January 26, 2026

Dear Madame Mayor and Honorable Members of the City Council of the City of San Antonio;

I read the letter from Mr. Puente to Councilperson Gavito dated October 10, 2025. I believe comments and assertions in the Puente letter are not consistent with the current understanding of the Trinity and Edwards aquifers and how they interact.

I have studied and investigated the Edwards and Trinity aquifers for the past three decades. My qualifications to comment on the technical assertions in the Puente letter are summarized in Appendix A.

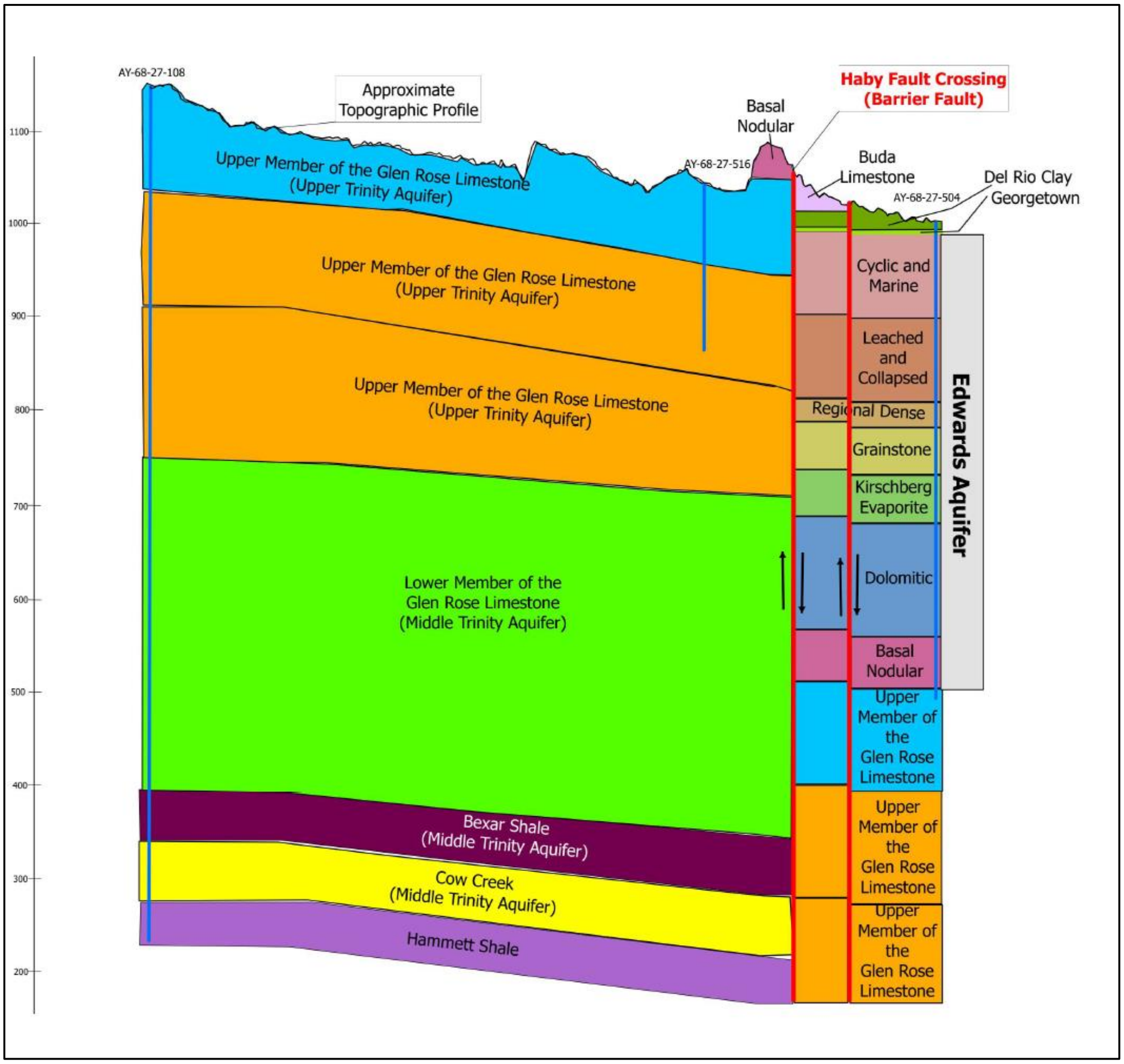
I would like to address the following passages from page 3 of the Puente letter.

> *The central question asked about the development, and that has been debated publicly, is how much of the water in Helotes Creek actually enters into the Edwards Aquifer Recharge Zone through the Haby Crossing Fault. There are a myriad of scientific investigations and reports that discuss this interaction. They range from the Haby Crossing Fault being a complete barrier, to the Fault allowing water to travel between the two aquifers, essentially the Trinity Aquifer and the Edwards Aquifer acting as one. SAWS staff looked at the subsurface geology through cross-sections to see how the Glen Rose formation interacts geologically with the Edwards Geologic Group.*
>
> *The Haby Crossing Fault is a major fault that has placed the two aquifers (the Trinity and the Edwards) side by side or juxtaposed. The cross-section shows that where the Cavernous meets the other side of the fault, it is side by side to the Buda Limestone, Del Rio Clay, and the Georgetown Formation. These are confining units and water will not travel through them. There is only a small portion of the upper Edwards adjacent to the Cavernous Unit. This portion of the Edwards Aquifer has very low porosity that would restrict the waters ability to travel through the rock matrix. If any water does travel through the rock matrix it would be through bedding planes or fractures and would be a minimal amount, if any.*

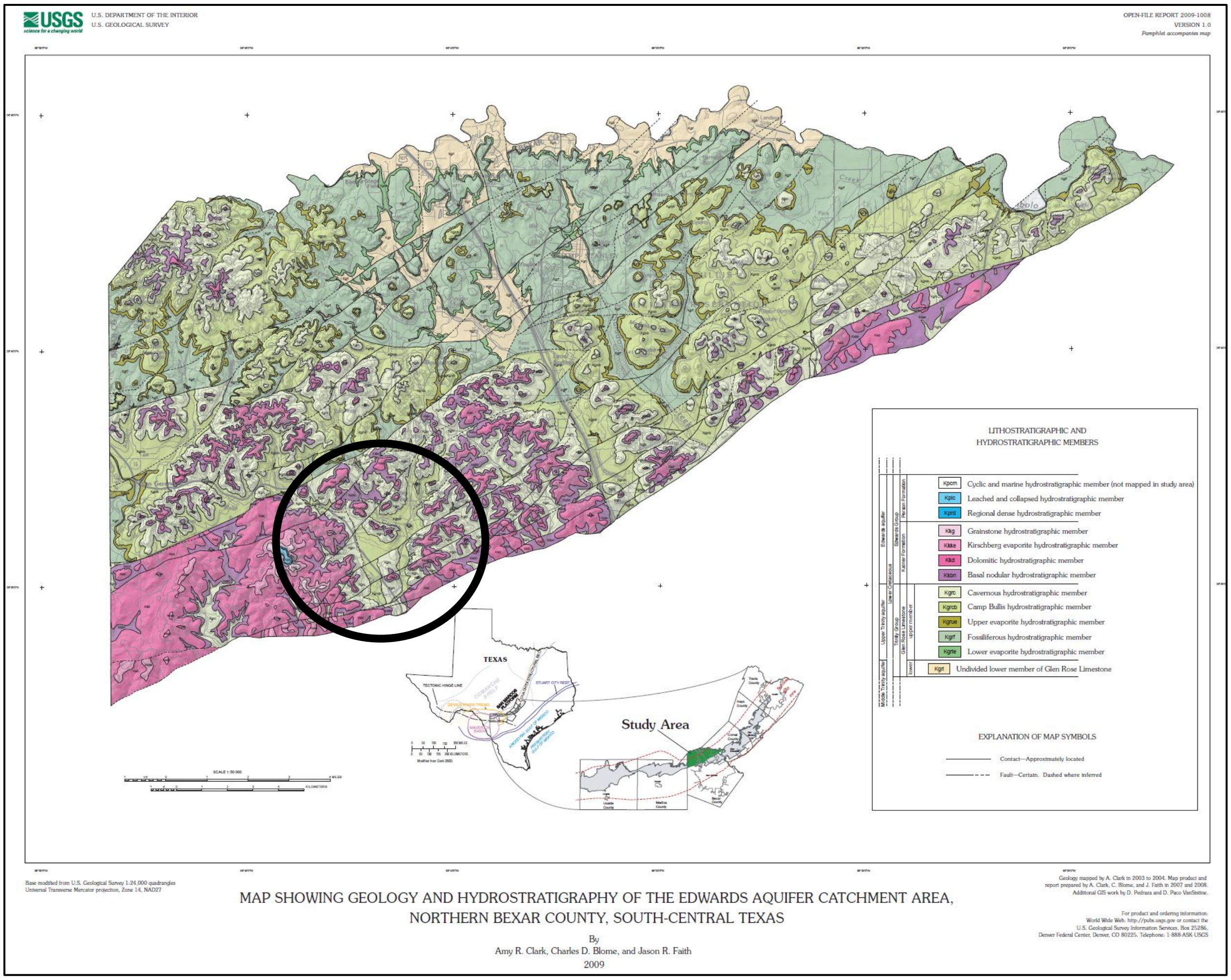
There are conceptualizations from this passage which merit comment.

Haby Crossing Fault

The conceptualization of the Haby Crossing Fault as described in and visually rendered in Attachment 1 of the Puente letter is not representative of the Haby Crossing Fault as understood by the technical community. Faults and fault blocks, in general and in the Trinity Aquifer in particular, are more complex than implied in the Puente letter. A fault, such as the Haby Crossing Fault, is not comprised of a single fault surface with the total offset exhibited on a single fault plane. Faults are more complex. Faults tend to be comprised of multiple planes of offset. As shown by the U.S. Geological Survey (Clark et al., 2009, 2016), there are a multitude of faults that comprise the total offset between the Trinity and Edwards proximal to the Haby Crossing Fault. This feature is readily apparent in Helotes Creek where bedrock is exposed.



Attachment 1 from the Puente letter



Clark et al. (2009) map

Note the multiple mapped faults in the Helotes Creek watershed denoted with the circle

The figure below (Ferrill et al., 2025) describe Balcones Fault Zone faulting at the Canyon Lake Gorge, located north of San Antonio. Although this study was not conducted in the Helotes watershed, the figure realistically conceptualizes how faulting occurs in the Balcones Fault Zone, which includes the Haby Crossing Fault in the Helotes Creek watershed.

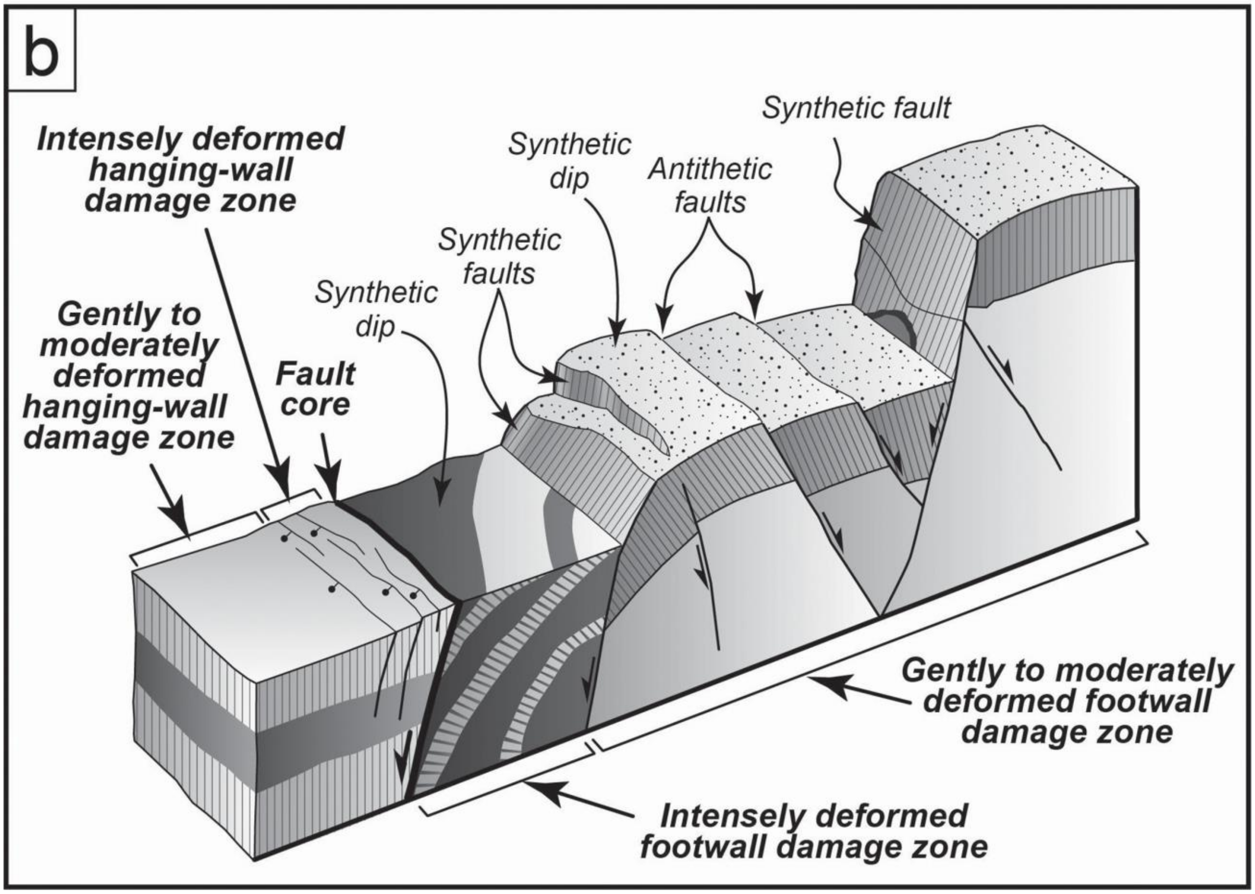
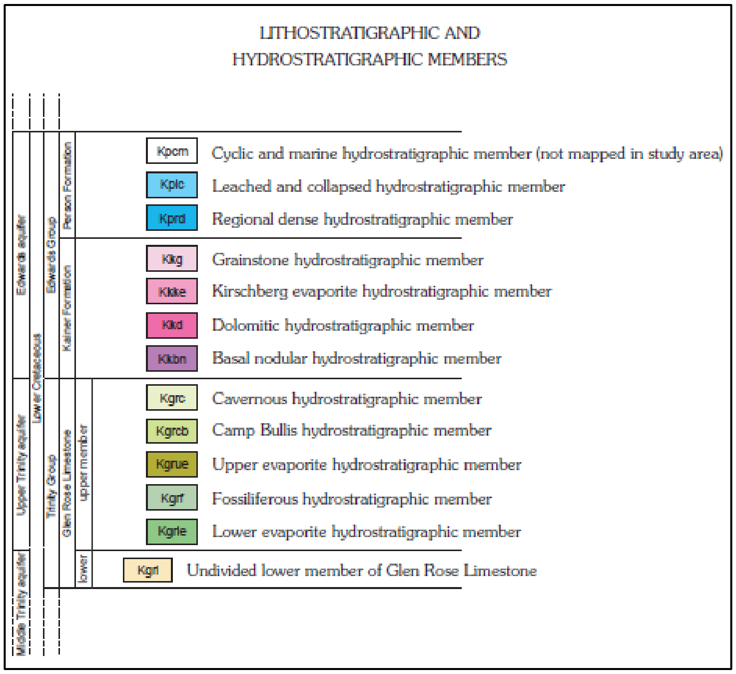


Figure 1(b) from Ferrill et al. (2025)

Please contrast the technical rendering by Ferrill et al. (2025) of how faulting more accurately occurs with the conceptualization of the Haby Crossing Fault included as Attachment 1 of the Puente letter. The Puente characterization of Haby Crossing Fault is overly simplistic and provides the misleading impression by lumping pervious and impervious units together that flow across the Haby Crossing Fault is sealed off by the juxtaposition of impervious layers on one side of the fault with impervious layers on the other side of the fault.

The upper Glen Rose is not a monolithic formation with uniform properties as implied in Attachment 1 of the Puente letter. In reality, the U.S. Geological Survey (Clark et al., 2009, 2016) demonstrates that the upper Glen Rose is comprised of alternating geologic units with variable degrees of pervious or impervious properties.



Legend extracted from the Clark et al. (2009) map

The EAA also characterizes faulting in the Balcones Fault Zone as multiple faults (Johnson et al., 2010), similar to that presented by Ferrill et al. (2025), and not the simplistic generalization presented by Puente as Attachment 1.

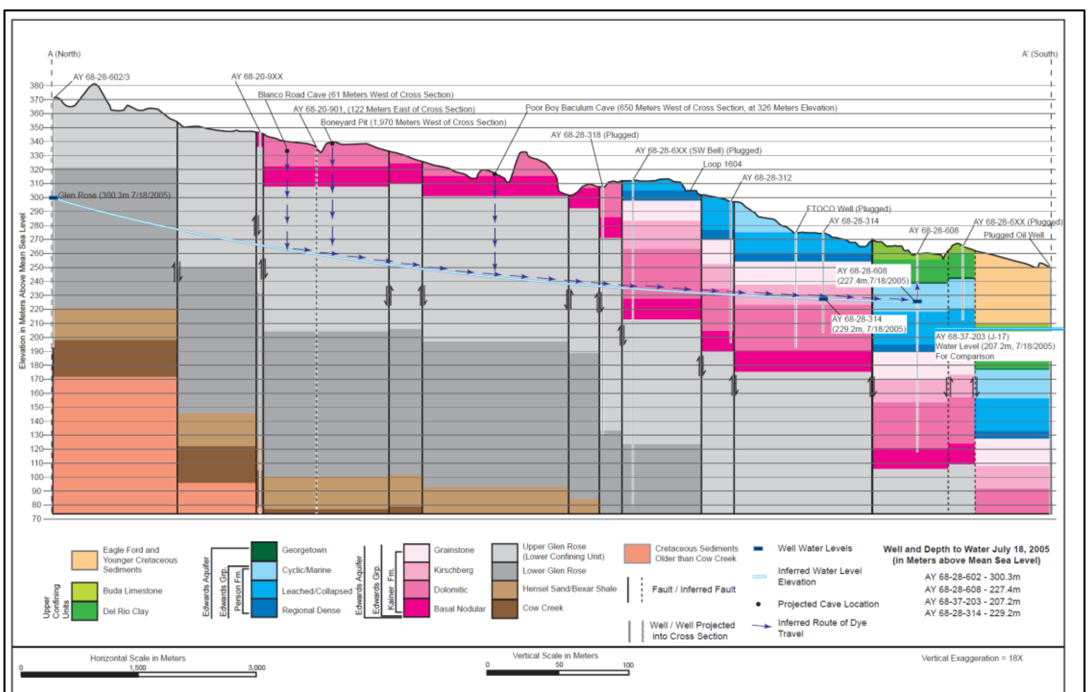


Figure 36. Schematic Cross Section of the Flowpath beneath Panther Springs Creek

Figure 36 from Johnson et al. (2010)

The Southwest Research Institute (SwRI) research team that conducted the comparison study of wastewater discharge facilities in the Helotes Creek watershed (Flores et al., 2020) envisioned the Haby Crossing Fault as characterized by the U.S. Geological Survey, the Edwards Aquifer Authority, and Ferrill et al. (2025), and not the simplistic rendering by SAWS as presented in the Puente letter.

The following excerpt from Flores et al. (2020) describes how the complexity of faulting of the Trinity and Edwards aquifers in and proximal to the Helotes Creek watershed as incorporated into the SwRI analysis (Flores et al., 2020).

> *Groundwater flow within the central portion of the study domain and upgradient (northwest) from Haby Crossing Fault is influenced by relay-ramp structures. Relay ramps are geological structures that form as tilted panels of rock that transfer displacement between two overlapping sub-parallel (en echelon) faults (Twiss and Moores, 1992). Relay ramps themselves may provide lateral continuity and unbroken fluid pathways with aquifers from aquifer recharge areas into the artesian zone and within the artesian zones (Collins and Hovorka, 1997; Ferrill and Morris, 2001; Hunt, et al., 2015). Within a relay ramp, subsidiary normal faults and extension fractures commonly form that are oblique to the bounding faults and can influence groundwater movement (Grimshaw and Woodruff Jr., 1986; Collins and Hovorka, 1997; Ferrill and Morris, 2001). Fault zones themselves can also produce conduits or barriers to groundwater flow in the Trinity and Edwards aquifers (e.g. Maclay, 1995; Ferrill, et al., 2008); Ferrill et al., 2019b). This conduit versus barrier behavior is strongly influenced by lithology and mechanical character of rock layers during deformation, and the related deformation mechanisms, as well as the amount of displacement on the fault (e.g. Ferrill and Morris, 2008; Ferrill and Morris, 2003; Ferrill et al., 2019b).*

[Please note that references included in this passage and in the following passages are included in the subject documents.]

To counter the claim that the Haby Crossing Fault acts as a barrier to flow, evidence of cross-formational flow from the Trinity Aquifer to the Edwards Aquifer is described by Toll et al. (2018) as follows:

> *Cross-formational flow between the Trinity and Edwards hydrostratigraphic units can also occur laterally, rather than vertically, where permeable blocks of these units are juxtaposed at the boundary of the Edwards (Balcones Fault Zone) region. Hunt and*

others (2007) noted that water levels were similar in the Edwards and Upper Trinity aquifers along the western edge of the Edwards Aquifer in Hays and Travis counties, indicating good hydraulic communication between the units. Dye tracing tests have also indicated lateral connections between the Upper Trinity and Edwards hydrostratigraphic units (Johnson and others, 2010). Previous groundwater models of the Trinity hydrostratigraphic units acknowledge this connection by implementing a discharge component from the Trinity hydrostratigraphic units in the HCT region into the Edwards hydrostratigraphic unit in the Edwards (Balcones Fault Zone) region. Kuniansky and Ardis (2004) simulated a flow of between 1,900 to 2,300 acre-feet per year per mile into the Edwards hydrostratigraphic zone along the fault zone, which they conceptualized as "equivalent to a low permeability seepage face with a slow drip of water per square foot of area." Previous TWDB GAMs in the study area (Mace and others, 2000; Jones and others, 2011) also included lateral flow into the Edwards hydrostratigraphic unit as a significant discharge component from the Trinity hydrostratigraphic units. However, Hunt and others (2015) found that flow can be laterally continuous within the Middle Trinity hydrostratigraphic unit across the boundary from the Hill Country portion of the Trinity Aquifer to the Barton Springs segment of the Edwards (Balcones Fault Zone) Aquifer. This indicates that lateral cross-formational flow from the Middle Trinity hydrostratigraphic unit into the Edwards hydrostratigraphic units is likely lower along that portion of the boundary than the area further west, in the San Antonio segment of the Edwards (Balcones Fault Zone) Aquifer.

Similarly, Flores et al. (2020) support the presence of cross-formational flow from the Trinity Aquifer to the Edwards Aquifer at the Helotes Creek watershed by the following:

2.3.3 Interformational flow of the Edwards and Trinity aquifers

Informal subdivisions of HSUs, faults, and structural controls on groundwater movement offer better constraint on potential interformational flow between the Edwards and Trinity aquifers in the study area. The informal HSUs delineated by Clark et al. (2016) highlight transmissive HSUs (i.e., upper Person and Kainer of the Edwards Aquifer; cavernous, evaporite, and Honey Creek of the Trinity Aquifer) that are susceptible to lateral communication of juxtaposed transmissive units.

The Haby Crossing Fault is conceptualized to be the primary structural feature that allows interformational flow between the Edwards and Trinity aquifers in the study area (Figure 2-5 and Figure 2-6). Throw of approximately 82 feet in the east and 492 feet in the west on the Haby Crossing Fault in the study area is sufficient to juxtapose *permeable Edwards aquifer HSUs in the hanging wall of the fault against permeable HSUs of the Trinity Aquifer on the footwall of the fault. Specifically, the fault juxtaposes the cavernous HSU of the Trinity Aquifer on the upthrown side of the fault with the water-bearing HSUs in the Person and Kainer formations of the Edwards Aquifer on the downthrown side of the fault (Figure 2-7 and Figure 2-8). Past work has shown that the Haby Crossing Fault and similar faults do not act as barriers to flow, but instead allow hydraulic communication and interaquifer groundwater flow paths across fault planes (Ferrill et al., 2005; Ferrill, et al., 2008; Johnson et al., 2010; Saribudak and Hawkins, 2019). Previous studies suggest 60-100% of faulted Trinity units are in contact with the water-bearing HSUs in the Person and Kainer formations of the Edwards Aquifer along the Haby Crossing Fault (Ferrill et al., 2005).*

The exact nature of the hydraulic relationship and interformational flow between the Edwards and Trinity aquifers at and downgradient from Haby Crossing Fault is therefore not well constrained. Uncertainty arises due to the fact that water that recharges the Cavernous unit north of Haby Crossing Fault may or may not pass through additional Trinity Aquifer units before arriving at the Edwards Aquifer. This flowpath is complicated by the karstic nature of both the Edwards and Trinity aquifers which introduces the potential for both diffuse- and conduit-flow mechanisms. The conceptualization embraced in this evaluation is that Haby Crossing Fault does not act as a barrier to flow and that virtually all water that discharges from the Helotes Creek watershed north of Haby Crossing Fault eventually recharges the Edwards Aquifer in close proximity to the study area. Hence, this conceptual uncertainty has minimal bearing on this evaluation due to the fact that all water discharged from the Helotes Creek watershed is assumed to eventually recharge the Edwards Aquifer.

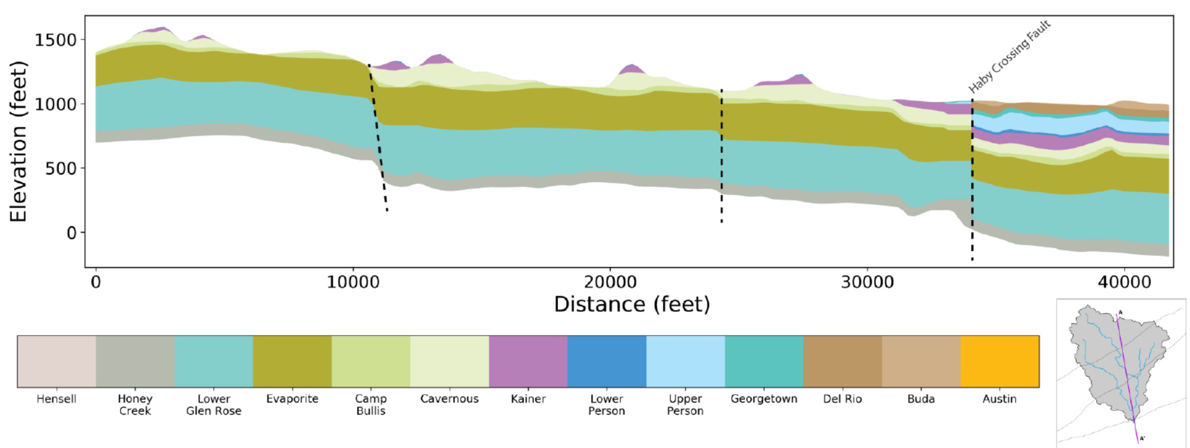


Figure 2-5 Cross section of HSUs within the Helotes Creek watershed. Vertical exaggeration = 5×.

Figure 2-5 from Flores et al. (2020)

Figure 2-7 from Flores et al. (2020) illustrates how the SwRI research team characterized groundwater flow from the Trinity Aquifer to the Edwards Aquifer in Helotes Creek watershed and incorporated it into its analyses. Note that the main structural offset in the middle of Figure 2-7 is the Haby Crossing Fault. As clearly shown in Figure 2 of Clark et al. (2009), the U.S. Geological Survey also characteries the Haby Crossing Fault as a conduit, not a barrier, to flow from the Trinity Aquifer to the Edwards Aquifer. This understanding that the Haby Crossing Fault is not a barrier to flow as conceptualized by Flores et al. (2020) is not recent.

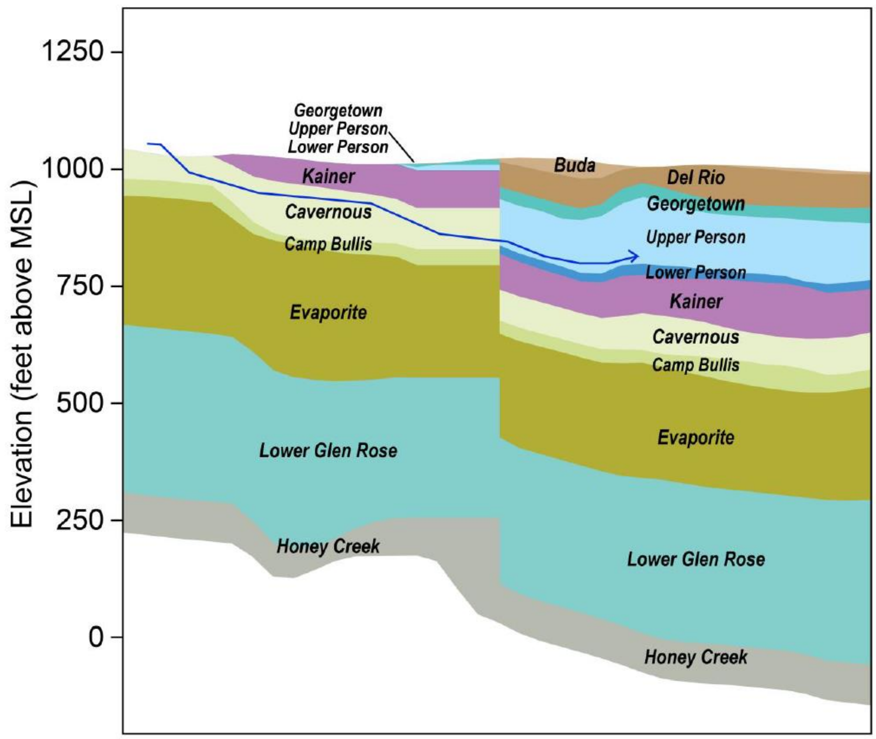


Figure 2-7 Juxtaposition of Edwards and Trinity hydrostratigraphic units along the Haby Crossing Fault from the cross section in Figure 2-5. Fault displacement is approximately 200 feet.

Figure 2-7 from Flores et al. (2020)

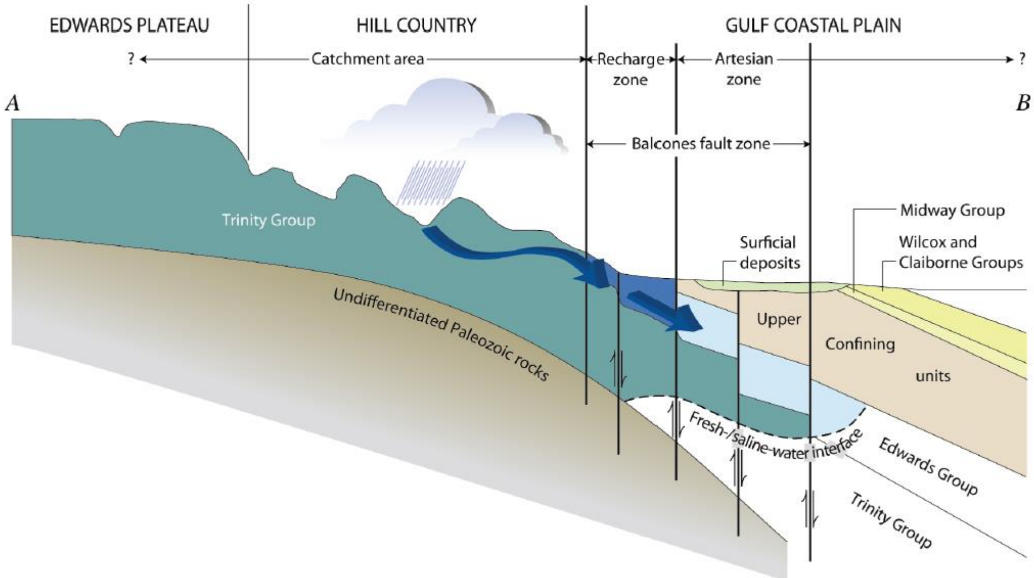


Figure 2. Conceptual cross section through the Trinity and Edwards aquifers (profile A-B shown in fig. 1).

Figure 2 from Clark et al. (2009)

Note also that the elevation of groundwater in the Trinity Aquifer updip of the Haby Crossing Fault is above the elevation of groundwater in the Edwards Aquifer downdip of the Haby Crossing Fault. The difference in groundwater elevation between the Trinity Aquifer updip from the Haby Crossing Fault relative to the lower groundwater elevation in the Edwards Aquifer downdip of the Haby Crossing Fault provides the driving mechanism for interformational flow from the Trinity Aquifer to the Edwards Aquifer in the Helotes Creek watershed, regardless of how circuitous the actual flow path. What is not explained in the Puente letter is that if groundwater is not going from the higher Trinity Aquifer to the lower Edwards Aquifer, where is it going? The conceptualization of groundwater flow in the Helotes Creek watershed as described in the Puente letter is internally inconsistent in that it fails to explain where groundwater from the Trinity Aquifer in the Hill Country Catchment area (also referred to as the Edwards Aquifer Contributing Zone) goes if it does not go to the Edwards Aquifer.

Tracer Tests

The most direct measure of groundwater flow through a karst system is via a tracer test. In such tests, dye is injected into the geologic system at a specific location. Multiple locations downgradient from the discharge point are monitored for breakout. The EAA conducted multiple tracer tests in Panther Spring Creek to ascertain the hydraulic relationship between the Trinity and Edwards aquifers (Johnson et al., 2010). Dye was introduced at six different injection points during multiple tests (See Figure 35 from Johnson et al., 2020 below). Tracer results are graphically presented in Figure 36 below (Johnson et al., 2010). Results were unambiguous and repeatable. The travel times of the dyes were approximately one mile per day. Dye that was injected at six different locations on the updip side of faults within the Balcones Fault Zone were detected on the downdip side of the Balcones Fault Zone.

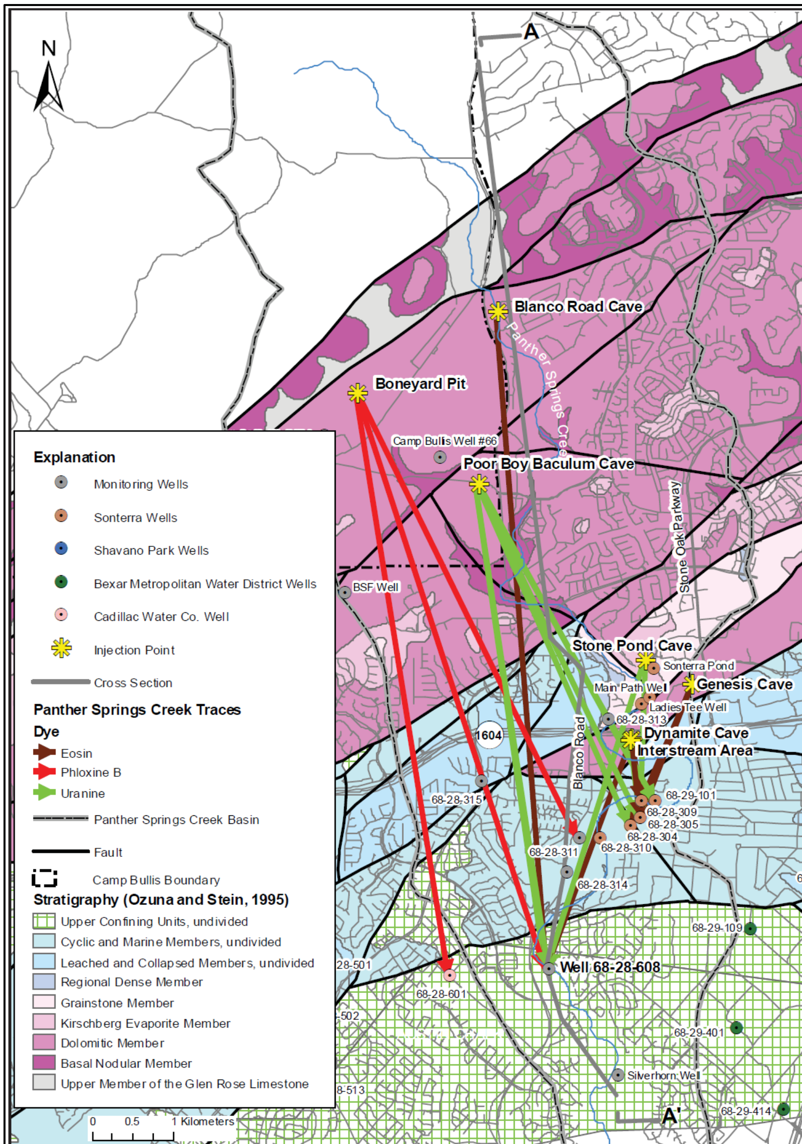


Figure 35. Geologic Map with Tracer-Test Results

Figure 35 from Johnson et al. (2010)

Although slightly removed from Bexar County, but still in the Balcones Fault Zone, the Barton Spring system near Austin has been well conceptualized over the past several decades using multiple tracer tests conducted by several different hydrologists and research teams (Zappitello et al., 2019). Again, offset along the Balcones Fault Zone has been shown to redirect groundwater flow but to not be a barrier to flow.

Rate of Groundwater Flow in the Balcones Fault Zone

The apparent velocity of the dye in the EAA tracer tests in northern Bexar County varied with a maximum velocity of 4,980 meters/day or over 3 miles/day (Johnson et al., 2010). Dye at the Canyon Lake tracer test travelled at approximately 987 meters/day (0.61 miles/day) perpendicular to the fault and 2,596 meters/day (1.61 miles/day) parallel to the Hidden Valley fault zone (Ferrill et al., 2025). Groundwater flow to Barton Springs was measured with velocities ranging from 1 to 7 miles/day (1.6 – 11.3 kilometers/day)(Zappitello et al., 2019). Groundwater velocities measured in the Balcones Fault Zone are consistent with tracer test results for karst aquifers worldwide [3,015 tracer tests with an average velocity of 1,940 m/day (1.2 mile/day) (Worthington and Ford, 2009)].

Attenuation of Pathogens

Mr. Puente stated: "*The distance from the Wastewater Treatment Facility to the Edwards Aquifer Recharge Zone, being 5.4 miles, also allows the effluent to potentially naturally attenuate before entering the Edwards Aquifer Recharge Zone*." Pathogens, namely bacteria and viruses, can persist in groundwater for weeks and months. Karst aquifers, such as the Trinity and Edwards aquifers, are particularly vulnerable to degradation due to pathogens due to rapid groundwater velocities and short travel times. The SAWS well located on Tippecanoe Street on the west side of San Antonio is approximately 14 miles from the proposed location of effluent discharge in Helotes Creek watershed. At a groundwater velocity of one mile per day, effluent discharged at Guajolote Ranch could reach the Edwards Aquifer Recharge Zone in less than a week and the Tippecanoe SAWS well in two weeks. This is insufficient time for pathogens to attenuate to sufficiently low concentrations to be benign.

It is noteworthy that pathogens have already been detected at the Tippecanoe well. In December 2021, E. coli bacteria were detected in the SAWS well on Tippecanoe Street. The well was removed from production to be disinfected and purged. To claim that SAWS's well fields are too distant to be impacted by pathogens released in Helotes Creek watershed is not correct.

Unfortunately, the extent to which SAWS wells already encounter pathogens and other contaminants is not readily known. I have not been successful in the identification of a summary of occurrences of pathogen detections at SAWS wells. In the absence of a compilation of pathogen detections at SAWS wells, it is not possible to ascertain to the degree to which recharge from the Edwards Aquifer Contributing and Recharge zones has already been degraded by ill-advised development.

The risk to water-quality safety of recharge to karst aquifers is well known in the technical community. Communities reliant of centralized water supplies from karst aquifers are at risk when the rapid rate of recharge to public supply wells is not adequately managed and protected. As documented in Green et al. (2006), Walkerton, a rural community in Ontario Canada, suffered multiple illnesses and deaths when a public supply well in a karst aquifer encountered pathogens from contaminated runoff. The first known case of a public supply well contaminated by cryptosporidium (a pathogen) occurred in 1948 in Braun Station, within a few miles of the proposed Guajolote development (Chalmers, 2012). These events highlight the risks posed by ill-advised development over the recharge areas of public supply wells located in karst terrains.

Impervious Geologic Layers in Helotes Creek Watershed

The Puente letter notes that Helotes Creek traverses the Camp Bullis and Cavernous Hydrostratigraphic Units (HSUs) (Clark et al., 2016). The Cavernous HSU is the topmost unit of the Trinity Aquifer. As noted by Clark et al. (2016) "*The high permeability of the overlying Edwards aquifer has introduced meteoric water into faults and fractures creating karstic groundwater flow paths that continue into the Trinity aquifer from the Edwards aquifer (Clark, 2004; Smith and others, 2005). Johnson and others (2010) have shown through dye tracing that the cavernous HSU of the upper zone of the Trinity aquifer is hydrologically indistinguishable from the Edwards aquifer.*" This HSU is also referred to as Interval A (Veni, 1987).

The Puente letter characterizes the Camp Bullis HSU as the following: "*Once water is discharged from the plant, the water would encounter two different zones of the upper Glen Rose Aquifer Formation in the creek bed. The first would be a geologic unit (Camp Bullis unit) resistant to water leaching downward into other formations*". This description implies that the Camp Bullis HSU acts as an impervious confining layer that prohibits all but negligible amounts of water to infiltrate.

A gain/loss study conducted in Helotes Creek (Green et al. 2011) however, determined that perennial baseflow in the creek infiltrates into the reach of Helotes Creek where the Camp Bullis HSU is present in the creekbed. This is likely due to faulting that compromises the ability of the Camp Bullis HSU to act as a confining unit. This is evidence that the Camp Bullis HSU is not a continuous impervious layer. During the gain/loss study it was observed that water continuously infiltrates through the Camp Bullis HSU along this reach. There is no baseflow in Helotes Creek from this point to downdip of the Haby Crossing Fault. As characterized in Figure 2.7 (Flores et al., 2020) and Figure 2 (Clark et al., 2009), baseflow in Helotes Creek has already infiltrated the subsurface and from that point downgradient, it flows as groundwater until it crosses the Haby Crossing Fault and enters the Edwards Aquifer.

Water Quality

Puente states in his letter that if the Trinity Aquifer and the Edwards Aquifer were acting as one unit with comingling waters, then the water chemistry on both sides of the fault should have more similarity or the water chemistry parameter values should be diluted to a midpoint. This assertion is included here for convenience.

> *If the Trinity Aquifer and the Edwards Aquifer were acting as one unit with comingling waters, then the water chemistry on both sides of the fault should have more similarity or the water chemistry parameter values should be diluted to a midpoint. SAWS staff looked at water quality data from USGS wells on both sides of the Fault. A comparison found that the two waters seemed to exhibit significantly differing water qualities. (See Attachment 2).*
>
> *The wells on either side of the Haby Crossing Fault, both in the Trinity Aquifer and the Edwards Aquifer, show stark differences in water chemistry parameters. As mentioned, if the water in the Helotes Creek were transmitting from the Trinity Aquifer into the Edwards Aquifer to any significant degree, the chemistry of the wells would show more signs of mixing than they do.*

Conceptualization of the chemistries of the Trinity Aquifer and Edwards Aquifer waters as stated above is predicated on sampling of two wells, one in the Trinity Aquifer and one in Edwards Aquifer. There have been hundreds, if not thousands, of water samples collected from the Trinity and Edwards aquifers in the San Antonio area and analyzed for chemistry. For example: Darling (2017), Fahlquist (2004), Maclay et al. (1995), Maclay and Small (1995), Musgrove et al. (2016, 2019), Opsahl et al. (2018a, 2018b, 2020), Smith and Hunt (2008), Tian et al. (2020, 2021), and Wong, et al. (2014). Given the wealth of water sampling, analysis, and investigations of the chemistries of the Trinity and Edwards aquifers, basing an argument of the hydraulic connectivity between the two aquifers on sampling of two wells is difficult to technically defend. As noted above, there is a wealth of water chemistry data available should SAWS elect to conduct a rigorous defensible examination of similarities and differences in the water chemistry of the Trinity and Edwards aquifers. SAWS should coordinate with the U.S. Geological Survey, Edwards Aquifer Authority, University of Texas-San Antonio, and Southwest Research

Institute, all of whom are active in the investigating the Trinity and Edwards aquifers, to ensure that its evaluation is defensible. The assertion that the Trinity Aquifer is separate from the Edwards Aquifer based on the water chemistry of two wells in the Puente letter is not technically defensible.

Mitigation

Mr. Puente claimed in his letter that SAWS negotiated nine controls into the agreement with the developer to mitigate the impact the development would have on the environment to make the project acceptable. The Guajolote tract is located in the Hill Country. The terrain is rolling with exposures of karst limestone bedrock at the ground surface. There is minimal soil cover. As is typical in the Hill Country, runoff is rapid with limited opportunity for infiltration, detention, or absorption/filtering of contaminants. Limiting impervious cover, assuring open space, and adding a modest layer of soil (i.e., less than a foot) will improve infiltration and slow runoff to some degree. These controls cannot sufficiently modify the dominant nature of the Hill Country environment to alter the conclusion in Flores et al. (2020) that the method of effluent discharge is not the major factor when comparing the type of wastewater facility. Even with the controls, the dominant factor will remain the total mass load of effluent released to the environment. This is because the limited soil, karst limestone, and rolling terrain of the Hill Country provide minimal retardation to water applied to the land surface, whether by precipitation or land application. These characteristics of the Hill Country in the Guajolote tract will remain dominant even with the nine controls imposed. As demonstrated by Flores et al. (2020), the time from when the effluent is released to the environment to the time that the effluent arrives at either private wells or public supply wells can be days to weeks. This impact will be realized irrespective of the type of wastewater facility including the nine mitigation controls negotiated by SAWS.

Mr. Donovan Burton, speaking on behalf of SAWS, claimed in his comments at the December 11, 2025, City of San Antonio Governance Committee meeting that the local geology in the Helotes Creek watershed mitigates risks to the environment by contamination from an effluent discharge facility. As stated herein, locating an effluent discharge facility over a karstic terrain in which groundwater velocities exceed a mile per day is the antithesis of the claim by Mr. Burton. There is clearly nothing in the geology of Helotes Creek watershed that would impede, to any degree, effluent released in the Helotes Creek watershed from entering the Edwards Aquifer in a matter of days to weeks.

Conclusions

The letter by Mr. Puente is absent of supporting technical documentation and citations. Assertions and opinions presented in the Puente letter are based on limited data and unsupported conceptualizations. During the preparation of two recent peer-reviewed texts on the Edwards Aquifer (Sharp et al., 2019 and Sharp and Green, 2022), I had the opportunity to review all available and relevant technical reports and peer-reviewed journal articles on the Edwards and Trinity aquifers, particularly in the San Antonio segment of the Edwards Aquifer. I encountered neither technical reports nor peer-reviewed journal articles by SAWS staff regarding the subjects that Mr. Puente opined in his letter. Nor am I aware of any technical reports or peer-reviewed journal articles by SAWS staff released since that time. It would be beneficial for a more in-depth review of the assertions by Mr. Puente if any subject documents he used in the preparation of his letter were made available.

To be clear, as a retiree of SwRI, I do not represent Southwest Research Institute. In this letter, I provide technical assessment of comments asserted in the Puente letter based on my understanding of the current science of the hydrogeology of the Helotes Creek watershed. I believe the characterization of the hydrology of Helotes Creek watershed that I provide is supported by the documents cited. Like any scientific evaluation, my conclusions may be changed, if and when, contradictory evidence or data become available. Neither are provided in the Puente letter. I welcome the opportunity to revisit my conclusions at the time SAWS makes such information available.

I am available for follow-up questions or comments as appropriate.

Sincerely,
Ronald T. Green, Ph.D., P.G.
210.316.9242
rgreen@contractor.swri.edu

References

Başağaoğlu , H., L. Gergen, and R.T. Green. 2015. Assessing the effects of the epikarst on groundwater recharge and regional fast -flow pathways in a karstic aquifer via impulse-response functions. *Journal of Hydrologic Engineering*. 20(11), 04015021.

Chalmers, R.M. 2012. Waterborne outbreaks of cryptosporidiosis. Ann Ist Super Sanita. 48(4):429-446. DOI: 10.4415/ANN_12_04_10.

Clark, A.R., Blome, C.D., and Faith, J.R, 2009, Map showing the geology and hydrostratigraphy of the Edwards aquifer catchment area, northern Bexar County, south-central Texas: U.S. Geological Survey Open-File Report 2009-1008, 24 p., 1 pl.

Clark, A.K., Golab, J.A., and Morris, R.R., 2016, Geologic framework and hydrostratigraphy of the Edwards and Trinity aquifers within northern Bexar and Comal Counties, Texas: U.S. Geological Survey Scientific Investigations Map 3366, 1 sheet, scale 1:24,000, pamphlet, https://doi.org/10.3133/sim3366.

Darling, B.K. (2017). Geochemical analysis of the distribution of recharge areas, range of groundwater ages, and evolution of hydrochemical signatures along flow paths in the Edwards and Trinity Aquifers of central Texas. (GSA Abstract; summarized in Tian et al. 2020.)

Edwards Aquifer Authority (2018) *Expanded Water Quality Monitoring Program: 2018 Annual Report.* Edwards Aquifer Authority, San Antonio, Texas. (Multi-year dataset of nutrients, major ions, metals, and organics from wells and springs in the San Antonio segment and associated EAHCP sites.)

Fahlquist, L. (2004). *Quality of Water in the Trinity and Edwards Aquifers, South-Central Texas, 1996–98.* U.S. Geological Survey Scientific Investigations Report 2004–5201, 20 p.

Ferrill, D.A., S.B. Johnson, R.N. McGinnis, F. P. Bertetti, G.R. Walter, K.J. Smart, and A.J. Cawood. 2025. Fault Zone Control on Rapid Groundwater Flow in Cretaceous Carbonates of the Hidden Valley Fault Zone, Texas. Lithosphere. Vol 2024, Number Special 15, Article ID Lithosphere_2024_178, 22p. https://doi.org/10.2113/2024/lithosphere_2024_178

Flores, M.E., R.T. Green, K. Nicholaides, P. Southard, R. Nunu, D. Ferrill, G. Walter, S. Stothoff, N. Martin, 2020. Comparative Evaluation of Wastewater Disposal Practices in the Contributing Zone of the Edwards Aquifer. Prepared by Southwest Research Institute for City of San Antonio, Parks and

Recreation Department, Edwards Aquifer Protection Program and San Antonio River Authority. 127 p.

Fratesi, S.E., R.T. Green, F.P. Bertetti, R.N. McGinnis, N. Toll, H. Başağaoğlu, L. Gergen, J. Winterle, Y. Cabeza, and J. Carrera. 2015. Development of a finite-element method groundwater flow model of the Edwards Aquifer: Final Report. Southwest Research Institute. Conducted for the Edwards Aquifer Authority. 180 p.

Green, R.T., J. Winterle, and S.E. Fratesi. 2019a. Numerical Groundwater Models., in Sharp, J.M., Jr., Green, R.T., and Schindel, G.M., eds., The Edwards Aquifer: The Past, Present, and Future of a Vital Water Resource: Geological Society of America Memoir 215, p. 19–28, https://doi.org/10.1130/2019.1215(08).

Green, R.T., F.P. Bertetti S.E. Fratesi, and G. Schindel. 2019b. San Antonio Pool of the Edwards Aquifer., in Sharp, J.M., Jr., Green, R.T., and Schindel, G.M., eds., The Edwards Aquifer: The Past, Present, and Future of a Vital Water Resource: Geological Society of America Memoir 215, p. 29–46, https://doi.org/10.1130/2019.1215(08).

Green, R., M. Flores, R. Nunu, K. Nicholaides, and P. Southard. 2019c. Water and Periphyton Sampling and Analysis in Helotes Creek watershed, Bexar County, Texas. 21p.

Green, R.T., F.P. Bertetti, and M.O. Candelario 2011. Field Assessment and Analytical Assessment of the Hydraulic Relationship between the Trinity and Edwards Aquifers. Proceedings of the Karst Conservation Initiative, Austin, Texas

Green, R.T., S. L. Painter, A. Sun, and S.R.H. Worthington. 2006. Groundwater Contamination in Karst Terrains. *Water, Air, and Soil Pollution: Focus*. DOI: 10.1007/s11267-005-9004-3. Vol 6. Nos. 1-2. pg 157-170.

Hunt, B.B., Smith, B.A., Kromann, J., Wierman, D.A., and Mikels, J.K., 2010, Compilation of pumping tests in Travis and Hays counties, central Texas. Barton Springs/Edwards Aquifer Conservation District Data Series Report 2010-0701. 86 p.

Hunt, B.B., B.A. Smith, A. Andrews, D.A. Wierman, A.S. Broun, and M.O. Gary, 2015, Relay ramp structures and their influence on groundwater flow in the Edwards and Trinity Aquifers, Hays and Travis Counties, Central Texas, Sinkhole Conference, October 5-10, 2015, Rochester, Minnesota

Hunt, B.B., Andrews, A.,G., and Smith, B.A., 2016, Hydraulic Conductivity Testing in the Edwards and Trinity Aquifers using multiport monitor well systems, Hays County, Central Texas, Barton Springs/Edwards Aquifer Conservation District Data Series Report 2016-0831. 43 p.

Maclay, R.W., Rettman, P.L., & Small, T.A. (1980) *Hydrochemical Data for the Edwards Aquifer in the San Antonio Area, Texas.* Texas Department of Water Resources, Limited Printing Report LP-131, 38 p.

Maclay, R.W., & Small, T.A. (1995) *Geology and Hydrology of the Edwards Aquifer in the San Antonio Area, Texas.* U.S. Geological Survey Water-Resources Investigations Report 95-4186, 97 p. (Includes major ions, TDS, and facies in a hydrogeologic framework.)

Musgrove, M., Solder, J.E., Opsahl, S.P., & Wilson, J.T. (2019). Timescales of water-quality change in a karst aquifer, south-central Texas. *Journal of Hydrology X,* 4, 100041. (High-frequency chemistry + age tracers in the Edwards.)

Musgrove, M., Opsahl, S.P., Mahler, B.J., Herrington, C., Sample, T.L., & Banta, J.R. (2016). Source, variability, and transformation of nitrate in a regional karst aquifer: Edwards aquifer, central Texas. *Science of the Total Environment,* 568, 457–469.

Opsahl, S.P., Musgrove, M., & Mahler, B.J. (2018). *Water-Quality Observations of the San Antonio Segment of the Edwards Aquifer, Texas, With an Emphasis on Processes Influencing Nutrient and Pesticide Geochemistry and Factors Affecting Aquifer Vulnerability, 2010–16.* U.S. Geological Survey Scientific Investigations Report 2018–5060, 79 p.

Opsahl, S.P., Musgrove, M., Mahler, B.J., & Lambert, R.B. (2018) *Water-Quality Observations of the San Antonio Segment of the Edwards Aquifer, Texas, With an Emphasis on Processes Influencing Nutrient and Pesticide Geochemistry and Factors Affecting Aquifer Vulnerability, 2010–16.* U.S. Geological Survey Scientific Investigations Report 2018-5060, 67 p.

Opsahl, S.P., Musgrove, M., & Mecum, K.E. (2020) *Temporal and Spatial Variability of Water Quality in the San Antonio Segment of the Edwards Aquifer Recharge Zone, Texas, With an Emphasis on Periods of Groundwater Recharge, September 2017–July 2019.* U.S. Geological Survey Scientific Investigations Report 2020-5033, 37 p.

Sharp, J.M., Jr., and Green, R.T. 2022. The Edwards Aquifer. The Groundwater Project. ISBN: 978-1-77470-029-7. https://doi.org/10.21083/978-1-77470-029-7.

Sharp, J.M., Jr., Green, R.T., and Schindel, G.M. 2019a. The Edwards Aquifer: The Past, Present, and Future of a Vital Water Resource: Geological Society of America Memoir 215, 312 p, https://doi.org/10.1130/2019.1215(08).

Sharp Jr., J.M., R.T. Green, and G.M. Schindel. 2019b. Introduction., in Sharp, J.M., Jr., Green, R.T., and Schindel, G.M., eds., The Edwards Aquifer: The Past, Present, and Future of a Vital Water Resource: Geological Society of America Memoir 215, p. 1–8, https://doi.org/10.1130/2019.1215(08).

Stepchinski, L.M., R.T. Green, F. P. Bertetti, R.M. McGinnis, N. J. Toll, R.R. Nunu, N.E. Deeds, D. Lupton, B. Fratesi, K.D. H. Gulliver, M.E. Flores, J. Harding, M.O. Gary, S. Johnson, B.B. Hunt, and B. Smith. 2017. Final Report for the Study of Brackish Aquifers in Texas – Project No. 4 – Trinity Aquifer. Prepared for Texas Water Development Board. 308p.

Tian, L., Smith, B.A., Doster, J.D., & Gao, Y. (2021). Isotopic tracers of sources of water for springs from the Edwards Aquifer. *Hydrology Research,* 52(3), 787–807. ($\delta^{18}O$, δD, ^{3}H, ^{14}C, $^{87}Sr/^{86}Sr$ – geochemical fingerprints of spring discharge.)

Tian, L., Smith, B.A., Hunt, B.B., Doster, J.D., & Gao, Y. (2020). Geochemical evaluation of hydrogeologic interaction between the Edwards and Trinity Aquifers based on multiport well assessment in central Texas. In: *NCKRI Symposium 8, 16th Sinkhole Conference,* p. 270–279. (Major ions, TDS, nitrates, isotopes across stacked Edwards/Trinity intervals.)

Toll, N.J., R.T. Green, R.N. McGinnis, L.M. Stepchinski, R.R. Nunu, G.R. Walter, J. Harding, N.E. Deeds, M.E. Flores, and K.D.H. Gulliver. 2019. Conceptual Model Report for the Hill Country Trinity Aquifer Groundwater Availability Model. Contract Report for the Texas Water Development Board. 282 p.

Smith, B.A., & Hunt, B.B. (2008). Multilevel monitoring and characterization of the Edwards and Trinity aquifers of central Texas. *Gulf Coast Association of Geological Societies Transactions,* 58, 833–840. (Includes water-chemistry stratification between units.)

Veni, George, 1994, Geomorphology, hydrology, geochemistry, and evolution of the karstic Lower Glen Rose aquifer, south-central Texas: Pennsylvania State University, Ph.D. dissertation, 712 p.

Wong, C.I., Kromann, J.S., Hunt, B.B., Smith, B.A., & Banner, J.L. (2014). Investigating groundwater flow between Edwards and Trinity aquifers in central Texas. *Groundwater,* 52(4), 624–639. (Major ions + Sr isotopes from multiport wells in both aquifers.)

Worthington, S R H, and Ford, D C. 2009. Self-organised permeability in carbonate aquifers. *Groundwater*, Vol. 47(3), 326–336. DOI: https://doi.org/10.1111/j.1745-6584.2009.00551.x

Zappitello, S.J., D.A. Johns, and B.B. Hunt. 2019. Summary of Groundwater Tracing in the Barton Springs Edwards Aquifer from 1996 to 2017. City of Austin, Texas. DR-19-04.

Appendix A

Qualifications of Ronald T. Green, Ph.D., P.G. as an expert on the Edwards Aquifer

Comments by Dr. Green are his alone and do not represent any group or entity.

Dr. Ronald T. Green retired in 2020 after 30 years at Southwest Research Institute. At the time of his retirement, he was an Institute Scientist and served on the SwRI Advisory Committee on Research. He currently works as an independent contractor. Dr. Green co-authored and co-edited two recent books on the Edwards Aquifer (Sharp et al., 2019a; Sharp and Green, 2022). Included are three articles on the hydrogeology of the Edwards and Trinity aquifers (Sharp et al., 2019b; Green et al., 2019a,b). Dr. Green was the senior technical investigator of "Comparative Evaluation of Wastewater Disposal Practices in the Contributing Zone of the Edwards Aquifer" that was conducted by Southwest Research Institute for the City of San Antonio, Parks and Recreation Department, Edwards Aquifer Protection Program (Flores et al., 2020).

Dr. Green personally performed geologic and hydrologic field surveys and assessments of the Helotes Creek watershed including a gain/loss study (Green et al., 2011) and water-quality analysis investigations (Green et al., 2019c). Although many of these studies are referenced "Aquifer Edwards", due to the close hydraulic interaction between the Edwards Aquifer and the Trinity Aquifer, the Trinity Aquifer is intrinsically included in these investigations. Please note that the hydraulic relationship between the Edwards Aquifer and the Trinity Aquifer is specifically focused on in Fratesi et al. (2015), Başağaoğlu et al. (2015), Toll et al. (2017), and Stepchinski et al. (2019), all of which Dr. Green was the senior member of the research teams at Southwest Research Institute. Dr. Green resides in Helotes, Texas and is a licensed geoscientist in Texas.