APPENDIX C

AERMOD Report

Report

Bingham Canyon Mine Expansion

AERMOD Modeling Analysis

Submitted to

Utah Division of Air Quality

Prepared for

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1.0 Introduction

The Bingham Canyon Mine (BCM) is currently limited to an annual material throughput of 197,000,000 tons per year (tpy) for ore and waste rock combined. This limit was established by the *Notice of Intent to Increase Annual Ore and Waste Rock Production at the Kennecott Utah Copper Bingham Canyon Mine*, issued in 1999. In 2008, the Utah Division of Air Quality (UDAQ) issued Approval Order (AO) DAQE-IN0105710023-08. Condition 21.A of the 2008 AO includes the material throughput limit established in the 1999 Notice of Intent (NOI), stating that the "total material moved (ore and waste) shall not exceed 197,000,000 tons per 12-month period." To maintain the current level of metal production, Kennecott Utah Copper LLC (KUC) proposes to increase the BCM's annual throughput of ore and waste rock material to 260,000,000 tpy.

The BCM is not subject to Utah Administrative Code R307-410, which describes the emissions impact analysis requirements, since the emissions of point and fugitive sources are expected to be the same or decrease for pollutants that are in attainment for Salt Lake County. As a result, dispersion modeling is not required for the requested increase in material throughput to maintain the current level of metal production. However, KUC is submitting this near-field modeling analysis demonstrating that particulate matter less than 10 micrometers in aerodynamic diameter (PM_{10}) impacts from the proposed project will not violate the near-field National Ambient Air Quality Standards (NAAQS) near the mine.

The BCM's potential to emit (PTE) emissions after the increase in material throughput to 260,000,000 tpy of ore and waste rock are also summarized in Table 3-16 of the NOI. Appendix B-1 summarizes the emission rates used in the modeling analysis.

1.1 Regulatory Status

The BCM is located in an area that is classified as a nonattainment area for sulfur dioxide (SO_2) and for particulate matter (PM) less than 10 micrometers in aerodynamic diameter (PM_{10}); it is classified as a maintenance area for 8-hour ozone. The PM_{10} NAAQS are listed in Table C-1.

TABLE C-1
National Ambient Air Quality Standards

Averaging Period/ Pollutant	NAAQS ($\mu g/m^3$)	Significant Monitoring Concentrations ($\mu g/m^3$)
24-hour PM_{10}	150[a]	10
Annual PM_{10}	NS	NS

NOTES:
$\mu g/m^3$ = microgram per cubic meter
NS = no standard
[a] Not to be exceeded more than once per year on average over 3 years

1.2 Monitor Data

There are a number of PM_{10} ambient air quality monitors in the vicinity of Salt Lake City and Provo, Utah. Since the BCM is located outside of each city, KUC operates a PM_{10} ambient monitor near the city of Copperton.

Selecting a representative background PM_{10} concentration for the proposed KUC mine life extension project is critical because existing operations at the mine would be included in the modeling and need to be excluded from a representative background value. The criteria outlined in the *Federal Register* Section 40, Part 51 Appendix W, were used to determine a monitored value near the BCM site, which would include PM_{10} concentrations from (a) natural sources, (b) nearby sources other than the ones currently under consideration, and (c) unidentified sources.[1]

The Copperton, Utah, PM_{10} monitor is maintained by KUC and has records over the last 5 years. The monitor is located within the city of Copperton, Utah, and is approximately 2 kilometers east of the main mining pit. The monitoring equipment is operated and maintained by KUC staff consistent with EPA ambient monitoring requirements. Third-party audits are conducted quarterly as required by EPA monitoring requirements. The data are reported regularly to the town of Copperton. The eight highest recorded concentrations over the past 5 years are summarized in Table C-2.

TABLE C-2
Copperton, Utah PM_{10} Monitoring Data, 2003 through 2007

Rank	24-hour Monitor Value ($\mu g/m^3$)	Date
1	139.3	May 18, 2007
2	93.9	September 10, 2005
3	81.5	July 21, 2005
4	77.8	December 30, 2003
5	67.1	July 15, 2005
6	66.9	July 6, 2005
7	65.1	October 27, 2007
8	59.1[a]	February 4, 2004

NOTES:
$\mu g/m^3$ = Microgram per Cubic Meter
[a] Used as natural background

The Copperton, Utah, data demonstrate there have not been any recorded exceedances of the PM_{10} 24-hour NAAQS over this time period. The PM_{10} NAAQS allows for one exceedance of the standard per year averaged over 3 years.

For modeling purposes, an appropriate background value for an existing facility should not allow for any overlap of existing operations in the background value. Therefore, a further analysis of the data, following 40 *Code of Federal Regulations* (CFR) 51, Appendix W, guidelines, concluded a number of the maximum recorded impacts could be discounted in

1 40 CFR 51 Appendix W Section 8.2.1(a)

regards to modeling due to natural dust events (UDAQ, 2002). Other values were eliminated from consideration for background values because they occurred during periods when the existing operations would impact the monitored value. Using these procedures, the maximum background PM_{10} value selected was 59.1 micrograms per cubic meter (µg/m^3). Appendix C-1 contains a technical memorandum for selecting the 24-hour PM_{10} concentration at Copperton for modeling and the determination of valid or invalid data based on meteorological conditions and dust events.

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2.0 Near-field Modeling

2.1 Model Selection

The U.S. Environmental Protection Agency (EPA)-approved American Meteorological Society/EPA Regulatory Model (AERMOD) Improvement Committee Model dispersion modeling system was used to evaluate near-field air quality impacts. The latest generation of the EPA's dispersion model is AERMOD Version 09292, which is recommended for predicting impacts in the near-field (within 50 kilometers) of industrial point sources as well as area and volume sources. Preprocessors associated with the AERMOD modeling system are summarized in Section 2.2.

Terrain surrounding the BCM is classified as complex terrain. Complex terrain is defined as terrain above final plume height. AERMOD is able to accurately calculate complex terrain impacts by determining the horizontal plume state and terrain following plume state impacts. The total complex terrain impact is a weighted sum of the two extreme plume states. This is an enhanced calculation algorithm embedded in AERMOD that allows the model to calculate complex terrain impacts in the same modeling framework instead of specifying the use of complex terrain algorithms in the model.

An air quality modeling analysis was conducted for the project following guidance and procedures outlined in 40 CFR 51, Appendix W (EPA, 2005), the *AERMOD Implementation Guide* (EPA, 2008), and the *Utah Division of Air Quality Modeling Guidelines* (UDAQ, 2008).

2.2 Modeling Options and Assumptions

AERMOD was used with regulatory default options as recommended in the EPA Guideline on Air Quality Models (EPA, 2005). The following supporting preprocessors for AERMOD were also used:

- AERMET (Version 06341), for processing meteorological data by UDAQ
- AERMAP (Version 09040), for extracting receptor elevations and controlling hill heights

Post-project PTE emissions were calculated on an annual throughput of 260,000,000 tons per year. Therefore, annual average daily emissions were increased by 20 percent to account for daily variability in the mine operations and to capture a worst-case day scenario for comparison to the NAAQS.

2.3 Emission Source Characterization

Emissions of PM_{10} come from a variety of different sources at the BCM. Fugitive dust is emitted from roads, haultruck loading and dumping, and ore and waste rock transfer and handling sources. Particulate PM_{10} from haultruck exhaust (tailpipe emissions) are also included.

The BCM is a very large open pit mine. Therefore, the sources located within the pit influence boundary were modeled as area sources in the AERMOD model for all emissions within the pit. The area source emissions were estimated by applying a 20 percent escape factor as discussed in Section 3 of the NOI. This escape factor was derived based on a computational fluid dynamics modeling study conducted by the University of Utah in 1996 (Appendix D). Sources outside of the mine pit influence boundary were modeled with the applicable source type. Sources outside and inside the pit influence boundary are described in Table C-3.

TABLE C-3
AERMOD Emission Sources

Source Name	Description	Source Type
Main1	Main mine pit area and haulroads inside the mine pit influence boundary.	Area source
Haulroads	Haulroads outside the mine pit influence boundary	String of volume sources
Haultruck Dumping	Haultruck dumping locations outside the mine pit influence boundary	Volume source
C6/C7 Transfer	Conveyor transfer point, baghouse. Outside pit.	Point source
C7/C8 Transfer	Conveyor transfer point, baghouse. Outside pit.	Point source
Limebin1	Lime storage. Outside pit.	Point source
Limebin2	Lime storage. Outside pit.	Point source

Particle size distributions were assigned to each source in order to account for particle deposition between the emission location and the ambient receptors. A majority of the emissions are from fugitive sources (roads, loading, dumping, hauling, and crushing) and exhaust emissions from haultrucks. Therefore, the emissions from the pit area used a particle size distribution that was proportioned based on the percentage of representative source types for each source. The representative source types at the BCM for particle size distributions were aggregate rock mining and vehicle exhaust. The EPA's *AP-42, Fifth Edition* publishes emissions factors and particle size distribution for these sources. The EPA's *AP-42*, Appendix B, Table B.2-2, Categories 1 and 2 were used to determine the particle size distributions for diesel exhaust and aggregate dust source types. Table C-4 summarizes the particle size distribution breakdown from the open pit area source.

TABLE C-4
Particle Size Distribution

Particle Size Bin[a]	Main1[b]
0 to 1	0.183
1 to 2	0.127
2 to 2.5	0.071
2.5 to 3	0.051
3 to 4	0.122
4 to 5	0.086
5 to 6	0.068
6 to 10	0.293

NOTES:
[a]Micrometers
[b]Mass fraction

Appendix B-1 summarizes the emission rate for each source included in the AERMOD modeling analysis.

The haulroads were modeled as a string of volume sources outside the main pit influence boundary. At the end of each haulroad, a single volume source was used for the truck dumping operations. Truck traffic and dumping operations were apportioned across the mine site based on communications with mine operations staff. Table C-5 summarizes the volume source parameters used for the haulroads and dump sites.

TABLE C-5
Haulroad and Dump Site AERMOD Modeling Source Parameters

Source	Number of sources	Elevation	Width (feet)	Height (feet)	Initial Horizontal Dimension (feet)	Initial Vertical Dimension (feet)
Haulroads	576	AERMAP[a]	100	40	23.256	9.302
Truck Dumping	6	AERMAP[a]	100	40	23.256	9.302

[a] The AERMAP pre-processor was used to determine base elevations for haulroads and truck dumping sources.

The PM_{10} emissions from sources outside the main pit also require a particle size distribution to account for dry deposition as well. Depending on the emissions from the source type, a particle size distribution was proportioned based on the percentage of representative source types for each group as either exhaust emissions or fugitive emissions. Table C-6 summarizes the particle size bin fractions for exhaust and fugitive aggregate emission types.

TABLE C-6
Particle Size Distributions (mass fraction of PM_{10})

Particle Bin Size (µg)	Exhaust Emissions	Fugitive Aggregate
1	0.854	0.078
2	0.063	0.137
2.5	0.021	0.078
3	0.000	0.059
4	0.021	0.137
5	0.010	0.098
6	0.000	0.078
10	0.031	0.333

Source: AP-42, Table B.2.2, Categories 1 and 3.

2.4 Receptors

The base modeling receptor grid for AERMOD modeling consisted of receptors that were placed at the ambient air boundary and Cartesian-grid receptors that were placed beyond the boundary at spacing that increases with distance from the origin. The property boundary was used as the ambient air boundary, except for along the eastern and southern property boundaries.

Because the KUC permit boundary extends into Copperton the receptor boundary was moved slightly inside of the KUC permit boundary. There are two conveyor baghouse point sources directly to the west of Copperton; therefore, the baghouse transfer points just to the west of Copperton were used to establish this eastern most ambient air boundary.

A year-round public access road crosses through the southern portion of the KUC property boundary (Butterfield Canyon Road). Therefore, receptors were placed along the road and were used as the south and southeast receptor boundary.

Additionally two discrete receptors were placed inside of the permit boundary at a small housing community just west of the baghouses and at the Ore House Saloon along West State Highway. These locations are accessible to the general public; therefore, they are considered ambient air.

Figure C-1 shows the base AERMOD receptor grid for the project. Property boundary receptors were placed at 50-meter intervals. Beyond the property boundary, receptor spacing was at 100-meter spacing from property boundary to 2 kilometers. Receptors were not placed beyond 2 kilometers for this analysis since as expected for primarily fugitive sources; previous modeling exercises for this project indicated the maximum concentrations are at or near the ambient boundary and downwind concentrations are reduced significantly beyond 2 kilometers from the facility boundary using AERMOD.

All receptors and source locations are in Universal Transverse Mercator North American Datum 1927 (NAD27), Zone 12 coordinate system.

Terrain in the vicinity of the project was accounted for by assigning base elevations and controlling hill heights to each receptor. These values are used in AERMOD to determine the horizontal plume state and terrain following plume state impacts used to determine the modeled pollutant concentrations. Digital Elevation Model (DEM) data from the U.S. Geological Survey (USGS) in 7.5-minute format (30-meter resolution or better) were used to determine receptor elevations.

AERMAP (Version 09040) was used to calculate the receptor elevations and the controlling hill heights. A sufficient AERMAP domain and DEM file selection were identified to encompass the 10 percent slope calculation recommended by the EPA to calculate the controlling hill heights in AERMAP.

2.4.1 AERMET

The AERMET preprocessor (Version 06341) was used to prepare the Herriman surface meteorological dataset provided by UDAQ. Upper air sounding data from the Salt Lake City Airport were used in conjunction with the surface data. Years 2004 through 2006 were used for this analysis and a wind rose is attached in Figure C-2.

The Herriman dataset was modified to reflect invalid data between October 1, 2004, and October 12, 2004. The wind direction sensor was inoperable during this period and UDAQ agreed to this change on May 18, 2009 (e-mail from UDAQ to CH2M HILL presented in Appendix C-3). No other changes to the data set were made.

FIGURE C-1
KUC Receptor Grid

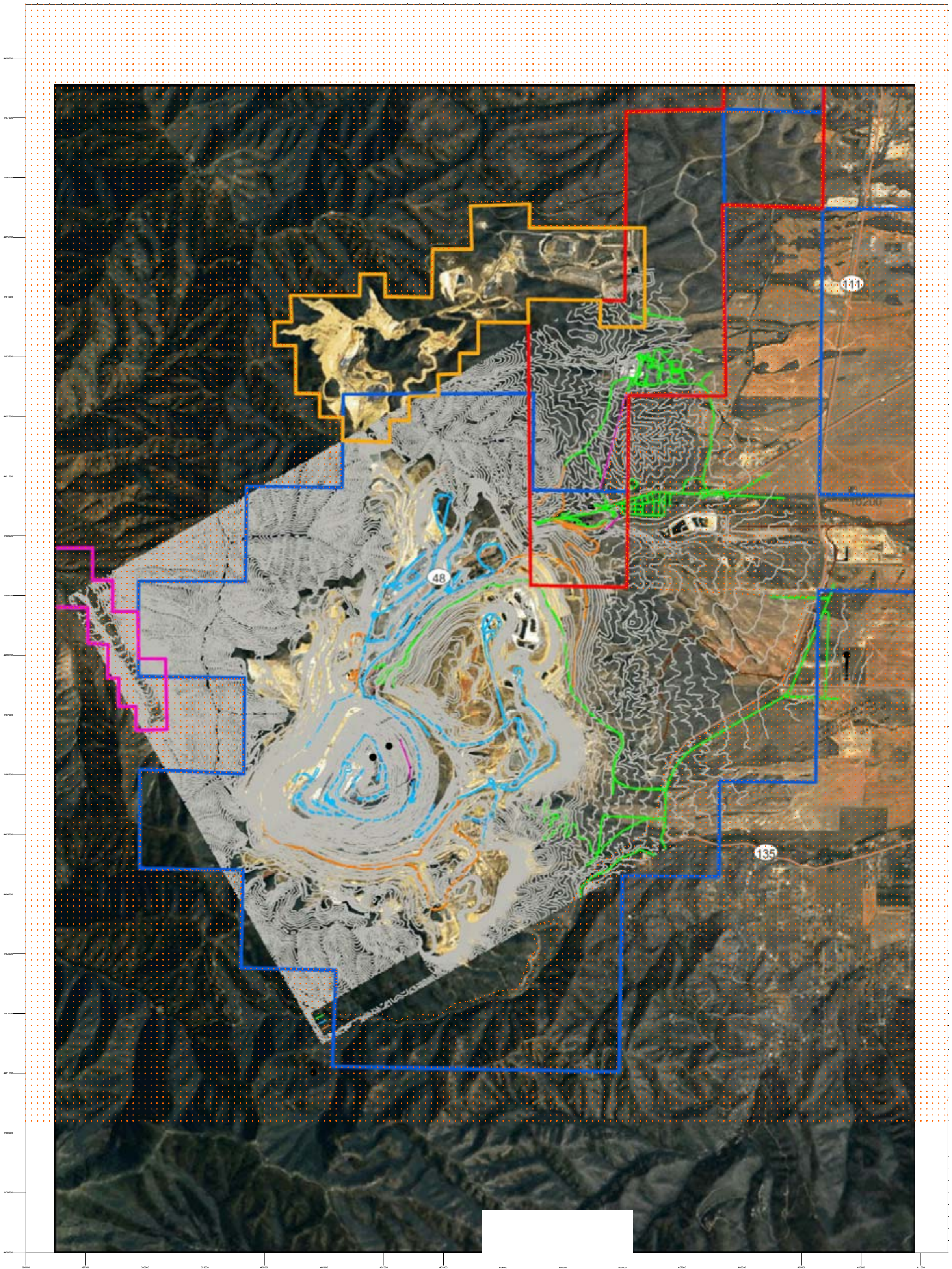
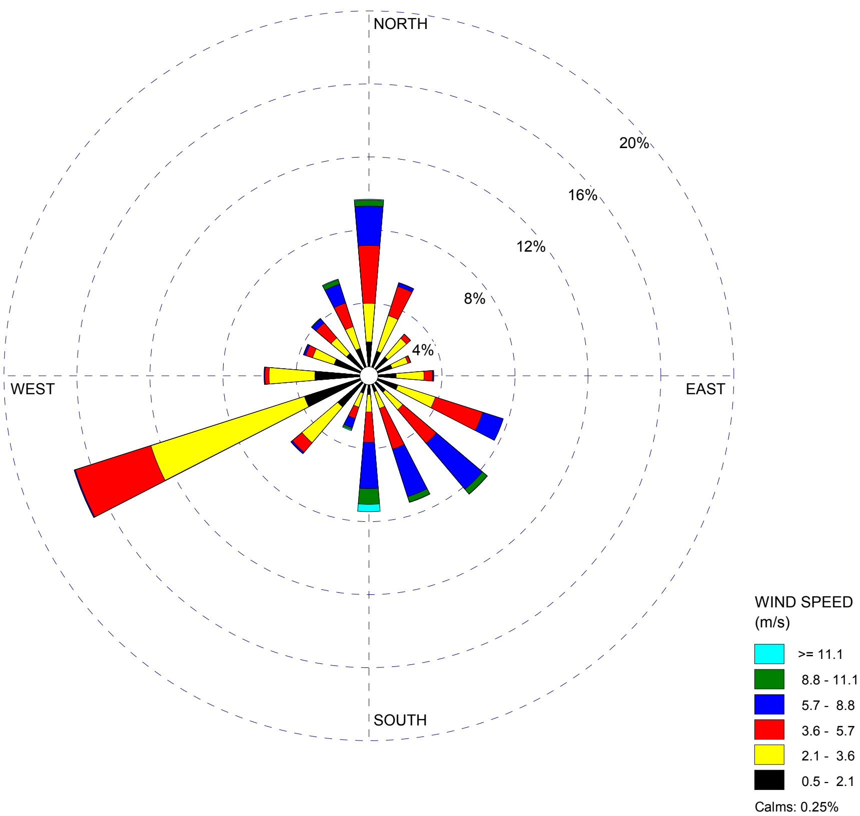


FIGURE C-2
Herriman, Utah, 4-year Wind Rose

WIND ROSE PLOT:
Herriman Meteorological Data Set
AERMET Processed Data 2004 through 2007

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:
10-m AGL
Processed by UDAQ

COMPANY NAME:
CH2M HILL

AVG. WIND SPEED:
3.69 m/s

PROJECT NO.:
KUC

WRPLOT View - Lakes Environmental Software

3.0 Results

As discussed previously, the PM_{10} NAAQS allows for one exceedance of the standard per year averaged over 3 years. Therefore, conservatively, the highest of the highest-second-high from each modeled year were used in conjunction with the applicable background value for comparison to the NAAQS.

The AERMOD modeling results are summarized in Table C-7. The modeling results indicate the predicted post project 24-hour PM_{10} impact from the KUC facility would be 85.1 μg/m^3.

TABLE C-7
KUC 24-hour PM_{10} AERMOD Modeling Results

2004	2005	2006
61.8	69.2	**85.1**

NOTE:
Results in μg/m^3
Bold values indicate modeled concentration used for comparison to the NAAQS.

This analysis includes some conservative assumptions in that the modeled emissions represent the total potential PM_{10} emissions from the BCM, including those from current operations. Also, a background PM_{10} concentration from the data measured at the Copperton, Utah, monitor site is added to the modeled value. It is likely that the measured data include emissions from current operations under some meteorological conditions. Therefore, addition of the modeled concentration and the background measured concentrations may be double counting some contribution from current operations.

TABLE C-8
Post-project Total 24-hour PM_{10} Impact[a]

Scenario	Modeled Concentration (μg/m^3)	Copperton, Utah, Background Concentration[a]	Total Concentration	Above 150 μg/m^3 NAAQS?
Post-project	85.1	59.1	144.2	No

NOTES:
[a]Background concentration from the Copperton, Utah, monitoring station

The results indicate that the total impact from the emissions associated with post-project maximum throughput of 260,000,000 tpy and background would result in post-project impacts of 144.2 μg/m^3. This is less than the NAAQS of 150 μg/m^3. As indicated in the Section 2.2 of the AERMOD report, these results include a 20 percent increase in the annual average daily emissions to account for variability in the daily operations.

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4.0 References

U.S. Environmental Protection Agency (EPA). 2004. AERMET User's Guide.

U.S. Environmental Protection Agency (EPA). 2005. 40 *Code of Federal Regulations* 51, Appendix W.

U.S. Environmental Protection Agency (EPA). 2008. AERMOD Implementation Guide.

Utah Division of Air Quality (UDAQ). 2002. *Utah State Implementation Plan, Section 1x, Part A.*

Utah Division of Air Quality (UDAQ). 2008. UDAQ Modeling Guidelines.

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APPENDIX C-1

PM_{10} Ambient Monitor Data

KUC Bingham Canyon Mine Life Extension Project PM_{10} Background Value

Kennecott Utah Copper LLC (KUC) is proposing to increase the annual rate of ore and waste rock production at the Bingham Canyon Mine (BCM) located near Copperton, Utah. This increase in production may result in an increase of particulate matter (PM) emissions, specifically emissions of PM less than 10 micrometers in aerodynamic diameter (PM_{10}), which is a criteria pollutant regulated by the state and U.S. Environmental Protection Agency (EPA). KUC will submit a modeling analysis using the EPA approved American Meteorological Society/EPA Regulatory Model (AERMOD) modeling system to demonstrate compliance with the PM_{10} National Ambient Air Quality Standards (NAAQS) standard after the proposed modification.

The modeling analysis will include total operations and the results compared to the NAAQS for PM_{10} of 150 micrograms per cubic meter (μg/m^3) for a 24-hour period[2]. This comparison will include both the modeled concentration from BCM emissions and the background PM_{10} concentrations to account for other sources of PM_{10} in the area. The proposed background value for this project is 59.1 μg/m^3.

This memorandum summarizes the top 15 monitored days for PM_{10} near the BCM site and the justification for selection of the proposed background value.

Monitored Concentrations

The Copperton, Utah, PM_{10} monitor is maintained by KUC, and data collected during the period of 2003 and 2007 were used for this analysis. The monitor is located within the City of Copperton and is approximately 2 kilometers northeast of the main mining pit. Table 1 summarizes the maximum 15 monitored 24-hour PM_{10} concentrations from the KUC PM_{10} monitor between 2003 and 2007. The data demonstrates there have not been any recorded exceedances of the PM_{10} 24-hr NAAQS over this time period. The meteorological conditions for each of the 15 days were studied in order to assess the probability that emissions from BCM sources were contributing to the monitored concentration on a given day. The prevailing meteorological conditions for each day based on data collected at both the Herriman and Salt Lake City monitoring sites are summarized in Table 1 also. Figure 1 shows the location of the Copperton PM_{10} monitor in relation to the KUC active mine site.

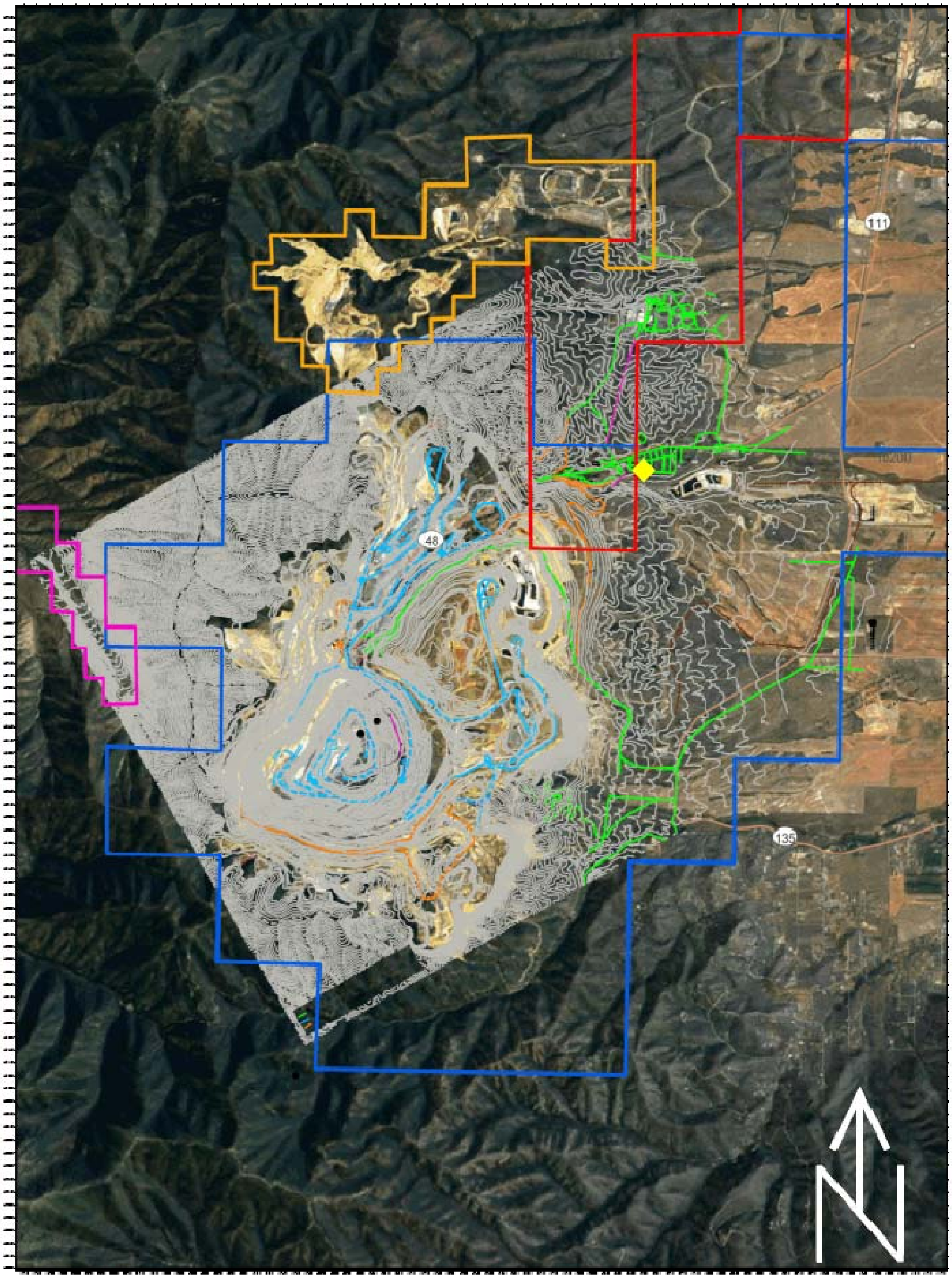
[2] The 150 μg/m^3 24-hour standard is allowed to be exceeded once per year on average over 3 years.

TABLE 1
KUC 24-Hour PM_{10} Monitored Concentrations
Top 15 Concentrations

Rank	Date	Monitored Concentration [a]	Meteorological Conditions
1	05/18/2007	139.291	Suspect: Missed Collection Period [b]
2	09/10/2005	93.941	Gusts greater than 33 mph [c], Average speed 13.1 mph, Average direction from NN [d]
3	07/21/2005	81.5	Stronger Winds from NNW, Average Speed 7.7 mph, Gust 31 mph
4	12/30/2003	77.768	Average Speed 11.4 mph, average direction from SSE
5	07/15/2005	67.1	Gusts greater than 17 mph, average speed 5.5 mph, average direction from NNW
6	07/06/2005	66.9	Gusts greater than 18 mph, average speed 7.3 mph, average direction from SE
7	10/27/2007	65.053	Gust greater than 18 mph, average speed 4.1 mph, average direction (everywhere, mostly low wind speed)
8	02/04/2004	59.136	Average Speed 7.5 mph, average direction from NW
9	03/03/2006	58.1	Gusts greater than 39 mph, average speed 15.0 mph, average direction from SSE
10	07/27/2005	57.4	Gusts greater than 17 mph, average speed 7.0 mph, average direction SSE
11	08/05/2005	57	Gusts greater than 20 mph, average speed 8.1 mph, average direction SSE
12	12/03/2004	56.797	Gust greater than 14 mph, average speed 6.0 mph, average direction from SE
13	01/27/2007	56.64	Gust greater than 10 mph, average speed 2.7 mph, average direction NNW
14	07/18/2005	56.5	Gusts greater than 22 mph, average speed 7.2 mph, average direction from SE
15	11/18/2004	55.029	Gusts greater than 14 mph, average speed 4.1 mph, average direction from SSE

NOTES:
[a] $\mu g/m^3$= Micrograms per Cubic Meter
[b] The data collected on May 18, 2007, has been invalidated since the collection period was missed. The data recovery from the site is very good (>90 percent). Therefore, invalidating this monitor value would not jeopardize the completeness of the monitored data.
[c] mph = Miles per Hour
[d] Compass rose directions. i.e. NW = northwest

FIGURE 1
KUC PM_{10} Monitor Location



PM10 Monitor Location

Representative Background Concentration for KUC Modeling

Selecting a representative background PM_{10} concentration for the proposed KUC mine expansion extension project is critical because existing operations at the mine are included in the modeling and need to be excluded from a representative background value. The criteria outlined in the Federal Register Section 40, Part 51 Appendix W, was used to determine a monitored value near the BCM site, which would include PM_{10} concentrations from (a) natural sources, (b) nearby sources other than the ones currently under consideration, and (c) unidentified sources.[3]

In addition, monitored concentration values were discarded due to nonmanmade natural dust events that occur during days with high wind gusts. The landfills and dry sand beaches along the Great Salt Lake, north of Magna, Utah, are the predominant sources of fugitive dust events.[4] Therefore, data on days with strong gusts from the north were also disregarded as a representative background value since the landfills and dry sand beaches along the Great Salt Lake would be a major contributor to the monitored background value. The identified value that fits all criteria would then be used as the representative PM_{10} background with the KUC mine life extension AERMOD modeling analysis.

The modeling would include emissions calculated for the proposed operations at the mine including haultruck traffic, conveyor transfer of ore, and dumping operations. Since many of these operations are currently conducted at the mine, the background value must not include current impacts from the mine in order to avoid double accounting for their contribution to ambient concentrations. Therefore, monitored values that include corresponding winds from the 90 degree sector upwind of the monitor location will be excluded from consideration as a representative background[5] value on the basis of condition (b) from the previous paragraph. Winds from this sector are defined as those between 180 degrees and 270 degrees, where zero degrees is defined as true north.

Wind roses for the top 10 highest PM_{10} monitored days are included in Appendix A-2. Table 2 summarizes the top 10 monitored PM_{10} concentrations and the percentage of hourly winds that blew southwest from the excluded sector during each monitored day.

Table 1 indicates the first ranked value was disregarded because of a missed collection period. Table 1 also indicates the second and third ranked values had high wind gusts (greater than 30 miles per hour) from the north. Table 2 demonstrates that the fourth through seventh highest values occurred on days with a significant percentage of winds from the southwest sector. Therefore, the top seven ranked values have been determined not representative of background for the KUC modeling analysis.

February 4, 2004, was the only day in the top 10 monitored values that did not have winds blowing from the southwest sector and/or did not have any major wind gusts from the north. Therefore, February 4, 2004, is most representative and 59.1 $\mu g/m^3$ is proposed as the 24-hour PM_{10} background concentration for the KUC modeling analysis. The proposed background concentration meets the criteria from 40 *Code of Federal Regulations* (CFR) 50 Appendix W and the Utah State Implementation Plan.

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[3] 40 CFR 51 Appendix W Section 8.2.1(a)

[4] *Utah State Implementation Plan. Section IX, Part A.* UDAQ, Air Quality Board, 2002

[5] 40 CFR 51 Appendix W Section 8.2.2(b)

TABLE 2
Kennecott Utah Copper Corporation Wind Conditions
Top 10 Concentrations

Rank	Date	Monitored Concentration [a]	Percentage of Winds From SW Sector [b]
1	05/18/2007	139.291	Suspect [c]
2	09/10/2005	93.941	16.7% from SW sector
3	07/21/2005	81.5	4.7% from SW sector
4	12/30/2003	77.768	29.2% from SW sector
5	07/15/2005	67.1	18.2% from SW sector
6	07/06/2005	66.9	21.7% from SW sector
7	10/27/2007	65.053	8.3% from SW sector
8	02/04/2004	59.136	0.0% from SW sector
9	03/03/2006	58.1	21.6% from SW sector
10	07/27/2005	57.4	10.0% from SW sector

NOTES:
SW= Southwest
[a] $\mu g/m^3$= Micrograms per Cubic Meter
[b] Defined as the sector between 180 degrees and 270 degrees from true north
[c] The maximum monitored value was labeled suspect since a collection period was missed. No wind data were required.

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