# ***Revised Responses to TR RAIs Dated May 28, 2010***

## ***Meteorology***

***TR RAI 2.5-1***

***Regulatory Guide 3.63 recommends comparing a concurrent period of meteorological data from a National Weather Service (NWS) station with the long-term meteorological data from that NWS station. The NWS station selected for this comparison should be in a similar geographical and topographical location and be reasonably close (preferably within 50 miles) to the site. Regarding the long-term representativeness of the data collected onsite, please address the following issues.***

***TR RAI 2.5-1(a)***

*a.* ***In Section 2.5 of the Technical Report (TR), the applicant compared weather data from the NWS site at Chadron, Nebraska. Consistent with Regulatory Guides 3.63, 3.46 and NUREG-1569, Acceptance Criterion 2.5.3(3), explain why the applicant chose the NWS site at Chadron, Nebraska, over other potential NWS sites as a representative location for the purpose of comparing meteorological data.***

**TR RAI 2.5-1(a) Response**

In accordance with Regulatory Guide 3.63 and NUREG-1569, Acceptance Criterion 2.5.3(3), Powertech re-evaluated the analysis in TR Section 2.5 regarding the long-term representativeness of the meteorological data. Powertech determined that a Newcastle, Wyoming meteorological station provides a better comparison to the Dewey-Burdock project area than the Chadron NWS station previously evaluated. The following provides justification for the Newcastle station as a representative location for the purpose of comparing meteorological data and will be incorporated into Section 2.5 of the revised TR.

IML Air Science (IML), in Sheridan, Wyoming, operates a meteorological station in Newcastle, Wyoming, which has generated more than nine years (2002 to present) of hourly meteorological data. Newcastle is approximately 30 miles north-northwest of the Dewey-Burdock project area and provides a better comparison to the project area than the Chadron NWS site in terms of elevation, surrounding topography and proximity to the southwestern flank of the Black Hills.

The meteorological station at Newcastle is used to supplement the ambient air quality compliance demonstration. The station meets the requirements of Ambient Air Monitoring Guidelines for the Prevention of Significant Deterioration (EPA, 1987). Table TR RAI 2.5-1a-1 identifies the instruments and associated specifications at this station.

The specifications in Table TR RAI 2.5-1a-1 meet or exceed the requirements set forth in Regulatory Guide 3.63, Section C3. All instruments are audited for accuracy on a semiannual basis. Representative audit reports, spanning the baseline monitoring period for the Dewey-Burdock Project, are attached to this RAI response package as Appendix 2.5-D. Data recovery for all parameters at the Newcastle meteorological station exceeded 96% for both long-term (2002 through 2010) and concurrent-year (7/18/2007 to 7/17/2008) periods.

**Table TR RAI 2.5-1a-1: Newcastle MET Station Equipment List**

| Parameter | Instrument | Range | Accuracy | Threshold | Instrument Height |
|---|---|---|---|---|---|
| Wind Speed | RM Young 05305 Wind Monitor AQ | 0 to 112 mph | ±0.4 mph or 1% of reading | 0.9 mph | 10 meters |
| Wind Direction | RM Young 05305 Wind Monitor AQ | 0 to 360º | ±3º | 1.0 mph | 10 meters |
| Temperature | Fenwal Electronics 107 Temperature Probe | -25º to 50º C | ±0.2º C @ 0 - 60º C, ±0.4º C @ -35º C | -- | 2 meters |
| Precipitation | Met One Tipping Bucket | 0 to 12 inches | ±0.5% @ 0.5 in/hr rate | 0.01 inch | 1 meter |
| Barometric Pressure | Campbell Scientific - 105 | 600 – 1060 millibar | ±0.5 mb @ 20º C | -- | 2 meters |
| Relative Humidity | CS 500-L Temp/RH probe | 0 – 100% -40º to 60ºC | ±3% RH 10% to 90% | -- | 2 meters |
| Data Logger | CS CR510 | -- | -- | -- | -- |

Source: IML, 2011

***TR RAI 2.5-1***

***Regulatory Guide 3.63 recommends comparing a concurrent period of meteorological data from a National Weather Service (NWS) station with the long-term meteorological data from that NWS station. The NWS station selected for this comparison should be in a similar geographical and topographical location and be reasonably close (preferably within 50 miles) to the site. Regarding the long-term representativeness of the data collected onsite, please address the following issues.***

***TR RAI 2.5-1(b)***

***b. On page 2-58 of the TR, the applicant states that the years 1978-2007 were used for comparison of the NWS site data. On page 2-59 of the TR, the applicant states that January 1, 1978 to July 17, 2008 were used for long-term meteorological comparison. Please clarify what years were used for determining long-term representativeness of meteorological conditions.***

**TR RAI 2.5-1(b) Response**

The TR incorrectly identified the dates for the long-term meteorological comparison. The on-site meteorological station at the Dewey-Burdock project area was operated continuously from July 18, 2007 to July 17, 2008. As stated in the response to TR RAI 2.5-1(a), the Newcastle meteorological station, operated by IML, was used to evaluate the long-term representativeness of the data collected at the project area. The following information will be incorporated into Section 2.5 of the revised TR.

To determine whether the period of data collection (July 18, 2007 to July 17, 2008) was representative of long-term meteorological conditions, weather data from the Newcastle meteorological station for the same period was compared to data collected at the Newcastle site over the long term (2002 through 2010).

Table TR RAI 2.5-1b-1 summarizes the one-year and nine-year averages for Newcastle alongside the one-year average at the Dewey-Burdock project area. This table shows that average wind speeds and fluctuations in wind direction (sigma theta) at Newcastle were comparable for the two periods of record. Wind speeds averaged slightly higher at the Dewey-Burdock project area, with temperatures slightly lower and relative humidity slightly higher (a consequence of the lower temperatures). The similarities drawn between the two sites are not intended to imply equivalence. Rather, they are meant to suggest that the prominent meteorological forces affecting regional weather patterns exert themselves at both sites. If this case can be made, then year-to-year variations at one site may imply parallel, temporal variations at the other site.

**Table TR RAI 2.5-1b-1: Regional (Newcastle) vs. On-Site Meteorology**

| Parameter | Newcastle 9-Year Average | Newcastle 1-Year Average | Dewey-Burdock 1-Year Average |
|---|---|---|---|
| Wind Speed (mph) | 6.8 | 7 | 8.7 |
| Sigma Theta (º) | 19.3 | 19.6 | 18.7 |
| Temperature (ºF) | 47 | 51.9 | 45.5 |
| Relative Humidity (%) | 58.1 | 55.3 | 60.9 |

***<u>TR RAI 2.5-1</u>***

***Regulatory Guide 3.63 recommends comparing a concurrent period of meteorological data from a National Weather Service (NWS) station with the long-term meteorological data from that NWS station. The NWS station selected for this comparison should be in a similar geographical and topographical location and be reasonably close (preferably within 50 miles) to the site. Regarding the long-term representativeness of the data collected onsite, please address the following issues.***

***<u>TR RAI 2.5-1(c)</u>***

c. ***NRC staff notes that the applicant has provided an analysis of meteorological data from the NWS site in Chadron for temperature and wind speed, but not wind direction. Consistent with Regulatory Guides 3.63, 3.46 and NUREG-1569, Acceptance Criterion 2.5.3(3), demonstrate that the wind direction data obtained onsite are representative of the long-term meteorological conditions in the site vicinity.***

**<u>TR RAI 2.5-1(c) Response</u>**

As described in the response to TR RAI 2.5-1(a), Powertech determined that the Newcastle meteorological station is more representative of the project area than the Chadron NWS site. Although the Chadron NWS site represents the closest NWS station with hourly wind data, it was eliminated from consideration since it is more than 60 miles from the project area and the wind patterns are substantially different (refer to Figure TR RAI 2.5-1c-8, which shows comparative wind roses for the Newcastle, Dewey-Burdock, and Chadron weather stations. Instead, the Newcastle meteorological station was chosen due to its proximity (approximately 30 miles away) and similar elevation, surrounding topography and proximity to the southwestern flank of the Black Hills. The meteorological instruments at Newcastle meet or exceed both NWS and NRC standards (refer to Table TR RAI 2.5-1a-1 in the response to TR RAI 2.5-1(a)).

For demonstrating that baseline monitoring is representative of long-term conditions, particular emphasis is placed on wind speed, wind direction and atmospheric stability, as these parameters impact MILDOS-AREA modeling as well as air quality monitoring locations. While the Newcastle meteorological station is not strictly representative of the Dewey-Burdock project area, it is sufficiently close in distance and geography to infer the regional relationship between the baseline monitoring period (7/18/2007 to 7/17/2008) and long-term conditions. The following describes how the baseline monitoring period is representative of long-term meteorological conditions in the region. This discussion will be incorporated into Section 2.5 of the revised TR.

Figure TR RAI 2.5-1c-1 shows wind roses at the Newcastle station for the nine full years of monitoring and for the one year corresponding to the Dewey-Burdock baseline monitoring period. Figure TR RAI 2.5-1c-2 presents a graphical comparison of short and long-term wind direction distributions. Both figures demonstrate qualitatively that the period from 7/18/2007 to 7/17/2008 is representative of the longer term.

The long-term representativeness can be demonstrated quantitatively by isolating wind speed and wind direction variables to correlate short-term and long-term frequency distributions. IML Air Science has developed a statistical methodology for assessing the degree to which the distributions of wind speed class and wind direction frequencies from one year of monitoring at a particular location represent the long-term distributions at that same location (Appendix 2.5-E).

For the joint frequency wind distribution used in the MILDOS-AREA model, wind speeds are divided into six classifications ranging from mild (0 – 3 mph) to strong (> 24 mph). Likewise, wind directions are divided into 16 categories corresponding to the compass directions illustrated in Figure TR RAI 2.5-1c-2.

The percent of the time that winds occur in each of the six wind speed categories can be calculated to produce a wind speed frequency distribution. The percent of the time that winds blow from each of the 16 directions can be calculated to produce a wind direction frequency distribution. For each parameter, the one-year and nine-year distributions can then be compared. Linear regression analysis provides a useful tool to assess the degree of correlation between short and long-term distributions.

Figure TR RAI 2.5-1c-3 presents the correlation for the wind speed distributions at Newcastle. Each point represents one of the six wind speed classes. The x-coordinate corresponds to the percent of the one-year period during which the wind speed fell in a given class, while the y-coordinate corresponds to the percent of the nine-year period during which the wind speed fell in that same class.

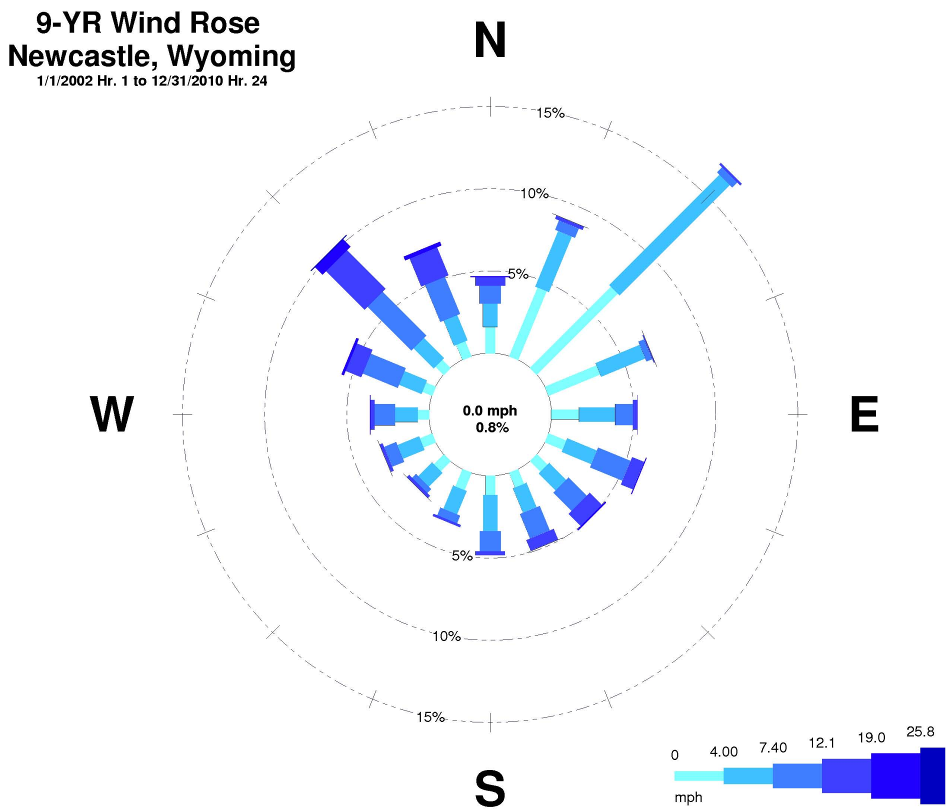
The regression line (red) in Figure TR RAI 2.5-1c-3 represents the least-squares fit to the six data points. The corresponding $R^2$ value of 0.994 implies very strong linear correlation. The linear slope of 0.98 further implies that short and long-term wind speed frequencies are substantially equivalent.

A similar analysis can be performed for wind direction frequencies. Figure TR RAI 2.5-1c-4 presents this correlation at Newcastle. Each point represents one of the 16 wind direction categories. The x-coordinate corresponds to the percent of the one-year period during which the wind blew from a given direction, while the y-coordinate corresponds to the percent of the nine-year period during which the wind blew from that same direction.

The regression line (red) in Figure TR RAI 2.5-1c-4 represents the least-squares fit to the 16 data points. The corresponding $R^2$ value of 0.954 implies very strong linear correlation. The linear slope of 0.78 further implies that short and long-term wind direction frequencies are similar.

Figures TR RAI 2.5-1c-1 through TR RAI 2.5-1c-4 offer conclusive evidence that the 2007-2008 baseline monitoring year adequately represents the last nine years at Newcastle. Since the one-year wind data serve as reliable predictors of the long-term wind conditions at Newcastle, and since the Dewey-Burdock project area experiences similar regional weather patterns, it is concluded that the one-year baseline monitoring represents long-term meteorological conditions at the Dewey-Burdock project area.

**Figure TR RAI 2.5-1c-1: Newcastle 9-Year and 1-Year Wind Roses**



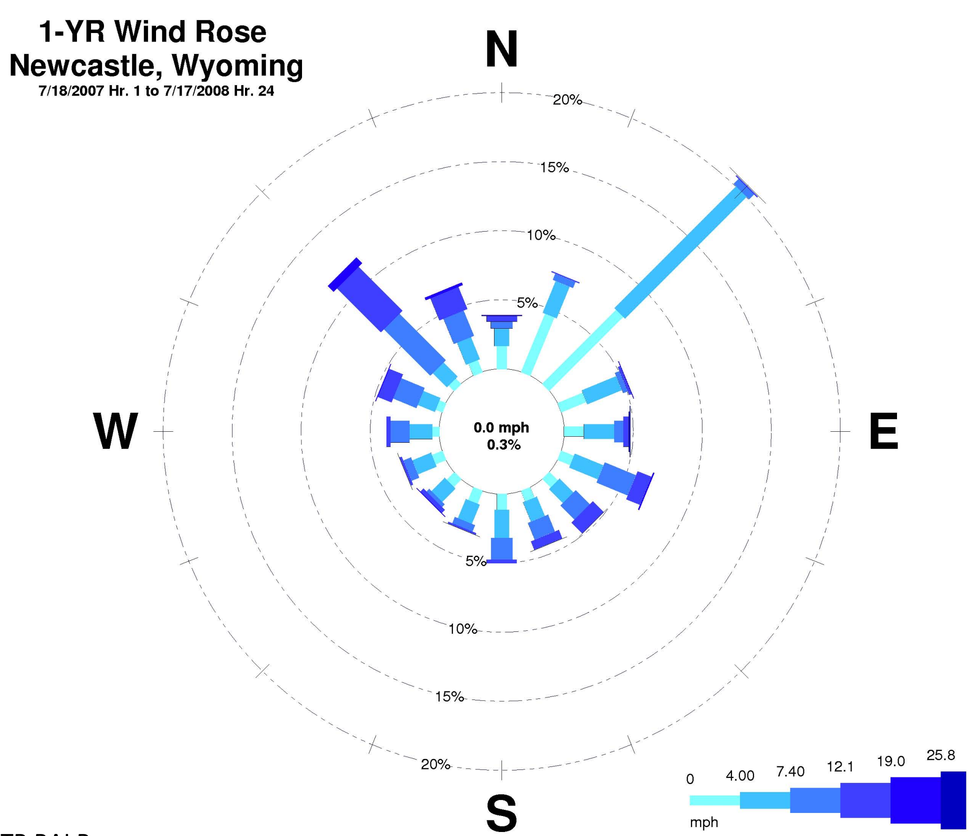
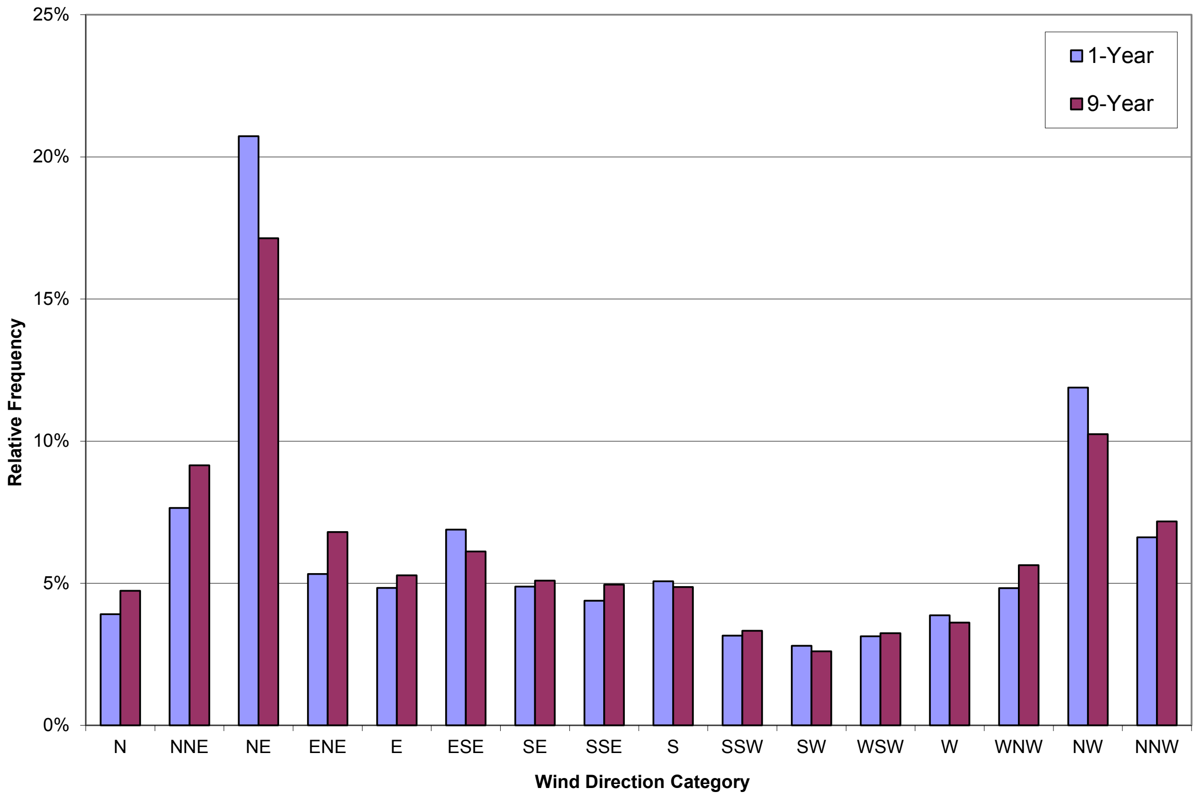



**Figure TR RAI 2.5-1c-2: Newcastle Short vs. Long-Term Wind Direction Distribution**




This same methodology can be used to determine whether or not Newcastle weather data are strictly representative of the Dewey-Burdock project area. Figure TR RAI 2.5-1c-5 compares the wind direction distributions for the baseline monitoring year at the two sites.

With an $R^2$ of 0.052, Figure TR RAI 2.5-1c-5 indicates little or no correlation of wind direction frequencies between the two sites. This result is heavily influenced by what appears to be an outlier. The NE sector constitutes 3.5% of the winds at Dewey-Burdock and 20.7% of the winds at Newcastle. This difference may stem from local topographic effects. Newcastle is situated in a “bowl” at the base of the Black Hills, and is subject to mild convection winds that tend to blow down the mountain from evening to early morning hours. This common phenomenon is related to differential air temperatures that cycle diurnally, with the cooler mountain air sinking to the adjoining valleys at night. Figure 2.5-1c-6 shows the long-term wind rose for Newcastle for daytime hours only (9:00 a.m. to 5:00 p.m.). During these hours the NE component is substantially diminished relative to Figure TR RAI 2.5-1c-1, presumably due to the absence of down-slope convection breezes. It is reasonable to assume that the Dewey-Burdock project area, situated several miles farther from the mountains than Newcastle, would not experience the same degree of diurnal convection breezes

**Figure TR RAI 2.5-1c-3: Newcastle Wind Speed Correlation**

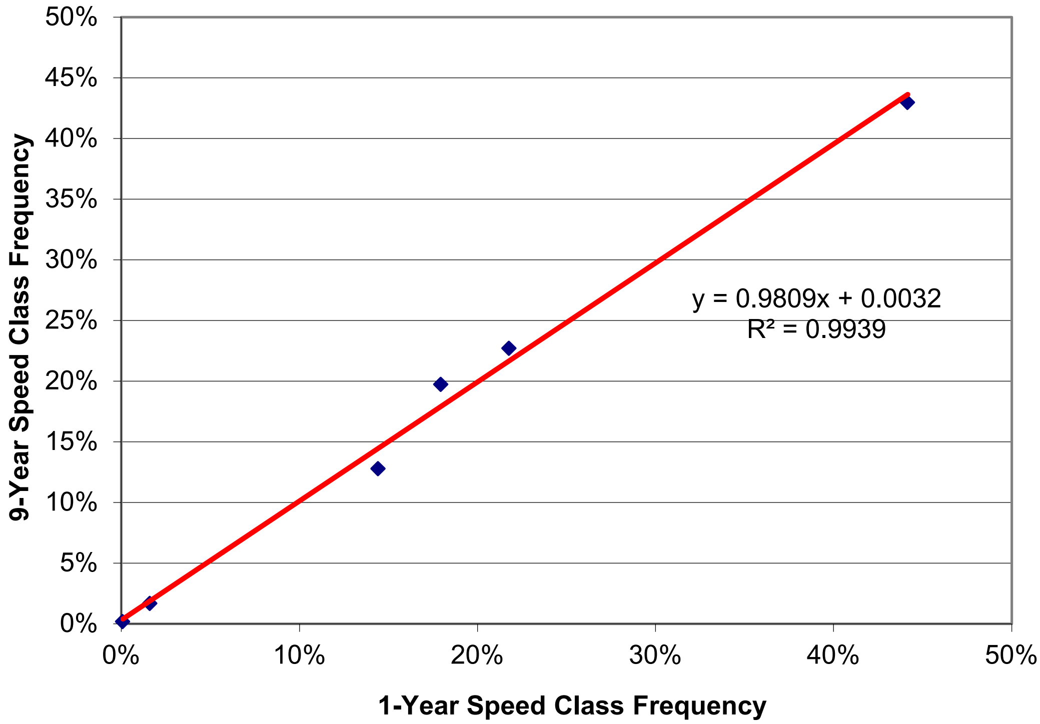



**Figure TR RAI 2.5-1c-4: Newcastle Wind Direction Correlation**

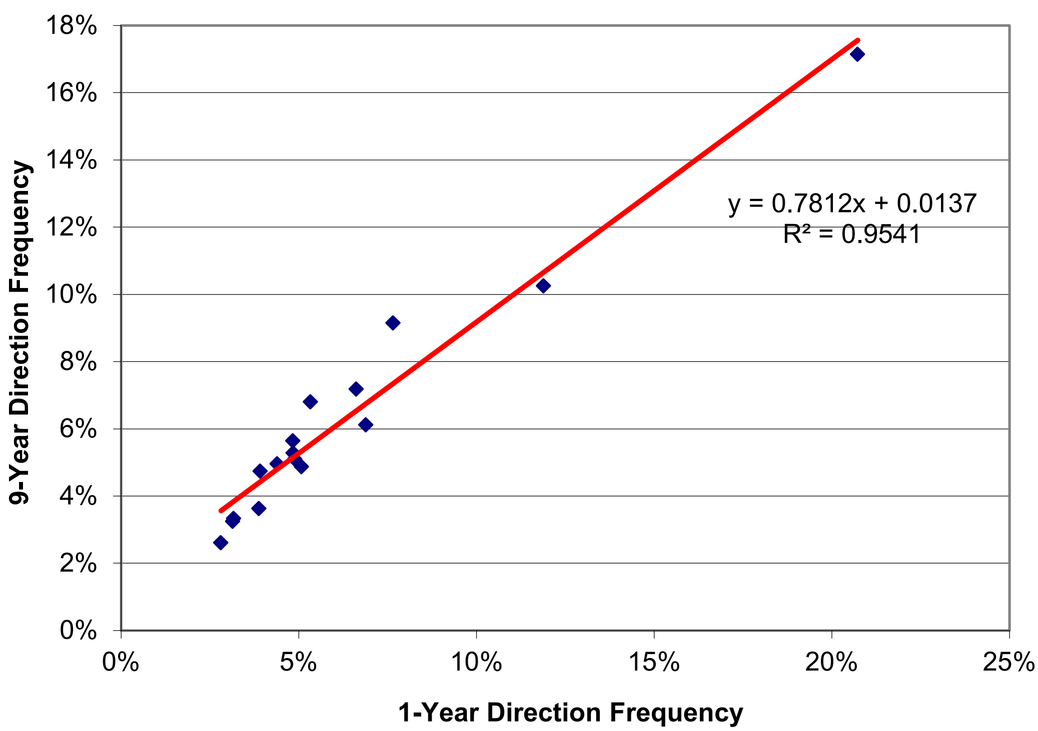
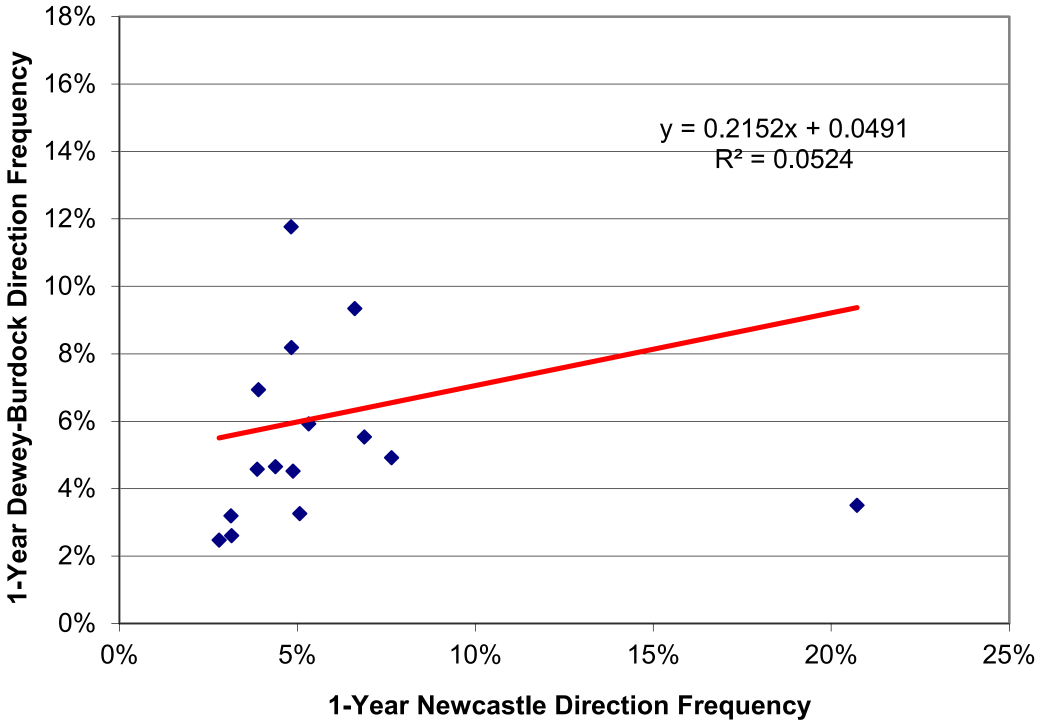


**Figure TR RAI 2.5-1c-5: 1-Year Newcastle vs. Dewey-Burdock Wind Direction**




If the NE component is removed from each frequency distribution, a mild correlation between the two sites emerges. Figure TR RAI 2.5-1c-7 presents the same regression analysis as Figure TR RAI 2.5-1c-5, except with the NE outlier removed. While the much higher $R^2$ value of 0.60 still suggests no more than a weak correlation, it supports the premise that both sites are influenced by similar regional weather patterns. Appendix 2.5-E of this document presents the results of another study showing that in northeastern Wyoming, spatial variations in wind patterns (attributable to local topography) far exceed temporal variations (attributable to synoptic weather systems from year to year). Hence, the conclusion that using the baseline year to represent long-term conditions is valid at either the Newcastle or the Dewey-Burdock project area, but not between the two sites.

Figure TR RAI 2.5-1c-8 compares the baseline year wind roses from Newcastle, Dewey-Burdock, and Chadron. With the exception of the NE component discussed above, the Newcastle wind rose resembles that of Dewey-Burdock. On the other hand, the Chadron wind rose reflects an entirely different wind regime. The meteorological differences between Chadron and these other two sites may be attributed to the much greater distance from Chadron to the Black Hills, its lower elevation (3,280 ft), and the increased influence of Great Plains weather patterns.

**Figure TR RAI 2.5-1c-6: Daytime Wind Rose at the Newcastle Station**

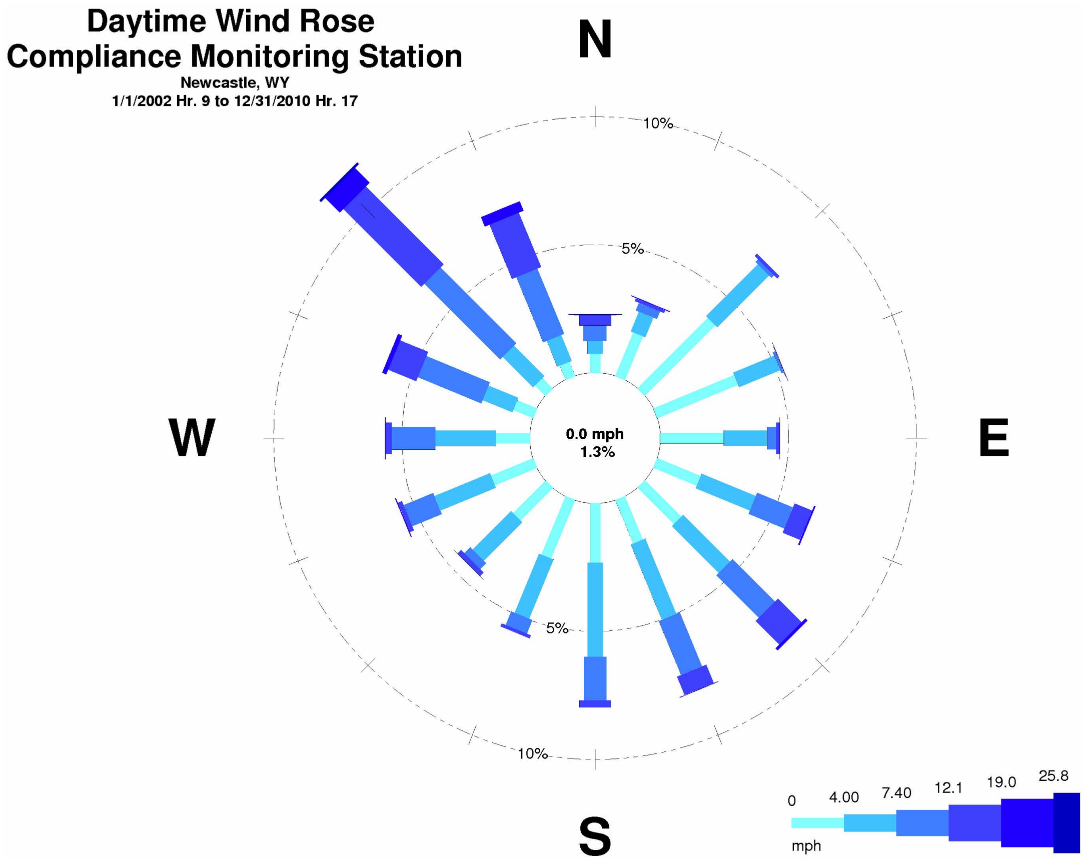
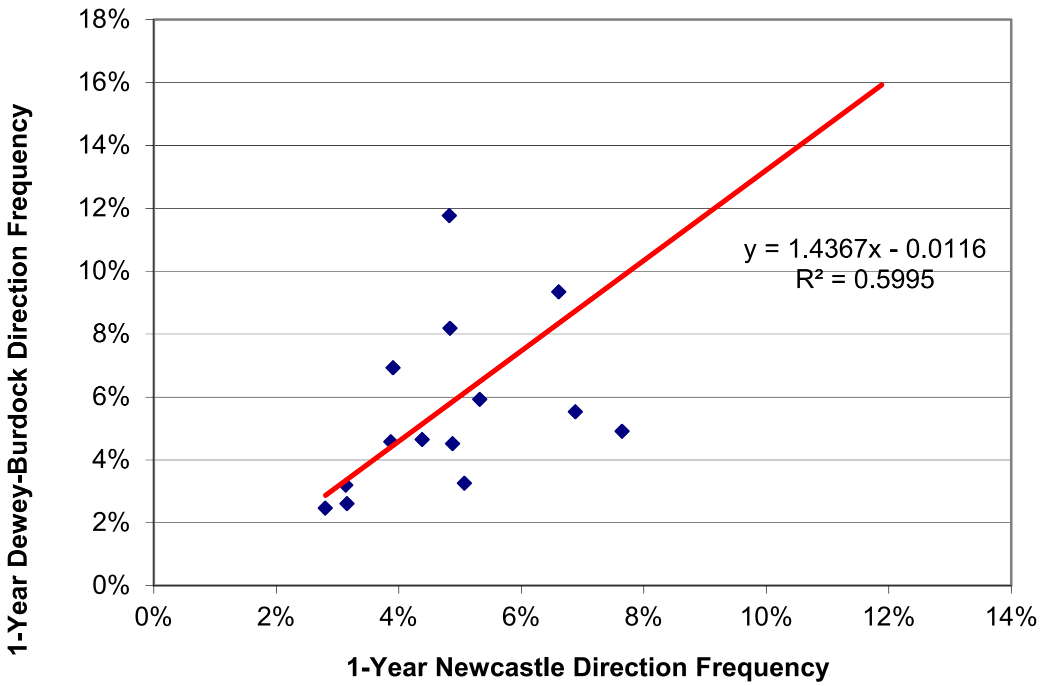



**Figure TR RAI 2.5-1c-7: Adjusted 1-Year Newcastle vs. Dewey-Burdock Wind Direction – Without NE Outlier**



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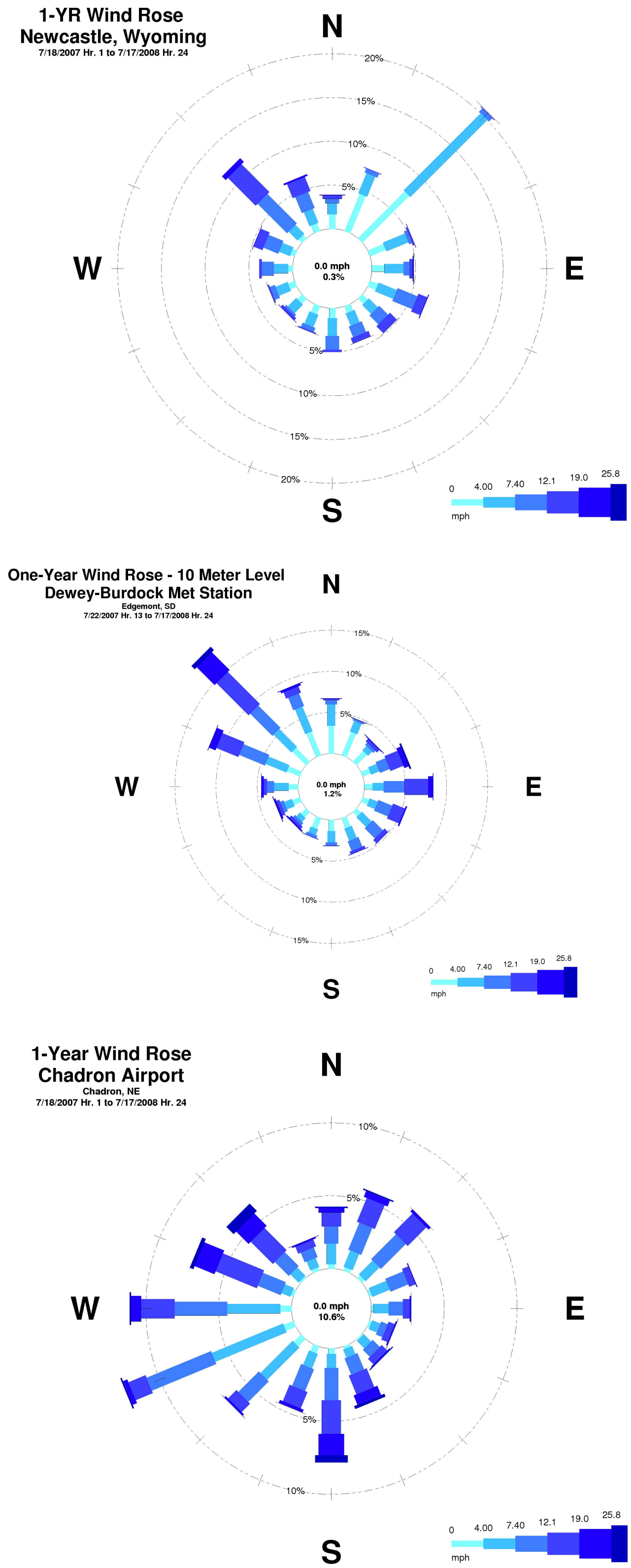
## Figure TR RAI 2.5-1c-8:  Comparative 1-Year Wind Roses



***TR RAI 2.5-2***

***Regulatory Guide 3.63 recommends the basic reduced wind direction, wind speed, and atmospheric stability data should be averaged over a period of 1 hour. At least 15 consecutive minutes of continuous data during each hour should be used to represent a 1-hour average data. Please demonstrate that this data is consistent with the recommendations in Regulatory Guide 3.63 or provide justification for an alternate methodology.***

**TR RAI 2.5-2 Response**

The following description of the meteorological station at the Dewey-Burdock project area and data collection will be incorporated into Section 2.5 of the revised TR.

The Dewey-Burdock meteorological monitoring station was configured and installed by the South Dakota Office of Climatology at South Dakota State University. Parameters monitored include wind speed, wind direction, ambient temperature, relative humidity and solar radiation. Please refer to the response to TR RAI 2.5-3 for a discussion on how the data were used to determine atmospheric stability classes and resulting joint frequency distributions, thus meeting the goals of Regulatory Guide 3.63. The hourly average wind speed and wind direction reported at the site represent averages of twelve 5-minute data points for each hour.

***TR RAI 2.5-3***

***Regulatory Guide 3.63 recommends that quarterly and annual wind direction, wind speed, and atmospheric stability data be compiled in joint frequency and joint relative frequency (i.e., decimal frequency) form for heights representative of effluent releases. In addition, stability categories should be established to conform as closely as possible with those of Pasquill. Please provide this data consistent with Regulatory Guide 3.63 or provide justification for an alternate methodology.***

**TR RAI 2.5-3 Response**

In the original TR Section 2.5 and the associated MILDOS-AREA modeling, atmospheric stability class was determined from solar radiation during the daylight hours, and the assumption of worst-case conditions (i.e., most stable air) at night. This assumption was necessitated by the absence of vertical temperature gradient (delta-T) measurements that are normally used to assign nocturnal stability classes according to the SRDT (solar radiation delta-T) method. For any given hourly wind speed, the assumption of a positive delta-T (increasing temperature with height) produced the most stable class possible and, therefore, the lowest modeled pollutant dispersion. The following presents the stability classes and joint frequency distribution for the Dewey-Burdock project area and describes the methodology used for calculations. The information presented below will be incorporated into the revised TR.

In absence of the delta-T measurements required by the SRDT method, an alternate, sigma theta method was used to determine atmospheric stability classes and resulting joint frequency distributions. The method is turbulence-based, which uses the standard deviation of the horizontal wind direction ($\sigma_\theta$) in combination with the scalar mean wind speed. Since $\sigma_\theta$ was not logged, it was necessary to derive this parameter from the hourly variation of 5-minute wind directions.

The procedure for deriving hourly average $\sigma_\theta$ values is outlined as follows:

1. Compute a scalar mean wind direction by averaging 5-minute azimuth angles over four, 15-minute periods for each hour. The choice of 15-minute averaging periods is intended to minimize the effect of wind meander (wind direction changes over longer periods that are non-random and unrelated to turbulence). The use of 5-minute source data further reduces the likelihood of conflicts between scalar and vector averages.
2. Compute a standard deviation of each 15-minute grouping of 5-minute wind directions, based on the differences between the 5-minute readings and the 15-minute mean from step 1 above.
3. Compute an hourly average standard deviation as the geometric average of the four 15-minute standard deviations from step 2 above.

Steps 1 and 2 utilize the Mitsua method: $\overline{\theta} = \frac{1}{N}\sum_{1}^{N} D_i$ (N = 3 in this case)

| | | |
|---|---|---|
| where | $D_i = \theta_i$ | for i = 1 |
| | $D_i = D_{i-1} + \delta_i + 360$ | for $\delta_i < -180$ and $i > 1$ |
| | $D_i = D_{i-1} + \delta_i$ | for $\lvert\delta_i\rvert < 180$ and $i > 1$ |
| | $D_i = D_{i-1} + \delta_i - 360$ | for $\delta_i > 180$ and $i > 1$ |
| | $D_i$ = undefined | for $\delta_i = 180$ and $i > 1$ |

$\delta_i = \theta_i - D_{i-1}$ for $i > 1$

$\theta_i$ is the azimuth angle of the wind vane for the i[th] sample

then $$\sigma_\theta = \left\{ \frac{1}{N}\sum_1^N D_i^{\ 2} - \frac{1}{N}\left(\sum_1^N D_i\right)^2 \right\}^{1/2}$$

In step 3, the hourly average standard deviation can then be calculated from these 15-minute values:

$$\sigma_\theta(1-hr) = \sqrt{\frac{(\sigma_{\theta_1})^2 + (\sigma_{\theta_2})^2 + (\sigma_{\theta_3})^2 + (\sigma_{\theta_4})^2}{4}}$$

The above procedure, when applied to the Dewey-Burdock wind data, yields hourly $\sigma_\theta$ values similar to the hourly values logged at the nearby Newcastle meteorological station. Newcastle $\sigma_\theta$ values averaged 19.6º during the baseline monitoring year, while the derived $\sigma_\theta$ values from Dewey-Burdock data averaged 18.7º.

Having developed these hourly $\sigma_\theta$ values, the choice remained whether to use the sigma theta method exclusively, or to use a hybrid method that takes advantage of solar radiation (SR) data during the daytime. To facilitate this choice, the two methods were compared along with the original method which used SR during the day, and assumed worst-case delta-T (WC) at night. Figure TR RAI 2.5-3-1 shows the results of this comparison.

The sigma theta method was ruled out since it resulted in a much higher percentage of the hours in the least stable class. Stability class A produces the greatest amount of atmospheric mixing and pollutant dispersion, so the sigma theta method compromises the preference for conservatism. The remaining two methods yield similar results. The hybrid SR/ST method was chosen because it makes use of the greatest amount of monitoring data covering both daytime and nighttime.

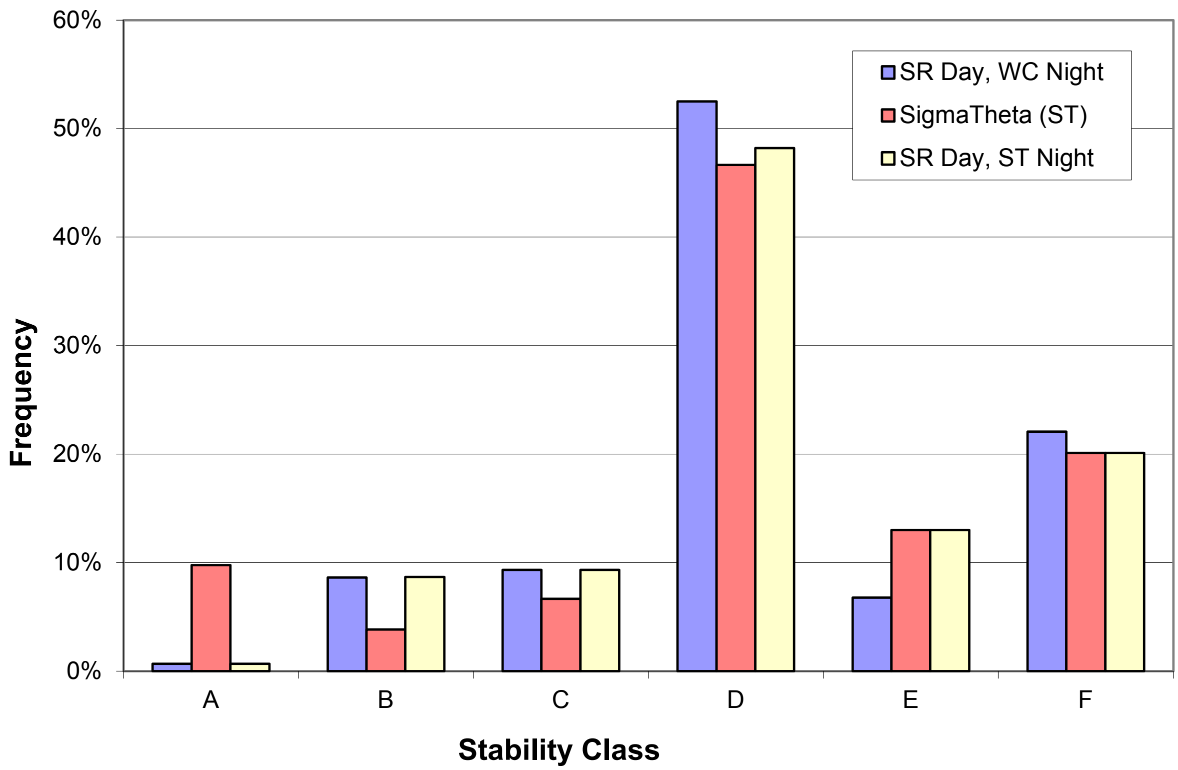
Based upon the data and method selections discussed above, the combination of hourly wind speed, wind direction and stability class was used to generate Joint Frequency Distributions (JFDs) for the anticipated release height of 10 meters. It should be noted that for the TR and MILDOS-AREA modeling the hourly average wind directions were previously computed as the arithmetic average of the 5-minute directions. This error was corrected by computing vector average wind directions, which are reflected in the annual and quarterly JFDs for the Dewey-Burdock project area (Tables TR RAI 2.5-3-1 through TR RAI 2.5-3-5). The annual JFD in Table TR RAI 2.5-3-1 was used as the basis for a revised MILDOS-AREA model run. The remaining JFD tables reflect the following monitoring periods:

- Table TR RAI 2.5-3-2 (1st Quarter): January 1, 2008 through March 31, 2008

- Table TR RAI 2.5-3-3 (2nd Quarter): April 1, 2008 through June 30, 2008
- Table TR RAI 2.5-3-4 (3rd Quarter): July 2007 and 2008 and August 1, 2007 through September 30, 2007
- Table TR RAI 2.5-3-5 (4th Quarter): October 1, 2007 through December 31, 2007

Each table footer shows the number of hours for which valid data are available and the total number of hours possible.

**Figure TR RAI 2.5-3-1: Comparative Atmospheric Stability Methods for Dewey-Burdock**




The original TR based the wind analysis at the project area on data from the 3-meter level, with data recoveries exceeding 99%. Regulatory guidance specifies that wind characteristics should reflect the anticipated release height for modeled emission sources. Therefore, the JFDs depicted below are based on 10-meter wind data. Joint data recovery (wind speed and wind direction) for the baseline year was 87%, which is above the recommended minimum of 75% (Regulatory Guide 3.63). Individual data recovery was also approximately 87%, which is slightly below the recommended 90% for individual parameters. However, the tradeoff between marginal recovery percentage and representative height above the ground appears justified in this case. Additional information including a comparison of 3-meter and 10-meter wind roses is provided in the response to TR RAI 2.5-4.

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**Table TR RAI 2.5-3-1: Annual (July 18, 2007 to July 17, 2008) Joint Frequency Distribution**

| Stability Class | Wind Direction | Wind Speed (mph) - One Year (Calm = 1.22%) | | | | | | Row Total |
|---|---|---|---|---|---|---|---|---|
| | | < 3 | 4 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | > 24 | |
| A | N | | | | | | | |
| | NNE | | 0.000131 | | | | | 0.000131 |
| | NE | | | | | | | |
| | ENE | | | | | | | |
| | E | | | | | | | |
| | ESE | 0.000274 | | | | | | 0.000274 |
| | SE | | 0.000262 | | | | | 0.000262 |
| | SSE | 0.000274 | 0.000393 | | | | | 0.000667 |
| | S | 0.000274 | 0.000524 | | | | | 0.000798 |
| | SSW | 0.000411 | 0.000786 | | | | | 0.001197 |
| | SW | 0.000411 | 0.000393 | | | | | 0.000804 |
| | WSW | 0.000137 | 0.000786 | | | | | 0.000923 |
| | W | 0.000274 | 0.000393 | | | | | 0.000667 |
| | WNW | 0.000411 | 0.000524 | | | | | 0.000935 |
| | NW | | | | | | | |
| | NNW | | | | | | | |
| B | N | 0.002740 | 0.000524 | | | | | 0.003264 |
| | NNE | 0.001096 | | | | | | 0.001096 |
| | NE | 0.001096 | | | | | | 0.001096 |
| | ENE | 0.000822 | 0.000262 | | | | | 0.001084 |
| | E | 0.000822 | 0.000131 | 0.000131 | | | | 0.001084 |
| | ESE | 0.000411 | 0.000393 | 0.000655 | | | | 0.001459 |
| | SE | 0.001781 | 0.001964 | 0.002095 | | | | 0.005841 |
| | SSE | 0.002603 | 0.004191 | 0.001441 | | | | 0.008234 |
| | S | 0.005206 | 0.003143 | 0.000524 | | | | 0.008872 |
| | SSW | 0.005069 | 0.001702 | 0.000131 | | | | 0.006902 |
| | SW | 0.003562 | 0.002226 | 0.000393 | | | | 0.006181 |
| | WSW | 0.003699 | 0.002881 | 0.000262 | | | | 0.006842 |
| | W | 0.003836 | 0.005369 | 0.001441 | | | | 0.010646 |
| | WNW | 0.004384 | 0.004191 | 0.003405 | | | | 0.011979 |
| | NW | 0.004384 | 0.001833 | 0.000917 | | | | 0.007134 |
| | NNW | 0.003973 | 0.001048 | 0.000131 | | | | 0.005151 |
| C | N | | 0.001310 | | | | | 0.001310 |
| | NNE | | 0.000393 | | | | | 0.000393 |
| | NE | | 0.000131 | | | | | 0.000131 |
| | ENE | | 0.000262 | 0.000131 | | | | 0.000393 |
| | E | | 0.001310 | 0.001702 | 0.000131 | | | 0.003143 |
| | ESE | | 0.001964 | 0.003274 | 0.000131 | | | 0.005369 |
| | SE | | 0.003798 | 0.004191 | 0.000131 | | | 0.008119 |
| | SSE | | 0.004845 | 0.003405 | | | | 0.008250 |
| | S | | 0.005500 | 0.000786 | | | | 0.006286 |
| | SSW | | 0.001572 | 0.000917 | | | | 0.002488 |
| | SW | | 0.001702 | 0.000655 | | | | 0.002357 |
| | WSW | | 0.003929 | 0.001310 | | | | 0.005238 |
| | W | | 0.006548 | 0.001310 | 0.000393 | | | 0.008250 |
| | WNW | | 0.011524 | 0.008905 | 0.000131 | 0.000393 | | 0.020953 |
| | NW | | 0.007072 | 0.004845 | 0.001441 | 0.000393 | | 0.013751 |
| | NNW | | 0.005107 | 0.001833 | | | | 0.006941 |

**Table TR RAI 2.5-3-1: Annual (July 18, 2007 to July 17, 2008) Joint Frequency Distribution (Cont.)**

| Stability Class | Wind Direction | Wind Speed (mph) - One Year | | | | | | Row Total |
|---|---|---|---|---|---|---|---|---|
| | | < 3 | 4 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | > 24 | |
| D | N | 0.008493 | 0.010215 | 0.002226 | 0.001310 | 0.000393 | | 0.022637 |
| | NNE | 0.007671 | 0.004976 | 0.001702 | 0.000524 | | 0.000131 | 0.015005 |
| | NE | 0.002740 | 0.002750 | 0.004060 | 0.002357 | 0.000131 | 0.000393 | 0.012431 |
| | ENE | 0.001781 | 0.005631 | 0.012834 | 0.013751 | 0.002357 | 0.002095 | 0.038449 |
| | E | 0.003288 | 0.007596 | 0.024227 | 0.016370 | 0.001572 | 0.000655 | 0.053707 |
| | ESE | 0.001644 | 0.007858 | 0.011655 | 0.009691 | 0.000917 | | 0.031764 |
| | SE | 0.001096 | 0.006024 | 0.007727 | 0.002226 | 0.000262 | | 0.017335 |
| | SSE | 0.002740 | 0.004584 | 0.004060 | 0.001441 | 0.000393 | | 0.013216 |
| | S | 0.002740 | 0.003012 | 0.001048 | 0.000131 | | | 0.006930 |
| | SSW | 0.003425 | 0.001964 | 0.001441 | 0.000393 | | | 0.007222 |
| | SW | 0.001370 | 0.000917 | 0.002095 | 0.002488 | 0.000917 | 0.000131 | 0.007918 |
| | WSW | 0.002329 | 0.002226 | 0.002619 | 0.003274 | 0.001048 | 0.000655 | 0.012151 |
| | W | 0.001644 | 0.003536 | 0.003274 | 0.003405 | 0.001702 | 0.000131 | 0.013692 |
| | WNW | 0.003699 | 0.011655 | 0.018989 | 0.021870 | 0.004453 | 0.000393 | 0.061059 |
| | NW | 0.005617 | 0.016370 | 0.038371 | 0.047669 | 0.019120 | 0.003143 | 0.130289 |
| | NNW | 0.006575 | 0.015191 | 0.008643 | 0.005631 | 0.001833 | 0.000393 | 0.038267 |
| E | N | 0.006438 | 0.010084 | 0.000786 | | | | 0.017308 |
| | NNE | 0.004247 | 0.004191 | 0.000131 | | | | 0.008568 |
| | NE | 0.002466 | 0.002226 | 0.000655 | | | | 0.005347 |
| | ENE | 0.001370 | 0.003929 | 0.002881 | | | | 0.008180 |
| | E | 0.000548 | 0.006810 | 0.007203 | | | | 0.014561 |
| | ESE | 0.000274 | 0.004453 | 0.003405 | | | | 0.008131 |
| | SE | 0.000548 | 0.004191 | 0.002095 | | | | 0.006834 |
| | SSE | 0.000411 | 0.003667 | 0.000655 | | | | 0.004733 |
| | S | 0.000411 | 0.001310 | | | | | 0.001721 |
| | SSW | 0.000274 | 0.001048 | 0.000524 | | | | 0.001845 |
| | SW | 0.000137 | 0.001179 | 0.000262 | | | | 0.001578 |
| | WSW | 0.000822 | 0.000786 | | | | | 0.001608 |
| | W | 0.000959 | 0.002881 | 0.001048 | | | | 0.004888 |
| | WNW | 0.001507 | 0.004584 | 0.004191 | | | | 0.010281 |
| | NW | 0.001644 | 0.009429 | 0.005107 | | | | 0.016180 |
| | NNW | 0.004932 | 0.009691 | 0.003667 | | | | 0.018289 |
| F | N | 0.018082 | 0.006679 | | | | | 0.024761 |
| | NNE | 0.019178 | 0.004715 | | | | | 0.023893 |
| | NE | 0.012877 | 0.003143 | | | | | 0.016020 |
| | ENE | 0.007260 | 0.003798 | | | | | 0.011058 |
| | E | 0.006027 | 0.003274 | | | | | 0.009301 |
| | ESE | 0.006164 | 0.002095 | | | | | 0.008260 |
| | SE | 0.004521 | 0.002226 | | | | | 0.006747 |
| | SSE | 0.007808 | 0.003536 | | | | | 0.011344 |
| | S | 0.005480 | 0.002488 | | | | | 0.007968 |
| | SSW | 0.005206 | 0.001179 | | | | | 0.006384 |
| | SW | 0.004384 | 0.001441 | | | | | 0.005824 |
| | WSW | 0.003973 | 0.001179 | | | | | 0.005151 |
| | W | 0.004795 | 0.002750 | | | | | 0.007545 |
| | WNW | 0.008219 | 0.004191 | | | | | 0.012410 |
| | NW | 0.013151 | 0.006417 | | | | | 0.019568 |
| | NNW | 0.017808 | 0.006941 | | | | | 0.024749 |

7,636 valid hours out of 8,784

**Table TR RAI 2.5-3-2*:* 1st Quarter (January 1, 2008 to March 31, 2008) Joint Frequency Distribution**

| Stability Class | Wind Direction | Wind Speed (mph) - Winter (Calm = 0.6%) | | | | | | Row Total |
|---|---|---|---|---|---|---|---|---|
| | | < 3 | 4 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | > 24 | |
| A | N | | | | | | | |
| | NNE | | | | | | | |
| | NE | | | | | | | |
| | ENE | | | | | | | |
| | E | | | | | | | |
| | ESE | | | | | | | |
| | SE | | | | | | | |
| | SSE | | | | | | | |
| | S | | | | | | | |
| | SSW | | | | | | | |
| | SW | | | | | | | |
| | WSW | | | | | | | |
| | W | | | | | | | |
| | WNW | | | | | | | |
| | NW | | | | | | | |
| | NNW | | | | | | | |
| B | N | 0.005197 | | | | | | 0.005197 |
| | NNE | 0.001890 | | | | | | 0.001890 |
| | NE | 0.001890 | | | | | | 0.001890 |
| | ENE | 0.000945 | | | | | | 0.000945 |
| | E | 0.000945 | | | | | | 0.000945 |
| | ESE | 0.000945 | | 0.000463 | | | | 0.001408 |
| | SE | 0.001890 | 0.000463 | | | | | 0.002353 |
| | SSE | 0.003307 | 0.001390 | | | | | 0.004698 |
| | S | 0.005670 | 0.000927 | | | | | 0.006597 |
| | SSW | 0.003780 | 0.000463 | | | | | 0.004243 |
| | SW | 0.004252 | | | | | | 0.004252 |
| | WSW | 0.003307 | 0.000927 | | | | | 0.004234 |
| | W | 0.004725 | 0.003244 | | | | | 0.007969 |
| | WNW | 0.004725 | 0.001854 | 0.001390 | | | | 0.007969 |
| | NW | 0.003780 | 0.000463 | 0.000927 | | | | 0.005170 |
| | NNW | 0.005670 | | | | | | 0.005670 |
| C | N | | 0.002317 | | | | | 0.002317 |
| | NNE | | 0.000927 | | | | | 0.000927 |
| | NE | | 0.000463 | | | | | 0.000463 |
| | ENE | | 0.000463 | 0.000463 | | | | 0.000927 |
| | E | | | 0.003244 | | | | 0.003244 |
| | ESE | | 0.001854 | 0.002317 | | | | 0.004171 |
| | SE | | 0.003244 | 0.003244 | | | | 0.006487 |
| | SSE | | 0.004171 | 0.001854 | | | | 0.006024 |
| | S | | 0.002780 | 0.001390 | | | | 0.004171 |
| | SSW | | | 0.000927 | | | | 0.000927 |
| | SW | | 0.002317 | | | | | 0.002317 |
| | WSW | | 0.003707 | 0.000463 | | | | 0.004171 |
| | W | | 0.005097 | 0.000463 | | | | 0.005561 |
| | WNW | | 0.010195 | 0.008341 | | | | 0.018536 |
| | NW | | 0.014829 | 0.004171 | | | | 0.018999 |
| | NNW | | 0.007414 | 0.003244 | | | | 0.010658 |

**Table TR RAI 2.5-3-2: 1st Quarter (January 1, 2008 to March 31, 2008) Joint Frequency Distribution (Cont.)**

| Stability Class | Wind Direction | Wind Speed (mph) - Winter (Calm = 0.6%) | | | | | | Row Total |
|---|---|---|---|---|---|---|---|---|
| | | < 3 | 4 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | > 24 | |
| D | N | 0.010867 | 0.010658 | 0.002317 | | 0.000463 | | 0.024305 |
| | NNE | 0.007560 | 0.006487 | 0.000927 | | | | 0.014974 |
| | NE | 0.003780 | 0.001854 | | 0.000927 | | | 0.006560 |
| | ENE | 0.000945 | 0.003244 | 0.009268 | 0.003707 | | | 0.017164 |
| | E | 0.001417 | 0.006024 | 0.014365 | 0.008341 | | | 0.030148 |
| | ESE | 0.001417 | 0.005561 | 0.007878 | 0.000927 | | | 0.015783 |
| | SE | 0.000945 | 0.005561 | 0.005097 | | | | 0.011603 |
| | SSE | 0.003307 | 0.005561 | 0.002780 | 0.000463 | | | 0.012112 |
| | S | 0.002362 | 0.003244 | 0.000463 | 0.000463 | | | 0.006533 |
| | SSW | 0.002362 | 0.002317 | 0.000927 | | | | 0.005606 |
| | SW | 0.000472 | 0.000463 | 0.002780 | 0.001854 | | | 0.005570 |
| | WSW | 0.001417 | 0.002780 | 0.001390 | 0.002780 | | 0.001854 | 0.010222 |
| | W | 0.000472 | 0.005097 | 0.004171 | 0.003244 | 0.002317 | 0.000463 | 0.015764 |
| | WNW | 0.003307 | 0.013902 | 0.024560 | 0.028267 | 0.005561 | 0.000927 | 0.076523 |
| | NW | 0.004252 | 0.016682 | 0.052363 | 0.055607 | 0.022243 | 0.001854 | 0.153001 |
| | NNW | 0.006142 | 0.015292 | 0.011585 | 0.008804 | 0.001390 | | 0.043214 |
| E | N | 0.008977 | 0.013438 | 0.001854 | | | | 0.024269 |
| | NNE | 0.006615 | 0.005561 | | | | | 0.012175 |
| | NE | 0.002835 | 0.000463 | 0.000927 | | | | 0.004225 |
| | ENE | 0.000472 | 0.002317 | 0.002317 | | | | 0.005106 |
| | E | 0.001417 | 0.004634 | 0.005561 | | | | 0.011612 |
| | ESE | 0.000472 | 0.002780 | 0.004634 | | | | 0.007887 |
| | SE | 0.000945 | 0.003707 | 0.003244 | | | | 0.007896 |
| | SSE | 0.000945 | 0.000927 | | | | | 0.001872 |
| | S | | 0.001390 | | | | | 0.001390 |
| | SSW | 0.000472 | | 0.000463 | | | | 0.000936 |
| | SW | 0.000472 | 0.000927 | | | | | 0.001399 |
| | WSW | 0.001890 | 0.000463 | | | | | 0.002353 |
| | W | 0.001417 | 0.003707 | 0.002780 | | | | 0.007905 |
| | WNW | 0.001417 | 0.008804 | 0.009268 | | | | 0.019490 |
| | NW | 0.002835 | 0.014365 | 0.008804 | | | | 0.026004 |
| | NNW | 0.005197 | 0.013438 | 0.006024 | | | | 0.024660 |
| F | N | 0.021262 | 0.008804 | | | | | 0.030066 |
| | NNE | 0.027876 | 0.006024 | | | | | 0.033900 |
| | NE | 0.016064 | 0.004171 | | | | | 0.020235 |
| | ENE | 0.010867 | 0.003244 | | | | | 0.014111 |
| | E | 0.006615 | 0.004634 | | | | | 0.011249 |
| | ESE | 0.004725 | 0.000927 | | | | | 0.005652 |
| | SE | 0.006615 | 0.001854 | | | | | 0.008468 |
| | SSE | 0.008977 | 0.004171 | | | | | 0.013148 |
| | S | 0.006142 | 0.001854 | | | | | 0.007996 |
| | SSW | 0.003307 | 0.000927 | | | | | 0.004234 |
| | SW | 0.003780 | | | | | | 0.003780 |
| | WSW | 0.002835 | 0.000927 | | | | | 0.003762 |
| | W | 0.004252 | 0.002317 | | | | | 0.006569 |
| | WNW | 0.009450 | 0.006024 | | | | | 0.015474 |
| | NW | 0.016537 | 0.008341 | | | | | 0.024878 |
| | NNW | 0.023624 | 0.009268 | | | | | 0.032892 |

2,158 valid hours out of 2,184

Powertech (USA) Inc.

**Table TR RAI 2.5-3-3: 2nd Quarter (April 1, 2008 to June 30, 2008) Joint Frequency Distribution**

| Stability Class | Wind Direction | Wind Speed (mph) - Spring (Calm = 0.82%) | | | | | | Row Total |
|---|---|---|---|---|---|---|---|---|
| | | < 3 | 4 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | > 24 | |
| A | N | | | | | | | |
| | NNE | | 0.000458 | | | | | 0.000458 |
| | NE | | | | | | | |
| | ENE | | | | | | | |
| | E | | | | | | | |
| | ESE | 0.000965 | | | | | | 0.000965 |
| | SE | | 0.000458 | | | | | 0.000458 |
| | SSE | 0.000483 | 0.000916 | | | | | 0.001398 |
| | S | 0.000483 | 0.001832 | | | | | 0.002314 |
| | SSW | 0.000483 | 0.002289 | | | | | 0.002772 |
| | SW | 0.001448 | 0.000916 | | | | | 0.002364 |
| | WSW | 0.000483 | 0.001832 | | | | | 0.002314 |
| | W | 0.000965 | 0.000916 | | | | | 0.001881 |
| | WNW | 0.001448 | 0.001374 | | | | | 0.002822 |
| | NW | | | | | | | |
| | NNW | | | | | | | |
| B | N | 0.000965 | 0.000916 | | | | | 0.001881 |
| | NNE | 0.000965 | | | | | | 0.000965 |
| | NE | 0.000483 | | | | | | 0.000483 |
| | ENE | 0.001448 | 0.000916 | | | | | 0.002364 |
| | E | 0.000483 | | | | | | 0.000483 |
| | ESE | | | 0.001374 | | | | 0.001374 |
| | SE | 0.002896 | 0.004121 | 0.003205 | | | | 0.010222 |
| | SSE | 0.001448 | 0.009615 | 0.003205 | | | | 0.014268 |
| | S | 0.003861 | 0.005495 | 0.000458 | | | | 0.009813 |
| | SSW | 0.002896 | 0.003663 | 0.000458 | | | | 0.007017 |
| | SW | 0.003861 | 0.005495 | 0.000916 | | | | 0.010271 |
| | WSW | 0.003378 | 0.008242 | 0.000916 | | | | 0.012536 |
| | W | 0.000483 | 0.009158 | 0.002747 | | | | 0.012387 |
| | WNW | 0.004344 | 0.006868 | 0.006868 | | | | 0.018080 |
| | NW | 0.002413 | 0.001374 | 0.002289 | | | | 0.006076 |
| | NNW | 0.002413 | 0.000458 | | | | | 0.002871 |
| C | N | | 0.001374 | | | | | 0.001374 |
| | NNE | | | | | | | |
| | NE | | | | | | | |
| | ENE | | 0.000458 | | | | | 0.000458 |
| | E | | 0.002747 | 0.002289 | 0.000458 | | | 0.005495 |
| | ESE | | 0.001832 | 0.006410 | 0.000458 | | | 0.008700 |
| | SE | | 0.005952 | 0.003205 | 0.000458 | | | 0.009615 |
| | SSE | | 0.004579 | 0.004579 | | | | 0.009158 |
| | S | | 0.007326 | 0.000916 | | | | 0.008242 |
| | SSW | | 0.001832 | 0.001374 | | | | 0.003205 |
| | SW | | 0.000916 | 0.002289 | | | | 0.003205 |
| | WSW | | 0.002747 | 0.000916 | | | | 0.003663 |
| | W | | 0.006868 | 0.002289 | 0.001374 | | | 0.010531 |
| | WNW | | 0.010073 | 0.010531 | 0.000458 | 0.001374 | | 0.022436 |
| | NW | | 0.002289 | 0.004579 | 0.005037 | 0.000458 | | 0.012363 |
| | NNW | | 0.002289 | 0.001374 | | | | 0.003663 |

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**Table TR RAI 2.5-3-3: 2nd Quarter (April 1, 2008 to June 30, 2008) Joint Frequency Distribution (Cont.)**

| Stability Class | Wind Direction | Wind Speed (mph) - Spring (Calm = 0.82%) | | | | | | Row Total |
|---|---|---|---|---|---|---|---|---|
| | | < 3 | 4 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | > 24 | |
| D | N | 0.003861 | 0.006868 | 0.002747 | 0.001832 | 0.000458 | | 0.015766 |
| | NNE | 0.003378 | 0.004121 | 0.001832 | 0.001374 | | | 0.010704 |
| | NE | 0.003378 | 0.004579 | 0.007326 | 0.003205 | 0.000458 | 0.000916 | 0.019862 |
| | ENE | 0.002413 | 0.008242 | 0.013278 | 0.024725 | 0.005952 | 0.007326 | 0.061937 |
| | E | 0.002896 | 0.006410 | 0.039835 | 0.027473 | 0.005495 | 0.002289 | 0.084398 |
| | ESE | | 0.007784 | 0.012363 | 0.011447 | 0.002289 | | 0.033883 |
| | SE | 0.001931 | 0.008242 | 0.010531 | 0.002289 | 0.000458 | | 0.023451 |
| | SSE | 0.000965 | 0.004121 | 0.003663 | 0.002289 | 0.000916 | | 0.011954 |
| | S | 0.001448 | 0.001374 | 0.001374 | | | | 0.004195 |
| | SSW | 0.002896 | 0.000916 | 0.002747 | 0.000916 | | | 0.007475 |
| | SW | 0.001448 | 0.001374 | 0.000916 | 0.002747 | 0.003205 | 0.000458 | 0.010148 |
| | WSW | 0.000965 | 0.001374 | 0.005037 | 0.007326 | 0.002747 | | 0.017449 |
| | W | 0.000483 | 0.003205 | 0.004579 | 0.006410 | 0.000916 | | 0.015593 |
| | WNW | 0.001931 | 0.012821 | 0.015568 | 0.019689 | 0.005495 | | 0.055502 |
| | NW | 0.004826 | 0.016941 | 0.033883 | 0.065018 | 0.023352 | 0.005952 | 0.149973 |
| | NNW | 0.005309 | 0.011905 | 0.008242 | 0.006868 | 0.003205 | 0.001374 | 0.036902 |
| E | N | 0.000965 | 0.007326 | | | | | 0.008291 |
| | NNE | 0.002413 | 0.003205 | 0.000458 | | | | 0.006076 |
| | NE | 0.001931 | 0.000916 | 0.000458 | | | | 0.003304 |
| | ENE | 0.000965 | 0.004579 | 0.005037 | | | | 0.010581 |
| | E | | 0.007784 | 0.007784 | | | | 0.015568 |
| | ESE | | 0.004121 | 0.002289 | | | | 0.006410 |
| | SE | | 0.004121 | 0.002289 | | | | 0.006410 |
| | SSE | | 0.002289 | 0.000458 | | | | 0.002747 |
| | S | 0.000965 | 0.000458 | | | | | 0.001423 |
| | SSW | | 0.002289 | 0.000916 | | | | 0.003205 |
| | SW | | 0.001374 | 0.000458 | | | | 0.001832 |
| | WSW | | 0.000916 | | | | | 0.000916 |
| | W | 0.000483 | 0.002289 | 0.000916 | | | | 0.003688 |
| | WNW | 0.000483 | 0.000458 | 0.000916 | | | | 0.001856 |
| | NW | 0.000965 | 0.005495 | 0.004579 | | | | 0.011039 |
| | NNW | 0.002413 | 0.005952 | 0.001374 | | | | 0.009739 |
| F | N | 0.008687 | 0.007326 | | | | | 0.016013 |
| | NNE | 0.009653 | 0.002747 | | | | | 0.012400 |
| | NE | 0.007722 | 0.002289 | | | | | 0.010011 |
| | ENE | 0.006274 | 0.004121 | | | | | 0.010395 |
| | E | 0.004826 | 0.002289 | | | | | 0.007116 |
| | ESE | 0.005792 | 0.002747 | | | | | 0.008539 |
| | SE | 0.001448 | 0.001374 | | | | | 0.002822 |
| | SSE | 0.001931 | 0.001374 | | | | | 0.003304 |
| | S | 0.002413 | 0.001832 | | | | | 0.004245 |
| | SSW | 0.004826 | 0.000916 | | | | | 0.005742 |
| | SW | 0.000965 | 0.001374 | | | | | 0.002339 |
| | WSW | 0.000965 | 0.000458 | | | | | 0.001423 |
| | W | 0.001931 | 0.002289 | | | | | 0.004220 |
| | WNW | 0.001931 | 0.003205 | | | | | 0.005136 |
| | NW | 0.006757 | 0.008242 | | | | | 0.014999 |
| | NNW | 0.005792 | 0.002289 | | | | | 0.008081 |

2,184 valid hours out of 2,184

**Table TR RAI 2.5-3-4: 3rd Quarter (July 2007 and 2008, August and September 2007) Joint Frequency Distribution**

| Stability Class | Wind Direction | Wind Speed (mph) - Summer (Calm = 1.4%) < 3 | 4 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | > 24 | Row Total |
|---|---|---|---|---|---|---|---|---|
| A | N | | | | | | | |
| | NNE | | | | | | | |
| | NE | | | | | | | |
| | ENE | | | | | | | |
| | E | | | | | | | |
| | ESE | | | | | | | |
| | SE | | 0.000873 | | | | | 0.000873 |
| | SSE | 0.000893 | 0.000873 | | | | | 0.001765 |
| | S | 0.001091 | | | | | | 0.001091 |
| | SSW | 0.001983 | 0.000873 | | | | | 0.002856 |
| | SW | | 0.000873 | | | | | 0.000873 |
| | WSW | | 0.001745 | | | | | 0.001745 |
| | W | | 0.000873 | | | | | 0.000873 |
| | WNW | | 0.000873 | | | | | 0.000873 |
| | NW | | | | | | | |
| | NNW | | | | | | | |
| B | N | | 0.000873 | | | | | 0.000873 |
| | NNE | | | | | | | |
| | NE | 0.000893 | | | | | | 0.000893 |
| | ENE | | | | | | | |
| | E | 0.001785 | | 0.000873 | | | | 0.002658 |
| | ESE | 0.000893 | 0.002618 | 0.000873 | | | | 0.004383 |
| | SE | 0.001091 | 0.004363 | 0.007853 | | | | 0.013307 |
| | SSE | 0.004165 | 0.006981 | 0.003490 | | | | 0.014636 |
| | S | 0.005752 | 0.008726 | 0.002618 | | | | 0.017096 |
| | SSW | 0.003967 | 0.002618 | | | | | 0.006585 |
| | SW | 0.001785 | 0.002618 | 0.000873 | | | | 0.005276 |
| | WSW | 0.002876 | 0.001745 | | | | | 0.004621 |
| | W | 0.003769 | 0.009599 | 0.004363 | | | | 0.017731 |
| | WNW | 0.004662 | 0.005236 | 0.006981 | | | | 0.016878 |
| | NW | 0.001091 | 0.005236 | | | | | 0.006326 |
| | NNW | 0.005950 | 0.000873 | 0.000873 | | | | 0.007696 |
| C | N | | 0.000873 | | | | | 0.000873 |
| | NNE | | 0.000873 | | | | | 0.000873 |
| | NE | | | | | | | |
| | ENE | | | | | | | |
| | E | | 0.002618 | 0.000873 | | | | 0.003490 |
| | ESE | | 0.004363 | 0.004363 | | | | 0.008726 |
| | SE | | 0.004363 | 0.010471 | | | | 0.014834 |
| | SSE | | 0.007853 | 0.006981 | | | | 0.014834 |
| | S | | 0.006981 | 0.000873 | | | | 0.007853 |
| | SSW | | 0.002618 | 0.000873 | | | | 0.003490 |
| | SW | | 0.002618 | | | | | 0.002618 |
| | WSW | | 0.003490 | 0.004363 | | | | 0.007853 |
| | W | | 0.007853 | 0.001745 | | | | 0.009599 |
| | WNW | | 0.015707 | 0.013962 | | | | 0.029668 |
| | NW | | 0.002618 | 0.007853 | | 0.001745 | | 0.012216 |
| | NNW | | 0.003490 | 0.001745 | | | | 0.005236 |

**Table TR RAI 2.5-3-4: 3rd Quarter (July 2007 and 2008, August and September 2007) Joint Frequency Distribution (Cont.)**

| Stability Class | Wind Direction | Wind Speed (mph) - Summer (Calm = 1.4%) | | | | | | Row Total |
|---|---|---|---|---|---|---|---|---|
| | | < 3 | 4 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | > 24 | |
| D | N | 0.007340 | 0.011344 | 0.003490 | 0.004363 | 0.000873 | | 0.027410 |
| | NNE | 0.008629 | 0.006108 | 0.002618 | 0.000873 | | 0.000873 | 0.019100 |
| | NE | 0.000893 | 0.001745 | 0.009599 | 0.006108 | | 0.000873 | 0.019217 |
| | ENE | 0.002678 | 0.007853 | 0.028796 | 0.020942 | | | 0.060270 |
| | E | 0.004464 | 0.013962 | 0.031414 | 0.014834 | | | 0.064673 |
| | ESE | 0.004662 | 0.013962 | 0.027923 | 0.032286 | 0.001745 | | 0.080578 |
| | SE | 0.001091 | 0.007853 | 0.013962 | 0.006108 | 0.000873 | | 0.029887 |
| | SSE | 0.001091 | 0.002618 | 0.004363 | 0.002618 | 0.000873 | | 0.011562 |
| | S | | 0.004363 | 0.003490 | | | | 0.007853 |
| | SSW | 0.003967 | 0.000873 | 0.002618 | 0.000873 | | | 0.008330 |
| | SW | | 0.001745 | 0.006108 | 0.006108 | | | 0.013962 |
| | WSW | | 0.001745 | 0.004363 | | 0.000873 | | 0.006981 |
| | W | 0.000893 | 0.000873 | 0.002618 | | 0.001745 | | 0.006128 |
| | WNW | 0.002678 | 0.006981 | 0.013962 | 0.027051 | 0.000873 | | 0.051544 |
| | NW | 0.003967 | 0.006108 | 0.026178 | 0.030541 | 0.010471 | | 0.077265 |
| | NNW | 0.004165 | 0.012216 | 0.006981 | 0.002618 | | | 0.025980 |
| E | N | | 0.007853 | | | | | 0.007853 |
| | NNE | 0.001785 | 0.006108 | | | | | 0.007894 |
| | NE | 0.001983 | 0.005236 | 0.001745 | | | | 0.008964 |
| | ENE | | 0.006981 | 0.001745 | | | | 0.008726 |
| | E | | 0.010471 | 0.016579 | | | | 0.027051 |
| | ESE | 0.000893 | 0.006108 | 0.006108 | | | | 0.013109 |
| | SE | | 0.002618 | 0.000873 | | | | 0.003490 |
| | SSE | 0.000893 | 0.002618 | 0.001745 | | | | 0.005256 |
| | S | | 0.002618 | | | | | 0.002618 |
| | SSW | | 0.002618 | 0.000873 | | | | 0.003490 |
| | SW | | 0.000873 | 0.000873 | | | | 0.001745 |
| | WSW | | 0.000873 | | | | | 0.000873 |
| | W | | 0.002618 | | | | | 0.002618 |
| | WNW | | 0.002618 | 0.000873 | | | | 0.003490 |
| | NW | | 0.006108 | | | | | 0.006108 |
| | NNW | 0.001785 | 0.001745 | 0.001745 | | | | 0.005276 |
| F | N | 0.005752 | 0.004363 | | | | | 0.010115 |
| | NNE | 0.011109 | 0.003490 | | | | | 0.014599 |
| | NE | 0.007538 | 0.005236 | | | | | 0.012774 |
| | ENE | 0.005950 | 0.003490 | | | | | 0.009441 |
| | E | 0.002678 | 0.003490 | | | | | 0.006169 |
| | ESE | 0.004662 | 0.002618 | | | | | 0.007280 |
| | SE | 0.005356 | 0.000873 | | | | | 0.006229 |
| | SSE | 0.004860 | 0.007853 | | | | | 0.012713 |
| | S | | 0.003490 | | | | | 0.003490 |
| | SSW | 0.000893 | 0.000873 | | | | | 0.001765 |
| | SW | 0.003769 | 0.000873 | | | | | 0.004642 |
| | WSW | 0.001983 | 0.000873 | | | | | 0.002856 |
| | W | 0.002876 | 0.001745 | | | | | 0.004621 |
| | WNW | 0.004662 | 0.003490 | | | | | 0.008152 |
| | NW | 0.010216 | 0.003490 | | | | | 0.013707 |
| | NNW | 0.003967 | 0.006108 | | | | | 0.010075 |

1,146 valid hours out of 2,208

**Table TR RAI 2.5-3-5: 4th Quarter (October 1, 2007 to December 31, 2007) Joint Frequency Distribution**

| Stability Class | Wind Direction | Wind Speed (mph) - Fall (Calm = 2.14%) | | | | | | Row Total |
|---|---|---|---|---|---|---|---|---|
| | | < 3 | 4 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | > 24 | |
| A | N | | | | | | | |
| | NNE | | | | | | | |
| | NE | | | | | | | |
| | ENE | | | | | | | |
| | E | | | | | | | |
| | ESE | | | | | | | |
| | SE | | | | | | | |
| | SSE | | | | | | | |
| | S | | | | | | | |
| | SSW | | | | | | | |
| | SW | | | | | | | |
| | WSW | | | | | | | |
| | W | | | | | | | |
| | WNW | | | | | | | |
| | NW | | | | | | | |
| | NNW | | | | | | | |
| B | N | 0.003437 | 0.000466 | | | | | 0.003902 |
| | NNE | 0.000982 | | | | | | 0.000982 |
| | NE | 0.000982 | | | | | | 0.000982 |
| | ENE | 0.000491 | | | | | | 0.000491 |
| | E | 0.000491 | 0.000466 | | | | | 0.000957 |
| | ESE | | | | | | | |
| | SE | 0.000982 | | | | | | 0.000982 |
| | SSE | 0.002455 | | | | | | 0.002455 |
| | S | 0.005892 | | | | | | 0.005892 |
| | SSW | 0.009329 | 0.000466 | | | | | 0.009794 |
| | SW | 0.003437 | 0.000931 | | | | | 0.004368 |
| | WSW | 0.004910 | | | | | | 0.004910 |
| | W | 0.006383 | 0.001397 | | | | | 0.007779 |
| | WNW | 0.003928 | 0.003259 | | | | | 0.007187 |
| | NW | 0.008838 | 0.001862 | | | | | 0.010700 |
| | NNW | 0.002946 | 0.002793 | | | | | 0.005739 |
| C | N | | 0.000466 | | | | | 0.000466 |
| | NNE | | | | | | | |
| | NE | | | | | | | |
| | ENE | | | | | | | |
| | E | | 0.000466 | | | | | 0.000466 |
| | ESE | | 0.000931 | 0.000466 | | | | 0.001397 |
| | SE | | 0.001862 | 0.002793 | | | | 0.004655 |
| | SSE | | 0.004190 | 0.001862 | | | | 0.006052 |
| | S | | 0.005587 | | | | | 0.005587 |
| | SSW | | 0.002328 | 0.000466 | | | | 0.002793 |
| | SW | | 0.001397 | | | | | 0.001397 |
| | WSW | | 0.005587 | 0.000931 | | | | 0.006518 |
| | W | | 0.006983 | 0.000931 | | | | 0.007914 |
| | WNW | | 0.012104 | 0.005121 | | | | 0.017225 |
| | NW | | 0.006518 | 0.004190 | | | | 0.010708 |
| | NNW | | 0.006518 | 0.000931 | | | | 0.007449 |

**Table TR RAI 2.5-3-5: 4th Quarter (October 1, 2007 to December 31, 2007) Joint Frequency Distribution (Cont.)**

| Stability Class | Wind Direction | Wind Speed (mph) - Fall (Calm = 2.14%) | | | | | | Row Total |
|---|---|---|---|---|---|---|---|---|
| | | < 3 | 4 - 7 | 8 - 12 | 13 - 18 | 19 - 24 | > 24 | |
| D | N | 0.011293 | 0.012570 | 0.000931 | 0.000466 | | | 0.025259 |
| | NNE | 0.011784 | 0.003724 | 0.001862 | | | | 0.017370 |
| | NE | 0.001964 | 0.002328 | 0.001862 | 0.000931 | | | 0.007085 |
| | ENE | 0.001473 | 0.004190 | 0.007449 | 0.008845 | 0.002328 | | 0.024285 |
| | E | 0.004910 | 0.006983 | 0.014432 | 0.013966 | | | 0.040292 |
| | ESE | 0.001964 | 0.006983 | 0.006052 | 0.004655 | | | 0.019655 |
| | SE | 0.000491 | 0.003259 | 0.004190 | 0.002328 | | | 0.010268 |
| | SSE | 0.004910 | 0.005121 | 0.005587 | 0.000931 | | | 0.016549 |
| | S | 0.005892 | 0.003724 | | | | | 0.009616 |
| | SSW | 0.004910 | 0.003259 | | | | | 0.008169 |
| | SW | 0.002946 | 0.000466 | 0.000466 | 0.000931 | | | 0.004808 |
| | WSW | 0.005892 | 0.002793 | 0.000466 | 0.001397 | 0.000466 | 0.000466 | 0.011478 |
| | W | 0.004419 | 0.003724 | 0.001397 | 0.002328 | 0.001862 | | 0.013730 |
| | WNW | 0.006383 | 0.010708 | 0.019553 | 0.014898 | 0.004190 | 0.000466 | 0.056197 |
| | NW | 0.008838 | 0.020950 | 0.035382 | 0.031192 | 0.016294 | 0.003259 | 0.115914 |
| | NNW | 0.009820 | 0.020019 | 0.006983 | 0.002793 | 0.001862 | | 0.041477 |
| E | N | 0.012766 | 0.010708 | 0.000931 | | | | 0.024404 |
| | NNE | 0.004910 | 0.002793 | | | | | 0.007703 |
| | NE | 0.002946 | 0.003724 | | | | | 0.006670 |
| | ENE | 0.003437 | 0.003259 | 0.001862 | | | | 0.008558 |
| | E | 0.000491 | 0.006052 | 0.003259 | | | | 0.009802 |
| | ESE | | 0.005587 | 0.001862 | | | | 0.007449 |
| | SE | 0.000982 | 0.005587 | 0.001397 | | | | 0.007965 |
| | SSE | | 0.008380 | 0.000931 | | | | 0.009311 |
| | S | 0.000491 | 0.001397 | | | | | 0.001888 |
| | SSW | 0.000491 | | | | | | 0.000491 |
| | SW | | 0.001397 | | | | | 0.001397 |
| | WSW | 0.000982 | 0.000931 | | | | | 0.001913 |
| | W | 0.001473 | 0.002793 | | | | | 0.004266 |
| | WNW | 0.003437 | 0.005587 | 0.004190 | | | | 0.013213 |
| | NW | 0.001964 | 0.010242 | 0.004655 | | | | 0.016862 |
| | NNW | 0.008838 | 0.013966 | 0.004655 | | | | 0.027460 |
| F | N | 0.030932 | 0.005121 | | | | | 0.036053 |
| | NNE | 0.024058 | 0.006052 | | | | | 0.030110 |
| | NE | 0.017675 | 0.001862 | | | | | 0.019538 |
| | ENE | 0.005401 | 0.004190 | | | | | 0.009591 |
| | E | 0.008347 | 0.002793 | | | | | 0.011140 |
| | ESE | 0.008838 | 0.002328 | | | | | 0.011165 |
| | SE | 0.004910 | 0.004190 | | | | | 0.009100 |
| | SSE | 0.014239 | 0.002793 | | | | | 0.017032 |
| | S | 0.010802 | 0.003259 | | | | | 0.014060 |
| | SSW | 0.009820 | 0.001862 | | | | | 0.011682 |
| | SW | 0.008838 | 0.003259 | | | | | 0.012097 |
| | WSW | 0.009329 | 0.002328 | | | | | 0.011656 |
| | W | 0.009329 | 0.004190 | | | | | 0.013519 |
| | WNW | 0.015220 | 0.003724 | | | | | 0.018945 |
| | NW | 0.017675 | 0.004190 | | | | | 0.021865 |
| | NNW | 0.031423 | 0.009777 | | | | | 0.041199 |

2,148 valid hours out of 2,208

***TR RAI 2.5-4***

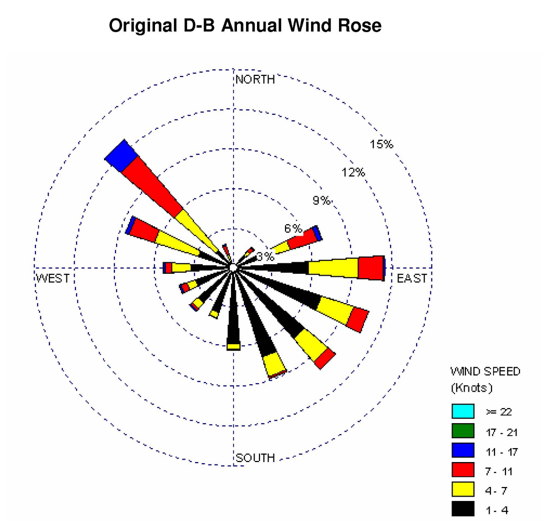
***Consistent with Regulatory Guide 3.63, please provide an annual wind rose summary for the 16 compass directions for the project site.***

**TR RAI 2.5-4 Response**

Wind roses were originally generated for the project area based on hourly average wind speeds and directions (SDSU, 2011). Hourly averages were computed from the 5-minute averages recorded by the data logger. Wind speeds were logged in miles per hour (mph), while 5-minute wind directions were logged as azimuth angles, in degrees clockwise from north. The hourly average wind direction computation was necessitated by the fact that the hourly averages supplied by the data logger contained only categorical wind directions (N, NNE, NE, etc.). Upon re-evaluation of the data, it was determined that the wind directions were incorrectly computed as arithmetic averages of the 5-minute directions. The following describes how the wind directions in the TR were incorrect and provides revised wind direction data and wind roses. The revised wind direction data and wind roses will be incorporated into Section 2.5 of the revised TR.

The correct method of calculating wind direction requires computation of vector averages and can lead to different results than wind directions calculated using an arithmetic average, particularly for winds trending out of the north. To illustrate, if half of the 5-minute averages for a particular hour show 359º and the other half show 1º, the vector average will produce 0º (true north) while the arithmetic average will produce 180º (true south). The result of this error was a wind rose that under-accounted for northerly winds and over-accounted for southerly winds (Figure TR RAI 2.5-4-1).

**Figure TR RAI 2.5-4-1: Original Dewey-Burdock Annual Wind Rose**




Source: TR Appendix 2.5-C

Figure TR RAI 2.5-4-2 contains the adjusted annual wind rose for Dewey-Burdock at the 10-meter height, based on vector averaging of the 5-minute wind directions. It resembles Figure TR RAI 2.5-4-1, except for the NNW, N, NNE, and S directions.

Figures TR RAI 2.5-4-3 through TR RAI 2.5-4-6 show the quarterly wind roses for the Dewey-Burdock project area, also at the 10-meter height. The period from January through March was used for the 1st Quarter, April through June for 2nd Quarter, July through September for 3rd Quarter and October through December for 4th Quarter. The summer wind rose reflects hourly data from both 2007 and 2008.

Joint wind data recovery at the Dewey-Burdock 10-meter height was approximately 87% for the baseline monitoring year, compared to the Regulatory Guide 3.63 recommendation of 75% for joint data recovery. Most of the invalid records occurred in the six weeks after the station began operating (late July and August 2007). Data recovery at the 3-meter height was over 99% for the year. To verify that the missing data at 10 meters did not significantly skew the wind analysis, an annual and a summer wind rose were generated for the 3-meter level. Figure TR RAI 2.5-4-7 compares the annual wind roses at 3 and 10 meters, while Figure TR RAI 2.5-4-8 compares the summer wind roses. For each period, the wind directions are distributed similarly at both heights. The principal differences can be explained by the normal increase in wind speeds with height, and by the greater frequency of winds from the regionally dominant (northwesterly) direction at 10 meters.

Figure TR RAI 2.5-4-2: Corrected Dewey-Burdock Annual Wind Rose

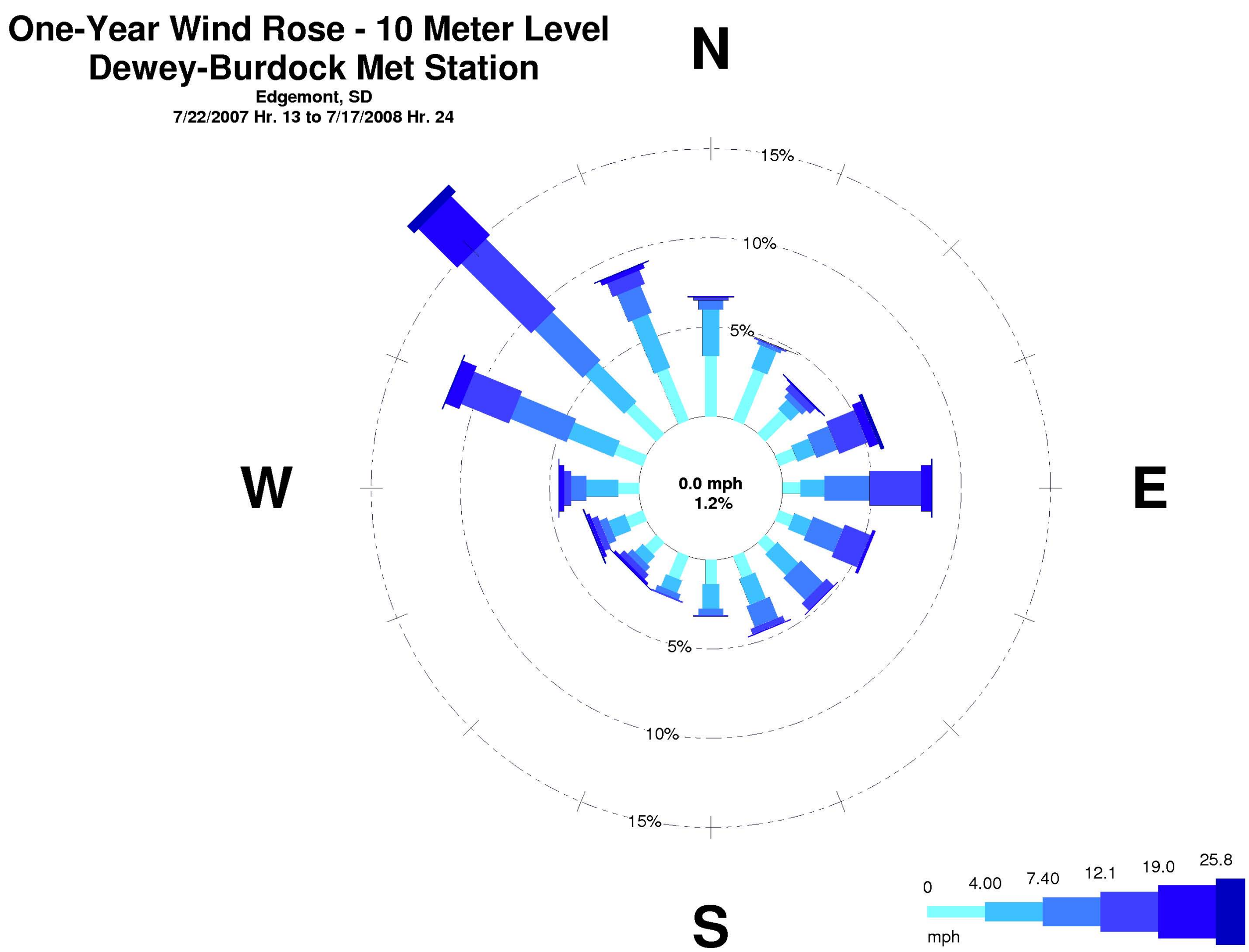
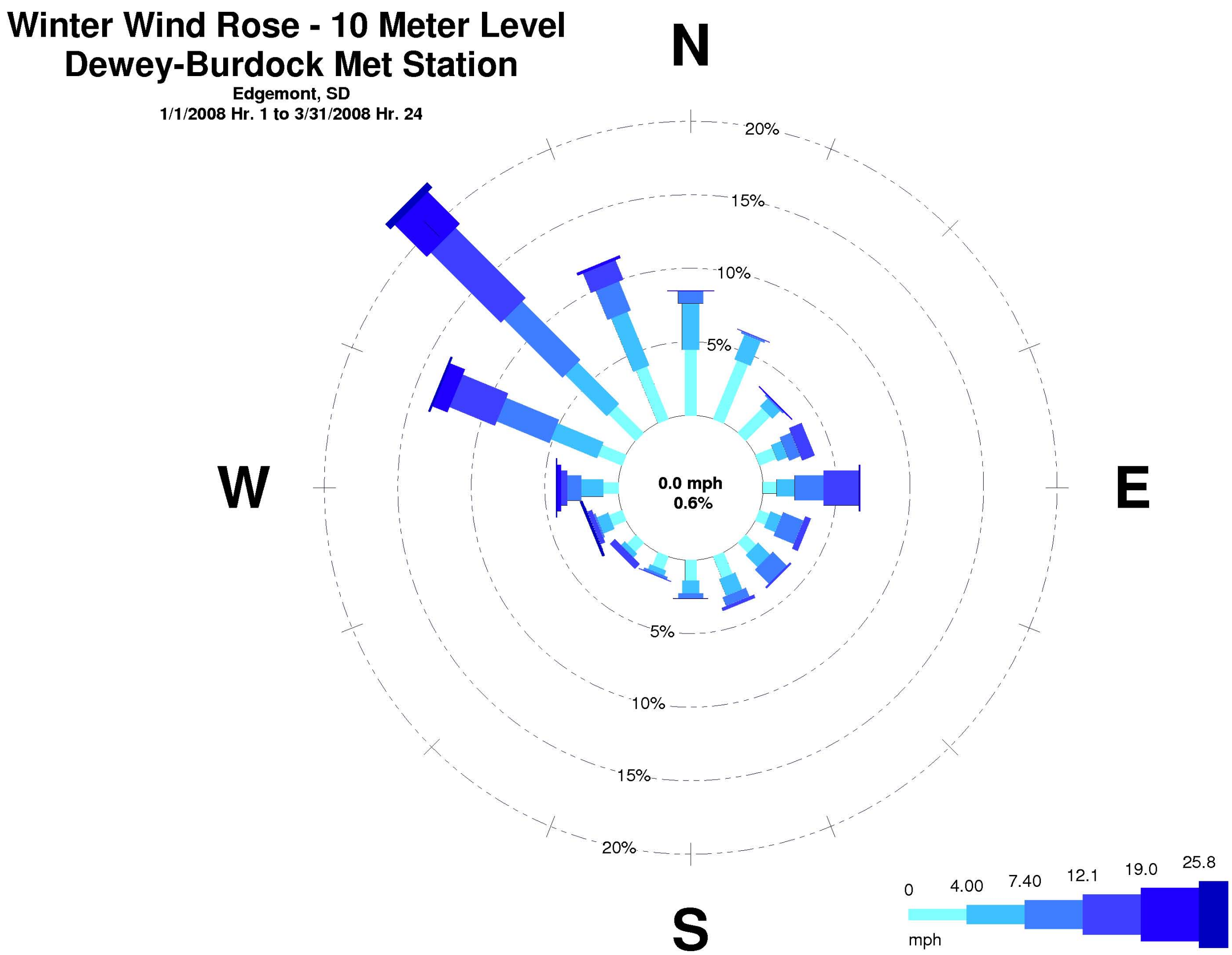
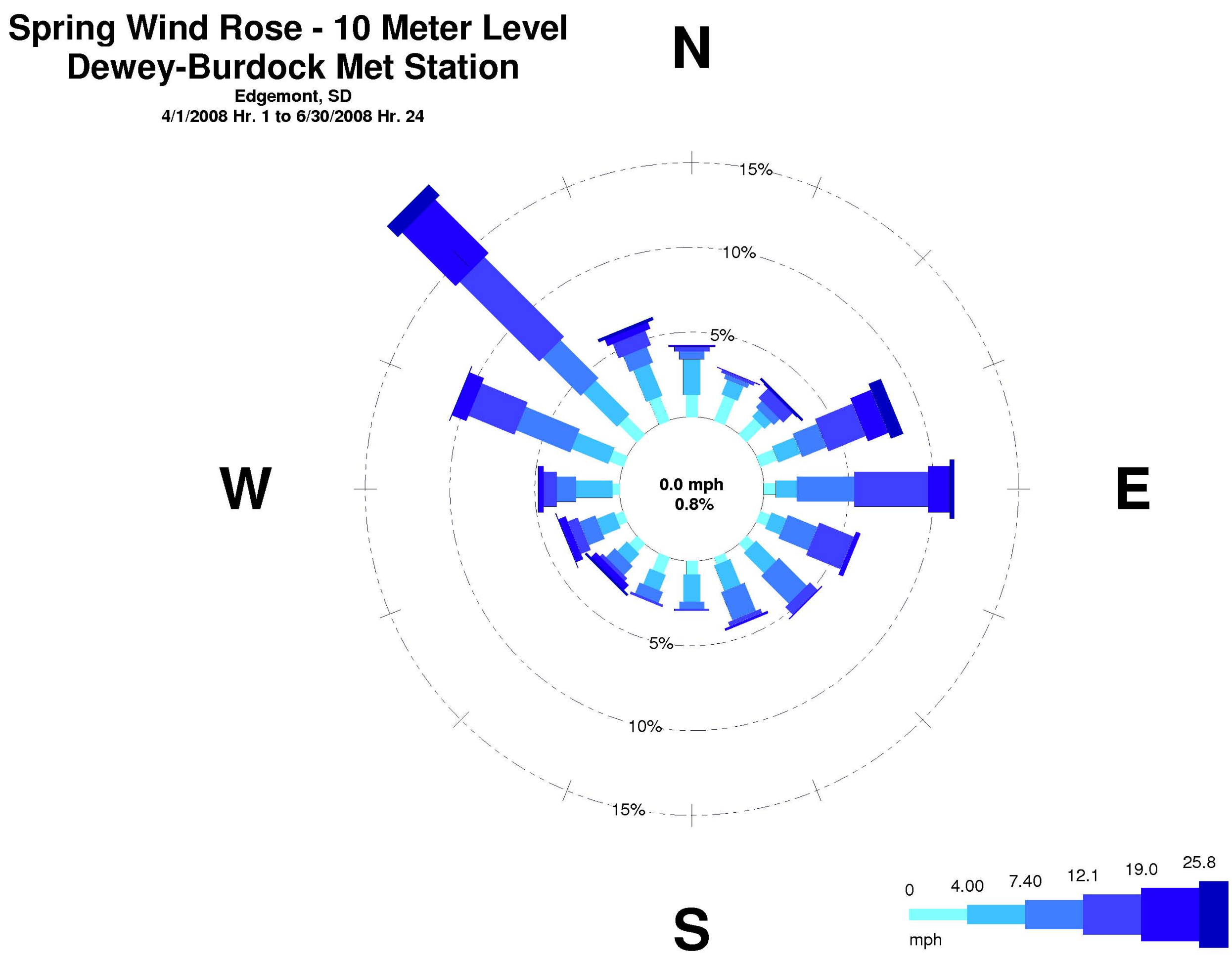


**Figure TR RAI 2.5-4-3: Corrected Dewey-Burdock 1st Quarter Wind Rose**



Powertech (USA) Inc.

**Figure TR RAI 2.5-4-4: Corrected Dewey-Burdock 2nd Quarter Wind Rose**



POWERTECH (USA) INC.

**Figure TR RAI 2.5-4-5: Corrected Dewey-Burdock 3rd Quarter Wind Rose**

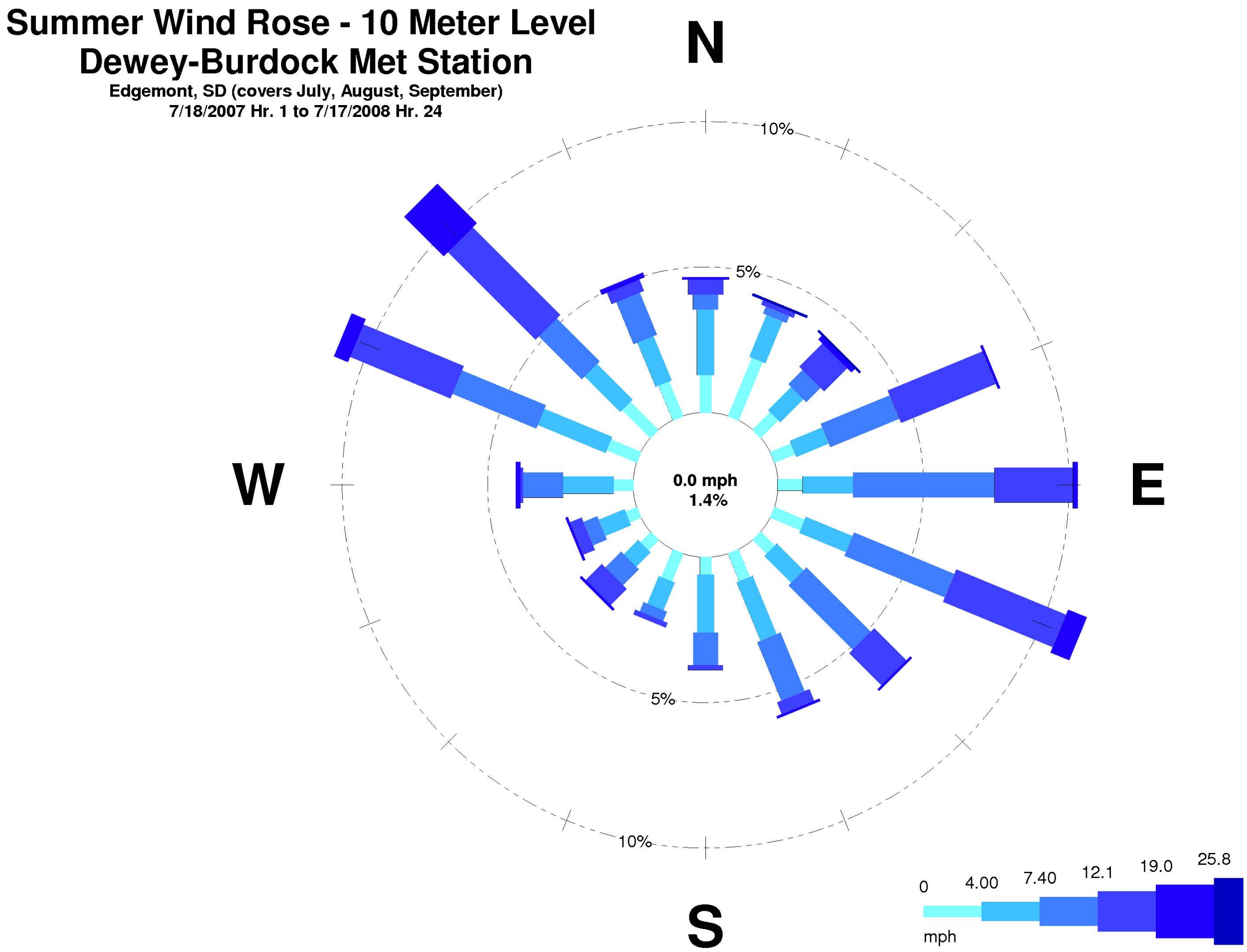


**Figure TR RAI 2.5-4-6: Corrected Dewey-Burdock 4th Quarter Wind Rose**

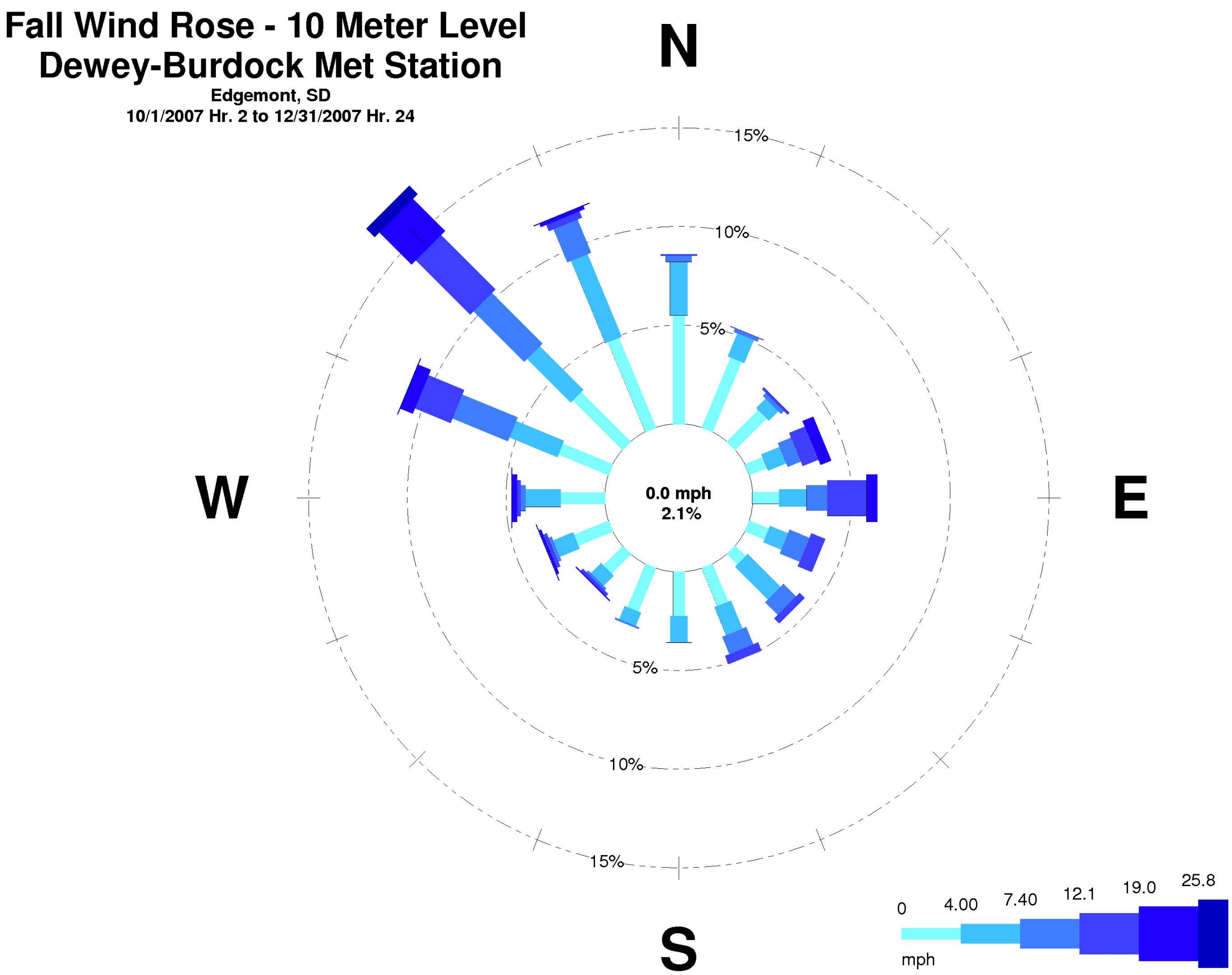
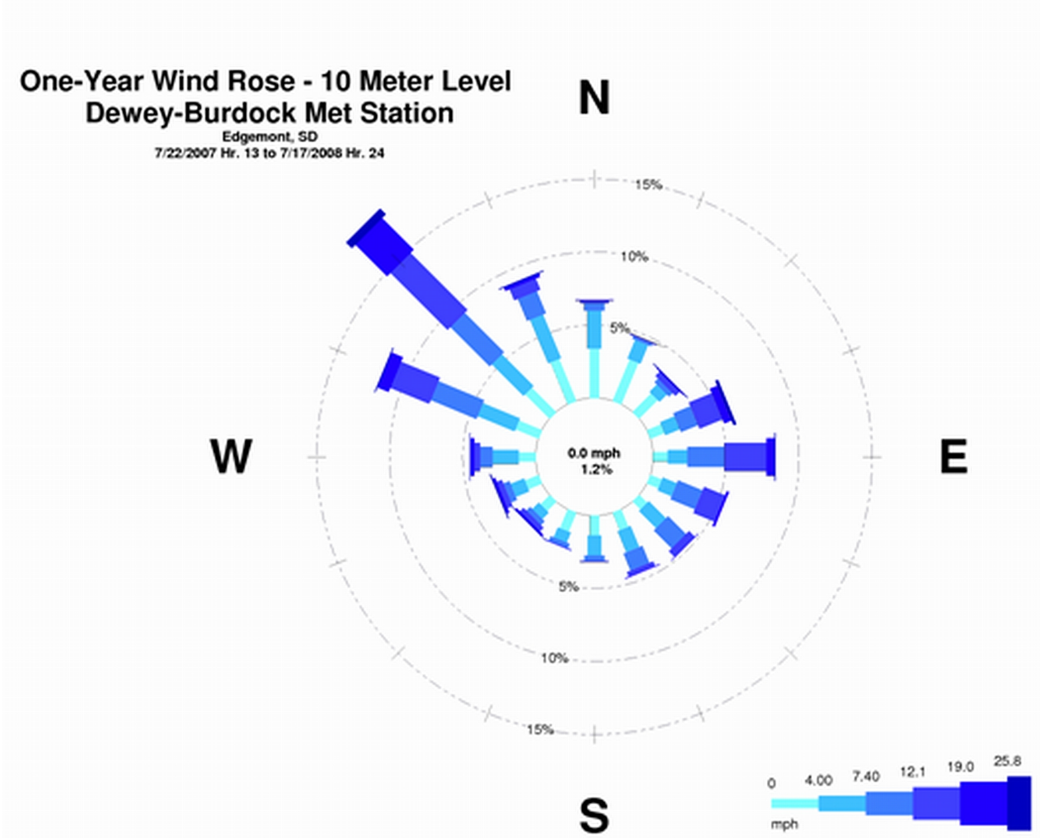
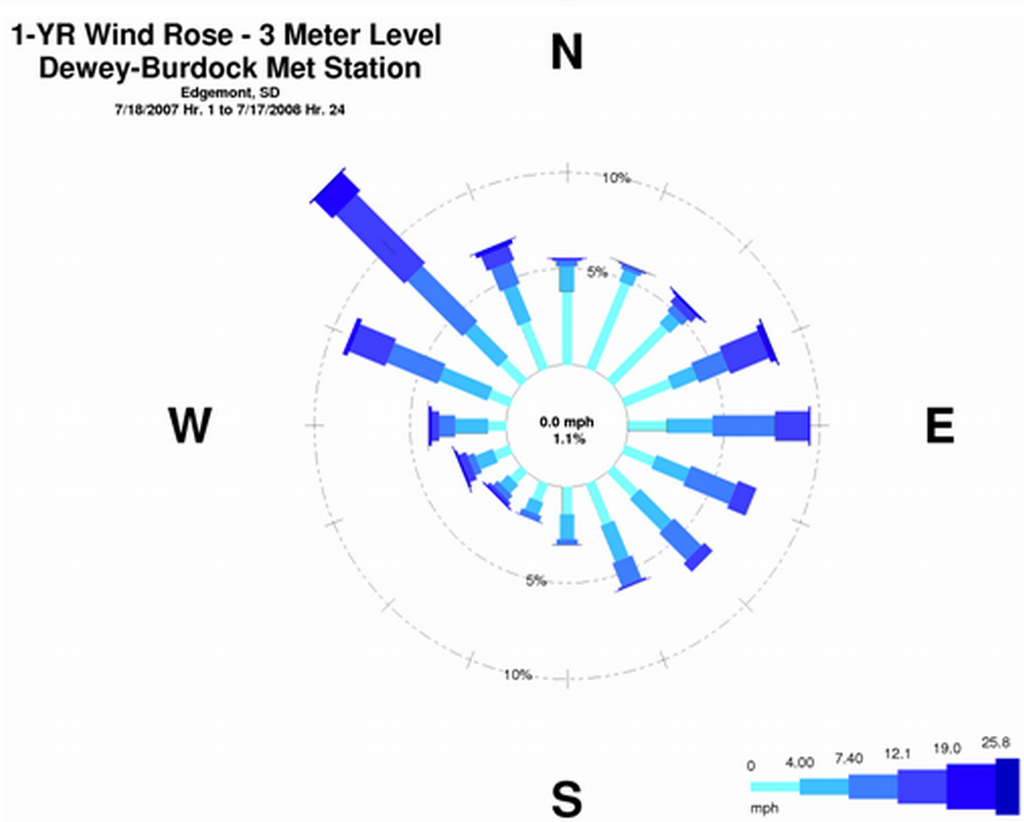


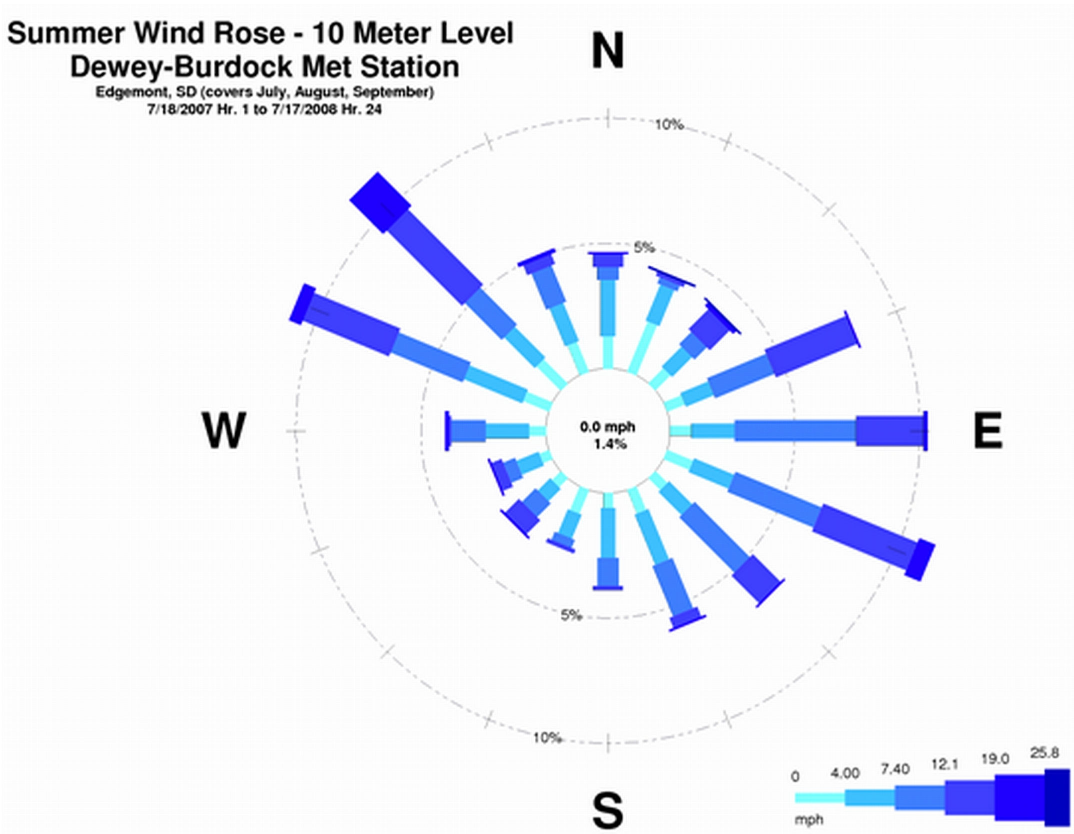
**Figure TR RAI 2.5-4-7: Dewey-Burdock Annual Wind Rose Comparison: 10m vs. 3m**

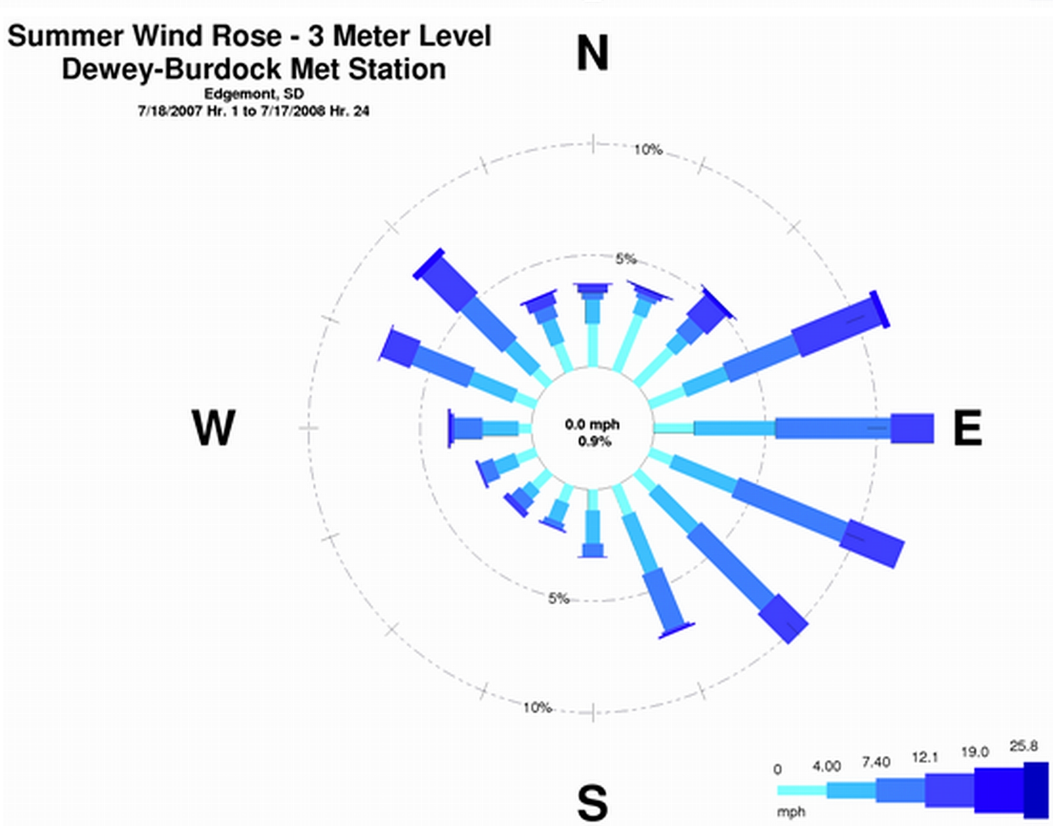


Powertech (USA) Inc.

**Figure TR RAI 2.5-4-8: Dewey-Burdock Summer Wind Rose Comparison: 10m vs. 3m**



***TR RAI 2.5-5***

***The following questions refer to Section 2.5.3.2 (Wind Patterns) regarding the applicant's discussion of wind at the project site.***

***TR RAI 2.5-5(a)***

a. ***On page 2-83, the applicant discusses wind speed in units of miles per hour when referring to Table 2.5-7. However, the data in Table 2.5-7 (and Figures 2.5-22 and 2.5-23) are presented in units of knots. Please make units of wind speed consistent.***

**TR RAI 2.5-5(a) Response**

Section 2.5 of the TR will be revised to include a discussion of the revised atmospheric stability and joint frequency distribution, as described in the response to TR RAI 2.5-3. The revisions will include a discussion of the wind patterns observed at the project area during the monitoring period using consistent units. Consistent units of miles per hour will be used to describe wind speed throughout Section 2.5 in the revised TR. The revised TR will provide the wind data in a format that can easily be confirmed by NRC.

***TR RAI 2.5-5***

***The following questions refer to Section 2.5.3.2 (Wind Patterns) regarding the applicant's discussion of wind at the project site.***

***TR RAI 2.5-5(b)***

***b. Also on page 2-83, the applicant discusses wind data for the months of May and December. However, this data cannot be confirmed because the data in Table 2.5-7 appears to be a yearly tabulation while the data in Figures 2.5-22 and 2.5-23 are seasonal. Please provide data to confirm the applicant's statements for wind data.***

**TR RAI 2.5-5(b) Response**

Section 2.5 of the TR will be revised to include a discussion of the revised atmospheric stability and joint frequency distribution, as described in the response to TR RAI 2.5-3. The revisions will include a discussion of the wind patterns observed at the site during the monitoring period. The revised annual and quarterly joint frequency distribution tables, included in the response to TR RAI 2.5-3, will be included in the revised TR. The revised TR will provide the wind data in a format that can readily be confirmed by NRC.

***<u>TR RAI 2.5-6</u>***

***Figures 2.5-22 and 2.5-23 summarize seasonal wind patterns on wind roses. Please specify the location and months included in each seasonal wind rose on the legend and/or titles of the figures.***

**<u>TR RAI 2.5-6 Response</u>**

Figures 2.5-22 and 2.5-23 in the TR have been replaced by Figures TR RAI 2.5-4-3 through TR RAI 2.5-4-6 in the response to TR RAI 2.5-4. The revised figures show the quarterly wind roses for the Dewey-Burdock project area at the 10-meter height. The period from January through March was used for the 1$^{st}$ Quarter, April through June for 2$^{nd}$ Quarter, July through September for 3$^{rd}$ Quarter and October through December for 4$^{th}$ Quarter. The 3$^{rd}$ quarter wind rose reflects hourly data from both 2007 and 2008.

***TR RAI 2.5-7***

***Regulatory Guide 3.63 recommends that an indication of the atmospheric stability can be obtained by a method such as isolation-cloud cover and wind speed (Pasquill-Gifford and similar methods), temperature lapse rate method, wind fluctuation method, split-sigma method, or Richardson Number. Please explain the method by which the applicant obtained the atmospheric stability.***

**TR RAI 2.5-7 Response**

Please refer to the response to TR RAI 2.5-3 for a detailed description of the method used to calculate atmospheric stability at the Dewey-Burdock project area. The method discussed in the TR was re-evaluated and determined to be inadequate since delta temperature was not measured at the site. The method described in the response to TR RAI 2.5-3 was determined to be the most accurate in determining daytime and nighttime atmospheric stability. Section 2.5 of the TR will be revised to incorporate the method and results included in the response to TR RAI 2.5-3.

***TR RAI 2.5-8***

***Consistent with Regulatory Guides 3.63, 3.46 and NUREG-1569, Acceptance Criterion 2.5.3(1), please provide a discussion of wind stability class and average inversion height in the description of the local meteorological conditions.***

**TR RAI 2.5-8 Response**

Please refer to the response to TR RAI 2.5-3 for a detailed description of the method used to calculate atmospheric stability at the Dewey-Burdock project area. The method discussed in the TR was reevaluated and determined to be inadequate since delta temperature was not measured at the site. The method described in the response to TR RAI 2.5-3 was determined to be the most accurate in determining both daytime and nighttime atmospheric stability. Section 2.5 of the TR will be revised to incorporate the method and results included in the response to TR RAI 2.5-3.

The following discussion of mixing height will be incorporated into Section 2.5 of the revised TR.

Mixing height is the height of the atmosphere above the ground that is well mixed due either to mechanical turbulence or convective turbulence. The air layer above this height is stable. Higher mixing heights are associated with greater dispersion, all other parameters being the same. Stable periods have much lower mixing heights and accompanying lapse rates allowing for less temperature variation. The MILDOS-AREA model uses mixing height, along with other wind parameters, to predict pollutant dispersion. Unstable air leads to more dispersion, which leads to lower predicted impacts on ambient air quality.

The default mixing height of 100 meters was used for Dewey-Burdock MILDOS-AREA modeling. This is very conservative given that both morning and afternoon mixing heights at Rapid City, SD averaged much higher. Table TR RAI 2.5-8-1 provides these average mixing heights, computed from upper air and surface data at the Rapid City Airport, which is the closest site to the project area with upper air data.

**Table TR RAI 2.5-8-1: Rapid City Airport Mixing Height Averages, 1984-1991**

| Averaging Period | Morning | Afternoon |
|---|---|---|
| Average Mixing Height (meters) | 333 | 1,547 |

For comparison purposes, average mixing heights were derived from the AERMOD calculations used for dispersion modeling, based on hourly data obtained from the NWS stations in Rapid City (upper air), Custer, and the local Edgemont station. The AERMOD calculation is based on a combination of mechanically and convectively driven boundary layer processes. The results of these calculations are provided on a quarterly basis in Table TR RAI 2.5-8-2. The annual average mixing height is 1,110 meters, an order of magnitude higher than the default used for modeling.

**Table TR RAI 2.5-8-2: Quarterly Mixing Height Averages**

| | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
|---|---|---|---|---|
| Average Mixing Height (m) | 936 | 1,285 | 1,382 | 839 |

***<u>TR RAI 2.5-9</u>***

***Consistent with Regulatory Guide 3.63, please provide threshold values for the meteorological instruments measuring wind direction and wind speed.***

**<u>TR RAI 2.5-9 Response</u>**

Table TR RAI 2.5-9-1 lists the specifications of the instruments installed at Dewey-Burdock, including the threshold values. The table will be incorporated into the revised TR.

**Table TR RAI 2.5-9-1: Dewey-Burdock Meteorological Instrumentation and Specifications**

| Instrument | Model | Manufacturer | Accuracy/Threshold | Operating Temperature | Required Standard |
|---|---|---|---|---|---|
| Precipitation | VR6101 | Vaisala | 0.01 inch/0.01 inch | -40°C to 60°C | 0.1 inch |
| Wind Direction | 024A | Met-One | ±5 degrees/1 mph | -50°C to 70°C | ±5 degrees |
| Wind Speed | 014A | Met-One | 0.25 mph/1 mph | -50°C to 70°C | 1.0 mph |
| Temperature and RH | HMP45C | Vaisala | Temp: ±2% for 10-90% RH: ±3% of 90-100% RH | -40°C to 60°C | Consistent with current state of the art |
| Solar Radiation | LI200X | Lt-Cor | Absolute error in natural daylight is ±5% max; ±3% typical | -40°C to 65°C | Consistent with current state of the art |

***TR RAI 2.5-10***

***Regulatory Guide 3.63 recommends that meteorological systems should be inspected at least once every 15 days and serviced at a frequency that will minimize extended periods of outage and ensure an annual data recovery of at least 90% for each individual parameter measured (at least an annual 75% joint data recovery for wind speed, wind direction, and atmospheric stability). Please demonstrate that the applicant's system maintenance and servicing schedule during the onsite data collection period is consistent with Regulatory Guide 3.63 or provide justification for an alternate methodology.***

**TR RAI 2.5-10 Response**

The following describes the operation of the meteorological station at the Dewey-Burdock project area, installed as part of the baseline monitoring program. As described in the response to TR RAI 2.5-2, the meteorological station was configured and installed by the South Dakota Office of Climatology at South Dakota State University. According to State Climatologist Dennis Todey, the automated weather station at Dewey-Burdock was installed at the request of Powertech and is part of the South Dakota Automated Weather Data Network (AWDN), one of 40 stations currently in operation across the state. The following information will be included in Section 2.5 of the revised TR.

All instruments were factory-calibrated prior to installation. Both the Met-One wind speed sensor and the Met-One wind direction sensor have an operating threshold of 1.0 mph (0.45 m/sec). No instrument audits or re-calibrations were performed at the Dewey-Burdock weather station during the baseline monitoring year. Data quality control during the baseline monitoring period was conducted by comparing hourly averages to nearby stations. In a letter from Dr. Todey to Powertech, included in Appendix 2.5-F, it was reported that no data quality issues were detected that would have required a special site visit.

During the baseline year, wind data recovery was 87% at the 10-meter level and 99.7% at the 3-meter level. Temperature data recovery was 97.5%, relative humidity data recovery was 100%, and solar radiation data recovery was 99.8%.

***<u>TR RAI 2.5-11</u>***

***Regulatory Guide 3.63 recommends that meteorological systems be calibrated at least semiannually to ensure that the system accuracies in this guide are met. Please demonstrate that the applicant's calibration program during the onsite data collection period is consistent with Regulatory Guide 3.63 or provide justification for an alternate methodology.***

**<u>TR RAI 2.5-11 Response</u>**

The following information will be incorporated into the revised TR.

Please refer to the response to TR RAI 2.5-10 for a discussion of the operation of the meteorological station installed at the Dewey-Burdock project area, including system maintenance. The instruments were factory calibrated prior to installation and verified remotely throughout the monitoring period. Although no instrument audits or re-calibrations were performed, the operator (South Dakota State University) did not detect any anomalies throughout the monitoring period.

## ***Geology and Seismology***

***TR RAI 2.6-1***

***Figure 2.2-3 in the TR indicates that the Newcastle Sandstone may be 0 to 150 feet thick in the Black Hills area. Sections 2.6.2.2 and 2.7.2.2.6 of the TR provide conflicting site information concerning the presence of the Newcastle Sandstone within the overlying confining unit (Graneros Group). NRC staff requests that the application clarify the presence or absence of the Newcastle Sandstone at the project site.***

**TR RAI 2.6-1 Response**

The Newcastle Sandstone is present in the region but not in the Dewey-Burdock project area. The Newcastle Sandstone was not deposited within and adjacent to the Dewey-Burdock project area. The following information will be included in the revised TR.

There is no Newcastle Sandstone on the surface or in the subsurface within the Dewey-Burdock project area. Figure 2.2-3 of the TR, entitled "Stratigraphic Column of the Black Hills Area," shows the regional presence of this unit. While the Newcastle Sandstone is present within the Graneros Group regionally, there are areas, including the Dewey-Burdock project area, where it is absent. As shown on TR Figure 2.2-3, the Newcastle Sandstone is equivalent to the Muddy Sandstone, which is a prolific oil producer in much of Wyoming and Colorado. Because the Muddy Sandstone (or its equivalent) has been the target of extensive oil & gas exploratory drilling, its regional presence (or absence) in the subsurface has been well delineated. Drilling on the Dewey-Burdock project area has encountered no Newcastle Sandstone. Geologic cross sections H-H' and J-J' (Exhibits 2.7-h and 2.7-j), referenced in the response to TR RAI P&R-1 and included with this response package, illustrate the geologic sections where, if present, the Newcastle Sandstone would occur. On these sections, a 400-foot thickness of low-permeability Graneros Group shale is shown overlying the Fall River Formation. The lower 200 feet of the Graneros Group is made up of the Skull Creek Shale. If present, the Newcastle Sandstone would immediately overlie this shale unit. However, as shown on the cross sections, there is no sandstone in this interval; instead, the Mowry Shale overlies the Skull Creek Shale.

***TR RAI 2.6-2***

***NRC staff notes that the U.S. Geological Survey's Burdock Quadrangle (Schnable, 1963) shows the presence of the Minnewaste Limestone where it outcrops east of the license area. The application indicates that the Minnewaste unit is not present at the site. Please further clarify where the Minnewaste Limestone may be present within the license area (i.e., using logs and other site data). If present, please provide a description of the unit and any anticipated affects the unit may have on the proposed operations.***

**TR RAI 2.6-2 Response**

The following discussion will be added to the revised TR to clarify that the Minnewaste Limestone is not present within the project area.

Although present regionally, the Minnewaste Limestone Member of the Lakota Formation is not present within the Dewey-Burdock project area. Darton (1909) noted that the Minnewaste Limestone is some 20 feet thick at its type locality at the falls of the Cheyenne River (25 miles east of the project area, now under Angostura Reservoir. In USGS Professional Paper 763 (Gott et al., 1974), the Minnewaste Limestone is described in the type locality as being a pure limestone, but grading out laterally to a sandy limestone and to a calcareous sandstone at its margins. Gott et al. also state that it is discontinuous west and northwest of the type locality (toward the Dewey-Burdock project area).

A review of all drill hole and geologic lithology logs shows the Minnewaste Limestone does not occur within the project area. Geologic cross section E-E' (Exhibit 2.7-1e), along the northeastern portion of the project area, illustrates the geologic section where, if present, the Minnewaste Limestone would occur. If present, this limestone unit would occur immediately beneath the Fuson Shale confining unit and above the Chilson Member of the Lakota Formation. A limestone would have a characteristically high (off-scale) response on the resistivity curve on the electric logs. As shown on cross section E-E' (Exhibit 2.7-1e), no limestone is present.

***TR RAI 2.6-3***

***NRC staff notes that the description of the geochemistry of the ore zones is limited. The applicant's description did not sufficiently describe site-specific minerals in the clays, silts, and carbonaceous media that are present in the ore zones of the two sub-aquifers of the Inyan Kara. Also, the applicant did not provide a sufficient description of the geochemistry associated with site specific mineralogy, common ions present, and oxidation-reduction conditions. NRC staff requests a further description of the mineralogy and associated geochemistry of the mineralized zones consistent with NUREG 1569, which states, "A geologic and geochemical description of the mineralized zone and the geologic units immediately surrounding the mineralized zone is provided."***

**TR RAI 2.6-3 Response**

The following information will be included in the revised TR.

Uranium deposits within the project are classic, sandstone, roll-front type deposits, located along oxidation-reduction boundaries, similar to those in Wyoming, Nebraska and Texas. These type deposits are usually “C” shaped in cross section, with the concave side of the deposit facing up-dip, toward the outcrop. Roll-front deposits are a few tens of feet to 100 or more feet wide and often thousands of feet long. It is generally believed these epigenetic uranium deposits are the result of uranium minerals leached from the surface environment, transported down-gradient by oxygenated groundwater and precipitated in the subsurface upon encountering a reducing environment at depth. These roll-front deposits are centered at and follow the interface of naturally occurring chemical boundaries between oxidized and reduced sands (See Figure TR RAI 2.6-3-1). Roll-front deposits similar to those in the Dewey-Burdock project area are generally described in the ISR GEIS, NUREG-1910, Section 2.1.2.

Within the project area, roll-front deposits occur at depths of less than 100 feet in the outcrop area of the Fall River Formation and at depths of up to 800 feet in sands of the Chilson Member of the Lakota Formation in the northwestern part of the project area. The mineralized sandstones are typically fine to medium grained quartz sands that are moderately to very well sorted and show subangular to subrounded grain angularity. Scattered pyrite concretions up to 1" in diameter are sometimes present as are very thin carbonaceous stringers and very well cemented calcite zones. The average thickness of this mineralization is 4.6 feet and the average grade is 0.21 percent $U_3O_8$ in the project area.

There is a geochemical “footprint” associated with these uranium roll-front systems, consisting of 1) a reduced zone, 2) an oxidized zone, and 3) an ore zone. The following is a geological and geochemical description of each of these zones for uranium deposits within the Dewey-Burdock project area. Information included in this description was obtained from a 1971 petrographic study of core from the Dewey portion of the project area by Homestake-Wyoming Partners utilizing microscopic, thin section, polished section, X-ray powder diffraction and spectrographic analyses (Honea, 1971).

**Reduced Zone** – This zone represents the original character of the Inyan Kara sediments, unaffected by any mineralizing events. Today, it is the unaltered portion of the system, ahead of or down-gradient of the roll front. Reduced sandstones are grey in color, pyritic and/or carbonaceous. Organic material consists of carbonized wood fragments and interstitial humates. Pyrite is abundant within the host sandstones and present as very small cubic crystals or as very fine grained aggregates. Marcasite is also present as nodular masses in the sandstones. This disseminated pyrite resulted from replacement of original iron (magnetite or similar minerals) and organic material. This early-stage pyrite precipitation contains trace amounts of transition metals (Cu, Ni, Zn, Mo and Se) and resulted from either biogenic (bacterial) or inorganic reduction of groundwater sulfate. Plagioclase and potassium feldspar clasts are fresh and, with the exception of localized areas of calcite cementing, calcite is sparse - averaging only 0.15%. A heavy mineral suite (ranging from trace to 3%) of tourmaline, ilmenite, apatite, zircon and garnet is typical of those found in mature, siliceous sandstones.

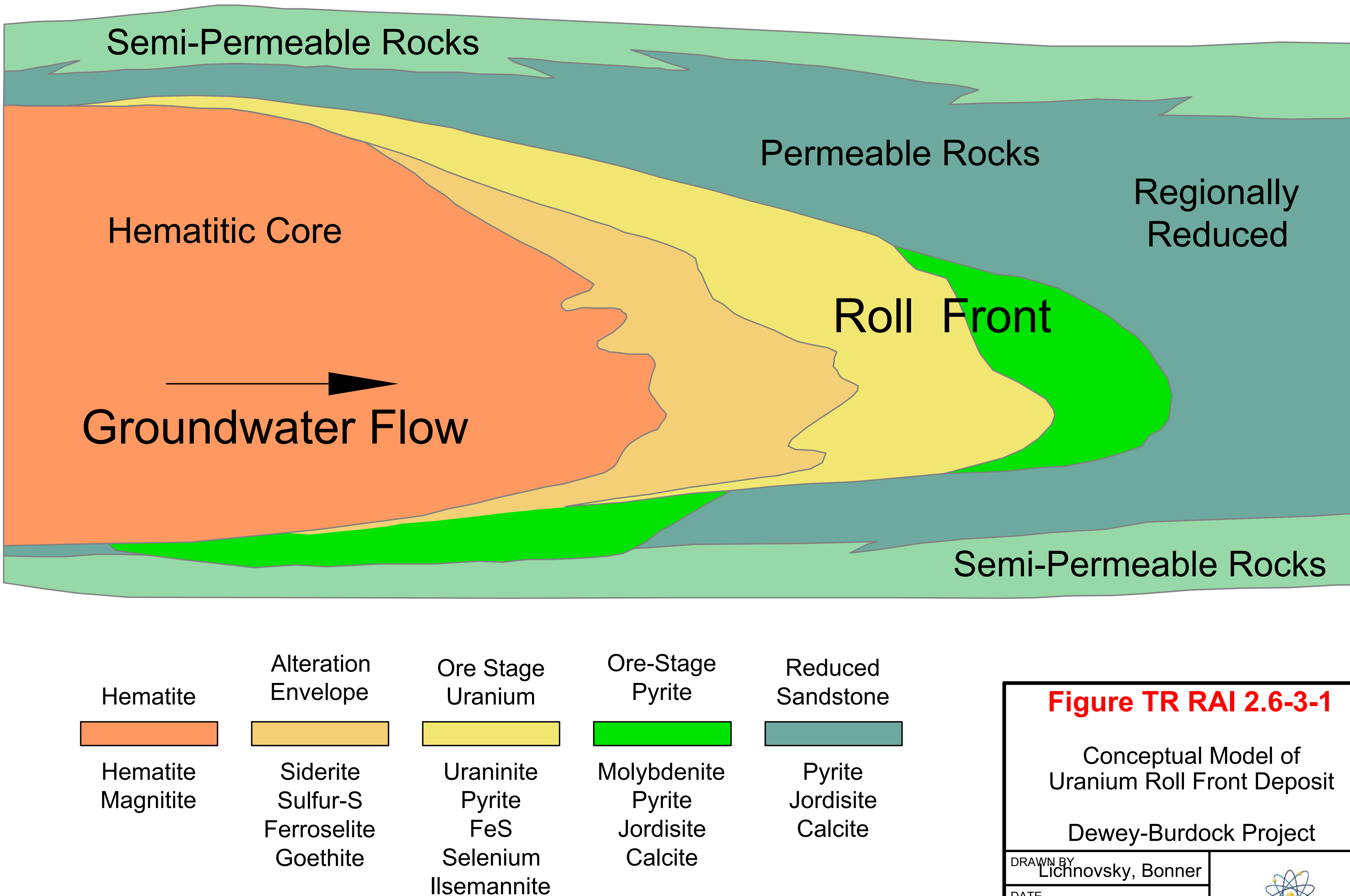
**Oxidized Zone** – This portion of the system, behind or upgradient of the roll front, is characterized by the presence of iron oxides resulting in a brown, pink, orange or red staining of host sandstones. The oxidized zone marks the progression of the down-gradient movement of mineralizing solutions through the host sandstones. Within the oxidized zone, original iron has been altered and is present as hematite or goethite as grain coatings, clastic particles or as pseudomorphs after original pyrite. Goethite is considered to be metastable and is found near the oxidation/reduction boundary, while the more stable hematite is found greater distances upgradient from the roll front. The heavy mineral leucoxene – a white titanium oxide, is also present as a pseudomorph of ilmenite. All organic material has been destroyed in the oxidized zone, where quartz particles will show solution or etching effects and feldspars have been replaced with clays.

In the oxidation process of the original pyrite, it is believed the transition metals (Cu, Ni, Zn, Mo and Se) were liberated and incorporated into the mineralizing solution. This solution was slightly alkaline, initially having a positive oxidation potential. Uranium was in solution as the anionic uranyl dicarbonate complex. Other metals associated with uranium were also carried in anionic complexes. Within the project area, the oxidized zone in Inyan Kara sands has been mapped over a lateral distance of 15 miles and found to extend up to 4-5 miles down-dip from the outcrop.

**Ore Zone** – This portion of the system is located at the oxidation/reduction boundary where metals were precipitated when mineralizing solutions encountered a steep Eh (oxidation/reduction potential) gradient and a strongly negative oxidation potential. Sandstones in this zone are greenish-black, black, or dark grey in color. The primary uranium minerals are uraninite and coffinite, which occur interstitial to and coating sand grains and as intergrowths with montroseite (VO(OH)) and pyrite. Other vanadium minerals (haggite and doloresite) are found adjacent to the uranium mineralization, extending up to 500 feet into the oxidized portion of the system. Overall, the V:U ratios can be as high as 1.5:1. The high concentrations of uranium and vanadium within the ore zone indicate the original source of these metals was external to the Inyan Kara sediments.

Transition metals were also precipitated at or adjacent to the oxidation/reduction boundary. Native arsenic and selenium are found adjacent to the uranium, in the oxidized portion of the front - filling pore spaces between quartz grains. Molybdenum is found as jordisite adjacent to the uranium on the reduced portion of the front. The relatively low concentrations of transition metals indicate their source could have been internal to the Inyan Kara sediments rather than having been introduced from overlying tuffaceous material which is believed to be the source of the uranium and vanadium.

Late stage deposition of calcite and pyrite also appear to be part of the ore-forming process. Filling of pore spaces by nodular and concretionary calcite is found with the uranium mineralization and extending out into the reduced portion of the front. It is believed that uranium was transported as a uranyl dicarbonate complex and carbonate deposition took place along with the precipitation of uranium. Late stage, coarse grained, nodular or concretionary pyrite is also found associated with uranium ore and adjacent to the uranium in the reduced portion of the front.




Source: Uranium Geology and Exploration, 1978, Richard H. DeVoto

**Figure TR RAI 2.6-3-1**

Conceptual Model of Uranium Roll Front Deposit

Dewey-Burdock Project

| | |
|---|---|
| DRAWN BY | Lichnovsky, Bonner |
| DATE | 21-Jun-2011 |
| FILENAME | Figure TR RAI 2.6-3-1.dwg |

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***TR RAI 2.6-4***

***Page 2-15 of the TR states, "Twenty-six wells in the vicinity of the project site were deemed abandoned because of the condition and inactivity of the well; these wells termed abandoned are not considered properly plugged and abandoned." Figure 2 in Appendix 2.2-A indicates that abandoned wells 606, 636, 659, 690 are at or near proposed well field areas. NRC staff notes that the application does not contain well abandonment and plugging records for the above-referenced wells and other Appendix 2.2A abandoned wells within the license area. Consistent with Section 2.6.3 of NUREG 1569, please provide abandonment records for abandoned water wells within the license area. For abandoned water wells that cannot be documented with abandonment records, please clarify whether such wells that are located at or near well fields may potentially impact the containment of process fluids (i.e., improper well construction or poor well condition that may potentially lead to an excursion).***

**TR RAI 2.6-4 Response**

Please refer to the response to TR RAI P&R-10, which presents the updated well inventory for the project area and the surrounding 2 km area. Powertech will update Appendix 2.2-A in the revised TR to include well abandonment and well completion records, where available. Following is the currently known information about the wells referenced in this RAI and general information about how Powertech will address these and similar wells during well field design.

- Well 606: Powertech has confirmed that well 606 has been plugged and abandoned. Confirmation included visual observation that cement had been placed within the well casing.
- Well 636: Powertech has confirmed that well 636 has been plugged and abandoned. Confirmation included visual observation that cement had been placed within the well casing.
- Well 690: This is an Unkpapa well installed and used as a monitor well for the Burdock pumping test, as described in the response to TR RAI 2.7-16. Powertech assumes that the well in question is well 660, and not well 690.
- Wells 659 and 660: These wells are included on Table TR RAI P&R-10-2: Historical Wells Not Present. These wells were not present at the surface during the field investigations. Powertech will continue to investigate for these wells and design pump testing to detect any potential impacts from these wells on ISR operations as described below. Any new information regarding these wells will be reported to NRC prior to licensing, if available, or the information will be included after licensing as a part of the well field hydrogeologic data packages.

As with any other site proposed for ISR uranium recovery, historical exploration holes and wells are present within the project area. Powertech will use the best available information and best professional practices to locate boreholes or wells in the vicinity of potential well field areas, including historical records, use of color infrared imagery, field investigations, and potentiometric surface evaluation and pump testing conducted for each well field as part of the development of the well field hydrogeologic packages. As with other ISR facilities, Powertech anticipates that some unplugged holes or wells may be encountered during well field design. The procedures Powertech will use to detect and mitigate any unplugged holes or wells that have the potential to impact the control and containment of well field solutions are described in the response to TR RAI P&R-9. These include attempting to locate the wells with best professional practices, designing pump testing to detect unplugged boreholes or wells, and using best professional practices to locate, re-enter and plug boreholes and wells with cement pursuant to South Dakota requirements.

## ***Hydrology***

***TR RAI 2.7-1***

***NRC staff found the proposed satellite plant location in Figure 2.7-1 of the TR abuts the northern license boundary, where surface drainage appears to flow to the north directly outside of the license boundary. Staff notes that Exhibit 3.2-1 of the TR Supplement does not show the satellite plant to be near the proposed license boundary. Staff requests clarification of the proposed satellite plant location shown in Figure 2.7-1.***

**TR RAI 2.7-1 Response**

TR Figure 2.7-1 depicted general locations for the Dewey Satellite Facility and Burdock CPP. The proposed locations have been refined and are shown on Exhibits 3.1-2 and 3.1-3. These exhibits are included with this RAI response package and will be included with the revised TR along with a revised TR Figure 2.7-1. The Satellite Facility is proposed in the SW/4 of Section 29, T6S, R1E. Surface drainage in this area is southwest to Beaver Creek, as shown on Exhibits 3.1-2 and 3.1-3.

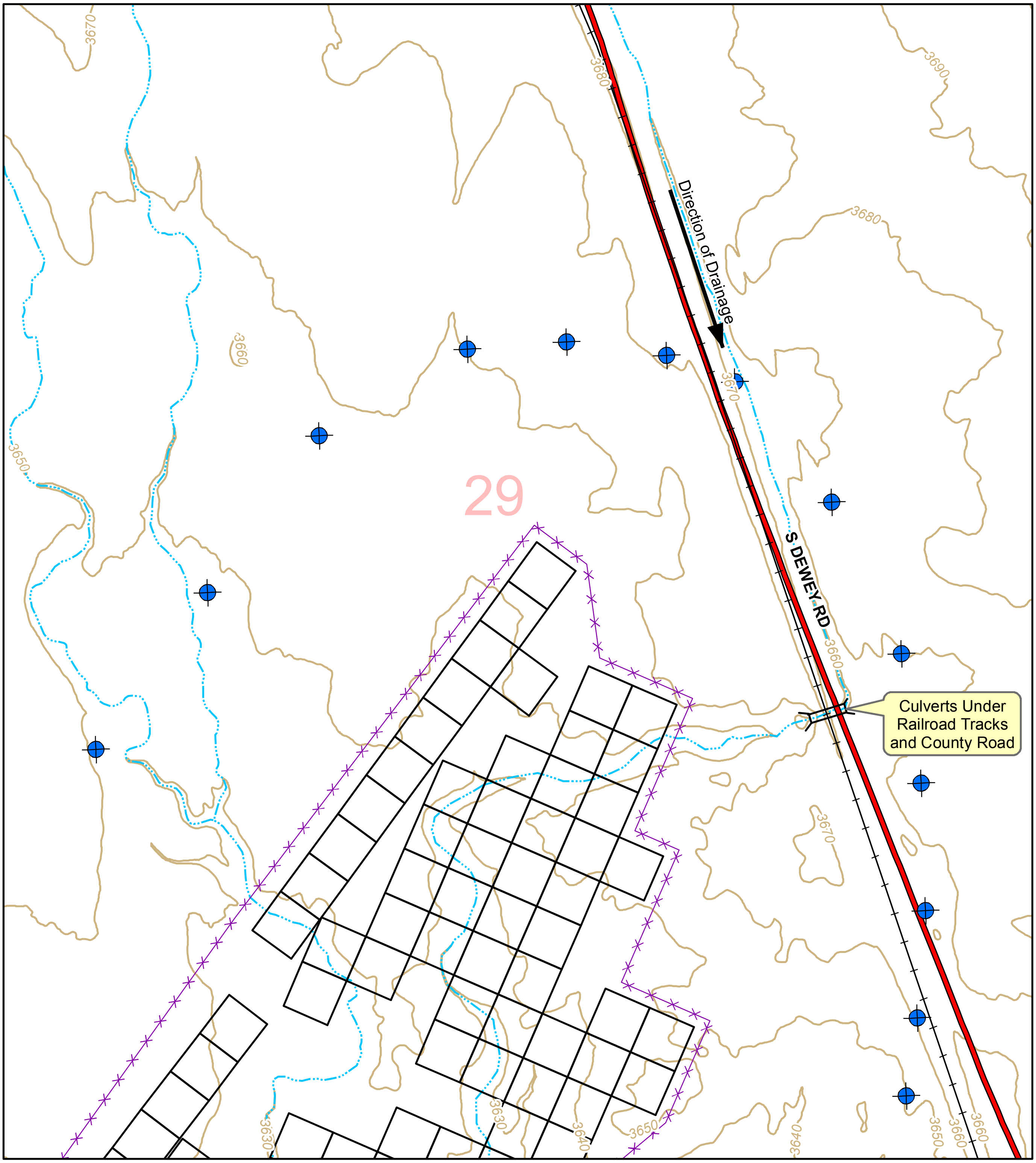
***TR RAI 2.7-2***

***Exhibit 3.2-1 of the TR Supplement indicated that the horizontal excursion monitoring well ring for Dewey Well field #1 is traversed by a set of railroad tracks. Staff was uncertain of the surface drainage in the topographic low areas on the northeast side of the tracks and whether the construction of the tracks includes any type of drainage system you might see for a double track construction (i.e., surface and/or subsurface drainage system). Staff is uncertain if standing water in poorly drained areas will hamper access to wells and potentially facilitate well leakage. Please clarify the surface drainage of this area.***

**TR RAI 2.7-2 Response**

Figure TR RAI 2.7-2-1 depicts the northern portion of proposed Dewey Well Field 1 area where some of the perimeter monitor wells will likely be located across a railroad and county road from the well field. Powertech investigated the drainage in this area in May 2011 and determined that there are culverts beneath the county road and the railroad which will prevent ponding of water near the monitor wells. The railroad culverts consist of two 5' x 6' rectangular box culverts. One 18" corrugated metal pipe culvert provides drainage for the county road. Despite an unusually high amount of rainfall during May 2011, no ponded water was observed in this area. The monitor wells will be located outside of the drainage channel and will not be subject to flooding. Adequate access to the perimeter monitor wells will be available even during infrequent storm events that trigger ephemeral flow through the railroad and county road culverts.

Note that the potential well field and monitor well locations shown on Figure TR RAI 2.7-2-1 are only conceptual locations at this time. A revised, detailed design will be provided in a well field hydrogeologic data package.




## Legend

- Potential Monitor Wells
- Potential Well Field Fence
- Well Field Grid
- BNSF Railroad
- County Roads
- Ephemeral Streams

Feet: 0 150 300
Meters: 0 50 100

N

# Figure TR RAI 2.7-2-1

Dewey Well Field 1
Drainage Detail
Twp 6S, Rng 1E, Sec 29
Dewey-Burdock Project

| | |
|---|---|
| DRAWN BY | Mays, Hetrick |
| DATE | 20-Jun-2011 |
| FILENAME | Figure TR RAI 2.7-2-1.mxd |

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***TR RAI 2.7-3***

***Consistent with criteria of Section 2.7.3 of NUREG-1569, please provide appropriate estimates of peak flood discharges and water levels produced by large floods on Pass Creek, Beaver Creek, and local small drainage areas. Please also provide an appropriate estimate of the aerial extent of significant peak flow during flooding of Beaver Creek and Pass Creek in the areas where Dewey Well fields I and III and Burdock Well fields III and V. Furthermore, please discuss the safety measures to be undertaken for well fields and monitoring wells located in areas that may be subject to erosion or inundation.***

**TR RAI 2.7-3 Response**

A detailed analysis of potential flooding within the project area is contained in Appendix 2.7-M, Dewey-Burdock Project Flood Analysis, as part of this submittal. This appendix will be included with the revised TR. Exhibit 2.7-3 has been revised to show the inundation boundaries. The TR will be updated to include text discussing the protection of wells that are located within the 100-year inundation boundary. A summary of the safety measures used to protect wells in areas subject to erosion or inundation is presented below. Please also refer to the response to TR RAI MI-5, which describes the methods used to estimate peak flows and delineate inundated areas.

Peak flood estimates, as well as water levels and flood inundation boundaries for Beaver Creek and Pass Creek, are discussed in Section 2.7.3 of the TR. Smaller ephemeral drainages within the project area were also modeled and are included in Appendix 2.7-M. HEC-HMS models were used to calculate peak discharges for various storm events for the drainages within the project area. HEC-RAS models were used to predict the 100-year flood inundation boundary for the channels within the project area.

The 100-year flood inundation boundary for the entire project area and its effects on the project facilities including well fields will be discussed in the revised TR. Most facilities will be located outside of the 100-year flood inundation boundary. All facilities which must be located within the 100-year inundation boundary will be protected from damage by a system of structures such as straw bales, collector ditches, engineered diversion structures and/or berms. Above-grade well field infrastructure will be located outside of the 100-year flood inundation boundary. If it is necessary to place an individual well head within the inundation boundary, diversions or erosion control structures will be constructed to divert flow and protect the well head. The well head also will be sealed to withstand brief periods of submergence. Refer to TR Figures 3.1-3 and 3.1-6, which show that all ISR wells and monitor wells will be sealed. All pipelines, including the proposed plant-to-plant pipeline, will be buried below the frost line and therefore will not be affected by flooding. Pipeline valve stations will be located outside of the 100-year flood inundation boundary.

***TR RAI 2.7-4***

***NRC staff notes that ephemeral stream tributaries flow through all the proposed well fields shown in Exhibit 3.1-4 of the TR Supplement. NRC also notes that the plant-to-plant pipeline and Burdock Well field V-to-plant pipeline crosses several ephemeral drainage channels including Pass Creek. Please provide an estimate of high water marks of significant channel flow and provide specific plans for the protection of infrastructure (e.g., well heads and header houses) within the high water marks of significant channel flow. This information is necessary to assess erosion risks to well field infrastructure and pipelines.***

**TR RAI 2.7-4 Response**

Please refer to the response to TR RAI 2.7-3 for a description of flood inundation areas and protection of infrastructure. That information is summarized below.

Peak flood estimates and flood inundation boundaries for Beaver Creek and Pass Creek are provided in TR Section 2.7.3. Flood inundation areas for smaller ephemeral drainages within the project area are provided in Appendix 2.7-M, which is included with this RAI response package and will be included with the revised TR. Exhibit 2.7-3 depicts the modeled flood inundation areas for all surface water features during the 100-year, 24-hour storm event in relation to proposed facilities and infrastructure.

Most facilities will be located outside of the 100-year flood inundation boundary, including the CPP, Satellite Facility, ponds, land application areas, deep disposal wells, and header houses. Appendix 3.1-A depicts the diversion channels designed to protect the ponds and facilities from flooding. Drawing Nos. 101 and 102 (pages 3.1-A-33 and 34) depict the division channel designs for the CPP and Satellite Facility, respectively. If it is necessary to place an individual well head within the flood inundation boundary, diversions or erosion control structures will be constructed to divert flow and protect the well head. The well head also will be sealed to easily withstand the brief periods of submergence that will occur with the infrequent runoff events in this semiarid area. Refer to TR Figures 3.1-3 and 3.1-6, which show that all ISR wells and monitor wells will be sealed. All pipelines, including the proposed plant-to-plant pipeline, will be buried below the frost line and therefore will not be affected by flooding. Pipeline valve stations will be located outside of the 100-year flood inundation boundary.

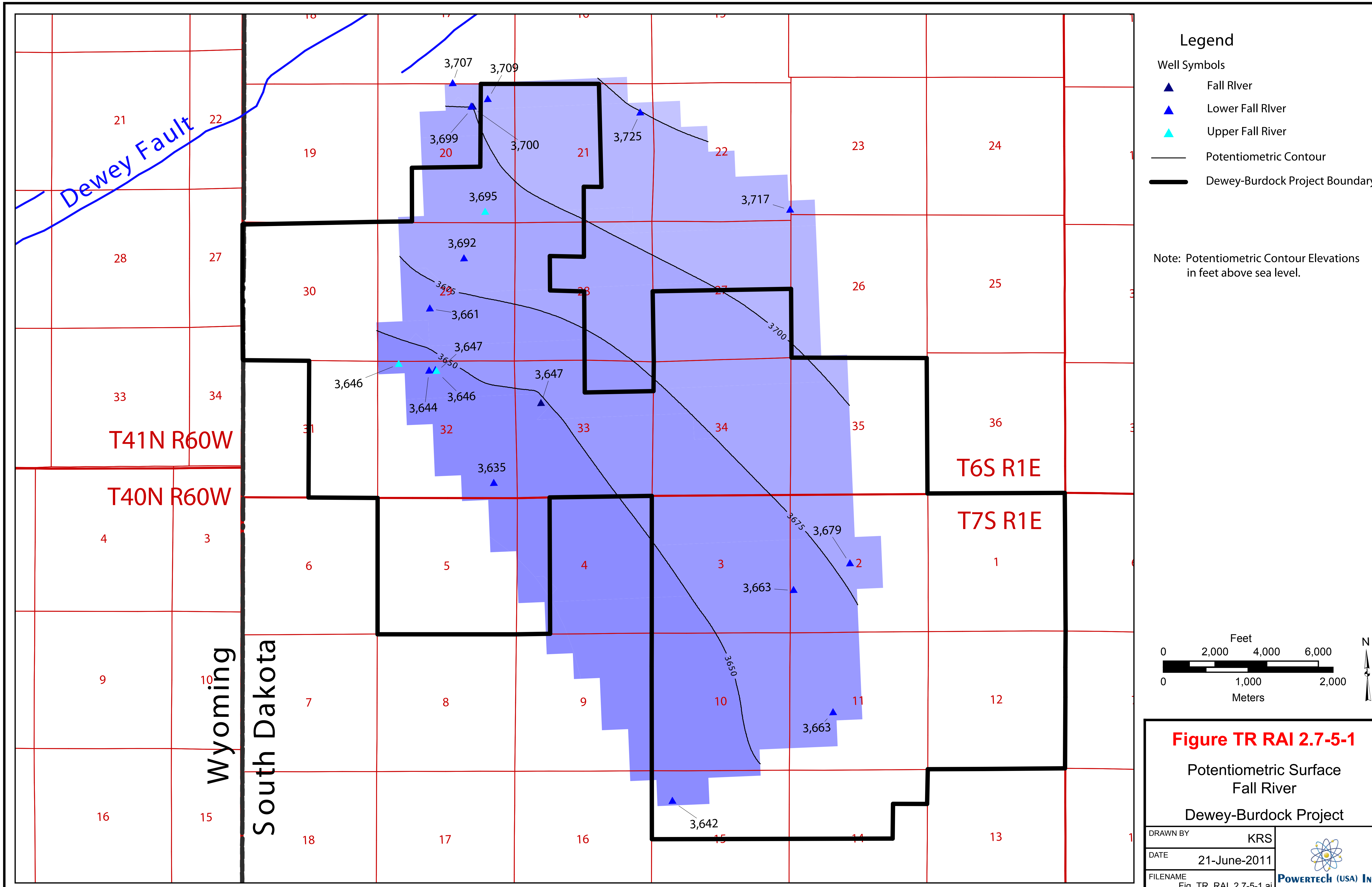
***TR RAI 2.7-5***

***NRC Staff notes that the location of several of the potentiometric contour lines in Figures 2.7-14 and 2.7-15 of the TR conflicts with water level data posted at several of the well points. Please explain the cause of this error.***

**TR RAI 2.7-5 Response**

The following information will be included in the revised TR.

The potentiometric contour maps for the Fall River Formation and the Chilson Member of the Lakota have been revised and are presented as Figures TR RAI 2.7-5-1 and 2.7-5-2, respectively. The prior versions of these maps were prepared from water level measurements taken at different times over a several-year period, whereas the revised contour maps are based on water level measurements collected during a 5-day period, April 25 through April 29, 2011. The wells used in the development of the contour maps, their respective completion intervals, times of measurement and measured water level elevations will be included within the revised TR. The current set of potentiometric surface maps includes several additional monitoring points compared to previous mapping efforts, providing better data density for modeling the potentiometric surface. Additional details are provided in the response to TR RAI P&R-12(b).



Legend
Well Symbols
Fall RIver
Lower Fall RIver
Upper Fall River
Potentiometric Contour
Dewey-Burdock Project Boundary
Note: Potentiometric Contour Elevations in feet above sea level.
Dewey Fault
Wyoming
South Dakota
T41N R60W
T40N R60W
T6S R1E
T7S R1E
3,707
3,709
3,699
3,700
3,725
3,695
3,717
3,692
3,661
3,647
3,646
3,644
3,646
3,647
3,635
3,679
3,663
3,663
3,642
3700
3675
3650
Feet
0 2,000 4,000 6,000
0 1,000 2,000
Meters
N
Figure TR RAI 2.7-5-1
Potentiometric Surface
Fall River
Dewey-Burdock Project
DRAWN BY KRS
DATE 21-June-2011
FILENAME Fig_TR_RAI_2.7-5-1.ai
POWERTECH (USA) INC.

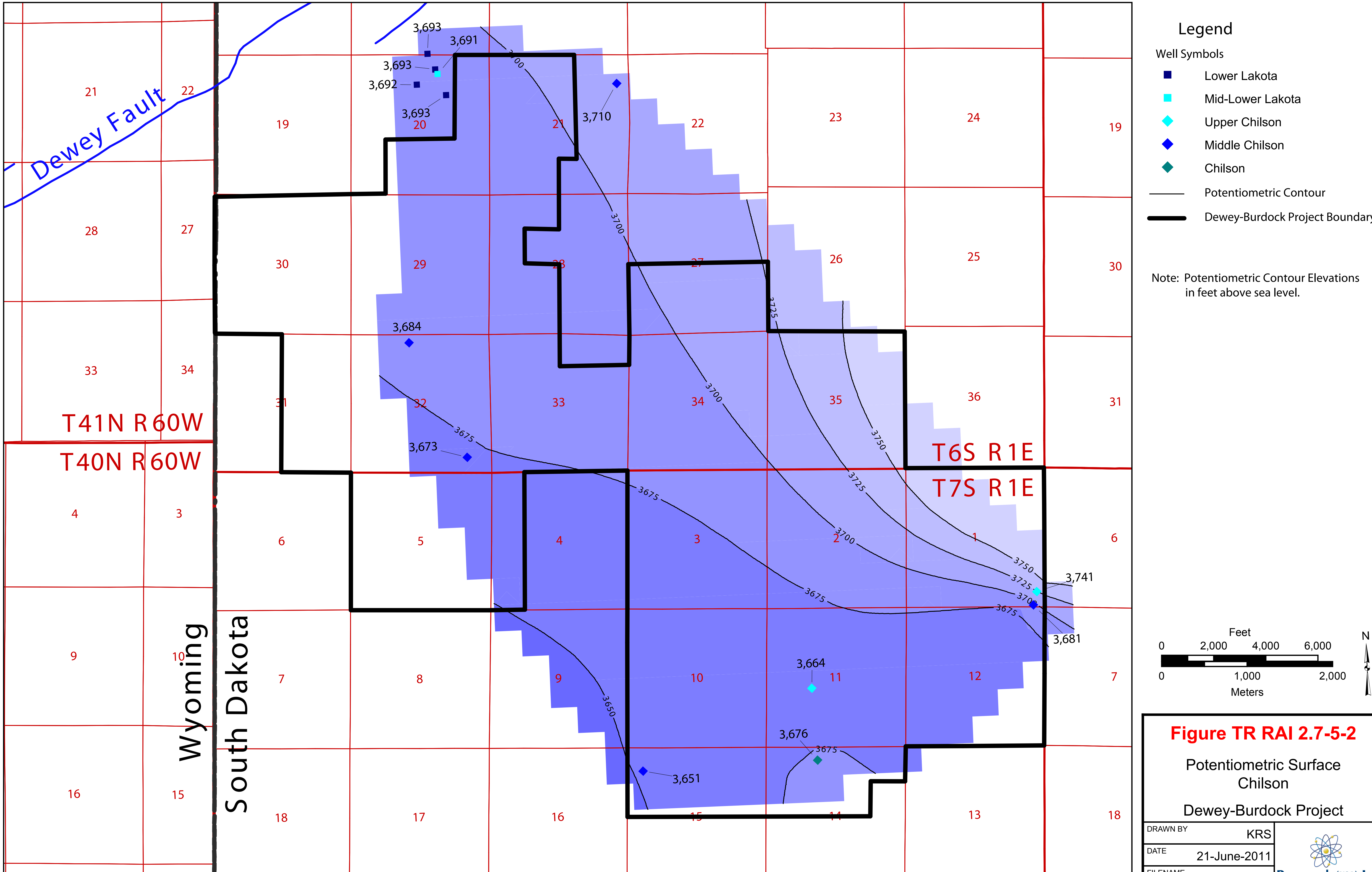



**Figure TR RAI 2.7-5-2**

Potentiometric Surface Chilson

Dewey-Burdock Project

| | |
|---|---|
| DRAWN BY | KRS |
| DATE | 21-June-2011 |
| FILENAME | Fig_TR_RAI_2.7-5-2.ai |

POWERTECH (USA) INC.

***TR RAI 2.7-6***

***NRC Staff found that the description of the methods used to measure the groundwater levels or water potential measurements and the subsequent method of calculation used to establish groundwater elevations at each well in Section 2.7.2.2.8 of the TR were incomplete. Please provide a complete description of the method used to determine potentiometric head for the artesian wells.***

**TR RAI 2.7-6 Response**

The procedures for measuring the static water level and calculating the water level elevation, or potentiometric surface elevation, in monitor wells are summarized below for non-flowing and flowing wells. TR Section 2.7 will be updated to include the procedures described below.

Non-Flowing Wells

The following procedures apply to wells where the static water level is below the top of the casing (non-flowing wells):

- Measure the depth to water in the well using either an electric water level tape or a chalked tape. All measurements are made from a fixed reference point, either notched or clearly marked on the top of the casing. This reference point is surveyed so the elevation is known to the nearest 0.01 ft. For each well this reference point is the measuring point elevation (MPE). The depth to water is measured to the nearest one hundredth (0.01) of a foot.
- Record the measured depth to water in the log book, indicating the date and time that the measurement was taken.
- Note any field observations regarding the condition of the well, well casing, any leakage around the casing, noticeable odor, water color, etc. in field log book.
- Subtract the depth to water from the MPE to get the water surface elevation (potentiometric surface elevation) for that well on that date.

Flowing Artesian Wells

The following procedures are followed for wells in which the static water level is above the top of the casing (flowing wells):

- Install pressure gauge at the well head.
- Allow well to flow freely at surface to bleed off any air that may be trapped in the casing.
- Shut in well by closing all valves at the well head and check for leaks. Allow the pressure at the well head to stabilize.
- Measure and record the vertical distance between the surveyed reference point elevation (MPE) for each well and the center of the pressure gauge.
- Observe and record any field observations regarding condition of well head, well casing, piping and valves, leakage from the piping or around the casing, color of the water, odor, or inability to attain a constant pressure reading in the shut-in well.
- Read pressure gauge to nearest 0.01 pounds per square inch (psi) or 0.01 foot; record reading in field log book, noting date and time the measurement was taken.
- Convert pressure gauge reading to feet of water if necessary (psi x 2.307 = ft of water). This is the height of the potentiometric surface above the elevation of the pressure gauge.

- Add (or subtract) the difference in elevation between the MPE and the pressure gauge to get the elevation of the pressure gauge.
- Add the pressure reading in feet to the elevation of the pressure gauge to get the potentiometric surface elevation for that well on that date.

***<u>TR RAI 2.7-7</u>***

***The Fall River isopach map of Dewey Well field I (Supplemental Exhibit 3.2-9) and Dewey Well field I Cross Section (Supplement Exhibit 2.1-3) show ore zones proposed for uranium recovery within a plausible channel deposit. This scenario is also seen in the detailed information for Burdock Well field I (Supplemental Exhibit 3.2-12 and Supplement Exhibit 2.1-4). Staff notes that these data illustrations do not provide sufficient information concerning these plausible channel deposits. Staff requests structure maps of the base of the Chilson aquifer for Burdock Well field I and the base of the Fall River aquifer for Dewey Well field I. Also, please modify Exhibits 2.1-3 and 2.1-4 to show all interbedded sandstones and shales within the Chilson and Fall River aquifers as well as the perimeter, overlying, and underlying monitoring wells and their screened intervals. Noting that Section 3.2 of the TR Supplement states, "location of any flow problems caused by clay stringers," please further discuss the effects of channel deposits and interbedded shales on the containment of production fluids and the adequacy of groundwater monitoring layout.***

**<u>TR RAI 2.7-7 Response</u>**

The TR will be revised to include the following information.

Although additional geologic and hydrologic characterization are provided to specifically respond to this RAI, it should be noted that much more detailed geologic and hydrologic characterization and well field design will be included in well field hydrogeologic data packages after license issuance but prior to commencement of any ISR operations. As described in the responses to other RAIs (e.g., TR RAI 5.7.8-14), delineation drilling will be undertaken to further characterize the zones of mineralization and to identify the interbedded sand and clay intervals. Design of the injection and recovery well pattern for each well field, and associated monitoring system(s), will take into account the hydrogeology to ensure that production fluids can be contained within the production zone and adequately monitored. As detailed in the response to TR RAI 5.7.8-9, ISR operations will be monitored by perimeter monitor wells screened over the entire thickness of the production zone.

In addition to delineation drilling, well field scale pumping tests will be conducted prior to development of each well field to further evaluate the hydraulic characteristics within the production zone and to demonstrate continuity between the production zone and perimeter monitor well ring. Results of any hydrogeologic testing will also be included in the well field data package prior to commencement of any ISR operation.

The Fall River Formation and the Fuson Shale and Chilson Member of the Lakota Formation are of fluvial depositional origin and consist of interbedded channel and overbank deposits. The uranium deposits are associated with channel deposits very similar to those in many other states including Nebraska, Texas, and Wyoming that have been successfully developed for ISR operations.

Geologically, the Fall River Formation is physically and hydraulically separated from the underlying Chilson Member by the Fuson Shale. Similarly, the Chilson Member is physically and hydraulically isolated from the underlying regional aquifers by the Morrison Formation. A structural contour map for the top of the Fuson Shale in the vicinity of Dewey Well Field 1 is provided as Exhibit 2.6-6, and a structural contour map of the top of the Morrison Formation is presented in Exhibit 2.6-7. These maps are equivalent to structural contour maps for the base of the Fall River and base of the Chilson, respectively, as requested by this RAI. As described in the response to TR RAI P&R-8, Powertech has also prepared a structure contour map of the Morrison Formation throughout the project area. This is provided as Exhibit 2.6-1.

These structure contour maps reflect the attitude and topography of the confining units underlying the Fall River Formation in the Dewey area and the Chilson Member in the Burdock area. In both areas, the confining units are shown to dip gently to the west and southwest, away from the core of the Black Hills Uplift. In the Dewey area, the structure contour map also may reflect some minor scouring, but cross sections in the area show a consistent 50-foot thickness of Fuson Shale. In the Burdock area, there is a depression on the Morrison structure contour map, but this appears to be related to depositional environment of the Morrison Formation as opposed to later scouring. Cross sections in this area show a consistent 80-foot thickness of Morrison shales.

Geologic cross sections (Exhibits 2.7-1a through 2.7-1h and 2.7-1j) have been drawn through potential well fields in the project area. These nine cross sections incorporate selected representative geophysical logs and illustrate the interbedded nature of the sand and clay layers. The interbedded clay beds within both the Fall River and Chilson sandstones are sufficiently continuous as to further subdivide the Fall River and Chilson into discrete, mappable channel sandstone units (i.e., Upper Fall River, Lower Fall River, Upper Chilson, etc.). These channel sands often contain multiple ore bodies.

Exhibit 2.7-1h is drawn through proposed Dewey Well Field 1. Exploration hole DB08-32-11 penetrates a 97-foot thick sequence of the Morrison Formation and the entire thickness of the Unkpapa Sandstone and bottoms in the Sundance Formation. This provides a cross-sectional view of the lowermost confining unit (the Morrison Formation) as well as deeper stratigraphy below the project area. As shown in this cross section, all uranium ore bodies are contained in the Lower Fall River Sand in the F13, F12 and F11 roll fronts. There are over 400 feet of Graneros Group clays overlying the Fall River Formation, and the Fuson Shale maintains an average thickness of 50 feet along the cross section.

Exhibit 2.7-1a illustrates the proposed Burdock Well Field 1. While uranium mineralization can be seen in all three Chilson sand units, this well field is planned to be recovering uranium from the Lower Chilson sand. Exploration hole DB08-11-18 penetrates a 72-foot thick sequence of the Morrison Formation and the entire thickness of the Unkpapa Sandstone and bottoms in the Sundance Formation. The thickness of the Fuson Shale ranges from 30 to 60 feet, and the thickness of the uppermost confining unit (the Graneros Group) varies from 30 to 200 feet along this cross section.

The text in Section 3.2 of the TR Supplemental Report referred to delineation drilling being used to identify the location of any flow problems caused by clay stringers. This is a reference to potential smaller scale lenticular, interbedded clay zones within the mineralized sands. Detailed delineation drilling will be conducted to map smaller changes in the depositional environment which may have a potential to change flow on a smaller scale. Design of the pattern areas for each well field and the associated monitoring system will account for any of these potential flow features to ensure that lixiviant can be contained within the production zone and adequately monitored. Well field pump tests will also be conducted in order to demonstrate communication between production zones and perimeter monitor well rings. All of this mapping, design, and testing information will be included in the well field hydrogeologic packages, which will be prepared for each well field prior to operation.

***TR RAI 2.7-8***

***Considering the uncertainty of the flow regime close to the Dewey Fault and the size and potential complexity of the rest of the project site, NRC staff found the amount of well points used to represent the potentiometric maps of the Fall River, Lakota, and Unkpapa water bearing units to be insufficient. Staff noted an unusual potentiometric surface in the Dewey portion and was unable to determine the source of the anomaly. Staff also noted that well points used in Figures 2.7-14 and 2.7-15 of the TR did not include available wells provided in Appendix 2.2-A (e.g., Fall River Wells 7, 8, 17, 18. and 20; and Lakota Wells 1, 2, 13, 14, 16, 42, 51, 96, 115, 147, 510, 620, 696, 697, and 7002). Staff notes that Section 2.7.2.2.8 of the TR indicated that some of the additional wells listed in Appendix 2.2-A are difficult to access for water level measurements. However, staff is uncertain if the wells can be reasonably accessed with additional efforts. Staff requests potentiometric maps of the Fall River, Lakota, and Unkpapa water bearing units that include all wells that are reasonably accessible for water level measurements.***

**TR RAI 2.7-8 Response**

The following information will be added to the revised TR.

Powertech was able to access 5 additional wells (14, 17, 147, 510, and 620) for the purpose of measuring depth to water. The potentiometric contour maps for the Fall River Formation and the Chilson Member of the Lakota were revised to include the additional wells and are presented in the response to TR RAI 2.7-5. The revised contour maps are based on water level measurements collected over a 5-day period, April 25 through April 29, 2011, rather than based on "average" water levels taken over several years. The wells used to develop the potentiometric contour maps are shown on the maps presented in the response to TR RAI 2.7-5.

As noted in this RAI, there are other wells within the project area listed in Appendix 2.2-A to the TR but not used in the development of potentiometric contour maps. The reasons certain wells were not used previously in the development of the potentiometric contour maps are summarized in Table TR RAI 2.7-8-1. Also listed are mitigative actions taken to correct problems with the use of certain wells. For well location information and completion intervals, refer to the response to TR RAI P&R-10.

The revised potentiometric contour maps provide a regional flow direction and hydraulic gradient in accordance with the guidance in NUREG-1569, Section 2.7.3(3). Based on pump test results showing variable transmissivity, variations in the configuration of the potentiometric surfaces for the Fall River and Chilson are acknowledged and expected (see discussion in the response to TR RAI P&R-12(b)).

**Table TR RAI 2.7-8-1: Reasons Wells Not Used in Development of Potentiometric Contour Map**

| Hydro ID | Reason(s) Wells Not Used in Development of Potentiometric Contour Maps |
|---|---|
| 1 | Well cannot be shut in. |
| 2 | Well cannot be shut in. |
| 7 | Domestic water well with pump – measurement of water level requires well to be removed from service. |
| 8 | Domestic water well with pump – measurement of water level requires well to be removed from service. |
| 13 | Domestic water well with pump – measurement of water level requires well to be removed from service. |
| 14 | Well has now been accessed and included in monthly monitoring program |
| 16 | Domestic water well with pump – measurement of water level requires well to be removed from service. |
| 17 | Well currently being monitored; verification of completion interval is pending. |
| 18 | Domestic water well with pump – measurement of water level requires well to be removed from service. |
| 20 | Domestic water well with pump – measurement of water level requires well to be removed from service. |
| 42 | Domestic water well with pump – measurement of water level requires well to be removed from service. |
| 51 | Well cannot be shut in. |
| 96 | Domestic water well with pump – measurement of water level requires well to be removed from service. |
| 115 | Domestic water well with pump – measurement of water level requires well to be removed from service. |
| 147 | Well currently being monitored for water levels; survey of measurement point is pending. |
| 510 | Well currently being monitored for water levels; verification of completion interval and survey of measurement point are pending. |
| 620 | Well currently being monitored for water levels; verification of completion interval is pending. |
| 696 | Flowing artesian well; well currently being monitored for water levels. |
| 697 | Flowing artesian well; well currently being monitored for water levels. |
| 7002 | Well cannot be shut in. |

***TR RAI 2.7-9***

***NRC staff notes that the potentiometric groundwater surfaces of the Fall River and the Lakota are above ground surface within the southern portion of Well field Dewey I, the western portion of Well field Dewey III, and Well field Burdock V. These areas are within alluvium along Beaver Creek and Pass Creek. NRC staff notes that unplugged exploration test holes recognized in Section 2.7.2.2.16 of the TR (i.e., Section 2.7.2.2.16 of the TR states, "Locally unidentified structural features or more likely old, unplugged exploration holes enhance this interaquifer connection.") may be a pathway for production zone groundwater to be discharged via artesian flow to alluvial aquifers and plausibly be discharged from alluvial aquifers to Beaver Creek and/or Pass Creek. Please provide additional information regarding the potential for whether groundwater is discharging to alluvial aquifers as referenced above.***

**TR RAI 2.7-9 Response**

The following text describes additional investigations that have been performed and will be performed to assess the extent of alluvium and saturated alluvium within the project area and whether groundwater is discharging to alluvial aquifers. Section 2.7 of the TR will be updated to include the following information.

Powertech performed extensive investigation into all surface water features within the project area. This included field investigations during the initial baseline monitoring period and the use of color infrared (CIR) imagery. All surface water features and sources of groundwater flow to the surface are believed to be identified within the project area.

With one exception, groundwater discharging to the ground surface is limited to existing flowing artesian wells, which will be controlled and mitigated as described in the response to TR RAI P&R-9 and TR RAI P&R-10. The only feature that was identified that was indicative of groundwater discharge from exploration boreholes at or near surface was in the “alkali flats” area in the southwestern corner of the Burdock portion of the project area (N/2NE/4 Section 15, T7S, R1E). This is an area of known discharge from the Fall River and Chilson to the surface through abandoned exploration holes documented by TVA.

CIR Imagery

To evaluate possible groundwater discharge to the alluvium within the Beaver and Pass Creek drainages, CIR satellite imagery was obtained from the National Agriculture Image Program (NAIP) of the USDA Farm Services Agency for the project area and vicinity. The imagery was photographed in 2010 and produced with a resolution of one meter. CIR imagery is commonly used to delineate areas of active vegetative growth; in semiarid regions such as the project area, such areas are often indicative of enhanced water supply, such as occurs with irrigation or subirrigation.

CIR imagery for the project area and vicinity is presented in Figure TR RAI 2.7-9-1. The CIR imagery was examined visually for any anomalies that may suggest groundwater discharge at or near surface, such as from upward flow through an open borehole or a natural spring. Within the project area, there are several flowing artesian wells that at times are allowed to discharge groundwater to the surface. A good example of this is the artesian well area depicted on Figure 2.9-6, which is provided with the response to TR RAI 2.9-32(b) and discussed in the response to TR RAI 2.9-22. These areas are generally visible on the CIR imagery.

The “alkali flats” area had a noticeable signature on CIR and is depicted on Figures TR RAI 2.7-9-2 and TR RAI 2.7-9-3.

Outside the project area, the CIR imagery clearly shows two springs near the town of Dewey along the Dewey Fault (Figure TR RAI 2.7-9-4). These locations were later verified by Powertech personnel and the springs were sampled for water quality analysis. Results of the analysis are pending. The results of this investigation strongly support the use of CIR data to identify areas of groundwater discharge, and with the exception of alkali flats support the lack of such discharge from exploration boreholes within the project area. Powertech will continue to use CIR imagery to assess the potential for groundwater discharge to the surface or alluvium within the project area. The obvious evidence of groundwater discharge in the alkali flats area suggests that if similar situations existed at other locations in the project area they would be readily detectable.

Potentiometric Surface Evaluation

Powertech also evaluated areas where the potentiometric surface of the Fall River and Chilson are above ground surface or above the base of the alluvium in order to assess the potential for groundwater discharge to the alluvium. Those areas within the Beaver Creek and Pass Creek drainages where the potentiometric surfaces for the Fall River and Chilson are above the ground surface are depicted on Figures TR RAI 2.7-9-5 and TR RAI 2.7-9-6, respectively. These figures were generated using the potentiometric surfaces described in TR RAI 2.7-5 and shown in Figure TR RAI 2.7-5-1 and Figure TR RAI 2.7-5-2. Note that the areas with potentiometric surface above ground surface are limited to the west and south by the extent of data used to construct the potentiometric surface.

Alluvial Drilling Program

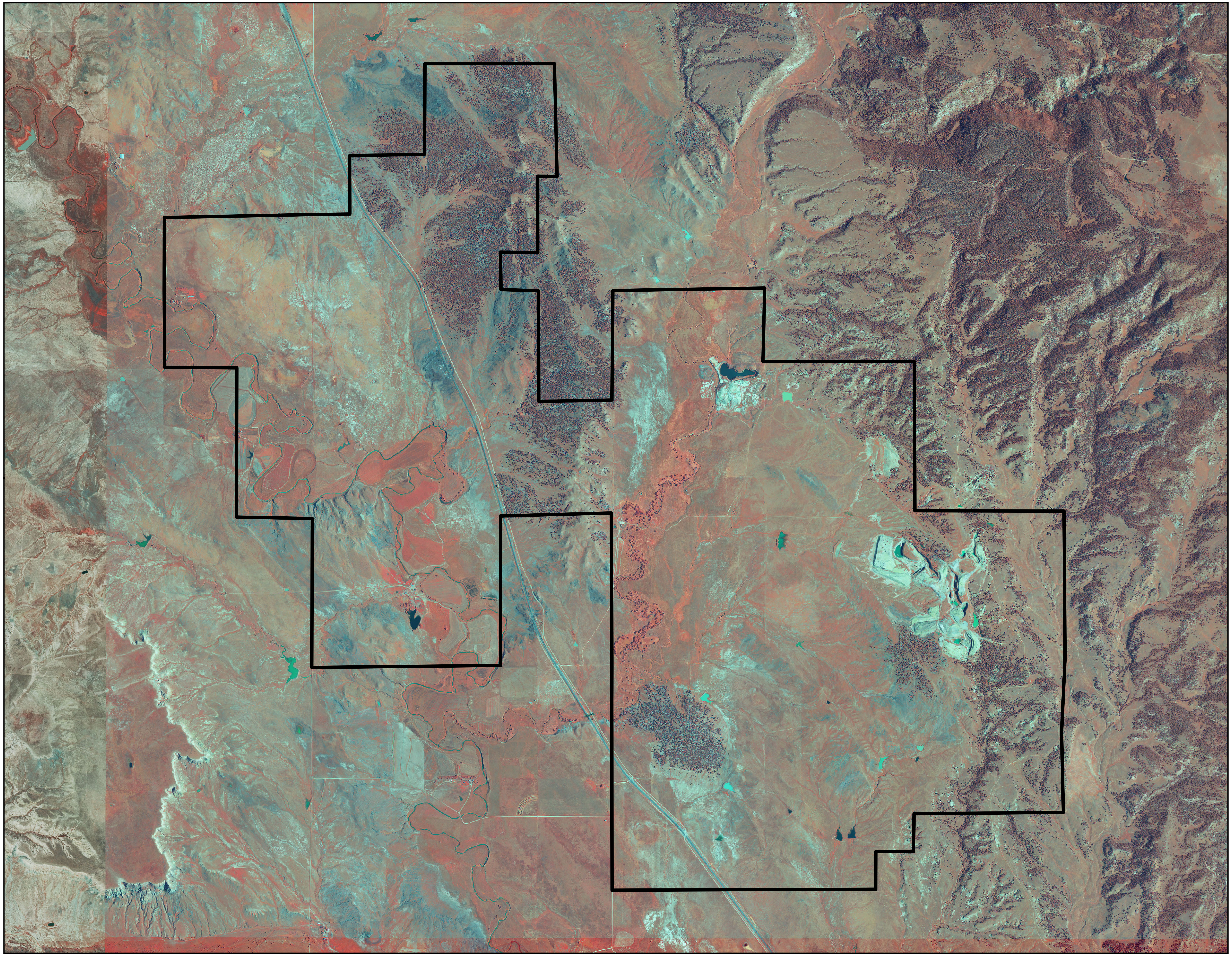
An alluvial drilling program was completed in May 2011 to further address potential discharge to alluvium from underlying aquifers. Nineteen borings were drilled into the alluvium along Beaver Creek and Pass Creek, many of which were dry. Three borings were completed as alluvial monitoring wells. The thickness of the saturated alluvium at these wells ranged from 10 to 12 feet. The alluvium in the Pass

Creek drainage is up to 50 feet thick; in the Beaver Creek drainage, the alluvium is up to 30 feet thick. Results of the alluvial drilling program did not indicate any areas of discharge to the alluvium from underlying aquifers but rather were consistent with limited recharge occurring from surface waters in the upland portions of the project area. Please see Figure TR RAI 2.7-9-7, which depicts the potentiometric surface of the Pass Creek and Beaver Creek alluvium. Please also see Exhibit 2.6-8, which depicts the alluvial isopach within the project area.

The results from the May 2011 alluvial drilling program in the Beaver Creek and Pass Creek drainages are consistent with the historical field observations in that neither the past field investigations nor the recent drilling program identified any areas other than the alkali flats noted above where there was evidence to suggest groundwater is discharging into the alluvium or at the ground surface from bedrock formations.

Well Field Delineation Drilling and Pump Testing

The issue regarding possible upward flow through unplugged or improperly sealed boreholes and/or natural geologic features will be further evaluated during the planned delineation drilling and well field-scale pump testing prior to the development of each well field.  This is described in detail in the response to TR RAI 5.7.8-14, which describes the pump testing that will be done and the measures that will be taken to plug any wells or boreholes that could potentially affect or be affected by ISR operations, including potential effects on the alluvial aquifer.



**Legend**

Dewey-Burdock Project Boundary

Feet
0 2,000 4,000 6,000
0 500 1,000 1,500
Meters
N

## Figure TR RAI 2.7-9-1

Color Infrared Imagery (2010 Data)

Dewey-Burdock Project

| | |
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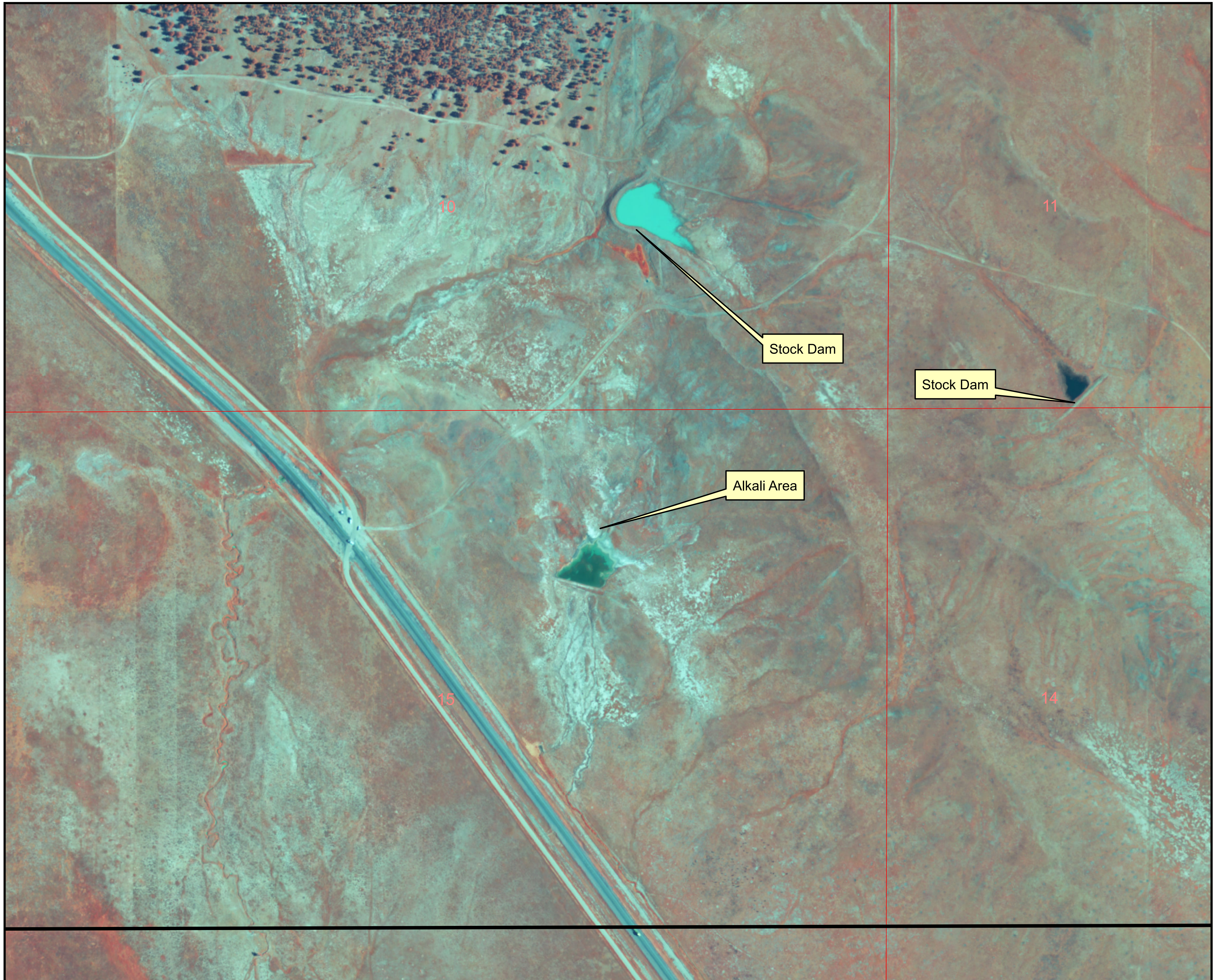
| DRAWN BY | JLM |
| DATE | 21-June-2011 |
| FILENAME | Fig_TR_RAI_2.7-9-1.mxd |

POWERTECH (USA) INC.




## Legend

Dewey-Burdock Project Boundary

## Key Map

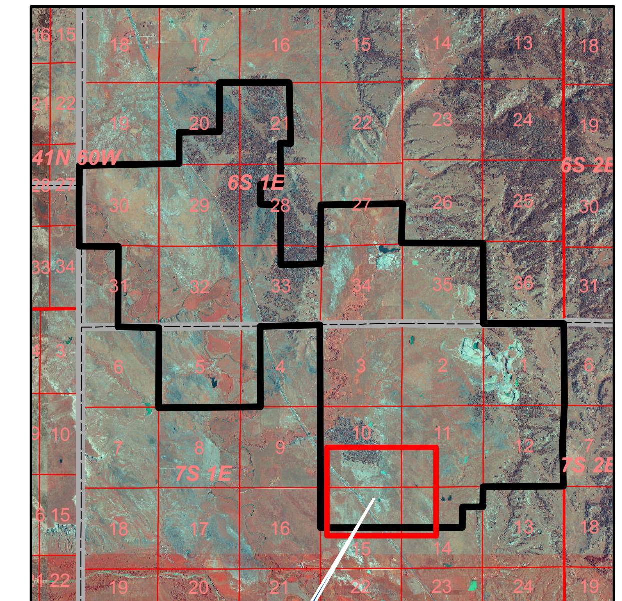


Fig 2.7-9-2 Area

Feet
0 250 500 1,000
0 100 200 300
Meters
N

# Figure TR RAI 2.7-9-2

Color Infrared Imagery (2010 Data)
Alkali Area Near Burdock

Dewey-Burdock Project

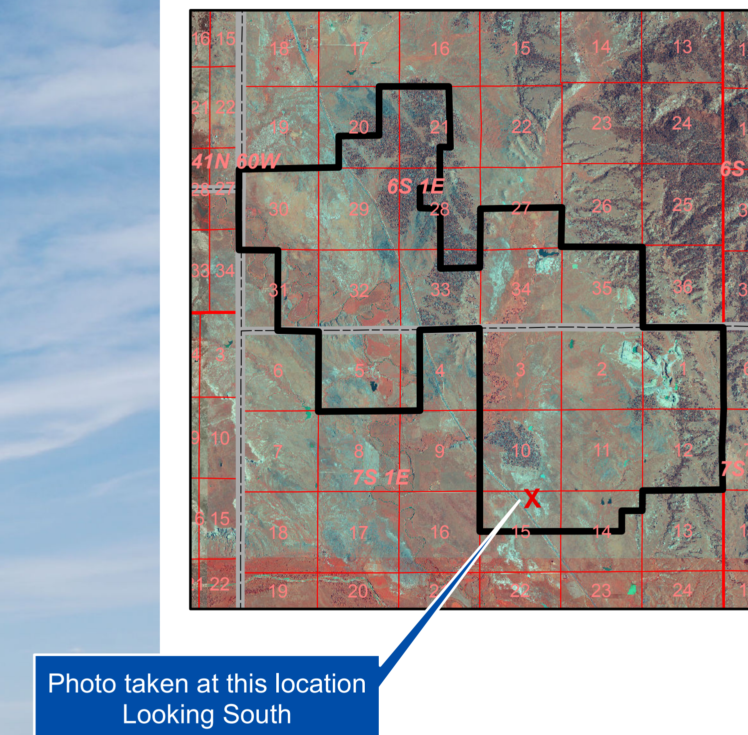
| | |
|---|---|
| DRAWN BY | JLM |
| DATE | 21-June-2011 |
| FILENAME | Fig_TR_RAI_2.7-9-2.mxd |

POWERTECH (USA) INC.

## Legend

Dewey-Burdock Project Boundary

### Key Map




N

Scale: None

**Figure TR RAI 2.7-9-3**

Photograph of Alkali Area, Looking South, Near Burdock

Dewey-Burdock Project

| | |
|---|---|
| DRAWN BY | JLM |
| DATE | 21-June-2011 |
| FILENAME | Fig_TR_RAI_2.7-9-3.mxd |

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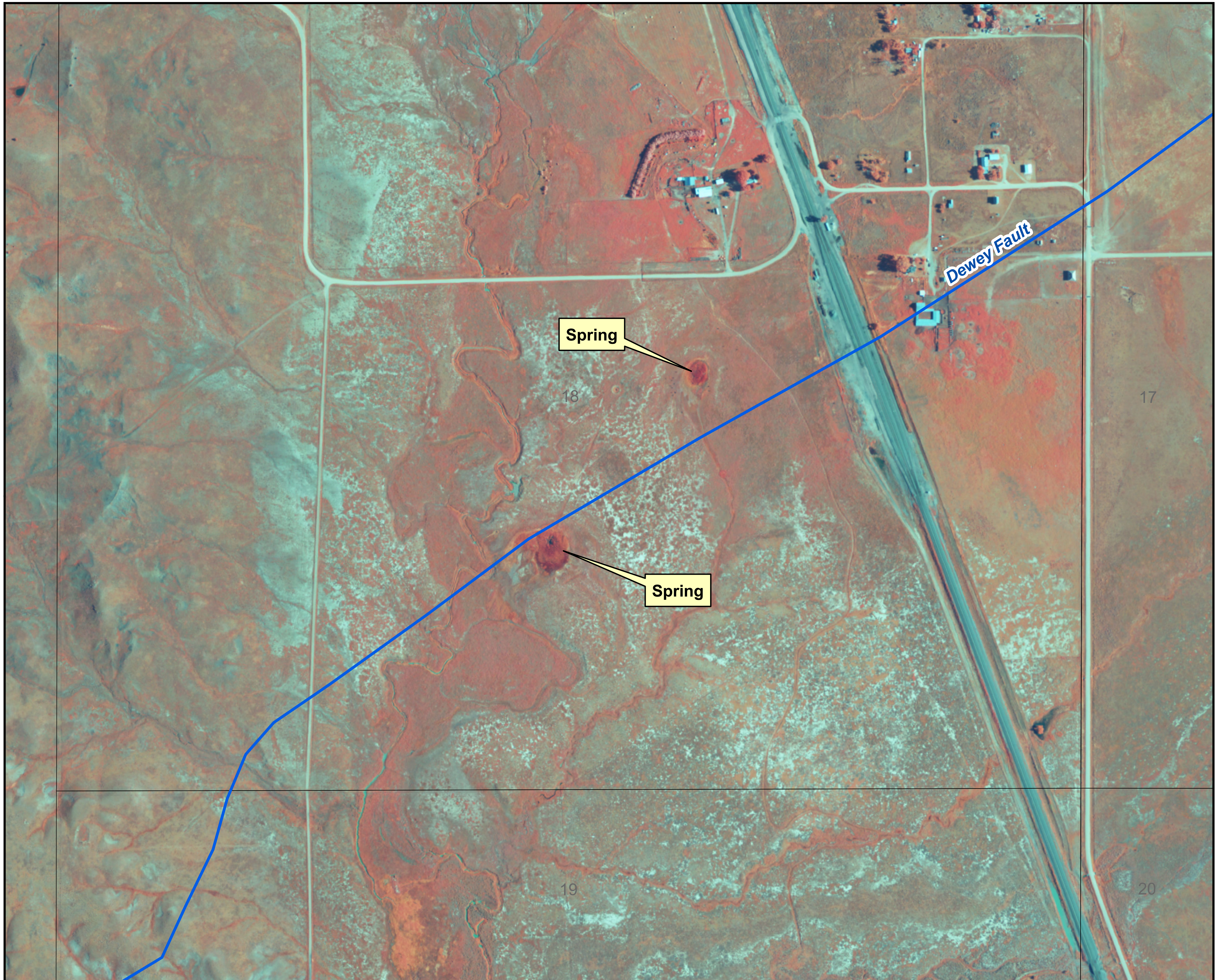
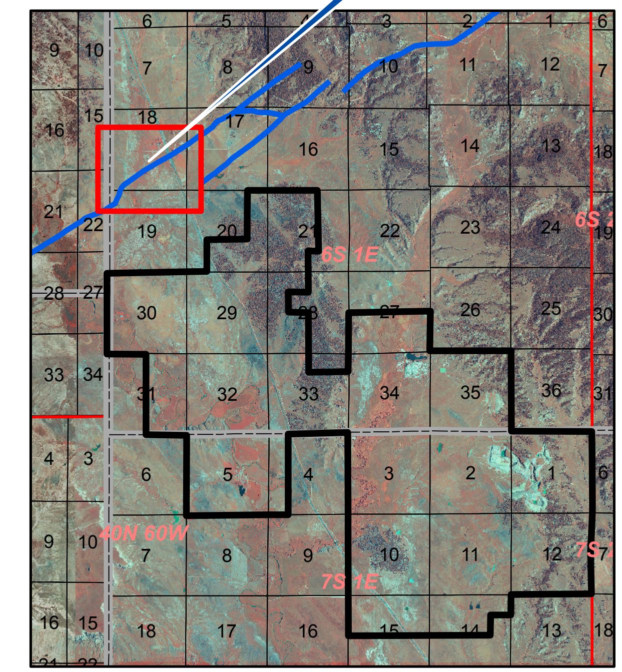



## Legend

- Dewey Fault
- Dewey-Burdock Project Boundary




**Key Map**

Feet: 0, 250, 500, 1,000
Meters: 0, 100, 200, 300
N

**Figure TR RAI 2.7-9-4**

Color Infrared Imagery (2010 Data)
Springs near the Town of Dewey

Dewey-Burdock Project

| | |
|---|---|
| DRAWN BY | JLM |
| DATE | 21-June-2011 |
| FILENAME | Fig_TR_RAI_2.7-9-4.mxd |

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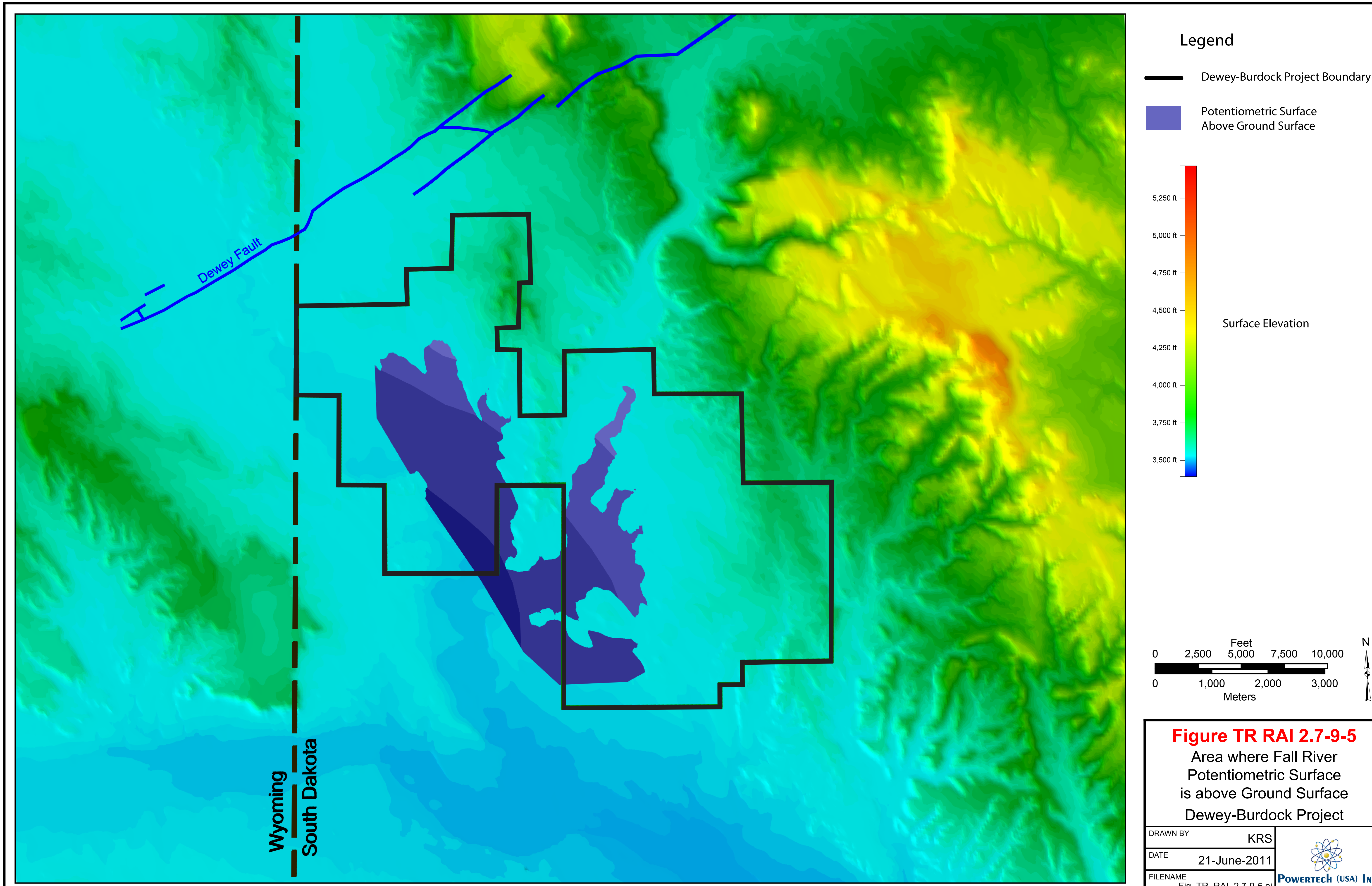


**Figure TR RAI 2.7-9-5**
Area where Fall River Potentiometric Surface is above Ground Surface
Dewey-Burdock Project

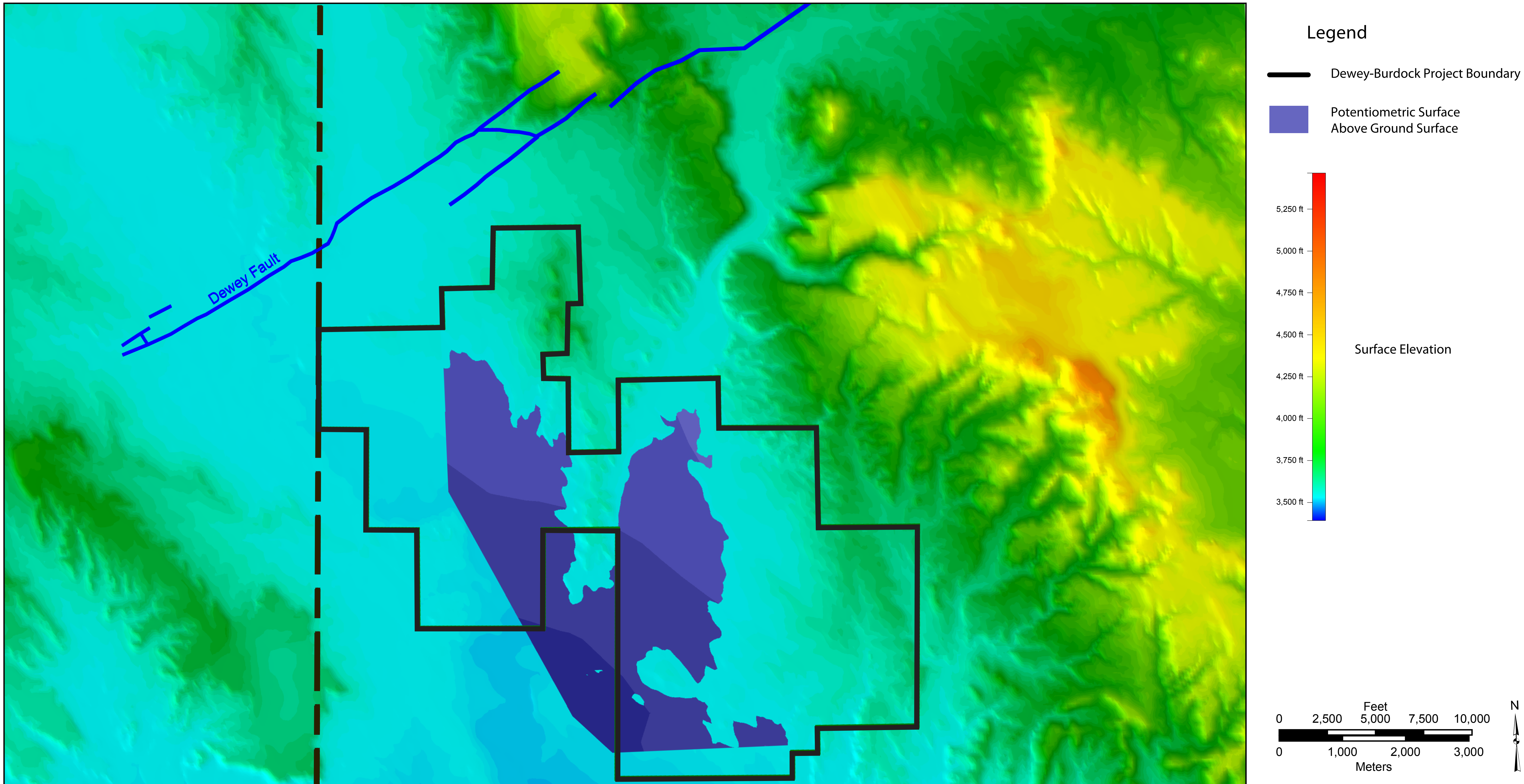


**Figure TR RAI 2.7-9-6**

Area where Chilson Potentiometric Surface is above Ground Surface

Dewey-Burdock Project

| | |
|---|---|
| DRAWN BY | KRS |
| DATE | 21-June-2011 |
| FILENAME | Fig_TR_RAI_2.7-9-6.ai |

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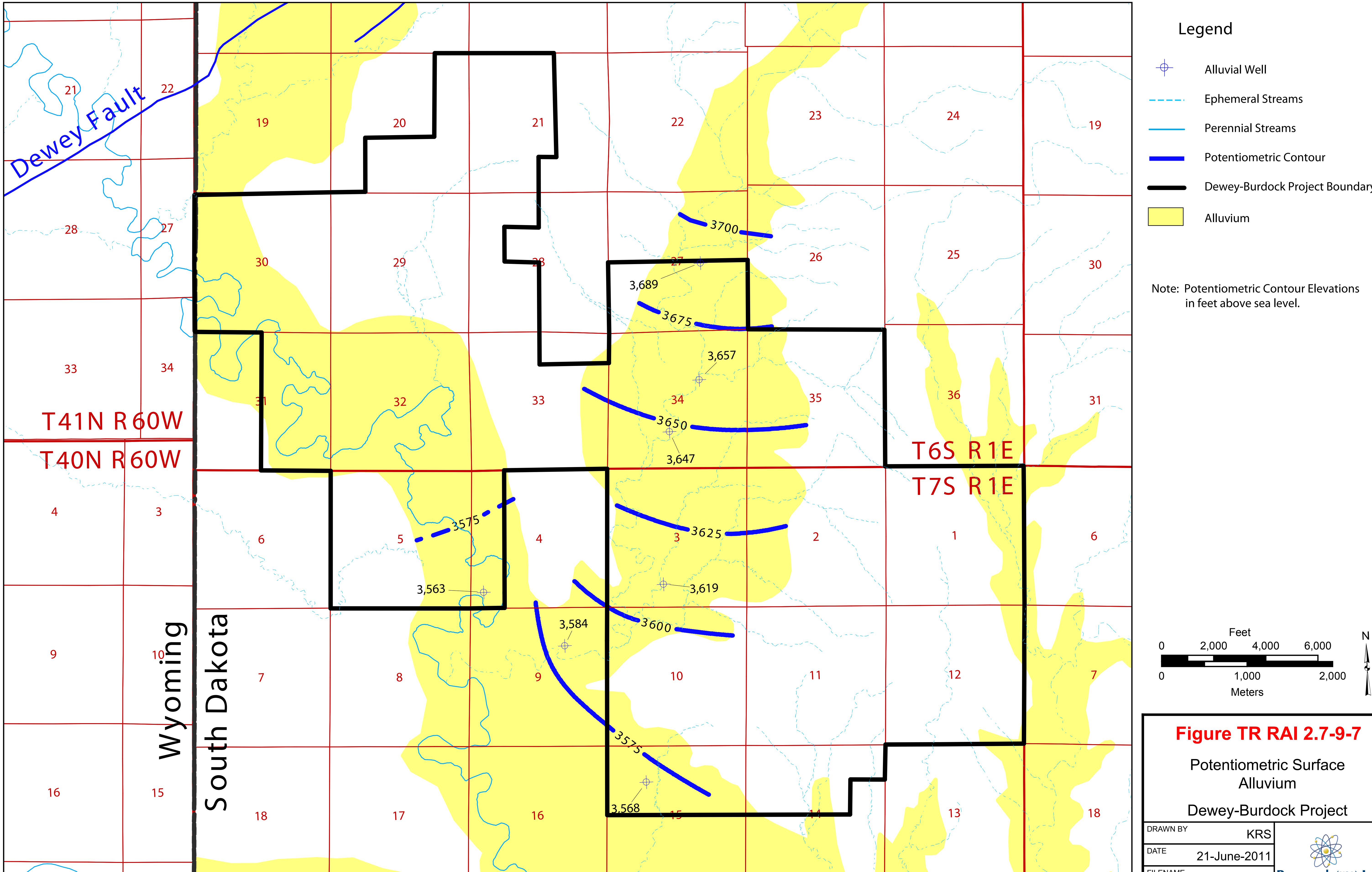


Figure TR RAI 2.7-9-7

Potentiometric Surface Alluvium

Dewey-Burdock Project

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| DRAWN BY | KRS |
| DATE | 21-June-2011 |
| FILENAME | Fig_TR_RAI_2.7-9-7.ai |

POWERTECH (USA) INC.

***TR RAI 2.7-10***

***The application states that springs are not present within the license area. NRC staff is uncertain if the statement includes potential springs that may directly feed wetlands and/or surface impoundments in the license area. Staff is uncertain if unplugged exploratory drill holes (discussed in the above-referenced RAI 12) may have potentially created a spring(s) that feeds a wetlands and/or surface impoundment with production zone groundwater in areas of flowing artesian conditions and the unconfined Fall River aquifer. Please provide a discussion to clarify whether wetlands, surface impoundments, and open mine pits at or downgradient of all proposed production are potentially spring fed with production zone groundwater.***

**TR RAI 2.7-10 Response**

The following information will be included in the revised TR.

Based on the extensive site investigations that have been undertaken by Powertech and others, there are no known natural springs within the project area. There is, however, one isolated area in the southwest corner of the Burdock portion of the project area, known as “alkali flats” or the “alkali area,” where groundwater is discharging to the ground surface presumably through improperly plugged exploratory boreholes. This area is described in the Response to TR RAI 2.7-9.

As discussed in the response to TR RAI 2.7-9, the results from the May 2011 alluvial drilling program in the Beaver Creek and Pass Creek drainages did not indicate any areas other than the alkali flats where there is evidence that groundwater is discharging from exploration boreholes to the alluvium or ground surface.

Seepage in the alkali flats area is apparent at the land surface, which suggests that if a similar situation were to exist at other locations within the project area, it would be readily detectable.

CIR imagery was used to further evaluate possible groundwater discharge to the alluvium within the Beaver and Pass Creek drainages as described in the response to TR RAI 2.7-9. Other than the alkali area, no areas were identified from the CIR imagery that are indicative of groundwater discharge from exploration boreholes at the surface or to the alluvium within the Beaver Creek and Pass Creek drainages or elsewhere within the project area.

Potential upward groundwater movement through unplugged or improperly plugged boreholes or natural geologic features will be evaluated further during the planned delineation drilling and aquifer testing prior to the development of each potential well field.

***TR RAI 2.7-11***

***The TR Supplement stated "Any such water which falls within an area to be mined by POWERTECH shall be removed." NRC staff notes that the applicant may have intended to say "water well" instead of "water." This discrepancy should be corrected or clarified. Please also identify wells to be removed.***

**TR RAI 2.7-11 Response**

Powertech intended to say "water well" instead of "water" when referring to removing wells from private use. The confusion stemmed from quoting a portion of the standard lease agreement, the full text of which is provided below. (Note: all lease agreements formerly held by Denver Uranium have been assigned to Powertech)

> *"DENVER URANIUM shall compensate LESSOR for water wells owned by LESSOR at the execution of this lease, as follows: Any such water which falls within an area to be mined by DENVER URANIUM, shall be removed from LESSOR's use. Prior to removal, DENVER URANIUM shall arrange for the drilling of a replacement water well or wells, outside of the mining area, in locations mutually agreed upon between LESSOR and DENVER URANIUM, as may be necessary to provide water in a quantity equal to the original well and of a quality which is suitable for all uses the original water well served at the time such well was removed from LESSOR's use."*

For a description of the wells to be removed from use and the procedures to remove wells from use and install replacement wells (if needed), refer to the response to TR RAI P&R-10.

This information will be included in the revised TR.

***TR RAI 2.7-12***

***The application stated "if any water well on the Property outside of a mining area or well field is materially and substantially diminished in quantity or quality due to POWERTECH's exploration, development or mining activities, POWERTECH will provide LESSOR with such additional water well or wells as may be necessary to provide water in a quantity equal to the original well and of a quality which was suitable for all uses the diminished well served." This statement appears to imply that the applicant will wait until a water well experiences diminished water quality before acting. Please state those measures to be used to detect and inform potential human receptors of a water quality impact.***

**TR RAI 2.7-12 Response**

The following describes how Powertech will monitor water supply wells for potential impacts and inform the well owner if impacts to water quality or quantity occur. Procedures for well replacement are also provided. For additional information on the number and location of existing wells, please refer to the response to TR RAI P&R-10. The following information will be incorporated into the revised TR.

**Evaluation of Potential Impacts and Well Replacement Procedures**

During the design of each well field, all nearby water supply wells will be evaluated for the potential to be impacted by ISR operations or the potential to interfere with ISR operations. If needed, this evaluation will also include groundwater modeling. The results of the evaluation will be contained within a well replacement plan described in the hydrogeologic data package for each well field.

At a minimum, all domestic wells within the project area and all stock wells within ¼ mile of well fields will be removed from private use. Depending on the well construction, location and screen depth, Powertech may continue to use the well for monitoring or plug and abandon the well.

The well owner will be notified in writing prior to removing any well from private use. Powertech will work with the well owner to determine whether a replacement well or alternate water supply is needed.

Replacement wells will be located an appropriate distance from the well fields and will target an aquifer outside of the ore zone that provides water in a quantity equal to that of the original well and of a quality which is suitable for the same uses as the original well, subject to the lease agreement and South Dakota State water law.

An example of a replacement well is provided in Figure TR RAI P&R-10-2 in the response to TR RAI P&R-10, which shows use of the project Madison well to supply water by pipeline to local stock tanks.

**Operational Monitoring**

The response to TR RAI 5.7.8-17 describes the operational groundwater monitoring plan that will be used to assess potential impacts to domestic and livestock wells. The monitor well ring will provide advance warning before any wells outside the ring have potential to be impacted. If routine monitoring of a water supply well indicates diminished water quantity or quality, the well owner will be notified in writing and the well will be removed from use. Powertech will work with the well owner to determine if well replacement is necessary.  Well replacement procedures are described above. The monitoring and well replacement or abandonment procedures to be implemented by Powertech will assure that there will be no effects on anyone or any water well outside the monitor well ring.

***TR RAI 2.7-13***

***Below are comments and associated requests for information from NRC's review of water wells located at or near the project site.***

***TR RAI 2.7-13(a)***

*a.* ***Non-verified wells in Appendix 2.2-A of the TR are described as wells that were not located at the site and may or may not still exist. If any of these wells or other wells are discovered prior to the closure of the project site, please describe those procedures to be used to protect public health.***

***For each of the wells above, please provide the applicant's plans for protecting public health, determining when well replacement is necessary, the means of notifying the affected parties and the NRC staff when such a replacement is necessary, and the manner in which the potential for contamination migration is precluded.***

**TR RAI 2.7-13(a) Response**

A revised well inventory is provided in the response to TR RAI P&R-10 and will be included within the revised TR. Table P&R-10-2 lists 28 wells identified in historical records that were not present at the surface during field investigations. The following information will be incorporated into the revised TR.

Historical records and field investigations of the project area and 2 km surrounding area were used to develop the well inventory. A preliminary investigation of the wells was completed in 2007, and additional surveys to evaluate the use and condition of the wells were conducted in 2011. A total of 107 wells are currently identified within 2 km of the project area. There are also 28 wells with historical records that are currently not present at the surface and 8 wells with historical records that have been visually confirmed as plugged and abandoned.

Table P&R-10-2 in the response to TR RAI P&R-10 lists the wells identified in historical records that were not present at the surface during the field investigations. These wells are depicted on Figure TR RAI P&R-10-1. Several of these wells are suspected to be plugged and abandoned. Powertech will continue to investigate for these potential wells. During design of well fields, pump testing will be designed to locate any such wells and to detect any potential adverse impacts from such wells on the ISR operations. In the event that a well is located, it will be evaluated and, if necessary, reported to the SERP and mitigated following the procedures described in the response to TR RAI P&R-9.

***<u>TR RAI 2.7-13</u>***
***Below are comments and associated requests for information from NRC's review of water wells located at or near the project site.***

***<u>TR RAI 2.7-13(b)</u>***

b. ***Appendix 2.2-A of the Technical Report indicates that stock wells 618 and 628 tap an unknown water-bearing zone and the Inyan Kara water-bearing zone, respectively. According to Figure 11 in Appendix A, these stock wells appear to be located within a proposed wellfield area. NRC staff notes that the construction and condition of these wells are unknown. Please describe the applicant's plans to address these wells if they are located in a well field, completed in the ore zone, and to protect public health.***

***For each of the wells above, please provide the applicant's plans for protecting public health, determining when well replacement is necessary, the means of notifying the affected parties and the NRC staff when such a replacement is necessary, and the manner in which the potential for contamination migration is precluded.***

**<u>TR RAI 2.7-13(b) Response</u>**
The following provides details on wells 618 and 628 and describes procedures Powertech will utilize to protect public health. For additional information on the number and location of existing wells, please refer to the response to TR RAI P&R-10. Wells 618 and 628 are depicted on Exhibit 3.1-1. Please refer to the responses to TR RAI P&R-10 and TR RAI 2.7-12 for well replacement procedures. The following information will be incorporated into the revised TR.

Well 618 is located within ¼ mile of a proposed well field and occasionally used for livestock watering purposes. The exact construction details of the well are unknown; therefore, prior to well field design Powertech will conduct an investigation of the well using a down-hole tool to determine the well depth and screened interval. Due to its proximity to a proposed well field, the well will be removed from private use.

Well 628 is located approximately ¾ mile from the nearest proposed well field and is used for occasional livestock watering. Although complete construction details of the well are currently unknown, Powertech has determined that the total well depth is 520 feet, and groundwater levels suggest that the well is screened in the upper Fall River Formation. Prior to well field design, an additional investigation of the well will be completed using a down-hole camera or other tool to determine the screened interval. If it is determined that the well has potential to adversely affect or be adversely affected by ISR operations or if routine monitoring indicates changes in water quality, the well will be removed from private use.

Procedures described in the responses to TR RAI P&R-10, TR RAI 2.7-12, and TR RAI P&R-9 will be used to take appropriate actions with these wells including replacement if necessary and evaluation for plugging and abandonment.

***TR RAI 2.7-13***

***Below are comments and associated requests for information from NRC's review of water wells located at or near the project site.***

***TR RAI 2.7-13(c)***

c. ***Appendix 2.2- A of the TR indicates that TVA wells 605, 609, 637, and 668 appear to be* within proposed wellfield areas. *NRC staff notes that the condition of these monitoring wells is unknown.***

***For each of the wells above, please provide the applicant's plans for protecting public health, determining when well replacement is necessary, the means of notifying the affected parties and the NRC staff when such a replacement is necessary, and the manner in which the potential for contamination migration is precluded.***

**TR RAI 2.7-13(c) Response**

The following provides details on wells 605, 609, 637, and 668 and describes procedures Powertech will utilize to protect public health. Please refer to the tables and figures provided with the response to TR RAI P&R-10 for well locations. The following information will be incorporated into the revised TR.

A field investigation of the location designated as well 605 showed only a vertical pipe discharging to a livestock watering tank. Powertech determined that the vertical pipe is not actually a well but the end of an underground pipeline supplied from well 668 by artesian pressure. Well 605 has been added to Table TR RAI P&R-10-2: Historical Wells Not Present.

Well 609 is an historical monitor well. According to TVA documents, this well is completed at a depth of 1,000 ft (verified by Powertech) and screened from 903 to 966 ft across the lower Chilson. Since the well is located approximately 0.4 mile from a proposed well field, it will be evaluated as part of the well field design. The evaluation will determine if the well has the potential to be adversely affected or to adversely affect ISR operations. If it is determined that the well has potential to adversely affect ISR operations, the well will be plugged and abandoned or otherwise mitigated.

Well 637 is an historical monitor well located within a proposed well field. A field investigation determined that the well consists of a 2-inch steel casing, although other construction details are unknown. Prior to well field design a down-hole tool will be utilized to determine the screened interval and total depth. During well field design well 637 will be evaluated to determine if the well has the potential to be adversely affected or to adversely affect ISR operations. If it is determined that the well has potential to adversely affect ISR operations, the well will be plugged and abandoned or otherwise mitigated.

Well 668 is located within a proposed well field area. The well was installed by TVA as an aquifer pump test well for hydrogeologic investigations and is currently used for livestock. According to TVA documents, the well has a total depth of 574 feet and is screened across the Chilson and Fall River. This was recently verified by Powertech.

Prior to ISR operations well 668 will be removed from private use. Powertech will notify the well owner in writing and work with the well owner to determine whether a replacement well or alternate water supply is needed. Well replacement procedures are described in the response to TR RAI P&R-10. Because of its completion in both the Fall River and Chilson, Powertech anticipates plugging and abandoning well 668 prior to ISR operations within ¼ mile.

***<u>TR RAI 2.7-13</u>***

***Below are comments and associated requests for information from NRC's review of water wells located at or near the project site.***

***<u>TR RAI 2.7-13(d)</u>***

*d.* ***Figure 8 in Appendix 2.2-A of the TR appears to show that domestic well 16 is within or immediately adjacent to a proposed well field area. Staff is uncertain if production at this well field is proposed in the Lakota water bearing zone that the domestic well taps.***

**<u>TR RAI 2.7-13(d) Response</u>**

The following provides details on well 16 and describes procedures Powertech will utilize to protect public health. Please refer to the tables and figures provided with the response to TR RAI P&R-10 for well locations. Please refer to the responses to TR RAI P&R-9, TR RAI P&R-10, and TR RAI 2.7-12 for procedures on plugging and abandonment and well replacement. The following information will be incorporated into the revised TR.

Well 16 is a domestic well that provides water to a seasonal residence. The well is located within a proposed well field and will be removed from private use prior to operations. Since the construction details of the well are unknown, Powertech has implemented an investigation plan with the landowner to enter the well with a down-hole camera or other tool to determine construction details. Based on well construction the well will either be used as a monitor well or plugged and abandoned. Powertech has drilled a replacement well into the Unkpapa for well 16.

***TR RAI 2.7-13***

***Below are comments and associated requests for information from NRC's review of water wells located at or near the project site.***

***TR RAI 2.7-13(e)***

*e.* ***Appendix 2.2-A of the TR indicated that Lakota domestic wells 13 and 42 are within the license boundary and Inyan Kara domestic wells 2, 7, 8, 18, 20, 96, 115, and 135, 4002 are outside of the license boundary in the vicinity of the site.***

***For each of the wells above, please provide the applicant's plans for protecting public health, determining when well replacement is necessary, the means of notifying the affected parties and the NRC staff when such a replacement is necessary, and the manner in which the potential for contamination migration is precluded.***

**TR RAI 2.7-13(e) Response**

The following provides details on the domestic wells within 2 km of the project boundary and describes procedures Powertech will utilize to protect public health. For additional information on the number and location of existing wells, please refer to the response to TR RAI P&R-10. Please refer to the responses to TR RAI P&R-9, TR RAI P&R-10, and TR RAI 2.7-12 for procedures on plugging and abandonment and well replacement. The following information will be incorporated into the revised TR.

Powertech will remove wells 13, 42, and 4002 from private use. As described in the response to TR RAI P&R-10, there are a total of eight domestic wells within the project boundary, including wells 13, 42 and 4002. All of these wells will be removed from private use prior to ISR operations. Powertech will notify the well owners in writing and work with the well owners to determine whether a replacement well or alternate water supply is more appropriate. Well replacement procedures are described in the response to TR RAI P&R-10.

Powertech plans to monitor wells 2, 7, 8, 18, 96, and 115 as part of its operational groundwater monitoring plan that is presented in the response to TR RAI 5.7.8-17. These wells are all outside of the project boundary but within the surrounding 2 km area. As such, they are unlikely to be adversely affected by ISR operations. Nevertheless, these wells will be sampled annually for all parameters listed in
Table 6.1-1.

Wells 20 and 135 are not within 2 km of the project boundary and will not be adversely affected by ISR operations.

***TR RAI 2.7-13***

***Below are comments and associated requests for information from NRC's review of water wells located at or near the project site.***

***TR RAI 2.7-13(f)***

*f.* ***Appendix 2.2- A of the TR indicated that stock wells 17, 49, 38, and 61 tap either the Fall River or Lakota water-bearing zones. These stock wells appear to be located at, or immediately adjacent to, possible production zones.***

***For each of the wells above, please provide the applicant's plans for protecting public health, determining when well replacement is necessary, the means of notifying the affected parties and the NRC staff when such a replacement is necessary, and the manner in which the potential for contamination migration is precluded.***

**TR RAI 2.7-13(f) Response**

The following provides details on wells 17, 38, 49, and 61 and describes procedures Powertech will utilize to protect public health. For additional information on the number and locations of existing wells, please refer to the response to TR RAI P&R-10. Please refer to the responses to TR RAI P&R-9, TR RAI P&R-10, and TR RAI 2.7-12 for procedures on plugging and abandonment and well replacement. The following information will be incorporated into the revised TR.

Stock wells 17, 38, 49 are expected to be removed from private use prior to ISR operations within ¼ mile. Powertech will notify the well owners in writing and work with the well owners to determine whether a replacement well or alternate water supply is more appropriate. Negotiations and decisions regarding well replacements will be noted in SERP records. Well replacement procedures are described in the response to TR RAI P&R-10.

Well 61 is more than ¼ mile from currently identified potential well field areas. This well will be evaluated during the course of well field development and delineation drilling for its potential to be adversely affected by or to adversely affect ISR operations. Procedures described in the responses to TR RAI P&R-10, TR RAI 2.7-12, and TR RAI P&R-9 will be used to take appropriate actions with this well including replacement if necessary and evaluation for plugging and abandonment. The stock well also will be monitored as part of the operational groundwater monitoring plan described in the response to TR RAI 5.7.8-17. This includes quarterly sampling for the indicator parameters of chloride, conductivity, and alkalinity.

***TR RAI 2.7-13***
***Below are comments and associated requests for information from NRC's review of water wells located at or near the project site.***

***TR RAI 2.7-13(g)***

*g.* ***Appendix 2.2-A of the TR indicated that Lakota stock wells 12, 51, 510, 619, 620, and 650 are located within the license boundary.***

***For each of the wells above, please provide the applicant's plans for protecting public health, determining when well replacement is necessary, the means of notifying the affected parties and the NRC staff when such a replacement is necessary, and the manner in which the potential for contamination migration is precluded.***

**TR RAI 2.7-13(g) Response**
The following provides details on wells 12, 51, 510, 619, 620 and 650 and describes procedures Powertech will utilize to protect public health. For additional information on the number and locations of existing wells, please refer to the response to TR RAI P&R-10. Please refer to the responses to TR RAI P&R-9, TR RAI P&R-10, and TR RAI 2.7-12 for procedures on plugging and abandonment and well replacement. The following information will be incorporated into the revised TR.

Wells 12, 51, 510, 619, 620 and 650 are used for stock watering and are located within the project area. Powertech has verified the locations of the wells; however, not all completion details are currently known. A down-hole camera or other tool will be used to determine well construction details in all of the wells. These stock wells are more than ¼ mile from currently identified potential well field areas. They will be evaluated during the course of well field development and delineation drilling for the potential to be adversely affected by or to adversely affect ISR operations. Procedures described in the responses to TR RAI P&R-10, TR RAI 2.7-12, and TR RAI P&R-9 will be used to take appropriate actions with these wells including replacement if necessary and evaluation for plugging and abandonment. The stock wells also will be monitored as part of the operational groundwater monitoring plan described in the response to TR RAI 5.7.8-17. This includes quarterly sampling for the indicator parameters of chloride, conductivity, and alkalinity.

***TR RAI 2.7-14***

***Referring to Appendix 2.2-A of the TR, please determine and provide the "Type Use" of Lakota wells 51 and 14, which are located within the license boundary. Once their use is determined, provide additional discussion, as needed, of the water quality risk to the well(s) from the project and any measures that will assure environmental and humans receptors of water from a well are not subjected to any potential diminished water quality from project operations.***

**TR RAI 2.7-14 Response**

The following provides details on wells 14 and 51 and describes procedures Powertech will utilize to protect public health. Please refer to the response to TR RAI P&R-10 for information on the number and locations of existing wells. Please refer to the responses to TR RAI P&R-9, TR RAI PR&-10, and TR RAI 2.7-12 for procedures on plugging and abandonment and well replacement. The following information will be incorporated into the revised TR.

Wells 14 and 51 are both used to supply water for livestock. Well 14 is located approximately ¾ mile northwest of the proposed Burdock Well Field I and is completed in the Lower Fall River Formation. Well 51 is completed in the Chilson and is located outside of the project area, approximately 1 mile west of the proposed Burdock Well Field I.

Due to the proximity of the wells within 2 km of the project boundary, both will be included in the groundwater operational monitoring program, as described in the response to TR RAI 5.7.8-17. In addition, the wells will be evaluated during well field design. In the event that either of these wells has the potential to be adversely affected by or to adversely affect ISR operations, it will be removed from private use. Powertech will notify the well owner in writing and work with the well owner to determine whether a replacement well or alternate water supply is more appropriate. Well replacement procedures are described in the response to TR RAI P&R-10.

***TR RAI 2.7-15***

***Consistent with Section 2.7.4 of NUREG-1569, please provide a table listing the data on a parameter-by-parameter, well-by-well or surface-water location by surface-water-location basis using appropriate statistical methods. Include results of all field-measured parameters including elevations and/or depth to water. For sampling locations that were dry or ice, please note that information in the appropriate column rather than omitting the data altogether from the table. For concentrations below the minimum detection level, please report the data as "less than" and the PQL. Based on the data presented in the application, the staff cannot reconstruct this information with any degree of certainty to perform an independent, statistically valid basis. Furthermore, duplicate samples should be used only for QA/QC evaluations and should not be used for statistically evaluations.***

**TR RAI 2.7-15 Response**

Revised summary tables presenting surface water and groundwater sample results are provided in revised TR Appendix 2.7-C and 2.7-G, respectively. Appendix 2.7-C replaces previous TR Appendix 2.7-C (Statistics for Surface Water Constituents At or Above PQL). Appendix 2.7-G replaces previous TR Appendix 2.7-G (Groundwater Quality Data). These revised appendices will be included with the revised TR. Consistent with Section 2.7.4 of NUREG-1569, groundwater and surface water analytical data are presented in tables on a date-by-date, parameter-by-parameter, and well-by-well or surface water location-by-surface water location basis. The following describes the presentation of data in Appendices 2.7-C and 2.7-G.

All field-measured parameters, including water level elevations for groundwater sampling locations, are presented with the corresponding laboratory data. Footnotes on each surface water quality table indicate the sampling frequency and reasons why samples were not collected during a scheduled sample event (frozen, dry, etc.). For concentrations reported as non-detect by the laboratory, the data are reported as "< RL" where RL is the laboratory reporting limit. In cases where the laboratory reported a numerical value less than the RL, the numerical results are provided along with the value of the RL, with a footnote explaining the reporting convention. The summary tables present the minimum, maximum and mean concentrations for each parameter at each sample location. Means were calculated using a value of ½ of the RL when non-detect data occurred.

Duplicate sample results have been removed from the water quality result tables.  A separate quality assurance review, with duplicate and field blank sample results tabulated and evaluated, will be provided for groundwater and surface water samples in the revised TR.

Groundwater quality summary tables are provided at the beginning of Appendix 2.7-G describing the mean, standard deviation, minimum, and maximum values for each constituent in the four zones monitored. The monitored zones, in descending order, are the alluvium, Fall River Formation, Chilson Member of the Lakota Formation, and Unkpapa Sandstone.

Laboratory data packages are provided in revised Appendix 2.7-F (surface water) and 2.7-H (groundwater), which are included with this RAI response package and will be included with the revised TR. These appendices include indices by sample ID and date.

***TR RAI 2.7-16***

***Please provide the rationale or justification for only one location to establish the pre-operational groundwater quality of the Sundance/Unkpapa waterbearing zone. The staff notes that several wells are completed in the Sundance/Unkpapa aquifer; however, no samples were collected by the applicant. Spatial variations in water quality should be determined to establish a conceptual model for the aquifer. This information is especially important if the applicant proposes not to monitor the Sundance/Unkpapa aquifer as the lower aquifer. Is the Sundance/Unkpapa the underlying aquifer?***

**TR RAI 2.7-16 Response**

The following response describes how Powertech has collected additional samples from the Unkpapa Sandstone in response to this RAI, how Powertech commits to pre-operational and operational monitoring in the Unkpapa, and whether the Unkpapa is the underlying aquifer. This information will be provided in the revised TR.

Four Unkpapa wells have been sampled as part of the baseline monitoring program. Two of these wells (690 and 693) were installed and used as monitor wells for the Burdock (well 690) and Dewey (well 693) pumping tests. These wells were sampled once in 2008 during the pumping tests. The other two wells (703 and 704) were installed in 2008 to replace domestic wells near potential well field areas. The former domestic wells were replaced because they were completed in the Fall River or Chilson targeted for ISR operations. One water quality sample was collected from each of these wells during baseline monitoring.

Water quality results from the Unkpapa available to date are provided in Appendix 2.7-G, which is described in the response to TR RAI 2.7-15. A summary of Unkpapa radionuclide concentrations available to date is provided in Appendix 2.9-J. Analysis of spatial variations in Unkpapa water quality will be completed following the additional sampling described below.

Powertech proposes to sample Unkpapa wells 690, 693, and 703 four times (including the initial samples) prior to ISR operations for parameters listed in Table 6.1-1. Water samples from the Unkpapa can no longer be obtained from well 704 because this well was cemented off in the Unkpapa in 2009 and perforated in the Chilson due to low yield from the Unkpapa. Prior to ISR operations, well 704 will be replaced in accordance with procedures described in the response to TR RAI 2.7-12 and TR RAI P&R-10. Additionally, Powertech will include Unkpapa wells 690, 693, and 703 in the operational groundwater monitoring program as described in the response to TR RAI 5.7.8-17. Quarterly samples will be analyzed for all parameters in Table 6.1-1.

The Unkpapa Sandstone is considered the first aquifer below the Morrison Formation, a regional confining unit 60 to 140 feet thick throughout the project area. The Unkpapa will be the underlying aquifer when there is not a suitable or distinct hydrogeologic unit within the Chilson (such as the Lower

Chilson sand) below a production zone. For production zones in the lowest portion of the Chilson, the Unkpapa will be the underlying aquifer.

Excursion monitoring is not proposed in the Unkpapa. The justification for not performing excursion monitoring is as follows:

1) The Unkpapa Sandstone shows substantially higher potentiometric head than the Fall River and Chilson throughout the project area. During ISR operations, the potentiometric head will be reduced (creating a cone of depression) in the Chilson and Fall River due to a net withdrawal (production flow greater than injection flow) in order to maintain well field bleed. Flow into the Unkpapa from production zones in the Fall River and Chilson operating at a substantially lower potentiometric head would be impossible.
2) The Morrison Formation is prevalent across the entire project area and will act as an aquitard to prevent flow into the Unkpapa from the Fall River and Chilson. This was demonstrated by the pumping tests conducted by Powertech, where no response occurred in the Unkpapa during pumping of either the Fall River or Chilson.
3) The Unkpapa is a low-yield aquifer determined by recent water supply well installation by Powertech (refer to the above discussion on well 704).

A map detailing the location of the three Unkpapa monitoring locations relative to currently identified potential well field areas is shown in Figure TR RAI 5.7.8-17-6 provided with the response to TR RAI 5.7.8-17.

***TR RAI 2.7-17***

***The heading in Table 2.7-3 implies that a parameter concentration exceeds a Maximum Contaminant level even for those parameters that do not have an MCL. Please explain whether or not the applicant was referring to standards other than MCLs.***

**TR RAI 2.7-17 Response**

This RAI appears to refer to Table 2.7-35 in the TR. Some of the water quality standards presented in Table 2.7-35 were not EPA MCLs. This was described in the table footnote but was not clear in the table title or the applicable column title. Table 2.7-35 has been revised to clearly illustrate the comparison of baseline groundwater quality to parameters with EPA MCLs and other standards. The revised Table 2.7-35 is provided below. Please note that Table 2.7-35 includes data from Hydro ID 635, which was removed from the Unkpapa groundwater quality summary table pending confirmation of the screened interval. Table 2.7-35 will be updated based on confirmation findings, as necessary, and included in the revised TR. The revised TR will also include an appendix of comparison of each well water quality with EPA MCLs and other standards.

Table TR RAI 2.7-17-1 compares the water quality in the various groundwater monitoring zones (i.e., alluvium, Fall River, Chilson, and Unkpapa) with EPA MCLs and secondary standards. One or more wells in all of the monitoring zones exceeded the MCL for gross alpha, while one or more wells in the alluvium, Fall River and Chilson also measured concentrations above the MCL for arsenic, radium-226, and uranium. A comparison to EPA secondary standards shows that one or more wells in all zones were above the standards for iron, sulfate, and TDS. Additional secondary standards exceeded in one or more well included pH, chloride, and aluminum.

**Table TR RAI 2.7-17-1: Groundwater Quality Comparison with EPA MCLs and Secondary Standards**

| Monitoring Zone | Parameters Exceeding EPA MCLs in One or More Wells | Parameters Exceeding EPA Secondary Standards in One or More Wells |
|---|---|---|
| Alluvium | Arsenic, gross alpha, radium-226, uranium | Chloride, iron, manganese, sulfate, TDS |
| Fall River | Arsenic, gross alpha, radium-226, uranium | Iron, manganese, pH, sulfate, TDS |
| Chilson | Arsenic, gross alpha, radium-226, uranium | Aluminum, iron, manganese, pH, sulfate, TDS |
| Unkpapa | Gross alpha | Iron, pH, sulfate, TDS |

**Table 2.7-35: Groundwater Quality Comparison with EPA MCLs and Other Public Water Supply Standards**

| Test Analyte/Parameter | Units | MCL[a] or Other Standard | Number of Samples Analyzed* | Number of Detections | Number of Detections Equal to or Above Referenced Standard |
|---|---|---|---|---|---|
| ***Bulk Properties*** | | | | | |
| pH | standard units | <6.5; >8.5[b] | 271 | 271 | 0; 8 |
| TDS | mg/l | 500[b] | 271 | 271 | 271 |
| ***Cations/Anions*** | | | | | |
| Sodium, Na | mg/l | 20[c]; <30[d]; >60[d] | 271 | 271 | 271 ; 0 ; 267 |
| Chloride, Cl | mg/l | 250[b] | 271 | 271 | 4 |
| Fluoride, F | mg/l | 4; 2[b] | 271 | 266 | 0; 0 |
| Sulfate, SO4 | mg/l | 250[b] | 271 | 271 | 271 |
| Nitrate (as Nitrogen) | mg/l | 10 | 271 | 30 | 0 |
| Nitrite (as Nitrogen) | mg/l | 1 | 271 | 1 | 0 |
| Nitrate and Nitrite (Combined) | mg/l | 10 | 271 | 158 | 0 |
| ***Trace Metals (Total)*** | | | | | |
| Antimony, Sb | mg/l | 0.006 | 228 | 1 | 0 |
| Arsenic, As | mg/l | 0[e]; 0.010 | 228 | 191 | 191; 28 |
| Barium, Ba | mg/l | 2 | 228 | 6 | 0 |
| Beryllium, Be | mg/l | 0.004 | 228 | 3 | 0 |
| Boron, B | mg/l | 6[f] | 228 | 54 | 0 |
| Cadmium, Cd | mg/l | 0.005 | 228 | 0 | 0 |
| Chromium, Cr (total) | mg/l | 0.1 | 228 | 2 | 1 |
| Copper, Cu | mg/l | 1.0[b]; 1.3[g] | 228 | 6 | 0; 0 |
| Iron, Fe | mg/l | 0.3[b]; 5[h] | 228 | 217 | 114; 28 |
| Mercury, Hg | mg/l | 0.002 | 280 | 2 | 0 |
| Manganese, Mn | mg/l | 0.05[b]; 0.8[h] | 228 | 227 | 215; 38 |
| Molybdenum, Mo | mg/l | 0.04[f] | 228 | 7 | 2 |
| Nickel, Ni | mg/l | 0.1[f] | 228 | 1 | 1 |
| Lead, Pb | mg/l | 0[e]; 0.015[g] | 228 | 27 | 27; 8 |
| Selenium, Se | mg/l | 0.05 | 228 | 42 | 0 |
| Silver, Ag | mg/l | 0.10[b] | 228 | 0 | 0 |
| Strontium, Sr | mg/l | 4[f] | 228 | 227 | 64 |
| Thallium, Tl | mg/l | 0.0005[e]; 0.002 | 228 | 1 | 1; 1 |
| Uranium, U | mg/l | 0[e]; 0.030 | 232 | 171 | 171; 28 |
| Zinc, Zn | mg/l | 5[b]; 2[f] | 228 | 57 | 0; 0 |
| ***Trace Metals (Dissolved)*** | | | | | |
| Aluminum, Al | mg/l | <0.05[b]; >0.2[b] | 271 | 1 | 0; 0 |
| Arsenic, As | mg/l | 0[e]; 0.010 | 271 | 146 | 146; 18 |
| Barium, Ba | mg/l | 2 | 271 | 0 | 0 |
| Boron, B | mg/l | 6[f] | 271 | 70 | 0 |
| Cadmium, Cd | mg/l | 0.005 | 271 | 0 | 0 |
| Chromium, Cr (total) | mg/l | 0.1 | 271 | 0 | 0 |

**Table 2.7-35: Groundwater Quality Comparison with EPA MCLs and Other Public Water Supply Standards (Continued)**

| Test Analyte/Parameter | Units | MCL[a] or Other Standard | Number of Samples Analyzed* | Number of Detections | Number of Detections Equal to or Above Referenced Standard |
|---|---|---|---|---|---|
| ***Trace Metals (Dissolved) (Continued)*** | | | | | |
| Copper, Cu | mg/l | 1.0[b]; 1.3[g] | 271 | 2 | 0; 0 |
| Iron, Fe | mg/l | 0.3[b]; 5[h] | 271 | 103 | 44; 6 |
| Mercury, Hg | mg/l | 0.002 | 271 | 0 | 0 |
| Manganese, Mn | mg/l | 0.05[b]; 0.8[h] | 271 | 266 | 234; 48 |
| Molybdenum, Mo | mg/l | 0.04[f] | 271 | 2 | 2 |
| Nickel, Ni | mg/l | 0.1[f] | 271 | 0 | 0 |
| Lead, Pb | mg/l | 0[e]; 0.015[g] | 271 | 6 | 6; 0 |
| Selenium, Se | mg/l | 0.05 | 271 | 26 | 0 |
| Silver, Ag | mg/l | 0.10[b] | 271 | 0 | 0 |
| Uranium, U | mg/l | 0[e]; 0.030 | 271 | 199 | 199; 37 |
| Zinc, Zn | mg/l | 5[b]; 2[f] | 271 | 46 | 0; 0 |
| ***Radionuclides*** | | | | | |
| Alpha Particles (Dissolved) | pCi/L | 0[e]; 15 | 271 | 271 | 191; 191 |
| Beta Particles and Photons (Dissolved) | mRem/yr | 0[e]; 4 | 271 | 267 | (i) |
| Radium-226 and 228 (Combined, Dissolved) | pCi/L | 0[e]; 5 | 265 | 249 | 249; 101 |
| Radon-222 (Total) | pCi/L | 0[e]; 300[j] | 251 | 251 | 249; 194 |

Notes:

(a) MCL - 40 CFR 141, National Primary Drinking Water Regulations, maximum contaminant level, enforceable.

(b) 40 CFR 141, National Secondary Drinking Water Regulations, non-enforceable standard, water exceeding standard may cause cosmetic and/or aesthetic effects.

(c) Drinking water advisory, non-enforceable, for persons on restricted sodium diets, from "2009 Edition of the Drinking Water Standards and Health Advisories," EPA 822-R-09-011, p. 12, U.S. Environmental Protection Agency, Washington, D.C., Fall 2009.

(d) Drinking water advisory, non-enforceable, taste threshold, from EPA 822-R-09-011, p. 12.

(e) 40 CFR 141, National Primary Drinking Water Regulations, maximum contaminant level goal, non-enforceable.

(f) Health advisory lifetime standard, non-enforceable, from EPA 822-R-09-011, pp. 8-9.

(g) 40 CFR 141, National Primary Drinking Water Regulations, action level, which, if exceeded, triggers treatment.

(h) Permit limit calculated by US EPA Region 8 drinking water toxicologist based on human-health criteria for Region 8 Underground Injection Control Class V permitting program (http://www.epa.gov/region8/water/uic/r8cvprog.html).

(i) Not compared; gross beta reported in pCi/L.

(j) Proposed maximum contaminant level.

* Number of samples includes quarterly samples from 19 wells (wells 2, 7, 8, 13, 16, 18, 42, 619, 628, 631, 635, 650, 675, 676, 677, 678, 679, 4002, 7002) collected between the third quarter of 2007 and the second quarter of 2008, one year of monthly samples from 12 wells (615, 622, 680, 681, 688, 689, 694, 695, 696, 697, 698, 3026) collected between early 2008 and early 2009, less one missed sample in March 2008 from 695, one year of monthly samples from 2 wells (705 and 706) collected between January and December 2010, 21 duplicate samples, and 7 mid-month samples (2 from 680, 3 from 681, and 1 from 688 and 689 each).

***TR RAI 2.7-18***

***The applicant identified 48 sub impoundments in the application. The applicant did not provide summary data on the eight sub impoundments (Sub12 through Sub19). The staff cannot determine whether or not the subset of impoundments is representative of the 48 impoundments without that information. Please address this comment.***

**TR RAI 2.7-18 Response**

The TR incorrectly stated the number of impoundments identified during the July 2007 field survey. During the field survey, 40 impoundments were identified within and surrounding the project area. In addition to the 40 impoundments, 8 stream sampling sites were established on Beaver Creek, the Cheyenne River, Pass Creek, Bennett Canyon, and unnamed tributaries. These stream sampling sites were originally designated as Sub12 through Sub19; however, since the sampling sites were located on streams the sites were renamed BVC01, BVC04, CHR01, CHR05, PSC01, PSC02, BEN01, and UNT01, respectively. Section 2.7 of the TR will be revised to accurately reflect the number of impoundments identified within and surrounding the project area. Please refer to the response to TR RAI 29-43(a) for further discussion regarding pre-operational and operational impoundment monitoring.

***TR RAI 2.7-19***

***The analytical data includes results for the dissolved, suspended and total analyzed fractions of a constituent at one or more sampling events at a single location. The applicant did not discuss differences/relationships between the various fractions and at times appears to include more than one fraction in a statistical analysis. Please clarify the analytical results as discussed above.***

**TR RAI 2.7-19 Response**

The surface water and groundwater appendices have been revised as described in the response to TR RAI 2.7-15, TR RAI RI-4(b), and TR RAI 2.9-50. The following revised appendices are included with this response package and will be included with the revised TR:

- Appendix 2.7-C Surface Water Quality Summary Tables
- Appendix 2.7-F Surface Water Analytical Results
- Appendix 2.7-G Groundwater Quality Summary Tables
- Appendix 2.7-H Groundwater Analytical Results
- Appendix 2.9-I Radionuclide Concentrations in Surface Water
- Appendix 2.9-J Radionuclide Concentrations in Groundwater

The revised summary tables clearly indicate whether each result pertains to dissolved, suspended or total analyzed fraction of each constituent. The following information will be incorporated into the revised TR.

Surface water and groundwater samples collected as part of the baseline monitoring program were analyzed for constituents listed in Table 2.7-22 and 2.7-30 of the TR, respectively. The constituents met the recommendations of Regulatory Guide 4.14 and NUREG-1569 Table 2.7.3-1. Metals were analyzed for dissolved fractions, while radionuclides were typically analyzed for the dissolved and suspended fractions. In some samples analysis was also completed for total metals and total radionuclides.

Relationships between dissolved and suspended radionuclide concentrations were evaluated for both the groundwater and surface water. Based on a comparison of all radionuclide concentrations in groundwater provided in Appendix 2.9-J, the dissolved and suspended radionuclide fractions in groundwater were generally similarly small. However, some differences are apparent. For example, approximately half (51%) of the Pb-210 analyses were higher for the dissolved fraction versus suspended (36% - the remaining 13% were equal). Higher dissolved fractions were most apparent in Ra-226 and uranium. During the baseline monitoring 244 groundwater samples were analyzed for both dissolved and suspended Ra-226. The results show that the majority (91%) of the samples measured higher dissolved than suspended Ra-226. The maximum dissolved Ra-226 measured was 1,440 pCi/L, while the maximum suspended Ra-226 concentration was 15.3 pCi/L. Similarly, dissolved uranium was measured at higher concentrations than the suspended fraction (nearly 70%).

Relationships for the surface water radionuclide concentrations indicated that suspended fractions are slightly higher for all constituents, with the exception of uranium. The results show that the majority (83.5%) of the samples measured higher dissolved uranium. Overall, the concentrations of radionuclides in surface water are generally near or below the applicable detection limits.

***<u>TR RAI 2.7-20</u>***

***The applicant includes surface impoundment Sub05 in the surface water monitoring program. However, sampling results for surface impoundment Sub05 are not presented in the application nor is the lack of results discussed. Please explain this lack of data.***

**<u>TR RAI 2.7-20 Response</u>**

The TR will be revised to include the following information.

Surface impoundment Sub05 was dry throughout the baseline monitoring program. As part of the baseline monitoring program, Sub05 was visited on a quarterly basis from July 2007 to June 2008. During each quarterly visit the impoundment was found to be dry and no samples were collected. A summary of impoundment sampling for the baseline surface water monitoring program is provided in the response to TR RAI 2.9-43(a). This includes a table illustrating which impoundments were sampled during each quarterly sampling event and indicating why others, such as Sub05, were not sampled.

***<u>TR RAI 2.7-21</u>***

***On Page 2-195, the applicant indicates that water quality data were collected during the 2008 pumping test at additional wells listed in a table entitled "Additional Well Data"; however, the data are not presented in the application in either Appendix 2.7-G (Groundwater Quality Data), a table entitled "Additional Water Quality Data and Statistics by Well" in Appendix 2.7-1, or Appendix 2.7-B 2008 (Pumping Tests: Results and Analyses). Please address this discrepancy.***

**<u>TR RAI 2.7-21 Response</u>**

Please refer to the response to TR RAI 2.7-15, which describes revised Appendix 2.7-G. This appendix includes additional groundwater quality results on a well-by-well basis, including the eight wells sampled during the 2008 pumping tests (Well IDs 49, 682, 684, 685, 686, 687, 691, and 692). An additional well, 683, was not sampled during the 2008 pump tests as originally planned. Appendix 2.7-G has been provided with this RAI response package and will be included with the revised TR.

***<u>TR RAI 2.7-22</u>***
***Please address discrepancies in the following data.***

- ***Data for Well 2 in Appendix 2.7-G differ from the data for Well 2 in Appendix 2.7-I.***
- ***Data for Well 7 in Appendix 2.7-I list an additional sampling event from the data for Well 7 in Appendix 2.7-G.***

**<u>TR RAI 2.7-22 Response</u>**
The appendices in the TR have been revised, as described in the response to TR RAI 2.7-15. Appendix 2.7-G has been revised to include all of the groundwater sampling results, including Wells 2 and 7. During the baseline monitoring (July 2007 to June 2008) Wells 2 and 7 were each sampled four times. Previous TR Appendices 2.7-G and Appendix 2.7-I have been replaced by Appendix 2.7-G, a copy of which has been provided with this RAI response package and will be included with the revised TR.

***TR RAI 2.7-23***

***The mean value for radon for well #18 is 5 pCi/L in Appendix 2.7-I; however, this mean is not consistent with the listed range in data values (762-1210 pCi/L). Please explain this apparent discrepancy.***

**TR RAI 2.7-23 Response**

The mean radon concentration for Well 18 was incorrectly reported in Appendix 2.7-I of the TR. As described in the response to TR RAI 2.7-15, Appendix 2.7-G has been revised to include all of the groundwater sample results. The summary statistics reported in Appendix 2.7-G for well 18 show that during baseline monitoring the mean Radon-222 concentration in Well 18 was 1,034 pCi/L. Appendix 2.7-G and Appendix 2.7-I have been replaced with the revised Appendix 2.7-G, which has been included with this RAI response package and will be included with the revised TR.