April 17, 2012

The following files are available for the EPRI Kincaid Run Data Set:

Informational Files

BullRunDiscussion.pdf: This file [39KB]

UA5600format.txt: Explains Upper Air 5600 format [1.9KB]

KB48andKB49_SF6Data_Format.txt: Original archive format for SF6 concentration data values. [3KB]

BullRun-SF6-SamplingSummary.txt: In the original investigations, the data was divided into two (2) data sets; one for model development and one for model evaluation. This file list in a table format the days included in Developmental and Evaluation data sets. [3KB]

Bull Run Suspect SF604162012.pdf: In developing the Kincaid data for distribution, I developed an objective scheme for assessing the quality of the sampling along the SF6 arcs. I used the same objective scheme for the Bull Run SF6 data. This file discusses the 43 cases where my assessment scheme determined the maximum SF6 concentration might be suspect. Upon reviewing, it is my opinion that 5 cases are suspect; 28 cases are OK; 5 cases will be difficult to replicate (likely non-steady transport), and 5 cases fail to provide a representative arc-max due to truncated sampling along the arc. [152KB]

Meteorological Data Files

BullRunNearSurfaceMetData04162012.txt: Hourly near-surface meteorological observations collected at the Bull Run plant site. [226KB]

BullRunTowerMetData04122012.txt: Hourly meteorological observations collected from the 100-m tower located near the Kincaid plant site. [285KB]

BullRun-KB-88(NWS-UA5600).txt: US National Weather Service Upper Air data in 5600 format. Data begin August 26, 1982 and end October 25, 1982. Upper air balloon was released from Nashville, TN. [114KB]

| | | NWS Hourly Surface Weather Data 1982 | Format | |
|---|---|---|---|---|
| Bristol.zip | TN | W13877.h82 | W13877.txt | [208KB] |
| Chattanooga.zip | TN | W13882.h82 | W13882.txt | [210KB] |
| Knoxsville.zip | TN | W13891.h82 | W13891.txt | [206KB] |
| Nashville.zip | TN | W13897.h82 | W13897.txt | [210KB] |
| Lexington.zip | KY | W93820.h82 | W93820.txt | [212KB] |
| Asheville.zip | NC | W03812.h82 | W03812.txt | [207KB] |

The hourly data for the stations listed above was obtained from:
http://www.epa.gov/ceampubl/tools/metdata/us_met.html
The meteorological data files available at this site contain measurements taken at 237 weather stations located throughout the United States for a period extending from 1961 to 1990. Exact collection dates vary by weather station. These data files are compatible with the EXAMS, PRZM, and EXPRESS systems distributed through the EPA Center for Exposure Assessment Modeling (CEAM).

SF6 Tracer Data Files

BullRunSF604112012.txt: Detailed listing of SF6 concentration values at each receptor along an arc. There were 12 receptor arcs, but not all were active during each hour of sampling. In this file, the data values are listed separately for each receptor arc that was active during each hour. Note, the receptors have been placed on arcs using an objective scheme that I developed when I was preparing the Kincaid data for distribution. [6.6MB]

BullRunSF6Max04112012.dat: A listing of the maximum SF6 concentration seen along each arc and the objective 'judgment' code of whether the maximum is likely well characterized by the sampling available. I have also included the QC index for the Development Data distributed in the Harmonization Model Validation Kit, but since I used a different scheme for assigning receptors to arcs, these QC index values are only useful for informational purposes. [223KB]

BullRunSF6-Arcs04112012.pdf: This file displays the SF6 concentration values in a fashion similar to that employed by the original investigators. Note, the receptors have been placed on arcs using an objective scheme that I developed when I was preparing the Kincaid data for distribution. [534KB]

BullRun-KB-48(SF6-Developmental).txt: SF6 data for the Developmental data set, in the original format of the Bull Run data archive. [1.05MB]

BullRun-KB-49(SF6-Evaluation).txt: SF6 data for the Evaluation data set, in the original format of the Bull Run data archive. [923KB]

BullRunCombinedSF6-48and 49.txt: A spliced together version of the SF6 data for the Developmental and Evaluation data sets, in the original format of the Bull Run data archive. [1.69MB]

SO2 Data Files

BullRunHourlySO204112012.txt: Listing of SO2 concentration values (PPB) at each receptor for each hour. There were a maximum of 20 receptors active for any 7-day period. The number of receptors and locations vary from 7-day period (168 hours) to the next. There were 10 7-day periods. [325KB]

BullRunSO2Format.txt: Description of format used to create data archive of hourly SO2 values (BullRunHourlySO204112012.txt). [4KB]

BullRunListSO2SourceDatao4172012.txt: I processed the data archive files available to me, in order to derive an SO2 emission rate, so that the hourly SO2 monitoring data might be used in model performance analyses. Unfortunately, I could only compute SO2 emission rates for the 480 period from Aug 1, 1982 through Aug 20, 1982. During this 480 hour period the maximum emission SO2 rate was 2786 g/s; the minimum SO2 emission rate was 1463 g/s, and the average SO2 emission rate was 2035 g/s.

Hour convention:
---
All hours refer to hour ending, local standard time (LST)

Site description:
---
The Bull Run steam plant is located 20km west of Knoxville, TN and 8km east of Oak Ridge, TN, on the east bank of the Melton Hill Lake. Water from the Milton Hill Lake is used to cool the 950 MW, coal-fired, one-unit plant(twin furnaces operate as a single unit to product steam). The plant consumes about 1800 tons of low-sulfur coal per day, delivered by rail from various mines in eastern Kentucky. The emission limit for the plant is four pounds of SO2 per million Btu; its emission rate is approximately 2.5kg/s. The Bull Run steam plant has electrostatic precipitators and no controls for sulfur dioxide emissions. Emissions are vented through a single 244m stack with an exit diameter of 9m. Stack emissions generally are not visible.

The Bull Run steam plant is located in the broad Tennessee River valley (about 60 km wide) that separates the Great Smoky Mountains, rising to over 1700 m (msl) to the east and southeast, and the Cumberland Plateau, rising to over 900 m to the northwest. Within the broad Tennessee River valley, a system of smaller parallel ridges and valleys, with breaks in between, runs northeast-southwest. These minor ridges rise 60 to 180 m above the local valleys. In the immediate vicinity of the plant, the ridges are approximately 100 m high, with a distance of about 1 or 2 km between ridge tops. Most of the region is covered by forests. It is also important to note that the Melton Hill Lake, a 1 km-wide tributary of the Tennessee River, cuts perpendicular across the ridges near the Bull Run steam plant, which uses the river water for cooling.

Construction of Data Archive
---
One of the original purposes of the Electric Power Research Institute (EPRI) field studies of tall stack transport and diffusion was to establish data sets that could be used for evaluation of atmospheric transport and diffusion model performance.

As part of this effort, the data collected at Bull Run was divided into two independent data sets so that the data used to evaluate an air quality transport and diffusion model would be independent of that used to develop a model. Half of the data set was used for a model development program sponsored by EPRI and was called the Developmental data set. The other half of the data set was used to evaluate the Hybrid Plume Dispersion Model (HPDM), Hanna and Paine (1989), and was called the Evaluation data set.

The Developmental and Evaluation data have been merged together in my release of this data archive.

Stack information:
---
Power Production: 950 Megawatt

Location:
UTM-E (km): 756.246
UTM-N (km): 3989.82
Lat. (deg): 36.0211 N
Long. (deg): 84.1564 W

Stack base elevation:
247 m

Stack height:
244 m

Stack inner diameter:
9 m

## Source Measurements

Source measurements were carried out in two places in the ductwork, near the outlet from the electrostatic precipitator. These locations were chosen as being most appropriate since there are no test ports in the stack. The position of the source monitors is indicated in the linked figure as the "outlet test plane". The parameters monitored were sulfur dioxide concentration, flue gas velocity and temperature, and oxygen concentration. At the end of each intensive, a series of manual tests was carried out to verify the data obtained by the monitoring instruments.

| Source Emissions Measurement Systems | | | |
|---|---|---|---|
| Variable | Measurement Locations | Frequency of Measurements | Equipment |
| SO2 | Stack ductwork – two locations | Continuous | Lear Siegler SM810 |
| O2 | Stack ductwork – two locations | Continuous | Lear Siegler CM50 |
| Temperature | Stack ductwork – two locations | Continuous | Lear Siegler SM800 |
| Velocity | Stack ductwork – two locations | Continuous | Averaging Pitot Tube |

## SF6 Tracer Monitoring Network

A network of approximately 1600 potential tracer sampling locations was used at the Bull Run site. The network design consisted of concentric circles at average radial distances of 0.5, 1, 2, 3, 5, 7, 10, 15, 20, 30, 40, and 50 km from the power plant. Using the existing roadway network, the downwind distance of the samplers assigned to an arc varied; the target accuracy was 1% of the distance from the power plant stack, or 50 meters, whichever was smaller.

Tracer tests generally lasted six to nine hours. During this period, SF6 tracer gas was injected continuously into the ductwork of the stack. During each test approximately 200 sampling sites located on five to seven of the arcs in a sector ranging from 90° to 180° of arc, were operating. The sampling array was chosen on the basis of the expected meteorological conditions and remained fixed during any given test period.

SF6 tracer data are available for:
August 28, 1982 through October 16, 1982.

SUMMARY OF SF6 SAMPLING

SF6 DEVELOPMENTAL DATA SET
NUMBER OF DAYS: 20 NUMBER OF HOURS: 165

```
       Key1..............Key24
       ------------------------
                111111111122222
MMDDYY 123456789012345678901234  NUM   YYJJJ
080282 000000000011111111100000  186   82214
080582 000000000111000000000000  188   82217
080682 000000000011111111100000  207   82218
080782 000000000011111111100000  205   82219
081382 000111111111000000000000  213   82225
081482 000000000111111111000000  193   82226
```

```
081682 000000000011111111100000  201   82228
081882 000000000011111111100000  211   82230
082182 000000000000000111111111  223   82233
092282 000000000011111111100000  183   82265
092482 000000000000000111111111  198   82267
092882 000111100000000000000000  184   82271
093082 000000000011111111100000  205   82273
100282 000000000000111110000000  197   82275
100482 000011111111100000000000  205   82277
100582 000000000000111111110000  209   82278
100682 000000000000000111111111  202   82279
101082 000000000011111111100000  198   82283
101582 000000000000111111110000  197   82288
101882 000011111111100000000000  196   82291
```

```
  SF6 EVALUATION DATA SET
  NUMBER OF DAYS:  18  NUMBER OF HOURS:  162

       Key1..............Key24
       ------------------------
                111111111122222
MMDDYY 123456789012345678901234  NUM   YYJJJ
072882 000000000011111111100000  150   82209
073082 000000000011111111100000  187   82211
080182 000000000011111111100000  176   82213
080382 000000000000111111110000  190   82215
080882 000000000011111111100000  197   82220
081082 000111111111000000000000  190   82222
081582 000000000011111111100000  205   82227
082082 000000000011111111100000  212   82232
082382 000000000011111111100000  214   82235
082482 000000000011111111100000  212   82236
092382 000000000011111111100000  192   82266
092682 000000000011111111100000  192   82269
100182 000000000000111111110000  198   82274
100382 000111111111000000000000  201   82276
100982 000000000000111111110000  207   82282
101182 000000000000000111111111  207   82284
101382 000011111111100000000000  189   82286
101682 000000000011111111100000  196   82289
```

```
 MM = MONTH
 DD = DAY OF MONTH
 YY = YEAR
 KEY1..KEY24: 0=NO SAMPLING THIS HOUR
              1=SAMPLING OCCURRED THIS HOUR
 NUM = NUMBER OF RECEPTORS
 JJJ = JULIAN DAY NUMBER
```

SF6 Quality Codes
---

Harmonization QC Index

In 1991, a European initiative was launched for increased cooperation and standardization of atmospheric dispersion models for regulatory purposes. Conferences are held approximately every 18 months. As part of this initiative a Model Validation Kit was developed starting in 1993. Currently, the kit contains four field data sets as well as software for model evaluation.

In developing this kit, it was decided to only report the maximum SF6 concentration value seen along each sampling arc. For the Bull Run SF6 tracer results, subjective Quality Codes (QC) were assigned for both the

Developmental and Evaluation data sets to each maximum SF6 concentration as to how confident they were that a true maximum was seen.

Using the same logic as was applied to the Kincaid Developmental data set, QC codes were developed for Bull Run for both the Developmental and Evaluation data sets.

Note: my objective placement of receptors along arcs differs in some cases with the subjective placement used in defining arcs by Dr. Steve Hanna and Dr. Joseph Chang, hence, I do not recommend use of these QC index values.

0 This observed maximum concentration should clearly be disregarded.
1 This observed maximum concentration is most probably not the maximum value.
2 An observed maximum concentration is identified, but the true value may be slightly different.
3 A relatively well-defined maximum concentration is observed.

Judgment QC Code

Objective quality (judgment) code John Irwin developed for this listing of the entire set of SF6 concentrations sampled during the EPRI Bull Run field study, where objective criteria were used to place receptors along arcs. For discussion of -2 and -3 Arc-max values, see, 'Logic Behind Kincaid SF6-Arcs.pdf', and 'Bull Run Suspect SF6 Arc-Max Values.pdf'.

0 Number of nonzero concentration values is two (2) or less.
1 Number of nonzero concentration values is three (3) to four (4), deemed too few to use.
2 At least five nonzero concentration values, but observed maximum is not in the middle portion of the sampling array along the arc.
3 At least five nonzero concentration values, and observed maximum is within the middle portion of the sampling array along the arc.
-2 Meets criteria listed for "2", but difference between nearby concentration values and observed maximum looks suspicious.
-3 Meets criteria listed for "3", but difference between nearby concentration values and observed maximum looks suspicious.

Meteorological Measurements:
---

The meteorological measurements were collected from (1) a 122-m TVA tower (base elevation 317 m), located near the crest of a 70 m ridge about 1.8 km west of the stack, (2) the central observing station (base elevation 248 m), located at about the same elevation as the stack base in a field near the river about 5.3 km northwest of the stack, (3) one acoustic sounder (base elevation 259 m) about 1 km east of the stack, (4) various National Weather Service (NWS) stations. The attached map shows the locations of the TVA tower, central observing station (labeled as Micro-Met), and stack.

The above data represent only a portion of the total data collected during the Bull Run field experiments. Refer to "Catalog of Data for the EPRI Plume Model Validation and Development Data Base: Moderately Complex Terrain Site," 1985, EPRI EA-3762, Electric Power Research Institute, 3412 Hillview Avenue, Palo Alto, California, 94304, for a detailed description of the measurement program.

| Location | Measurement Height | Frequency | Equipment |
|---|---|---|---|
| 122-m Tower | | | |
| Wind Direction | 10, 30, 50, 100 m | 10-sec | Teledyne Geotech 15658 |
| Wind Speed | 10, 30, 50, 100 m | 10-sec | Teledyne Geotech 15648 |
| Temperature | 10, 50, 100 m | 10-sec | Teledyne Geotech T-200 |
| Dewpoint | 100 m | 10-sec | Teledyne Geotech DP-200 |
| Micro-Met Tower | 10 m | | |
| Temperature Diff | 2-10 m | 10-sec | Teledyne Geotech T-200 |
| Temperature | 1 m | 10-sec | Teledyne Geotech T-200 |
| Central Station | | | |
| Atmos. Pressure | 1 m | Hourly | Teledyne Geotech 5P-200 |
| Net Radiation | 1 m | 10-sec | Science Associates 622-1 |
| Solar Radiation | 1 m | 10-sec | Eppley NIP |
| Sky Radiation | 1 m | 10-sec | Eppley 8-48 |
| Acoustic Sounder | | | |
| Mixing Height | 1 m | 15-min | Acoustic Sounder |

NWS METEOROLOGICAL STATIONS
When the Bull Run SF6 data were first analyzed, only the Nashville, TN and Knoxville, TN station observations were used. In constructing this data archive it was decided to provide observations from several other NWS stations that are in the vicinity of the Bull Run site.

The data provided here was obtained from
http://www.epa.gov/ceampubl/tools/metdata/index.html
The data represents a unique blending from four sources.
#1. Solar and Meteorological Surface Observation Network (SAMSON) 1961-1990 data sets, Version 1.0, Sep 1993
#2. National Solar Radiation Data base (NSRDB) version 1.1; NSRDB Hourly Data Files Text files downloaded from http://rredc.nrel.gov/solar/old_data/nsrdb/ -- provided updated radiation parameters.
#3. EarthInfo NCDC Summary of the Day and Surface Airways, 2001 -- provided daily and hourly values for precipitation, and daily evaporation. Missing evaporation was calculated using the Kohler-Nordenson-Fox Class-A Evaporation Pan version of the Penman-Monteith equations.
#4. Evapotranspiration (Et0) formulae based on: Crop Evapotranspiration - Guidelines for Computing Crop water requirements. FAO Irrigation and Drainage Paper 56 by Richard G. Allen, Luis S. Pereira, Dirk Raes, and Martin Smith. Water Resources, Development and Management Service, FAO -Food and Agriculture Organization of the United Nations, Rome, 1998. ISBN 92-5-104219-5. This book may be found online at http://www.fao.org/docrep/X0490E/x0490e00.htm

| NWS Station | Latitude | Longitude | Elevation MSL (m) | Approximate Distance From Stack (km) |
|---|---|---|---|---|
| Bristol, TN | 36.84 N | 82.40 W | 465 | 168 |
| Chattanooga, TN | 35.03 N | 85.20 W | 211 | 145 |
| Knoxville, TN | 35.82 N | 83.98 W | 268 | 28 |
| Nashville, TN | 36.12 N | 86.68 W | 180 | 230 |
| Lexington, KY | 38.03 N | 84.60 W | 294 | 227 |
| Ashville, NC | 35.43 N | 82.55 W | 160 | 160 |

NWS RADIOSONDE
The radiosonde data comes from the station in Nashville, TN
36.20N 86.567W 180m
Thus, the radiosonde station is approximately 230 km west of the source.

Site characteristics used in the 1987/88 HPDM project:
---

The values of Monin-Obukhov length, friction velocity and mixing height are provided for information purposes. It is suggested that one might do better to compute new values using currently accepted practices.

The procedure used to estimate values for the Monin-Obukhov length, surface friction velocity and mixing height are described in Hanna and Paine (1989). Estimates were made for 'average moisture conditions' and 'dry conditions'. The monthly values for surface roughness length, albedo and Bowen ratio used in these computations are listed below.

Average Moisture Conditions

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 30 - 80 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.30 | 0.30 | 0.61 | 0.61 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.50 | 0.50 | 0.50 |
| 0.54 | 0.54 | 0.13 | 0.13 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.14 | 0.14 | 0.14 |
| 1.80 | 1.80 | 0.54 | 0.54 | 0.38 | 0.38 | 0.38 | 0.38 | 1.10 | 1.10 | 0.88 | 0.88 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 81 - 160 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.38 | 0.38 | 0.56 | 0.56 | 0.74 | 0.74 | 0.74 | 0.74 | 0.74 | 0.50 | 0.50 | 0.50 |
| 0.50 | 0.50 | 0.13 | 0.13 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| 1.68 | 1.68 | 0.57 | 0.57 | 0.71 | 0.71 | 0.71 | 0.71 | 1.96 | 1.96 | 1.04 | 1.04 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 161 - 215 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.18 | 0.18 | 0.37 | 0.37 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.31 | 0.31 | 0.31 |
| 0.53 | 0.53 | 0.13 | 0.13 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| 1.68 | 1.68 | 0.42 | 0.42 | 0.39 | 0.39 | 0.39 | 0.39 | 1.46 | 1.46 | 0.75 | 0.75 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 216 - 240 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.20 | 0.20 | 0.41 | 0.41 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | 0.34 | 0.34 | 0.34 |
| 0.46 | 0.46 | 0.13 | 0.13 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | 0.15 |
| 1.70 | 1.70 | 0.41 | 0.41 | 0.32 | 0.32 | 0.32 | 0.32 | 1.13 | 1.13 | 0.67 | 0.67 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 241 - 310 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.45 | 0.45 | 0.71 | 0.71 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.61 | 0.61 | 0.61 |
| 0.46 | 0.46 | 0.13 | 0.13 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | 0.15 |
| 1.75 | 1.75 | 0.62 | 0.62 | 0.66 | 0.66 | 0.66 | 0.66 | 1.71 | 1.71 | 1.05 | 1.05 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 311 - 29 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.35 | 0.35 | 0.51 | 0.51 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.44 | 0.44 | 0.44 |
| 0.50 | 0.50 | 0.13 | 0.13 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| 1.70 | 1.70 | 0.51 | 0.51 | 0.53 | 0.53 | 0.53 | 0.53 | 1.61 | 1.61 | 0.89 | 0.89 |

Dry Conditions

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 30 - 80 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.30 | 0.30 | 0.61 | 0.61 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.50 | 0.50 | 0.50 |
| 0.54 | 0.54 | 0.13 | 0.13 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.14 | 0.14 | 0.14 |
| 1.80 | 1.80 | 0.54 | 0.54 | 0.38 | 0.38 | 1.40 | 1.40 | 2.05 | 2.05 | 0.88 | 0.88 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 81 - 160 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.38 | 0.38 | 0.56 | 0.56 | 0.74 | 0.74 | 0.74 | 0.74 | 0.74 | 0.50 | 0.50 | 0.50 |
| 0.50 | 0.50 | 0.13 | 0.13 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| 1.68 | 1.68 | 0.57 | 0.57 | 0.71 | 0.71 | 1.54 | 1.54 | 2.93 | 2.93 | 1.04 | 1.04 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 161 - 215 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.18 | 0.18 | 0.37 | 0.37 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.31 | 0.31 | 0.31 |
| 0.53 | 0.53 | 0.13 | 0.13 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| 1.68 | 1.68 | 0.42 | 0.42 | 0.39 | 0.39 | 1.46 | 1.46 | 2.73 | 2.73 | 0.75 | 0.75 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 216 - 240 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.20 | 0.20 | 0.41 | 0.41 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | 0.34 | 0.34 | 0.34 |
| 0.46 | 0.46 | 0.13 | 0.13 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | 0.15 |
| 1.70 | 1.70 | 0.41 | 0.41 | 0.32 | 0.32 | 1.15 | 1.15 | 2.03 | 2.03 | 0.67 | 0.67 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 241 - 310 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.45 | 0.45 | 0.71 | 0.71 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.61 | 0.61 | 0.61 |
| 0.46 | 0.46 | 0.13 | 0.13 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | 0.15 |
| 1.75 | 1.75 | 0.62 | 0.62 | 0.66 | 0.66 | 1.31 | 1.31 | 2.36 | 2.36 | 1.05 | 1.05 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 311 - 29 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.35 | 0.35 | 0.51 | 0.51 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.44 | 0.44 | 0.44 |
| 0.50 | 0.50 | 0.13 | 0.13 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| 1.70 | 1.70 | 0.51 | 0.51 | 0.53 | 0.53 | 1.41 | 1.41 | 2.61 | 2.61 | 0.89 | 0.89 |

References

Hanna, S.R., and Paine, R.J., (1989): Hybrid plume dispersion model (HPDM) development and evaluation. J. Of Applied Meteorology. (28):206-224.

Hudischewskyj, A.B., and Reynolds, S.D., (1985): Catalog of Data for the EPRI Plume Model Validation and Development Data Base: Moderately Complex Terrain Site. Prepared for the Electric Power Research Institute Environmental Physics and Chemistry Program, Energy Analysis and Environment Division, EA-3762, Research Project 1616-9.