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Assessment of Citizen Perceptions and Knowledge for a Groundwater Monitoring Network Design

prepared by

Asako Stone and Jenny Chapman

submitted to

Nevada Site Office
National Nuclear Security Administration
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Las Vegas, Nevada

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EXECUTIVE SUMMARY

A survey study was conducted as part of an effort to ensure monitoring systems are in place for protection of the health and safety of citizens and the environment in Nevada if the proposed Yucca Mountain repository becomes operational. The survey assessed citizen knowledge and concerns about groundwater resources and about a groundwater monitoring network for the proposed Yucca Mountain nuclear waste repository. Residents in Amargosa Valley, Beatty, and Pahrump in Nye County, Nevada, and in Death Valley in Inyo County, California, were solicited to participate in the survey study via mail. Their contact information was retrieved from the corresponding county assessor's office, which was publically available upon request.

The survey was developed in collaboration with the Nye County Nuclear Waste Project Office and was distributed to every home owner in Amargosa Valley and Death Valley and to selected home owners in Beatty and Pahrump. A total of 117 completed surveys were compiled for the analysis, of which 58 were from Amargosa Valley, 27 were from Beatty, two were from Death Valley, and 30 were from Pahrump.

A series of statistical analyses were conducted between towns, genders, and age groups to investigate whether targeted communications for different groups would be necessary for a groundwater monitoring network to be effective. Content analyses were also conducted to better assess participants' knowledge and concerns that close-ended questionnaires would have missed.

The results of the survey study suggest that residents of Amargosa Valley are highly dependent on water directly retrieved from private wells. Even though they are less concerned about Yucca Mountain contaminating their groundwater resources than participants in Beatty and Pahrump (partially due to their familiarity with groundwater concepts and aquifer properties), the vulnerability of and concerns regarding water resources should be taken into account when developing and managing a groundwater monitoring network (GMN). Women are more worried about their water supply than men. Because familiarity with groundwater concepts and aquifer properties negatively correlates with such worries, it would be worthwhile to familiarize women with relevant concepts to alleviate their worries. Support for a GMN positively correlates with faith in technology. Thus, understanding technical aspects of a GMN might have a positive effect on the perceived value of a GMN to citizens in these communities.

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CONTENTS

EXECUTIVE SUMMARY iii
LIST OF FIGURES vii
LIST OF TABLES vii
LIST OF ACRONYMS viii
INTRODUCTION 1
THE SURVEY STUDY 1
Participants 1
Design 2
Demographic Information (Question 1) 3
Knowledge (Questions 2 through 7) 3
Dependency (Questions 8 through 10) 3
Concerns (Questions 11 through 19) 3
Well Locations (Question 20) 4
Trust (Question 21) 4
Perceptions about a GMN (Question 22 through 28) 4
Confidence (Questions 29 through 32) 5
Faith in Technology (Question 33) 5
Preferred Form of Communication (Question 34) 5
Procedures 5
Analysis 5
RESULTS 5
Question 1. Demographic Information 5
Question 2. Knowledge of the general location of the water supply wells 6
Question 3. Knowledge about the type of aquifer from which participants pump from 7
Question 4. Familiarity with basic groundwater concepts 8
Question 5. Familiarity with aquifer properties 9
Question 6. Where participants get their household water 10
Question 7. Participants' sources of water 10
Question 8. How participants use their water 11
Question 9. Whether participants' water at home is treated 13
Question 10. Dependency on water that is obtained directly from a domestic well 13
Question 11. Worry about the water participants' use 14
Question 12. Family members with heightened risks for health problems 15
Question 14. Worry about water supply being contaminated from any sources 16
Question 16. Worry about water supply being contaminated by Yucca Mountain 17
Question 17. Worry about water supply being contaminated by the Nevada Test Site 18
Question 18. Worry about health of your local wildlife if a repository were to become operational 19
Question 19. Financial consequences due to a repository 20
Question 20. Well locations 21
Question 21. Trust in agencies 21
Question 22. Aspects of groundwater that should be monitored 22
Question 23. How often groundwater should be monitored 23

Question 24. How long groundwater should be monitored BEFORE nuclear waste arrives 24
Question 25. Support for monitoring groundwater 24
Question 26. Perceived usefulness of a GMN 25
Question 27. Perceived ability of a GMN to provide advance warning 25
Question 28. Perceived ability of a GMN to make them feel safe 25
Question 29. Confidence in a GMN to provide information openly and honestly 25
Question 30. Confidence in a GMN taking public health into account 26
Question 31. Confidence in a GMN ensuring early detection of potential risks 26
Question 32. Confidence in a GMN's capability to assess health risks associated with groundwater 26
Question 33. Faith in technology 26
Question 34. Preferred form of communication 27
Question 35. Opinions 27
CONCLUSIONS 28
REFERENCES 29

LIST OF FIGURES

1. Location map of the towns included in the study. 2

LIST OF TABLES

1. Knowledge of the general location of the water supply wells as a function of Town. 6
2. Knowledge of the general location of the water supply wells as a function of Gender. 6
3. Knowledge of the general location of the water supply wells as a function of Age. 7
4. Knowledge about the type of aquifer participants pump from as a function of Town. 7
5. Familiarity with basic groundwater concepts as a function of Town. 8
6. Familiarity with basic groundwater concepts as a function of Gender. 8
7. Familiarity with basic groundwater concepts as a function of Age. 8
8. Familiarity with aquifer properties as a function of Town. 9
9. Familiarity with aquifer properties as a function of Gender. 9
10. Familiarity with aquifer properties as a function of Age. 10
11. Where participants get their household water as a function of Town. 10
12. Participants' sources of water. 11
13. How participants use their water. 12
14. Whether participants' water at home is treated as a function of Town. 13
15. Dependency on water that is obtained directly from a domestic well as a function of Town. 13
16. Worry about the water participants' use as a function of Town. 14
17. Worry about the water participants' use as a function of Description. 14
18. Family members with heightened risks for health problems as a function of Town. 15
19. Family members with heightened risks for health problems. 15
20. Worry about water supply being contaminated from any sources as a function of Town. 16
21. Worry about water supply being contaminated from any sources as a function of Gender. 16
22. Worry about water supply being contaminated from any sources as a function of Age. 16
23. Participant's additional concerns. 17
24. Worry about water supply being contaminated by Yucca Mountain as a function of Towns. 17
25. Worry about water supply being contaminated by Yucca Mountain as a function of Gender. 18
26. Worry about water supply being contaminated by Yucca Mountain as a function of Age. 18

27. Worry about water supply being contaminated by the Nevada Test Site as a function of Town....18
28. Worry about water supply being contaminated by the Nevada Test Site as a function of Gender....19
29. Worry about water supply being contaminated by the Nevada Test Site as a function of Age....19
30. Worry about health of your local wildlife if a repository were to become operational as a function of Town....19
31. Worry about health of your local wildlife if a repository were to become operational as a function of Gender....20
32. Worry about health of your local wildlife if a repository were to become operational as a function of Age....20
33. Financial consequences due to a repository as a function of Town....20
34. Financial consequences due to a repository as a function of Gender....21
35. Financial consequences due to a repository as a function of Town....21
36. Trust in Agency....22
37. Other Agencies Participants Identified As Trustworthy....22
38. Aspects of groundwater that should be monitored....23
39. Other Aspects of Groundwater Participants Identified As Important....23
40. Proffered Frequency of Monitoring....24
41. When to Start Groundwater Monitoring....24
42. Support for monitoring groundwater....24
43. Preferred Form of Communication....27
44. Opinions....28

LIST OF ACRONYMS

ANOVA	analysis of variance
DOE	U.S. Department of Energy
GMN	Groundwater Monitoring Network
NSHE	Nevada System of Higher Education
NTS	Nevada Test Site
NWRPO	Nuclear Waste Repository Project Office
YM	Yucca Mountain

INTRODUCTION

The Environmental Monitoring Systems Initiative identified designing a groundwater monitoring network (GMN) as one of its priorities to protect human health and the environment should the proposed Yucca Mountain (YM) high-level nuclear waste repository be built. As part of the effort to design an effective GMN, a survey was conducted to record citizen priorities and concerns regarding their groundwater resources and YM to ensure that critical local knowledge was included in monitoring network design. The survey also assessed participants' perceptions towards YM and a GMN.

The survey was developed in collaboration with the Nye Country Nuclear Waste Project Office to ensure their knowledge and concerns were incorporated. Upon development of the survey, it was reviewed and approved by the Institutional Review Board to ensure that the survey study was in compliance with the federal standard for protecting the rights and welfare of the human participants.

THE SURVEY STUDY

Participants

A total of 532 residents were solicited to participate in the survey study via mail, of which 234 were residents of Amargosa Valley, NV, 151 were residents of Beatty, NV, 10 were residents of Death Valley, CA, and 137 were residents of Pahrump, NV. Figure 1 is a location map of the towns included in the study. The number of participants were justified based on the population of Amargosa Valley and on a statistical power analysis to ensure that meaningful inferences could be drawn from the number of collected surveys. In addition to Amargosa Valley and Death Valley, Beatty and Pahrump were added as study sites during the survey development stage to address concerns raised by Nye County personnel. Names and addresses of Nye County and Inyo County residents are publically available from the county assessor's office. Potential participants were solicited via mail.

A total of 117 completed surveys were collected for the study. The return rate was 24.8 percent (N=58) in Amargosa Valley, 17.9 percent (N=27) in Beatty, 20.0 percent (N=2) in Death Valley, and 21.9 percent (N=30) in Pahrump. Of the 117 participants, 106 indicated their gender: 69 (65.1 percent) were male and 37 (34.9 percent) were female. One hundred thirteen participants indicated their age group: 30 (26.5 percent) participants were in age group 1 (18 to 55), 41 (36.3 percent) were in group 2 (56 to 65), and 42 (37.2 percent) were in age group 3 (66 and above). A higher return rate in Amargosa Valley was expected. Because residents in Amargosa Valley were of special interest, the researchers attended a town board meeting in Amargosa Valley to describe the mail-in survey prior to sending it out. Residents of Amargosa Valley also received personalized recruitment letters with hand-written addresses.

The responses from participants in Death Valley were not included in the statistical significance tests between towns because there were not enough participants from Death Valley to draw any meaningful inferences. Their responses were included in any other non-statistical analyses. One survey was removed from the study because the participant failed to fill out any of the survey questions. Thus, the statistical analyses were conducted with a total of 116 data input.

Design

The survey was developed based on literature review and on the project's specific need for information. Because some of the questions are personal and could be sensitive, a mail-in survey method was used instead of a phone interview. The following is the list of categories that the survey addressed.

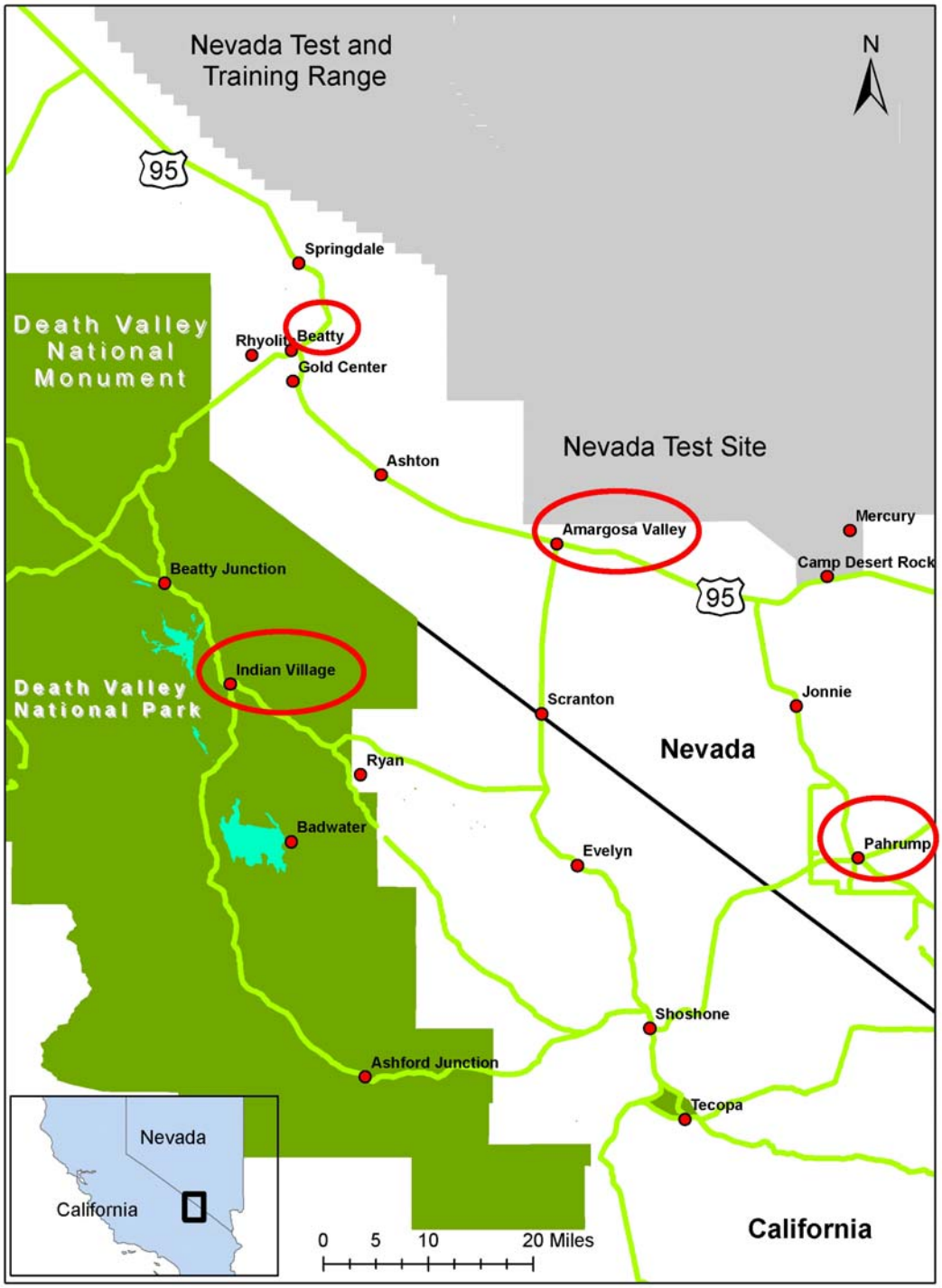

Figure 1. Location map of the towns included in the study.

Demographic Information (Question 1)

Amongst the demographic information that was compiled over the years for social scientific studies (not specific to Yucca Mountain research), only a few factors were revealed to be relevant and predictive: gender and race. Past studies suggest that gender influences perception of risk, such that women tend to express their concerns about risks more than men (Brody, 1984; Stallen and Thomas, 1988; Freudenburg, 1993; Greenberg and Schneider, 1995; Siegrist, 1998; Siegrist *et al*., 2005). In this study, participants were asked to indicate their age group rather than actual age to address concerns that were raised during the survey development. Gender, age (18 to 25, 26 to 35, 36 to 45, 46 to 55, 56 to 65, or 66 and above), county of residence, and zip code were assessed in the survey. For analyses, age groups 18 to 25, 26 to 35, 36 to 45, and 46 to 55 were grouped together as one group to equalize the sample size.

Knowledge (Questions 2 through 7)

Past research suggests that people have a fundamental need to reduce uncertainty in their social world (Yamagishi and Yamagishi, 1994; Hogg, 2000), and they constantly draw inferences from social information. When people face uncertainty, or lack of knowledge, they tend to minimize uncertainty by relying on their social information, such as trust (e.g. Siegrist and Cvetkovich, 2000). In this survey, knowledge rather than lack of knowledge was assessed to identify ways to incorporate effective communication strategies in the design of the GMN. Questions regarding participant's knowledge include the following:

- General location of the water supply wells in the closest town or municipal district
- Whether their groundwater is pumped from alluvial sediments or bedrock aquifers
- Familiarity with basic groundwater concepts
- Familiarity with aquifer properties
- Where participants get their household water

Dependency (Questions 8 through 10)

The extent to which participants depend on groundwater was assessed to understand their vulnerability to groundwater issues. The question "How dependent are you on water that is obtained directly from a domestic well?" was evaluated with a 5-point scale with 1 being not at all and 5 being very much. In addition, how participants use their water and whether participants' water at home is treated were assessed to better understand participants' groundwater usage.

Concerns (Questions 11 through 19)

To better understand participants' concerns regarding groundwater resources and YM, the following questions were asked:

- Are you worried about the water you use?
- Is anyone in your household at a heightened risk for health problems?
- If yes, do you feel comfortable describing?

- How worried are you about your water supply being contaminated from any sources?
- How worried are you about your water supply being contaminated by Yucca Mountain in particular if the repository were to open?
- How worried are you about your water supply being contaminated by the Nevada Test Site in particular?
- How worried are you about health of your local wildlife if a repository were to become operational?
- How do you think your financial situation would change if a repository were to become operational?

Well Locations (Question 20)

Locations of wells that participants know and are willing to report were compiled to ensure that the wells are considered during the monitoring network design process.

Trust (Question 21)

Trust is an important factor for perceived risk (e.g., Earle and Cvetkovich, 1995; Siegrist, 1999, 2000; Siegrist *et al*., 2005; Williams and Noyes, 2007;). The question, "Who would you trust to operate the network? Please rank the following options with 1= trust the most and 4 (5 if you fill out the option e) = trust the least" was asked with the following options: U.S. Department of Energy (DOE) contractors, Nye County Nuclear Waste Repository Project Office (NWRPO), State of Nevada, Nevada System of Higher Education (NSHE), and Other (please specify).

Perceptions about a GMN (Question 22 through 28)

Participants' perceptions about a GMN were one of the main focuses of the survey study. The following questions were asked:

- What aspects of groundwater should be monitored? (Options: water levels, arsenic, nitrates, radioactive elements, metals, and others)
- How often should groundwater be monitored? (Options: never, once a year, once a month, once a quarter, or continuously)
- How long should groundwater be monitored BEFORE nuclear waste arrives at Yucca Mountain if a repository were to become operational? (Options: 1 year, 5 years, 10 years, or wait until it opens)
- How strongly do you feel that groundwater should be monitored if the Yucca Mountain repository becomes active?
- How useful do you think this groundwater monitoring network would be to protect your health and safety?
- How able do you think this groundwater monitoring network would be to provide advance warning to protect your health and safety? a 5-point scale with 1 being not at all and 5 being very much
- How able do you think this groundwater monitoring network would be to make you feel safe regarding the proposed repository?

Confidence (Questions 29 through 32)

While trust is based on relations with others and involves risks especially in an uncertain situation (Metley, 1999; Siegrist *et al*., 2003, 2005), confidence is based on familiarity and its object is not limited to people (Siegrist *et al*., 2003, 2005). Siegrist *et al*. (2003, 2005) define confidence as "based on experience or evidence, that certain future events will occur as expected." Confidence is an important factor to assess because it will indicate confidence in a groundwater monitoring network's ability to securely protect water resources. Participants' confidence in a GMN was assessed by the following questions:

- How confident are you that this groundwater monitoring network would provide information about possible health effects openly and honestly to the public?
- How confident are you that public health would be taken into account when planning and operating this groundwater monitoring network?
- How confident are you that this groundwater monitoring network would ensure that any potential risks to the public will be detected early?

Faith in Technology (Question 33)

To assess participants' faith in the GMN's technology, Hine *et al.'s* (1997) faith in science and technology measurements were modified and applied. Participants were asked to answer the following question with a 5-point scale with 1 being not at all and 5 being very much: "How true do you think is the following statement? Most problems can be solved by applying more and better technology."

Preferred Form of Communication (Question 34)

Participants' preferred forms for updates regarding the groundwater monitoring network were assessed to identify effective communication modes. The alternatives included the following: letters, phone calls, public briefings, e-mails, newsletters, website, fax, and other. Participants were asked to specify if they selected 'other'.

Procedures

The survey was mailed to potential participants with the recruitment letter and a post-marked envelope with the return address. Participants were asked to complete the survey and mail it back to the researcher.

Analysis

For statistical significance tests, binary logistic regressions were used for nominal data, while analysis of variance (ANOVA) and t-tests were used for interval data. As secondary analyses, a series of correlations were conducted and significant results were presented.

RESULTS

Question 1. Demographic Information

Please refer to the participants section on page 1.

Question 2. Knowledge of the general location of the water supply wells

Binary logistic regressions were conducted to examine whether there is a significant difference in participants' responses depending on their location. The results showed that there was a significant difference in responses between Amargosa Valley and Pahrump (odds ratio=0.471, X^2=9.662, p<.01), Amargosa Valley and Beatty, (odds ratio=4.00, X^2=3.861, p<.05) and between Pahrump and Beatty (odds ratio=0.056, X^2=12,276, p<.001). In other words, participants in Amargosa Valley responded that they knew the general location of the water supply wells in the closest town or municipal district significantly more frequently than those in Beatty and Pahrump.

Table 1. Knowledge of the general location of the water supply wells as a function of Town.

Town	Response	Frequency	Percent
Amargosa	No	14	25
	Yes	42	75
Beatty	No	2	7.7
	Yes	24	92.3
Pahrump	No	18	60
	Yes	12	40
All	No	34	30.4
	Yes	78	69.6
Total		112	100

A binary logistic regression was conducted to examine whether there is a significant difference in participants' responses depending on their gender. The results showed that there was a significant difference in knowledge between genders (odds ratio=0.365, X^2=5.149, p<.05). In other words, male participants responded that they knew the general location of the water supply wells significantly more frequently than female participants.

Table 2. Knowledge of the general location of the water supply wells as a function of Gender.

Gender	Response	Frequency	Percent
Male	No	16	23.5
	Yes	52	76.5
Female	No	16	45.7
	Yes	19	54.3
Total		112	100

A binary logistic regression was conducted to examine whether participants' age is a factor to predict their responses. The results showed that there was no statistically significant difference among age groups (1 vs. 2: odds ratio=0.660, X^2=0.620, p=.431; 1 vs. 3: odds ratio=1.002, X^2=0.001, p=.994; 2 vs. 3: odds ratio=1.521, X^2=0.763, p=.382).

Table 3. Knowledge of the general location of the water supply wells as a function of Age.

Age	Response	Frequency	Percent
1 (18-55)	No	8	27.6
	Yes	21	72.4
2 (56-65)	No	15	36.6
	Yes	26	63.4
3 (> 65)	No	11	27.5
	Yes	29	72.5
Total		112	100

Question 3. Knowledge about the type of aquifer from which participants pump from

Question 3 assessed participants' knowledge about what types of aquifers they have in their area. Even though private wells are most likely in alluvium, types of aquifers could differ depending on a variety of factors such as locations, geologic conditions, and depths of wells. It was assumed that participants are knowledgeable of their residential area. Table 4 summarizes the responses. While only 29.8 percent (N=17) of participants in Amargosa Valley reported that they did not know whether groundwater in their area is from an alluvial sediment or a bedrock aquifer, 70.8 percent (N=17) of participants in Beatty and 46.7 percent (N=14) of participants in Pahrump reported they did not know.

Logistic regressions were conducted to examine whether there was a significant difference in participants' responses between towns. The results showed that participants in Amargosa Valley reported that they did not know whether groundwater in their area originated from alluvial sediments or bedrock significantly less frequently than those in Beatty (odds ratio=0.175, X^2=10.641, p<.001). Even though there were anecdotal differences in the responses between Amargosa Valley and Pahrump, there was no statistical difference (odds ratio = 0.697, X^2 =2.395, p=.122). There was no statistical difference between Beatty and Pahrump, either (odds ratio=2.776, X^2=3.105, p=.078).

Table 4. Knowledge about the type of aquifer participants pump from as a function of Town.

Town	Response	Frequency	Percent
Amargosa	1	33	57.9
	2	7	12.3
	3	17	29.8
Beatty	1	2	8.3
	2	5	20.8
	3	17	70.8
Pahrump	1	9	30
	2	7	23.3
	3	14	46.7
All	1	44	39.6
	2	19	17.1
	3	48	43.2
Total		111	100

Question 4. Familiarity with basic groundwater concepts

The mean score of participants as a whole was 2.71 out of 5.0 for Question 4. An ANOVA was conducted to examine whether there was a statistical difference in participants' perceived familiarity with basic groundwater concepts among towns. The results showed that there was a statistically significant difference in responses between towns, $F(2,111)=4.471$, $p<.05$. Post-hoc analyses revealed that the mean score of Amargosa Valley is significantly higher than that of Beatty $t(82)=2.133$, $p<.05$ and that of Pahrump $t(86)=2.533$, $p<.05$. There was no significant difference in the mean score between Beatty and Pahrump, $t(54)=0.433$, $p=.666$. In other words, participants in Amargosa Valley reported their familiarity with basic groundwater concepts as significantly than those in Beatty or Pahrump. There was no statistical difference in perceived familiarity between participants in Beatty and Pahrump.

Table 5. Familiarity with basic groundwater concepts as a function of Town.

Town	Mean	N	SD
Amargosa	3.06	58	1.354
Beatty	2.42	26	1.036
Pahrump	2.28	30	1.31
Total	2.71	114	1.322

An independent sample t-test was conducted to examine whether the mean score for perceived familiarity differed between genders. The results showed that there is a significant difference between genders, such that the mean score of men was significantly higher than that of women, $t(103)=2.745$, $p<.01$. In other words, men reported their familiarity with basic groundwater concepts as significantly than women did.

Table 6. Familiarity with basic groundwater concepts as a function of Gender.

Gender	Mean	N	SD
Male	2.93	69	1.261
Female	2.22	36	1.227
Total	2.69	105	1.288

A one-way ANOVA was conducted to examine the effect of age on familiarity with basic groundwater concepts. The mean scores of perceived familiarity about basic groundwater concepts did not depend on participants' age group, $F(2, 109)=0.228$, $p=.796$. In other words, participants' age did not affect their familiarity with basic groundwater concepts.

Table 7. Familiarity with basic groundwater concepts as a function of Age.

Age	Mean	N	SD
1 (18-55)	2.57	29	1.321
2 (56-65)	2.78	41	1.379
3 (>65)	2.73	42	1.245
Total	2.71	112	1.306

Question 5. Familiarity with aquifer properties

To investigate participants' familiarity with aquifer properties, the following question was asked: "How familiar are you with aquifer properties such as porosity and permeability?" and rated on a 5-point scale. The mean score as a whole was 2.42 out of 5, which is slightly lower than that of Question 4 although not statistically significant, $F(1, 225)=1.643$, $p=.102$.

To examine whether participants' perceived familiarity about aquifer property differs among towns, a one-way ANOVA was conducted. The results showed that there was no significant difference in perceived familiarity among towns, $F(2,109)=1.923$, $p=.151$. Because of the mean difference between Amargosa Valley and the other two towns, Beatty and Pahrump were grouped together as "the others" to conduct a follow-up independent sample t-test. The results showed that there was a significant difference in perceived familiarity between Amargosa Valley and the others, such that participants in Amargosa Valley indicated that they were significantly more familiar with aquifer properties than those in Beatty and Pahrump, $t(110)=1.969$, $p<.05$. In other words, participants in Amargosa Valley perceived aquifer properties as familiar concepts more than those in Beatty and Pahrump.

Table 8. Familiarity with aquifer properties as a function of Town.

Town	Mean	N	SD
Amargosa	2.67	57	1.489
Beatty	2.16	25	0.954
Pahrump	2.18	30	1.283
Total	2.42	112	1.344

To examine effects of gender on perceived familiarity, an independent t-test was conducted. The results showed that there was a statistically significant difference in the mean score between men (2.60) and women (2.00), such that the mean score for men on perceived familiarity was significantly higher than women's, $t(101)=2.196$, $p<.05$. In other words, men evaluated their familiarity with aquifer properties higher than women. This is consistent with the result of Question 4.

Table 9. Familiarity with aquifer properties as a function of Gender.

Gender	Mean	N	SD
Male	2.59	69	1.339
Female	2.0	35	1.231
Total	2.39	104	1.322

To examine effects of age on perceived familiarity with aquifer properties, a one-way ANOVA was conducted with IV=age and DV=perceived familiarity. The results showed that there was no statistical difference among the age groups, $F(2, 107)= 0.881$, $p=.430$.

Table 10. Familiarity with aquifer properties as a function of Age.

Age	Mean	N	SD
1 (18-55)	2.16	29	1.370
2 (56-65)	2.58	41	1.370
3 (>65)	2.44	41	1.241
Total	2.41	111	1.321

Question 6. Where participants get their household water

Understanding where participants acquire household water is a way to assess their dependency and vulnerability relevant to the groundwater resources. Out of 115 participants, 37 (32.1 percent) participants reported that they get their water from a municipal water supply while 77 (67.0 percent) participants reported that they get their water from a domestic well. One participant (0.9 percent) indicated that she or he does not know.

Binary logistic regressions were conducted to investigate whether there were significant differences in participants' responses patterns among towns. The results showed a significant difference between Amargosa Valley and Beatty (odds ratio=0.006, X^2=31.825, p<.001), between Amargosa Valley and Pahrump (odds ratio=0.225, X^2=13.490, p<.001), and between Beatty and Pahrump (odds ratio=7.437, X^2=9.155, p<.005). In other words, Amargosa Valley is heavily dependent on domestic wells compared to Beatty and Pahrump. Beatty is heavily dependent on municipal water, unlike Amargosa Valley and Pahrump.

Table 11. Where participants get their household water as a function of Town.

Town	Response	Frequency	Percent
Amargosa	Municipal	2	3.40
	Domestic	56	96.6
Beatty	Municipal	23	85.2
	Domestic	4	14.8
Pahrump	Municipal	12	40.0
	Domestic	17	56.7
	Don't know	1	3.3
All	Municipal	37	32.1
	Domestic	77	67.0
	Don't know	1	0.9
Total		115	100

Question 7. Participants' sources of water

Question 7 assessed participants' sources of water. The tables below summarize the results.

Table 12. Participants' sources of water.

Town	Sources	Response	Frequency	Percent
Amargosa	Municipal	No	56	96.6
		Yes	2	3.4
	Domestic Well	No	4	6.9
		Yes	54	93.1
	Bottled Water	No	34	58.6
		Yes	24	41.4
	Others	No	57	98.3
		Yes	1	1.7
Beatty	Municipal	No	4	14.8
		Yes	23	85.2
	Domestic Well	No	22	81.5
		Yes	5	18.5
	Bottled Water	No	11	40.7
		Yes	16	59.3
	Others	No	25	96.2
		Yes	1	3.8
Pahrump	Municipal	No	17	56.7
		Yes	13	43.3
	Domestic Well	No	13	43.3
		Yes	17	56.7
	Bottled Water	No	17	56.7
		Yes	13	43.3
	Others	No	27	90
		Yes	3	10
Total			116	100

Question 8. How participants use their water

Question 8 assessed ways in which participants use their water. The tables below summarize the results.

Table 13. How participants use their water.

Town	Use	Response	Frequency	Percent
Amargosa	General Household	No	2	3.4
		Yes	56	96.6
	Drinking	No	9	15.5
		Yes	49	84.5
	Gardening	No	10	17.2
		Yes	48	82.8
	Family Business	No	55	94.8
		Yes	3	5.2
	Mid-to-Large Business	No	57	98.3
		Yes	1	1.7
	As an employee	No	57	98.3
		Yes	1	1.7
Beatty	General Household	No	0	0
		Yes	27	100
	Drinking	No	7	25.9
		Yes	20	74.1
	Gardening	No	1	3.7
		Yes	26	96.3
	Family Business	No	27	100
		Yes	0	0
	Mid-to-Large Business	No	27	100
		Yes	0	0
	As an employee	No	25	92.6
		Yes	2	7.4
Pahrump	General Household	No	0	0
		Yes	30	100
	Drinking	No	4	13.3
		Yes	26	86.7
	Gardening	No	4	13.3
		Yes	26	86.7
	Family Business	No	30	100
		Yes	0	0
	Mid-to-Large Business	No	30	100
		Yes	0	0
	As an employee	No	30	100
		Yes	0	0
Total			116	100

Question 9. Whether participants' water at home is treated

Binary logistic regressions were conducted to examine whether there is a significant difference in responses among towns. The results showed that there is a significant difference between Amargosa Valley and Beatty (odds ratio=6.667, X^2=12.765, p<.001) and between Amargosa Valley and Pahrump (odds ratio=1.757, X^2=4.614, p<.05). There was no significant difference between Beatty and Pahrump (odds ratio=0.463, X^2=2.018, p=.155). In other words, likelihood of water in Amargosa Valley being treated is significantly lower than that in Beatty and Pahrump. There is no statistical difference in likelihood of water being treated between Beatty and Pahrump. The results suggest that participants in Amargosa Valley are significantly less likely to treat their water than those in Beatty or Pahrump.

Table 14. Whether participants' water at home is treated as a function of Town.

Town	Response	Frequency	Percent
Amargosa	No	48	84.2
	Yes	9	15.8
Beatty	No	12	44.4
	Yes	15	55.6
Pahrump	No	19	63.3
	Yes	11	36.7
Total		114	100

Question 10. Dependency on water that is obtained directly from a domestic well

A one-way ANOVA was conducted to examine the effect of a participant's location on their dependency on groundwater. The results showed that there was a significant difference in the mean score among towns, F(2,108)=41.319, p<.001. The post-hoc analyses revealed that there was a significant difference between Amargosa Valley and Beatty, such that participants in Amargosa Valley depend on water from a domestic well significantly more than those in Beatty, t(26)=7.964, p<.001. Participants in Amargosa Valley also depend on water from a domestic well significantly more than those in Pahrump, t(28)=4.044, p<.001. There was a significant difference between Beatty and Pahrump, such that participants in Pahrump depend more on a domestic well than those in Beatty, t(52)=2.476, p<.05.

Table 15. Dependency on water that is obtained directly from a domestic well as a function of Town.

Town	Mean	N	SD
Amargosa	4.93	57	0.417
Beatty	2.25	26	1.693
Pahrump	3.46	28	1.895
Total	3.93	111	1.692

There is a positive correlation between Question 4 (familiarity with groundwater concepts) and Question 10 (r=0.202, p<.05). In other words, a higher dependency on water from a domestic well correlates with a higher familiarity with groundwater concepts.

Question 11. Worry about the water participants' use

Participants in Beatty were significantly more worried about water they use than those in Pahrump (odds ratio=0.327, X^2=3.826, p<.05), otherwise, there was no statistical difference between towns, genders, or age groups.

Table 16. Worry about the water participants' use as a function of Town.

Town	Response	Frequency	Percent
Amargosa	No	34	60.7
	Yes	22	39.3
Beatty	No	12	46.2
	Yes	14	53.8
Pahrump	No	22	73.3
	Yes	8	26.7
Total		112	100

Those who reported that they are worried about the water they use were asked to describe their worries. Thirty seven participants out of the 44 responded. Responses from participants in Death Valley are also included. Table 17 summarizes the results.

Table 17. Worry about the water participants' use as a function of Description.

Concerns	Frequency					Percent
	Amargosa	Beatty	DV	Pahrump	Total	
Alkali	1	0	0	0	1	2.27
Arsenic	0	3	0	0	3	6.82
Contamination	2	1	0	4	7	15.91
Dairy farm	9	0	0	0	9	20.45
Fertilizers	2	0	0	0	2	4.55
Fluoride	1	1	0	1	3	6.82
Mercury	0	1	0	0	1	2.27
Minerals	0	3	0	0	3	6.82
Nevada Test Site	4	0	0	1	5	11.36
Nitrates	2	0	0	0	2	4.55
None	1	0	0	1	2	4.55
Overconsumption	2	0	0	0	2	4.55
Pahute Mesa	0	1	0	0	1	2.27
Radioactive materials	1	0	0	0	1	2.27
Radium	1	2	0	0	3	6.82
Sedimentation	1	0	0	1	2	4.55
Toxins	1	0	0	0	1	2.27
Trioxides	0	1	0	0	1	2.27
Uncertainty	1	0	1	1	3	6.82
Water price	0	0	0	1	1	2.27
Water quality	1	2	1	2	6	13.64
Water table	3	0	0	1	4	9.09
Yucca Mountain	3	0	0	1	4	9.09

Question 12. Family members with heightened risks for health problems

Overall, 28 participants (25 percent) out of 112 reported that they have someone in their household at a heightened risk for health problems.

Table 18. Family members with heightened risks for health problems as a function of Town.

Town	Response	Frequency	Percent
Amargosa	No	40	71.4
	Yes	16	28.6
Beatty	No	20	74.1
	Yes	7	25.9
Pahrump	No	24	82.8
	Yes	5	17.2
Total		112	100

Of the 28 participants, 18 participants reported that they felt comfortable describing their health problems. Table 19 summarized the results.

Table 19. Family members with heightened risks for health problems.

Health problem	Frequency				Percent
	Amargosa	Beatty	Pahrump	Total	
Age	1	0	0	1	5.56
Asthma	1	0	0	1	5.56
Cancer	2	1	1	4	22.22
Coronary disease	1	0	0	1	5.56
Diabetes	3	1	0	4	22.22
Emphysema	1	0	0	1	5.56
Gastrointestinal problems	1	0	0	1	5.56
Heart problem	1	0	0	1	5.56
High blood pressure	1	0	0	1	5.56
High cholesterol	1	1	0	2	11.11
HIV	0	0	1	1	5.56
Kidney problems	2	1	0	3	16.67
Lack of spleen	1	0	0	1	5.56
Leukemia	0	0	1	1	5.56
Low immune system	0	0	1	1	5.56
Lymphoma	0	0	1	1	5.56
Pulmonary fibroses	0	0	1	1	5.56
Seizures	0	1	0	1	5.56
Septic tank problem	0	0	1	1	5.56

Question 14. Worry about water supply being contaminated from any sources

To examine whether the mean score for worry is significantly different among towns, a one-way ANOVA was conducted. The results showed that there was no significant difference among towns, $F(2,107)=0.298$, $p=.743$.

Table 20. Worry about water supply being contaminated from any sources as a function of Town.

Town	Mean	N	SD
Amargosa	3.29	55	1.471
Beatty	3.15	26	1.413
Pahrump	3.03	29	1.529
Total	3.19	110	1.464

To examine the effects of gender on worry, an independent t-test was conducted. The results showed that there was a significant difference in worry between genders, such that women's mean score for worry was significantly higher than men's, $t(100)=2.079$, $p<.001$. In other words, female participants worry about their water significantly more than do men. This is consistent with past studies.

Table 21. Worry about water supply being contaminated from any sources as a function of Gender.

Gender	Mean	N	SD
Male	2.96	67	0.186
Female	3.6	35	0.211
Total	3.16	102	1.464

To examine the effects of age on worry, a one-way ANOVA was conducted. The results showed that there was no significant difference between age groups, $F(2, 105)=0.117$, $p=.890$.

Table 22. Worry about water supply being contaminated from any sources as a function of Age.

Age	Mean	N	SD
1 (18-55)	3.26	29	1.380
2 (56-65)	3.20	40	1.310
3 (>65)	3.09	39	1.697
Total	3.18	108	1.467

There is a positive correlation between Question 10 and Question 14, such that a higher dependency on water from a domestic well correlates with a higher worry about their water supply being contaminated ($r=0.211$, $p<.05$).

Participants were also asked to list sources of contamination that they were worried about (Question 15). Table 23 summarizes their responses. Along with NTS and YM, dairies in Amargosa Valley were identified as a source of concern regarding contamination in both Amargosa Valley and Pahrump. Another contamination source of concern is agriculture-

related, like pesticides, and contamination from the low-level waste site located south of Beatty (U.S. Ecology).

Table 23. Participant's additional concerns.

Concern	Frequency				Percent
	Amargosa	Beatty	Pahrump	Total	
Agriculture	6	2	5	13	23.64
Construction	0	1	0	1	1.82
Dairies	22	0	1	23	41.82
Military bases	0	2	0	2	3.64
Mining	0	1	0	1	1.82
NTS	13	8	4	25	45.45
US Ecology	6	0	0	6	10.91
YM	8	4	8	20	36.36

Question 16. Worry about water supply being contaminated by Yucca Mountain

Participants were asked to rate their worry about their water supply being contaminated by Yucca Mountain, in particular, if the repository were to become operational. A one-way ANOVA was conducted to examine whether there was a significant difference in participants' worries about their water supply being contaminated specifically by Yucca Mountain. The results showed that there was no statistical difference between towns, $F(2,109)=2.448$, $p=.091$.

Because of the difference in the mean between Amargosa Valley and the other two towns, Beatty and Pahrump were grouped together as "the others" to conduct an independent sample t-test. The results showed that it was marginally significant, such that participants in Amargosa Valley perceived marginally significantly lower concern than those in Beatty and Pahrump, $t(110)=1.934$, $p=.055$. In other words, participants in Amargosa Valley are not as worried about Yucca Mountain contaminating their water as those in Beatty and Pahrump.

Table 24. Worry about water supply being contaminated by Yucca Mountain as a function of Towns.

Town	Mean	N	SD
Amargosa	2.15	55	1.568
Beatty	2.50	27	1.581
Pahrump	2.97	30	1.814
Total	2.45	112	1.662

An independent t-test was conducted to examine whether there is a significant difference between genders on worry. The results showed that female participants were significantly more worried about Yucca Mountain contaminating their water supply than male participants, $t(101)=1.988$, $p<.05$.

Table 25. Worry about water supply being contaminated by Yucca Mountain as a function of Gender.

Gender	Mean	N	SD
Male	2.16	68	1.558
Female	2.85	36	1.740
Total	2.40	104	1.648

A one-way ANOVA was conducted to examine effects of age on worry. The results showed that there was no significant difference between different age groups, $F(2,107)=0.041$, $p=.959$. In other words, participants' age did not affect the way they responded to the question.

Table 26. Worry about water supply being contaminated by Yucca Mountain as a function of Age.

Age	Mean	N	SD
1 (18-55)	2.35	39	1.635
2 (56-65)	2.45	41	1.684
3 (>65)	2.42	30	1.64
Total	2.40	110	1.64

Question 16 is negatively correlated with Question 4 ($r=-0.283$, $p<.01$) and Question 5 ($r=-0.204$, $p<.05$). Participants who reported that they were familiar with basic groundwater concepts (Question 4) and aquifer properties (Question 5) tend to be less worried about their water supply being contaminated by Yucca Mountain. This is also evident in some comments at the end of the survey: some participants, especially in Amargosa Valley, mentioned that they were not concerned with Yucca Mountain because it would take a long time for contaminants to travel through groundwater sources.

Question 17. Worry about water supply being contaminated by the Nevada Test Site

Overall, participants reported that they are more worried about their water supply being contaminated by the Nevada Test Site than Yucca Mountain. A one-way ANOVA was conducted to examine whether there was a significant difference in participants' worry between towns. The results were not statistically significant, $F(2,109)=1.434$, $p=.243$. However, this follows the same trend as Question 16 in that the mean score of Amargosa Valley is lower (2.26) than that of Beatty (2.81) or Pahrump (2.73).

Table 27. Worry about water supply being contaminated by the Nevada Test Site as a function of Town.

Town	Mean	N	SD
Amargosa	2.26	55	1.449
Beatty	2.81	27	1.760
Pahrump	2.73	30	1.706
Total	2.52	112	1.604

The mean score of male participants (2.26) was lower than that of female participants (2.75), which is consistent with the results of Question 14 and Question 16. An independent t-test was conducted to examine whether there is a significant difference between genders. The results showed that there was no statistical difference, $t(101)=1.464$, $p=.146$.

Table 28. Worry about water supply being contaminated by the Nevada Test Site as a function of Gender.

Gender	Mean	N	SD
Male	2.26	68	1.537
Female	2.75	36	1.615
Total	2.43	104	1.574

A one-way ANOVA was conducted to examine whether different age groups responded to Question 17 differently. The results showed that there was no statistical differences between age groups, $F(2, 107)=1.083$, $p=.342$.

Table 29. Worry about water supply being contaminated by the Nevada Test Site as a function of Age.

Age	Mean	N	SD
1 (18-55)	2.19	39	1.458
2 (56-65)	2.56	41	1.667
3 (>65)	2.73	30	1.617
Total	2.48	110	1.583

Question 18. Worry about health of your local wildlife if a repository were to become operational

A one-way ANOVA was conducted to examine whether concerns about health of participants' local wildlife differ between towns. The results showed that there was a statistical difference between towns, $F(2,109)=3.527$, $p<.05$. Post-hoc analyses revealed that there was a marginally significant difference between Amargosa Valley and Beatty, such that participants in Beatty reported that they were worried about health of their local wildlife more than those in Amargosa Valley, $t(80)=1.929$, $p=.057$. Participants in Pahrump also reported that they were more worried about health of their local wildlife than those in Amargosa Valley, $t(49)=2.272$, $p<.05$. There was no statistical difference between Beatty and Pahrump, $t(55)=0.457$, $p=.65$.

Table 30. Worry about health of your local wildlife if a repository were to become operational as a function of Town.

Town	Mean	N	SD
Amargosa	1.97	55	1.402
Beatty	2.63	27	1.542
Pahrump	2.83	30	1.797
Total	2.36	112	1.584

An independent t-test was conducted to examine whether participants' worry about their local wildlife was statistically different between genders. The results showed that there was a statistical difference between genders, such that female participants were more worried than male participants, $t(101)=2.484$, $p<.05$.

Table 31. Worry about health of your local wildlife if a repository were to become operational as a function of Gender.

Gender	Mean	N	SD
Male	2.1	68	1.502
Female	2.9	36	1.675
Total	2.38	104	1.605

A one-way ANOVA was conducted to examine whether there were statistical differences between age groups in participants' worry about their local wildlife. The results showed that there was no statistical significance between age groups, $F(2, 107)=0.426$, $p=.654$.

Table 32. Worry about health of your local wildlife if a repository were to become operational as a function of Age.

Age	Mean	N	SD
1	2.36	39	1.618
2	2.18	41	1.520
3	2.53	30	1.634
Total	2.34	110	1.578

Question 18 negatively correlated with Question 4 ($r=-0.323$, $p<.01$) and Question 5 ($r=-0.220$, $p<.05$). Participants who reported a higher familiarity with groundwater concepts (Question 4) and aquifer properties (Question 5) tend to score lower with respect to worry about their local wildlife (Question 18).

Question 19. Financial consequences due to a repository

Participants were asked to evaluate changes to their financial situation if a repository were to become operational. In general, participants didn't perceive any notable financial changes if a repository were to become operational. A one-way ANOVA was conducted to examine whether there was a significant difference in participants' opinions about their financial situation if a repository were to become operational. The results showed that there was no statistical significant between towns, $F(2,106)=0.502$, $p=.753$

Table 33. Financial consequences due to a repository as a function of Town.

Town	Mean	N	SD
Amargosa	3.35	54	1.261
Beatty	3.22	27	1.258
Pahrump	3.13	28	1.507
Total	3.26	109	1.319

Female participants scored lower (3.00) than male participants (3.46). However, an independent t-test did not show a statistical significance between genders, $t(95)=1.574$, $p=.119$.

Table 34. Financial consequences due to a repository as a function of Gender.

Gender	Mean	N	SD
Male	3.46	67	1.331
Female	3.00	34	1.224
Total	3.31	101	1.305

A one-way ANOVA was conducted to examine whether there was a significant difference in participants' opinions about their financial situation if a repository were to become operational. The results showed a significance, $F(2, 104)=3.380$, $p<.05$. Post-hoc analyses revealed that the age group 1 (18 to 55) reported that a repository would have a more positive effect on their financial situation than the age group 2 (56 to 65), $t(66)=2.466$, $p<.05$ and the age group 3 (>65), $t(67)=2.216$, $p<.05$. There was no statistical difference between age groups 2 and 3, $t(68)=0.226$, $p=.822$.

Table 35. Financial consequences due to a repository as a function of Town.

Age	Mean	N	SD
1 (18-55)	3.80	30	1.215
2 (56-65)	3.12	38	1.062
3 (>65)	3.05	39	1.512
Total	3.29	107	1.312

Question 19 was positively correlated with Question 4 (0.323, $p<.01$), such that a higher familiarity with groundwater concepts was associated with a positive opinion about participants' financial effect if a repository were to become operational. Likewise, Question 19 was positively correlated with Question 5 ($r=0.302$, $p<.01$), such that a higher familiarity with aquifer properties was associated with a positive opinion about their financial effect.

Question 20. Well locations

Participants were asked to describe locations of private wells or springs that they would like the research group to consider during monitoring network development. We acknowledge that 20 participants provided information and that the information will be incorporated for future use during the design of the monitoring well system. The location information provided by survey participants is not presented in this report to protect the respondents' privacy.

Question 21. Trust in agencies

To better understand participants' trust in different agencies and whom they would trust to monitor their groundwater, participants were asked to evaluate DOE, NWRPO, State of Nevada, and NSHE. An independent t-test showed that NSHE was evaluated significantly

more positively than NWRPO in Amargosa Valley, t(77)=2.477, p<.05. There was no statistical difference between any other agencies in Amargosa Valley. In Beatty, NSHE was evaluated significantly more positively than DOE, t(27)=2.658, p<.05. There was no statistical difference between any other agencies. There was no statistical difference between any agencies in Pahrump, F(3,75)=1.246, p=.299. However, NSHE was more positively evaluated (1.95) than the other agencies (Nevada=2.00; NWRPO=2.37; and DOE=2.68).

Table 36. Trust in agency.

Town		Mean	N	SD
Amargosa	DOE	2.60	42	1.466
	NWRPO	3.18	40	1.430
	Nevada	2.92	38	1.363
	NSHE	2.44	39	1.209
Beatty	DOE	3.44	16	1.459
	NWRPO	2.43	14	1.399
	Nevada	2.53	17	1.463
	NSHE	1.92	13	1.605
Pahrump	DOE	2.68	19	1.493
	NWRPO	2.37	19	1.383
	Nevada	2.00	21	1.265
	NSHE	1.95	20	1.317
Total	DOE	2.79	77	1.490
	NWRPO	2.82	73	1.447
	Nevada	2.58	76	1.398
	NSHE	2.21	72	1.321

Table 37 shows the list of entities that participants identified as the most trustworthy besides the ones mentioned above. Among 20 participants who identified other entities, 10 participants indicated that they would trust an independent or a private entity the most.

Table 37. Other agencies participants identified as trustworthy.

Entity	Frequency				Percent
	Amargosa	Beatty	Pahrump	Total	
Independent/Private	5	1	4	10	50.0
Multiple parties	2	0	0	2	10.0
Desert Research Institute	1	0	0	1	5.0
Fire department	1	0	0	1	5.0
Nye County	1	0	0	1	5.0
Public/Ourselves	1	1	0	2	10.0
Hydro Dynamics Group	1	0	0	1	5.0
Environmental Protection Agency	0	1	1	2	10.0

Question 22. Aspects of groundwater that should be monitored

To better understand participants' concerns and interests regarding groundwater monitoring, aspects that should be monitored in participants' opinion were assessed. The

figure below depicts the results. In general, participants reported that all the identified aspects are important to monitor.

Table 38. Aspects of groundwater that should be monitored.

What to Monitor	Frequency				Percent
	Amargosa	Beatty	Pahrump	Total	
Water level	45	17	26	88	78.60
Arsenic	38	20	27	85	75.90
Hazardous waste	42	17	22	81	72.30
Radioactive elements	49	24	30	103	92.00
Metals	40	18	24	82	73.20

Participants were also asked to identify important aspects to be monitored. Table 39 summarizes the results. For example. bacteria and waste water from dairies were listed by three respondents (15.79 percent).

Table 39. Other aspects of groundwater participants identified as important.

What to Monitor	Frequency				Percent
	Amargosa	Beatty	Pahrump	Total	
Bacteria	1	0	2	3	15.79
Fluoride	0	1	0	1	5.26
Hazardous waste	2	0	0	2	10.53
Heavy metals	0	0	1	1	5.26
Potassium	1	0	0	1	5.26
Sodium	1	0	0	1	5.26
Organic contaminants	1	0	0	1	5.26
Pathogens	2	0	0	2	10.53
Pesticides	0	0	1	1	5.26
Radon	1	0	0	1	5.26
Sulfates	1	0	0	1	5.26
Uranium	0	1	0	1	5.26
Waste water from dairy	3	0	0	3	15.79

Question 23. How often groundwater should be monitored

Participants' opinion about how often groundwater should be monitored was assessed. The figure below summarizes the results. While the majority of participants in Amargosa Valley thought that a weekly monitoring was optimal, those in Beatty and Pahrump reported that they thought that groundwater should be monitored continuously.

Table 40. Proffered frequency of monitoring.

Frequency of Monitoring	Frequency				Percent
	Amargosa	Beatty	Pahrump	Total	
Never	2	0	0	2	1.8
Annually	7	2	3	12	10.8
Monthly	9	8	8	25	22.5
Weekly	26	4	5	35	31.5
Continuously	13	11	19	37	33.3

Question 24. How long groundwater should be monitored BEFORE nuclear waste arrives

Participants were asked about how long groundwater should be monitored before nuclear waste arrives at YM if a repository were to become operational. The figure below summarizes the results. A majority of participants responded that groundwater should be monitored a year prior to YM becoming operational.

Table 41. When to start groundwater monitoring.

When to Start Monitoring	Frequency				Percent
	Amargosa	Beatty	Pahrump	Total	
1 Year	26	8	16	50	45.0
5 Years	7	6	8	21	18.9
10 Years	7	8	4	20	18.0
Wait	17	1	1	20	18.0

Question 25. Support for monitoring groundwater

To assess participants' support for monitoring groundwater, they were asked to rate their feeling about their groundwater being monitored. A one-way ANOVA was conducted to examine whether there is a statistical difference in support for monitoring groundwater between towns. The results showed that there was a marginal difference between towns, $F(2, 107)=2.666$, $p=.074$. Because of the mean difference between Amargosa Valley and the other towns, Beatty and Pahrump were grouped together as "not-Amargosa=0" to conduct a follow-up analysis. An independent t-test showed that there was a significant difference between Amargosa Valley and the other towns, such that participants in Amargosa Valley supported monitoring groundwater significantly less than the other towns, $t(104)=2.201$, $p<.05$. There was no statistical difference between genders, $t(84)=1.551$, $p=.151$ and between age groups, $F(2.105)=0.427$, $p=.653$.

Table 42. Support for monitoring groundwater.

Town	Mean	N	SD
Amargosa	3.9	56	1.406
Beatty	4.29	24	1.343
Pahrump	4.55	30	0.922
Total	4.16	110	1.298

Participants' responses were positively correlated with their responses to Question 14 (worry about groundwater contamination in general, 0.411, $p<.01$), Question 17 (worry about groundwater contamination from NTS, $r=0.313$, $p<.01$), and Question 18 (worry about health of their local wildlife if a repository becomes operational, 0.431, $p<.01$). In other words, a stronger worry about groundwater contamination in general and from NTS and about health of their local wildlife is associated with a stronger support for monitoring groundwater.

Question 26. Perceived usefulness of a GMN

To understand how useful participants perceive a GMN to protect their health and safety, they were asked to rate a GMN's usefulness. The overall mean of the responses was 3.70 ($N=109$, $SD=1.447$), which was a fairly positive response for a perceived usefulness of a GMN. There was no statistical difference between towns, $F(2,106)=0.207$, $p=.813$, between genders, $t(98)=0.635$, $p=.527$, or between age groups, $F(2,104)=1.880$, $p=.158$. Perceived usefulness of a GMN positively correlates with worry about groundwater contamination in general (Question 14, $r=0.357$, $p<.01$), from YM (Question 16, $r=0.230$, $p<.05$), and from NTS (Question 17, $r=0.193$, $p<.05$). It is also positively correlated with faith in technology (Question 33, $r=0.235$, $p<.05$).

Question 27. Perceived ability of a GMN to provide advance warning

Participants were asked how able they think a GMN would be to provide advance warning to protect their health and safety. The overall mean of the responses was 3.61 ($N=108$, $SD=1.403$), which was a fairly positive response for a perceived ability of a GMN to provide advance warning to protect their health and safety. There was no statistical difference between towns, $F(2,105)=0.263$, $p=.769$, between genders, $t(79)=0.807$, $p=.442$, or between age groups, $F(2,103)=1.005$, $p=.370$. Perceived ability to provide advance warning positively correlates with worry about groundwater contamination in general (Question 14, $r=0.242$, $p<.05$), from YM (Question 16, $r=0.845$, $p<.01$), but not from NTS (Question 17 $r=0.069$, $p=.421$). It was also positively correlated with faith in technology (Question 33, $r=0.298$, $p<.01$).

Question 28. Perceived ability of a GMN to make them feel safe

To assess a GMN's ability to address citizens' perceived safety, participants were asked how able they think a GMN would be to make them feel safe regarding the proposed repository. The overall mean of the responses was 3.28 ($N=108$, $SD=1.475$), which is lower than perceived ability to provide advance warning to protect their health and safety. There was no statistical difference between towns, $F(2,105)=0.560$, $p=.573$, between genders, $t(97)=0.331$, $p=.741$, or between age groups, $F(2,103)=0.556$, $p=.575$. Perceived ability to make them feel safe was positively correlated with worry about groundwater being contaminated in general (Question 14, $r=0.279$, $p<.05$) and faith in technology (Question 33, $r=0.316$, $p<.01$).

Question 29. Confidence in a GMN to provide information openly and honestly

Participants were asked to evaluate their confidence in a GMN providing information about possible health effects openly and honestly to the public. The overall mean of the responses was 3.02 ($N=108$, $SD=1.413$), which is lower than perceived ability to make them feel safe. There was no statistical difference between towns, $F(2,105)=1.550$, $p=.247$, between genders, $t(97)=0.083$, $p=.934$, or between age groups, $F(2,103)=0.508$, $p=.603$.

Perceived confidence in a GMN communicating risks openly and honestly positively correlates with worry about groundwater being contaminated in general (Question 14, $r=0.231$, $p<.05$) and faith in technology (Question 33, $r=0.409$, $p<.01$). There was a negative correlation between Question 29 and trust in NWPO (Question 21, $r=-0.289$, $p<.05$). In other words, those who evaluated NWPO's trustworthiness lower tend to evaluate their confidence in a GMN higher.

Question 30. Confidence in a GMN taking public health into account

Participants were asked to evaluate their confidence that public health would be taken into account when planning and operating a GMN. The overall mean of the responses was 3.09 ($N=109$, $SD=1.375$). There was no statistical difference between towns, $F(2,106)=0.578$, $p=.563$, between genders, $t(98)=0.400$, $p=.690$, or between age groups, $F(2,104)=0.972$, $p=.382$. Perceived confidence was positively correlated with faith in technology (Question 33, $r=0.300$, $p<.01$). There was a negative correlation between Question 30, and trust in NWPO (Question 21, $r=-0.302$, $p<.05$). In other words, those who evaluated NWPO's trustworthiness lower tend to evaluate their confidence in a GMN higher.

Question 31. Confidence in a GMN ensuring early detection of potential risks

Participants were asked to rate how confident they were that a GMN would ensure that any potential risks to the public would be detected early. The overall mean of the responses was 3.16 ($N=109$, $SD=1.325$). There was no statistical difference between towns, $F(2,106)=0.481$, $p=.619$, between genders, $t(98)=0.486$, $p=.628$, or between age groups, $F(2,104)=1.920$, $p=.152$. Perceived confidence was positively correlated with faith in technology Question 33, $r=0.377$, $p<.01$. There was a negative correlation between Question 31 and trust in NWPO (Question 21, $r=-0.279$, $p<.05$). In other words, those who evaluated NWPO's trustworthiness lower tend to evaluate their confidence in a GMN higher.

Question 32. Confidence in a GMN's capability to assess health risks associated with groundwater

Participants were asked to evaluate their confidence in a GMN's capability in assessing any health risks associated with groundwater. The overall mean of the responses was 3.29 ($N=112$, $SD=1.301$). There was no statistical difference between towns, $F(2,109)=0.286$, $p=.752$, between genders, $t(101)=0.906$, $p=.367$, or between age groups, $F(2,107)=1.556$, $p=.216$. Perceived confidence in a GMN's capability to assess health risks negatively correlates with worry about groundwater contamination from YM (Question 16, $r=-0.236$, $p<.05$) and worry about health of their local wildlife (Question 18, $r=-0.299$, $p<.01$). It is also negatively correlated with faith in technology (Question 33, $r=0.371$, $p<.01$). There was a negative correlation between Question 31, and trust in NWPO (Question 21, $r=-0.284$, $p<.05$). In other words, those who evaluated NWPO's trustworthiness lower tend to evaluate their confidence in a GMN higher.

Question 33. Faith in technology

To assess participants' faith in technology, they were asked to evaluate how true they think the statement "most problems can be solved by applying more and better technology" was. The overall mean of the responses was 3.59 ($N=113$, $SD=1.126$). There was no statistical difference between towns, $F(2,110)=0.055$, $p=.946$, between genders, $t(102)=1.360$, $p=.177$, or between age groups, $F(2,108)=0.641$, $p=.529$. Faith in technology

positively correlates with perceived financial consequences if a repository becomes operational (Question 19, r=0.341, p<.01).

Question 34. Preferred form of communication

Participants' preferred form for updates from a GMN was assessed to better understand how a GMN could effectively communicate with citizens. The figure below summarizes the results. There was no significant difference in the response pattern between towns, genders, or age groups. While most participants identified letters as a preferred form of communication, they did not favor phone calls or fax. Besides those that are included in the figure below, a total of three participants listed radio, four participants listed TV, one participant listed postings at post offices, and two participants listed newspaper as the prefered method of communication. Considering that the least favored communication form, fax, received seven affirmative responses, letters, newsletters, and briefings (respectively) were the most preferred forms of communication.

Table 43. Preferred form of communication.

Form of Communication	Frequency				Percent
	Amargosa	Beatty	Pahrump	Total	
Letters	43	14	18	75	67.60
Phones	16	4	5	25	22.50
Briefings	23	14	13	50	47.70
Emails	23	11	11	45	40.50
Newsletters	28	11	14	53	47.70
Website	19	14	12	45	40.50
Fax	3	1	3	7	6.50

Question 35. Opinions

Participants were asked to share their opinions about groundwater resources and a groundwater monitoring network. A total of 64 participants shared their opinions. Their responses were content analyzed and condensed into Table 44. Of the 64 participants, 18 of them (28.13 percent) expressed their distrust in government regarding a repository and/or a groundwater monitoring network. Fifteen participants (23.44 percent) showed their support for a groundwater monitoring network, and most of them volunteered to be actively involved in monitoring. Other notably frequent opinions include concerns with dairies in Amargosa Valley (N=9, 14.06 percent), water quality (N=6, 9.38 percent), and water quantity (N=6, 9.38 percent).

Table 44. Opinions.

Comments	Frequency				Percent
	Amargosa	Beatty	Pahrump	Total	
Concerned with dairies	9	0	0	9	14.06
Concerned with diversion	0	1	0	1	1.56
Concerned with US Ecology	2	0	0	2	3.13
Concerned with wells	2	0	0	2	3.13
Desire a website	1	0	0	1	1.56
Desire university involvement	0	1	1	2	3.13
Distrust in government	7	5	6	18	28.13
Monitoring – against	0	0	1	1	1.56
Monitoring – support	9	1	5	15	23.44
NTS – concerned with	3	0	0	3	4.69
Uncertainty – aquifer	1	0	1	2	3.13
Uncertainty – economy	2	0	0	2	3.13
Water is fine	2	0	0	2	3.13
Water quality	6	0	0	6	9.38
Water quantity	5	0	1	6	9.38
YM – against	2	1	1	4	6.25
YM – concerned with	1	0	0	1	1.56
YM – not concerned with	1	1	2	4	6.25
YM – support	1	1	1	3	4.69
N	38	11	15	64	100.00

CONCLUSIONS

The following conclusions can be drawn from this study:

1. Residents of Amargosa Valley are highly dependent on water directly retrieved from a private well. Even though they are less concerned about YM contaminating their groundwater resources than participants in Beatty and Pahrump (apparently due in part to their familiarity with groundwater concepts and aquifer properties), their vulnerability to and concerns about their water resources should be taken into account when developing and managing a GMN.
2. Women are more worried about their water supply than men. Because familiarity with groundwater concepts and aquifer properties negatively correlates with such worries, it would be worthwhile to familiarize women with relevant groundwater concepts.
3. Support for a GMN positively correlates with faith in technology. Thus, understanding technical aspects of a GMN might have a positive effect on people's perceived value of a GMN. In other words, outreach efforts regarding the GMN should include education on technical aspects of the GMN.
4. Most effective methods for communication and updates regarding a GMN include letters, briefings, and newsletters.
5. Perceptions towards a GMN are often correlated with worry about groundwater contamination. Information about NTS in addition to YM should be included in outreach efforts regarding the GMN.

REFERENCES

Brody, C. J. (1984). Differences by sex in support for nuclear power. Social Forces. 63, 209-228.

Earle, T. C. and G. Cvetkovich. (1995). Social Trust: Toward a Cosmopolitan Society. Westport, CT: Praeger.

Freudenburg, W. R. (1993). Risk and recreancy: Weber, the division of labor, and the rationality of risk perceptions. Social Forces. 71, 909-932.

Greenberg, M. R. and D.F. Schneider. (1995). Gender differences in risk perception: effects differ in stressed vs. non-stressed environments. *Risk Analysis*. 15, 503-511.

Hine, D. W., C. Summers, M. Prystupa, and A. McKenzie-Richer. (1997). Public opposition to a proposed nuclear waste repository in Canada: An investigation of cultural and economic effects. *Risk Analysis*. 17(3), 293–302.

Hogg, M. A. (2000). Social identity and social comparison In J. Suls & L. Wheeler (Eds.), Understanding group behavior: Vol. 2. Small group processes and interpersonal relations, 227-253. Mahwah, NJ: Erilbaum.

Metley, D. (1999). Institutional trust and confidence. A journey into a conceptual quagmire, in G. Cvetkovich and R. Lofstedt (eds) Social Trust and the Management of Risk, 100-

Siegrist, M. (1998). Belief in gene technology: the influence of environmental attitudes and gender. Personality and Individual Differences. 24, 861-866.

Siegrist, M. (1999). A causal model explaining the perception and acceptance of gene technology. *Journal of Applied Social Psychology*. 29, 2093-2106.

Siegrist, M. (2000). The influence of trust and perceptions of risks and benefits on the acceptance of gene technology. *Risk Analysis*. 20, 195-203.

Siegrist, M. and G. Cvetkovich. (2000). Perception of hazards: the role of social trust and knowledge. *Risk Analysis*. 20, 713-719.

Siegrist, M., T.C. Earle, and H. Gutscher. (2003). Test of a trust and confidence model in the applied context of electromagnetic field (EMF) risks. *Risk Analysis* 23(4), 705-716.

Siegrist, M., H. Gutscher, and T.C. Earle. (2005). Perception of risk: The influence of general trust, and general confidence. *Journal of Risk Research*, 8(2), 145-156.

Stallen, P.J. and A. Thomas, A. (1988). Public concern about industrial hazards. *Risk Analysis*. 8, 237-245.

Williams, D. J. and J.M. Noyes. (2007). How does our perception of risk influence decision-making? Implications for the design of risk information. Journal of Theoretical Issues in Ergonomics Science. 8(1), 1-35.

Yamagishi, T., and M. Yamagishi. (1994). Trust and commitment in the United States and Japan. Motivation and Emotion. 18, 129-166.

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