Colorado Department of Public Health and Environment

BART Control Technology Visibility Improvement Modeling Analysis Guidance

April 12, 2006 Air Pollution Control Division / Technical Services Program

This document presents the Air Pollution Control Division (Division) dispersion modeling guidance for estimating the degree of visibility improvement from potential Best Available Retrofit Technology (BART) control technology options. It describes dispersion modeling and analysis methods for quantifying the degree of visibility improvement from potential BART control scenarios/strategies. It does not explain how the visibility results are factored into the BART determination process (i.e., 5-step process). For that, refer to applicable rules and/or the Division's "BART Analysis Procedures" guidance.

A standard set of metrics is presented for making side-by-side comparisions of pre-control and post-control visibility impacts. However, source operators may provide additional information to characterize the degree of improvement/impairment from proposed control scenarios/strategies.

Since the recommended modeling approach in this guidance for the BART control scenario/strategy analysis relies on the Division's subject-to-BART modeling protocol and uses peak 24-hour average emission rates, the pre-control modeling results (for all pollutants and all BART-eligible units at a given facility) are suitable for determining if impacts from a BART-eligible source are below the "contribution threshold." Thus, if pre-control modeled impacts are below the applicable contribution threshold, submit a revised subject-to-BART modeling report to the Division for review.

1. Model Selection

Use the CALPUFF modeling system to determine the visibility improvement expected at Class I federal areas from applying potential BART controls. Another modeling system may be used as discussed in the 40 CFR 51 Appendix Y (BART Guideline). If a different modeling system is proposed, submit a protocol to the Division that explains the technical rationale for the model selection.

If CALPUFF is used, the following model versions are acceptable:

- July 2004 version:
  - CALPUFF: version 5.711a, level 040716
  - CALMET: version 5.53a, level 040716
  - POSTUTIL: version 1.31, level 030528
  - CALPOST: version 5.51, level 030709
- December 2005 version:
  - CALPUFF: version 5.711b, level 051216
  - CALMET: version 5.53b, level 051216
  - POSTUTIL: version 1.31, level 030528
  - CALPOST: version 5.51, level 030709
- February-March 2006 "VISTAS" version:
  - CALPUFF: version 5.754, level 060202
  - CALMET: version 5.722, level 060322
  - POSTUTIL: version 1.43, level 060206
  - CALPOST: version 5.6393, level 060202

- Processors modified or developed by the Division for the BART analysis:
  - Division's 98th percentile postprocessor:
    - BART98_v4.EXE – This postprocessor reads a file called "deciview24.dat" that is generated from a modified version of CALPOST.
  - CALPOST versions modified by the Division to generate the delta-deciview output file "deciview24.dat" required by the Division's 98th percentile postprocessor:
    - CALPOST_BART98_v3.EXE (version 5.51_CO_v3, level 030709) – This version is compatible with the July 2004 and December 2005 versions of CALPUFF. If needed or requested, the Division will modify the VISTAS version of CALPOST or other newer versions.[1]

Although the Division does not have written approval from U.S. EPA to use the December 2005 and VISTAS versions of the CALPUFF modeling system, the July 2004 version of the modeling system has been generally accepted by U.S. EPA and Federal Land Managers. In the absence of

[1] If a newer version of CALPOST becomes available and is approved by U.S. EPA, it may be used. If it generates the metrics described in section 3, then the Division's BART98_v4 postprocessor does not need to be used. If the new version of CALPOST does not generate the requested metrics, either calculate the metrics with existing CALPOST output files or modify CALPOST to output the "deciview24.dat" file needed by the Division's postprocessor (BART98_v4). If CALPOST is modified, submit the revised code and executable file to the Division along with the modeling report. Alternatively, the Division will modify newer versions of CALPOST upon request to output the "deciview24.dat" file.

written approval from U.S. EPA to use the newer versions of CALPUFF, the Division performed a consequence analysis to determine if the December 2005 and the VISTAS versions of the modeling system are equivalent to the July 2004 version for purposes of BART modeling in Colorado. The Division's analysis demonstrates equivalency based on the model setup in the Division's protocol. However, the analysis did not evaluate the consequence of other parameter settings. Consequently, if the December 2005 or VISTAS versions listed above are applied in a way that differs from the Division's recommended setup, consult with the Division to determine if an analysis should be submitted to demonstrate equivalency with the July 2004 version or with the latest U.S. EPA approved version. If newer versions of the CALPUFF modeling system (e.g., version 6) are approved by U.S. EPA, they may be used.

2. Model Application

If CALPUFF is used, as recommended, follow the procedures in the latest version of the Division's subject-to-BART protocol ("*CALMET/CALPUFF BART Protocol for Class I Federal Area Individual Source Attribution Visibility Impairment Modeling Analysis")* except where this guidance recommends a different approach. If another modeling system is proposed, submit a detailed protocol to the Division for review. The Division will work with U.S. EPA, federal land managers (FLMs), and others, as appropriate, to evaluate the modeling protocol.

2.1. Modeling Report and Data

Submit a modeling report as part of the 5-step BART analysis process. It should contain as much information as necessary to describe the modeling process and convey results. The modeling report should describe the modeling process, emissions estimation process, particulate matter speciation process, and provide the visibility impact results that will be factored into the 5-step BART analysis process.

The modeling report should include CDs and/or DVDs with model and postprocessor input/output files, although the gridded hourly CALMET.DAT files do not need to be submitted due to their large size. The mesoscale model (e.g., MM5) input files do not need to be submitted if the files were originally provided by the Division.

The protocol/report does not need to address the CALMET/CALPUFF model setup and parameters if the modeling follows the Division's subject-to-BART modeling protocol, as recommended. However, any deviations from the protocol should be explained and justified.

If a different modeling system is used, a complete protocol should be submitted for Division review and the modeling report should contain a complete discussion of model setup and application.

Consult with the Division to determine how many printed copies of the modeling report and how many sets of CDs/DVDs should be submitted.

Submit the modeling report in a format (e.g., PDF files) suitable for publishing on the Internet.

2.2. Source Configuration and Stack Parameters

The pre-control source configuration and stack parameters should be consistent with the pre-control emissions scenario. The post-control source configuration and stack parameters should reflect anticipated changes from installation of the control technology being evaluated. For example, stack gas exit velocities, stack gas exit temperatures, or other parameters might change due to the presence of emission controls. Similarly, if changes in building downwash parameters are expected to occur, the pre- and post-control modeling may reflect the changes.

2.3. Emission Rates for Modeling

Perform the visibility change analysis with peak 24-hour emission rates, as described in this section. If a source operator believes that other emission scenarios and/or averaging periods will provide valuable information about the degree of visibility change from a given BART scenario/strategy, additional pre- and post-control emission scenarios may be submitted.

2.3.1. Pre-Control Emission Estimates

Pre-control emission rates are intended to reflect peak 24-hour average emissions that may occur in the future under the source's current permit. There are a several ways the emission rates may be determined.

For each BART-eligible unit at the facility, determine the pre-control peak 24-hour average emission rate for SO_2, NOx, and direct particulate matter (PM) emissions (e.g., filterable and condensable PM2.5 and PM10) for each fuel and operational scenario allowed under the source's current permit. For simplicity and to reduce the number of modeling scenarios, a source operator may determine the peak 24-hour emission rate for each pollutant from all fuel/operational scenarios and combine the peak emission rates to produce a single pre-control emissions scenario. For example, the NOx emission rate might be from a natural gas-fired scenario while the SO_2 emission rate is from a coal-fired scenario. However, if a source believes it is problematic to combine emissions from different fuel/operational scenarios, individual emission scenarios may be developed for each fuel/operational scenario allowed under the permit.

Historic data (e.g., CEM data) may be used to determine peak 24-hour emission rates. If historic emissions/operational data are used, it should:

1. Reflect operations from the most recent 3 to 5 year period unless a more recent period is more representative due to the recent installation of emission controls or due to other recent permit modifications.
2. Account for "high capacity utilization" during normal operating conditions.

3. Not include periods of start-up, shutdown, and malfunction, although these periods may be included for simplicity.
4. Be a good indicator of anticipated future peak emissions allowed under the current permit.
5. Account for fuel/material flexibility allowed under the source's permit. For example, if the unit is allowed to use more than one fuel, and the fuel resulting in the highest emission rates is not reflected in the historic data, conduct additional analysis to determine the peak 24-hour average emissions. Similarly, if a raw material has variable properties (e.g., variable sulfur content) and the raw material resulting in the highest emission rates was not used during the historic data period, conduct additional analysis.

If historic data are not a good indicator of anticipated future peak emissions allowed under the current permit, use supplemental emission calculations to determine the peak 24-hour average emission rates.

Allowable short-term (≤24-hours) emission rates or federally enforceable short-term emission limits (≤24-hours) may be used instead of CEM data or other historic data. If 24-hour emission limits do not exist, use limits of a shorter averaging period. If limits do not exist, use maximum hourly emissions based on emission factors and design capacity.

2.3.2. Post-Control Scenario/Strategy Emissions

Determine the post-control peak 24-hour average emission rates for each BART-eligible unit at the facility. The post-control emission rates should reflect the effects of the emissions control scenario/strategy under evaluation on the peak 24-hour pre-control emission rates. The averaging period (e.g., 24-hour average) of the pre- and post-control emissions should be the same. Refer to section 2.4 for additional guidance on PM speciation.

2.3.3. Documentation and Supporting Data

Submit documentation and supporting data to explain how the emission rates were determined. The Division will review the emissions data and calculations and provide comment if necessary.

2.3.4. Use of Emission Rates from Subject-to-BART Analysis

In the subject-to-BART analysis process, many sources provided 24-hour peak emission rates for use in the Division's CALPUFF modeling. However, the Division did not review the emission rates if the modeled impacts were above 0.5 deciviews. Source operators should contact the Division and provide supporting information as early in the process as possible to determine if the subject-to-BART emission rates used in the Division's initial modeling analysis are acceptable for representing the pre-control emission rates for this analysis. Additional information from the source operator may be requested for this review.

2.4. Treatment of Direct Particulate Matter Emissions

In most cases, refined treatment of PM emissions was not necessary in the subject-to-BART modeling because impacts from SO_2 and NOx were above the contribution threshold. However, in the degree of improvement analysis, changes in visibility impacts caused by accounting for light scattering effects from direct PM species and particle size distribution may be an important factor in the BART determination. Consequently, adjust the subject-to-BART model setup as necessary to account for the modeled PM species and their size parameters. For example, emissions of fine PM (diameter<2.5 µm) and coarse PM (2.5<diameter<10 µm) should be determined.

If several size categories of PM are modeled, for example, the concentration data from various PM size categories should be combined into appropriate PM species with POSTUTIL. However, it is acceptable to directly model speciated PM emissions in CALPUFF with the following species: fine PM (PMF), coarse PM (PMC), elemental carbon (EC), organic aerosols (SOA), and sulfate (SO4). Use appropriate size parameters for the dry deposition of particles in CALPUFF.

Explain how the emissions were speciated and how the size parameter settings were determined. As with other aspects of the analysis, the Division will review the information and provide comment if necessary.

2.5. Modeling Process

<u>Step A</u>. Model the pre-control emission rates for SO_2, NOx, and direct PM emissions (filterable and condensable PM2.5 and PM10) from all BART-eligible units at the facility.

<u>Step B</u>. (If there are no applicable presumptive limits, then skip this step and go to step D.) Using the same model setup from step A, model the presumptive emission limits from applicable rules and guidance. If presumptive limits exist only for SO_2 and NOx and the source already has PM controls, determine the post-control PM emissions by adjusting the pre-control emission rate based on expected changes in speciated emissions caused by the SO_2 and/or NOx controls. For sources where the presumptive limits are not being proposed as BART, the intent of step B is to provide a bench mark for quantifying the degree of visibility improvement from the presumptive emission limits.

<u>Step C</u>. Compare the pre-control (step A) and post-control (step B) results using the methods described in section 3.

<u>Step D</u>. For each control scenario/strategy evaluated, model post-control emissions for SO_2, NOx, and direct PM emissions (filterable and condensable PM2.5 and PM10) from all BART-eligible units at the facility. There could be many combinations of potential control

scenarios. Consequently, the Division does not expect source operators to conduct an exhaustive set of modeling analyses that examine every possible combination of potential BART controls for various pollutants. Instead, the Division expects source operators to exercise reasonable professional judgment when deciding how many modeling analyses are necessary to characterize the degree of visibility improvement. The actual number of modeling analyses will depend on how the modeling results are factored into the BART determination process and language in applicable rules and other guidance. If the weight of the modeling results is relatively low compared to other factors, only a limited number of modeling analyses may be necessary. As the weight of the modeling analysis becomes greater, so will the Division's level of interest in modeling details and the types of metrics presented to describe the expected change in visibility impacts.

Step E. Compare the pre-control (step A) and post-control (step D) results using the methods described in section 3.

The recommended modeling process is shown in **Figure 1**.

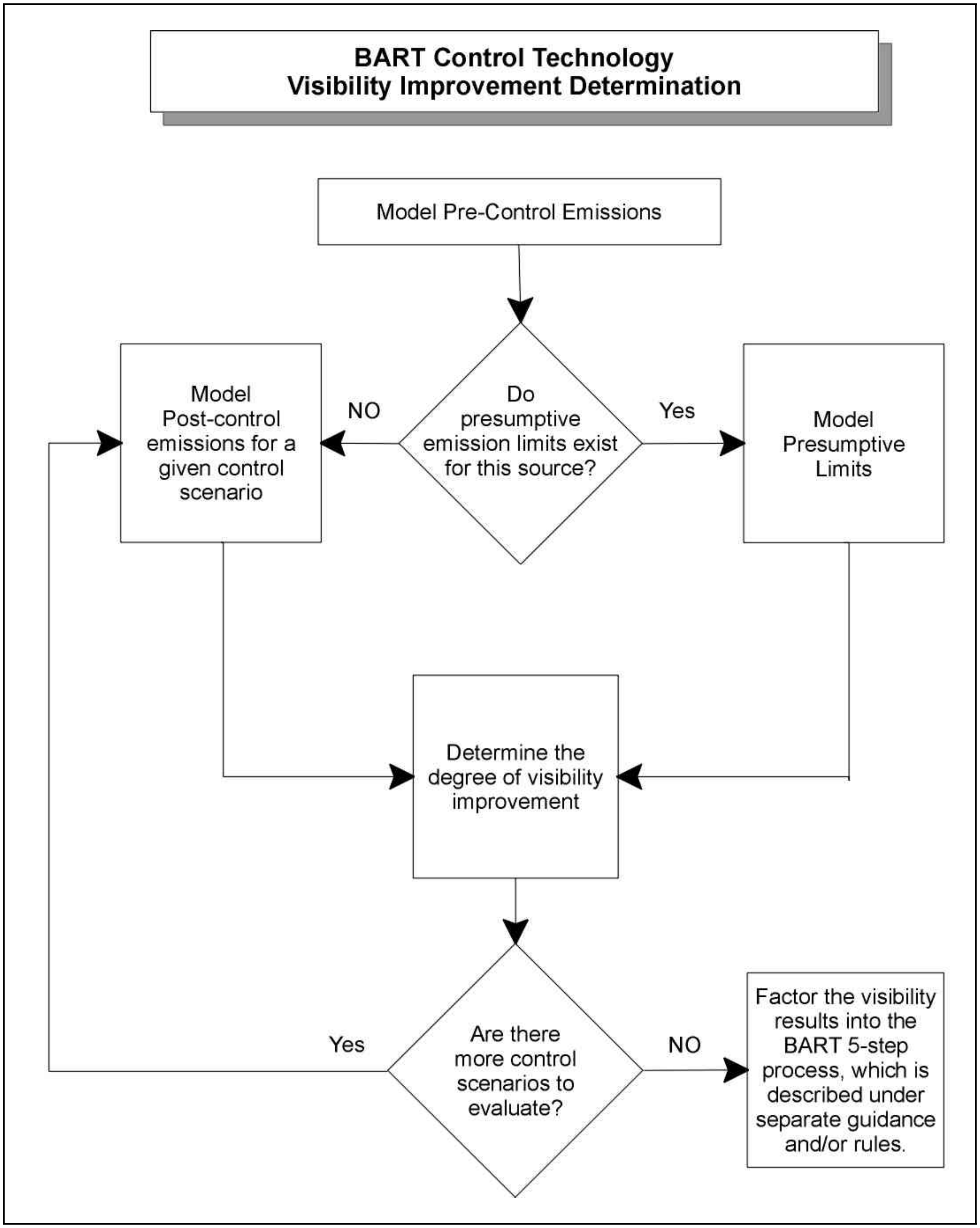

Figure 1. Flowchart showing recommended modeling process.

3. Degree of Visibility Change Determination

The Stationary Sources Program's BART guidance recommends that source operators model the visibility improvement resulting from each control scenario/strategy evaluated. It also recommends that the source operator explain how the 5-factors were considered. The metrics discussed in this section are intended to help provide a common framework for quantifying the degree of change from control scenarios/strategies. The BART analysis should discuss the recommended metrics in this section (plus others, as appropriate) and how the results have been factored into the BART determination process.

Compare the magnitude and frequency (e.g., days per year with impacts above 0.5 dv and 1.0 dv) of the delta-deciview impacts for the pre-control and post-control scenario being evaluated. If the final rule specifies a "contribution threshold" different from 0.5 dv, also generate metrics for the final threshold. The Division's postprocessor can generate results for any contribution threshold.

To reduce the analysis burden, a subset of the recommended comparison metrics, below, may be used for some of the comparisons if reasonable conclusions can be made without generating all of the recommended metrics. However, for the final control scenario/strategy proposed as BART, use all of the recommended metrics plus others needed to characterize the change in visibility.

3.1. Recommended Metrics for Characterizing the Change in Visibility Impacts

For each year modeled, conduct the following pre- and post-control comparisons for each Class I federal area where the 98th percentile value, as determined with the methods in the Division's subject-to-BART protocol, is greater than or equal to 0.5 dv. If the final rule specifies a "contribution threshold" different from 0.5 dv, include/exclude Class I areas as appropriate based on the final threshold.

- Compare the highest modeled delta-deciview value from all modeled receptors at a given Class I area for each year simulated.
    - Compare the number of days impacts are above 0.5 dv.
    - Compare the number of days impacts are above 1.0 dv.
- Compare the day-specific 98th percentile value[2] (Method 1 in the Division's BART98_v4 processor).

[2] In the day-specific method, the 98th percentile value is determined from the distribution of values containing the highest modeled delta-deciview value for each day of the simulation from all modeled receptors at a given Class I area.

- Compare the receptor-specific 98th percentile value[3] (Method 2a in the Division's BART98_v4 processor) .
  - Compare the number of days impacts are above 0.5 dv.
  - Compare the number of days impacts are above 1.0 dv.
- Compare the difference in visibility impacts for the "1st high" delta-deciview values from each receptor (i.e., the receptor-by-receptor difference in 1st high values for each year modeled).
- Compare the difference in visibility impacts for the "98th percentile" delta-deciview values from each receptor (i.e, the receptor-by-receptor difference in 8th high values for each year modeled).

In addition, the source operator may provide any additional information or metrics that help describe the expected degree of visibility improvement or impairment.

The Division's BART post-processor program (BART98_v4) generates the values needed to perform the comparisons above (see section 3.2). To effectively communicate the results, graphical analyses are recommended but not required.

3.2. Postprocessor – BART98_v4 – for Generating Metrics

The Division's postprocessor may be used to generate the required metrics. The postprocessor should be executed separately for each pre-control and post-control scenario. Then, the results from the files below are compared to determine the "difference" in visibility impacts. If the Division's postprocessor is used, refer to the "readme_BART98_v4.txt" file for instructions. The postprocessor generates a number of files, including:

- ***_ dv_report_ALL.txt** -- file with summary results; "ALL" means that all visibility species from the CALPOST postprocessor are included in the delta-deciview values. The asterisk is a placeholder for the rest of the file name. That is, to make file management easier, the postprocessor reads the CALPOST.LST filename from CALPOST specified by the user and inserts it in front of the generic file name.
- ***_Method1_1st-High_ALL.txt** – file with the largest delta-deciview results for each day of the simulation; this file provides the same daily delta-dv summary values

[3] In the receptor-specific method, the 98th percentile value is determined at each receptor from the distribution of modeled daily delta-deciview values. This is similar to the approach used for permit modeling for ambient air quality standards. For example, for a 365 day simulation, the first step is to find the 98th percentile value (i.e., 8th high value) for each receptor. The second step is to search all of the receptors to find the one with the highest 98th percentile value. For a one year simulation, the 98th percentile value is also known as the "high 8th high" value.

contained in the standard CALPOST list file. This is also the distribution of results used for the subject-to-BART determation.

- ***_Method2a_1st-High_ALL.txt** – file with the "1st-high" delta-deciview value for each receptor.
- ***_Method2a_nth-High_ALL.txt** -- file with the "98th percentile" delta-deciview value for each receptor.
- ***_dv_top37_ALL.txt** – file with the top 37 delta-deciview values for each receptor. Although the Division's standard metrics do not include an analysis with the data from this file, it should be submitted to the Division for review.

3.3. Example Comparison of Pre- and Post-Control Visibility Change

This section provides an example showing the difference in metrics between a hypothetical pre- and post-control comparision. Other approaches may be used to compare the metrics.

(Repeat for each year modeled and for each Class I area with impacts over 0.5 deciviews.)

Great Sand Dunes National Park – Visibility Change from "Example Scenario #1"

For the 2002 meteorological period, example scenario #1 reduces the 1st-High delta-deciview value from 2.377 deciviews (dv) to 1.731 dv. It decreases the number of days with impacts over 0.5 dv from 14 to 6 (see **Figure 2**)*. However, both the pre- and post-control results have 2 days over the 1.0 dv threshold. Similarly for the 98th percentile value day-specific value[4], which does not consider the 7 worst days for a year, example scenario #1 reduces the delta-deciview value from 0.611 dv to 0.465 dv.*

For the same meteorological period, example scenario #1 reduces the receptor-specific 98th percentile delta-deciview value[5] from 0.586 dv to 0.450 dv. It decreases the number of days with impacts over 0.5 dv from 9 to 0 (see **Figure 3***). Both the pre- and post-control results have 0 days over the 1.0 dv threshold. The summary metrics are shown on the next page.*

Figure 4 *illustrates the degree of visibility improvement for the 1st-high delta-deciview value at each receptor at Great Sand Dunes National Park. Similarly,* **Figure 5** *shows the degree of visibility improvement for the 98th percentile delta-deciview value at each receptor. The figures*

[4] In the day-specific method, the 98th percentile value is determined from the distribution of values containing the highest modeled delta-deciview value for each day of the simulation from all modeled receptors at a given Class I area.

[5] In the receptor-specific method, the 98th percentile value is determined at each receptor from the distribution of modeled daily delta-deciview values. This is similar to the approach used for permit modeling for ambient air quality standards. For example, for a 365 day simulation, the first step is to find the 98th percentile value (i.e., 8th high value) for each receptor. The second step is to search all of the receptors to find the one with the highest 98th percentile value. For a one year simulation, the 98th percentile value is also known as the "high 8th high" value.

illustrate that example scenario #1 results in visibility improvement at all receptors at this Class I federal area.

Figure 6 *shows the "1st-high" and "98th percentile" values for each receptor at the Class I area. The control scenario reduces visibility impacts by about 0.5 to 0.65 deciviews on the worst days. Based on the 98th percentile value, the scenario reduces impacts by about 0.1 to 0.16 deciviews.* [Add additional discussion and metrics as necessary to support the way the modeling results are factored into the BART analysis process.]

PRE-CONTROL MODELING RESULTS (*_ dv_report_ALL.txt):

```
Summary of delta-deciview results:

The largest delta-deciview change is:   2.377 dv
    Number of days with delta-deciview => 0.5:      14
    Number of days with delta-deciview => => 1.00:   2


98th Percentile Results:
-------------------------------------------------------------
Method 1. DAY-SPECIFIC - closest modeled value:
    The ' 8 High' value from the model is:  0.611 dv
       at receptor      77 on day   11(2002)

Method 2a. RECEPTOR-SPECIFIC - closest modeled value:
    The 'High  8 High' value from the model is:  0.586 dv
       at receptor     167 on day   11(2002)
    Number of days with delta-deciview => 0.5:    9
    Number of days with delta-deciview => 1.00:   0

Method 2b. RECEPTOR-SPECIFIC - Weighted Average at X[(n+1)p]:
    The calculated 98th percentile value
    using a weighted averaging method is:    0.600 dv
       at receptor     189
       using days  166(2002) and   3(2002)
-------------------------------------------------------------
```

POST-CONTROL MODELING RESULTS (*_ dv_report_ALL.txt):

```
Summary of delta-deciview results:

The largest delta-deciview change is:   1.731 dv
    Number of days with delta-deciview => 0.5:    6
    Number of days with delta-deciview => 1.00:   2


98th Percentile Results:
-------------------------------------------------------------
Method 1. DAY-SPECIFIC - closest modeled value:
    The ' 8 High' value from the model is:  0.465 dv
       at receptor     167 on day  166(2002)

Method 2a. RECEPTOR-SPECIFIC - closest modeled value:
    The 'High  8 High' value from the model is:  0.450 dv
       at receptor     179 on day   11(2002)
    Number of days with delta-deciview => 0.5:    0
    Number of days with delta-deciview => 1.00:   0

Method 2b. RECEPTOR-SPECIFIC - Weighted Average at X[(n+1)p]:
    The calculated 98th percentile value
    using a weighted averaging method is:    0.455 dv
       at receptor     178
       using days  166(2002) and  11(2002)
-------------------------------------------------------------
```

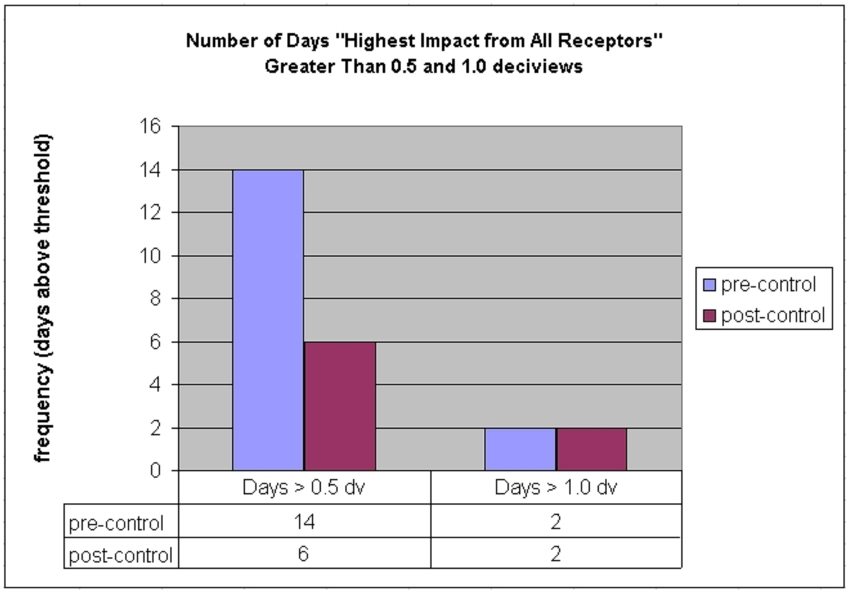

***Figure 2**. Comparison of the frequency of days the largest delta-deciview value is equal to or greater than 0.5 dv and 1.0 dv for control scenario: "example scenario #1"*

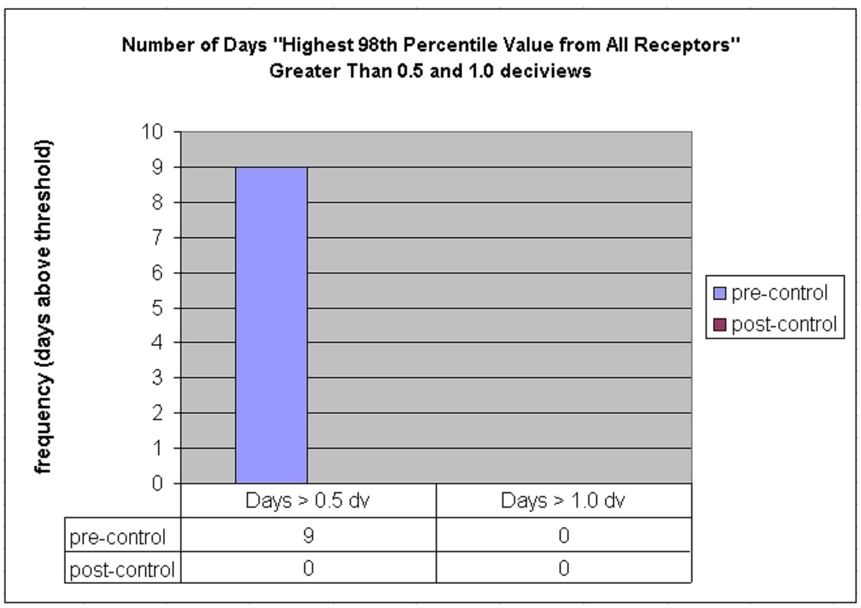

***Figure 3**. Comparison of the frequency of days the 98th perecentile delta-deciview value is equal to or greater than 0.5 dv and 1.0 dv for control scenario: "example scenario #1"*

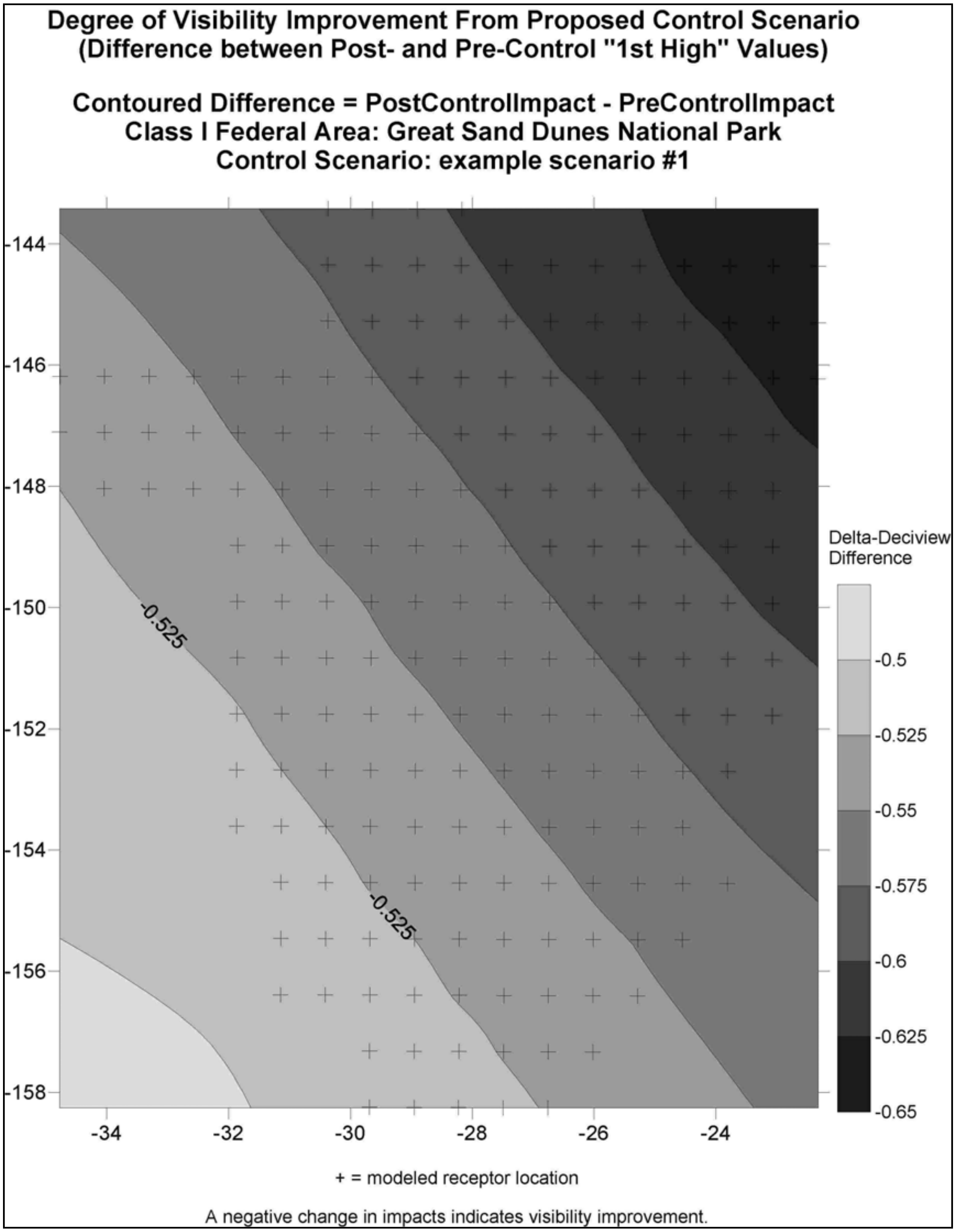

Figure 4. *Delta-deciview isopleths of the difference in 1st-high values (on a receptor-by-receptor basis) from comparison of the pre-control and post-control files: "*_Method2a_1st-High_ALL.txt."*

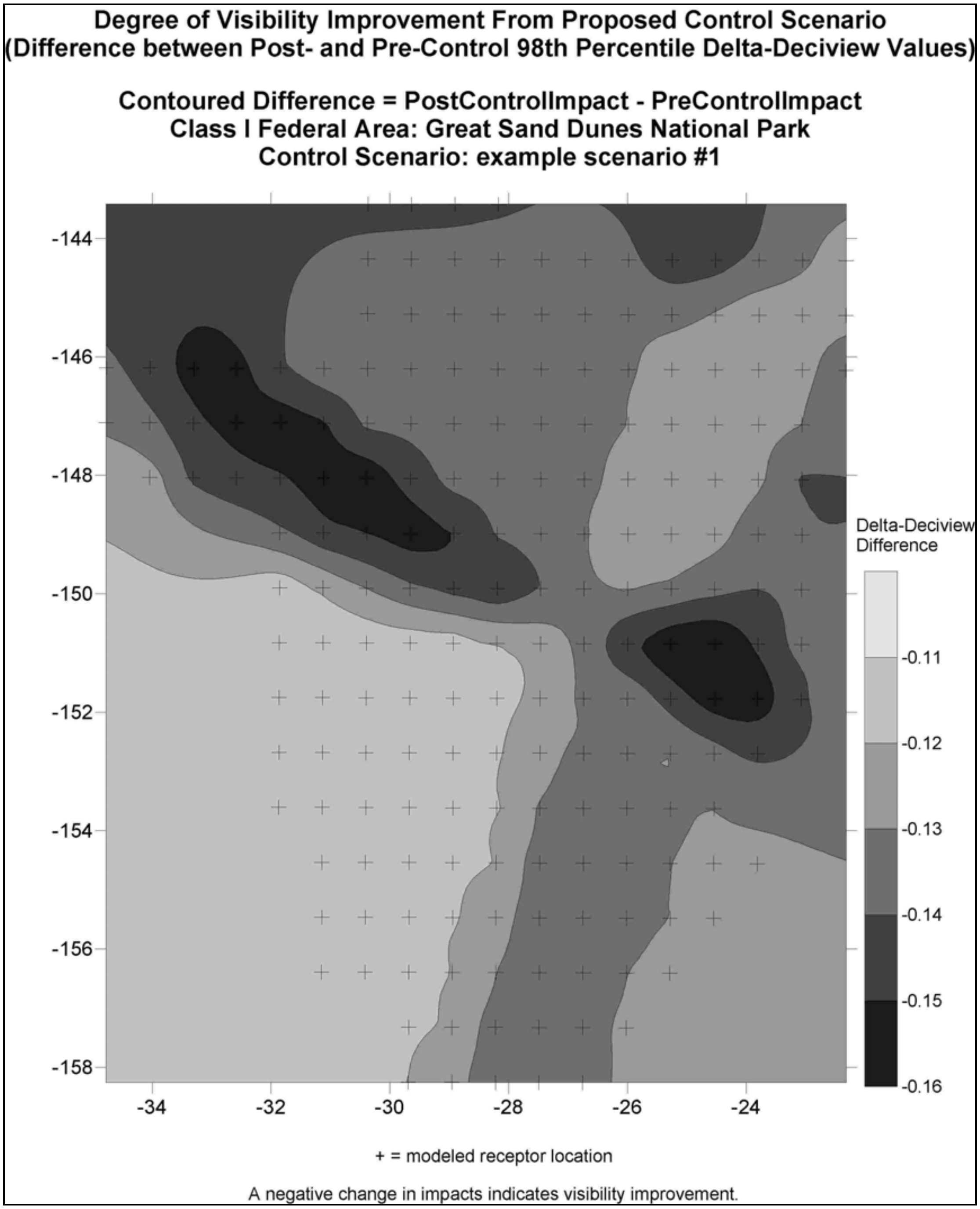

Figure 5 *Delta-deciview isopleths of the difference in 98th percentile values (on a receptor-by-receptor basis) from comparison of the pre-control and post-control files: "*_Method2a_nth-High_ALL.txt."*

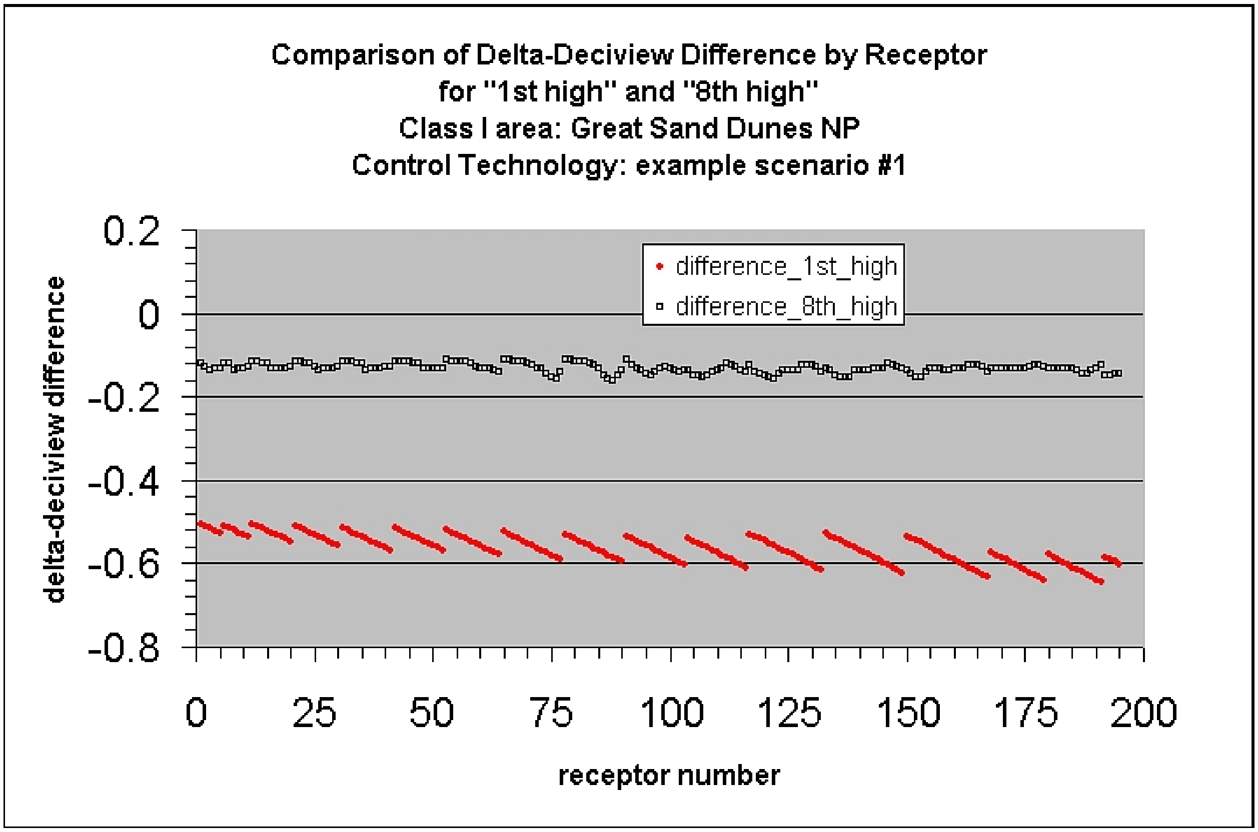

Figure 6. *The bottom set of points ("difference_1st_high") compares the difference in delta-deciview values (on a receptor-by-receptor basis) found by comparing the 1st-high pre-control and 1st-high post-control files (*_Method2a_1st-High_ALL.txt). Similarly, the top set of points ("difference_8th_high") compares the difference in delta-deciview values found by comparing the pre- and post-control files (*_Method2a_nth-High_ALL.txt).*