SEARCHING FOR ARSENIC

2018 ARSENIC SYMPOSIUM – CALIFORNIA STATE UNIVERSITY, FRESNO

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INITIAL GRADUATE RESEARCH

- Focused on groundwater, and specifically a water quality-related topic.


- Historical information suggested that the Hanford-Lemoore area had unusually high concentrations of arsenic in groundwater, relative to surrounding areas.

- Readily available data reportedly existed regarding well construction, pumping, water levels and dissolved arsenic concentrations in the city of Hanford.
GRADUATE RESEARCH QUESTIONS

- IS THERE A RELATIONSHIP BETWEEN SUBSURFACE LITHOLOGIES AND ARSENIC CONCENTRATIONS?
- CAN THE SUBSURFACE GEOCHEMICAL ENVIRONMENT BE ADEQUATELY DESCRIBED?
- IS THERE A RELATIONSHIP BETWEEN WELL CONSTRUCTION AND ARSENIC CONCENTRATIONS?
- WHAT RELATIONSHIP MIGHT EXIST BETWEEN WELL OPERATIONS AND ARSENIC CONCENTRATIONS?
GRADUATE RESEARCH APPROACH

• COMPARE WELL DEPTH & WELL CONSTRUCTION, TO REPORTED DISSOLVED ARSENIC CONCENTRATIONS.

• AS FEASIBLE, COMPARE SUBSURFACE LITHOLOGIES AND ARSENIC CONCENTRATIONS.

• COMPARE WELL OPERATION TO REPORTED DISSOLVED ARSENIC CONCENTRATIONS.
GRADUATE RESEARCH DATA

• 24 CITY WELL CONSTRUCTION RECORDS, INDICATING WELL DEPTH, AND THE LENGTH OF BOTH THE GRAVEL PACK AND INTAKE STRUCTURE. WELLS HAD BEEN CONSTRUCTED BETWEEN 1949 AND 1989, AND RANGED IN DEPTH FROM 405’ TO 1500’.


• MONTHLY PUMPING RATES AND WATER LEVELS FOR THE 24 WELLS WAS GENERALLY AVAILABLE AND REVIEWED.
GRADUATE RESEARCH FINDINGS

- Shallow wells have greater dissolved arsenic concentrations than deep wells.
- Wells with long intake structures/gravel packs have greater dissolved arsenic concentrations, especially shallow wells.
- Wells with shorter intake structures, restricted gravel pack lengths, and intra-aquifer seals had reduced arsenic concentrations.
- Deep wells, with short intake structures, properly sealed off from clays, had the lowest concentrations of dissolved arsenic.
- Indications of increased arsenic concentrations with increased duration and severity of pumping.
GRADUATE RESEARCH CONCLUSIONS

• MORE WELL CONSTRUCTION VS [A$_3$] ASSESSMENT WAS NEEDED. DEEPER WELLS, WITH SHORTER INTAKE STRUCTURES AND GRAVEL PACKS, SHOULD HAVE LESS DISSOLVED ARSENIC PRESENT IN THE WELL WATER SAMPLES.
  • NOT PLACING INTAKE STRUCTURES ADJACENT TO CLAYS, PROBABLY LEADS TO REDUCED DISSOLVED ARSENIC CONCENTRATIONS IN WELL WATER SAMPLES.

• EXTENSIVE ASSESSMENT OF GEOCHEMICAL CONDITIONS WITH DEPTH.

• FLOW RATE VERSUS [A$_2$] SHOULD BE FURTHER ASSESSED. THE DURATION AND INTENSITY OF PUMPING MAY BE AFFECTING THE CONCENTRATION OF DISSOLVED ARSENIC IN THE WELL WATER SAMPLES.
GRADUATE RESEARCH POST-MORTEM

• MORE DETAILED FORMATION SAMPLING AND ANALYSIS, SPECIFICALLY SEARCHING FOR ARSENIC-ENRICHED CLAYS, AND ASSESSING TOTAL VERSUS LEACHABLE ARSENIC CONCENTRATIONS.

• TIME AND FLOW DEPENDENT WATER SAMPLING AND ANALYSIS, TO SEARCH FOR STRONGER INDICATIONS OF THEIR RELATIONSHIP WITH DISSOLVED ARSENIC.

• DESIGN SMARTER WELLS, BUILD BETTER WELLS.
ARSENIC IN OUR PROFESSIONAL PRACTICE

• IN GENERAL, ARSENIC IS NOT EVERYWHERE.

• REPORTED ARSENIC IN GROUNDWATER, OCCURS MOSTLY IN ONE OF TWO PLACES, BEING 1) WITHIN THE DEPOSITIONAL BASIN OF A RIVER SYSTEM, AND 2) IN SPECIFIC FRACTURED BEDROCK AQUIFERS, MOSTLY ASSOCIATED WITH LEUCOCRATIC GRANITES.

• TODAY I WILL FOCUS ON THE ALLUVIAL BASIN AREAS.
WHERE WE SUSPECT ARSENIC IS...

- Clays and silts, with a higher organic concentration, such as might be found in ancient marsh deposits, associated with a riverine depositional system.

- Arsenic may be bio-accumulated in the organic matter, it may be in microcrystalline or amorphous minerals, or it may be a replacement for some other mineral in the fine-grained structure of these clays and silts.

- Within groundwater, the arsenic likely leaches out (chemically, mechanically, or both) of the clays and silts, and if in a geochemically conducive groundwater, remains mobile and available during extraction associated with pumping.
HOW WE LOOK FOR ARSENIC..

• COLLECTION OF FORMATION SAMPLES USING A SIDE-WALL CORE GUN.

• ANALYSIS OF FORMATION SAMPLES USING A MODIFIED TCLP EXTRACTION METHOD, ANALYZING FOR TOTAL AND LEACHABLE ARSENIC.

• INTENTIONALLY BY-PASSING DEPTHS/AQUIFERS KNOWN TO CONTAIN ARSENIC.

• SHORT-VERTICAL SPAN ZONE TESTING FOCUSED BOTH ON LIKELY AQUIFERS, AND AVOIDING CLAY LAYERS THAT MIGHT CONTAIN LEACHABLE ARSENIC.
AVOIDANCE VERSUS TREATMENT IN OUR PRACTICE...

• A PROPERLY DESIGNED AND EXECUTED OPEN-BOREHOLE ASSESSMENT CAN REVEAL THE PRESENCE OF AN ARSENIC PROBLEM, BEFORE THE CONSTRUCTION OF A NEW MULTI-MILLION DOLLAR WELL AND PUMPING STATION... AVOIDANCE.

• A PROPERLY DESIGNED AND CONSTRUCTED WELL, WHICH INCLUDES INTRA-AQUIFER SEALS, ALONG WITH DEEP PRIMARY WELL SEALS, SHOULD PROVIDE SUFFICIENT WATER WITH ACCEPTABLE DISSOLVED ARSENIC CONCENTRATIONS, SUCH THAT TREATMENT IS AVOIDED.

• AVOIDANCE IS GENERALLY FAR LESS EXPENSIVE THEN TREATMENT!
PRACTICE RESULTS...

- Since about 1990, about 25 new deep, high capacity wells constructed with thorough open borehole assessments, and properly designed and constructed, have met historical, and in most cases the current drinking water standard for arsenic in groundwater, in areas known for elevated arsenic concentrations in groundwater.
RECOMMENDATIONS AND NEXT STEPS…

• INVEST IN OPEN-BOREHOLE ASSESSMENTS, RATHER THAN IN TREATMENT.

• INVEST IN THOROUGH GEOLOGIC, GEOPHYSICAL AND GEOCHEMICAL ASSESSMENTS BEFORE COMMITTING MILLIONS OF DOLLARS INTO THE GROUND.

• INVEST IN, AND INSIST ON, PROPERLY CONSTRUCTED WELLS FOR BOTH WATER QUANTITY AND WATER QUALITY.
CONCLUSIONS AND PERSPECTIVE..

• MY INITIAL BELIEF, AND OUR SUBSEQUENT WORK, STRONGLY SUPPORTS RELATIONSHIPS BETWEEN WELL DEPTH AND CONSTRUCTION, AND DISSOLVED ARSENIC IN THE WELL WATER. FURTHERMORE, OUR WORK SUPPORTS SOME MECHANISM BETWEEN ARSENIC CONCENTRATIONS AND PUMPING RATES.

• CURRENT WORK STRONGLY SUGGESTS THAT PROPER WELL DESIGN AND CONSTRUCTION, BASED ON IDENTIFICATION AND AVOIDANCE, IS BETTER THEN TREATMENT, AT ACHIEVING WELL WATER WITH ACCEPTABLE ARSENIC CONCENTRATIONS, AND LESS PRONE TO VARIATIONS CAUSED BY PUMPING RATES.

• INSUFFICIENT TIME AND MONEY ARE INVESTED IN UNDERSTANDING THE SUBSURFACE CONDITIONS, IN GENERAL, AND AS SUCH WE ARE LEFT WITH THE HOPE THAT TREATMENT WILL OVERCOME WHAT COULD HAVE BEEN AVOIDED.
THANK YOU, AND MAY I ANSWER ANY QUESTIONS?