Global Positioning System-Based Mapping of Public Water System Facilities in Wyoming

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CHAPTER I
INTRODUCTION

PURPOSE

In recognition of the U.S. Environmental Protection Agency's (USEPA) recently adopted ground-water protection strategy (USEPA 1991), the Water Quality Division (WQD) of the Wyoming Department of Environmental Quality (DEQ) has placed a priority on the development of a spatially-referenced database for the coordinate locations of all groundwater-based sources (i.e., wellhead and springs) for community and noncommunity public water system (PWS) facilities in Wyoming. Additionally, in order to plan and implement groundwater quality protection programs, such as the Wyoming State Wellhead Protection Program, there is a need to assemble readily available digital data related to PWS facilities and sources. A substantial amount of work has already been directed toward this goal by the USEPA through the development of the **Safe Drinking Water Program Database**. This relational database has an assortment of tables associated with PWS systems, including (representing): identification information, locational information, construction information, permit tracking, inspection/operation information, and enforcement/compliance tracking. To spatially reference this data, it becomes necessary that the locations for each PWS source are accurately located and incorporated within USEPA's database.

In September of 1995, the Wyoming Department of Environmental Quality, Water Quality Division (WDEQ/WQD) contracted with the Wyoming Water Resources Center (WWRC) at the University of Wyoming to establish locations for a portion of the remaining groundwater sources within the USEPA PWS database. Dates of the contract were Oct. 1, 1995 to Dec. 31, 1996 with the majority of field

work being accomplished from May, 1996 to September, 1996. Within this final report the tasks and methodologies employed throughout the contract period are described.

PUBLIC WATER SYSTEMS

> A [Public Water System (PWS)] is a system that provides piped water for human consumption and regularly serves at least 25 persons or has at least 15 service connections. A PWS may receive its water from ground water sources, surface water sources or a combination of the two sources; in some cases, one PWS may purchase all or part of its water from another PWS, (USEPA, 1994).

Within Wyoming there are over 900 PWSs with approximately 1350 sources (i.e., surface- or ground-water) supplying water to these facilities. The two main types of PWSs are community and non-community water systems. A community water system is a PWS that serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents (40 CFR 141.2). In Wyoming there are currently 355 community PWSs with 92 of these owned by incorporated communities (Table 1). Approximately 455,396 people throughout Wyoming (83% of total population) receive their water from these systems. As shown in Table 2, which further divides Wyoming population figures, 288 out of 355 or 81% of the community PWS serve populations of less than 500 people with the remaining 67 or 19% serving populations ranging from 500-55,0000.

Class of System	Number of Systems	Total Population Served
Community PWS	355	455,396
Transient Non-Community	359	72,765
Non-Transient Non-Community	102	19,869

Table 1. Total Active Public Water Systems in Wyoming by Class

Source: USEPA Safe Drinking Water Program Database (12/15/96)

Class of System	Number of Systems	Population Served by System				
		<25	26-500	501-3,300	3,301-10,000	10,001>
Community PWS	355	3	285	43	14	10
Transient Non-Community	359	1	343	12	3	-
Non-Transient Non-Community	102	-	94	8	-	-

Table 2. Wyoming Public Water Systems by Class and Size (surface and groundwater sources)

Source: Data collected for the WDEQ/WQD 1996 Water Quality Assessment Report: 305B (Collected by Vanessa Forselius)

Non-community systems can be classified as by transient or non-transient (USEPA, 1994). These classifications are based strictly on the type of population being served by the system, and does not reflect in any way the size of this population. A transient, non-community water system is a PWS that serves at least 25 people daily, but only the same individuals for less than 6 months (e.g. campgrounds, rest areas, parks, service stations, and guest ranches (40 CFR 141.2)). There are 359 of these systems located in Wyoming serving an estimated population of 72,765 (Table 1). This population number appears small in comparison to the community systems. However, the number would greatly increase if it included all users that obtain water from the system rather than the daily number of people that use the facility. A non-transient, non-community water system is a PWS that serves at least 25 of the same persons for over 6 months of the year (e.g. schools, office buildings, and mines (40 CFR 141.2)). There are 102 non-transient non-community PWSs in Wyoming serving 19,869 people.

USEPA has different regulations for the various system classes. Community systems are subject, for the most part, to all of the USEPA's drinking water regulations as are non-transient non-community systems. Transient non-community facilities, where public water consumption occurs only over short

periods of time, have far fewer regulations. (For more information, see Drinking Water Standard Setting, Question and Answer Primer, USEPA, 1994)

USEPA SAFE DRINKING WATER PROGRAM DATABASE

The USEPA was mandated by the Safe Drinking Water Act (SDWA) to enforce and monitor regulation compliance of all public water systems to the specific standards established in the Act (USEPA, 1994). In order to effectively handle the large amount of data created from such a task, the **Safe Drinking Water Program Database** was developed for all the States and administered by each regional USEPA office. This database, as mentioned before, has a number of relational tables ranging from locational data to enforcement and compliance tracking.

For this project, two specific tables from this Database were used in reference to Wyoming. First was the ***system*** table which provides the foundation for the Database. This table contains the descriptive variables relating to each system, including the system's general locale (town, county, state), the system owner(s) or contact, type of system, activity of system, population the system serves, etc. The unique identifier for this table is the *system identification number*. This field is found in all other tables and is the direct link between each.

The second table utilized for this project was the ***sources*** table. It contains the descriptive variables relating to the source or sources for each system: location (latitude/longitude and legal description), source type (groundwater or surface water), name of source, etc. This table uses a double-field unique identifier which is tied to the *system identification number* and the *source identification number*. This is necessary due sources having a unique *source identification number* that relates only to each respective system.

SCOPE OF WORK

The primary objective of this project was to obtain and record latitude and longitude coordinates for up to 80% of the PWS groundwater sources contained within USEPA's **Safe Drinking Water Program Database** that had not been previously mapped. Specifically, this included three major tasks:

1) Update and modify the ***system*** and ***source*** tables found in USEPA's database for use by Wyoming's Department of Environmental Quality, Water Quality Division.
2) Locate PWS groundwater sources.
3) Convert ***system*** and ***source*** tables into a usable and spatial Geographic Information System (GIS) database for DEQ/WQD.

Chapters Two through Five examine the methodologies and procedures employed in each of these tasks. Additionally, Chapter Five will identify future work relating to the use of GIS and the **Safe Drinking Water Program Database**.

CHAPTER II
DATABASE UPDATING

Although the main focus of this project was centered around locating groundwater sources, the initial work involved updating the ***system*** table. This was accomplished by distributing a "letter of intent" and a questionnaire to owners/managers of all systems containing at least one water source utilizing groundwater (Appendix A). The purpose of this mailing was two-fold: 1) obtain specific well information, and 2) update the contact information (i.e. contact name, address, and phone number). Additionally, the letter gave PWS owner(s) and/or manager(s) an understanding of the project's purpose and scope before being contacted by a WWRC employee.

Systems to be surveyed were identified by querying both the ***system*** and ***source*** tables, to find all active systems with at least one groundwater source. In total, 1000+ individual groundwater source questionnaires were mailed to nearly 800 PWS systems meeting this criteria.

Response to the survey approached 50% with approximately 400 system owners/managers replying. Information obtained from the returned questionnaires was then used to check and update changes to the ***system*** table, which proved to be a valuable resource when contacting owners/managers for property access and directions to the locations of their groundwater sources.

CHAPTER III
DATA COLLECTION

INTRODUCTION

The primary objective of this project was to collect locational data for each groundwater source that had not been located within the USEPA's **Safe Drinking Water Program Database**. After examining all alternatives for gathering this data, it was determined that Global Positioning System (GPS) technology would be applied on-site for each source, following recommendations made in USEPA's Locational Data Policy for achieving location accuracy goals (USEPA 1992a).

In order to effectively use GPS, certain tasks had to be completed. These included: querying the existing USEPA Database to generate a list of all unmapped groundwater sources with associated contact information, preplanning data collection, in-field lat/long data collection, post-processing of location data, and finally transferring the data from GPS to an acceptable database format.

GLOBAL POSITIONING SYSTEM

GPS is a radio based satellite system developed by the Department of Defense for accurately locating positional data (Kennedy, 1996). This system has four major components: 24 orbiting satellites, data collection receivers, base station receivers, and the user. Recent advances in this technology and decreases in price have allowed for GPS to reach a wider audience of users. The accuracy, ease of use, efficiency, and GIS compatibility of GPS technology was fundamental to this project.

The accuracy of GPS for locating real world features is the single biggest reason many natural resource managers have employed this technology. There are a variety of factors that influence the accuracy of the System: type of equipment,

data collection methodologies and settings, inherit GPS errors, post-processing techniques, and data exchange procedures. The type of receiver used for collecting data however, directly influences all the other factors. There are three basic grades of receivers; recreational, mapping, and surveying. Accuracy and cost increase when going from the recreational grade receiver to the surveying grade. Additionally, the type of procedures available to the user also changes as receiver upgrading occurs.

For this project, a Trimble Pro XL[1] receiver was used in gathering locational data for each PWS groundwater source. This is a eight channel, mapping grade receiver that maintains accuracy standards of approximately one meter after applying post-processing techniques. This receiver is also accompanied by a data logger that allows for ease in attributing and describing features.

The remainder of this chapter briefly describes the methodologies employed in using GPS, specifically Trimble GPS products, throughout the project. However, prior to traveling to data collection sites, a number of pre-planning tasks had to be accomplished relating not only to GPS but also to establishing a tentative schedule. The pre-planning steps allowed for the data to be collected as accurately and efficiently as possible.

DATABASE QUERY

The initial phase of this project involved first querying the system and source tables in order to create a list of collection sites. It was necessary to determine which systems were still active, and of these systems, which had groundwater sources that had not yet been located. Once this was completed, a list was created for each county containing contact, system, and well information necessary to find the source.

[1] Pro XL is a registered trademark of Trimble Navigation Limited, Sunnyvale, CA, USA.

PRE-PLANNING

This phase was two-fold: 1) contacting owners/managers to obtain permission and help in locating the source, and 2) establishing standards for certain critical settings within the receiver. Initially field personnel would contact PWS system owners/managers prior to going to the site. This quickly became economically unfeasible due to the number of calls necessary to contact people. The most efficient way proved to be direct communication with owners/operators on-site. Usually the Chamber of Commerce for each city became a valuable asset since they could direct personnel to the general locations.

Certain critical settings insured that the data would be collected as accurately as possible. All of the manufacturer's recommended settings were followed in configuring the receiver, including the number of positions collected for each source, the logging interval of the positions, the number of satellites available, and the Position Dilution of Precision (PDOP). All of these are fairly self-explanatory except for PDOP which is a measurement of the number and geometry of the satellites being used for data collection. Finally, a data dictionary was created, requiring the user to input the unique identifiers for each source (i.e. system identification number, source identification number, and groundwater source (spring or well)). All pre-planning activities were completed prior to leaving the office for data collection.

GPS DATA COLLECTION

Each groundwater source required that 30 positions be logged at one second intervals. Additionally at no time could the Precision Dilution of Position (PDOP) fall above six. All positions were collected using the 3-D setting with no less than four satellites being used. Each day, all collected data were downloaded to a laptop PC for safety and storage.

POST-PROCESSING

Once the data had been downloaded, project accuracy requirements made it necessary to post-process or differentially correct the data. GPS points collected without applying this process can have worst case accuracy errors of 100 meters. However, data that has been differentially corrected usually falls within one to two meters of its true location (specific for Trimble Pro XL receiver). In order to differentially correct GPS data collected in the field, the user must have access to base station GPS data and post-processing software.

For this project all base station data were obtained from the Casper BLM/UW station. A base station is an eight to twelve channel GPS receiver placed on a known location which produces correction files that can be applied to any data collected within a 300 mile radius of the station. Correction files can be downloaded via a modem and use of a bulletin board. Through the use of differential correction software these files can be applied to field data. Trimble's PFINDER[2] software with the **MCORR400** algorithm was applied for all collected data. Finally, all corrected positions were averaged to produce a single latitude and longitude for each groundwater source.

DATA TRANSFER

The final step in data collection is to transfer all the groundwater source locations back to the original table to be included with all PWS sources. This was accomplished through the use of PFINDER's **export** command and then combining all database tables to form a single table relating only to the locations collected by WWRC. This table was then related to the original ***source*** table allowing for all collected latitudes and longitudes to be placed respectively within the table.

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[2] PFINDER is a registered trademark of Trimble Navigation Limited, Sunnyvale, CA, USA.

PROJECT SUMMARY FOR DATA COLLECTION

From USEPA's Safe Water Drinking Act Program Database *source* table 511 active groundwater sources were lacking latitude and longitude descriptors. Of these, 419 were located by this project with an additional 59 new sources added to the table. These additions to the database were operational or partially completed wells not listed within USEPA's database and, according to the PWS contact, were or going to be part of that system.

There were a number of different reasons why 92 of the 511 listed sources were not located, however the biggest factor was dictated by the time and travel schedule during the data collection phase of the project. Every county throughout Wyoming except Campbell County was visited by a WWRC employee. Campbell County was excluded due to the number of mining PWSs (mines require safety training be completed before data can be collected within the permit area) and pre-existing data in the Gillette area which was collected by the State Engineer's Office. This county contributed to nearly half of the groundwater sources that currently lack locations and should be the focus of future data collection efforts.

CHAPTER IV
DATABASE MODIFICATION

Once the PWS coordinate values were collected, post-processed, and transferred to a table, it became necessary to modify the ***source*** and ***system*** tables to accommodate additional fields. The ***source*** table was significantly altered to fall in compliance with standards established by the Definitions for the Minimum Set of Data Elements for Ground Water Quality (USEPA, 1992b). Although USEPA's **Safe Drinking Water Program Database** followed these standards, this project included the use of only the ***system*** and ***source*** tables which together would serve as a "stand alone" Wyoming PWS geographic information system database.

The majority of the supplemental elements aided in describing the methods and errors associated with data gathering techniques. Additionally, some fields were developed that specifically relate to this project. Appendices B & D detail the structure of the two tables with Appendices C & E describing each field's significance and associated attribute options.

Added fields within the tables are denoted with an asterisk (*) in Appendices C& E. The ***system*** table has only one addition being the UW_UPDATE field. The ***source*** table has a multitude of changes. The most apparent of these changes is the additional latitude and longitude fields. The original database had a field for degrees, minutes, seconds for both latitude and longitude. For GIS conversion however, it was necessary to create a field that had each coordinate in decimal degrees. This allowed for the ***source*** table, the decimal degrees fields specifically, to be used in creating a spatial database. One other notable field is the REASON code which describes why the groundwater source was not located during this project or if it was a new source not listed in USEPA's database.

CHAPTER V

GEOGRAPHIC INFORMATION SYSTEM DATABASE

BACKGROUND

The final phase of this project was to create a Geographic Information System (GIS) database from USEPA's ***system*** and ***source*** tables. A GIS is a computer-based system that captures, stores, edits, manipulates, analyzes, synthesizes, and displays geographically referenced information (Burrough, 1985). This project's GIS database includes PWS source locations, roads, streams, cities, and counties as data layers. In producing the GIS, it was necessary for all layers to have a common datum, projection, and units. Since the GPS collected data were created in decimal degrees using a geographic projection with reference to the WGS84 datum, these parameters were applied to all data layers.

ARCVIEW GIS INTERFACE

Due to compatibility with DEQ, the GIS software utilized in this project was ArcView[3] by Environmental Systems Research Institute (ESRI), Inc. ArcView is a "point & click" GIS software that allows for ease and efficiency in querying, displaying, and updating GIS data. Both the ***system*** and ***source*** tables were placed within the GIS. Source locations provided the spatially referenced data with a link being established to the system attributes. This provided a methodology to quality check the data by comparing source locations with their corresponding system local descriptors (i.e. street, city, county, etc.).

In order to create the PWS sources data layer, the decimal degree latitude and longitude fields from the ***source*** table were used. By applying the **add event**

[3] ArcView is a registered trademark of Environmental Systems Research Institute, Inc., Redlands, CA USA.

theme action in ArcView, these fields were chosen to represent x, y for the layer and placed within the GIS along with the other associated attributes (fields). This direct link to the *source* and *system* database files allows for future updates to be made directly to the table using a database software or through ArcView. Either method provides for the new positions or attributes to be incorporated automatically within the GIS. All other data layers were pre-existing GIS layers developed by the WWRC GIS Lab.

ADDITIONAL GIS RESEARCH

With a majority of the sources located, additional future research can be focused on developing a customized graphical user interface (GUI) specific to PWS data. When notified by the USEPA Safe Drinking Water Program of PWS updates, changes, and/or additions , DEQ/WQD would have the ability to directly place these changes within the GIS and maintain a up-to-date, dynamic database. The USEPA could also benefit by utilizing this interface to aid in monitoring and regulating Wyoming PWSs. Finally, a GUI would allow for a quicker and easier methodology for querying the data.

Other future work could be concentrated on the use of GIS for delineating wellhead protection areas. This approach which has been utilized in various States (Rifai, et. al., 1993) allows for a systematic and efficient method to be developed in determining appropriate Wellhead Protection Areas (WHPAs) for PWSs. Lastly, as changes occur within WHPAs, GIS provides the capabilities necessary to make these updates and produce refined protection areas in the manner of minutes.

In summary, the GIS mapping of PWS systems has the potential to help facilitate the following:

- Development of local wellhead protection programs.
- Aid local governments in planning and management decisions specially when coupled with the WQD groundwater vulnerability and contaminant source identification digital data layers.

- Accessing information relating to the well locations, ownership, well construction information, water quality data, and other pertinent information for PWSs in Wyoming.

- Establishing a link between the State Engineer's permit number and the PWS ID for each groundwater source.

For many PWSs it will be necessary to collect a variety of additional attribute data relating to each source in order to perform the activities described above. However with accurate locations present within the database, the ability to combine spatial data layers enhances and expedites this attributing process. Therefor it becomes vital for this database to have consistent accuracy standards throughout the records. It was noticeable when examining source locations within the GIS that accuracy fluctuated in respect to previously located sources. This discrepancy is directly related to the varying methods and techniques employed in collecting the locations. A need exists to standardize location accuracy for all sources found in the database in order to effectively and confidently utilize this database to its full potential. By maintaining this accuracy assurance and control, the role of GIS in monitoring, regulating, and protecting PWSs throughout Wyoming will continue to develop in the upcoming years.

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40 CFR 141.2.

APPENDIX A

UW PWS PROJECT "LETTER OF INTENT" AND QUESTIONNAIRE

THE STATE OF WYOMING

JIM GERINGER
GOVERNOR

Department of Environmental Quality

Herschler Building ● 122 West 25th Street ● Cheyenne, Wyoming 82002

ADMINISTRATION	ABANDONED MINES	AIR QUALITY	INDUSTRIAL SITING	LAND QUALITY	SOLID & HAZARDOUS WASTE	WATER QUALITY
(307) 777-7758	(307) 777-6145	(307) 777-7391	(307) 777-7368	(307) 777-7756	(307) 777-7752	(307) 777-7781
FAX 777-7682	FAX 634-0799	FAX 777-7682	FAX 777-6937	FAX 634-0799	FAX 777-5973	FAX 777-5973

January 3, 1996

Re: Safe Drinking Water, GPS Mapping of Public Water Supply Wells

Dear Water System Operator/Owner:

I am writing this letter to inform you that the Department of Environmental Quality (DEQ) has contracted with the University of Wyoming (UW) Water Resources Center to accurately locate public water supply wells in Wyoming by latitude and longitude. DEQ and the UW Water Resources Center need your assistance to help facilitate the GPS (Global Positioning System) mapping of your well(s). The GPS equipment will utilize satellites to accurately determine the locations of your wells(s).

The Region VIII EPA (Environmental Protection Agency) Safe Drinking Water Program does periodically perform sanitary surveys on public water systems in Wyoming, and the surveys include locating well(s) with GPS equipment. The EPA is providing funds to DEQ for this project to complete state-wide mapping in the next year.

GPS mapping of your well(s) will help in protecting your water supply from contamination. In the future, DEQ and UW will be able to assist interested parties in providing maps and reference information on your water supply well(s) (e.g., to local water system representatives for locating contaminant sources, developing wellhead protection programs, and planning for new well(s)). Water systems with approved wellhead protection plans will be able to apply for monitoring waivers (i.e., eliminate monitoring for specific parameters) from the EPA which will enable significant cost reductions.

The information on the enclosed GPS Mapping Survey will assist the UW personnel in setting up the locating of your system's well(s). **Please complete the enclosed GPS Mapping Survey within the next three weeks and send it via the provided self-addressed envelope.** You will be contacted before your system's well(s) are scheduled to be mapped. Your cooperation in providing assistance to this project is greatly appreciated.

Sincerely,

Phillip Stump
Water Quality Division
f:...\PWS-GPS\CREDENT.LTR

GPS MAPPING SURVEY

ID 5600822

NAME of PWS _____
ADDRESS _____
CITY JACKSON_____
COUNTY 039_____
STATE WY_____
ZIP 83001_____

CONTACT _____
CONTACT PHONE _____

(PLEASE WRITE IN THE CORRECT INFORMATION, IF NECESSARY)

Total Number of Wells Serving the System_____

Has the Lat./Long. for all the wells been
determined during an EPA Sanitary Survey?_____

Name & No. of Each Well	Date of Completion	Total Depth (ft)	State Engineer's Permit No.	Annual Volume of Water Pumped (Gallons)	Lenght of Screening in Wall (ft)

How was the annual volume of water pumped determined?
____ meter ___ estimated from: ___ave. pumping rate_____gpm. or _____gpd.
___pump capacity_____gpm.

Contact: Jim Oakleaf, Wyoming Water Resources Center, GIS Lab
P.O. Box 3067, Laramie, WY 82071 (307)766-2735

APPENDIX B

SYSTEM TABLE STRUCTURE

SYSTEM TABLE STRUCTURE

DATA FILE NAME: SYSTEMS.DBF
51 FIELDS: STARTING IN POSITION 1

COL	ITEM NAME	WDTH	OPUT	TYPE	N.DEC
1	ID	7	7	C	-
8	NAME	30	30	C	-
38	ADDR1	30	30	C	-
68	ADDR2	30	30	C	-
98	CITY	15	15	C	-
113	COUNTY	3	3	C	-
116	STATE	2	2	C	-
118	ZIP_4	5	5	C	-
123	PHONE	12	12	C	-
135	CONTACT	20	20	C	-
155	SALUTATION	22	22	C	-
177	C_TITLE	10	10	C	-
187	C_ADDR	30	30	C	-
217	C_CITY	15	15	C	-
232	C_STATE	2	2	C	-
234	C_ZIP	5	5	C	-
239	C_PHONE	12	12	C	-
251	UW_UPDATE	2	2	C	-
253	IND_RESERV	5	5	C	-
258	PWS_TYPE	1	1	C	-
259	ACT_FLAG	1	1	C	-
260	FILTERED	1	1	C	-
261	SOURCECODE	1	1	C	-
262	SYS_BEGIN	5	5	C	-
267	DEACT_DATE	5	5	C	-
272	D_REASON	1	1	C	-
273	PCT_SURF	4	3	B	-
277	PCT_GRND	4	3	B	-
281	PCT_P_SURF	4	3	B	-
285	PCT_P_GRND	4	3	B	-
289	OWNER_TYPE	1	1	C	-

290	REG_ENTITY	1	1	C	-
291	POP_SERVED	4	7	B	-
395	SERV_CONCT	4	5	B	-
399	SEASON_BEG	5	5	C	-
304	SEASON_END	5	5	C	-
309	REQD	4	2	B	-
313	COMP_CYCLE	1	1	C	-
314	BACT_LAB	4	4	C	-
318	LASTUPDATE	8	10	D	-
326	Q1	1	1	C	-
327	Q2	1	1	C	-
328	Q3	1	1	C	-
329	Q4	1	1	C	-
330	TAKEN	4	3	B	-
334	VIO_FLAG	1	1	C	-
335	ENF_FLAG	4	4	C	-
339	COMMENTS	65	65	C	-

APPENDIX C

SYSTEM TABLE FIELD DESCRIPTORS

SYSTEM TABLE FIELD DESCRIPTORS

ID	System identification number
NAME	System name
ADDR1	System address
ADDR2	Additional system address
CITY	System city
COUNTY	System county (FIPS code)
STATE	System state
ZIP_4	System ZIP
PHONE	Phone Number
CONTACT	Contact or manager of system
SALUTATION	Contact Salutation
C_TITLE	Contact Title
C_ADDR	Contact Address
C_CITY	Contact City
C_STATE	Contact State
C_ZIP	Contact ZIP code
C_PHONE	Contact phone number
*UW_UPDATE	Answered UW questionnaire 1996 (Y - answered)
IND_RESERV	Indian reservation code if system is located within one
PWS_TYPE	Classification type of the system: C - Community water system N - Non-community water system P - Non-transient/non-community water system
ACT_FLAG	System activity flag: A - Active I - Inactive
FILTERED	Filtered source (Y - yes)
SOURCECODE	Primary water source for system: S - Non-purchased surface water P - Purchased surface water G - Non-purchased groundwater W - Purchased groundwater Y - Non-purchased groundwater under direct surface water influence Z - Purchased groundwater under direct surface water influence

SYS_BEGIN	Date system began
DEACT_DATE	Date system was deactivated
D_REASON	Reason system was deactivated: A - System abandoned C - PWS exists - can't contact D - Duplicate PWS M - System merged/consolidated N - Not currently monitored O - Other P - Purged form inventory S - System discontinued U - Unqualified as PWS
PCT_SURF	Percentage of system using surface water
PCT_GRND	Percentage of system using groundwater
PCT_P_SURF	Percentage of system using purchased surface water
PCT_P_GRND	Percentage of system using purchased groundwater
OWNER_TYPE	Type of PWS owner: 1 - Federal government 2 - Private 3 - State government 4 - Local government 5 - Mixed public/private 6 - Native American
REG_ENTITY	Entity which regulates the PWS: F - Federal agencies only S - State agencies only B - Both state and federal N - Not regulated by either federal or state
POP_SERVED	Population system supplies to
SERV_CONCT	Number of service connections
SEASON_BEG	Date when system is started for year
SEASON_END	Date when system is shut down for year
REQD	Minimum water samples required
COMP_CYCLE	Compliance cycle
BACT_LAB	Bacteria lab used for testing
LASTUPDATE	Last update of this record
Q1	Quarter one
Q2	Quarter two
Q3	Quarter three
Q4	Quarter four
TAKEN	Number of samples taken
VIO_FLAG	Violation Flag (Y-yes)
ENF_FLAG	Enforcement Flag (Y- yes)
COMMENTS	Additional comments relating to system

APPENDIX D

SOURCE TABLE STRUCTURE

SOURCE TABLE STRUCTURE

DATAFILE NAME: SOURCES.DBF

37 FIELDS: STARTING IN POSITION 1

COL	ITEM NAME	WDTH	OPUT	TYPE	N.DEC
1	ID	7	7	C	-
8	SE_ID	3	3	C	-
11	NAME	30	30	C	-
41	SE_REC_TYP	1	1	C	-
42	SE_CODE	1	1	C	-
43	AVAIL	1	1	C	-
44	SELLER_ID	9	9	C	-
53	LATD	4	2	B	-
57	LATM	4	2	B	-
61	LATS	4	6	F	3
65	LATDD	8	10	F	6
73	LONGD	4	3	B	-
77	LONGM	4	2	B	-
81	LONGS	4	6	F	3
85	LONGDD	8	11	F	6
93	LL_SOURCE	15	15	C	-
108	LL_METHOD	15	15	C	-
123	LL_DATUM	15	15	C	-
138	LL_EOE	15	15	C	-
153	LL_DATE	8	10	D	-
161	TOWNSHIP	4	4	C	-
165	RANGE	4	4	C	-
169	SECTION	2	2	C	-
171	QSEC	2	2	C	-
173	QQSEC	2	2	C	-
175	ALTITUDE	6	6	I	-
181	A_POINT	1	1	C	-
182	A_UNITS	10	10	C	-
192	A_SOURCE	15	15	C	-
207	A_METHOD	15	15	C	-
222	A_DATUM	15	15	C	-
237	A_EOE	15	15	C	-
252	A_DATE	8	10	D	-

260	LASTUPDATE	8	8	C	-
268	REASON	6	6	C	-
274	POINT_CODE	10	10	C	-

APPENDIX E

SOURCE TABLE FIELD DESCRIPTORS

SOURCE TABLE FIELD DESCRIPTORS

ID	System identification number
SE_ID	Source identification number
NAME	Source name
SE_REC_TYP	Source record type - describes whether the record is related to a source of water or another type of entity: S - Source record E - Entity record P - Plant record
SE_CODE	Source type: S - Non-purchased surface water P - Purchased surface water G - Groundwater W - Purchased groundwater
AVAIL	Circumstances under which a source of water is used P - Permanently utilized I - Used intermittently O - Used on some other basis S - Seasonally utilized E - Emergency use only
SELLER_ID	System from which water is purchased
LATD	Latitude degrees
LATM	Latitude minutes
LATS	Latitude seconds
*LATDD	Latitude decimal degrees (used for mapping purposes)
LONGD	Longitude degrees
LONGM	Longitude minutes
LONGS	Longitude seconds
*LONGDD	Longitude decimal degrees (used for mapping purposes)
*LL_SOURCE	Agency or group that determined latitude and longitude: WWRC - Wyoming Water Resources Center USEPA - Environmental Protection Agency DEQ - Department of Environmental Quality SEO - State Engineer Office
*LL_METHOD	Method used to determine Latitude and Longitude: SUR-GPS - surveyed using differential-mode GPS NAT-GPS - natural resources GPS

NAV-GPS - navigational-quality GPS
SUR-C - cadastral survey
MAP - digital or manual interpolation from map or photo
LORAN-C - Loran-C navigation device
ADDMAT - Address matching
PHOTO - GM Aerial photography
SPCSCONV - State Plane conversion
TSRCONV - Township/Range conversion
UTMCONV - UTM conversion
PHOTODRAW - Digital or manual raw photo extraction
PMTSEN - Remote sensing
ZIP - Zip code centroid
UNKNOWN - Method unknown

*LL_DATUM — Reference datum:
NAD83 - North American Datum of 1983
NAD27 - North American Datum of 1927
WGS84 - World Geodetic System of 1984
WGS72 - World Geodetic System of 1972
UNKNOWN - Datum unknown

*LL_EOE — Latitude and longitudes estimate of error (+ or - ## meters)

*LL_DATE — Date in which position was determined

TOWNSHIP — Township

RANGE — Range

SECTION — Section

QSEC — Quarter section

QQSEC — Quarter-quarter section

*ALTITUDE — Altitude

*A_POINT — Measuring point of altitude
A - Airline
C - Top of well casing
K - Kelly bushing
L - Land or ground surface
U - Underground surface (e.g. caves)

*A_UNITS — Units used for altitude measurement (feet or meters)

*A_SOURCE — Agency or group that determined altitude

*A_METHOD — Method used to determine altitude
A - Differential-mode GPS
B - Absolute-mode GPS
C - Surveyed from a benchmark
D - Digitally interpolated from a map or photo
E - Manually interpolated from a map or photo

*A_DATUM — National reference datum for altitude

*A_EOE — Altitude estimate of error (+- # meters)

*A_DATE — Date altitude determined

LASTUPDATE	Date which fields were updated
*REASON	Why groundwater source was not located or does not have associated attributes: PURCH - Using purchased water from other source location CNC - Could not contact while gathering data DCE - Data corruption error during post-processing GPS data INACT - Inactive source and/or system MINE - System located on mine NCDTF - Not completed due to funding (mainly Campbell county) NEW - Source new or being developed (created in 1996 only) NLD - Source not listed in database individually WNC - Contact would not cooperate with the use of GPS DUPL - Duplicate within database
*POINT_CODE	Code differentiating between source type and who located it (for mapping and QA/QC purposes): EPA_GW - Groundwater source located by USEPA EPA_PGW - Purchased groundwater source located by USEPA EPA_SW - Surface water source located by USEPA EPA_PSW - Purchased surface water source located by USEPA WWRC_GW - Groundwater source located by WWRC

*Indicates new field created by WWRC specific for project and not found within USEPA's ***system*** and ***source*** tables.