TO: **Siskiyou County Government, Yreka;**
Analytical Environmental Services, Sacramento, consultants

FROM: **Dr. Daniel Axelrod**, 2536 Muledeer Dr, Weed. CA 96094
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RE: **Crystal Geyser draft EIR comments, interested party**

DATE: **February 27, 2017**

About the comments author. I am a professional physicist (Ph.D in Physics from UC Berkeley 1974, Postdoctoral Fellow for three years at the Cornell University School of Applied and Engineering Physics, and for 28 years University of Michigan Physics Professor and currently Physics Emeritus Professor), currently a co-Principal Investigator in federally-sponsored research at U. Michigan, and a fulltime Mt. Shasta area community member for 13+ years. Although I am not a professional hydrologist, I do have: (a) many years of research involving diffusive and hydrodynamic flows and depletion zones in chemical systems; (b) expertise in fluorescence and fluorescence tracer applications (including international awards for excellence in fluorescence theory and experiment); and (c) extensive research and teaching experience in what constitutes a valid scientific study (author/coauthor on ~ 130 peer-reviewed publications, 20 book chapters and reviews, and frequent peer-reviewer for technical journals). I have also studied and previously commented in detail upon the report issued by CG's consultant Geosyntec issued in 2014 and coauthored the 2014 "Mt. Shasta Area Water Supply Vulnerability Study" reported to the Mt. Shasta City Council in 2014.

General summary of comments. These comments on the DEIR concern the general area of hydrology (section 4.8). **In general, section 4.8 is completely inadequate in scientifically addressing the key issues for the community: will CG pumping adversely affect the availability and water quality at neighboring residential wells, and present and projected city wells in the area, in both the short and long term?** Virtually no experimental data is presented in this regard and the theoretical analysis that substitutes for actual testing is not appropriate for volcanic regions.

Organization of specific comments. The following sections of these comments present the specific criticisms:

A. **Overview**
B. **Section 4.8 inaccurately summarizes Appendix P .**
C. **Geological complexity.**
D. **SECOR hydrological study 1998a.**
E. **SECOR tracer study 1998b.**
F. **Studies after SECOR add very little new information.**
G. **The alluvial ("upper") layer.**
H. **Are the "upper" and "lower" aquifers connected?**
I. **Inappropriate use of oversimplified theory**
J. **Recharge of "upper system" and "lower system".**

K. Big Springs and DEX-6 water levels and precipitation.
L. Groundwater static water levels and hydrographs.
M. Groundwater flow: rates, directions, and structure.
N. Effect on Groundwater supply
O. Sustainability
P. Mitigation measures ignored.
Q. CG usage and questions of trust.
R. Water composition.
S. Age of water.
T. Concerning the experiment results on age of water
U. Precipitation in the Mt. Shasta area.
V. Unaddressed NOP comments.
W. EIR process as implemented here.
X. Conclusions
Y. References

The comments deal with the main section 4.8. They also deal with its Appendix P upon which section 4.8 is almost entirely based, and also with the SECOR 1998 studies, upon which the bulk of Appendix P is based. Section 4.8, Appendix P, and SECOR are thereby inextricably linked and must be viewed together, organized according to topic rather than paragraph-by-paragraph in each document. In addition, these comments refer to two unpublished supplements included here (at the end) from hydrology experts whose comments have direct bearing on the issues raised.

Because of the great detail and length of this comment letter, I include an **"Executive Summary"** starting on the next page, immediately followed by list of **"Suggested Mitigations"**. That will be followed by the in-depth review of the DEIR, complete with specific quotations and references to the DEIR and outside experts.

Executive Summary

A. Overview. This draft EIR is completely inadequate in scientifically addressing the key issues for the community: will CG pumping adversely affect the availability and water quality at neighboring residential wells, and present and projected city wells in the area, in both the short and long term? Virtually no experimental data is presented in this regard and the theoretical analysis that substitutes for actual testing is not appropriate for volcanic regions.

B. Section 4.8 inaccurately summarizes Appendix P . Section 4.8 does not correctly summarize Appendix P, upon which is completely based.

C. Geological complexity. The geological structures in the relevant region around the project zone have **not** been established, the connections to Big Springs or neighborhood aquifers never proven, and the flow directions not well known. The DEIR performs no new geological studies of the area and incorrectly assumes these structures are known.

D. SECOR hydrological study 1998a. A key reference for DEIR hydrology, SECOR 1998a, was not designed to check on the effect of industrial pumping on neighboring residential wells. As a result, the DEIR also omits any concern about residential wells. An EIR citing an actual field study with data on this key question is needed before the project is approved.

E. SECOR tracer study 1998b. The procedures, professionalism, and even legality of SECOR 1998b are questionable.

F. Studies after SECOR add very little new information. After SECOR in 1998, no tests were even attempted to evaluate the impact of industrial pumping on neighboring residential wells. Other than the limited new well testing, previous studies were "reviewed", meaning that we are back to almost exclusive reliance on the inadequate SECOR studies of 1998. So the CG contention that many studies were done is false, and the DEIR should explicitly point out the paucity of studies and data with regard to impact on residential wells at city wells in the area. The DEIR should address this question: what will be done if adverse effects are seen on neighboring wells? Mitigations are needed here, suggested in the next section of this letter.

G. The alluvial ("upper") layer. The alluvial layer was never mapped on a small scale. This is a severe shortcoming in the data because the neighboring residential wells are drilled into that layer so it is essential to understand the contiguity or lack thereof.

H. Are the "upper" and "lower" aquifers connected? Publicly available data shows that a shallow CG well near the residential wells suffered a large drop during Dannon pumping. It is not mentioned by the DEIR, a serious shortcoming. The DEIR seems to rely only on data and references provided to it by Crystal Geyser and its consultants.

I. Inappropriate use of oversimplified theory In place of actual field measurements and data, DEIR section 4.8 relies on oversimplified and inappropriate theories and computer programs.

J. Recharge of "upper system" and "lower system". The DEIR must be more explicit about how and why the recharge area is set as it is.

K. Big Springs and DEX-6 water levels and precipitation. Data shows that the DEX-6 level is sensitive to precipitation events; this is ignored by the DEIR. Upside-down presentation of graph needs to be checked and corrected, not just copied from Geosyntec..

L. Groundwater static water levels and hydrographs. The DEIR is essentially saying that it is skipping any serious study of alluvial wells! This is a severe shortcoming in the DEIR, because the alluvial wells are at the depth and material of the residential wells.

M. Groundwater flow: rates, directions, and structure. Actual geological layers are more complex than are modeled by the overly-simple programs cited as meaningful in the DEIR, a clear conflict between reality and models.

N. Effect on Groundwater supply. A serious EIR designed to assay impacts on residential wells would have done (or propose to do) experiments that check the impact on residential wells. The present DEIR does not touch this subject, a major deficiency. The DEIR does not even address the possibility of city expansion and water use in the CG area as identified in several existing city documents.

O. Sustainability An important aspect of the environmental impact - sustainability - is admittedly possible to study, but it was just skipped over for lack of time and/or money.

P. Mitigation measures ignored. Very clear mitigations suggested by hydrologists are required, feasible and ignored by the DEIR. This includes monitoring of CG wells, neighborhood wells, and caps or shutdowns imposed if there are problems.

Q. CG usage and questions of trust. The DEIR says that CG promises to install monitoring equipment. But who gets the reports? Who has authority to release them to the public? Is there going to be continuous monitoring of residential wells? At whose expense? What are the standards to determine if impacts observed in residential wells are worthy of concern? Who declares that CG pumping might be the cause? Who imposes appropriate responses, such as temporary shut-downs or caps? A serious EIR would attempt to answer these questions (and others) and would appear under the category of "mitigations". This EIR does not even ask the questions, and denies that mitigations are necessary.

R. Water composition. Contradictions in inferences from the water composition analysis are left unexplained.

S. Age of water. Concerning the experiment results on age of water, the DEIR gives no note as to their inconsistencies, widely varying ranges, and questionable relevancy to whether industrial pumping affects on neighboring wells and groundwater levels.

T. Precipitation in the Mt. Shasta area. The table and interpretation here is not clear.

V. Unaddressed NOP comments. Numerous comments I made in my Notice of Preparation comments, submitted on time by email dated 7-23-16, were not even addressed by the DEIR. This is a serious omission.

W. EIR process as implemented here. There needs to be an investigation as to whether the years-longdelay in commissioning a DEIR was intentionally set to let the project proceed in the hopes it would eventual be considered a *fait accompli.* In addition, the very late unveiling of the previous secret SECOR document, upon which most of Section 4.8 ultimately depends, is a violation of the required 45-day comment period.

X. Conclusions. DEIR section 4.8 is woefully inadequate in informing the community about possible environmental impacts upon residential water sources and upon future city plans for further use of groundwater in that region. The whole DEIR project was unnecessarily delayed for years, then grossly underfunded and overly rushed when it was finally commissioned.

Suggested Mitigations
related to input hydrology

1. Water usage by CG on both the productions well and the domestic well be continuously monitored, on a mandatory basis, overseen by independent experts, and the results made publicly available. The costs of monitoring will be borne entirely by CG.

2. Groundwater levels in the CG production well, domestic well, and monitoring wells, be continuously monitored, on a mandatory basis, overseen by independent experts, and the results made publicly available. The list of wells to be monitored specifically includes DEX-6, DEX-3a, DEX-1, MW1, MW-2, MW-3, and any subsequent wells CG puts into production or the RWQCB requests for further monitoring of the leach field area. The costs of monitoring will be borne entirely by CG.

3. Private residential wells in a one-half mile radius of the plant be continuously monitored for both groundwater level and for quality, at the option of the owners, with the monitoring costs borne by CG.

3. Maximum production rates (caps) should be set before production start-up, to ensure (as determined by independent experts) the likely protection of neighboring wells. The caps would be mandatory.

4. In the event that problems are detected in CG wells and/or the private residential wells that, in the opinion of independent experts, are likely due to CG operations, then the mandatory cap levels must be lowered, perhaps to zero (a production shutdown) if deemed necessary by independent experts. All costs of stricter caps and shutdowns will be borne entirely by CG.

5. A Financial Assurance fund be set up before the start of production, that will provide neighboring residences and/or the City with full compensation for the cost of repairing or deepening wells, with costs borne entirely by CG. The fund must be available even if CG sells the property to a successor, or changes name, or goes bankrupt, or abandons the plant.

6. Future public water sources for the city located in the CG hydrological area must be protected. If CG operations decrement the availability and water quality of such future City-owned services (as deemed by the City), adjudication must give the City top priority. If the City chooses to develop a well in the same groundwater flow as CGH's production well, but possibility upstream from it to protect future City well quality and quantity, CG must, as mitigation now, agree to foreswear any priority claims to that groundwater source.

Detailed comments

Within each lettered topic above, each comment on a statement in the DEIR or Appendix P or SECOR or the supplements is identified with the relevant abbreviation as follows:

4.8-xx: The main section 4.8 , page xx

AppP-xx: Appendix P page xx. This Appendix was written by the RCS consulting firm.

SECOR 1998a or b-xx: The very recently released SECOR 1998a hydrology study and the SECOR 1998b tracer study provide much of the source material presented by RCS (Appendix P).

Supp1-xx: Letter dated March 19, 2014 and presented to the Mt. Shasta City Council on March 24, 2014 from Lee Davisson. He is a state-certified hydrologist (California Professional Geologist GEO8697). His comments were written solely from his position as President, ML Davisson and Associates, Inc. Apart from these comments, he is also on the Research Staff, Lawrence Livermore National Laboratory. Lee Davisson has an MS in Geology, Geochemistry, Isotope Geochemistry from UC Davis. He is a specialist in Mt. Shasta hydrology with expertise investigating water resource development, management, water quality, and analysis. **Supp1** in full is appended to the end of this document.

Supp2-xx: Detailed recent report on Spring Hill hydrology, "Geology and Hydrology of a Dacitic Satellite Cone in the Southern Cascades: Spring Hill, Mount Shasta" by Allison Austin. She is currently at UC Santa Barbara in the Ph.D. program in volcano geophysics. Allison Austin received her B.S. in Geology from Guilford College in 2002, and her M.S. in Geology from Northern Arizona University in 2007, specializing in the eruptive dynamics of silicic magma through shallow aquifer systems. She expanded on this work during a year-long Fulbright grant to further study the phreatomagmatic fragmentation mechanisms of rhyolite. This research resulted in two publications in peer-reviewed journals. She has spent 15 years working professionally as a scientist and researcher for a variety of projects, including as an environmental consultant for Superfund clean-up initiatives. Her area of expertise is directly related to the geology of the Spring Hill area. **Supp2** benefits from a more complete set of groundwater elevation measurements and air-based LIDAR measurements, data which is publicly available but the DEIR has partly ignored. Supp2 in full is appended to the end of this document.

Supp3: This is a graph of groundwater levels vs time in CG well DEX-3a, not reported in the DEIR but highly relevant. The data is publicly available from the Regional Water Quality Control Board, Central Valley. **Supp3** is shown at the appropriate point in Section H below.

Supp4: This is a map from the CA Dept. of Fish and Game showing local watershed areas, available at https://map.dfg.ca.gov/bios/?al=Hydrography:10 . **Supp4** is shown at the appropriate point in Section J below.

There is redundancy in these comments because of the redundancies of the DEIR and its sources; each and every appearance of the same shortcoming in the DEIR or its sources receives a response.

Direct extended quotes from the EIR or its sources or the supplements are always in *italics.*

A. Overview

4.8-48 What was **not** done, but should have been done, is nicely outlined in the concluding "disclaimer" of Appendix P (written by the company RCS) itself:

"No other work such as the drilling, testing or sampling of existing wells at these sites was performed by RCS, nor was any field mapping or investigations performed to help determine the characteristics of the aquifer systems beneath the site. Rather, this report has relied heavily on work performed by others on characterizing the aquifer systems, and on our evaluations of existing data and information."

AppP-1 The Introduction/Background says:

"Based on the County of Siskiyou Notice of Preparation (NOP) of an Environmental Impact Report (EIR), Crystal Geyser (CG) acquired an existing water bottling plant in 2013..."

There are two errors here. First, CG did not acquire the property based on a NOP. They acquired the property three years before the NOP for this EIR. This error is probably just a grammatical/wording problem. Second, the property they acquired was not a water bottling plant. It was an empty building, devoid of equipment, used as a warehouse, and not in operation since late 2010.

B. Section 4.8 inaccurately summarizes Appendix P

4.8-1: Section 4.8 is based almost entirely on Appendix P. However, Section 4.8 does not even correctly summarize Appendix P. For example, 4.8 says:

" In the region of the project site, the shallow alluvium is referred to as the "Upper Aquifer System" while the underlying volcanic rocks are known as the "Lower Aquifer System", which is hydraulically connected to the aquifer from which Big Springs flows. Groundwater under the project site flows to the south, along Spring Hill and to the west, bending to the west-southwest, west of and south of Spring Hill."

The "upper" vs "lower" structure, the connections at Big Springs, and the directions of flow are stated as an established scientific fact in 4.8-1. However, Appendix P handles it differently as follows.

AppP-5: *"In the region of the proposed bottling facility, the alluvium is reportedly referred to as the "Upper Aquifer System" by Cal-Trout, local drilling companies and residents (Mr. Jeff Zukin, September 9, 2016, personal communication). However, this system has not been designated as such in the available scientific reports and/or literature."*

4.8-6: Here is another example of Appendix P inaccurately summarized in section 4.8:

"The recharge area for these springs includes the fractured andesite that is the source of water for the project site wells".

This is stated by 4.8 as an established fact. However, Appendix P never directly demonstrates that the fractured andesite that carries Big Springs water is hydraulically connected to DEX-6, the production source for CG

C. Geological complexity

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The fact is that the geological structures in the relevant region around the project zone has **not** been established, the connections to Big Springs or neighborhood aquifers never proven, and the flow directions not well known. On this very issue, certified hydrologist Lee Davisson of UC Lawrence Livermore Lab, who specializes in Mt. Shasta hydrology, has stated in a letter presented to the Mt. Shasta City Council: (as excerpted from Suppl doc 1):

Supp1-1: *"...I think it is important to point out that groundwater in and around the city of Mt. Shasta is anything but simple. This stems from the fact that groundwater and its emergence as spring discharge is controlled by potentially complex and **largely unmapped** subsurface conduits created by the volcanic deposits in which they flow...*

Unfortunately, the complexity of the local groundwater in Mt. Shasta only adds to the uncertainty and level of concern for negative impacts..."

Too little is understood (and likely documented) to estimate impacts at the spatial and volumetric scales of groundwater production planned by the bottling plant."

Supp2-7: The more recent report from volcanic geologist Allison Austin seconds this view of complexity, with somewhat more detail based on a more complete set of groundwater elevation data and interpolated groundwater elevation contours, LIDAR images, and a close knowledge of the Mt. Shasta area:

"Mount Shasta's long-lived and compositionally diverse eruptive history makes for a highly complicated subterranean geology, which creates challenges in accurately assessing the volume and movement of stored groundwater. Sourced from glacial / snow melt and precipitation on the flanks of Mount Shasta, percolated groundwater flows through an unknown network of faults and blocky rubble, basaltic lava tubes, fractured andesite, and tuff units, as well as through fractured bedrock and sedimentary deposits – all with different degrees of permeability. The path groundwater takes before emerging at a place like Big Springs, whose output volume far exceeds

other springs on the southwestern slopes of Mount Shasta (California Trout, 2014), is very difficult to determine. "

Supp2-12: Austin sees evidence for a fault zone on the east side of Spring Hill, a very specific kind of complexity that would affect flow directions:

"The dynamics of groundwater from multiple channels intersecting within a fault zone at the edge of a silicic intrusion present a complicated hydraulic situation with many unknowns. Groundwater dynamics along the eastern side of Spring Hill appear to be particularly complex because the degree of permeability underneath and along the edges of Spring Hill remain unclear and it is not known how much water filters through Spring Hill versus deflecting around it. The outcrop of Rocky Point can be connected to a larger lava-flow-like feature with an apparent planar orientation on the northeast side of the dome (Figure 7B), where steep groundwater contours suggest this potentially fault-controlled geometry (SECOR, 1998) locally deflects groundwater flow along a plane that extends to the southeast."

D. SECOR hydrological study 1998a

This DEIR performs no new geological studies of the area. Instead, it relies almost exclusively on SECOR 1998a and 1998b. SECOR is not merely a cited reference. It is a central and essential part of the DEIR 4.8, It is thereby appropriate to critique SECOR here, as it is an essential part of 4.8. See section W (DEIR Process) below for comments on the delay in making SECOR public.

Two SECOR documents were released to the public, designated in Appendix P as: SECOR 1998a (March), the "Hydrological Evaluation Report"; and SECOR 1998b (June), the "Tracer Investigation"

The 1998 SECOR studies are invoked by all subsequent "studies" (Source Group, Geosyntec) to reassure the public that Crystal Geyser will have no hydrological impact. SECOR 1998a involved some drawdown tests to check hydraulic connectivity between wells on Dannon property, in particular, some hydraulic connectivity between wells DEX-6 and DEX-1 (the one closest to Big Springs). SECOR 1998b involved the second step toward the goal of Big Springs: tracer tests to see if fluorescent dye injected into the well DEX-1would show up later flowing out from Big Springs. With these two sets, Dannon hoped to demonstrate to the State that their production well DEX-6 was connected to Big Springs, and therefore they could call the bottled product "spring water". In fact, SECOR 1998a and b were **never designed** to check on the effect of industrial pumping on neighboring residential wells. Rather, they were designed to prove to the State that the bottled water could be labeled "spring water".

The "proof" of this connection was not easy. Tracer tests from DEX-6 directly to Big Springs were reportedly not successful. So instead, they tried to show a hydraulic connection between DEX-6 and DEX-1 (by drawdown tests) coupled with a tracer connection between DEX-1 and Big Springs. Both aspects of this are problematic, as will be discussed here.

Nonetheless, CG has summarized the results to be much more positive than they are, and repurposed this tenuous connection as a public relations geological argument "proving" the lack of impact: since the flow rate at Big Springs has been fairly robust even during the time of Dannon/CC pumping, then the pumping must have no impact on "the Big Springs aquifer". Based on the repurposed SECOR results, the "Big Springs Aquifer" is to be accepted (in CG's view) as the same as that used by DEX-6.

However. review of SECOR reveals a number of serious problems. Appendix P-8 correctly summarizes the mission of SECOR:

AppP-8: *"Thus, the basic purposes of the work were to verify that: the production wells were hydraulically connected to the Big Springs; the water pumped from the wells was of the same chemical composition as that from the springs; the wells could produce at relatively high rates; and these wells would be secure and provide increased sanitary protection."*

SECOR 1998a-5-1: As directly stated in the SECOR Hydrological report conclusions:

"The overall objective of the hydrogeologic evaluation of the Site was to demonstrate that the proposed spring water production boreholes at the Site meet the Federal and California State requirements necessary to be permitted as spring water production boreholes"

The question of the effect of industrial scale pumping at DEX-6 on the shallow alluvial neighboring residential wells - the key question of concern to the community - was not even raised by SECOR 1998a. Therefore, **an actual field study with data on this key question is needed before the project is approved.**

4.8-28: CG has long argued that a lack of a large effect of DEX-6 pumping on Big Springs proves there can be no deleterious effect on neighboring wells. This of course assumes that water flowing under DEX-6 is all headed toward Big Springs, which has never been shown. It is, however, the DEIR admits that much of the water emerging from Big Springs does not flow under DEX-6:

"... one gallon pumped at DEX-6 would result in less than one gallon decrease in flows at Big Springs because groundwater from other areas of the aquifer would supplement the flow."

Section 4.8 is essentially admitting that it is possible that Big Springs receives some of its water from sources that are not accessible to DEX-6. Therefore (although the conclusion is not stated), monitoring Big Springs is a poor proxy for monitoring of actual residential wells.

AppP-9: Point #2 on AppP-9 summarizes the SECOR finding that Spring Hill is an andesite volcanic plug that has ascended through glacial-fluvial deposits.

Supp2-6: But according to Austin's more careful study of the rock types in the area, Spring Hill is not andesite at all, but dacite:

"The andesite through which groundwater emerges at Big Springs cannot be clearly correlated with the Spring Hill dacite and likely results from an older lava flow."

Supp2-1: The distinction between Big Springs andesite and Spring Hill dacite has a consequence for groundwater flow patterns:

"Because the andesite at Big Springs cannot be correlated with the Spring Hill dome dacite, the dynamics of this deeper aquifer remain poorly understood and it is unclear if the water issuing from Big Springs is the same as that tapped by wells within the Spring Hill dome."

Supp2-12: This complexity and heterogeneity of rock type affects groundwater dynamics:

"Groundwater dynamics within the deeper fractured zone are harder to constrain because fracture network, water source, flow path, and the relationship between andesite and dacite are not known. The recharge area for this aquifer system could be from anywhere on the mountain, or from a combination of sources, and residence time for water in this aquifer is likely longer than for shallow percolating groundwater. It is important to note that residence time refers only to the time the water has spent underground and does not indicate the potential reserve held within an aquifer. Data are insufficient to estimate how much water is stored within this deeper aquifer, or how many years of water our current usage rates will provide us."

In other words, DEX-6 water may not even flow toward Big Springs because, as one possibility, Spring Hill might impose an impermeable block. But that possibility is not mentioned (possibly because it contradicts the CG narrative that DEX-6 and Big Springs water are feeding off the same aquifer). **A DEIR should mention all the reasonable possibilities** and consequences, even when they do not support the conclusions desired by the project owners.

AppP-9: Point #3 suggests that SECOR found the existence of a "structural geologic feature" NE of Spring Hill. Somewhat enigmatically, App-P reports that "SECOR stated that this feature did not have an effect on groundwater flow directions". **Evidence for that conclusion is not given.**

Supp2-Figure 6: However, the recent studies by volcanic hydrology expert Allison Austin suggest that the "feature" in question, a fault zone, deflects groundwater to the SE (not SW toward Big Springs), based on a study of groundwater levels in the area.

"The dynamics of groundwater from multiple channels intersecting within a fault zone at the edge of a silicic intrusion present a complicated hydraulic situation with many unknowns. Groundwater dynamics along the eastern side of Spring Hill appear to be particularly complex because the degree of permeability underneath and along the edges of Spring Hill remain unclear and it is not known how much water filters through Spring Hill versus deflecting around it. The outcrop of Rocky Point can be connected to a larger lava-flow-like feature with an apparent planar orientation on the northeast side of the dome (Figure 7B), where steep groundwater contours suggest this potentially fault-controlled geometry (SECOR, 1998) locally deflects groundwater flow along a plane that extends to the southeast".

Therefore, the CG/Geosyntec Report conclusion that DEX-6 water flows toward Big Springs, and that Big Springs is thereby a proxy for the health of that flow, is in serious question. Unfortunately, **App-P ignores this reasonable uncertainty.** This makes a difference, because if the water flowing past DEX-6 flows S or SE, that would takes it under the residential neighborhoods east of CG, rather than out to Big Springs. **An EIR must investigate these reasonable possibilities rather than ignore them.**

AppP-11 Appendix P here accepts without question the unsubstantiated conclusions of the SECOR report:

*" * The geologic "stratum" from which Big Springs originates is present beneath the site.*
* *The saturated fractured andesite encountered in the boreholes for wells DEX-6, DEX-7 and OB-1 appears to be hydraulically connected to the same fractured andesite from which the Big Springs flows...."*

App P-11 also quotes the SECOR report as saying:

"Groundwater obtained from the proposed production borehole DEX-6 is of the same quality and composition as water from the Big Springs."

Similarity in quality and composition does not prove a common source; it is likely that even widely separated water sources in the Cascades have similar quality and composition. Unfortunately, **this obvious fact is not noted by the DEIR.**

SECOR1998a-3-11: The core of SECOR 1998a is an attempt to show interconnectivity between their various wells and boreholes by "drawdown" tests, with the goal, as mentioned, to find connectivity to Big Springs. Drawdown tests employ vigorous pumping at a particular well and then the consequent decrease in level at other select wells is monitored. The selection of which wells to monitor, however, is revealing of **SECOR's (and the DEIR's) lack of interest in residential wells.** Not a single well that is perforated into the shallow alluvial layer (the layer in which residential wells are perforated) is monitored for response to industrial-level pumping at their deeper wells including the production well DEX-6. The hydraulic pumping test description begins in SECORa section 3.7

SECOR1998a-3-12: Pumping was done at several (deep) boreholes and wells. None monitored any wells outside the Dannon property, and certainly not any of the numerous shallow alluvial residential wells nearby. However, DEX-3a is a shallow alluvial well on Dannon/CG property, closest to the neighborhood to the east. Was DEX-3a monitored for drawdown upon pumping at any of their wells? No, it was not. SECOR gives a "reason" why not (in this case, for pumping at OB-1):

"No measured drawdowns were recorded for well DEX-3a during this test. Well DEX-3a is completed in a saturated zone within glacial deposits and influence from pumping was not expected in this well."

In other words, an effect on shallow wells was "not expected" so they did not bother checking.

SECOR1998a-3-11 and Figure 12: One "shallow" well, DEX-3B, was monitored during drawdown at borehole OB-1 (but not at DEX-6). Here is the entire analysis:

"A limited amount of drawdown was recorded in well DEX-3b and may or may not be attributable to pumping from borehole OB-1. Well DEX-3b is interpreted to be completed in a shallower aquifer unit present within the glacio-fluvial deposits which overlie the andesite aquifer."

SECOR1998a-Table 2: DEX-3b is laterally close to DEX-3a but more than 250 feet deeper, so the two wells sample different environments. Drawdown responses in DEX-3a and in neighboring residential wells were technically possible to measure, but SECOR chose not to do so.

SECOR1998a-3-12,13 and Figure 15: Since DEX-6 is the production well, drawdown test upon pumping at DEX-6 are important, even though no responses in shallow wells were recorded. The response in DEX-1 is particularly important because it forms the first step of the dubious two step argument connecting DEX-6 with Big Springs. (Step 1, DEX-6 to DEX-1 by hydraulics; Step 2, DEX-1 to Big Springs by tracer). When DEX-6 is pumped at a rate of 490 gpm, by the end of 63 hours, DEX-6 has dropped by 1.13 feet and DEX-1 level has dropped by about 0.5 feet, supposedly "proving" a hydraulic connection.

This interpretation is problematic for two reasons. First, pumping at DEX-6 creates a depletion zone (a depression in groundwater level) that surrounding regions rush to refill, thereby lowering their levels. But this is the **reverse direction of normal flow.** It is very possible that in normal (unpumped flow), water near DEX-6 would not head toward DEX-1 at all. The two wells may be in effective equilibrium (or very slow flow) with normal (unpumped) groundwater levels. There is a "backflow" only because of the artificially-induced depletion zone. Second, even toward the end of the 63 hours, the groundwater levels in both DEX-6 and in DEX-1 are still dropping, with no sign of a plateau It is possible that continuous production level pumping for weeks and years will cause much more serious groundwater level drops, even in the deep wells.

AppP-33: Appendix P reports theoretical results for simultaneous pumping at DEX-6 and the Domestic Well for the fractured rock ("lower") aquifer, and came up with the curious inference that

"the groundwater flow is 30 degrees south of east, and has an average gradient of 0.003 ft/ft."

That inferred SE direction contradicts the assumption the fractured andesite flow from DEX-6 is toward the W or SW so it can appear at Big Springs. The inference undercuts the EIR's own case that DEX-6 water is heading toward Big Springs.

AppP-43: Adding confusion to the case is the statement in the Preliminary Conclusions and Recommendations::

"Calculation of groundwater underflow was performed for a cross sectional area within the fractured aquifer system, perpendicular to the groundwater flow direction...along with a groundwater gradient value of 0.003, and a groundwater flow direction to the southwest."

So what is the flow direction, 30 degrees south of east, or SW? It cannot be both. (At least the .003 figure is repeated in both cases.) . Does the simultaneous pumping of DEX-6 and the Domestic Well change the flow direction drastically from what would be seen with either one individually? If so, that again raises questions about the impact of pumping on residential wells, questions unposed by the DEIR.

AppP-35: This section repeats the desired but unfounded conclusion:

"Pumping of groundwater from both DEX-6 and the Domestic Well may exert some effect on the Big Springs because it appears that these wells extract their supply from the same fractured rock system that supports those springs, and because of their proximity to the springs."

The softening words here are "**may** exert **some** effect" and "**appears**", but as discussed, there is little actual justification even for those hedge words.

AppP-35/36: Appendix P nonetheless draws conclusions:

"Thus, it appears that the future water use at the proposed bottling plant would be considered to be insignificant with regard to the total flow at the Big Springs."

The conclusion is probably correct. If water in DEX-6 is definitely headed toward Big Springs, then Big Springs would be drawn down only minimally (because the Big Springs flow rate is so high). If a DEX-6 water was heading somewhere else (say to the SE), then Big Springs would draw down even less. **However, this is all a distraction from the real issue. None of this conversation about Big Springs bears upon the possible effect on residential neighborhood wells, which is the real environmental impact concern, one not adequately addressed by this EIR.**

AppP-36: Appendix P does comment dismissively on the residential well situation:

"With regard to nearby residential wells, the predicted drawdown impact is also minimal, ranging from only 0.09 ft in the Pelletier Well to 0.45 ft in the Russo Well. Again, it is cautioned that these calculations are only approximate and actual drawdown could be either greater or less, depending upon pumping conditions (see Table 2 and above discussion)."

The statement that "these calculations are only approximate" puts them in the best possible light. The truth is, the calculations are based on very little knowledge of the actual pattern of rock layers, both vertically and laterally. "Approximate" might not even be close to the truth. **Actual testing is needed.**

E. SECOR tracer study 1998b

AppP-11: Appendix P cites the fluorescent tracer study SECOR 1998b commissioned with the goal of more directly proving commonality of the DEX-6 and Big Springs water. These tracer experiments tried to establish a connection between DEX-1 and Big Springs. But the real question they were going after is whether the CG production well DEX-6 is connected to Big Springs. Why did they not simply report tracer results from DEX-6 to Big

Springs? Because they did not work at all? **A proper EIR would ask these questions and attempt to answer them.**

The procedures, professionalism, and even legality of SECOR 1998b are questionable. The problems are discussed in the next few paragraphs here. SECOR 1998b describes tests to check transmission of a fluorescent tracer fluorescein from DEX-1, a CG well perforated into the deep andesite layer, to Big Springs about 800 ft to the west. Note that DEX-1 is **not** the CG production well, but just the CG well closest to Big Springs.

Please ignore SECOR's various different misspellings of fluorescein throughout their report, which do, however, raise questions about SECOR's experience with the fluorescein tracer technique.

In this discussion of the fluorescent tracer results, I can be considered to be a professional "expert" (see my qualifications at the beginning of these comments).

SECOR 1998b-2: After the failure of the first tracer test on June 8-9, 1998, where no tracer was detected at any observing stations at Big Springs, **a huge bolus of fluorescein**, possibly 5x to 50x greater than permitted by RWQCB, was dumped into DEX-1 for a second test. (The ambiguity "5x to 50 x is due to a SECOR arithmetic error, whereby SECOR claims that 50 ppm/100ppm = 5000, whereas it is only 500. Exactly whether the error is in the numerator, the denominator, or the arithmetic is unknown.)

The tracer study was reportedly done with permission by the RWQCB Central Valley Region. Apparently , the permission was based on an experimental plan printed in the SECOR report as Appendix A dated June 2, 1998, a week or so prior to the testing. That was probably the very plan submitted and approved to RWQCB, although it does not say that explicitly.

SECOR 1998b- Appendix A, Tracer Test Procedures (unnumbered page): The plan explains what will be done if the first test fails:

*"If breakthrough of the tracer at Big Springs has not been detected after 2 days (i.e. 48 hours after the test began), additional tracer at a higher concentration will be injected into well DEX-1. The concentration of the injected fluorescein tracer will be increased by **100 times** over the previous injection concentration."* (emphasis added here in bold)

In other words, the plan says that if the first test (at a specified concentration and volume - 500 gallons - of fluorescein solution poured into DEX-1) failed to show any connection with Big Springs (and it did fail), then SECOR could do a second test at **100x** the concentration of the first test.

But what SECOR actually used for the second test was **500 to 5000x** the concentration !!

SECOR 1998b-2: *"On June !0, 1998, a second tracer introduction was performed. Five hundred gallons of water and dye were mixed at a calculated concentration of approximately 50 parts per million (ppm) or **5000 times** the initial concentration."*

Note that 50 ppm is 500 rather than 5000 times the initial concentration, a SECOR arithmetic error as noted. There is **no** evidence presented that this 5 to 50-fold increase factor over the maximum 100x stated in the plan was ever requested for approval, much less granted. This evident failure to seek or receive approval to dump 5 to 50x the concentration of a fluorescent dye into an aquifer raises some questions which the DEIR needs to address:
(a) Does the second test, with its volume and last-minute greatly increased concentration, follow standard accepted professional procedures in the field for similar such tests? **The DEIR does not address this point** nor acknowledge a problem here.

(b) Were Mount Shasta City public officials (with jurisdiction over Big Springs as the featured attraction in the City Park) notified that the approved plan was to be exceeded by a factor of 5 to 50? This would be a matter of concern because of the possibility that the dye might appear in a public waterway used by many residents and tourists for filling up drinking jugs. Were City officials notified about any plan? Were any warnings given, before the test, that fluorescein is well known to produce anaphylactic shock in sensitive individuals?

(c) Were the officials at the State Hatchery, which uses almost all of the Big Springs Creek water downstream for cultivating trout, notified of the possibility of a large and unplanned bolus of fluorescent dye heading their way, to be ingested by fish?

(d) Since SECOR implicitly acknowledged that RWQCB consultation and approval was necessary for 1 x and 100 x fluorescein concentrations, should they have been aware that 500x to 5000x would also necessitate approval?

Another problem with SECOR 1998b tracer test #2, apart from the unapproved bolus concentration, is evident. SECOR claims **that "three out of five" stations reported a positive result. This claim is misleading.** The truth is only "two out of four", if one counts only independent readings, as should be.

The community was told in public meetings with CG consultants that at least three out of five stations needed to show a positive result for fluorescein to convince the State of the "spring water" labeling. There were indeed five stations, but note the details:

SECOR 1998b-2 "Tracer Study Procedures and Results"

"Four sampling stations located along the natural orifice of the spring and one station within the creek below the confluence of the flow from all the spring emergences were used to collect discrete samples (Figure 1 and Appendix C)."

So, four of the stations were positioned at points (laterally separated) where the water flows out of the rocks, as shown in SECOR 1998b Figure 1. **But only two out of those four showed a positive result (and only after the 500x to 5000x dose)**. The fifth station was positioned downstream in the same creek!! If positioned in the downstream flow of the two positive stations, which would not be difficult to do, the fifth station would necessarily detect the very same transient fluorescence increase as came out of the two positive stations near the rocks. In other word, the "third" out of "five" was measuring the same tracer as the first two: it was basically measuring the same thing twice. It was not an independent location. So the truth was 2 out of 4, not 3 out of 5. If the State required 3 out of 5 for spring water bottling labeling, and they were told 3 out of 5 were positive, they were being misled.

The issue here, however, is not the questionable validity of the "spring water" State certification. Rather, it is whether there is any professional standard for detected tracer concentration to indicate hydraulic connectivity. **No such standard is given or even suggested by SECOR 1998b.** In other words, how much fluorescein must leak through to show meaningful hydrological connectivity? If the standard is "any detectable level", then (in an extreme limit) even one molecule of fluorescein, if detected, would prove that DEX-1 water is "connected" to Big Spring water. This would be absurd. A "positive" result needs to be compared with some accepted standard. A meaningful standard would be to say what fraction of the water that flows from the borehole of DEX-1 actually appears at Big Springs? 100%? 50%? 10%? **SECOR does not ask, much less answer, this central question**, which is the only sensible way to evaluate the "positive" result for its significance.

SECOR 1998b-2/3 Despite SECOR's ignoring this central question, one can calculate some rough estimates for the fraction of water in the DEX-1 borehole (at any given time) that would actually appear at Big Springs eventually, based on SECOR's reported concentration data for tracer test #2, as follows.

The concentration fluorescein added to DEX-1 was reported at 57.8 ppm (parts per MILLION). The peak concentration appearing (~21 hours later) at stations 1 and 2 averaged 0.7 ppb (parts per BILLION). The signal lasted for about 10 hours, during which the average concentration was about 0.44 ppb (for station 2; station 1 is similar) This a dilution factor of 1:130,000. The total volume of fluoresceinated water added to DEX-1 was 500 gallons. So how much fluorescein-contaminated water in total eventually appeared at Big Springs? That is, how many gallons flowed through Big Springs during that 10 hour time period? SECOR1998b-1 says Big Springs flows at 10,000 gallons per minute. Since only about half the width of the stream showed a "positive" result for fluorescein (stations 1 and 2), let us assume that the fluorescein was carried in a flow of 5000 gallons/minute. Five thousand gpm equals 3.0 million gallons in 10 hours. If **all** of the fluorescein solution actually appeared in those 3.0 million gallons, after starting in DEX-1 with a volume of 500 gallons, it would have been be diluted by an average factor of 1:(3,000,000/500) = 1:6,000. But the actual observed dilution factor was *much more* dilute, 1:130,000, as shown above. Therefore, we can conclude that only 6,000/130,000 ever appeared in Big Springs. In other words, only about 4.5% of the water that is at DEX-1 at any given time will *ever* appear in Big Springs. More than 95% of the DEX-1 water goes **somewhere else !** Is this enough of a "connection" to say that DEX-1 water is headed for Big Springs? Yes, but only 4.5% of it. Another way of saying it: DEX-1 is 4.5% "connected" to Big Springs. Or less precisely, the connection between DEX-1 and Big Springs is very weak at best. SECOR, and therefore **the whole DEIR, is ignoring a comparison of their results to any professional standards, and are thereby devoid of meaning.**

Of course, if 95% of the dye went "somewhere else", that may well have been into the water table/aquifer supplying residential wells. There is no record of any warnings being issued in this regard, nor any notifications afterward. Indeed, the whole affair has been kept secret for 19 years.

Compounding these doubts and the incorrect conclusions from tracer test #2 are questions concerning the fluorescence measurement procedures themselves. There is no information about how the discrete samples were quantitated by Baker Labs, so it is difficult to endorse or criticize them. But the field measurements were done using a Turner Designs Model 10AU Datalogging Fluorometer. A check of the present-day Turner Designs website still has the specs for that model and it shows that the fluorometer uses fixed excitation and emission filters: it does not take complete excitation or emission spectra. The problem is that the results are then susceptible to any organic contaminant that might be partially fluorescent (and many are). Organic contaminants are a reasonable concern because the Big Springs stations are immediately below a busy roadway and busy railroad tracks. Transient peaks of contaminants cannot be ruled out. Also, SECOR-1998b-2 acknowledges (in the description of tracer test #1) that turbidity could account for a significant portion of the "fluorescence" signal (up to 0.159 ppb). Turbidity and fluorescent organic contamination can be transient depending on what heavy truck or train equipment rumbled by and shook loose these contaminants.

Nonetheless, one could argue that controls would show that the "peaks" are real, that they do not occur except after the one time (tracer test #2) that fluorescein was injected into DEX-1. The problem is, **there are no controls.** The continuous flow fluorometer was not even run for a full day before or after the peak in question, so diurnal variations in truck and rail traffic, temperature, and flow rate could were not controlled against. The fluorescence traces as presented in Figures 3-5 are very noisy and unstable, varying over 100 ppt before the "fluorescence peak" of 100 ppt appears, and even before the dye was introduced into DEX-1. In the Field Notes (SECOR 1998b Appendix D), the experimenter notes problems with light leaks through the tubing and bubbles in the sample chamber and groups of visitors causing repeated disruptions. I am not claiming the "positive" results are definitely wrong; I am only claiming that experimental problems and lack of good controls put them in some doubt.

Some of that data came from discrete samples analyzed by Baker Labs. Did these have good controls? The run for station 1 lasted for several days. At first, readings were taken every two hours but eventually only once every 8 hours, so a relevant transient caused by some non-fluorescent incident could be missed. The run for station 2, the only other "positive" data stream, was ended shortly after the main peak, so there is essentially **no control data.**

These considerations, all unaddressed by the DEIR, place into question the scientific reliability, ethics, and perhaps legality of using the results of the 500x to 5000x tracer test #2 to support any of the hydrological contentions that flow from that test. Many of the inferences of SECOR, then Appendix P (RCS) and then 4.8, depend on these results as "proving" that DEX-1 and Big Springs are hydrologically connected. The inferences all rest exclusively upon tracer test #2, which, for the reasons stated above, are shaky at best.

F. Studies after SECOR add very little new information

CG has claimed that there have been many geological studies in the area that prove that their pumping will have no consequence. However, the review of these studies starting on App-P-12 shows that only the just-released SECOR study supplied the bulk of the information, skimpy as it is.

AppP-12: The Source Group 2005 added only a "capture zone analysis" for DEX-6. Unfortunately, the size of the "capture zone" was only theoretically calculated, not measured, evidently based on oversimplified theories assuming an infinite single pool and the consequent size of the depletion zone, given previously inferred values for gradient, transmissity, and pumping rate. **The DEIR fails to point out that the actual geology may be far more complicated.** Therefore, The Source Group 2005 can hardly be considered a useful study, also a conclusion unmentioned by the DEIR.

The next study, Geosyntec 2102 provided no discussion of groundwater at all, and is properly ignored by the DEIR.

Geosyntec was then commissioned by CG to do more studies in 2014. The only new field tests that were performed were well testing of DEX-6 and the Domestic well. **No tests were even attempted to evaluate the impact of industrial pumping on neighboring residential wells.** Other than the limited new well testing, previous studies were "reviewed", meaning that we are back to almost exclusive reliance on the inadequate SECOR studies of 1998. So the CG contention that many studies were done is false, and **the DEIR should explicitly point out the paucity of studies and data with regard to impact on residential wells at city wells in the area.**

Did RCS - the hydrology consultants for this EIR - do any new studies?

AppP-16: According to AppP-16, all that RCS did for this EIR is observe locations of wells and obtain information on plant operations (presumably from CG). No information that bears on the key question of the impact on neighboring wells was obtained or developed. **This lack of new information falls short of the meaning of "environmental impact report".**

However, the information that CG supplied to RCS on their expected pumping rates is interesting. CG says these rates will be monitored. However, the key question is: **what will be done if adverse effects are seen on neighboring wells? And will the rates be made public? Mitigations are needed here, possibly temporary shutdowns or caps on production rates if problems are encountered.** But Section 4.8 ignores this and just says "less than significant impact and no mitigations required", more like a chant than the result of scientific study. **This is clearly inadequate for a serious EIR that purports to protect the community.**

G. The alluvial ("upper") layer

Appendix P (the RCS study) contains statements which are occasionally cautious in a scientific sense (although as discussed previously, this proper caution is rarely transmitted to the main section 4.8 which is based on Appendix P). Appendix P says that the alluvial layer was never mapped on a small scale. **This is a severe shortcoming in the data** because the neighboring residential wells are drilled into that layer so it is essential to understand the contiguity or lack thereof.

AppP-5: Regarding the naming of "Upper Aquifer System" (and the consequent implication that it is one system), Appendix P admits,

"However, this system has not been designated as such in the available scientific reports and/or literature."

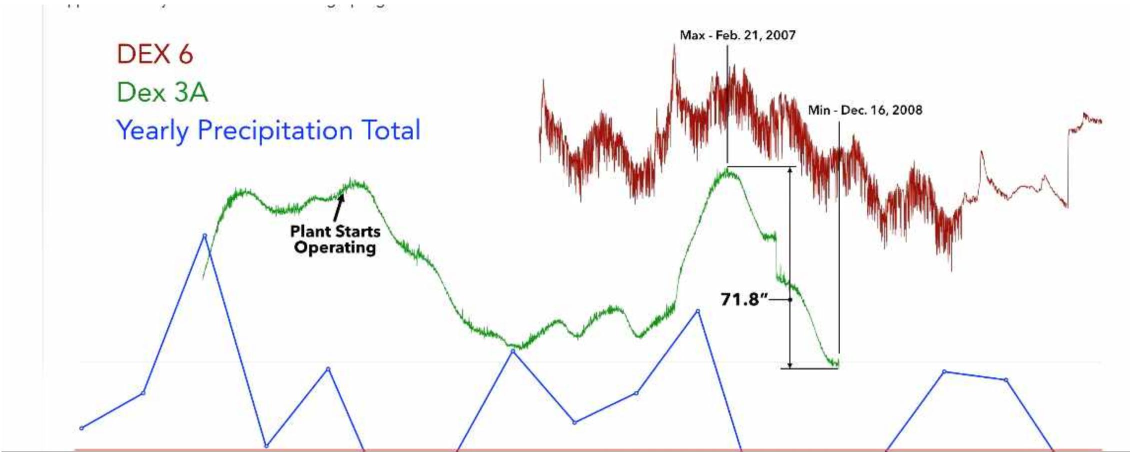
Nonetheless, the name "Upper Aquifer System", which implies contiguity, was given by "local drilling companies", and (notably) by Cal-Trout and by Mr. Jeff Zukin.

It is worth noting that Cal-Trout has a research contract funded by Crystal Geyser, and Mr. Zukin is an employee of Geosyntec which was hired by Crystal Geyser in 2014 to write a report. So reference to an "Upper Aquifer system" with the implication that it is one contiguous system, is, at best, hearsay, and with the Crystal Geyser connection, certainly not an independent disinterested evaluation.

H. Are the "upper" and "lower" aquifers connected?

Figure 4.8-2: This Figure shows a clear one-foot drop in DEX-6 during the period that Dannon/CC was pumping most heavily (i.e., not importing some of their water by truck from Dunsmuir). But no comment is provided on how levels in the "upper" aquifer as seen by shallower wells fared during this time. The "upper" aquifer is the one tapped by residential wells, so how the "upper" aquifer fares during pumping is important. Unfortunately, this key question is **not addressed** in the EIR.

Supp-3: Fortunately, the public has had access to groundwater level records for DEX-3a, a shallower well drilled into the "upper" layer on CG property, data provided directly from by the RWQCB Central Valley region (see suppl doc 2, also shown below as Figure A). The green line is DEX-3a



[redacted]

Figure A

It shows a 6 foot drop during the Feb 21, 2007 to Dec. 16, 2008, after which data is not available. Therefore, the assumption that we need deal with a single aquifer (the lower) to model effects of pumping (implicit in the use of the PUMPIT program, discussed below) is not justified and ignores the groundwater levels in the very layer (the alluvial one) accessed by neighboring residential wells.

The fact that the publicly available data used to generate the above graph is not even mentioned by the DEIR is a serious shortcoming of the EIR, because it is highly relevant to the behavior of shallow alluvial wells during the time of Dannon/CocaCola pumping. It is unfortunate that **the DEIR seems to rely only on data and references provided to it by Crystal Geyser and its consultants.**

App-P-9: Appendix P itself acknowledges the complexity in quoting some "key conclusions" of the SECOR 1998a report (without revealing the report itself, which was secret until last week)

"There are two aquifer systems in the vicinity of the proposed site, a glacial-fluvial sedimentary aquifer system and a fractured andesitic bedrock aquifer system. However, it was noted in the report that groundwater occurs only within the fractured andesite on the west and southwest sides of the proposed facility whereas in the central and east sides of the site, it occurs in the fractured andesite, tuff, and glacialfluvial deposits (SECOR, 1998a, pg. 4-2)."

In other words, SECOR appears to have reported that no groundwater is seen in the upper layer on the W and SW side but it is seen in all layers elsewhere. No word is given concerning how this vague description relates to DEX-6, which is located to the north of the plant, just east of Spring Hill. Very little can be concluded from SECOR as quoted above, except that Big Springs flow and residential well flow are NOT identical. **Whether DEX-6 shares any commonality with the residential wells is not addressed.**

I. Inappropriate use of oversimplified theory

In place of actual field measurements and data, 4.8 relies on oversimplified and inappropriate theories and computer programs. These programs assume just one aquifer. Assuming there is just one aquifer (the "lower") in the whole area makes the theoretical analysis simpler but it may not be appropriate. Professional volcanic hydrology expert Davisson addresses this point clearly:

Supp-1 *"A porous sedimentary basin lends itself readily to groundwater flow prediction using mathematical modeling based on continuum mechanics. However, this approach fails to achieve the same results for groundwater aquifers comprising fractured material because the occurrence and spatial scale of subsurface conduits transporting groundwater is largely unknown."*

4.8-26 Nonetheless, the DEIR proceeds anyway with advertising an overly simple program called PUMPIT, which is based on the Theis equation. The Theis equation assumes a stagnant uniform, open, porous sedimentary basin, whose inappropriateness is exactly what Davisson comments upon. The resulting inappropriate and oversimplified analysis in the DEIR concludes that

"the potential impact on the productivity of surrounding groundwater wells from operation of the Proposed Project would be ***less than significant*** *and no mitigation is required."*

The case for "less than significant" is so weak that at least **monitoring w/caps should be required as mitigations.**

AppP-10 Most of the DEIR's conclusions stem from those of SECOR 1998a and 1998b.. AppP-10 reports that SECOR also used that same (inappropriate) theory to make hydrological conclusions without actual evidence:

"SECOR (1998a) performed a Theis drawdown analysis, which yielded a theoretical drawdown impact value of approximately 0.19 ft at a rate of 500 gpm, at the location of Big Springs in the City park."

The Theis equation assumes a single stagnant aquifer pool of infinite extent with no gravitational slope, clearly not the case in highly sloped heterogeneus layers of volcanic rock, fractures, and lava channels. **AppP and Section 4.8 should not draw any conclusions from such inappropriate use.** Furthermore, the goal of SECOR was to bolster the desired contention that DEX-6 was feeding on the same aquifer as Big Springs, in order to certify the water as "spring water" for advertising purposes. So SECOR just assumed that was the case, in order to calculate theoretical "drawdown" to a location that may not even be hydraulically connected.

AppP-32: Appendix P here confirms that PUMPIT uses the Theis equation to calculate a theoretical impact of proposed pumping on water levels. As mentioned, this is completely inappropriate for heterogeneous sloped fractures and lava tubes and multiple layers with different rock types. The last paragraph on this page adds that fractured rock systems is "unconfined", another unjustified assumption.

AppP-34: Appendix P here forthrightly presents a list of real-world factors not taken into account by PUMPIT. However, it also states:

"Based on our long-term field experience in water level monitoring during actual pumping tests, drawdown impacts in nearby wells induced by pumping of wells under real-world conditions tend to be significantly less than those which have been theoretically-calculated using the same model software that has been used herein."

In other words, the suggestion (based on "long-term field experience") is that PUMPIT yields a "worst-case scenario" for well-pumping impact on neighboring groundwater levels. This is an important (if questionable) statement. To raise it beyond trust, some documentation of similar cases (in complex volcanic aquifers and industrial-level pumping) would be more convincing. If such documentation cannot be produced, one may assume it does not exist. Furthermore, a worst-case scenario might include the possibility that an existing volcanic pathway for water flow might collapse and redirect the flow elsewhere. At the very least, **actual tests of pumping at DEX-6 and monitoring the response at neighboring wells should be done, before CG is given permission to proceed. Again, this is quite different from a "no mitigation required" response to a complex and unstudied situation.**

AppP-44: The Appendix P Preliminary Conclusions and Recommendations section summarizes the situation:

"These calculations were performed using a simple analytical model called PUMPIT, which is based on gross assumptions for an ideal aquifer system."

One of the many possible actual deviations from ideality is posited in one sentence but not pursued:

"In addition, changes in direction of groundwater flow and gradient can impose an additional imprint and, thus, also tend to make pumping-induced changes."

In other words, if the already-complex groundwater flow pattern changes, then the effect of pumping can change. It is also possible that pumping itself could induce permanent changes to the groundwater flow pattern (from, say, collapse of lava tubes); **this possibility is not mentioned, but should be.** There is a long history of overpumping in the Central Valley leading to irreversible changes and land subsidence.

J. Recharge of "upper system" and "lower system"

As to the source of water in the "upper" aquifer, Appendix P says:

AppP-5: *"Groundwater recharge to this aquifer system is generally from infiltration of direct precipitation on the land surface and from infiltration of surface water runoff along local streams and creeks."*

Appendix-P-6 states:

"A small amount of recharge would also occur from subsurface sewage disposal systems, assuming such systems were in direct contact with the alluvium."

This would appear to be a matter of some concern, both to residential wells and to CG. How "small" is small? **There needs to be more quantitative information here.**

App-P-13: SECOR 1998a judged the recharge area (not separately defined for recharging upper vs lower) at 6 sq miles, and Geosyntec increased that to 7.2 sq miles. This increase was declared, not on the basis of field measurements, but on

"…topographic map interpretation and use of Geographical Information System (GIS) software…".

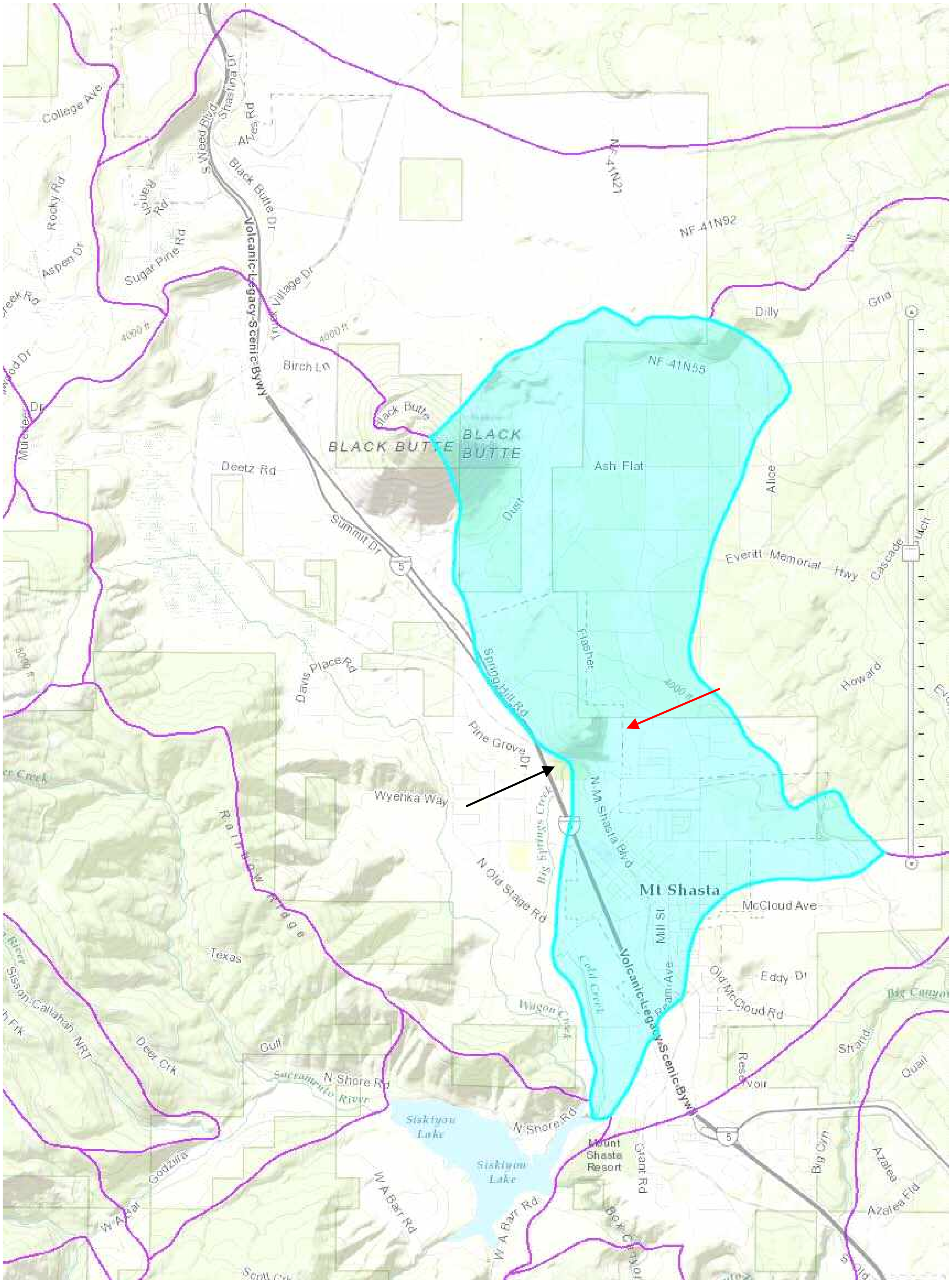
However, topographic maps show only the surface topography. The location and interconnections of underground channels and impermeable layers, and their slopes, is what is really relevant to recharge area, and that information is not evident in topo maps. "GIS software" is a very vague and meaningless descriptor because it says nothing about what features were being plotted; there are hundreds of different types of GIS software packages. The DEIR must be more explicit about how the recharge area was determined.

RCS, the author of Appendix P, says on this page:

"RCS considers the current depiction of this recharge area to be reasonable."

Perhaps it is "reasonable" but is it true? Where is the evidence? **Truth is the responsibility of a valid EIR to determine (or at least to judge) and it fails in that regard here.**

Supp4: The idea that surface topography determines the subsurface recharge area leads to some remarkable conclusions that contradict the whole thesis that DEX-6 and Big Springs share one big aquifer. The CA Dept. of Fish and Game has published a map of surface watersheds in the Mt. Shasta area (https://map.dfg.ca.gov/bios/?al=Hydrography:10), shown here:


College Ave
S Weed Blvd
Shastina Dr
Alves Rd
Black Butte Dr
Rocky Rd
Aspen Dr
Sugar Pine Rd
Volcanic Legacy Scenic Byway
Village Dr
NF-41N21
NF-41N92
Dilly
Grid
NF-41N55
Birch Ln
Black Butte
BLACK BUTTE
BLACK BUTTE
Deetz Rd
Ash Flat
Alice
Dust
Summit Dr
Everitt Memorial Hwy
Cascade
Davis Place Rd
Spring Hill Rd
Flasher
Howard
4000 ft
Pine Grove Dr
Wyehka Way
N Mt Shasta Blvd
Big Springs Creek
N Old Stage Rd
Mt Shasta
McCloud Ave
Mill St
Texas
Eddy Dr
Old McCloud Rd
Cold Creek
Wagon Creek
Deer Crk
Sisson-Callahan NRT
Gulf
N Shore Rd
Sacramento River
Siskiyou Lake
Siskiyou Lake
Mount Shasta Resort
Grant Rd
W A Barr Rd
Big Cyn
Azalea
Azalea Rd
Quail
Big Canyon
Godzilla
Scott Crk

The light blue area is the "Cold Creek" drainage, and it covers all of the CG plant. The location of DEX-6 is indicated by the red arrow. The distinctly different drainage just to the west (outlined in purple) is the "Big Springs Creek" drainage and it accepts all the water from Big Springs (black arrow). If we were to assume that surface topography determines subsurface recharge areas, then Big Springs would be disconnected for DEX-6, because they reside in different surface watersheds. Clearly, SECOR's citation of "*topographic map interpretation and use of Geographical Information System (GIS) software"* tells us exactly nothing about how recharge area was determined.

K. Big Springs and DEX-6 water levels and precipitation

Although flow rates in Big Springs may be irrelevant to the question of possible impacts to neighboring residential wells, it is nonetheless interesting to follow Big Springs as a crude measure of the general availability of deep groundwater, and its possible response to drought.

App-P-17: Point # 8 says the flow rate in Big Springs has dropped by 17% from 1998 to May 25, 2016. AppP gives no insights as to whether this decrease is a result of drought or any other identifiable cause or whether it is unusual.

Figure 4.8-4. This graph is upside down , or its vertical axis is marked upside down. The sudden brief dropoffs of Big Springs Creek water level depicted in the graph are much more likely to be sudden rises in water level due to snowmelt runoff and heavy rainstrorms. There is no natural mechanism that would cause sudden dropoffs in winter. This error crept into the Geosyntec 2014 Report and it is just copied here without a critical view. The result of the error is to incorrectly show a slow increase in Big Springs flow when in fact it is a slow decrease, during the years of Dannon/CocaCola operation.

AppP-Figure 6: DEX-6, perforated in the deep "lower aquiifer", shows groundwater level fluctuations over time that might give a clue to its sensitivity to industrial-scale pumping and to its connection with surface water and to the "upper aquifer". This is presented in Figure 6 of AppP, based on data acquired by Geosyntec, and replotted here with finer points to better show rapid fluctuations. The graph is plotted on the same time axis as measured Big Springs flow and precipitation events.

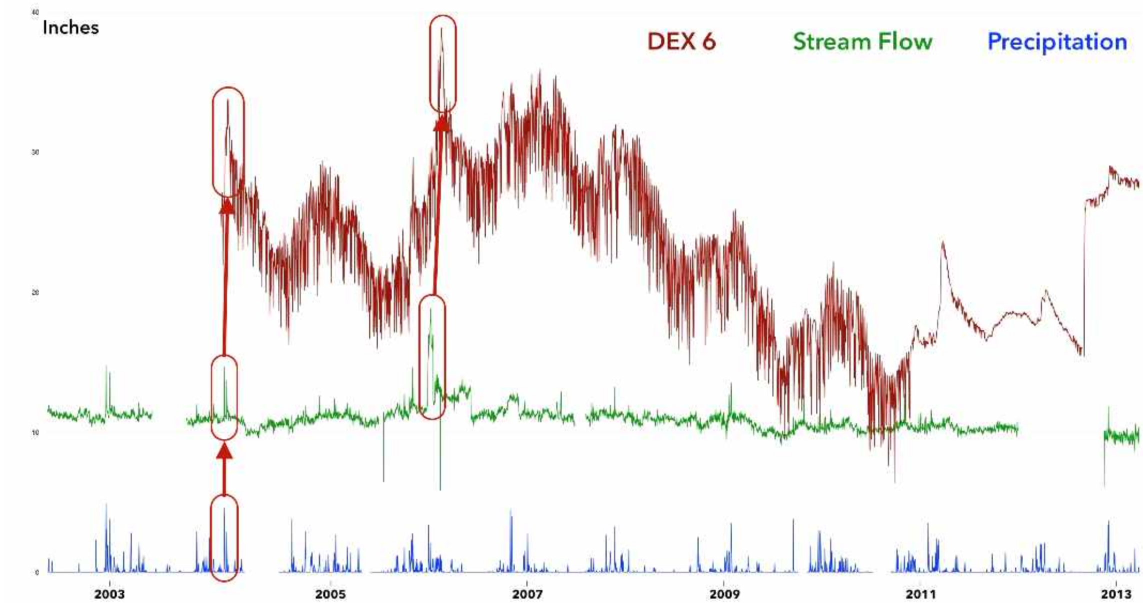


Figure B

Here, Big Springs level is plotted correctly so that upward means "more water". The upward spikes in Big Springs level and precipitation also correspond to upward spikes in DEX-6 groundwater level, especially obvious in 2004 and 2006. This has important implications: (1) DEX-6 water level is quite sensitive, quite quickly, to surface water input, which contradicts the contention that it receives water only from the Appendix P - hypothesized "lower" aquifer; (2) If DEX-6 is hydraulically connected to water all the way up to the surface (at least to some extent), then DEX-6 could easily be hydraulically connected to water at intermediate depths (the "upper aquifer") which are those depths tapped by neighboring residential wells. In other words, with such a hydraulic connection, **there is a distinct possibility that drawdown of DEX-6 could affect neighboring residential wells. The DEIR does not make this point.**

AppP-14: The brief downward spikes in DEX-6 probably correspond to pumping episodes. Pumping stopped shortly before 2011, and the graph became much smoother. This interpretation is consistent with the view of AppP-14. Note AppP adds no new useful data, particular no information on exactly when Dannon/CocaCola were pumping, for what duration, and at what rate. Such information might explain why the DEX-6 curve rises from 2003 to 2006 and falls thereafter: in the earlier years, Dannon/CC imported 65% of its water by truck from Dunsmuir so presumably its pumping rate was less. Thereafter, 100% came from DEX-6. **That information, if available, may clarify how much pumping leads to how much loss in DEX-6, even if that says nothing about losses in neighboring residential wells. The DEIR does not discuss this issue.**

L. Groundwater static water levels and hydrographs

AppP-26: RCS successfully obtained static water level data from CG staff, for several of their wells. This is a positive development, because CG had withheld this data from the community for several years. The focus is on two wells: DEX-1 and DEX-6, both perforated into deep fractured andesite (the "lower aquifer").

AppP-27: Appendix P then presents a remarkable and highly significant statement:

"The remaining monitoring wells had much shorter periods of record and/or were constructed in the alluvial aquifer and, thus, ***were not considered as useful for our current analysis.****"* (emphasis added in bold.)

The DEIR is essentially saying that it is **skipping** any serious study of alluvial wells! **This is a severe shortcoming in the DEIR**, because the alluvial wells are at the depth and material of the residential wells. Clearly, CG was not interested in the history or welfare of residential wells but only of their own production well. Part of the shortcoming may be due to RCS, which chose not to comment on the alluvial data that does exist (obtainable from the RWQCB), or due to CG, which did not gather extensive data from alluvial wells.

Fortunately, as mentioned before, we have acquired (directly from the RWQCB) the DEX-3a data set, which does exist but the DEIR chose to ignore. That data (Figure A above) shows a drastic 6 foot drop during the years of pumping (see earlier comments with graph). **The EIR should and must include the essential data from shallow alluvial wells.** Numerous comments from residential neighbors have been made concerning a negative impact on their wells during those years of pumping, and no problems since pumping ended. **Those comments have been ignored.**

AppP-28 Appendix P here reports that static water level data for DEX-1 is incomplete, because it misses the period 2009-2014 (see AppP Fig 5-1 with its dashed line gap representing missing data.) Inclusion of that period would have clearly show the effect of pumping on a neighboring well because pumping was going "full blast" until late 2010 and then ceased completely. Although DEX-1 is a deep well perforated in andesite, unlike the shallow residential wells of concern to the community, records showing the effect of industrial pumping on any adjacent well static water levels is exactly what is needed in a serious EIR.

AppP-28: Point #3 reports that static water levels generally declined during the drought years. This is to be expected, but the EIR needs to point out that even where the "age" of water (see discussion below) is measured in decades, the actual availability of water responds much more rapidly to recent precipitation trends. It is unfortunate that quantitative data for alluvial wells during drought is not given in this regard.

AppP-42: In this Preliminary Conclusions section, there is an acknowledgement that DEX-6 pumping may have had an effect on a neighboring well, DEX-1:

"Thus, it appears that pumping of DEX-6 when the former bottling plant was in operation did, in part, cause a decline in water levels in DEX-1, although this possible cause and effect relationship cannot be firmly established."

But since DEX-1 draws its water largely from the "lower aquifer" andesite, **the lack of concern for "upper aquifer" alluvium residential wells is evident.** The DEIR contains no mention of the more relevant "upper aquifer" DEX-3a records (which we obtained from the RWQCB, Figure A above), which show a large decline in water level during the pumping years. **Mention of DEX-3a records would undercut the argument that "no mitigations are necessary".**

M. Groundwater flow: rates, directions, and structure

AppP-18: The field measurements that might bear on how much water is flowing in what direction are well-driller and geological logs, and measurements of groundwater levels (from which gradients can be inferred). These look at static groundwater levels and rock types vs depth. Although these are basically snapshots at fixed points rather than descriptions of a flow field, this DEIR adds nothing new, mainly just a review (one might say rehash) of the old SECOR 1998a-reported snapshots. An EIR should provide new information where needed, which is clearly here.

AppP-19: However, this section does report that those drilling logs included "anomalous descriptions" because of difference in the drilling rock profiles between wells OB-2 and OB-3. This indicates that the layering is more complicated than assumed in the models, and should be reported in this light.

AppP-20: Appendix P alludes to some complexity:

"The boreholes for these two wells (DEX 3A and 3B) were drilled to depths of 148 and 403 ft bgs, respectively, and revealed a different type of lithology, compared to that in the previous two wells (DEX-1 and DEX-2) discussed above."

Again, this argues for a more complex layering than is modeled by the overly-simple programs cited as meaningful in the DEIR, a clear conflict between reality and models.

AppP-22 Appendix P here does summarizes the complex situation, in which shallow alluvial wells (such as DEX 3A) and (by our own inference here) residential wells behave differently than deep andesite wells.

"The available log data tend to indicate two basic aquifer systems occur in the area: a shallow alluvial aquifer system; and an underlying, fractured andesite aquifer system. However, the data are conflicting in that a few wells seem to indicate groundwater in the shallower "alluvial" aquifer system while most of the logs show groundwater originating in the fractured andesite, which would thereby constitute the second aquifer system. The actual geometry of the hydrogeologic system in the vicinity of the plant is complex, because depositional systems in volcanic terrane are composed of great lateral and vertical variability, due to the different rock types typically involved, such as: hard, fractured volcanic rocks, lahars, ash fall tuffs, and ejecta. Thus, for DEX-1, DEX-2, DEX-4, DEX-6, and DEX-7 it can be inferred that these wells can extract groundwater from the same fractured andesite system. Further, the SWL (static water levels) *depths in these wells appear to indicate that groundwater is likely governed by unconfined conditions in the fractured rock system. However, DEX-3a, -3B and DEX-5 appear to have groundwater contained in different depositional systems that are discontinuous from these fractured andesite aquifer system."*

It would be helpful if this honest acknowledgement of complexity actually led to an acknowledgement that the conclusions based on overly simple models (such as PUMPIT discussed above in "Inappropriate use of oversimplified models) are invalid. **The corollary is that the 4.8 conclusions about how the impact on neighboring wells is "less than significant" are also likely invalid.**

AppP-29 Here begins a theoretical discussion of groundwater underflow. Unlike the Theis equation-based theories, this one does include gravitational effects of water flowing downhill. Unfortunately, the parameters used are from deep andesite ("lower aquifer") data sets, so little is learned about the residential wells perforated in the shallow alluvial layers. **That should be a concern for the DEIR, but evidently it is not.**

AppP-30 Appendix P here briefly discusses attempts to include the Domestic Well in the analysis, where static groundwater levels are input parameters. When the Domestic Well parameters are included, a flow from SE to NW is deduced:

"Thus, it appears possible that there is an additional component to groundwater flow entering the fractured rock aquifer system from the southeast and at a gradient of 0.002 ft/ft is because this well is perforated within both the shallower alluvial aquifer and the underlying fractured rock aquifer system. However, for the purposes of this analysis only DEX-6 was used, as this is the main production well for the plant."

In other words, inclusion of the Domestic Well parameters showed that the flow pattern is much more complicated than the analysis wanted to deal with, so those parameters were ignored.

Nonetheless, in the next paragraph, it is stated without data justification, that if Domestic Well was pumped at expected rates (as used to supplement DEX-6) then " It is very unlikely there would be a significant water level drawdown impact on the fractured rock aquifer" The "unlikely" descriptor is meant to be reassuring but it not backed up by real data or analysis.

AppP-31: Here, the oversimplified theoretical analysis concludes that

"the cross sectional underflow (Q) at DEX-6 is calculated to be about 777,600 gpd, or about 2.39 AF/day, or ±873 AF/yr. "

4.8-25: The average gpm of usage from DEX-6 + the Domestic Well is estimated at 139+11=150 gpm). Multiplied by 60 min/hr x 2 production lines, this gives 216,000 gpd. That means that CG pumping with two production lines will account for fully 28% of the estimated cross sectional underflow at DEX-6. **The effect of that significant withdrawal on any other possible users downstream is not discussed or even mentioned.** A serious study of environmental impacts must include those possible effects.

At the bottom of this page, there is a comparison of the total calculated underflow to the residential use, which is claimed to be:

"only a small fraction (2½%) of the total underflow in the area."

This would seem to be a relevant calculation, and one that (had it been based on more realistic theory) might even be a relief to residential neighbors. But the calculated total underflow is largely in the deep andesite. The residential use is all from the overlying alluvial layers. Is it possible that alluvial layers groundwater levels are sensitive to the andesite levels below? The large amplitude fluctuations in shallow DEX 3A (noted earlier and in the Figure A above but not discussed in this DEIR) would suggest that might be the case.

More to the point, the community is not primarily concerned with whether residential use is a significant portion of the deep underflow. That issue is a red herring. The question is whether CG pumping is a significant portion of that underflow. As discussed above, that is 28% (when the Domestic Well is counted). That is the pumping that can have a serious effect on groundwater levels, and thereby affect residential wells.

AppP-41: Finally, the Preliminary Conclusions and Recommendations manages to ignore the overwhelming evidence of complexity and instead says:

"Based on our review of the available data and driller's logs and geologic logs, it is concluded that one basic aquifer system that is defined by fractured volcanic andesite rocks of the Mt. Shasta volcanics supplies groundwater to the plant."

Then, in the next sentence, the DEIR shows its lack of concern for the "upper aquifer" where the residential wells are perforated:

"It should be noted that there is what is locally known as a "shallower" aquifer system, but extraction of groundwater from this system for plant operations is considered to be negligible (the Domestic Well may obtain a small but unknown portion of its supply from this shallower system). Also of note is the existence of several residential wells located northeast, east and southeast of the plant, which obtain their supply from either the shallow or the fractured rock aquifer systems, or both."

This is a remarkable statement: it acknowledges the existence of the nearby residential wells but expresses **no concern about their viability or the impact of industrial pumping.**

N. Effect on Groundwater supply

4.8-29 : This section makes the following statement with regard to the alleged lack of projected effect on city wells:

*"Development within the City would not affect the groundwater aquifer from which the project would draw water, as the City obtains its water from Cold Creek, two miles south east of the project site, or from **wells located within the city limits which is in a separate watershed from the project site."*** (emphasis added in bold)

As Supp4, the watershed map from the Dept. of Fish and Game (shown above on page 21) makes clear, CG property is in the same (not "a separate") watershed as much of the city. **No**

evidence is presented that CG pumping does not affect groundwater levels under the city within some radius. There are two operating city wells with a mile to the SE of DEX-6 that supply city water part time and proposed city wells even closer, so the issue of **the impact of DEX-6 on wells within city limits deserves much more careful attention than the brush-off provided by section 4.8-29.**

Mount Shasta City Plans. The City's Master Water Plan, identifies a future well site in the vicinity of the Crystal Geyser facility. **The effect of CG industrial pumping on groundwater at this future public well site must be addressed,** but it is not even mentioned.

According to the City's Comment letter on the DEIR written by ENPLAN (ENPLAN, 2017):

"The City's 2010 Water Master Plan identifies development of a new well at the base of Spring Hill and the addition of an additional 1.0 million gallon reservoir on Spring Hill. These improvements are also identified in the 2011 City of Mt. Shasta Municipal Services Review Report. In addition, the City's General Plan Land Use Element (2007) identifies the Spring Hill Area, north of the Crystal Geyser facility, as a special planning area in the City because of its unique development opportunities as well as the challenge of infrastructure limitations and development constraints. The City's General Plan calls for a Specific Plan that would set the proposed density.

The City's Impact Fee Report (2009), which identifies the Spring Hill area as the primary growth area for the City, states it is reasonable to assume approximately 2,585 dwelling unit equivalents (DUEs) within the vacant 341 acres. This could result in approximately 4,373 new residents, essentially doubling the population of the City.

The City's water system does not currently extend to or serve the Spring Hill Area. Consequently, commercial uses have been approved and developed with private systems. This is generally contrary to the City's policies concerning water service for commercial uses and may complicate the development of a more efficient public water system in the future.

It does not appear the DEIR addresses potential impacts of the Project on the City's future municipal well or cumulative impacts associated with future well and residential development as described above. The DEIR's conclusion that cumulative impacts to groundwater supply are less than significant is not supported, and the DEIR needs to be amended accordingly. "

The possibility of City expansion and water interests in the vicinity of CG must be addressed in mitigations. Public use of water resources must take priority over private industrial uses.

Supp2-12: The analysis by volcanic geologist Austin posits a possible mechanism by which pumping at DEX-6 could affect available groundwater in the alluvium above:

"A porous shallow aquifer through unconsolidated sediments appears to be topographically-controlled, whereas a deeper aquifer system through fractured dacite / andesite appears to be structurally-controlled. The amount of vertical groundwater movement between these systems is

unknown, though some degree of connectivity is indicated by self-potential anomalies along the eastern edge of Spring Hill (Figure 8)."

This is not quoted here to argue that this view is correct or to set one expert against another. The point is that the possibility that DEX-6 pumping affects residential wells is a theoretical possibility, and that actual experiments need to be done. A serious EIR designed to assay impacts on residential wells would have done (or propose to do) such experiments. **The present DEIR does not touch this subject, a major deficiency.**

O. Sustainability

AppP-44: The key question of sustainability - how long pumping operations be carried out before damage might be noted - is final mentioned in the Preliminary Conclusions and Recommendations, but then it is blown off as "beyond the scope" of this project:

"The "Sustainable" yield of the aquifer systems and the impact of the pumping on this yield was not determined. In order to determine the "Sustainable" (aka Perennial Yield), a more comprehensive study needs to be performed. In essence, determining the Perennial Yield requires a determination of the water balance of the area, as governed by the following equation: Inflow-Outflow = Change in Groundwater Storage. This type of study is beyond the current scope of this project, but can be performed at a later time."

The descriptor "...beyond the scope of this (EIR) project" means that the **DEIR project was inadequate and underfunded**, so it could not do a complete job. An important aspect of the environmental impact - sustainability - is admitted here as possible to study, but it was just skipped over for lack of time and/or money.

P. Mitigation measures ignored

4.8-30: Based only on the previously described fallacious reasoning and paucity of data, section 4.8 nonetheless concludes:

"Due to the local topography and residential zoning of adjacent properties to the north east, there are no other reasonably foreseeable developments that would significantly utilize the groundwater aquifer for water supply. Therefore, cumulative impacts associated with groundwater supply are ***less than significant*** *and no mitigation is required."*

"As described above, the Proposed Project would result in less-than-significant impacts to hydrology and water quality; therefore, no mitigation measures are required. "

Supp-1: However, certified hydrologist Lee Davisson says in his letter:

"...concerns for any negative impact can be addressed by monitoring groundwater levels in wells within the general vicinity of the bottling plant groundwater production, as well as any spring discharges. It is best to start this monitoring as soon as possible because the baseline of natural variability in water levels and spring discharge rates need to be established in order to distinguish it from any impacts from groundwater pumping at the plant. This would not only

serve the interests of those concerned about negative impacts, but also those of the bottling plant since they stand to be implicated if any change in water levels and spring discharges were to occur in the absence of baseline information."

The conclusion here is that very clear mitigations of this type are both required and feasible.

Q. CG usage and questions of trust

AppP-33: With regard to DEX-6 production:

"When the second line is placed into production, the well would need to supply 216,788 gpd."

That figure is based entirely upon what CG says. To ensure that we know what the actual usage is (other than relying on trust) , public agencies must impose monitoring, public reporting, and enforceable caps if necessary. Those are necessary mitigations, not the "no mitigations necessary" mantra.

AppP-42: In the Preliminary Conclusions and Recommendations section, we find the same problem with trusting CG. It says "Phase 1 **will** consist..." and Phase 2 **will** consist, and many other incidence of confidence in CG pronouncements expressed in the word "**will**...". How do we know that any of these announced plans **will** be adhered to?

AppP-16: In this Field Reconnaissance section, the DEIR says that CG promises to install monitoring equipment. But who gets the reports? Who has authority to release them to the public? Is there going to be continuous monitoring of residential wells? At whose expense? What are the standards to determine if impacts observed in residential wells are worthy of concern? Who declares that CG pumping might be the cause? Who imposes appropriate responses, such as temporary shut-downs or caps? **A serious EIR would attempt to answer these questions** (and others). That would appear under the category of "mitigations". **This EIR does not even ask the questions, and denies that mitigations are even necessary.**

AppP-46 In this Preliminary Recommendations section, the topic of monitoring is again broached, but little more:

"A regular program of data collection and database maintenance is essential to providing a longterm accumulation of data that can be reviewed for possible changes in groundwater conditions over time. Examples of such data collection efforts are as follows:

1. Continue the monitoring and recording of flow rates and water levels in the production wells and groundwater monitoring wells at the proposed bottling. Such monitoring is necessary to check trends in the data on both a seasonal and longterm basis. ..."

Again, the questions of who does the moinitoring, who sees the results, and who acts upon them are left unasked, perhaps because the evidently pre-ordained task of this DEIR is to avoid recommending obvious mitigations.

AppP-47: Continuing In the Preliminary Recommendations, the DEIR almost (but not quite) states a concern for the impact on neighboring residential wells:

"Conduct a longer-term aquifer test on the Domestic Well only, in order to determine T and S values, if possible, of the "shallow" aquifer system and impact on other offsite wells. Preferably, this could be performed by packing off the "deeper" fractured rock aquifer system and pumping from only the shallower alluvial sediments. (These alluvial sediments may not be able to yield significant quantities of water to a well, based on their fine-grained nature, although some sand and gravel layers could greater amounts, comparatively. Such testing could provide a final determination of this)."

But this suggestion for future testing is only a suggestion, with no teeth. Likewise for the rest of the valid suggestions on App-P-47. This DEIR is outlining what scientifically **could** have been done, but was not, if only this study were adequately funded to be a serious exploration of impact and sustainability.

R. Water composition

AppP-38: The observation here, based on Piper diagrams, is that OB-1 and Big Springs have a somewhat different ionic solute composition than do the rest of the wells (including DEX-6). Therefore, one can could conclude that the source of Big Springs is at least somewhat distinct from DEX-6. That conclusion would contradict the repeated statements (beginning with SECOR) that the two share the same source. As a result, **that obvious conclusion is left unstated here. It should be included.**

AppP-39: But on the very next page, the observations based on Stiff diagrams, revert back to the old mantra:

"...the Stiff patterns for OB-1, OB-2 OB-3, DEX-6 and the Big Springs show the same basic shape, indicating that the character of the groundwater between the Big Springs and the wells is similar and likely from the same volcanic rock source."

The contradiction in inferences from the Piper vs Stiff diagrams is left unexplained.

S. Age of water

AppP-6 and -9: The DEIR should note that "age of water" measurements have been quite variable. The DEIR Appendix P (citing SECOR) says:

"...that the age of the water from Big Springs andOB-1 was greater than 33 years old. "

Supp-3: On the other hand, a recent study from UC Livermore (Visser etal, 2017, Table 11) shows that several of the "Big Springs" sites have a reported age of >12 years and one is >60 years. The water age is highly dependent on the location of the sample around Mt. Shasta, ranging from 0 to >60 years. Therefore, any conclusions drawn by SECOR from the "age" should be cast in some doubt.

AppP-10: Appendix_P reports a SECOR result

"..that the water from Big Springs and from the groundwater monitoring wells and production wells were generally similar in composition, and that the groundwater ranged in age from 21 to 81 years old."

The DEIR gives **no** note as to the inconsistency, wide range, and questionable relevancy of any of these results to the question of environmental impact of industrial pumping on neighboring wells and groundwater levels.

T. Precipitation in the Mt. Shasta area.

AppP-26: The table here is not clear. It says:

"This increase in precipitation with elevation is evident in a comparison of total snowfall data from 2009 to 2016 between the Shasta Ski Park and the Mt. Shasta City gages:"

The Ski Park snowfall numbers do not show much of a persistent trend from 2009-2016, but the Mt. Shasta City measurements show a clear decrease in snowfall. But this is likely due, not to an "increase in precipitation with elevation" but to an increasingly warm temperature with decrease in altitude whereby the precipitation in the City tended to fall as rain. This is convolved with an actual decrease in precipitation overall because of drought in 2012-16.

U. Unaddressed NOP comments

Numerous comments I had made in my Notice of Preparation comments, submitted on time by email dated 7-23-16, were not even addressed by the DEIR. This is a serious shortcoming; NOP comments are supposed to be addressed in the process. Here are those comments, quoted directly:

1. "The draft EIR should have the following goals as concerns hydrology:

(a) Determine and evaluate any short (weeks) and medium (months) term decrease of groundwater levels, both locally and within a radius that affects neighborhood wells, during periods of heavy CG pumping and at full build out.

(b) Evaluate the recharge time and spatial extent of the recharge after periods of heavy pumping, both locally and within a neighborhood-inclusive radius.

(c) Evaluate the long-term impact on groundwater levels in the area, particularly in drought times. ”

2. "What has been the historical relationship between (a) groundwater levels at the production well and monitoring wells and (b) the actual rate of pumping? The publicly available data on this important point is skimpy but more crucial information may be available if Dannon/Coca-Cola/CG can be induced to provide it."

3. "Third party impacts must be studied. Is there a maximum rate of DEX-6 pumping, over which depletion of surrounding wells will become a problem? What is that rate? This maximum rate is important to know so reasonable and enforceable caps can be imposed. "

4. "CG is presently talking about one or two production lines, but is it possible they may eventually increase to more? If so, the full build-out pumping rate should also be evaluated for environmental impacts."

5. "Will overpumping lead to a permanent rerouting of underground flow patterns? This could conceivably occur if certain underground channels collapse when they no longer carry water due to combined effects of drought and overpumping. Collapse has been observed at other locations (e.g., the Central Valley), attributable to overpumping. Has there ever been a study of this possibility here and at what depletion level/pumping rate it might be triggered?"

6. "What is the recovery time for groundwater levels lowered by pumping at DEX-6? "Recharge times" evidently have never been measured after long-term pumping. The only measurement reported by Geosyntec has been after a short 60-hr pumping episode. But recharge times are likely to increase greatly with prolonged pumping because it produces a much deeper and wider depletion zone. The recharge times should be measured both at DEX-6 itself and at surrounding alluvial wells within a mile at least."

7. "The EIR must evaluate whether a drop in groundwater levels will deprive the nearby forests of groundwater moisture both upstream and downstream from the pumping. The roots of trees do not necessarily extend directly down to the groundwater level, but lowering the groundwater level could weaken trees by reducing their access to water percolating up from shallow aquifers and flow channels. The weakening might lead to drying, insect vulnerability, death, and increased fire hazard (and of course a consequent reduction in outdoor-oriented tourism)."

8. "Can overpumping affect the water quality? Can the load of existing impurities in the groundwater - silt, minerals, and toxic pollution (from point sources such as the Erickson Trucking oil spill several years ago across the street from the present CG) - be affected by changes in the flow rate or direction of underground streams as a result of heavy pumping?"

V. EIR process as implemented here

1-2 What circumstances triggered an EIR over this project? The introduction to the whole DEIR says:

"For the purpose of CEQA, the term responsible agency includes all California public agencies other than the lead agency that have discretionary approval power over the project or an aspect of the project. The following agencies are identified as potential responsible agencies:

Siskiyou County Air Pollution Control District
City of Mt. Shasta
Central Valley Regional Water Quality Control Board"

This means that at least three agencies have potential discretionary power to grant or deny permits. On the other hand, the County website **http://www.co.siskiyou.ca.us/content/community-development-crystal-geyser-project** says:

"The issue is that while the bottling facility operation is a permitted use under the subject property's heavy industrial zoning classification, the installation of the caretaker's residence is a discretionary action under CEQA. In making the determination about the appropriate level of the environmental document for the use permit application, County staff considered the whole of the bottling operations. In addition, staff also considered that while the project does require discretionary permits from other agencies, these other agencies only have permitting responsibilities for certain limited aspects of the entire bottling facility. This permitting arrangement has led to considerable concern voiced by the community over the potential of unaddressed environmental impacts. To analyze the defined project and to address the permitting concerns, the County informed Crystal Geyser that an environmental impact report (EIR) was required to be prepared in conjunction with the submitted use permit application."

Both the County and Crystal Geyser - and the Mount Shasta City Council - had long insisted that there was no available trigger and in fact let this project proceed for years without a discretionary permit being required, despite the obvious and predictable responsibility of the above listed agencies cited in the DEIR. Now, after years of construction on the site, the County and this DEIR suddenly claim there are multiple possible triggers for the EIR. This delay of several years while construction was proceeding is and was wrong: an EIR should be ordered at the earliest possible date, before the project owners invest significant time and money, and the community is forced to draw out its objections in repeated presentations to the MS City Council and the County Board of Supervisors, as well as extra-legal forums.

There needs to be an investigation as to whether the delay was intentionally set to let the project proceed in the hopes it would eventual be considered a *fait accompli.* If the County was engaged in intentional stone-walling to achieve a delay, that would be a clear perversion of the intent and purpose of an EIR. The intent of an EIR is to examine its environmental impacts of a **future** project **before** it is started.

One other issue about the process needs attention. **There has been an unacceptable delay in public disclosure of SECOR.** As mentioned, SECOR is a central and essential part of DEIR 4.8, without which the whole of 4.8 cannot be evaluated by the public. Until last week (for 19 years!), SECOR 1998a and 1998b were kept a secret, not available to the public. Public disclosure SECOR less than three weeks before the DEIR comments are due for submission is an apparent violation of the required 45-day public comment period. In response to a letter from Marsha Burch, lawyer for the Gateway Neighborhood Association, requesting the deadline be reset to allow adequate time for a community response to SECOR, Interim Community Development Department Director William Navarre wrote, "...there is no requirement under CEQA to make cited documents available for public review, nor a basis here to require extension of the public comment period." (Letter dated Feb. 21, 2017.) That judgment may apply to documents that are publicly available somewhere (online, public library, government records, etc) - citation only may be sufficient in such cases - but SECOR was not available anywhere **at all**. Either SECOR should have been made available in a timely fashion or not cited at all.

X. Conclusions.

In conclusion, **DEIR section 4.8 is woefully inadequate** in informing the community about possible environmental impacts upon residential water sources and upon future city plans for further use of groundwater in that region. In fact, it is virtually useless in approaching those issues. The DEIR needs to address this issue, based upon real relevant field data and appropriate theoretical analysis, both of which are completely lacking in the DEIR as it stands.

The uselessness of the DEIR in informing the public about hydrological impacts is in no way a reflection on the competency of the DEIR authors. They may be fine scientists. The problem, in my view, is that this whole DEIR project was grossly underfunded, such that adequate studies could not be done. All that could be done was to review, once again, the same old, incomplete, fallacious, and misleading data gathered in 1998. In addition, the time scale allotted for these studies was far too short, barely enough time for the authors to do the writing, much less gather and analyze serious data.

Y. References

Ate Visser, Jean E. Moran*, Amanda Deinhart, Elizabeth Peters*, Richard Bibby, and Bradley K. Esser . 2017. "California GAMA Special Study: Tracers of recent recharge to predict drought impacts on groundwater: Mount Shasta Study Area", Lawrence Livermore National Laboratory Report LLNL-TR-691810

Comments on Draft Environmental Impact Report (State Clearinghouse No. 2016062056) drafted by ENPLAN (City consultants) and approved by MS City Council on Feb. 23, 2017.

Sincerely yours,

Daniel Axelrod

Daniel Axelrod, Ph.D.

Supplement 1 (Davisson) starts on the next page

TO: Daniel Axelrod, The Water Group

March 19, 2014

FROM: M. Lee Davisson, PG

You had requested that I supply some commentary and recommendations on potential influences of new groundwater water production planned with the opening of the Crystal-Geyser bottling plant in Mt. Shasta. As we had discussed on the telephone, the planned production rate of up to one million gallons per day for the bottling plant will only equate to a small fraction of the daily discharge understood to originate from Big Spring located in the same area. This simple comparison seems to alleviate concern for negative groundwater impact caused by the groundwater production. However, I think it is important to point out that groundwater in and around the city of Mt. Shasta is anything but simple. This stems from the fact that groundwater and its emergence as spring discharge is controlled by potentially complex and largely unmapped subsurface conduits created by the volcanic deposits in which they flow. Contrary to most groundwater basins that are formed by accumulation of sediments derived from stream deposits and exhibit inter-granular porosity, recent volcanic material in the Mt. Shasta area comprises successive layers of eruptive material that is non-porous. Groundwater can only reside in this material where it has formed interconnected fractures or buried lava tubes. A porous sedimentary basin lends itself readily to groundwater flow prediction using mathematical modeling based on continuum mechanics. However, this approach fails to achieve the same results for groundwater aquifers comprising fractured material because the occurrence and spatial scale of subsurface conduits transporting groundwater is largely unknown.

Unfortunately, the complexity of the local groundwater in Mt. Shasta only adds to the uncertainty and level of concern for negative impacts. As you articulated to me, the bottling plant would extract water from wells located north of the Big Spring discharge. One question that is fair to ask is whether the water that they pump is the same water as Big Spring? My past research experience using isotope measurements on spring water in this area, Hat Creek Valley, and the Fall River Springs (Davisson and Rose, 1997; Davisson and Rose, 2014; Rose and Davisson, 1996; Rose et al., 1996) has shown me on more than one occasion that waters collected just a few hundred yards apart can have distinctly different recharge sources. This is undoubtedly due to independent subsurface conduits that are not connected. It is reasonable to expect the possibility of the same in the Mt. Shasta area.

I realize that the opening of the bottling plant has positive outcomes for the local economy of Mt. Shasta, and I believe that much of the concern for its possible negative impact to groundwater supply can easily be addressed with simple monitoring approaches. Firstly, determining whether the groundwater produced by the bottling plant in their wells is from the same source as Big Spring can be addressed with some inexpensive oxygen and hydrogen isotope measurements combined with general mineral analysis. Previous measurements we made of Big Spring in 1997 indicated that its water originated at a much higher elevation than comparable springs to the south (e.g., Mossbrae Spring). Note that it would be wise to measure these parameters in Big Spring and the bottling plant wells periodically over the course of a single water year, since recharge sources can change with spring snowmelt. Secondly, your concerns for any negative impact can be addressed by monitoring groundwater levels in wells within the general vicinity of the bottling plant groundwater production, as well as any spring discharges. It is best to start this monitoring as soon as possible because the baseline of natural variability in water levels and spring discharge rates need to be established in order to distinguish it from any impacts from groundwater pumping at the plant. This would not only serve the interests of those concerned about negative impacts, but also those of the bottling plant since they stand to be implicated if any change in water levels and spring discharge were to occur in the absence of baseline information.

One more recommendation is warranted. Attempts to try and predict negative impacts or even no-impact on groundwater levels and spring discharge rates will be fraught with high uncertainty, based on points laid out above. Too little is understood (and likely documented) to estimate impacts at the spatial and volumetric scales of groundwater production planned by the bottling plant. This situation is ideally suited to collect baseline information on groundwater levels and spring discharges instead so that a framework can be established that makes future assessments and decisions better informed.

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Supplement 2 (Austin) starts on the next page

Geology and Hydrology of a Dacitic Satellite Cone in the Southern Cascades: Spring Hill, Mount Shasta

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ABSTRACT

Spring Hill is a small, vegetated satellite dome on the western flank of Mount Shasta that has long been classified as a Sargents-Ridge era andesitic cone (200-300 ky), although recent petrologic data describe it as dacitic in composition (Cowdrey, 2016). Here, the Spring Hill dome is suggested to have extruded contemporaneously with neighboring Black Butte (<10 ky) along a northwest-southeast trending fault which mirrors regional structural weaknesses.

At least two aquifers appear to converge at Spring Hill, where there is a 173' difference in groundwater table in less than a mile. A combination of permeable and impermeable layers is interpreted to cause groundwater to flow at different depths through distinct aquifers in unique directions. A shallow aquifer of percolated water appears to be topographically controlled, flowing south-southwest from the summit of Mount Shasta through poorly consolidated reworked volcanic material. A second, deeper aquifer system appears to be structurally controlled, flowing southeast from Black Butte through older fractured dacite / andesite. The permeability of an intrusive volcanic plug in the inferred fault and its subsequent consequences to groundwater movement are poorly understood. Because the andesite at Big Springs cannot be correlated with the Spring Hill dome dacite, the dynamics of this deeper aquifer remain poorly understood and it is unclear if the water issuing from Big Springs is the same as that tapped by wells within the Spring Hill dome.

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1. INTRODUCTION

Spring Hill is perhaps best known for the clear, abundant water that pours from a series of springs at its base. Known as Big Springs, this water defines the headwaters of the Sacramento River, which ultimately feeds the farmlands of California's Central Coast. Despite its proximity to the town of

Mount Shasta and the recent drought-driven concerns about the sustainability of area groundwater resources, the complex geology and hydrology of Spring Hill are relatively under-studied. This purpose of this manuscript is both to summarize what is known about the geologic strata and groundwater dynamics of Spring Hill and to provide new interpretations of available data.

Spring Hill is located just north of Mount Shasta City and is bordered by Ski Village Drive to the south, residential neighborhoods to the southeast, Shasta National Forest to the northeast, industrial land to the north, and Mount Shasta City Park to the west. The summit of Mount Shasta rises to the northeast, and Black Butte lies to the north-northwest (Figure 1). Spring Hill's peak is 640' above Mount Shasta City Park, the home of Big Springs, where the headwaters of the Sacramento River emerge at the surface.

The majority of Spring Hill is currently owned by Crystal Geyser Water Company (previously owned and operated by Dannon / CocaCola), although a meandering trail to the summit up the southeast side is open to the public and accessible from Ski Village Drive. A sign at the base of the trail states that Spring Hill was “formed by eruptions from unstable fractures on the flank of Mount Shasta. Eventually the fractures reach the magma chamber and generate eruptions called flank eruptions, which in turn produce a parasitic cone.”

2. GEOLOGIC SETTING

A. REGIONAL

Located near the southern end of the Cascades Range, Mount Shasta, at 14,179', towers over the surrounding landscape (Figure 2a). Paralleling the western North American coast from southern British Columbia to northern California, the Cascades are a product of hundreds of millions of years of subduction-generated magmas rising to the surface, as the Juan de Fuca and Gorda oceanic plates in the Pacific Ocean slide underneath the North American plate. The current Cascades are built on the eroded remains of an older volcanic chain that was active between 40 Ma and 17 Ma (Christiansen et al., 1977).

Underlying Mount Shasta, a regional north-south alignment of local faults, volcanic structures, and the orientations of bedrock structure underlie Mount Shasta may reflect a regional zone of weakness (Figure 2b; Christensen et al., 1977; Blodgett et al., 1985). The regional bedrock consists of some of the oldest rocks in northern California, including the 475 Ma ophiolite, in which peridotite is typically altered to dark green serpentine. This ancient oceanic lithosphere was thrust up onto the continent during Mesozoic subduction, and is overlain by younger metamorphic and sedimentary deposits (Mack, 1960).

B. MOUNT SHASTA

Last active about 230 years ago, Mount Shasta is the largest stratovolcano in the Cascade Range by volume and the second most active next to Mount Saint Helens. Shasta has grown through the expulsion of 85 to 90 cubic miles of volcanic material during the past 600,000 years (Figure 2c; Harris, 2005). Around 350,000 years ago, the northwest side of the mountain collapsed in one or more massive landslides and water-saturated debris avalanches. This collapse left a horseshoe-shaped scar on the northern side of the mountain and covered the Shasta Valley with a 45km^3 debris avalanche deposit (Cradell et al., 1984). Since then, Mount Shasta has rebuilt itself by adding many layers of pyroclastic debris and lava during four major eruptive episodes, each from a distinct vent. Three of these vents create a series of overlapping cones oriented along a N-S lineament that includes the modern summit (Christiansen et al., 1977). Shastina, the fourth cone, stands alone as a distinct peak west of the summit.

Each of these episodes followed a similar three-stage pattern that began with an intense cycle of alternating explosive and effusive eruptions of two-pyroxene andesite. This initial phase was followed by andesite-to-dacite dome extrusion into the primary vent and, finally, by a migration of eruptive activity to the flanks of the volcano, where lavas ranging from basaltic andesite to rhyodacite have been erupted from satellite vents or “parasitic cones”(Christiansen et al., 1977, Hirt, 2001). Flank eruptions most commonly occur in areas with a pre-existing structural weakness (Christiansen et al., 1977).

The present shape of Mount Shasta has been significantly altered by two major glaciations, as well as by abundant volcanic activity that began about 10,000 years ago. These Holocene eruptions resulted in the construction of the Shastina and Hotlum cones on the summit, and Black Butte on the western flank (Christiansen et al., 1977). Mount Shasta has erupted every 250 years for the last 750 years, with low-level seismicity consistently apparent as magma moves underground (USGS, 2012).

C. SUBDUCTION-RELATED VOLCANISM

The complex geology of Mount Shasta encompasses a wide variety of igneous compositions, typical for a long-lived stratovolcano associated with a subduction zone. The subducting Juan de Fuca and Gorda plates are created from dense basaltic (mafic) material that was carried by convection currents in the mantle to the Earth's surface. At such divergent plate boundaries, new seafloor crust is continually created as lava spills out onto the ocean floor through a long fissure as two plates move away from each other. As these plates encounter a more buoyant and silica-rich continental plate, subduction occurs and water released from the sinking oceanic plate triggers melting of the overlying mantle wedge (Figure 2a). This primary melt is basaltic and rises into the overlying crust, eventually pooling in magma chambers, where it melts and mixes with crustal rocks to feed volcanoes on the surface. During its ascent, the melt interacts with the overlying crust, incorporates country silica-rich rock (silicic) that changes the chemical compositions of the rising basalts, causing an increase in their viscosities.

Silica creates a network bond, so an increase in its percentage causes an increase in a melt's "stickiness", which has a direct effect on the resulting styles of eruption and volcanic features. Basalts have the lowest percentages of silica, making them the least viscous type of magma. Basalt flows commonly build networks of lava tubes, which allow the lava to flow long distances from its vent. Gas-rich basalt can eject red-black vesiculated scoria to form cinder cones.

The longer a magma body stalls underground, the more differentiated it becomes. Denser and more mafic minerals tend to settle to the bottom of the reservoir and lighter, more silicic melt tends to gather near the top. Volatiles also tend to partition themselves into the melt, causing internal pressures that can trigger eruptive episodes. As melts become more silicic, they tend to become more explosive due to pressure build-up from trapped gases. Large pyroclastic flows can be generated that result in the formation of tuff deposits. Andesite has more silica than basalt, dacite more than andesite, and rhyolite is the most silica-rich melt. Highly silicic melts extrude as cohesive domes and plugs, or as fractured lava flows.

When any composition of magma encounters shallow groundwater, extremely explosive eruptions can ensue as the water superheats to steam, causing a rapid increase in volume and pressure without adequate accommodating space. Overlying strata are forcibly ejected along with highly-fragmented magmatic material, creating a crater in the ground surface surrounded by a tuff ring. Such eruptive behavior is called phreatomagmatic – literally water : magma interactions. Phreatic eruptions are those which result only from steam explosions, without any magmatic contribution.

Primary pyroclastic and lava deposits on the slopes of a volcano experience secondary redeposition through a wide variety of erosive processes, such as glaciers, debris flows, and perennial streams. The resulting sedimentary deposits are commonly poorly sorted with high permeability, draping the slopes and providing a filter for percolating groundwater.

3. SPRING HILL GEOLOGY

Geologic studies and resulting data for Spring Hill are limited. The following sections summarize: 1) Geologic field observations, petrographic analyses, and interpretations of geologic strata, and 2) hydrologic setting, groundwater elevation, and geophysical data. These sections are followed by a discussion and interpretation of the data.

A. FIELD OBSERVATIONS

Deposits along the trail to the summit of Spring Hill are apparently homogenous in composition (Figure 3i), and consist dominantly of very fine-grained, pink to light gray, angular blocky dacite (>90%) with a variable percentage of phenocrysts (sub-mm to 2 mm), perhaps pyroxene (Figure 3a). Phenocryst percentage and size appear to increase upslope. Occasional volcanic, metamorphic, and peridotite xenoliths are observed throughout the stratigraphy, some with red halos, indicating alteration by heat as pieces of the country rock were incorporated into the melt during its ascension (Figure 3b).

Trail-side vertical sections are composed of angular blocks with an average size of 15 mm to 1.5 m in an ash-lapilli matrix. Block size generally increases upslope (Figure 3e-f). It is not clear if these are primary deposits (tuff from volcanic explosions) or secondary deposits (reworked and redeposited tuff due to erosional processes). The only in-situ outcrops observed were at Rocky Point, a small lobe to the east of the summit (Figure 3g), that is apparently composed of the same dacite as the blocks on the slopes. Blocks near this outcrop display flow banding (Figure 3c) and rare pumiceous textures (Figure 3d), consistent with late-stage dome extrusion of a highly-silicic magma (Austin-Erickson et. al., 2010).

B. PETROLOGY

Recent petrographic and XRF studies of rocks sampled from Rocky Point confirm that Spring Hill lava is dacitic in composition, with sub-0.5-mm phenocrysts of plagioclase, hornblende, quartz and clinopyroxene held in a groundmass composed of dominantly trachytic plagioclase (Cowdrey, 2016). The hornblende phenocrysts display 10-27- µm-thick decompression reaction rims, which indicate the magma ascended from depth in 8-12 days. The samples contain 10% microvesicles that are also sub-0.5 mm in size (Cowdrey, 2016).

Black Butte, a nearby silicic satellite dome that has been dated to 9 ky (Harris, 2005), is composed of dacitic rocks very similar in groundmass and overall composition to the Spring Hill lavas (McManta et al., 2006; Cowdrey, 2016). However, the average phenocryst size at Black Butte is larger those at Spring Hill than and the reaction rims on the hornblende are 34-50 -µm thick (McManta et al., 2006). These observations are suggestive of a slower magma ascent (12-30 days) at Black Butte, which is consistent with effusive dacitic eruptions (McManta et al., 2006).

C. GEOLOGIC ENVIRONMENT

Residential and industrial well logs around Spring Hill provide valuable information about the underground geologic strata and unit relationships. Cross-sections created from these borehole data help to characterize the Spring Hill dome (Figures 4-5b).

The N and E sides of Spring Hill create a localized catchment area for glacial fill and other secondary volcanic sedimentary deposits (Qs), which thicken away from Spring Hill, from 15' to 400' (Geosyntec, 2014). These poorly-consolidated Quaternary-aged apron deposits serve as a shallow aquifer whose likely recharge is primarily percolation of surface water, sourced by domestic wells to the east. Unit Qrs refers to resedimented Spring Hill volcanic deposits due to erosion on the dome's slopes.

Because the Spring Hill dome only outcrops at Rocky Point, the rest of its extent must be inferred by well logs. Dome material can be seen in most all of the Crystal Geyser industrial wells (DEX-1 and 2, and DEX 4-7), as well as in well #115464 to the north. All other industrial and residential wells to the east are confined to the Qs unit. Although the drill logs refer to Spring Hill lava as andesite, because the petrographic data indicate it is dacite, it will be called as such here. The Spring Hill dacite (Qd) appears to be consistently highly fractured and, as such, is a good source of groundwater. One additional 20-foot section of 'andesite' is described in DEX-3B, which is both overlain and underlain by Qs deposits and cannot be definitively correlated with the Spring Hill dacite.

Directly overlying the Spring Hill dacite on the east side of Spring Hill is a layer of volcanic tuff (Qvt), described in drill logs as poorly sorted and variably consolidated. A yellow coating on clasts increases in occurrence with depth, and is interpreted here as the result of hydrothermal alteration resulting from intrusion of the Spring Hill dome. This same tuff (Qvt) can be seen at the Spring Hill summit, although in this location it is overlain by a thick layer of cemented tuff (Qct) and is underlain by a pumice-rich deposit (Qpt). A deep layer of pumice at the summit is notable because it is not found elsewhere, and because it provides information about the potential emplacement mechanism of Spring Hill (discussed below). Well #115476 to the northwest of the dome has the only other drill log to specifically note the presence of a highly cemented, apparently impermeable layer (Qct), which overlies Qvt.

Water levels are not the same in each well, differences that likely reflect localized changes in fracture patterns and porosity. Groundwater appears at multiple elevations in some wells, such as in DEX-3B which has two distinct water tables both above and below the andesite lens. In well DEX-6, the primary water source is from the fractured dacite (Qd), although the drill log indicates that additional water seeps in through both the overlying Qvt and Qs units. The andesite through which groundwater emerges at Big Springs cannot be clearly correlated with the Spring Hill dacite and likely results from an older lava flow.

D. AGE

Spring Hill has been previously mapped as a satellite cone from the Sargeants Ridge eruptive period (Figure 1c), though the location and source of this date were not documented (Christiansen et al., 1977). The dome appears very well preserved and is composed of dominantly angular blocks of similar composition that show no evidence of glacial erosion. In light of the recent petrographic studies that show similarities between Black Butte and Spring Hill lavas (Cowdrey, 2016), it is possible that Spring Hill is considerably younger than previously thought, perhaps contemporaneous with Black Butte. Obtaining a date from the outcrop at Rocky Point would be the best way to definitively answer this question.

4. GROUNDWATER

A. OVERVIEW

The summit of Mount Shasta encompasses 7 distinct watersheds, separated by zones of topographic highs and lows, and additionally holds the headwaters of three rivers – the Sacramento, the Shasta, and the McCloud (USDA / USFS, 2012). Spring Hill and Big Springs are located within the Box Canyon watershed, which feeds the upper Sacramento River Basin. The Sacramento River travels southward from its source, eventually irrigating California's northern Central Valley, the United States' most productive agricultural lands (Famiglietti et al., 2011).

Mount Shasta's long-lived and compositionally diverse eruptive history makes for a highly complicated subterranean geology, which creates challenges in accurately assessing the volume and movement of stored groundwater. Sourced from glacial / snow melt and precipitation on the flanks of Mount Shasta, percolated groundwater flows through an unknown network of faults and blocky rubble, basaltic lava tubes, fractured andesite, and tuff units, as well as through fractured bedrock and sedimentary deposits – all with different degrees of permeability. The path groundwater takes before emerging at a place like Big Springs, whose output volume far exceeds other springs on the southwestern slopes of Mount Shasta (California Trout, 2014), is very difficult to determine. Recent isotope studies of the four Big Springs outlets indicate that each is fed from a similar elevation, though travel time is remarkably different, with ages ranging from >12 years to >60 years (Visser et al., 2016).

A report from a 1953 United States Geological Survey investigation of the Shasta valley groundwater summarizes this problem: “The last element – estimating the ground-water storage capacity – was abandoned, finally, because of the difficulty in assigning rational values to the specific yield of the volcanic rocks that underlie much of Shasta valley...” (Mack, 1960).

B. PERMEABILITY OF DEPOSITS

The rock units that compose the slopes of Mount Shasta encompass a wide range of compositions, textures, and depositional styles, differences that form complex networks of groundwater movement and storage through variably connected aquifer systems. Western Cascade andesites are the oldest volcanic rocks exposed in the Box Canyon watershed. These flow deposits are "dense, hard, [and] fine-grained... with joint spaces ranging from a few tenths of an inch to as much as 3 feet... Many springs issue from joints in [these] andesites.. Where joints are not found, the andesite is virtually impermeable.. (Blodgett et al., 1985)." The permeability and inner structure of the Spring Hill dacite are unknown. Although the dome does appear to be fractured along its edges, the inner core may be quite coherent which would limit its ability to effectively filter groundwater.

Overlying the andesite and dacite units are a series of poorly sorted primary pyroclastic deposits as well as reworked glacial and fluvial deposits which create an effective catchment and storage for percolated groundwater (Blodgett et al., 1985). Within these units, however, are occasional, very fine-grained, impermeable tuff layers that can block downward percolation, perching groundwater and creating localized areas of horizontal groundwater flow. Many of the wells within Mount Shasta City tap into an artesian aquifer which may result from groundwater confined within such impermeable ash layers (Blodgett et al., 1985).

C. GROUNDWATER CONTOUR MAP

Groundwater levels are reported in elevation above mean sea level (MSL), with higher values correlating to a shallower water table. Groundwater contour lines can be drawn using these points to create a topographic map of the water table, which can be used to infer groundwater dynamics. Groundwater normally flows perpendicular to the water table elevation contours unless there is an impermeable barrier which causes it to flow along elevation.

Plotted water tables (Figure 6) provide a "snapshot" of Spring Hill groundwater flow patterns, assuming that the reported well elevation data were collected at around the same time. Water levels in some wells can fluctuate seasonally from 1 to 27 feet, whereas other wells demonstrate steady-state conditions and have very little local variability (Blodgett et al., 1985). Because drought and groundwater pumping can additionally alter groundwater flow dynamics, it is important to monitor and interpret changes in groundwater flow patterns over time.

The groundwater dynamics of Spring Hill are not straight forward. The "Lower" well has the lowest groundwater elevation (3524') in the area, whereas the Russo domestic well reports the highest groundwater elevation (3697'). A 173' difference in water table over less than one mile represents a significant change in water level that needs to be understood and accounted for. Rather than looking at Figure 6 as a single hydraulic system, it is more useful to consider it as a three-dimensional slice of groundwater dynamics within different aquifer systems at different depths, which intersect around the area of Big Springs.

The data suggest the presence of at least two aquifer systems at Spring Hill: one shallow and one deep. The geologic data confirm that the shallow water tables are located in the Qs unit (poorly-consolidated sediments from secondary erosion processes). The water table in these surface sediments appears to deepen to the southwest, consistent with reports by Geosyntec (2014) on Crystal Geyser property wells and by Harrison/Roberts (2015) on the Gateway Neighborhood wells. This flow direction is also in agreement with the direction of surface water flowing southwestward from the summit of Mount Shasta (Figure 2c). Because the recharge source for this aquifer is likely dominated by precipitation on Mount Shasta's slopes, it is assumed that the source of the water for this aquifer is the Box Canyon watershed.

A deeper aquifer system occurs in fractured andesite / dacite, though the relative ages and connectivity of these units are unclear. Groundwater contours indicate that water is flowing southeast from the general direction of Black Butte (Figure 2c) and is likely a primary source of water for Big Springs, where it flows out of jointed andesite. These data are consistent with a reported primary southeast groundwater flow direction for the Spring Hill area in 1985 (Blodgett et al.). It is unknown how this andesite aquifer interacts with the Spring Hill dacite because very little data exist for the contact of these units on the western side of the dome.

D. LIDAR

Lidar mapping is accomplished aerially by using a laser to scan the ground surface of an area, exposing weathering and rock patterns that may otherwise be obscured by vegetation and development. A Lidar survey of Mount Shasta (USGS, 2014) is a helpful tool in mapping the apparent characteristics and extent of geologic units, as well as the resulting topographic controls that are likely to influence groundwater flow. The poorly consolidated sediments that comprise unit Qs to the north and east of Spring Hill can be identified in the Lidar map as a delta-like catchment of draped sediment eroding off of upper slopes of Mount Shasta (Figure 7A). The extent of this unit appears to be controlled by topographic features, such as the long lobe of lava extending eastward from the base of Black Butte and a ridge that runs north from Spring Hill. These topographic highs additionally define the edges of a morphologically distinct, rocky-appearing unit around Black Butte, which is likely related to the Big Springs andesite.

Ephemeral streams and surface drainage patterns observed on the surface of the Qs unit may arguably be used to extrapolate shallow percolated groundwater flow directions. These surface channels indicate that as sediment 'slumps' down gradient, it appears to 'bank' off of topographic highs to the north and west and flow around Spring Hill, gradually becoming funneled in a southward direction toward the city of Mount Shasta. The surface morphology of Spring Hill suggests that the nose on it southwestern base acts as a 'mirco-catchment'', creating a shoulder of piled-up sediment along its eastern edge (Figure 7B).

E. SELF POTENTIAL GEOPHYSICAL DATA

Self potential passively measures differences in natural ground potentials which can provide information about features that create electrical anomalies, such as groundwater flow, structural features, and buried ore bodies. Because negative electrons flow upgradient, the direction of groundwater flow can be inferred as moving perpendicular to positive contours (Wiley, 1997). As such, strong negative anomalies can either be caused by topographic highs or by underground features, such as appears to be the case for the strong negative anomalies to the east of Spring Hill (i.e. at the top of the dashed red arrow in Figure 8).

These features are associated with a southern flow of groundwater along the edge of the Spring Hill dome and are not associated with a topographic high. Rather, they likely result from water being deflected by impermeable layers along the southeastern edge of the Spring Hill dome and/or water flowing along a fault path. The borehole stratigraphy of this zone indicates that the edge of the dome is somewhere between DEX-5 and DEX-3, which correlates precisely with the SP anomalies. Thus, the primary aquifer in Figure 8 is indicated by the dashed red line and appears to be structurally controlled, while minor groundwater inputs are indicated by the smaller, solid red arrows which correspond with percolated water flowing south and east off the surface of Spring Hill.

4. INTEPRETATIONS

A. EMPLACEMENT OF SPRING HILL ALONG A FAULT

Spring Hill appears to have formed from a small pulse of viscous dacitic magma that quickly made its way up from a magma chamber beneath Mount Shasta through a weakness in the pre-existing rock to erupt along the southwestern flank of Mount Shasta. Eruptive dynamics and timing of the Spring Hill dome emplacement remain speculative though it is not uncommon for tuff rings and small domes to form from small 'burps' of magma in the vicinity of larger domes of similar composition (i.e. Austin-Erickson et al., 2008). Because the underlying structure of Spring Hill is unknown, the degree of permeability and volume occupied by this hardened igneous mass are similarly unknown. The outermost 'rind' of a dome is commonly brecciated, though such permeability cannot be assumed to extend into the dome's center (Manley and Fink, 1987; Goto et al., 2004).

The apparent increase in both block size and phenocryst percentage upslope suggest the tuff units exposed on Spring Hill's slopes are of primary deposition rather than result of erosion and secondary redeposition. Dacitic magmas produce tuff during explosive eruptions, which could result from any combination of magmatic, phreatic, or phreatomagmatic behavior. The rapid ascent rates indicated by hornblende reaction rims are suggestive of phreatomagmatic or phreatic eruption, which ensues quickly due to the release of overburden pressure (Figure 9). In such a scenario, as groundwater is locally depleted and/or rising magma congeals into an impermeable conduit, the eruption can transition to dominantly magmatic behaviour, eventually resulting in the doming uplift of its own crater - a well-documented eruptive sequence at other silicic centers extruding through groundwater (i.e. Austin-Erickson et. al., 2010; Austin-Erickson et. al., 2008).

Vesiculated dacite (pumice) is the result of gas being released from the rising magma at the time of fragmentation. The lack of visible vesicles in surface deposits is suggestive of either rapid fragmentation prior to degassing (likely related to phreatomagmatism) or effusive extrusion after degassing. Pumice deposits within the dome could represent crater facies from magmatic explosions, or alternatively could result from exsolved gases trapped beneath a cemented cap as the dome intrusion cooled, a textural sequence commonly observed in rhyolitic domes (Manley and Fink, 1987). The latter sequence could result from the Spring Hill dome non-explosively pushing up older deposits, only extruding onto the surface at Rocky Point. Although this seems unlikely given the rate of ascent, it could account for the Sargent's Hill date of Spring Hill if older slope material was sampled rather than primary lava flow.

The long axis of Spring Hill trends northwest-southeast, in line with Black Butte (Figures 1A and 4), evidence for the presence of a fault or fracture network along this well-defined regional lineament, through which magmas erupted to build both Black Butte and Spring Hill. The compositional and eruptive similarities as well as the clear structural alignment between Spring Hill and Black Butte are additionally suggestive that they are from the same time period and formed from magma extruding along a structural weakness. The groundwater contours define a sudden and dramatic hydraulic jump along this lineament, which, along with geophysical anomalies and the presence of highly fractured underlying rocks, further suggests the presence of a fault along the eastern side of Spring Hill.

B. INTERACTION OF MULTIPLE AQUIFER SYSTEMS

Morphologic, hydrologic, geologic, and chemical data suggest that at least two distinct aquifers are interacting at Spring Hill. A porous shallow aquifer through unconsolidated sediments appears to be topographically-controlled, whereas a deeper aquifer system through fractured dacite / andesite appears to be structurally-controlled. The amount of vertical groundwater movement between these systems is unknown, though some degree of connectivity is indicated by self-potential anomalies along the eastern edge of Spring Hill (Figure 8). The large output volume of Big Springs likely results from the intersection of these different water sources.

Groundwater percolating through the shallow aquifer in unit Qs does not appear to take a linear path from the top of the mountain but follows a winding journey as it is deflected off and funneled by localized topographic highs. There appears to be multiple drainage patterns within the Qs unit, however, and local changes in porosity and water movement are likely controlled by discontinuous layers of permeable and impermeable strata. Such complexity is reflected by water isotope data which reveal a range of groundwater ages within the Qs unit (Visser et al., 2016). It seems likely that this water would have a shorter residence time than water travelling in deeper aquifers, which would make it more susceptible to drought conditions when surface water is limited.

Groundwater dynamics within the deeper fractured zone are harder to constrain because fracture network, water source, flow path, and the relationship between andesite and dacite are not known. The recharge area for this aquifer system could be from anywhere on the mountain, or from a combination of sources, and residence time for water in this aquifer is likely longer than for shallow percolating groundwater. It is important to note that residence time refers only to the time the water has spent underground and does not indicate the potential reserve held within an aquifer. Data are insufficient to estimate how much water is stored within this deeper aquifer, or how many years of water our current usage rates will provide us.

The dynamics of groundwater from multiple channels intersecting within a fault zone at the edge of a silicic intrusion present a complicated hydraulic situation with many unknowns. Groundwater dynamics along the eastern side of Spring Hill appear to be particularly complex because the degree of permeability underneath and along the edges of Spring Hill remain unclear and it is not known how much water filters through Spring Hill versus deflecting around it. The outcrop of Rocky Point can be connected to a larger lava-flow-like feature with an apparent planar orientation on the northeast side of the dome (Figure 7B), where steep groundwater contours suggest this potentially fault-controlled geometry (SECOR, 1998) locally deflects groundwater flow along a plane that extends to the southeast.

Fractured dacite in well logs on the eastern side of Spring Hill cannot be definitively correlated with the andesite aquifer of Big Springs and thus could reflect a localized system of groundwater movement along the eastern side of Spring Hill that is controlled by faulting and the intrusive Spring Hill dome. Additionally, the knob at the southwestern edge of Spring Hill allows for the accumulation of unconsolidated sediments that likely trap shallow percolating water flowing south along the eastern edge of the dome.

5. CONCLUSIONS

Petrographic, morphologic, geologic, geophysical, and hydraulic data suggest that Spring Hill is a dacitic dome that intruded along a northwest-southeast trending fault in line with local and regional structural weaknesses. It is suggested here that Spring Hill's emplacement was contemporaneous with Black Butte, which would make it significantly younger than previously thought. At least two aquifer systems appear to converge at Spring Hill, one flowing southeast through deeper fractured andesite / dacite, and one flowing south-southwest through shallow overlying poorly consolidated sediments. Some degree of connectivity between these aquifers is indicated by the data, though the volume of water flowing through each aquifer and degree of interaction between them are not known. The fractured dacite aquifer reported in drill logs from the eastern edge of Spring Hill does not appear to be connected to the andesite unit of Big Springs and is likely a result of complex localized structural controls on the geology and hydrology of this area.

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Allison Austin received her B.S. in Geology from Guilford College in 2002, and her M.S. in Geology from Northern Arizona University in 2007, specializing in the eruptive dynamics of silicic magma through shallow aquifer systems. She expanded on this work during a year-long Fulbright grant to further study the phreatomagmatic fragmentation mechanisms of rhyolite. This research resulted in two publications in peer-reviewed journals. She has spent 15 years working professionally as a scientist and researcher for a variety of projects, including as an environmental consultant for Superfund clean-up initiatives. She is currently pursuing her Ph.D. in volcano infrasound. Her area of expertise is directly related to the geology of the Spring Hill area.

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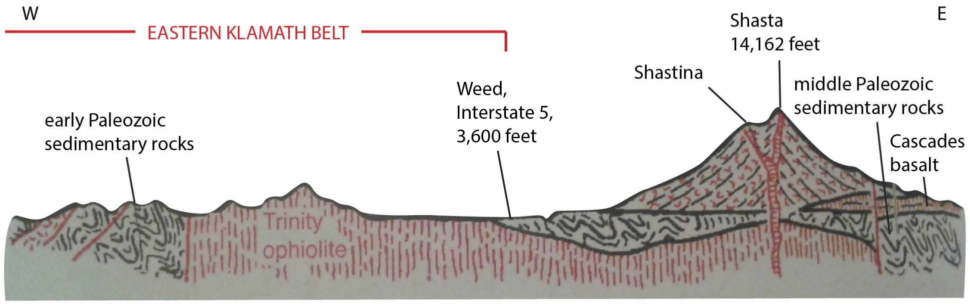
A. Aerial view from Google Earth (looking north) of Spring Hill's long axis alignment with Black Butte.

B. The view to the northeast from Hatchery Lane in Mount Shasta.

C. Looking northwest from the Mt. Shasta City Park entrance.

Figure 1: Views of Spring Hill.



B. Schematic geologic cross-section at Weed illustrates that Mt. Shasta intruded through basement rocks of the Eastern Klamath belt, which are faulted along a N-S trend.
- Reproduced from Alt and Hyndman, 2000; adapted from Wagner and Saucedo, 1987.

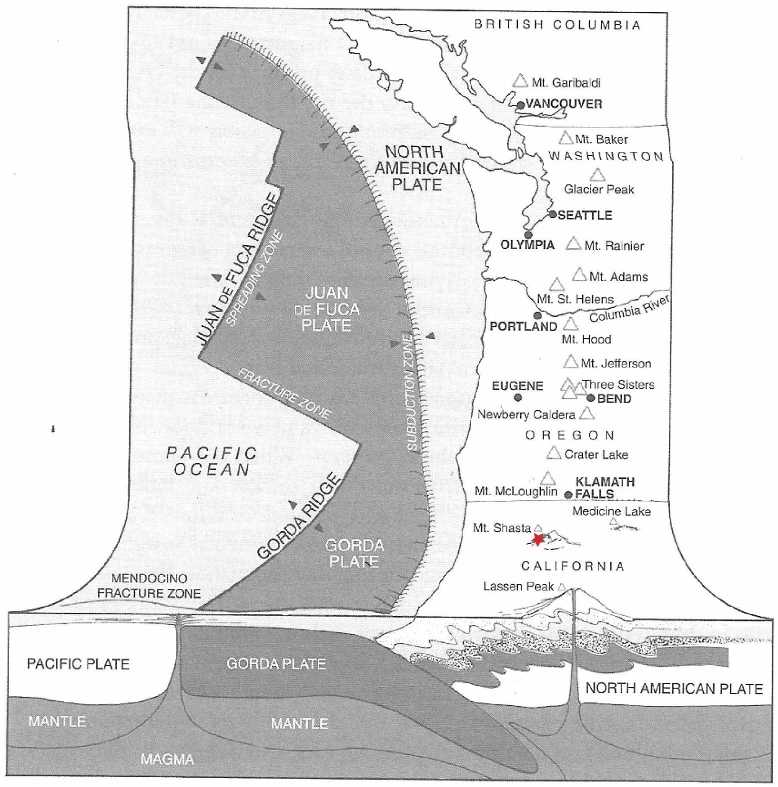
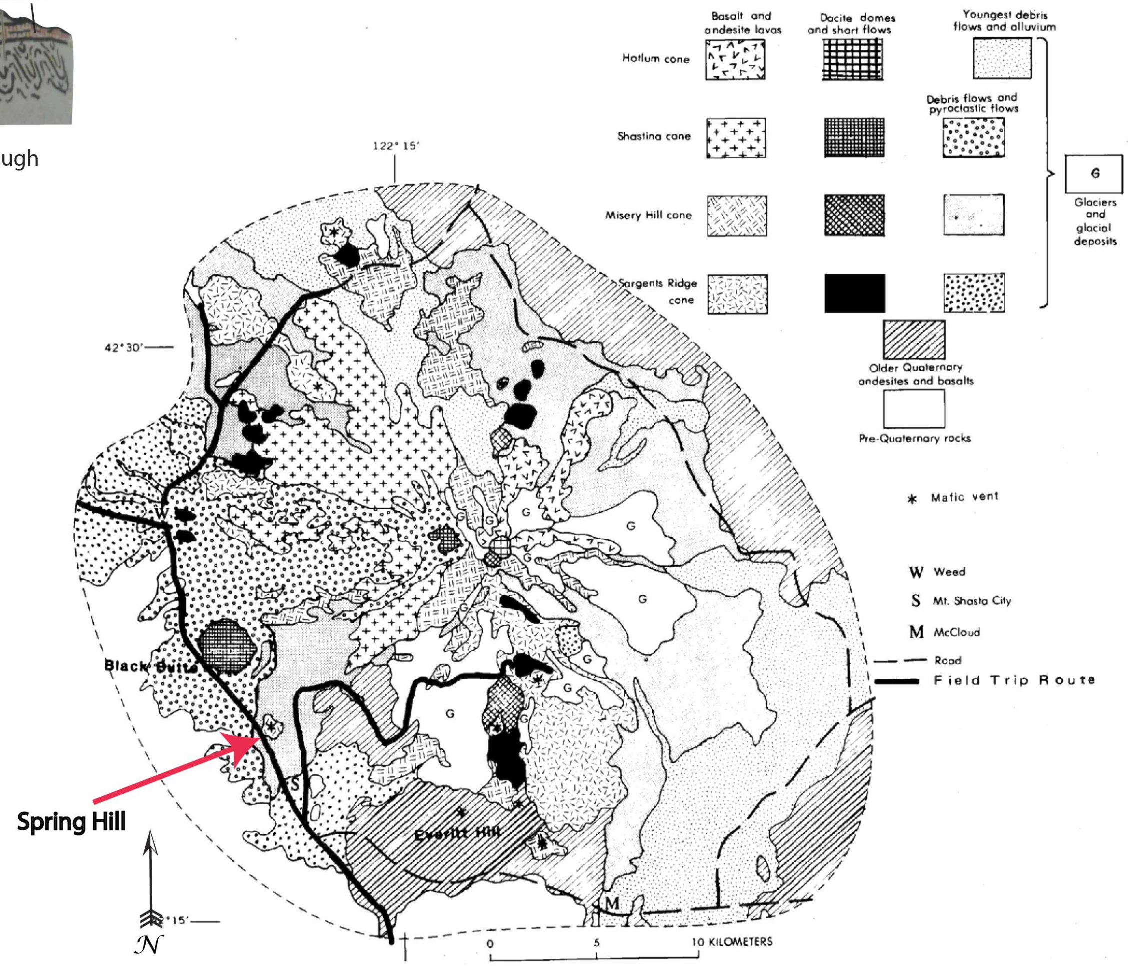


Plate movement along the northwest coast of the United States. The Juan de Fuca and Gorda crustal plates are slowly sliding under the western margin of North America. Subduction generates magma beneath the edge of the continental plate, providing fuel for the Cascade volcanoes. —Adapted from B. L. Foxworthy and M. Hill, *Volcanic Eruptions of 1980 at Mount St. Helens —The First 100 Days* (U.S. Geological Survey Professional Paper 1249 [1982])

-Reproduced from Harris, 2005

A.



C. Mount Shasta geologic map.
- Reproduced from Christiansen and Miller, 1989

Figure 2: Geologic setting of Mount Shasta and Spring Hill

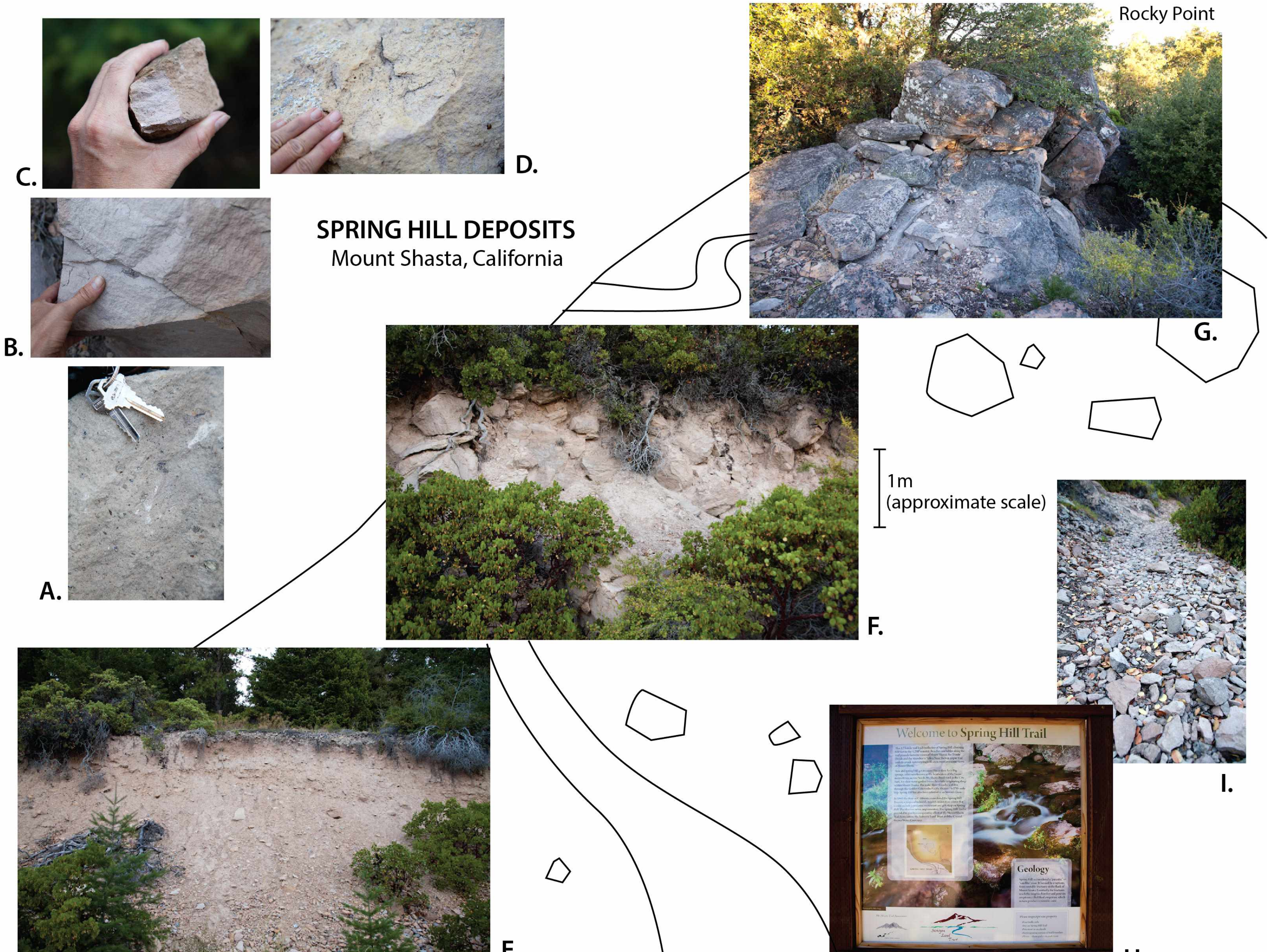
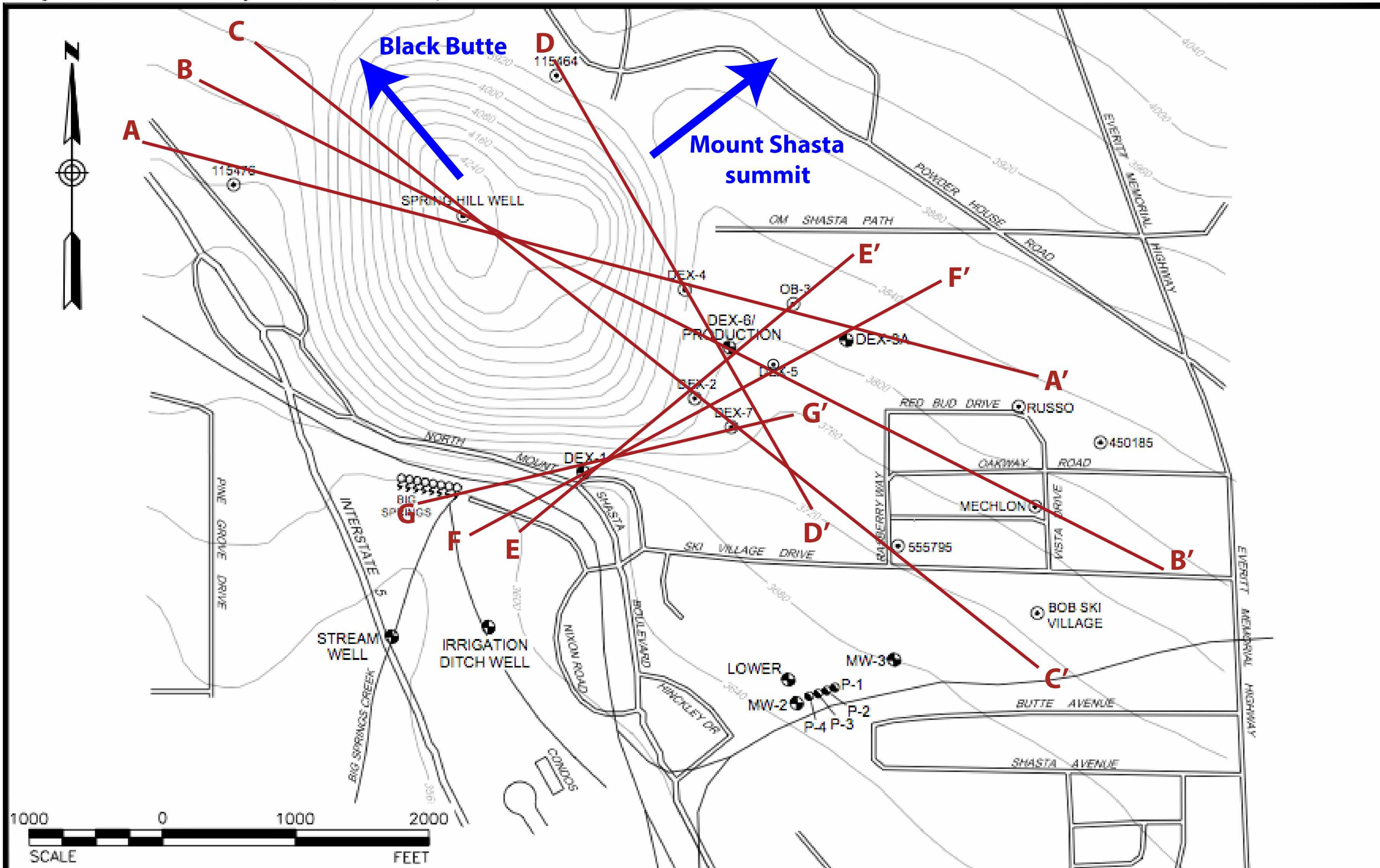


Figure 3

8/13/2015, Allison Austin

Drawing file: 12397477-F1-SITEVIC.dwg Mar 05, 2013 - 1:39pm



LEGEND

- DEX-3A MONITORING WELLS PART OF QUARTERLY MONITORING PROGRAM
- 450185 OTHER MONITORING WELLS
- P-1 LEACHFIELD PIEZOMETER

Base Map
Golder Associates
Sacramento, CA

PROJECT No. 12397477 FILE No. F1-SITEVIC CADD JDR DATE 03/05/13

SITE VICINITY MAP

Overlay: 2/15/2017, Allison Austin

Figure 4: Cross-section transect locations

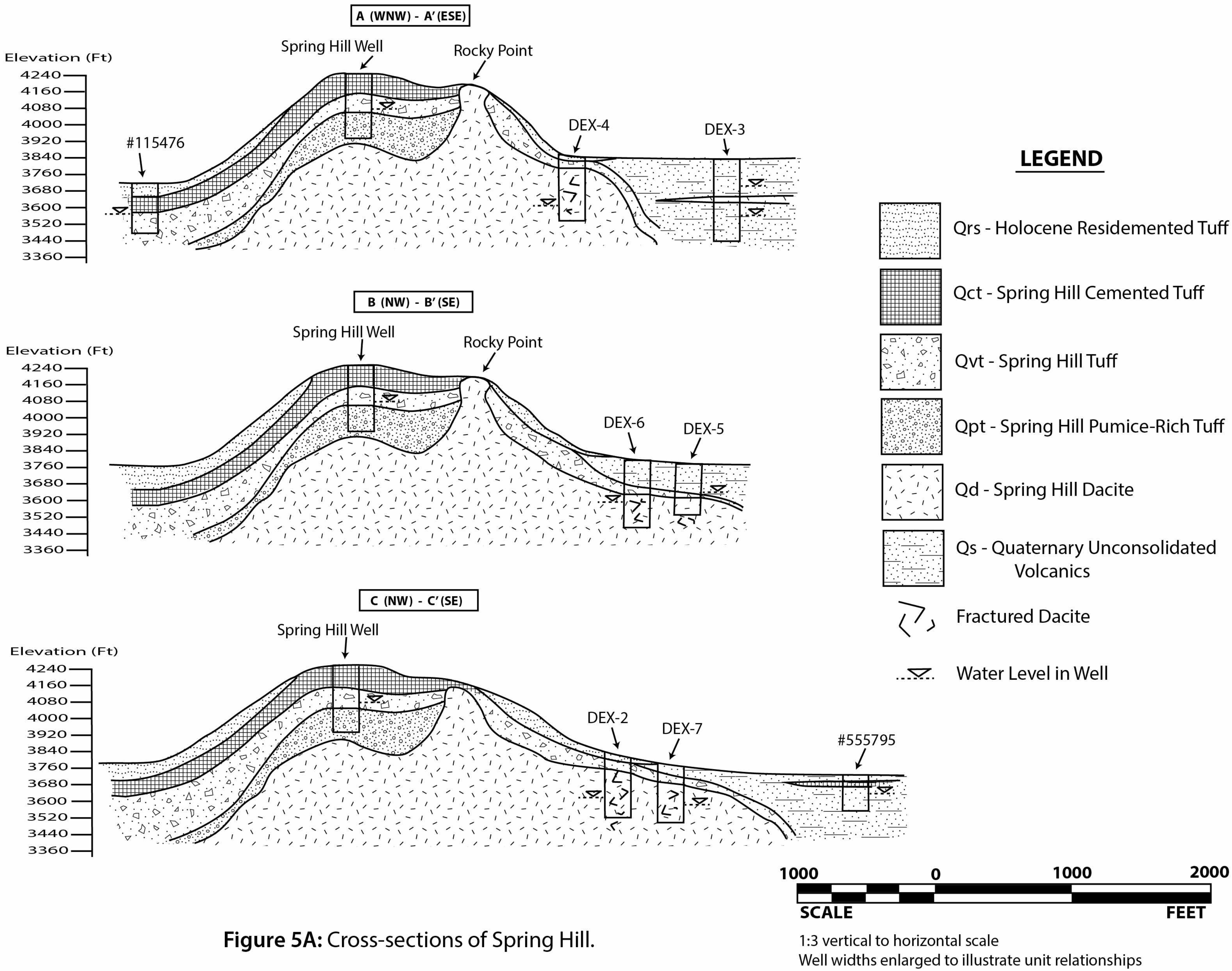


Figure 5A: Cross-sections of Spring Hill.

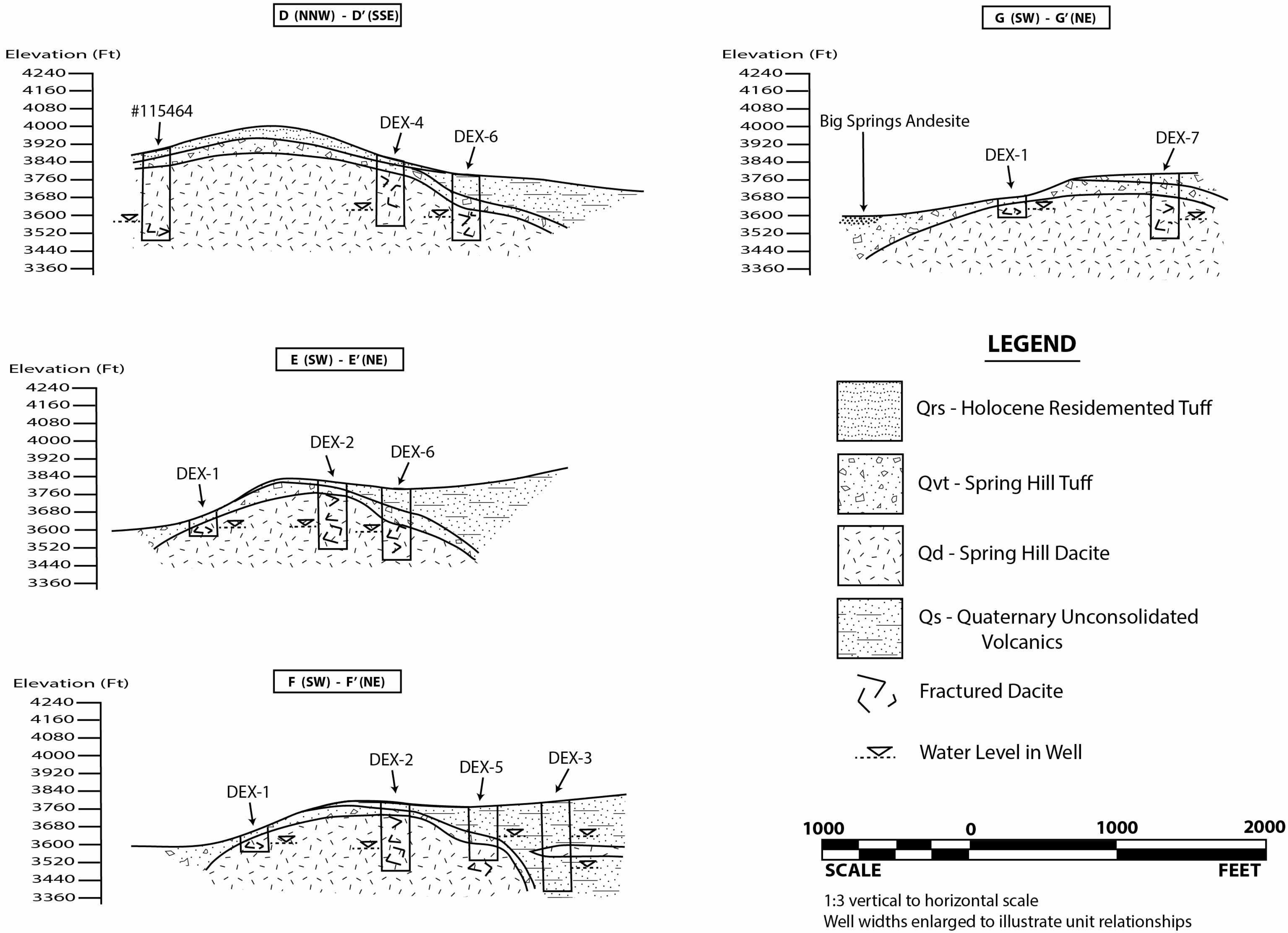


Figure 5B: Cross-sections of Spring Hill.

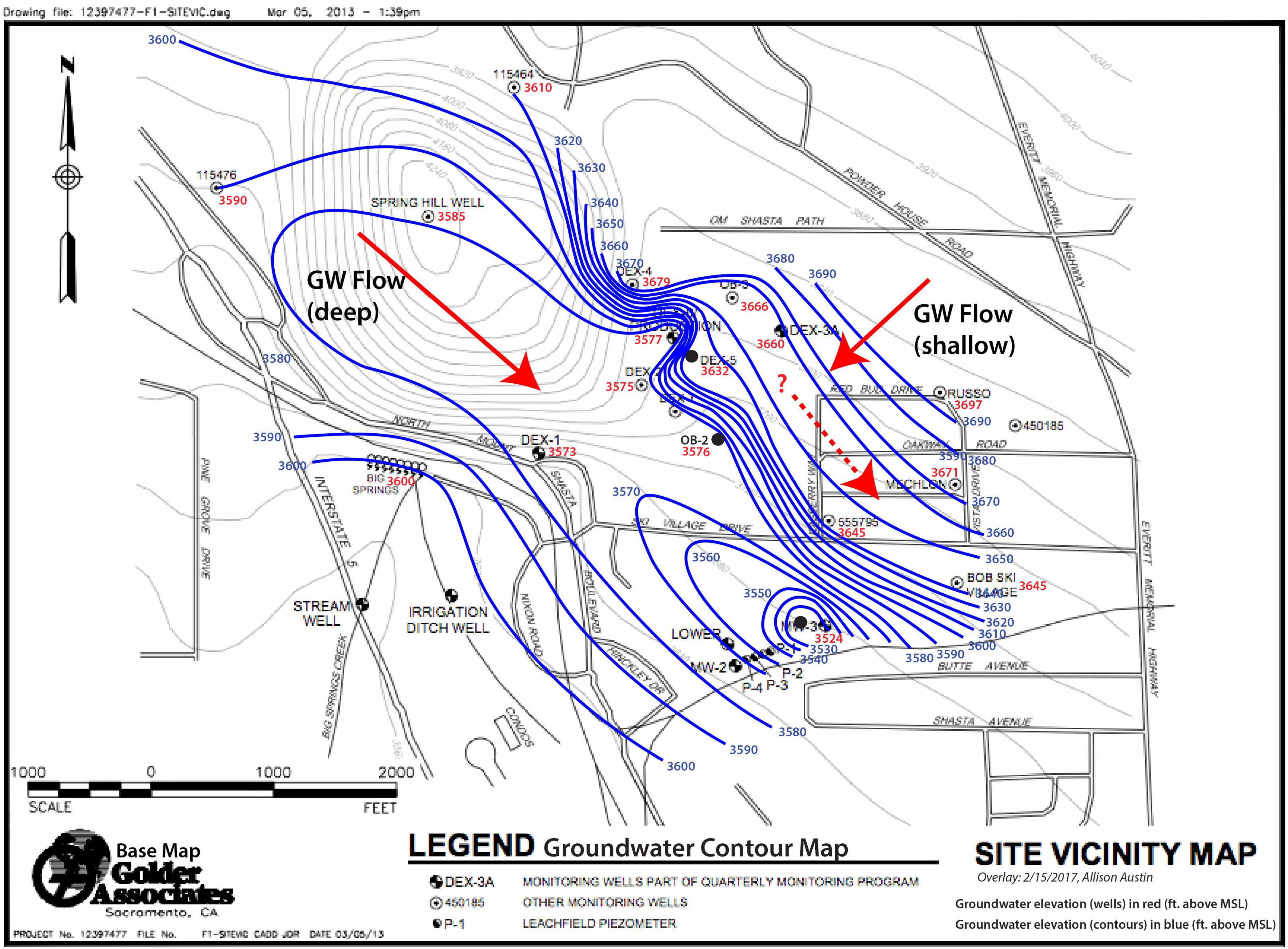


Figure 6: Spring Hill groundwater elevation and inferred flow directions for both shallow and deeper aquifers.
Groundwater elevation data marked in red are from Fig 5-1 and Fig 5-2, respectively, in CH2MHill, 2001 .

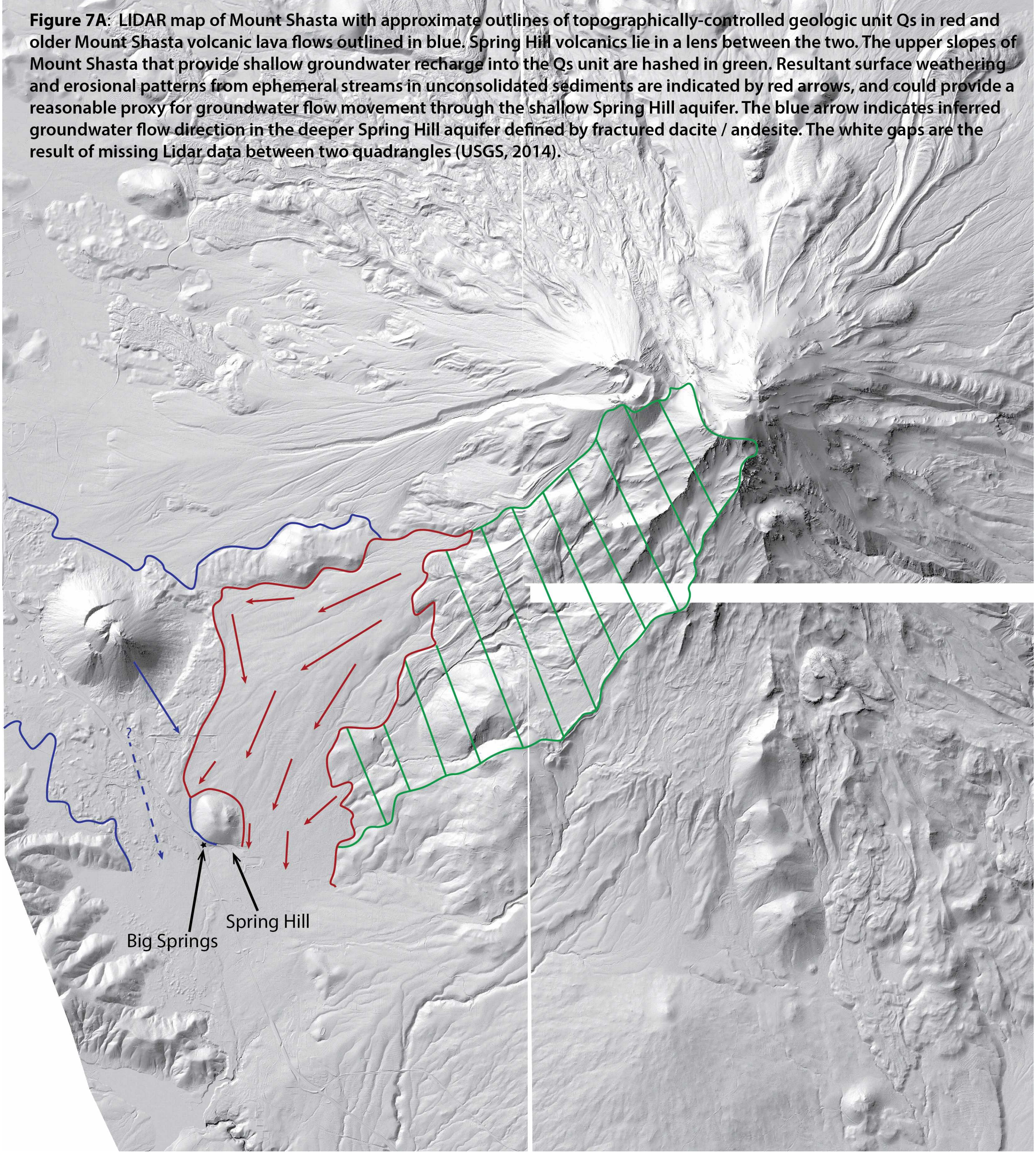


Figure 7A: LIDAR map of Mount Shasta with approximate outlines of topographically-controlled geologic unit Qs in red and older Mount Shasta volcanic lava flows outlined in blue. Spring Hill volcanics lie in a lens between the two. The upper slopes of Mount Shasta that provide shallow groundwater recharge into the Qs unit are hashed in green. Resultant surface weathering and erosional patterns from ephemeral streams in unconsolidated sediments are indicated by red arrows, and could provide a reasonable proxy for groundwater flow movement through the shallow Spring Hill aquifer. The blue arrow indicates inferred groundwater flow direction in the deeper Spring Hill aquifer defined by fractured dacite / andesite. The white gaps are the result of missing Lidar data between two quadrangles (USGS, 2014).

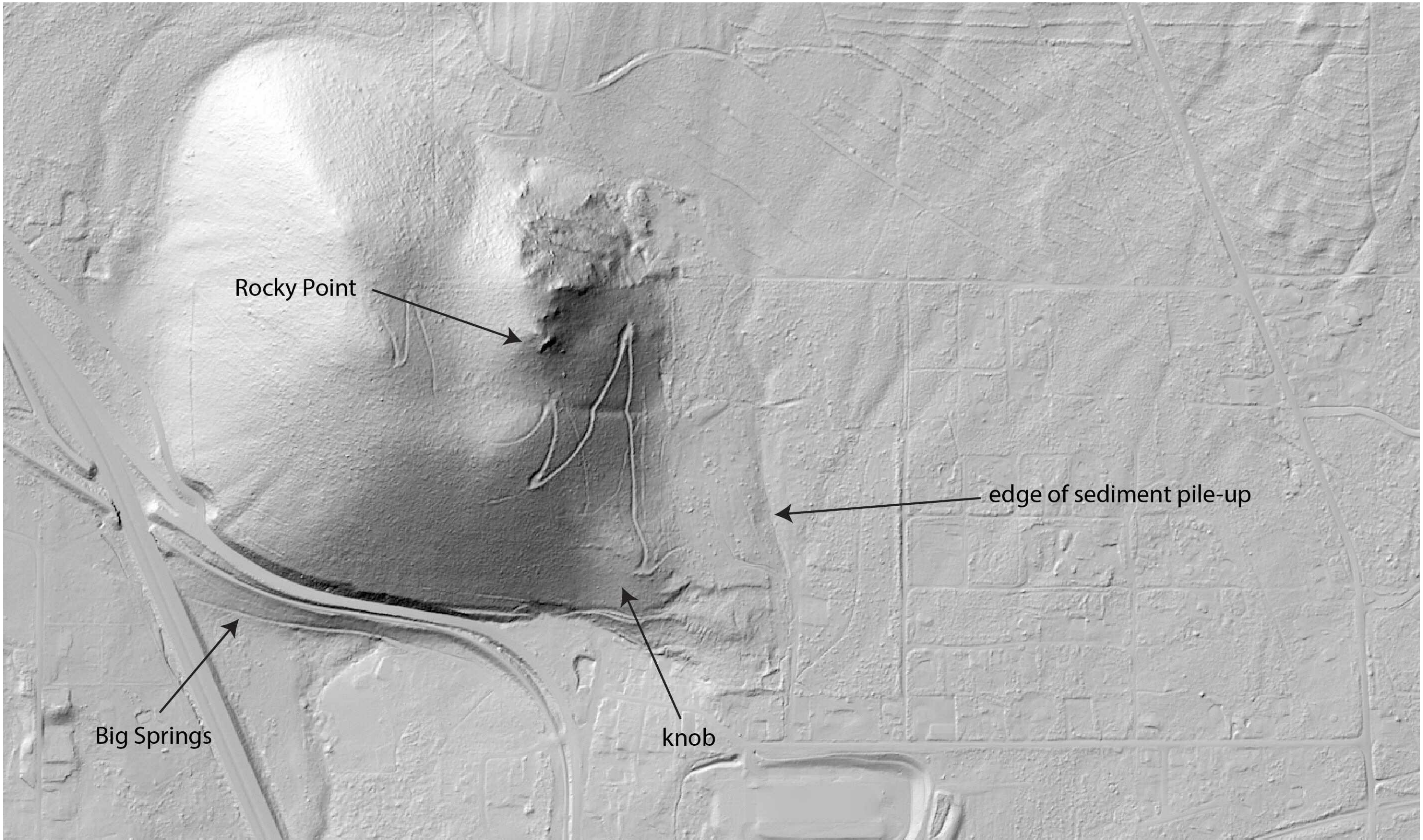


Figure 7B: Close-up Lidar image of the Spring Hill area. Notice the morphology of Rocky Point and, on the hillside below it, a rocky plane visible with an apparent northwest-southeast orientation. Also notice the sediment 'pile-up' on the eastern side of the dome between the rocky plane and the bottom-most knob.

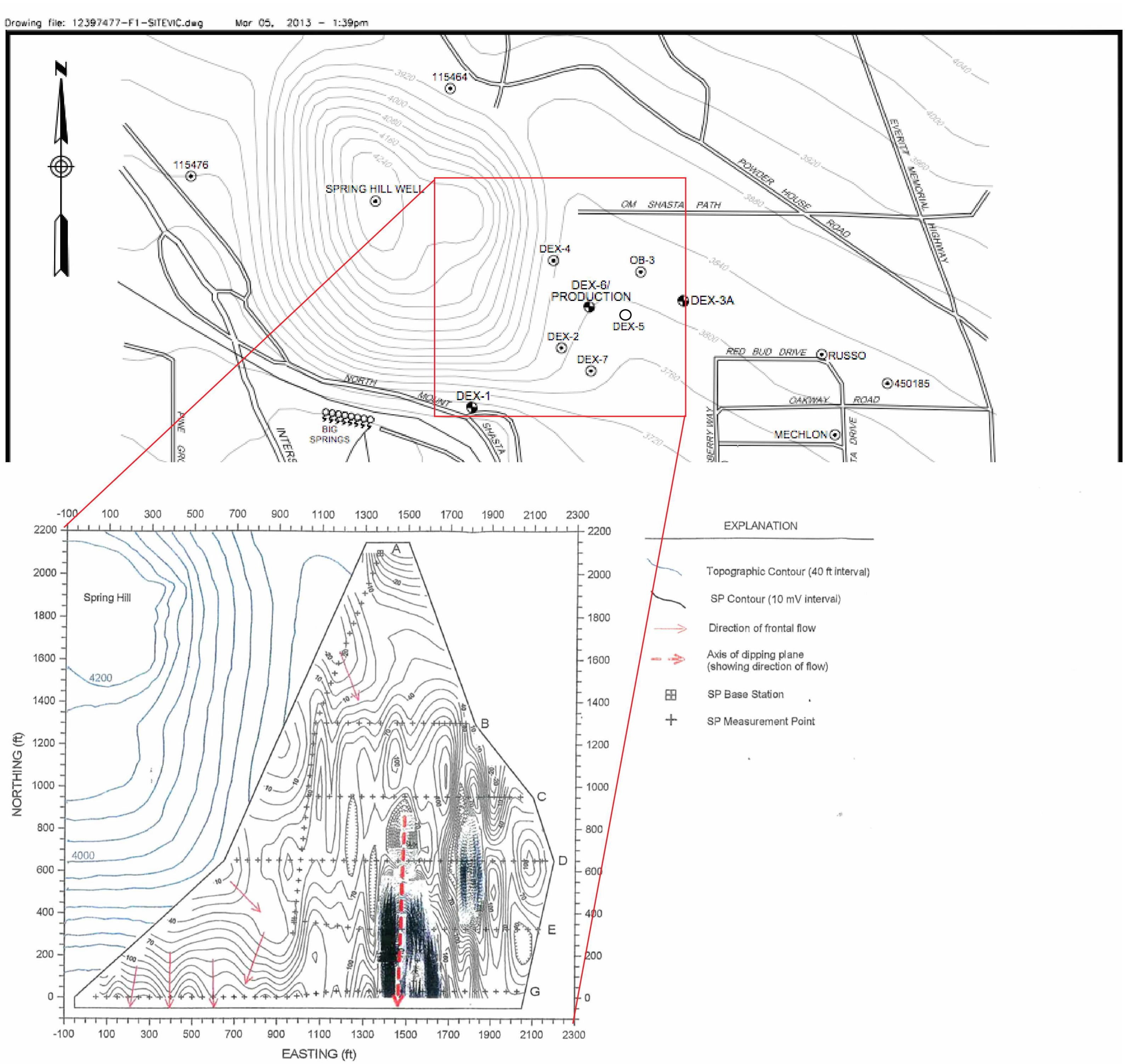


Figure 8: Self potential measurements calculated in the southeastern area of Spring Hill (SECOR, 1998), with results that indicate an apparent structural control on groundwater movement within the sediment 'pile-up' to the east of the knob. Major and minor groundwater flow directions are indicated by the red arrows.

NORCAL GEOPHYSICAL CONSULTANTS INC.

JOB #: 97-415.03
DATE: 9/97
DRAWN BY: SPD
APPROVED: WGB

SURVEY LOCATION:
BIG SPRINGS
MT. SHASTA, CALIFORNIA
CLIENT: SECOR

SP CONTOUR MAP
STREAMING POTENTIAL SURVEY

PLATE 2

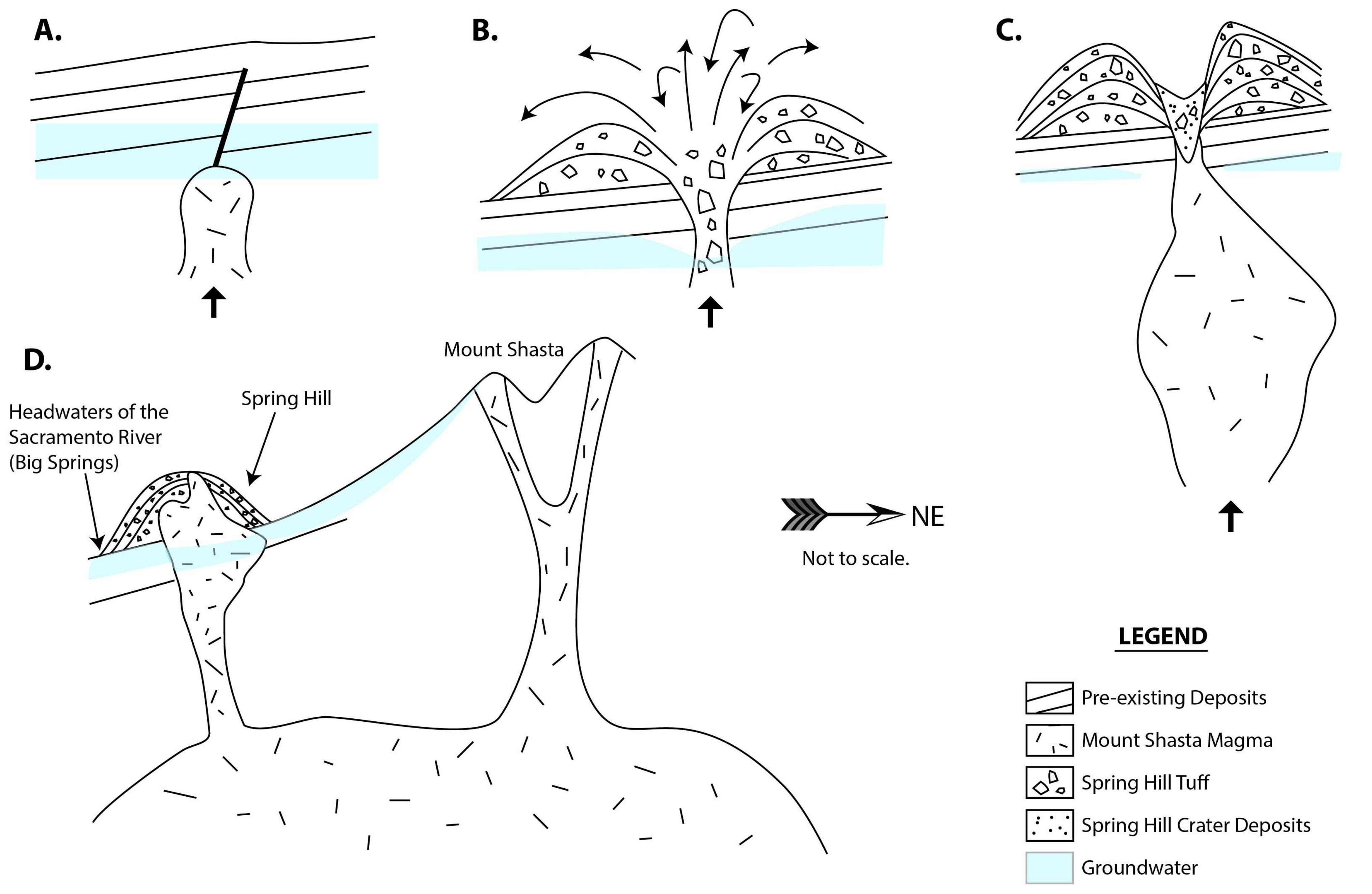


Figure 9: Schematic cross-sections illustrating a potential phreatic / phreatomagnatic emplacement mechanism and resulting internal of Spring Hill dome. [Note: This is an oversimplification of a complicated process, and it is unlikely all of Mount Shasta's eruptive centers are being fed from one central magma chamber.]