

WELLHEAD PROTECTION PLAN
FOR
CITY OF WHITEWATER, WISCONSIN



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Madison, WI 53715

APRIL 1997

TABLE OF CONTENTS

Page No.

SECTION 1 - INTRODUCTION

1.01 PURPOSE OF PLAN 1-1
1.02 SCOPE 1-1
1.03 DEFINITIONS 1-1

SECTION 2 - GROUNDWATER HYDRAULICS

2.01 AQUIFER CHARACTERISTICS 2-1
2.02 ZONE OF INFLUENCE (CONE OF DEPRESSION) 2-1
2.03 GROUNDWATER FLOW / RECHARGE AREA 2-1
2.04 WELLHEAD PROTECTION AREAS 2-2

SECTION 3 - POTENTIAL SOURCES OF CONTAMINATION

3.01 GENERAL 3-1

SECTION 4 - PROTECTION PLAN

4.01 PUBLIC EDUCATION PROGRAM 4-1
4.02 WATER CONSERVATION PROGRAM 4-1
4.03 CONTINGENCY PLAN 4-2
4.04 MANAGEMENT PLAN 4-3

LIST OF APPENDICES

- APPENDIX A - CONTAMINANT MAP
- APPENDIX B - WELLHEAD PROTECTION ORDINANCE
- APPENDIX C - WELL ABANDONMENT ORDINANCE
- APPENDIX D - WELLHEAD PROTECTION ZONES
- APPENDIX E - CALCULATIONS

SECTION 1 INTRODUCTION

This section presents the purpose and scope of this plan in addition to a list of definitions used in the plan.

1.01 PURPOSE OF PLAN

The purpose of this plan is to identify protection areas based on hydrogeologic information and calculations for Well No. 9 in the City of Whitewater. Pursuant to NR 811 a wellhead protection plan must be in place prior to placing in service any new municipal well.

1.02 SCOPE

The plan area includes those portions of the city presently supplied with water by the Whitewater Water Utility as well as areas outside the Service Area.

The plan includes the following specific items:

- Hydrogeologic data
- General groundwater and geology conditions in the area
- An inventory of known and potential contaminant sources (map)
- Wellhead protection strategies
- Wellhead protection ordinance and resolution

1.03 DEFINITIONS

Recharge Area - Area in which water reaches the zone of saturation by surface infiltration and encompasses all areas or features that supply groundwater recharge to a well.

Time of Travel - The time needed for a particle of water in the aquifer to travel a given distance.

Transmissivity - The rate of flow through a vertical section of an aquifer at a constant hydraulic gradient.

Wellhead Protection Area - Shall be defined as that area contained in the attached map. This area shall correspond to the area where recharge occurs that will arrive at the well within a five-year period.

Zone of Influence (Cone of Depression) - The area of an aquifer where normal flow of groundwater is altered due to the pumping of a well. In this plan it is defined as the extent of the aquifer where the water table is lowered by one foot assuming 30 days of continuous pumping at Well No. 9 with no recharge.

Groundwater Divide - The crest of the water table or potentiometric surface. Groundwater flows away at right angles in both directions from this line.

SECTION 2
GROUNDWATER HYDRAULICS

The discussion below presents aquifer information for Well No. 9 including a description of the cone of depression, recharge area, and the Wellhead Protection area.

2.01 AQUIFER CHARACTERISTICS

The formations and the associated depths to them were tabulated from drilling information and are presented in Table 2.01-1.

TABLE 2.01-1
AQUIFER FORMATION DATA
WELL NO.9
WHITEWATER, WISCONSIN

Formation	Depth to Top of Formation (ft)
Galena-Platteville	11
St. Peter and other Sandstones	252
Mt. Simon	710
Pre-Cambrian	950

2.02 ZONE OF INFLUENCE (CONE OF DEPRESSION)

The cone of depression was calculated based upon pump test information. The radius was found to be 2.6 miles (Appendix E).

2.03 GROUNDWATER FLOW / RECHARGE AREA

Groundwater flow information was determined from two publications; *Groundwater Resources and Geology of Walworth County, Wisconsin*, Information Circular No. 34, U.W.-Extension Geological and Natural History Survey, and *Geology and Groundwater Resources, Rock County, Wisconsin*, Geological Survey Water-Supply Paper 1619-X. Groundwater flow direction was judged to be to the northeast. The groundwater divide was determined to be between 6 and 6½ miles south and southwest of Well No. 9. The recharge area was

estimated to include the zone of influence (2.6 mile radius around Well No. 9) extended south and southwest to the groundwater divide.

2.04 WELLHEAD PROTECTION AREAS

Pursuant to NR 811 a wellhead protection area shall encompass that portion of the recharge area equivalent to a five-year time of travel to the well. Exhibit A (Appendix D) shows the wellhead protection area based on a five-year time of travel to Well No. 9. The area was placed around a line that runs northeasterly through the well. Northeast was chosen because Information Circular No. 34 (identified above) indicates groundwater flow is generally in this direction at Well No. 9. The calculations are presented in Appendix E.

SECTION 3
POTENTIAL SOURCES OF CONTAMINATION

3.01 GENERAL

A search was conducted to identify the potential contamination sources within a half mile radius of Well No. 9. To the best of our knowledge and belief, all potential contamination sites were located. There is the possibility that potential contamination sources could remain unidentified within the site area. This could occur if the potential sources were unrecorded, abandoned, or located below ground.

TABLE 3.01-1
WELLHEAD PROTECTION PLAN
RECORDS ACCESSED
WHITEWATER, WISCONSIN

- DILHR Tank List
- Spills List
- Superfund Sites in Wisconsin
- Wisconsin Sites Nominated for Inclusion on the NPL List
- WDATCP List of Licensed Fertilizer Facilities
- EPA ERNs in Wisconsin
- Hazardous Waste Treatment, Storage, or Disposal Sites List

USGS topographical maps were also used to help identify other potential sources such as cemeteries, quarries and storm water detention ponds.

Items described below are located on the map included in Appendix A.

3.02 STORM/SANITARY SEWERS AND LIFT STATIONS

City storm sewers will be located within a half mile of the well site, but none will be located within the fifty-foot minimum set back around the well.

The city's sanitary sewers also will be located within a half mile of the well. If sanitary sewers are required within 200 feet of the well, they will be installed with water main class material. There may also be lift stations located within a half mile of the well, but will not infringe upon the 200-foot minimum set back.

3.03 RESIDENTIAL FUEL OIL TANKS

There are no known residential fuel oil tanks within one-half mile of the well site.

3.04 SEPTIC TANKS / FIELDS / MOUNDS

Several septic tanks are located within a half mile from the well. These tanks are located at the north side of Highway 59 in the SW $\frac{1}{4}$, Section 8, and on the south side of CTH S in the NE $\frac{1}{4}$ of Section 7. The well site selection is such that the septic tanks do not infringe upon the minimum set-back distance of 400 feet.

3.05 CEMETERIES

There are no cemeteries located with one-half mile of the well site.

3.06 STORM WATER DRAINAGE PONDS

There are no storm water drainage ponds within a half mile of the well site area.

3.07 GASOLINE TANKS - UST/LUST

There are no residential underground tanks within a half mile of the well site. A reconnaissance trip around the area showed no other signs of underground tanks.

3.08 WASTEWATER TREATMENT PLANT

The Whitewater Wastewater Treatment Plant is located over two and one-half miles northeast of the well site area.

3.09 JUNK YARDS

To the best of our knowledge, there are no junk yards located in or near the site.

3.10 LIVESTOCK GRAZING SITE

No livestock grazing sites were observed in the immediate area on the day of our reconnaissance. The area is predominately agricultural however, and fields not presently used for grazing may be in the future.

3.11 AGRICULTURAL FIELDS

There are several agricultural fields located within the half mile radius. The history of pesticide, herbicide, and fertilizer use is not known for this area. The City of Whitewater has several sludge spreading sites located around the City. None of these sites are within a one-half mile radius of the site. There is a site, however, located just outside the one-half mile radius from the site, west of the site. No sludge spreading sites are within the NR811 code required setback of 1,000 feet.

3.12 ROAD SALT APPLICATION

Application of salt to the roadways occurs within a half mile of the well site. The nearest road that would receive salt is Highway 59, located southeast of the well site area. The road does not drain toward the well site area. This lowers the potential for contamination due to salt applied to the roadway. No road salt storage sites were located within a half mile of the site.

3.13 PRIVATE WELLS

There are private wells on lots located north and southeast of the site. This area is located on the topographic map of this site. These wells are expected to be abandoned when city water is extended into this area.

3.14 RAILROAD LINES

The Wisconsin and Southern railroad tracks run through the SE $\frac{1}{4}$ of Section 7 and would be within one half mile of the well.

3.15 PESTICIDE/FERTILIZER HANDLING OR STORAGE FACILITY

A large abandoned fertilizer plant is located southeast of the site, between the railroad tracks and Highway 59. The plant is approximately one-half mile from the site. The plant is owned by Kaiser Aluminum and was shut down in 1984. Since that time a considerable amount of remedial activity has occurred on the site to clean up what apparently was left over fertilizer product and to remove a cooling water settling lagoon. Remedial efforts included removal and disposal of approximately 220 cubic yards of contaminated soil and the installation of a series of monitoring wells and piezometers. Contaminants found in the soil and shallow groundwater include 2,4D and Silvex (2,4,5T). Many studies and reports have been conducted to determine the effect on both the groundwater and surface water in the area. Contaminants were also detected in the small creek to the southeast of the immediate site.

Current activity consists of continued monitoring around the site. It is not known if the extent of contamination or plume has ever been fully defined.

This site is currently used for packaging of landscaping aggregate.

3.16 OTHER

The following were not found within a half mile of the well:

- Quarries/Gravel Pits
- Municipal Sludge Sites
- Septage Disposal Sites
- Soil Absorption Units —
- Landfills
- Coal Storage
- Salt Storage
- Hazardous Waste Storage, Treatment or Disposal Site
- Chemical Handling Industry

SECTION 4 PROTECTION PLAN

This section presents the programs and contingency plans which make up the wellhead protection plan. The literature listed below is to be distributed by the City of Whitewater.

4.01 PUBLIC EDUCATION PROGRAM

DNR PUBL-WR-303 92 "Wellhead Protection: An ounce of Prevention" will be provided to all residents along with a map of the wellhead protection area and a letter describing the City of Whitewater's wellhead protection program.

An informational meeting will be held for all residents describing groundwater movement, how groundwater can become contaminated, and the city's wellhead protection plan.

DNR PUBL-WR-324-93 "Water Activities to Encourage Responsibility" will be provided to the school district for use in fourth grade classrooms.

The publication of Wisconsin's "Groundwater Study Guide" will be provided to the school district to be used in the junior high science curriculum.

EPA Publication 570-9-91-UICI "Does Your Facility Generate Automotive Wastes?" will be provided to all owners of such facilities within the wellhead protection area along with a letter describing the city wellhead protection program.

4.02 WATER CONSERVATION PROGRAM

DNR PUBL-WR-065 90 "Save Wisconsin's Water" will be provided to all residents along with a letter from the city.

Low-cost, water-saving fixtures will be made available for purchase at local vendors.

All customer hookups are metered and a regular meter testing program is in place.

4.03 CONTINGENCY PLAN

A. Contact List*

Department of Natural Resources

Department of Natural Resources	(414) 229-0800
-----	(414) 263-8500
Peter Woods, DNR	(414) 229-0823

Fire Department

Fire Department	(414) 473-0555
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Police Department

Police Department	(414) 473-0555
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Wisconsin Emergency Response

County Emergency Government	(414) 741-4432
City Emergency Government	(414) 473-0570
Utility Director -	(414) 473-0540
Home	(414) 473-3088
Water Utility Superintendent -	(414) 473-0543
Home	(414) 473-5895

* The emergency contact list will be posted at the city's well houses.

B. Alternative Water Source

The current maximum daily pumpage rate is 2.1 mgd (1,458 gpm). The city currently has a firm pumping capacity (pumping capacity with largest pumping unit out of service) of 3,000 gpm and therefore can meet current maximum day demands with more than one well out of service. With Well No. 9 on-line, the City will have firm well capacity of 4,000 gpm. This will be sufficient to meet both the city's maximum day demand and an anticipated LS Power demand of 2,000 gpm.

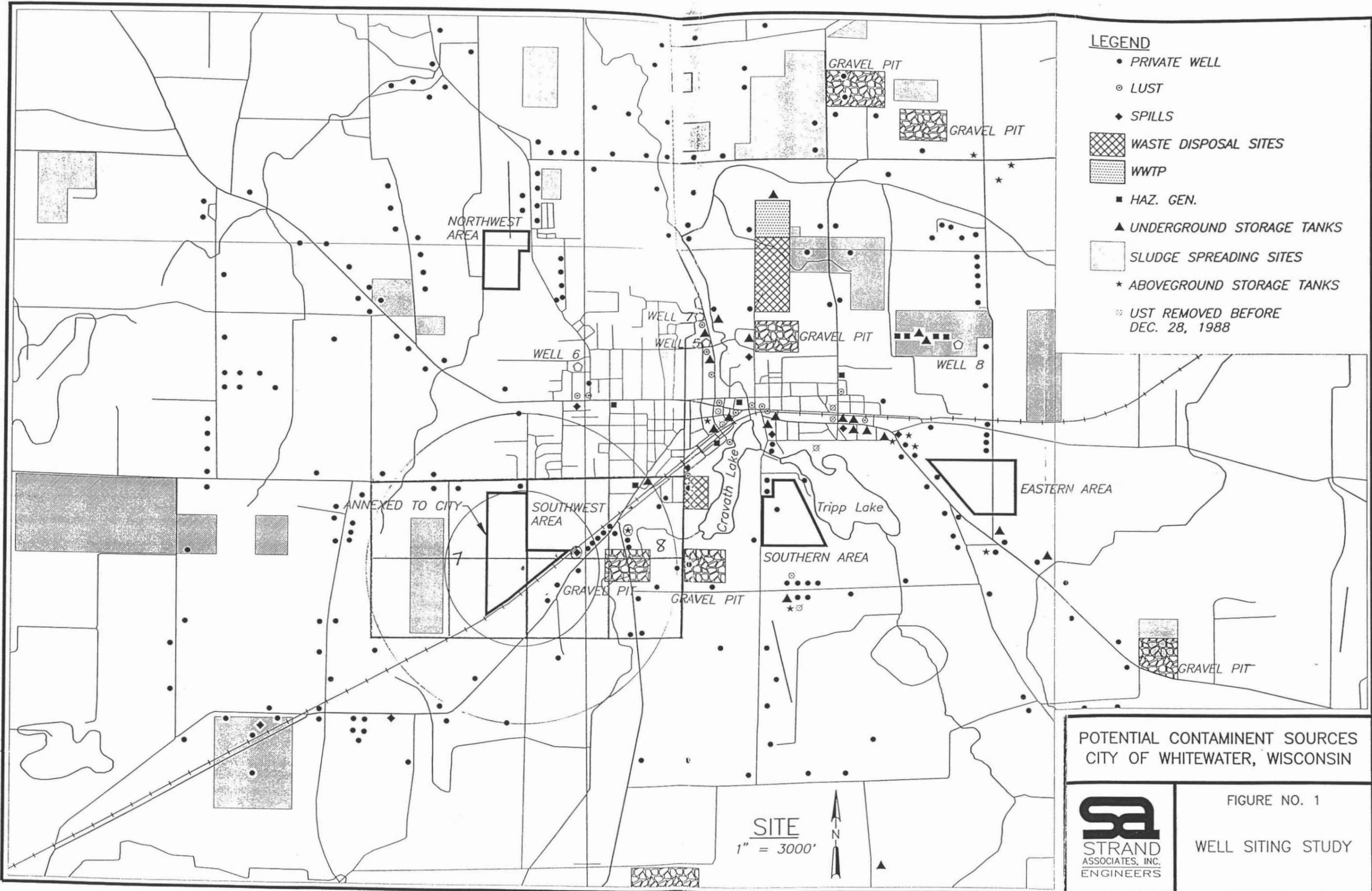
4.04 MANAGEMENT PLAN

The City of Whitewater has adopted and is enforcing its well abandonment ordinance. A permitting system has been established for nonpotable wells meeting the well code. The adopted well abandonment ordinance can be found in Appendix C.

The Wellhead Protection Ordinance, Appendix B, is intended to establish certain land use practices and activities in areas that pose a risk to the water supply.

APPENDIX A
CONTAMINANT MAP

DWN BY: RLR PLOT DATE: 10/27/94 FILE: L:\MAP\W-WATER\MASTER



LEGEND

- PRIVATE WELL
- LUST
- ◆ SPILLS
- ▨ WASTE DISPOSAL SITES
- ▩ WWTP
- HAZ. GEN.
- ▲ UNDERGROUND STORAGE TANKS
- SLUDGE SPREADING SITES
- * ABOVEGROUND STORAGE TANKS
- ⊙ UST REMOVED BEFORE DEC. 28, 1988

POTENTIAL CONTAMINANT SOURCES
CITY OF WHITEWATER, WISCONSIN



FIGURE NO. 1

WELL SITING STUDY

SITE
1" = 3000'



APPENDIX B
WELLHEAD PROTECTION ORDINANCE AND RESOLUTION

AN ORDINANCE AMENDING CHAPTER 19
OF THE MUNICIPAL CODE FOR THE CITY OF WHITEWATER

The Common Council of the City of Whitewater, Walworth County, Wisconsin does hereby ordain as follows:

Section I: Section 19.49 of the Municipal Code of the City of Whitewater is hereby created to read as follows

(1) TITLE

This section shall be known, cited and referred to as the "Wellhead Protection Ordinance" (hereinafter "WHP Ordinance").

(2) PURPOSE AND AUTHORITY

(a) The residents of the City of Whitewater (hereinafter "the City") depend exclusively on groundwater for a safe drinking water supply. Certain land use practices and activities can seriously threaten or degrade groundwater quality. The purpose of the WHP Ordinance is to protect the City's municipal water supply and areas from which City wells draw water, and to promote the public health, safety and general welfare of the residents of the City.

(b) These regulations are established pursuant to the authority granted by the Wisconsin legislature in 1983, Wisconsin Act 410 (effective May 11, 1984), which specifically added groundwater protection to the statutory authorization for municipal planning and zoning in order to protect the public health, safety and welfare. Areas appropriate for protection in the WHP are established in the Wellhead Protection Plan ("hereinafter the Plan") for City of Whitewater, Wisconsin, dated September 1996 and prepared by Strand Associates, Inc. The Plan document is hereby incorporated herein by this reference, and a copy is on file in the office of the City Clerk.

(3) APPLICABILITY

The regulations specified in the WHP Ordinance shall apply only to lands within those portions of the five-year Time of Travel Zones (hereinafter sometimes "TOT") of Well No. 9 shown on the Wellhead Protection Map (See Exhibit A in Appendix D of WHP) ("hereinafter the Map"), which areas also lie within the City of Whitewater corporate limits.

(4) DEFINITIONS

(a) Aquifer - A saturated, permeable geologic formation that contains and will yield significant quantities of water.

(b) Cone of Depression - The area around a well, in which the water level has been lowered at least one tenth of a foot by pumping of the well.

(c) Existing Facilities Which May Cause or Threaten To Cause Environmental Pollution - Existing facilities which may cause or threaten to cause environmental pollution within the

corporate limits of the City's well No. 9 recharge area which include but are not limited to the Wisconsin Department of Natural Resources' draft list of "Inventory of Sites or Facilities Which may Cause or Threaten to Cause Environmental Pollution," and Department of Industry, Labor and Human Relations list of "Leaking Underground Storage Tanks" (hereinafter "LUST's") and the Registry of Waste Disposal Sites in Wisconsin, all of which are incorporated herein, together with future amendments thereto, as if fully set forth.

(d) Five Year Time of Travel (TOT) - The Five Year TOT is a portion of the recharge area, the outer boundary of which it is determined or estimated that groundwater and potential contaminants will take five years to reach a pumping well. The Five year TOT for Whitewater's municipal well No. 9 is established based on the uniform flow equation. The TOT area is shown on the Map. The TOT area shown on the Map is hereinafter referred to as "the TOT."

(e) Groundwater Divide - Ridge in the water table, or potentiometric surface, from which ground water moves away at right angles in both directions. Line of highest hydraulic head in the water table or potentiometric surface.

(f) Groundwater Protection Overlay District - Shall be defined as that area within the TOT shown on the map attached as Exhibit A and incorporated herein as if fully set forth.

(g) Recharge Area - Area in which water reaches the zone of saturation by surface infiltration and encompasses all areas or features that supply groundwater recharge to a well.

(h) Wellhead Protection Area - Those proportions of the TOT which lie within the City of Whitewater corporate limits.

(5) WELLHEAD PROTECTION AREA (hereinafter "WPA")

(a) INTENT. The area to be protected is the Whitewater WPA (as determined by the Plan) contained within the City boundary limits. These areas are designated on the map. These lands are subject to land use and development restrictions because of their close proximity to the TOT and the corresponding high threat of contamination.

(b) PERMITTED USES. The following are the only permitted uses within the WPA.

1. Any existing use, even though listed on Prohibited Uses, below, located within such areas to the extent that use currently exists, subject to the requirements for existing prohibited uses, (e) below.
2. Those uses permitted under Whitewater Zoning Code consistent with the Zoning Map, as amended by action of the Whitewater City Council and which are not prohibited under Section (c) below.

(c) PROHIBITED USES. The following uses, if created after the adoption of the WHP Ordinance, are prohibited uses within the Wellhead Protection area designated on the Map. These uses are prohibited based on the high probability that activities routinely associated

with these uses (storage, use, and handling of potential pollutants) will cause groundwater contamination. Uses not listed are not considered permitted uses.

- (1) Underground storage tanks of any size
- (2) Septage and/or sludge spreading
- (3) Animal waste land spreading
- (4) Animal waste facilities
- (5) Animal confinement facilities
- (6) Gas stations
- (7) Vehicle repair establishments, including auto body repair
- (8) Printing and duplicating businesses
- (9) Bus or truck terminals
- (10) Repair shops
- (11) Landfills or waste disposal facilities
- (12) Wastewater treatment facilities
- (13) Spray wastewater facilities
- (14) Junk yards or auto salvage yards
- (15) Bulk fertilizer and/or pesticide facilities
- (16) Asphalt products manufacturing
- (17) Dry-cleaning businesses
- (18) Salt storage
- (19) Electroplating facilities
- (20) Exterminating businesses
- (21) Paint and coating manufacturing
- (22) Hazardous and/or toxic materials storage
- (23) Hazardous and/or toxic waste facilities
- (24) Radioactive waste facilities
- (25) Recycling facilities
- (26) Cemeteries

(d) Where any of the uses listed in (c) above exist within the WPA on the effective date of this ordinance, owners of these facilities will be allowed to upgrade such uses to facilitate or enhance groundwater protection. Plans for the proposed upgrade must be approved by the Plan Commission, and the appropriate permit issued by the City Building Inspector/ Zoning Administrator's office prior to any work being initiated. Expansion of the prohibited use may be allowed with approval of the Planning Commission.

(e) REQUIREMENTS FOR EXISTING PROHIBITED USES, (5) (c) ABOVE.

1. Such uses shall provide copies of all federal, state and local facility operation approvals or certificate to the City Zoning Administrator and ongoing environmental monitoring results to the City Director of Public Works.
2. Such uses shall provide additional environmental or safety structures/monitoring as deemed necessary by the City, which may include but are not limited to stormwater runoff management and monitoring.
3. Such uses shall replace equipment or expand in a manner that improves the existing environmental and safety technologies already in existence.

4. Such uses shall have the responsibility of devising and filing with the City a contingency plan satisfactory to the City Zoning Administrator for the immediate notification of City officials in the event of an emergency.

(6) ENFORCEMENT

(a) In the event the individual and/or facility engaging in permitted use(s) under this ordinance causes the release of any contaminants which endangers the WPA, the activity causing said release shall immediately cease and a cleanup satisfactory to the City shall occur.

(b) The individual/facility causing the release of contaminants shall be responsible for all costs of cleanup. The costs of cleanup shall include, but not be limited to, City consultant fees, at the invoice amount plus administrative costs for oversight, review and documentation.

1. The cost of City employees' time associated in any way with the cleanup based on the hourly rate paid to the employee multiplied by a factor determined by the City representing the City's cost for expenses, benefits, insurance, sick leave, holidays, overtime, vacation, and similar benefits.
2. The cost of City equipment employed.
3. The cost of mileage reimbursed to City employees attributed to the cleanup.

(c) Following any such discharge the City may require additional test monitoring and/or bonds/sureties as it deems necessary and reasonable.

(d) Penalties for noncompliance shall be provided pursuant to Section 19.75.080 of the code.

(7) EFFECTIVE DATE: This ordinance shall take effect upon passage and publication.

Adopted this _____ day of _____, 1997.

VOTE:

APPROVED:

Ayes: _____

City Manager

Noes: _____

ATTEST:

Adopted: _____

Published: _____

City Clerk

APPENDIX C
WELL ABANDONMENT ORDINANCE



CITY OF WHITEWATER
402 W. Main Street
P O Box 178
Whitewater, Wisconsin 53190

(414) 473-0540
Fax: (414) 473-0549

DEAN R. FISCHER
Director of Public Works

DEPARTMENT OF PUBLIC WORKS
FAX TRANSMISSION COVER SHEET

COMPANY NAME: Strand Associates

ATTENTION: Bruce Jacobs

DATE: 8/29/96 TIME: _____

COMMENTS: Well Abandonment Ord.

TOTAL PAGES INCLUDING COVER PAGE 3

IF PROBLEMS OCCUR DURING TRANSMISSION CONTACT:

16.04.060 Inspection and tests. The utility will make systematic inspection of all unmetered water taps at least once every twelve months for the purpose of checking waste and unnecessary use of water. (Prior code §11.06).

16.04.070 Hydrants. The director of public works shall maintain all hydrants in good serviceable condition at all times, and to this end inspections should be frequent and thorough and the results recorded in the office of the director of public works so that no hydrant may be found frozen or out of order when emergency demands its quick use. (Prior code §11.07).

16.04.080 Construction--Handling water mains and service pipes. (a) Where excavating machines are used in digging sewers all water mains shall be maintained at the expense of the contractor.

(b) Contractors must ascertain for themselves the existence and location of all service pipes. Where they are removed, cut or damaged in the construction of a sewer, the contractor must, at his own expense, at once cause them to be replaced or repaired. He must not shut off the water service pipes from any consumer for a period exceeding six hours without first gaining permission from the director of public works. (Prior code §11.08).

16.04.090 Backfilling trenches. Trenches in unpaved streets shall be refilled with moist, damp earth or by means of water tamping. When water tamping is used the water shall be turned into the trench after the first twelve inches of backfill has been placed and then the trench shall be kept flooded until the remainder of the backfill has been put in. (Prior code §11.09).

16.04.095 Private well abandonment. (a) The purpose of this section is to prevent unused and/or improperly constructed wells from serving as a passage for contaminated surface or near-surface waters or other materials to reach the usable groundwater. These wells must be properly filled and sealed.

(b) All private wells located on any premises which is served by the public water system of the city shall be properly filled within ninety days of receiving written notice that the existing well does not meet standards set forth here. Only those wells for which a well operation permit has been granted by the city engineer may be exempted from this requirement; subject to conditions of maintenance and operation.

(c) A permit may be granted to a well owner to operate a well for a period not to exceed five years if the following requirements are met. Application shall be made on forms provided by the city engineer:

(1) The well and pump installation meet the requirements of Chapter NR 812, Wisconsin Administrative Code, and a well constructor's report is on file with the Department of Natural Resources, or certification of the acceptability of the well has been granted by the Private Water Supply Section of the Department of Natural Resources;

(2) The well has a history of producing safe water and presently produces bacteriologically safe water, as evidenced by three samplings two weeks apart;

(3) The proposed use of the well can be justified as being necessary in addition to water provided by the public water system;

(4) No physical connection shall exist between the piping of the public water system and the private well.

(d) Wells to be abandoned shall be filled according to the procedures outlined in Chapter NR 812, Wisconsin Administrative Code. The pump and piping must be removed and the well checked for obstruction prior to plugging. Any obstruction or liner must be removed.

(e) A well abandonment report must be submitted by the well owner to the city and Department of Natural Resources on forms provided by the agency (available at the office of the city engineer). The report shall be submitted immediately upon completion of the filling of the well. The filling must be observed by the plumbing inspector.

(f) Any person, firm or corporation or other well owner violating any provision of this section shall upon conviction be punished by a fine of not less than fifty dollars nor more than five hundred dollars together with the cost of prosecution. Each twenty-four-hour period during which a violation exists shall be deemed and constitute a separate offense. (Ord. 1324 §§1, 2, 1995; Ord. 1068 §1, 1985).

16.04.100 Water use--Permit required. The law forbids free service, hence no water shall be taken without proper permit. Parties desiring to introduce water on their premises must make formal application to the water office and sign an application card or permit constituting a contract for water supplied and its specific use, which contract embodies these regulations as part of the same. (Prior code §11.10).

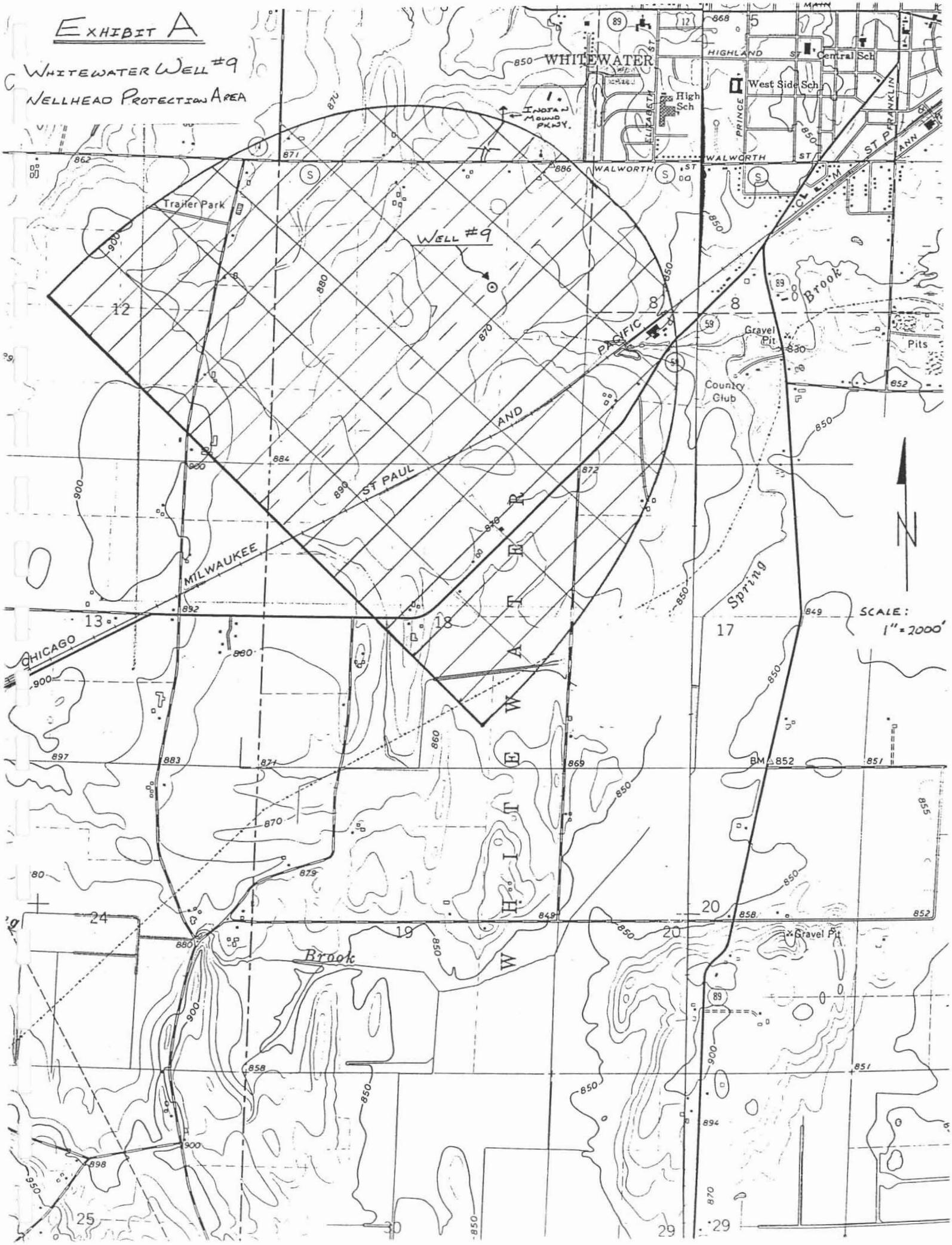
16.04.110 Tapping mains. No person unless authorized by the utility shall be permitted to tap or make any connection with any street main or distribution pipe. (Prior code §11.11).

16.04.120 Service connections. (a) Each applicant for water service shall at the time of making application for such water service execute and deliver to the utility a

APPENDIX D
WELLHEAD PROTECTION AREA

EXHIBIT A

WHITEWATER WELL #9
WELLHEAD PROTECTION AREA



APPENDIX E
CALCULATIONS

PROJECT WHITEWATER WELL #9 WELLHEAD PROTECTION	BY JDN	DATE 8/16/96	JOB NO. 407-020
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WHP AREA DELINEATION USING + UNIFORM FLOW EQUATION

$$X_L = -\frac{Q}{2\pi Kbi}, \quad Y_L = \pm \frac{Q}{2Kbi}$$

(FROM "DETERMINING WELLHEAD PROTECTION BOUNDARIES - AN INTRODUCTION"
⇒ WISCONSIN DEPARTMENT OF NATURAL RESOURCES, JAN. 1993)

① THE GROUNDWATER FLOW DIRECTION WAS DETERMINED TO BE GENERALLY TO THE NORTHEAST FROM A WATER TABLE MAP (1973) OF WALWORTH CO., (GROUND-WATER RESOURCES AND GEOLOGY OF WALWORTH COUNTY, WISCONSIN, INFORMATION CIRCULAR NO. 34, BY THE U.W.-EXTENSION GEOLOGICAL AND NATURAL HISTORY SURVEY.) AND A PIEZOMETRIC SURFACE MAP (1958) (GEOLOGY AND GROUND-WATER RESOURCES, ROCK COUNTY, WISCONSIN, GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1619-X)

② HYDRAULIC GRADIENT (i) DETERMINATION

HYDRAULIC GRADIENT (i) WAS ESTIMATED USING A POTENTIOMETRIC CONTOUR MAP OF WALWORTH COUNTY FROM THE ABOVE MENTIONED INFORMATION CIRCULAR NO. 34 AND THE TWO MAPS INDICATED ABOVE. i WAS DETERMINED FOR CONDITIONS WHEN THE PUMP WAS RUNNING AND NOT RUNNING (SEE APPENDIX)

$$i_{\text{RUNNING PUMP}} = \phi. \phi 122$$

$$i_{\text{PUMP NOT RUNNING}} = \phi. \phi \phi 63$$

③ PUMP TEST INFORMATION

* $Q = 1500 \text{ gpm} = 2160000 \text{ gpd}$

Q = PUMPING RATE

* $b = 880 \text{ ft}$

b ⇒ BASED ON 965 ft (WELL DRILLED Slightly INTO POTENTIOMETRIC ZONE) MINUS THE DEPTH TO THE NON-PUMPING WATER LEVEL

* $T = 23713 \frac{\text{gpd}}{\text{ft}}$

T = TRANSMISSIVITY

$$* K = \frac{T}{b} = \frac{23713 \frac{\text{gpd}}{\text{ft}}}{880 \text{ ft}} = 26.95 \frac{\text{gpd}}{\text{ft}^2}$$

$$= \left(26.95 \frac{\text{gpd}}{\text{ft}^2}\right) \left(\frac{1.48}{7.48 \frac{\text{gpd}}{\text{ft}^3}}\right) \left(\frac{-1d}{2412}\right) \left(\frac{112}{36005}\right) = 4.17 \times 10^{-5} \text{ ft/s}$$

PROJECT WHITewater Well #9 WHPA	BY JDN	DATE 8/22/96	JOB NO. 407-020
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④ RESULTS FROM WDMR SOFTWARE "T-GUESS" RUN BY DAVE JOHNSON ON 8/19/96 [PHONE CONVERSATION WITH JOHN NELSON]

* $T = 4.77 \times 10^{-2} \text{ ft}^2/\text{s}$
 * $K = 5.49 \times 10^{-5} \text{ ft/s}$
 $= (5.49 \times 10^{-5} \frac{\text{ft}}{\text{s}} * \frac{3600 \text{ s}}{1 \text{ hr}} * \frac{24 \text{ hr}}{1 \text{ d}} * \frac{7.48 \text{ gpd}}{1 \text{ ft}^3/\text{d}})$
 $= 35.48 \frac{\text{gpd}}{\text{ft}^2}$

⑤ DETERMINE $X_L \neq Y_L$

* A RANGE OF VALUES SHALL BE CALCULATED FOR $X_L \neq Y_L$ GIVEN

$X_L = \frac{Q}{2\pi Kbi}$, $Y_L = \pm \frac{Q}{2Kbi} \Rightarrow Q, \text{ gpd}; K, \frac{\text{gpd}}{\text{ft}^2}; b, \text{ ft}; i, \frac{\text{ft}}{\text{ft}}$
 (PUMPING GRADIENT $i = 0.0122 \text{ ft/ft}$)

DESCRIPTION	X_L (ft)	$\pm Y_L$ (ft)	"SAMPLE CALCULATIONS"
① VALUES FROM "T-GUESS"	902.5	2835.3	$\frac{2,160,000 \text{ gpd}}{2\pi (35.48 \frac{\text{gpd}}{\text{ft}^2}) (880 \text{ ft}) (0.0122 \frac{\text{ft}}{\text{ft}})} = X_L$
② VALUES FROM PUMP TEST	1188.2	3732.7	$\frac{2,160,000 \text{ gpd}}{2\pi (26.95 \frac{\text{gpd}}{\text{ft}^2}) (880 \text{ ft}) (0.0122 \frac{\text{ft}}{\text{ft}})} = X_L$
③ WITH $K = 3.3 \times 10^{-5} \text{ ft/s}$ ($K = 21.33 \frac{\text{gpd}}{\text{ft}^2}$) DAVE JOHNSON TYPED THIS AS A POTENTIAL VALUE ON 8/19/96 CONVERSATION	1501.2	4716.2	$\frac{2,160,000 \text{ gpd}}{2\pi (21.33 \frac{\text{gpd}}{\text{ft}^2}) (880 \text{ ft}) (0.0122 \frac{\text{ft}}{\text{ft}})} = X_L$
④ WITH $K = 1.0 \times 10^{-5} \text{ ft/s}$ ($K = 6.46 \frac{\text{gpd}}{\text{ft}^2}$) CHOSEN RANDOMLY	4956.8	15572.2	$\frac{2,160,000 \text{ gpd}}{2\pi (6.46 \frac{\text{gpd}}{\text{ft}^2}) (880 \text{ ft}) (0.0122 \frac{\text{ft}}{\text{ft}})} = X_L$
⑤ WITH PUMP TEST VALUES AND $i = 0.0063 \text{ ft/ft}$ (PUMP OFF)	2300.9	7228.4	$\frac{2,160,000 \text{ gpd}}{2\pi (26.95 \frac{\text{gpd}}{\text{ft}^2}) (880 \text{ ft}) (0.0063 \frac{\text{ft}}{\text{ft}})} = X_L$

TO INTRODUCE A FACTOR OF SAFETY ^(F.S.) THE WELLHEAD PROTECTION AREA WILL BE CHOSEN BETWEEN THE VALUES INDICATED IN ③ & ⑤ ABOVE.

WELL #9 WILL BE SURROUNDED BY A WELLHEAD PROTECTION AREA DEFINED BY $X_L = 2500 \text{ ft} \neq Y_L = \pm 5300 \text{ ft}$
 (F.S. $\Rightarrow 1.12$ to 2.77)
 $\left. \begin{matrix} 1.07 \\ * \end{matrix} \right\}$ TIMES THE T-GUESS VALUES

PROJECT	BY JDN	DATE 8/22/96	JOB NO. 407-020
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⑥ 5 YEAR TIME OF TRAVEL CALCULATION

* A RANGE OF VALUES SHALL BE CALCULATED FOR VELOCITY WHEN THE PUMP IS RUNNING

* THE PUMP WAS PROJECTED TO PRODUCE $165 \times 10^6 \frac{\text{GAL H}_2\text{O}}{\text{YR}}$
 \Rightarrow THEREFORE THE PUMP WILL RUN:

$$(165 \times 10^6 \frac{\text{GAL}}{\text{YR}}) \times (5 \text{ YRS}) \left(\frac{\text{MIN}}{1000 \text{ GAL}} \right) \left(\frac{1 \text{ HR}}{60 \text{ MIN}} \right) \left(\frac{1 \text{ DAY}}{24 \text{ HR}} \right)$$

\uparrow T.O.T. \uparrow PUMPING RATE

573 DAYS IN 5 YEARS

* TIME THE PUMPS NOT RUNNING IN 5 YEARS:

$$(5 \text{ YRS} \times \frac{365 \text{ d}}{\text{YR}}) - 573 \text{ DAYS} = \underline{1252 \text{ DAYS}}$$

* DISTANCE TRAVELED IN 5 YEARS WHEN THE PUMP IS NOT RUNNING:

$$\text{DISTANCE} = (V)(t) \quad t = 1252 \text{ DAYS}$$

$$V = \frac{[5.49 \times 10^{-5} \frac{\text{ft}}{\text{s}} \times \frac{3600 \text{ s}}{\text{HR}} \times \frac{24 \text{ HR}}{\text{DAY}}] \phi. \phi \phi 63}{\phi. \phi 5} \quad V = \frac{K I}{r} \quad \left(\begin{array}{l} \text{WORST CASE } V \text{ IS WHEN } K \text{ FROM} \\ \text{T. GUESS IS USED, } n = .05, \\ i_{\text{PUMP NOT RUNNING}} = \phi. \phi \phi 63 \end{array} \right)$$

$$V = \phi. 6 \phi \text{ ft/d} \Rightarrow \boxed{\text{DIST.} = (\phi. 6 \phi \text{ ft/d})(1252 \text{ DAYS}) = 751.2 \text{ ft}}$$

** CALCULATION OF VELOCITY AND DISTANCE TRAVELED WHEN PUMP IS RUNNING

$$V = \frac{K i}{r} \Rightarrow r = \phi. \phi 5, \quad i_{\text{PUMP}} = \phi. \phi 122 \text{ ft}, \quad K = \text{VARIABLE } \frac{\text{ft}}{\text{s}}$$

RANGE GIVEN IN "GROUNDWATER & WELLS" IS 5% - 30% P. 67

$$\text{DIST.} = (V \frac{\text{ft}}{\text{d}})(573 \text{ days}), \quad \text{TOTAL DIST.} = \text{PUMPING DIST.} + 751.2 \text{ ft}$$

	$V (\frac{\text{ft}}{\text{s}}) \times 86400 \frac{\text{s}}{\text{d}} = V (\frac{\text{ft}}{\text{d}}) \times 573 \text{ d} = \text{DIST. (ft)}$	"SAMPLE CALCULATION"	
Ⓐ $K = 5.49 \times 10^{-5} \frac{\text{ft}}{\text{s}}$ (T. GUESS VALUE)	1.34×10^5	1.16 ft/d	$\frac{(5.49 \times 10^{-5} \frac{\text{ft}}{\text{s}})(0.0122 \text{ ft})}{0.05} = V (\frac{\text{ft}}{\text{s}})$
Ⓑ $K = 5.5 \times 10^{-4} \frac{\text{ft}}{\text{s}}$ (RANDOM CHOICE)	1.34×10^4	11.6 ft/d	$\frac{(5.5 \times 10^{-4} \frac{\text{ft}}{\text{s}})(0.0122 \text{ ft})}{\phi. \phi 5} = V (\frac{\text{ft}}{\text{s}})$

PROJECT	BY JDN	DATE 8/22/96	JOB NO.
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DESCRIPTION	$\sqrt{\left(\frac{ft}{s}\right) \times 86400 \frac{s}{d} = \sqrt{\left(\frac{ft}{d}\right) \times 573} = D_{TST.} (ft)$			"SAMPLE CALCS."
(C) $K = 2.01 \frac{ft}{d}$ [UPPER END OF K-RANGE FROM "GROUNDWATER AND WELLS" P. 75]	—	$\phi.49$	281	$\frac{(2.01 \frac{ft}{d})(.0122)}{.05} = \sqrt{\left(\frac{ft}{s}\right)}$
(D) $K = 1.0 \times 10^{-4} \frac{ft}{s}$ (CHOSEN RANDOMLY)	2.44×10^{-5}	2.11	1208	$\frac{(1.0 \times 10^{-4} \frac{ft}{s})(.0122)}{.05} = \sqrt{\left(\frac{ft}{s}\right)}$
(E) $K = 3.5 \times 10^{-4} \frac{ft}{s}$ (CHOSEN RANDOMLY)	8.54×10^{-5}	7.38	4227.9	$\frac{(3.5 \times 10^{-4})(.0122)}{.05} = \sqrt{\left(\frac{ft}{s}\right)}$
(F) $K = 9 \times 10^{-4} \frac{ft}{s}$ (CHOSEN RANDOMLY)	2.2×10^{-4}	18.97	10871.8	$\frac{(9 \times 10^{-4})(.0122)}{.05} = \sqrt{\left(\frac{ft}{s}\right)}$

TO INTRODUCE A FACTOR OF SAFETY, (F.S.), THE 5 YR PUMPING TRAVEL DISTANCE WILL BE CHOSEN BETWEEN THE VALUES INDICATED IN (E) & (F) ABOVE

THE UPGRADIENT DISTANCE DUE TO PUMPING FOR WELL #9 WILL BE 4748.8 ft. (F.S. \Rightarrow 1.12 TO 7.16) * OVER THE T-GUESS VALUE.

THE TOTAL DISTANCE THE WELLHEAD PROTECTION AREA WILL EXTEND UPGRADIENT FROM WELL #9 (IN A SOUTHWESTERLY DIRECTION):

$$TOTAL DISTANCE = 4748.8 + 751.2 \text{ ft}$$

TOTAL UPGRADIENT DISTANCE = 5500 ft

PROJECT WHITewater Well #9 WHP AREA	BY JDN	DATE 8/23/96	JOB NO. 407-020
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⑦ THE Wellhead PROTECTION AREA SHALL BE BOUNDARY BY :

$$\begin{array}{l}
 X_L = 25\phi\phi \text{ ft} \\
 Y_L = \pm 53\phi\phi \text{ ft} \\
 \text{UPGRADIENT DISTANCE} = 55\phi\phi \text{ ft}
 \end{array}
 \left. \begin{array}{l} \\ \\ \end{array} \right\} \begin{array}{l} \text{UNIFORM FLOW} \\ \text{EQUATION} \\ \\ \text{5 YEAR TIME OF TRAVEL} \\ \text{CALCULATION} \end{array}$$

THE AREA SHALL BE ORIENTED ABOUT A CENTER LINE THAT RUNS THROUGH Well #9, IN NORTHEASTLY/SOUTHWESTLY DIRECTION (REFER TO EXHIBIT A).

THIS ORIENTATION WAS CHOSEN BASED UPON THE GROUNDWATER FLOW DIRECTION (TO THE NORTH AND NORTHEAST) AS DETERMINED BY INFORMATION CIRCULAR NO. 34; BY THE U.W. - EXTENSION GEOLOGICAL AND NATURAL HISTORY SURVEY AND THE UNITED STATES GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1619-X.

APPENDIX (A2) LISTS SOME OF THE THINGS THAT WERE CONSIDERED WHEN CHOOSING THIS Wellhead PROTECTION AREA. THE LONG OF DEPRESSION WAS CALCULATED, BUT AFTER DETERMINING THE UNIFORM FLOW EQUATION VARIABLES, IT WAS CONSIDERED TO BE TOO LARGE OF AN AREA FOR THIS WELL.

PROJECT WHITewater Well #9 Wellhead Protection	BY JDN	DATE 8/27/96	JOB NO. 407-020
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① HYDRAULIC GRADIENT (i) DETERMINATIONS

② Pump NOT RUNNING

THE HYDRAULIC GRADIENT WILL EQUAL THE DIFFERENCE BETWEEN PIEZOMETRIC SURFACE ELEVATIONS (INFO. CIRCULAR #34; REFER TO PAGE 1) DIVIDED BY THE HORIZONTAL DISTANCE THAT SEPARATES THEM (IMMEDIATELY SOUTHWEST OF THE CITY OF WHITewater) WHEN THE PUMP AT WELL #9 IS NOT RUNNING.

$$i = \frac{h_1 - h_2}{L}$$

$$i = \frac{850 \text{ ft} - 800 \text{ ft}}{1.5 \text{ mi} \left(\frac{5280 \text{ ft}}{\text{mi}} \right)}$$

$$i = \underline{\underline{0.0063 \text{ ft/ft}}}$$

$i \Rightarrow$ HYDRAULIC GRADIENT (ft/ft)

$h_1 \Rightarrow$ PIEZOMETRIC SURFACE ELEVATION (ft)

$h_2 \Rightarrow$ PIEZOMETRIC SURFACE ELEVATION - DOWN GRADIENT FROM h_1 (ft)

$L \Rightarrow$ DISTANCE BETWEEN h_1 & h_2

③ Pump RUNNING

FROM WELL #9 PUMP TEST DATA, THE WATER SURFACE ELEVATION AT THE WELL ^(h_2) WHILE THE PUMP IS RUNNING WAS CALCULATED TO BE 711 ft. ^(h_1) $h_2 = 875.91' - 88.78' - \frac{1000 \text{ GPM}}{17.2 \frac{\text{ft}}{\text{min}}} \left(\begin{matrix} \text{ELEV. CHANGE TO STATE} \\ = 50' \\ \text{PUMPING RATE} \\ \text{SPECIFIC CAPACITY} \end{matrix} \right)$. THE UPGRADIENT PIEZOMETRIC SURFACE ELEVATION ^(h_1) WAS DETERMINED FROM WATER SUPPLY PAPER 1619-X (REFER TO P. 1). A MEASURED ELEVATION AT A WELL SOUTHWEST OF WHITewater (ROCK COUNTY) WAS USED TO DETERMINE $h_1 = 876'$. THE DISTANCE BETWEEN THEM WAS DETERMINED TO BE 13,530 ft.

$$\therefore i = \frac{876' - 711'}{13530 \text{ ft}} \Rightarrow \underline{\underline{i = 0.0122 \text{ ft/ft}}}$$

PROJECT <u>WHITEWATER WELLHEAD PROTECTION AREA</u>	BY <u>JDN</u>	DATE <u>8/27/96</u>	JOB NO. <u>407-020</u>
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② WHP AREA CONSIDERATIONS

- ① GROUNDWATER AND WELLS SECOND EDITION BY FLETCHER G. DRISCOLL
- ⇒ P. 75 SHOWS A HYDRAULIC CONDUCTIVITY RANGE OF
APPROXIMATELY 15 gpd/ft^2 TO $3.5 \times 10^{-2} \text{ gpd/ft}^2$ FOR FREMONT SANDSTONE
- ⇒ P. 67 SHOWS A POROSITY RANGE OF 5% TO 30% FOR SANDSTONE
(SEE TAB.)
5% WAS USED IN VELOCITY CALCULATIONS TO INTRODUCE
A FACTOR OF SAFETY.
- ② THE TWO REPORTS INDICATED ON P. 1 WERE USED TO ESTIMATE
THE LOCATION OF THE GROUNDWATER DIVIDE. THE DIVIDE
WAS ESTIMATED TO BE 6 TO 6 1/2 MILES SOUTH & SOUTHWEST
OF WELL # 9.
- ③ PUMPING RATE OF WELL # 9 WHEN IT GOES ON-LINE = 1000 GPM
- ④ UNIFORM FLOW EQUATION BOUNDARIES WITH A 1.12 TO 2.77
FACTOR OF SAFETY INCLUDED ($x_L = 2500 \text{ ft}$, $y_L = \pm 5300 \text{ ft}$)
- ⑤ 5 YEAR TIME OF TRAVEL = THE SUM OF THE DISTANCE
TRAVELED WHEN THE PUMP IS OFF PLUS THE DISTANCE
TRAVELED WHEN THE PUMP IS ON.
- ⑥ CONE OF DEPRESSION RADIUS = 2.6 MILES
(SEE P. 5 & A3)

PROJECT WHITewater Well #9 WHP AREA	BY JDN	DATE 8/5/96	JOB NO. 407-020
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③ CONF OF DISPERSION (RECALCULATION W/ ACTUAL TRANSMISSIVITY VS. ESTIMATED VALUE)

COMPUTE CONF OF DISPERSION RADIUS FOR Well No. 9 AT PROPOSED CAPACITY.

$$Q = 1000 \text{ GPM}$$

$$T = 23,713 \frac{\text{GPD}}{\text{ft}} \quad (\text{FROM TEST PUMP})$$

$$S = 2.08 \times 10^{-3} \quad (\text{FROM TEST PUMP})$$

30 d PUMPING WITHOUT RECHARGE

$$W(u) = \frac{T S \overset{\text{DRAWDOWN}}{\downarrow}}{114.6 Q} = \frac{(23,713)(1 \text{ ft})}{114.6 (1000 \text{ GPM})} = \phi.2\phi7$$

THIS CORRESPONDS TO $u \approx 1.037$ (APPROX 9.E., GROUNDWATER & WELLS P. 921)

$$u = \frac{1.87 r^2 S}{T t} \Rightarrow r = \sqrt{\frac{u T t}{1.87 S}}$$

$$= \left[\frac{(1.037)(23,713)(30 \text{ d})}{(1.87)(2.08 \times 10^{-3})} \right]^{1/2}$$

$$= 13771.8 \text{ ft}$$

$$r = 2.6 \text{ MILES}$$

(AS OPPOSED TO THE 3.5 MILE ESTIMATE FROM THE Well #9 SITE INVESTIGATION)