A STUDY OF THE RELATIONSHIP BETWEEN INFORMATION AND ATTITUDE FOR USERS AND NON-USERS OF COMPUTERIZED WATER RESOURCE MANAGEMENT SIMULATION

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A U.S. Water Resources Council Study of U.S. water supplies identified water resources as the nation's most serious long range problem (12). Numerous articles in the popular press and TV specials reflect high public interest as well as indicate the magnitude of water resource problems. Public interest in environmental issues has been shown to represent a major and enduring social concern, however public knowledge of issues is distressingly low (4). A study of the water knowledge possessed by 160 university-bound high school graduates supports the survey findings (8). High school graduates possessed limited water knowledge particularly in the areas of (a) current issues, (b) water resource management, and (c) the historical influence of water on human affairs. Students scored higher in areas concerning the (a) water cycle, (b) physical and chemical properties of water, and (c) the physical effects of water on the earth. It can be argued that these recent high school graduates scored higher in content areas commonly taught in the public schools while scoring lower in areas seldom taught. Water resource management was identified as one such content area.

A number of professional organizations are addressing the problem of how, when, what and whom to teach about water. One of the objectives of the Water Resources Education Project (11) is the application of computer technology to the complex problem of water resource education.

Computerized instruction is commonly found in one of three forms: (a) drill and practice, (b) tutorial, or (c) simulation (6). Of the three forms only simulation has the potential for creating interaction with functioning models of real phenomena. McLean (7) defines simulation as an "operating model of the real world made up of selected sets of interrelationships that reduce complex problems to manageable size for instructional purposes." The use of computer simulation for complex environmental problems has great potential. It is uniquely suited to environmental education because it can (a) speed up or slow down time, (b) employ expensive or unavailable materials and procedures, (c) act to objectively select random phenomena, (d) provide active participation and input by the learner, (e) provide immediate feedback, (f) reduce complex problems to manageable size, (g) create problem situations where processes and concepts from many disciplines are interrelated in the search for solutions, and (h) allow exploration of alternatives without having to live with harmful consequences (10, 1).

A current drawback of computer simulation is that participation is limited to one or a few persons at any one time. A critical ingredient of environmental education is missing. Group interaction in clarifying problems, considering alternatives and trade-offs, decision-making and cooperative action so necessary in environmental problem solving is slighted. A multi-user interactive computer simulation (MICS) solves this problem by providing input from a number of participants at one time, summarizing interactions and sharing results simultaneously with all participants. In addition to simultaneous group interaction, a MICS models situations where relevant environmental concepts and issues are considered objectively in the absence of excessive emotional bias common to local site-specific water issues. Emotional involvement is present but not to the degree it interferes with consideration of rational alternatives!

The Water Resources Management Simulator (WRMS), a multi-user interactive computer, is designed to improve understanding of the major factors involved in intelligent management of water resources. The WRMS offers a visual model of hydrologic information and provides up to 30 participants the opportunity to develop and evaluate water management strategies. The WRMS models four problem areas common to river basins: (a) source and quantity, (b) use of water, (c) quality and (d) political management of the water resource. The WRMS operator can choose to model any one of nine different river basins.

A large simulator panel (Figure 1) placed in view of the audience is programmed to display snow pack and instream flow based on actual USGS data for the basin being modeled. Instream flow, and water quality (silt and dissolved solids) are monitored by visual up and downstream LED (Light Emitting Diode) displays. Flashing lights indicate serious low water or flood conditions. The Sub Basin Storage and Demand displays show current ground and surface water reserves, and the relative demand by users. Horizontal LED's indicate the proportion of ground or surface water used and the proportion of water consumed or returned to the stream. A clock in the upper right hand corner displays accelerated time in months and years.

The simulator is operated by participants using several small control consoles (Figure 2). Water management decisions regarding impoundment, demand, surface or ground source, technology applied to water use, and treatment of used water are made with controls on the consoles. Consoles allow participant input to the large display panel in four water use categories: (a) irrigation, (b) livestock, (c) municipal and industrial, and (d) energy. A fifth console provides for the creation and management of a reservoir. The hydrologic situation and user input is summarized and displayed on the main panel providing the audience with the consequences of various user management practices. As the simulation operates, important data such as monthly instream flow, ground and surface water reserves and total demand are presented as a video color graphics display. In addition this data is stored in memory and can be retrieved for manual graph plotting.

The participants in a simulation may interact with the river basin model at any time, changing variables to optimize their situation. Supply/demand, pollution, applied technology, or other issues may be discussed, new management strategies planned and another simulation initiated to test these newly developed strategies. A major attribute of the WRMS is its ability to place groups of people in policy-making situations involving real variables and alternatives, and to present within reasonable time, the probable consequences of their various water management strategies.

Using an MICS format similar to that of the WRMS but related to energy resources, Dunlap (5) studied the effect of simulation on inservice teacher energy related attitudes. He found elementary teachers attitudes changed the greatest and secondary teachers the least. Dunlap suggested that a lack of initial awareness of the issues may have resulted in a greater attitudinal shift in the elementary teacher population. Cartwright and Heikkinen (2) also using the energy-environment simulator studied its effect on the energy concepts and attitudes of college students at various levels of cognitive development. The energy-environment simulator was found to be more effective than a slide presentation covering the same concepts, and students at lower stages of cognitive development learned almost as much as the more cognitively mature students. However, the treatment did not significantly alter subjects attitudes toward energy or energy-related issues. Using computer simulated experiments in college chemistry courses, Cavin and Lagowski (3) found students in the computer simulation groups generally achieved as well or better than students in regular laboratory groups. They also suggested there was evidence to support use of computer simulated experiments with low as well as high-aptitude students.

The development of educational computer simulation is in its infancy and although the number of available simulations is rapidly increasing, the analysis of computer simulation experiences and related research base is not extensive (9). The intent of this study was to create base line data concerning the potential of interactive computer simulation for public information dissemination and attitude development in water resource management.

OBJECTIVE

The major purpose of this study was to identify the effects of a multi-user computerized water resource management simulation (WRMS) on the water resource knowledge and attitude of 13- to 18-year-old and adult subjects. Using the WRMS treatment, Water Resource Management Assessment Test, and Water Concern Scale, the following null hypotheses were tested.

There is no significant difference between WRMS users' and non users':

- mean knowledge scores for 13- to 15-year old, and 16- to 18-year-old subjects and adults;
- mean attitude scores for 13- to 15-year old, and 16- to 18-year-old subjects and adults;
- response on individual attitude test items by group.

In addition the study examined the differences between 13- to 18-year-old and adult subject's scores for knowledge and attitude, and the correlation between knowledge and attitude scores for 13- to 18-year-old subjects and adults.

METHOD

The WRMS knowledge test was developed directly from the stated objectives for the simulator following critique of the objectives by over 60 science educators and water specialists. In addition, test items were reviewed by two environmental science specialists and the content validity found to be satisfactory. The Kronbach Alpha reliability coefficient for the 25 water resource management knowledge questions was .87. Eighteen multiple choice, and 7 true/false questions were included. Each question was given a one point value. Thus, a perfect score is 25.

Attitude toward water resources was determined by administering the Water Concerns Scale. Watkins (13), using factor analysis of interview data, isolated five questions which measured attitude regarding concern for water resources. The five items make up the Water Concern Scale (Appendix B). Subjects responded to each item by indicating their choice of: strongly agree, agree, undecided, disagree and strongly disagree. The Likert-type statements (Table XIII) were weighted on a scale of 1 to 5, with 5 indicating a greater concern for water resources. Responses totaling 25 indicated the highest possible level of concern.

The population studied included 866 subjects ranging in age from 13 years to adult. Thirteen to eighteen-year-old subjects were given WRMS treatment as part of their junior or senior high school classes. Approximately 50% of the students at a particular grade in each school system were assigned to the WRMS treatment group and 50% to the control group.

Each of the one and one half hour WRMS training sessions was presented by a trained coordinator. Each coordinator followed a specific outline. All sessions used the same slide presentation introducing (a) simulation, (b) simulation variables controlled by users, and (c) data displayed on the main simulator panel. In addition to the session outline the slide presentation assisted in keeping presentations uniform.

FINDINGS

Table I compares mean knowledge scores of WRMS users and non-users by group. The junior high (age 13-14-15) and senior high (age 16-17-18) subjects not receiving WRMS treatment show lower mean scores than adults, as might be expected. Senior high and adult groups receiving WRMS instruction scored significantly higher than the control group. For 16- to 18-year-old and adult subjects, null hypothesis 1 was rejected!

TABLE I

t-Test Comparison of User with Non-user WRMS Knowledge Scores for Junior High, Senior High, and Adult Groups

Source		N	$\bar{x}$	SD	Degrees of Freedom	t	P	Range Correct Respon.
Grade 7,8,9	Non-user	238	9.60	3.26	483	0.192	0.100	2-18
	User	255	9.70	3.14	281			3-18
Grade 10,11,12	Non-user	103	9.86	3.32	248	4.69	0.0001*	1-18
	User	147	12.39	5.19	246			2-22
Adult	Non-user	102	14.14	3.12	194.0	5.52	0.0001*	4-23
	User	94	16.46	2.71	193.4			10-24

*Significant Dif.

Table II compares mean attitude scores of WRMS users and non-users by group. No significant differences existed between 7-9th grade and adult users and non-users of the WRMS, although a slight mean increase is evident. High school students using the WRMS exhibited a significantly higher attiutude toward water issues. For high school students (16- to 18-year-old subjects) null hypotheses 2 was rejected!

To determine if a significant difference in knowledge and attitude exists between student and adult users and non-users, t-test comparisons were made. Tables III and IV summarize this information.

TABLE II

Attitude t-Test Comparison of WRMS User and Non-User
Mean Scores for Junior High, Senior High and Adult Groups

Source		N	$\bar{x}$	SD	t	P
Grade 7,8,9	Non-user	141	15.4	2.89	.46	0.64
	User	255	15.6	2.88		
Grade 10,11,12	Non-user	102	15.3	2.64	2.16	0.03*
	User	147	16.19	3.05		
Adult	Non-user	115	17.91	2.27	.40	0.68
	User	102	18.05	2.96		

*Significant at the .05 level of confidence

TABLE III

t-Test Comparison of Adult and Student WRMS
User and Non-users Knowledge Scores

Source		N	$\bar{x}$	SD	t	P
Users	Student	403	10.67	4.21	16.52	0.0001*
	Adult	94	16.46	2.71		
Non-Users	Student	247	9.69	3.3	11.5	0.0001*
	Adult	102	14.14	3.1		

*Significant at the .05 level of confidence

TABLE IV

t-Test Comparison of Adult and Student
WRMS User and Non-user Attitude Scores

	Source	N	$\bar{x}$	SD	d.f.	t	P
User	Student	402	15.8	2.9	502	6.8	.0001*
	Adult	102	18.05	2.9	156		
Non-user	Student	247	15.34	3.02	360	8.9	.0001*
	Adult	115	17.9	2.2	288		

*Significant at the .05 level of confidence

As might be expected, adults initially (WRMS non-users) knew more and had higher concern for water issues than did students. This relationship also existed between adults and students receiving WRMS treatment. Both adult and student mean knowledge and attitude scores increased with WRMS treatment but adult scores remained significantly higher than students. A notable exception existed between attitude scores of twelfth grade and adult users and non-users. Table V shows summary by item response frequencies and x^2 values comparing adults and twelfth graders. Significant differences existed favoring adults over student WRMS non-users, however, those twelfth graders and adults using the WRMS showed no significant difference on any of the five items. The WRMS treatment appears to moderate the differences between 18 year old subjects and adults.

To determine the relationship existing between knowledge and attitude scores, Pearson correlation coefficients were determined for all students and adults studied. Table VI shows correlation coefficients for students by grade.

TABLE V

Chi Square Values and Summary Attitude Response Frequencies by Item for Adult and Twelfth Grade Users and Non-users

Item		WRMS Users %		Chi-Square		WRMS Non-users %		Chi-Square	
		Agree & St. Agree	Disagree & St. Disag.	x^2	P	Agree & St. Agree	Disagree & St. Disag.	x^2	P
1.	Adult	86.1	13.86	0.32	0.56	74.1	25.8	1.5	0.21
	12th grade	89.7	10.2			86.3	13.6		
2.	Adult	79.7	20.2	2.35	0.12	35.2	64.71	4.9	0.02*
	12th grade	66.6	33.3			64.1	35.8		
3.	Adult	21.2	78.7	0.04	0.83	16.98	83.0	7.0	0.007*
	12th grade	22.8	77.1			41.6	58.3		
4.	Adult	22.45	77.5	0.08	0.76	11.7	88.2	4.3	0.03*
	12th grade	25.0	75.0			31.25	68.7		
5.	Adult	94.17	5.83	0.01	0.89	95.6	4.3	4.3	0.47
	12th grade	94.74	5.26			92.3	7.6		

TABLE VI

Correlation Between Knowledge and
Attitude Scores for Students by Grade

Source	N	Pearson	Level of Significance	Mean Attitude
7th	115	.144	.12	15.29
8th	222	.182	.006*	15.81
9th	59	.345	.007*	15.71
10th	130	.294	.0007*	15.71
11th	48	.037	.800	15.89
12th	71	.452	.0001*	16.04

*Significant at >.05 level

A positive correlation existed between knowledge and attitude for students in grades 8, 9, 10 and 12. This relationship existed for 75% of the 13 to 18-year-old population. Table VII describes correlation between knowledge and attitude for adults.

TABLE VII

Correlation Between Knowledge and
Attitude Scores of Adults

Source	N	Pearson	Level of Significance	Mean Attitude Score
Adults	203	-0.119*	0.09	18.01

*Not significant

The relationship existing between knowledge and attitude for adults is not significant. It is of interest to note however, that at the .09 level of confidence a negative relationship exists. The more this population of adults knew, the less they tended to register concern for water issues. The mean attitude score for adults was relatively high.

Comparison of mean by item responses between WRMS users and non-users for the seventh through twelfth grade groups is shown in Table VIII. Seventh, tenth and eleventh grade subjects using the WRMS compared with non-users showed no significant differences on any of the five attitude items. Significant differences existed in favor of: eighth grade users on items 1 and 2; ninth grade users on item 2; and twelfth grade users on items 2, 4 and 5. Significant differences existed in favor of ninth grade WRMS non-users on item 29 for twelfth grade non-users on item 26. Concern for water issues was significantly different favoring WRMS users in six instances and significantly different in favor of non-users in two instances. A discernable pattern exists in that eighth, ninth and twelfth grade subjects using the WRMS tended to agree (high level of concern) with the statement "Water reclaimed from waste is as good as any other water." Twelfth graders appear to show greater shift toward positive attitude than did other grades.

SUMMARY OF RESULTS AND CONTRIBUTION TO KNOWLEDGE

There has been little research conducted in the application of interactive computer simulation to information dissemination and attitude shifts. The purpose of this study was to determine the effects of the WRMS, a multiuser interactive computer simulation on the knowledge, attitude and their interrelationship for 13- to 18-year-old and adult subjects.

Comparison of 13- to 18-year-old subjects and adult WRMS users and nonusers knowledge and attitude scores determined that:

TABLE VIII

Summary of t-test Comparison of WRMS User with Non-user Attitude Scores by Students Grade

Question	Source	Group: 7th $\bar{x}$	7th t	8th $\bar{x}$	8th t	9th $\bar{x}$	9th t	10th $\bar{x}$	10th t	11th $\bar{x}$	11th t	12th $\bar{x}$	12th t
(26) We really haven't thought about cutting down our use of water.	User	2.3	-.044	2.6	2.4*	2.5	.18	2.5	0.63	2.8	-0.29	1.6	-2.8*
	Non	2.5		2.3		2.5		2.4		2.9		2.2	
(27) Water reclaimed from waste is as good as any other water.	User	2.8	0.01	3.0	1.9*	3.3	3.0*	3.0	1.5	3.0	0.17	3.8	3.7*
	Non	2.8		2.7		2.5		2.7		2.9		2.8	
(28) Mankind has a right to free and unlimited use of water.	User	3.1	-1.5	3.3	-0.6	2.9	1.0	3.0	0.39	3.0	0.80	3.1	1.6
	Non	3.7		3.3		2.9		3.0		2.0		3.1	
(29) Nature has a way to solve supply problems before they get serious.	User	2.8	-1.8	3.0	-1.3	2.4	-2.0*	3.2	0.01	2.8	0.31	3.9	2.8*
	Non	3.5		3.1		3.0		3.2		2.7		3.2	
(30) It's the people who should do something about the water problem.	User	4.0	0.9	4.0	0.74	3.9	0.02	4.1	-0.17	3.8	-1.6	4.7	2.4*
	Non	3.7		3.9		4.9		4.1		4.3		4.2	

*Significant at .05 level of confidence

A. 13- to 15-year-old WRMS users showed:

(1) higher levels of water resource management knowledge and (2) higher levels of concern for water issues. For the total population of 14- and 15-year-old subjects a significant positive correlation existed between knowledge and attitude scores.

B. 16- to 18-year-old WRMS users showed:

(1) Significantly higher levels of water resource management knowledge, and (2) significantly higher levels of concern toward water issues. For all 16- to 18-year-old subjects a significant positive correlation existed between knowledge and attitude scores.

C. Adult WRMS users had a (1) significantly higher knowledge score, and (2) slightly higher level of concern for water issues. For all adult subjects a slight negative correlation existed between knowledge and attitude scores at a 0.09 level of significance.

D. Adult mean knowledge and attitude scores were significantly higher than those of the total 13- to 18-year-old population, however there was a trend for older students using the WRMS to approach adult attitude levels.

The WRMS is an effective (a) water information dissemination tool, particularly at the senior high school and adult levels, and (b) a method of increasing concern for water issues particularly with 16- to 18-year-old high school students. Correlation between knowledge and attitude scores was generally positive for all students and negative for all adults. The ability of WRMS treatment to significantly increase adult knowledge, the initial high adult attitude scores and negative correlation between adult knowledge and attitude suggest that the WRMS may moderate extremely high levels of adult concern for water issues.

The application of the Water Resource Management Simulator as a public education tool has great potential. The simulator's ability to increase knowledge and concern for water issues prior to actual confrontation with water issues makes it a valuable asset in the public education arena. The current cost ($4500) inhibits widespread use, however, large school districts, state and federal agencies as well as universities could make it available to a large segment of the general population.

The suggestion that the WRMS reduces extreme levels of concern for water issues is supported by Ramsey and Rickson's study (11) of high school students environmental knowledge and attitude. They found that high knowledge levels are related to moderate, as opposed to extreme, stands on pollution abatement. The potential of interaction with the WRMS being a moderator of extreme bias needs to be explored.

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APPENDIX A

Water Resource Management Simulator Knowledge Test

WATER RESOURCE MANAGEMENT KNOWLEDGE TEST

1. Water users can be divided into municipal, industrial, livestock, irrigation, and energy. Which of the following uses the most water?

    a. municipal/industrial
    b. industrial
    c. livestock
    d. irrigation
    e. not sure

2. Water in Oklahoma's rivers generally flows toward the

    a. Northeast
    b. Northwest
    c. Southeast
    d. Southwest
    e. not sure

3. A major aquifer in Oklahoma is the

    a. Perrniam
    b. Ogallala
    c. Nubian
    d. Hennessey Shale
    e. not sure

4. Water is used to cool coal and nuclear electrical energy generating plants. Which procedure uses the least amount of water?

    a. flow through in closed pipes
    b. evaporative cooling
    c. non-consumptive
    d. condensation cooling
    e. not sure

5. Water is used to cool coal and nuclear electrical energy generating plants. Which procedure returns the least water back to the surface reserve?

    a. flow through in closed pipes
    b. evaporative cooling
    c. consumptive
    d. condensation cooling
    e. not sure

6. Which of the following sewage treatment procedures returns the least polluted water back into the surface reserve?

    a. secondary
    b. floculation
    c. primary
    d. tertiary
    e. not sure

7. Which of the following irrigation methods requires the least amount of water?

   a. sprinkler method
   b. percolation method
   c. flood method
   d. hydrologic
   e. not sure

8. Which of the following irrigation methods returns the most water back into the surface reserve?

   a. sprinkler
   b. percolation
   c. flood
   d. hydrologic
   e. not sure

9. Which would you consider the most feasible solution to Oklahoma's water problems?

   a. new sources of water
   b. new reservoirs and dams
   c. conservation
   d. drill more wells
   e. not sure

10. What percent of all water used in Oklahoma is used for irrigation purposes?

   a. 20%
   b. 50%
   c. 75%
   d. 90%
   e. not sure

11. "Dilution is the solution to pollution" means:

   a. dilution reduces the amount of pollutant present
   b. adding "clean" water reduces the concentration of pollutants
   c. removal of pollutants from surface water
   d. greater stream flow reduces the amount of pollutants
   e. not sure

12. The greatest water pollutant in Oklahoma is:

   a. salt
   b. PCB's
   c. silt
   d. DDT
   e. not sure

13. The most harmful consequence of little winter snowfall in the mountains is

   a. snow mobiles are restricted to certain areas
   b. it makes for poor skiing
   c. wild game animals do not move from higher elevations to the lower elevations
   d. spring snow melt and runoff will be insufficient
   e. not sure

14. During which month of the year does irrigation in the Southwest demand the greater amount of water?

   a. September
   b. May
   c. December
   d. February
   e. not sure

15. Most of the earth's water is stored in

   a. precipitation and clouds
   b. rivers and lakes
   c. ground water and lakes
   d. oceans and snowpack
   e. not sure

TRUE OR FALSE (mark A for true, and B for false)

16. There are alternative forms of energy and water that we can develop to meet our needs.

17. The amount of ground and surface water available for use varies by geographic region.

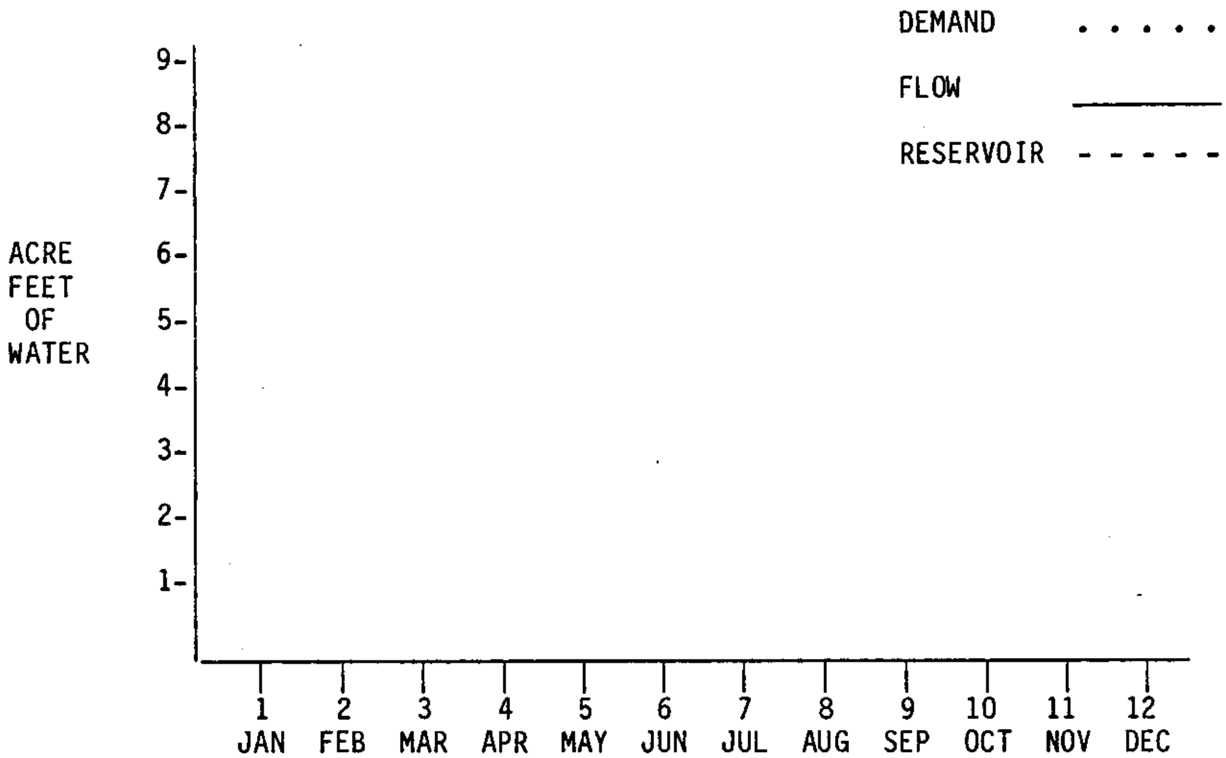
18. Where both ground and surface water are available to a community, the decision as to which will be used is made by the Oklahoma Water Resource Board.

19. We have little control over the amount of water available to us.

20. The demand for water by municipal, industrial, agricultural and energy users usually peaks at the same time stream flow peaks.

21. The "life span" of a reservoir is related to the silt load carried in streams and rivers carrying water to the reservoir.

22. Water quality is subject to available technology, but the choice of technologies is made through public policy.



23. How is downstream water quality affected in the dry months of July, August, and September?

    a. remains the same
    b. lower concentration of pollutants
    c. higher concentration of pollutants
    d. less pollutants in August than in July
    e. not sure

24. The increased demand in July is probably due to

    a. industrial users
    b. municipal users
    c. irrigation users
    d. not sure

25. What action would you take to end the supply/demand problem July through September?

    a. build a dam
    b. initiate conservation practices
    c. find new water supply sources
    d. not sure

APPENDIX B

Water Concerns Scale

WATER CONCERNS SCALE

1. We really haven't thought about cutting down our use of water.

    a. strongly agree
    b. agree
    c. undecided
    d. disagree
    e. strongly disagree

2. Water reclaimed from waste is as good as any other water.

    a. strongly agree
    b. agree
    c. undecided
    d. disagree
    e. strongly disagree

3. Mankind has a right to free and unlimited use of water.

    a. strongly agree
    b. agree
    c. undecided
    d. disagree
    e. strongly disagree

4. Nature has a way to solve water supply problems before they get serious.

    a. strongly agree
    b. agree
    c. undecided
    d. disagree
    e. strongly disagree

5. It's the people who should do something about the water problem.

    a. strongly agree
    b. agree
    c. undecided
    d. disagree
    e. strongly disagree