

APPENDIX 3. DESCRIPTIONS OF WELL CUTTINGS AND WIRELINE NOTES FOR THE SOUTHLAND ROYALTY SA #1 AUGUSTINE TEST WELL

Southland Royalty SA #1 Augustine Test Well. Located at SW1/4 SW1/4 NE1/4 Section 35, T2S, R8W, in Socorro County, NM. Ground elevation of 6,970 ft.

| Unit | Description | Depth (ft) |
|------|---|------------|
| | UPPER SANTA FE GROUP, EOLIAN AND LOCAL PLAYA-MARGIN SEDIMENTS (Late Pleistocene and Holocene) – unit QTsupe-bf | 0–47 |
| 1 | QUARTZ-RICH SAND: Light gray (10YR 7/1) and fL-clU, minor vL-vcU; subangular to subrounded and poorly sorted. Sand composed of quartz, sanidine, and plagioclase with 5–7% black mafic grains (mostly biotite and hornblende); 20% felsic-dominated volcanic grains. Described using 20–30 ft interval. Derived from north flank of Mt Withington? Lower gamma ray signature compared to underlying strata. @18–20 ft: Low resistivity suggests clayey textures; possible playa facies of a localized lake near the VLA. @44–58 ft: Low resistivity suggests clayey textures; possible playa facies of a localized lake near the VLA. | 0–47 |
| | UPPER SANTA FE GROUP, HETEROLITHIC GRAVELLY SUBUNIT (Pleistocene) – unit QTsupe-bf; possibly associated with large drainage sourced from drainage divide to east in addition to highlands to northeast. | 47–140 |
| 2 | SANDY PEBBLES: Pebbles are up to 10 mm diameter. Sand and pebbles are both composed of subrounded, felsic volcanic rocks that include probable Hells Mesa Tuff. | 47–60 |
| 3 | PEBBLY SAND: Pebbles are 2-16 mm, subrounded, and include hornblende-bearing dacites-andesites and probable Hells Mesa Tuff. Sand is pinkish gray (7.5YR 7/2), vfU-mL (minor mU-vcU), poorly sorted, and composed of 50–60% creamy-colored volcanic lithics (with hornblende and biotite phenocrysts), minor sanidine and creamy-colored feldspar, 5% quartz, 7% black mafics (hornblende and biotite). | 60–80 |
| 4 | SANDY PEBBLES: Pebbles are subrounded, 2–20 mm long, and include probable Hells Mesa Tuff and intermediate clasts. Sand is 7.5YR 7/2, vfL—vcU, subrounded to subangular, poorly sorted, and composed of 25% [sanidine (probably includes some plagioclase) + lesser quartz], 7% black hornblende + biotite, and rest are creamy-colored (felsic) volcanic lithic grains and possible very minor potassium feldspar. | 80–85 |
| 5 | CLAY AND SAND: Light gray (7.5YR 6-7/2), vfU-mU (minor cL-vcU), subangular (mostly) to subrounded, moderately sorted, and composed of creamy-colored (felsic) volcanic lithics, 25–30% sanidine (mostly; probably includes some plagioclase) + quartz, 5% black biotite + hornblende. Very low resistivity on wireline logs. | 85–110 |
| 6 | INTERBEDDED SANDY PEBBLES, CLAY, AND SAND: Pebbles are up to 19 mm but mostly 1–10 mm, subrounded to subangular, and heterolithic. Gravel compositions are mostly Hells Mesa Tuff and non- to welded felsite tuffs, with lesser Vicks Peak Tuff, mafic-rich breccia clasts (biotite and hornblende, correlate to Spears Group), basalt, and andesite (basalt and andesite are the least abundant). @110–140 ft: Probably clayey based on very low resistivity values on wireline logs. | 110–140 |

| Unit | Description | Depth (ft) |
|------|---|------------|
| 7 | <p>INTERBEDDED SANDY PEBBLES AND SAND: Pebbles are up to 19 mm but mostly 1–10 mm, subrounded to subangular, and heterolithic. Gravel compositions are mostly Hells Mesa Tuff and non- to welded felsite tuffs, with lesser Vicks Peak Tuff, mafic-rich breccia clasts (biotite and hornblende, correlate to Spears Group), basalt, and andesite (basalt and andesite are the least abundant).</p> <p>@150–159 ft: Probably clayey based on very low resistivity values on wireline logs. Sand description: Pink (7.5YR 7/2-3), fL-vcU, subangular (mostly) to subrounded, poorly sorted, and composed of creamy-colored (felsic) volcanic clasts, 1/3 sanidine (mostly) and quartz, and 3% black biotite and hornblende.</p> <p>@170–175 ft: Probably clayey based on very low resistivity values on wireline logs.</p> <p>UPPER SANTA FE GROUP, HETEROLITHIC GRAVELLY SUBUNIT BUT VERY SPARSE INTERMEDIATE DETRITUS (Pliocene to Pleistocene) – unit QTsupe-bf; probably sourced from volcanic highlands to south.</p> | 140–~200 |
| 8 | <p>INTERBEDDED SANDY PEBBLES AND SAND:</p> <p>@220–225 ft: Probably clayey based on very low resistivity values on wireline logs. Sand description: fU-vcU, subangular (mostly) to subrounded, poorly sorted, and composed of creamy-colored (felsic) volcanics, 30–35% [sanidine (likely includes plagioclase) and lesser quartz], and 3-4% [black biotite and hornblende].</p> <p>@235–240 ft: Probably clayey based on very low resistivity values on wireline logs.</p> <p>@245–253 ft: Probably clayey based on very low resistivity values on wireline logs.</p> <p>@282–355 ft: Probably clayey based on very low resistivity values on wireline logs. Sand description at 290–300 ft: pink to light gray (7.5YR 7/2-3), fU-vcU, subangular (mostly) to subrounded, poorly sorted, and composed of creamy-colored (felsic) volcanic grains, 25–30% sanidine (mostly) + quartz, 3% black mafics (biotite and hornblende).</p> | ~200–340 |
| 9 | <p>SAND AND MINOR PEBBLY INTERVALS: Sand is light gray (7.5YR 7/2), fU-vcU, subangular, poorly sorted, and composed of creamy-colored (felsic) volcanic grains, 40–45% sanidine (mostly) + minor quartz, 5% biotite + hornblende (black and fresh). Sand described at 330–340 ft depths.</p> <p>UPPER SANTA FE GROUP, HETEROLITHIC GRAVELLY SUBUNIT; MODERATE GAMMA RAY VALUES (Pliocene-Pleistocene) – unit QTsupe-bf; possibly associated with large drainage sourced from drainage divide to east in addition to input from highlands to northeast.</p> | 310–340 |
| 10 | <p>SANDY PEBBLES: Pebbles are 2–12 mm, mostly subrounded, and various shades of gray. Gravel composition: crystal-rich and crystal-poor tuffs (probably mostly Hells Mesa Tuff and Vicks Peak Tuff, respectively) w/ 15–30% hornblende- + biotite-rich intermediate clasts and 5% basaltic andesite. No sign of cementation.</p> <p>@390–400 ft: Vesicular, aphanitic basalt (La Jara Peak basaltic andesite) pebble seen.</p> | 340–460 |
| 11 | <p>Gradational interval based on gradual shift in gamma-ray log.</p> <p>MIDDLE TO LOWER SANTA FE GROUP, Monolithic piedmont sediment with high gamma ray values (likely Miocene) – unit TsmIpe; inferred source area dominated by fine-grained, high-gamma ray ignimbrites (Vicks Peak, La Jencia, and possibly Rockhouse Canyon Tuffs).</p> | 465–470 |
| | | 470–690 |

| Unit | Description | Depth (ft) |
|------|--|----------------|
| 12 | SANDY PEBBLES: Sand is cU-vcU and similar in composition to pebbles. Pebbles are 2-12 mm long, angular to subrounded (mostly subangular), poorly sorted, and composed of light gray, crystal poor felsic volcanic rock (probably Vicks Peak Tuff). 1–5% of clasts show eutaxitic texture. @469–665 ft: High gamma ray values, especially compared to overlying sediment. @ 540–560 ft: Basaltic pebbles are observed. @560–590 ft: Sandy pebbles, as described above, but with 25–35% out-sized (up to 15 mm), angular, dark gray, vesicular basalt-basaltic andesite pebbles. Otherwise, composed of cU-vcU sand and vf-f pebbles composed of crystal-poor tuff; angular to subrounded and light gray. | 470–590 |
| 13 | PEBBLY SAND: Pebbles are subrounded to subangular and up to 12 mm long; composed of light gray, crystal-poor (aphanitic) felsites along with 10–20% very dark gray, subangular basaltic andesite (pyroxene and plagioclase phenocrysts). No sign of a subsurface flow based on wireline logs, so basaltic andesite inferred to be reworked as a clastic deposit. | 590–600 |
| 14 | SANDY PEBBLES: vL to vcU sand and 2–13 mm long pebbles that are mostly angular to subangular (minor subrounded); 1–3% vesicular, aphanitic basalt to basaltic andesite clasts + sand grains. Otherwise, clasts + grains are light gray to light reddish brown and aphanitic. @640–650 ft: As above, but clasts are more angular and up to 15 mm long. | 600–690 |
| | MIDDLE TO LOWER SANTA FE GROUP, HETEROLITHIC sediment with moderately high gamma ray values (likely Miocene) – unit Tsm1pe; probably sourced from volcanic highlands to south (no basaltic andesite, abundant quartz and sanidine, lower gamma ray signature than overlying unit). | 690–725 |
| 15 | PEBBLY SAND: Pebbles are angular to subangular, aphanitic, light gray, and 2–12 mm long. Bimodal sand: (1) cU-vcU (mostly vL-vcU) and like the pebbles but angular to subrounded (mostly subangular); (2) light brown to pink (7.5YR 6-7/3), fU-mU (mostly mL) sand that is well sorted, and composed of sanidine+quartz (50–65%), blocky, free-grain mafics (black and fresh, 3–5%), and rest is creamy-colored felsic lavas or feldspar. Slightly lower gamma ray values than Units 12–14. @690–700: Gradational zone with unit 14; unit 14 sand with 25% subrounded grains containing 5–10% of the #2 sediment. @717–725 ft: Mixing of locally derived conglomerate, based on gamma ray curve and cuttings. 10% of sediment is #2 sand; rest is vL-vcU, monolithic sand and 2–14 mm long pebbles. Pebbles are light gray and composed of aphanitic felsic rocks (with 1% sanidine phenocrysts up to 0.8mm long and euhedral). | 690–725 |
| | VICKS PEAK TUFF WITH VERY HIGH GAMMA RAY SIGNATURE (early Oligocene) | 725–740 |
| 16 | VERY COARSE SAND AND PEBBLES: Very coarse sand and pebbles (up to 17 mm) composed of angular (minor subangular), monolithic, fine-grained felsic rock with 1–3% euhedral sanidine phenocrysts (0.5–1.0 mm); no sign of flame or eutaxitic textures. Gray to light gray (N6/ to 7/). | 1,210–1,315 |
| | LA JENCIA TUFF WITH VERY HIGH GAMMA RAY SIGNATURE (early Oligocene) | 735–923 |
| 17 | ANGULAR FRAGMENTS: Reddish gray to gray (2.5YR 6/1 to 5YR 5/1-2), angular fragments 2–13 mm long. 1% fiamme and 1–3% euhedral sanidine phenocrysts 0.1–2.0 mm long. Percentage of fiamme increases down-hole in this unit. Upper part of this unit may be part of Vicks Peak Tuff. @780–800 ft: Fiamme are 10–15% and trace mafic phenocrysts are seen, including biotite. @880–930 ft: Angular fragments, up to 15 cm, of grayish to pinkish gray (5YR 6/1-2) welded tuff. Distinctive fiamme is 1–5%. Sanidine phenocrysts are 2–3% and up to 2 mm long. | 735–923 |

| Unit | Description | Depth (ft) |
|------|--|------------------|
| | UPPER SPEARS GROUP, MOSTLY REWORKING LOWER APHINITIC VOLCANIC UNIT (early Oligocene) – gamma ray values are similar to those in Unit 15. | 923–987 |
| 18 | SANDY PEBBLES: Sand is vcl-vcU and subrounded to angular. Pebbles are 2–12 mm long, rounded to subangular. Both sand and pebbles are similar and composed of reddish gray to pale red (2.5YR 6/1-2) aphanitic tuff and/or rhyolite. Estimate 10–15% slough from Unit 17. Described at 930–950 ft. | 923–950 |
| 19 | PEBBLY SAND: Pebbles are angular to subangular, 2–10 mm long, and composed of gray to reddish brown aphanitic tuff or rhyolite. One subrounded-rounded pebble at 950–960 ft that is 13 mm long and crystal-rich (sanidine with lesser biotite and hornblende). @970–980 ft: At least one tuff clast that has 3% sanidine phenocrysts (up to 1 mm long) plus mafic phenocrysts. I also see some crystal-rich tuffs (Hells Mesa Tuff?). @970–990 ft: Sand is light brown (7.5YR 6/3), vfU-vcU (mostly mL-vcU), subrounded(mostly) to subangular, poorly sorted, and composed of sanidine (likely also plagioclase) and quartz, 7% blocky mafics, and rest are orangish felsites (aphanitic tuffs or lavas or perhaps feldspars). UPPER SPEARS GROUP COMPOSED OF NOTABLE PROPORTIONS OF HELLS MESA TUFF (early Oligocene) – high gamma ray values, but typically less than those of La Jencia Tuff and Vicks Peak Tuff above. | 950–987 |
| 20 | SANDY PEBBLES WITH REWORKED HELLS MESA TUFF: Pebbles are 2–10 mm long, angular to subrounded (mostly subangular). They are composed of crystal-rich and fine-grained tuffs (latter are reddish brown, some of which have flame). Also possible reddish brown basaltic andesite. The sand is light brown (7.5YR 6/3), fU-vcU, and poorly sorted. The cL-vcU sand fraction is subangular and like the pebbles (with minor quartz and sanidine crystals); fU-mU sand is subrounded with 60–65% being sanidine and quartz, 5% is blocky mafics, and the rest are orangish feldspars or orange-gray, fine-grained felsites. The fine-grained sand is commonly strongly cemented, but the cemented agent does not effervesce with HCl. | 987–1,000 |
| 21 | CONGLOMERATE: 1/3 reddish gray (2.5YR 6/1), very sparsely porphyritic, fine-grained tuffs (with sanidine phenocrysts) and ~2/3 tannish white, crystal-rich tuff; tannish white tuff has 15% crystals up to 2 mm long that are in a tannish white, fine-grained matrix; crystals include quartz with lesser lithic grains and minor biotite. @1,010–1,020 ft: Minor fU-cl sand like that seen in 987–1,000 ft; possible slough. | 1,000–1,020 |
| 22 | SAND: Light gray (7.5YR 7/1), cL-vcU sand and very fine pebbles (2–4 mm) composed of subangular to subrounded sanidine and quartz; probably not indurated; 2–5% blocky, black mafics; 1–2% biotite grains up to 2.0 mm long. Interpreted to be derived from erosion of Hells Mesa Tuff. Possible unconformity at base. | 1,020–1,047 |
| | HELLS MESA TUFF (early Oligocene) – High gamma ray signature, but very high (comparable to La Jencia and Vicks Peak Tuff) at 1,094–1,125 ft | 1047–1155 |
| 23 | QUARTZ-RICH UPPER ZONE, ANGULAR FRAGMENTS: Pale red (2.5YR 7/2; lesser 2.5YR 5/1-2). Sand-size fraction is fU to 4 mm long (4 mm grain is a quartz) and composed of quartz and sanidine with 1% biotite. 1–2% volcanic lithics. Pebble-size fragments are 2–12 mm long and comprised of angular, 2.5YR 7/2, crystal-rich tuffs composed of 15% quartz + sanidine and minor (2%) volcanic lithics and biotite. Lower contact lies between 1,070 and 1,080 ft. | 1,047–1,075 |

| Unit | Description | Depth (ft) |
|------|--|----------------------------|
| 24 | <p>QUARTZ-RICH UPPER ZONE, ANGULAR FRAGMENTS: White fragments are bigger and more abundant; there are lesser (20%), smaller rhyolite-dacite fragments. Sand is mU-vcU and composed of 20% quartz and sanidine. Larger white fragments are up to 10 mm long and contain 15% phenocrysts of sanidine, quartz, and lesser biotite in a fine-grained matrix. Quartz phenocrysts are up to 2 mm long.</p> <p>@ 1,094–1,125 ft: Very high gamma ray signature</p> <p>@1,125–1,133: Low resistivity & SP, but high gamma ray. Perhaps a tuff-flow break.</p> | 1,075–1,133 |
| 25 | <p>QUARTZ-POOR LOWER ZONE, ANGULAR FRAGMENT: Material is mL-vcU sand-size and 2–16 mm. Light gray (5YR 7/1) and has 5% phenocryst of sanidine, quartz, and biotite (up to 1 mm); 1–3% volcanic lithic fragments.</p> <p>MIDDLE SPEARS GROUP COMPOSED OF REWORKED, FINE-GRAINED VOLCANIC UNIT (early Oligocene) – moderately high to high gamma ray values comparable to those in 665–717 ft.</p> | 1,133–1,155 1,155–1,267 |
| 26 | <p>SANDY CONGLOMERATE: Sand cU to vcU and pebbles are 2–9 mm. Collectively, they are angular to subrounded (mostly subangular) and low-moderately sorted. Pebbles are: 30–35% fine-grained, pumiceous tuff; ~25% reddish gray (2.5YR 6/1) fine-grained tuff, and 40–45% gray (10YR 5/1) tuffs. Flattened pumices are seen in the first two tuff types (pumiceous tuff and 2.5YR 6/1 tuff, the pumiceous of the first type having vapor-phase alterations). 1% sanidine phenocrysts ≤0.8 mm long. Probably all of the tuffs are reworked fine-grained volcanic unit (inferred to be Rockhouse Canyon Tuff).</p> | 1,155–1,200 |
| 27 | <p>COARSE CONGLOMERATE: Light gray (7.5YR 7/1), fU-vcU sand and fine pebbles-size (2–10 mm), angular fragments mixed with 10% brown (7.5YR 5/2), subangular, aphanitic fragments. Both are probably tuffs. Fine- to medium-grained sand is subangular and composed 2/3 sanidine (and likely other clear feldspar), 1/3 orange quartz or feldspar, and 3% hornblende and other mafics. Pebble-size fragments have 5% phenocrysts (mostly sanidine up to 1.5 mm long and lesser mafics). Sanidine grains are chatoyant. Angular fragments probably are due to crushing of very coarse to coarse pebbles and/or cobbles.</p> | 1,200–1,210 |
| 28 | <p>PEBBLY SAND: Sand is fU-vcU and pebbles are 2–12 mm. Pebbles are angular to subrounded. Pebbles are composed of gray, reddish brown, and white tuff. White tuff is probably compressed pumice or ash. Rest of pebbles are aphanitic and have ~1% sanidine phenocrysts. Sand is subangular to subrounded and composed of 30-35% sanidine (and other clear feldspar) and 60-65% fine-grained tuff detritus. Interval characterized by low resistivity, probably due to ash altering to clay.</p> <p>@1,240–1,250 ft: Cuttings are white because of higher amounts (~75%) of compressed pumice or consolidated ash.</p> <p>1,260–1,270 ft: Cuttings are white because of higher amounts (~75%) of compressed pumice or consolidated ash.</p> <p>@1,270–1,280 ft: 40% of reddish tuff (correlated to the lower fine volcanic unit) and 60% white, consolidated pumice or ash.</p> | 1,210–1,280 |
| 29 | <p>CONGLOMERATE DERIVED FROM LOWER, FINE-GRAINED TUFF UNIT: Gray (7.5YR 5/1), dense, welded tuff. ~5% fiamme that are 0.2 mm thick, very long, and mostly vapor-phase altered. 1–2% euhedral sanidine phenocrysts up to 1 mm long; plagioclase crystals noted on the original well logs. Low resistivity on wireline logs, except for moderate to high resistivity at 1,327–1,348 ft depth.</p> <p>@1,320–1,340: 10–15% fiamme.</p> <p>@1,280–1,460 ft: High gamma ray signature</p> <p>LOWER CRYSTAL-POOR VOLCANIC UNIT, LIKELY ROCKHOUSE CANYON TUFF (late Eocene)</p> | 1,280–1,460 1,460–1,795 |

| Unit | Description | Depth (ft) |
|------|--|--------------|
| 30 | <p>ANGULAR FRAGMENTS: Reddish gray (2.5YR 6/1) tuff rock with 5–8% distinct flame. Still crystal-poor, with 1% sanidine and biotite that are both ≤ 1 mm long and euhedral.</p> <p>@1,460–1,478: Gradual increase in resistivity; inferred to reflect a weathered upper part of the tuff rock.</p> <p>@1,280–1,664 ft: High gamma ray signature</p> <p>@1,664 to 1,795 ft: Very high gamma ray signature</p> | 1,460–1,765 |
| 31 | <p>ANGULAR FRAGMENTS: White (N8), with 10–20% reddish gray tuff clasts, non-welded tuff with 10% sanidine and quartz phenocrysts (mostly sanidine) up to 2 mm long and euhedral. 0.5% biotite, 0.5% volcanic lithics up to 2 mm.</p> | 1,765–1,795 |
| | Total Depth | 1,795 |



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