Response to Anonymous Referee #1's comment on "A decision tree model to estimate the value of information provided by a groundwater quality monitoring network" by A. Khader et al.

The reviewer has indicated that he generally approves the paper and would like to see future applications of the presented methodology in different locations. He offers comments, feedback, and suggestions to improve the paper and polish it up. We must say that we are so grateful for his thoughtful comments and helpful suggestions to restate some terms, paragraphs, and improve the figures. We make nearly all these recommended changes.

Below we provide our response to each comment and point out manuscript revisions that address those comments. Numbered **red text** quotes original reviewer comments. Our responses are in black. *Italic smaller black text* quotes directly from the revised manuscript.

1. The paper references a key research in (Khader and McKee 2012) but not yet published. I'm thrilled to read this paper when it comes out.
   (Khader and McKee 2012) is still under review, but we expect that the review process will finish soon. For your interest, the paper was based on chapter 2 of A. Khader's PhD dissertation which can be accessed through this link: http://digitalcommons.usu.edu/etd/1325/. We now cite the dissertation instead of the submitted paper.

2. Please be consistent in using contamination and pollution. Generally contamination is used in the context of an already existed harmful substance in groundwater while pollution is used in the context of introducing harmful substances to groundwater (e.g., wastewater). I think in your paper context, it should be used as contamination.
   Thanks, we now use contamination throughout.

3. To clearly set the problem or motivation of your paper, I think you should rewrite the first couple sentences in the abstract something like: "Groundwater contaminated with nitrate poses a serious health risk to infants when this contaminated water is used for culinary purposes. To avoid this health risk, first, people need to know whether their culinary water is contaminated or not. Therefore, there is a need to design an effective groundwater monitoring network, acquire information on groundwater conditions, and use acquired information to inform management options. These actions require time, money, and effort"
   Thanks, changes made.

4. In page 13806, line 17, at this point; I would use the blue baby syndrome instead of the scientific name. Just to engage your reader with something familiar.
   Thanks, we make this change.

5. In page 13806, line 17, "no" instead of "not"
   We are sorry, but I couldn't find a "not" on line 17.

6. In page 13807, line 21-25: long sentence. I would break into two sentences

Thanks, changes made. It now is: "*For example, infants who drink water with NO_3^- concentrations less than 45 mg/l are unlikely to get the disease. On the other hand, 57% of infants who drink water with NO_3^- concentrations between 45 and 225 mg/l will experience methemoglobinemia, and almost all infants who drink water with NO_3^- concentrations greater than 225 mg/l will be affected.*"

7. Page 13811, line 16, what do you mean by "active cells"?
   Active cells are those cells in the finite difference grid that represent the aquifer. GW flow and fate and transport modeling calculations were conducted in these cells. We have added this text to clarify.

8. Page 13812, line 17, so each cell has a distribution of nitrate, then did you take the average nitrate value to decide whether it's greater than 45 mg/L? Or what did you consider?
   We actually consider the probability that the nitrate concentration is below 45 mg/L as explained in section 3.2.1. However, in this sentence we are referring more generally to the nitrate concentration in the aquifer rather than how we model that concentration.

9. General question: how did you implement your decision tree model? did you use spreadsheets or any specific software? It would be interesting to mention it in your paper.
   We used Excel spreadsheets. This sentence was added to section 3: *"The decision tree model and the outcome costs were implemented using Excel spreadsheets."*

10. Page 13812, line 20, is the $150 considered as one-time cost (i.e., permanent treatment)? How about follow-up costs if any?
    It was considered as one-time cost with no follow-up. This cost was analyzed further in the sensitivity analysis (page 13822 line 11, discussion paper). This sentence was added to section 3: *"This cost will be considered as a one-time cost and it will be further analyzed in the sensitivity analysis in section 4."*

11. Page 13813, line 9, use "might" instead of "may"
    Thanks, change made.

12. Page 13815, line 12, how often the nitrate sampling was at? $12 per well per year sounds very inexpensive and probably for one sample. Also, I'd put the dollar sign before the number
    Yes, it's one sample per year. We added this sentence to section 3.1: *"Nitrate sampling cost ($12/well/year), considering only one sample per year for simplicity."*

13. Page 13817, lines (9-12) please explain what are the RVM runs? Also cite this work since it is from a previous research.
    We've added the following paragraph to section 2: *"The Monte Carlo simulations yield 10,000 nitrate concentration values for each aquifer water model cell. However, available RVM modeling tools cannot handle a problem of this size, so Khader and McKee (2012) performed 100 RVM model runs where in each run, 100 nitrate concentration target for each cell were randomly but conditionally sampled from the total Monte Carlo population to preserve the spatial correlation of concentrations between cells."*

14. I'd mention type 1 error before type 2. Just for the sake of better flow of ideas. Unless you have a reason for doing the opposite way.

    The probabilities where mentioned based on their order of appearance in the decision tree (Figure 4). [P2/p1] (type II error) appeared before [P1/p2] (type I error), and this is why it was explained before.

15. Page 13821 lines 10-16. I'd re-write this paragraph to better communicate your ideas

    We've modified this paragraph to: *"We estimate the upper bound on WTP for the monitoring system as the difference in expected costs associated with (i) recourse actions taken after implementing the monitoring system", and (ii) the best uninformed option to not use the aquifer. Fig. 6 shows that this WTP, which is measured ex-ante, is below the expected costs to install and operate the monitoring system. This result shows that the proposed monitoring system does not have value"*

16. Page 13819, lines 1-3, re-write the first sentence.

    The sentence was modified to: *"People's response to decision maker's recommendation is an important factor that determines the structure of the decision tree and likelihood of outcomes, as shown in Fig. 4."*

17. Was the survey conducted through mail or direct interviews? What was the time frame of this interview? Did you get the Institutional Review Board acceptance on the study? If so, please do mention it

    The survey was conducted by direct interviews in the summer of 2011 and had Institutional Review Board (IRB) approval. We've added these sentences to section 3.2.2: *"The study was approved by the institutional review board at Utah State University and surveys were administered directly to participants in summer 2011 at centers throughout the study area where they also pay their water bills."*

18. Page 13821, line 1-2, how much (%) did you relax the abidance ratio?

    It depended on the decision maker's prior actions and the monitoring results (for the case where the decision maker first chose to monitor). This sentence was added to section 4: *"the abidance ratio was relaxed to the values of probabilities A1 – A4 estimated from the survey results."*

19. Later in page 13822, line 26, you mentioned that 86% of people is served by wells…I would move these details to section 3 where it's more relevant.

    This information is the result of an assumption in the methods that people are distributed according to the pumping rates of the supply wells. We mention this point here rather than in section 2 to set the stage for the sensitivity analysis in Fig.7 (the base case scenario).

20. Page 13825 line 25, I'd mention the decision tree method earlier in the conclusion, like in line 7. It's your contribution after all.

    We've modified the first sentence in the paragraph to: *"This paper presents a decision tree method to estimate the value of information provided by a groundwater quality monitoring network located in an aquifer whose water poses a spatially heterogeneous and uncertain health risk."*

21. Page 13826 line 14: "…Eocene Aquifer but" Instead I'd say "but probably using a modified version of the proposed monitoring system."

Thanks, change made.

22. Figures 1-4 and 7

    Please see the modified figures below.

23. Figure 3: In the management option of "Proposed monitoring" I think you should include the chance of nitrate concentration actually being <45 or >45 in the bottom scenario with [p2]. Just like the above scenario in the same management option

    In this scenario, we assume full abidance. This means that if the monitoring network suggests that the water is polluted, people for sure will use alternative sources of water regardless of the actual nitrate concentration. The outcome is the same regardless of the actual nitrate concentration. Thus there is no need to add further branches to the decision tree.

24. Figure 5: I wonder why there isn't a significant cost difference between full and partial abidance!

    There are likely 2 reasons. First, due to the results of the survey which showed that abidance rate is high in 3 out of 4 scenarios (the values of A2, A3, and A4 are 0.96, 0.62, 0.97, respectively as shown in table 1). Second, due to the scale of Fig. 5 and the fact that the expected costs of recourse actions are high in all scenarios, the differences between full and partial abidance were not clear. These differences are more apparent in Fig. 6, where the scale is smaller. To address this comment, we have added a sentence to section 4: *"Expected costs only increase slightly due to the results of the survey which showed that the abidance rate is high in 3 out of 4 scenarios (the values of A2-A4 are 0.96, 0.62, 0.97, respectively as shown in table 1)"*

25. Figure 6: Why there is a big difference in the willingness to pay between the proposed and perfect monitoring systems? If I understand right, is this caused by the RVM model deficiency to predict the actual nitrate? The RVM model sounds to produce much better results compared to conventional models. So the chance of error should be pretty small, is that right?

    The deficiency did not come from the RVM method itself, but rather from the fact that due to lack of proper data for modeling, not all sources of uncertainty in nitrate concentrations where modeled nor did we take into account temporal variations in nitrate concentration. This sentence was added to section 4: *"Alternatively, decision makers could improve monitoring system accuracy by including other sources of uncertainty like human activities and on-ground nitrate loading, and considering temporal variations in nitrate concentrations (Khader and McKee 2012)."*

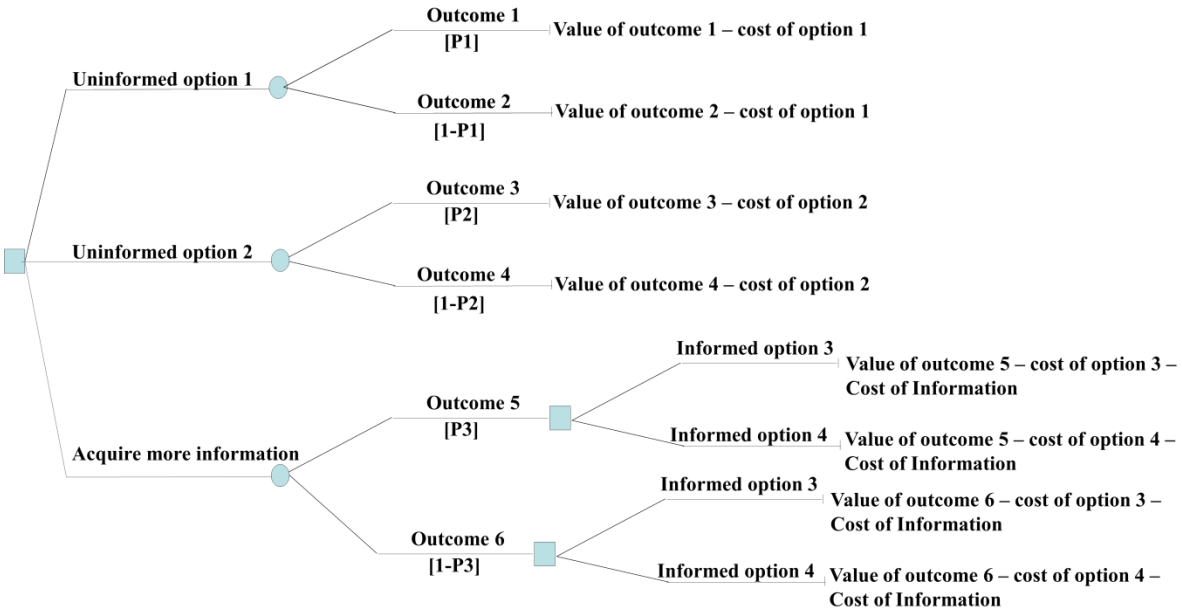

Figure 1. Example decision tree with three alternatives yielding six potential outcomes with probabilities P1, P2, P3, and complements 1-P1, 1-P2, and 1-P3.

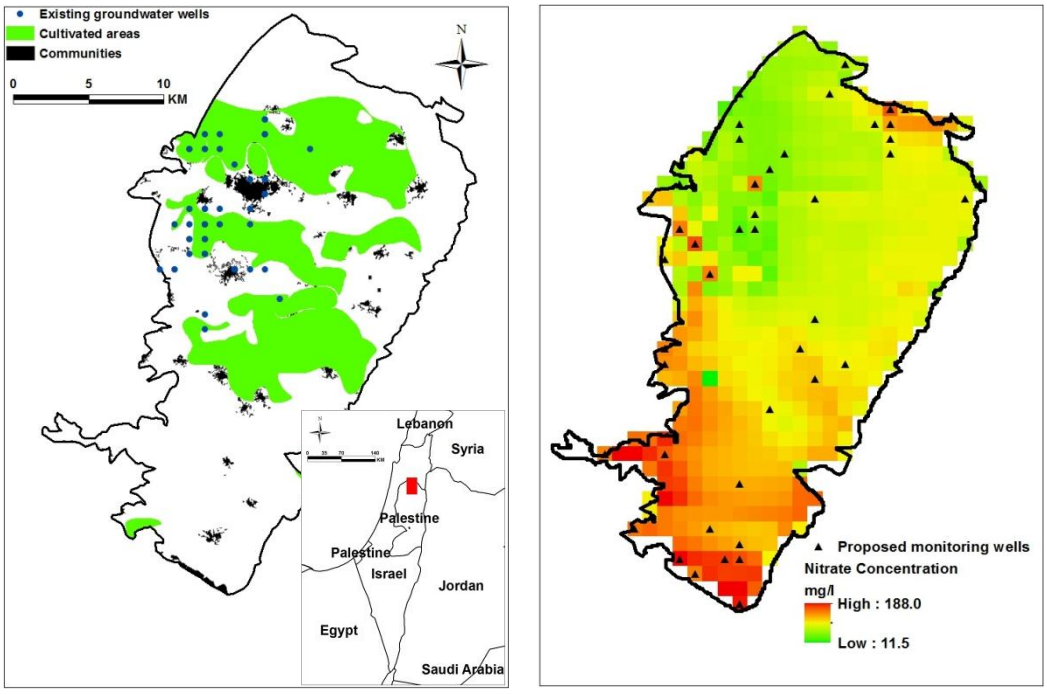

Figure 2. Eocene Aquifer study area. (Left) Palestinian communities, abstraction wells, and cultivated areas. (Right) Average nitrate concentrations predicted by Monte Carlo simulations and proposed monitoring well locations (Khader and McKee 2012) .

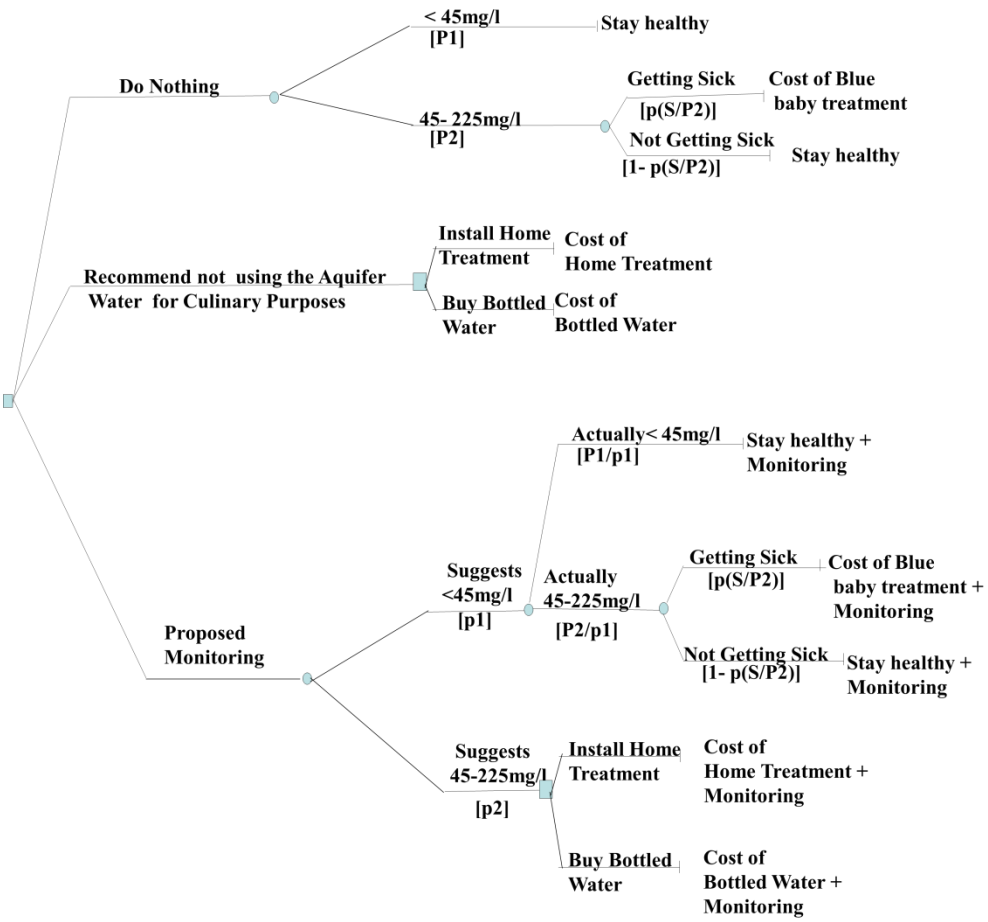

Figure 3. Decision tree model for the scenario where people fully abide with decision maker recommendations

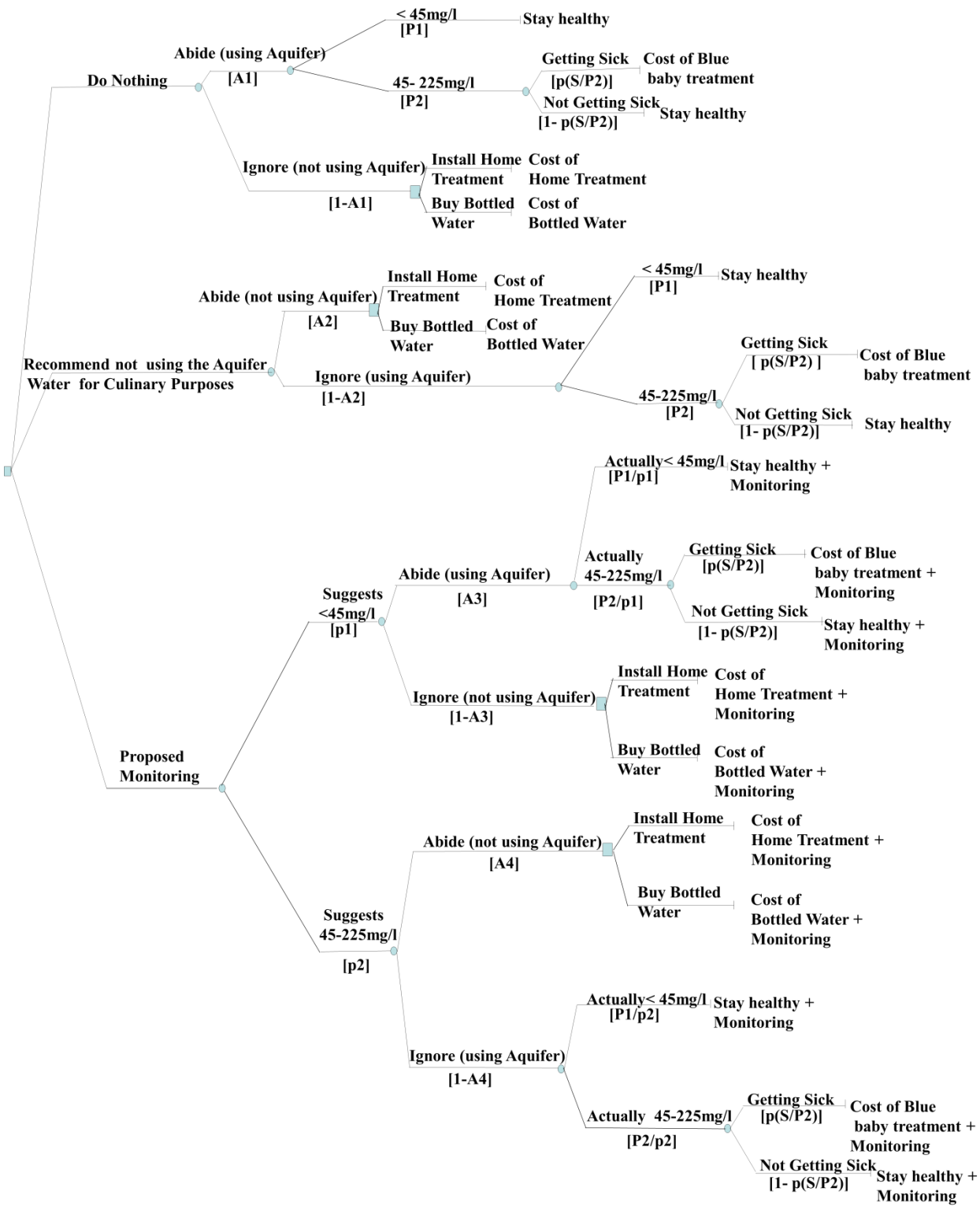

Figure 4. Decision tree model for the scenario where some people abide with, and others ignore decision makers' recommendations.

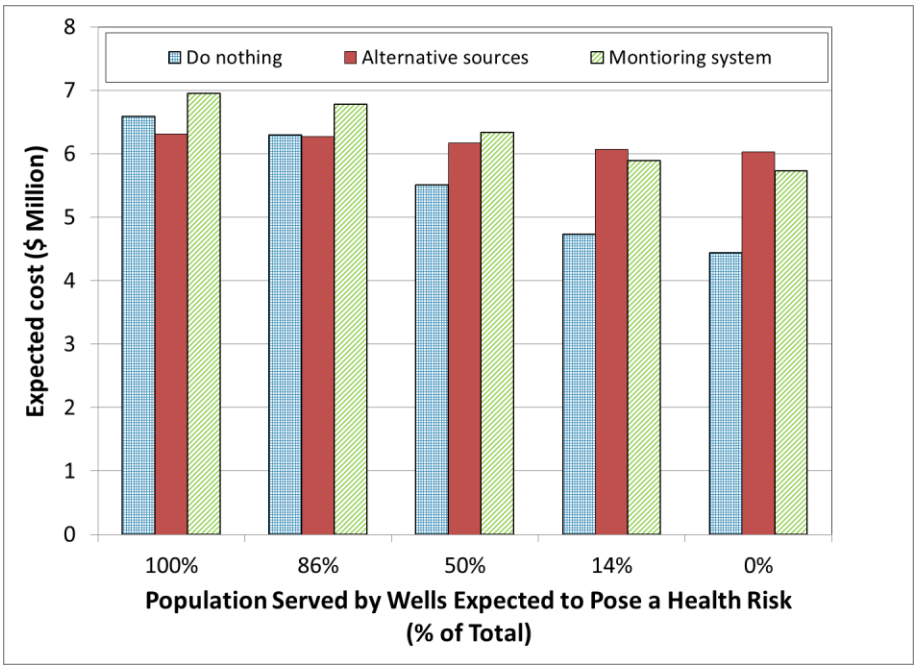

Figure 7. Expected costs for alternatives with partial abidance under population redistribution scenarios where more/less people use nitrate-contaminated aquifer water.