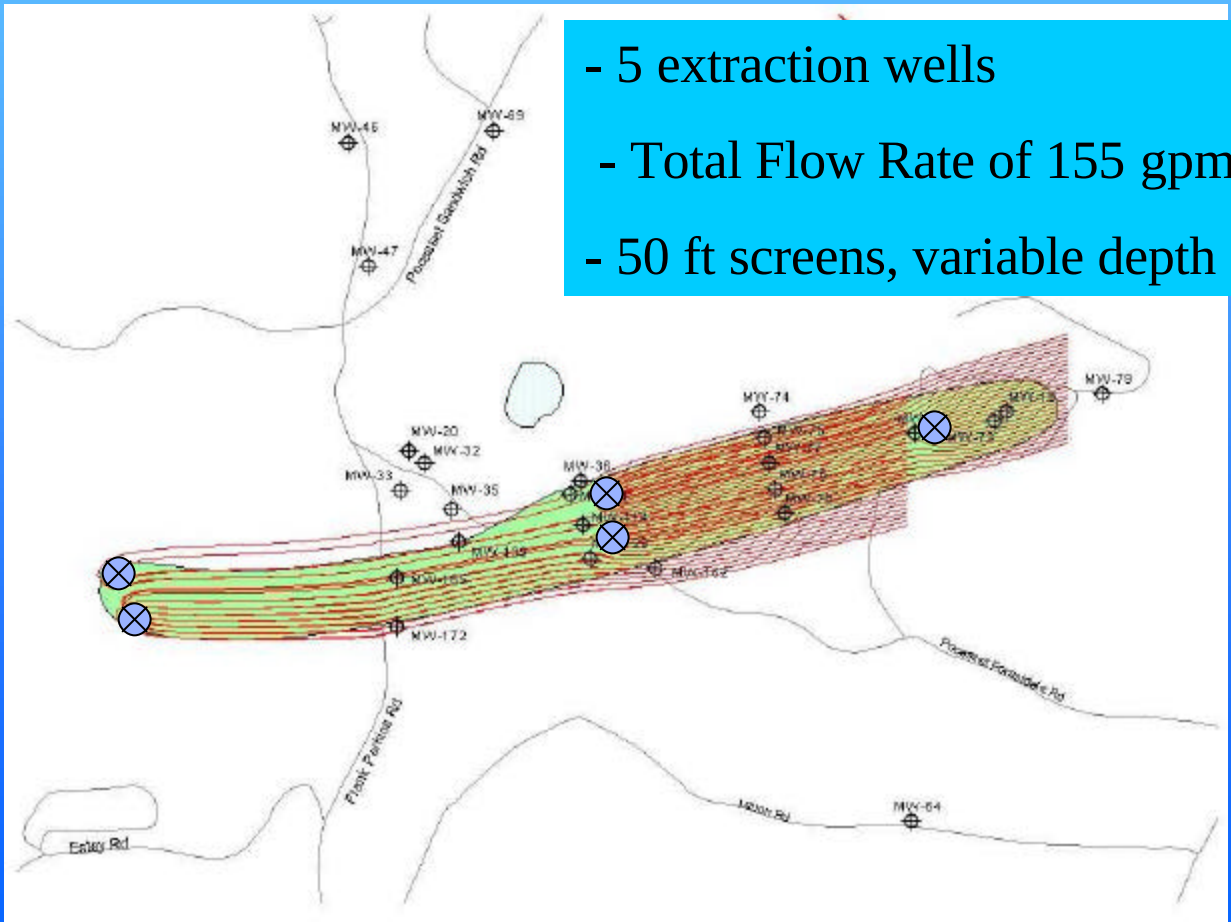

Total Mass of RDX in Aquifer
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Mass (kg)
0
5
10
15
20
25
30
Time (years)
Single Well Pumping at Toe of Plume (100 gpm)
Five Wells Pumping at 145 gpm

PLUME COLLAPSE - SURFACE DISCHARGE AT DEMO 1



PLUME COLLAPSE - 5 EXTRACTION WELLS (2 AT TOE OF PLUME)

- 5 extraction wells
- Total Flow Rate of 155 gpm
- 50 ft screens, variable depth



DELIVERABLES AND SCHEDULE

- Draft FS - 10/16/01
- Final FS - 12/31/01
- Remedy Selection Plan - 01/28/02
- RA/RD - ???

CONCLUSIONS/RECOMMENDATIONS

- Subregional Model Developed that Matches Major Plume Parameters and Configuration
- Model Suggests Source(s) are 20 to 30 Years Old
- Source(s) are Still Active and Not Exhausted
- Existing Plume can be Captured by a Single Well at 100 to 150 gpm
- Plume Collapse is Possible Using Additional Extraction Wells
- Recalibration of Model After Collection of O&M Data and Refinement of O&M Parameters