DOCUMENT REVIEW COMMENT FORM—(AZ STATE PARKS)

Commenter	Chapt	Section	Pg	Line	Comment/Change requested

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Casavant	3- Affected Environment and Environmental Consequences	Geology, Minerals, Paleont Issues, Cause and Effect Relationships of Concern	1	26	"The potential for subsidence to occur is linked primarily to groundwater withdrawal. " It may be possible that undrilled, mis- or unidentified cave or dissolution features (hypogenic) could be missed or still might exist at depth below the current water table). Many cave experts understand that various caves in the SW exhibit directly or imply a hypogenic stage on their history. Dissolution processes and outcomes, produced from upward migration of heated brines (geothermal) along faults, fractures and bedding planes from fault reactivation and transient associated pressure releases from past and modern seismic events had also produce additional rock deformation, and/ changes to overburden pressures. Assocciated hydrosulfuric acid production and resultant dissolution have been tied to the process for not only caves genesis in carbonate- / evaporite-rich strata, but also for the emplacement of economic or other mineralization (e.g. metasomatism) at local and regional scales. It is theorized that the early genesis of many caves in the SW and SE AZ was most likely initiated through combinations of these processes. Later tectonic deformation, uplift, isostatic unroofing, and other exhumation/erosional processes lead to the removal of overburden. With sufficient loss of overburden processes epigenic processes involving vadoic (above the watertable) carbonic acid production, infiltration and depositional processes in air-filled caves and voids. Continued dissolution, removal, and/or re-deposition of calcium carbonate and/or other speleogenic minerals and features in SE AZ caves characterize more recent cavern formation as a result of more Quaternary climate changes and basin erosion, downdropping that resulted in reduced recharge and lowering of water tables. Thus, collapse associated with rock mechanical failure above dissolution corridors and caves as overburden removal and water table changes occur is plausible to consider, even though this was not recognized and/or currently acknowledged from surface or shallow subsurface mapping and drilling programs. ______________________ ********* Subsidence **Pg. 25, line 37**—It was noted here that cave-karst elements can play a role in ground subsidence, and that genetic processes and linkage to groundwater changes is plausible. The risk for subsidence in the highly mineralized pit may be low, but that risk may not hold in regions within or outside the pit where mineralization is decreased or absent, and where rock deformation and resultant fluid pathways are still29 exist.

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Casavant	3- Affected Environment and Environmental Consequences	Geology, Minerals, Paleont Analysis Methodology, Assumptions, Uncertain & Unknown Information	2	20-21	"The **probability** of finding paleontological and cave resources can be broadly predicted from the geological units present at or near surface." …. True in part--but maybe not so much. The statement is largely unsupported, statistically or otherwise, in relation to caves. Oil geologists learn early in carbonate stratigraphy training that reservoir properties are heterogeneous in small and large ways- laterally and vertically. Small and larger facies changes and intra-formational parasequence boundaries can and do result in changes to subsurface porosity (storage) and permeability (void connectivity) (mostly secondary) across and within carbonate units. The idea of "pure limestone" (no insoluble residues) hardly exists in the SE or elsewhere in the Paleozoic carbonates. Hoag et al, 2012 and Spencer (2012) commentary provided to the CNF elect to reveal select list of examples of "known" caves and summations or opinions on modern karst and paleokarst developments. The caving community is familiar with many caves that what is is published. Much of the data and locations are known to the CNF. It seems that there is an implication to the presence and likelihood of caves in the Paleozoic units are common to Colorado Plateau and central AZ "transition" regions, as well as SE AZ, but a wobbly case that the degree of hosted mineralization in SE AZ deduces the likelihood of cave formation at the proposed mine site is practically nill because the host rock has been completely changed in its dissolution character—and because no caves have been found in the immediate area. It seems scientifically unsupported to imply that the greater the distances of known caves (humanly accessible features) from the proposed pit site, the lower the chance that cavern formation in or near the immediate area (or any other area that hosts both intensively or moderately deformed and mineralized carbonate strata for that matter). Studies abound in the cave science, geoscience and geological engineering literature that caution strongly against employing such local or distal assumptions. The 2012 reports to the CNF team also imply that groundwater interconnectivity and behavior within the Rosemont area is well understood (and therefore, capable of being modeled to a high degree of accuracy) . The implication relies is largely on standard geologic surface mapping that had targeted mineral exploration and not cave exploration. The absence and size of exposed various surface dissolution and cave features were brought to play, as well as a lack of identified encounters with cave features during deposit and overburden drilling program were used as basis for lowering the risk. It is good to be cognizant that drill patterns, drilling objective or expertise might not have been cognizant of when/if a featured was drilled----In fact, studies at other cave sites (e.g. Kartchner Caverns) reveals that many subtle and even some obvious karst features at the surface went unrecognized for decades by seasoned field and mining geologists who roamed the area and even mapped the cave-bearing hills. Studies now reveal that various subtle topographic elements are spatially and genetically linked to significant epi-karst processes and cave features that lie just tens to 100s of feet below the surface. Who knew, right? For centuries, no one—and even for 2 decades after these remarkable caves were discovered. As petroleum geologists and engineers know well, one is best to "bank" on the utility and value of interpreting and blending a diverse array of both subtle and obvious geological data and clues in order to get "closer to right" and to set a range of scenarios that risk analyses can integrate and test outcomes. Some of these data on cave and structure that various CAs shared with the CFS, although provided in review of the DFEIS (e.g. travertine at Scholefield spring, hi-res geo and drainage lineaments that overlay and align with mapped faults, fracture sets, etc), none of this information and perspective made it's way into documentation for CA review of the draft FEIS ---Additionally, in the identification of deep and shallow subsurface karst and caves, important drilling parameters (RPM, drill rates, pump rates, return annular flows and rates, torque, hole deviations, etc.) are compared/contrasted with core and rock cutting information, pressure data and other measures before the prudent petroleum geologist and/or engineer will wave a declaration or interpretation that a local and area presence or absence of void space, dissolution, permeability, cave or other karst scale features exist depth.

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Casavant	3- Affected Environment and Environmental Consequences	Geology, Minerals, Paleont Analysis Methodology, Assumptions, Uncertain & Unknown Information	2	20-21	Continued The level of technical knowledge and experience required for ensuring accurate and informed oversight on a complex topic like subsurface and surface cave and karst hydrology remains incomplete in this case study. The comprehensiveness of internal and external assessments rests the technical strengths and weakness of logic and data provided in rebuttal & claims of low-probability for presence and understanding of subsurface presence and interconnectedness. Published and accomplished "cave experts" who could have weighed in on the review were not sought. Given the importance of groundwater and spring resources and ecosystems—should they have?

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Casavant	3-Affected Environment and Environmental Consequences	Geology, Minerals, Paleont CNF Land and Resource Mgmt Plan Federal Cave Res Protect Act 1988	9 8	37-41 23-25	…knowingly destroying, disturbing …..any significant cave or altering free movement of any animal or plant life into or out of any significant cave on Federal lands…. Will there be/should there be monitoring protocol(s) that gain for the public unbiased, independent, timely and scientifically qualified, determinations and reporting of dissolution features that intersect and very likely extend beyond the pit dimensions--laterally and vertically? At other caves in SE AZ and elsewhere throughout AZ and the U.S., qualitative and quantitative measures for assessing of linkage and probable extension of underground passageway away or within mining areas that involve mineralized and non-mineralized carbonate strata are successfully being applied and beneficial. These include various analyses of different air and water data, identification and analysis of diagnostic geologic and hydrologic features (e.g. scalloping, vug frequency/dimension studies, presence of certain clastic and calcium carbonate sedimentary deposits in voids, etc.) at the surface or internal to the feature which are diagnostic and underground flow that favors both dissolution and deposition, certain geophysical surveys that are properly designed and targeted to image voids in carbonate media, tracer studies, and other tools of investigation. In many carbonate terrains the identification of dissolution corridors, even small ones at one location, can be indicative of the potential of linked and larger dissolution and permeability development elsewhere and proximal within the system—regardless of whether relatively rare and direct surface exposures such as sinkholes, or cave entrances are located, have or have not been accurately identified and logged (e.g. collapsed or non-collapsed sinkhole or corridor filled and masked by sediment and vegetation, mined out, etc.). Thus, time and pre-planned cost-effective investment in updated, accurate, and independent (non-industry related) inventorying and monitoring of surface features before and during mining activities and features uncovered or intercepted during mining seems prudent to consider. This might include protocols for ascertaining currently "unknown" or missed cave indicator features/data that could be more proximal to the proposed site than what is currently in the literature—and/or what pre-mine standard economic geologic mapping and drilling analyses deterministically revealed, described or was able to deduce. In well studied cave and karst settings all over the world and even in SE AZ, investment sof time and study are teaching both the cave management and geoscience community that the typical economic geology field mapping methods, scale, and tools employed by accomplished geologists, hydrologists and cavers may not accurately ascertaining various unequivocal spatial and genetic linkages (subtle and obvious) between geomorphic and structural geologic elements at the surface and underground passageway and cave development at depths ranging from tens to hundreds of feet below the surface. Even certain geophysical surveys, which have been successfully designed and applied in multiple terrains for cave exploration, has been negated or downplayed in the opinion by some experts consulting on the Rosemont EIS. This may not prudent to protocols that address the true intent of the 1988 federal law. Many of these new lessons have been piloted and tested in the regional vicinity, as well as above and belowground in accessible research laboratories and natural systems like Kartchner Caverns.

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Casavant	3-Affected Environment and Environmental Consequences	Geology, Minerals, Paleont CNF Land and Resource Mgmt Plan Federal Cave Res Protect Act 1988	 9 8	 37-41 23-25	Continued Some experts and resource managers may opine that Kartchner and other cavern settings that have been referred to in the DEIS commentaries are “unique” —and don’t apply to the Rosemont /northern Santa Rita Mountain area. More specifically, the CFS has had to consider opinions, which state that active surface and near-surface karst processes and void generation are simply not at work at Kartchner Caverns or most other caves in SE AZ. In contrast, there are also various cave experts and scientific literature available in the public domain that state otherwise. The so-called “unique” geologic setting of Kartchner and nearby Whetstones range shares a number of very common surface and subsurface geologic and hydrologic attributes and processes that can be seen in the history and continued development of cave processes and speleogenesis in the Santa Ritas—except for the degree and type of mineralization in the proposed Rosemont pit area that has been assumed to mostly obliterated the capacity of the Paleozoic carbonates intervals to promote or host cave-forming processes. Unfortunately, USFS, agency and industry partners, and the public may or do not have enough information and independent analyses that fully characterize just how laterally or vertically homogeneous or heterogeneous the metasomitized host rocks in the pit and surrounding mine area actually are. Major fault and fracture systems that were responsible for guiding past episodes and distributions of mineralization still provide rock fabric and controls on Cenozoic-age cave developments that are taking place at depth and in areas that are both proximal and distant from mineralized areas. Most mineralized and hydrologic systems are often linked in time and space. almost invariably heterogeneous along their lengths and trends in terms of of mineralization, diagenesis / cementation in comparison to the less disturbed and potentially more permeable inter-fault regions. A number of the mapped major and minor fault zones in the economically mineralized region are mapped or can be extrapolated outside of the area of interest into areas of less mineralization. Recent lineament mapping of known and probable geological textures as well as anomalously linear reaches and trends of drainage networks should have suggested areal extension of permeability zones outside of the mineralized regions. Surface and groundwater connectivity and flow characteristics may vary in time and space but still be viable along these corridors—especially after a seismic event which can abruptly change current hydrologic or reservoir properties. Given this plausibility of such outcome or settings, it is interesting to note that the groundwater model uses a very conservative approach that does not recognize such attributes at depth. A strong case can be made for caves (discovered “after the fact”) like Kartchner that a exploratory drilling program and geologic surface study might miss underground cave potential in low- to non mineralized areas. The more obvious and easily mapped, cement-filled, iron-rich faults and fault zones that dissect the cave-bearing hills (exhibiting highly cemented and brecciated segments often associated with releasing bends or dilation zones) failed to provide early and even recent geologic mappers a true sense or prediction of the degree of active (but subtle) karstification and cave-development taking place at depth—above and below the local water table. For the most part, earlier studies failed to recognized subtle but important geomorphic clues that strengthen surface to subsurface linkages. If this uncertainty can long exist to time and space with a well known cave resources, it begs one to consider how much more discovery awaits us on the issue of cave and karst identification and management on public lands. The question remains as to how far and how linked to surface infiltration and groundwater flow processes and environments might be along fault zones. and dissolution features found on the pit floor and walls, will be beyond the mined area. It should be conservatively expected that such zones would host on-going hypogenic or epigenic dissolutional histories and processes that are capable of being active and dispersed both along and between presently “known” structural and/or mineralized zones that project outward from the area of interest.

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Casavant	3-Affected Environment and Environmental Consequences	Geology, Minerals, Paleont CNF Land and Resource Mgmt Plan Federal Cave Res Protect Act 1988	 9 8	 37-41 23-25	Continued Such regions present a potential to link pathways and cave environs (regardless of scale) that pre-exist above and below the water table, but were indeterminate before mining was approved. It may be determined (or assumed if one is prudent) that these environs, discovered during the process of mining (a great number caves in the southwest are found, but often not logged or preserved) sustain and affect the free movement or livelihood of cave invertebrates and vertebrates within the mining area and extending out to adjacent public lands. It is not clear how the FCPA of 1988 or CNF resource management plan minimized and preserves these resources and environments. If the federal and state agencies do not place much value on AZ's cave invertebrate biota, then this is not a issue. Know though that more and more states are realizing the long-term value of inventorying, monitoring, and protecting various cave biota (invertebrate and vertebrate) as critical proxies for manage important groundwater quantity and quality. At this time it is uncertain to ascertain the level of CFN's internal knowledge and data base in regard to rigorous scientific study and understanding of surface and subsurface environs and cave biota. It appears from public records that few I&M efforts and scientific study have been supported and completed. Knowledge of potential known and unknown species of cave invertebrates and vertebrates that could impacted or should be on any monitoring list appears to be inadequate and thus, undervalued. A recent excellent and meticulous 2-year re-inventory of the cave invertebrate population of Kartchner Caverns revealed an increase from 39 to over 96 species that are directly sustained by the caverns and linked surface and subsurface geohydrologic settings (Pape et al, 2013, numerous papers in press; 2013 ASP internal report). A preliminary and revealing study of troglophile and troglobitic invertebrate species populations surveyed in 14 CNF caves reveals that nearly 50% of the species identified were classified as RARE or UNCOMMON. Their ecological significance remains largely unknown. (Pape, B., 1994, Cave Biota Survey Coronado Nat'l Forest). Could / should such information and biota add value to the natural resource system and story for the stewards of public lands? It's worth some prudent reflection.

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R.R. Casavant	3-Geology, Minerals & Paleontology	Cave Resource Regulations	9	37	The wording of this cave management section emphasizes or implies that the location and characterization of karst resources is already known. This is misleading and negates significance for pre-development surveying of cave karst resources for a better understanding and protection and surface and subsurface hydrologic function that supports cave ecosystems. From a statistical and cave/karst genesis standpoint, most if not all all carbonate and evaporate formations throughout the Southwest either host known karst/cave elements, and/or present a potential to host such features that have not yet discovered, are buried or lie within the subsurface. State licencing of geological engineers and well-published experts in the field of karst science (most who were not consulted in the development of this FEIS) agree that in deformed carbonate strata that karst elements most likely exist and therefore, should be engineered and modeled in planning and development stages. In almost all carbonate regimes, studies show that the state of knowledge in determining the true geographic character and hydrologic connectivity of surface and subsurface karst/cave elements still remains largely under-characterized--due in part to the lack of human access into parts of the system, lack of actual or discovered surface expressions (e.g. sinkholes, etc.), and the incompleteness and scale of many standard surface/subsurface geological and geophysical reconnaissance, survey and mapping programs—whose intent and objectives are not to identify, log and investigate subtle and obvious clues for karst and cave development on the surface or in the relatively shallow subsurface. It is not a coincidence that when a significant cave is discovered, the majority of so-called "cave experts" and geologists who "know the area" are pleasantly surprised. In short, the absence of evidence is NOT evidence of absence. In carbonate settings (whether highly to lightly mineralized) the processes of physical and chemical dissolution, migration and re-precipitation are active and to some extent predictable. Natural physical and compositional heterogeneities inherent to host and altered rock units guarantees uncertainty in prediction and thus risk-analysis when planning geo-engineering activities that involve such rock units. Ascertaining and predicting the actual locations of underground dissolution corridors, passageways and caverns throughout the world and in our Southwest region continue to remain elusive. Even in the well-known and cave-prone Paleozoic age carbonate strata across SE Arizona (ie. Kartchner Caverns being one of the more recently significant cave resource discoveries), prior consideration and certainty of presence was guess work at best. What this implies is that without the obvious or telltale presence of surface sinkhole development, that often the prediction and consideration by most geoscientists and cave experts for hidden or covered karst features remains wanting--until such time discovery results from intentional or unintentional access. Comparative surface and subsurface studies of karst element at locations such as Kartchner Caverns (before and after discovery) are revealing that standard field mapping methods were and still are not adequate for a resource identification of features even of that significance and size beforehand. There remains a need to update techniques and methods for identifying or risking the possibility of cave and karst development at depth from surface indentifiers. Caves in carbonate units can become better "known" or predicted through certain geophysical survey methods (e.g. electrical resistivity methods, gravity, etc. etc.). Most often though cave resources are deterministically identified through physical human or other faunal access points (e.g. sinkholes), but a host of other features and clues for mapping and identification exists. Just a few of these include dissolution enhanced fracture fabrics, in-part breccia-hosting fault zones, anomalous topographic expressions, vegetation lineaments and anomalies, detailed comparative analyses of drainage networks, fault/stream/spring tracer analyses, and geo-fabric (e.g. lineament) mapping and comparative analysis with meso- and megascale known and inferred fault and fracture fabrics.

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					Other methods for predicting, inferring or identifying karst developments at depth in the planning, monitoring and analysis of drilling programs include diagnostic changes in various drilling parameters or function such as zones of drilling fluids loss/gains, loss of core and rock cuttings returns (often associated with dissolution corridors, fault zones of varying scale), abrupt changes in drill rates within or at unit boundaries of a carbonate rock units, significant fluctuations in RPM and torque associated with loss circulation zones or down-hole borehole collapse, increased vugginess in core and cutting samples, zones and frequency of dissolution cavities on surface and in core, and core recovery/loss data. To predict beforehand occurrence or not in cave-prone stratigraphic units, without integrating study of a number of other geologic and engineering data seems to be somewhat presumptuous and not scientifically rigorous.
Casavant	3-Affected Environment and Environmental Consequences	Geology, Minerals, Paleont	11	19	Faulting NO mention of interpreted and documented oblique components on compressional and extensional fault features and zones in the southern or norther Santa Ritas and the Rosemont area is provided. The logic behind this tread of thought is to provide a better understanding of stress fields, strain on the likelihood for fault reactivations and variations in fault character, mineralization and groundwater behavior—which appears to not adequately address such variation and linkage to enhance secondary porosity and zones permeability. Additionally, locations and trends of strike-slip or oblique components relative to regional or local stress fields influence frictional strength and fluid flow characteristics that can vary significantly and locally along and/or within the same fault or fault zone. In some areas, the fluid-rock frictional strength linkage and local stress fields played important roles in hypogenic and epigenic processes that controlled mineralization emplacement, and coeval and later state cave-development histories and processes.
Casavant	3-Affected Environment and Environmental Consequences	Geology, Minerals, Paleont	11	30	ROSEMONT GEOMORPHIC DESCRIPTION, INFORMATION & MAP FOR REVIEW & IMPROVED UNDERSTANDING It is noted that although a detailed description of the Rosemont Deposit geology is provided to the public, no significant details or maps relevant to the geomorphic landscape, processes, and elements (e.g. drainage network pattern analysis, spring locations, etc. to name just a few). Although it was decided by the CFS prior to the DEIS to include springs into a separate section, an overlay or map of springs and drainage networks (down to first-order streams) that were provided to the CNF would be prudent to allow reviewers a more comprehensive and detailed picture of the natural geologic fabric and composition of the study area

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Casavant	3-Affected Environment and Environmental Consequences	Geology, Minerals, Paleont	14		Add geomorphic map with drainages, topo contours, springs
Casavant	3-Affected Environment and Environmental Consequences	Geology, Minerals, Paleont Unknown cave-karst	29	15	In regard to the discussion on the definition of karst relating to topographic influences and features that influence drainage that results in rock dissolution, this is fine. However, the statement that "definitional features of karst topography with respect to supplying water to caves, are not present in Southeastern AZ"---may well be erroneous depending on which cave expert one is informed by. At a host of surface and underground locations throughout SE AZ, karst topography and processes can be observed and deduced to be at play. Processes and observational features vary greatly in scale. In fact, topographic and subsurface geomorphic and geologic studies at easily accessible locations like Kartchner Caverns reveals that karst processes and settings are active and classifiable. Be assured that many are subtle but that also some which are and were obvious relatively large in scale, were previously missed or not identified by many field geologists—unless they were directed to look closely and cognizant of what lay beneath them in the subsurface. Comparative geologic studies of cave and karst elements at Kartchner for example, indicate that features and processes can vary greatly in their expression (size, scale, morphological character, composition), and yet, are spatially and genetically linked to significant cave and karst processes and cave features lying just tens to 100s of feet below the surface. Definitive comments like the one above should be tempered so the CNF will noted as presenting the information in an objective and most science-informed manner that it can.
					It might be worth adding a discussion that various mines and mineral progams in the CNF had their roots in cave discoveries first. Subsequent working of the prospect or deposit all but obliterated evidence of the surface expressions and linkage. H How much statistical research has the CNF done on this association? There may be some interesting statistical and genetic findings related to landscape evolution and land use development that are revealed by such independent research.

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Casavant	3-Affected Environment and Environmental Consequences	Geology, Minerals, Paleont Unknown cave-karst	32	4, 5,6	Line 4 is correct. However, line 5-6: "A review of available information by the Coronado's consulting geologists (mining geologists) and cave specialist indicated that no impacts are expected to any unknown caves."---- seems to be a catch-22. The statement implies the plausibility of unknown caves that might be encountered. This is logical given the natural heterogeneity in rock properties and mineralization that will most likely characterize the stacked and highly deformed carbonate strata that straddle both mineralized and less or non-mineralized areas. Given that the CNF consulting geologists are mining geologists could this inadvertently put the CNF into a false picture of a "conflict of interest" or application of the best technical experience on behalf of the public interest? Can/should the CNF provide an independent argument and research for the public on this matter by inviting another, more experience, and well-published cave scientist to independently review the topic and genetic linkage. The issue here is not only involves cave features that may exist within the mineralized zone (lower risk based the rock alteration), but also hypogene and epigene features that may lie adjacent to, or under the economic mineralized area and possess linkage with the pit via regional and local geologic structure that are on trend (bedding planes, faults, fracture networks). Was this potential connectivity adequately addressed or modeled and risked in the accepted groundwater model?
Casavant	3-Affected Environment and Environmental Consequences	Geology, Minerals, Paleont Climate change	33	37	"No effects from expected climate change are anticipated for geological, paleontological, or cave resources." Given known and proven genetic linkages between surface and groundwater hydrologic settings and cave resources and ecosystems all over the world, never mind SE AZ, what evidence can/is CNF providing to the public on support of such a definitive statement? Has the CNF team independently reviewed the superb descriptive and statistical analyses, modeling and published results of the book "Assessment of Climate Change in the Southwest U.S." by UA researcher Greg Garfin and others? How does the EIS statement stand in regard to this study? Some brief explanation of validation and source of data for review is recommended.

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Casavant	3-Affected Environment and Environmental Consequences	Geology, Minerals, Paleont Mitigation	34	13	"--**coordinate the investigation with appropriate resource specialist".**" Will this include experienced and independent monitoring and science-based investigation by an external independent academic cave scientist and researcher?
					Issue of WET vs DRY caves. Discussions and belaboring on this topic in earlier consulting presentations and reports is largely semantics. It may be inadvertently attempting to designate the value of "dry" caves over "wet" caves. Dry (and for that matter so-called relic caves) present active formation development, support a variety of unique cave life as well as important ecosystem processes and linkages. They are still part of the local hydrology because the channel meteoric waters into the aquifer.