

PM2.5 NAAQS Modeling – Challenges & Possible Solutions

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PM2.5 NAAQS Modeling – Agenda (My Focus: Background)

■ Some Challenges

- AERMET with AERSURFACE & 2001 NLCD
- Background Concentrations > 50% of NAAQS
- Computing Run Time
- Direct Emissions (Condensable + Filterable)
- Emission Factors & Emission Testing

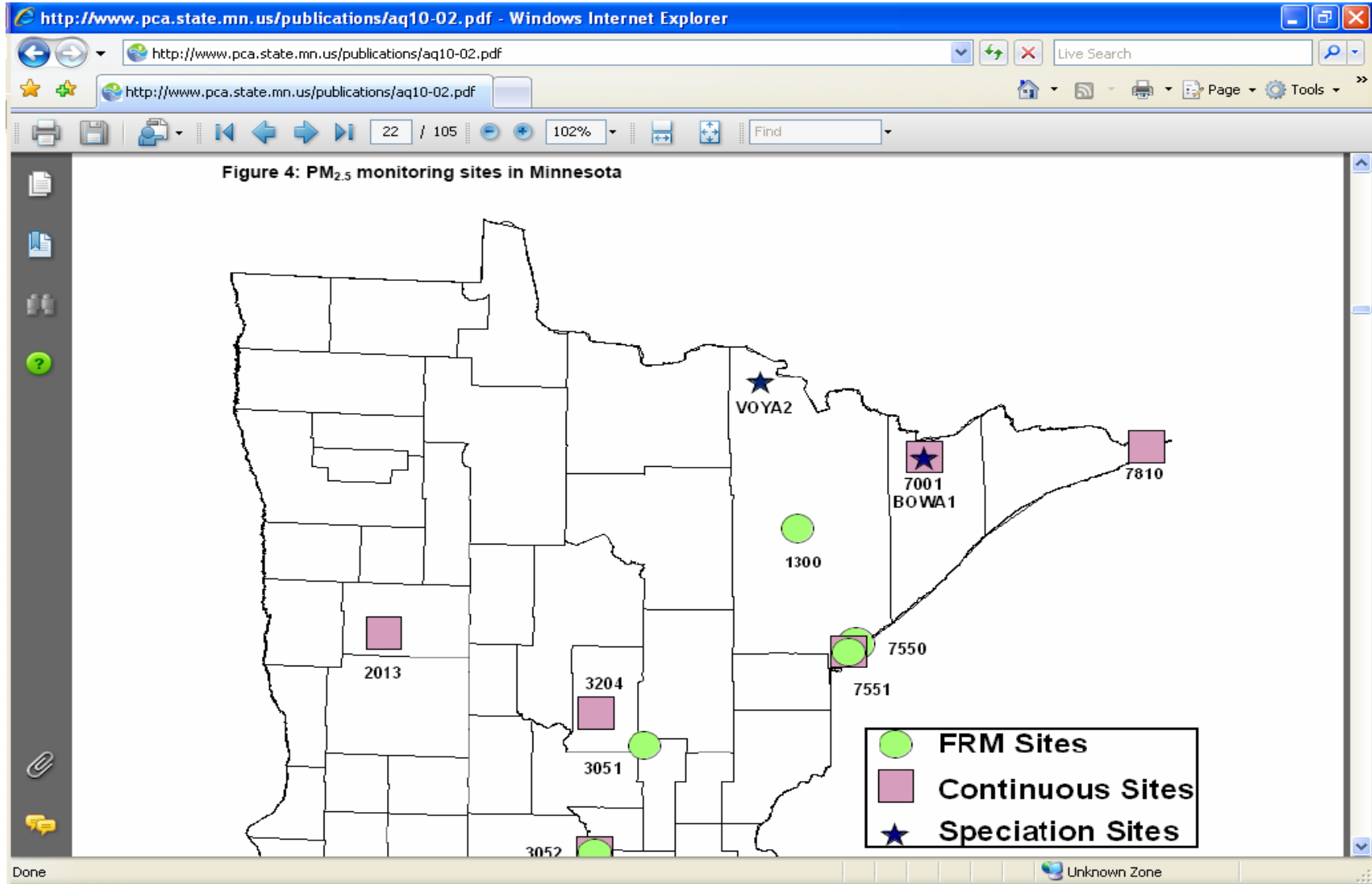
■ Possible Solutions (Background)

■ Possible Evaluations (Background)

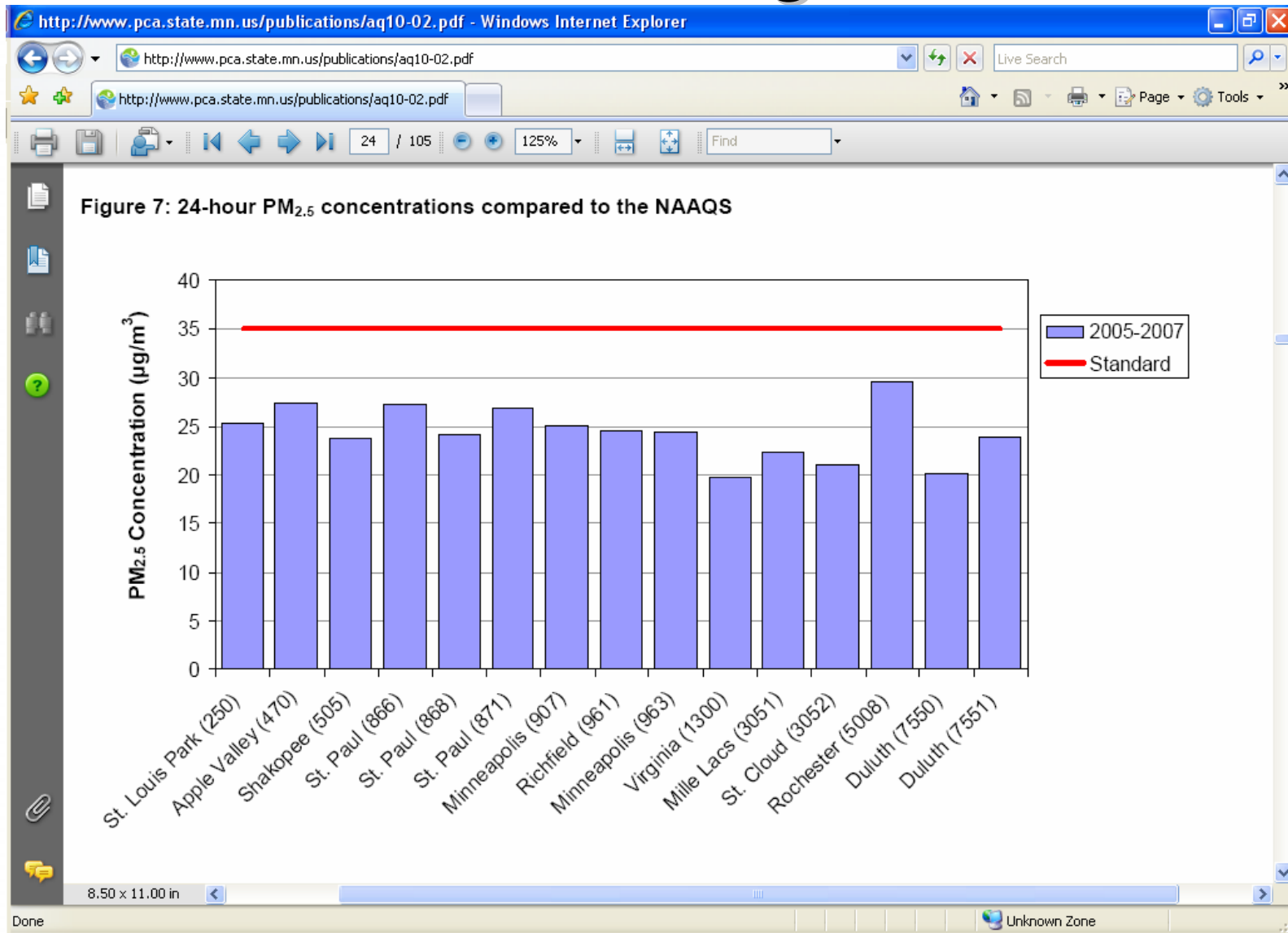
PM2.5 NAAQS Modeling

- High 24-Hour PM2.5 Background
 - PM2.5 > 50% of NAAQS (Statewide)
 - My focus: 24-hour PM2.5 in northern MN
 - Federal Reference Method (FRM) Sites
 - Site 1300 (Virginia)
 - Site 3051 (Mille Lacs)
 - Site 7550 (Duluth)
 - Site 7551 (Duluth)
- High Annual PM2.5 Background
 - PM2.5 ~50% of NAAQS (Statewide)

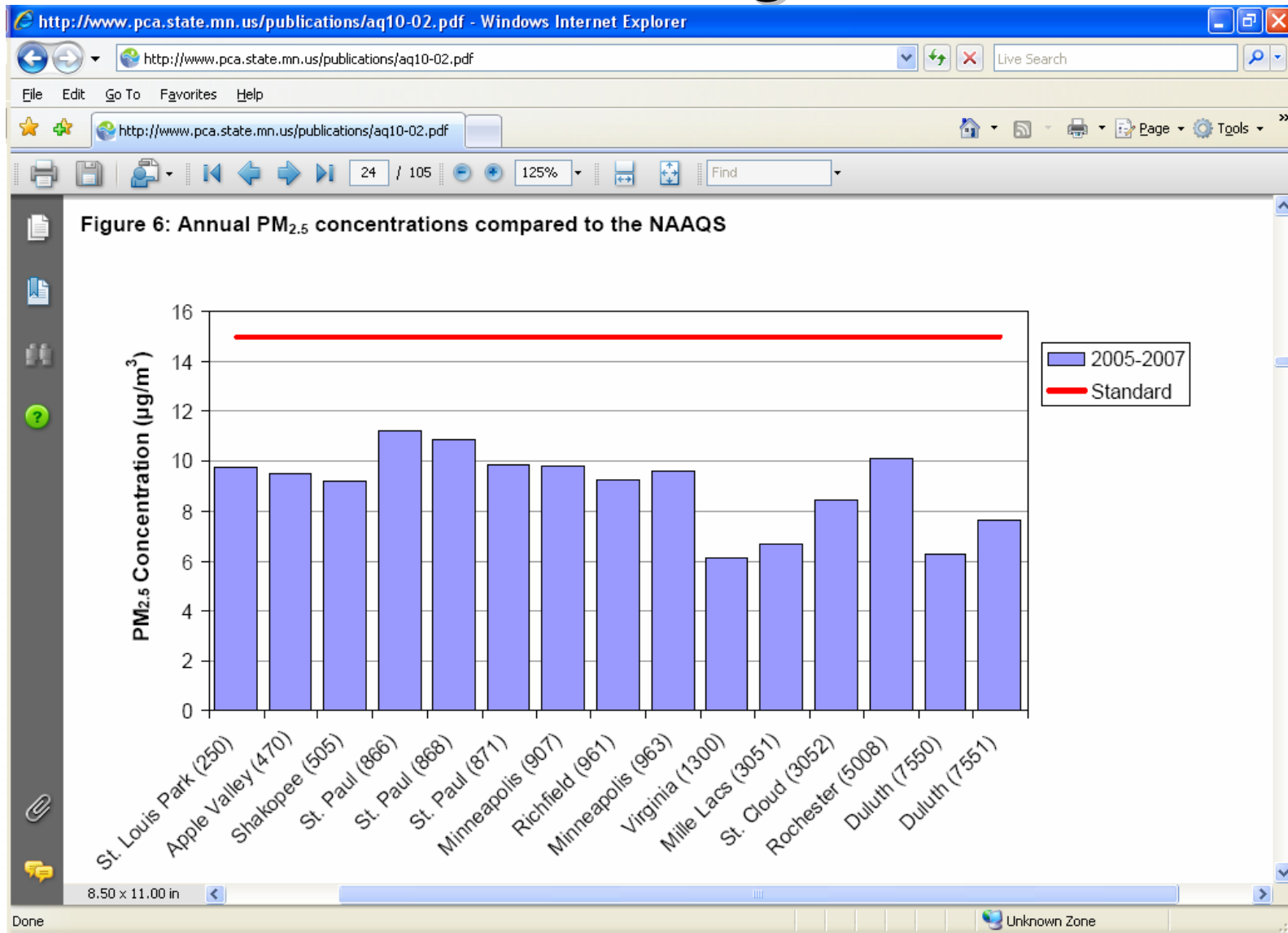
PM_{2.5} FRM Sites – Northern MN



24-Hour PM_{2.5} Background Values



Annual PM_{2.5} Background Values



MPCA Thoughts on Background

■ Problem:

- Past methods to account for background in NAAQS modeling demonstrations lack space/time “pairing” of facility impacts with monitored background impacts.
- Can we PREDICT background in time and space?

■ Possible Solution:

- Using available emissions data from area and mobile source inventories...
- Can we MODEL background in time and space the same way we do for emissions from a project?

MPCA Thoughts on Background

- Instead of adding it (traditional approach)..
- Let's model it (modeled approach)

- Others are thinking about this too
 - 9th Conference on Air Quality Modeling
 - Presentation by Bob Paine of ENSR
 - One of the original AERMIC members
 - Bob mentions PM_{2.5} NAAQS modeling with modeled background (see his slides 11-14)

MPCA Thoughts on Background

- Traditional Approach (Appendix W)
 - First model the facility and nearby sources
 - Then add representative/conservative background
 - 98th percentile (24-hour values of 20 to 30 ug/m³ in MN)
 - 50th percentile (annual values of 6 to 11.5 ug/m³ in MN)
- Modeled Approach (Maybe) (Pending)
 - Model “ALL” sources
 - Facility & Nearby & FAR[FWE+CWE] & BKG Sources
 - Maximize pairing in space/time
 - Extra Requirements
 - EPA/MPCA written approval
 - EPA Model Clearinghouse vetting or EPA Region 5 vetting
 - Post-Construction Ambient Monitoring?
 - Rewrite AERMOD code? Appendix W? Other Guidance?

PM2.5 Background

- Modeled Background Approach (Idea Stage)
 - Ready or not – here it is – warts and all



PM2.5 Background – Topics (Modeled Background Approach)

- Some Concepts
- Some Details
- Some Tests
- Next Steps
 - Possible Future Work
 - Possible Vetting Schedule

PM2.5 Background – Concepts

■ Key Concepts for Modeled Background

- Let's avoid unpaired sums
- Optimize “pairing” to avoid:
 - Modeled maximum on day A
 - Monitored maximum on day B
- Idea: model it (don't add it)
 - Single AREACIRC source
 - Let AERMOD do the pairing

PM2.5 Background – Some Details (Modeled Background Approach)

■ Possible Solution for Background (BKG)

- Goal: optimize “pairing”

- How: model it!! [sources and background]

- Model BKG within ?? km to optimize “pairing”
- Model: Facility + Nearby + “FAR” + BKG Sources
 - Model facility sources as usual
 - Model nearby sources as usual
 - Model First-Approximation Run (FAR) Sources
 - » Regional/Facility-Wide Emissions (FWE)
 - » Regional/County-Wide Emissions (CWE)
 - Model BKG via large AREACIRC Source

PM2.5 Background – Four Tests (Modeled Background Approach)

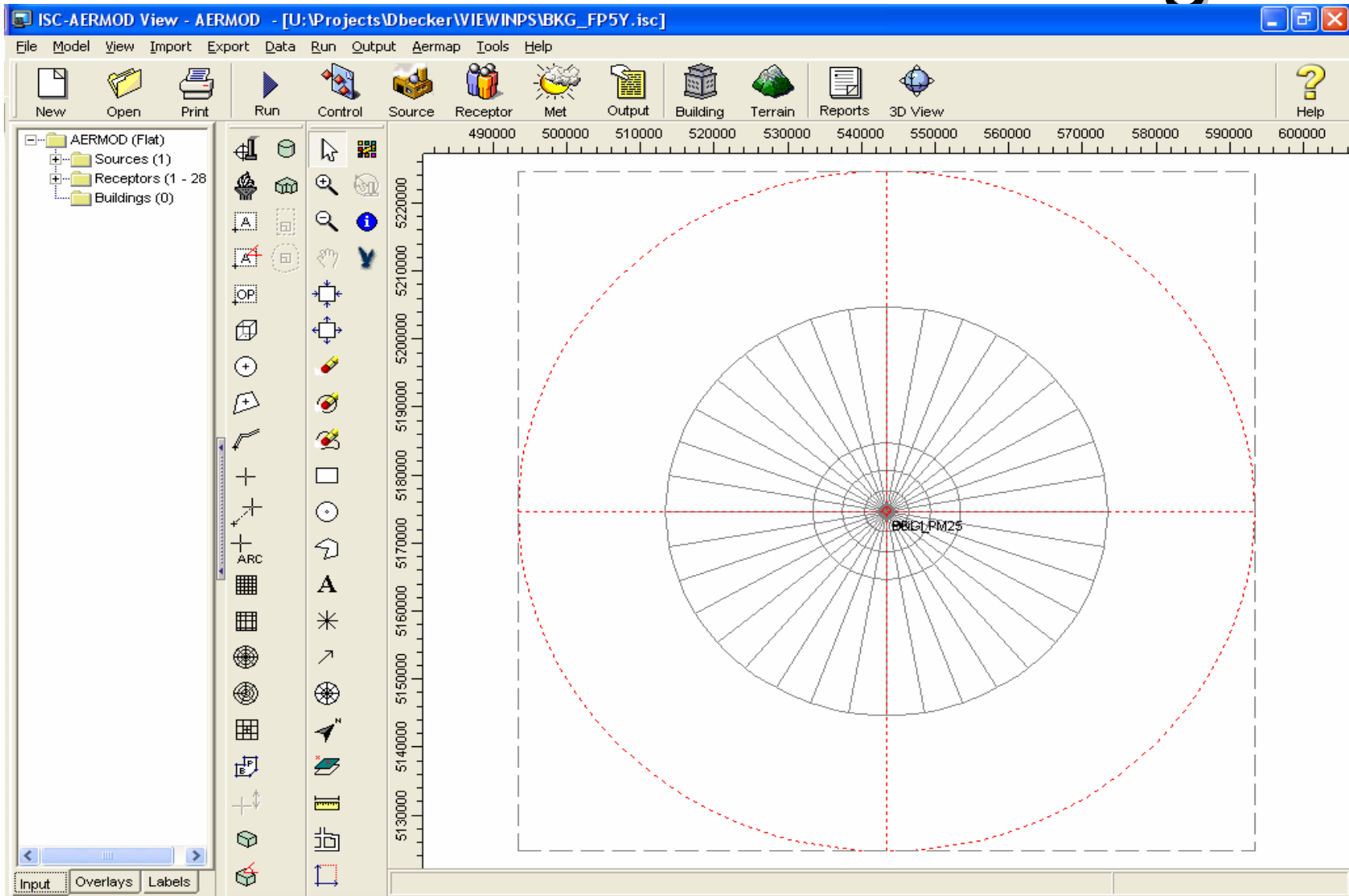
1. Significant Concentration Gradient
 - FLAT Terrain (288 receptors out to 30km)
 - ELEV Terrain (950 receptors out to ~3km)
2. AREACIRC Radii (1 receptor)
3. Full Distribution (1 receptor)
4. Simple Example & Comparison (1 receptor)

PM2.5 Modeled Background Test1

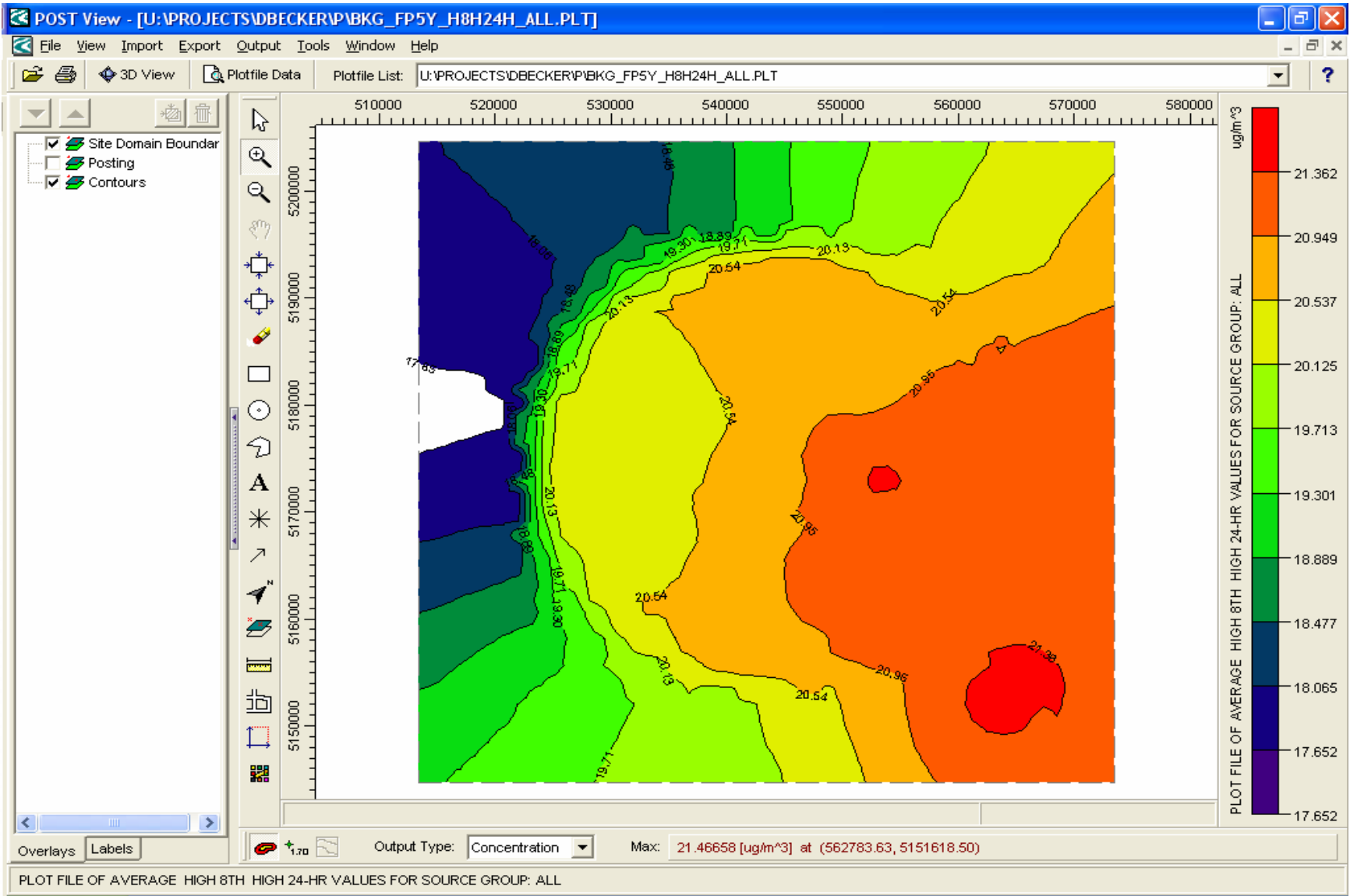
Significant Concentration Gradient

- AREACIRC – Carlton County BKG Test
 - Radius: 50,000 meters (i.e. 50KM)
 - Emission Flux = $12.5 * 0.2287E-08$ g/s/m²
 - $0.2287E-08$ = Carlton county PM2.5 emissions on MPCA EDA website (area, non-road, on-road) / county size
 - <http://www.pca.state.mn.us/data/edaAir/emissions.cfm>
 - http://www.naco.org/Template.cfm?Section=Find_a_County
 - Release Height = 10.0 meters
 - Initial Sigma-Zo = 4.65 meters
 - Duluth surface & St. Cloud upper air met data
- FLAT terrain results are encouraging
 - This may be fine for long-range transport
 - This may have significant computational advantages

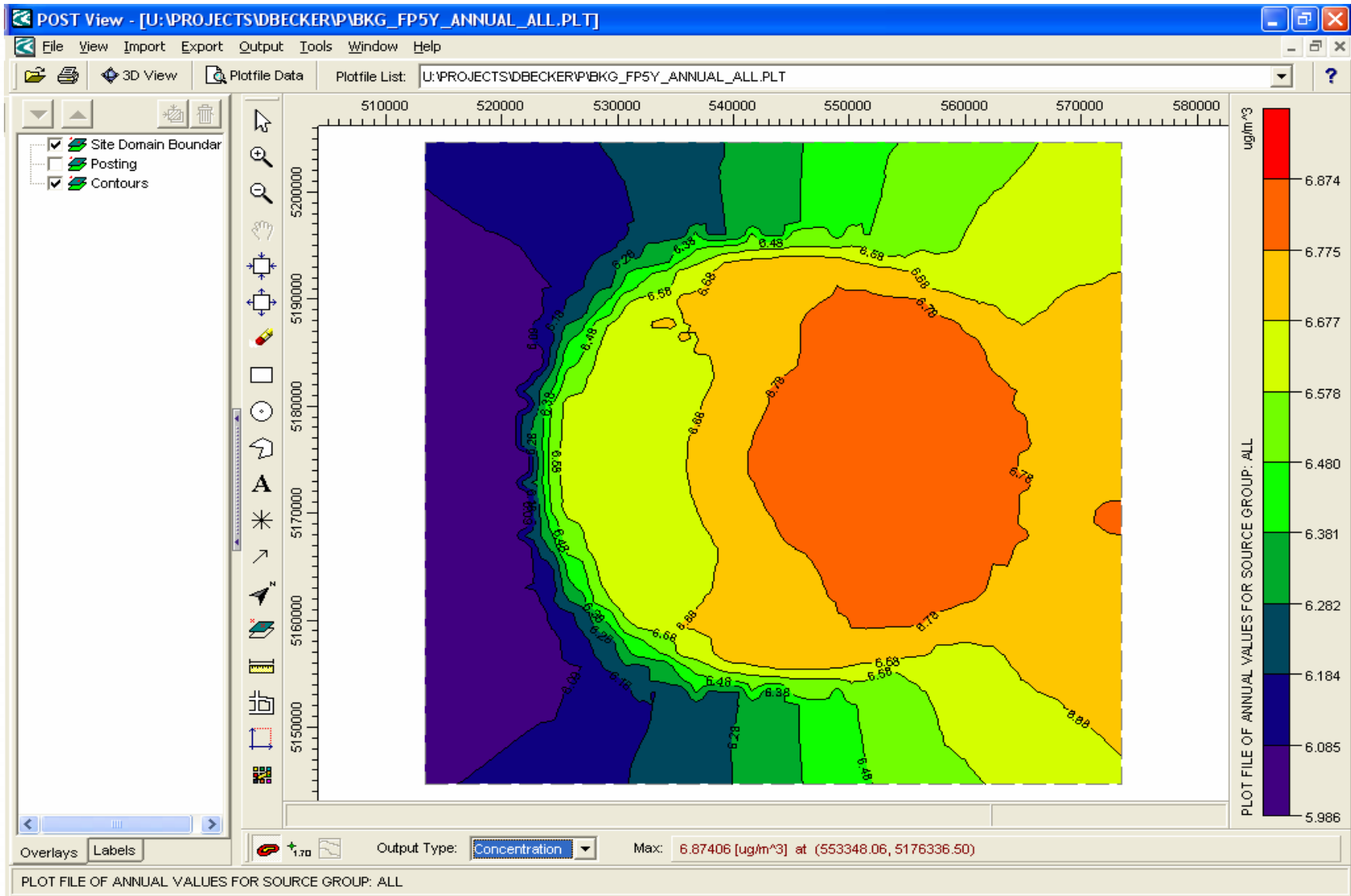
AREACIRC & FLAT terrain grid



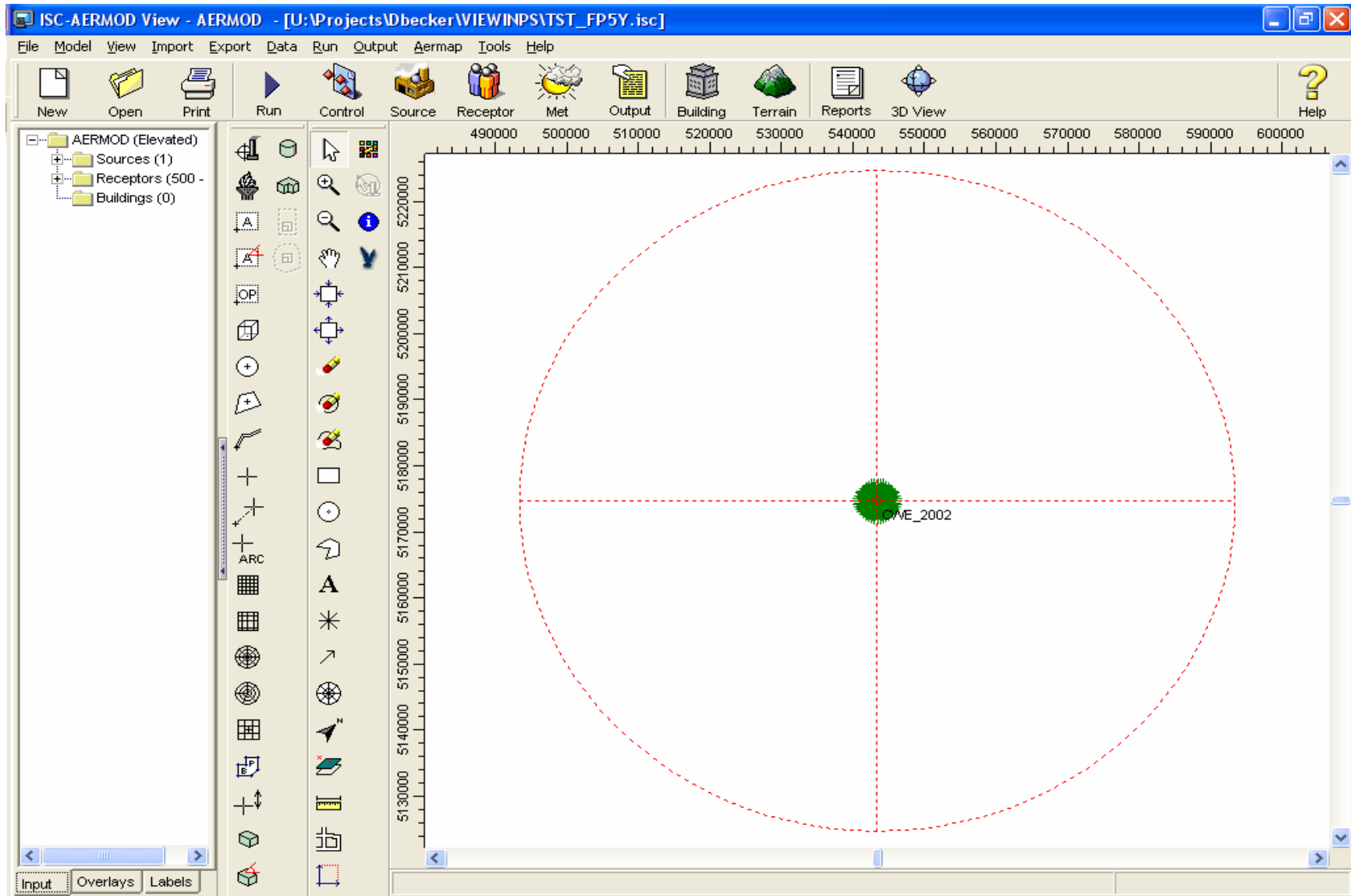
24HOUR FLAT Terrain Results



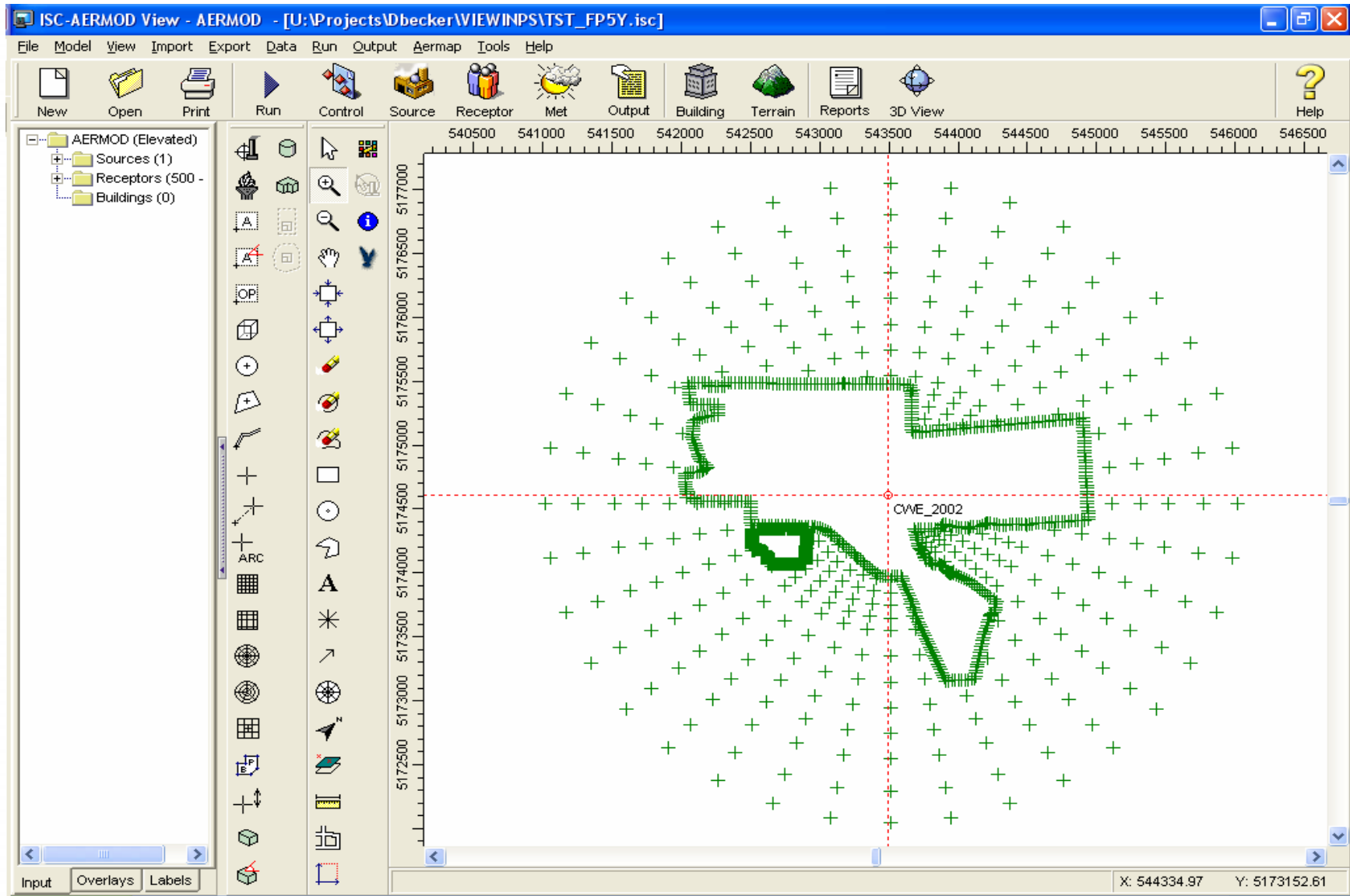
ANNUAL FLAT Terrain Results



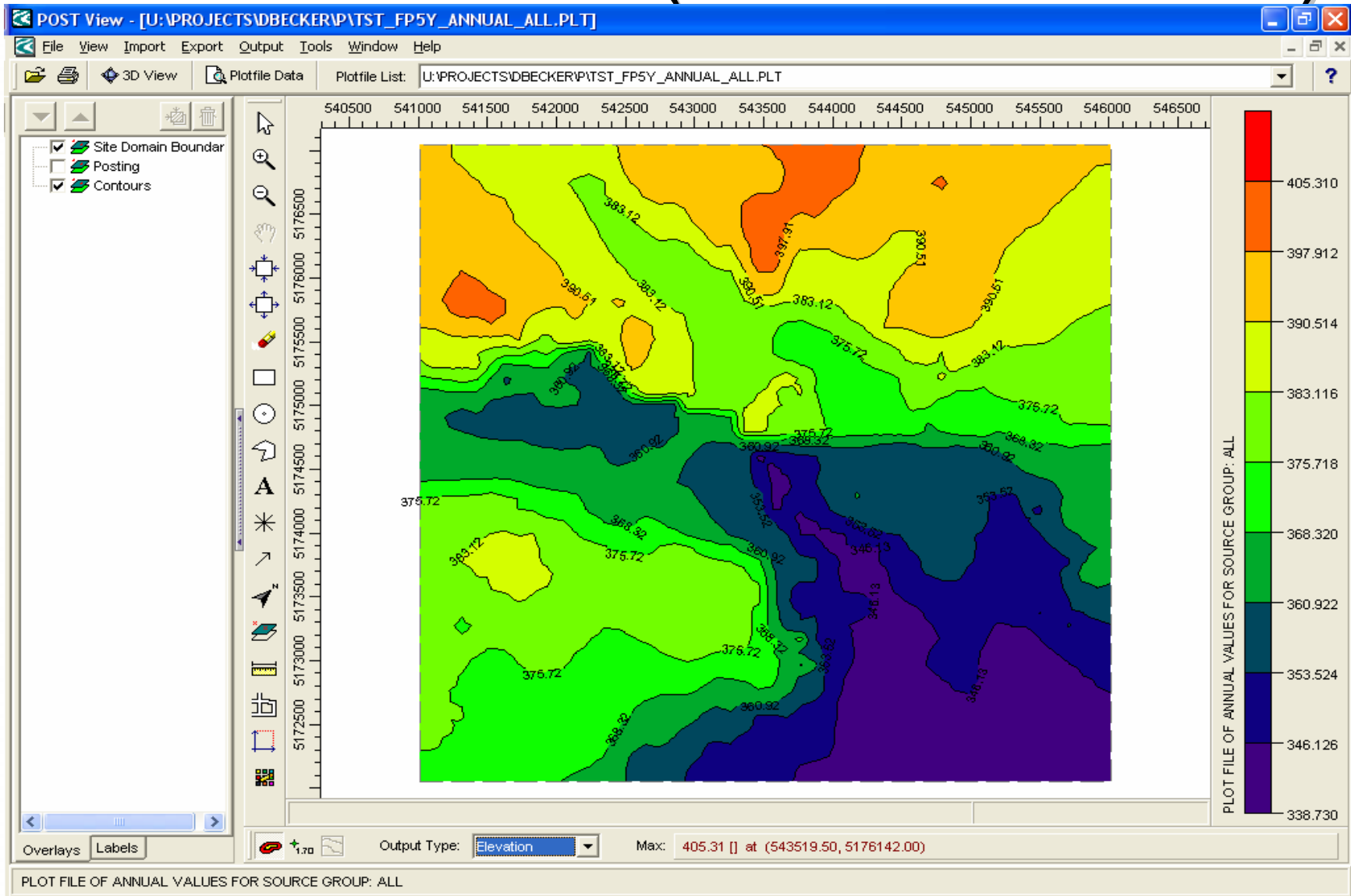
AREACIRC & ELEV Terrain Grid



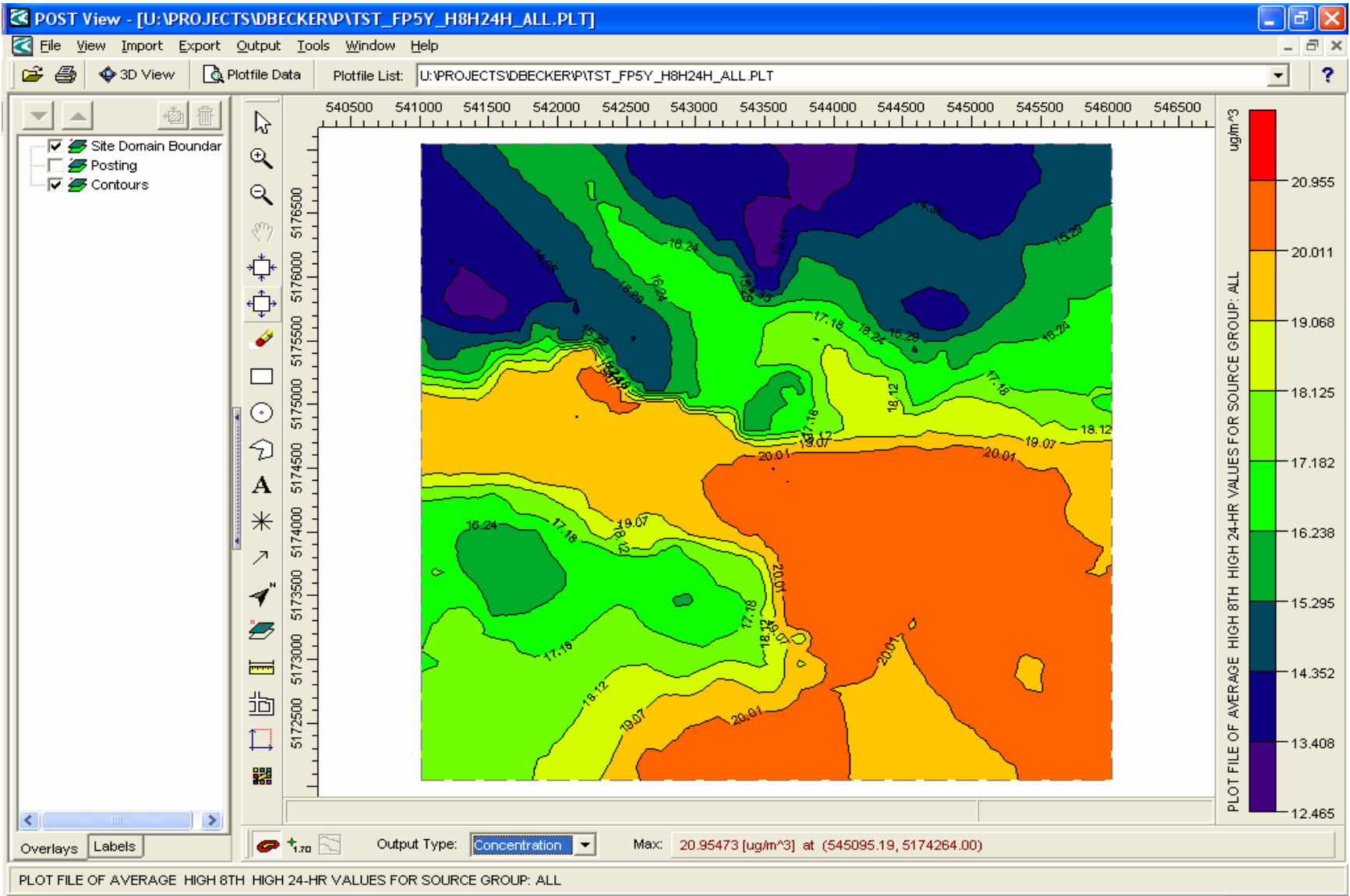
AREACIRC & ELEV Terrain Grid



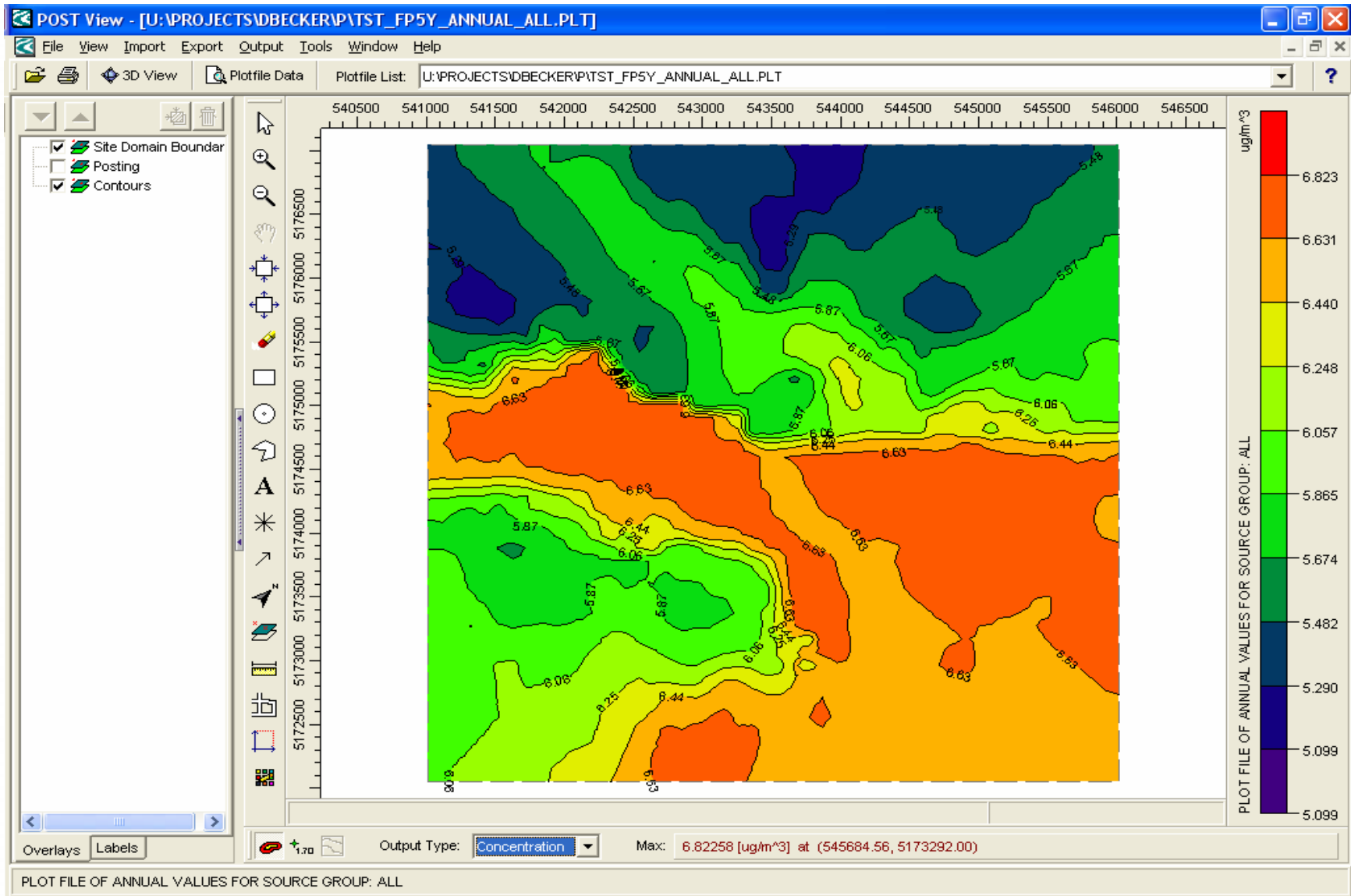
ELEV TERRAIN (~200 Feet Relief)



24HOUR ELEV Terrain Results



ANNUAL ELEV Terrain Results



PM2.5 Modeled Background Test2 (Three Different AREACIRC Radii)

■ AREACIRC – Carlton County BKG Test

- 3 Radii: 50,000m, 500,000m, and 5,000,000m
- Emission Flux = $0.2287\text{E-}08$ g/s/m²
- Release Height = 10.0 meters
- Initial Sigma-Zo = 4.65 meters
- Duluth surface & St. Cloud upper air met data

■ Results are encouraging

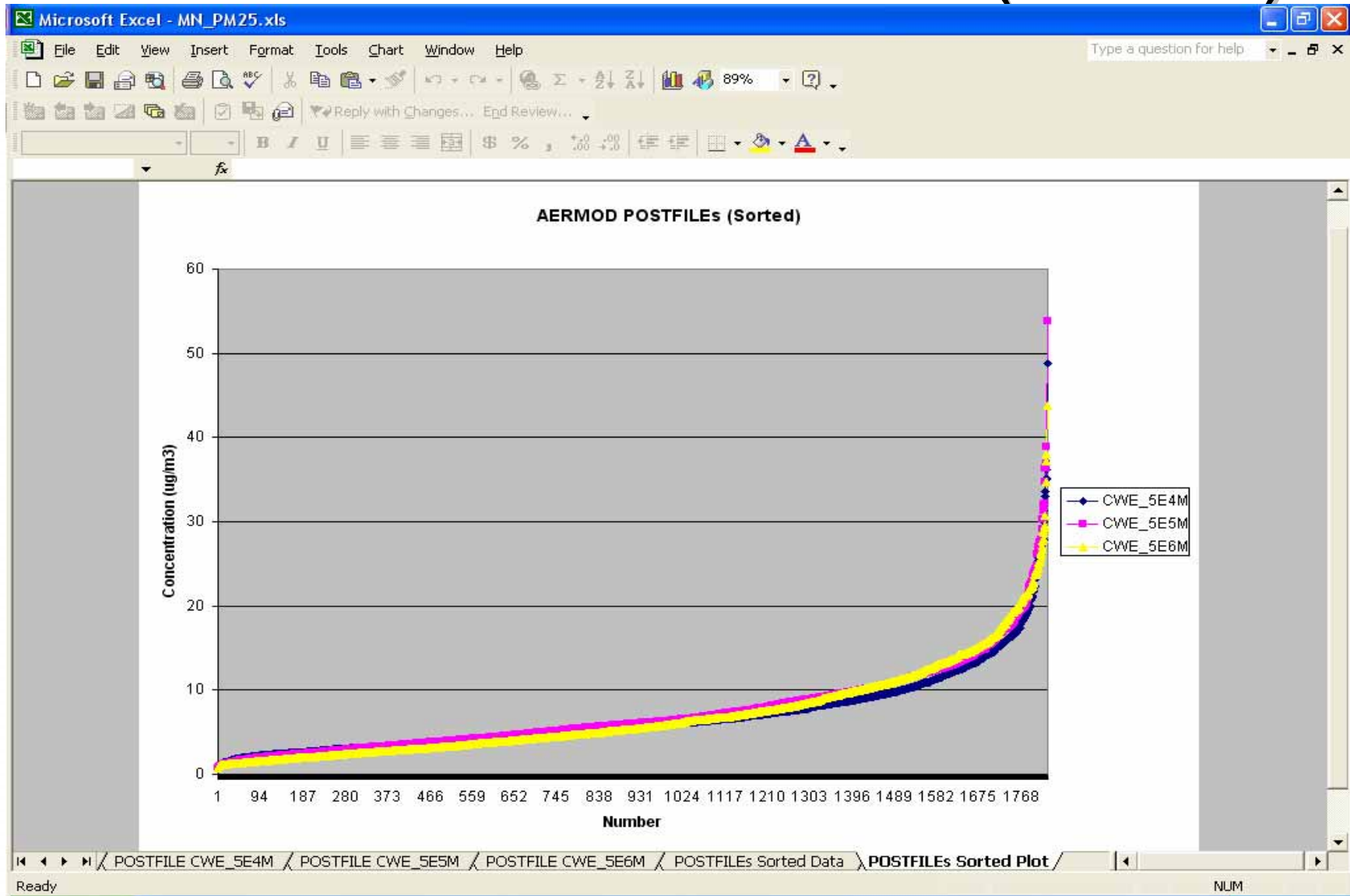
PM2.5 Modeled Background Test2 (Three Different AREACIRC Radii)

- Results for Radius = 50,000 meters
 - Annual = 0.5 ug/m³ (monitor/model ~13)
 - 24hour = 1.6 ug/m³ (monitor/model ~14)
- Results for Radius = 500,000 meters
 - Annual = 1.5 ug/m³ (monitor/model ~4.3)
 - 24hour = 4.5 ug/m³ (monitor/model ~ 4.9)
- Results for Radius = 5,000,000 meters
 - Annual = 6.2 ug/m³ (monitor/model ~1.1)
 - 24hour = 20.0 ug/m³ (monitor/model ~1.1)

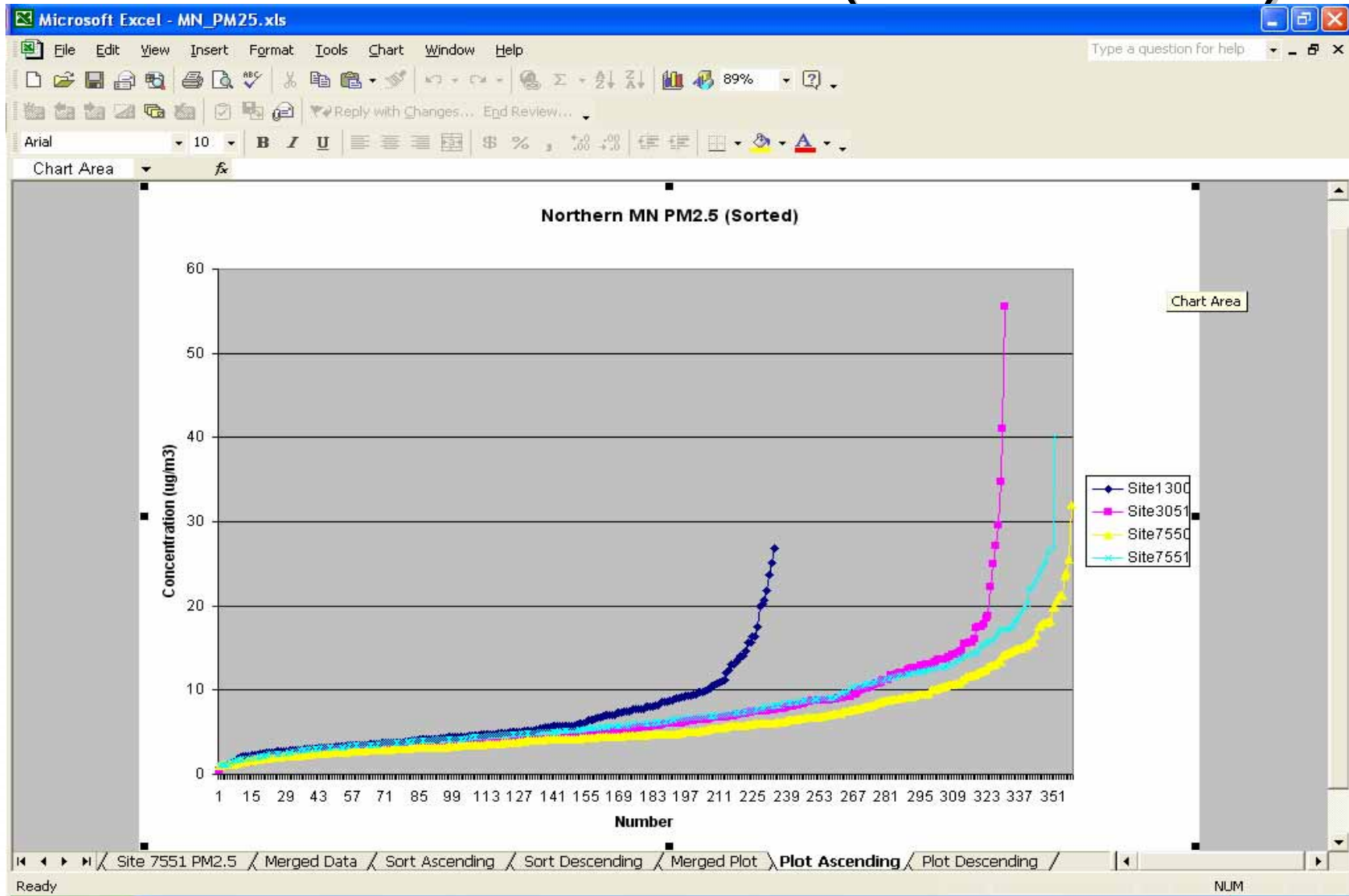
PM2.5 Modeled Background Test3 (3 Different Radii; Full Distribution)

- Model Assumptions (Background Only)
 - AREACIRC Emission Flux = $\text{Scalar} * 0.22870\text{E-}07 \text{ g/s/m}^2$
 - Scalar=12.5, 4.9, 1.1 (by radii)
 - Radii = $5\text{E}4$, $5\text{E}5$, $5\text{E}6$ meters
 - Release Height = 10.0 meters
 - Initial Sigma- Z_0 = 4.65 meters
 - Meteorology – Duluth surface & St. Cloud upper air
- Modeled Background (AERMOD AREACIRC)
 - 24hour: Approx. 20 $\mu\text{g}/\text{m}^3$ (98th percentile)
 - Annual: Approx. 6 $\mu\text{g}/\text{m}^3$ (arithmetic mean)
- Monitored Background (PM2.5 FRM Sites-northern MN)
 - 24hour: 20 to 22 $\mu\text{g}/\text{m}^3$ (98th percentile)
 - Annual: ~ 6 to 7 $\mu\text{g}/\text{m}^3$ (arithmetic mean)
- Results are encouraging

AREACIRC POSTFILEs (Sorted)



Northern MN PM2.5 (2005-2007)



PM2.5 Modeled Background Test4 (Simple Example & Comparison)

- Traditional (Regular) Approach
- Experimental Modeled Approach

24-Hour PM_{2.5} AERMOD Results traditional background approach

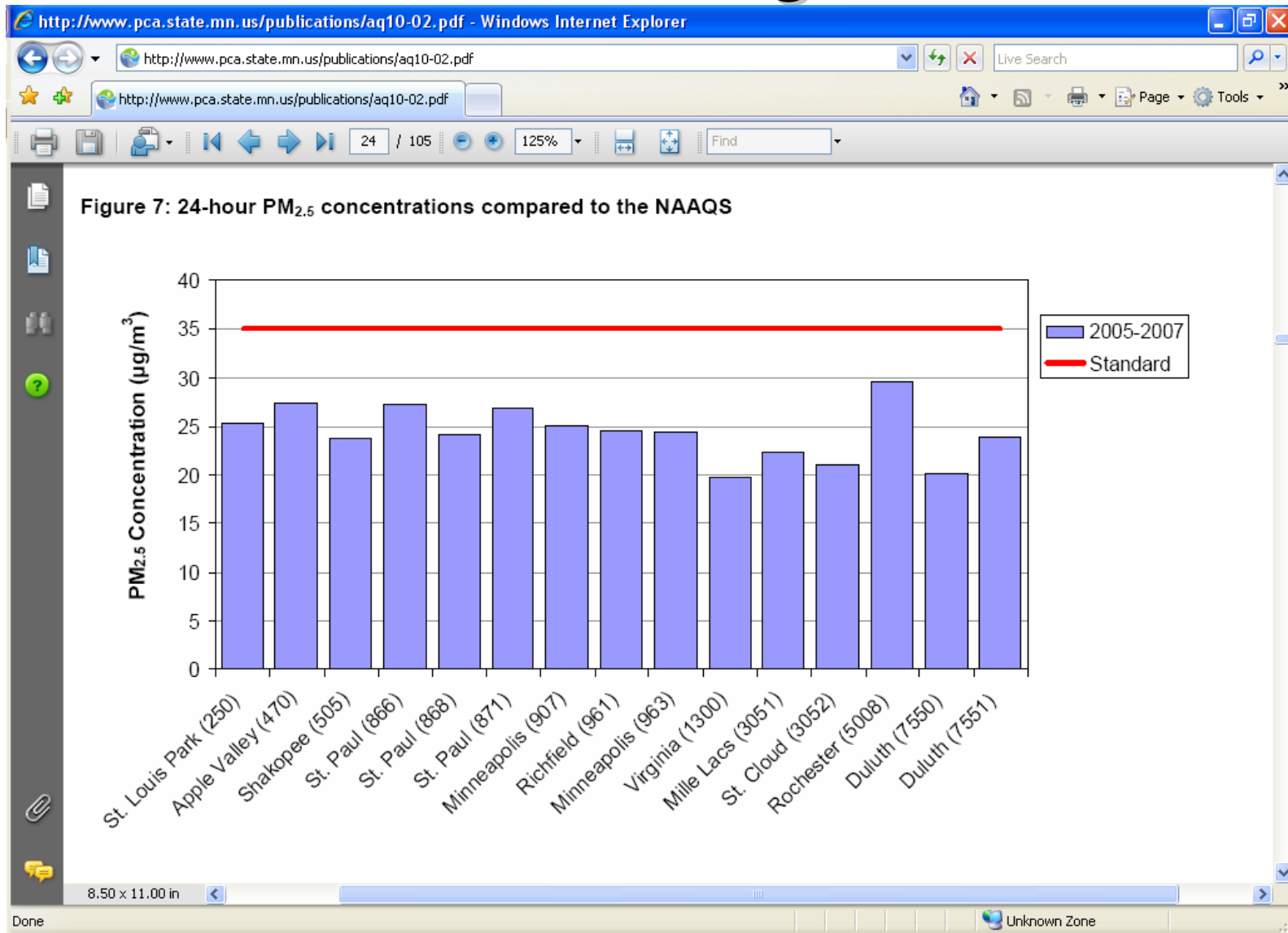
- Modeled Facility = 17 ug/m³
- Monitored “BKG” = 20 ug/m³
- Total Impact = 37 ug/m³ (>NAAQS)

24-Hour PM_{2.5} AERMOD Results experimental background approach

- Modeled Facility = 17 ug/m³
- Modeled “BKG” = 20 ug/m³
- Modeled “ALL” = 25 ug/m³ (< NAAQS)



24-Hour PM_{2.5} Background Values



Summary of Preliminary Tests

- Goal: reasonable PM2.5 NAAQS modeling results
- How: paired sums (sources and background)

- The Good News: preliminary results are encouraging
- The Bad News: experimental only – needs vetting!!
- The Ugly News: ugly runtimes
 - AREACIRC with just one receptor:
 - 0.1-0.2 hours for Radius = 50,000 meters
 - 0.2-0.8 hours for Radius = 500,000 meters
 - 2.0-7.0 hours for Radius = 5,000,000 meters

- Next Steps: different meteorology/regions, vetting, etc.

Possible Future Work

- Different Meteorology
 - INL, HIB, DLH, MSP, RST, etc.
- Different Regions in MN
 - Northern Minnesota (Rural)
 - Southern Minnesota (Rural)
 - Twin Cities Metro (Urban)
- Different States
 - IL, IN, MI, MN, OH, WI, etc.

Possible Vetting Schedule

- Oct. 22, 2008 – 1st Conference Call
 - EPA Region 5 staff
 - EPA OAQPS
 - EPA Region 5 states (IL, IN, MI, MN, OH, WI)
- Nov. 6, 2008 – Upper Midwest A&WMA
- Testing (2008 - 2009)
- USEPA Vetting (2010)
- Regulatory Use (????)

Questions?

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