

PART F1. Index Maps and Diagrams (Plates F1-1 to F1-10) and Tables (TbIs. F1-1 to F1-6); with Names and Acronyms of Hydrogeologic Subdivisions and Fault Zones

PLATE and TABLE Numbers

- Pl. F1-1. (p. 3)** Index map of the Mesilla Basin region (MBR) showing locations of the Study Area (**Fig. 1-3**, red outline), major landscape features in the northern Mexican Highland section of the B&R province, and basins of the southern RG-rift province (**Fig. 1-1**). Blue shading shows the approximate extent of the areas inundated by pluvial-Lakes Palomas and Otero at their respective Late Pleistocene high stands in the Zona Hidrogeológica de Conejos Médanos/El Barreal basin complex, and the Tularosa Basin. Swanson Geoscience, LLC compilation on a 2017 Google Earth® image-base.
- Pl. F1-2. (p. 12)** U.S. Bureau of Reclamation Map showing locations of major surface-water management structures of the Rio Grande Project between the San Marcial (removed 1964) and Fort Quitman Gaging Stations. EBID indicates Elephant Butte Irrigation District operations (courtesy of Rhea Graham; *cf.* USBOR 2011).
- Pl. F1-3. (Rpt. PL. 1A; p. 4)** Study Area index map showing locations of the Mesilla, Southern Jornada, and El Parabién groundwater (GW) basins (MeB, SJB and EPB; outlined in green, orange and red, respectively). Also shown are the locations of hydrogeologic cross-section A-A' to S-S' (Report PLATES 5a to 5s), major terrain features (incl. the Mesilla Valley, Selden Canyon and El Paso del Norte of the Rio Grande), and the Las Cruces and El Paso/Ciudad Juárez metropolitan centers. USGS DEM base, with UTM-NAD83 SI-system and latitude/longitude coordinates
- Pl. F1-4. (F1-4a and 1-4b; p. 7)** Index maps to major geohydrologic features of the Study Area (**Fig. 1-3**). The approximate pre-development (~1976) potentiometric-surface altitude (amsl) is shown on **Pl. F1-4a** with 20- and 100-ft contours, and on **Pl. F1-4b** with 5-, 10-, and 30-m contours. Major surface-watershed divides are shown by solid and dashed thick blue lines. The dashed blue line with arrows in the map's SW corner marks the approximate boundary between EPdN- and Los Muertos Basin-directed GW flow.
- Pl. F1-5. (Rpt. PL. 2B; p. 8)** Index map for major hydrogeologic subdivisions of the Study Area (**Fig. F1-5**). The Mesilla GW Basin (MeB) is in blue shades, and the Mesilla Valley of the Rio Grande is in dark blue. El Parabién and Southern Jornada GW Basins (EPB and SJB) are in pink and light green, respectively. SCyn-Selden Canyon and EPdN-El Paso del Norte. Solid and dashed black lines are boundaries of interbasin-uplift and intrabasin subdivisions. Acronyms and names of hydrogeologic-subdivision categories, including fault zones (lines with bar and ball symbols), are defined in **Tbl. F1-2** (Rpt. **TBL. 2**); and those for fault zones are listed on **Tbl. F1-3**. USG DEM base.
- Table F1-1. (p. 9 and 10)** Names and acronyms of hydrogeologic subdivisions shown on maps, cross-sections, and well-information spreadsheet (Rpt. **PLS. 1 to 8**, **TBLS. 1 to 3**).
- Table F1-2. (p. 11)** Names, and Acronyms for Basin- and Subbasin-Boundary Fault Zones (**Pl. F1-5**).
- Pl. F1-6. (p. 12)** Pliocene and Early Pleistocene geomorphic setting of the ARG distributive fluvial system (DFS-red lines) that terminated in the Lake Cabeza de Vaca (LCdV) basin complex of Strain (1966, 1971). Schematic depiction of ARG distributary channel-belt in the southeastern B&R province (adapted from Hawley 1975, Fig. 2). Explanations of the symbols that show the general positions of primary Distributive Fluvial System (DFS)-apex and channel-belt-segments of ancestral

rivers with fluvial-deltaic termini in the LCdV basin complex on **Table F1-3**. The Rios Casas Grandes (violet), Santa Maria and Carmen (pink and orange), and the Mimbres River (yellow) remain as the major surface and subsurface flow fluvial contributors to ephemeral lake-plain remnants of Late Quaternary Paleo-Lake Palomas: Lagunas Guzman, Santa Maria and Patos, and El Barreal-Salinas de Unión. Only parts of the Mesilla Basin and Hueco Bolson have surface/subsurface connection with Rio Grande at present (*cf.* **Pls. F1-2** and **F1-3**; Hawley 1975, Gile et al. 1981, Connell et al. 2005, Castiglia and Fawcett 2006, Weissmann et al. 2011, Davidson et al. 2013, and Nichols 2015). 2018 Google Earth® image base.

Table F1-3. (p. 13) Explanation of **Plate F1-6** alpha-numeric symbols for Pliocene and early Pleistocene Distributive Fluvial Systems (DFSs) of ancestral-river systems with fluvial-deltaic termini in the Paleo-Lake Cabeza de Vaca complex (LCdV) and Bolson de los Muertos (BdlM).

Plate F1-7. (p. 14) Schematic distribution patterns of major lithofacies assemblages (LFAs) in intermontane-basin and river-valley fills of the RG-rift province. Modified from Hawley and others (1995, Fig. 6) and Hawley and Kernodle (2000). *See* **Plate 1-8** and **Tables F1-4** to **F1-6**.

Plate F1-8. (p. 15) Idealized triangular diagram of dominant textural classes in lithofacies assemblages (LFAs) 1 to 10; and primary LFA composition of SFG Hydrostratigraphic Units (HSUs) - USF/MSF/LSF. *See* **Plate F1-7** and **Tables F1-4** to **F1-6**.

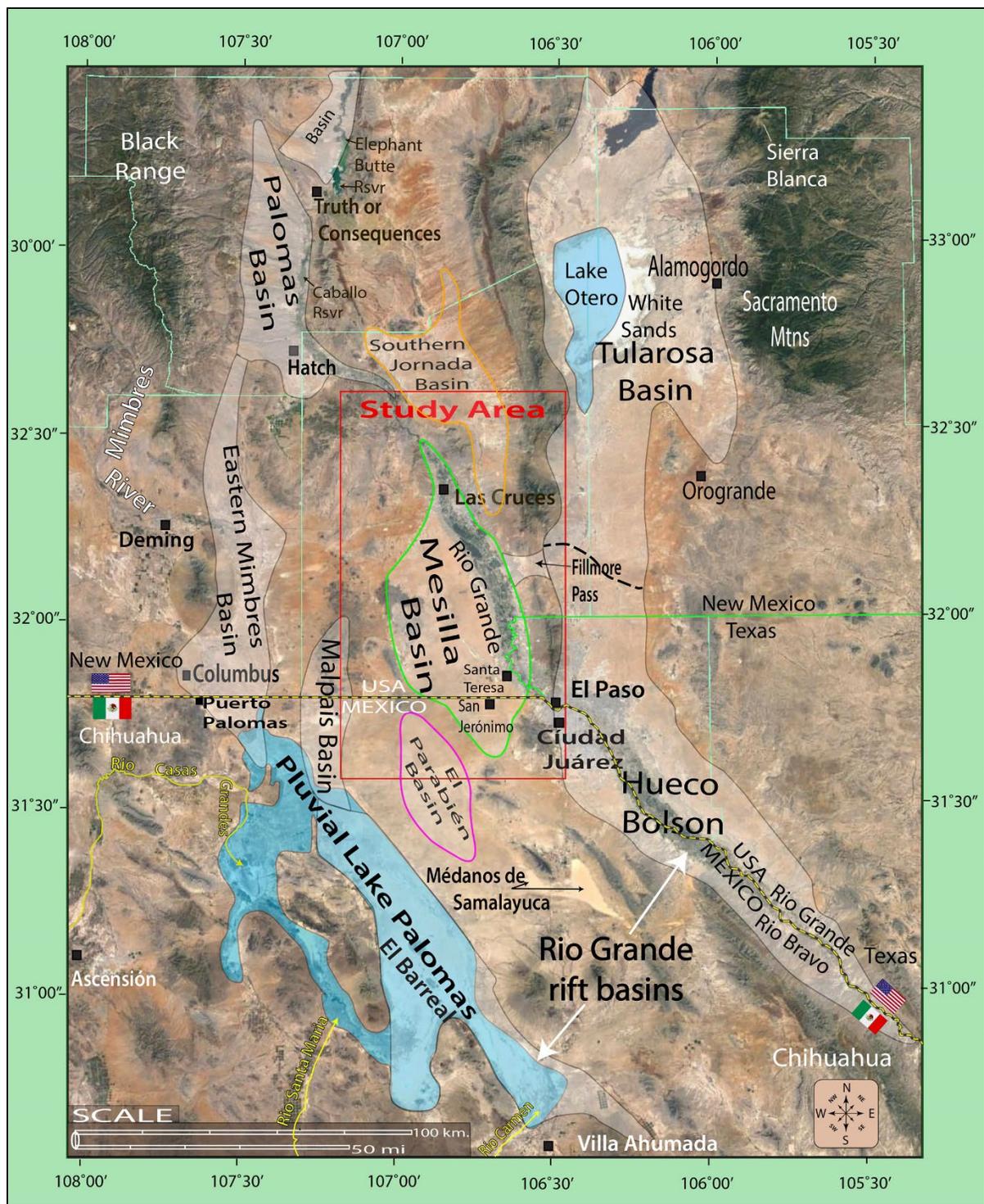
Table F1-4. (p. 16) Summary of depositional setting and dominant textures of major lithofacies assemblages (LFAs) in Santa Fe Group basin fill (1-10) and Rio Grande Valley fill (a-c) in the intermontane basins of the Rio Grande rift tectonic province. Modified from Hawley and Kernodle (2000). *See* **Plates F1-7** and **8**, and **Tables F1-5** and **F1-6**.

Table F1-5. (p. 17) Summary of major sedimentary properties that influence groundwater-flow and aquifer-production potential of Lithofacies Assemblages (LFAs) 1 to 10 in Santa Fe Group basin fill. Modified from Haase and Lozinsky (1992). *See* **Plate F1-7** and **8**, and **Table F1-4**.

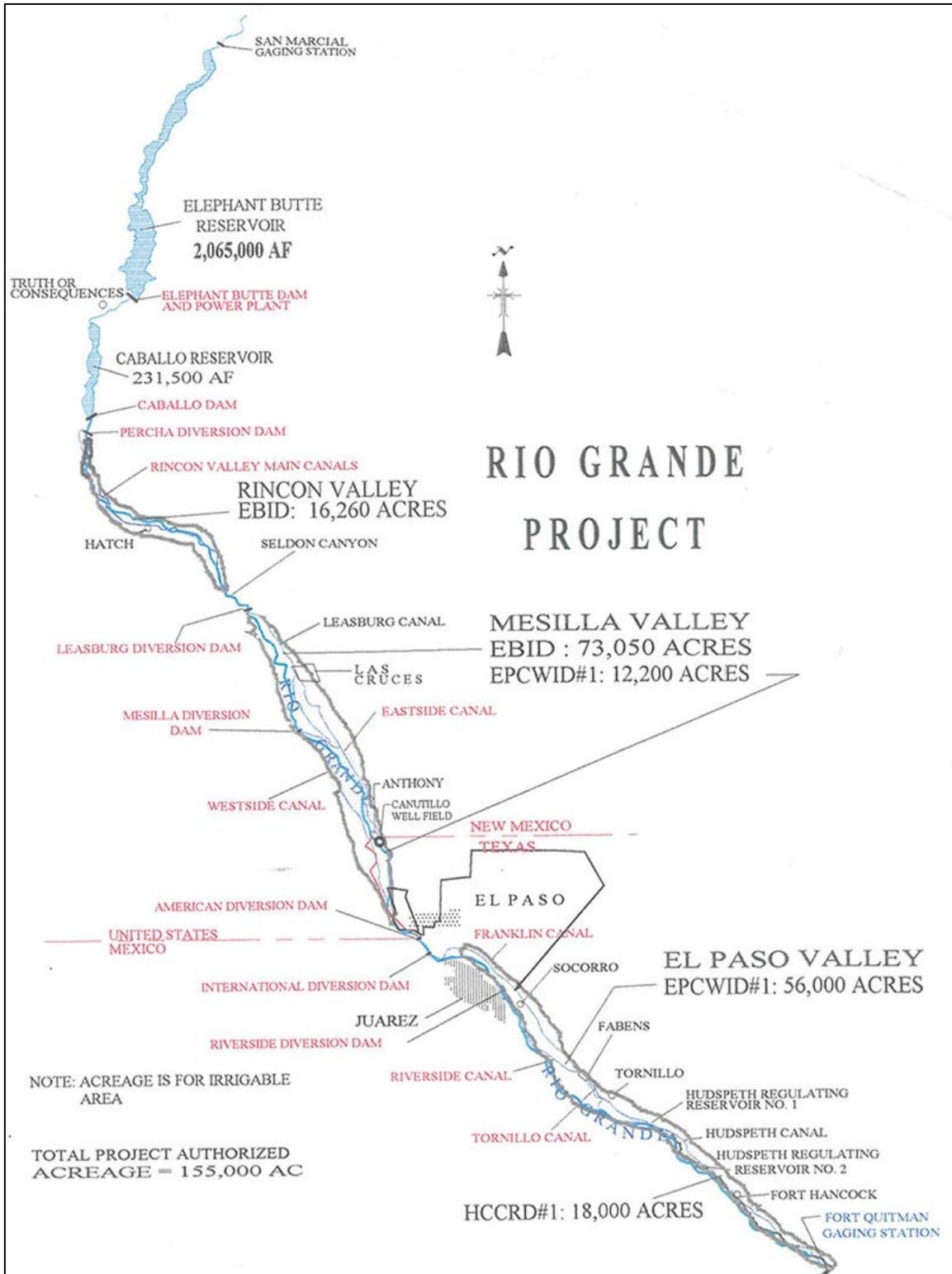
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Pl. F1-9. (Modified from Hawley et al. 2009, Fig. 6; p. 18) Correlation diagram of major Time-Rock classes, and lithostratigraphic and hydrostratigraphic units of Cenozoic Age in the southern RG-rift region of New Mexico, Texas, and Chihuahua. Bedrock units: Qb—Quaternary basalt, Tb—Tertiary mafic volcanics, and Tv—older Tertiary intermediate and silicic volcanics, and associated plutonic-igneous and sedimentary rocks. *See* **Pls. F1-7** and **F-8**, **Tbls. F1-4** to **F1-6**.

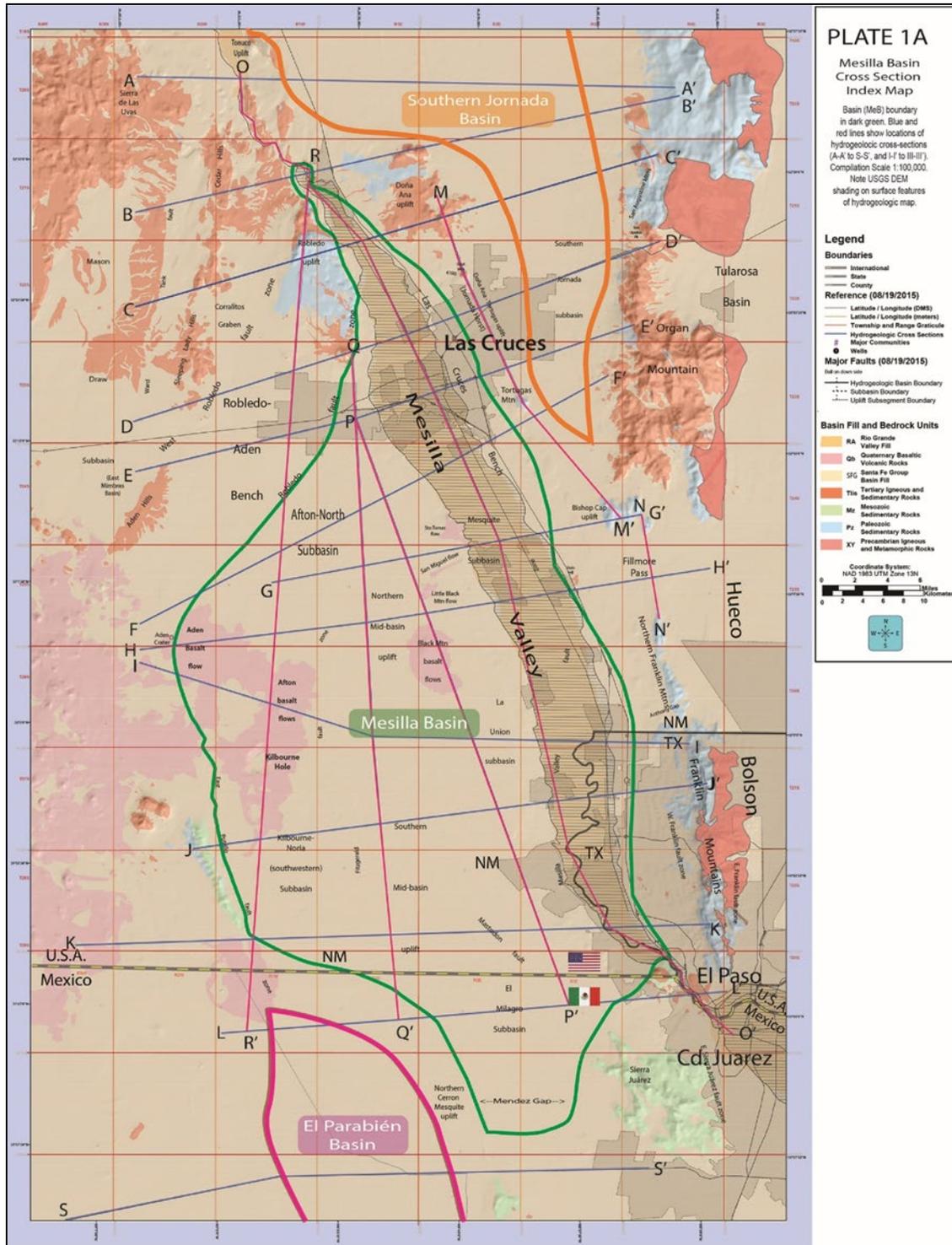
Pl. F1-10. (p. 19) Definitions of Divisions of Geologic Time used in this report.



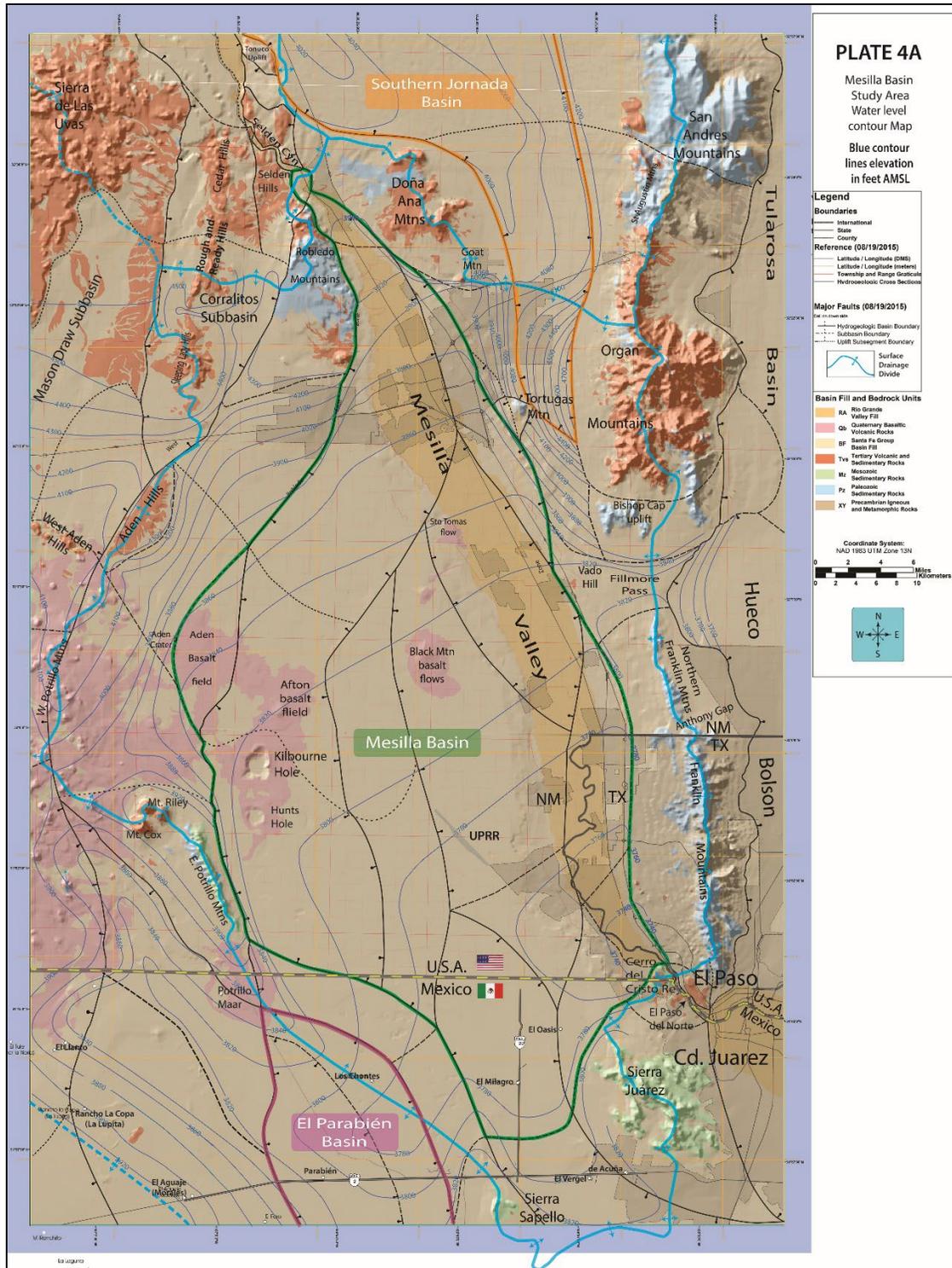
Pl. F1-1. Index map of the Mesilla Basin region (MBR) showing locations of the Study Area (Fig. 1-3, red outline), major landscape features in the northern Mexican Highland section of the B&R province, and basins of the southern RG-rift province (Fig. 1-1). Blue shading shows the approximate extent of the areas inundated by pluvial-Lakes Palomas and Otero at their respective Late Pleistocene high stands in the Zona Hidrogeológica de Conejos Médanos/El Barreal basin complex, and the Tularosa Basin. Swanson Geoscience, LLC compilation on a 2017 Google Earth® image-base.



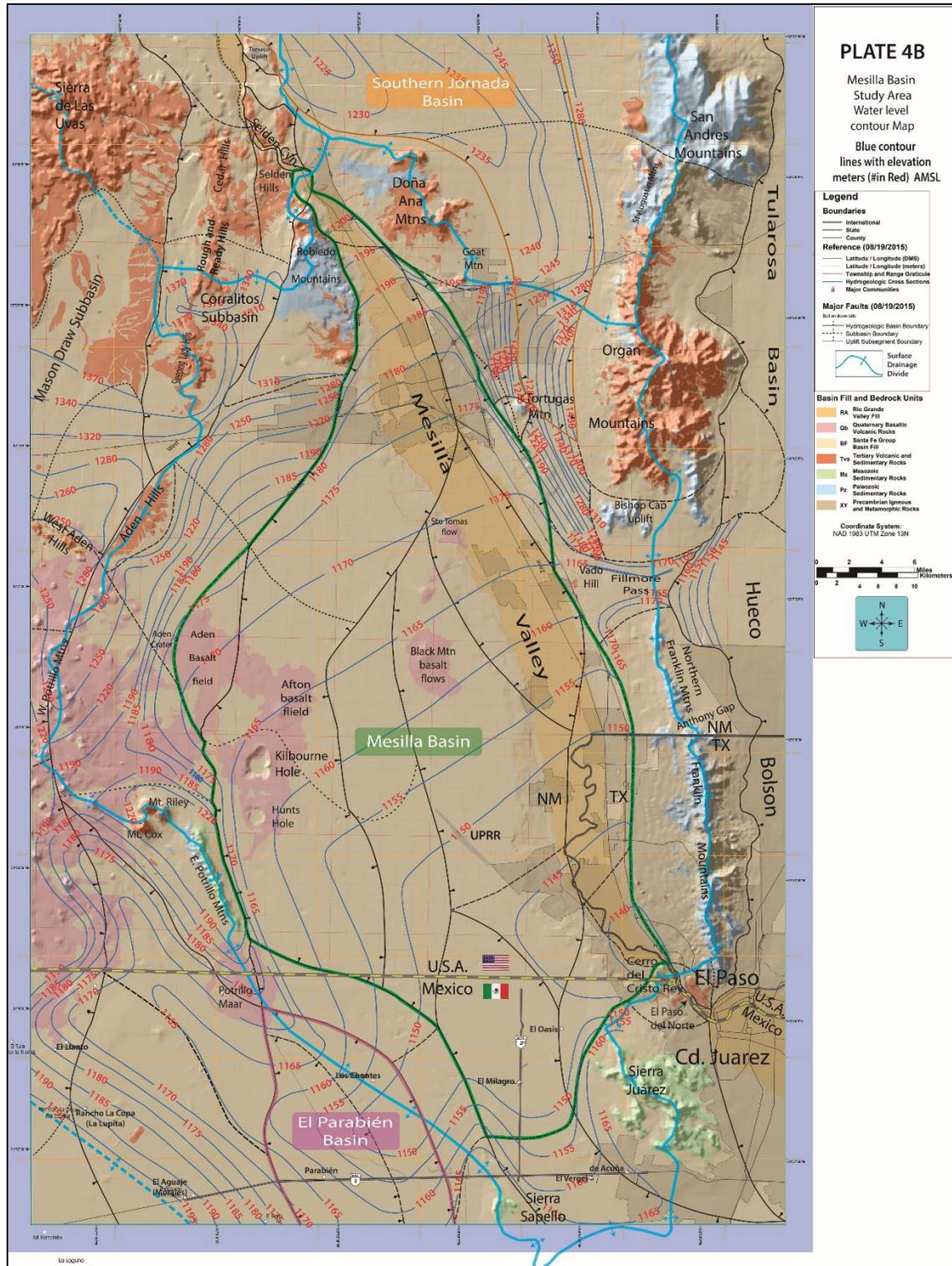
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Pl. F1-3. (Rpt. PL. 1A) Study Area index map showing locations of the Mesilla, Southern Jornada, and El Parabién groundwater (GW) basins (MeB, SJB and EPB; outlined in green, orange and red, respectively). Also shown are the locations of hydrogeologic cross-section A-A' to S-S' (Report PLATES 5a to 5s), major terrain features (incl. the Mesilla Valley, Selden Canyon and El Paso del Norte of the Rio Grande), and the Las Cruces and El Paso/Ciudad Juárez metropolitan centers. USGS DEM base, with UTM-NAD83 SI-system and latitude/longitude coordinates.



Pl. F1-4a. Index map to major geohydrologic features of the NM WRI Study Area (Fig. 1-3). The approximate pre-development (~1976) potentiometric-surface altitude (amsl) is shown on **Pl. F1-4a** with 20- and 100-ft contours, and on **Pl. F1-4b** with 5-, 10-, and 30-m contours. Major surface-watershed divides are shown by solid and dashed thick blue lines. The dashed blue line with arrows in the map's SW corner marks the approximate boundary between EPdN- and Los Muertos Basin-directed GW flow.



Pl. F1-4b. Index map to major geohydrologic features of the NM WRRRI Study Area (Fig. 1-3). The approximate pre-development (~1976) potentiometric-surface altitude (amsl) is shown on **Pl. F1-4a** with 20- and 100-ft contours, and on **Pl. F1-4b** with 5-, 10-, and 30-m contours. Major surface-watershed divides are shown by solid and dashed thick blue lines. The dashed blue line with arrows in the map's SW corner marks the approximate boundary between EPdN- and Los Muertos Basin-directed GW flow.

Table F1-1. Names and acronyms of hydrogeologic subdivisions shown on maps, cross-sections, and well-information spreadsheet (Rpt. **PLS. 1 to 8, TBLs. 1 to 3**).

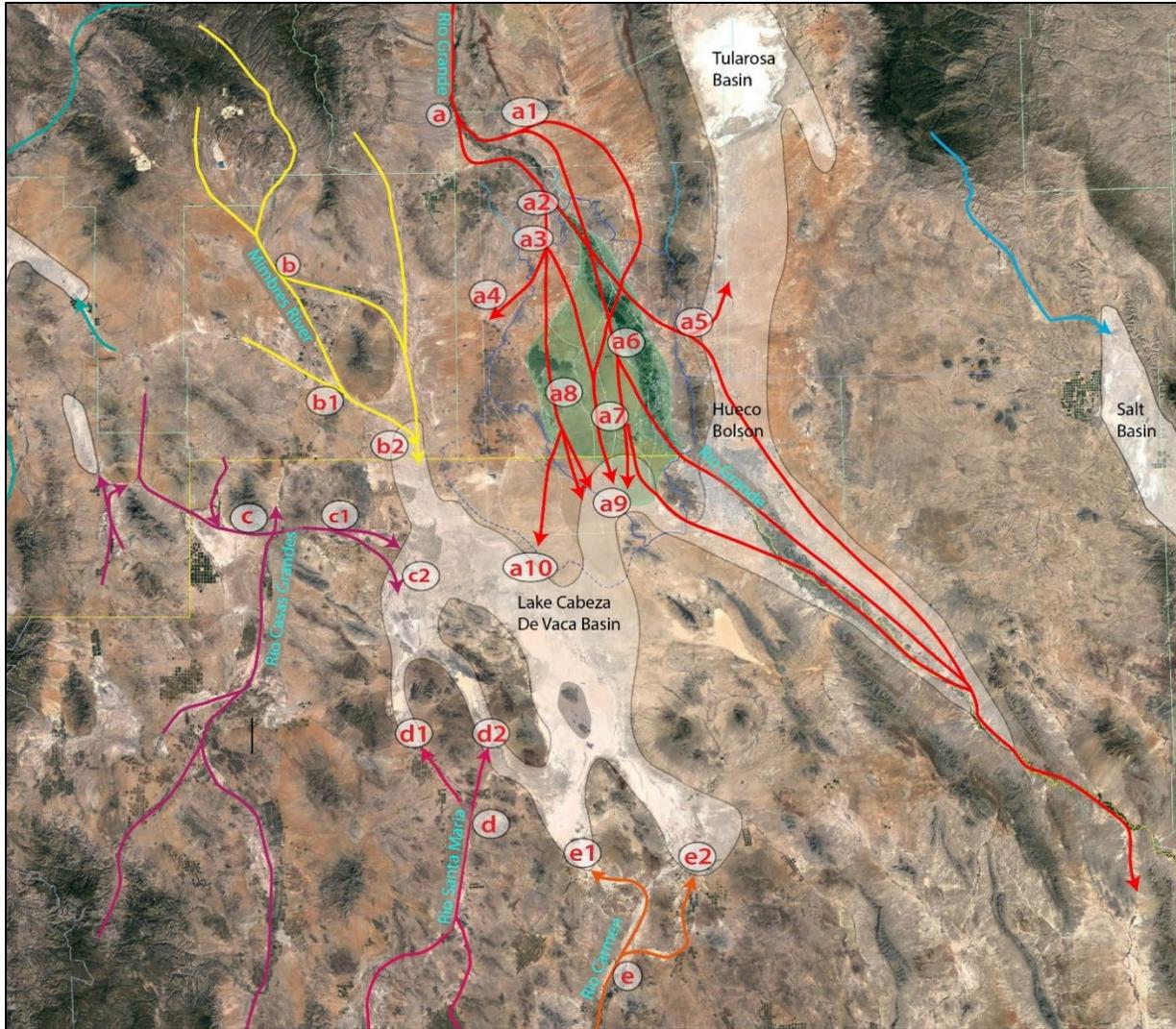
<u>ACRONYM</u>	<u>RIO GRANDE (RG) VALLEY AND CANYONS (NARROWS)</u>	
EPdN	El Paso del Norte (Cyn)	
MeV	Mesilla Valley	
SCyn	Selden Canyon (Cyn)	
EPJV	El Paso-Juárez Valley	
<u>ACRONYM</u>	<u>MESILLA GW BASIN (MeB)</u>	<u>SUBDIVISION (2,419: area in km²)</u>
MeB-ACBn	Mesilla Basin	Anthony-Canutillo Bench (138)
MeB-AfSB	Mesilla Basin	Afton Subbasin (180)
MeB-AOBn	Mesilla Basin	Anapra-Oasis Bench (72.7)
MeB-BMSB	Mesilla Basin	Black Mountain Subbasin (353)
MeB-EABn	Mesilla Basin	East Aden Bench (70.7)
MeB-EMSB	Mesilla Basin	El Milagro Subbasin (203)
MeB-FASB	Mesilla Basin	Fairacres Subbasin (382)
MeB-KNSB	Mesilla Basin	Kilbourne-Noria Subbasin (278)
MeB-LBic	Mesilla Basin	Leasburg Inflow Corridor (25.4)
MeB-LCBn	Mesilla Basin	Las Cruces Bench (97.5)
MeB-MSB	Mesilla Basin	Mesquite Subbasin (228)
MeB-NMbH	Mesilla Basin	North Mid-Basin High (143)
MeB-SMbH	Mesilla Basin	South Mid-Basin High (121)
MeB-STBn	Mesilla Basin	Santa Teresa High (89.5)
MeB-SPoc	Mesilla Basin	Sunland Park Outflow Corridor (33.4)
<u>ACRONYM</u>	<u>OTHER GW BASINS (B)</u>	<u>SUBDIVISION</u>
EPB	El Parabién Basin (N-part—Drains to MeB)	
EPB-EESB	El Parabién Basin	El Espejo Subbasin (157)
EPB-LCSB	El Parabién Basin	Los Chontes Subbasin (126)
HB	Hueco Bolson (W-edge—Receives inflow from MeB through EPdN)	
HB-NWSB	Hueco Bolson	Northwestern Subbasin
HB-NWSB	Hueco Bolson	Southwestern Subbasin
MbB	Mimbres Basin (No-flow boundary with MeB; surface and subsurface flow to Los Muertos Basin (LMB—Bolsón de los Muertos))	
MbB-WPBn	Mimbres Basin	West Potrillo Bench
MpB	Malpais GW Basin (E-edge—connects with BTC, MbB, and LMB)	
MpB-GLSB	Malpais Basin	Guzmans Lookout Subbasin (SB)
MpB-LLBn	Malpais Basin	La Laguna Bench (Bn)
RVB	Rincon Valley GW Basin (Drains to MeB through SCyn)	
RVB-BASB	Rincon Valley Basin	Bignell Arroyo Subbasin (47.2)
RVB-TNoc	Rincon Valley Basin	Tonuco Outflow Corridor (5)
SJB	Southern Jornada GW Basin (495-Drains to MeB and RVB)	
SJB-ERSB	Southern Jornada Basin	Experimental Range Subbasin (264)
SJB-ILSB	Southern Jornada Basin	Isaacks Lake Subbasin (164)
SJB-TvSB	Southern Jornada Basin	Talavera Subbasin (68.2)
SWTB	Southwestern Tularosa Basin	
<u>ACRONYM</u>	<u>UPLAND GW BASIN</u>	<u>SUBDIVISION</u>
CCUB	Cedar-Corralitos Upland Basin (UB)	
CCUB-CHSB	Cedar-Corralitos	Cedar Hills Subbasin (96.2)
CCUB-CRSB	Cedar-Corralitos	Corralitos Ranch Subbasin (205)

Table F1-1. (concluded) Names and abbreviations of basin/inter-basin subdivisions.

<u>ACRONYM</u>	<u>INTERBASIN HIGH (IBH)</u>	<u>SUBDIVISION</u>
PSH	Potrillo-Sapello High (163)	
PSH-LJS		La Joya Sector (93.5)
PSH-CMIC		Chontes-Milagro Inflow Corridor (69.5) (EPB-LCSB to MeB-EMSB)
<u>ACRONYM</u>	<u>INTERBASIN UPLIFT (U)</u>	<u>SUBDIVISION</u>
AHU	Aden Hills Uplift	
ARU	Aden-Robledo Uplift	
ARU-AdS	Aden-Robledo Uplift	Aden Sector (S)
ARU-SR _{ic}	Aden-Robledo Uplift	South Robledo Inflow Corridor (145)
BCU	Bishop Cap Uplift	
BHU	Black Hills Uplift	
CAHU	Campus-Andesite Hills Uplift	
CCRU	Cerro del Cristo Rey Uplift	
CMU	Camel Mountain Uplift	
DAMU	Doña Ana Mountains Uplift	
EAU	El Aguaje Uplift (310)	
EPU	East Potrillo Uplift	
EPU-BT _{ic}	East Potrillo Uplift	Brock Tank Inflow Corridor (227)
EPU-PR _S	East Potrillo Uplift	Potrillo-Mt. Riley Sector (S)
FMU	Franklin Mountains Uplift	
OMU	Organ Mountains Uplift	
RMU	Robledo Mountains Uplift	
SAMU	San Andres Mountains Uplift	
SHU	Selden Hills Uplift	
SJU	Sierra Juárez Uplift	
SSU	Sierra Sapello Uplift (41)	
TMU	Tonuco Mountain Uplift	
TtU	Tortugas Uplift	
TtMU	Tortugas Uplift	Tortugas Mountain Uplift (U)
TtU-NT _{ic}	Tortugas Uplift	North Tortugas Inflow Corridor (63.5)
TtU-ST _{ic}	Tortugas Uplift	South Tortugas Inflow Corridor (59.2)
UGU	Uvas-Goodsight Uplift	
UGU-SLU	Uvas-Goodsight Uplift	Sierra de las Uvas (U)
UGU-MDS	Uvas-Goodsight Uplift	Mason Draw Sector (S)
UGU-ML _{ic}	Uvas-Goodsight Uplift	Muzzle Lake Inflow Corridor (to Mimbres Basin-MbB)
<u>ACRONYM</u>	<u>MAJOR INTERBASIN GROUNDWATER-FLOW CORRIDORS</u>	
BTC	Border Tank Corridor (214) (Malpais Basin to El Parabién Basin underflow)	
ETNC	East Tonuco Corridor (13.5) (Jornada Basin to Rincon Valley Basin underflow)	
FPC	Fillmore Pass Corridor (73.7) (Mesilla Basin-Hueco Bolson—potential inter-basin underflow)	
MVIC	Méndez-Vergel Inflow Corridor (115) (possible Hueco Bolson to Mesilla Basin underflow)	

Table F1-2. Names, and Acronyms for Basin- and Subbasin-Boundary Fault Zones (**Pl. F1-5**).

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| <p>I. Groundwater Basin/Intrabasin-Boundary Fault Zones (fz)</p> <p>A. Mesilla and El Parabién Basins</p> <ol style="list-style-type: none"> 1. Mesilla Basin (MeB) <ul style="list-style-type: none"> CBfz—Chamberino fz EVfz—El Vergel fz EPfz—East Potrillo fz ERfz—East Robledo fz FGfz—Fitzgerald fz MBfz—Mid-Basin fz MDfz—Mastodon fz MVfz—Mesilla Valley fz NRfz—Noria fz SPfz—San Pablo fz SSfz—Sierra Sapello fz TTfz—Tortugas fz 2. El Parabién Basin (EPB) <ul style="list-style-type: none"> EFfz—El Faro fz EGfz—El Girasol fz LCfz—Los Cuates fz <p>B. Southern Jornada and Rincon Valley Basins</p> <ol style="list-style-type: none"> 1. Southern Rincon Valley Basin (SJB) <ul style="list-style-type: none"> TNfz—Tonuco fz WTfz—Ward Tank fz 2. Southern Jornada Basin (SJB) <ul style="list-style-type: none"> EJfz—East Jornada fz Jfz—Jornada fz <p>C. Hueco Bolson and Tularosa Basin</p> <ol style="list-style-type: none"> 1. Northwestern Hueco Bolson (NWHB) <ul style="list-style-type: none"> FMfz—Franklin Mountain fz SJfz—Sierra Juárez fz 2. Southwestern Tularosa GW Basin (SWTB) <ul style="list-style-type: none"> OMfz—Organ Mountains fz SAMfz—San Andres Mountains Fz <p>D. Western-Border Basins</p> <ol style="list-style-type: none"> 1. Cedar-Corralitos Upland Basin (CCUB) <ul style="list-style-type: none"> CHfz—Cedar Hills fz WRfz—West Robledo fz WTfz—Ward Tank fz 2. Northeastern Mimbres Basin (Mbb) <ul style="list-style-type: none"> WTfz—Ward Tank fz WRfz—West Robledo fz 3. Malpais Basin (MpB) <ul style="list-style-type: none"> LPfz—La Peña fz | <p>II. Inter-basin Uplift Fault Zones (fz)—Boundary and Interior</p> <p>A. Aden-Robledo Uplift (ARU) <ol style="list-style-type: none"> 1. ERfz—East Robledo fz 2. WRfz—West Robledo fz </p> <p>B. Doña Ana Mountain Uplift (DAMU) <ol style="list-style-type: none"> 1. Jfz—Jornada fz 2. MVfz—Mesilla Valley fz 3. TTfz—Tortugas fz </p> <p>C. East Potrillo Uplift (EPU) <ol style="list-style-type: none"> 1. EPfz—East Potrillo fz 2. MRfz—Mount Riley fz </p> <p>D. El Aguaje Uplift (EAU) <ol style="list-style-type: none"> 1. EFfz—El Faro fz 2. LPfz—La Peña fz </p> <p>E. Franklin Mountains Uplift (FMU) <ol style="list-style-type: none"> 1. FMfz—Franklin Mountains fz 2. WFfz—West Franklin fz </p> <p>F. Organ Mountain Uplift (OMU) <ol style="list-style-type: none"> 1. EJfz—East Jornada fz 2. OMfz—Organ Mountains fz </p> <p>G. Robledo Mountain Uplift (RMU) <ol style="list-style-type: none"> 1. ERfz—East Robledo fz 2. WRfz—West Robledo fz </p> <p>H. Sierra Juárez Uplift (SJU) <ol style="list-style-type: none"> 1. SJfz—Sierra Juárez fz 2. EVfz—El Vergel fz </p> <p>I. Sierra Sapello Uplift <ol style="list-style-type: none"> 1. SSfz—Sierra Sapello fz 2. LCfz—Los Cuates fz </p> <p>J. Southern San Andres Mtns (SAMU) <ol style="list-style-type: none"> 1. EJfz—East Jornada fz 2. SAMfz—San Andres Mountains fz </p> <p>K. Tortugas Uplift (TtU) <ol style="list-style-type: none"> 1. Jfz—Jornada fz 2. TTfz—Tortugas fz </p> <p>III. Inter-basin Corridor Boundary-fault zones (fz)</p> <p>A. Border Tank Corridor (BTC) <ol style="list-style-type: none"> 1. LPfz—La Peña fz 2. MRfz—Mount Riley fz </p> <p>B. Fillmore Pass Corridor (FPC) <ol style="list-style-type: none"> 1. FMfz—Franklin Mountains fz 2. MVfz—Mesilla Valley fz </p> <p>C. Méndez-Vergel Corridor (MVC) <ol style="list-style-type: none"> 1. EVFZ—El Vergel fz 2. SSfz—Sierra Sapello fz </p> |
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Pl. F1-6. Pliocene and Early Pleistocene geomorphic setting of the ARG distributive fluvial system (DFS- red lines) that terminated in the Lake Cabeza de Vaca (LCdV) basin complex of Strain (1966, 1971). Schematic depiction of ARG distributary channel-belt in the southeastern B&R province (adapted from Hawley 1975, Fig. 2). Explanations of the symbols that show the general positions of primary Distributive Fluvial System (DFS)-apex and channel-belt-segments of ancestral rivers with fluvial-deltaic termini in the LCdV basin complex on **Table F1-3**. The Rios Casas Grandes (violet), Santa Maria and Carmen (pink and orange), and the Mimbres River (yellow) remain as the major surface and subsurface flow fluvial contributors to ephemeral lake-plain remnants of Late Quaternary Paleo-Lake Palomas: Lagunas Guzman, Santa Maria and Patos, and El Barreal-Salinas de Unión. Only parts of the Mesilla Basin and Hueco Bolson have surface/subsurface connection with Rio Grande at present. (*cf.* **Pls. F1-2** and **F1-3**; Hawley 1975, Gile et al. 1981, Connell et al. 2005, Castiglia and Fawcett 2006, Weissmann et al. 2011, Davidson et al. 2013, and Nichols 2015). 2018 Google Earth® image base.

Table F1-3. Explanation of Plate **F1-6** alpha-numeric symbols for Pliocene and Early Pleistocene Distributive Fluvial Systems (DFSs) of ancestral rivers with fluvial-deltaic termini in the Paleo-Lake Cabeza de Vaca complex (LCdV) and Bolson de los Muertos (BdLM).

A. APEX AREA OF THE ANCESTRAL RIO GRANDE-CAMP RICE FM DFS (ARG-DFS) IN THE SOUTHERN JORNADA BASIN, HUECO BOLSON, AND LOS MUERTOS BASIN (BdLM) —RED LINES

- a1. Eastern Rincon Valley head of the ARG-DFS distributary-channel complex in the Southern Jornada Basin.
- a2. Upper Selden Canyon head of the ARG-DFS distributary-channel complex in the central and eastern Mesilla Basin area.
- a3. Lower Selden Canyon head of the ARG-DFS distributary-channel complex in the western Mesilla Basin area.
- a4. Cedar-Corralitos Basin head of the ARG-DFS distributary-channel complex in the northwestern Mesilla and northeastern Mimbres Basin areas.
- a5. Fillmore Pass head of the ARG-DFS distributary-channel complex in the western Tularosa Basin and northwestern Hueco Bolson area (**Fig. 1-15**, Seager 1981 [Fig. 84]).
- a6. South-central Mesilla Basin head of the ARG-DFS distributary-channel complex in the El Parabién Basin-Paso del Norte area.
- a7. Southeastern Mesilla Basin head of the ARG-DFS distributary-channel complex in the El Parabién Basin, Méndez-Vergel Corridor, and southwestern Hueco Bolson area.
- a8. Southwestern Mesilla Basin head of the ARG-DFS distributary-channel complex in the El Parabién Basin and the northeastern LCdV-BdLM.
- a9. South-central termini of ARG-DFS fluvial-deltaic distributaries in the northeastern LCdV-BdLM.
- a10. Southwestern termini of ARG-DFS fluvial-deltaic distributaries in the northwestern LCdV-BdLM.

B. APEX AREA OF THE ANCESTRAL RIO MIMBRES-UPPER GILA GP DFS (ARM-DFS—YELLOW LINES) IN THE NORTHERN LCdV-BdLM

- b1. Southeastern Mimbres Basin head of the ARM-UGDFS fluvial-deltaic distributaries.
- b2. Southern termini of ARM-DFS fluvial-deltaic distributaries in the northern LCdV-BdLM.

C. APEX AREA OF THE ANCESTRAL RIO CASAS GRANDES-BOCA GRANDE DFS (ARCG-DFS—VIOLET LINES) IN THE NORTHWESTERN LCdV-BdLM

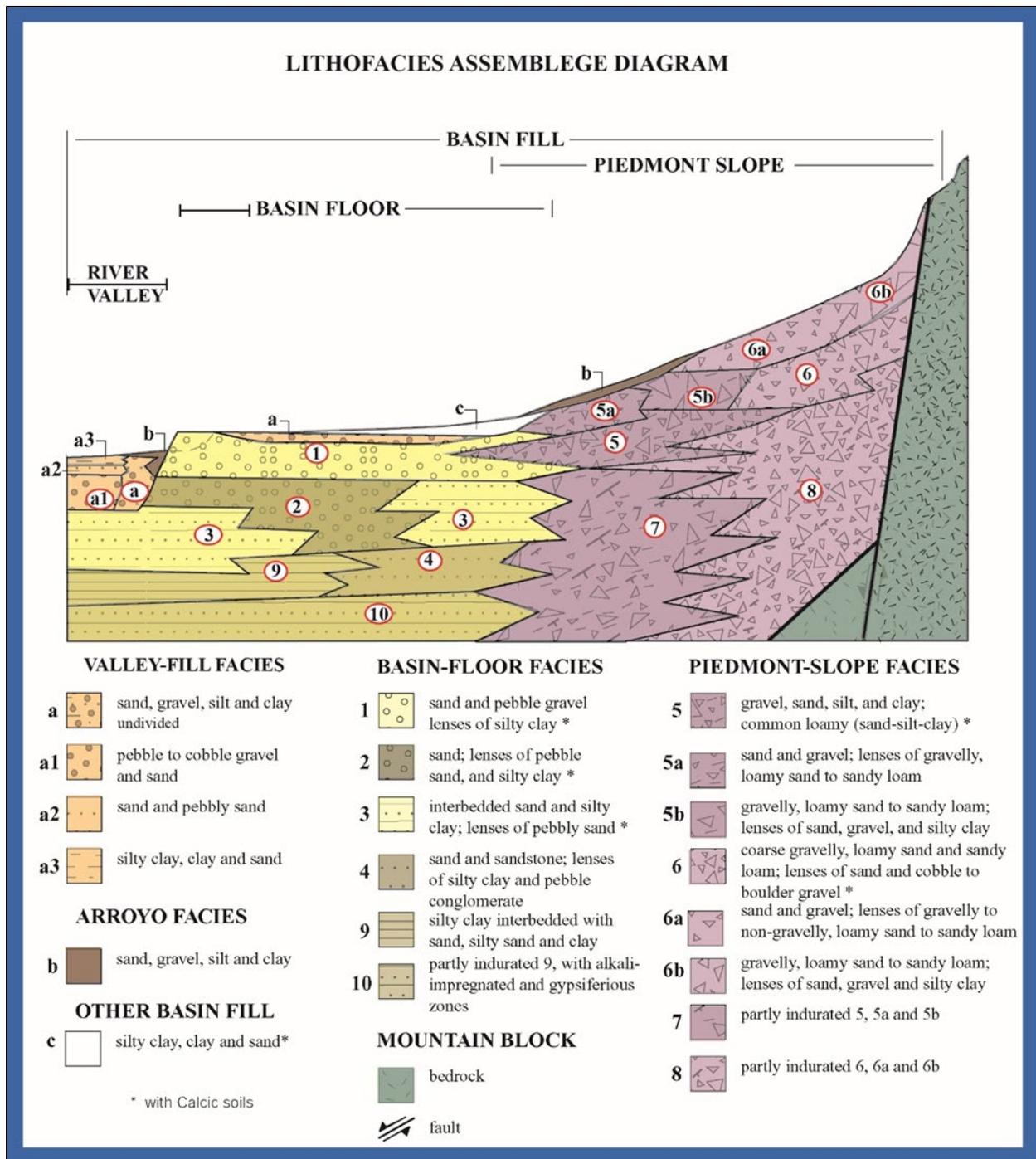
- c1. Head of ARCG-BGDFS fluvial-deltaic distributaries in the northwestern LCdV-BdLM
- c2. Eastern termini of ARCG-DFS fluvial-deltaic distributaries in the northwestern LCdV- BdLM

D. APEX AREA OF THE ANCESTRAL RIO SANTA MARIA DFS (ARSM-DFS—PINK LINES) IN THE SOUTHWESTERN LCdV-BdLM

- d1. Eastern termini of ARSM-DFS fluvial-deltaic distributaries south of Laguna Santa Maria.
- d2. Western termini of ARSM-DFS fluvial-deltaic distributaries south of Laguna Fresnal

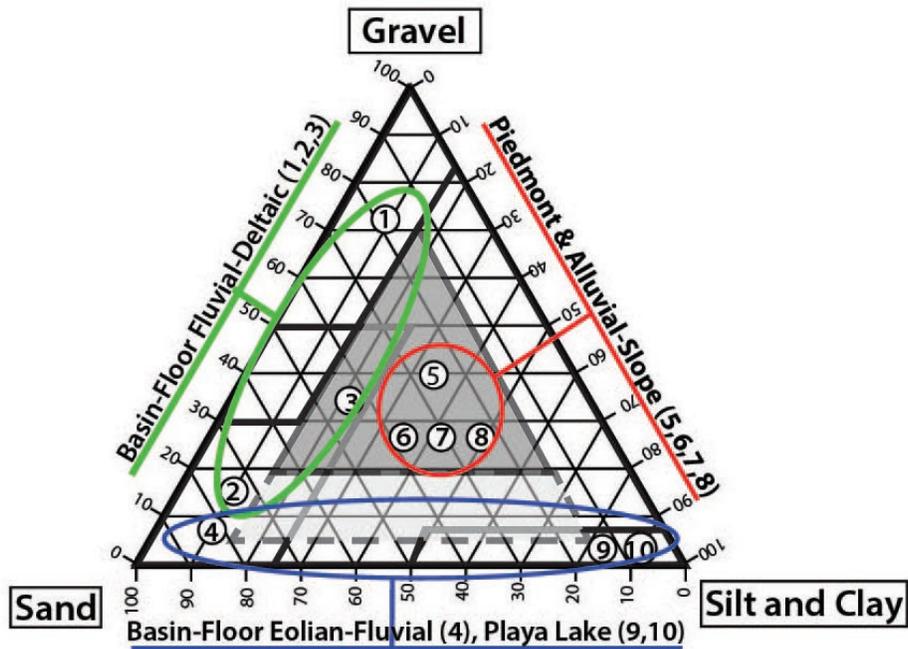
E. APEX AREA OF THE ANCESTRAL RIO CARMEN DFS (ARC-DFS—ORANGE LINES) IN THE SOUTHEASTERN LCdV-BdLM

- e1. Eastern termini of ARC-DFS fluvial-deltaic distributaries in the southeastern LCdV-BdLM near Villa Ahumada and Laguna Patos.
- e2. Western termini of ARC-DFS fluvial-deltaic distributaries northwest of Carrizal in the southeastern LCdV-BdLM



Pl. F1-7. Schematic distribution patterns of major lithofacies assemblages (LFAs) in intermontane-basin and river-valley fills of the RG-rift province. Modified from Hawley and others (1995, Fig. 6) and Hawley and Kernodle (2000). See Plate 1-8 and Tables F1-4 to F1-6).

Dominant Lithofacies Assemblage (LFA)



Primary Hydrostratigraphic Unit (HSU) Components

USF-2,4: 1,2,3,9 MSF-2, 4: 2,3,9,10 LSF: 4,7,8,9,10
 USF-1,3: 5,6 MSF-1,3: 7,8

General Properties

Provenance:	Non-to Partly Indurated: 1,2,3,4,5,6,9,10
Local: 5,6,7,8	Partly Indurated to Indurated: 7,8
Extrabasinal/Local: 1,2,3,9,10	

Pl. F1-8. Idealized triangular diagram of dominant textural classes in lithofacies assemblages (LFAs) 1 to 10; and primary LFA composition of SFG Hydrostratigraphic Units (HSUs) - USF/MSF/LSF. See **Plate F1-7** and **Tables F1-4** to **F1-6**.

Table F1-4. Summary of depositional setting and dominant textures of major lithofacies assemblages (LFAs) in Santa Fe Group basin fill (1-10) and Rio Grande Valley fill (a-c) in the intermontane basins of the Rio Grande rift tectonic province. Modified from Hawley and Kernodle (2000). See **Plates F1-7** and **8**, and **Tables F1-5** and **F1-6**.

Lithofacies	Dominant depositional settings and process	Dominant textural classes
1	Basin-floor fluvial plain	Sand and pebble gravel, lenses of silty clay
2	Basin-floor fluvial, locally eolian	Sand; lenses of pebbly sand and silty clay
3	Basin-floor, fluvial-overbank, fluvial-deltaic and playa-lake; eolian	Interbedded sand and silty clay; lenses of pebbly sand
4	Eolian, basin-floor alluvial	Sand and sandstone; lenses of silty sand to clay
5	Distal to medial piedmont-slope; alluvial fan	Gravel, sand, silt, and clay; common loamy (sand-silt-clay)
5a	Distal to medial piedmont-slope, alluvial fan; associated with large watersheds; alluvial-fan distributary-channel primary; sheet-flood and debris-flow secondary	Sand and gravel; lenses of gravelly, loamy sand to sandy loam
5b	Distal to medial piedmont-slope, alluvial fan; associated with small steep watersheds, debris-flow sheet-flood, and distributary-channel	Gravelly, loamy sand to sandy loam; lenses of sand, gravel, and silty clay
6	Proximal to medial piedmont-slope, alluvial-fan	Coarse gravelly, loamy sand and sandy loam; lenses of sand and cobble to boulder gravel
6a	Like 5a	Sand and gravel; lenses of gravelly to non-gravelly, loamy sand to sandy loam
6b	Like 5b	Gravelly, loamy sand to sandy loam; lenses of sand, gravel, and silty clay
7	Like 5	Partly indurated 5
8	Like 6	Partly indurated 6
9	Basin-floor-alluvial flat, playa, lake, and fluvial-lacustrine; distal-piedmont alluvial	Silty clay interbedded with sand, silty sand, and clay
10	Like 9, with evaporite processes (paleophreatic)	Partly indurated 9, with gypsiferous and alkali-impregnated zones
a	River-valley, fluvial	Sand, gravel, silt, and clay
a1	Basal channel	Pebble to cobble gravel and sand (like 1)
a2	Braided plain, channel	Sand and pebbly sand (like 2)
a3	Overbank, meander-belt oxbow	Silty clay, clay, and sand (like 3)
b	Arroyo channel and valley-border alluvial-fan	Sand, gravel, silt, and clay (like 5)
c	Basin floor, alluvial flat, cienega, playa, and fluvial-fan to lacustrine plain	Silty clay, clay, and sand (like 3,5, and 9)

Table F1-5. Summary of major sedimentary properties that influence groundwater-flow and aquifer-production potential of Lithofacies Assemblages (LFAs) 1 to 10 in Santa Fe Group basin fill. Modified from Haase and Lozinsky (1992). See **Plates F1-7 and 8**, and **Table F1-4**.

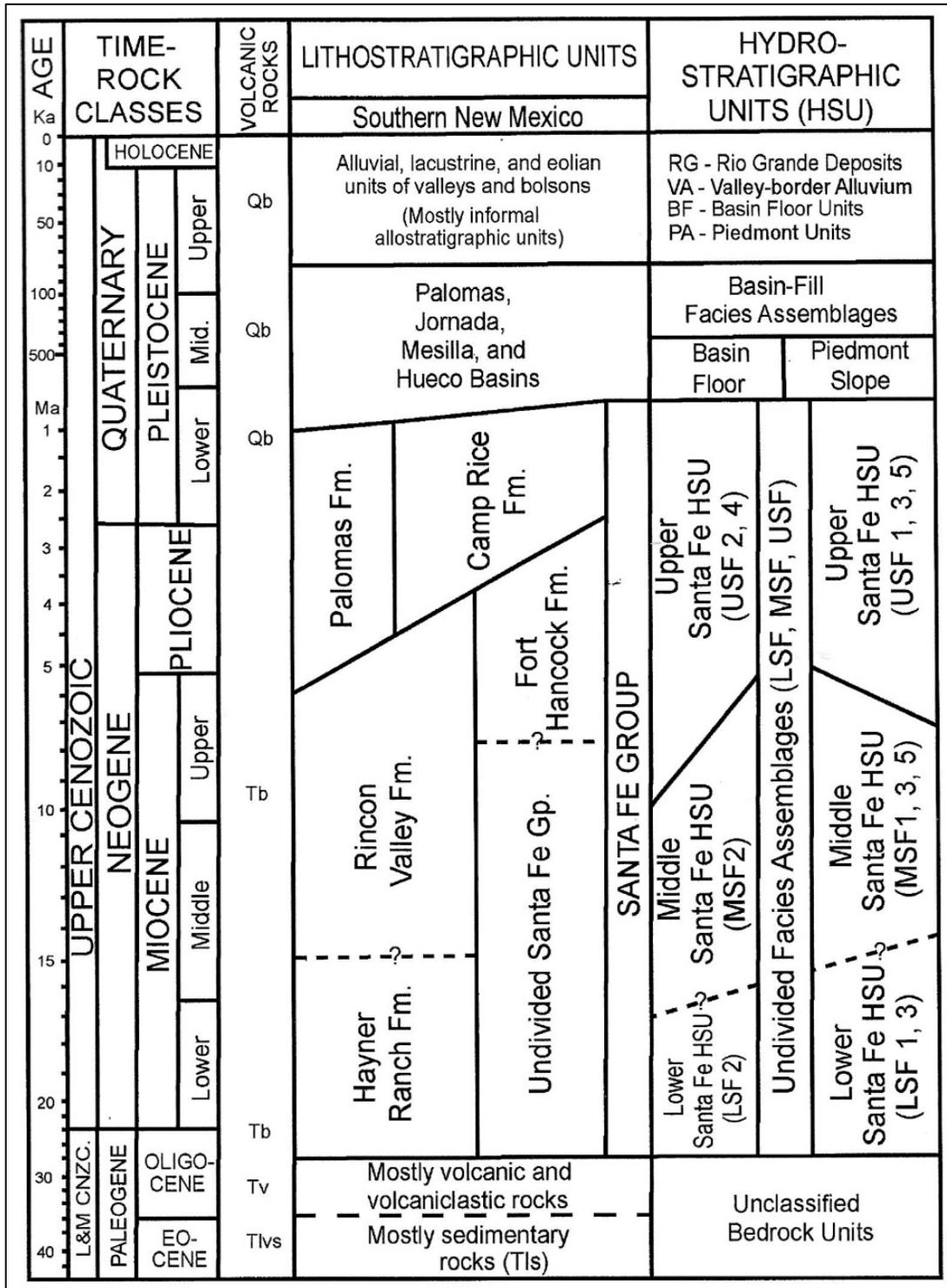
Lithofacies	Ratio of sand plus gravel to silt plus clay ¹	Bedding thickness (meters)	Bedding configuration ²	Bedding continuity (meters) ³	Bedding connectivity ⁴	Hydraulic conductivity (K) ⁵	Groundwater production potential
1	High	>1.5	Elongate to planar	>300	High	High	High
2	High to moderate	>1.5	Elongate to planar	>300	High to moderate	High to moderate	High to moderate
3	Moderate	>1.5	Planar	150 to 300	Moderate to high	Moderate	Moderate
4	Moderate to low*	>1.5	Planar to elongate	30 to 150	Moderate to high	Moderate	Moderate
5	Moderate to high	0.3 to 1.5	Elongate to lobate	30 to 150	Moderate	Moderate to low	Moderate to low
5a	High to moderate	0.3 to 1.5	Elongate to lobate	30 to 150	Moderate	Moderate	Moderate
5b	Moderate	0.3 to 1.5	Lobate	30 to 150	Moderate to low	Moderate to low	Moderate to low
6	Moderate to low	0.3 to 1.5	Lobate to elongate	130 to 150	Moderate to low	Moderate to low	Low to moderate
6a	Moderate	0.3 to 1.5	Lobate to elongate	30 to 150	Moderate	Moderate to low	Moderate to low
6b	Moderate to low	0.3 to 1.5	Lobate	<30	Low to moderate	Low to moderate	Low
7	Moderate*	0.3 to 1.5	Elongate to lobate	30 to 150	Moderate	Low	Low
8	Moderate to low*	>1.5	Lobate	<30	Low to moderate	Low	Low
9	Low	>5	Planar	>150	Low	Very low	Very low
10	Low*	>5	Planar	>150	Low	Very low	Very low

¹High >2; moderate 0.5-2; low <0.5
²Elongate (length to width ratios >5); planar (length to width ratios 1-5); lobate (asymmetrical or incomplete planar beds).
³Measure of the lateral extent of an individual bed of given thickness and configuration.
⁴Estimate of the ease with which groundwater can flow between individual beds within a particular lithofacies. Generally, high sand + gravel/silt + clay ratios, thick beds, and high bedding continuity favor high bedding connectivity. All other parameters being held equal, the greater the bedding connectivity, the greater the groundwater production potential of a sedimentary unit.
⁵High 10 to 30 m/day; moderate, 1 to 10 m/day; low, <1 m/day; very low, <0.1 m/day.
*Significant amounts of cementation of medium to coarse-grained beds (as much as 50%)

Table F1-6. Summary of major sedimentary properties that influence groundwater-flow and aquifer-production potential of Lithofacies Assemblages (LFAs) a to c in post-SFG RG-valley and basin fills. Modified from Hawley and Kernodle (2000). See **Plates F1-7 and 8**, and **Table F1-4**.

Lithofacies	Ratio of sand plus gravel to silt plus clay ¹	Bedding thickness (meters) ³	Bedding configuration ²	Bedding continuity (meters) ³	Bedding connectivity ⁴	Horizontal hydraulic conductivity (K) ⁵	Groundwater production potential
a	High to moderate	>1.5	Elongate to planar	>300	High to moderate	High to moderate	High to moderate
a1	High	>1.5	Elongate to planar	>300	High	High	High
a2	High to moderate	>1.5	Planar to elongate	150 to 300	Moderate to high	Moderate	Moderate
a3	Moderate to low	>1.5	Planar to elongate	30 to 150	Moderate to high	Moderate to low	Moderate to low
b	Moderate to low	0.3 to 1.5	Elongate to lobate	<300	Moderate	Moderate to low	Moderate to low
c	Low to moderate	0.3 to 1.5	Elongate to lobate	30 to 150	Low	Low	Low

¹High >2; moderate 0.5-2; low <0.5
²Elongate (length to width ratios >5); planar (length to width ratios 1-5); lobate (lenticular or discontinuous planar beds).
³Measure of the lateral extent of an individual bed of given thickness and configuration.
⁴Estimate of the ease with which groundwater can flow between individual beds within a particular lithofacies. Generally, high sand + gravel/silt + clay ratios, thick beds, and high bedding continuity favor high bedding connectivity. All other parameters being held equal, the greater the bedding connectivity, the greater the groundwater production potential of a sedimentary unit.
⁵High, 10 to 30 m/day; moderate, 1 to 10 m/day; low, <1 m/day; very low, <0.1 m/day.



Pl. F1-9. (modified from Hawley et al. 2009, Fig. 6) Correlation diagram of major Time-Rock classes, and lithostratigraphic and hydrostratigraphic units of Cenozoic Age in the southern RG-rift region of New Mexico, Texas, and Chihuahua. Bedrock units: Qb—Quaternary basalt, Tb—Tertiary mafic volcanics, and Tv—older Tertiary intermediate and silicic volcanics, and associated plutonic-igneous and sedimentary rocks. See Pls. F1-7 and F-8, Tbls. F1-4 to F1-6.

Pl. F1-10. Definitions of Divisions of Geologic Time used in this report.

ERA	Period	Epoch (u/m/l *)	Age (years**)
CENOZOIC (Cz)			
	Quaternary (Q)		
		Holocene (Qu)	0-11,400
		<i>Historic</i>	0-1580 CE
		Pleistocene	11,400-2.6 Ma
		Late (Qu)	11,400-126 ka
		Middle (Qm)	126 ka-780 ka
		Early (Ql)	780 ka-2.6 Ma
	Tertiary (T)		
		Late: Neogene	
		Pliocene (Tu)	2.6-5.3 Ma
		Late	2.6-3.6 Ma
		Early	3.6-5.3 Ma
		Miocene (Tu)	5.3-23 Ma
		Late	5.3-11.6 Ma
		Middle	11.6-16 Ma
		Early	16-23 Ma
		Early: Paleogene	
		Oligocene (Tm)	23-34 Ma
		Eocene (Tl)	34-55.8 Ma
		Paleocene (Tl)	55.8-65.5 Ma
MESOZOIC (Mz)			
		Cretaceous (K)	65.5-145.5 Ma
		Jurassic (Jr)	145.5-199.6 Ma
		Triassic (Tr)	199.6-251 Ma
PALEOZOIC (Pz)			
		Permian (P, Pzu)	251-299 Ma
		Pennsylvanian (Pn, Pzu)	299-318 Ma
		Mississippian (M, Pzu)	318-359 Ma
		Devonian (D, Pzl)	359-416 Ma
		Silurian (S, Pzl)	416-444 Ma
		Ordovician (O, Pzl)	444-488 Ma
		Cambrian (C, Pzl)	488-542 Ma
PRECAMBIAN-PROTEROZOIC (XY)			542 Ma-2.5Ba
PRECAMBIAN-ARCHAEN			2.5-3.85 Ba

***u/m/l** = upper/middle/lower – rock[litho]-stratigraphic units

**Ba=billion years, Ma=million years, and ka=thousand years

Modified from Koning and Read (2010, Table 2)