Environment

Submitted to:
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Denver, Colorado

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November 7, 2012

Modeling Protocol for the Pinedale Anticline Record of Decision Milestone #3 Visibility Goal

Approval: Modeling Protocol for the Pinedale Anticline Record of Decision
Milestone #3 Visibility Goal
November 7, 2012

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List of Acronyms

AQD	Air Quality Division
AQS	USEPA Air Quality System
BART	Best Available Retrofit Technology
B_{ext}	Light Extinction
BOLA	Boulder Lake IMPROVE Monitor
BRID	Bridger Wilderness Area IMPROVE Monitor
BTEX	benzene/toluene/ethylbenzene/xylene
BLM	Bureau of Land Management
CASTNET	Clean Air Status and Trends Network
CGF	central gathering facility
dv	deciview
ddv	delta-decview
FLAG	Federal Land Managers' Air Quality Related Values Work Group
FLM	Federal Land Manager
ICE	internal combustion engine
IMPROVE	Interagency Monitoring of Protected Visual Environments
km	kilometer
km^2	square kilometer
LCC	Lambert Conic Conformal
MMIF	Mesoscale Model Interface Program
NO_X	nitrogen oxides
PAPA	Pinedale Anticline Project Area
PM	particulate matter
R	correlation coefficient
ROD	Record of Decision
SCR	selective catalytic reduction
SEIS	Supplemental Environmental Impact Statement
SO_2	sulfur dioxide
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
VOC	volatile organic compound
WA	Wilderness Area
WDEQ	Wyoming Department of Environmental Quality
WestJumpAQMS	West-Wide Jump Start Air Quality Modeling Study
WRAP	Western Regional Air Partnership
WRF	Weather Research and Forecasting Model

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1.0 Introduction

On behalf of Ultra Petroleum (Ultra), SWEPI LP (Shell), and QEP Resources (QEP) (collectively referred to as the "Operators"), AECOM Technical Services, Inc. (AECOM) is submitting this modeling protocol to the Bureau of Land Management (BLM) and the Wyoming Department of Environmental Quality (WDEQ), Air Quality Division (AQD). The modeling protocol describes the technical methods to be used for modeling visibility impacts at the Bridger Wilderness Area (WA) as mandated in the 2008 Record of Decision (ROD) for the Pinedale Anticline Oil and Gas Exploration and Development Project Supplemental Environmental Impact Statement (SEIS). The project area is shown in **Figure 1-1**.

1.1 Record of Decision Final Visibility Goal

The ROD contains a final air quality goal, intended to ensure that emissions from the Pinedale Anticline Project Area (PAPA) result in zero days of visibility impairment over 1 deciview (dv) at Bridger WA (BLM 2008). The final goal for visibility is defined as Milestone #3 in Section 4.1.1 of the ROD:

> *Within 78 months [or by March 12, 2015] after signing of this ROD modeled project related visibility impacts will be no greater than 0 days of visibility impairment over 1 dv at the Bridger Wilderness Area. Unless BLM, WDEQ-AQD, and the Operators have reached an alternative approach to achieve the goal of zero days of visibility impairment, BLM may reduce the pace of development to achieve this goal.*

For modeling the PAPA sources, visibility impairment is clarified to mean the change in light extinction [or delta-dv (ddv)] due to emissions from the PAPA (AECOM 2012). Visibility Implementation Measure #4 from the ROD states:

> *No later than the fifth annual planning session following signing of this ROD, Operators will submit to the collaborative group an evaluation of alternatives, and recommend a plan that addresses all sources from project activities, and of which the aim is to meet a predicted visibility impact objective of no more than zero days greater than 1.0 dv of visibility impairment. The Operators' evaluation will include modeling of the expected reduction in predicted visibility impairment which can be achieved by each alternative as well as an implementation schedule. All visibility modeling shall be performed using protocols approved by WDEQ-AQD and BLM in consultation with EPA.*

Using the modeling inputs and methodology described in this document, a base case year 2015 will be modeled by the Operators and alternative scenarios aimed at meeting a predicted visibility impact of no more than zero days greater than 1.0 ddv of visibility impairment will be evaluated as necessary in order to demonstrate compliance with the zero days greater than 1.0 ddv visibility goal. The final results of this modeling will be provided in a separate report.

1.2 Document Organization

This document is organized into four chapters. Chapter 2.0 presents an evaluation of visibility observations at Bridger WA that will be considered when evaluating the modeling methodologies and results. Chapter 3.0 provides a discussion of the modeling technical methods to be used in the study. Chapter 4.0 provides an overview of the PAPA sources and emission inventory assumptions. Chapter 5.0 contains a list of references.

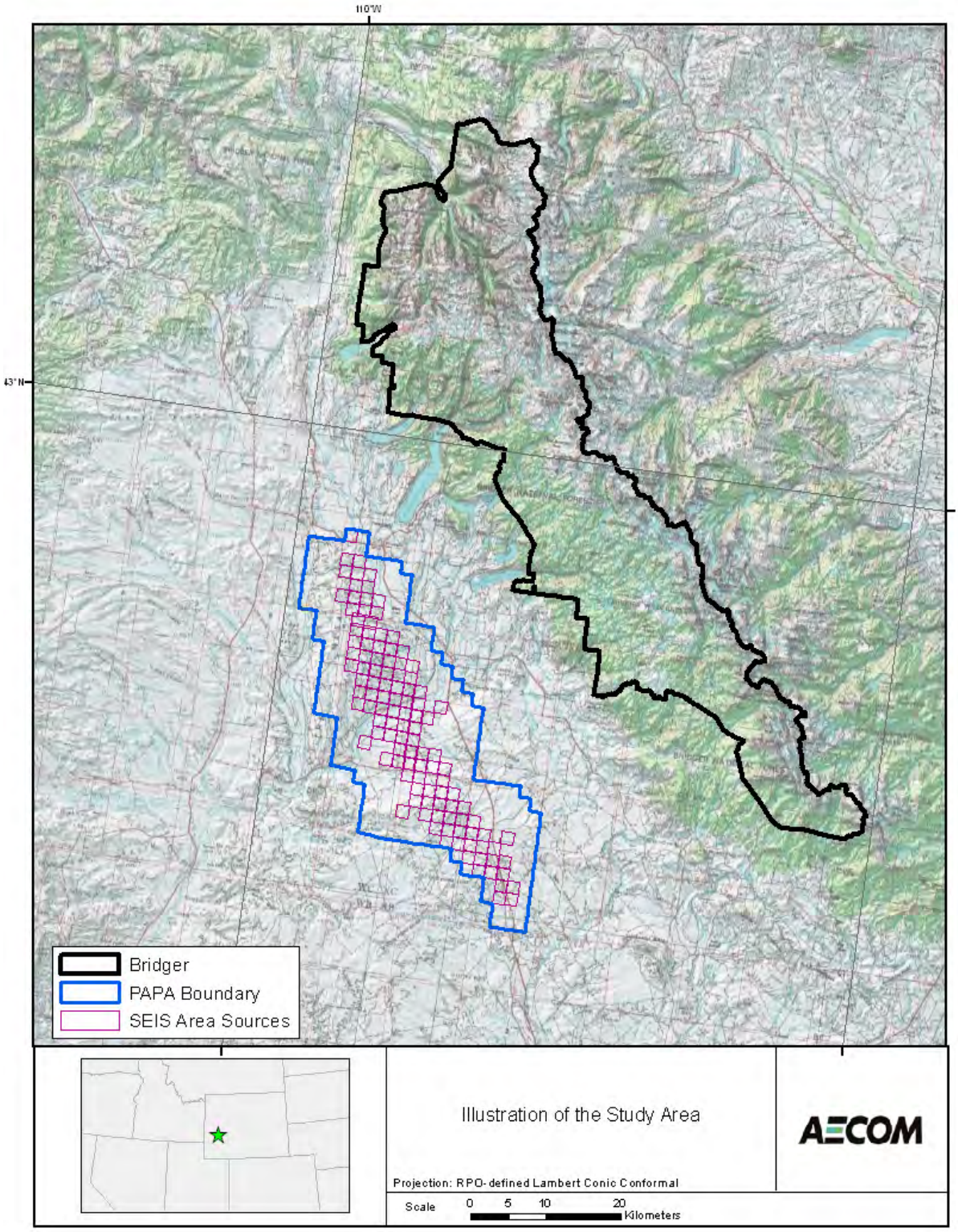

Figure 1-1 Pinedale Anticline ROD Modeling Study Area

2.0 Evaluation of Visibility Observations at Bridger Wilderness Area

Implementation of the ROD includes several measures to mitigate visibility impacts, including reducing nitrogen oxides (NO_X) emissions from drill rigs and other sources, as needed, to ensure protection of visibility at Bridger WA. The focus of NO_X emissions for mitigation was based on the visibility modeling conducted for the SEIS, which predicted visibility impacts due to nitrate formed from emissions of NO_X. Since the ROD was signed in September 2008, the Operators have complied with the visibility milestones to reduce NO_X emissions and subsequent nitrate impacts on Bridger WA.

The SEIS modeling cited in the ROD used the CALPUFF model to predict visibility impacts at Bridger WA. CALPUFF is a United States (U.S.) Environmental Protection Agency (USEPA)-approved long-range transport model (USEPA 2005a) and is used in many USEPA programs such as the Best Available Retrofit Technology (BART) visibility modeling (USEPA 2005b) and New Source Review visibility modeling (USEPA 2005a; U.S. Forest Service [USFS] et al. 2010). The CALPUFF model is proposed for use in the ROD visibility modeling (BLM 2012).

An important consideration of the ROD visibility modeling is that CALPUFF employs a simple chemical mechanism that has been shown to over-predict chemical transformation, especially nitrate (Morris et al. 2006, 2005; Atmospheric and Environmental Research, Inc. [AER] 2009, 2008). In order to ensure that mitigation is effective based on the ROD visibility modeling, the known conservatisms of the CALPUFF model will be considered in light of actual monitored data when evaluating the modeling methodologies and results. To that end, an analysis of visibility-impairing species measured at two Interagency Monitoring of Protected Visual Environments (IMPROVE) monitors in the Bridger WA is presented in this chapter.

2.1.1 IMPROVE Monitor Overview

There are two IMPROVE monitoring sites that are intended to assess visibility impacts at the Bridger WA. These sites are called “Boulder Lake” (BOLA) and “Bridger” (BRID). They are located 17 kilometers (km) from each other and within 20 km of the Pinedale Anticline project boundary as illustrated in **Figure 2-1**. The BOLA monitor has been operational since August 26, 2009, while the BRID monitor has been operating since 1988.

A limited study was conducted to analyze and compare the monitored visibility and species contributions during the time period when there is data from both sites, which was from August 26, 2009 through March 31, 2011. It is noted that data from January 1 through March 31, 2011, are considered preliminary until the IMPROVE team at Colorado State University finalizes that data. Species extinction or total extinction data was not available for the preliminary data. For the period of August 26, 2009 to March 31, 2011, the data capture was 95 percent at BRID and 98 percent at BOLA.

Since the time period of concurrent data between the two sites is short, it is important to understand the time period in context to historical data. **Figure 2-2** shows that 2009 and 2010 generally were representative of the longer-term (1998-2010) monitored extinction data at BRID with all values well within the range of previously monitored extinction data.

2.1.2 Comparison of IMPROVE Time Series Plots

The time series of air concentrations for several species important to light extinction are provided below. **Figure 2-3** compares the particulate nitrate concentrations at both sites during the concurrent time period (August 26, 2009 through March 31, 2011). To provide context for the measured nitrate concentrations during the concurrent period compared to the entire period of record at BRID (March 1988 through March 2011), **Figure 2-4** shows the measured nitrate concentrations at BRID over

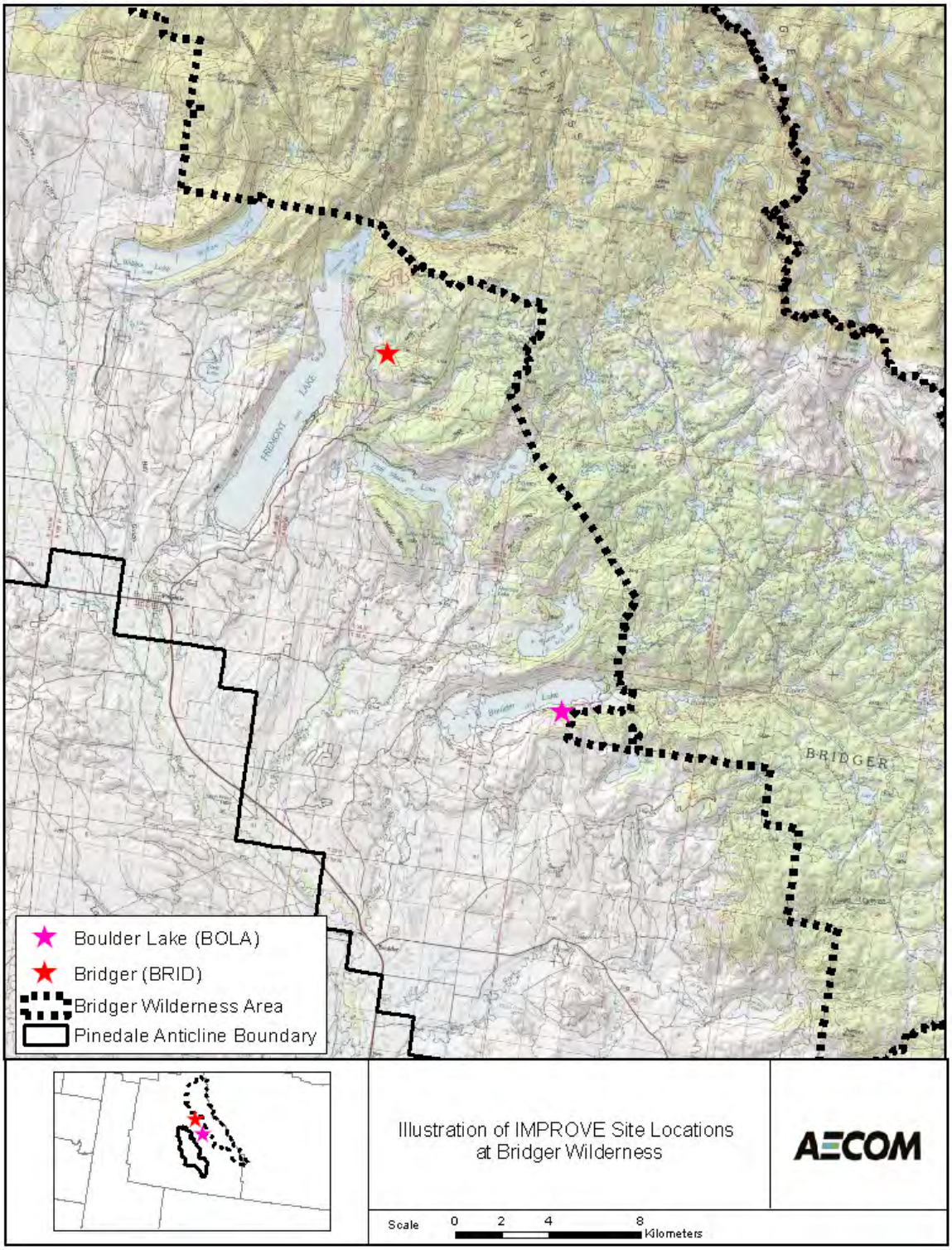

Figure 2-1 IMPROVE Site Locations at Bridger Wilderness Area

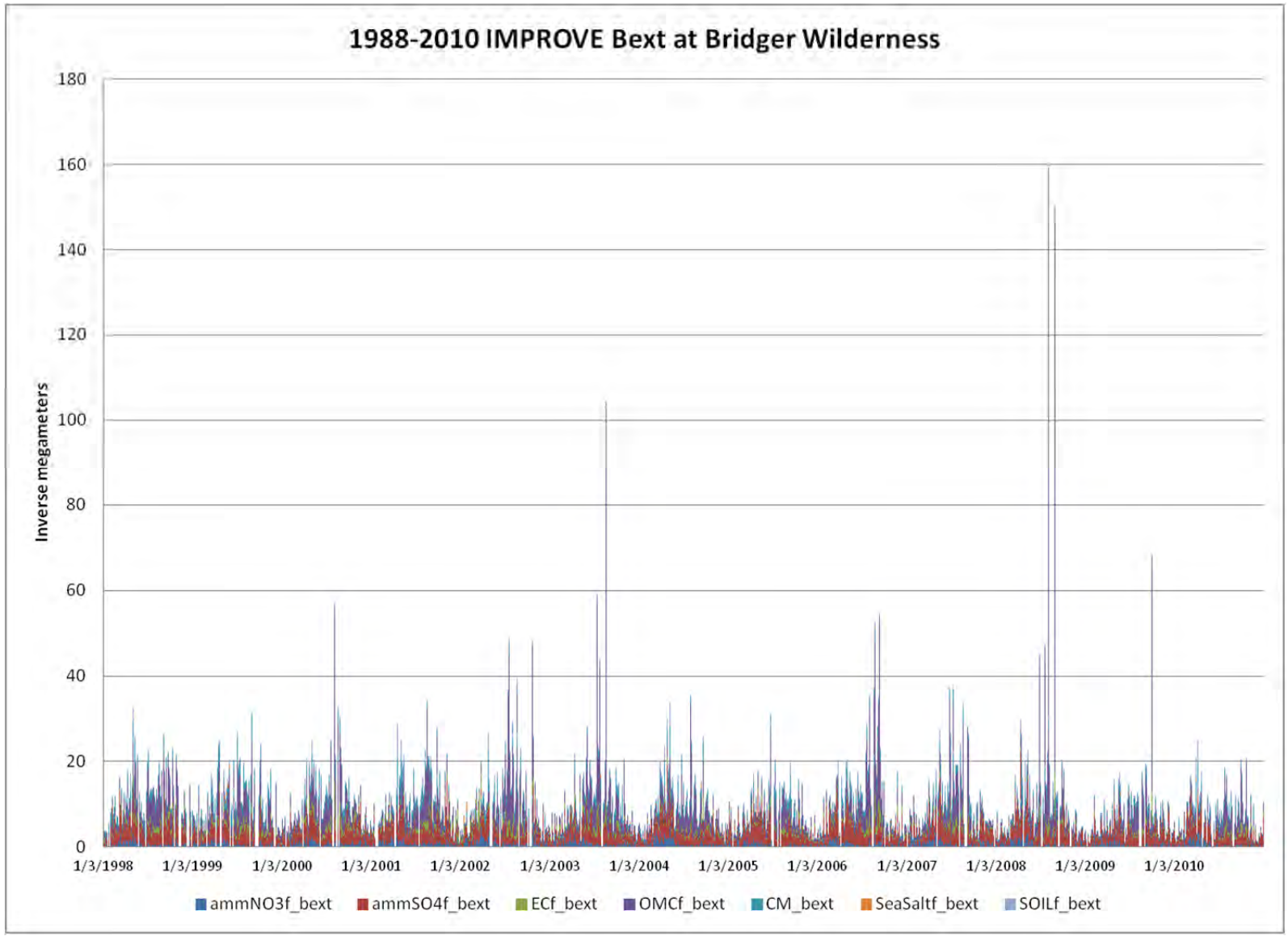

Figure 2-2 1998-2010 IMPROVE Light Extinction (B_{ext}) at Bridger Wilderness Area

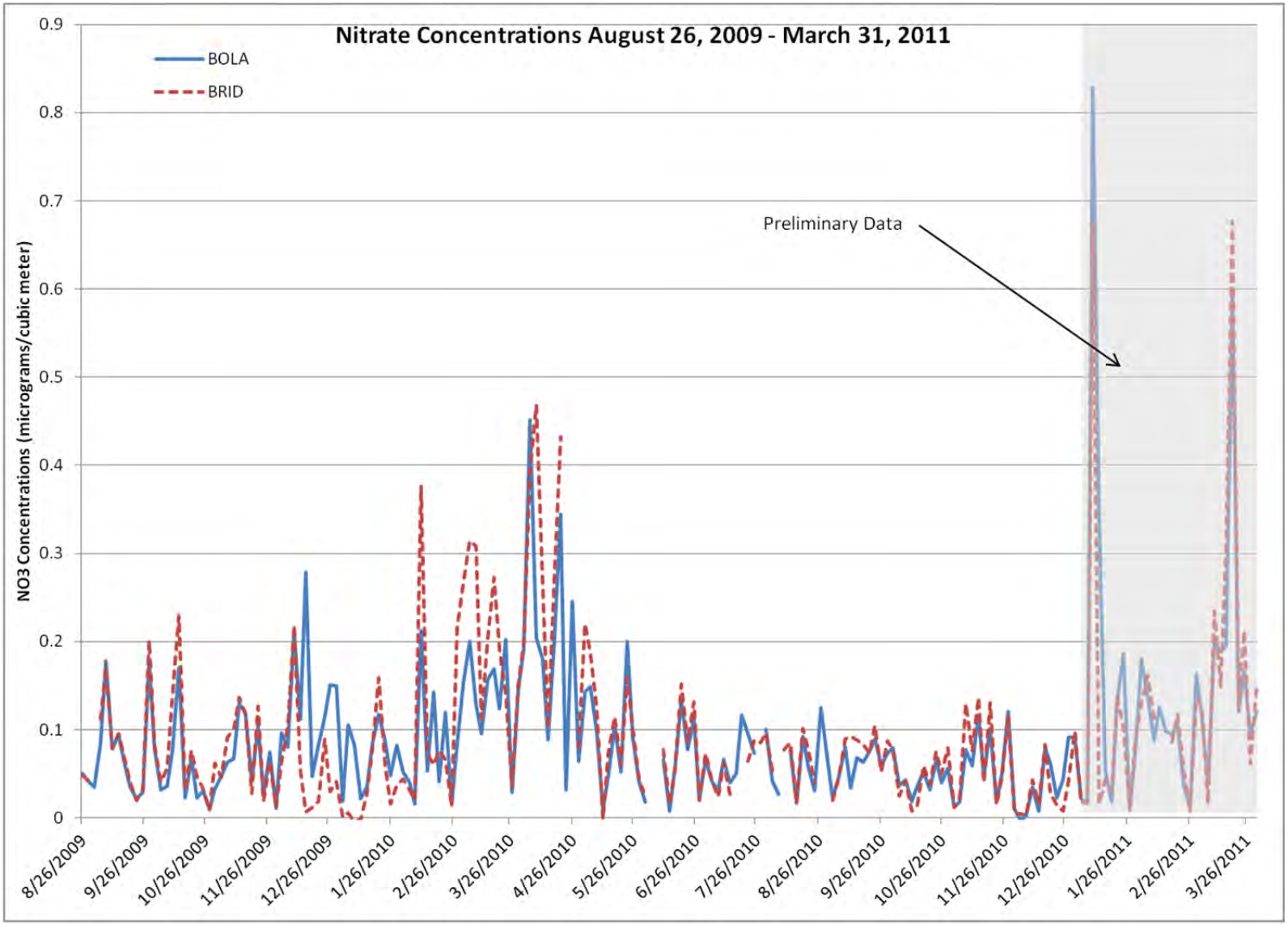

Figure 2-3 Nitrate Concentrations August 26, 2009 – March 31, 2011

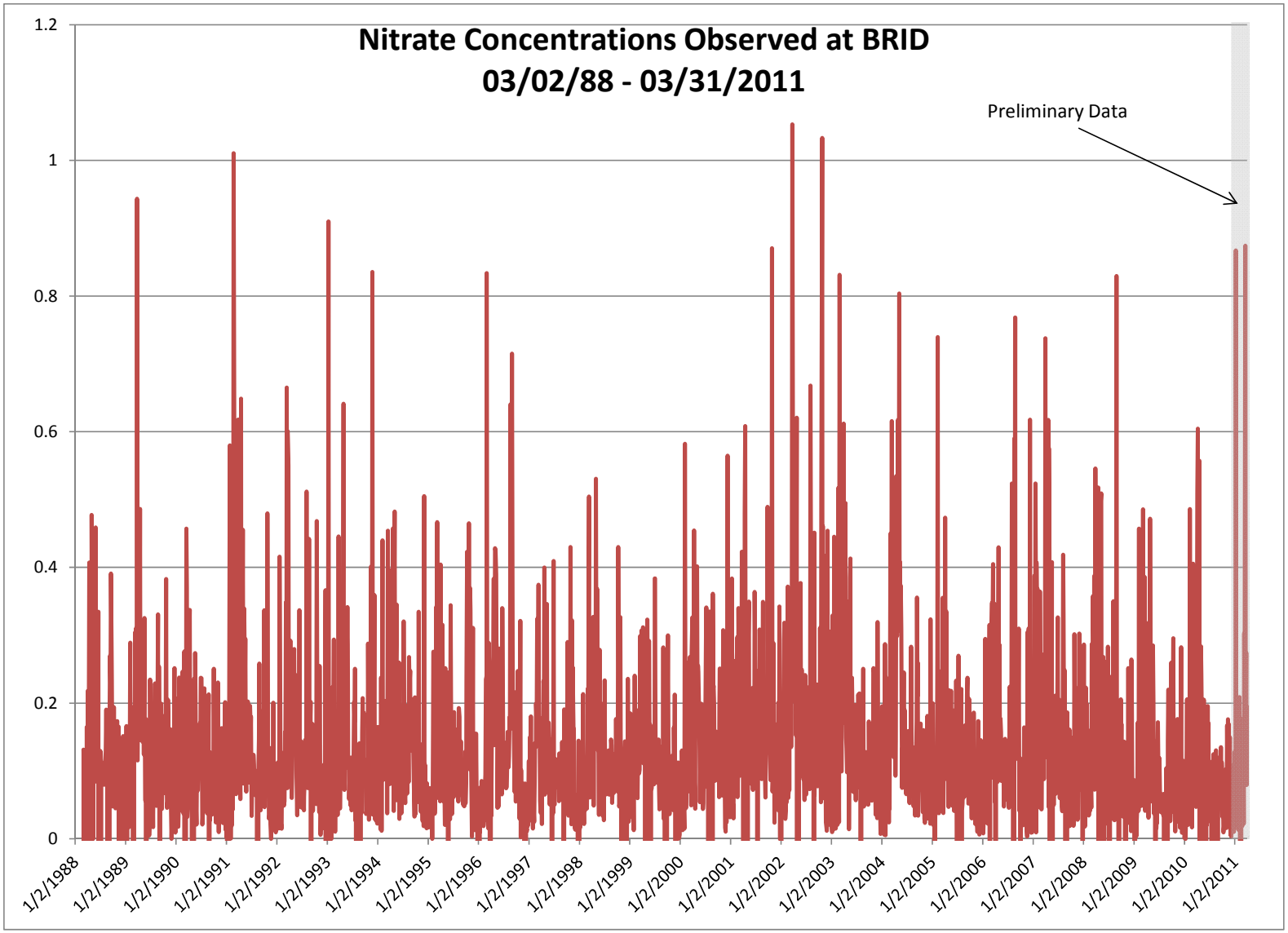

Figure 2-4 BRID Nitrate Concentrations March 2, 1988 – March 31, 2011

the entire period of record. Conclusions made from the figures presented in this section are provided in Section 2.1.4. **Figure 2-5** illustrates the correlation between the particulate nitrate concentrations and quantifies the correlation coefficient (R) at 0.84. A value of R of -1 indicates a perfect negative correlation; a value of R of 0 indicates no correlation; and a value of R of 1 indicates a perfect positive correlation. A value of R that is greater than 0.8 generally is described as a strong correlation.

Figure 2-6 compares the particulate sulfate concentrations at both sites during the concurrent time period. **Figure 2-7** illustrates the correlation between the particulate sulfate concentrations and quantifies the value of R to be 0.98.

Figure 2-8 compares the organic carbon concentrations at both sites during the concurrent time period. **Figure 2-9** illustrates the correlation between the organic carbon concentrations and quantifies the value of R to be 0.93.

A time series of the total measured extinction from all light-impairing species (without Rayleigh scattering) at both sites is provided in **Figure 2-10**. **Figure 2-11** illustrates the correlation between the total extinction and quantifies the value of R at 0.95. This very high level of agreement indicates that both sites are observing the same magnitudes and changes in visibility-impairing pollutants at the same time.

Review of these time series and correlations plots, although over a short time period (potential of 195 samples per site during the review period), show very good agreement in terms of the magnitude of the concentrations and the timing of the concentration fluctuations. The high R values indicate a very strong, positive correlation between the two sites for these species that are important to light extinction at Bridger WA.

2.1.3 Comparison of IMPROVE Species Contribution

Analyses of the speciation of the 20 percent worst days at BRID and BOLA during 2010 are provided in **Figures 2-12** through **2-15**. Each figure represents the average contribution of each species to any of the 20 percent worst days in a quarter (where quarter 1 is defined as January through March, etc.). Each of the sites have similar species profiles for each quarter and both sites also show the change in predominant species from sulfates in the first two quarters to organic carbon the last two quarters. Nitrate plays a small role in visibility at both sites over the year. It is noteworthy that the contribution (percentage) of nitrate to total extinction on a quarterly basis at BRID is consistently higher to or equal to that at BOLA. The same similarities and trends can be seen in the monthly-averaged species profiles (**Figure 2-16**) that are comprised of all days in the month.

2.1.4 Conclusions

Based on the analyses presented in this chapter, it can be reasonably concluded that both BOLA and BRID are affected by the same air mass on a consistent basis, not only in terms of species composition and magnitude, but also on a temporal basis. Although the period of concurrent monitoring is short, the long period of monitoring at BRID shows that 2010 is a typical year and can be used as a basis of comparison between the two sites.

Based on this review of the measured visibility data, nitrate has historically (and remains) a small component of measured visibility degradation at the Bridger WA. Analysis of the IMPROVE data over the most recent 12 years of monitoring (1998 to present) show that among the observed species that obscure visibility, the contribution of nitrate to actual overall visibility impacts is less than 10 percent for both typical days and the worst visibility days.

Visual inspection of **Figure 2-4** suggests there is no distinct upward trend in nitrate concentrations measured at BRID during the entire 22-year period of record. A further comparison of the newer BOLA IMPROVE monitoring data, which was sited to capture PAPA impacts, to the existing BRID IMPROVE monitor shows good correlation for nitrate and other visibility impairing species at the two sites.

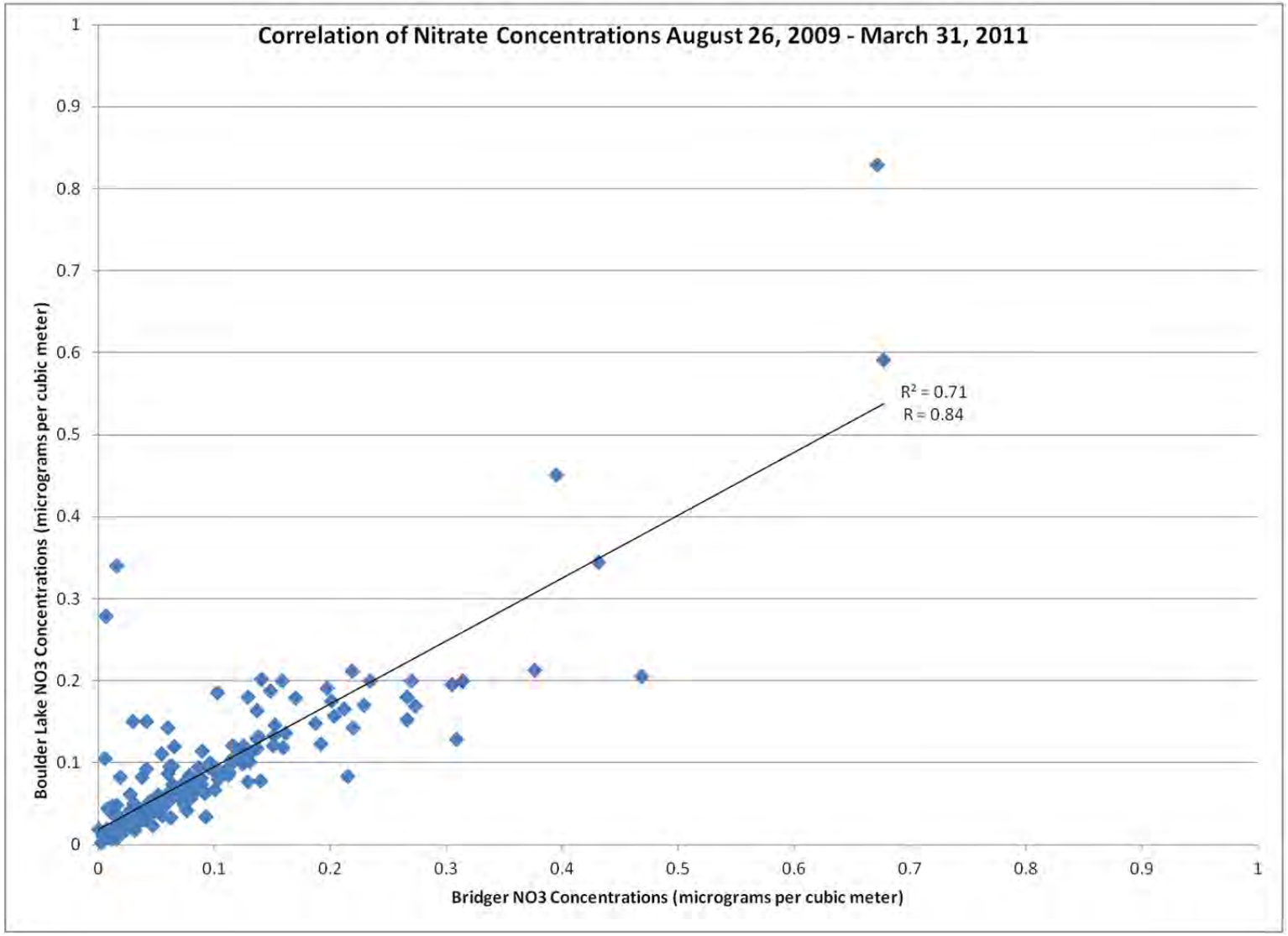

Figure 2-5 Correlation of Nitrate Concentrations August 26, 2009 – March 31, 2011

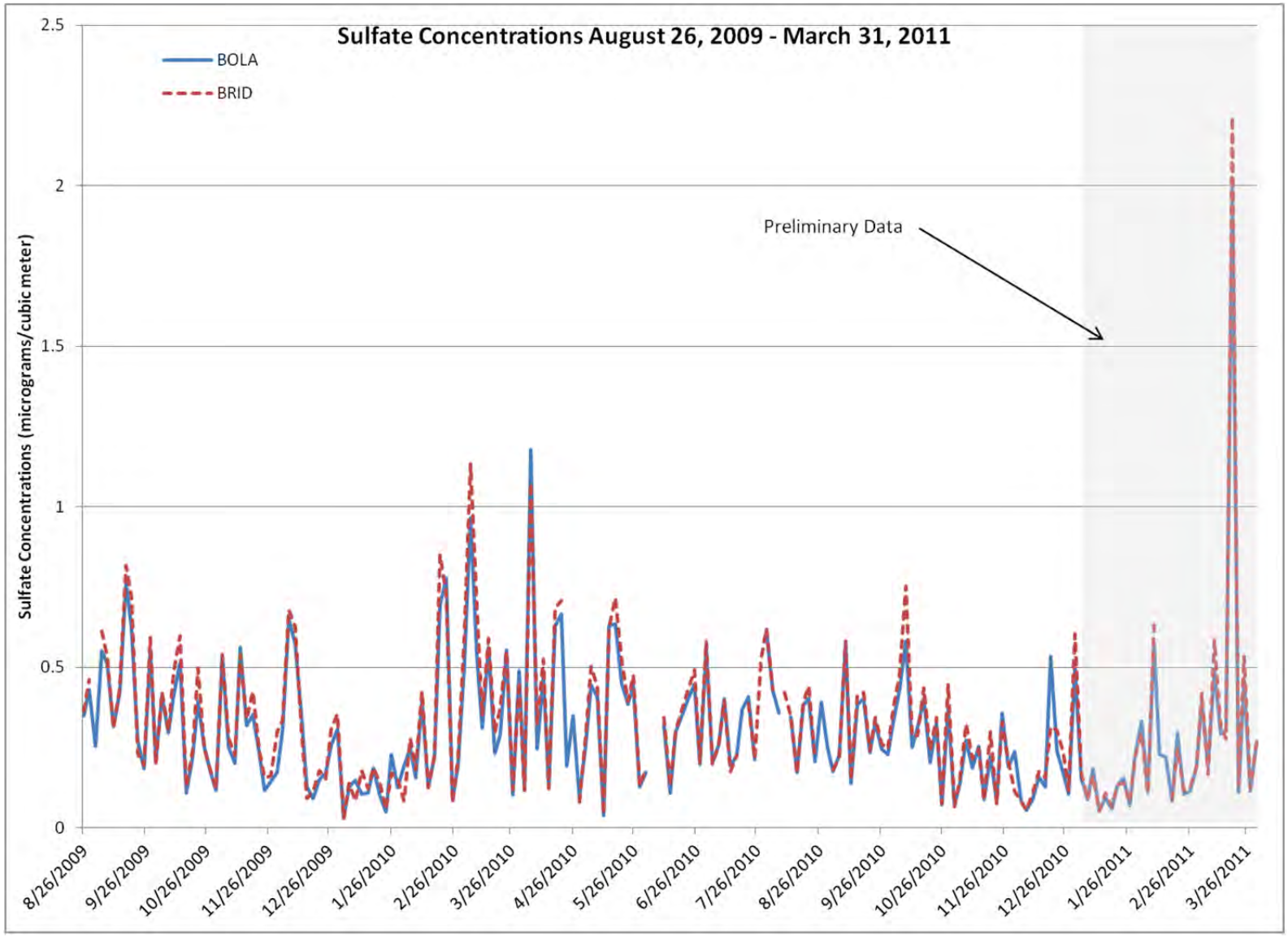

Figure 2-6 Sulfate Concentrations August 26, 2009 – March 31, 2011

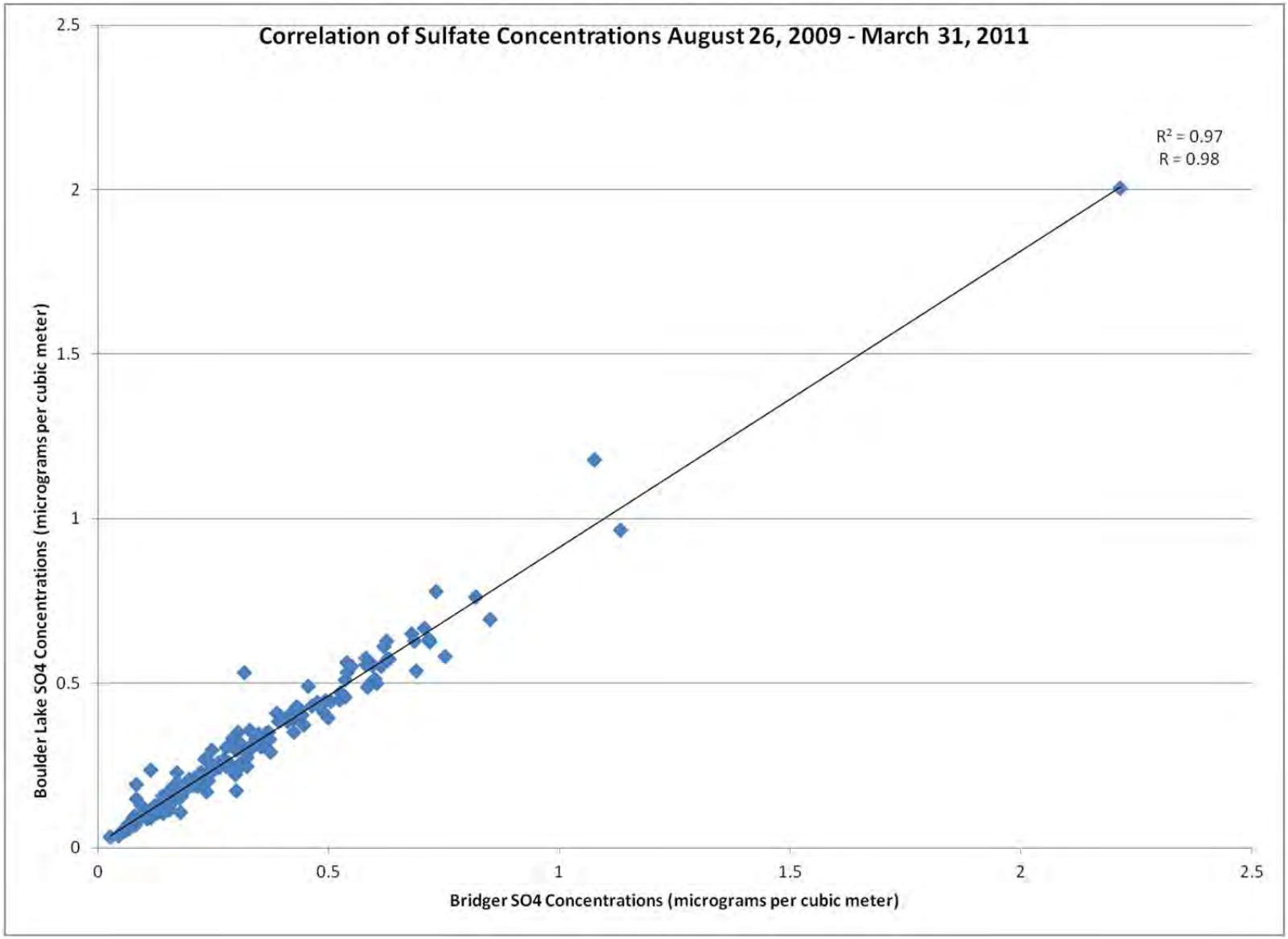

Figure 2-7 Correlation of Sulfate Concentrations August 26, 2009 – March 31, 2011

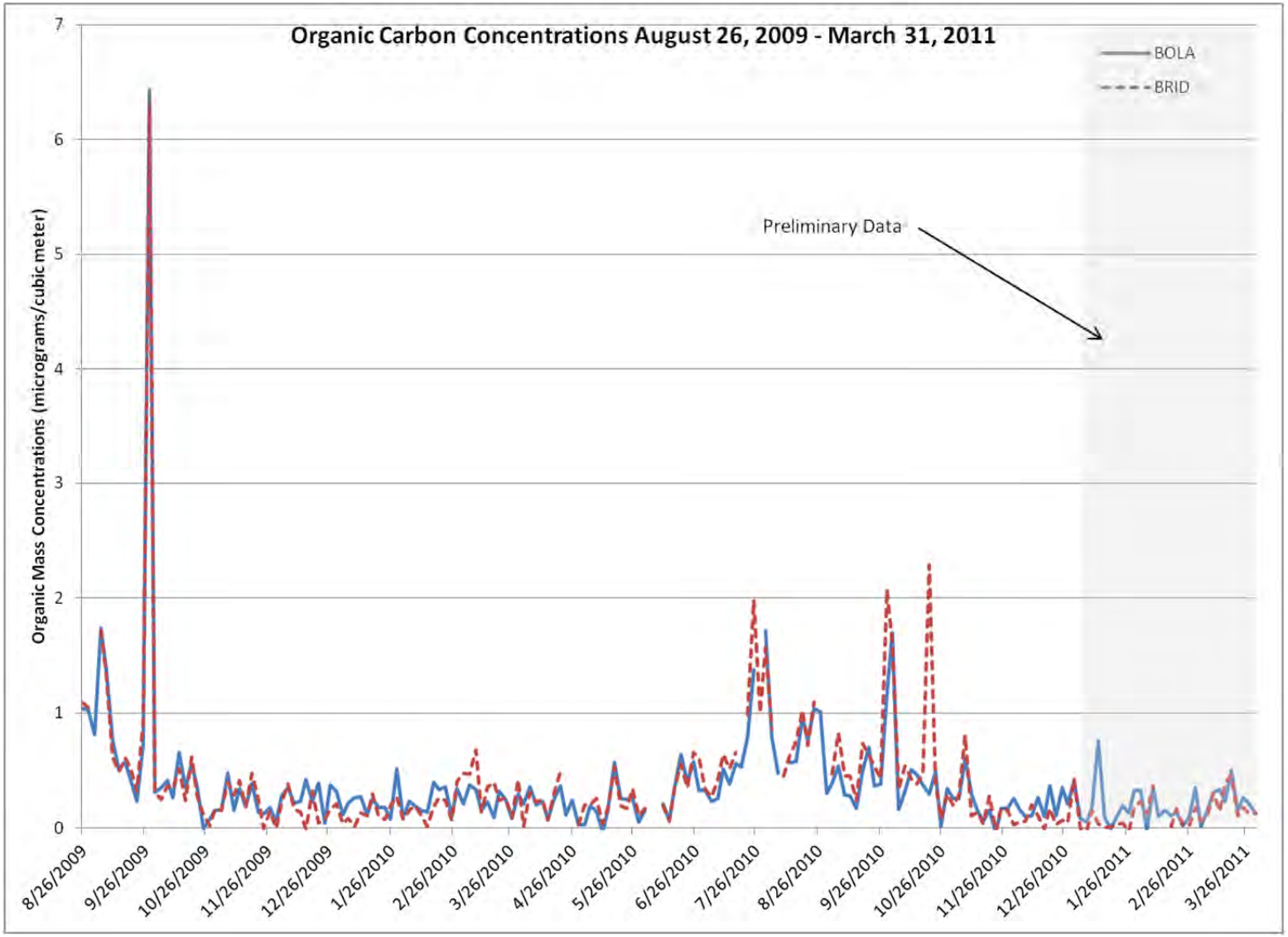

Figure 2-8 Organic Carbon Concentrations August 26, 2009 – March 31, 2011

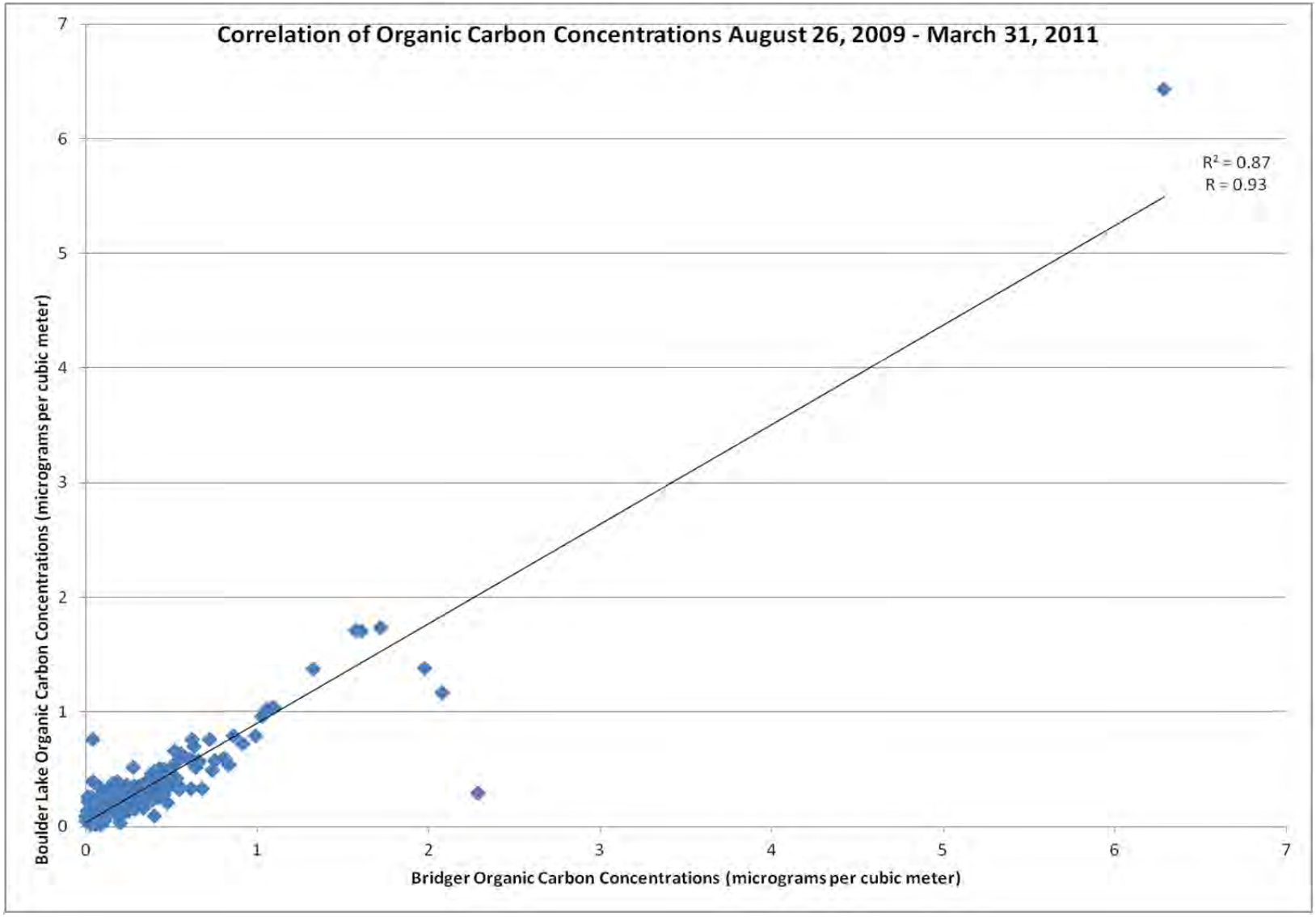

Figure 2-9 Correlation of Organic Carbon Concentrations August 26, 2009 – March 31, 2011

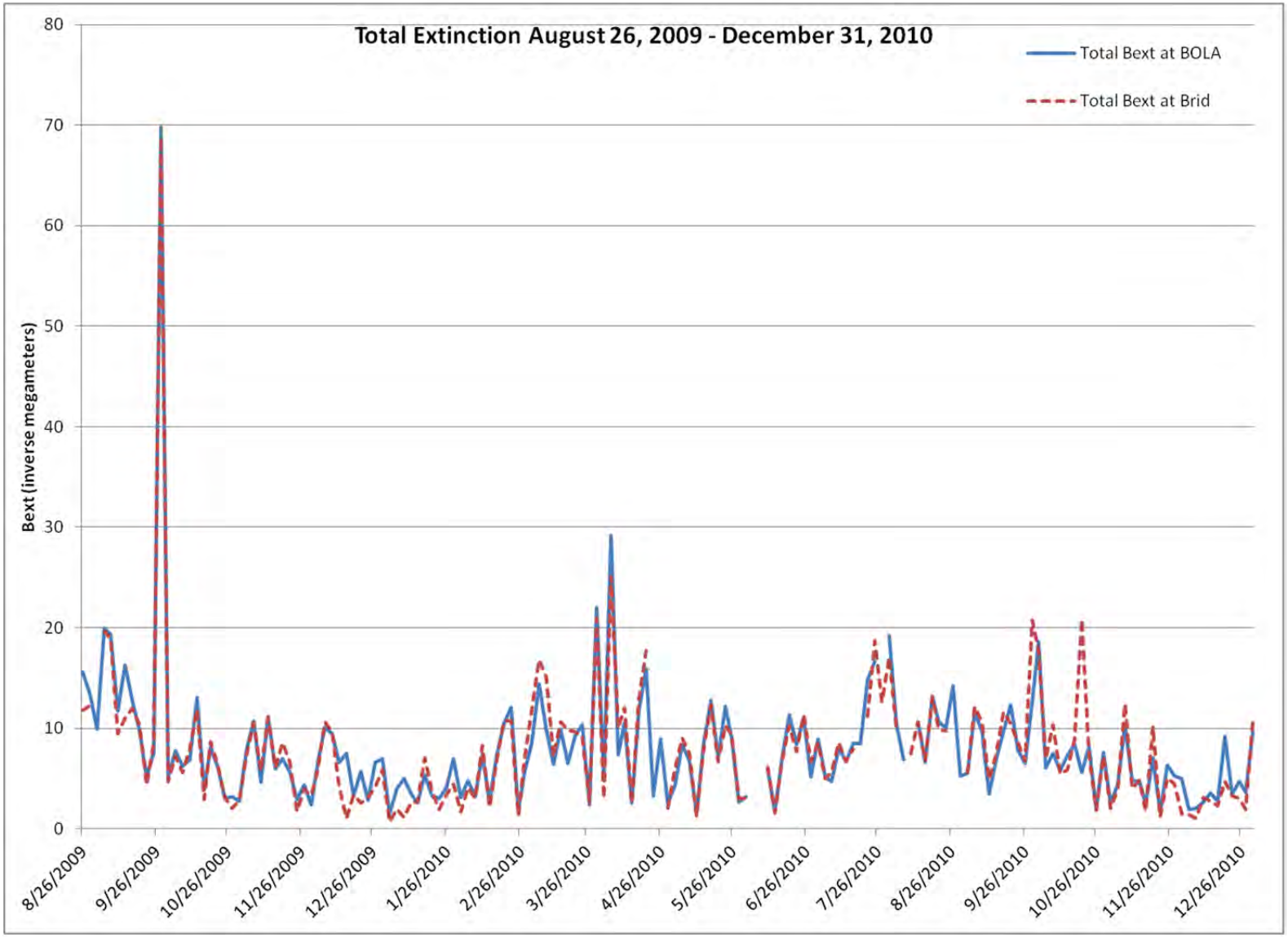

Figure 2-10 Total Light Extinction (B_{ext}) August 26, 2009 – March 31, 2011

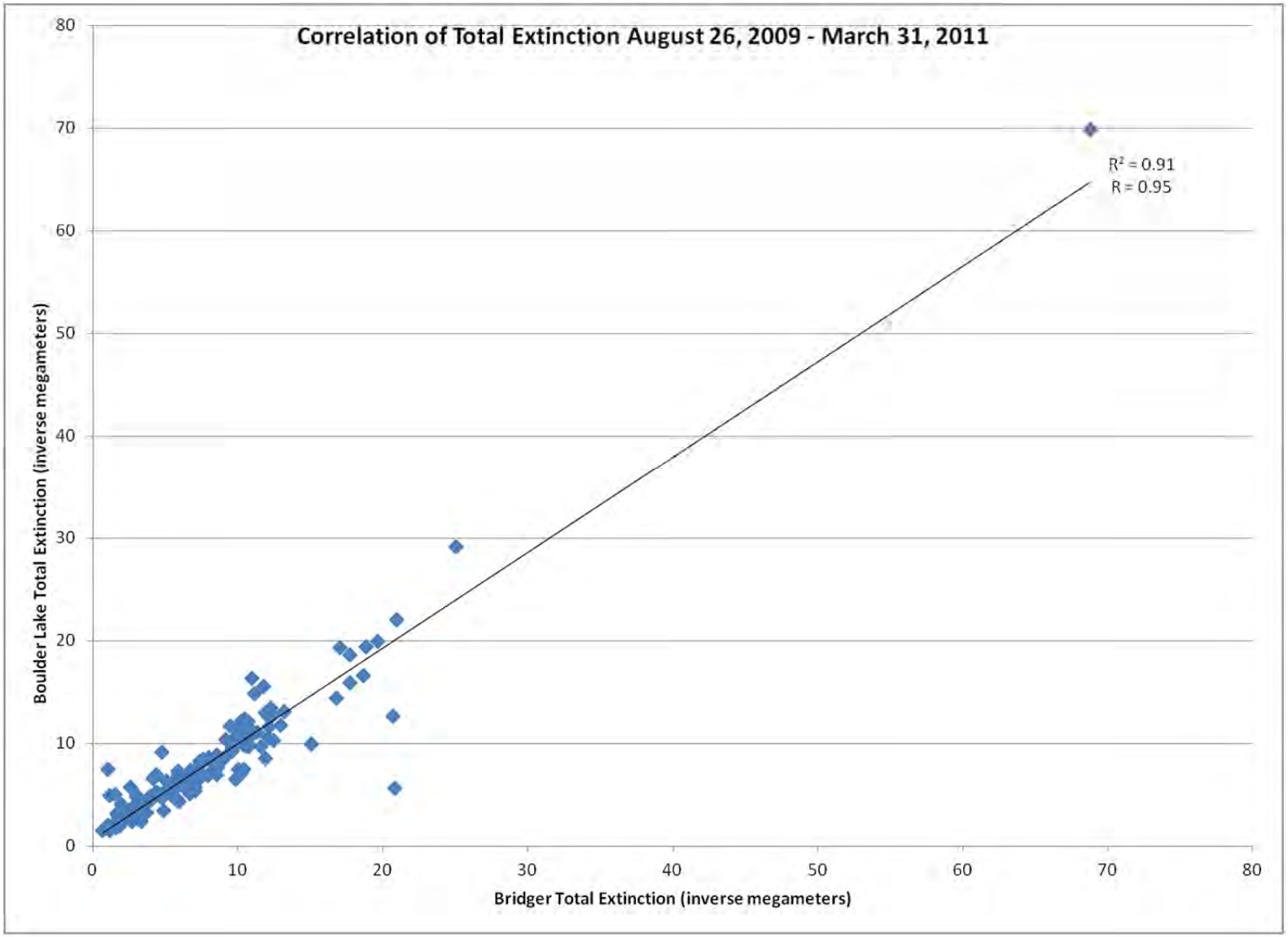

Figure 2-11 Correlation of Total Light Extinction (B_{ext}) August 26, 2009 – March 31, 2011

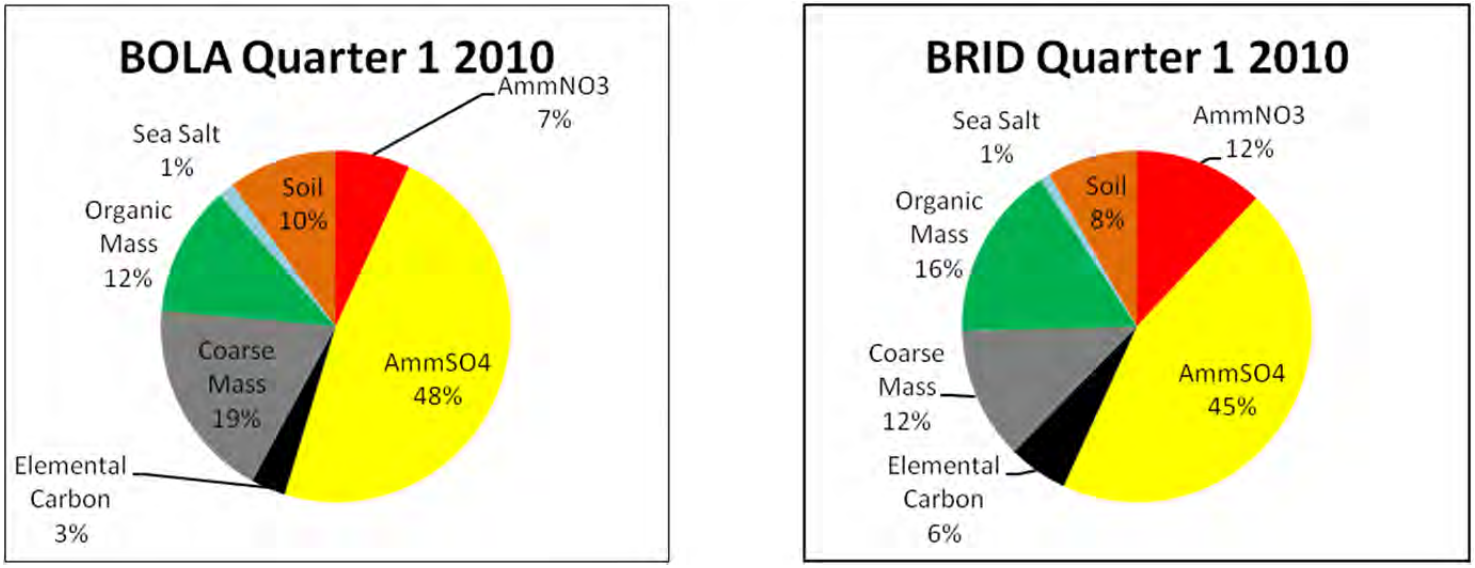

Figure 2-12 Comparison of Species Contribution to the 20% Worst Days in 2010 for Quarter 1

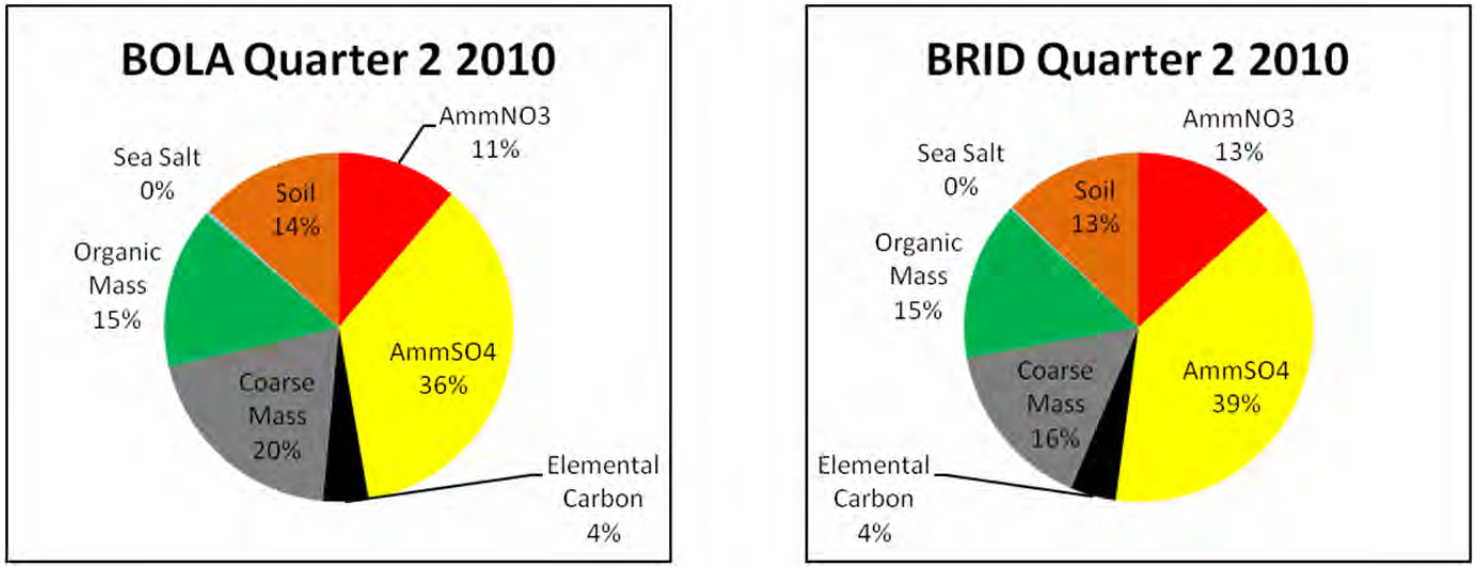

Figure 2-13 Comparison of Species Contribution to the 20% Worst Days in 2010 for Quarter 2

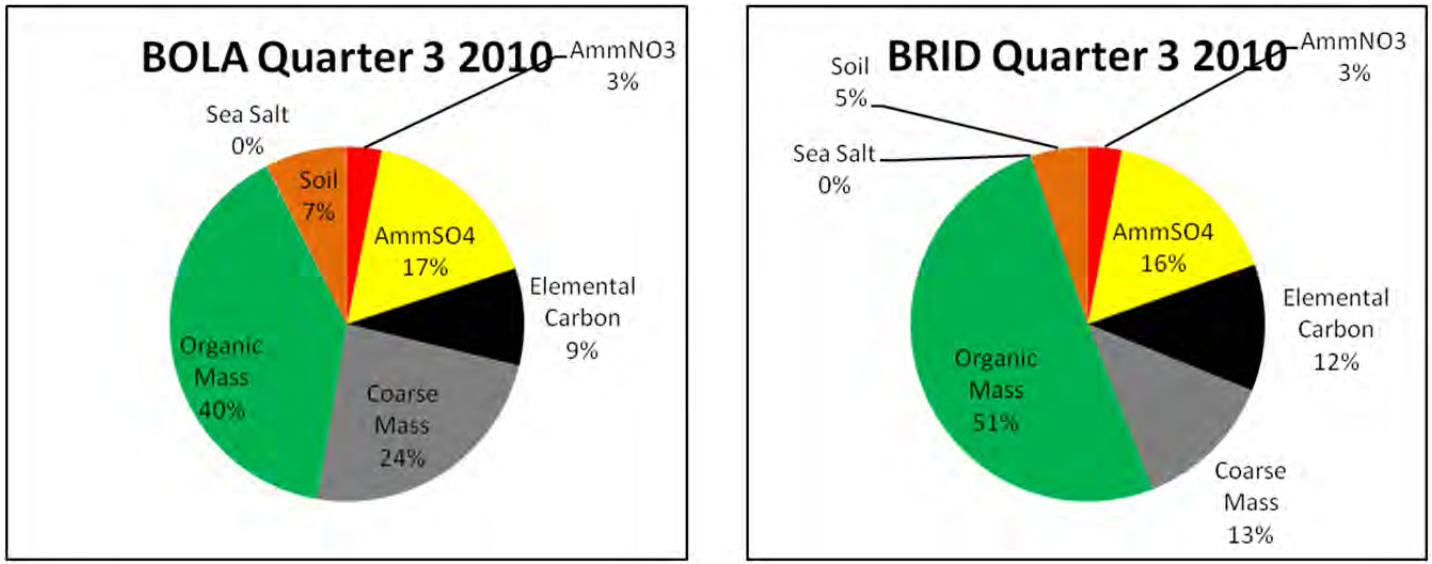

Figure 2-14 Comparison of Species Contribution to the 20% Worst Days in 2010 for Quarter 3

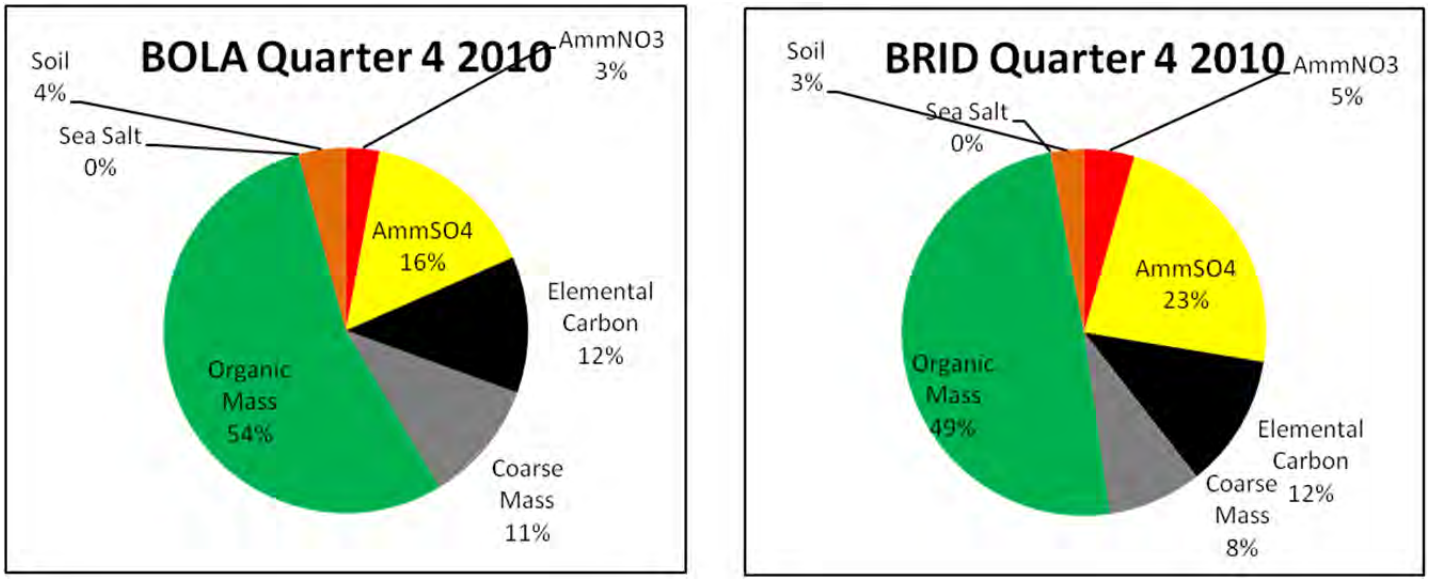

Figure 2-15 Comparison of Species Contribution to the 20% Worst Days in 2010 for Quarter 4

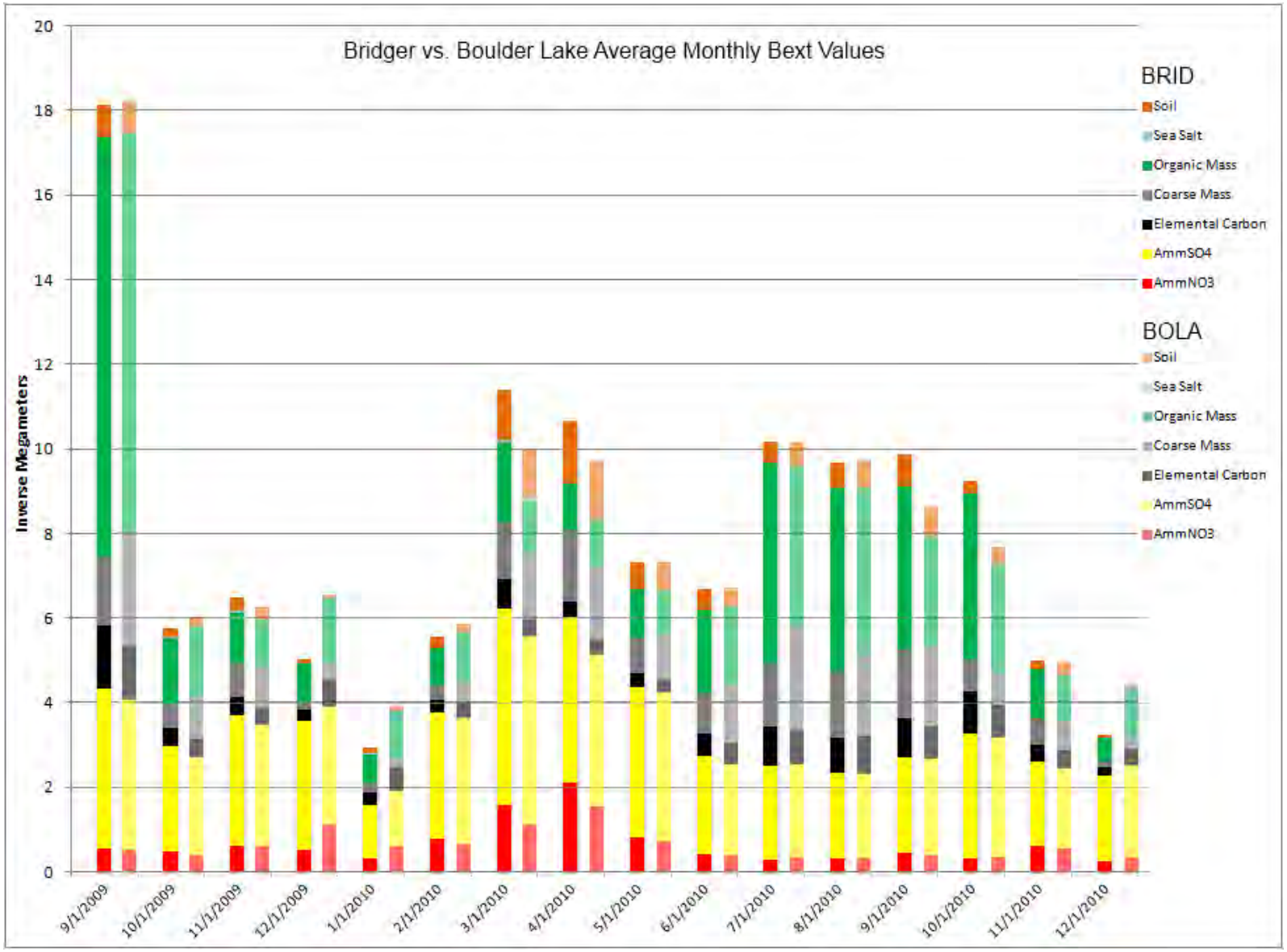

Figure 2-16 Monthly Averaged Species B_{ext} Contribution at BOLA and BRID

3.0 Modeling Technical Methods

3.1 Modeling Domain

The extent of the CALPUFF modeling domain for the ROD visibility modeling will be a subset of the CALPUFF modeling domain used in the SEIS modeling since the requirements of the ROD modeling analysis is entirely different than the requirements of the original SEIS modeling analysis. The regional SEIS modeling domain was 464 km in the x-direction and 552 km in the y-direction. The SEIS domain was developed to include non-project, regional emission sources in Colorado, Utah, and Idaho for cumulative impacts, and to capture Class I and sensitive Class II areas within 200-km of the PAPA, with a sufficient buffer to account for recirculation/edge effects. In contrast, the proposed modeling domain for the ROD visibility modeling is sized to only model the PAPA sources and nearby Bridger WA while allowing for sufficient area for recirculation/edge effects (USEPA 1998), as required by the ROD. The proposed domain is 264 km in the x-direction and 328 km in the y-direction. The Mesoscale Model Interface Program (MMIF)/CALPUFF domain is shown in **Figure 3-1**, which includes the original SEIS modeling domain for reference.

The proposed ROD modeling is necessarily focused on the highest impacts, and frequency of those impacts, at the Bridger WA. Based on the proximity to the PAPA sources, these impacts of concern will occur on the western edge of Bridger WA and use of either domain will not change modeled design concentrations and frequencies of visibility impacts. As such, the ROD domain is proposed to be sufficient to determine the design concentrations and frequencies at Bridger WA.

Due to the use of the MMIF meteorological processor (discussed in Section 3.3.1), the datum and projection of the coordinate system for the ROD visibility modeling will differ than that used in the SEIS modeling. The use of the Lambert Conic Conformal (LCC) coordinate system will be the same, but the datum and origin of the LCC projection will be different for this study. This difference is due to the fact that MMIF retains the projection used in the original Weather Research and Forecasting (WRF) modeling, which ultimately requires CALPUFF to be run in the same projection as the original WRF run. A comparison of the projection information is provided in **Table 3-1**.

Table 3-1 Comparison of LCC Projection Definition

Geographic Parameter	SEIS Modeling	ROD Visibility Modeling
RLAT0	43.05	40
RLON0	109.8	97
XLAT1	30	33
XLAT2	60	45
Datum	WGS-84	NWS-84

Although the projection information is different than the original SEIS modeling, the relative locations of the PAPA field and the Bridger WA are the same in the two analyses. The difference in projections is the cause of the tilt of the original SEIS modeling domain relative to the ROD visibility modeling domain evident in **Figure 3-1**.

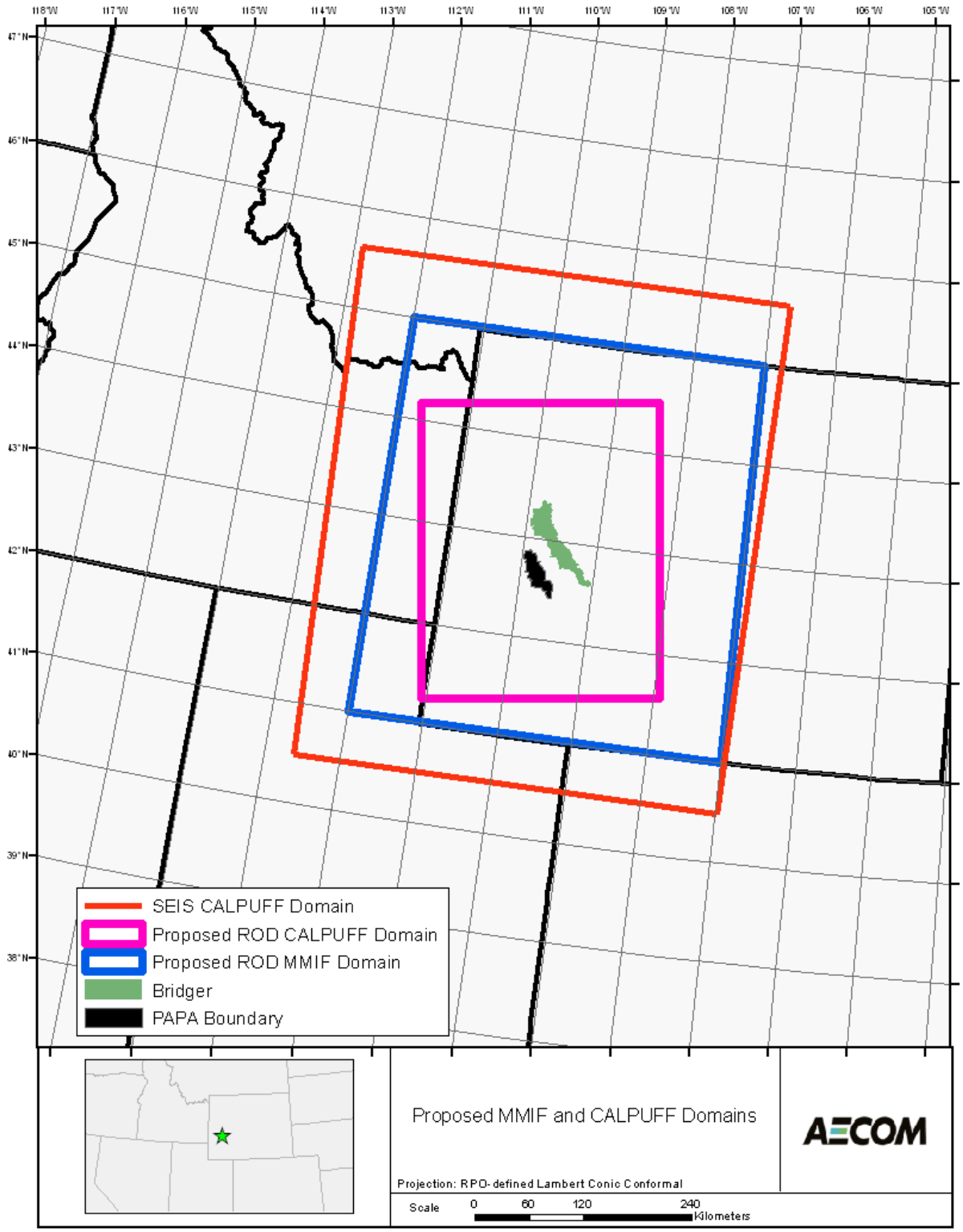

Figure 3-1 MMIF/CALPUFF Domain

3.2 Model Selection

3.2.1 Meteorological Preprocessor

The MMIF program Version 2.1 (ENVIRON 2012a) will be used to develop the meteorological fields for input into CALPUFF (AECOM 2012).

3.2.2 CALPUFF Modeling System

The USEPA-approved version of the CALPUFF modeling system (Version 5.8) will be used as the modeling platform for the study (Bott 2012). Version 5.8 of the CALPUFF dispersion model will be used to calculate PAPA source impacts, but CALPOST Version 6.292 will be used to calculate the PAPA visibility impacts (ddv) since it incorporates the latest Federal Land Managers' (FLM) Air Quality Related Values Work Group (FLAG) methodology (USFS et al. 2010). Both programs are freely available on the model developer's (TRC) website and on USEPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) website[1].

3.3 Meteorological Data and MMIF Processing

3.3.1 MMIF Options

The 2008 WRF meteorological model output produced as part of the Western Regional Air Partnership's (WRAP) West-Wide Jump Start Air Quality Modeling Study (WestJumpAQMS) (ENVIRON et al. 2012b) will be used as the meteorological dataset for input into the CALPUFF modeling. The WestJumpAQMS WRF model was run for an extensive 4-km domain that focuses on the intermountain West, including the PAPA and surrounding areas including the Bridger WA.

The WestJumpAQMS modeling output will be extracted for the air quality modeling domain shown in **Figure 3-1** and processed into CALPUFF-ready format using the MMIF meteorological preprocessor. The WRF model output will be processed with MMIF with the following options selected:

- Output for CALPUFF Version 5.8;
- The WRF vertical layers will be interpolated to the FLM/USEPA-recommended vertical layers using the TOP option;
- The Pasquill-Gifford stability classes will be calculated with the Golder option; and
- Planetary boundary layer heights will be recalculated.

This will result in the CALPUFF-ready meteorological files with the following specifications:

- Projection of LCC with RLAT0 = 40N, RLON0 = 97W, XLAT1 = 33N and XLAT2 = 45N;
- Datum = NWS-84;
- NX = 66;
- NY = 82;
- NZ = 10;
- DGRIDKM = 4.; and
- ZFACE = 0., 20., 40., 80., 160., 320., 640., 1200., 2000., 3000., 4000.

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[1] http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#calpuff.

The MMIF output, for the entire year of 2008, will be consistent with both the original WRF model output and USEPA-recommended settings as applicable.

3.3.2 MMIF Quality Assurance

The MMIFstat program (Version 1.0) (ENVIRON 2010) is designed to generate time series plots and model performance metrics for various meteorological parameters. The program compares meteorological observations to the final MMIF meteorological fields within a selected domain. MMIFstat produces standard performance metrics (e.g., bias, root mean square error [total, systematic and unsystematic] and index of agreement) for wind speed, wind direction, temperature, and humidity at both an hourly and daily time interval.

Surface observations available in the CALPUFF modeling domain will be compared to the final MMIF meteorological fields. Time series plots for daily-averaged meteorological parameters for two winter months and two summer months will be generated to assess WRF/MMIF performance during distinct times of the year. More detailed analyses (e.g., hourly comparisons or sub-domains) will be conducted on an as-needed basis.

The model performance will be compared to the standard benchmarks for mesoscale meteorological modeling listed in the MMIFstat user guide. These benchmarks are not intended to pass or fail a model, rather they are provided to put the results in context to other meteorological modeling and quantify known error and bias that can affect the dispersion model results.

3.4 CALPUFF Input and Options

The sections below discuss model inputs and options that will be used for the CALPUFF model. The PAPA emission inventory is discussed separately in Chapter 4.0.

3.4.1 CALPUFF Options

All switch settings will conform to the USEPA-recommended values and/or model defaults in alignment with the MREG=1 setting, which forces the model to verify that pertinent model options conform to USEPA guidance. If the model options do not conform to USEPA guidance, the model will not run. The model options that comprise MREG=1 along with settings to be used in the ROD visibility modeling are provided in **Table 3-2**.

Table 3-2 USEPA-recommended CALPUFF Model Options and Settings

Model Option	USEPA-defaults	Notes
METFM	1 or 2	Meteorological Format: 1 will be used for CALMET.DAT
AVET	60 minutes	Used for sigma-y calculation: 60 minutes will be used
PGTIME	60 minutes	Used for sigma-y calculation: 60 minutes will be used
MGAUSS	1	Vertical distribution of mass: 1 will be used (Gaussian)
MCTADJ	3	Puff/terrain adjustment: 3 will be used (partial plume path)
MTRANS	1	Transitional plume rise: 1 will be used (transitional rise invoked)
MTIP	1	Stack tip downwash: 1 will be used (downwash invoked)
MCHEM	1 or 3	Chemical mechanism: 3 will be used (1 invokes MESOPUFF; 3 invokes RIVAD)
MWET	1	Wet deposition: 1 will be used (invokes wet deposition)
MDRY	1	Dry deposition: 1 will be used (invokes dry deposition)

Table 3-2 USEPA-recommended CALPUFF Model Options and Settings

Model Option	USEPA-defaults	Notes
MDISP	2 or 3	Dispersion scheme: 2 will be used (2 invokes similarity theory; 3 invokes PG coefficients)
MPDF	0 or 1	Vertical skewing of puff: 1 will be used (0 when MDISP=3; 1 when MDISP=2)
MROUGH	0	Puff adjusted for roughness: 0 will be used (puff will not be adjusted for roughness)
MPARTL	1	Partial penetration of inversion: 1 will be used (penetration allowed)
SYTDEP	550 meters	Lateral puff size needed to invoke time dependent dispersion: 550 meters will be used
MHFTSZ	0	Invoke time dependent dispersion in the vertical: 0 will be used

Project-specific model input such as source information, background data, etc., is detailed below.

3.4.2 Computational Grid

The CALPUFF modeling domain, in which puffs are tracked, will be a subset of the MMIF domain as shown in **Figure 3-1**.

3.4.3 Receptors

The receptor locations for the Bridger WA will be the same as used in the SEIS modeling. The SEIS modeling used the publicly-available FLM receptor dataset for Class I areas. This dataset has 684 receptors covering the Bridger WA as shown in **Figure 3-2**.

3.4.4 Plume Downwash

The potential effects of plume downwash will not be considered for PAPA point sources consistent with the SEIS.

3.4.5 Background Ozone Data

Representative hourly ozone data is required for use in the chemical transformation of primary pollutant emissions. Hourly ozone from all stations is used by CALPUFF to oxidize NO_X and sulfur dioxide (SO_2) emissions within the modeling domain to nitric acid and sulfuric acid, respectively. The predicted nitric acid and sulfuric acid are then partitioned in CALPUFF between the gaseous and particulate nitrate and sulfate phases based on the available ammonia, and ambient temperature and relative humidity. Further refinement of the partitioning is discussed in Section 3.6.

Hourly ozone data from USEPA Air Quality System (AQS) and Clean Air Status and Trends Network (CASTNET) ozone sites within or just outside the modeling domain will be used in the analysis. The sites with ozone data available for 2008 are illustrated in **Figure 3-3**. Several sites are in the immediate vicinity of the PAPA field and Bridger WA: the WDEQ-operated Boulder, Jonah, and Daniel monitoring sites; and the Pinedale CASTNET monitoring site. Each of the sites has good data capture for the entire year of 2008, except for Jonah, which collected data for the period of January through April. The 2008 daily maximum 8–hour ozone values for the USEPA AQS sites are shown in **Figures 3-4** through **3-6** for Boulder, Daniel, and Jonah, respectively.

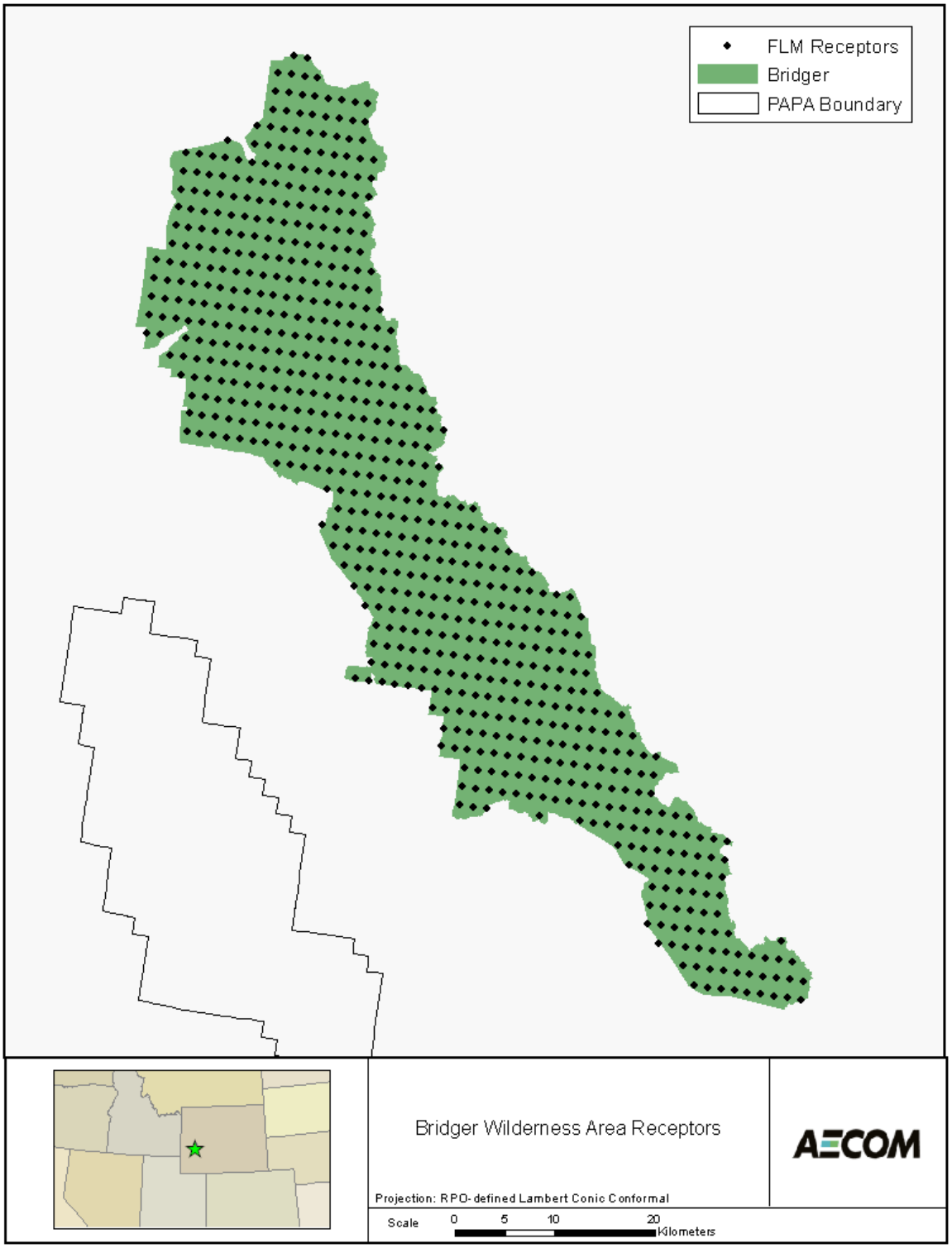

Figure 3-2 Bridger Wilderness Area Receptors

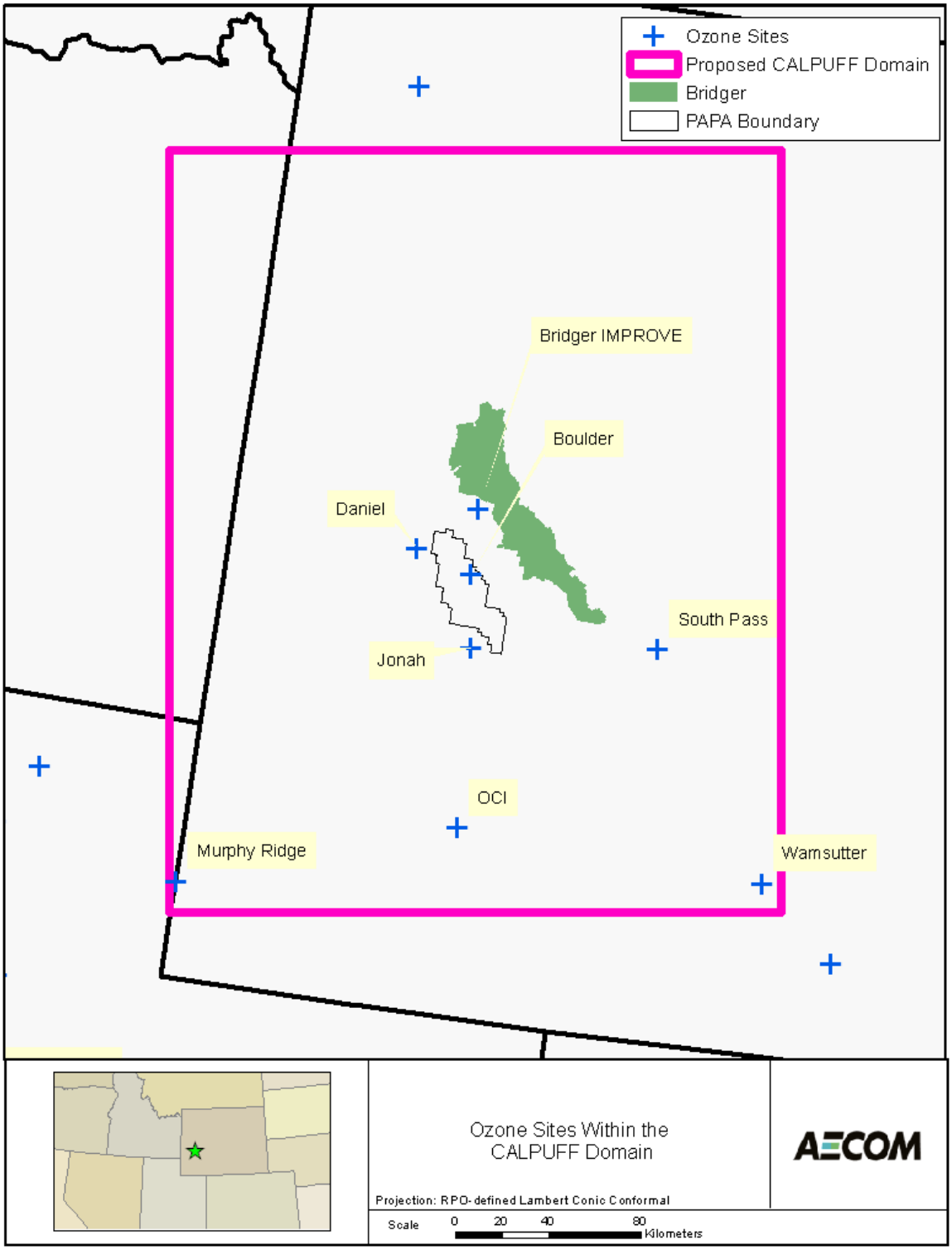

Figure 3-3 Ozone Sites Within and Near MMIF/CALPUFF Domain

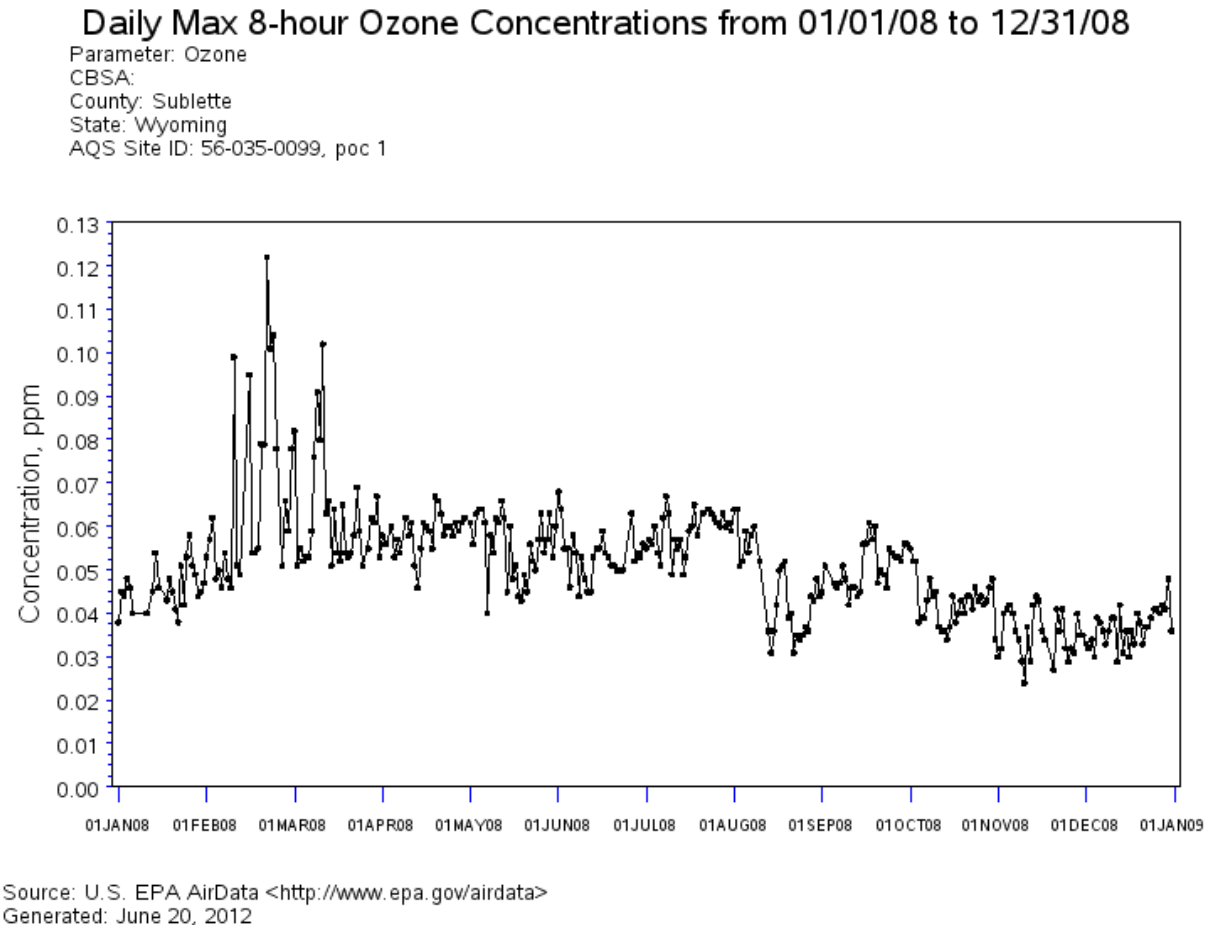

Figure 3-4 2008 Hourly Ozone Values for the Boulder Site

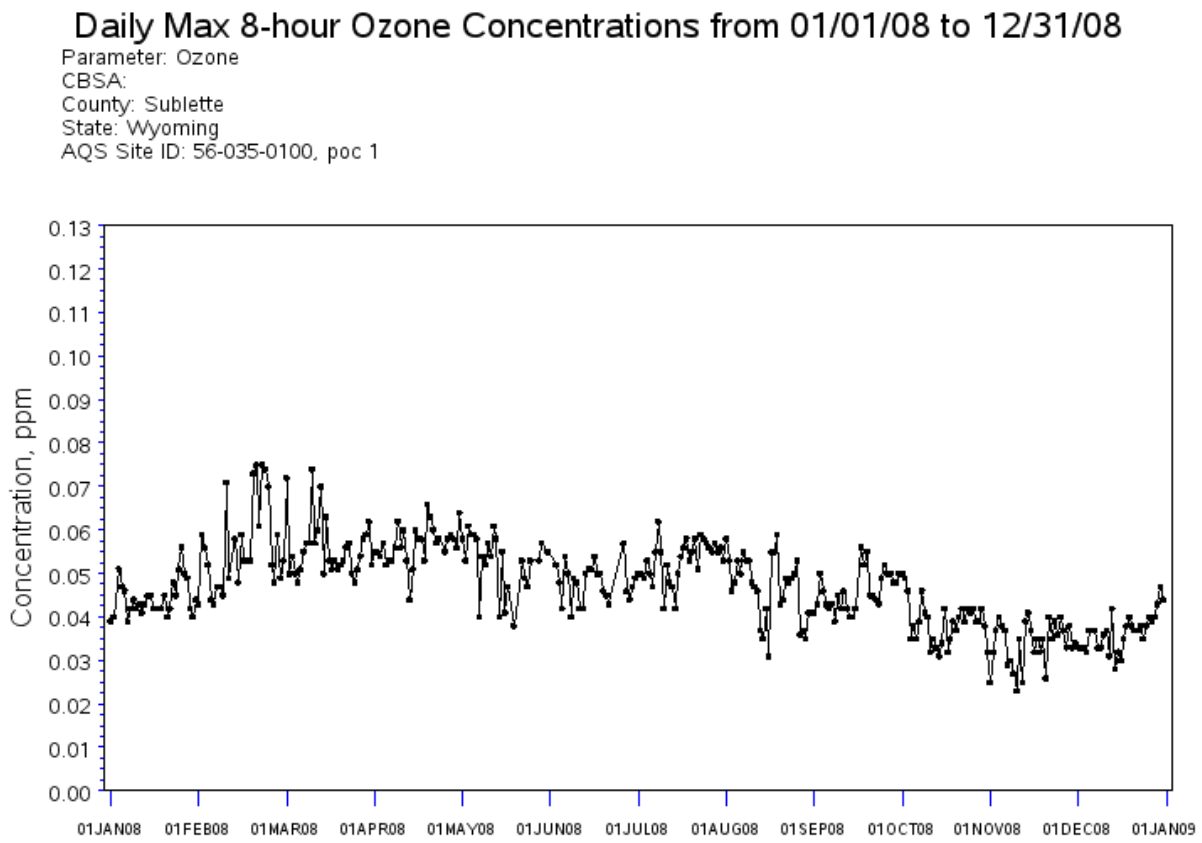

Figure 3-5 2008 Hourly Ozone Values for the Daniel Site

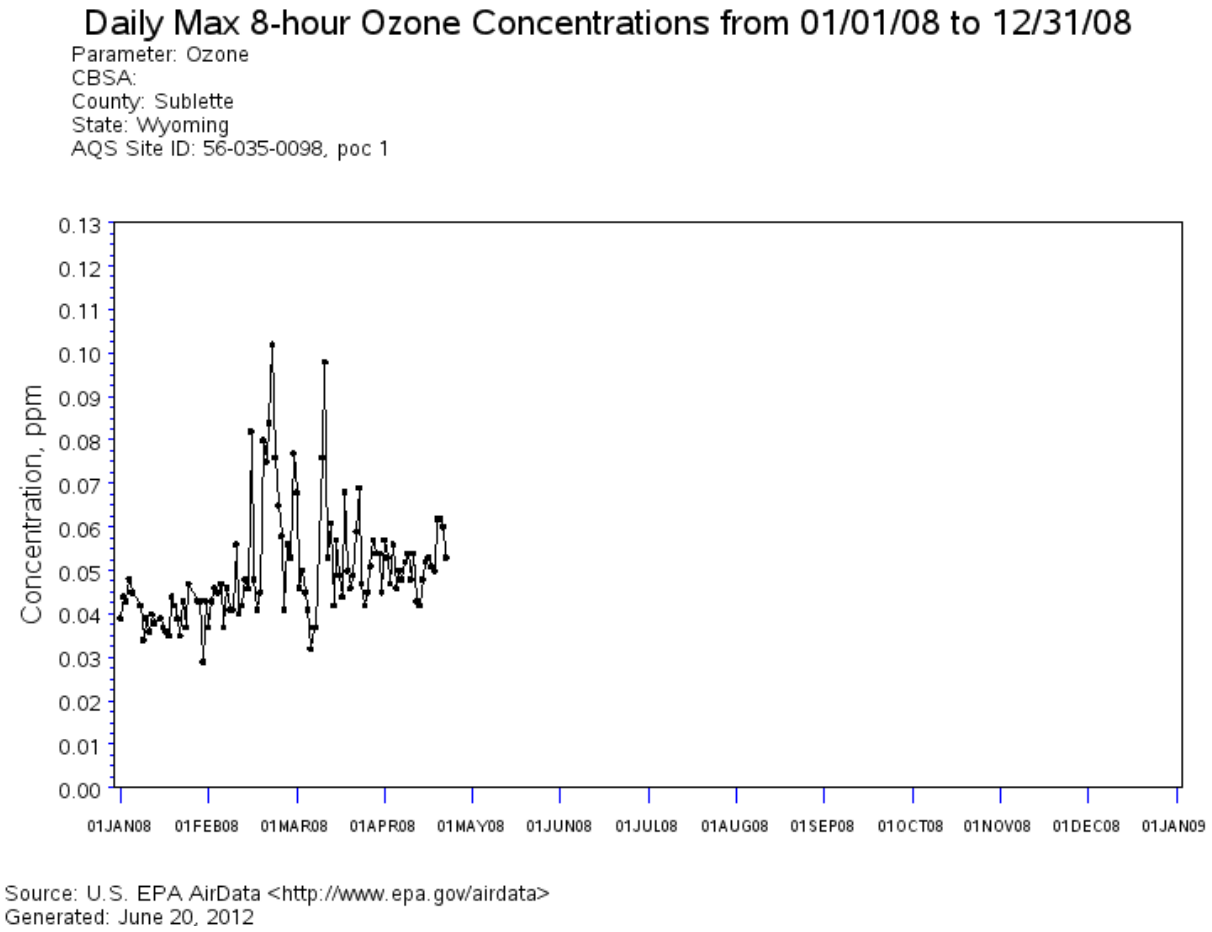

Figure 3-6 2008 Hourly Ozone Values for the Jonah Site

3.4.6 Background Ammonia Data

Representative monthly ammonia background values also are required for use in the chemical transformation of primary emissions. Without representative data available, the SEIS modeling used the suggested values from the Interagency Workgroup on Air Quality Modeling Phase 2 report for arid lands at 20 degrees Celsius (1 part-per-billion of ammonia) for all months.

Since the SEIS modeling, Shell has collected background ammonia values at the Boulder site within the PAPA area, which is labeled on **Figure 3-3**. The data collected from the years of 2007 to 2011 is available and will be used for the analysis. The periodic data (typically collected every 3 days) will be averaged into monthly values for each of the 5 years (e.g., the January data from all 5 years will be used to develop a composite January monthly average) and be used as model input. The composite monthly averaged data is provided in **Table 3-3**.

3.5 CALSUM Processing

The CALUSM postprocessor (Version 1.33) will be used to combine separate CALPUFF output files (binary concentration files) into a single output file for further post-processing.

3.6 POSTUTIL Processing

The POSTUTIL postprocessor (Version 1.56) will be used to repartition the CALPUFF-predicted nitrate concentrations using the MNITRATE=1 setting. This setting in POSTUTIL repartitions the particulate nitrate and gaseous nitric acid concentrations based on nitrate and sulfate concentrations from all modeled sources at a given receptor, the available background ammonia, and gridded temperature and humidity data. This remedies the existing model treatment of ammonia for overlapping puffs, which allows the same ammonia molecules to be used by multiple puffs at the same time to form particulate nitrate, thus leading to particulate nitrate over-predictions.

3.7 CALPOST Processing

CALPOST Version 6.292 will be used to calculate the visibility impacts from the PAPA sources at the Bridger WA receptors. The visibility impacts will be calculated and summarized in terms of ddv (AECOM 2012). The PAPA visibility impacts will be determined by comparing the impacts of sulfate, nitrate, nitrogen dioxide, course particulate matter (PM), and fine PM from the PAPA sources to the annual average natural conditions at the Bridger WA.

The ddv calculations will follow FLAG 2010 guidance including the use of the MVISCHECK = 1 to ensure compliance with FLAG guidance. All settings will comply with MVISCHECK, including:

- MVISBK = 8 to invoke the latest FLAG guidance (latest IMPROVE equation); and
- M8_MODE = 5 to use species specific relative humidity factors.

The species concentrations of the annual average natural background conditions at Bridger WA will be defined as provided in Table 6 of the FLAG 2010 document. The species-specific relative humidity adjustment factors for the Bridger WA will be obtained from Tables 7, 8 and 9 from the FLAG 2010 document.

Following FLAG 2010 guidance, the 98th percentile value (or 8th highest value) will be summarized and reported. The maximum impacts will also be reported in an appendix in the final report.

Table 3-3 5-Year Composite Monthly-Averaged Ammonia Data

	January	February	March	April	May	June	July	August	September	October	November	December
2007	0.016	0.01	0.15	0.13	0.29	0.25	0.76	0.86	0.33	0.13	0.09	0.01
2008	0.002	0.01	0.08	0.10	0.15	0.39	1.00	1.09	0.65	0.27	0.12	0.05
2009	0.044	0.05	0.31	0.44	0.39	0.57	0.88	0.86	0.70	0.25	0.10	0.07
2010	0.029	0.03	0.14	0.21	0.26	0.42	0.80	0.55	0.40	0.27	0.04	0.02
2011	0.02	0.02	0.03	0.14	0.17	0.30	0.74	0.56	0.43	0.15	0.02	0.04
5-Year	**0.02**	**0.02**	**0.14**	**0.20**	**0.25**	**0.39**	**0.84**	**0.78**	**0.50**	**0.21**	**0.07**	**0.04**

4.0 Emissions Inventory Development

Emissions estimates from PAPA development and production activities will be prepared by the Operators. These emissions will be reflective of field-wide operations and source locations for March 2015. These emissions will be prepared for the source categories listed below, which are consistent with those provided in the annual emission inventories submitted to the WDEQ:

- Central Gathering Facilities (CGF), which includes stationary engines;
- Well pad production sources;
- Well pad production controls;
- Drill rigs;
- Well completions;
- Compressor stations;
- Gas plants; and
- Construction mobile sources.

Each source category may be further divided into subgroups described in this chapter. NO_X is the primary pollutant of concern for visibility, and will be the focus of the inventory development. PM and SO_2, which also are visibility impairing pollutants, also will be quantified.

The inventory components discussed in this chapter provide the frame work and general approach to be used for estimating future year emissions. The inventory will present a “base case” 2015 emission scenario to be run in CALPUFF to determine if additional mitigation is needed to achieve zero days of visibility impairment over 1 ddv at the Bridger WA.

4.1 Central Gathering Facilities

Sources at CGFs consist primarily of permitted, internal combustion engines (ICE), along with other equipment that emit combustion-related pollutants. The engines burn either natural gas or diesel fuel, depending on the facility. Emission rates will be obtained from WDEQ permits or from stack test results, if available. Engines that run full time will be modeled at their projected hourly emission rates for calendar year 2015.

Other sources to be modeled at the CGFs will include organic emission controls (combustors and enclosed flares), various natural gas-fired heaters, and emergency flare pilot gas combustion located at the CGFs.

The sources will be modeled as point sources with locations and stack parameters provided by the Operators or obtained from permit applications.

4.2 Well Pad Production Sources

Well pad production sources include natural gas-fired production heaters and dehy reboilers. These sources are highly intermittent and typical burner run times will be used to determine reasonable emission rates for modeling purposes. Emissions will be calculated using emission factors and fuel use, consistent with the methods used to prepare the annual WDEQ inventories. Winter heaters will only be modeled during winter months, which will be from November through April.

The emissions will be modeled as 1 square km (km^2) area sources, consistent with the SEIS, and shown in **Figure 1-1**. The area source dimensions and placement will be obtained from the SEIS and

re-projected into the proposed modeling domain. Each Operator's emissions will be allocated among the area sources based on the location of the well pads in the PAPA.

4.3 Well Pad Production Controls

Well pad production controls include dehy benzene/toluene/ethylbenzene/xylene (BTEX) combustors and tank volatile organic compounds (VOC) combustors. Seasonally operated pneumatic heat trace circulation pumps also are controlled by the BTEX combustor(s) on some pads. The BTEX and VOC combustors operate continuously but the pneumatic pumps typically only operate in winter from November through April. Emissions will be calculated using emission factors and fuel use, similar to the methods used to prepare the annual WDEQ inventories.

The sources will be modeled as 1 km^2 area sources. The area source dimensions and placement will be obtained from the SEIS and re-projected into the proposed modeling domain. Each Operator's emissions will be allocated among the area sources based on the location of the well pads in the PAPA.

4.4 Drill Rigs

A drill rig typically contains three diesel-fired ICEs and a diesel-fired boiler. The load on the ICEs varies during the operation and not all of the ICEs may be running at the same time. Drill rig boilers only operate in the winter months to provide heat to the system. All drill rig engines in the PAPA have selective catalytic reduction (SCR) emission controls installed. Emissions from drill rigs will be obtained from source test results, and will be developed consistent with actual drill rig operation and control.

Drill rigs will be modeled as point sources. The number of drill rigs, their locations, and stack parameters will be provided by the Operators.

4.5 Well Completions

The primary source of combustion emissions from well completions are diesel-fired ICEs driving the hydraulic fracturing process. Other auxiliary engines and support equipment accompany a completion crew to a well pad site. The time it takes to complete a well varies, but a typical duration is about 2 to 3 days. Once a well is completed, the crew may stay on-site to complete another well, move to a new well pad, or cease operations for a prolonged period of time. As such, the time a crew spends on a given well pad is highly speculative for future years.

Emission rates will be provided by the Operators and will be based on emission factors or New Source Performance Standards, fuel logs, and other information. The emission rates used in modeling will take into account the intermittent nature of the operation.

Well completion emissions will be allocated to 1-km^2 area sources within each Development Area where the Operators will have concentrated development activities. The area source dimensions and placement will be obtained from the SEIS and re-projected into the proposed modeling domain.

4.6 Compressor Stations

Compressor stations and support facilities that serve the PAPA are listed below by Operator:

- Pinedale Complex operated by QEPFS, which consists of the Gobbler's Knob compressor station and the Pinedale Stabilization Plant; and
- Paradise compressor station operated by Enterprise.

Emissions from the Falcon compressor station, which was included in the SEIS modeling and is no longer in operation due to a catastrophic fire and destruction of the facility, will be accounted for by the

Operators and summarized in the emission inventory to be submitted to the BLM and WDEQ under separate cover.

Natural gas and diesel-fired ICEs and turbines are the primary source of emissions from these facilities. Emission rates will be obtained from WDEQ permits or from stack test results, if available. Engines that run full time will be modeled at their average hourly emission rates. Engines that do not run full time will be modeled at a prorated emission rate based on expected operating hours. Other sources at these facilities will be modeled at their maximum emission rates, or prorated for non-continuous operations, as applicable.

The sources will be modeled as point sources with locations and stack parameters provided by the Operators or obtained from permit applications.

4.7 Gas Plants

The only natural gas processing plant in the region that serves the PAPA is the expansion at the Black's Fork gas plant. This facility consists of natural gas-fired turbines and other support equipment. Emission rates will be obtained from WDEQ permits.

The Black's Fork sources will be modeled as point sources. Locations and stack parameters will be provided by the Operators or obtained from permit applications.

4.8 Construction Mobile Sources

Well pad construction sources consist of tailpipe emissions from non-road mobile equipment. Emission rates will be calculated using emission factors along with acreages, miles traveled, or number of wells developed, as appropriate. Construction activities occur year round, though there is more construction activity during the warm season months from May through October, and only during daylight hours. The modeling will reflect these variations. Construction mobile sources will be modeled as area sources and be allocated to the appropriate 1-km^2 areas where new pad construction is expected to occur.

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