# APPENDIX A1

The following preview satellite images show the salt crust extent of the Bonneville Salt Flats in October 1988 and October 2003. The October 1988 image is the source of the revised 1988 salt crust boundary. Preview images were obtained from the U.S. Geological Survey's Earth Explorer website, http://edcsns17.cr.usgs.gov/EarthExplorer/. The source data set for the images is Thematic Mapper (TM) Landsat 4-5, and contains satellite images with a period of record from July 1982 to present. Spatial coverage that includes the Bonneville Salt Flats is shown in Figure A1.1. The latitude – longitude coordinates (degree/minute/second) from the northwest to the southeast corner of this coverage are 41/31/08 N – 114/02/35 W, and 40/38/16 N – 112/34/23 W, respectively.

To facilitate comparison of the salt crust distribution in the October 1988 and 2003 Landsat 4-5 images, their respective coverages were cropped to include the Bonneville Salt Flats and selected adjacent land marks such as Floating Island (see yellow-bounded rectangle in Figure A1.1). Comparison of Figures A1.2A and B show the effects on salt-crust area that resulted from the 1996 construction of a berm extending from the north end of the lease collection ditch to Floating Island as part of the Salt Laydown Project. This berm usually restricted the transient winter pond to the west side of the collection ditch (Figure A1.2B). Prior to the berm's construction, the winter pond had an unrestricted path that allowed it to flow around the north end of the collection ditch and deposit a thin layer of salt on the east side of the collection ditch (Figure A1.2A).

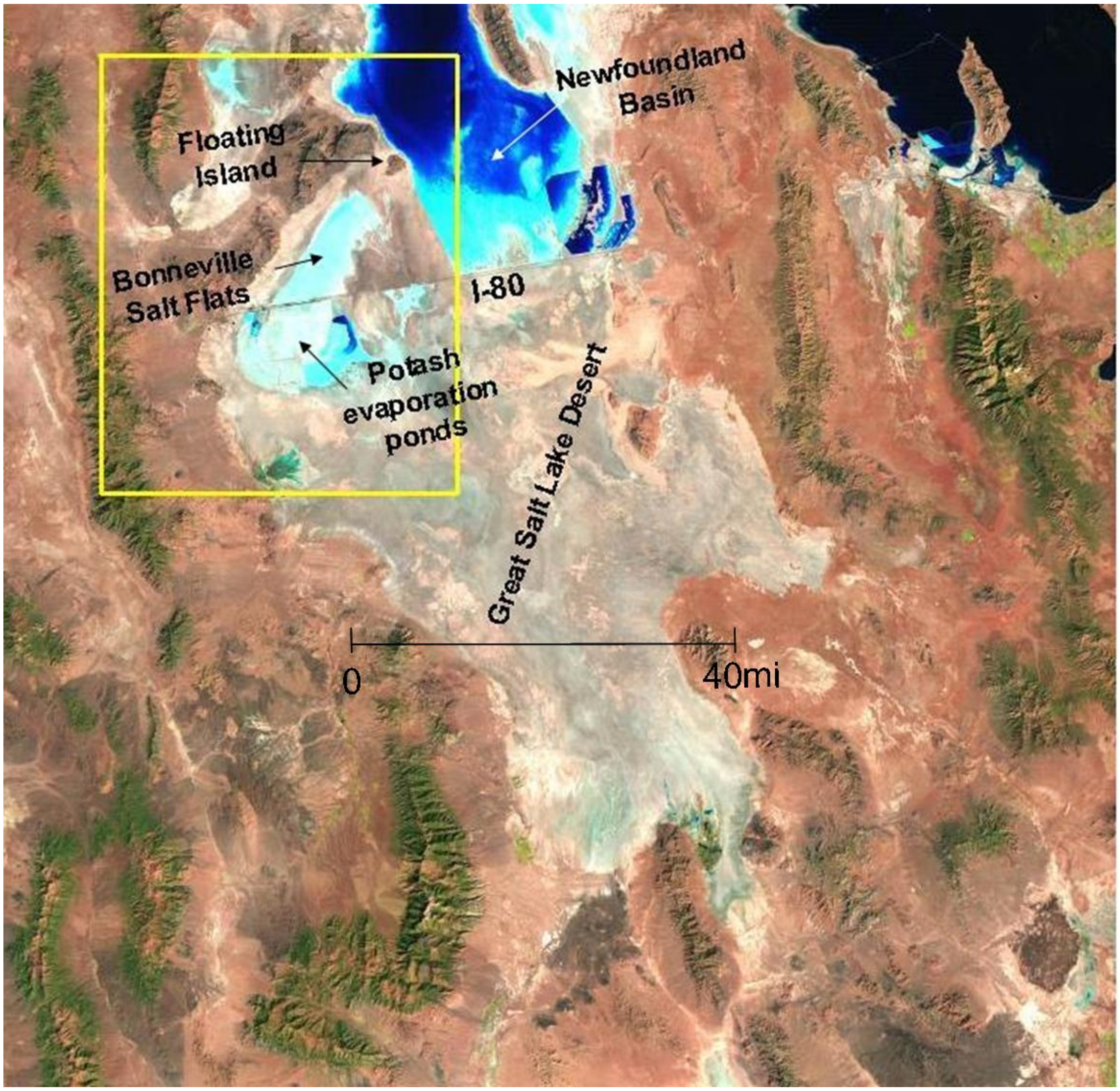


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**Figure A1.1**. – October 17, 1988 TM Landsat 4-5 preview imagery of the Great Salt Lake Desert, which includes Bonneville Salt Flats and Newfoundland Basin. The 1988 and 2003 images illustrated in Figures A1.2A and B were cropped to match an area similar to that shown bounded by the yellow rectangle. Scale bar is approximate.

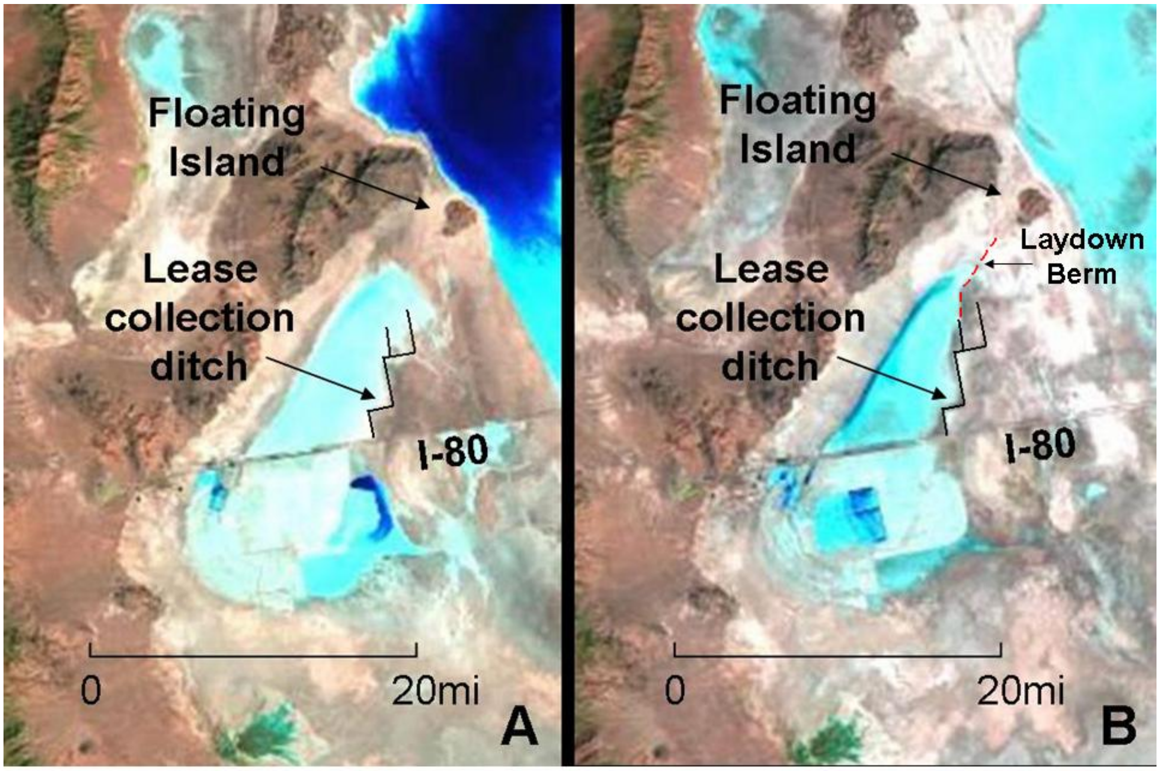


**Figure A1.2**. – Comparison of cropped TM Landsat 4-5 satellite images of Bonneville Salt Flats dated October 17, 1988 (A1.2A) and October 11, 2003 (A1.2B). The visible salt crust north of I-80 in figure A1.2A is the source of the revised 1988 salt-crust boundary (also see Figure A1.1). The difference between 1988 and 2003 salt-crust area is due to the 1996 construction of a berm from the north end of the lease collection ditch to Floating Island as part of the 1997-2002 Salt Laydown Project. Bar scales are approximate.

## APPENDIX A2

**Table A2.1.1. – Salt-crust stratigraphic logs for bore holes D-03 through D-15B (see Figure 4)**

| Bore Hole | **D-03** | | **D-05** | | **D-07** | | **D-10** | | **D-11** | | **D-12B** | | **D-14** | | **D-15B** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thickness | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches |
| DCH | 0.04 | 0.50 | 0.12 | 1.44 | 0.03 | 0.36 | 0.10 | 1.25 | 0.11 | 1.32 | 0.50 | 6.00 | 0.20 | 2.38 | 0.15 | 1.80 |
| 1st Gyp | 1.46 | 17.5 | 0.38 | 4.56 | 1.27 | 15.24 | 1.17 | 14.00 | 0.14 | 1.68 | 1.24 | 14.88 | 0.18 | 2.13 | 0.50 | 6.00 |
| CH | | | 0.32 | 3.84 | | 0.00 | 0.00 | | 2.15 | 25.80 | 1.06 | 12.72 | 2.29 | 27.50 | 2.55 | 30.60 |
| Measured | 1.50 | 18.00 | 0.82 | 9.84 | 1.30 | 15.60 | 1.27 | 15.25 | 2.40 | 28.80 | 2.80 | 33.60 | 2.67 | 32.00 | 3.20 | 38.40 |
| SC/Clay | 1.50 | 18.00 | 1.70 | 20.40 | 1.30 | 15.60 | 1.27 | 15.25 | 2.40 | 28.80 | 2.80 | 33.60 | 2.67 | 32.00 | 3.20 | 38.40 |
| STWL | | | | | | | 0.08 | 1.00 | 0.77 | 9.24 | 1.34 | 16.08 | 1.08 | 13.00 | 0.85 | 10.20 |

DCH Dense-cemented halite (surface stratum of the salt crust)
Gyp Gypsum
CH Coarse halite
Measured Total salt crust measured
SC/Clay Distance below ground level to salt crust/clay interface
STWL Distance below ground level to static water level

**Table A2.1.2. - Salt-crust stratigraphic logs for bore holes D-24 through D-41 (see Figure 4)**

| Bore Hole | **D-24** | | **D-25** | | **D-30** | | **D-34** | | **D-37** | | **D-41** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thickness | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches |
| DCH | 0.13 | 1.50 | 0.17 | 2.00 | 0.19 | 2.25 | 0.21 | 2.50 | 0.29 | 3.50 | 0.25 | 3.00 |
| 1st Gyp | 0.04 | 0.50 | 0.04 | 0.50 | 0.02 | 0.25 | 0.04 | 0.50 | 0.02 | 0.25 | 0.15 | 1.75 |
| CH | 3.92 | 47.00 | 2.54 | 30.50 | 3.38 | 40.50 | 4.08 | 49.00 | 2.27 | 27.25 | 2.60 | 31.25 |
| Measured | 4.08 | 49.00 | 2.75 | 33.00 | 3.58 | 43.00 | 4.33 | 52.00 | 2.58 | 31.00 | 3.00 | 36.00 |
| SC/Clay | 4.08 | 49.00 | 2.75 | 33.00 | 3.58 | 43.00 | 4.33 | 52.00 | 2.58 | 31.00 | 3.00 | 36.00 |
| STWL | 0.98 | 11.75 | 1.92 | 23.00 | 0.65 | 7.75 | 0.25 | 3.00 | 0.25 | 3.00 | 0.42 | 5.00 |

DCH Dense-cemented halite (surface stratum of the salt crust)
Gyp Gypsum
CH Coarse halite
Measured Total salt crust measured
SC/Clay Distance below ground level to salt crust/clay interface
STWL Distance below ground level to static water level

**Table A2.1.3. - Salt-crust stratigraphic logs for bore holes D-02 through D-17 (see Figure 4)**

| Bore Hole | D-02 | | D-04 | | D-06B | | D-08 | | D-09 | | D-13 | | D-16 | | D-17 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thickness | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches |
| DCH | 0.02 | 0.25 | 0.13 | 1.50 | 0.38 | 4.50 | 0.10 | 1.20 | 0.13 | 1.50 | 0.13 | 1.50 | 0.19 | 2.25 | 0.13 | 1.50 |
| 1st Gyp | 1.15 | 13.75 | 1.42 | 17.00 | 1.29 | 15.50 | 0.15 | 1.80 | 1.46 | 17.50 | 1.38 | 16.50 | 1.31 | 15.75 | 1.08 | 13.00 |
| CH | | | | | | | 0.27 | 3.20 | | | | | | | | |
| 2nd Gyp | | | | | | | 0.05 | 0.60 | | | | | | | | |
| Measured | 1.17 | 14.00 | 1.54 | 18.50 | 1.67 | 20.00 | 0.57 | 6.80 | 1.58 | 19.00 | 1.50 | 18.00 | 1.50 | 18.00 | 1.21 | 14.50 |
| SC/Clay | 1.17 | 14.00 | 1.54 | 18.50 | 1.67 | 20.00 | 1.30 | 15.60 | 1.58 | 19.00 | 1.50 | 18.00 | 1.50 | 18.00 | 1.21 | 14.50 |
| STWL | | | 1.71 | 20.50 | | | 1.25 | 15.00 | | | | | 1.31 | 15.75 | | |

DCH  Dense-cemented halite (surface stratum of the salt crust)
Gyp  Gypsum
CH  Coarse halite
Measured  Total salt crust measured
SC/Clay  Distance below ground level to salt crust/clay interface
STWL  Distance below ground level to static water level

**Table A2.1.4. - Salt-crust stratigraphic logs for bore holes D-18 through D-27 (see Figure 4)**

| Bore Hole | D-18 | | D-19 | | D-20 | | D-21 | | D-22 | | D-23 | | D-26 | | D-27 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thickness | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches |
| DCH | 0.08 | 1.00 | 0.25 | 3.00 | 0.21 | 2.50 | 0.15 | 1.75 | 0.04 | 0.50 | 0.25 | 3.00 | 0.06 | 0.75 | 0.04 | 0.50 |
| 1st Gyp | 0.54 | 6.50 | 0.13 | 1.50 | 0.77 | 9.25 | 2.02 | 24.25 | 0.96 | 11.50 | 0.13 | 1.50 | 1.10 | 13.25 | 0.88 | 10.50 |
| CH | | | 0.13 | 1.50 | 0.98 | 11.75 | | | | | 0.31 | 3.75 | | | | |
| 2nd Gyp | | | 1.17 | 14.00 | 0.25 | 3.00 | | | | | 1.17 | 14.00 | | | | |
| Measured | 0.63 | 7.50 | 1.67 | 20.00 | 2.21 | 26.50 | 2.17 | 26.00 | 1.00 | 12.00 | 1.85 | 22.25 | 1.17 | 14.00 | 0.92 | 11.00 |
| SC/Clay | 0.63 | 7.50 | 1.67 | 20.00 | 2.21 | 26.50 | 2.17 | 26.00 | 1.00 | 12.00 | 1.85 | 22.25 | 1.17 | 14.00 | 0.92 | 11.00 |
| STWL | | | 0.08 | 1.00 | 1.04 | 12.50 | | | | | 0.10 | 1.25 | | | | |

DCH  Dense-cemented halite (surface stratum of the salt crust)
Gyp  Gypsum
CH  Coarse halite
Measured  Total salt crust measured
SC/Clay  Distance below ground level to salt crust/clay interface
STWL  Distance below ground level to static water level

**Table A2.1.5. - Salt-crust stratigraphic logs for bore holes D-28 through D-43 (see Figure 4)**

| Bore Hole | D-28 | | D-31 | | D-32 | | D-33 | | D-36 | | D-38 | | D-39 | | D-43 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thickness | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches |
| DCH | 0.29 | 3.50 | 0.17 | 2.00 | 0.10 | 1.25 | 0.27 | 3.25 | 0.15 | 1.75 | 0.33 | 4.00 | 0.06 | 0.75 | 0.13 | 1.50 |
| 1st Gyp | 0.17 | 2.00 | 0.04 | 0.50 | 1.02 | 12.25 | 0.17 | 2.00 | 0.67 | 8.00 | 0.13 | 1.50 | 0.60 | 7.25 | 0.73 | 8.75 |
| CH | 0.42 | 5.00 | 1.58 | 19.00 | | | 2.40 | 28.75 | | | 2.15 | 25.75 | | | | |
| 2nd Gyp | 0.75 | 9.00 | | | | | | | | | | | | | | |
| Measured | 1.63 | 19.50 | 1.79 | 21.50 | 1.13 | 13.50 | 2.83 | 34.00 | 0.81 | 9.75 | 2.60 | 31.25 | 0.67 | 8.00 | 0.85 | 10.25 |
| SC/Clay | 1.63 | 19.50 | 1.79 | 21.50 | 1.13 | 13.50 | 2.83 | 34.00 | 0.81 | 9.75 | 2.60 | 31.25 | 0.67 | 8.00 | 0.85 | 10.25 |
| STWL | 0.17 | +2.00 | | | | | 0.13 | +1.50 | | | 1.29 | 15.50 | | | 0.06 | +0.75 |

DCH  Dense-cemented halite (surface stratum of the salt crust)
Gyp  Gypsum
CH  Coarse halite
Measured  Total salt crust measured
SC/Clay  Distance below ground level to salt crust/clay interface
STWL  Distance below ground level to static water level

**Table A2.1.6. - Salt-crust stratigraphic logs for bore holes D-44 through D-56 (see Figure 4)**

| Bore Hole | D-44 | | D-46 | | D-48 | | D-49 | | D-50 | | D-51 | | D-55 | | D-56 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thickness | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches |
| DCH | 0.21 | 2.50 | 0.04 | 0.50 | 0.02 | 0.25 | 0.02 | 0.25 | 0.02 | 0.25 | 0.02 | 0.25 | 0.08 | 1.00 | 0.31 | 3.75 |
| 1st Gyp | 0.10 | 1.25 | 0.83 | 10.00 | 1.06 | 12.75 | 1.23 | 14.75 | 1.23 | 14.75 | 1.48 | 17.75 | 0.58 | 7.00 | 0.02 | 0.25 |
| CH | 2.02 | 24.25 | | | 0.08 | 1.00 | | | | | | | | | 2.67 | 32.00 |
| 2nd Gyp | | | | | | | | | | | | | | | 0.71 | 8.50 |
| Measured | 2.33 | 28.00 | 0.88 | 10.50 | 1.17 | 14.00 | 1.25 | 15.00 | 1.25 | 15.00 | 1.50 | 18.00 | 0.67 | 8.00 | 3.71 | 44.50 |
| SC/Clay | 2.33 | 28.00 | 0.88 | 10.50 | 1.17 | 14.00 | 1.25 | 15.00 | 1.25 | 15.00 | 1.50 | 18.00 | 0.67 | 8.00 | 3.71 | 44.50 |
| STWL | 0.06 | 0.75 | 0.88 | 10.50 | 1.63 | 19.50 | 1.08 | 13.00 | | | | | | | 1.88 | 22.50 |

DCH  Dense-cemented halite (surface stratum of the salt crust)
Gyp  Gypsum
CH  Coarse halite
Measured  Total salt crust measured
SC/Clay  Distance below ground level to salt crust/clay interface
STWL  Distance below ground level to static water level

**Table A2.1.7. - Salt-crust stratigraphic logs for bore holes D-57 through D-64 (see Figure 4)**

| Bore Hole | D-57 | | D-58 | | D-59 | | D-60 | | D-61 | | D-62 | | D-63 | | D-64 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thickness | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches |
| DCH | 0.06 | 0.75 | 0.31 | 3.75 | 0.08 | 1.00 | 0.27 | 3.25 | 0.02 | 0.25 | 0.33 | 4.00 | 0.21 | 2.50 | 0.00 | 0.00 |
| 1st Gyp | 0.71 | 8.50 | 1.90 | 22.75 | 1.04 | 12.50 | 0.13 | 1.50 | 1.19 | 14.25 | 1.17 | 14.00 | 0.10 | 1.25 | 0.67 | 8.00 |
| CH | | | | | | | 2.04 | 24.50 | | | | | 1.15 | 13.75 | | |
| 2nd Gyp | | | | | | | 1.48 | 17.75 | | | | | 1.04 | 12.50 | | |
| Measured | 0.77 | 9.25 | 2.21 | 26.50 | 1.13 | 13.50 | 3.92 | 47.00 | 1.21 | 14.50 | 1.50 | 18.00 | 2.50 | 30.00 | 0.67 | 8.00 |
| SC/Clay | 0.77 | 9.25 | 2.21 | 26.50 | 1.13 | 13.50 | 3.92 | 47.00 | 1.21 | 14.50 | 1.50 | 18.00 | 2.50 | 30.00 | 0.67 | 8.00 |
| STWL | | | | | | | 1.17 | 14.00 | | | 1.58 | 19.00 | 0.83 | 10.00 | | |

DCH Dense-cemented halite (surface stratum of the salt crust)
Gyp Gypsum
CH Coarse halite
Measured Total salt crust measured
SC/Clay Distance below ground level to salt crust/clay interface
STWL Distance below ground level to static water level

**Table A2.1.8. - Salt-crust stratigraphic logs for bore holes D-65 through D-72 (see Figure 4)**

| Bore Hole | D-65 | | D-66 | | D-67b | | D-68 | | D-69 | | D-70 | | D-71 | | D-72 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thickness | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches |
| DCH | 0.13 | 1.50 | 0.25 | 3.00 | 0.15 | 1.75 | 0.06 | 0.75 | 0.17 | 2.00 | 0.06 | 0.75 | 0.02 | 0.25 | 0.08 | 1.00 |
| 1st Gyp | | | 1.50 | 18.00 | | | 0.94 | 11.25 | 0.17 | 2.00 | 1.44 | 17.25 | 0.85 | 10.25 | 0.38 | 4.50 |
| CH | 1.15 | 13.75 | | | 2.56 | 30.75 | | | 0.25 | 3.00 | | | 0.29 | 3.50 | 0.21 | 2.50 |
| 2nd Gyp | 0.79 | 9.50 | | | 0.50 | 6.00 | | | 0.50 | 6.00 | | | | | 0.92 | 11.00 |
| CH | | | | | | | | | 1.04 | 12.50 | | | | | | |
| Measured | 2.06 | 24.75 | 1.75 | 21.00 | 3.21 | 38.50 | 1.00 | 12.00 | 2.13 | 25.50 | 1.50 | 18.00 | 1.17 | 14.00 | 1.58 | 19.00 |
| SC/Clay | 2.06 | 24.75 | 1.75 | 21.00 | 3.21 | 38.50 | 1.00 | 12.00 | 2.13 | 25.50 | 1.50 | 18.00 | 1.17 | 14.00 | 1.58 | 19.00 |
| STWL | 1.79 | 21.50 | 0.17 | +2.00 | 0.75 | 9.00 | 0.75 | 9.00 | 0.42 | 5.00 | | | 1.38 | 16.50 | 1.71 | 20.50 |

DCH Dense-cemented halite (surface stratum of the salt crust)
Gyp Gypsum
CH Coarse halite
Measured Total salt crust measured
SC/Clay Distance below ground level to salt crust/clay interface
STWL Distance below ground level to static water level

**Table A2.1.9. - Salt-crust stratigraphic logs for bore holes D-29 through D-54 (see Figure 4)**

| Bore Hole | **D-29** | | **D-35** | | **D-42** | | **D-45** | | **D-52** | | **D-53** | | **D-54** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thickness | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches | ft | inches |
| DCH | 0.10 | 1.25 | 0.21 | 2.50 | 0.21 | 2.50 | 0.33 | 4.00 | 0.21 | 2.50 | 0.33 | 4.00 | 0.08 | 1.00 |
| 1st Gyp | 0.06 | 0.75 | 0.04 | 0.50 | 0.13 | 1.50 | 0.08 | 1.00 | 0.17 | 2.00 | 0.08 | 1.00 | 0.08 | 1.00 |
| CH | 0.50 | 6.00 | 1.17 | 14.00 | 0.50 | 6.00 | 0.08 | 1.00 | 0.63 | 7.50 | 0.13 | 1.50 | 0.13 | 1.50 |
| 2nd Gyp | 0.08 | 1.00 | 0.13 | 1.50 | 0.17 | 2.00 | 0.08 | 1.00 | 0.17 | 2.00 | 0.08 | 1.00 | 0.08 | 1.00 |
| CH | 1.33 | 16.00 | 0.13 | 1.50 | 0.63 | 7.50 | 0.21 | 2.50 | 0.17 | 2.00 | 0.33 | 4.00 | 1.08 | 13.00 |
| 3rd Gyp | 1.13 | 13.50 | 0.13 | 1.50 | 0.25 | 3.00 | 0.08 | 1.00 | 0.17 | 2.00 | 0.17 | 2.00 | 0.08 | 1.00 |
| CH | | | 1.04 | 12.50 | 1.46 | 17.50 | 0.08 | 1.00 | 0.58 | 7.00 | 0.50 | 6.00 | 0.29 | 3.50 |
| 4th Gyp | | | 1.83 | 22.00 | 1.67 | 20.00 | 0.13 | 1.50 | 0.67 | 8.00 | 0.25 | 3.00 | 0.13 | 1.50 |
| CH | | | | | | | 0.67 | 8.00 | | | 1.13 | 13.50 | 0.13 | 1.50 |
| 5th Gyp | | | | | | | 0.13 | 1.50 | | | 0.71 | 8.50 | 0.08 | 1.00 |
| CH | | | | | | | 1.13 | 13.50 | | | | | 0.75 | 9.00 |
| 6th Gyp | | | | | | | 1.63 | 19.50 | | | | | 0.71 | 8.50 |
| Measured | 3.21 | 38.50 | 4.67 | 56.00 | 5.00 | 60.00 | 4.63 | 55.50 | 2.75 | 33.00 | 3.71 | 44.50 | 3.63 | 43.50 |
| SC/Clay | 3.21 | 38.50 | 4.67 | 56.00 | 5.00 | 60.00 | 4.63 | 55.50 | 2.75 | 33.00 | 3.71 | 44.50 | 3.63 | 43.50 |
| STWL | 0.42 | 5.00 | 0.63 | 7.50 | 0.50 | 6.00 | 0.54 | 6.50 | 0.42 | 5.00 | 0.46 | 5.50 | 0.33 | 4.00 |

DCH  Dense-cemented halite (surface stratum of the salt crust)
Gyp  Gypsum
CH  Coarse halite
Measured  Total salt crust measured
SC/Clay  Distance below ground level to salt crust/clay interface
STWL  Distance below ground level to static water level

**Table A2.2.1. – Comparison of salt-crust thickness difference between mud-auger and UDOT-pole measurement methods (auger < pole, n=23; and auger = pole, n=5)**

| UTM-E | UTM-N | Bore Hole# | Auger | Pole | A-P, in. | A-P, ft. | Location on Salt Crust |
|---|---|---|---|---|---|---|---|
| 264843.95 | 4519159.10 | D-26 | 14.0 | 20.4 | -6.4 | -0.53 | Thin salt crust, E margin (0.75 in DCH, 13.25 in gyp) |
| 258806.53 | 4519028.32 | D-37 | 31.3 | 34.8 | -3.5 | -0.29 | Thick salt crust, W margin (3.5 in DCH, 0.25 in gyp, 27.25 in CH) |
| 262352.54 | 4522327.37 | D-23 | 22.3 | 25.2 | -3.0 | -0.25 | Thin salt crust, W margin (3.0 in DCH, 1.5 in gyp, 3.75 in CH, 14.0 in gyp) |
| 267644.08 | 4523412.73 | D-70 | 18.0 | 20.4 | -2.4 | -0.20 | Thin salt crust, E margin (0.75 in DCH, 17.25 in gyp) |
| 261313.67 | 4518449.85 | D-35 | 56.0 | 58.2 | -2.2 | -0.18 | Thick salt crust, 2003 Track (E 7-mi) (2.5 in DCH, 0.5 in gyp, 14.0 in CH, 4.5 in CH&gyp, 12.5 in CH, 22.0 in 4th gyp, ) |
| 259833.75 | 4520329.35 | D-33 | 34.0 | 36.0 | -2.0 | -0.17 | Thick salt crust, W margin (3.25 in DCH, 2.0 in gyp, 28.75 CH) |
| 264345.80 | 4519792.88 | D-65 | 24.8 | 26.4 | -1.7 | -0.14 | Thick salt crust, E margin (1.5 in DCH, 13.75 CH, 9.5 in gyp) |
| 267416.49 | 4526308.55 | D-72 | 19.0 | 20.4 | -1.4 | -0.12 | Thin salt crust, N end International Track (1.0 in DCH, 4.0 in gyp, 2.5 in CH, 11.0 in gyp) |
| 262049.90 | 4522723.73 | D-68 | 12.0 | 13.2 | -1.2 | -0.10 | Thin salt crust, W margin (0.75 in DCH, 11.25 in gyp) |
| 262768.62 | 4516590.66 | D-36 | 9.8 | 10.8 | -1.1 | -0.09 | Thin salt crust, E margin (1.75 in DCH, 8.0 in gyp) |
| 264571.93 | 4516908.69 | D-32 | 13.5 | 14.4 | -0.9 | -0.08 | Thin salt crust, E margin (1.25 in DCH, 12.25 in gyp) |
| 264040.96 | 4517584.38 | D-59 | 13.5 | 14.4 | -0.9 | -0.08 | Thin salt crust, E margin (1.0 in DCH, 12.5 in gyp) |
| 263630.10 | 4523312.39 | D-69 | 25.5 | 26.4 | -0.9 | -0.07 | Thick salt crust, International Track |
| 259637.77 | 4520571.04 | D-66 | 21.0 | 21.6 | -0.6 | -0.05 | Thin salt crust, W margin (3.0 in DCH, 18.0 in gyp) |
| 262545.79 | 4514295.37 | D-39 | 8.0 | 8.4 | -0.4 | -0.03 | Thin salt crust, E margin (0.75 in DCH, 7.25 in gyp) |
| 253730.47 | 4515068.88 | D-48 | 14.0 | 14.4 | -0.4 | -0.03 | Thin salt crust, W margin (0.25 in DCH, 12.75 in gyp, 1.0 in CH) |
| 264392.92 | 4524946.95 | D-71 | 14.0 | 14.4 | -0.4 | -0.03 | Thin salt crust, W margin (0.25 in DCH, 10.25 in gyp, 3.5 in CH) |
| 263336.50 | 4523667.59 | D-19 | 20.0 | 20.4 | -0.4 | -0.03 | Thin salt crust, W margin (3.0 in DCH, 14.0 in gyp) |
| 265073.15 | 4516275.43 | D-57 | 9.3 | 9.6 | -0.4 | -0.03 | Thin salt crust, E margin (0.75 in DCH, 8.5 in gyp) |
| 256419.07 | 4516865.08 | D-43 | 10.3 | 10.6 | -0.3 | -0.03 | Thin salt crust, W margin (1.5 in DCH, 8.75 in gyp) |
| 265657.75 | 4525934.81 | D-10 | 15.3 | 15.6 | -0.3 | -0.02 | Thin salt crust, W margin (1.25 in DCH, 14.0 in gyp) |
| 263572.55 | 4518175.72 | D-31 | 21.5 | 21.6 | -0.1 | -0.01 | Thick salt crust, E margin (2.0 in DCH, 19.0 in CH) |
| 262309.35 | 4517181.71 | D-58 | 26.5 | 26.6 | -0.1 | -0.01 | Thick salt crust, E margin (3.75 in DCH, 22.75 in gyp) |
| 267755.56 | 4527184.52 | D-03 | 18.0 | 18.0 | 0.0 | 0.00 | Thin salt crust, W margin (0.5 in DCH, 17.5 in gyp) |
| 266637.08 | 4524670.25 | D-12B | 33.6 | 33.6 | 0.0 | 0.00 | Thick salt crust, International Track |
| 266378.76 | 4522409.64 | D-16 | 18.0 | 18.0 | 0.0 | 0.00 | Thin salt crust, E margin (2.25 in DCH, 15.75 in gyp) |
| 266106.07 | 4520157.42 | D-22 | 12.0 | 12.0 | 0.0 | 0.00 | Thin salt crust, E margin (0.5 in DCH, 11.5 in gyp) |
| 257546.45 | 4518036.65 | D-62 | 18.0 | 18.0 | 0.0 | 0.00 | Thin salt crust, W limb Salduro Loop (4.0 in DCH, 14.0 in gyp) |

UTM-E & UTM-N  Universal Transverse Mercator coordinates (easting and northing, respectively), NAD 27 datum
A-P  Auger minus Pole thickness measurement (expressed in both feet and inches)
DCH  Dense-cemented halite
CH  Coarse halite
gyp  gypsum

**Table A2.2.2. - Comparison of salt-crust thickness difference between mud-auger and UDOT-pole measurement methods (auger > pole, n=27)**

| UTM-E | UTM-N | Bore Hole# | Auger | Pole | A-P, in. | A-P, ft. | Location on Salt Crust |
|---|---|---|---|---|---|---|---|
| 266880.06 | 4521778.82 | D-17 | 14.5 | 14.4 | 0.1 | 0.01 | Thin salt crust, E margin (1.5 in DCH, 13.0 in gyp) |
| 265843.57 | 4517899.38 | D-61 | 14.5 | 14.4 | 0.1 | 0.01 | Thin salt crust, E margin (0.25 in DCH, 14.25 in gyp) |
| 261589.23 | 4520696.48 | D-29 | 38.5 | 38.4 | 0.1 | 0.01 | Thick salt crust, International Track |
| 265339.22 | 4518530.30 | D-27 | 11.0 | 10.8 | 0.2 | 0.02 | Thin salt crust, E margin (0.5 in DCH, 10.5 in gyp) |
| 266600.14 | 4519529.26 | D-64 | 8.0 | 7.8 | 0.2 | 0.02 | Thin salt crust, E margin (0.0 in DCH, 8.0 in gyp) |
| 260973.73 | 4521494.42 | D-28 | 19.5 | 19.2 | 0.3 | 0.03 | Thick salt crust, W margin |
| 255138.12 | 4515888.11 | D-46 | 10.5 | 10.2 | 0.3 | 0.03 | Thin salt crust, W limb Salduro Loop (1.0 in DCH, 10.0 in gyp) |
| 261811.22 | 4517816.09 | D-60 | 47.0 | 46.2 | 0.8 | 0.07 | Thick salt crust, 2003 Track (E 7-mi) |
| 265604.77 | 4520788.24 | D-21 | 26.0 | 25.2 | 0.8 | 0.07 | Thin salt crust, E margin (1.75 in DCH, 24.25 in gyp) |
| 263076.13 | 4518806.39 | D-63 | 30.0 | 28.8 | 1.2 | 0.10 | Thick salt crust, 2003 Track (E 7-mi) |
| 257785.10 | 4517717.96 | D-41 | 36.0 | 34.8 | 1.2 | 0.10 | Thick salt crust, W limb Salduro Loop |
| 261606.18 | 4515467.17 | D-38 | 31.3 | 30.0 | 1.3 | 0.10 | Thick salt crust, E limb Salduro Loop |
| 264122.08 | 4522676.37 | D-67B | 38.5 | 37.2 | 1.3 | 0.11 | Thick salt crust, International Track |
| 268391.37 | 4525076.46 | D-09 | 19.0 | 17.6 | 1.4 | 0.11 | Thin salt crust, E margin (1.5 in DCH, 17.5 in gyp) |
| 263308.04 | 4515912.26 | D-55 | 8.0 | 6.6 | 1.4 | 0.12 | Thin salt crust, E margin (1.0 in DCH, 7.0 in gyp) |
| 256811.82 | 4516368.25 | D-44 | 28.0 | 26.4 | 1.6 | 0.13 | Thick salt crust, W limb Salduro Loop |
| 253993.66 | 4514754.90 | D-49 | 15.0 | 13.2 | 1.8 | 0.15 | Thin salt crust, W limb Salduro Loop (0.25 in DCH, 14.75 in gyp) |
| 252997.41 | 4514403.12 | D-50 | 15.0 | 13.2 | 1.8 | 0.15 | Thin salt crust, W limb Salduro Loop (0.25 in DCH, 14.75 in gyp) |
| 265383.25 | 4523683.26 | D-15B | 38.0 | 36.0 | 2.0 | 0.17 | Thick salt crust, International Track |
| 265111.41 | 4521419.42 | D-20 | 26.5 | 24.0 | 2.5 | 0.21 | Thick salt crust, 2003 Track (E 7-mi) |
| 261114.04 | 4516098.31 | D-56 | 44.5 | 42.0 | 2.5 | 0.21 | Thick salt crust, E limb Salduro Loop |
| 263845.28 | 4520429.16 | D-25 | 33.0 | 30.0 | 3.0 | 0.25 | Isopach High-Thick salt crust, 2003 Track (E 7-mi) |
| 262578.58 | 4519440.14 | D-30 | 43.0 | 39.6 | 3.4 | 0.28 | Thick salt crust (between Isopach highs @ D-25 & D-35) |
| 264852.50 | 4524365.65 | D-14 | 32.0 | 27.6 | 4.4 | 0.37 | Isopach High-Thick salt crust (2.38 in DCH, 2.13 in gyp, 27.5 in CH) |
| 253306.11 | 4514024.25 | D-51 | 18.0 | 13.2 | 4.8 | 0.40 | Thin salt crust, W limb Salduro Loop (0.25 in DCH, 17.75 in gyp) |
| 260320.15 | 4519709.37 | D-34 | 52.0 | 40.8 | 11.2 | 0.93 | Isopach High-Thick salt crust, International Track |
| 262848.70 | 4521688.18 | D-24 | 49.0 | 36.0 | 13.0 | 1.08 | Isopach High-Thick salt crust, International Track |

UTM-E & UTM-N  Universal Transverse Mercator coordinates (easting and northing, respectively), NAD 27 datum
A-P  Auger minus Pole thickness measurement (expressed in both feet and inches)
DCH  Dense-cemented halite
CH  Coarse halite
gyp  gypsum

**APPENDIX A3**

# INTRODUCTION

## Kriging Algorithms

Ordinary Kriging produces interpolation values by assuming a constant but unknown mean value, allowing local influences due to nearby neighboring values. Because the mean is unknown, there are few assumptions. This makes ordinary kriging particularly flexible, but perhaps less powerful than other methods.

Simple Kriging produces interpolation values by assuming a constant but known mean value, allowing local influences due to nearby neighboring values. Because the mean is known, it is slightly more powerful than ordinary kriging, but in many situations the selection of a mean value is not obvious (Environmental Systems Research Institute 1991-2002).

## Selected Kriging Algorithm and Methodology

The statistical method used to create each isopach map was ordinary kriging, which was accomplished in the following steps (Johnston and others 2001):

- The borehole data were examined with the Geostatistical Analyst "Explore Data" function, which helped identify the type of data distribution (normal or skewed) and any global trends:

    - 1988 and 2003 bore-hole data distributions were marginally normal with respective skewness values of 0.62 and 0.88.

    - Respective mean and median values of both the 1988 and 2003 salt-crust thickness measurements showed reasonable agreement, but the median was less than the mean in both data sets (thus positive skewness of data resulted).

    - Trend analysis of both 1988 and 2003 bore-hole data indicated a strong global trend from southwest to northeast that could be described using a second-order polynomial function; this trend exists because BSF salt crust is lens-shaped in cross section and has a long axis that trends northeast-southwest.

- Ordinary kriging using a spherical model was performed with the Geostatistical Analyst "Geostatistical Wizard," and the global trend was removed by selecting the trend removal second-order function.

- After detrending, examination of the semivariogram surfaces from both sets of bore-hole data (1988 and 2003) showed presence of directional autocorrelation or anisotropy (unlike the global trend which is due to fixed effects such as topography, the cause of anisotropy is usually unknown, and is modeled as random error).

- To better fit a model to the 1988 and 2003 data, the Anisotropy option of the Geostatistical Analyst was used, which calculates the semivariogram model in different directions and estimates the optimum parameters required to account for the observed anisotropy.

- After these parameters were input to the Geostatistical Wizard to calculate the semivariogram model, the final product was a kriged continuous surface of thickness values for each of the 1988 and 2003 bore-hole thickness data sets.

- Cross validation of the 1988 and 2003 data sets was performed to examine the degree of matching between the measured and predicted salt crust thickness measurements at each bore-hole location for the 1988 and 2003 kriged surfaces.

Examples of cross validation results for the 2003 auger borehole data sets are shown in the tables that follow.

Table A3.1. – Results of ArcGIS Geostatistical Wizard Cross Validation on 2003 boreholes D-02 through D-45

| Borehole# | UTM-E | UTM-N | Measured | Predicted | StdError | Error | Stdd_Error | NormValue |
|---|---|---|---|---|---|---|---|---|
| D-02 | 268978.89 | 4526512.30 | 1.17 | 1.59 | 0.431 | 0.420 | 0.973 | 1.159 |
| D-03 | 267755.56 | 4527184.52 | 1.50 | 1.35 | 0.440 | -0.146 | -0.331 | -0.451 |
| D-04 | 268054.98 | 4526801.68 | 1.54 | 1.45 | 0.420 | -0.087 | -0.208 | -0.372 |
| D-05 | 268547.04 | 4526187.00 | 1.70 | 1.31 | 0.374 | -0.388 | -1.038 | -1.159 |
| D-06B | 269051.13 | 4525548.17 | 1.67 | 1.23 | 0.491 | -0.442 | -0.901 | -1.027 |
| D-07 | 266914.26 | 4526948.55 | 1.30 | 1.39 | 0.510 | 0.086 | 0.168 | 0.036 |
| D-08 | 267914.59 | 4525672.95 | 1.30 | 1.90 | 0.431 | 0.596 | 1.382 | 2.019 |
| D-09 | 268391.37 | 4525076.46 | 1.58 | 1.65 | 0.438 | 0.066 | 0.151 | 0.000 |
| D-10 | 265657.75 | 4525934.81 | 1.27 | 1.64 | 0.514 | 0.369 | 0.717 | 0.757 |
| D-11 | 266150.26 | 4525315.25 | 2.40 | 2.31 | 0.466 | -0.087 | -0.187 | -0.257 |
| D-12B | 266637.08 | 4524670.25 | 2.80 | 2.21 | 0.499 | -0.586 | -1.173 | -1.315 |
| D-13 | 267797.71 | 4523219.96 | 1.50 | 1.31 | 0.394 | -0.189 | -0.480 | -0.619 |
| D-14 | 264852.50 | 4524365.65 | 2.67 | 2.31 | 0.464 | -0.363 | -0.782 | -0.967 |
| D-15B | 265383.25 | 4523683.26 | 3.20 | 2.93 | 0.502 | -0.267 | -0.532 | -0.663 |
| D-16 | 266378.76 | 4522409.64 | 1.50 | 2.06 | 0.499 | 0.561 | 1.125 | 1.407 |
| D-17 | 266880.06 | 4521778.82 | 1.21 | 1.27 | 0.466 | 0.055 | 0.119 | -0.036 |
| D-18 | 267376.11 | 4521155.48 | 0.63 | 0.66 | 0.546 | 0.026 | 0.048 | -0.109 |
| D-19 | 263336.50 | 4523667.59 | 1.67 | 1.52 | 0.451 | -0.153 | -0.338 | -0.491 |
| D-20 | 265111.41 | 4521419.42 | 2.21 | 2.41 | 0.497 | 0.199 | 0.400 | 0.372 |
| D-21 | 265604.77 | 4520788.24 | 2.17 | 1.43 | 0.465 | -0.738 | -1.588 | -1.638 |
| D-22 | 266106.07 | 4520157.42 | 1.00 | 1.22 | 0.466 | 0.224 | 0.481 | 0.491 |
| D-23 | 262352.54 | 4522327.37 | 1.85 | 2.12 | 0.433 | 0.273 | 0.632 | 0.663 |
| D-24 | 262848.70 | 4521688.18 | 4.08 | 2.92 | 0.498 | -1.162 | -2.332 | -2.445 |
| D-25 | 263845.28 | 4520429.16 | 2.75 | 3.01 | 0.498 | 0.265 | 0.532 | 0.575 |
| D-26 | 264843.95 | 4519159.10 | 1.17 | 1.51 | 0.464 | 0.340 | 0.734 | 0.911 |
| D-27 | 265339.22 | 4518530.30 | 0.92 | 1.26 | 0.467 | 0.340 | 0.728 | 0.806 |
| D-28 | 260973.73 | 4521494.42 | 1.63 | 2.09 | 0.508 | 0.463 | 0.911 | 1.091 |
| D-29 | 261589.23 | 4520696.48 | 3.21 | 3.75 | 0.511 | 0.536 | 1.048 | 1.315 |
| D-30 | 262578.58 | 4519440.14 | 3.58 | 3.76 | 0.499 | 0.176 | 0.352 | 0.333 |
| D-31 | 263572.55 | 4518175.72 | 1.79 | 1.46 | 0.460 | -0.332 | -0.722 | -0.911 |
| D-32 | 264571.93 | 4516908.69 | 1.13 | 1.01 | 0.480 | -0.123 | -0.256 | -0.411 |
| D-33 | 259833.75 | 4520329.35 | 2.83 | 2.39 | 0.393 | -0.444 | -1.130 | -1.233 |
| D-34 | 260320.15 | 4519709.37 | 4.33 | 3.42 | 0.530 | -0.906 | -1.710 | -1.796 |
| D-35 | 261313.67 | 4518449.85 | 4.67 | 4.47 | 0.548 | -0.202 | -0.368 | -0.533 |
| D-36 | 262768.62 | 4516590.66 | 0.81 | 1.58 | 0.469 | 0.767 | 1.635 | 2.445 |
| D-37 | 258806.53 | 4519028.32 | 2.58 | 2.96 | 0.513 | 0.381 | 0.743 | 0.967 |
| D-38 | 261606.18 | 4515467.17 | 2.60 | 2.25 | 0.513 | -0.349 | -0.681 | -0.806 |
| D-39 | 262545.79 | 4514295.37 | 0.67 | 0.88 | 0.652 | 0.207 | 0.318 | 0.257 |
| D-41 | 257785.10 | 4517717.96 | 3.00 | 2.25 | 0.435 | -0.750 | -1.725 | -2.019 |
| D-42 | 259271.78 | 4515821.17 | 5.00 | 4.57 | 0.611 | -0.426 | -0.697 | -0.857 |
| D-43 | 256419.07 | 4516865.08 | 0.85 | 1.46 | 0.493 | 0.605 | 1.228 | 1.512 |
| D-44 | 256811.82 | 4516368.25 | 2.33 | 2.11 | 0.485 | -0.222 | -0.457 | -0.575 |
| D-45 | 258512.81 | 4514211.49 | 4.63 | 4.50 | 0.633 | -0.126 | -0.198 | -0.295 |

UTM Universal Transverse Mercator coordinates (easting and northing); NAD 27 datum.
StdError Standard error; StddError Standard-deviation error

Table A3.2. – Results of ArcGIS Geostatistical Wizard Cross Validation on 2003 boreholes D-46 through D-72

| Borehole# | UTM-E | UTM-N | Measured | Predicted | StdError | Error | Stdd_Error | NormValue |
|---|---|---|---|---|---|---|---|---|
| D-46 | 255138.12 | 4515888.11 | 0.88 | 0.92 | 0.554 | 0.041 | 0.073 | -0.073 |
| D-48 | 253730.47 | 4515068.88 | 1.17 | 0.88 | 0.431 | -0.288 | -0.668 | -0.757 |
| D-49 | 253993.66 | 4514754.90 | 1.25 | 1.45 | 0.427 | 0.205 | 0.480 | 0.451 |
| D-50 | 252997.41 | 4514403.12 | 1.25 | 0.79 | 0.486 | -0.465 | -0.956 | -1.091 |
| D-51 | 253306.11 | 4514024.25 | 1.50 | 1.63 | 0.457 | 0.128 | 0.281 | 0.220 |
| D-52 | 256311.85 | 4514408.74 | 2.75 | 3.55 | 0.627 | 0.798 | 1.272 | 1.796 |
| D-53 | 260277.94 | 4514556.36 | 3.71 | 3.85 | 0.596 | 0.142 | 0.238 | 0.146 |
| D-54 | 257507.71 | 4515471.38 | 3.63 | 3.78 | 0.579 | 0.147 | 0.254 | 0.183 |
| D-55 | 263308.04 | 4515912.26 | 0.67 | 0.84 | 0.500 | 0.170 | 0.339 | 0.295 |
| D-56 | 261114.04 | 4516098.31 | 3.71 | 3.63 | 0.500 | -0.078 | -0.156 | -0.220 |
| D-57 | 265073.15 | 4516275.43 | 0.77 | -0.09 | 0.591 | -0.863 | -1.460 | -1.512 |
| D-58 | 262309.35 | 4517181.71 | 2.21 | 2.46 | 0.461 | 0.246 | 0.534 | 0.619 |
| D-59 | 264040.96 | 4517584.38 | 1.13 | 1.04 | 0.465 | -0.094 | -0.202 | -0.333 |
| D-60 | 261811.22 | 4517816.09 | 3.92 | 3.62 | 0.475 | -0.300 | -0.630 | -0.709 |
| D-61 | 265843.57 | 4517899.38 | 1.21 | 0.52 | 0.517 | -0.686 | -1.328 | -1.407 |
| D-62 | 257546.45 | 4518036.65 | 1.50 | 2.07 | 0.451 | 0.572 | 1.267 | 1.638 |
| D-63 | 263076.13 | 4518806.39 | 2.50 | 2.70 | 0.464 | 0.195 | 0.421 | 0.411 |
| D-64 | 266600.14 | 4519529.26 | 0.67 | 0.62 | 0.514 | -0.049 | -0.095 | -0.146 |
| D-65 | 264345.80 | 4519792.88 | 2.06 | 2.00 | 0.464 | -0.058 | -0.124 | -0.183 |
| D-66 | 259637.77 | 4520571.04 | 1.75 | 2.18 | 0.436 | 0.434 | 0.995 | 1.233 |
| D-67B | 264122.08 | 4522676.37 | 3.21 | 3.30 | 0.499 | 0.088 | 0.176 | 0.073 |
| D-68 | 262049.90 | 4522723.73 | 1.00 | 1.31 | 0.481 | 0.308 | 0.640 | 0.709 |
| D-69 | 263630.10 | 4523312.39 | 2.13 | 2.48 | 0.427 | 0.351 | 0.823 | 1.027 |
| D-70 | 267644.08 | 4523412.73 | 1.50 | 1.58 | 0.382 | 0.081 | 0.213 | 0.109 |
| D-71 | 264392.92 | 4524946.95 | 1.17 | 1.55 | 0.520 | 0.381 | 0.732 | 0.857 |
| D-72 | 267416.49 | 4526308.55 | 1.58 | 1.79 | 0.416 | 0.214 | 0.513 | 0.533 |

UTM  Universal Transverse Mercator coordinates (easting and northing); NAD 27 datum.
StdError  Standard error; StddError  Standard-deviation error

Table A3.3. – Prediction Errors from cross validation of 2003 borehole samples

| | |
|---|---|
| Mean | 0.00129 |
| Root-Mean-Square | 0.4094 |
| Average Standard Error | 0.49 |
| Mean Standardized | 0.003245 |
| Root-Mean-Square Standardized | 0.8376 |
| n | 69 |

# APPENDIX A4

Table A4.1. – Summary of bore-hole groundwater elevations (DTW) and brine chemistry from 16 bore holes on a 54-mile south-to-north transect that extended from bore hole #209 at the southern 100 g/L chloride contour to bore hole #8 at the center of the Bonneville Salt Flats (after Nolan c. 1926 and 1927) (see Figure 11).

| Bore hole | UTM-E | UTM-N | Surface Elev., ft[1] | DTW, ft BGL | DTW Elev., ft | Brine Chemistry, g/L | | | | | | Log |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | TDS | Cl | $K_2O$ | MgO | $SO_4$ | CaO | |
| 209 | 288,783.81 | 4,432,867.60 | 4254.0 | 3.5 | 4250.5 | 216.9 | 123.0 | 3.1 | ND | ND | ND | Barren flat. Clay to 8.5 ft. |
| 208 | 288,825.97 | 4,434,469.86 | 4252.0 | 4.0 | 4248.0 | ND | 118.0 | 3.8 | ND | 2.0 | ND | Barren flat. Clay to 6.0 ft; caved. |
| 207 | 288,868.14 | 4,436,114.28 | 4250.0 | 3.5 | 4246.5 | ND | 129.0 | 4.0 | ND | 2.0 | ND | Barren flat. Clay to 4.5 ft; caved. |
| 206 | 288,910.30 | 4,437,674.37 | 4249.0 | 3.5 | 4245.5 | ND | 125.0 | 4.6 | ND | 2.0 | ND | Barren flat. Clay to 7.0 ft; caved. |
| 192 | 288,952.47 | 4,439,192.30 | 4249.0 | 4.5 | 4244.5 | ND | 107.0 | 4.2 | ND | 2.0 | ND | Barren flat. Clay to 8.5 ft. |
| 129 | 288,734.25 | 4,444,869.94 | 4247.0 | 3.0 | 4244.0 | ND | 114.0 | 3.5 | ND | ND | ND | Barren flat. Clay to 7.0 ft; caved. |
| 219 | 279,212.44 | 4,449,143.15 | 4239.0 | 2.0 | 4237.0 | ND | 130.0 | 3.7 | ND | 2.0 | ND | Barren flat. Clay to 8.5 ft. |
| 224 | 271,454.14 | 4,459,051.84 | 4229.0 | 4.0 | 4225.0 | 193.9 | 110.5 | 2.9 | 7.3 | 3.6 | ND | Scattered dunes. Clay to 10.0 ft |
| 223 | 273,056.40 | 4,459,009.67 | 4229.0 | 6.5 | 4222.5 | ND | 132.0 | 3.4 | ND | 2.0 | ND | Barren flat. Clay to 8.5 ft. |
| 232 | 270,598.65 | 4,468,967.22 | 4227.0 | 4.0 | 4223.0 | ND | 138.0 | 3.9 | ND | ND | ND | Barren flat. Clay to 8.5 ft. |
| 55 | 260,188.69 | 4,478,965.84 | 4227.5 | 1.5 | 4226.0 | 257.0 | 144.5 | 5.0 | 4.3 | 2.8 | ND | Barren flat. Clay to 4.0 ft; caved. |
| 54 | 260,505.10 | 4,488,648.06 | 4224.0 | 2.0 | 4222.0 | ND | 121.0 | 5.3 | ND | ND | ND | Barren flat. Clay to 8.5 ft. |
| 246 | 252,721.36 | 4,498,551.76 | 4217.0 | 0.5 | 4216.5 | 199.3 | 114.5 | 4.6 | ND | ND | ND | Scattered brush. Clay to 5.0 ft; caved. |
| 3 | 250,063.50 | 4,514,055.96 | 4214.0 | 2.5 | 4211.5 | 283.5 | 165.9 | 5.5 | 5.7 | 5.2 | ND | Barren [mud]flat. Clay to 8 ft. |
| 5 | 253,227.62 | 4,513,644.62 | 4213.0 | 0.3 | 4212.8 | 335.5 | 189.5 | 12.2 | 10.6 | 4.1 | ND | Salt flat. Salt to 1.5 ft; clay to 8 ft. |
| 8 | 258,037.09 | 4,513,328.21 | 4213.0 | 0.3 | 4212.7 | 336.7 | 198.7 | 14.9 | 12.1 | 4.8 | ND | Salt flat. Salt to 3.5 ft; clay to 6 ft; caved. |

[1]Surface elevations estimated from bore-hole locations (Nolan 1927, plate 3) replotted on U.S. Geological Survey 7.5 minute topographic maps
DTW Depth to water
BGL Below ground level
TDS Total dissolved solids
ND No data

- Calculate groundwater gradient from bore-hole #209 to #8 within 100 g/L chloride contour associated with Bonneville Salt Flats (975 square-mile area designated as GSLD-BSF*), where:
    - Elevation difference between bore holes #209 & #8 (4254.0 & 4213.0 ft, respectively) = 41 feet
    - Estimated distance between bore holes #209 & #8 = 54 miles or 285,120 feet

**Equation 1**

$$Groundwater\ gradient \equiv \frac{41.0\ ft}{54\ mi} \equiv 0.76\ ft / mi$$

**Equation 2**

$$Groundwater\ gradient \equiv \frac{41.0\ ft}{285{,}120\ ft} \equiv 0.14 \times 10^{-3}$$

- Calculate Total Dissolved Solids (TDS) concentration gradient from bore hole #209 to #8 within 100 g/L chloride contour associated with Bonneville Salt Flats (975 square-mile area designated as GSLD-BSF*), where:
  - TDS difference between bore holes #209 & #8 (216.9 & 336.7 g/L, respectively) = 119.8 g/L
  - Estimated distance between bore holes #209 & #8 = 54 miles

**Equation 3**

$$TDS\ concentration\ gradient \equiv \frac{119.8\ g / L}{54\ mi} \equiv 2.2\ g / L / mi$$

*GSLD-BSF = Great Salt Lake Desert, Bonneville Salt Flats

# APPENDIX A5

Table A5.1. - Volume and area output from ArcGIS 3D Analyst[1], for 69 boreholes drilled in October, 2003, using the mud-auger-measurement method and 2003 salt-crust boundary; see Figure 8B.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 99,547,261.49 m |
| 3D Area: | 99,547,268.02 m |
| Volume: | 75,795,632.33 $m^3$ |

[1]Dataset is FY04TSC69clip, and output file is FY04TSC_69AareavolB.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 1**

$$75{,}795{,}632\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 61{,}440\ acre-ft$$

**Equation 2**

$$99{,}547{,}261\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 38.43\ mi^2$$

Conversion of acre-feet to tons:

**Equation 3**

$$61{,}440\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 146.9 \times 10^6\ tons$$

Table A5.2. - Volume and area output from ArcGIS 3D Analyst[1], for 55 of 69 boreholes drilled in October, 2003, using the UDOT pole-measurement method and 2003 salt-crust boundary; see Figure 8A.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 99,664,905.35 m |
| 3D Area: | 99,664,910.41 m |
| Volume: | 70,716,309.70 $m^3$ |

[1]Dataset is FY04_55pclip, and output file is FY04TSC_55Pareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 4**

$$70{,}716{,}310\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 57{,}323\ acre-ft$$

**Equation 5**

$$99{,}664{,}905\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 38.48\ mi^2$$

Conversion of acre-feet to tons:

**Equation 6**

$$57{,}323\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 137.1 \times 10^6\ tons$$

Table A5.3. - Volume and area output from ArcGIS 3D Analyst[1], for 118 boreholes drilled in 1988 using the UDOT pole-measurement method (Brooks, 1991) and revised 1988 salt-crust boundary (October 1988 Landsat 4-5); see Figure 9B.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 118,931,558.06 m |
| 3D Area: | 118,931,565.02 m |
| Volume: | 73,567,651.91 $m^3$ |

[1]Dataset is FY88118clipLS, and output file is FY88TSC_118bh_100188LS5bdryB_Pareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 7**

$$73{,}567{,}952\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre - ft}{43{,}560\ ft^3} \equiv 59{,}635\ acre - ft$$

**Equation 8**

$$118{,}931{,}558\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 45.9\ mi^2$$

Conversion of acre-feet to tons:

**Equation 9**

$$59{,}635\ acre - ft \times \frac{43{,}560\ ft^3}{1\ acre - ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 142.6 \times 10^6\ tons$$

Table A5.4. - Volume and area output from ArcGIS 3D Analyst[1], for 118 boreholes drilled in 1988 using the UDOT pole-measurement method and the 1988 salt-crust boundary defined by Brooks (1991, p. 8).

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 109,135,970.35 m |
| 3D Area: | 109,135,977.15 m |
| Volume: | 66,694,975.57 $m^3$ |

[1]Dataset is FY88118clip88, and output file is FY88TSC_118Pareavol88bdry.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 10**

$$66{,}694{,}976\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 54{,}063\ acre-ft$$

**Equation 11**

$$109{,}135{,}970\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 42.1\ mi^2$$

Table A5.5. - Volume and area output from ArcGIS 3D Analyst[1], for the 4 square-mile area excluded by Brooks (1991, p. 5-8); see Figure 2.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 8,656,756.51 m |
| 3D Area: | 8,656,757.02 m |
| Volume: | 6,747,593.70 $m^3$ |

[1]Dataset is FY88brookclip, and output file is FY88brookclipareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 12**

$$6{,}747{,}594\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 5{,}470\ acre-ft$$

**Equation 13**

$$8{,}656{,}757\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 3.34\ mi^2$$

Note: This area is based on ArcGIS calculation of area represented by cells above the 0.0-foot reference plane height (this is because thickness measurements taken from the salt-crust surface to the salt/clay interface were expressed as positive values). In an attempt to converge on 0.0 feet values, the ordinary kriging performed on the 1988 and 2003 bore-hole data by the ArcGIS Geostatistical Wizard predicted some negative thickness values in a small area of salt crust near the southeast corner of the 2003 GPS boundary. To more accurately calculate volume, these negative cells were eliminated by only considering values above the 0.0-foot reference plane. Consequently, as part of the volume calculation, the calculated area was slightly less than the measured polygon area of 4.0 square miles.

Conversion of acre-feet to tons:

**Equation 14**

$$5{,}470\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 13.1 \times 10^6\ tons$$

Table A5.6. - Volume and area output from ArcGIS 3D Analyst[1], for 2003 salt-crust area within the 1-foot thickness contour (see Figure 8B); salt-crust thickness was determined by the mud auger-measurement method.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 89,204,051.23 m |
| 3D Area: | 89,204,057.31 m |
| Volume: | 73,358,823.80 $m^3$ |

[1]Dataset is FY04A_1ftclip, and output file is FY04A_1ftcontClipareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 15**

$$73{,}358{,}824\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 59{,}465\ acre-ft$$

**Equation 16**

$$89{,}204{,}051\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 34.4\ mi^2$$

Conversion of acre-feet to tons:

**Equation 17**

$$59{,}465\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 142.2 \times 10^6\ tons$$

Table A5.7. - Volume and area output from ArcGIS 3D Analyst[1], for 2003 salt-crust area within the 2-foot thickness contour (see Figure 8B); salt-crust thickness was determined by the mud-auger-measurement method.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 55,414,905.36 m |
| 3D Area: | 55,414,909.50 m |
| Volume: | 58,135,210.66 $m^3$ |

[1]Dataset is FY04_2ftclip, and output file is FY04_2ftContClipareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 18**

$$58{,}135{,}211\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 47{,}125\ acre-ft$$

**Equation 19**

$$55{,}414{,}905\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 21.4\ mi^2$$

Conversion of acre-feet to tons:

**Equation 20**

$$47{,}125\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 112.7 \times 10^6\ tons$$

Table A5.8. - Volume and area output from ArcGIS 3D Analyst[1], for 2003 salt-crust area within the 3-foot thickness contour (see Figure 8B); salt-crust thickness was determined by the mud-auger-measurement method.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 33,852,194.72 m |
| 3D Area: | 33,852,196.67 m |
| Volume: | 41,474,725.88 $m^3$ |

[1]Dataset is FY04693ftclip, and output file is FY04tsc_69bh_inside3ftContour_Aareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 21**

$$41{,}474{,}726\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 33{,}620\ acre-ft$$

**Equation 22**

$$33{,}852{,}195\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 13.1\ mi^2$$

Conversion of acre-feet to tons:

**Equation 23**

$$33{,}620\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 80.4 \times 10^6\ tons$$

Table A5.9. – Distribution of 2003 salt-crust volume within selected thickness contours; volume based on mud-auger-measurement method.

| 2003 salt crust volume: | Acre-feet | Percent of total volume |
|---|---:|---:|
| Total volume | 61,440 | 100 |
| Vol w/in 1 to 4+-ft contour | 59,465 | 97 |
| Vol w/in 2 to 4+-ft contour | 47,125 | 77 |
| Vol w/in 3 to 4+-ft contour | 33.620 | 55 |

Table A5.10. - Volume and area output from ArcGIS 3D Analyst[1], for 2003 salt-crust area within the 1-foot thickness contour (see Figure 9A); salt-crust thickness was determined by the UDOT pole-measurement method.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 89,511,729.67 m |
| 3D Area: | 89,511,734.39 m |
| Volume: | 68,419,813.07 $m^3$ |

[1]Dataset is FY04551ftclip, and output file is FY04tsc_55bh_inside1ftcontour_Pareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 24**

$$68{,}419{,}813\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 55{,}462\ acre-ft$$

**Equation 25**

$$89{,}511{,}730\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 34.6\ mi^2$$

Conversion of acre-feet to tons:

**Equation 26**

$$55{,}462\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 132.6 \times 10^6\ tons$$

Table A5.11. - Volume and area output from ArcGIS 3D Analyst[1], for 2003 salt-crust area within the 2-foot thickness contour (see Figure 9A); salt-crust thickness was determined by the UDOT pole-measurement method.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 55,853,725.44 m |
| 3D Area: | 55,853,728.64 m |
| Volume: | 52,927,542.03 m$^3$ |

[1]Dataset is FY04552ftclip, and output file is FY04tsc_55bh_inside2ftcontour_Pareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 27**

$$52{,}927{,}542\ m^3 \times \frac{35.31\ ft^3}{1\,m^3} \times \frac{1\,acre-ft}{43{,}560\ ft^3} \equiv 42{,}903\ acre-ft$$

**Equation 28**

$$55{,}853{,}725\ m^2 \times \frac{1\,acre}{4{,}047\ m^2} \times \frac{1\,mi^2}{640\ acre} \equiv 21.6\ mi^2$$

Conversion of acre-feet to tons:

**Equation 29**

$$42{,}903\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 102.6 \times 10^6\ tons$$

Table A5.12. - Volume and area output from ArcGIS 3D Analyst[1], for 2003 salt-crust area within the 3-foot thickness contour (see Figure 9A); salt-crust thickness was determined by the UDOT pole-measurement method.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 28,255,977.78 m |
| 3D Area: | 28,255,979.25 m |
| Volume: | 31,568,125.47 $m^3$ |

[1]Dataset is FY04553ftclip, and output file is FY04tsc_55bh_inside3ftcontour_Pareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 30**

$$31{,}568{,}125\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 25{,}589\ acre-ft$$

**Equation 31**

$$28{,}255{,}978\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 10.9\ mi^2$$

Conversion of acre-feet to tons:

**Equation 32**

$$25{,}589\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 61.2 \times 10^6\ tons$$

Table A5.13. – Distribution of 2003 salt-crust volume within selected thickness contours; volume based on UDOT pole-measurement method.

| 2003 salt crust volume: | Acre-feet | Percent of total volume |
|---|---|---|
| Total volume | 57,323 | 100 |
| Vol w/in 1 to 4+-ft contour | 55,462 | 97 |
| Vol w/in 2 to 4+-ft contour | 42,903 | 75 |
| Vol w/in 3 to 4+-ft contour | 25,589 | 45 |

Table A5.14. - Volume and area output from ArcGIS 3D Analyst[1], for 1988 salt-crust area within the 1-foot thickness contour (see Figure 9B); salt-crust thickness was determined by the UDOT pole-measurement method.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 82,762,138.49 m |
| 3D Area: | 82,762,144.12 m |
| Volume: | 66,535,578.45 m$^3$ |

[1]Dataset is FY881881ftclp, and output file is FY88tsc_118bh_inside1ftcontour_Pareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 33**

$$66{,}535{,}578\ m^3 \times \frac{35.31\ ft^3}{1\,m^3} \times \frac{1\,acre - ft}{43{,}560\ ft^3} \equiv 53{,}934\ acre - ft$$

**Equation 34**

$$82{,}762{,}138\ m^2 \times \frac{1\,acre}{4{,}047\ m^2} \times \frac{1\,mi^2}{640\ acre} \equiv 31.9\ mi^2$$

Conversion of acre-feet to tons:

**Equation 35**

$$53{,}934\ acre - ft \times \frac{43{,}560\ ft^3}{1\ acre - ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 128.9 \times 10^6\ tons$$

Table A5.15. - Volume and area output from ArcGIS 3D Analyst[1], for outlier of 1988 salt-crust area within the 1-foot thickness contour (see Figure 9B); salt-crust thickness was determined by the UDOT pole-measurement method.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 476,562.36 m |
| 3D Area: | 476,562.36 m |
| Volume: | 148,273.43 m$^3$ |

[1]Dataset is FY881ftclpout, and output file is FY88tsc_118bh_inside1ftcontour_outlier_Pareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 36**

$$148{,}273\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 120\ acre-ft$$

**Equation 37**

$$476{,}562\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 0.18\ mi^2$$

Conversion of acre-feet to tons:

**Equation 38**

$$120\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 0.29 \times 10^6\ tons$$

Table A5.16. - Volume and area output from ArcGIS 3D Analyst[1], for 1988 salt-crust area within the 2-foot thickness contour (see Figure 9B); salt-crust thickness was determined by the UDOT pole-measurement method.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 55,497,619.26 m |
| 3D Area: | 55,497,622.34 m |
| Volume: | 53,773,389.45 m$^3$ |

[1]Dataset is FY881882ftclp, and output file is FY88tsc_118bh_inside2ftcontour_Pareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 39**

$$53{,}773{,}389\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 43{,}589\ acre-ft$$

**Equation 40**

$$55{,}497{,}619\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 21.4\ mi^2$$

Conversion of acre-feet to tons:

**Equation 41**

$$43{,}589\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 104.2 \times 10^6\ tons$$

Table A5.17. - Volume and area output from ArcGIS 3D Analyst[1], for 1988 salt-crust area within the 3-foot thickness contour (see Figure 9B); salt-crust thickness was determined by the UDOT pole-measurement method.

| | |
|---|---|
| Type: | Raster |
| Z Factor[2]: | 0.3048 |
| Plane Height: | 0.00 |
| Reference: | Above Plane |
| 2D Area: | 29,845,684.03 m |
| 3D Area: | 29,845,685.15 m |
| Volume: | 33,772,132.12 $m^3$ |

[1]Dataset is FY881883ftclp, and output file is FY88tsc_118bh_inside3ftcontour_Pareavol.txt
[2]Conversion from feet to meters (1 ft = 0.3048 m); X & Y coordinates are in meters, therefore Z (thickness which was expressed in feet) must also be in meters to calculate volume

Conversion of volume and area to acre-feet and square miles:

**Equation 42**

$$33{,}772{,}132\ m^3 \times \frac{35.31\ ft^3}{1\ m^3} \times \frac{1\ acre-ft}{43{,}560\ ft^3} \equiv 27{,}376\ acre-ft$$

**Equation 43**

$$29{,}845{,}684\ m^2 \times \frac{1\ acre}{4{,}047\ m^2} \times \frac{1\ mi^2}{640\ acre} \equiv 11.5\ mi^2$$

Conversion of acre-feet to tons:

**Equation 44**

$$27{,}376\ acre-ft \times \frac{43{,}560\ ft^3}{1\ acre-ft} \times \frac{109.8\ lbs}{1\ ft^3} \times \frac{1\ ton}{2000\ lbs} \equiv 65.4 \times 10^6\ tons$$

Table A5.18. – Distribution of 1988 salt-crust volume within selected thickness contours; volume based on UDOT pole-measurement method.

| 2003 salt crust volume: | Acre-feet | Percent of total volume |
|---|---|---|
| Total volume | 59,635 | 100 |
| Vol w/in 1 to 4+-ft contour | 54,054 | 91 |
| Vol w/in 2 to 4+-ft contour | 43,589 | 73 |
| Vol w/in 3 to 4+-ft contour | 27,376 | 46 |

# APPENDIX A6

Table A6.1. - Analyses from 1994, 1996, 1997, & 2000 brine samples collected from selected Bonneville Salt Flats monitoring wells (concentration as mg/L); data used for regression analysis of Chloride vs TDS (n = 65).

| Sample | Density | Na | Mg | K | Ca | Cl | SO4 | TDS | TDS, calculated[1] |
|---|---|---|---|---|---|---|---|---|---|
| 2KBLM-3 | 1.165 | 82150 | 2490 | 3500 | 1510 | 139380 | 4770 | 233800 | 236411 |
| 2KBLM-27 | 1.191 | 93590 | 2940 | 5340 | 1240 | 159400 | 4770 | 267280 | 268944 |
| 2KBLM-30 | 1.147 | 75950 | 1310 | 1890 | 1680 | 125580 | 4440 | 210850 | 213985 |
| 2KBLM-35 | 1.173 | 87380 | 1540 | 3190 | 1470 | 143180 | 4330 | 241090 | 242586 |
| 2KBLM-41 | 1.196 | 93070 | 4120 | 6740 | 1110 | 162020 | 5230 | 272290 | 273202 |
| 2KBLM-50B | 1.197 | 96210 | 2940 | 5700 | 1080 | 164020 | 6070 | 276020 | 276452 |
| 2KBLM-53 | 1.186 | 91590 | 2770 | 5060 | 1180 | 155600 | 4710 | 260910 | 262769 |
| 2KBLM-56 | 1.186 | 93070 | 2120 | 4590 | 1300 | 155220 | 4740 | 261040 | 262152 |
| 2KBLM-90 | 1.121 | 61830 | 1710 | 1890 | 1500 | 100740 | 4460 | 172130 | 173619 |
| 2KBLM-107 | 1.171 | 84430 | 2790 | 5060 | 1230 | 143810 | 5320 | 242640 | 243610 |
| 97BLM-6 | 1.197 | 93900 | 4700 | 9000 | 880 | 162900 | 5700 | 277080 | 274632 |
| 97BLM-3 | 1.162 | 84400 | 1450 | 3550 | 1500 | 137000 | 5250 | 233150 | 232543 |
| 97BLM-12 | 1.202 | 97000 | 1250 | 5900 | 1040 | 156900 | 4800 | 266890 | 264882 |
| 97BLM-25 | 1.188 | 93100 | 3150 | 6050 | 1020 | 155200 | 5950 | 264470 | 262119 |
| 97BLM-27 | 1.112 | 48400 | 550 | 1900 | 1470 | 76000 | 4950 | 133270 | 133416 |
| 97BLM-30 | 1.173 | 92700 | 1000 | 3300 | 1540 | 149900 | 4900 | 253340 | 253506 |
| 97BLM-41 | 1.197 | 94300 | 2850 | 6250 | 900 | 156600 | 5950 | 266850 | 264394 |
| 97BLM-43C | 1.201 | 97600 | 3000 | 6000 | 1050 | 162900 | 4800 | 275350 | 274632 |
| 97BLM-46 | 1.207 | 96400 | 2800 | 6500 | 850 | 158200 | 5800 | 270550 | 266994 |
| 97BLM-50B | 1.197 | 98700 | 3200 | 5550 | 1100 | 166400 | 5300 | 280250 | 280320 |
| 97BLM-53 | 1.196 | 96800 | 2450 | 5000 | 1150 | 156300 | 5150 | 266850 | 263907 |
| 97BLM-60 | 1.195 | 94500 | 4050 | 6550 | 1050 | 162200 | 5900 | 274250 | 273494 |
| 97BLM-61 | 1.204 | 94600 | 3700 | 6800 | 950 | 158200 | 5850 | 270100 | 266994 |
| 97BLM-82 | 1.198 | 97600 | 2550 | 4900 | 1150 | 162500 | 4850 | 273550 | 273982 |
| 97BLM-90 | 1.170 | 86800 | 1450 | 2650 | 1150 | 138800 | 4150 | 235000 | 235468 |
| 97BLM-93 | 1.191 | 94500 | 4550 | 7000 | 950 | 162800 | 7860 | 277660 | 274469 |
| 97BLM-99 | 1.164 | 76000 | 2250 | 4200 | 1050 | 122600 | 7100 | 213200 | 209143 |
| 97BLM-100 | 1.189 | 96300 | 3850 | 5550 | 1050 | 159800 | 6600 | 273150 | 269594 |
| 97BLM-107 | 1.183 | 90100 | 2450 | 4500 | 1100 | 147000 | 6000 | 251150 | 248794 |
| 97BLM-107A | 1.177 | 94500 | 1600 | 3800 | 1500 | 154200 | 5300 | 260900 | 260494 |
| 96BLM-3 | 1.171 | 93050 | 1900 | 4000 | 1100 | 149350 | 4850 | 254250 | 252613 |
| 96BLM-12 | 1.204 | 116500 | 2800 | 6000 | 900 | 190800 | 4200 | 321200 | 319971 |
| 96BLM-25 | 1.187 | 95350 | 3400 | 5900 | 800 | 163800 | 5100 | 274350 | 276094 |
| 96BLM-30 | 1.174 | 94850 | 1600 | 3550 | 1100 | 156950 | 4450 | 262500 | 264963 |
| 96LM-35 | 1.179 | 96600 | 1800 | 3900 | 1100 | 156550 | 4100 | 264050 | 264313 |
| 96BLM-41 | 1.196 | 98550 | 4700 | 8100 | 700 | 176200 | 5150 | 293400 | 296245 |
| 96BLM-43C | 1.201 | 103250 | 3600 | 6900 | 700 | 178200 | 4450 | 297100 | 299495 |
| 96BLM-46 | 1.206 | 99550 | 5200 | 8450 | 600 | 179800 | 4800 | 298400 | 302095 |
| 96BLM-50A | 1.194 | 97300 | 3600 | 5900 | 800 | 168150 | 4700 | 280450 | 283163 |
| 96BLM-53 | 1.194 | 101500 | 3550 | 5550 | 800 | 175200 | 4450 | 291050 | 294620 |
| 96BLM-61 | 1.208 | 101850 | 4800 | 8450 | 700 | 180800 | 4450 | 301050 | 303720 |
| 96BLM-93 | 1.189 | 92800 | 3800 | 8100 | 800 | 157000 | 6450 | 268950 | 265044 |
| 96BLM-99 | 1.159 | 91600 | 4900 | 5350 | 600 | 158700 | 6600 | 267750 | 267807 |
| 96BLM-101 | 1.076 | 37800 | 900 | 2200 | 1400 | 60900 | 4850 | 108050 | 108878 |
| 96BLM-107 | 1.184 | 93850 | 3500 | 6100 | 900 | 160800 | 5000 | 270150 | 271219 |
| 96BLM-60 | 1.193 | 96200 | 4300 | 8450 | 700 | 170650 | 5300 | 285600 | 287226 |

Table A6.1 (continued)

| Sample | Density | Na | Mg | K | Ca | Cl | SO4 | TDS | TDS, calculated[1] |
|---|---|---|---|---|---|---|---|---|---|
| 94BLM-3 | 1.174 | 95200 | 2700 | 3800 | 1048 | 156700 | 5020 | 264467.7 | 264557 |
| 94BLM-6 | 1.200 | 99300 | 8500 | 9400 | 834 | 185400 | 5790 | 309224.1 | 311195 |
| 94BLM-12 | 1.205 | 116900 | 4200 | 5700 | 781 | 192500 | 4340 | 324421.3 | 322733 |
| 94BLM-25 | 1.193 | 98300 | 5600 | 6200 | 924 | 173300 | 5590 | 289914.1 | 291532 |
| 94BLM-30 | 1.177 | 96100 | 3300 | 3800 | 1021 | 160300 | 5110 | 269630.9 | 270407 |
| 94BLM-35 | 1.177 | 95800 | 3000 | 4300 | 1027 | 159500 | 5020 | 268646.8 | 269107 |
| 94BLM-41 | 1.198 | 100500 | 6800 | 7300 | 865 | 181200 | 5180 | 301845.4 | 304370 |
| 94BLM-43C | 1.202 | 111700 | 5300 | 6400 | 824 | 186800 | 4830 | 315853.7 | 313470 |
| 94BLM-46 | 1.204 | 112600 | 7600 | 8300 | 757 | 195800 | 5310 | 330366.7 | 328096 |
| 94BLM-50A | 1.199 | 110600 | 4800 | 5500 | 824 | 186800 | 5020 | 313543.7 | 313470 |
| 94BLM-53 | 1.192 | 111200 | 5100 | 5800 | 839 | 184700 | 4830 | 312469.3 | 310058 |
| 94BLM-61 | 1.201 | 111600 | 6000 | 7700 | 801 | 189800 | 5120 | 321021.4 | 318346 |
| 94BLM-82 | 1.195 | 111300 | 4100 | 5500 | 834 | 185400 | 4920 | 312054.1 | 311195 |
| 94BLM-99 | 1.166 | 88900 | 6100 | 5800 | 1078 | 152600 | 6010 | 260488.2 | 257894 |
| 94BLM-101 | 1.188 | 97200 | 5600 | 5400 | 949 | 169900 | 5700 | 284749.4 | 286007 |
| 94BLM-107 | 1.188 | 97400 | 5300 | 5900 | 952 | 169500 | 5580 | 284632.4 | 285357 |
| 94BLM-60 | 1.193 | 98500 | 5900 | 7300 | 913 | 174800 | 5590 | 293003 | 293970 |
| 94BLM-71A | 1.200 | 100400 | 7500 | 9300 | 842 | 184400 | 6080 | 308521.5 | 309570 |
| 94BLM-28 | 1.196 | 100500 | 6100 | 6600 | 885 | 178500 | 5490 | 298075.5 | 299983 |

[1]Y = 1.625 * Cl concentration + 9913

Table A6.2. - Regression Output from data in Table A6.1.

| | |
|---|---|
| Constant | 9913 |
| Std Err of Y Est | 2083 |
| R Squared | 0.9972 |
| No. of Observations | 65 |
| Degrees of Freedom | 63 |
| X Coefficient(s) | 1.6250 |
| Std Err of Coef. | 0.0108 |

- Calculate TDS associated with 100,000 mg/L Cl using Y = m*X + b, where:
  - Y = TDS
  - m = 1.625 (slope)
  - X = 100,000 mg/L Cl
  - b = 9913 (Y intercept)

**Equation 3**

$$Y \equiv (1.625 \times 100{,}000) \oplus 9913 \equiv 172{,}417\, mg/L \quad TDS$$

- Calculate tons of TDS in aquifer pore space bounded within 100 g/L chloride contour associated with Bonneville Salt Flats (975 square-mile area designated as GSLD-BSF), where:
  - GSLD-BSF area = 624,078 acres
  - Estimated shallow-brine aquifer average depth = 20 feet
  - Estimated aquifer porosity = 45%
  - Estimated average TDS concentration (see Equation 1) = 172 g/L

**Equation 4**

$$Pore\, space, ft^3 \equiv 624{,}078\, ac \times \frac{43{,}560\, ft^2}{1\, ac} \times 20\, ft \times 0.45 \equiv 244.7 \times 10^9 \;\; ft^3$$

**Equation 5**

$$TDS, g \equiv 244.7 \times 10^9 \;\; ft^3 \times \frac{7.48\, gal}{1\, ft^3} \times \frac{1\, L}{0.264\, gal} \times \frac{172\, g\, TDS}{1\, L} \equiv 1.19 \times 10^{15}\; g\, TDS$$

**Equation 6**

$$TDS, tons \equiv 1.19 \times 10^{15}\; g\, TDS \times \frac{1\, Kg\, TDS}{1000\, g\, TDS} \times \frac{2.2\, lbs\, TDS}{1\, Kg\, TDS} \times \frac{1\, ton\, TDS}{2000\, lbs} \equiv 1.3 \times 10^9\; tons\, TDS$$

Note: for tonnage associated with 60% pore space, multiply 1.3 billion tons by 1.33 (i.e., 0.6/0.45).

- Calculate mass of salt removed from 38 square miles of BSF salt crust resulting from a simulated 1-inch rainfall event, where:

    - Area of salt crust in October 2003 = 38 square miles
    - Salt-crust depth dissolved by simulated 1-inch rainfall (White 2003, p. 259) = 0.143 inch
    - Salt-crust density (rounded from Mason and Kipp 1998, p. 54) = 110 lbs/cubic foot

**Equation 7**

$$Salt\ crust, tons \equiv 0.143\, in. \times \frac{1\, ft}{12\, in} \times \frac{43{,}560\ ft^2}{1\, acre} \times \frac{110\, lbs}{1\ ft^3} \times \frac{1\, ton}{2000\, lbs} \times \frac{640\, ac}{1\, mi^2} \times 38\, mi^2 \equiv 694{,}335\, tons\ salt\ crust$$

- Calculate percentage of dissolved salt crust contained in 80 square miles of shallow-brine aquifer, and then calculate tonnage of dissolved salt removed through the lease collection ditch, where:

    - Estimated tonnage of TDS contained in 80 square miles of shallow-brine aquifer (after Mason and Kipp 1998, p. 54) = 179 million tons
    - Estimated tonnage of TDS withdrawn annually from lease collection ditch (Mason and Kipp 1998, p. 106) = 850,000 tons

**Equation 8**

$$\%\, dissolved\ in\, 80\, mi^2 \equiv \frac{0.694 \times 10^6\ tons}{(179 \oplus 0.69) \times 10^6\ tons} \times 100 \equiv 0.39\,\%$$

**Equation 9**

$$TDS\ dissolved\ salt\ crust, tons \equiv 850{,}000\, tons\, TDS \times 3.9 \times 10^{-3} \equiv 3{,}315\, tons\ TDS$$

- Calculate tons of TDS contained in 38 square miles of shallow-brine aquifer associated with 2003 salt-crust area, where:

    - Estimated shallow-brine aquifer average depth = 20 feet
    - Estimated aquifer porosity = 45%
    - Estimated average TDS concentration (Mason and Kipp 1998, p. 54) = 286 g/L

**Equation 10**

$$Pore\, space, ft^3 \equiv 38\, mi^2 \times \frac{640\, ac}{1\, mi^2} \times \frac{43{,}560\ ft^2}{1\, ac} \times 20\ ft \times 0.45 \equiv 9.53 \times 10^9\ \ ft^3$$

**Equation 11**

$$TDS, g \equiv 9.53 \times 10^9\ \ ft^3 \times \frac{7.48\, gal}{1\ ft^3} \times \frac{1\, L}{0.264\, gal} \times \frac{286\, g\, TDS}{1\, L} \equiv 77.22 \times 10^{12}\ g\, TDS$$

**Equation 12**

$$TDS, tons \equiv 77.22 \times 10^{12}\ g\,TDS \times \frac{1\,Kg\,TDS}{1000\,g\,TDS} \times \frac{2.2\,lbs\,TDS}{1\,Kg\,TDS} \times \frac{1\,ton\,TDS}{2000\,lbs} \equiv 84.94 \times 10^{6}\ tons\,TDS$$

- Calculate percentage of dissolved salt crust contained in 38 square miles of shallow-brine aquifer, and then calculate tonnage of dissolved salt removed through the lease collection ditch, where:

    - Estimated tonnage of TDS contained in 38 square miles of shallow-brine aquifer (see equations 8-10) = 84.9 million tons
    - Estimated tonnage of TDS withdrawn annually from lease collection ditch (Mason and Kipp 1998, p. 106) = 850,000 tons

**Equation 13**

$$\%\,dissolved\ in\ 38\,mi^{2} \equiv \frac{0.694 \times 10^{6}\ tons}{(84.94 \oplus 0.69) \times 10^{6}\ tons} \times 100 \equiv 0.81\%$$

**Equation 14**

$$TDS\ dissolved\ salt\ crust, tons \equiv 850{,}000\,tons\,TDS \times 8.1 \times 10^{-3} \equiv 6{,}885\,tons\ TDS$$

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