Smithfield Hog Production

Groundwater Discharge Report and Application
For
Christensen Finisher Farm Site
Millard County, Utah

Prepared by
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January 4, 2018

Report Number: RE0617

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January 4, 2018

Division of Water Quality
Utah Department of Environmental Quality
Salt Lake City, Utah 84114-4870

Subject: Groundwater Discharge Permit Application and Report
For Smithfield Hog Production
Christensen Finisher Farm Site
Millard County, Utah

Enclosed are the application, required backup information and reports for the submission of the Utah Groundwater Discharge Permit Application for the project listed above. The project is to be located approximately 7.6 miles northwest of Fillmore, in Millard County, Utah.

We appreciate this opportunity to be of service on this phase of the project and look forward to being of service as the project progresses. If you have any questions, please contact this office at your convenience.

Sincerely,
GEM Engineering, Inc.

Joel A. Myers, P.E.
President

1-4-18

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ATTACHMENTS

Attachment A	**Composite Location, & Topographic Map**
Attachment B	**Well Logs and Water Quality Report**
Attachment C	**Project Documents**
Attachment D	**Specifications and QA / QC for HDPE Liners**
Attachment E	**State of Utah Department of Natural Resources Technical Publication No. 98** **"GROUND-WATER HYDROLOGY OF PAHVANT VALLEYAND ADJACENI' AREAS, UTAH"** **By Walter F. Holmes and Susan A. Thiros**
Attachment F	**Water Quality Handling & Analysis Plan**

SECTION 1: INTRODUCTION

1.1 Nature of Application

This site will be 8800 hog finisher site with a single basin to contain the waste. The waste will be contained only temporarily and will be utilized as fertilizer on the adjacent fields to grow crops. There will be no treatment of the waste except that which occurs naturally as the waste sets in the containment basin before it is applied to the fields as fertilizer. There will be farm sites with one containment basin for this submittal.

1.2 Manure Handling System

The swine will be confined inside environmentally controlled buildings. The floors supporting the swine will consist of concrete slats (reinforced concrete slats spaced approximately 1.25" apart). Manure will be worked through the slats and temporarily stored in shallow concrete pits below. The pit floors and exterior walls will be constructed according to specifications and drawings, submitted in Attachment D, to assure wastewater is retained. The manure will be emptied approximately once a day into a temporary storage basin. No recycle water will be utilized. The barns will utilize a scraper plate manure collection system. The manure collected in the basin will be land applied at the appropriate time of the year for growing crops.

1.3 Topography and Soils

The topography surrounding the facility slopes roughly 1% down towards the south (see **Attachment A**). The soil types in the area surrounding the facility site are typical alluvial materials consisting primarily of silt, sand, and gravel. The surface soil types at the proposed facility location are typically organic silt and silty sands.

The groundwater table is located roughly 75 to 110 feet below existing grade based on information from the closest well logs and adjusting for the increase in surface elevation. The groundwater will be protected by certified Flexible Membrane Liners (FML), inspection procedures and monitoring wells.

1.4 Climate

Table 1-1 shows weather data collected near from Fillmore, Utah area roughly 7.6 miles southeast of the facility lacation.

The climate in the area is typically warm and dry in the summer and cold and dry in the winter.

Table 1-1 Weather Data For Fillmore, Utah

	Jan	Feb	Mar	Apr	May	Jun
Average high in °F:	37	43	53	62	72	82
Average low in °F:	20	24	31	37	45	53
Av. precipitation in inch:	1.34	1.46	2.05	1.89	1.61	0.91
Average snowfall in inch:	11	13	11	6	1	0

	Jul	Aug	Sep	Oct	Nov	Dec
Average high in °F:	88	86	77	64	49	37
Average low in °F:	60	59	50	39	29	20
Av. precipitation in inch:	0.75	0.83	1.1	1.73	1.54	1.54
Average snowfall in inch:	0	0	0	2	10	13

Climate data for Fillmore, UT Longitude: -112.328, Latitude: 38.9664
Average weather Fillmore, UT - 84631 - 1981-2010 normals

Fillmore, Utah weather averages

Annual average high temperature:	2.5°F
Annual average low temperature:	38.9°F
Average temperature:	50.7°F
Average annual precipitation - rainfall:	16.75 inches
Av. annual snowfall:	67 inches

1.5 Groundwater

The Utah Groundwater Discharge Permit Application was obtained from the Utah Department of Environmental Quality – Division of Water Quality web site and is incorporated into this report on the following 9 pages.

MAIL TO:
Division of Water Quality
Utah Department of Environmental Quality
Salt Lake City, Utah 84114-4870

Application No.:_____
Date Received:_____
(leave both lines blank)

UTAH GROUNDWATER DISCHARGE PERMIT APPLICATION

Part A - General Facility Information

Please read and follow carefully the instructions on this application form. Please type or print, except for signatures. This application is to be submitted by the owner or operator of a facility having one or more discharges to groundwater. The application must be signed by an official facility representative who is: the owner, sole proprietor for a sole proprietorship, a general partner, an executive officer of at least the level of vice president for a corporation, or an authorized representative of such executive officer having overall responsibility for the operation of the facility.

1. **Administrative Information.** Enter the information requested in the space provided below, including the name, title and telephone number of an agent at the facility who can answer questions regarding this application.

   Facility Name: Christensen Finisher Sites

   Mail Address: J and J Swine, LLC, 1065 East 150 North, Springville, UT 84663
   (Number & Street, Box and/or Route, City, State, Zip Code)

   Facility Legal Location* County: Millard
   T. 20S, R. 5W, Sec. 31, North 1/2,
   Site # 1 Lat. 39 ° 2 ' 3.36"N. Long. 112 ° 27 ' 0.65 "W
   *Note: A topographic map or detailed aerial photograph should be used in conjunction with a written description to depict the location of the facility, points of groundwater discharge, and other relevant features/objects. **(See Attachment** B)

   Contact's Name: Andrade Christensen Phone No.: 801-787-6728
   Title: Owner

2. **Owner/Operator Information.** Enter the information requested below, including the name, title, and phone number of the official representative signing the application.

   Owner
   Name: *Andrade Christensen* *Phone No.:* 801-787-6728

   Mail Address: J and J Swine, LLC, 1065 East 150 North, Springville, UT 84663
   (Number & Street, Box and/or Route, City, State, Zip Code)

   Operator
   Name: Same Phone No.:(____)_____
   (If different than Owner's above)

   Mail Address:_____
   (Number & Street, Box and/or Route, City, State, Zip Code)

   Official Representative
   Name: Same Phone No801-787-6728

   _____

   Title: Owner

MAIL TO:
Division of Water Quality
Utah Department of Environmental Quality
Salt Lake City, Utah 84114-4870

Application No.:_____
Date Received:_____
(leave both lines blank)

3. **Facility Classification** (check one)

   [X] New Facility
   [ ] Existing Facility
   [ ] Modification of Existing Facility

4. **Type of Facility** (check one)

   [ ] Industrial
   [ ] Mining
   [ ] Municipal
   [X] Agricultural Operation
   [ ] Other, please describe:_____

5. **SIC/NAICS Codes:** NAICS-112210 – Hog Farms and Hog Production
   Enter Principal 3 Digit Code Numbers Used in Census & Other Government Reports

6. **Projected Facility Life**: 20 years

7. **Identify principal processes used, or services preformed by the facility. Include the principal products produced, and raw materials used by the facility:**

   This facility will be utilized for hog production. Hogs will be raised to maturity and then transported to other off-site facilities by truck for processing

8. **List all existing or pending Federal, State, and Local government environmental permits:**

		Permit Number
[ ]	NPDES or UPDES (discharges to surface water)	
[ ]	CAFO (concentrated animal feeding operation)	
[ ]	UIC (underground injection of fluids)	
[ ]	RCRA (hazardous waste)	
[ ]	PDS (air emissions from proposed sources)	
[ ]	Construction Permit (wastewater treatment)	
[ ]	Solid Waste Permit (sanitary landfills, incinerators)	
[x]	Septic Tank/Drainfield	TBD by Health Dept
[ ]	Other, specify_____	

9. Name, location (Lat._____°_____'_____"N,Long._____°_____'_____"W) and description of: each well/spring (existing, abandoned, or proposed), water usage(past, present, or future); water bodies; drainages; well-head protection areas; drinking water source protection zones according to UAC 309-600; topography; and man-made structures within one mile radius of the point(s) of discharge site. Provide existing well logs (include total depth and variations in water depths).

Name	Location	Description	Status	Usage

See report and location maps included with this application

The above information must be included on a plat map and attached to the application.

Part B - General Discharge Information

Complete the following information for each point of discharge to groundwater. If m
ore than one discharge point exists, photocopy and complete this Part B form for each discharge point.

1. **Location** (if different than Facility Location in Part A): County: **Same as in Part A all sites**
   T._____, R._____, Sec._____, _____1/4 of _____1/4,
   Lat._____°_____'_____"N.Long. _____°_____'_____"W

2. **Type of fluid to be Discharged or Potentially Discharged**
   (check as applicable)

   Discharges (fluids discharged to the ground)

   [ ] Sanitary Wastewater: wastewater from restrooms, toilets, showers and the like
   [ ] Cooling Water: non-contact cooling water, non contact of raw materials, intermediate, final, or waste products
   [ ] Process Wastewater: wastewater used in or generated by an industrial process
   [ ] Mine Water: water from dewatering operations at mines
   [x] Other, specify: Hog Production Waste Water

   Potential Discharges (leachates or other fluids that may discharge to the ground)

   [ ] Solid Waste Leachates: leachates from solid waste impoundments or landfills
   [ ] Milling/Mining Leachates: tailings impoundments, mine leaching operations, etc.
   [ ] Storage Pile Leachates: leachates from storage piles of raw materials, product, or wastes
   [ ] Potential Underground Tank Leakage: tanks not regulated by UST or RCRA only
   [x] Other, specify: None

3. **Discharge Volumes**
   For each type of discharge checked in #2 above, list the volumes of wastewater discharged to the ground or groundwater. Volumes of wastewater should be measured or calculated from water usage. If it is necessary to estimate volumes, enclose the number in parentheses. Average daily volume means the average per operating day: ex. For a discharge of 1,000,000 gallons per year from a facility operating 200 days, the average daily volume is 5,000 gallons.

Discharge Type:	Daily Discharge Volume (Average)	(Maximum)	all in units of
None	0	0	

4. **Potential Discharge Volumes**
   For each type of potential discharge checked in #2 above, list the maximum volume of fluid that could be discharged to the ground considering such factors as: liner hydraulic conductivity and operating head conditions, leak detection system sensitivity, leachate collection system efficiency, etc. Attach calculation and raw data used to determine said potential discharge.

Discharge Type:	Daily Discharge Volume (Average)	(Maximum)	all in units of
Leakage	0	0	

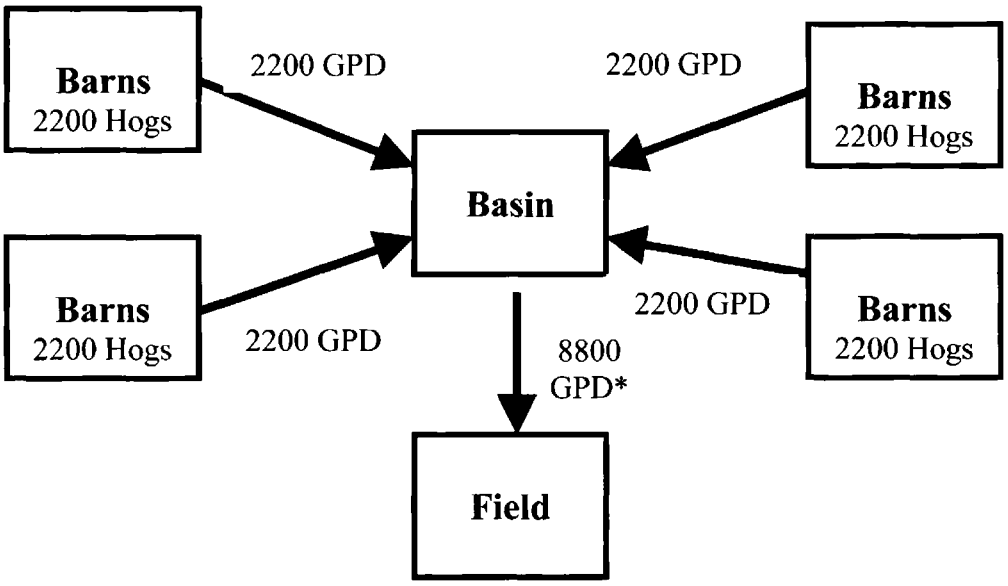
5. Means of discharge or Potential Discharge (check one or more as applicable)

[x]	lagoon, pit, or surface impoundment (fluids)	[ ]	industrial drainfield
[x]	land application or land treatment	[ ]	underground storage tank
[ ]	discharge to an ephemeral drainage (dry wash, etc.)	[ ]	percolation/infiltration basin
[ ]	storage pile	[ ]	mine heap or dump leach
[ ]	landfill (industrial or solid wastes)	[ ]	mine tailings pond
[ ]	other, specify_____		

6. Flows, Sources of Pollution, and Treatment Technologies

Flows. Attach a line drawing showing: 1) water flow through the facility to the groundwater discharge point, and 2) sources of fluids, wastes, or solids which accumulate at the potential groundwater discharge point. Indicate sources of intake materials or water, operations contributing wastes or wastewater to the effluent, and wastewater treatment units. Construct a water balance on the line drawing by showing average flows between intakes, operations, treatment units, and wastewater outfalls. If a water balance cannot be determined, provide a pictorial description of the nature and amount of any sources of water and any collection or treatment measures. See the following example.

Facility Water Flow



* Flow from Basin to Field will be on an as needed basis with an average flow of 8800 GPD*

7. Discharge Effluent Characteristics

Established and Proposed Groundwater Quality Standards - Identify wastewater or leachate characteristics by providing the type, source, chemical, physical, radiological, and toxic characteristics of wastewater or leachate to be discharged or potentially discharged to groundwater (with lab analytical data if possible). This should include the discharge rate or combination of discharges, and the expected concentrations of any pollutant (mg/l). If more than one discharge point is used, information for each point must be provided.

Hazardous Substances - Review the present hazardous substances found in the Clean Water Act, if applicable. List those substances found or believed present in the discharge or potential discharge.

Part C - Accompanying Reports and Plans

The following reports and plans should be prepared by or under the direction of a professional engineer or other groundwater professional. Since groundwater permits cover a large variety of discharge activities, the appropriate details and requirements of the following reports and plans will be covered in the pre-design meeting(s). For further instruction refer to the Groundwater Permit Application Guidance Document.

8. Hydrogeologic Report

Provide a Geologic Description, with references used, that includes as appropriate:

Structural Geology – regional and local, particularly faults, fractures, joints and bedding plane joints; **Stratigraphy** – geologic formations and thickness, soil types and thickness, depth to bedrock; **Topography** – provide a USGS MAP (7 ½ minute series) which clearly identifies legal site location boundaries, indicated 100 year flood plain area and applicable flood control or drainage barriers and surrounding land uses.

Provide a Hydrologic Description, with references used, that includes:
Groundwater – depths, flow directions and gradients. Well logs should be included if available. Include name of aquifer, saturated thickness, flow directions, porosity, hydraulic conductivity, and other flow characteristics, hydraulic connection with other aquifers or surface sources, recharge information, water in storage, usage, and the projected aerial extent of the aquifer. Should include projected groundwater area of influence affected by the discharge. Provide hydraulic gradient map indicating equal potential head contours and groundwater flow lines. Obtain water elevations of nearby wells at the time of the hydrologic investigation. Collect and analyze groundwater samples from the uppermost aquifer which underlies the discharge point(s). Historic data can be used if the applicant can demonstrate it meets the requirements contained within this section. Collection points should be hydraulically up and downgradient and within a one-mile radius of the discharge point(s). Groundwater analysis should include each element listed in Groundwater Discharge Permit Application, Part B7.

NOTE Failure to analyze for background concentrations of any contaminant of concern in the discharge or potential discharge may result in the Executive Secretary's presumptive determination that zero concentration exist in the background groundwater quality.

Sample Collection and Analysis Quality assurance – sample collection and Preservation must meet the requirements of the EPA RCRA Technical Enforcement Guidance Document, OSWER-9959.1, 1986 [UAC R317-6-6.3(I,6)]. Sample analysis must be performed by State of Utah certified laboratories and be certified for each of the parameters of concern. Analytical methods should be selected from the following sources [UAC R317-6-6.3L]: Standard Methods for the Examination of Water and Wastewater, 20th Ed.,1998; EPA, Methods for Chemical Analysis of Water and Wastes, 1983; Techniques of Water Resources Investigation of the U.S. Geological Survey, 1998, Book 9; EPA Methods published pursuant to 40 CFR Parts 141, 142, 264 (including Appendix IX), and 270. Analytical methods selected should also include minimum detection limits below both the Groundwater Quality Standards and the anticipated groundwater protection levels. Data shall be presented in accordance of accepted hydrogeologic standards and practice.

Provide Agricultural Description, with references used, that includes:
If agricultural crops are grown within legal boundaries of the site, the discussion must include: types of crops produced; soil types present; irrigation system; location of livestock confinement areas (existing or abandoned).

Note on Protection Levels:

After the applicant has defined the quality of the fluid to be discharged (Groundwater Discharge Permit Application, Part B), characterized by the local hydrogeologic conditions and determined background groundwater quality (Hydrogeologic Report), the Executive Secretary will determine the applicable groundwater class, based on: 1) the location of the discharge point within an area of formally classified groundwater, or the background value of total dissolved solids. Accordingly, the Executive Secretary will determine applicable protection levels for each pollutant of concern, based on background concentrations and in accordance with UAC R317-6-4.

9. **Groundwater Discharge Control Plan:**
   Select a compliance monitoring method and demonstrate an adequate discharge control system. Listed are some of the Discharge Control Options available.

   No Discharge – prevent any discharge of fluids to the groundwater by lining the discharge point with multiple synthetic and clay liners. Such a system would be designed, constructed, and operated to prevent any release of fluids during both the active life and any post-closure period required.

   Earthen Liner – control the volume and rate of effluent seepage by lining the discharge point with a low permeability earthen liner (e.g. clay). Then demonstrate that the receiving groundwater, at a point as close as practical to the discharge point, does not or will not exceed the applicable class TDS limits and protection levels* set by the Executive Secretary. This demonstration should also be based on numerical or analytical saturated or unsaturated groundwater flow and contaminant transport simulations.

   Effluent Pretreatment – demonstrate that the quality of the raw or treated effluent at the point of discharge or potential discharge does not or will not exceed the applicable groundwater class TDS limits and protection levels* set by the Executive Secretary.

   Contaminant Transport/Attenuation – demonstrate that due to subsurface contaminant transport mechanisms at the site, raw or treated effluent does not or will not cause the receiving groundwater, at a point as close as possible to the discharge point, to exceed the applicable class TDS limits and protection levels* set by the Executive Secretary.

   Other Methods – demonstrate by some other method, acceptable to the Executive Secretary, that the groundwater class TDS limits and protection levels* will be met by the receiving groundwater at a point as close as practical to the discharge point.

   *If the applicant has or will apply for an alternate concentration limit (ACL), the ACL may apply instead of the class TDS limits and protection levels.

   Submit a complete set of engineering plans and specifications relating to the construction, modification, and operation of the discharge point or system. Construction Permits for the following types of facilities will satisfy these requirements. They include: municipal waste Containment Basins; municipal sludge storage and on-site sludge disposal; land application of wastewater effluent; heap leach facilities; other process wastewater treatment equipment or systems.

   Facilities such as storage piles, surface impoundments and landfills must submit engineering plans and specifications for the initial construction or any modification of the facility. This will include

the design data and description of the leachate detection, collection and removal system design and construction. Provide provisions for run on and run-off control.

10. Compliance Monitoring Plan:
The applicant should demonstrate that the method of compliance monitoring selected meets the following requirements:

Groundwater Monitoring – that the monitoring wells, springs, drains, etc., meet all of the following criteria: is completed exclusively in the same uppermost aquifer that underlies the discharge point(s) and is intercepted by the upgradient background monitoring well; is located hydrologically downgradient of the discharge point(s); designed, constructed, and operated for optimal detection (this will require a hydrogeologic characterization of the area circumscribed by the background sampling point, discharge point and compliance monitoring points); is not located within the radius of influence of any beneficial use public or private water supply; sampling parameters, collection, preservation, and analysis should be the same as background sampling point; groundwater flow direction and gradient, background quality at the site, and the quality of the groundwater at the compliance monitoring point.

Source Monitoring – must provide early warning of a potential violation of groundwater protection levels, and/or class TDS limits and be as or more reliable, effective, and determinate than a viable groundwater monitoring network.

Vadose Zone Monitoring Requirements – Should be: used in conjunction with source monitoring; include sampling for all the parameters required for background groundwater quality monitoring; the application, design, construction, operation, and maintenance of the monitoring system should conform with the guidelines found in: Vadose Zone Monitoring for Hazardous Waste Sites; June 1983, KT-82-018(R).

Leak Detection Monitoring Requirements – Should not allow any leakage to escape undetected that may cause the receiving groundwater to exceed applicable groundwater protection levels during the active life and any required post-closure care period of the discharge point. This demonstration may be accomplished through the use of numeric or analytic, saturated or unsaturated, groundwater flow or contaminant transport simulations, using actual filed data or conservative assumptions. Provide plans for daily observation or continuous monitoring of the observation sump or other monitoring point and for the reporting of any fluid detected and chemical analysis thereof.

Specific Requirements for Other Methods – Demonstrate that: the method is as or more reliable, effective, and determinate than a viable groundwater monitoring well network at detecting any violation of groundwater protection levels or class TDS limits, that may be caused by the discharge or potential discharge; the method will provide early warning of a potential violation of groundwater protection levels or class TDS limits and meets or exceeds the requirements for Vadose zone or leak detection monitoring.

Monitoring well construction and groundwater sampling should conform to A Guide to the Selection of Materials for Monitoring Well Construction. Sample collection and preservation, should conform to the EPA RCRA Technical Enforcement Guidance Document, OSWER-9950.1,

September 1986. Sample analysis must be performed by State-certified laboratories by methods outlined in UAC R317-6-6.3L. Analytical methods used should have minimum detection levels which meet or are less than both the groundwater quality standards and the anticipated protection levels.

11. **Closure and Post Closure Plan:** The purpose of this plan is to prevent groundwater contamination after cessation of the discharge or potential discharge and to monitor the discharge or potential discharge point after closure, as necessary. This plan has to include discussion on: liquids or products, soils and sludges; remediation process; the monitoring of the discharge or potential discharge point(s) after closure of the activity.

12. **Contingency and Corrective Action Plans:** The purpose of this Contingency plan is to outline definitive actions to bring a discharge or potential discharge facility into compliance with the regulations or the permit, should a violation occur. This applies to both new and existing facilities. For existing facilities that may have caused any violations of the Groundwater Quality Standards or class TDS limits as a result of discharges prior to the issuance of the permit, a plan to correct or remedy any contaminated groundwater must be included.

    Contingency Plan – This plan should address: cessation of discharge until the cause of the violation can be repaired or corrected; facility remediation to correct the discharge or violation.

    Corrective Action Plan – for existing facilities that have already violated Groundwater Quality Standards, this plan should include: a characterization of contaminated groundwater; facility remediation proposed or ongoing including timetable for work completion; groundwater remediation.

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Andrade Christensen - Owner	801-787-6728
NAME & OFFICIAL TITLE (type or print)	PHONE NO. (area code & no.)
SIGNATURE	1/9/18 DATE SIGNED

SECTION 2: DESCRIPTION OF PRODUCTION FACILITIES

The facility is to be located in the north ½ of section 31, T20S, R5W SLB & M. This site will be an 8800 hog finisher site with a single basin to contain the waste. The waste will be contained only temporarily and will be utilized as fertilizer on the adjacent fields to grow crops. There will be no treatment of the waste except that which occurs naturally as the waste sets in the containment basin before it is applied to the fields as fertilizer.

Potential discharges would include the possible leaking of the basins or the pipes into or out of the facility. Both the influent into and the efluent out of the facility will be closely monitored. Therefore, any leakege will be identified by a corespoinding drop in the amount of either influent or effluent. Furthermore, in compliance with groundwater discharge permit requirements, monitoring wells will be installed to verify that the groundwater is not contanimated due to sewage leakage.

2.1 Farm Site Population

There is one farm site proposed for this permit. The sites will consist of 8 (1100) head wean to finisher barns containing pigs sized from 15 to 270 pounds. Table 1-2 summarizes the swine population anticipated for the farm sites:

Table 1-2

Animal Type	Average Animal Weight (lbs)	Population	Total Live Animal Weight (LAW) for Animal Type (lbs)
Finisher Pig	135	8800/site	1,188,000

2.2 Farm Site Locations

The locations of the finishing farms are identified on Attachment A. Table 1-3 indicates the latitude and longitude of the site.

Table 1-3

Farm Number	Latitude	Longitude
1	N 39° 2' 3.36"	W 112° 27' 0.65"

SECTION 3: GEOLOGIC AND HYDRAULIC EVALUATION

3.1 Geologic Conditions

The rocks in the Pahvant valley area range from Precambrian age to Holocene in age. The Pahvant Range, the eastern boundary of the study area, is generally considered to be part of the eastern edge of the Basin and Range physiographic province, and consists of consolidated rocks of Paleozoic to Cenozoic age. The stratigraphy of the canyon Mountains, in the northeastern part of the study area, are similar to that of the Pahvant Range but includes rocks of Precambrian age.

In the local area of the proposed farm site the geologic conditions consist of alluvium or colluvium overlying a basalt flow. The basalt flow is underlain valley fill which could be up to thousands of feet thick.

3.1.1 Faulting & Seismicity

The Pahvant Valley lies within a zone of pronounced seismic activity. There are many faults in the Pahvant Valley approximately 2.5 miles to the west of the proposed farm sites with the closest mapped faults to the site being the Pahvant fault approximately 2.5 miles west of the proposed farm site.

It does not appear that any known active faults transect the proposed farm sites.
From southwestern Utah to northwestern Montana (Christenson and Dean, 1983).

3.2 Stratigraphy

The stratigraphy at the site generally consists of alluvium and colluvium (Quaternary) overlying basalt flows. The following is an excerpt from the **State of Utah Department of Natural Resources, Technical Publication No. 98, "GROUND-WATER HYDROLOGY OF PAHVANT VALLEYAND ADJPCENI' AREAS, UTAH" By Walter F. Holmes and Susan A. Thiros**

"Alluvial fans which developed along the mountain fronts, predominantly during Quaternary tine, were deposited synchronously with sediments laid down by intermittent lakes. The fans

extended into the basin where they interfingered with lakebed deposits consisting of gravel, sand, silt, and clay. These deposits are unconsolidated and form one of the principal aquifers in Pahvant Valley. Pleistocene Lake Bonneville, the last of the intermittent lakes to inundate the area, existed between approximately 30,000 to 10,000 years B.P. (Oviatt and Currey, 1987, p. 259).

Bars, spits, and beaches fronted by Lake Bonneville can be found at or below the Provo substage level of 4,830 feet in Pahvant Valley. Basaltic and rhyolitic volcanic rocks were deposited in the study area during late Tertiary and Quaternary tine, the result of extension within the Basin and Range province (Hoover, 1974, p. 38).

Silicic volcanism, which formed rhyolite domes and volcaniclastic deposits, took place in the central and southern part of the study area with White Mountain, a small silicic dome in Pahvant Valley, being extruded less than 1 million years ago (Hoover, 1974, p.19). The name White Mountain is derived from the white gypsiferous sand deposits blown against the dome's base from the surrounding playa.

Basaltic rocks, found near or at the surface in the study area, were deposited during the past one million years. Basalt flows extend from 100 to 800 feet above the valley floor, fronting a north-south-trending ridge which divides the study area into Pahvant Valley on the east and the Sevier Desert on the west. Hoover (1974, p. 5) divides these eruptive events into three episodes based on composition and age relations. The Beaver Ridge and Kanosh volcanic fields, ranging in age from 918,000 to 536,000 years B.P., comprise Episode 1. The eastward extent of the Beaver Ridge basalts is unknow because of normal faulting and a veneer of alluvium that obscures the outcrops. The Kanosh field consists of several cones, including the Black Rock Volcano, and lava flows that also have been subsequently covered by alluvium.

Episode 2 is composed of the Pahvant volcanic field which ranges in age from about 130,000 to 30,000 years B.P. Extruded subaerially, the basalt flows of this field are the most extensive in the study area. The flow contains abundant pressure ridges, lava tubes, and polygonal joints (Condie and Barsky, 1972, p. 338). The final eruptive stage in the Pahvant field was contemporaneous

with Lake Bonneville and, therefore, was subaqueous. Pahvant Butte, a 750-foot-high tuff cone, rests uncomfortably upon the older Pahvant field basalts. The last eruptive episode occurring in the area consisted of the Tabernacle and the Ice Springs volcanic fields. The subaqueous Tabernacle field basalts mainly were extruded during the Provo substage of Lake Bonneville (less than 12,000 years B.P.) from the base of a tuff cone called Tabernacle Hill (Condie and Barsky, 1972, p. 339). The lack of Provo substage-level terraces and the occurrence of pillow-like structures at the outer edges of the flows indicate a subaqueous eruption. The cinders, spatter cones, and lava of the Ice Springs field, about 3 miles west of Flowell, disconformably overlie Lake Bonneville sediments with an estimated age between 4,000 to 1,000 years B.P. (Hoover, 1974, p. 20). Ice Springs lavas also overlap the southern -part of the Pahvant field. Travertine ridges and deposits located west of Hatton are still being formed at hot and warm springs in the area. The travertine deposits follow the same northward trend along which the Kanosh and Ice Springs Volcanic fields and Pahvant Butte are located."

3.3 Topography and Drainage

The proposed farm sites located in the Pahvant Valley as described previously. The topographical slope at the proposed site and the surrounding area is approximately 1%. The approximate elevation at the proposed farm sites is approximately 4645 feet above sea level (see **Attachment A**).

3.4 Hydrologic Description

USGS topographic maps show that the surface drains in and southeast direction. There are no known continuously flowing rivers, stream or surface waters within several miles of the proposed site.

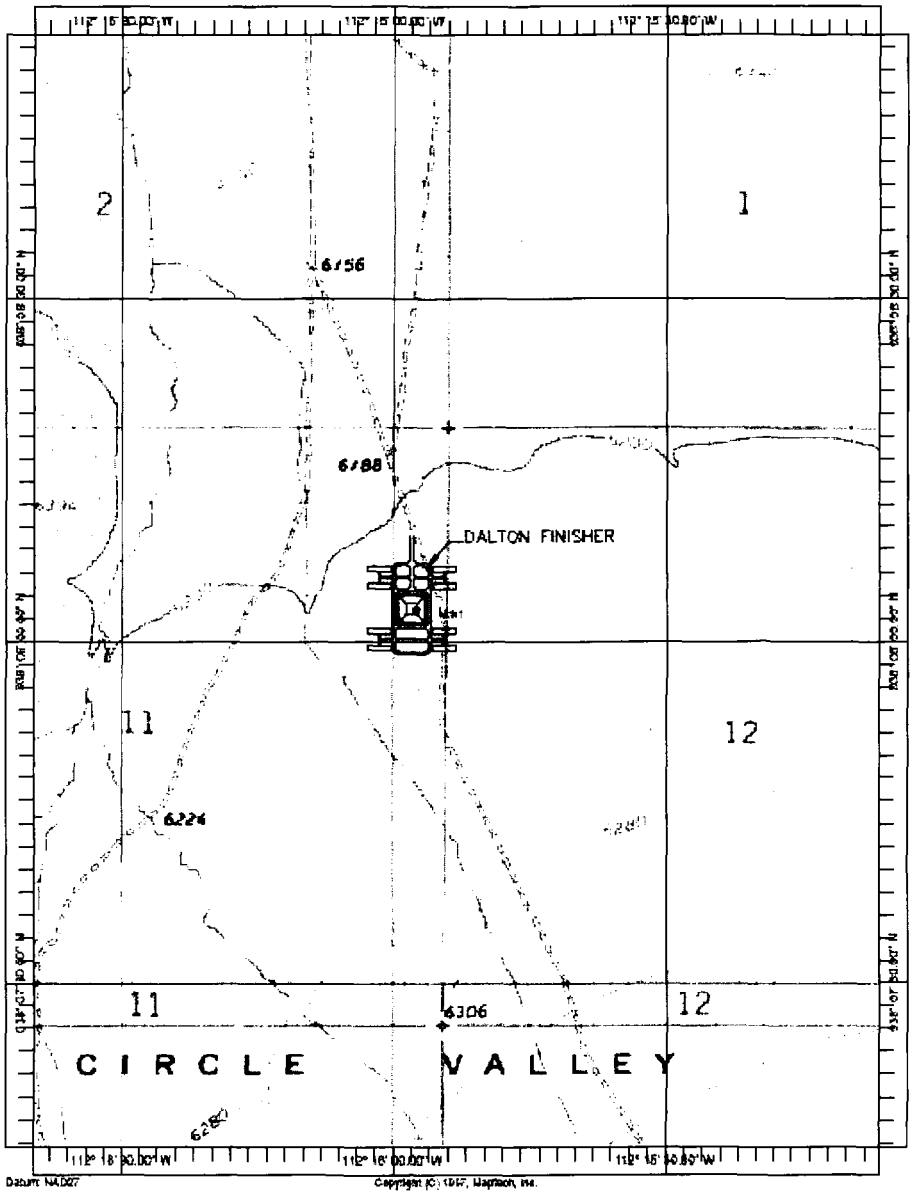


Figure 3-1 Topographic Map (USGS Map)

3.4.1 Groundwater Reservoir

In the **State of Utah Department of Natural Resources, Technical Publication No. 98, "GROUND-WATER HYDROLOGY OF PAHVANT VALLEYAND ADJPCENI' AREAS, UTAH" By Walter F. Holmes and Susan A. Thiros** the hydraulic properties of the groundwater reservoir in the area of the proposed farm sites are documented. The information from this publication is drawn upon freely in the following discussion.

Mower (1965) estimated 11,000,000 acre-feet of total ground water in storage in Pahvant Valley. Much of the ground water in the central and western parts of the study area is of poor quality and limited value, and is in fine-grained material which would yield little water to wells.

Hydraulic coefficients of the ground-water reservoir in Pahvant Valley were reported by Mower (1965,). The transmissivity of the unconsolidated basin fill ranges from about 2,000 to 40,000 feet squared per day, and the transmissivity of the basalt ranges from about 24,000 to 3,000,000 feet squared per day. The storage coefficient of the groundwater reservoir under artesian conditions ranges from 0.001 to 0.0001. The estimated specific yields for geologic units include 0.10 to 0.25 for the unconsolidated deposits, 0.06 for the basalt, and 0.12 for the combined unconsolidated basin fill and basalt.

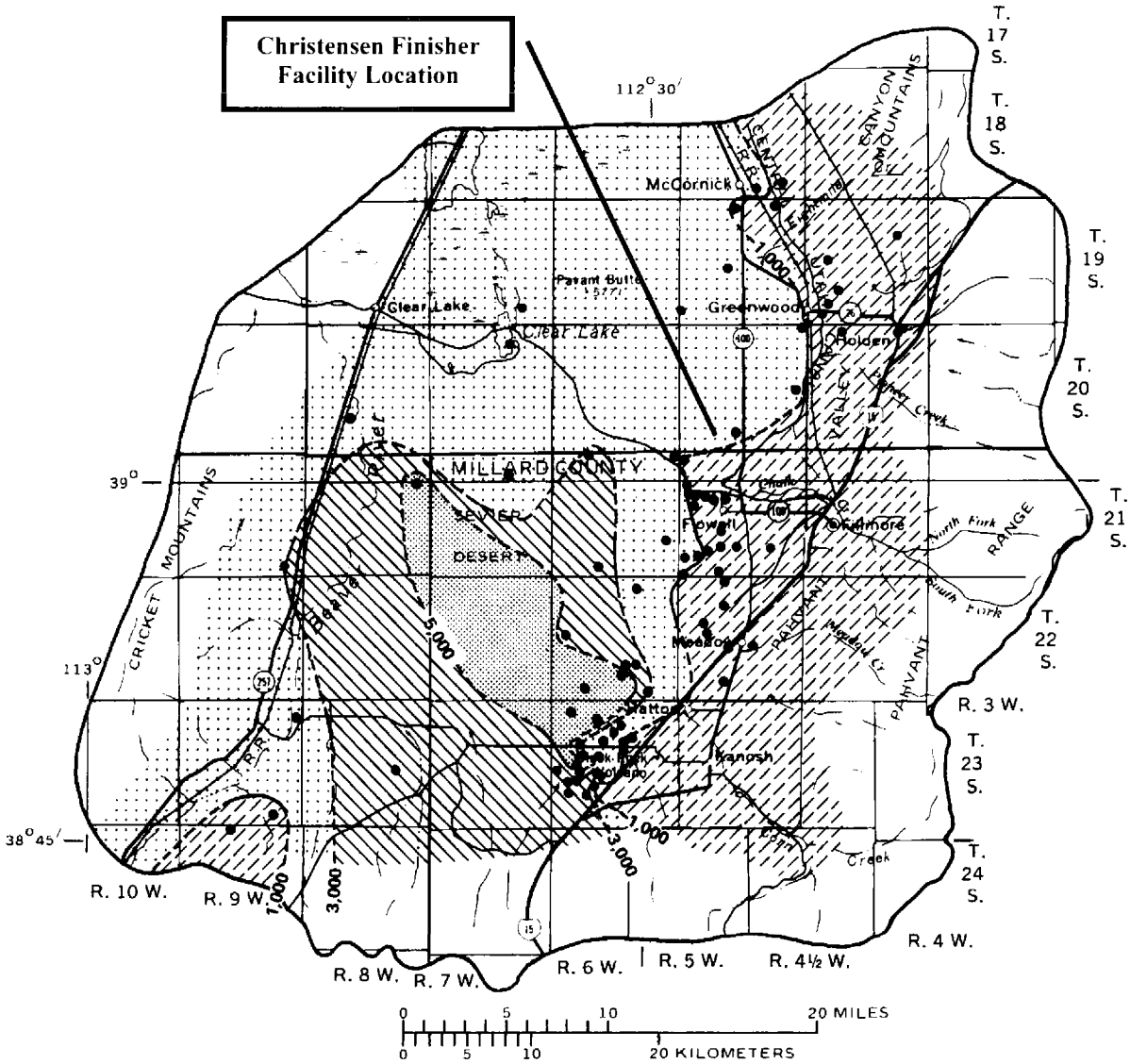
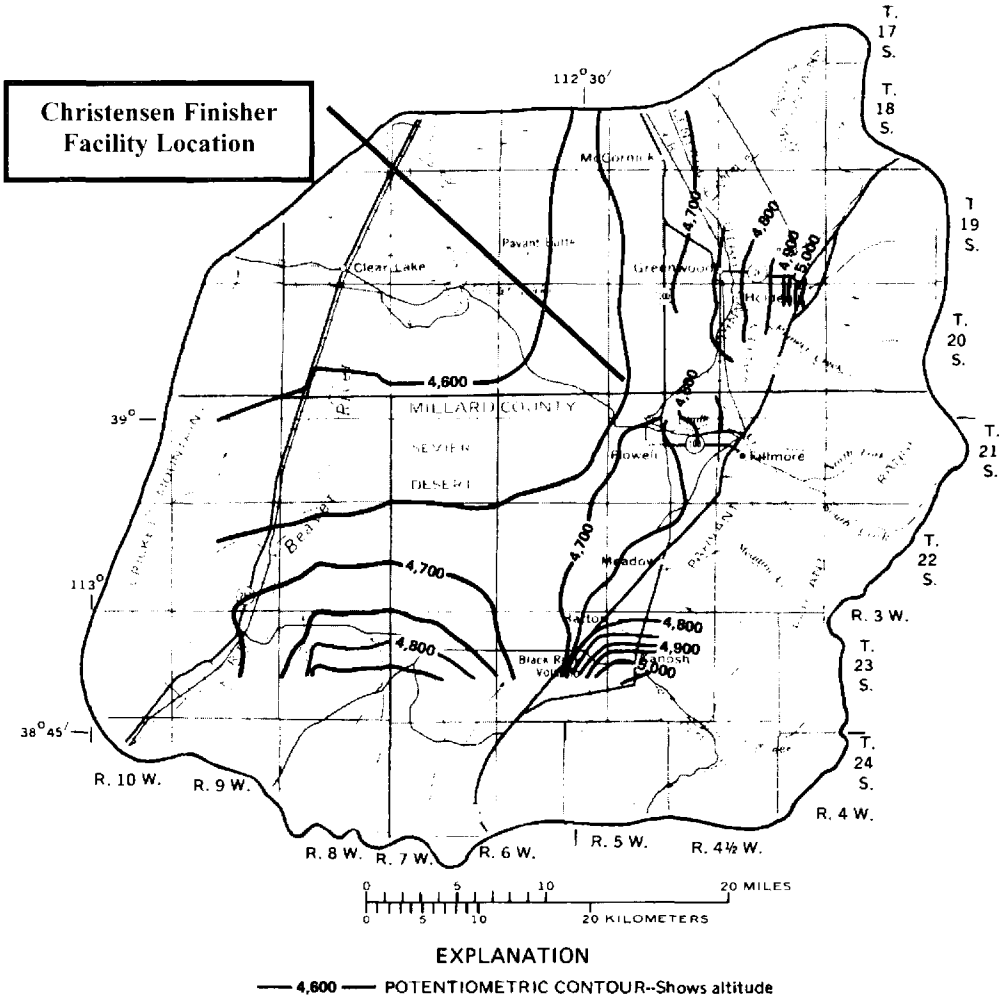


Figure 3-2 Well Locations Near Christensen Finisher Farm Sites

3.4.2 Groundwater Movement

The groundwater in the southern portion of the Pahvant Valley Basin is recharged by ephemeral streams, subsurface inflow from bedrock in the mountains, precipitation on the valley floor. The groundwater in the area of the proposed site flows down to the west-northwest direction the ground water slope in the basin is estimated 0.025 to 0.03 % to the north - northwest under the proposed site. The groundwater's approximate depth under the proposed facility site is estimated to be 75 to 100 feet below existing ground level in the vicinity of the proposed site.

The rate of lateral movement in the aquifer is extremely slow compared to that of a surface stream. The well logs for the wells in the area indicate silty sand and sandy clay at water table depth. Therefore, the percentage of sand in the aquifer beneath the site can be assumed to be between 10% and 15%. The Transmissivity for the full underling aquifer thickness is approximately 3,000 to 5000 ft^2 /day. The following is a map showing the potentiometric surface of the Pahvant Valley.



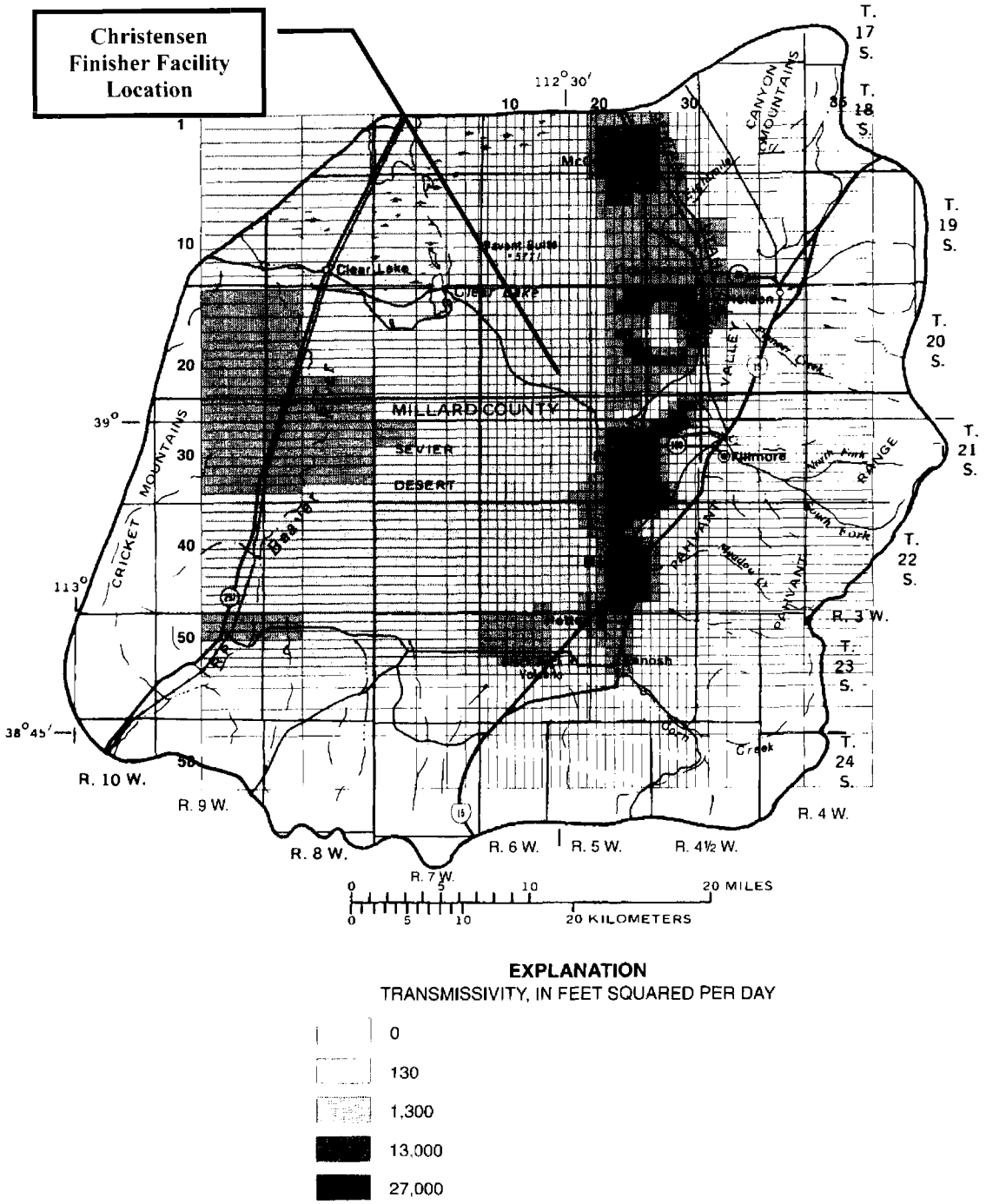


Figure 3-5 Transmissibility in the Pahvant Valley

3.4.3 Groundwater Quality

Existing wells referred to as piezometric wells in this report have been used to analyze the qroundwater quality surrounding the proposed sites. The chemical quality of water samples collected from ground-water sites in the study area is reported in Thiros (1988). The quality of the water in the ground-water reservoir varies considerably. Dissolved solids in water ranged from 300 milligrams per liter to 9,000 milligrams per liter. The water in the eastern part of the study area generally has dissolved-solids concentrations less than 1,000 milligrams per liter, while water in most of the remaining area has concentrations ranging from about 1,000 to 5,000 milligrams per liter.

3.4.4 Chemical Quality of Water

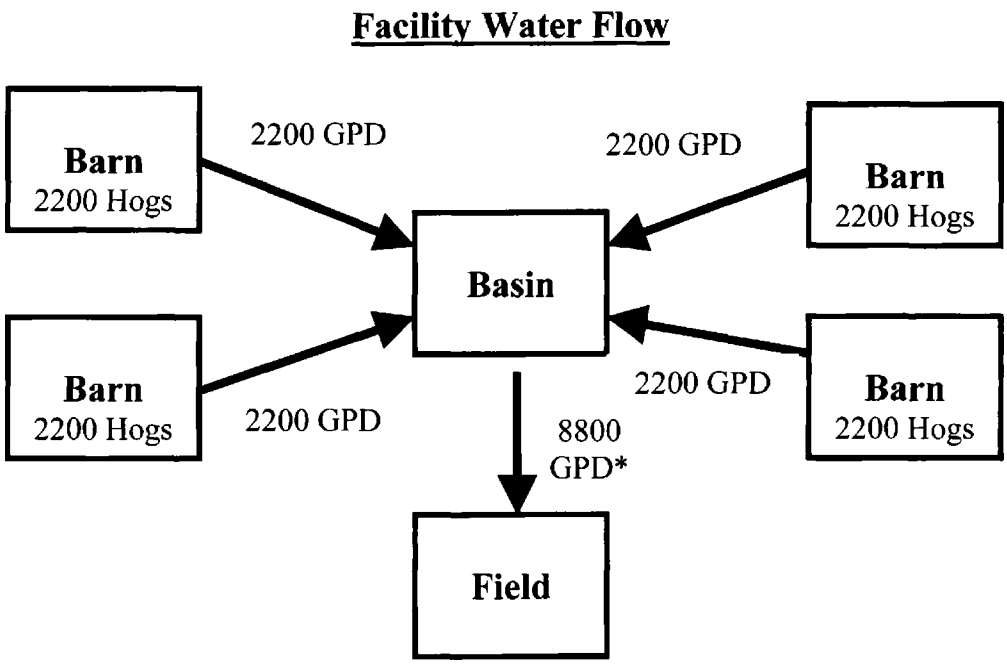
The proposed farm site is in the north central portion of the study area. It is estimated that dissolved solids will be between 500 and 1500 milligrams per liter near the proposed farm site. Since there is no data at the farm site this will need to be confirmed with further sampling when the monitoring wells are constructed.

SECTION 4: GROUNDWATER DISCHARGE CONTROL PLAN

The finisher farm is designed as a closed system and therefore with the exception of the Septic system which will be designed and approved through the local health department no wastewater will be discharged to the surrounding soil.

4.1 Finisher Waste Management Description

A diagram of the overall operation of the finisher facility is found in **Figure 4-1**



* Flow from Basin to Field will be on an as needed basis with an average flow of 8800 GPD*

Figure 4-1 Finisher Flow Diagram

4.1.1 Waste Flow Description

The sewage collected from the individual finisher buildings will drain into the waste containment basin. The waste will not be treated but will be pumped to agricultural fields at an agronomic rate to be utilized as fertilizer. The level of fluid in the containment will be strictly monitored and controlled. The basin is designed to hold approximately 425

days of waste produced by the hogs in the barn at full capacity.

4.1.2 Soil Information

The soil and water table around the site were investigated by reviewing the well logs for the wells which are near the facilities:

Well # 1 – (C-20-5) 32 cbb: S 35 ft, E 150 ft from E1/4 corner of Section 31, T 20S, R 5W, SL B&M

Well # 2–a20780(67-1177): S 1400 ft, W 50 ft from N1/4 corner of Section 33, T 20S, R 5W, SL B&M

Well # 3–a20068(67-218): S 4124 ft, E 1489 ft from NW corner of Section 6, T 21S, R 5W, SL B&M

Soil logs for the locations listed above are located in **Attachment B**. Information was obtained from Utah Division of Water Rights.

The shallowest groundwater in the surrounding borings was located roughly 46 feet below existing grade at Well # 3. The groundwater is estimated to be about 75 to 100 feet below the ground surface based on the topographical map and the above well information.

In order to meet DEQ criteria for Containment Basin construction, the seasonal high water table elevation must be at least 2 feet below the floor of the containment basin in hydrogeologically stable soil strata. At the facility location, the seasonal high water table will be more than 2 feet below the bottom of the proposed containment basin. Also, the soil strata underlying the facility site appear to be hydrogeologically stable. It appears that the proposed site will meet this criteria.

4.1.3 Containment Basin Overview

The owner of this facility will follow the previously accepted design criteria in developing containment basins for this facility. No digestion of the waste is necessary, because the hog manure will be utilized as fertilizer on an agricultural field.

A plan view of the containment basin is shown in **Figure 4-3**

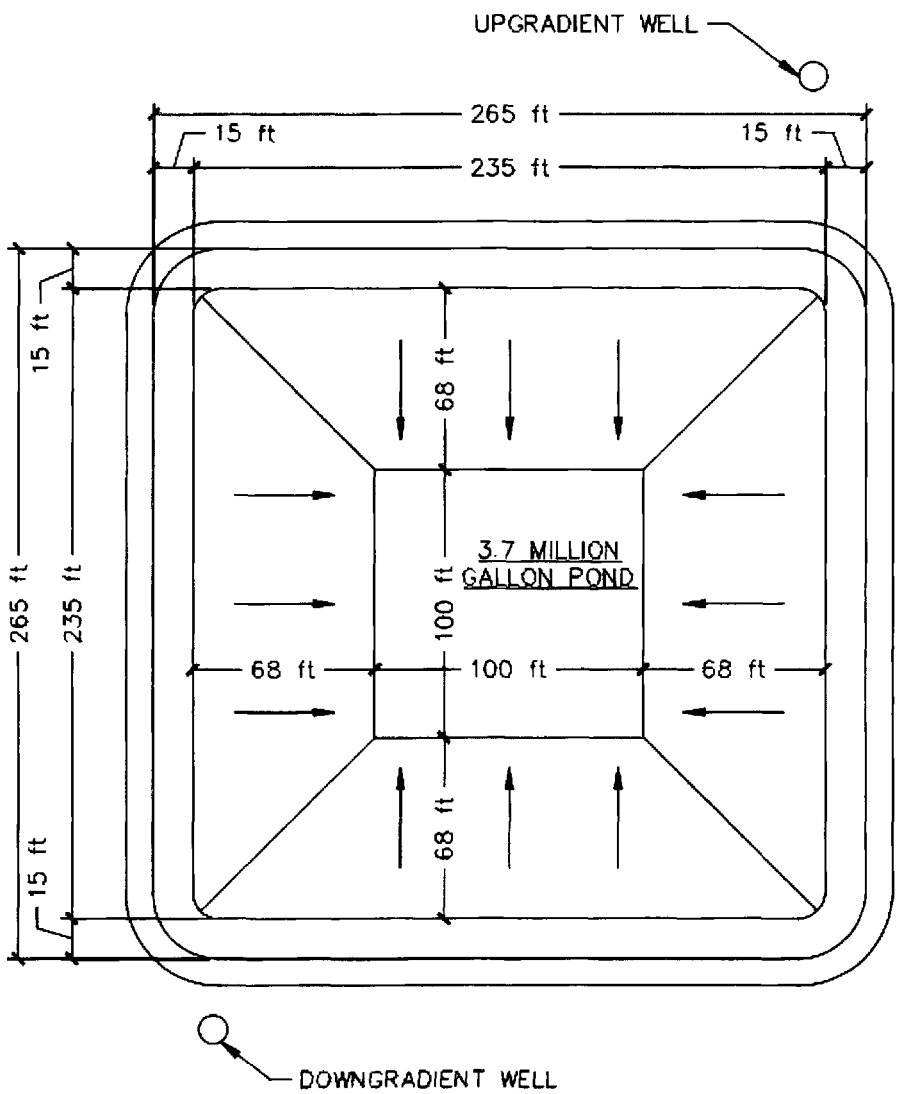


Figure 4-3 Containment Basin Detail and Monitoring Well Location

4.1.4 Waste Conveyance System

Waste shall be conveyed from the farm sites to the containment basin through either HDPE SDR 35 or PVC Schedule 40 sewer pipe, as shown in the Composite

Location & Plot Map included in **Attachment A**. The waste will gravity flow from the barns to the waste containment basins. The containment basin will be lined with a Flexible Membrane Liner (FML).

4.1.5 Containment Basin Management Plan

As previously described, the waste flows from the barn to containment basin and then is pumped to the fields at an agronomic rate. Should problems be encountered either in the liner or piping, the flow of sewage from the individual farm sites can be shut off and the contents of the basin(s) can be pumped to the existing field or containment basin so that repairs can be made, and the containment basin be put back into use.

SECTION 5: COMPLIANCE MONITORING PLAN

5.1 Groundwater Monitoring

Two monitoring wells, one upgradient and one downgradient, will be drilled for compliance monitoring of the containment basin site at the facility site. A Water Quality Sampling, Handling and Analysis Plan is included as **Attachment F**. All water samples taken from the monitoring wells will be processed according to the guidelines set forth in this plan. The installation guidelines and an outline of the proposed groundwater monitoring plan are as follows:

1.) Upgradient and downgradient monitor wells will be constructed. The proposed locations of these wells are shown in **Figure 4-3**. The monitor wells will have a total depth of 10' below the first encountered water table and will be constructed and developed as per requirements of the State of Utah, Department of Environmental Quality. The monitor wells will typically be constructed as shown in **Figure 5-1**. The upgradient wells will provide background data for the downgradient monitoring wells. These wells will be constructed at locations shown in **Figure 4-3** and in **Attachment D** at the proposed site.

2.) The static water level in each well and the elevation of the water level will be determined at least 8 days after the well has been completed. The water levels at each well will be compared with existing data to confirm the direction of groundwater movement.

3.) Monitoring wells will be sampled and tested according to the procedures outlined in the Water Quality Handling and Analysis Plan (**Attachment F**). It is anticipated that the monitoring wells will be 70 to 80 feet in depth below the ground surface at the proposed farm site location.

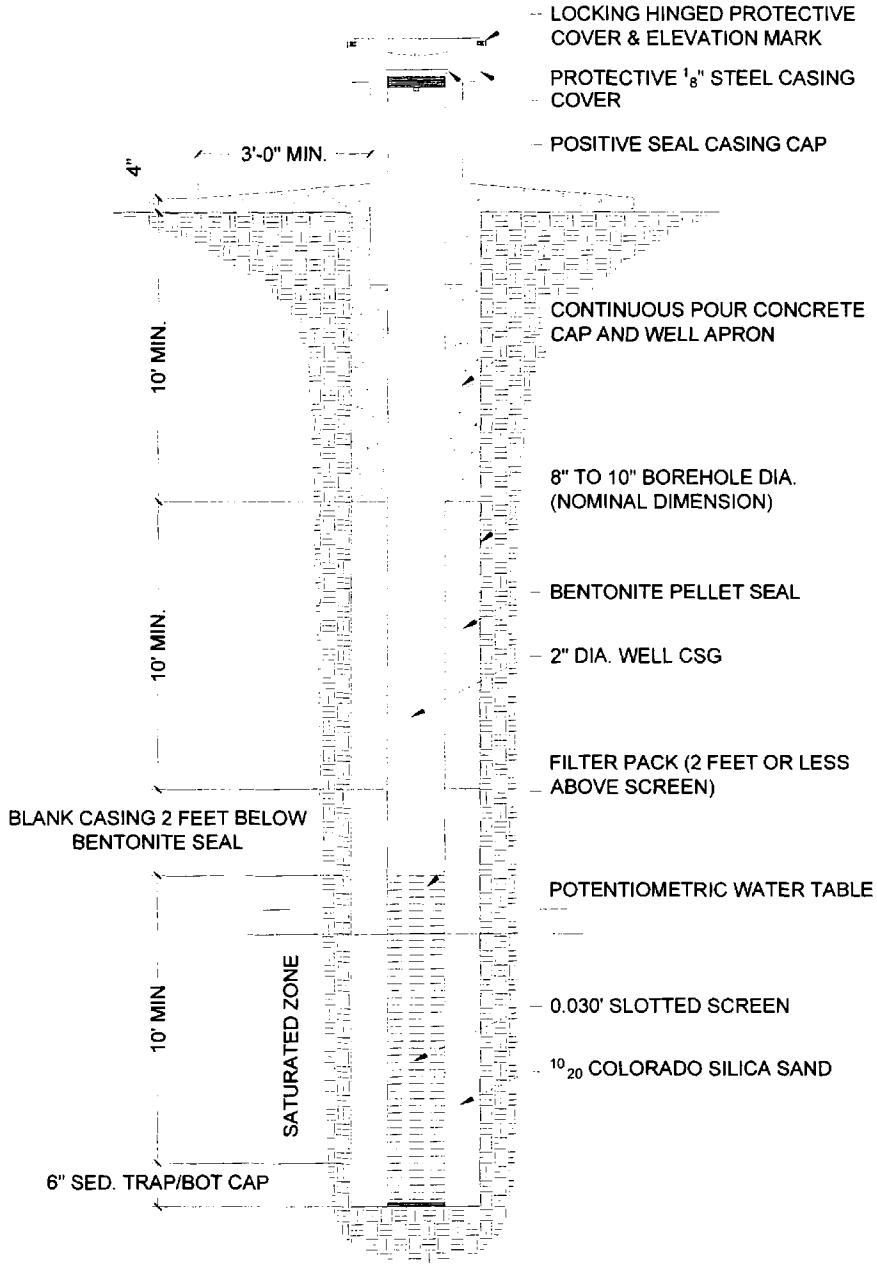


Figure 5-1 Typical Monitor Well Detail

5.1.1 Upgradient Groundwater Monitoring

The upgradient monitor well will be constructed and sampled prior to waste introduction to the Containment Basin at the site. The water in the upgradient well will be sampled and analyzed at least 8 days after the well is completed in order to determine the groundwater class protection levels and begin to establish background mean concentration levels. The groundwater protection levels of the upgradient well will be

determined according to UAC R317-6-4 from the analysis of eight independent samples taken at equal intervals during a period of one year. The accelerated background constituents that will be analyzed in a laboratory include: total dissolved solids, sulfate, calcium, magnesium, potassium, sodium, carbonate, bicarbonate, total phosphorous, chloride, nitrate-N/nitrite-N, and ammonia-N. The parameters that will be determined at the monitor well include: static water level, pH, temperature, and specific conductance.

The background mean concentration levels will be determined by averaging the upgradient monitor wells accelerated background data, then adding 2 standard deviations. The following parameters will constitute the quarterly monitoring from the upgradient well after all eight background analysis: static water level, pH, temperature and specific conductance. Also, the following constituents will be monitored quarterly: nitrate-N/nitrite-N, ammonia-N, total dissolved solids, bicarbonate, and chloride. After the groundwater properties have been well established the analysis frequency may be decreased to semi-annually.

5.1.2 Downgradient Groundwater Monitoring

If data from upgradient monitor wells indicate differing movement of groundwater than what is shown in this application, the locations for the downgradient monitor wells will be changed, sent to the DEQ for approval, and drilled at a different location than proposed in this application.

A first sample will be taken from the downgradient well at least eight days after it's construction and prior to waste flow to the digester system. Only the first sample from the downgradient well will be analyzed for the background parameters described in Section 5.1.1. After the first analysis, the well will be analyzed on a quarterly basis for the following constituents: nitrate-N/nitrite-N, ammonia-N, total dissolved solids, bicarbonate and chloride. The following field parameters will also be analyzed: static water level, pH, temperature, and specific conductance. After the groundwater properties have been well established the analysis frequency may be decreased to semi-annually.

5.1.3 Alternative & Additional Monitoring

In the event that the chemical quality proves that a common source comparison does not exist between the upgradient and downgradient well, a different background monitoring schedule may be proposed to the Department of Environmental Quality's Executive Secretary.

Additional Monitoring: Identification of the contaminants in the wastewater will be analyzed once a year. The analysis will identify the parameters required under the accelerated background monitoring at upgradient wells and also, the metals listed in Table 1 of the Groundwater Regulations, R317-6-6.3, (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver and zinc).

SECTION 6: CONTAINMENT BASIN SYSTEM LOCATION AND DESIGN

6.1 Containment Basin Description

A containment basin will be used at each finisher site to store the swine manure produced at the finisher sites. Effluent will be collected from the production building to the Containment Basin where the effluent will be stored allowed to evaporate. The Containment Basin will be lined. The liners will consist of a Flexible Membrane Liner (FML). The waste contained in the containment basin will be pumped and utilized as fertilizer in the near by fields.

6.2 Containment Basin Site Soils Investigation

A soil and water table investigation will be performed near the proposed Containment Basin locations before construction. The soil investigations will consist of 2 backhoe trenches approximately 15 feet in depth near the proposed farm sites. The groundwater underlying the Containment Basin must be at least 8 feet below the existing ground level. In order to meet DEQ criteria for Containment Basin construction, the seasonal high water table elevation must be at least 2 feet below the floor of the Containment Basin in hydrogeologically stable soil strata. At the proposed farm site, the seasonal high water table was more than 2 feet below the bottom of the proposed Containment Basin based on the hrydorgeolocical information available. Also, the soil strata underlying the Containment Basins appear to be hydrogeologically stable. It is proposed that bottom of containment basin be placed approximately 10 feet below the ground surface at these farm site locations. It is estimated that the groundwater is approximately 75 to 100 feet below the ground surface at the proposed site location. It is anticipated that basaltic bedrock will be encountered at approximately 10 feet below the site grade.

6.3 Containment Basin Design

The containment basins will be constructed with 60 mil HDPE liners as described in section 7 of this report and in accordance with the State of Utah Department of Environmental Quality regulations. A plan view and cross section of the containment basin can be found in Attachment D.

6.4 Waste Transfer System

Waste from the barns is transferred to the containment basin through either 12" SDR 32.5 HDPE or 12" SDR 35 PVC sewer pipe, installed at a 0.5% minimum slope. The effluent pipe and Containment Basin elevations allow the waste to gravity flow from the pits to the Containment Basin. The waste will then be pumped to the agricultural field for use as fertilizer at an agronomic rate.

6.5 Containment Basin Safety System Considerations

Access to the Containment Basins by humans and animals will be controlled by fencing. The fences will help to prevent damage to the Flexible Membrane Liners (FMLs) in the instances where they are used. Only authorized personnel will have access to the Containment Basin areas to prevent damage to the FMLs. Additionally, safety-warning signs will be posted near the Containment Basins.

6.6 Containment Basin Management Plan

The Containment Basin will be managed as a fertilizer producing system. The Containment Basin is designed to contain all of the waste produced by the hogs for 425 days. The waste will be pumped to the fields at an agronomic rate. Since the prevailing climatological conditions result in more evaporation than precipitation no excess volume will be provided other than the free board of 1.5 feet as show on the lagoon cross section in Attachment D. However, should unforeseen precipitation events occur, excess effluent could be land applied at agronomic rates at any time. The effluent will be applied according to soil and plant nutrient uptake rates. In this case, the effluent will be applied in a manner such as to avoid any contamination of surface waters, drinking wells, springs or pipelines.

SECTION 7: LAGOON AND CONTAINMENT BASIN CONSTRUCTION

7.1 Containment Basin Construction

Construction of the Barns and Containment Basin shall be done in accordance with design drawings and specifications. Earthwork and liner construction shall be tested and inspected by qualified independent geotechnical and/or engineering firms. At the completion of construction, and prior to operation of the facility, an independent performance certification document will be completed by a qualified professional engineer licensed in the State of Utah containing test information and certification that basin and liner construction meets requirements of the project design documents and the requirements contained within this report.

7.1.1 General Earthwork Construction

Earthwork and dike construction for excavation of digesters and equalization basins shall be done as follows:

A. The area scheduled for construction of basins and building pads shall be cleared and grubbed to remove topsoil and surface vegetation from the digester/basin areas.

B. Soil shall be excavated from the basin area and be used to construct building pads or dikes.

C. Basin dikes shall be constructed in 6-inch compacted lifts to obtain proper compaction. For building pad and digester dike construction, the soil shall be moistened and compacted to 90% of maximum dry density, as defined by AASHTO T-99. Moisture will be added to the soil during compaction to target 0 to 4 % above the optimum moisture.

D. The dikes will be constructed of relatively impermeable compacted native material.

E. A qualified inspector will perform the moisture content and dry density testing per every two feet of lift at random locations once every 400 feet along the Containment Basin dikes.

7.2 Flexible Membrane Liner

Specifications for manufacture, delivery, subgrade preparation, installation, and testing for FML liner installation are included in **Attachment E**. The QA/QC plan is also included in this attachment. The specifications were adapted from requirements set forth in previous projects and permit applications. Moreover, an industry standard known as the GRI standard GM13 which covers smooth and textured geosynthetics has been developed with the intent of forming an industry standard for manufacture and testing of geosynthetic liner material. This standard was developed by the Geosynthetic Research Institute at Drexel University, Philadelphia, PA. As stated in the specifications, the requirements of latest revision of the GRI standard will be applicable.

If the basins are to remain empty for an extended period of time they shall be properly ballasted using ultraviolet ray resistant sand bags with nylon ties. The minimum specification for ballasting liner is 30-lb. sand bags spaced 5-feet apart along the entire toe of dike in containment basins. Sand-filled HDPE tube or pipe may also be used as long as an equivalent amount of ballasting per lineal foot (6 lbs./ln.-ft.) is maintained.

On occasion, repairs may have to be made to liners if damage occurs out of the norm, or modifications need to be made. All repairs made to liner seams, or incident holes found in the liner shall be vacuum/bubble tested, documented and sent to the State DEQ for informational purposes and approval of the repairs. Unless significant modifications to the liner are made, such repairs shall be made without any requirements for approval from the State DEQ.

7.2.1 Flexible Membrane Liner Installation

The Containment Basins at the finishing farms may be lined with a Flexible Membrane Liner (FML) constructed of a High Density Polyethylene (HPDE). The subgrade will conform to the FML specifications of the Manufacture and the previously stated most resent GRI standards. The installation of the FML will also comply with the Quality Assurance/Quality Control (QA/QC) found in Attachment E. In Addition to the FML specifications and QA/QC, detailed drawings of typical liner anchoring methods, pipe penetrations, air vents and water level markings of liners are found in attachment E. The

following procedures will be used for installation of liners for the Containment Basins at the farm sites.

The Subgrade will be constructed according to the specifications as detailed below:

1. The subgrade material will come from either on-site material or approved stockpiles.
2. The earthwork for the anaerobic Containment Basins will be free of any foreign material such as stones greater than 3/8 inch in diameter, vegetation, brush, roots or similar material which could damage the FML.
3. The subgrade material shall be classified as either CH, CL, CL-ML, ML, SM, SC, SW or SP by the USCS Classification System.
4. A Moisture density curve will be developed for the subgrade material.
5. The minimum compacted thickness of the subgrade layer shall be 8 inches.
6. The subgrade will be compacted and graded to meet the FML contractor's specifications so as to avoid any ruts, irregularities or soft areas. The subgrade will be thoroughly compacted to provide support for the FML.
7. The subgrade will be compacted to a minimum of 90% maximum dry density as defined by AASHTO T-99. For proper compaction, moisture will be added to the soil during compaction to target 2% above the optimum moisture.
8. Installed density shall be confirmed by field test methods at a frequency of one test per 100'x100' grid square at the surface of the subgrade.

A 60-mil HDPE will be installed over the compacted subgrade. The HDPE material will meet the specifications indicated in the most resent GRI standard and in the QA/QC references in Attachment E. The drawings in Attachment E show typical liner anchoring methods and pipe penetrations of the liner material.

The HDPE liner will be installed according to the following procedure:

1. The earthwork for the anaerobic Containment Basins will be constructed so the subgrade will be free of any foreign material such as stones greater than 3/8 inch in diameter, vegetation, brush, roots or other similar materials which could damage the FML.
2. The earthwork will be compacted and graded to meet the FML contractor's specifications so as to avoid any ruts, irregularities or soft areas. The subgrade will be thoroughly compacted to provide support for the FML.
3. An anchor trench will be constructed along the crest of the berms for the purpose of securing the FML.
4. The FML will be assembled, seamed, tested and installed by the methods specified by a liner material recognized by the NSF (National Sanitation Foundation, Standard 54).
5. The FML will be certified as "holiday free" by electrical potentiometric means (spark tested) during manufacture.
6. Adequate slack will be maintained in the liner material during assembly and installation to minimize stresses due to variations in ambient temperature and incident radiation.
7. Heavily creased or otherwise defective liner material must be rejected.
8. Testing of coupons (strips of material) before seaming, stress cracks and all seams must be done in accordance with the manufacture's requirements.
9. Installation of the FML will ideally take place in temperatures ranging from 40 degrees Fahrenheit to 110 degrees Fahrenheit. In the event that the FML is installed during colder conditions (between 20 degrees Fahrenheit and 40 degrees Fahrenheit) the cold weather seaming procedures detailed in FML QA/QC, Attachment E, shall be followed.
10. Air Vents will be installed on all four sides of the Containment Basin as detailed in Attachment E and Compaction of the anchor trench backfill will provide a firm unyielding surface to secure the FML along the berms.

SECTION 8: FACILITY CLOSURE AND POST CLOSURE

Should facility operation terminate the liquid and sludge will be removed and land applied at agronomic rates unless alternative technologies are developed. The sludge and Containment Basin liquid will be land applied in such a way as to avoid ground water pollution as well as contamination of surface waters, drinking wells, springs or pipelines. Additionally, the parameters and constituents of the water in the monitoring wells detailed in Sections 5.1.1 and 5.1.2 will be observed for 5 years thereafter. The actual duration of post operation monitoring may be less, if justified by long term operation and a history of compliance.

SECTION 9: CONTINGENCY AND CORRECTIVE ACTION

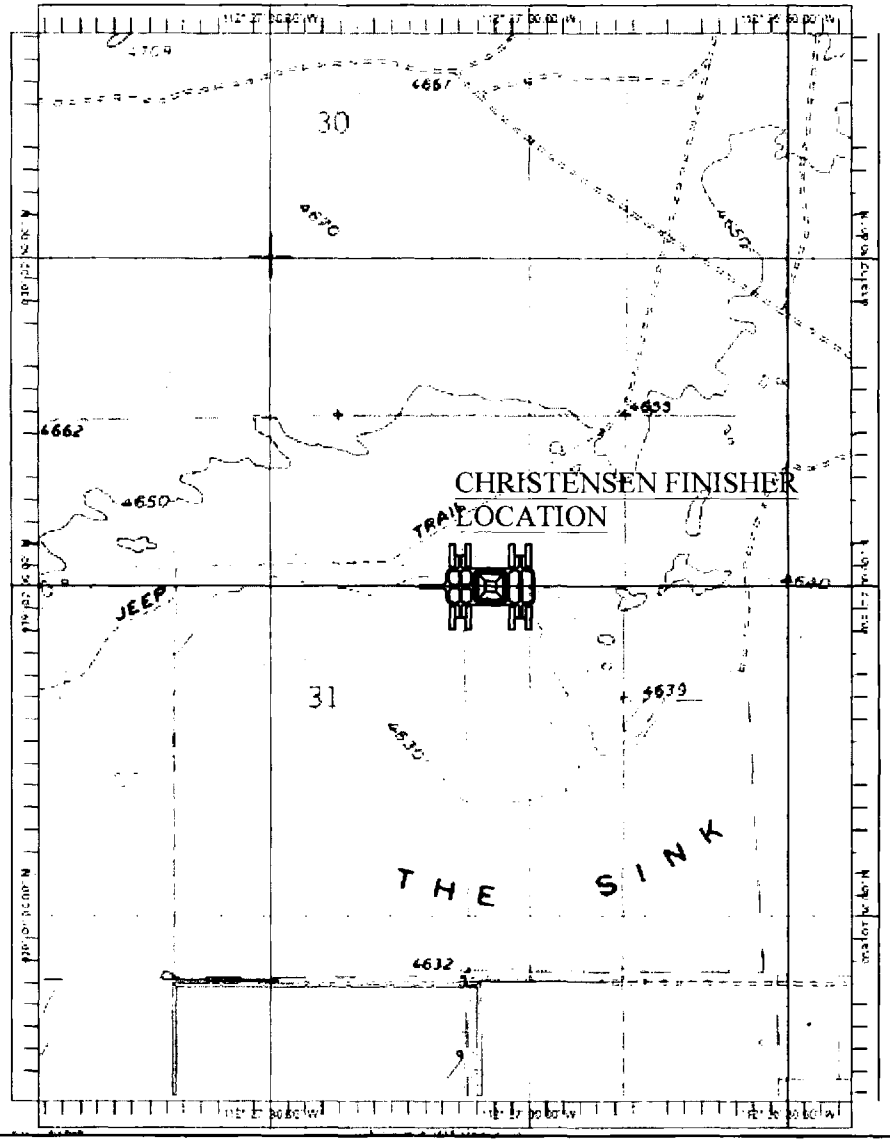
In addition to monitoring wells described in the previous section additional precautions will be implemented. The influent and effluent will be monitored on a regular basis to check for variations in the composition and quantity. The facility condition will also be checked on a daily basis to check for, among other things, damage to piping or liners and waste elevation in the containment basin. Should it become necessary to empty the containment basins for repairs, the liquid from the target basin will be transferred to one or more of the other existing Containment Basins or applied to the land at agronomic rates. Once any necessary repair work has been completed, the liner will be evaluated and re-certified prior to the reintroduction of liquid.

SECTION 10: ADJACENT PROPERTY OWNERS

J and J Swine, LLC own all of the land surrounding the proposed site.

ATTACHMENTS

Attachment A – Composite Location and Topographic Map



LOCATION
AND TOPOGRAPHIC PLAN
1:6000

NORTH

GEM
ENGINEERING, INC.
485 North Aviation Way
Cedar City, UT 84721
Phone (435) 867-6478
Fax (435) 867-4372
www.gemengineering.net

TITLE
CHRISTENSEN FINISHER SITE

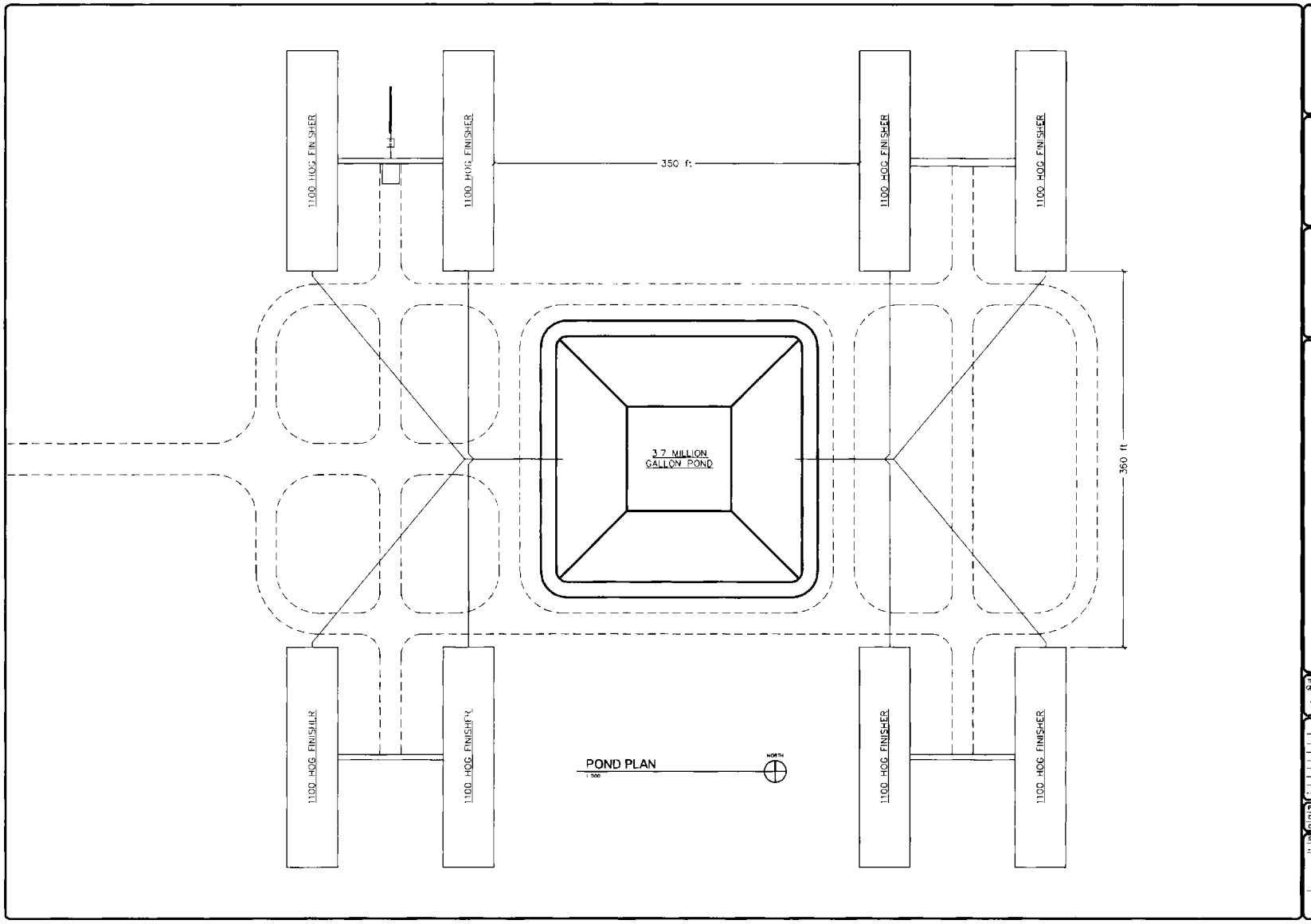
LOCATION
SEVIER COUNTY, UTAH

ISSUED REV. NO.	DATE	DESCRIPTION

PROJ. MGR. —
DESIGNER RWC
DRAWN BY RWC
SCALE REFER TO PLAN
JOB NO. —

DRAWING TITLE
COMPOSITE
LOCATION &
TOPOGRAPHIC MAP

SHEET NO.
ATTACH. A



GEM
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TITLE
CHRISTENSEN FINISHER SITE

LOCATION
SEVIER COUNTY, UTAH

ISSUED REV NO.	DATE	DESCRIPTION
--	--	--

PROJ. MGR. —
DESIGNER RWL
DRAWN BY RNC
SCALE REFER TO PLAN
JOB NO.

DRAWING TITLE
SITE PLAN

SHEET NO.
G-001

Attachment B –Well Logs

10M-Form No. 111-3-20-52

Copied DN 1-28-53
Exam. & Recorded MV 10-22-52
Exam. for filing MV 10-22-52
Final Copy checked
Indexed DN 1-20-53
Well No. (C-20-5)31daa-1

PAGE
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Report No. 9603
Filed Oct. 8, 1952
Rec. By DN
Ret'd

Report of Well and Tunnel Driller
STATE OF UTAH

(Separate report shall be filed for each well or tunnel)

GENERAL INFORMATION: Abandoned

Report of well or tunnel driller is hereby made and filed with the State Engineer, in compliance with Sec. 100-3-22, Utah Code Annotated, 1943. (This report shall be filed with the State Engineer within 30 days after the completion or abandonment of well or tunnel. Failure to file such report constitutes a misdemeanor.)

1. Name and address of person, ~~company or corporation boring or~~ drilling well ~~or tunnel.~~ (Strike words not needed)
   J. Clifford Petersen, Abraham, Utah
2. Name and address of owner of well ~~or tunnel~~ (Strike Words not needed) Joseph C. Christensen, Flowell, Utah
3. Source of supply is in Millard County; (Leave blank) drainage area; (Leave blank) artesian basin
4. The number of approved application to appropriate water is 22904
5. Location of well ~~or mouth of tunnel~~ is situated at a point S. 150 ft. and W. 30 ft. from E¼ Cor. Sec. 31, T20S, R5W, SLB&M
   (Describe by rectangular co-ordinates or by one course and distance with reference to U. S. Government Survey Corner — Copy description from well owner's approved application)
6. Date on which work on well ~~or tunnel~~ (Strike words not needed) was begun November 10, 1951
7. Date on which work on well ~~or tunnel~~ was completed ~~or abandoned.~~ (Strike words not needed) April 28, 1952
8. Maximum quantity of water measured as ~~flowing~~ (Strike words not needed), pumped or ____ on completion of well ~~or tunnel~~ in sec. ft. 2; or in gals. per minute ____ Date June 20, 19

DETAIL OF COLLECTING WORKS:

9. WELL: It is drilled, ~~dug~~ (Strike words not needed), flowing or pump well. Temperature of water ____ °F.
   (a) Total depth of well is 942 ft. below ground surface.
   (b) If flowing well, give water pressure (hydrostatic head) above ground surface don't know
   (c) If pump well, give depth from ground surface to water surface before pumping surface; during pumping 150
   (d) Size and kind of casing Black Pipe 175 of 16" 767 of 12" (If only partially cased, give details)
   (e) Depth to water-bearing stratum 475, 502, 533, 659, 766, 830, 862, 875 (If more than one stratum, give depth to each)
   (f) If casing is perforated, give depth from ground surface to perforations ____
   (g) Log of well 1-3 clay, 3-32 rock, 32-34 clay, 34-38 sand and gravel, 38-47 cla 47-55 gravel 55-66 clay, 66-67 gravel, 67-80 clay, 80-81 gravel, 81-160 clay, 160-161 gravel, 161-200 blue clay, 200-201 gravel, 201-300 blue clay, 300-301 gravel, 301-336 red clay, 336-338 red sand, 338-392 red clay and white, 392-39 sand and gravel, 393-424 red clay, 424-425 sand, 425-475 clay, 475-477 sand an gravel, 477-502 clay, 502-503 gravel, 503-533 clay, 533-538 sand and gravel, 538-659 clay, 659-660 fine sand, 660-690 clay, 690-692 thin layers of rock, 692-702 clay, 702-702 sand and gravel, 702-750 clay, 750-751 gravel, 751-766 clay, 766-769 gravel and sand, 769-830 clay, 830-831 sand, 831-862 clay, 862-863 gravel, 863-875 clay, 875-915 gravel and sand, 915-942 gravel and cla in small layers.
   (h) Well was equipped with cap, valve, or ____ (Strike words not needed) to control flow.

(Over)

WELL DRILLER'S REPORT

State of Utah
Division of Water Rights
For additional space, use "Additional Well Data Form" and attach

RECEIVED
MAR 15 2001
WATER RIGHTS
SALT LAKE

Well Identification

CHANGE APPLICATION: a20780(67-1177)

Owner *Note any changes*

L. B. Ranch
P.O Box 63
Meadow, UT 84644

Contact Person/Engineer:

Well Location *Note any changes*

COUNTY: Millard
SOUTH 1400 feet WEST 50 feet from the N4 Corner of
SECTION 33, TOWNSHIP 20S, RANGE 5W, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #)

Drillers Activity

3 miles north of Flowell

Start Date: 6/28/00 Completion Date: 7/12/00

Check all that apply: ☒ New ☐ Repair ☐ Deepen ☐ Clean ☐ Replace ☐ Public Nature of Use:

If a replacement well, provide the location of the new well. ____ feet north/south and _____ feet east/west of the existing well.

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	445	16"	Cable Tool	Water.

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (e.g., relative %, grain size, sorting, angularity, bedding, grain composition, density, plasticity, shape, cementation, consistancy, water bearing, odor, fracturing, minerology, texture, degree of weathering, hardness, water quality, etc.)
0	4													Top Soil
4	16				X								Brown	
16	25				X								Gray	
25	47				X								Lt Blue	
47	65				X		X						Lt Yellow	Seep of water
65	70				X								Brown	
70	87				X								Blue	
87	92	X					X	X					Lt Brown	
92	132				X								Lt Yellow	
132	207				X								Blue	

Static Water Level

Date 7/12/00 Water Level 87 feet Flowing? ☐ Yes ☒ No

Method of Water Level Measurement Bailer If Flowing, Capped Pressure _____ PSI

Point to Which Water Level Measurement was Referenced Top of Casing Ground Elevation (If known)

Height of Water Level reference point above ground surface 1½ feet Temperature _____ ☐ °C ☐ °F

SCANNED

[redacted] **Well Log** [redacted]

WELL DRILLER'S REPORT

State of Utah
Division of Water Rights
For additional space, use "Additional Well Data Form" and attach

RECEIVED
APR 23 2002
WATER RIGHTS
SALT LAKE

Well Identification

WATER RIGHT APPLICATION: 67-218(A28069)

Owner *Note any changes*

Garth J. Swallow Revocable Trust
4400 West 2100 North
Fillmore, UT 84631

Contact Person/Engineer: _____

Well Location *Note any changes*

COUNTY: Millard
SOUTH 4124 feet EAST 1489 feet from the NW Corner of
SECTION 6, TOWNSHIP 21S, RANGE 5W, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) _____

Drillers Activity

Start Date: 1-28-02 Completion Date: 3-20-02

Check all that apply: ☐ New ☐ Repair ☐ Deepen ☑ Clean ☐ Replace ☐ Public Nature of Use: IRR

If a replacement well, provide the location of the new well. ____ feet north/south and ____ feet east/west of the existing well.

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	90'	23.250"	Cable Tool	water

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (e.g., relative %, grain size, sorting, angularity, bedding, grain composition, density, plasticity, shape, cementation, consistancy, water bearing, odor, fracturing, minerology, texture, degree of weathering, hardness, water quality, etc.)
0	15				X								Brown	
15	22				X				X			Lava	Brown	Broken Lava rocks
22	32										X	Lava	Black	
32	52				X	X	X						Brown	
52	87'	X	X								X	Lava	Black	fractured lot of water
87'					X								Tan	

Static Water Level

Date 3-20-02 Water Level 46' feet Flowing? ☐ Yes ☒ No

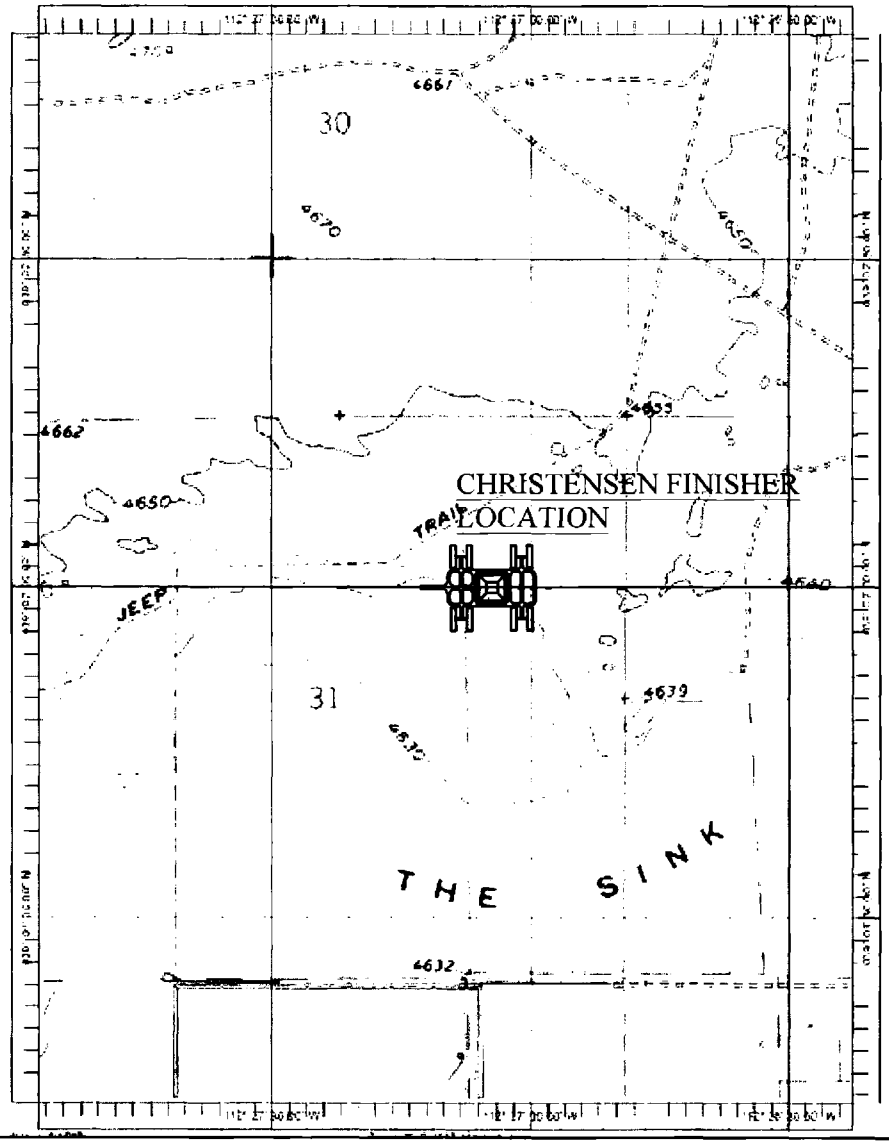
Method of Water Level Measurement Tape If Flowing, Capped Pressure _____ PSI

Point to Which Water Level Measurement was Referenced Ground Surface Ground Elevation (If known) _____

Height of Water Level reference point above ground surface 0 feet Temperature _____ ☐ °C ☐ °F

Well Log

Attachment C – Project Documents



LOCATION
AND TOPOGRAPHIC PLAN
1" = 1000'

NORTH

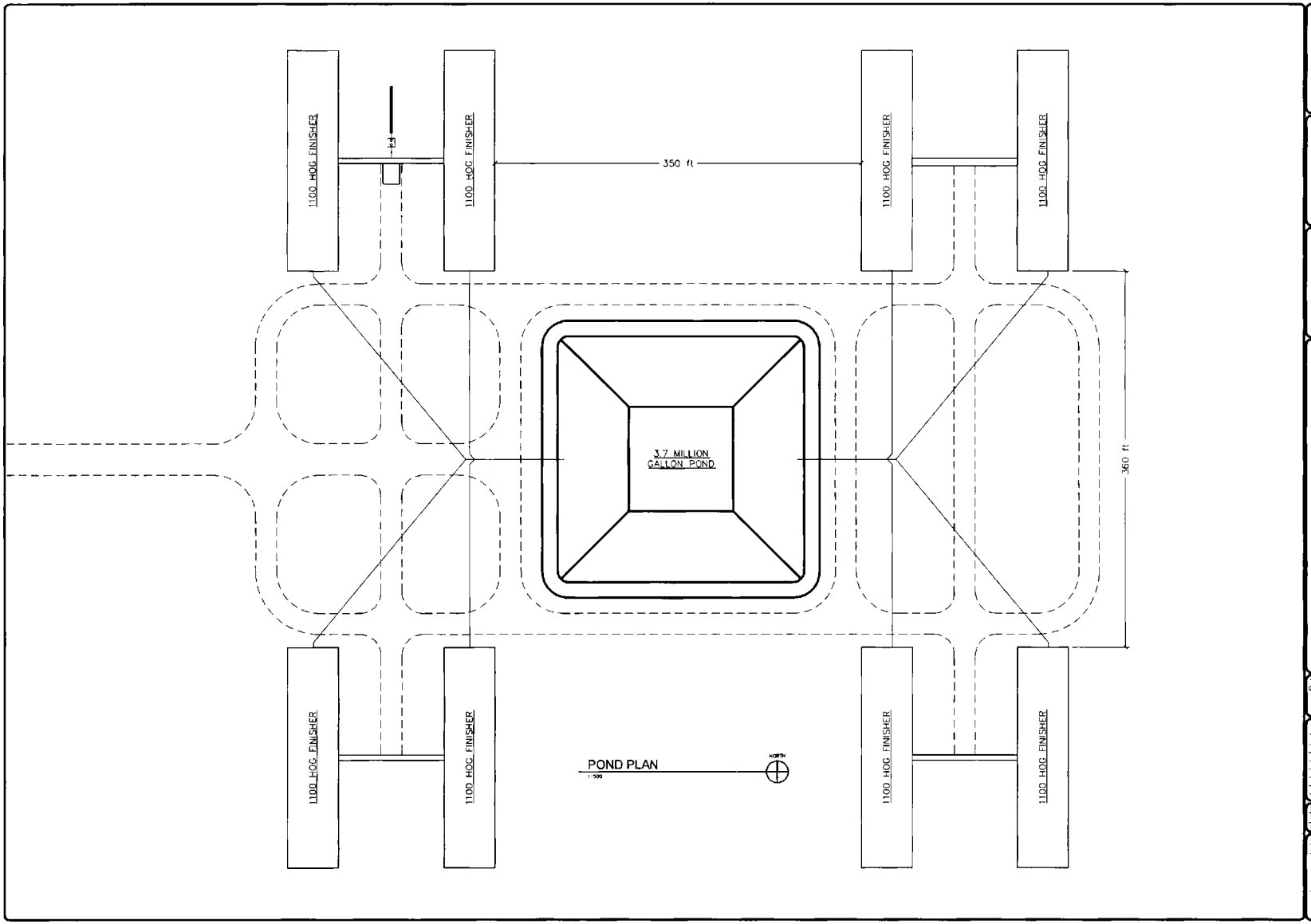
GEM
ENGINEERING, INC.
485 North Aviation Way
Cedar City, UT 84721
Phone (435) 867-6478
Fax (435) 867-4372
www.gemengineering.com

CHRISTENSEN FINISHER SITE

LOCATION
SEVIER COUNTY, UTAH

ISSUED REV NO.	DATE	DESCRIPTION
---	---	---

PROJ. MGR. –
DESIGNER RWC
DRAWN BY RWC
SCALE REFER TO PLAN
JOB NO.
DRAWING TITLE
COMPOSITE
LOCATION &
TOPOGRAPHIC MAP
SHEET NO.
ATTACH. A



GEM
ENGINEERING, INC.
485 North Aviation Way
Cedar City, UT 84721
Phone (435) 867-6478
Fax (435) 867-4372
www.gemengineeringinc.com

TITLE
CHRISTENSEN FINISHER SITE

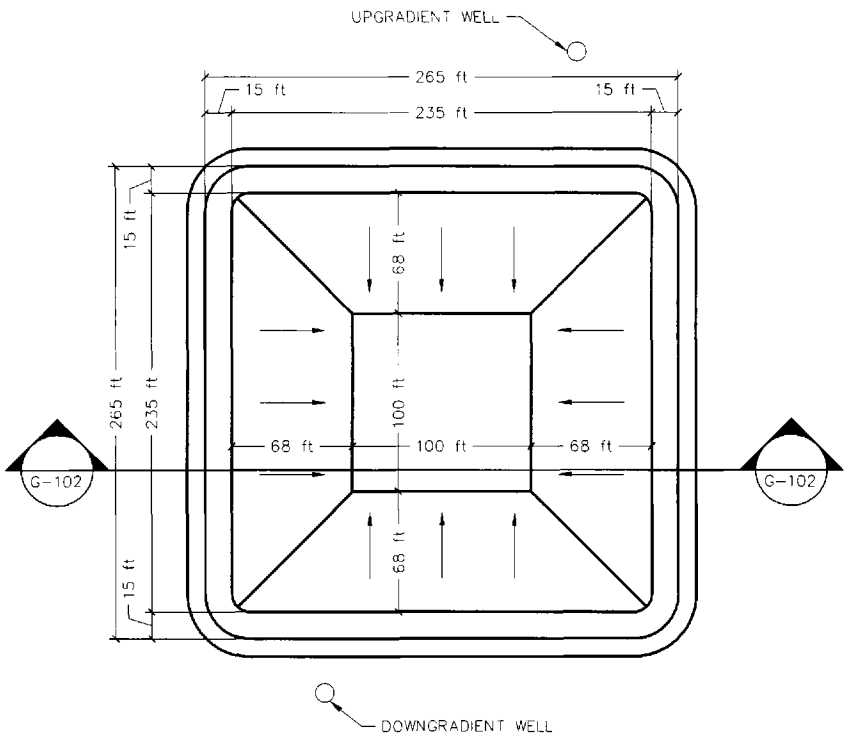
LOCATION
SEVIER COUNTY, UTAH

ISSUED REV NO.	DATE	DESCRIPTION
--	--	--

PROJ. MGR.	--
DESIGNER	RWC
DRAWN BY	RWC
SCALE	REFER TO PLAN
JOB NO.	

DRAWING TITLE
SITE PLAN

SHEET NO
G-001



POND PLAN

1:400

NORTH

GEM
ENGINEERING, INC.
485 North Aviation Way
Cedar City, UT 84721
Phone (435) 867-6478
Fax (435) 867-4372
www.gemengineering.com

TITLE
CHRISTENSEN FINISHER SITE

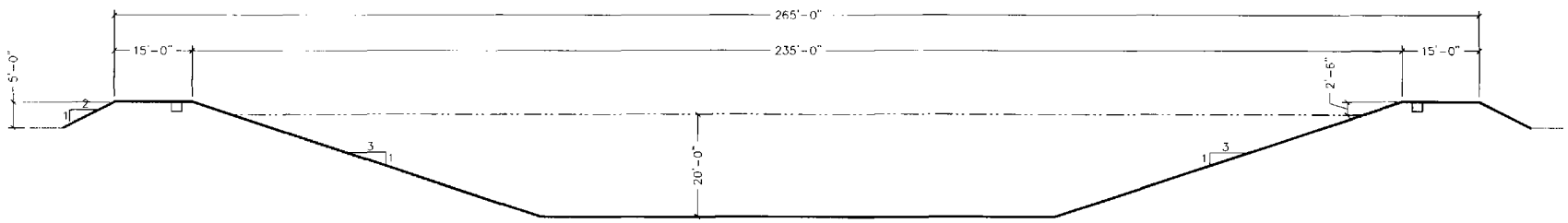
LOCATION
SEVIER COUNTY, UTAH

ISSUED REV. NO.	DATE:	DESCRIPTION
--	--	--

PROJ. MGR. --
DESIGNER RWC
DRAWN BY RWC
SCALE REFER TO PLAN
JOB NO.

DRAWING TITLE
POND PLAN

SHEET NO.
G-101



POND SECTION

NO SCALE

GEM
ENGINEERING, INC.
485 North Aviation Way
Cedar City, UT 84721
Phone (435) 867-6478
Fax (435) 867-4372
www.gemengineeringinc.com

TITLE
CHRISTENSEN FINISHER SITE

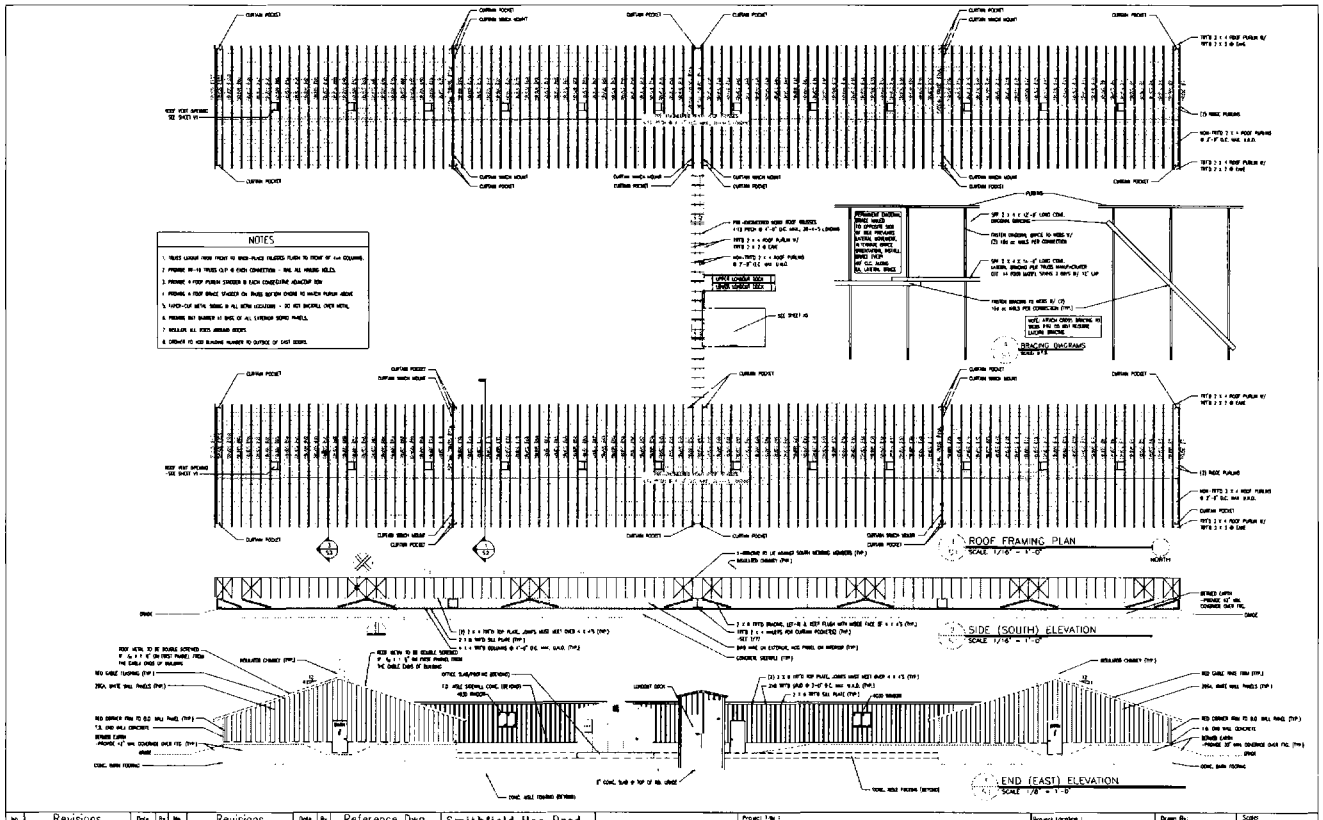
LOCATION
SEVIER COUNTY, UTAH

ISSUED REV NO.	DATE:	DESCRIPTION
--	--	--

PROJ. MGR. –
DESIGNER RWC
DRAWN BY RWC
SCALE REFER TO PLAN
JOB NO.

DRAWING TITLE
POND CROSS SECTION

SHEET NO
G-102



No.	Revisions	Date	By	No.	Revisions	Date	By	Reference Dwg.

Smithfield Hog Prod.
341 South Main
Milford, UT 84751
Phone (435) 387 2197

Project Title: 4400 HEAD H BARN

Sheet Title: ROOF FRAMING PLAN & ELEVATIONS

Sheet Number: S1

Project Location:

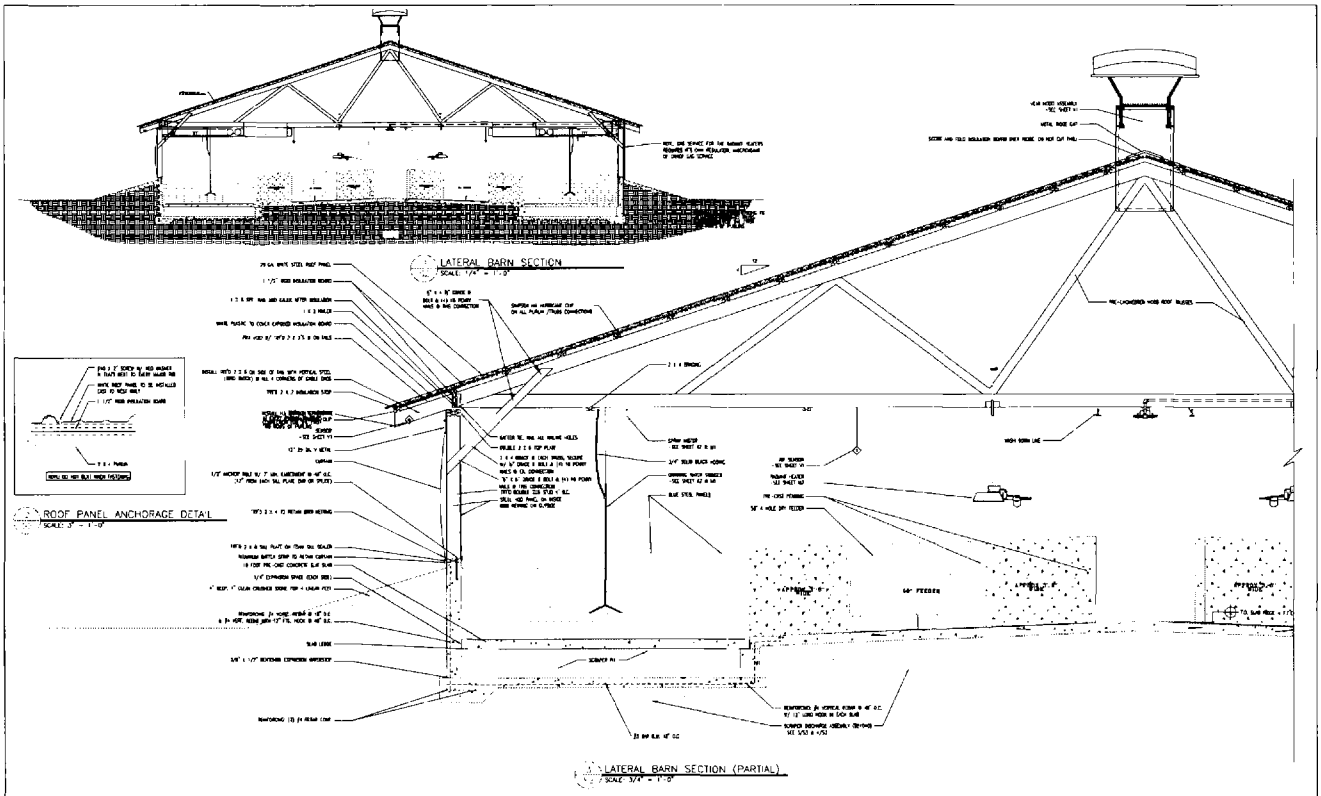
Drawn By: J. BLADDER

Checked By:

Date Drawn:

Scale:

Sheet #: of



No	Revisions	Date	By	No	Revisions	Date	By	Reference Dwg

Smithfield Hog Prod.
941 South Main
Milford, UT 84751
Phone (435) 387-2107

Project Title: 4400 HEAD H BARN

Sheet Title: LATERAL SECTIONS & DETAILS

Project Location

Sheet Scale: S2

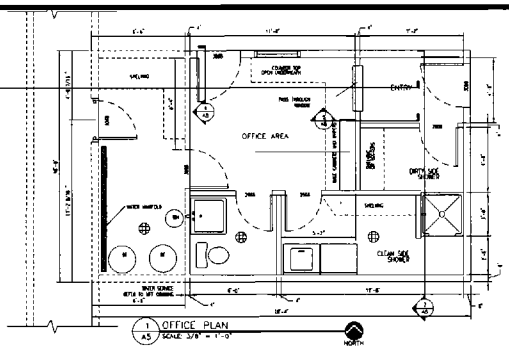
Drawn By: T. DE KOKKER

Checked By:

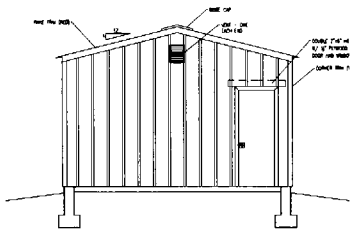
Date Drawn:

Scale:

Sheet # of



1 / A5 OFFICE PLAN
SCALE: 3/8" = 1'-0"



2 / A5 OFFICE ELEVATION
SCALE: 3/8" = 1'-0"

SPECIFICATIONS: CONCRETE CONTRACTOR

1. CONTRACTOR RESPONSIBLE TO SCHEDULE SEQUENCE OF CONCRETE W/ HOG PEN.
2. PROVIDE AND PLACE ALL REQUIRED REINFORCING AND ANCHOR BOLTS WITH VARIOUS TRADES.
3. PROVIDE AND BALLOW IN ALL REQUIRED OPEN LINES AND SLEEVES, UTILITY CONNECTIONS AS SHOWN ON DRAWINGS. VERIFY CHECK SHOW ELEVATIONS FOR PROPER SLOPE OF CONCRETE, & SLOP AS SHOWN. CONFIRM ALL REQUIRED PLUMBING LINES TO BE, T ALLOWED OF THE DRAWING LINES.
4. FINISH AND CURE CONCRETE PER MACHINE CONSTRUCTION REQUIRED.
5. FINISH AND CURE SPACES CLEAN SALE IN CONCRETE WITH SUBSTITUTE REQUIRED FINISH. PROVIDE REQUIRED SPACE AS SHOWN ON DRAWINGS.
6. STRIP FORMS AND CONSTRUCT CLEAN UP THE OF FORM AND REMOVE REJECTS TO SALE YARD.
7. CONTRACTOR TO FURNISH TO CONTRACT PROOF OF GENERAL LIABILITY AND WORKMANS COMPENSATION INSURANCE PRIOR TO COMMENCING WORK. 1 COPY OF CERTIFICATE OF INSURANCE TO BE FILED WITH THE INSPECTOR OWN.
8. CONTROLLED SLAPBOUT SPLIT OF FORM AND REPAIRS REJECTS TO YARD WORK. ALL WORK TO BE DONE IN A WORKMANS LIKE MANNER AND MEET THE APPROVAL OF BROWN COUNTY, AND MAINTAINED PLACES FREE OF DEBRIS, UNFINISHED, REPAIR ETC. ETC
9. CONTRACTOR RESPONSIBLE FOR WEATHER RELATED PROTECTION.

SPECIFICATIONS, PLUMBING CONTRACTOR

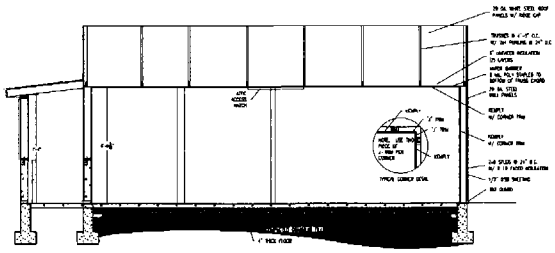
1. PROVIDE LABOR AS REQUIRED.
2. INSTALL ALL PLUMBING WORK, 14, OTHER INCLUDING: CAST-IRON WALL, BRACE METAL, WROUGHT, BUSHINGS, FITTINGS, WALL VALVES, PRESSURE TANK CONNECTION, HOSE BIBS FOR SPRINKLING, DRAIN BIBS, CONNECTIONS, SHOWER CONNECTIONS, AND OTHER ACCESSORIES AS SHOWN ON THE PLANS, BUILT WITH CODE, ETC. PARTS FOR CONNECTION TO THE SEWER SYSTEM, AND FOR A COMPLETE INSTALLATION.
3. HOUSE INSTALLATION OF WATER SYSTEM FOR COMPLETE INSTALLATION.
4. FLUSH AND CHECK SYSTEM FOR LEAKS.
5. CONTRACTOR TO FURNISH TO CONTRACT PROOF OF GENERAL LIABILITY AND WORKMANS COMPENSATION INSURANCE PRIOR TO COMMENCING WORK. 1 COPY OF CERTIFICATE OF INSURANCE TO BE FILED WITH THE INSPECTOR OWN.
6. CONTROLLED SLAPBOUT SPLIT OF FORM AND REPAIRS REJECTS TO YARD WORK. ALL WORK TO BE DONE IN A WORKMANS LIKE MANNER AND MEET THE APPROVAL OF BROWN COUNTY, AND MAINTAINED PLACES FREE OF DEBRIS, UNFINISHED, REPAIR ETC. ETC
7. CONTRACTOR RESPONSIBLE FOR WEATHER RELATED PROTECTION.

SPECIFICATIONS: ELECTRICAL CONTRACTOR

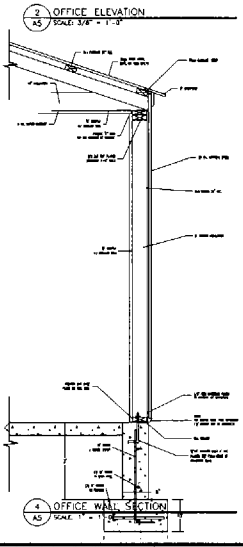
1. PROVIDE ALL MATERIALS AND LABOR AS DETAILED FOR A COMPLETE INSTALLATION.
2. PROVIDE STAY SERVICE DRAWING FOR CONSTRUCTION.
3. PROVIDE ALL ELECTRICAL WORK FOR CONSTRUCTION TO INCLUDE CONNECTIONS TO APPLIANCES AS REQUIRED, CLOSED SPACE OUTLET AND WELDING CONNECTIONS, AND ALL OTHER OTHER WORKS AS SHOWN ON THE CONTRACT DRAWINGS.
4. CONTRACTOR RESPONSIBLE TO WORK UP WIRING, TELEPHONE AND IN OFFICE.
5. CONTRACTOR TO FURNISH TO CONTRACT PROOF OF GENERAL LIABILITY AND WORKMANS COMPENSATION INSURANCE PRIOR TO COMMENCING WORK.
6. CONTROLLED SLAPBOUT SPLIT OF FORM AND REPAIRS REJECTS TO YARD WORK. ALL WORK TO BE DONE IN A WORKMANS LIKE MANNER AND MEET THE APPROVAL OF BROWN COUNTY, AND MAINTAINED PLACES FREE OF DEBRIS, UNFINISHED, REPAIR ETC. ETC
7. CONTRACTOR RESPONSIBLE FOR WEATHER RELATED PROTECTION.

SPECIFICATIONS, FRAMING CONTRACTOR

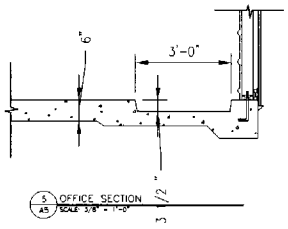
1. PROVIDE LABOR AND WALL ONLY WALLS, GRAVEYARD VENTILATION.
2. INSTALL ALL TRUSS, TRUSSES, BATTEN PLATES, SILLS, TOP PLATES, DOOR AND WINDOW BRACKETS WITH VARIOUS AS SHOWN, TRUSSES, PURLINS, ARTS AND BRACING.
3. PROVIDE PROPER SPACE AS SHOWN ON DRAWINGS.
4. PROVIDE ALL ROOF TRUSSES, PURLINS, BRACING AS SHOWN.
5. INSTALL ALL ROOF TRUSSES, BRACE TRUSSES, TRIM AND FLASHINGS AS REQUIRED.
6. INSTALL SCREWS AND BRACKETS, PLANK, FELT, AND LOOK, CHECK FOR SECURITY, STRAPPING AND CHAIN AS REQUIRED TO PREVENT SHIFTS.
7. INSTALL WINDOW SILL AND CLEARS ONLY AS SHOWN ON DRAWINGS AS TOLD AS REQUIRED.
8. CLEAN UP WORK AND REMOVE AS REQUIRED.
9. CONTRACTOR TO FURNISH TO CONTRACT PROOF OF GENERAL LIABILITY AND WORKMANS COMPENSATION INSURANCE PRIOR TO COMMENCING WORK.
10. CONTROLLED SLAPBOUT SPLIT OF FORM AND REPAIRS REJECTS TO YARD WORK. ALL WORK TO BE DONE IN A WORKMANS LIKE MANNER AND MEET THE APPROVAL OF BROWN COUNTY, AND MAINTAINED PLACES FREE OF DEBRIS, UNFINISHED, REPAIR ETC. ETC.
11. CONTRACTOR RESPONSIBLE FOR WEATHER RELATED PROTECTION.



3 / A5 OFFICE SECTION
SCALE: 3/8" = 1'-0"



4 / A5 OFFICE WALL SECTION
SCALE: 1" = 1'-0"



5 / A5 OFFICE SECTION
SCALE: 3/8" = 1'-0"

No	Revisions	Date	By	No	Revisions	Date	By	Reference Dwg.

Smithfield Hog Prod.
341 South Main
Milford, UT 84751
Phone: (435) 387-2027

Project Title	Project Location	Drawn By	Scale
4400 HEAD H BARN		T. GUETHEY	
Sheet Title: OFFICE PLAN, ELEVATIONS, AND DETAILS	Sheet Group: A4	Checked By	Sheet # 4 of
		Date Drawn	

MATERIAL LIST

[illegible]

ITEM	SYMBOL	DESCRIPTION	MANUFACT. MFR
1	CONDUIT	ALL CONDUIT SHALL BE RIGID PVC SCH.80 UNLESS OTHERWISE NOTED. ELECTRICAL CONTRACTOR SHALL ALLOW FOR EXPANSION AND CONTRACTION.	
2	G	PANEL BOARD SURFACE MOUNT, 120/240 VOLT, 1 PHASE, 3 WIRE, 5/8, GROUND BUS PLUG-ON BREAKERS. COPPER BUS. REFER TO SCHEDULE. SEE ONE-LINE DIAGRAM AND PANEL SCHEDULE.	SQUARE D CO
3	PANEL B, P2, P3, P4	PANEL BOARD SURFACE MOUNT 120/240 VOLT, 1 PHASE, 3 WIRE, 5/8, GROUND BUS PLUG-ON BREAKERS. COPPER BUS. REFER TO SCHEDULE. SEE ONE-LINE DIAGRAM AND PANEL SCHEDULE. A 10 SPACE PANEL.	SQUARE D CO
4	SC	SENSOR SCALLOP WINDOW, WATERPROOF CONTACT, SINGLE POLE, SINGLE THROW, SPECIFICATION GRADE. RED WIRE BACK SINGLE, 20 AMP, 120/277 VOLT, UL LISTED.	LEVITON ROSS PASS & SEYMOUR
5	SS	SENSOR DOUBLE SCALLOP WINDOW, WATERPROOF CONTACT, SINGLE POLE, SINGLE THROW. SPECIFICATION GRADE. RED WIRE BACK SINGLE, 20 AMP, 120/277 VOLT, UL LISTED. COMPLETE WITH 4 WATERPROOF SINGLE COVERS	LEVITON ROSS PASS & SEYMOUR COVER SHALL BE FABRITE PLUSTER OR EQUAL
6		RECEPTACLE DUPLEX, 125 VOLT, 20 AMP, 3 WIRE GROUNDING TYPE. FRONT OF POLYCARBONATE FACE, STRONGER BLADE, U.L.L.A. 2-208, U.L. LISTED. COMPLETE WITH WATERPROOF SINGLE COVER AND ADAPTED IN A 4"X 4" PVC BOX. COMPLETE WITH PVC SINGLE CAMB U.L.L.A. 39 IN USE COVER.	LEVITON ROSS PASS & SEYMOUR COVER SHALL BE FABRITE PLUSTER OR EQUAL
7		RECEPTACLE DUPLEX, 125 VOLT, 15 AMP, 3 WIRE GROUNDING TYPE. FRONT OF POLYCARBONATE FACE, STRONGER BLADE, U.L.L.A. 2-208, U.L. LISTED. COMPLETE WITH WATERPROOF SINGLE COVER AND ADAPTED IN A 4"X 4" PVC BOX. COMPLETE WITH PVC SINGLE CAMB U.L.L.A. 39 IN USE COVER.	LEVITON ROSS PASS & SEYMOUR COVER SHALL BE FABRITE PLUSTER OR EQUAL
8		RECEPTACLE DUPLEX, 250 VOLT, 20 AMP, SPECIFICATION GRADE, 2 POLE, 3 WIRE GROUNDING TYPE. BROWN FRONT OF POLYCARBONATE FACE, STRONGER BLADE, U.L.L.A. 2-208, U.L. LISTED. COMPLETE WITH WATERPROOF SINGLE COVER AND ADAPTED IN A 4"X 4" PVC BOX. COMPLETE WITH PVC U.L.L.A. 39 IN USE COVER.	HUBBELL ROSS PASS CALE LEVITON PASS & SEYMOUR COVER SHALL BE THYMC PLUSTER OR EQUAL
9		FIXED ELECTRICAL DISCONNECT SWITCH, 120/277 OPERATING, CONSIDERED RESISTANT TO CORROSIVE ATMOSPHERE AND WATERPROOF RATED FOR 1" OR 2" PVC WITH SCREW IN TYPE FUSE FUSE. SIZE FUSES PER MANUF. FULL LOAD AMPS.	FURNITE SQUARE D OR EQUAL
10	MP	PANELBOARD SURFACE MOUNT, 120/240 VOLT, 1 PHASE, 3 WIRE. 5/8" GROUND BUS 400 AMP BOLT-ON BREAKERS U.L.L.A. 50 CIRCUITS. SEE-ONE LINE DIAGRAM.	SQUARE D CO CUTLER HAMMER
11		RECEPTACLE DUPLEX, 125 VOLT, 20 AMP, 3 WIRE GROUNDING TYPE, FRONT OF POLYCARBONATE FACE, STRONGER BLADE, U.L.L.A. 2-208, U.L. LISTED. RATING IN SINGLE GANG BOX AND COVER.	LEVITON ROSS PASS & SEYMOUR BRYANT CALE
12		RECEPTACLE DUPLEX, 125 VOLT, 20 AMP, 3 WIRE GROUNDING TYPE, FRONT OF POLYCARBONATE FACE, STRONGER BLADE, U.L.L.A. 2-208, U.L. LISTED. RATING IN SINGLE GANG BOX AND COVER.	LEVITON ROSS PASS & SEYMOUR BRYANT CALE
13		RECEPTACLE DUPLEX, 250 VOLT, 20 AMP, 2 POLE, 3 WIRE GROUNDING TYPE. BROWN FRONT OF POLYCARBONATE FACE, STRONGER BLADE, U.L.L.A. 2-208, U.L. LISTED. COMPLETE WITH SINGLE GANG COVER.	HUBBELL ROSS BRYANT LEVITON PASS & SEYMOUR
14		THERMOSTAT SENSOR FOR SINGLE STAGE CONTROL	-
15		JUNCTION BOX 12" X 12" X 12"	- (OPTIONAL MANUFR)
16		SINGLE THROW TRANSFER SWITCH, FOR 400 AMP GENERATORS AND 400 AMP NONLOAD CONTACTS, 600 VOLT 3 POLE FOR EXCHANGE OF NORMAL, SAFE POWER DOUBLE THROW SWITCH FOR USE OUTDOORS (ONLY REQUIRED FOR SITES WITH EMERGENCY POWER)	ASCO TYCO OR EQUAL EMERGENCY POWER
17		FLOWMAN/REVERSE SENSOR FOR SCRAPER WASHER.	-
18		TIME CLOCK (5 AMPERE) FOR SCRAPER	-
19		TWO SOLENOID VALVES	-
20		DISCONNECT SWITCH, FUSED, 240 VOLT, 2 POLE, 400 AMP, 600 VOLT RATING, GROUND LUG. U.L.L.A. 39 MODEL 2-250 AMP 18-1 TYPE. U.L.L.A. 39 MODEL 2-250 AMP 50-1 TYPE.	SQUARE D BUSSMAN SIEMENS CUTLER HAMMER
21		LIQUID LEVEL SENSOR	

ELECTRICAL INSTALLATION KEY

1. "PLACEOF" INDICATES NEW, NUMBER/PLACE NUMBER.
2. "FOR/F" INDICATES ADDITIONAL LOT ITEM OR NEW SYMBOL.
3. "X" INDICATES NOT NOW USED TO DETERMINE ADDITIONAL INFORMATION OR MORE REQUIRED "SPECIFY" TO THE LOCAL R & SUPPLIER ON.
4. SHADED FIGURE INDICATES NORM LOAD WITH CONNECTION IN PARTICULAR CIRCUIT
5. ALL ELECTRICAL CONDUCTORS SHALL BE COPPER UNLESS OTHERWISE NOTED
6. [illegible] INDICATES NUMBER OF WIRES IN CONDUIT (Ground, Neutral Phase)
7. SUBSCRIPT KEY:
   a. NUMBERED NOTES
   b. NUMBERED "KS" NOTE ON BOTTOM CORE OF "KEY" PAGES
   c. DESCRIPTIVE ABBREVIATIONS WORDS (OPTIONAL)
   d. REFER TO ARCHITECTURAL LOT AND FOR FINAL DESCRIPTIONS AND NAMES/LOCATIONS BY ALL REMARKS
8. ABBREVIATED KEY

EC	ELECTRICAL CONTRACTOR
GC	GENERAL CONTRACTOR
MC	MECHANICAL CONTRACTOR
NF	NEW FRESH FIBER
E	EXISTING
NP	NEW PLUMBER
NE	NEW ELECTRIC
PV	PROCESSOR
FF	FRESHWATER
FC	FRESHWATER VENDOR FROM FINISHED FLOOR TO FOREBLUE
EC	ELECTRICAL CONTRACTOR
MC	MECHANICAL
WC	WEATHER

NEW WORK BY THIS CONTRACTOR (DARK SOLID LINE)

NEW WORK UNDERFLOOR OR UNDERGROUND BY THIS CONTRACTOR (DARK LINE DASHED LINE)

NEW WORK BY OWNER (LIGHT SOLID LINE)

EXISTING REMOVE UNDERGROUND

ELECTRICAL INSTALLATION NOTES

1. CONTRACTOR SHALL CONSIDERING INSTALLATION LOCATION OF CONDUIT WIRING AND ELECTRICAL EQUIPMENT LOCATION WITH OTHER TRADES.
2. ALL WIRING NOTED BELOW (Wing) BE BARE COPPER. ALL FEEDER WIRING (NO WIRING) SERVICE SHALL BE ALUMINUM UNDERGROUND SERVICE CONDUCT (U.S.L.) WITH ALTE INSULATION.
3. THE ELECTRICAL CONTRACTOR SHALL FURNISH AND INSTALL ALL TEMPORARILY COUPLED, WIRING AND REMOVE/PULL.
4. ALL SERVICE MADE THE FINISH BUILDINGS SHALL BE IN PVC SCH.80 ALL 40 CONDUIT UNLESS NOTED OTHERWISE.
5. ALL WIRING SHALL BE LABELED WITH WIRE MARKERS AT ALL SERVICE LOCATIONS ALL JUNCTION BOXES, PANELS, SWITCHGEAR, SWITCHES, WIRE CONNECTORS. LABELS NUMBERED SHALL BE ASSIGNED FOR EACH CIRCUIT AND SPLICES FOR ALL BUILDINGS
6. ALL WIRE SHALL CONFORM TO THE LATEST VERSION OF THE NATIONAL ELECTRICAL CODE. ALL INSTRUCTIONS ARE (LIGHT AS A GUIDE AND IS NOT INTENT TO REPLACE THE NATIONAL ELECTRICAL CODE.
7. ELECTRICAL EQUIPMENT AND INSTALLATION OF ALL ELECTRICAL WIRING, PIPING, THE TRENCH, PANELBOARD, SWITCHGEAR, SCHEDULE, PERIMETER, BOXES, CONTROLS, ECH ASSEMBLY, ETC. SHALL BE INSTALLED TO THAT MANUFACTURER INSTALLATION INSTRUCTIONS AND ALL OTHER APPLICATIONS. ADVANCE ROOF CONNECTORS ON COMMUNICATIONS BOXES SHALL BE TEMPORARY BY PROVIDER SCHEDULE PLACEMENTS.
8. THE CAPITAL INSTALLATION SHALL BE GUARANTEED BY THE CONTRACTOR
9. ALL ELECTRICAL EQUIPMENT SHALL BE SURFACE MOUNTED
10. A CAPITAL INSTALLATION GUARANTEE CONSULTATION SHALL BE INSTALLED IN ALL CIRCUITS AS ALL DETAILED WORK BUILDINGS.
11. ALL WALL MOUNTED SWITCHES AND RECEPTACLES SHALL BE INSTALLED AS NOTED.
12. ELECTRICAL CONTRACTOR SHALL BE RESPONSIBLE FOR ALL OPENINGS REQUIRED TO WALLS OPENINGS SHALL BE SEALED.
13. ELECTRICAL CONTRACTOR SHALL PROVIDE A PERMANENT CIRCUIT DIRECTORY FOR EACH PANEL.
14. THE CONTRACTOR SHALL SELECT AND PURCHASE THE SAME WIRE BRAND MATERIAL FOR ALL BUILDINGS OF ALL TYPES.
15. CIRCUIT NUMBERS ARE SHOWN FOR CIRCUIT DIAGRAMS. CIRCUITING SHALL FOLLOW WITH NUMBERING ON THE PANEL PROVIDED

SPECIFICATIONS - ELECTRICAL

1. PROVIDE ALL MATERIALS AND LABOR AS REQUIRED FOR A COMPLETE INSTALLATION.
2. PROVIDE UNDERGROUND SERVICE FROM NOTED TO SITE.
3. PROVIDE UNDERGROUND SERVICE FROM SITE TO BUILDING W/ 200 AMP PANEL.
4. PROVIDE ALL LEADS INCLUDING EXTERIOR LIGHTING, WATER HEATER, CONDUIT, ACTUATOR WIRING, CURTAIN DRIPPER WIRING, REACTY CONNECTION, OUTLETS, CONTROLLED POWER, INSTALLATION OF HOW DEFINED WIRING (TEMPERATURE WIRE, 1" 4" PLACED IN ZONE, PERMITS IN PARTICIPATE CONDUIT BOXES 3 ALARM, PLACEMENT OF CONTROLLED SENSORS, AUTOMATIC CURTAIN PERIP OUTLET AND ALL STATED ITEMS SHOWN OR DEMANDED FOR A COMPLETE INSTALLATION.
5. DIGITAL ALL PERIMETER AND COMPANY PRIOR TO LEAVING SITE.
6. LABEL-CALL CONTRACTOR IS RESPONSIBLE TO CONTACT THE PUBLIC UTILITIES TO DETERMINE THE LOCATION OF ANY PUBLIC UTILITY LINES INCLUDING WATER, GAS, ELECTRICAL LINES, SEWER LINES, TELEPHONE LINES, AND SIGNAL LINES PRIOR TO PROCEEDING.
7. CONTRACTOR IS RESPONSIBLE FOR THE COST OF REPAIR TO ANY UTILITY LINES INCLUDING TELEPHONE, ELECTRICAL LINES, WATER LINES, GAS LINES, TELEPHONE LINES, AND SIGNAL LINES IF DAMAGED WHEN PROCEEDING.
8. CONTRACTOR TO PROVIDE TO CUSTOMER PROOF OF GENERAL LIABILITY AND WORKMAN'S COMPENSATION INSURANCE PRIOR TO COMMENCING WORK.
9. COMPLETELY CLEAN UP THE JOB AND REPLACE DEBRIS TO YOUR WORK. ALL WORK TO BE DONE IN A WORKMAN LIKE MANNER AND NOT HAVE FREE OF TRASH, DEBRIS AND HAZARDOUS FLUIDS SUCH AS DIESEL, KEROSENE, GASOLINE, ETC.
10. CONTRACTOR RESPONSIBLE FOR REGARDS RELATED PROTECTION

LIGHTING FIXTURE SCHEDULE

MOUNTING (MTG) KEY:	LAMP TYPE KEY:	MOUNTING (MTG) KEY:	LENS/LOUVER (L/L) KEY:
RE - RECESSED SM - SUSPENDED C - CEILING SURFACE W - WALL RS - RECESSED SC - CONE PL - POLE O - OTHER (SEE REMARKS)	F - FLUORESCENT IN - INCANDESCENT MV - MERCURY VAPOR MH - METAL HALIDE HP - HIGH PRESSURE SODIUM LP - LOW PRESSURE SODIUM SV - SODIUM VAPOR LV - LOW VOLTAGE O - OTHER (SEE REMARKS)	RE - RECESSED B - BLACK WALLCOVERS C - CLEAR ALUMINT E - EXTRUDED G - GOLD FOIL F - FROSTED	L/L - LOUVER E - TEXTURED GLASS W - WALL WASHED R - RIBBED O - OTHER SEE REMARKS

CATALOG NUMBERS SHALL NOT BE CONSIDERED COMPLETE AND ACCURATE. SHALL NOT BE ORDERED BY MANUFACTURER AND CATALOG NUMBER ONLY. THEY ARE THE COMPLETE DESCRIPTION, NOTES AND REMARKS AND THE SPECIFICATION BY CONTRACTOR WITH CLOSER ATTENTION TO CONFORM WITH AND ACCESSORIES TO BE PROVIDED.

ALL LAMPS FOR THIS PROJECT SHALL BE FURNISHED AND INSTALLED BY THE ELECTRICAL CONTRACTOR UNLESS OTHERWISE NOTED

REFER TO SPECIFICATION SECTION 16-2-3 FOR LAMP AND BALLAST REQUIREMENTS, SHOP DRAWING SUBMITTAL REQUIREMENTS, AND ADDITIONAL INFORMATION

FIXT. NO.	DESCRIPTION	FIXT. TYPE	MTG	TYPE	CONNECTED LAMP TYPE	VOLT	U.L.	MANUFACTURER	REMARKS
F3	CLEAR GLASS FRONT LAMP TYPE	2' ROUND	CLING, RAISE UP	W	1-100 W-LAMP	120		CARLON [illegible] [illegible] OR EQUAL	COMPLETE WITH CLEAR GLASS, MOUNTING BOX
F3	OUTDOOR	-	CLING, RAISE UP	W TYPE FLUOR	2-FLAT 39	120		CARLON [illegible] OR EQUAL	COMPLETE WITH LAMPS

No.	Revisions	Date	By	No	Revisions	Date	By	Reference Dwg.

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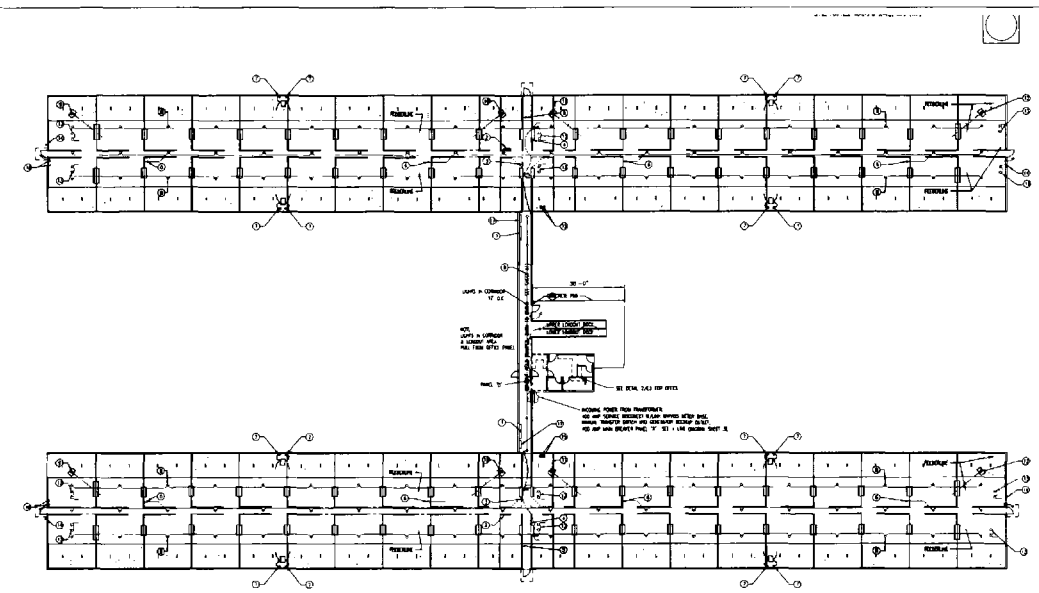
[illegible]

Project File	Project Location	Drawn By	Scale
4400 HEAD H BARN		T. BLACKNER	
Sheet Title	Sheet Group	Checked By	Sheet
SCHEDULES & NOTES	2651 E1	Date Drawn	of



1 / E2 ELECTRICAL FLOOR PLAN
SCALE: 1/16" = 1'-0"

PLAN DETAIL NOTES

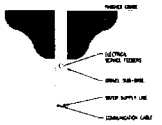
1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]
10. [illegible]
11. [illegible]
12. [illegible]
13. [illegible]
14. [illegible]
15. [illegible]

ELECTRICAL SHEET

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]
10. [illegible]
11. [illegible]
12. [illegible]

SITE ELECTRICAL NOTES

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]



2 / E2 UTILITY TRENCH DRAIN (TYPICAL)
SCALE: 1/2" = 1'-0"

No.	Revisions	Date	By	No.	Revisions	Date	By	Reference Dwg.

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THIS DRAWING IS THE REPRESENTED CIRCUIT TRUE FORM. ANY REPRODUCTION IN WHOLE OR IN PART WITHOUT WRITTEN CONSENT OF SMITH FOOD CORP. IS PROHIBITED.

[illegible]

Project Title: 4400 HEAD H BARN

Sheet Title: ELECTRICAL FLOOR PLAN

Project Location:

Sheet Number: E2

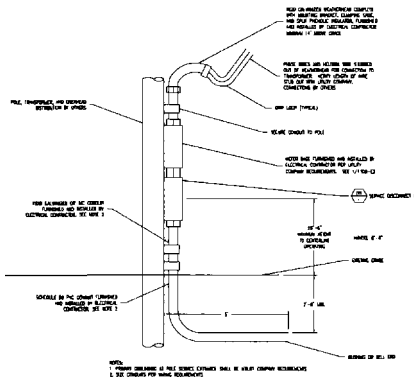
Drawn By: T. BLACKNER

Checked By:

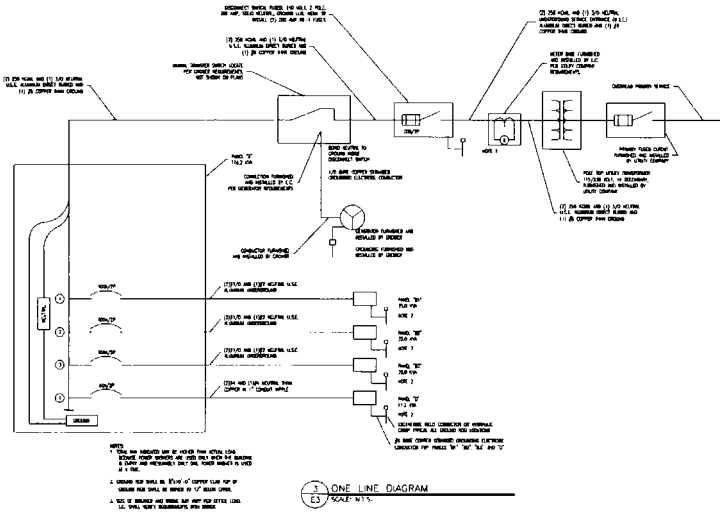
Date Drawn:

Scale:

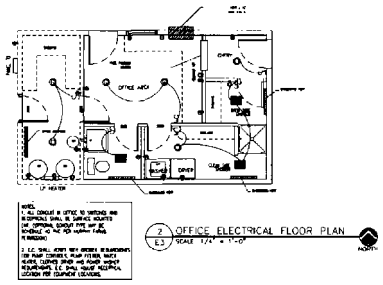
Sheet: of



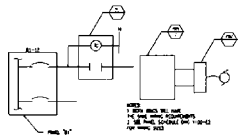
1 E3 TYPICAL POLE TOP WEATHER HEAD
SCALE: N.T.S.



3 E3 ONE LINE DIAGRAM
SCALE: N.T.S.



2 E3 OFFICE ELECTRICAL FLOOR PLAN
SCALE: 1/4" = 1'-0"



4 E3 SCRAPER MOTOR WIRING DIAGRAM
SCALE: N.T.S.

No.	Revisions	Date	By	No.	Revisions	Date	By	Reference Dwg.

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Project Title: 4400 HEAD H BARN

Sheet Title: ELECTRICAL POWER SCHEMATICS

Project Location:

Sheet Group: 2651 E3

Drawn By: T. BLADDER

Checked By:

Date Drawn:

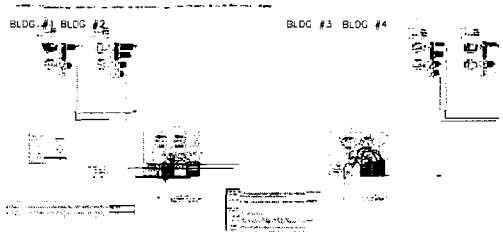
Scale:

Sheet #: of

Note: Cards in box will likely need to be moved to match this layout

Slot #1	Slot #2	Slot #3	Slot #4	Slot #5	Slot #6

1 / E4 EXPANSION BOX SCH. (TYP. EACH BARN)
SCALE: NTS



3 / E4 RS 42 CABLE WIRE DIAGRAM
SCALE: NTS

PANEL "B1" TYP. — 120/208 VAC 3PH 4W. — 225A. M.L. — SURFACE MOUN'

CKT NO.	LOAD V.A.	LOAD TYPE	LOAD DESCRIPTION	WIRE SIZE	P	AMP SIZE	PH	AMP SIZE	P	SIZE	LOAD DESCRIPTION	LOAD TYPE	LOAD V.A.	CKT NO.
1	450	LTS	FEED MOTORS	12	1	20	A	20	1	12	LIGHTS ROOM #3	LTS	450	2
3	450	LTS	NORTH LINE	12	1	20	B	20	1	12	LIGHTS ROOM #5	LTS	450	4
5	500		FEED MOTORS	12	1	15	C	-	-	-	SPARE			6
7	850	MTR	SOUTH LINE	12	2	15	A	15	2	12	2-7½" FANS	MTR	850	8
9	850		FEED MOTORS	-	-	-	B	-	-	-	ROOM #7		850	10
11	850	MTR	INCOMING	12	2	15	C	15	2	12	2-7½" FANS	MTR	180	12
13	850		SW & SW CURTAIN MACHINE	-	-	-	A	-	-	-	ROOM #2		180	14
15	700	MTR	2-7½" FANS	12	2	15	B	15	2	12	2-7½" FANS	MTR	700	16
17	700		ROOM #1	-	-	-	C	-	-	-	ROOM #1 & #2		700	18
19	1000	MTR	HEATER ROOM #4	12	1	20	A	20	1	12	HEATER ROOM #2	MTR	1000	20
21	1000	MTR	PRE-HEAT HEATERS RHAMS	12	1	15	B	20	1	12	HALLWAY CONV. RECEP.	RECP	1000	22
23	1000	MTR	PRE-HEAT HEATERS #2	12	1	15	C	20	1	12	PRE-HEAT LIGHTS	LTS	1000	24
25			SPARE		1	20	A	20	1	12	SPARE			26
27	1100	LTS	HEAT LAMPS RH1-R1	12	1	20	B	20	1	12	HEAT LAMPS RH2-R1	LTS	1100	28
29	1100	LTS	HEAT LAMPS RH1-R2	12	1	20	C	20	1	12	HEAT LAMPS RH2-R2	LTS	1100	30
31	1100	LTS	HEAT LAMPS RH1-R3	12	1	20	A	20	1	12	HEAT LAMPS RH2-R3	LTS	1100	32
33	1100	LTS	HEAT LAMPS RH1-R4	12	1	20	B	20	1	12	HEAT LAMPS RH2-R4	LTS	1100	34
35	1100	LTS	HEAT LAMPS RH1-R5	12	1	20	C	20	1	12	HEAT LAMPS RH2-R5	LTS	1100	36
37	1100	LTS	HEAT LAMPS RH1-R6	12	1	20	A	20	1	12	HEAT LAMPS RH2-R6	LTS	1100	38
39			SPARE		1	20	B	20	1		SPARE			40
41			SPARE		1	20	C	20	1		SPARE			42

2 / E4 ELEC. BREAKER PANEL (TYP.)
SCALE: NTS

No.	Revisions	Date	By	No.	Revisions	Date	By	Reference Dwg

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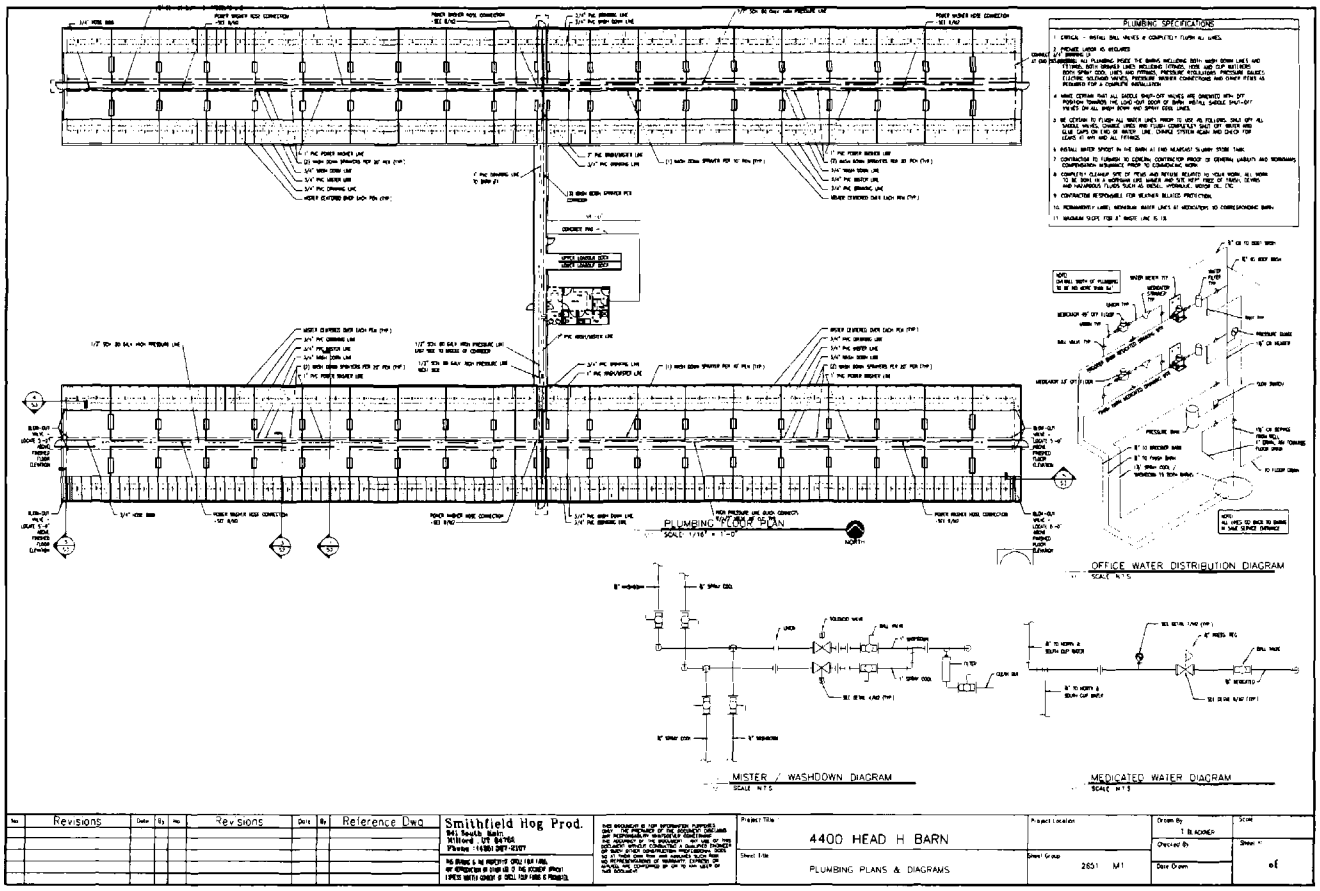
Project Title: 4400 HEAD H BARN	Project Location	Drawn By: T. BLADNER	Scale
Sheet Title: PANEL SCH & RELAY ASSIGN	Sheet Group: 2631 E4	Checked By	Sheet # of
		Date Drawn	



No.	Revisions	Date	By	No.	Revisions	Date	By	Reference Dwg.

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Phone: (435) 387-2107

Project Title: 4400 HEAD H BARN

Sheet Title: PLUMBING PLANS & DIAGRAMS

Project Location:

Sheet Group: 2851 M1

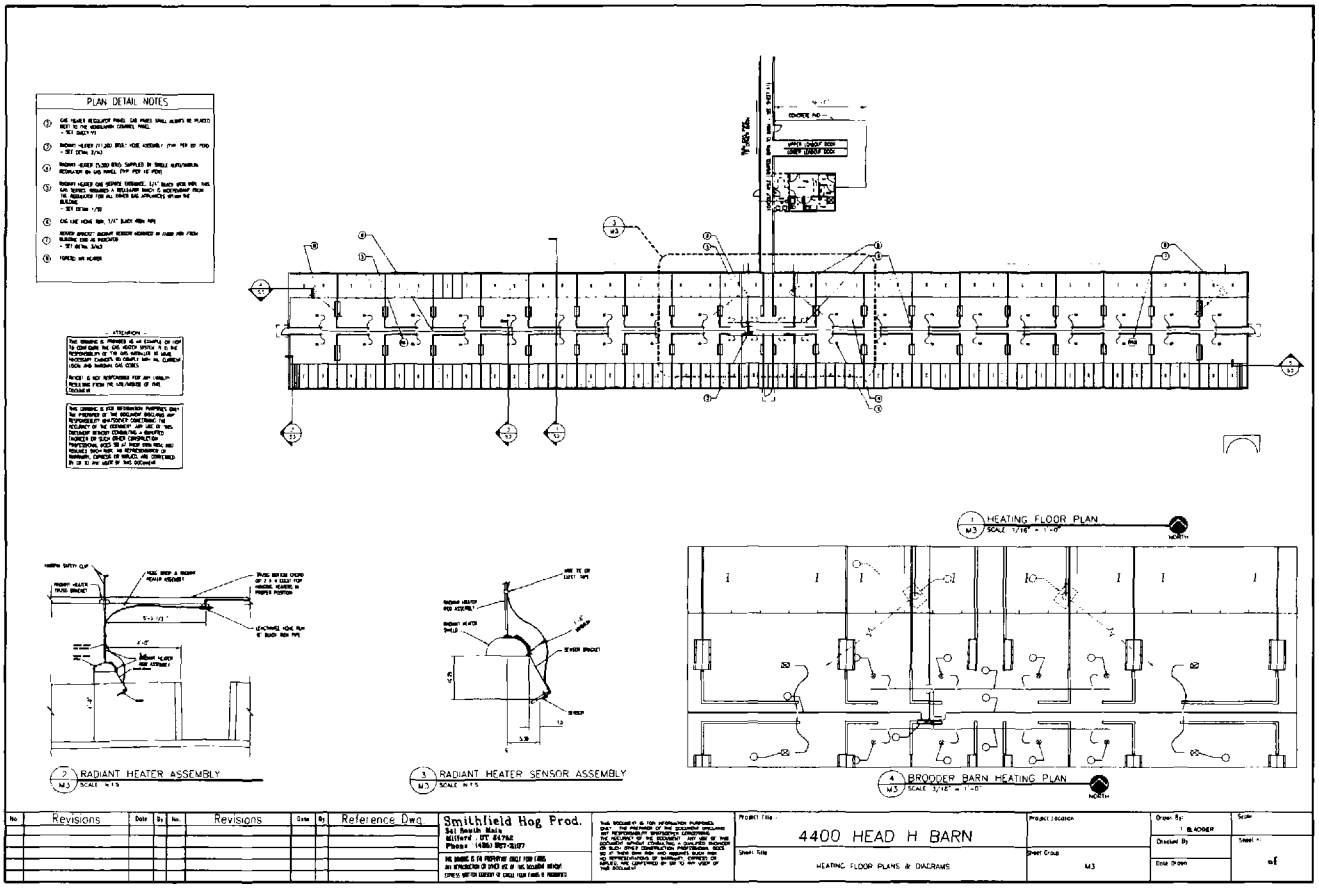
Drawn By: T. BLACKNER

Checked By:

Date Drawn:

Scale:

Sheet #: of


PLAN DETAIL NOTES
1 HEATING FLOOR PLAN
M3 SCALE 1/16" = 1'-0"
NORTH
4 BROODER BARN HEATING PLAN
M3 SCALE 3/16" = 1'-0"
NORTH
7 RADIANT HEATER ASSEMBLY
M3 SCALE N.T.S.
3 RADIANT HEATER SENSOR ASSEMBLY
M3 SCALE N.T.S.
Revisions
Reference Dwg.
Smithfield Hog Prod.
Sal Smith Main
Milford, UT 84751
Phone (435) 387-2107
4400 HEAD H BARN
HEATING FLOOR PLANS & DIAGRAMS
M3

Attachment D – Specifications and QA / QC for HDPE Liners

Specifications and QA / QC for HDPE Liners

1.0 SCOPE

1.1 These specifications describe High Density Polyethylene (HDPE) Lining Membranes. The supply and installation of these materials shall be in strict accordance with the Engineer's specifications and engineering drawings and be subject to the terms and conditions of the contract. The subgrade and the HDPE material will meet the specifications contained herein and in the GRI Test Method GM13.

2.0 MATERIAL

2.1 Physical Properties:

A. The HDPE liner material used in this project shall be a minimum of 60 mil in thickness and have the properties as called out in Table 1(a) of GRI Test Method GM13 (Attachment G).

B. Raw material shall be first quality polyethylene resin containing no more than 2% clean recycled polymer by weight.

C. Melt Index (ASTM D1238 Condition 190/2.16): <= 1.0 g / 10 min.

D. Dimensional stability in each direction at +/- 2% max (ASTM D 1204 – 100°C 1 hr).

E. Environmental stress crack resistance of 1500 hrs min (ASTM D 1693 Condition B).

F. The new membrane liner shall comprise HDPE material manufactured of new, first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures.

G. The lining material shall be manufactured a minimum of 22.5 feet seamless widths. Labels on the roll shall identify the thickness, length and manufacturer's roll number. There shall be no factory seams.

H. The liner material shall be so produced as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defect shall be repaired using the extrusion fusion welding technique in accordance with the manufacturer's recommendations.

I. The contractor shall, at the time of bidding, submit a certification from the manufacturer of the sheeting, stating that the sheeting meets physical property requirements for the intended application. FML rolls will not be installed, if any tested property is below the National Sanitation Foundation (NSF 54) minimum standard.

2.2 Handling:

A. Delivery: Transportation of the geomembrane shall be performed by the geomembrane manufacturer through an independent trucking firm or other party as agreed by the owner.

B. Offloading: Geomembrane, when off-loaded, shall be placed on a smooth well drained surface, free of rocks or any other protrusions which may damage the material. No special covering is necessary for geomembrane The following should be verified prior to off-loading the geomembrane:

1. Handling equipment used on the site is adequate and does not pose any risk of damage to the geomembrane.

2. Personnel informed of proper handling techniques and will do so with care.

C. Any welding rod delivered to the site prior to the geomembrane installation contractor's arrival should be kept covered and dry or placed in a storage facility.

D. Upon arrival at the site the geomembrane installation contractor shall conduct a surface observation of all rolls for defects and for damage. This inspection shall be conducted without unrolling rolls unless defects are found or suspected. The geomembrane installation contractor shall indicate any damage to the Project Manager / Owner.

E. Storage: The Project Manager / Owner shall provide storage space in a location(s) such that on-site transportation and handling are minimized. Storage space should be protected from theft, vandalism, passage of vehicles, and be adjacent to the area to be lined.

3.0 MANUFACTURER

3.1 Experience: The manufacturer of the lining material specified in the previous section shall have previously demonstrated the ability to produce this membrane by having successfully manufactured a minimum of ten million square feet of similar liner material for hydraulic lining installations. The liner material provided by the manufacturer must be listed by the NSF (National Sanitation Foundation) Standard 54.

3.2 Factory Quality Assurance and Control

A. Quality Assurance testing shall be carried out by the geomembrane manufacturer to demonstrate that the product meets this specification.

B. Raw Material: All compound ingredients of the HDPE materials shall be randomly sampled on delivery to the HDPE manufacturing plant to ensure compliance with specifications. Tests to be carried out shall include Density ASTM D1505 and Melt Index ASTM D1238, Condition E.

C. Manufactured Roll Goods: Samples of the production run shall be taken and tested according to ASTM D638 to ensure that tensile strength at yield and break, elongation at yield and break meet the minimum specifications. A quality control certificate shall be issued with the material.

D. All welding material shall be of a type supplied by the manufacturer.

E. All FML material shall be certified as "holiday free" by electrical potentiometric means (spark tested) or other equivalent approved means, during manufacture.

3.3 **Submittals**: The geomembrane manufacturer shall submit the following information to the Project Manager / Owner:

A. The origin (resin supplier's name, resin production plant), identification (brand name, number) and production date of resin.

B. A copy of the quality control certificates issued by the resin supplier noting results of density and melt index.

C. Reports on the tests conducted by the geomembrane manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the considered facility (these tests should include specific gravity [ASTM D792 Method A or ASTM 1505 and melt index ASTM D1238 Condition 1902.16]).

D. Reports on these tests conducted by the geomembrane manufacturer to verify the quality of the sheet.

E. A properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the specifications or equivalent.

F. After receipt of material, the geomembrane manufacturer shall provide the Project Manager / Owner with one quality control certificate for every roll of FML provided. The quality control certificate shall be signed by a responsible party. The quality control certificate shall include: roll numbers, identification and results of quality control tests. As a minimum, the quality control certificates shall include the results of the geomembrane properties tested by the method and at the frequency shown in the table below.

Property	Test Method	Frequency
Thickness	ASTM D 751	Every Roll
Density	ASTM D 792/1505	Every 5th Roll
Tensile Yield Strength	ASTM D 638	Every Roll
Yield Elongation	ASTM D 638	Every Roll
Tensile Break Strength	ASTM D 638	Every Roll
Break Elongation	ASTM D 638	Every Roll
Dimensional Stability	ASTM 1204	Every Roll
Tear Resistance	ASTM D 1004	Every Roll
Puncture Resistance	FRMS 101C-2065	Every Roll
Environmental Stress Crack Resistance	ASTM D 1693B	Every Roll
Carbon Black Content	ASTM D-1603	Every 5th Roll
Carbon Black Dispersion	ASTM D-3015	Every Resin Lot

4.0 INSTALLATION

4.1 Area Subgrade Preparation: The earthwork contractor shall be responsible for preparing the subgrade according to the basin's design and in accordance with the following specifications. If there is a discrepancy between the project design drawings and the following specifications the more stringent requirements shall apply.

A. The earthwork shall be smooth and free of all rocks, stones, sticks roots, sharp objects, or debris of any kind. No stones or other hard objects that will not pass through a 3/8" screen shall be present in the top 1" of the surfaces to be covered. No vegetation, brush roots or other foreign material shall be present on the surfaces to be lined.

B. The surface should be compacted so as to provide a firm, unyielding foundation for the membrane with no sudden, sharp or abrupt changes or break in grade. No ruts, irregularities or soft areas will be present on the surfaces to be lined. The subgrade shall be thoroughly compacted.

C. No standing water or excessive moisture shall be allowed.

D. An anchor trench shall be constructed in a square in accordance with detail DF3 / C.DF3 to secure the FML along the berm of the containment structure to be covered. See attached drawings at end of this specification for anchor and cover details.

E. The installation contractor shall certify in writing that the surface on which the membrane is to be installed is acceptable before commencing work. The FML will be assembled, seamed, tested and installed by the methods specified by a manufacturer recognized by the National Sanitation Foundation, Standard 54.

F. The subgrade shall be constructed so as to meet the following:

1. The subgrade material will come from either on-site or from approved stockpiles.

2. The earthwork for the anaerobic digesters and the equalization basins will be constructed so the subgrade will be free of any foreign material such as stones greater than 3/8 inch in diameter, vegetation, brush, roots or similar material which could damage the FML.

3. The subgrade material will be classified as CH, CL, CL-ML, ML, SM, SC, SW or SP by the USCS Classification System.

4. A moisture/density curve will be developed for the subgrade material.

5. The minimum compacted thickness of the subgrade layer shall be 8".

6. The subgrade will be compacted and graded to meet the installation contractor's specifications so as to avoid any ruts, irregularities and soft areas. The subgrade will be thoroughly compacted to provide support for the FML.

7. The subgrade will be compacted to a minimum of 90% dry density. For proper compaction, moisture will be added to the soil in quantities comparable to the OMC.

8. Installed density shall be confirmed by field test methods at a frequency of one test per 200' x 200' grid square.

9. A written statement by an independent professional engineer regarding the subgrade's structural integrity, along with supporting data will be submitted with the liner certification packet.

4.2 Dike Construction: The earthwork contractor shall be responsible for constructing dikes according to the following specifications:

A. The dike will be constructed of relatively impermeable material.

B. Each lift shall not exceed 6 inches in depth.

C. A geotechnical inspector will conduct compaction testing for each two vertical foot intervals at a frequency of 1 per every 400 linear feet.

D. A written statement by an independent professional engineer regarding the dike's structural integrity, along with supporting data will be submitted with the liner certification packet.

4.3 Anchor Trench:

A. The attached schematic detail DF3 / C.DF3 at the end of this specification indicates the anchor trench installation. Deviations from this design must be approved by the design engineer prior to use.

B. Compaction of the anchor trench backfilling will be done promptly after installation of the FML.

C. Compaction of the trench backfill shall include moisture added to the top 6 inches, with compaction done by a vibratory roller or tamper to firm unyielding surface.

D. Final grading will be implemented to produce a smooth uniform finish that slopes away from the digester and basins.

E. A client approved quality control technician shall inspect the anchor trench upon completion. Any portion of the anchor trench inadequately constructed will be re-dug and repaired in accordance with the specifications above.

4.4 Geomembrane Placement:

A. The installation of the HDPE must be done by the manufacturer, or a manufacturer's authorized distributor, using the manufacturer's extrusion or hot wedge welding equipment and installation methods. All supervisors overseeing the liner installation must

have five million square feet of supervisory liner experience. All field technicians must have one million square feet of seaming experience.

B. Field Panel identification: A field panel is the unit area of polyethylene which is to be seamed in the field, i.e., a field panel may be a complete roll or partial roll cut in the field. Smaller units used in the lining systems such as repairs, tabs, extensions, etc. need not be documented in the same manner as a field panel.

1. The installer will be responsible for marking each panel with the identification number and the appropriate manufacturer's roll number. It is suggested that the panel number be marked on each end of the panel, after each panel is placed, for ease of reference.

C. Field Panel Placement:

1. Placement Plan: Panel placement should take into account: site drainage (including sump or low point considerations), prevailing wind direction, subgrade construction, access to the site and the production schedule of the project. Adequate slack will be maintained in the liner material during assembly and after installation to minimize stress due to variations in ambient temperature and incident radiation.

2. Installation Sequence: Field deployed panels should be seamed as soon as possible after deployment to minimize the risk of wind or water damage.

3. Weather Conditions: Geomembrane panel deployment shall not proceed when ambient air temperature or adverse weather conditions exist which will jeopardize the integrity of the liner installation. Typically, installation shall not proceed when the ambient temperature is below 20°F or above 110°F. Special low temperature welding techniques may be required in conditions of ambient temperatures between 20°F and 40°F.

4. Geomembrane panel deployment shall not proceed if subgrade conditions have deteriorated due to moisture, or in the presence of high winds which might cause damage to the liner material. Deployed panels should be adequately ballasted at all times to limit the risk of wind damage.

5. Method of Deployment: The FML installation contractor shall proceed with deployment provided the following conditions are met. If the conditions below are not met the FML installation contractor shall cease deployment and resolve the problems with the Project Manager / Owner.

   - Any equipment used does not damage the subgrade.
   - The subgrade conditions have not deteriorated.
   - The subgrade is free of loose rocks, debris, ruts, etc.
   - The personnel who are in contact with the liner do not smoke wear damaging shoes or engage in other activities which risk damage to the liner.

- Adequate sandbags are present to weight the edges of the liner to avoid wind uplifting.
- Excessive traffic across the liner is avoided.

6. Damage: The FML installation manager and quality assurance technical shall visually inspect each panel, as soon as possible after deployment, for damage or areas needing repair. Appropriate marks indicating a need for repairs shall be done during the inspection. Heavily creased or otherwise defective material shall be rejected.

4.5 Field Seaming & Layout:

A. Individual panels of liner material shall be laid out and overlapped by a maximum of four inches (101 millimeters) for extrusion weld prior to welding or five inches (127 millimeters) for hot wedge weld prior to welding. Extreme care shall be taken by the installer in the preparation of the areas to be welded.

All sheeting shall be welded together by means of integration of the extrudate bead with the lining material. The composition of the extrudate shall be identical to the lining material, or all sheeting shall be welded together using the hot wedge welding system.

B. Seam Layout: In general, seams shall be oriented parallel to the plane of maximum slope, i.e., oriented along, not across the slope. In corners and odd shaped geometric locations the number of seams should be minimized. No horizontal seams should occur on a panel less than 5 lineal feet from the top of the slope. On slopes of less than 10% (6:1) this rule shall not apply. Seams will be installed at least four feet into the anchor trench.

1. A seam is considered a separate entity if it joins two panels. Repairs are not considered seams in this context.

2. A seam numbering system can be used to identify the seams. It is suggested that a simple numerical system be used or adjacent panel numbers can be utilized to identify the seam.

3. Seams will be welded to at least four feet into the anchor trench.

C. Seaming Equipment and Products: Approved processes for field seaming and repairing are extrusion welding and fusion welding. All welding equipment should have accurate temperature monitoring devices installed and working to ensure proper measurement of the fusion welding wedge temperature or the extrusion barrel temperature.

D. Extrusion Welding Process: This process shall be used primarily for repairs, patching and special detail fabrication and can also be used for seaming.

1. The extrusion welding apparatus (Handwelder) shall be equipped with gauges or other temperature monitoring devices to indicate temperature of the extrudate (resin) as well as the applicable pre-heat settings.

2. The FML installation contractor shall verify the following:

a. Equipment in use is functioning properly.

b. Welding personnel are purging the machine of heat-degraded extrudate prior to actual use.

c. All work by the personnel is performed on clean surfaces and done in a professional manner.

d. No seaming is done in adverse weather conditions.

E. Fusion Welding Process: This process shall be used for seaming panels together and is not generally used for patching or detail work.

1. The apparatus may be of a hot wedge type and shall be equipped with a "split wedge", used for pressure type seam testing.

2. Fusion welding equipment shall be self-propelled devices and shall be equipped with functioning speed controllers and monitors to assure proper control by the welding technician. The welding equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the lining material so as to ensure that changes in environmental conditions will not affect the integrity of the weld.

3. The FML installation contractor shall verify the following:

   a. Equipment in use is functioning properly.

   b. Welding personnel are performing seaming in a professional manner and are attentive to their duties.

4. **Figure F-1** below is a schematic detail which indicates acceptable fusion weld. Deviations from these must be approved by the design engineer prior to use.

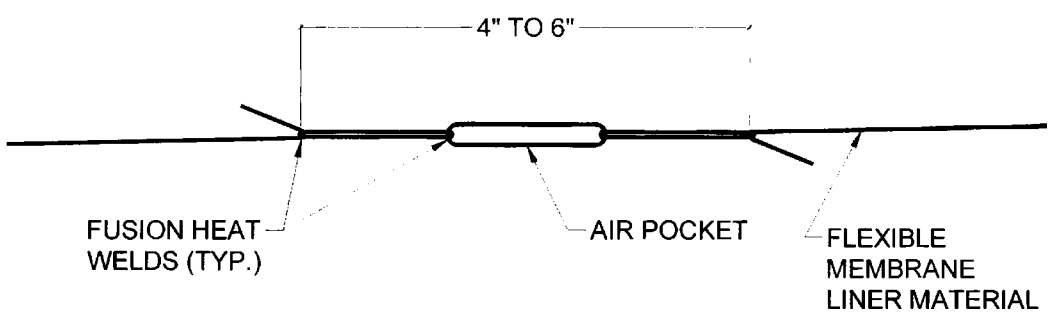


Figure F-1 – Typical Fusion Weld

F. Seam Preparation: The area to be welded shall be cleaned and prepared in accordance with this specification and the recommendations of the material manufacturer. The welding technician shall verify the following:

1. Prior to seaming the seam area shall be free of moisture, dust, dirt, sand or debris of any nature.

2. Seam is overlapped for fusion welding.

3. Seem is overlapped or extended beyond damaged areas at least 4" when extrusion welding.

4. Seam is properly heat tacked and abraded when the extrusion welding is done.

5. Seams are performed with the fewest number of unmatched wrinkles or "fish mouths".

G. Fish Mouths: No "fish mouths" shall be allowed within the seam area. Where "fish mouths" occur the material shall be cut, overlapped and an overlap extrusion weld shall be applied.

H. Slack: Adequate slack will be maintained in the liner during assembly and after installation to minimize stresses due to variations in ambient temperature and incident radiation.

I. Defective Material: Heavily creased or otherwise defective liner material will be rejected.

J. Weather Conditions for Seaming: No seaming shall be performed in ambient air temperatures or adverse weather conditions which will jeopardize the integrity of the liner installation. Ambient air temperatures shall not exceed 110°F nor be below 20°F during seaming. Additionally, seaming shall not proceed in conditions in which the liner is subject to dew or other condensation, rain, snow, frost or frozen subgrade.

K. Low Temperature Welding Procedures: The most important criteria for performing welding when the ambient temperature is between 20°F to 40°F is the condition of the trial weld. All trial welds should be made in conditions duplicating the actual welding environment. The following procedures should be used to maintain the quality of the weld in low temperature ambient conditions (20°F to 40°F).

1. Conduct additional trial welds when a welding machine has been shut off, or after a major change in ambient conditions. A major change in ambient conditions would include but is not limited to the following:

   a. Change in temperature of more than 20°F

   b. Change in wind speed of more than 10 mph.

   c. Change in the amount of sunshine on the liner.

2. The geomembrane and extrudate material must be dry and free from frost, dew, condensation or other moisture.

3. Hot wedge set temperatures may be increased up to 700°F in 10°F increments as necessary.

4. The hot wedge rate of travel should be slowed as necessary.

5. Length of trial weld seams should be increased to 5 ft for extrusion welds and 24 ft for fusion welds.

6. Clean the seam area immediately in front of the welding apparatus with a clean dry cloth.

7. Destructively test one specimen, no greater than 6" from the end of each seam to confirm the quality of the seam.

8. Increase handwelder (extrusion welder) pre-heat temperature up to 600°F in 20°F increments as necessary.

9. Increase handwelder extrudate temperature up to 530°F in 10°F increments as necessary.

10. If additional measures are needed to produce acceptable welds the following additional measures may be implemented:

    a. Install an insulating material such as a geotextile cushion beneath the seam being welded.

    b. Use hot air pre-heat (additional pre-heat for extrusion welding) 6" to 12" in front of the welding apparatus (both fusion and extrusion welders). Verify weld quality be means of a trial weld.

11. If trial welds still indicate that a quality weld cannot be produced be the above steps, a wind shield or an enclosure may be placed over the area to be welded. In the case of an enclosure, the enclosed area shall be heated by forced air or radiant means to an air temperature at or above 40°F.

12. All trial welds will be documented with samples (failures and approved) recorded, retained with samples attached to completion submittal records.

L. Temporary Bonding: The FML installation contractor shall verify that no solvents or adhesives are used in the seaming area. Tape or heat tacking is permissible for temporarily holding patches but is not a substitute for welding.

M. Trial seams / Welds: Trial seams / welds shall be made on appropriate sized pieces of geomembrane material to verify that seaming conditions are adequate.

1. Trial seams / welds shall be performed for each welder to be used and by each operator of extrusion welders, and by the primary operator of the fusion welder.

2. A passing trial seam / weld shall be made prior to seaming each day. If the apparatus is cooled down after use and additional trial seam may be required.

3. Fusion welded trial seams shall be approximately 5 foot long by 1 foot wide with the seam centered lengthwise. For extrusion welding the trial seam sample size shall be approximately 3 feet long by 1 foot wide with the seam centered lengthwise.

4. Test welds shall be marked with date, ambient temperature and welding machine number. All test weld samples will be retained and submitted with approved inspection reports.

5. Samples of weld ¼" to ½" wide shall be cut from the test weld and pulled by hand in peel. The weld should not peel.

6. Refer to Quality Assurance and Quality Control Section 5.2.B for testing requirements.

7. The geomembrane installation contractor shall assign each trial seam / weld sample a number and record the test results in the appropriate log.

8. Upon passing, unless otherwise specified, all trial seam / weld specimens must be retained and submitted with approval inspection reports.

4.6 Defects and Repairs

A. Once defective or areas requiring repair are identified as called out in Section 5.3. Each area shall be repaired in accordance with this section and non-destructively tested.

B. Repair Procedures: Any portion of the polyethylene lining system exhibiting a defect which has been marked for repair shall be repaired with one or more of the following appropriate procedures:

1. Repair Methods:

   - Patching: Used to repair holes, tears, un-dispersed raw materials in the sheet.
   - Grind and Re-Weld: Used to repair small section of extruded seams.
   - Spot Welding: Used to repair small, minor, localized flaws.
   - Flap Welding: Used to extrusion weld the flap of fusion weld in lieu of a full cap.
   - Capping: Used to repair failed seams.
   - Topping: Application of extrudate bead directly to existing seams.

2. The following conditions shall apply to all of the above methods:

   a. Surfaces of the polyethylene which are to be repaired shall be abraded.

b. All surfaces must be clean and dry at the time of the repair.

c. All seaming equipment and personnel used in repairing procedures shall be qualified and documented by the client's third party inspector.

d. All patches and caps shall extend at least 4" beyond the edge of the defect and all patches shall have rounded corners.

C. Large Wrinkles: Large wrinkles that remain in the sheet as a result of temperature expansion or uneven surface preparation may need removal in consideration of applied dead loads on the wrinkle, etc. Should the wrinkle need removing, the lower down slope edge of the wrinkle shall be cut, overlapped and repaired as described above. Both ends of the wrinkle repair shall be patched. Caution must be taken in removing any wrinkles. Wrinkles are needed to allow for future contraction of the geomembrane, especially in cold weather.

4.7 Liner Vents

A. The attached schematic detail DF4A / C.DF4 depicts a typical vent. Vents shall be installed in accordance with manufacturer's recommendations as well as requirements and recommendations indicated on project design drawings.

4.8 Pipe Penetrations

A. The attached schematic detail DF4B / C.DF4 depicts a pipe penetration. Pipe penetrations shall be installed in accordance with manufacturer's recommendations as well as requirements and recommendations indicated on project design drawings.

4.9 Final Earthwork, Backfilling and Equipment

A. Backfilling of Anchor Trench: Promptly after installation of the FML, the anchor trench shall be backfilled by the earthwork contractor or the installer, as specified in the contract. Backfilling should occur when the geomembrane is in its most contracted (taut) state. Care must be taken when backfilling to avoid damage to the FML.

B. Construction Equipment: Construction equipment or vehicles with steel tracks shall not be permitted directly on the geomembrane liner. Vehicles with rubber tires, without a tugged tread and with a loading of less than 6.0 lbs / in^2 weight are allowed, provided proper care is taken when operating the vehicle to avoid stressing the geomembrane. Other equipment such as portable generators shall be permitted if the support apparatus for the equipment protects the liner from being damaged.

5.0 QUALITY ASSURANCE AND QUALITY CONTROL

5.1 Materials:

A. The FML installation contractor or quality control technician shall verify that the property values certified by the geomembrane manufacturer meet all of the specifications; that the measurements of properties by the geomembrane manufacturer are properly documented; and that the test methods used are acceptable.

5.2 Field Seam Testing / Quality Control

A. The end user company, or their designated representative, reserves the right of access for inspection of any or all phases of this installation at their expense.

B. Qualifications of personnel: All personnel performing seaming operations shall be qualified by experience. At least one welder (Master Welder) shall be on site at all times during the seal welding process and have experience seaming a minimum of 5,000,000 ft^2 of geomembrane. The "Master Welder" shall provide supervision of the less experienced welding technicians during seaming, patching and testing operations.

C. Testing of coupons (strips of material) before seaming, stress cracks and all seams must be done in accordance with the FML manufacture's requirements.

D. Trial Welds / Seams:

1. Four specimens, each 1" wide and 6" apart from each other shall be cut from the trial seam. Two of the specimens shall be tested in shear and two specimens tested in peel. Both shear and peel tests shall be conducted to the yield point of the geomembrane. When testing a fusion welded seam the outside (top) weld of a split-wedge weld should be considered the primary weld and shall be the weld tested in peel. The specimen must exhibit the following properties to pass:

   a. Shear Test: Both specimens must meet or exceed the bonded seam strength values in shear of both specimens shall exhibit a bonded seam strength in shear that is greater than 90% of the minimum yield tensile strength of the parent material.

   b. Peel Test: Both specimens must exhibit failure of the parent material or meet or exceed the bonded seam strength values in peel, or strength values shall be greater than 70% of the minimum yield tensile strength of the parent material.

2. General seaming operations may proceed prior to the test being complete. Should a trial seam fail, a sample shall be removed 3 lineal feet from the start of the seaming operations and tested per the above. This procedure will be repeated and followed until a passing sample is located. All work preceding the passing sample shall be repaired.

E. Non-Destructive Seam Continuity Testing

1. Concept: The FML installation contractor shall non-destructively test and document all field seams over their full length using an air pressure test or vacuum test. The purpose of non-destructive tests is to check the continuity of the seams.

2. The FML installation contractor shall:

   a. Schedule all non-destructive testing operations.

   b. Instruct the testing personnel regarding marking of repairs needed, leaks and sign-off marks on seams and repairs.

   c. Monitor the operations of testing personnel to ensure that procedures for testing are followed.

3. On seams that cannot be non-destructively tested by vacuum or air-pressure methods due to physical constraints, (i.e. a boot detail) the seam shall be tested using other approved methods.

4. Vacuum Testing:

   a. Equipment:

      - Vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft gasketing material attached to the bottom, a valve assembly and a certified vacuum gauge.
      - Vacuum pumping device. Including back-up device
      - Foaming agent in solution.
      - Equipment suitable for applying the foaming agent.

   b. Procedure:

      - Wet the section of the seam with foaming agent.
      - Place the vacuum box over the wetted area.
      - Energize the pumping apparatus.
      - Obtain a minimum pressure of -5.0 psi.
      - For a period of approximately 10 seconds, observe, through the viewing window, for the presence of soap bubbles.
      - If no bubbles are observed, reposition the box on the next area for testing.
      - If bubbles are detected, mark and document location of the leak so repairs can be made.

5. Air Pressure Testing: The following procedures are applicable for seams produced by a double-fusion welding apparatus.

a. Equipment:

- Air pump or air tank equipped with pressure gage and capable of producing pressures of 30 psi.
- Sharp hollow needle to insert the air into the air chamber of the seam.

b. Testing Procedure:

- Installer will provide for approval a detailed seam testing map prior to the starting of seal tests.
- Seal both ends of the air channel in the seam to be tested.
- Insert the hollow needle into the air chamber at either end of the seam to be tested.
- Energize the air pump to a pressure of 30 psi and read pressure inserted into the chamber. Allow the pressure to stabilize and if necessary, re-pressurize to to a minimum 30 psi. Then record the pressure.
- Wait for a minimum of 5 minutes and then record the air pressure again.
- If the difference between the initial and the final pressure is greater than 3 psi the seam failed. Documentation required on all failed tests.
- Upon completion of all readings, open the opposite end of the seam with a needle or by cutting with a knife. The escaping air will confirm that the entire length of the seam was pressurized and therefore tested.
- Upon passing the air pressure test, the seam shall be marked and documented.
- All Seam tests shall be witnessed by client or clients inspector.

c. Procedure for Air Pressure Test Failure:

- While the seam air-channel is under pressure, traverse the length of the seam and listen for the leak. Once the area of the leak has been narrowed down, apply a soapy solution to the seam edge (do not trim excess material from edge of seam) and observe for bubbles formed by escaping air.
- As an alternative to the step above the seam may be re-tested in progressively smaller increments, until the area of leakage is identified.
- Repair the identified leaking area by extrusion welding the excess material at the edge of the seam and then vacuum test.
- In areas where the air channel is closed and the integrity of the weld is not suspect, vacuum testing is acceptable.

F. Destructive Seam Testing

1. Concept: Destructive seam tests shall be performed at locations selected by client's inspectors. The purpose of these tests is to evaluate bonded seam strength. Seam strength testing shall be performed and documented as work progresses.

2. Location and Frequency: The minimum frequency of sample removal shall be one sample per 750 ft of seam. The location of the test sample will be taken no greater than 6" from the end of the seam. Additional test samples removal as requested by the client or client's inspector. When cutting destructive tests in the FML liner, cut the

sample for the destructive test in anchor trench when possible to minimize cutting the liner in the submerged area of the basin. There must still be enough destructive seam tests to account for a tests for every 750 feet of seam for the entire liner.

3.

4. Size of Samples: The size of the sample for independent testing shall be 12" by minimal length with the seam centered lengthwise. The sample shall be cut into the following segments and distributed as follows:

   a. The first segment cut shall be 12" x 12" marked with the appropriate D/S number and given to the AQ technician for testing.

   b. The second segment, 12" x requested length (18" max) shall be marked with the appropriate D/S number and transmitted at the contractors cost to the independent testing laboratory or the quality assurance technician personnel for their dispersal.

5. Field Testing: The segments given to the quality assurance technician shall be tested in peel and in sheer using the following criteria:

   a. Ten specimens of 1" width shall be cut from the segment.

   b. Five of the specimens shall be tested in a peel configuration. The outside (top) weld of a split wedge weld shall be considered the primary weld and shall be the weld tested in peel.

   c. Five of the specimens shall be tested in a shear configuration.

   d. The geomembrane manufacturer shall supply a field tensiometer equipped with a drive / pull apparatus adjusted to a pull rate of 2"/min to 20"/ min and a means of measuring the strength of the sample.

   e. Pass Fail Criteria: The installers sample will pass when:

      - The peel specimens exhibit failure of the parent material.
      - The bonded strength peel values shall be greater than or equal to 70% of the minimum yield tensile strength of the parent material.
      - The shear specimens display parent material failure.
      - If the bonded seam strength in shear values is not listed, the shear values shall be greater than or equal to 90% of the minimum yield tensile strength of the parent material.

        Note: Locus of break determinations is to be in accordance with ANSI/NSF 54
      - Four out of five specimens meeting the above criteria constitute a passing test.

   f. Procedure for Failing Tests:

- Two samples of the same size shall be removed from the failed seam. The first sample shall be removed 10 lineal feet in front of the failed sample and the second shall be removed from behind the failed sample.
- Label the samples A and B and test in accordance with procedures listed above.
- If both samples A and B pass, seam between the location of samples A and B shall have the flap extrusion welded or be capped and non-destructively tested accordingly.
- If either sample A or B fails, additional samples shall be taken a minimum distance of 10 feet away from the failed test location. Testing shall continue as outlined above until the area of incorrect seam is isolated.
- In lieu of taking an excessive number of samples, the installer may opt at their cost to extrusion weld the flap or cap for the entire length of the seam then non-destructively test the seam.
- All failing tests shall be documented and forwarded to the client or client's representative within 24 hours, along with recommendation of correction

5.3 Defects and Repairs

A. Identification: All seams and non-seam areas of the polyethylene lining system shall be examined for defects in the seam or sheet.

B. Identification of the defect may be made by marking on the sheet/seam with paint or other marks. The following procedure shall be followed:

1. For any defect in the seam or sheet that is an actual breach (hole) larger than ¼" in the liner system, the installer personnel shall circle the defect and mark the letter "P" inside the circle. The letter "P" indicates that a patch is required.

2. For any defect in the seam or sheet that is less than a ¼" hole, the installer personnel shall only circle the defect indicating that the repair method may be only an extruded bead and a patch may not necessarily be required. Repair methods will be at the sole discretion of the client and the client's qualified inspection representative.

C. Unless otherwise specified, only the geomembrane installation contractor or quality assurance technician shall be permitted to mark on the liner system. The quality assurance technician shall use markings that are distinguishable from the geomembrane installation contractor markings.

D. Verification of Repairs: Each repair shall be non-destructively tested in accordance with requirements of these specifications and manufacturer's recommendations. Once passing tests are achieved a marking shall be placed on the repair, indicting the test is complete and the area has passed the test. If defects remain, appropriate markings shall be made to clearly indicate that additional repairs are required.

5.4 Final Approval

A. A final inspection of the completed liner will be conducted by the FML installation contractor, quality assurance technician and project manager / owner. This careful

evaluation will occur before the Division of Water Quality is asked to approve the use of the lined lagoon. The purpose of the inspections is to verify the following:

1. All repairs have been appropriately performed.
2. All test results are positive.
3. Area is free of scrap, trash and debris.
4. Anchor trench has been properly backfilled.
5. Liner has been installed according to the requirements of these specifications, the project documents and the manufacturer's recommendations.
6. Four (4) copies in three ring binders of all installation record documents will be required prior to final acceptance.

B. Each liner material test, construction inspection checklist, data sheet, or narrative report will be preserved for inspection by the Division of Water Quality. Waste shall not be discharged into the digesters or equalization basins prior to the approval of the Division of Water Quality.

6.0 Warranty and Guarantee

6.1 The manufacture / Installer shall provide a written warranty in accordance with the requirements specified by the owner and / or design engineer.

Attachment E

State of Utah Department of Natural Resources

Technical Publication No. 98

"GROUND-WATER HYDROLOGY OF PAHVANT VALLEY AND ADJACENI' AREAS, UTAH"

By Walter F. Holmes and Susan A. Thiros

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

Technical Publication No. 98

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Prepared by the
United States Geological Survey
in cooperation with the
Utah Department of Natural Resources
Division of Water Rights

1990

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CONVERSION FACTORS

For readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
acre	0.4047	hectare
	4,047	square meter
acre-foot	0.001233	cubic hectometer
	1,233	cubic meter
cubic foot per second	0.02832	cubic meter per second
foot	0.3048	meter
foot per day	0.3048	meter per day
foot squared per day	0.0929	meter squared per day
gallon	0.06308	liter per second
	0.00006308	cubic meter per second
gallons per minute	0.063	liters per second
inch	25.40	millimeter
	0.0254	meter
mile	1.609	kilometer
pound	1.121	kilogram per hectare
square mile	2.590	square kilometer

Chemical concentration and water temperature are given only in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 milligrams per liter, the numerical value is about the same as for concentrations in parts per million. Specific conductance is given in microsiemens per centimeter (µs/cm) at 25 degrees Celsius.

Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 1.8\ (°C) + 32.$$

The term acre-feet per year is also used in this report. To obtain acre-feet per year, divide cubic feet per second by 0.00138.

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

GROUND-WATER HYDROLOGY OF PAHVANT VALLEY AND ADJACENT AREAS, UTAH

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ABSTRACT

The primary ground-water reservoir in Pahvant Valley and adjacent areas is in the unconsolidated basin fill and interbedded basalt. Recharge in 1959 was estimated to be about 70,000 acre-feet per year and was mostly by seepage from streams, canals, and unconsumed irrigation water and by infiltration of precipitation. Discharge in 1959 was estimated to be about 109,000 acre-feet and was mostly from springs, evapotranspiration, and wells.

Water-level declines of more than 50 feet occurred in some areas between 1953 and 1980 because of less-than-normal precipitation and extensive pumping for irrigation. Water levels recovered most of these declines between 1983 and 1986 because of reduced withdrawals and record quantities of precipitation.

The quality of ground water in the area west of Kanosh has deteriorated since large ground-water withdrawals began in about 1953. The cause of the deterioration probably is movement of poor quality water into the area from the southwest and possibly the west during periods of large ground-water withdrawals and recycling of irrigation water. The quality of water from some wells has improved since 1983, due to increased recharge and decreased withdrawals for irrigation.

Water-level declines of more than 80 feet in some parts of Pahvant Valley are projected if ground-water withdrawals continue for 20 years at the 1977 rate of about 96,000 acre-feet. Rises of as much as 58 feet and declines of as much as 47 feet are projected with withdrawals of 48,000 acre-feet per year for 20 years. The elimination of recharge from the Central Utah Canal is projected to cause water-level declines of up to 8 feet near the canal.

INTRODUCTION

The Utah Department of Natural Resources, Division of Water Rights; local irrigation companies; and other water users in Pahvant Valley and adjacent areas need information on the ground-water system to enable them to better manage water resources. More specifically, information is needed on how changes in irrigation diversions and practices or possible future changes in ground-water withdrawals and recharge might affect the ground-water system. In order to address these concerns, the U.S. Geological Survey, in cooperation with the Utah Division of Water Rights, evaluated the ground-water hydrology of Pahvant Valley and adjacent areas during 1985-88.

Purpose and Scope

This report describes the ground-water hydrology of Pahvant Valley and adjacent areas and discusses the effects of possible future changes in ground-water withdrawals and recharge. Data on ground-water recharge, movement, discharge, hydraulic properties, water-level fluctuations, storage, and water

quality in the unconsolidated basin fill and interbedded basalt are presented. Results of a computer simulation, which was used to project the effects of future ground-water withdrawals and loss of recharge from the Central Utah Canal, also are described in this report.

Previous Studies and Acknowledgments

Previous studies of the ground-water hydrology of Pahvant Valley and adjacent areas include those by Meinzer (1911), Livingston and Maxey (1944), Dennis and others (1946), Nelson and Thomas (1953), Mower (1965 and 1967), Handy and others (1969), Hamer and Pitzer (1978), and Holmes (1983 and 1984). Previously published compilations of basic data include those by Mower (1963), Mower and Feltis (1964), Hahl and Cabell (1965), Enright and Holmes (1982), and Thiros (1988). Other data on changes in water levels and ground-water withdrawals are in a series of annual ground-water reports prepared by the U.S. Geological Survey, the most recent being that by Cordy and others (1988). Records from surface- and ground-water data-collection networks in Utah are published in a series of annual hydrologic data reports, the most recent being that by ReMillard and others (1988). A water-budget analysis for the Sevier River basin was published by the U.S. Department of Agriculture (1969).

This study could not have been completed without the cooperation of local well owners, irrigation companies, municipalities, utility companies, and the Utah Division of Water Rights and the Division of Wildlife Resources. Access to wells and springs, and data supplied by well owners and other agencies are appreciated.

Numbering System for Hydrologic-Data Sites

The system of numbering wells, springs, and other hydrologic-data sites in this report, illustrated in figure 1, is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the site, describes its position in the land net. By the land-survey system, the State of Utah is divided into four quadrants by the Salt Lake Base Line and Meridian, and these quadrants are designated by the uppercase letters A, B, C, and D, indicating the northeast, northwest, southwest, and southeast quadrants, respectively. Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section, and is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section--generally 10 acres[1]; the letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the well or spring within the 10-acre tract; the letter S preceding the serial number denotes a spring. The letters following the serial number denote W, a stream or X, a slough. Thus, (C-21-5)21aba-1 designates the first well constructed or visited in the NE¼, NW¼, NE¼, sec. 21, T. 21 S., R. 5 W.

---

[1]Although the basic land unit, the section, is theoretically 1 square mile, many sections are irregular. Such sections are divided into 10-acre tracts, generally beginning at the southeast corner, and the surplus or shortage is taken up in the tracts along the north and west sides of the section.

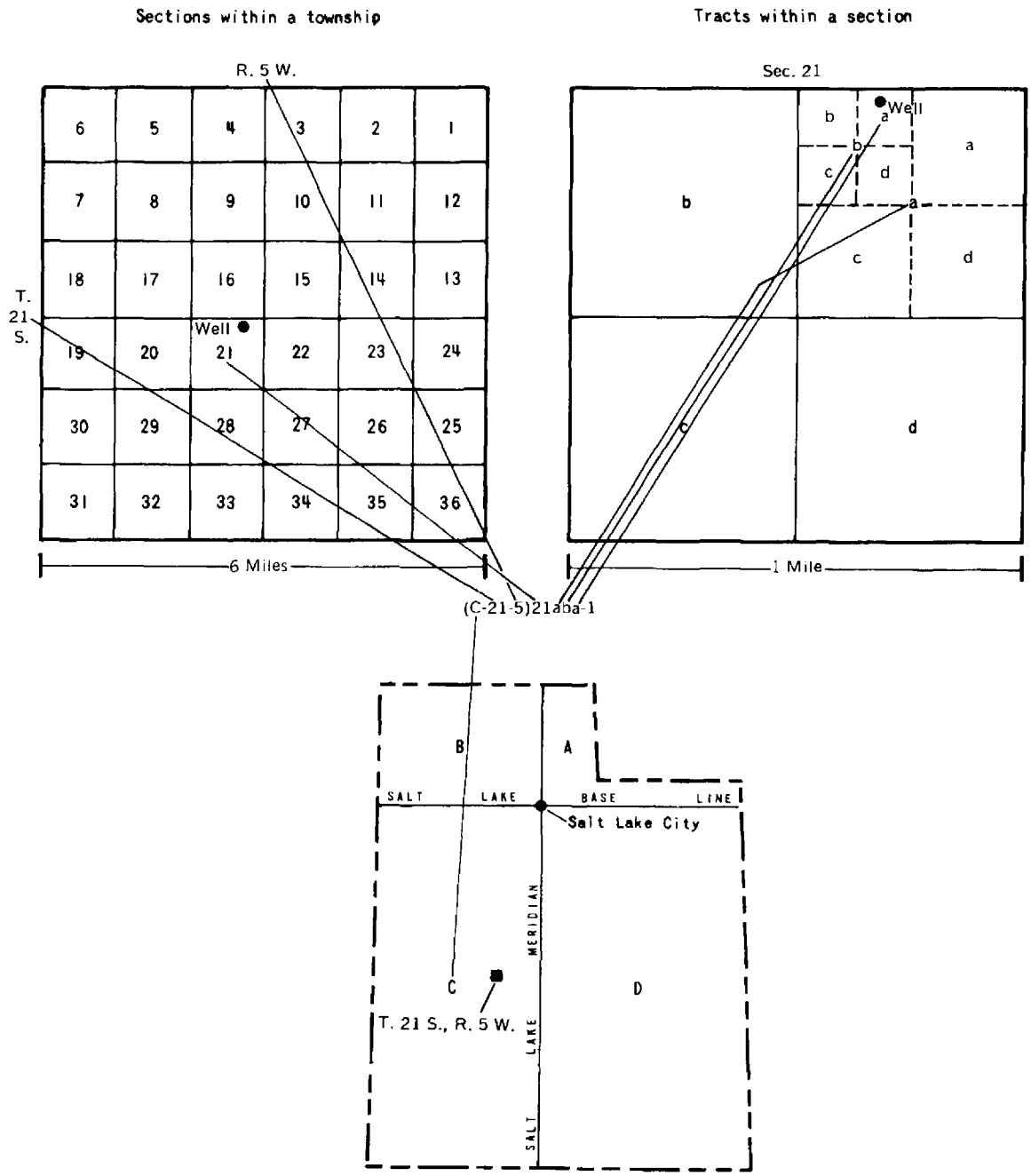

Figure 1.--Numbering system used in this report for hydrologic-data sites.

Description of the Study Area

Physiography

The study area is located in Millard County in west-central Utah (fig. 2) and is part of the Great Basin section of the Basin and Range province (Fenneman, 1931). The area encompasses about 1,600 square miles and includes Pahvant Valley on the east and the southern part of the Sevier Desert on the west. The highest point in the study area is Mine Camp Peak in the Pahvant Range with an altitude of 10,222 feet, and the lowest point is on the Beaver River channel at the northwest boundary of the study area with an altitude of about 4,560 feet.

The area is bounded on the east by the Canyon Mountains and the Pahvant Range, on the south by a topographic divide separating Pahvant Valley and the Sevier Desert from the Cove Creek drainage and the Milford area, and on the west by the Cricket Mountains. The northern boundary of the study area does not represent a topographic or ground-water divide. The boundary was located such that the study area included Clear Lake Springs, which is the primary natural ground-water discharge area for Pahvant Valley (pl. 1).

Geology

The rocks in the study area range from Precambrian to Holocene in age. The generalized geology of the study area is shown on plate 1.

The Pahvant Range, the eastern boundary of the study area, is generally considered to be part of the eastern edge of the Basin and Range physiographic province, and consists of consolidated rocks of Paleozoic to Cenozoic age. The stratigraphy of the Canyon Mountains, in the northeastern part of the study area, is similar to that of the Pahvant Range but includes rocks of Precambrian age.

Mitchell and McDonald (1987, p. 547) concluded from seismic data that normal Basin-and-Range-type faulting does not bound the Pahvant Range on the west or the Cricket Mountains on the east as was previously believed. The Sevier Desert basin was formed by normal movement (westward) along the deep-seated Sevier Desert detachment beginning in Paleocene to Eocene time. The Sevier Desert detachment has an average dip of 11 degrees west (Von Tish and others, 1985, p. 1082) and extends the length of the study area. Deposits of Tertiary age in the deepest part of the Sevier Desert basin within the study area may be more than 11,000 feet thick (Mitchell and McDonald, 1987, p. 539). The Cricket Mountains, the western edge of the study area, consist mainly of allochthonous Cambrian strata underlain by the Sevier Desert detachment. Crone and Harding (1984, p. 293) determined that recent high-angle normal faults near Clear Lake Springs either merge with or are truncated by this detachment.

Tertiary sedimentary deposits, chiefly fanglomerates and alluvium (Morris, 1978, p. 3), underlie most of the younger Cenozoic unconsolidated deposits in the study area and crop out at the base of the Pahvant Range and Canyon Mountains and as hills within Pahvant Valley. The Sevier River Formation of Pliocene to Miocene age (Steven and Morris, 1983, p. 2) consists of interlayered fine- to coarse-grained sediment deposited by fluvial and

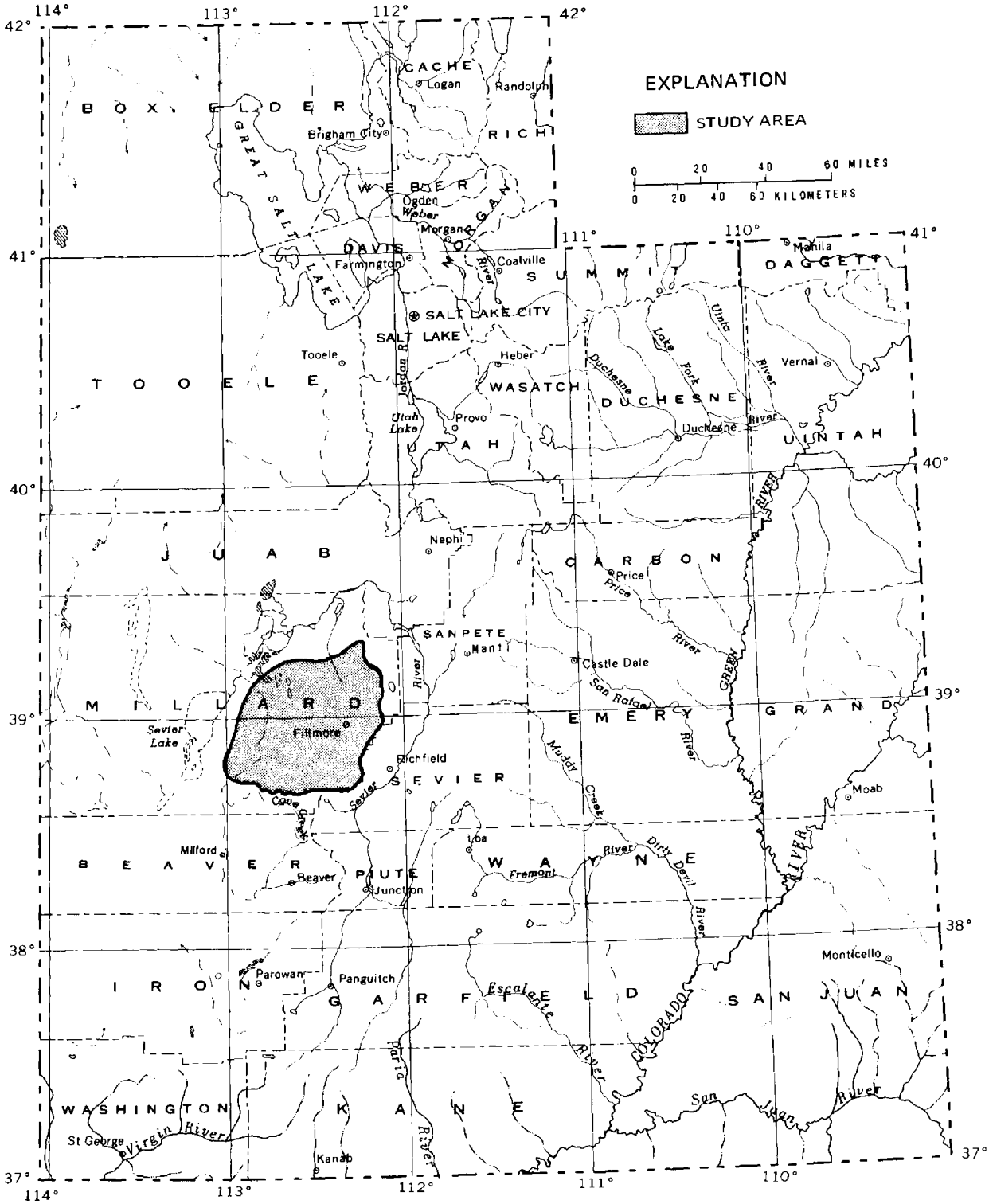

Figure 2.--Location of study area.

lacustrine processes. This unit is poorly to moderately consolidated and is largely impermeable to ground water occurring in the overlying unconsolidated deposits (Mower, 1965, p. 20). A disconformity separates the irregular surface of the Sevier River Formation from the younger lacustrine deposits. Exposed and possibly buried hills composed of the Sevier River Formation may influence or control the ground-water system of the area.

Alluvial fans which developed along the mountain fronts, predominantly during Quaternary time, were deposited synchronously with sediments laid down by intermittent lakes. The fans extended into the basin where they interfingered with lakebed deposits consisting of gravel, sand, silt, and clay. These deposits are unconsolidated and form one of the principal aquifers in Pahvant Valley. Pleistocene Lake Bonneville, the last of the intermittent lakes to inundate the area, existed between approximately 30,000 to 10,000 years B.P. (Oviatt and Currey, 1987, p. 259). Bars, spits, and beaches formed by Lake Bonneville can be found at or below the Provo substage level of 4,830 feet in Pahvant Valley.

Basaltic and rhyolitic volcanic rocks were deposited in the study area during late Tertiary and Quaternary time, the result of extension within the Basin and Range province (Hoover, 1974, p. 38). Silicic volcanism, which formed rhyolite domes and volcaniclastic deposits, took place in the central and southern part of the study area with White Mountain, a small silicic dome in Pahvant Valley, being extruded less than 1 million years ago (Hoover, 1974, p. 19). The name White Mountain is derived from the white gypsiferous sand deposits blown against the dome's base from the surrounding playa.

Basaltic rocks, found near or at the surface in the study area, were deposited during the past one million years. Basalt flows extend from 100 to 800 feet above the valley floor, forming a north-south-trending ridge which divides the study area into Pahvant Valley on the east and the Sevier Desert on the west. Hoover (1974, p. 5) divides these eruptive events into three episodes based on composition and age relations.

The Beaver Ridge and Kanosh volcanic fields, ranging in age from 918,000 to 536,000 years B.P., comprise episode 1. The eastward extent of the Beaver Ridge basalts is unknown because of normal faulting and a veneer of alluvium that obscures the outcrops. The Kanosh field consists of several cones, including the Black Rock Volcano, and lava flows that also have been subsequently covered by alluvium.

Episode 2 is composed of the Pahvant volcanic field which ranges in age from about 130,000 to 30,000 years B.P. Extruded subaerially, the basalt flows of this field are the most extensive in the study area. The flows contain abundant pressure ridges, lava tubes, and polygonal joints (Condie and Barsky, 1972, p. 338). The final eruptive stage in the Pahvant field was contemporaneous with Lake Bonneville and, therefore, was subaqueous. Pahvant Butte, a 750-foot-high tuff cone, rests unconformably upon the older Pahvant field basalts.

The last eruptive episode occurring in the area consisted of the Tabernacle and the Ice Springs volcanic fields. The subaqueous Tabernacle field basalts mainly were extruded during the Provo substage of Lake Bonneville (less than 12,000 years B.P.) from the base of a tuff cone called

Tabernacle Hill (Condie and Barsky, 1972, p. 339). The lack of Provo-substage-level terraces and the occurrence of pillow-like structures at the outer edges of the flows indicate a subaqueous eruption. The cinders, spatter cones, and lava of the Ice Springs field, about 3 miles west of Flowell, disconformably overlie Lake Bonneville sediments with an estimated age between 4,000 to 1,000 years B.P. (Hoover, 1974, p. 20). Ice Springs lavas also overlap the southern part of the Pahvant field.

Travertine ridges and deposits located west of Hatton are still being formed at hot and warm springs in the area. The travertine deposits follow the same northward trend along which the Kanosh and Ice Springs volcanic fields and Pahvant Butte are located.

Climate

The climate of the study area ranges from semiarid on the basin floor to subhumid at the higher altitudes in the mountains. Daytime temperatures on the basin floor during summer often exceed 40 °C and minimum temperatures during winter can be less than -20 °C. The 1951-80 normal annual temperature at Fillmore is about 11 °C (U.S. Department of Commerce, 1985).

The 1951-80 normal annual precipitation at Fillmore is 14.51 inches (U.S. Department of Commerce, 1985). February, March, and April are the wettest months while June, July, and August are the driest months. Precipitation generally was less than average during 1946-63 and 1974-77, near average during 1964-73, and above average from 1978-86. The 1982-85 average annual precipitation was 21.80 inches, 7.29 inches greater than the 1951-80 normal, and was the wettest four-year period on record (U.S. Department of Commerce, 1982-1985). The cumulative departure from average annual precipitation at Fillmore for 1946-86 is shown in figure 3.

The estimated annual evaporation for 1931-70 from bodies of fresh water was 69.52 inches at Milford, Utah, about 30 miles south of the study area (Waddell and Fields, 1977, table 12). The lower parts of the study area are topographically similar to the Milford area. Thus, the estimated annual evaporation from freshwater lakes in the lower altitudes of Pahvant Valley and adjacent areas is estimated to be about 70 inches.

Vegetation

The vegetation in uncultivated parts of Pahvant Valley and the Sevier Desert primarily consists of phreatophytes including greasewood, saltgrass, and rabbitbrush, with lesser amounts of saltcedar where the water table is near the surface and sagebrush where the water table is deeper. The vegetation in the higher areas primarily consists of sagebrush, juniper, pinyon pine, and oak on the foothills and low mountains, and pine, fir, aspen, oak, and sagebrush in the high mountains.

Irrigated croplands are restricted to Pahvant Valley in the eastern part of the study area. The main irrigated crops are alfalfa, grains, corn, and potatoes. In 1960, 35,300 acres of cropland were irrigated in Pahvant Valley of which 11,400 acres were irrigated exclusively with ground water (Mower, 1965, table 2). The Clear Lake Migratory Waterfowl Refuge, west of Pahvant

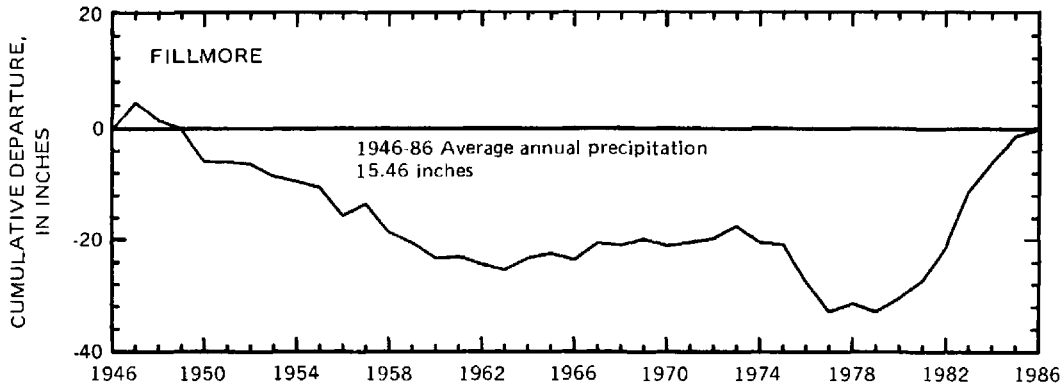

Figure 3.--Cumulative departure from average annual precipitation, 1946-86, at Fillmore, Utah.

Valley in the northern part of the study area, has more than 5,000 acres of lakes and marshes that are dependent on the flow of Clear Lake Springs.

Surface Water

The major sources of surface water in the study area are streams originating in the Canyon Mountains and the Pahvant Range along the eastern border of the study area and water imported from the Sevier River in the Central Utah Canal. The larger streams in the study area undergo many diversions for irrigation after leaving the mountain fronts. There has been no surface-water outflow from the study area since about 1914. With the exception of 1983-84, the Beaver River, which enters the study area on the southwest corner and leaves the study area on the northwest corner, has been dry within the study area since 1914. During 1983-84, however, some water in the Beaver River channel entered the study area and reached an earthen dam located about 6 miles south of Clear Lake Springs (Red Wilson, Beaver County News, oral commun., May 1985).

Chalk Creek is the largest stream in the study area. Gaging station 10232500, Chalk Creek near Fillmore, Utah, was operated by the U.S. Geological Survey during 1945-71. The average annual flow for 27 years of record was 22,000 acre-feet. Before irrigation began in Pahvant Valley (probably before 1900), much of the water in Chalk Creek flowed northwest across the valley to The Sink (pl. 1), a low-elevation area about 3 miles north of Flowell, where it percolated into underlying basalt (Mower, 1965, p. 12).

Corn Creek is in the southeast corner of the study area. Gaging station 10233500, Corn Creek near Kanosh, Utah, was operated by the U.S. Geological Survey during 1966-75, and the average annual flow for 10 years of record was 12,900 acre-feet. Some water from Corn Creek probably flowed to The Sink before irrigation began in Pahvant Valley.

Meadow Creek is east of the town of Meadow (pl. 1). Gaging station 10233000, Meadow Creek near Meadow, Utah, was operated by the U.S. Geological Survey during 1966-75, and the average annual flow for 10 years of record was 5,100 acre-feet.

The average annual flow from all other streams tributary to Pahvant Valley was estimated by Mower (1965, table 5) to be about 61,000 acre-feet. The estimate did not include flow from ephemeral streams in the Cricket Mountains which discharge into the Sevier Desert in the western part of the area.

Mower (1965, table 5) estimated the flow for the mountain area west of Corn Creek to be 100 acre-feet per 1,000 acres. The average elevation of the Cricket Mountains is about 1,000 feet lower than the average elevation for the mountain area west of Corn Creek, and the average annual precipitation is less than 10 inches, so the average annual flow from streams in the Cricket Mountains is probably less than 100 acre-feet per 1,000 acres. Assuming an average annual flow of 50 acre-feet per 1,000 acres, and an area of about 72,000 acres, which represents the area of the Cricket Mountains tributary to the study area above an altitude of 5,000 feet, the estimated annual average flow from the Cricket Mountains is 3,600 acre-feet.

The average annual inflow to the study area from the Central Utah Canal, based on data collected at a gaging station located about 2 miles east of McCornick during 1966, 1970-73, and 1975-77, is about 8,900 acre-feet (Roger Walker, Sevier River Commissioner, written commun., July 1985).

GROUND-WATER HYDROLOGY

Ground water in the study area is present in both consolidated rocks and unconsolidated basin fill. The primary ground-water reservoir is the unconsolidated basin fill, but consolidated basalt flows crop out and are interbedded with the unconsolidated fill in some parts of the study area and are considered part of the primary ground-water reservoir. Water in consolidated rocks in the mountains surrounding the study area provides the baseflow of perennial streams and springs, but these rocks are not considered part of the primary ground-water reservoir.

Unconsolidated Basin Fill and Interbedded Basalt

The primary ground-water system in the study area is the unconsolidated basin fill and the interbedded basalt. The fill consists of alluvial-fan and lacustrine deposits of gravel, sand, and silt near the mountains and lacustrine deposits of gravel, sand, silt, and clay interbedded with basalt in the central part of the study area. The fill becomes finer grained toward the central part of the area.

Previous studies have divided the ground-water system into an unconfined and an artesian system (Dennis and others, 1946, p. 40-49, and Mower, 1965, p. 32-33). The unconfined system includes about 50 feet of the saturated unconsolidated fill in most of the area and about 100 feet or less of basalt that is interbedded with the fill in the central part of the area. The confined system, in the Flowell area, is encountered at a depth of between 140 and 200 feet and is separated from the unconfined system by 15 to 75 feet of clay under weak artesian conditions (Dennis and others, 1946, p. 44).

Previous studies also divided the ground-water system into six ground-water districts (Mower, 1965, p. 31). The principal purpose of the division

was to delineate areas having similiar characteristics and common sources of recharge and areas of discharge. Ground-water movement between districts may occur and withdrawals in a district may affect water resources in adjacent districts. Because the districts are not completely hydrologically independent, they are not used in this report.

The thickness of the unconsolidated basin fill varies from a few feet near the mountain fronts to at least 1,400 feet as shown by a driller's log of the Neels Well (T. 20 S., R. 8 W.) reported by Meinzer (1911). The fill is underlain by and abuts against the Sevier River Formation of low permeability in the eastern part of the study area (Mower, 1965, p. 20). Tertiary volcanic rocks mark the southern boundary of the basin fill, and consolidated rocks in the Canyon Mountains, Pahvant Range, and Cricket Mountains form the eastern and western boundaries of the fill. Basin fill on the northern and northwestern edge of the study area is not bounded by consolidated rocks.

Basalt flows are interbedded with the unconsolidated basin fill in most of the study area. Basalt flows from the Kanosh and Pahvant volcanic fields crop out or are at shallow depths on the west side of Pahvant Valley near the central part of the study area. Other basalt flows have been identified at depths of more than 2,000 feet in the Gulf 1 Gronning Test Well (McDonald, 1976, pl. 3), north of the study area near Delta, and (using seismic-reflection data) near the northern boundary of the study area (Von Tish and others, 1985, fig. 3). The deeper basalt flows are of Pliocene age, and the flows at the surface or at shallow depths are of Pleistocene age. The deeper flows have been truncated by high-angle normal faults, are discontinuous in the subsurface, and are not considered to be part of the principal ground-water reservoir.

The basalt flows of Pleistocene age, some of which are only about 5,000 years old, also are faulted by north-trending, high-angle faults, but the degree of displacement in the subsurface is uncertain. The basalt flows are jointed and fractured, contain numerous lava tubes, and are permeable. They form an important part of the ground-water reservoir near Flowell and west of Kanosh. They also are the source for water discharging at Clear Lake Springs.

Recharge

Recharge to the principal ground-water reservoir in the study area is by seepage from streams, canals, and unconsumed irrigation water; infiltration of precipitation; and subsurface inflow from the Milford area. Subsurface inflow from consolidated rocks along the mountain fronts probably is small (Mower, 1965, p. 20). Total recharge varies from year to year and was estimated to be about 70,000 acre-feet in 1959. The methods and data used to calculate recharge are discussed in the following sections.

Seepage from streams

Recharge by seepage from streams in the study area is estimated to average about 20,000 acre-feet per year. Most of this recharge comes from streams on the east and south sides of Pahvant Valley, and was estimated to be 18,000 acre-feet in 1959 (Mower, 1965, table 9). Chalk and Corn Creeks contribute most of the recharge, but all major tributaries contribute some

recharge (Mower, 1965, p. 46). In addition, it is estimated that 2,000 acre-feet recharge the ground-water reservoir from the Cricket Mountains on the west side of the study area, an area not included in Mower's study.

Recharge from streams in 1983 and 1984 was much larger due to the unusually high flows and long duration of the spring runoff period. Chalk Creek had peak flows of more than 1,000 cubic feet per second and sustained flows of more than 500 cubic feet per second in the spring of 1983 and 1984 (Jack McBride, Chalk Creek Irrigation Company, oral commun., November 1986). An estimated 51,000 acre-feet of water entered The Sink area, north of Flowell, between March 10 and July 17, 1983, increasing to an estimated 62,000 acre-feet between March 17 and July 17, 1984 (Garth Swallow, Chalk Creek Irrigation Company, oral commun., December 1986). Estimates for the remainder of the irrigation season after July 17, 1983, and 1984 were not available. Most of the water ponded and eventually moved into the basalt that underlies the area at shallow depths. The quantity of water that actually recharged the basalt north of Flowell could not be measured, but based on limited data may have been as much as 60,000 acre-feet in 1983 and 70,000 acre-feet in 1984.

In May of 1984, a dam on Corn Creek, about 2 miles southeast of Kanosh, washed out and allowed an estimated 900 cubic feet per second of flow down the old Corn Creek channel for about 30 days (Cloyd Day, U.S. Department of Agriculture, Soil Conservation Service, oral commun., November 1986). Most of the water ponded on land at lower elevations about 7 miles west of Kanosh where round, symmetrical sinkholes, with diameters of about 20 to 40 feet and depths of 10 feet or greater, formed, draining the water into the underlying basalt in a few days. Recharge to the basalt west of Kanosh may have been as much as 50,000 acre-feet.

In 1984, part of the flood water from Corn Creek drained to the north and ponded against a basalt flow in sec. 25, T. 21 S., R. 6 W. In addition to the flow of Corn Creek, water from sloughs at the mouth of Pine Creek and Meadow Creek, as well as a number of uncontrolled flowing wells began discharging into channels that ponded against the basalt at this location in 1984. Flood-control measures to contain the water included channeling and diking which forced the flood waters to discharge into the permeable basalt flows at this location. Milo Anderson, a landowner in Flowell, estimated 125 cubic feet per second entered the basalt for most of the winter of 1984-85. Additional water entered the basalt south of the channeling and diking projects where the water had ponded against the basalt. Based on conversations with local landowners and measurements at the point of diversion into the basalt, [Thiros, 1988, table 8, location (C-21-6)24cdd-1X)], recharge to the basalt may have been as much as 40,000 acre-feet in 1984 and 30,000 acre-feet in 1985.

Seepage from the Central Utah Canal

Recharge by seepage from the Central Utah Canal has been estimated to be about 3,300 acre-feet per year (Mower, 1965, table 10). The 3,300 acre-feet per year was included in an estimated 27,000 acre-feet of recharge from unconsumed surface irrigation water (Mower, 1965, p. 48). Most of the seepage was thought to occur between the northern boundary where the Central Utah Canal enters the study area near McCornick and where the canal passes west of Cedar Mountain near the center of Pahvant Valley.

A seepage study of this reach of the Central Utah Canal, conducted by the U.S. Geological Survey during the summer of 1986, showed an average loss of 36 cubic feet per second (Enright, 1987). Assuming the canal was in operation for 90 days, the loss from the canal for 1986 would have been about 6,500 acre-feet out of about 16,000 acre-feet delivered or about a 40-percent loss. This agrees with estimates by Mower (1965, table 10) of 3,300 acre-feet per year out of an average flow of about 8,900 acre-feet per year, or 37 percent losses, based on data from 1966, 1970-73, and 1975-77 (Roger Walker, Sevier River Commissioner, written commun., July 1985).

Seepage from unconsumed irrigation water

Mower (1965, p. 48) had estimated recharge from unconsumed irrigation water to be 39,000 acre-feet per year in 1959--27,000 acre-feet from surface water (including seepage from the Central Utah Canal) and 12,000 acre-feet from ground water. Recharge has probably increased since 1959 because withdrawals of ground water for irrigation have increased. The quantity of ground water withdrawn in Pahvant Valley has increased from 60,000 acre-feet in 1959 to almost 100,000 acre-feet in 1977 (Cordy and others, 1988, table 3). Assuming that 25 percent of the increase in ground- and surface-water withdrawals in 1977 (10,000 acre-feet) was returned to the ground-water reservoir as recharge (Mower, 1965, p. 49), and recharge from other ground- and surface-water sources was the same as in 1959 (39,000 acre-feet), the value for unconsumed irrigation water may have been as large as 50,000 acre-feet.

Recharge primarily occurs on the alluvial fans at the mountain front on the east side of Pahvant Valley where irrigated fields are underlain by relatively permeable material susceptible to large seepage losses. Some recharge from unconsumed irrigation water occurs in the lower parts of Pahvant Valley such as The Sink, north of Flowell, and the area west of Kanosh, where permeable basalt flows are at or near the surface.

Infiltration of precipitation

Recharge by infiltration of precipitation is estimated to average about 11,000 acre-feet per year. About 8,000 acre-feet of recharge (5 percent of the precipitation) infiltrates in the upland parts of Pahvant Valley between the altitudes of 4,800 and 6,000 feet (Mower, 1965, p. 46), and 3,000 acre-feet per year of recharge (17 percent of the precipitation) occurs on the basalt outcrops in the central part of the study area (Mower, 1967, p. E27). Recharge from precipitation during periods of greater-than-normal rainfall is probably much larger than the 5 or 17 percent during average years because consumptive use by plants and soil moisture retention do not increase proportionally and, thus, more of the precipitation is available for recharge.

The average annual precipitation on the western side of the study area in and near the Cricket Mountains (not covered by previous reports), is less than 10 inches per year. Therefore, the area probably does not contribute substantial recharge from precipitation to the ground-water reservoir.

Subsurface inflow from the Milford area

Recharge by subsurface inflow from the Milford area was estimated by Mower (1974, table 9 and p. 33) to be 8 acre-feet per year. The estimate is based on an average transmissivity of 75 feet squared per day, a hydraulic gradient of 0.003, and a cross-sectional length of 4,000 feet. For the purposes of this report, this small quantity of recharge is insignificant.

Movement

Ground water in the study area generally moves from major recharge areas near the mountains on the east and south toward discharge areas in the lower parts of Pahvant Valley and the Sevier Desert. Some ground water leaves the study area along the northwest boundary, but the quantity is small. Plate 2 shows the potentiometric surface in the unconsolidated basin fill and interbedded basalt in spring 1986. The direction of ground-water movement is generally at right angles to the contour lines.

Ground-water movement has been affected in local areas by large withdrawals for irrigation. Handy and others (1969, fig. 4) show an area west of Kanosh where the direction of ground-water movement was reversed due to large ground-water withdrawals in 1967. The same condition existed in 1986 (pl. 2) and probably has occurred during other years when large quantities of ground water were pumped for irrigation. Mower (1965, pl. 4) showed a large, relatively flat area on the potentiometric surface near Flowell, which he attributed to large withdrawals for irrigation (Mower, 1965, p. 41).

Ground-water movement to the west in the unconsolidated basin fill is restricted both laterally and vertically, beginning at the western border of Pahvant Valley, by the fine-grained silts and clays in the subsurface. Mower (1967, p. E11) referred to a ground-water dam that laterally confines subsurface water to the permeable beds in the unconsolidated deposits within the valley. The result of the restricted flow to the west is water levels greater than 50 feet above land surface in the area near Flowell (Thiros, 1988, table 3). Some water probably leaks upward into the permeable basalt layers that are interbedded with the fine-grained unconsolidated basin fill.

The movement of ground water from Pahvant Valley through the basalt to the west and north toward Clear Lake Springs is not well understood. Mower (1967, p. E16) states that although the hydraulic gradient in the basalt is only about 1 foot per mile, the movement of water may be fast due to the large permeability of the basalt aquifer. In addition, Mower (1967, p. E16) noted a transition zone of small permeability near the southern boundary of T. 21 S., R. 6 W., where the basalt from the older Beaver Ridge and Kanosh volcanic fields is in contact with basalt from the Pahvant field.

The rate of ground-water movement in the basalt can be estimated based on responses in the discharge at Clear Lake Springs to changes in the recharge to the basalt in Pahvant Valley. Several areas of Pahvant Valley have contributed substantial amounts of recharge to the basalt between 1983 and continuing through 1987 (see section on recharge by "Seepage from streams").

Surface water was diverted to control flooding, beginning in the spring of 1983, from Corn and Meadow Creeks and Pine Creek and Meadow Creek sloughs

into the basalt southwest of Flowell. The flood waters entered and disappeared into the basalt of the Ice Springs volcanic field where it apparently found a path into the underlying Pahvant basalt flow. The basalt flows in the area have been cut by a number of high-angle normal faults (pl. 1). The faults and related fractures probably provide a permeable conduit for ground water to move to Clear Lake Springs. In addition, the springs probably mark the western boundary of the Pahvant basalt flow. West of the springs, ground-water movement is restricted by relatively impermeable lake sediments. Therefore, water moving through the permeable basalts toward the northwest encounters the relatively impermeable lake sediments, and is forced to the surface at Clear Lake Springs.

Recharging water also enters and moves through basalt at The Sink, about three miles northwest of Flowell, and at an area about seven miles west of Kanosh in T. 23 S., R. 6 W., sec. 8. Flood waters from Chalk Creek collected in The Sink in 1983 and 1984 and eventually disappeared, much of it into the ground. In 1984, flood waters from Corn Creek collected and formed a lake in the topographically low area about 7 miles west of Kanosh and disappeared into a series of sinkholes that opened and drained the lake. Both areas are underlain by permeable basalt at depths of less than 50 feet. The potentiometric-surface contours (pl. 2) indicate that water entering the basalt at these locations will move toward Clear Lake Springs.

Mower (1967, p. E27) developed an empirical relationship between October-April precipitation on the basalt, ground-water withdrawals, and low flow of the springs. Since most of the precipitation on the basalt occurs in March and April, the time lag between precipitation and discharge of the spring is about six or seven months. In addition, Mower (1967, p. E23) states that water-level changes in observation wells in Pahvant Valley and changes in the discharge of the springs are directly related; however, changes in the discharge of the springs lag behind the changes in the water levels by one to two months.

The ground-water velocity in the basalt can be estimated using the equation:

$$v = KI/\Theta$$

where v = velocity of ground water,
K = hydraulic conductivity of basalt,
I = hydraulic gradient, and
Θ = porosity of the basalt.

Assuming K is 10,000 feet per day, I is 0.001, and Θ is 0.05, the average velocity is about 200 feet per day.

To gain a better understanding of the travel time in the basalt, a dye study was conducted. On October 29, 1985, 50 pounds of Rhodamine WT[1] dye was injected into water being diverted into the basalt west of Flowell, a distance of about 12 miles from Clear Lake Springs. Daily samples, collected at Clear

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[1]Use of the trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Lake Springs through the end of February 1987, did not contain detectable concentrations of dye. Although the dye study did not confirm that ground water was moving to the springs, it is possible that the concentration was too small to be detected. Another possibility is that the flow path and time of travel was greater than the time of the study period.

Discharge

Discharge from the ground-water reservoir in the study area is by springs, evapotranspiration, subsurface outflow, and wells. Discharge varies from year to year and was estimated to be about 109,000 acre-feet in Pahvant Valley in 1959.

Springs

Most of the discharge from springs is from Clear Lake Springs. Prior to any ground-water development in Pahvant Valley (about 1915), the discharge of the springs was probably between 14,000 and 22,000 acre-feet per year. Numerous measurements by the Utah Division of Wildlife Resources from 1959 through 1985 and streamflow records collected by the U.S. Geological Survey from 1985 to 1987 as part of this study, are shown in figure 4.

The discharge of Clear Lake Springs varied from 13 to 30 cubic feet per second until the fall of 1983. In the fall of 1983, the discharge of the springs began to increase rapidly and measurements from November 1984 to August 1985 showed discharges of more than 80 cubic feet per second (fig. 4). The increase in discharge of the springs is due to increased recharge to basalt north and southwest of Flowell and west of Kanosh. (See section on recharge by "Seepage from streams" previously discussed in this report.)

Springs and seeps in an area west of Meadow were estimated to be discharging about 3,000 to 3,500 acre-feet per year in the early 1940's (Dennis and others, 1946, p. 78-79). Numerous other springs and seeps were discharging water over broad meadowlands and playas west of Meadow. The discharge of many of the springs and seeps is collected in natural and man-made drains and was measured as part of this study and reported in Thiros (1988, table 7). Data are insufficient to determine if the discharge of these springs and seeps has substantially changed under the current (1987) hydrologic conditions.

Evapotranspiration

Discharge by evapotranspiration in the study area is estimated to be about 29,000 acre-feet per year. Mower (1965, p. 54) estimated evapotranspiration in Pahvant Valley to be 24,000 acre-feet per year. Evapotranspiration in the area not covered by previous studies (west of Pahvant Valley) is estimated to be about 5,000 acre-feet per year. This estimate is based on about 50,000 acres of phreatophytes, primarily greasewood, with an average density of 10 percent, and an annual consumptive use of 0.1 foot per year.

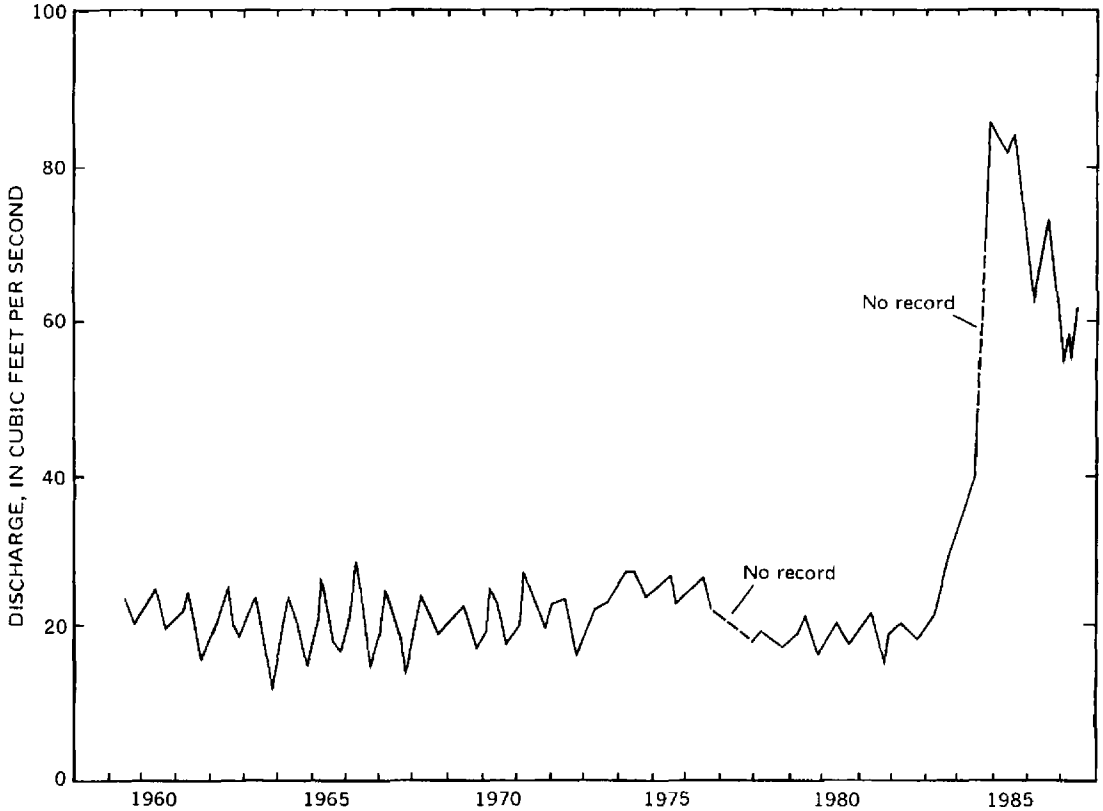


Figure 4.--Discharge of Clear Lake Springs, 1959-86.

Subsurface outflow

Subsurface outflow from the study area occurs along the northwestern border. The ground-water gradient along the border is estimated to be about 0.001, the transmissivity is estimated to be about 500 feet squared per day, and the distance across the boundary is about 16 miles. Therefore, using Darcy's Law, the estimated subsurface outflow is about 400 acre-feet per year.

Wells

Discharge by wells in the study area has varied considerably since the first successful wells were drilled near Flowell in about 1915. Estimated annual ground-water withdrawals from pumped and flowing wells in Pahvant Valley during 1946-86 is shown in figure 5. Discharge primarily was from flowing wells until the availability of electricity in 1952-53. With increased withdrawals from pumping wells after 1953, the discharge of flowing wells decreased, and from 1966 through 1983 was estimated at less than 1,000 acre-feet per year. Withdrawals from flowing wells increased to 9,500 acre-feet in 1984, 23,000 acre-feet in 1985, and 22,000 acre-feet in 1986 because of record quantities of precipitation and reduced withdrawals from pumped wells.

Ground-water withdrawals from wells reached a maximum in 1977 when withdrawals were about 96,000 acre-feet. Since that time, withdrawals have decreased as a result of greater-than-normal precipitation and availability of additional surface water, better irrigation practices, and the increasing cost of electricity. The 1972-81 estimated average annual withdrawal of ground water was 84,000 acre-feet while the 1982-85 average annual withdrawal was about 54,000 acre-feet. Most of the wells are completed at depths of between 200 and 500 feet in unconsolidated basin fill or between 100 and 200 feet in basalt.

Hydraulic Properties of the Basin Fill and Interbedded Basalt

Hydraulic coefficients of the ground-water reservoir in Pahvant Valley were reported by Mower (1965, tables 8 and 11 and p. 52). The transmissivity of the unconsolidated basin fill ranges from about 2,000 to 40,000 feet squared per day, and the transmissivity of the basalt ranges from about 24,000 to 3,000,000 feet squared per day. The storage coefficient of the ground-water reservoir under artesian conditions ranges from 0.001 to 0.0001. The estimated specific yields for geologic units include 0.10 to 0.25 for the unconsolidated deposits, 0.06 for the basalt, and 0.12 for the combined unconsolidated basin fill and basalt.

Water-Level Fluctuations

Water levels fluctuate in response to changes in the balance between recharge and discharge. Prior to development of the ground-water resources in the study area, water-level fluctuations were due primarily to changes in recharge from precipitation and surface-water infiltration. Ground-water withdrawals for irrigation, beginning in about 1915, have caused additional water-level fluctuations, both on a seasonal, as well as a long-term basis. Mower (1965, pl. 5) shows an area near Flowell where water-level declines from March to September 1960, were more than 45 feet as a result of ground-water withdrawals for irrigation during the summer months. Hydrographs of four representative wells showing seasonal water-level fluctuations during this study are shown in figure 6.

Water levels in wells (C-20-5)13daa-1 and (C-21-6)26aac-1 have large seasonal fluctuations because of surface-water infiltration. Well (C-20-5)13daa-1 is located near the Central Utah Canal. The highest water levels occur during the summer months when the canal is in use and losses from

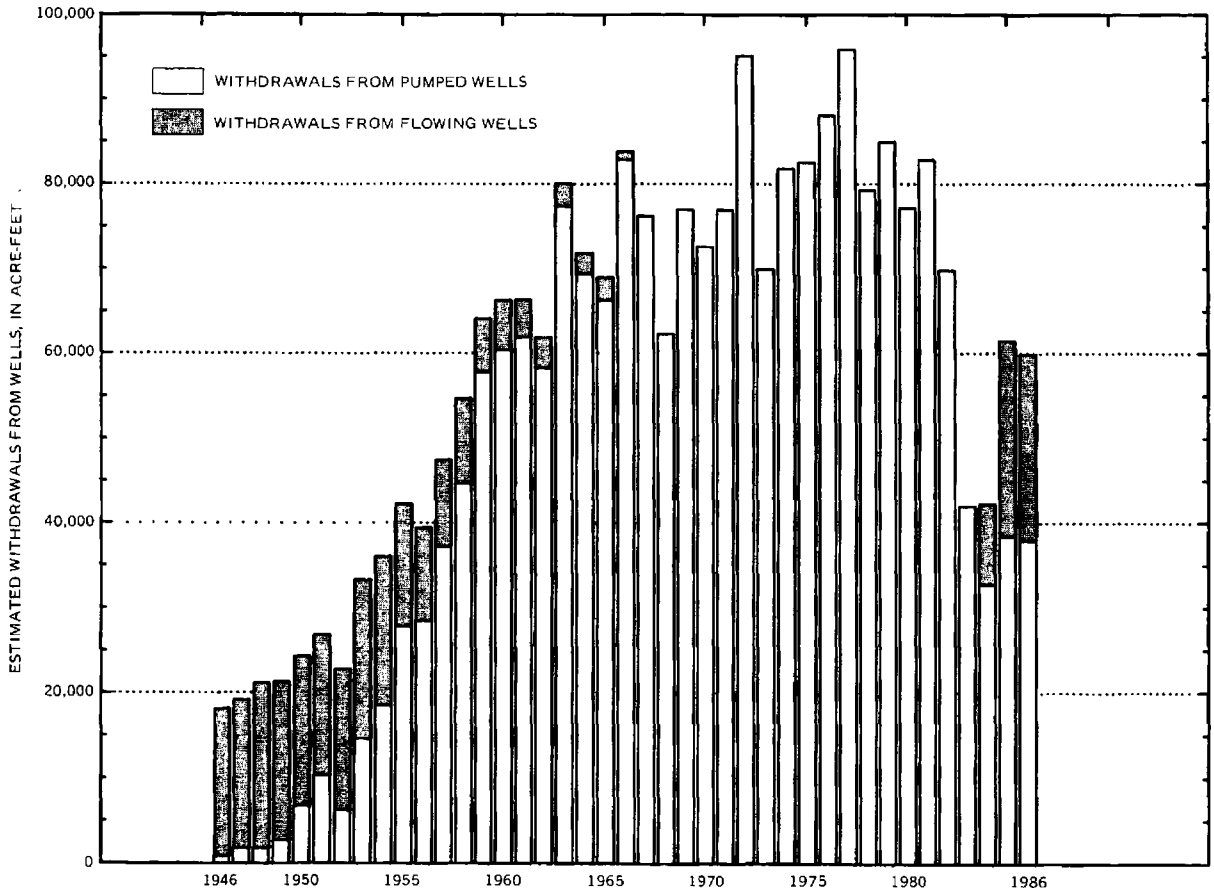


Figure 5. Estimated annual ground-water withdrawals, 1946-86, from pumped and flowing wells.

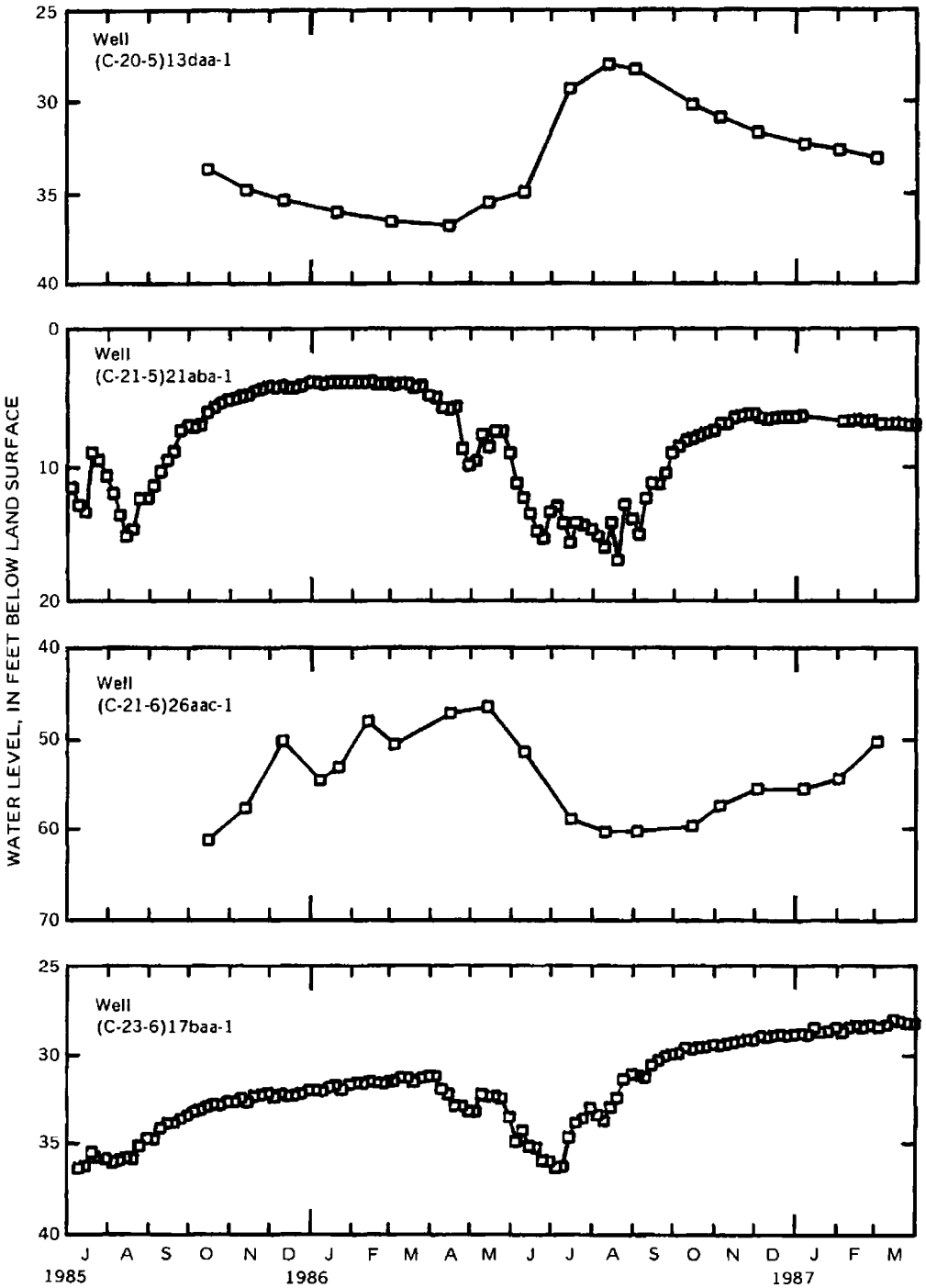


Figure 6.--Seasonal water-level fluctuations, July 1985 to April 1987, in four wells.

the canal are large (Enright, 1987, p. 3). Well (C-21-6)26aac-1 is located west of Flowell where water is diverted into the basalt. The highest water levels occur in the winter or spring when the quantity of water diverted into the basalt reaches its maximum.

Water levels in wells (C-21-5)21aba-1 and (C-23-6)17baa-1 have large seasonal fluctuations because of ground-water withdrawals for irrigation. Water levels in the two wells reach their highest levels at the end of March, and begin declining after the first part of April when irrigation begins. The water levels continue to decline through the summer months until the end of the main part of the irrigation season, normally between August and September. Water levels recover during the winter and early spring until the next irrigation season begins.

During the period of extensive pumping of ground water from the early 1950's to about 1980, a period of generally less-than-normal precipitation (fig. 3), water levels in some areas did not fully recover between irrigation seasons. Water-level declines of more than 50 feet occurred between 1953 and 1980 in some areas of Pahvant Valley. Most water levels recovered between 1983 and 1986 as a result of reduced withdrawals for irrigation and record quantities of precipitation. Hydrographs of eight representative wells showing long-term water-level fluctuations are shown in figure 7. Water-level changes from March 1960 to March 1986 are shown on plate 3.

Water levels in well (C-18-5)16bbc-1 near the northern boundary of the study area, about 3 miles north of McCornick, show only small fluctuations (less than 7 feet) over a period of 27 years. Water levels in well (C-19-4)30dab-1 show an almost steady decline from 1951 until about 1980 due to large withdrawals for irrigation. Water levels began to rise in 1983 due to record quantities of precipitation and less-than-normal withdrawals, and by 1986 more than one-half of the declines had been recovered.

In two wells near Flowell, (C-21-5)7cdd-2 completed in the basalt, and (C-21-5)21aba-1 completed in the unconsolidated basin fill, and one well near Meadow, (C-22-5)28dbd-1, the water levels generally declined until about 1965, they remained fairly consistent until 1983, then rose rapidly and fully recovered between 1983 and 1986. In well (C-21-6)26aac-1, completed in the basalt about 3.5 miles southwest of Flowell, water levels generally remained unchanged until 1983 when flood waters were diverted into the basalt near the well causing water levels to fluctuate with the quantity of water diverted into the basalt.

Water levels in well (C-23-6)10bdd-1, about 4.5 miles west-northwest of Kanosh, declined from 1953 to about 1968; they remained fairly constant other than seasonal fluctuations until about 1983, then rose rapidly in response to large amounts of recharge until 1986 when the water level was higher than predevelopment water levels. Water levels in well (C-23-6)20ccc-1, about 7 miles west of Kanosh, are similiar except that the water level has not fully recovered to the predevelopment level. Most of the recharge to this area is from Corn Creek to the east. Well 10bdd-1 is closer to the recharge area than well 20ccc-1 and, thus, has shown the largest rise.

Water-level measurements in Pahvant Valley in the spring of 1986 are generally higher than measurements in the spring of 1960 (pl. 3). Two areas

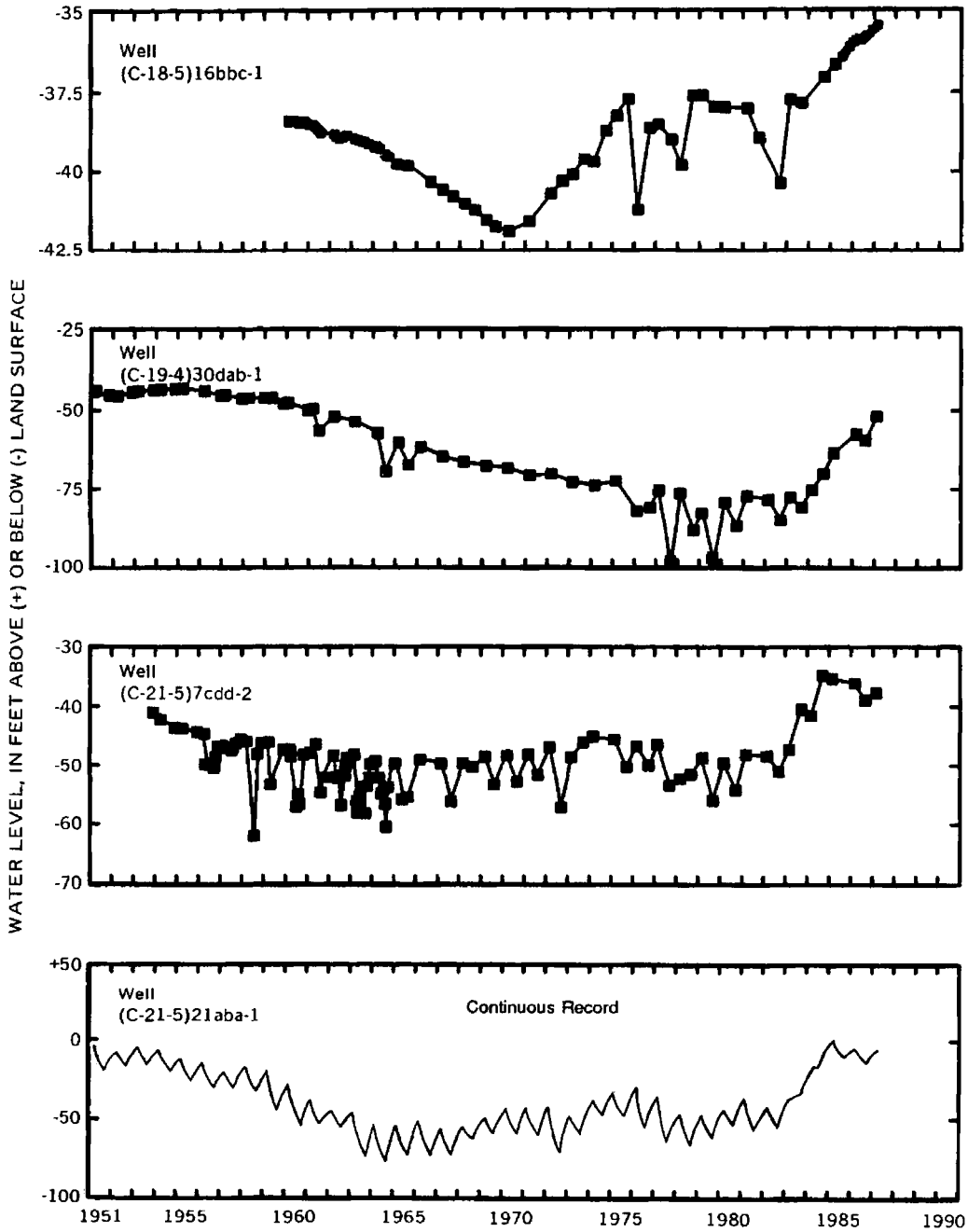


Figure 7.--Long-term water-level fluctuations, 1951-86, in eight wells.

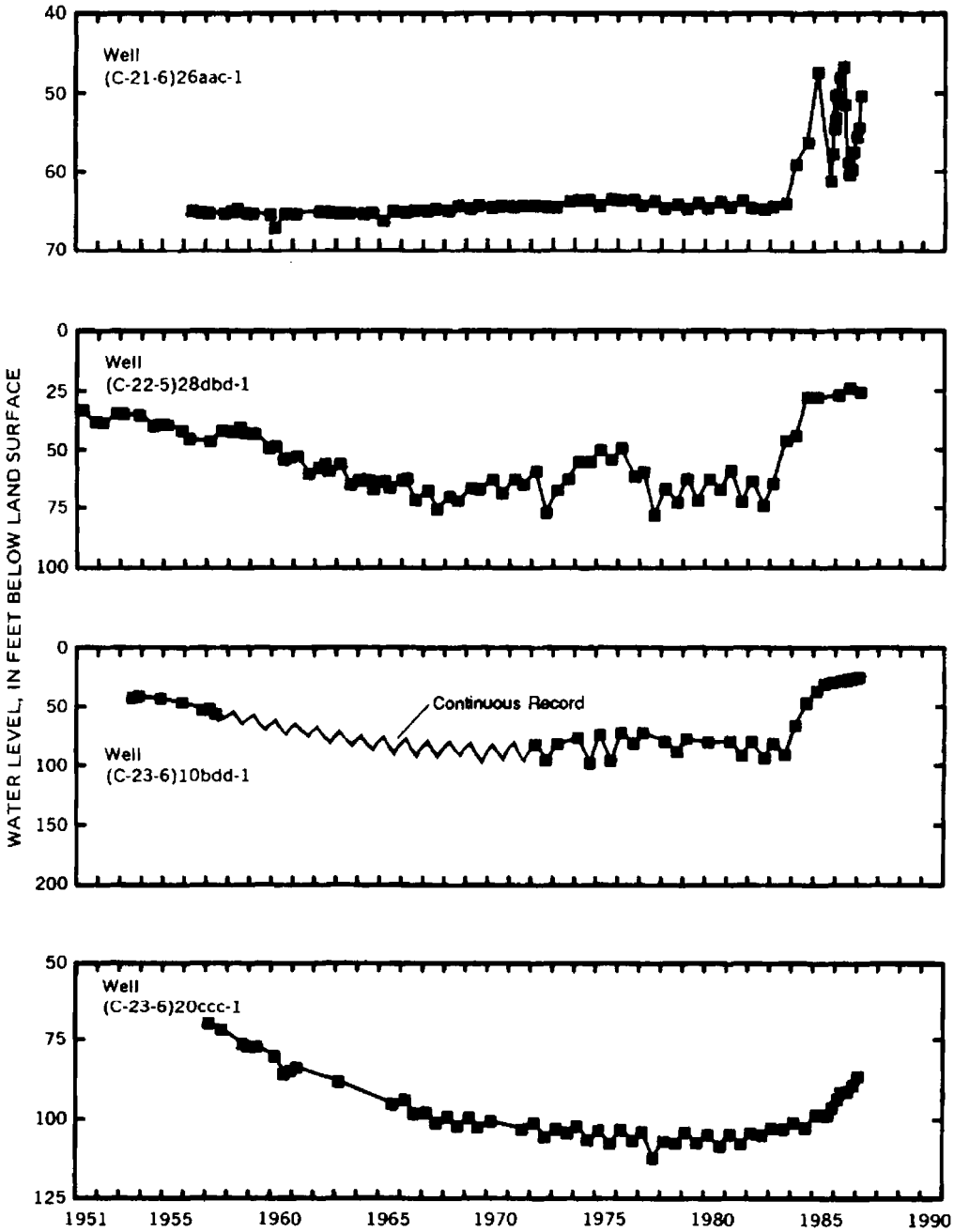


Figure 7.--Long-term water-level fluctuations, 1951-86, in eight wells--Continued.

of exception are in the northern part of Pahvant Valley near McCornick and in a small area west of Kanosh, where water levels have not fully recovered from large withdrawals during previous years. Water-level declines of similiar magnitude to those in the past (fig. 7), can be expected in the future with normal precipitation and large ground-water withdrawals.

Storage

The quantity of ground water in storage in the study area could not be determined with available data. Mower (1965, table 11) estimated 11,000,000 acre-feet of total ground water in storage in Pahvant Valley. Data for the area covered during this study, which is a much larger area than that used by Mower, are insufficient to make a meaningful estimate. Also, much of the ground water in the central and western parts of the study area is of poor quality and limited value, and is in fine-grained material which would yield little water to wells.

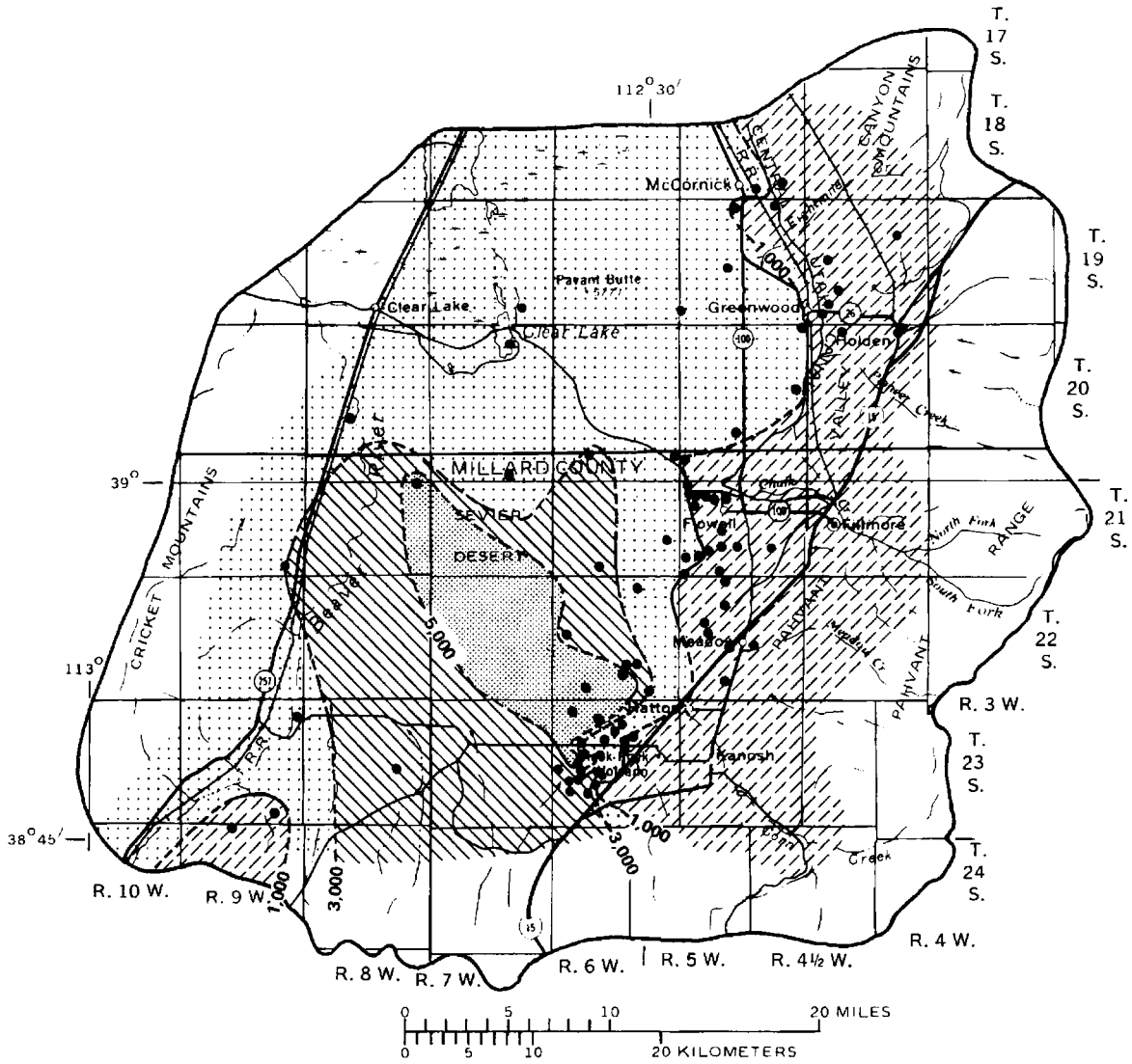
Quality of Ground Water

The chemical quality of water samples collected from ground-water sites in the study area is reported in Thiros (1988, tables 6 and 9). The quality of the water in the ground-water reservoir varies considerably.

Dissolved solids in water ranged from 300 milligrams per liter in well (C-19-4)17ccb-1 to 9,000 milligrams per liter in spring (C-22-6)34abd-S1. The water in the eastern part of the study area generally has dissolved-solids concentrations less than 1,000 milligrams per liter, while water in most of the remaining area has concentrations ranging from about 1,000 to 5,000 milligrams per liter. The largest concentrations of dissolved solids in wells in Pahvant Valley occur in the Kanosh farming district, about five miles west of the town of Kanosh, and in the area to the northwest of the farming district, where concentrations exceed 5,000 milligrams per liter. The water with smaller concentrations of dissolved solids is generally of the calcium magnesium bicarbonate type, while water with larger concentrations of dissolved solids is generally of the sodium chloride or sodium chloride sulfate type. Dissolved-solids concentrations in water samples from ground-water sites in 1985-87 are shown in figure 8.

The quality of ground water in some areas of Pahvant Valley has changed since large-scale withdrawals for irrigation began in about 1953. The largest changes have occurred in the Kanosh farming district, where dissolved-solids concentrations increased from about 2,000 to more than 6,000 milligrams per liter in water from some wells. The increase in the dissolved solids primarily is the result of an increase in sodium, chloride, and sulfate. Dissolved-solids concentrations in water from most wells in the district have decreased since 1983 as a result of greater-than-average precipitation and decreased ground-water withdrawals. Dissolved-solids concentrations in well (C-23-6)21bdd-1, located 5.25 miles west of the town of Kanosh, are shown in figure 9.

Handy and others (1969, p. D230) attributed the increase in dissolved solids in the Kanosh farming district to the recirculation of irrigation water, estimated to account for between 25 and 50 percent of the water that is pumped from wells; or the movement of poor quality water into the area from



EXPLANATION

—5,000--- LINE OF EQUAL DISSOLVED-SOLIDS CONCENTRATION--Dashed where approximately located. Interval, in milligrams per liter, is variable

DISSOLVED-SOLIDS CONCENTRATION

- 300 - 1,000 milligrams per liter
- 1,000 - 3,000 milligrams per liter
- 3,000 - 5,000 milligrams per liter
- 5,000 - 9,000 milligrams per liter
- NO DATA

• GROUND-WATER SITE--From which water was analyzed for dissolved-solids concentration

Figure 8.--Dissolved-solids concentrations in water samples from ground-water sites, 1985-87.

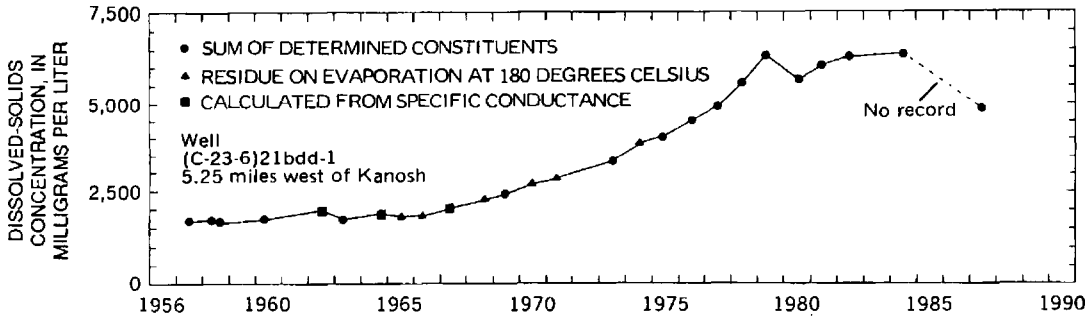


Figure 9.--Dissolved-solids concentrations in water from well (C-23-6)21bdd-1 near Kanosh, 1957-87.

north and west of the farming district. Hans Claassen and others (U.S. Geological Survey, written commun., 1987) also attributed the movement of poor quality water into the area from north and west of the farming district as the most likely explanation for the increase in dissolved solids. Water-level data were not available during the pumping season to verify the possibility.

In an effort to provide a better understanding of the source or cause of the increase in dissolved solids in the Kanosh area, water samples were collected as part of this project, and analyzed for major dissolved ions, dissolved nitrate plus nitrite, and hydrogen, oxygen, and carbon isotopes. Selected chemical analyses and results of the radioisotope analyses are given in table 1. The other analyses, as well as the historic water-quality data, are presented by Thiros (1988, tables 5-7 and 9).

The relation of sulfate and chloride in 136 ground-water samples collected in the Kanosh farming district between 1957 and 1987 is shown in figure 10. The data can be divided into three groups that describe linear relations of sulfate and chloride in three general areas, the southeastern, northern, and southwestern parts of the district. The division of the farming district into these three areas containing ground water with similar sulfate to chloride ratios, and the direction of ground-water movement in the spring of 1986 are shown in figure 11.

Ground water in the southeastern part of the district represents subsurface recharge water moving into the district from the Corn Creek area on the east. The water generally has small concentrations of dissolved solids (less than 1,000 milligrams per liter) and a sulfate to chloride ratio of about 1.2. Ground water in the southwestern part of the area generally has large concentrations of dissolved solids (greater than 1,500 milligrams per liter) and a sulfate to chloride ratio of about 0.34. Ground water in the northern part of the area, including discharge from warm springs in the northeastern part, generally has large dissolved-solids concentrations and a sulfate to chloride ratio of about 0.52. There are no water-quality samples from wells west of the farming district.

Table 1.--Chemical analyses for sulfate, chloride, nitrogen, and radioisotopes in water from selected wells and springs

[mg/L, milligrams per liter; permil, parts per thousand; pCi/L, picocuries per liter; --, no data; <, less than]

Location: For an explanation of the numbering system, see section on numbering system for hydrologic-data sites. Dashes (--), no data

Location	Date	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	C-13 / C-12 Stable isotope ratio permil	H-2 / H-1 Stable isotope ratio permil	O-18 / O-16 Stable isotope ratio permil	Tritium, total (pCi/L)
(C-20-7) 2ccd-S1	08-29-85	--	--	--	--	--	--	11
	08-29-85	--	--	--	--	--	--	18
(C-21-5)31cdd- 2	08-29-85	--	--	--	--	--	--	8.0
(C-21-6) 1ddb- 1	08-29-85	--	--	--	--	--	--	84
(C-21-8)12dcc- 1	07-30-87	1,300	4,200	0.360	-7.5	-112.0	-13.5	<0.3
(C-22-6)35ddb-S1	09-10-85	--	--	--	--	--	--	<1.0
(C-23-6)10ccc- 2	07-29-87	310	480	0.980	-6.5	-122.0	-16.2	<0.3
(C-23-6)15baa- 1	07-30-87	170	300	3.60	-9.1	-119.0	-15.9	55
(C-23-6)15bda- 1	07-29-87	68	130	3.80	-9.3	-119.0	-16.1	13
(C-23-6)17cdc- 1	07-29-87	1,000	2,800	1.90	-5.1	-119.0	-15.4	6.0
(C-23-6)17dad- 1	08-29-85	--	--	--	--	--	--	15
(C-23-6)21bdd- 1	07-29-87	390	1,700	21.0	-6.5	-120.0	-15.6	17
(C-24-4.5)4abb- 1	07-29-87	47	65	0.380	-10.3	-122.0	-16.4	33

The relation of sulfate and chloride in three wells in the northern, southeastern, and southwestern parts of the Kanosh farming district are shown in figure 12. The sulfate to chloride ratio in each of the wells has generally remained unchanged since sampling began in 1957, even though the sulfate and chloride concentrations have increased dramatically. A linear relation between sulfate and chloride in all three areas suggests the water has undergone evaporative concentration.

Water from some wells located near the boundaries of the areas shown in figure 11, such as well (C-23-6)21bdd-1, have fluctuating sulfate to chloride ratios (Thiros, 1988, table 6). During periods of less-than-normal precipitation and large ground-water withdrawals, such as 1975-77, water from well (C-23-6)21bdd-1 had a sulfate to chloride ratio of less than 0.4, while during periods of greater-than-normal precipitation and small ground-water withdrawals, such as 1982-85, the water had a sulfate to chloride ratio of greater than 0.5. During periods of less-than-normal precipitation and large ground-water withdrawals, more ground water from the southwest and possibly the west, with a lower sulfate to chloride ratio, moves into the aquifer at this location, causing a decline in the sulfate to chloride ratio.

The isotopic relation between deuterium and oxygen 18, carbon 13 and chloride, oxygen 18 and chloride, deuterium and chloride, and tritium and chloride is shown in figure 13 for five samples collected in the Kanosh farming district in 1987. The deuterium and oxygen 18 data for the Kanosh farming district plots to the right of the Colorado meteoric water line (Claassen, 1986) and the best-fit line describing the data has a slope of

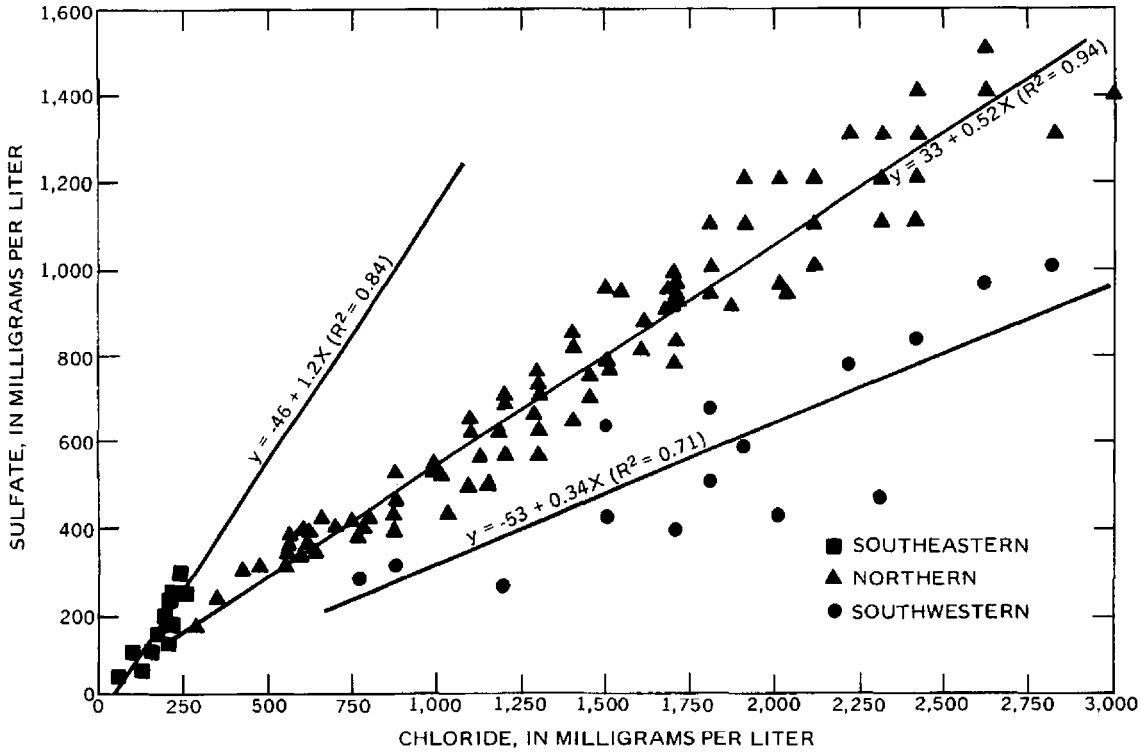


Figure 10.--Relation of sulfate and chloride in ground-water samples from the southeastern, northern, and southwestern parts of the Kanosh farming district.

about two, which is consistent with surface water that has undergone evaporation (Tyler Coplen, U.S. Geological Survey, written commun., 1987). The regression lines of carbon 13 and chloride, oxygen 18 and chloride, and deuterium and chloride show increasing isotopic weight along the general direction of ground-water flow (fig. 11).

Large amounts of tritium were added to the atmosphere from 1952 to the mid-1960's, produced by the atmospheric testing of thermonuclear weapons. By 1963, tritium levels had increased by approximately three orders of magnitude over that of prebomb natural levels of about 26 picocuries per liter (pCi/L) (Thatcher and others, 1977, p. 8). It was concluded by Coplen (written commun., 1987) that water with a tritium content less than 3.2 pCi/L was not recharged to an aquifer after 1952. An increase in tritium concentrations along the ground-water flow direction would be expected if recycling of irrigation water since the mid-1950's were the primary cause of the increased dissolved solids. The tritium concentrations in five samples ranged from less

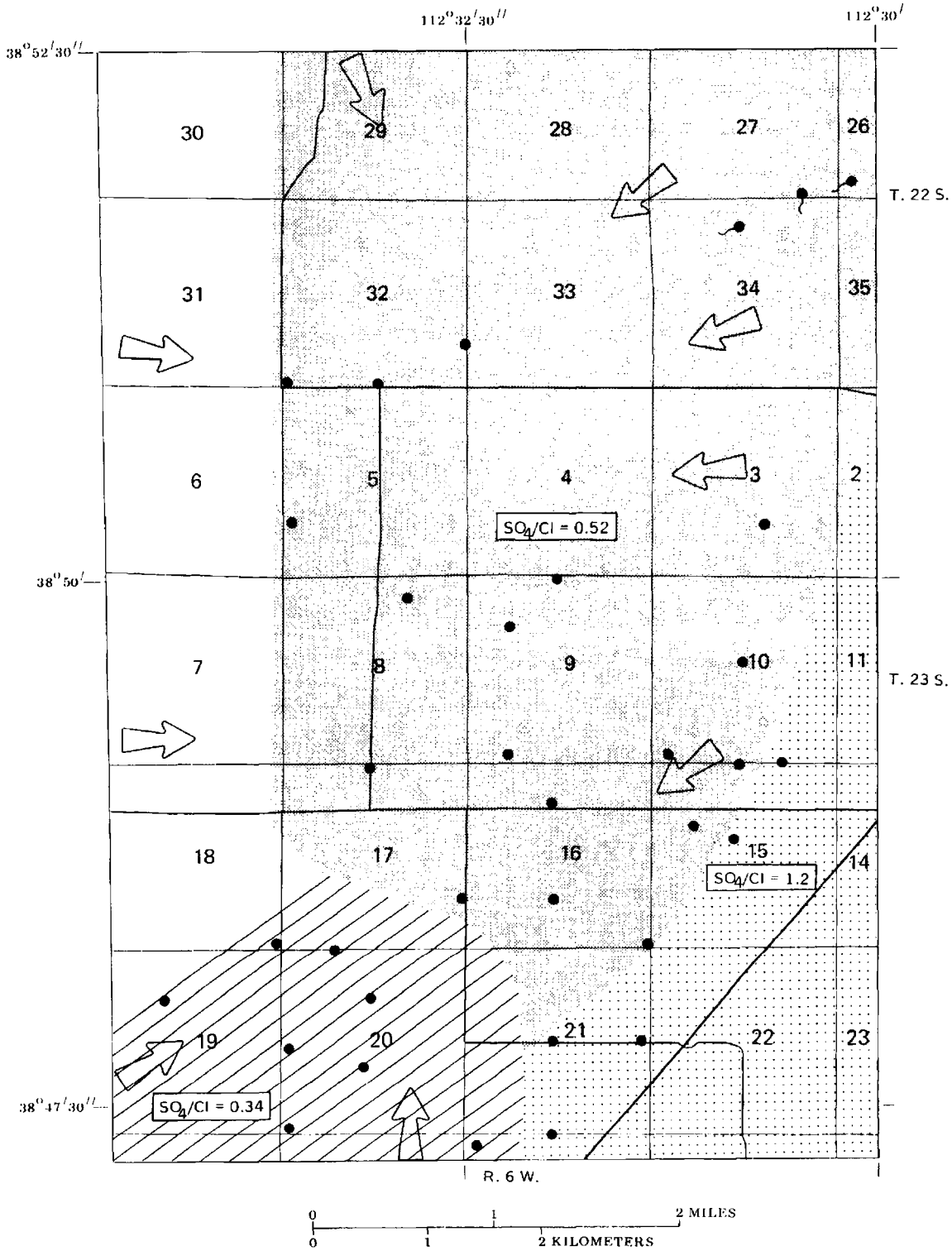


Figure 11.--Areas of generally similar sulfate to chloride ratios (SO_4 /Cl) and arrows showing direction of ground-water flow in the spring of 1986, in the Kanosh farming district.

EXPLANATION FOR FIGURE 11

AREA WHERE SULFATE TO CHLORIDE RATIO IS ABOUT 0.34

AREA WHERE SULFATE TO CHLORIDE RATIO IS ABOUT 0.52

AREA WHERE SULFATE TO CHLORIDE RATIO IS ABOUT 1.2

WELL FROM WHICH SULFATE TO CHLORIDE RATIO HAS BEEN CALCULATED

SPRING FROM WHICH SULFATE TO CHLORIDE RATIO HAS BEEN CALCULATED

DIRECTION OF GROUND-WATER FLOW IN SPRING 1986

ROAD

than 0.3 to 55 pCi/L and generally decreased as the water moved down the hydraulic gradient (fig. 13). Thus, the relation of tritium and chloride does not indicate evaporative concentration of post-1952 irrigation water.

Nitrogen, from the application of fertilizers, can sometimes be used as an indicator of recycled irrigation water. Results from eight samples collected in the southeastern part of the district indicate increases in chloride may be related to increases in dissolved nitrate plus nitrite. In the southwestern part (9 samples) and northern part (49 samples) of the area, where the largest increases in dissolved solids have occurred, results do not indicate any relation between the increase in chloride and an increase in dissolved nitrate plus nitrite. This would indicate that irrigation return flow in the southwestern and northern parts of the district is not the dominant cause of an increase in dissolved-solids concentrations in water from wells.

Water from some wells in the southwestern and northern parts of the district contained greater than 10 micrograms per liter of dissolved selenium. Water from wells sampled in the southeastern part of the district contained dissolved selenium concentrations of less than 10 micrograms per liter. A relation between selenium and chloride was not indicated by these limited data.

Based on the above observations, it is probable that the primary cause of deterioration in water quality in the southwestern and northern parts of the Kanosh farming district is the movement of water from the southwest and possibly the west into the aquifer during periods of large ground-water withdrawals. The water contains large concentrations of dissolved solids and selenium, small concentrations of nitrogen, and very little tritium. The deterioration of water quality in the southeastern part of the area may be the result of concentration by recycling of irrigation water and mixing of recharge water from the east with isotopically heavy water from the southwest and possibly the west.

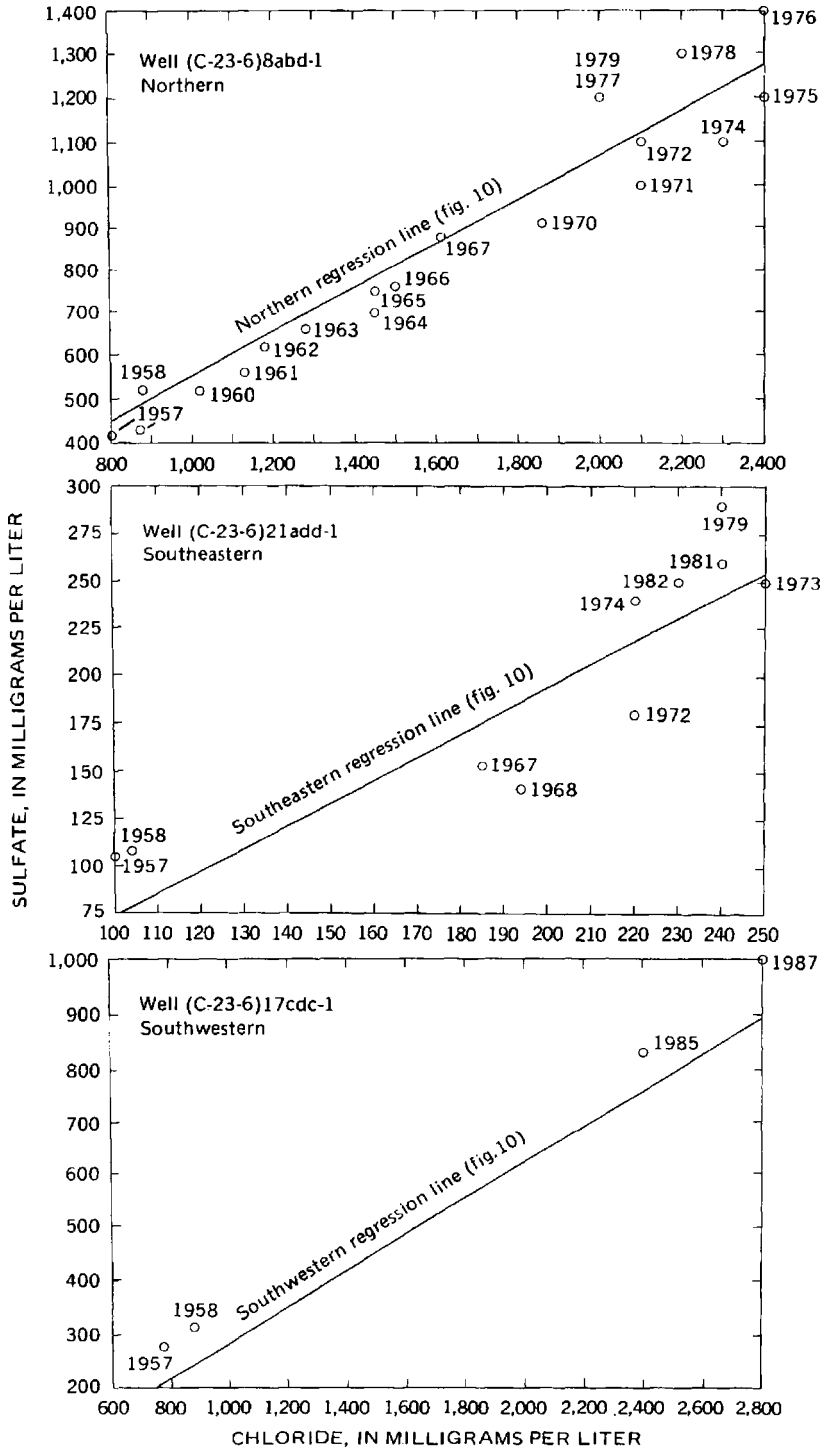


Figure 12.--Relation of sulfate and chloride in water samples from three wells in the northern, southeastern, and southwestern parts of the Kanosh farming district, showing year sample was taken.

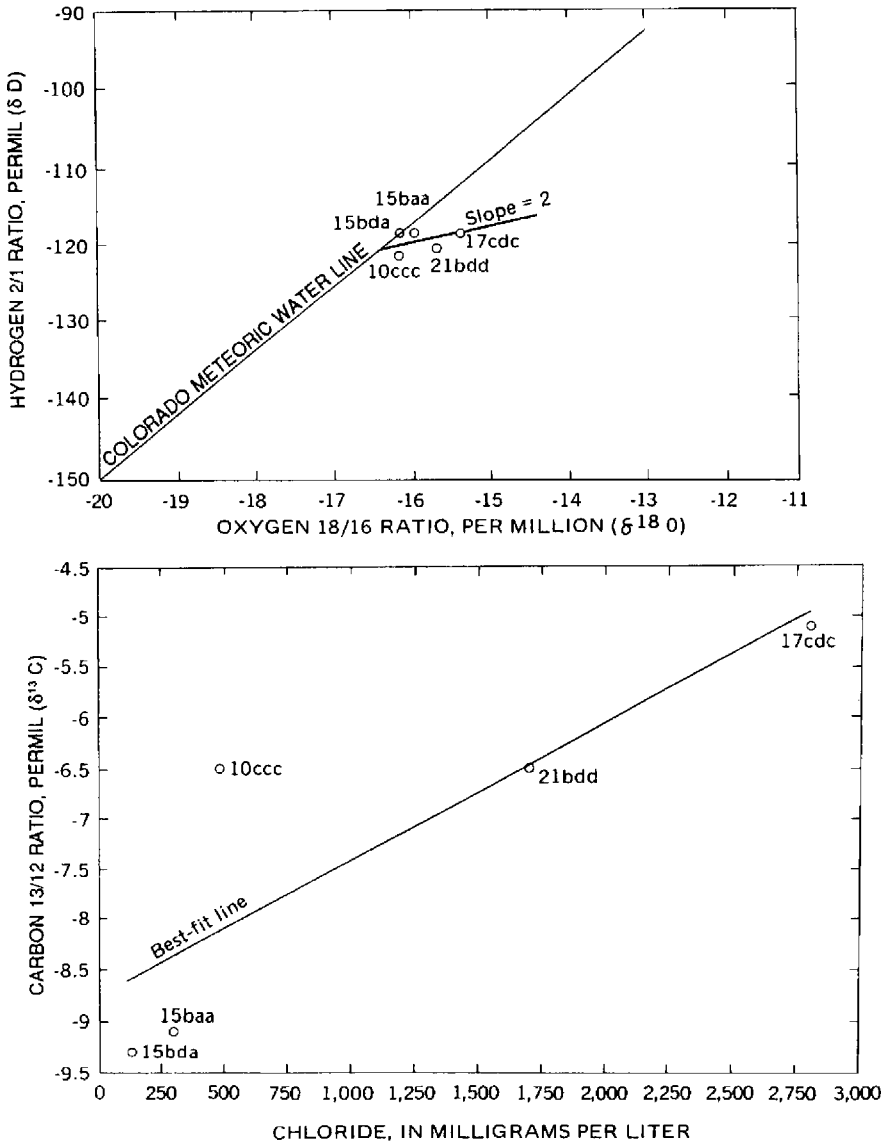


Figure 13.--Relation of deuterium to oxygen 18, and carbon 13, oxygen 18, deuterium, and tritium to chloride from sampled wells in the Kanosh farming district (T. 23 S., R. 6 W.).

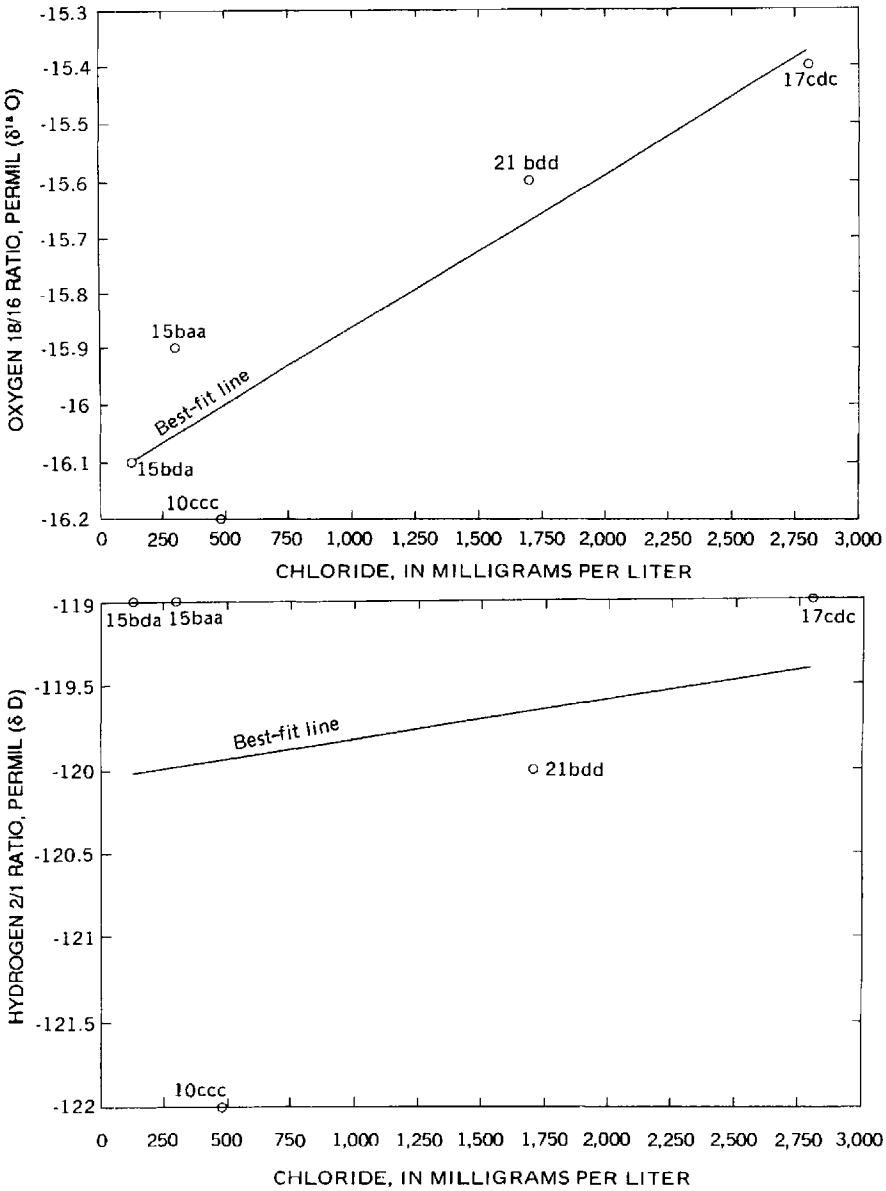


Figure 13.--Relation of deuterium to oxygen 18, and carbon 13, oxygen 18, deuterium, and tritium to chloride from sampled wells in the Kanosh farming district (T. 23 S., R. 6 W.)--Continued.

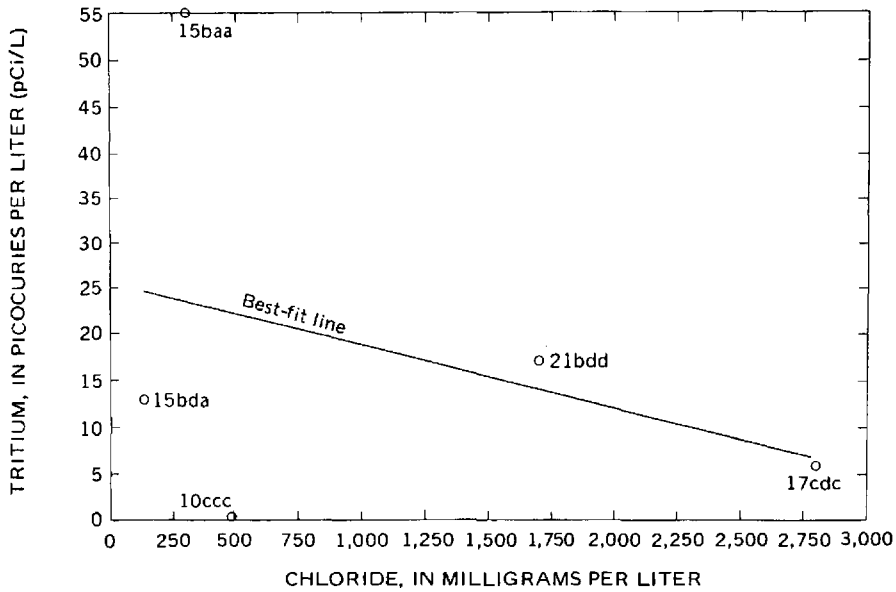


Figure 13.--Relation of deuterium to oxygen 18, and carbon 13, oxygen 18, deuterium, and tritium to chloride from sampled wells in the Kanosh farming district (T. 23 S., R. 6 W.)--Continued.

Projected Effects of Future Ground-Water Withdrawals and Loss of Recharge from the Central Utah Canal Using a Digital-Computer Model

A digital-computer model was used to simulate the principal ground-water reservoir of Pahvant Valley and the surrounding area. The model is a finite-difference ground-water flow model documented in McDonald and Harbaugh (1988), including a complete program listing. The model was used to project future changes in the ground-water system assuming various ground-water development options. In addition, the model was used to project the effects of the loss of recharge from the Central Utah Canal.

Model Design and Construction

A block-centered grid with variable grid spacing was used to model Pahvant Valley and the surrounding area. The grid consisted of 58 rows and 35 columns. Four layers were used to represent the unconsolidated basin fill and interbedded basalt making a total of 8,120 nodes of which about 6,360 were active. The area covered by individual nodes ranged from 0.25 square mile where many observation wells were located or where the change in water levels over a short distance is large, to about 4.3 square miles where data were

sparse or water-level changes and withdrawals were minimal. The model grid and information on the uppermost model layer are shown in plate 4, a generalized geologic section showing lithology and divisions of the ground-water reservoir into model layers in the Flowell area is given in figure 14, and the boundaries of each layer are shown in figures 15 to 18.

The first layer of the model initially represents the approximate upper 50 feet of saturated deposits. The water in the first layer is unconfined and the layer serves as a temporary storage reservoir for areally distributed recharge which may move into lower aquifers or be discharged from the layer by evapotranspiration or discharge to drains or springs. Changes in the balance between recharge and discharge can cause the saturated thickness to vary from the initial 50 feet.

The second layer of the model represents the next 100 feet (depth of 50 to 150 feet) of saturated deposits. Near the mountain fronts and extending for several miles toward the central part of the basin, the layer represents more permeable material. In the central part of the study area, the layer represents basalt that is interbedded with the unconsolidated basin fill. In areas adjacent to and extending for several miles west of the basalt, the layer represents a fine-grained confining unit.

The third layer of the model represents basin fill at depths of between 150 and 350 feet. Most ground-water withdrawals in the study area are from depths represented by the third layer in the model.

The fourth layer generally represents the poorly to moderately consolidated, somewhat permeable part of the Sevier River Formation. The aggregate thickness of the formation probably exceeds 800 feet (Mower, 1965, p. 19), which, except in some areas where the deposits have been reworked (Mower, 1965, p. 31), is relatively impermeable. The formation crops out at several locations within Pahvant Valley and may occur at very shallow depths at other locations.

The boundaries of the model include no-flow boundaries on the southwest, northeast, and east, represented by zero values of hydraulic conductivity or transmissivity in figures 15 to 18, and a no-flow boundary at the base of the model that corresponds approximately to the contact between the permeable, unconsolidated basin fill and reworked Sevier River Formation, and the relatively impermeable lower part of the Sevier River Formation (fig. 14 and Mower, 1965, p. 20). A number of no-flow nodes located in the interior of the model represent outcrops of the Sevier River Formation which forms the cores of several hills in the central part of Pahvant Valley. No-flow boundaries on the southern and southwestern borders of the study area represent consolidated rocks, which are relatively impermeable and do not contain substantial quantities of water (Mower, 1965, p. 20). The northwestern boundary of the model is a constant-head boundary (pl. 4) that simulates flow from the study area, primarily through fine-grained unconsolidated basin fill of low permeability, toward the areas of lower elevation in the Sevier Desert.

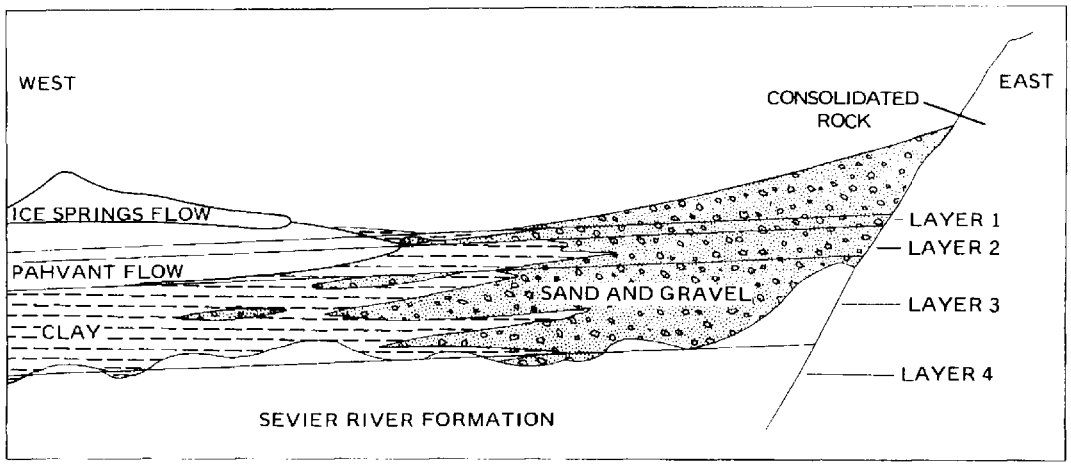


Figure 14.--Generalized geologic section showing lithology and divisions of the ground-water reservoir into model layers in the Flowell area.

Data Input

Data input to the model include initial water levels, areally distributed recharge, transmissivity or hydraulic conductivity, storage properties, confining-bed properties, evapotranspiration rates and depths of extinction, conductance terms for the interface between drains and porous material, and well discharge.

Initial water levels from wells in Pahvant Valley, representing conditions prior to about 1952 before large-scale withdrawals of irrigation water, were obtained primarily from Dennis and others (1946, pl. 1 and p. 85-96). Data from Livingston and Maxey (1944) and Mower (1965), as well as water levels reported in drillers' logs, also were used for initial water levels.

Areally distributed recharge used in the model includes seepage from streams, the Central Utah Canal, unconsumed irrigation water, and infiltration from precipitation. The quantities of recharge from these sources primarily are based on estimates reported for 1959 by Mower (1965, table 9). Recharge from unconsumed irrigation water increased after 1959 because of increased irrigation. The distribution of recharge from the various sources used in the steady-state model is shown on plate 4.

Hydraulic properties of the basin fill are based on results of aquifer tests reported by Mower (1965, table 8), Dennis and others (1946, p. 65), and descriptions of materials from drillers' logs. The simulated values do not always agree with the reported values derived from aquifer tests. The simulated values represent an average for a specific node and layer, which may not be the same interval represented by the aquifer test.

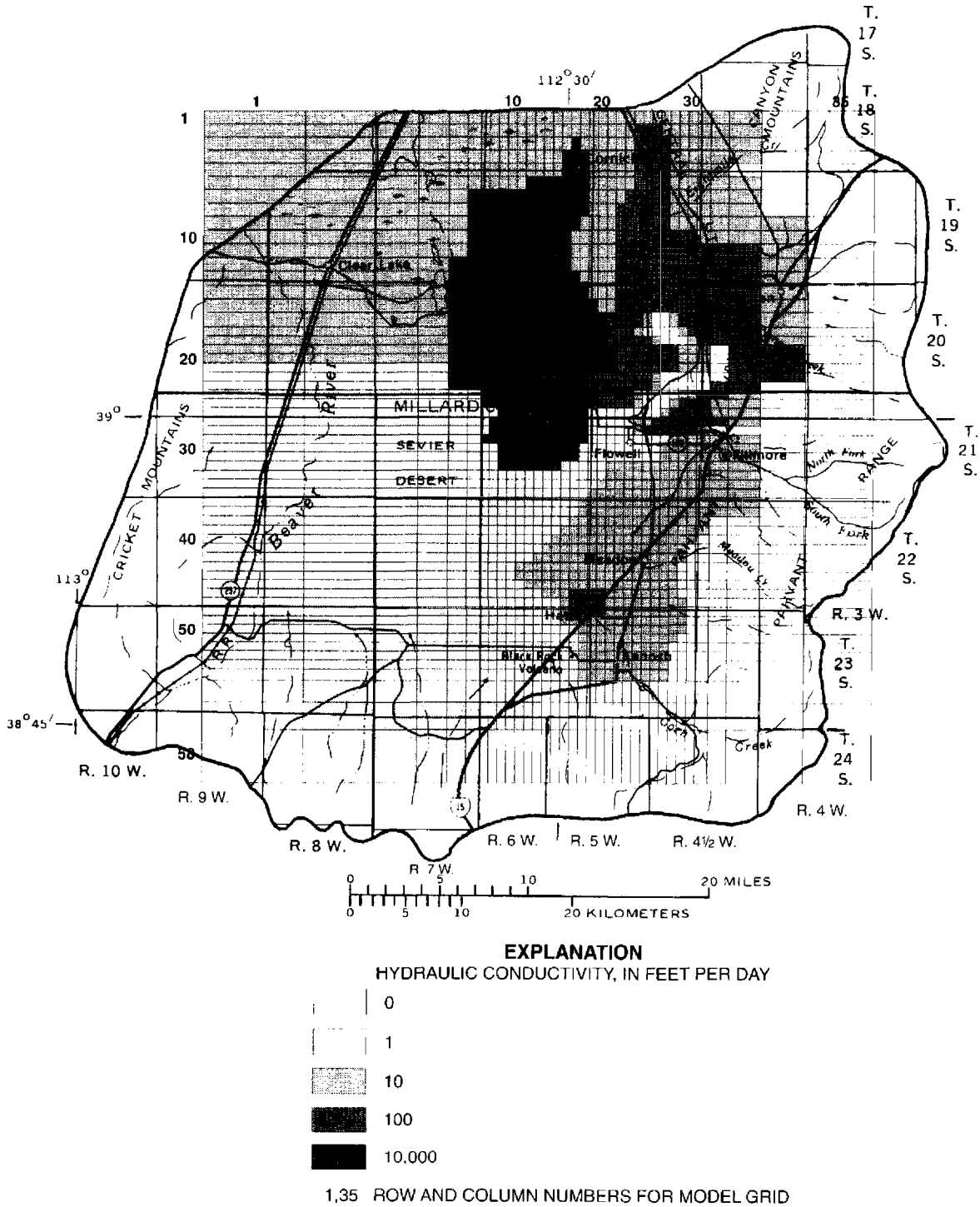
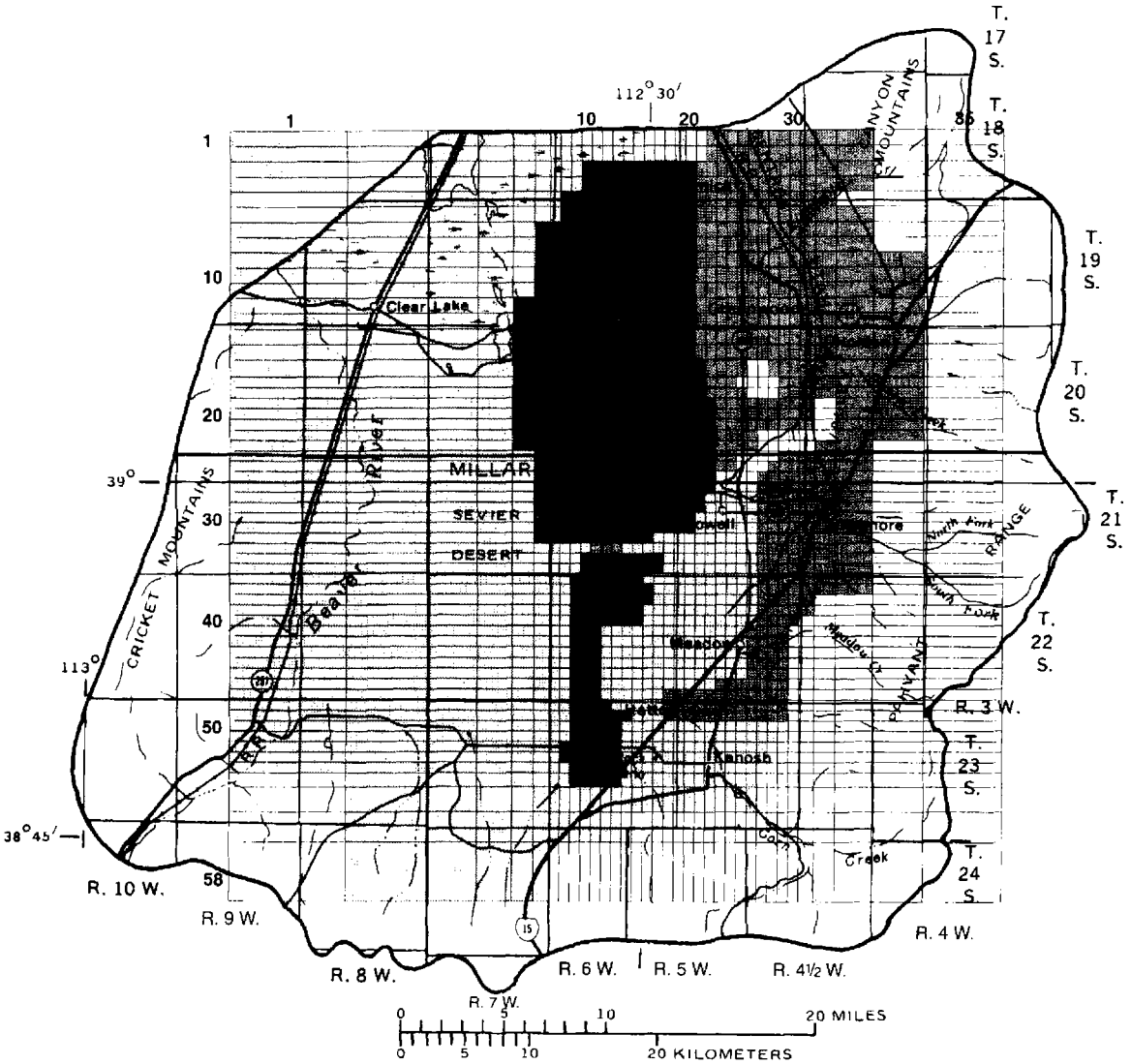


Figure 15.--Distribution of hydraulic conductivity used in layer 1 of the digital-computer model.



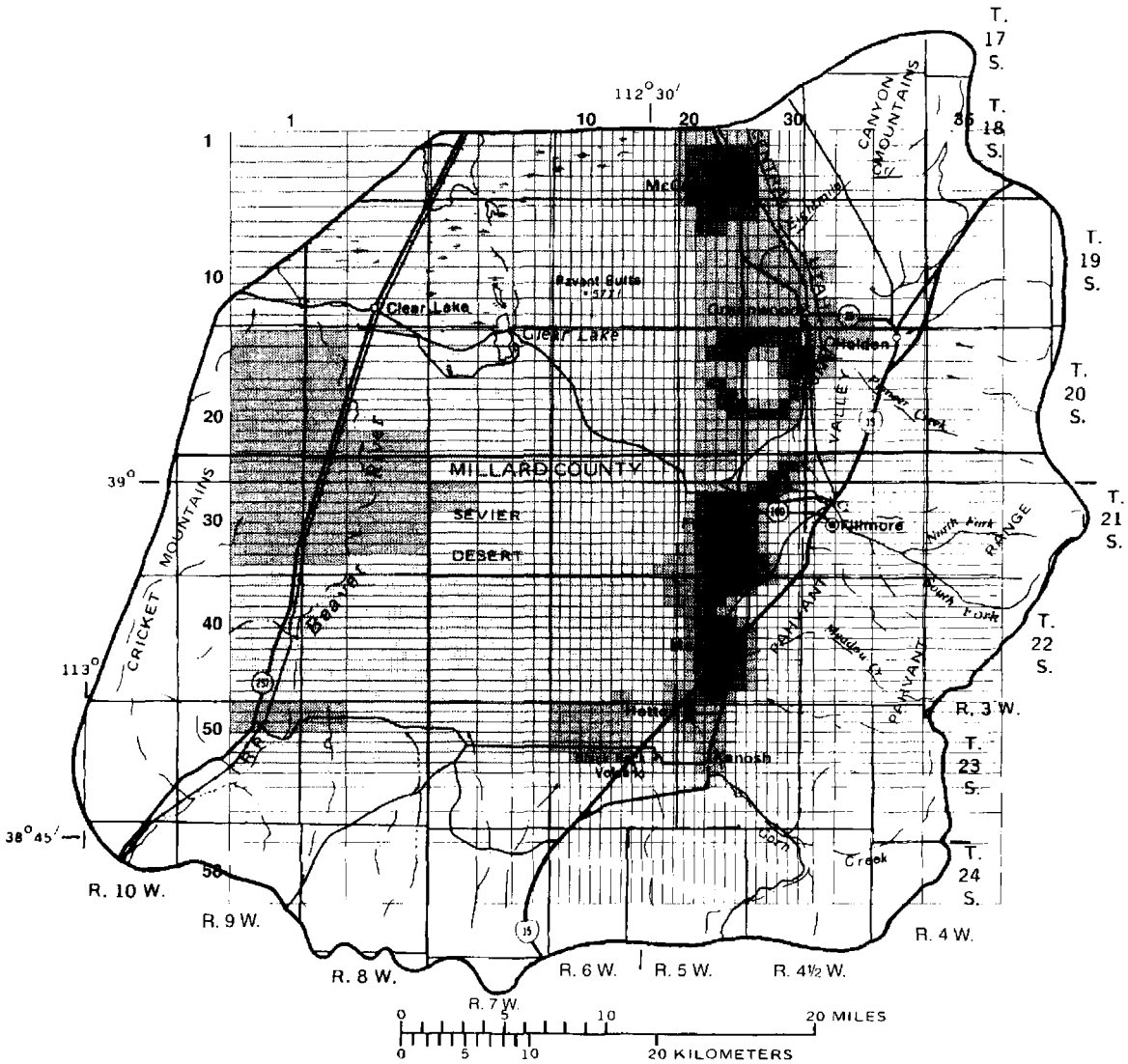
EXPLANATION

TRANSMISSIVITY, IN FEET SQUARED PER DAY

- 0
- 130
- 1,300
- 130,000

1,35 ROW AND COLUMN NUMBERS FOR MODEL GRID

Figure 16.--Distribution of transmissivity used in layer 2 of the digital-computer model.



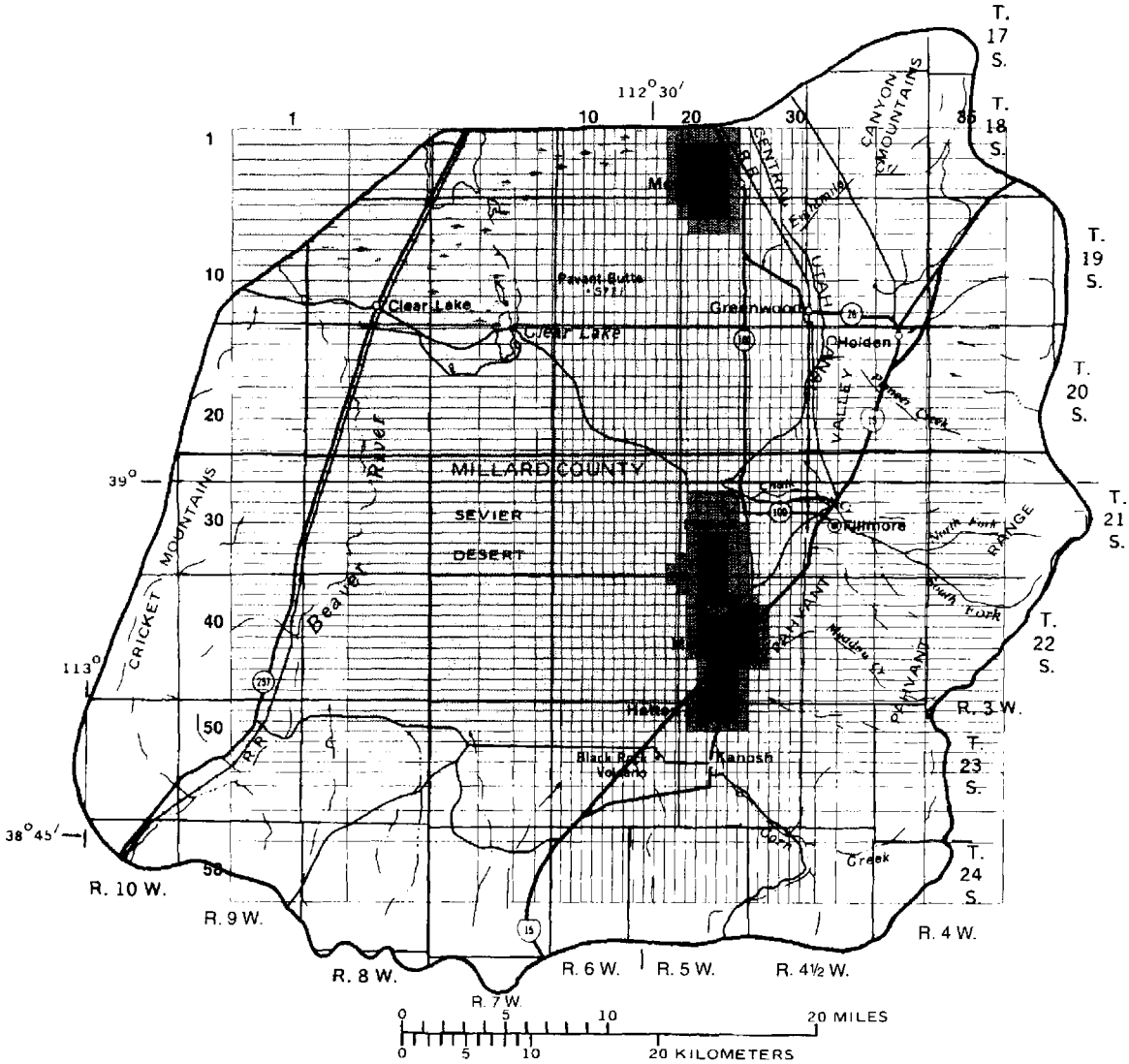
EXPLANATION

TRANSMISSIVITY, IN FEET SQUARED PER DAY

- 0
- 130
- 1,300
- 13,000
- 27,000

1,35 ROW AND COLUMN NUMBERS FOR MODEL GRID

Figure 17.--Distribution of transmissivity used in layer 3 of the digital-computer model.



EXPLANATION

TRANSMISSIVITY, IN FEET SQUARED PER DAY

- 0
- 130
- 1,300
- 13,000

1,35 ROW AND COLUMN NUMBERS FOR MODEL GRID

Figure 18.--Distribution of transmissivity used in layer 4 of the digital-computer model.

The hydraulic conductivity values used in the model for layer 1 (fig. 15) were generally set at 1 foot and 10 feet per day in most of the study area where the basin fill consists of clay, silt, or fine sand. A value of 10,000 feet per day was used where the fill was basalt, and 10 and 100 feet per day was used near the mountain fronts where the fill was mostly sand and gravel.

The transmissivity of layer 2 (fig. 16) in most of the area was set at 130 feet squared per day. In the basalt, the transmissivity was set at 130,000 feet squared per day, and near the mountain fronts, the transmissivity was set at 1,300 feet squared per day.

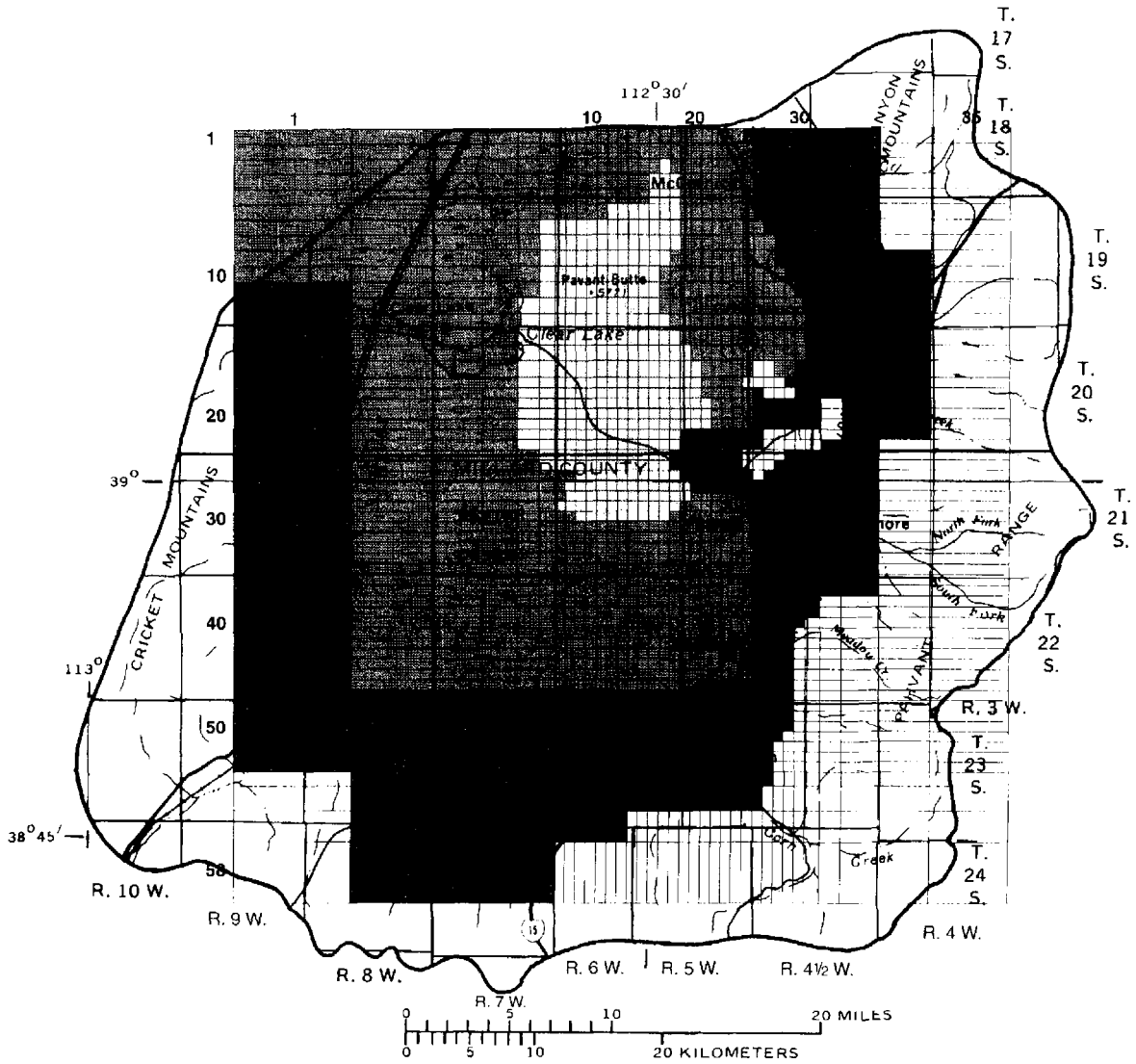
The transmissivity of layer 3 (fig. 17) was generally set at 13,000 and 27,000 feet squared per day in the central part of Pahvant Valley where the basin fill is generally well sorted sand and gravel; 130 feet squared per day west of Pahvant Valley; and 130 and 1,300 feet squared per day on the eastern side of Pahvant Valley. Layer 3 represents the most heavily pumped part of the basin fill.

The transmissivity of layer 4 (fig. 18) was generally set at 130 feet squared per day, which is thought to represent the upper part of the Sevier River Formation. Two areas were assigned values of 1,300 and 13,000 feet squared per day and are thought to be more permeable reworked material from the Sevier River Formation.

The specific yield in layer 1 (fig. 19) was set at 0.30 above an elevation of about 4,800 feet, where the materials primarily consist of sand and gravel. Below an elevation of 4,800 feet in layer 1, where the materials primarily are silt and clay, a specific yield of 0.20 was used. Below an elevation of about 4,800 feet, where the materials are primarily basalt of the Pahvant flow, a value of 0.06 was used.

The primary storage coefficient in layer 2 was set at an artesian value of 0.001. When the water level in a confined cell in layer 2 falls below the top of the cell, the model uses a secondary storage term representing specific yield. The secondary storage terms representing specific yield were set equal to the specific yield in layer 1 (fig. 19). The storage coefficient of layer 3 and layer 4 was set at an artesian value of 0.00005.

The vertical conductance terms used in the model were initially estimated from aquifer tests in the Sevier Desert, about 30 miles north of the study area (Holmes and Wilberg, 1982). These values were adjusted during the calibration procedure. Vertical conductance is calculated within the model by multiplying the vertical leakance term, which incorporates both vertical hydraulic conductivity and thickness, and the horizontal cell area (McDonald and Harbaugh, 1988, p. 5-12). The final values of vertical leakance in active nodes ranged from a low of 7.7×10^{-11} sec^{-1} in the central part of the area between layers 2 and 3 to a high of 3.1×10^{-6} sec^{-1} near the mountain fronts between layers 1 and 2. The vertical leakance between layers 3 and 4 was set at 2.3×10^{-7} sec^{-1} throughout the modeled area. The final distribution of vertical leakance between layers 1 and 2 and between layers 2 and 3 is shown in figures 20 and 21.



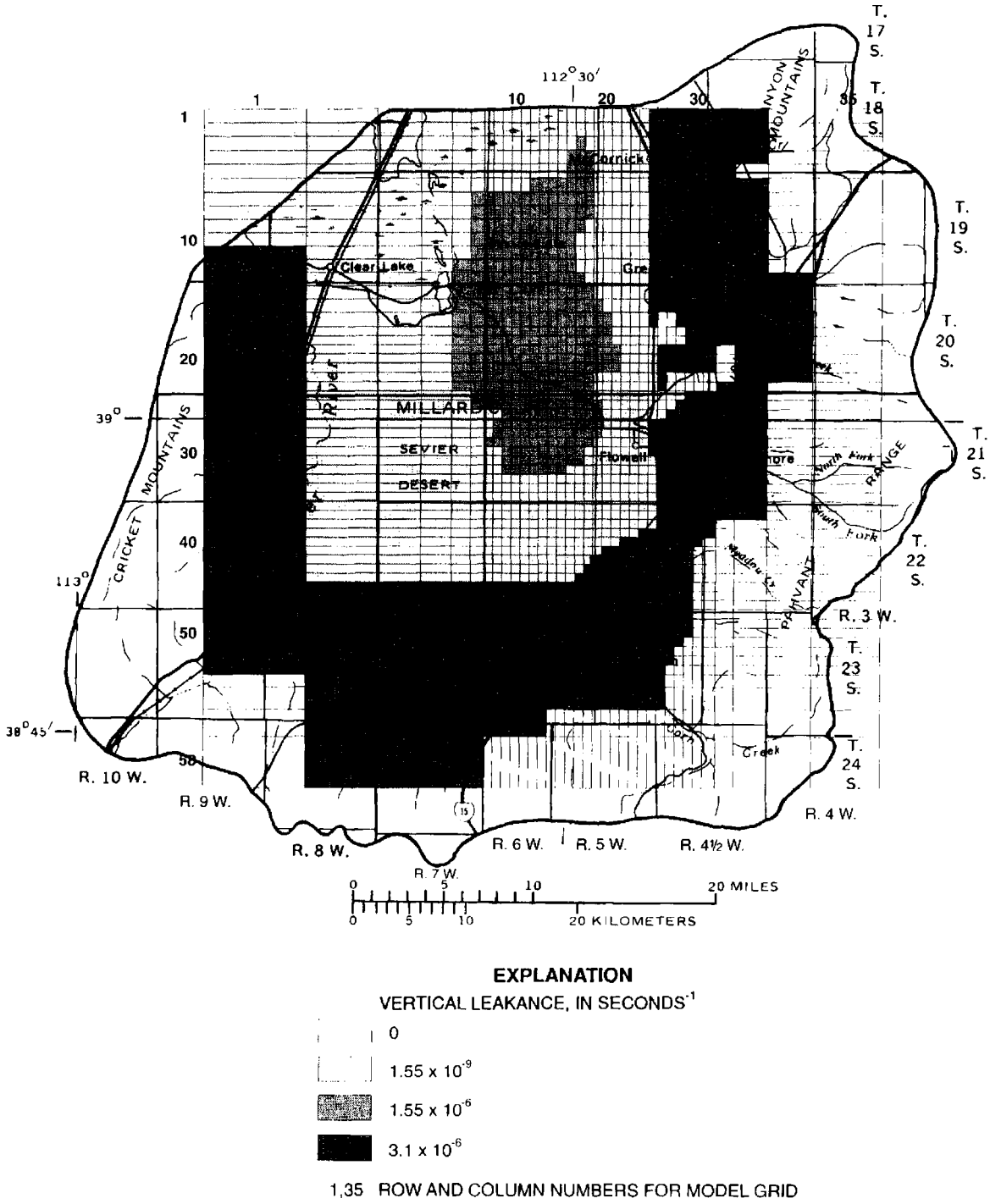
EXPLANATION

SPECIFIC YIELD

- 0
- 0.06
- 0.20
- 0.30

1,35 ROW AND COLUMN NUMBERS FOR MODEL GRID

Figure 19.--Distribution of specific yield used in layer 1 of the digital-computer model.



EXPLANATION

VERTICAL LEAKANCE, IN SECONDS^{-1}

- 0
- 1.55×10^{-9}
- 1.55×10^{-6}
- 3.1×10^{-6}

1,35 ROW AND COLUMN NUMBERS FOR MODEL GRID

Figure 20.--Distribution of vertical leakance between layers 1 and 2 used in the digital-computer model.

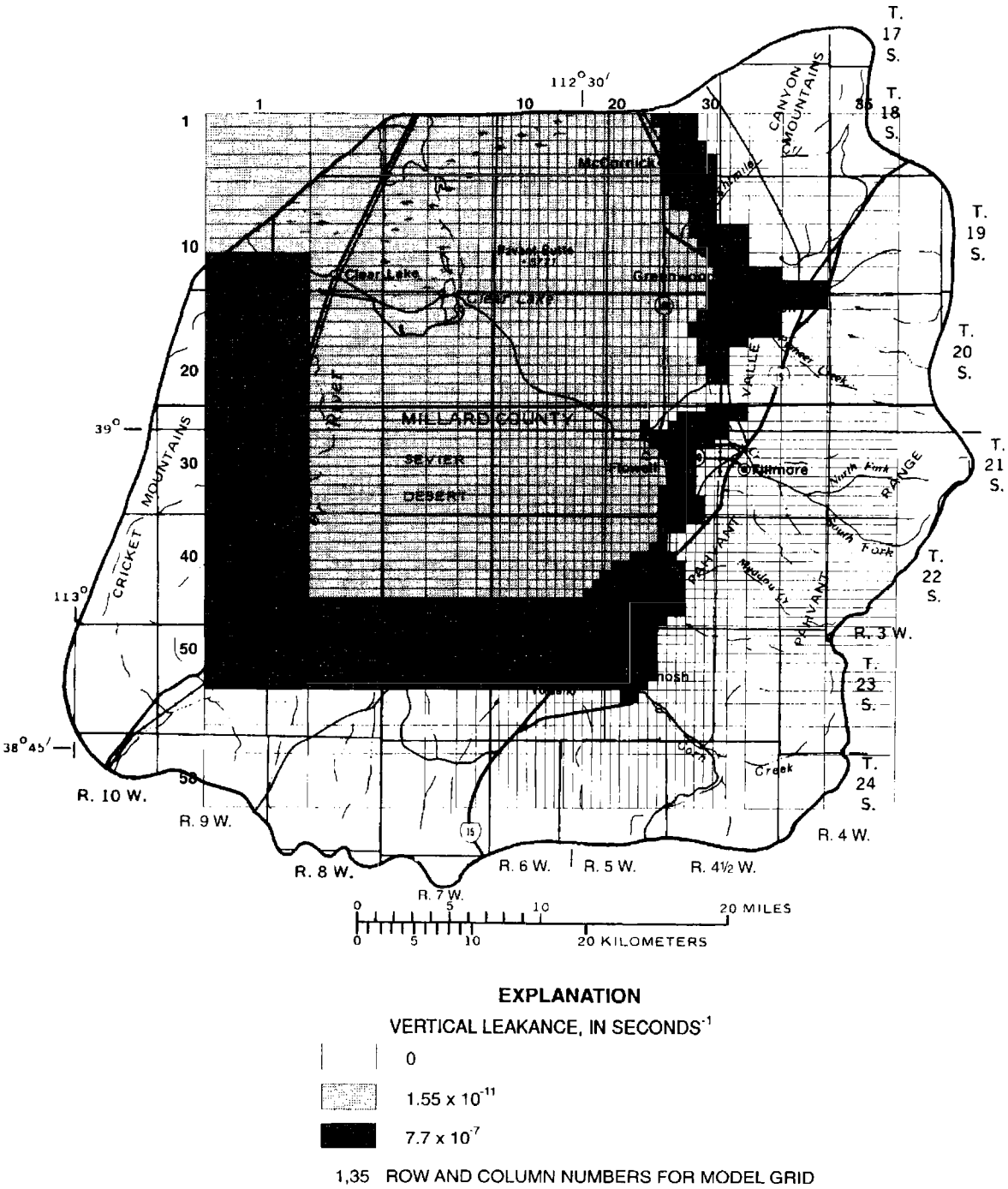


Figure 21.--Distribution of vertical leakance between layers 2 and 3 used in the digital-computer model.

Discharge from evapotranspiration, drains, wells, subsurface outflow, and springs are represented in the model. In the model, evapotranspiration (pl. 4) is head-dependent and requires the input of a maximum evapotranspiration rate and a depth of extinction (McDonald and Harbaugh, 1988, p. 10-8). The maximum evapotranspiration rate used was 2 feet per year, and the depth of extinction was set at 10 feet.

Simulation by the model of discharge from drains (pl. 4) is head-dependent and requires a conductance value for the interface between the cell and the drain, and the elevation of the drain (McDonald and Harbaugh, 1988, p. 9-7). A value of 10 feet squared per second was used for the conductance in all drains. This value was determined during the steady-state calibration of the model.

In the model, discharge from wells is based on records of ground-water withdrawals in the files of the U.S. Geological Survey in Salt Lake City. Ground-water withdrawals from the unconsolidated basin fill were simulated in layer 3, and withdrawals from the basalt were simulated in layer 2.

In all layers, discharge from constant-head nodes along the northwest side of the model (pl. 4) represents subsurface flow out of the modeled area. Discharge from an interior constant-head node in layer 1 (pl. 4) was used to simulate flow from Clear Lake Springs (pl. 1).

Steady-State Calibration

Steady-state calibration involved comparing model-computed water levels, computed discharge of Clear Lake Springs, and discharge of drains or sloughs to actual measured values, and adjusting some model parameters to obtain the best overall agreement with measured values. Steady-state conditions were assumed for the period prior to 1947, although 17,000 acre-feet per year was being withdrawn from flowing wells between 1930 and 1945 (Dennis and others, 1946, p. 80). Most of the flowing wells were drilled prior to 1935, and water levels and discharge from flowing wells remained fairly stable from 1935 through 1946.

Water-level measurements from 204 wells, most of which cover the period from 1940 to 1943, were used in the steady-state calibration and are reported by Dennis and others (1946, p. 85). A few more recent water levels were used for wells in remote areas, away from the effects of pumping. Nine of the water levels represent layer 1, 23 represent layer 2, 138 represent layer 3, and 34 represent layer 4. The relation between water levels computed by the model and those measured in wells is shown in figure 22. Model-generated water levels generally are in close agreement with the observed water levels, with maximum differences of about 25 feet for a single point. The largest differences occurred near Flowell, where a steep hydraulic gradient (pl. 2) was difficult to model. The potentiometric surface of layer 3 computed by the model for steady-state conditions is shown in figure 23.

The discharge of Clear Lake Springs varied from about 13 to 85 cubic feet per second and averaged about 25 cubic feet per second during 1959-85 (fig. 4). Disregarding the extremely large discharges during 1984-85, the average is about 21 cubic feet per second. The discharge of the springs has been reduced because of large ground-water withdrawals in Pahvant Valley (Mower,

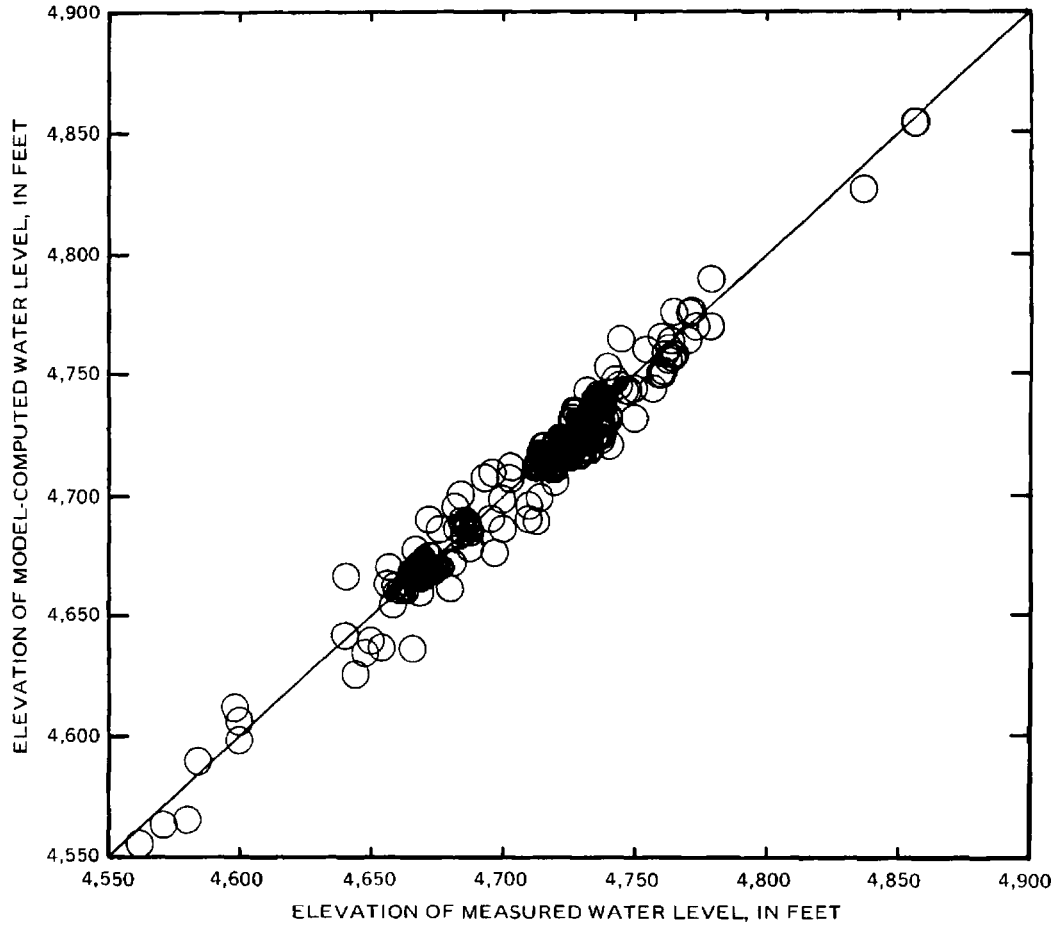
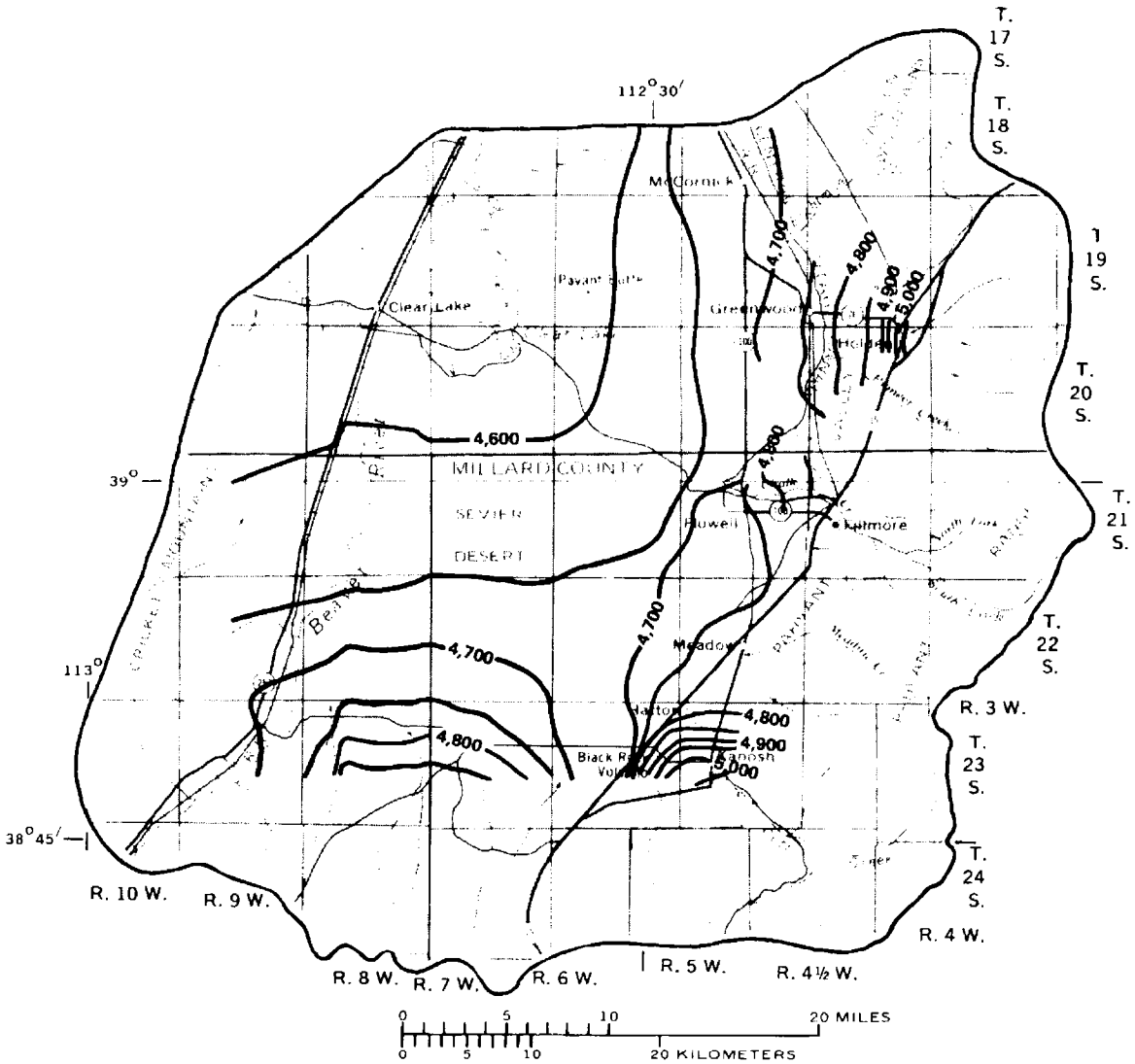


Figure 22.--Relation between measured and model-computed steady-state water levels in model nodes that include observation wells.

1967, p. E23). Prior to large-scale ground-water development, which began in about 1950, the discharge was probably between 25 to 30 cubic feet per second. The steady-state discharge calculated by the model was about 27 cubic feet per second, within the range of discharge estimated from the available data.

Dennis and others (1946, p. 55) reported the discharge of Meadow Creek slough in section 1, T. 22 S., R. 6 W. to be 4.6 cubic feet per second on June 20, 1944, and 5.1 cubic feet per second on April 12, 1945. Both reported measurements were in the spring or early summer, when maximum discharge might



EXPLANATION

—— 4,600 —— POTENTIOMETRIC CONTOUR--Shows altitude of the computed potentiometric surface. Contour interval 50 feet. National Geodetic Vertical Datum of 1929

Figure 23.--Model computed steady-state potentiometric surface of layer 3.

be expected, and both measurements may have included some flowing-well discharge. Also, in 1945, the artesian pressures were near historically large values, and many previously dry springs began to flow into Meadow Creek slough (Dennis and others, 1946, p. 55). Because the conditions in 1944-45 were conducive to greater-than-average flow, the model-computed flow of 1.8 cubic feet per second, represented by drain nodes, is probably a reasonable representation of long-term steady-state discharge. The steady-state ground-water budget computed by the digital model is shown in table 2.

Transient-State Calibration

Transient-state calibration was done by simulating ground-water withdrawals that were recorded during 1947-85 (39 yearly stress periods) and comparing measured water-level changes and measured changes in discharge at Clear Lake Springs, to computed water-level changes and computed changes in the discharge of Clear Lake Springs. Some minor adjustments to model parameters were made to improve the agreement of model-computed values of water levels and discharge at Clear Lake Springs with measured values.

During the transient calibration, it became apparent that varying the quantity of annual recharge produced model-computed values closer to the measured values than were the values obtained using a constant quantity of recharge equal to the long-term average. The best results were obtained when long-term average annual recharge was multiplied by a factor related to the percentage that the annual precipitation was greater than or less than the 1947-85 average. The factor was computed using the relation:

$$F = \left\{ [(P/P_{avg})-1] \times 4 \right\} + 1.0,$$

where P is the precipitation for the year and P_{avg} is 15.31. The lower limit of F was 0.5.

For example, in 1957, the precipitation at Fillmore was 17.52 inches, 2.21 inches or 14 percent greater than the 1947-85 average of 15.31 inches. The average recharge rate of about 66,000 acre-feet per year was multiplied by a factor of 1.56 [(0.14 X 4) +1], to obtain the recharge rate of about 103,000 acre-feet for 1957.

In addition, the distribution and average annual recharge in the model was increased after 1959 (stress period 13) from about 66,000 acre-feet per year to about 75,000 acre-feet per year. The additional recharge was added because increased irrigation, primarily from withdrawals of ground water for irrigation in the Kanosh and Meadow areas (Dennis and others, 1946, fig. 10 and Mower, 1965, pl. 10)(fig. 5), resulted in additional recharge from unconsumed irrigation water. Also, additional recharge from seepage from streams was simulated during 1983-85 (stress periods 37-39) when water was diverted into the basalt as a means of flood control or entered the basalt in flooded areas. (See sections entitled "Seepage from Streams" and "Movement"). The additional recharge from seepage from streams added during 1983-85 was varied during calibration. The final values were about 43,000 acre-feet during 1983, 139,000 acre-feet during 1984, and 28,000 acre-feet during 1985.

Table 2.—*Steady-state, reported, transient-state, and model-projected ground-water budgets for Pahvant Valley and surrounding areas, in acre-feet per year*

Budget element	Steady-state model (1946)	Reported by Mower (1965) (1959)	Transient-state model (1977)	Transient-state model (1985)	Projected using the 1977 rate of withdrawal for 20 years: x 1 (2005)	x 0.5 (2005)	Without recharge from the Central Utah Canal (2005)
			YEAR				
Recharge (precipitation, seepage from streams and canals, and unconsumed irrigation water)	66,000	[1]70,000	37,900	198,100	75,000	75,000	71,700
Discharge							
Clear Lake Springs	19,900	15,600	7,200	57,800	7,200	15,600	14,800
Wells	18,200	[2]64,000	95,900	61,500	95,900	48,000	48,000
Drains	1,300	not reported	700	3,300	1,000	1,500	1,500
Evapotranspiration	26,600	[3]29,000	15,400	23,500	13,000	19,000	18,100
Water going into (+) or out of (-) storage	0	-38,600	-80,700	+52,900	-41,500	-7,700	-9,600

[1]Includes 5,000 acre-feet of recharge from areas not included in previous studies.

[2]Revised from previously published value of 60,000 acre-feet (Mower, 1965, table 12).

[3]Includes 5,000 acre-feet of discharge from evaportranspiration from areas not included in previous studies.

The measured and computed water-level changes for 12 selected observation wells are shown in figure 24, and a comparison of the measured discharge at Clear Lake Springs with the computed discharge of the springs is shown in figure 25. The measured and computed water-level changes as well as the measured and computed discharge of Clear Lake Springs are in close agreement. Table 2 shows the ground-water budgets computed by the model at the end of 1977 and 1985 (stress periods 31 and 39).

Model Simulations

The calibrated model was used to project the effects of ground-water withdrawals and changes in recharge on water levels; discharge from Clear Lake Springs, from drains, and by evapotranspiration; and changes in ground-water storage. Withdrawals equal to the 1977 rate of 95,900 acre-feet, one-half the 1977 rate (48,000 acre-feet), and the elimination of recharge from the Central Utah Canal were simulated. An average recharge rate of 75,000 acre-feet per year was used when simulating changes in withdrawals, and a rate of 71,700 acre-feet of recharge was used when simulating the elimination of recharge from the Central Utah Canal (table 2). The simulation period was 20 years, assumed to be 1985-2005, and the same well locations used in 1977 were also used for simulating withdrawals. Water-level-change maps were prepared that represent the difference between the computed water levels at the end of each

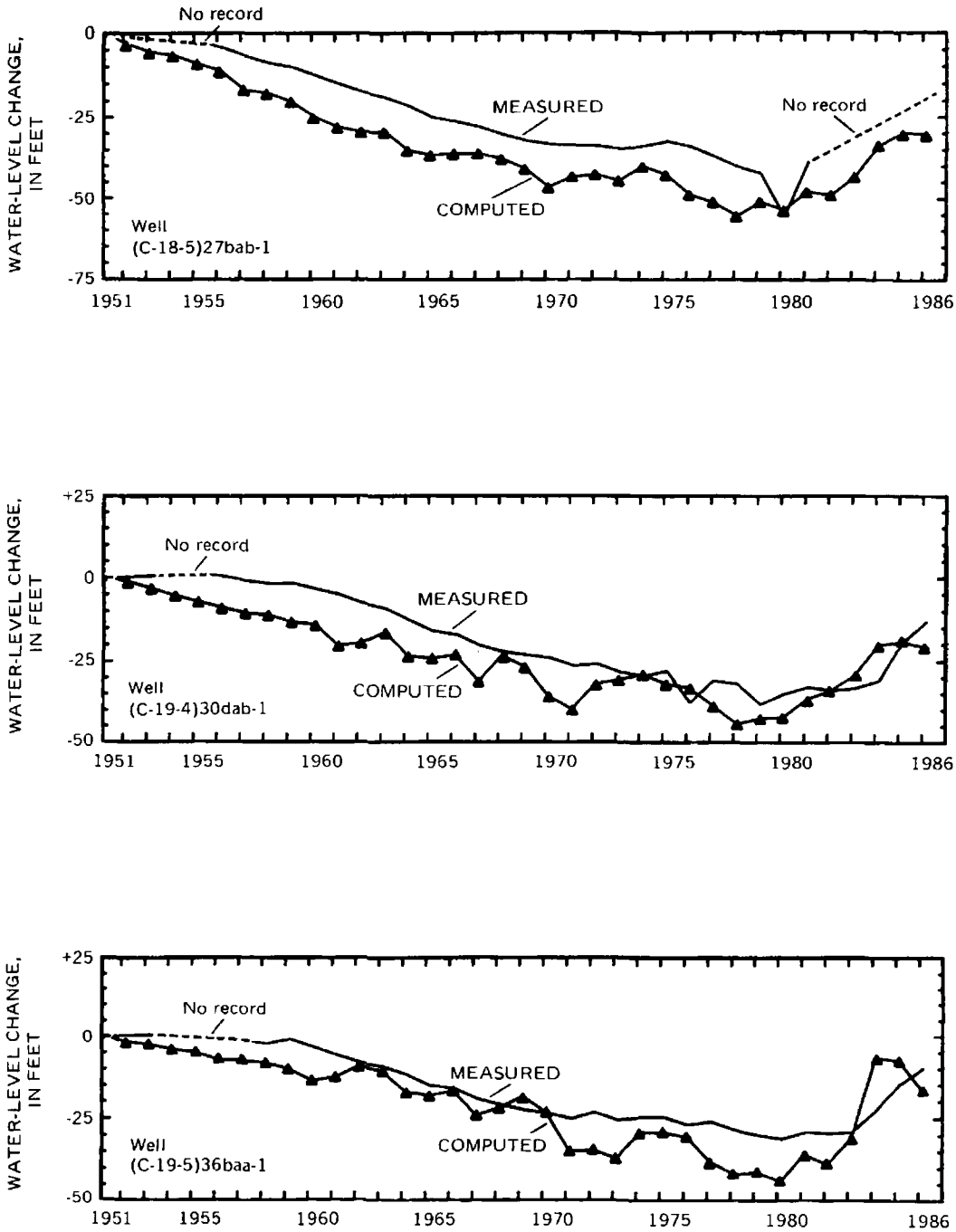
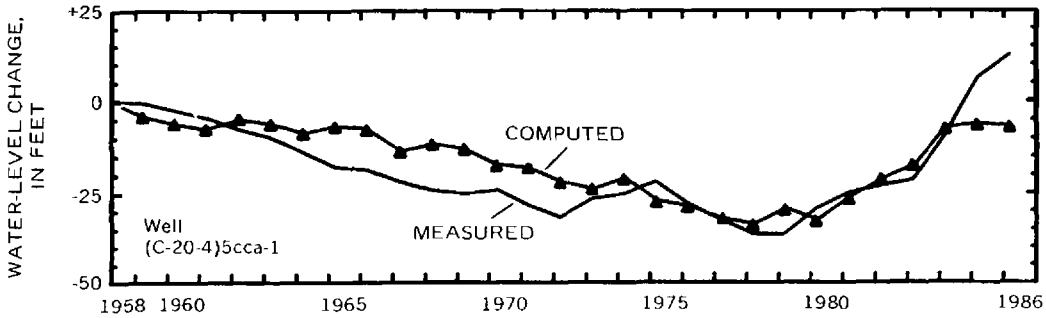
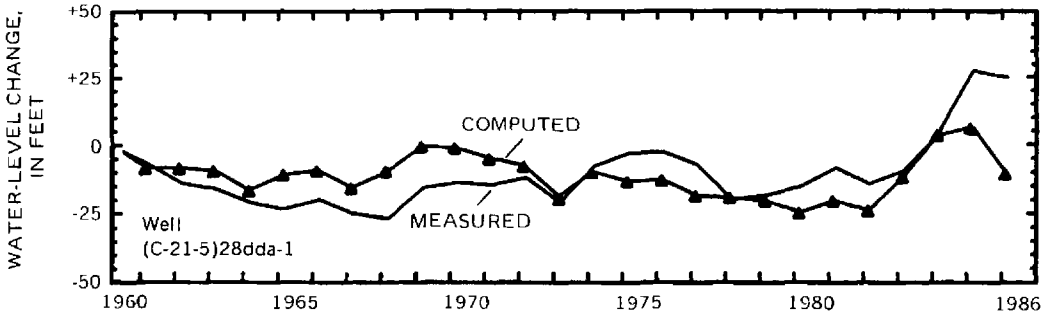


Figure 24.--Measured and computed water-level changes for 12 selected observation wells.





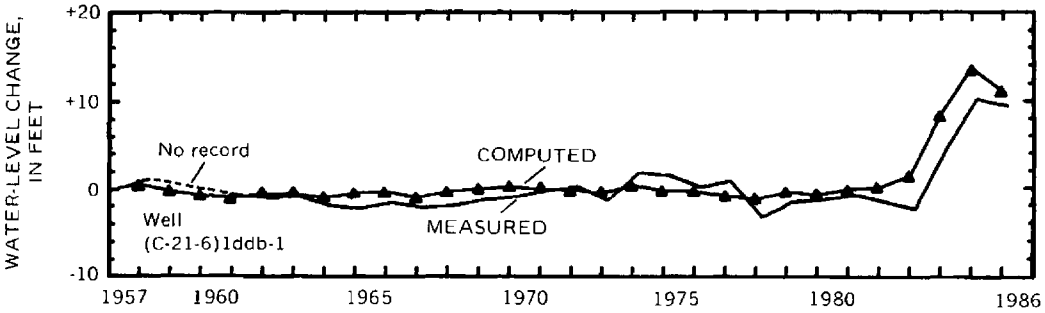
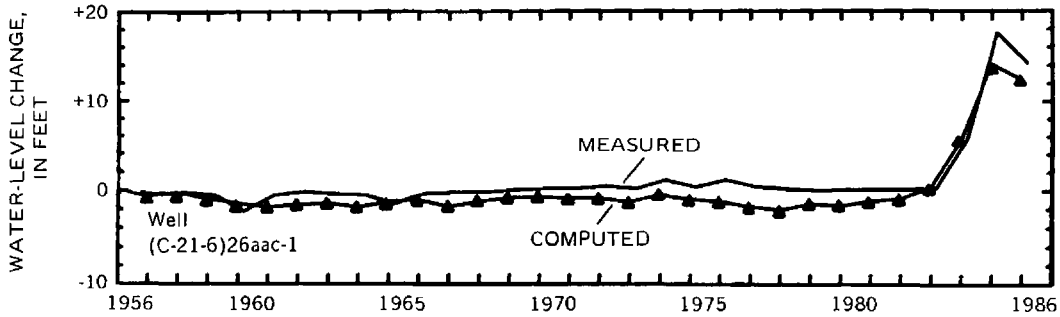
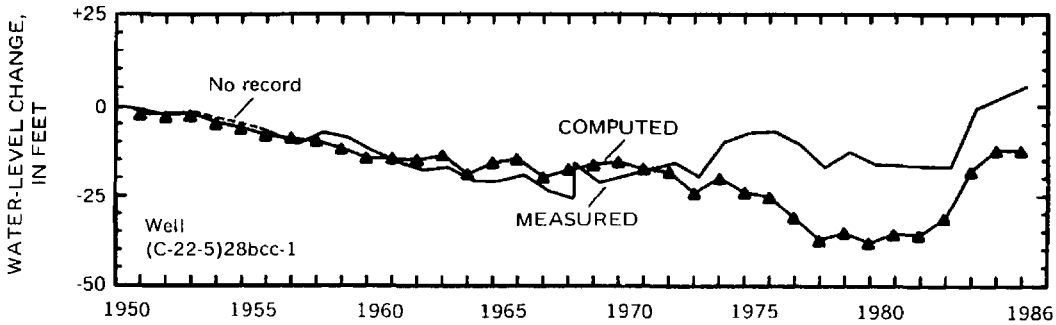


Figure 24.--Measured and computed water-level changes for 12 selected observation wells--Continued.





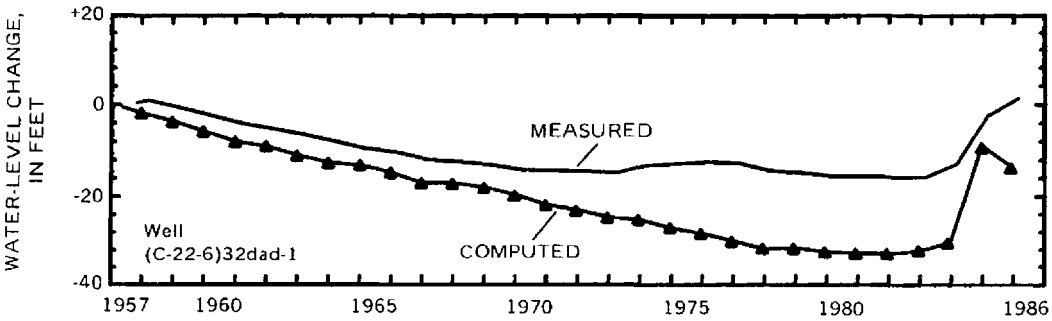
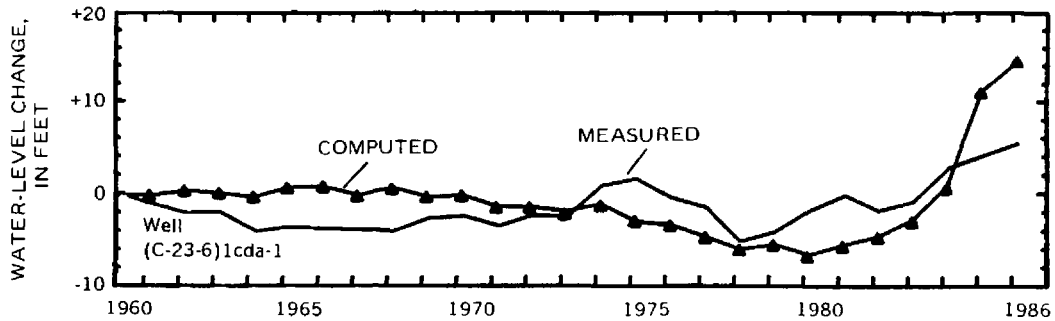
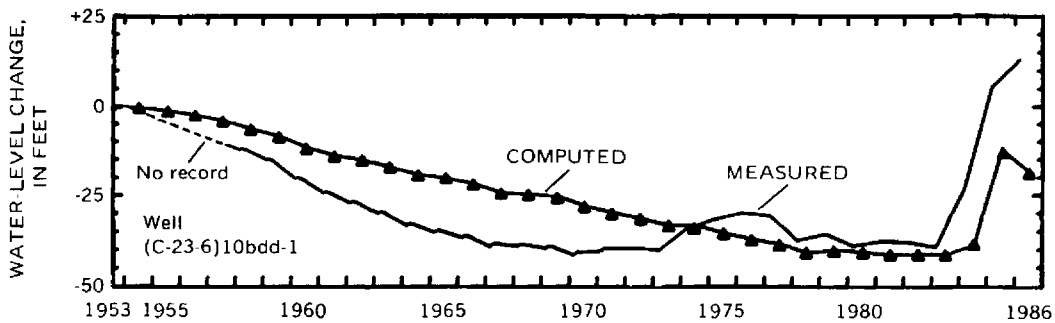


Figure 24.--Measured and computed water-level changes for 12 selected observation wells--Continued.





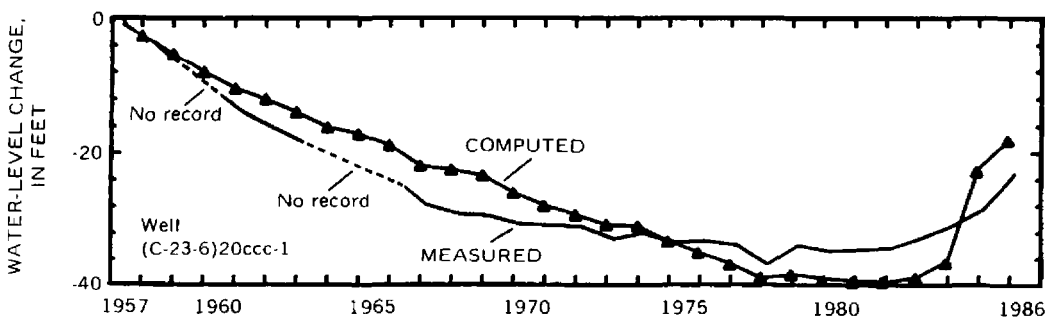


Figure 24.--Measured and computed water-level changes for 12 selected observation wells--Continued

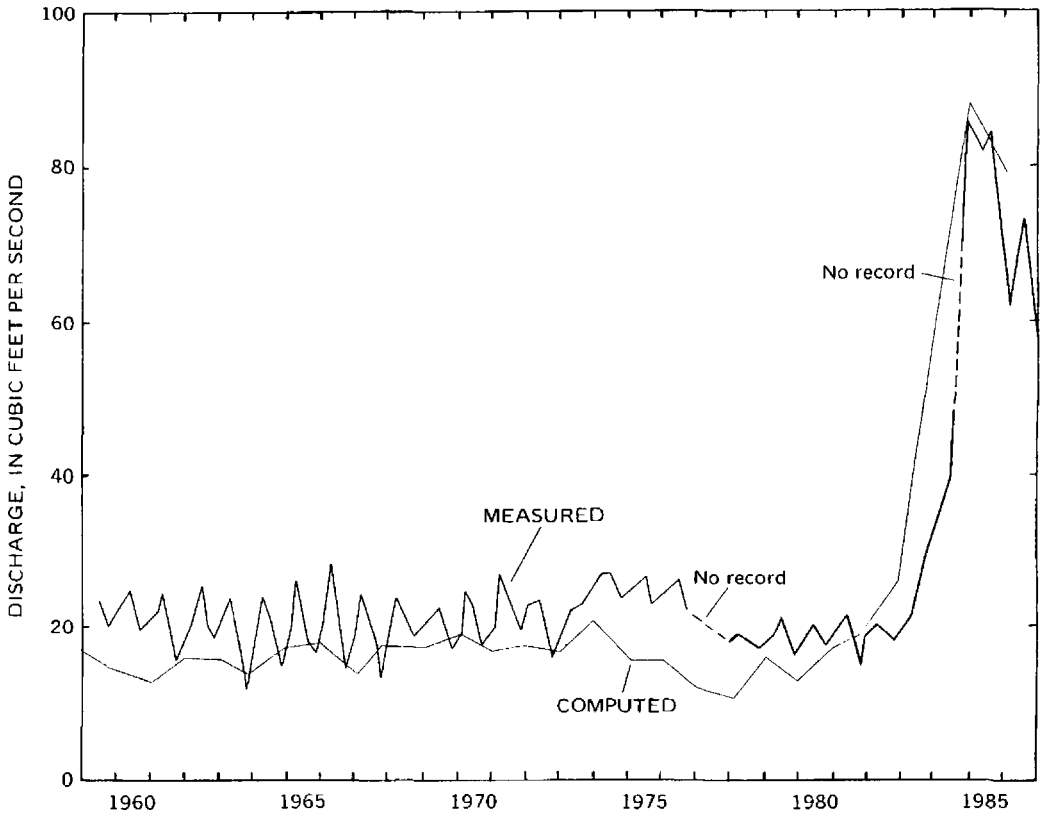
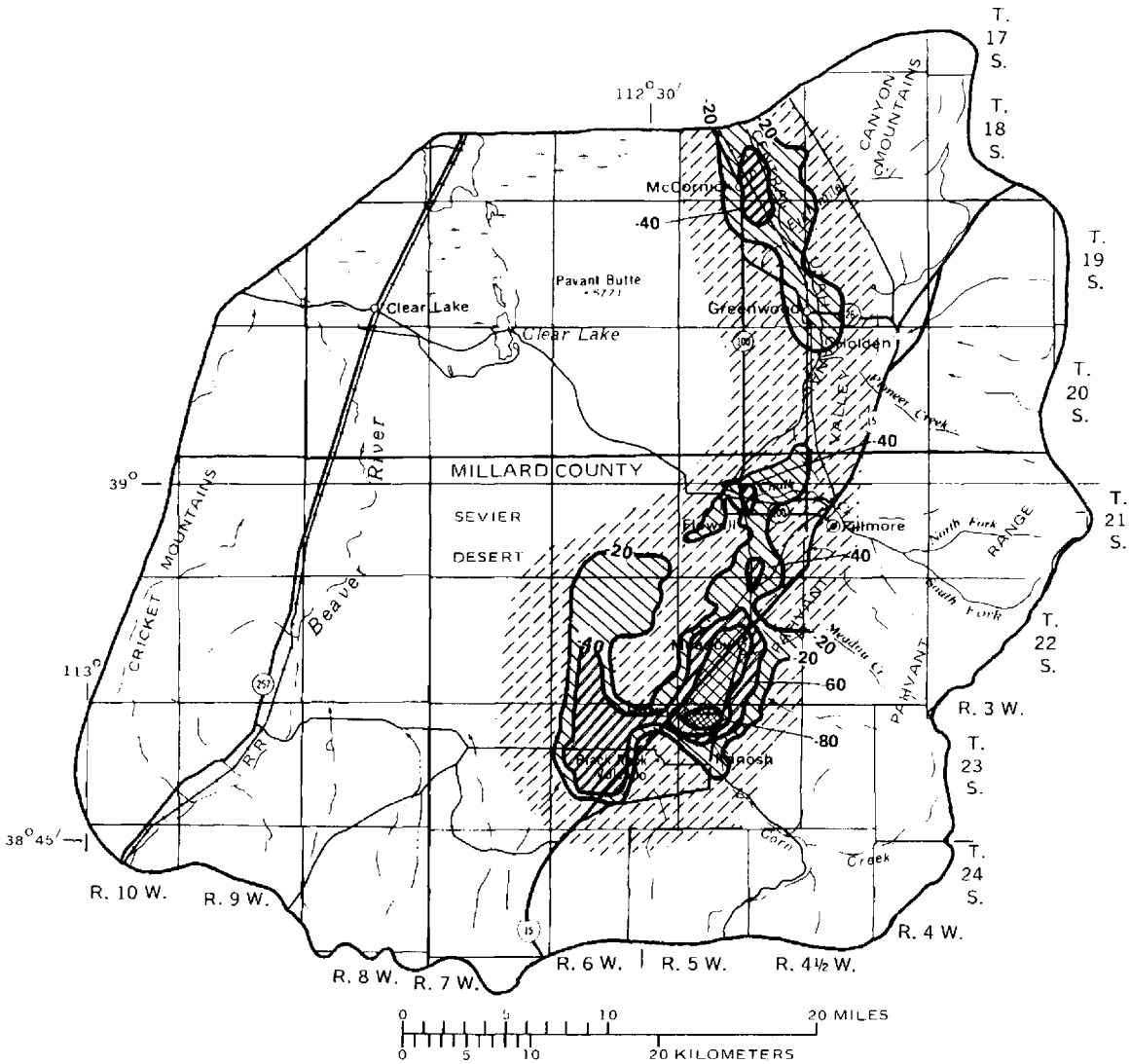


Figure 25.--Measured and computed discharge of Clear Lake Springs.

20-year simulation and the computed water levels at the end of 1985 in layers 2 and 3, the most heavily pumped part of the ground-water system. The results of the simulations are shown in figures 26 through 31.

Ground-water withdrawals equal to the 1977 rate for 20 years were projected to cause water-level declines of more than 80 feet in some parts of the modeled area in layers 2 and 3 (fig. 26 and 27). The ground-water budget at the end of the simulation is shown in table 2. Discharge from evapotranspiration, drains, and Clear Lake Springs were substantially reduced when compared with the budget for 1985. In addition, by the end of the 20-year simulation, about 41,500 acre-feet per year of ground water had been removed from storage.



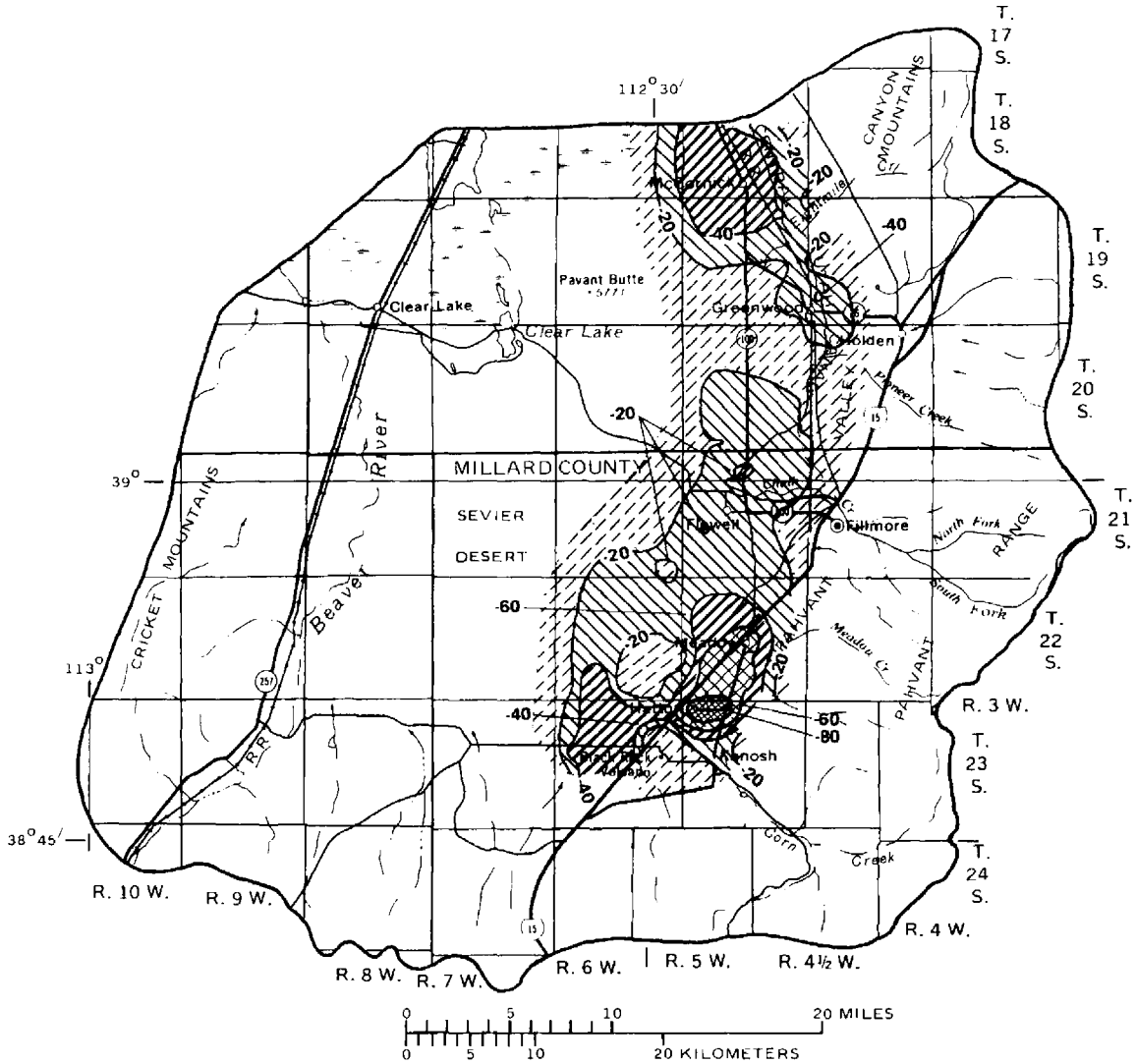
EXPLANATION

—20— LINE OF EQUAL WATER-LEVEL DECLINE, IN FEET–Contour interval is 20 feet

DECLINE (feet)

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- More than 80

Figure 26.--Projected water-level declines in layer 2 assuming ground-water withdrawals equal to the 1977 rate for a period of 20 years, 1985-2005.



EXPLANATION

-20 LINE OF EQUAL WATER-LEVEL DECLINE, IN FEET--Contour interval is 20 feet

DECLINE (feet)

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- More than 80

Figure 27 --Projected water-level declines in layer 3 assuming ground-water withdrawals equal to the 1977 rate for a period of 20 years, 1985-2005.

Ground-water withdrawals equal to one-half the 1977 rate for 20 years were projected to result in water-level rises of as much as 33 feet in some parts of the area and water-level declines of as much as 47 feet in other parts of the area in layer 2 (fig. 28). Water-level rises of as much as 58 feet were projected for layer 3 (fig. 29). The ground-water budget at the end of the simulation (table 2) showed that discharge from evapotranspiration, drains, and Clear Lake Springs was more than the previous simulation. About 7,700 acre-feet per year of ground water had been removed from storage by the end of the simulation. Based on these results, it is projected that for every 1,000 acre-feet of increase or decrease in withdrawals in Pahvant Valley, the discharge at Clear Lake Springs will decrease or increase by about 130 acre-feet, respectively.

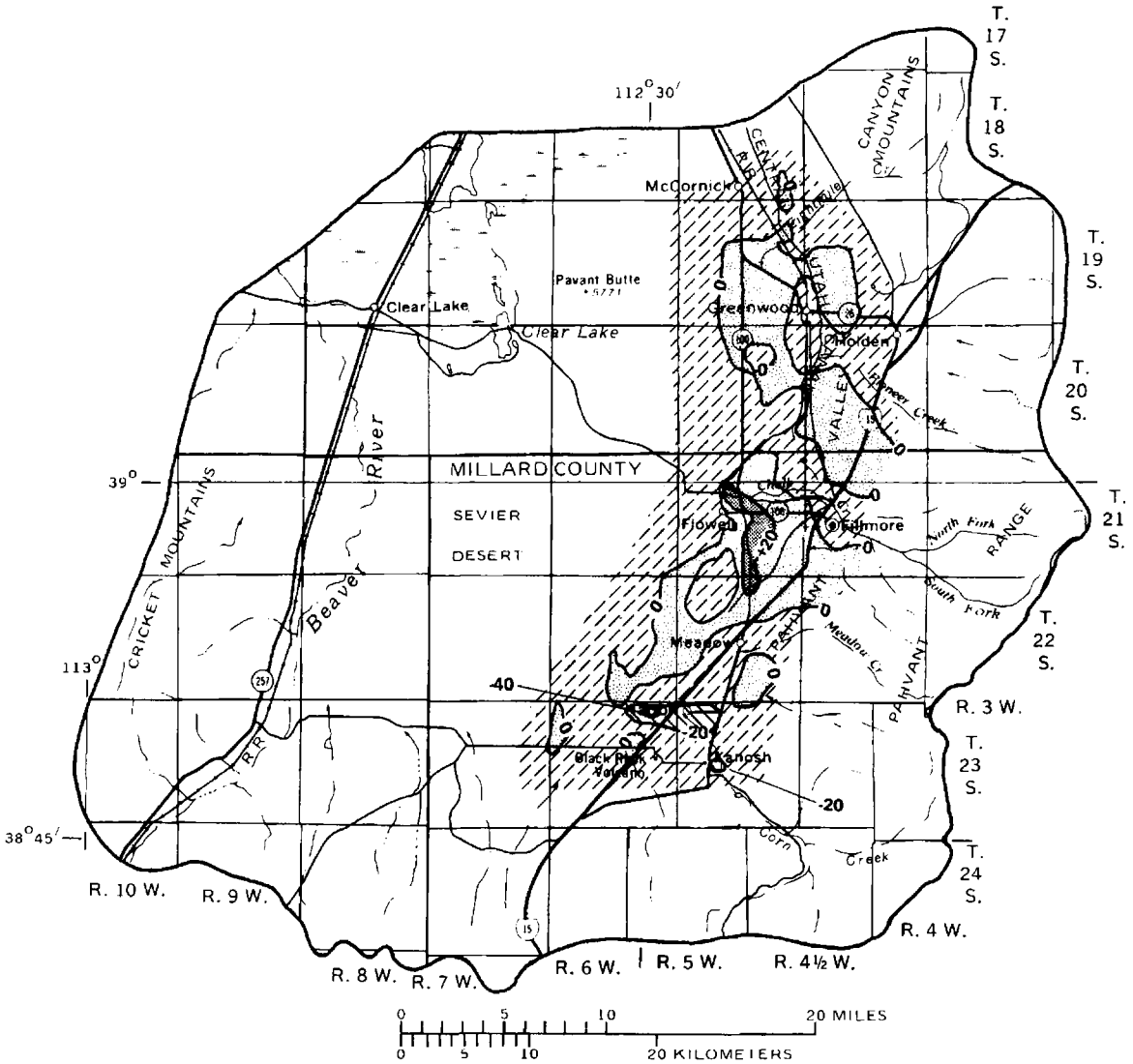
The elimination of recharge from the Central Utah Canal was projected to result in water-level declines of up to 8 feet in layer 2 near the canal (fig. 30) and up to 6 feet in layer 3 (fig. 31). Water levels in other parts of the area would not be affected. The loss of recharge from the canal is reflected in the ground-water budget by a decrease in discharge from Clear Lake Springs and from evapotranspiration, and an increase in the quantity of water being removed from storage (table 2) compared to values determined for projected withdrawals equal to one-half of the 1977 rate.

Limitations of Model

The ground-water model documented in this report has some limitations and simplifications. The use of a no-flow, northern boundary for the model, near McCornick, may cause the projected water-level declines in this area to be greater than might be expected if some ground-water movement across this boundary occurred. However, water levels in well (C-18-5)16bcc-1, located about 3 miles north of McCornick, do not show the effects of ground-water withdrawals, which indicates that the use of a no-flow boundary along the northern side of the model area is justified.

Recharge from all sources was varied with precipitation when, in fact, recharge from seepage from the Utah Central Canal or unconsumed irrigation water may not vary with precipitation. In addition, as more land came under irrigation, increased recharge from unconsumed irrigation water could not be estimated because data on increases in irrigated acreage were not available on a yearly basis nor were data showing changes in the surface-water distribution system. Changes in the model may be required if irrigation practices change, streamflow diversion patterns are altered, or the locations of ground-water withdrawals are changed.

Despite these limitations, the model should yield satisfactory results when projecting the effects on water levels and discharge using withdrawals of up to about 100,000 acre-feet per year for a period of about 20 years.

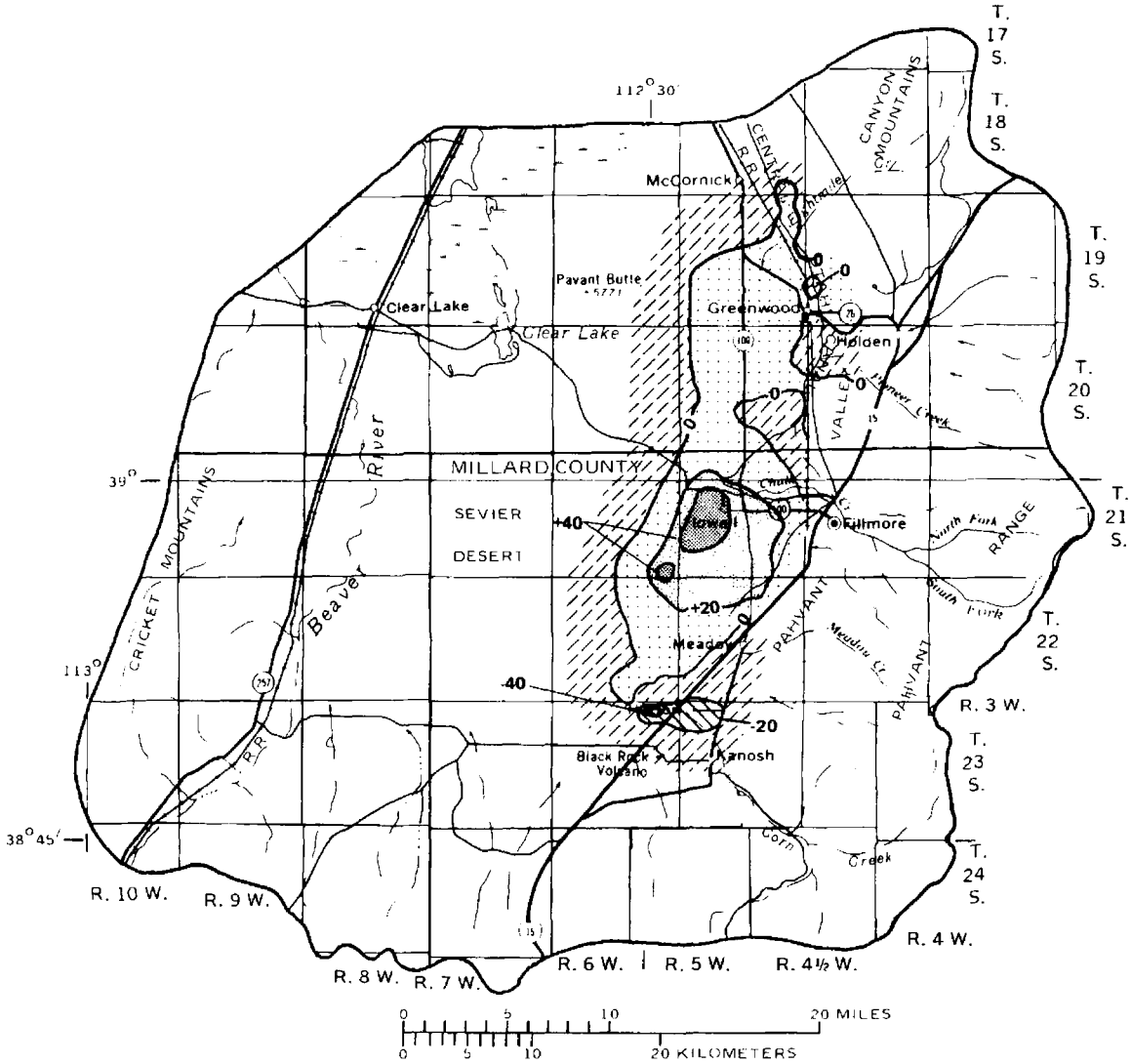


EXPLANATION

—— -20 —— LINE OF EQUAL WATER-LEVEL CHANGE, IN FEET--Contour interval is 20 feet

DECLINE (feet)	RISE (feet)
0 - 20	0 - 20
20 - 40	20 - 33
40 - 47	

Figure 28.--Projected water-level changes in layer 2 assuming ground-water withdrawals equal to one-half the 1977 rate for a period of 20 years, 1985-2005.



EXPLANATION

—20— LINE OF EQUAL WATER-LEVEL CHANGE, IN FEET--Contour interval is 20 feet

DECLINE (feet)	RISE (feet)
0 - 20	0 - 20
20 - 40	20 - 40
40 - 42	40 - 58

Figure 29.--Projected water-level changes in layer 3 assuming ground-water withdrawals equal to one-half the 1977 rate for a period of 20 years, 1985-2005.

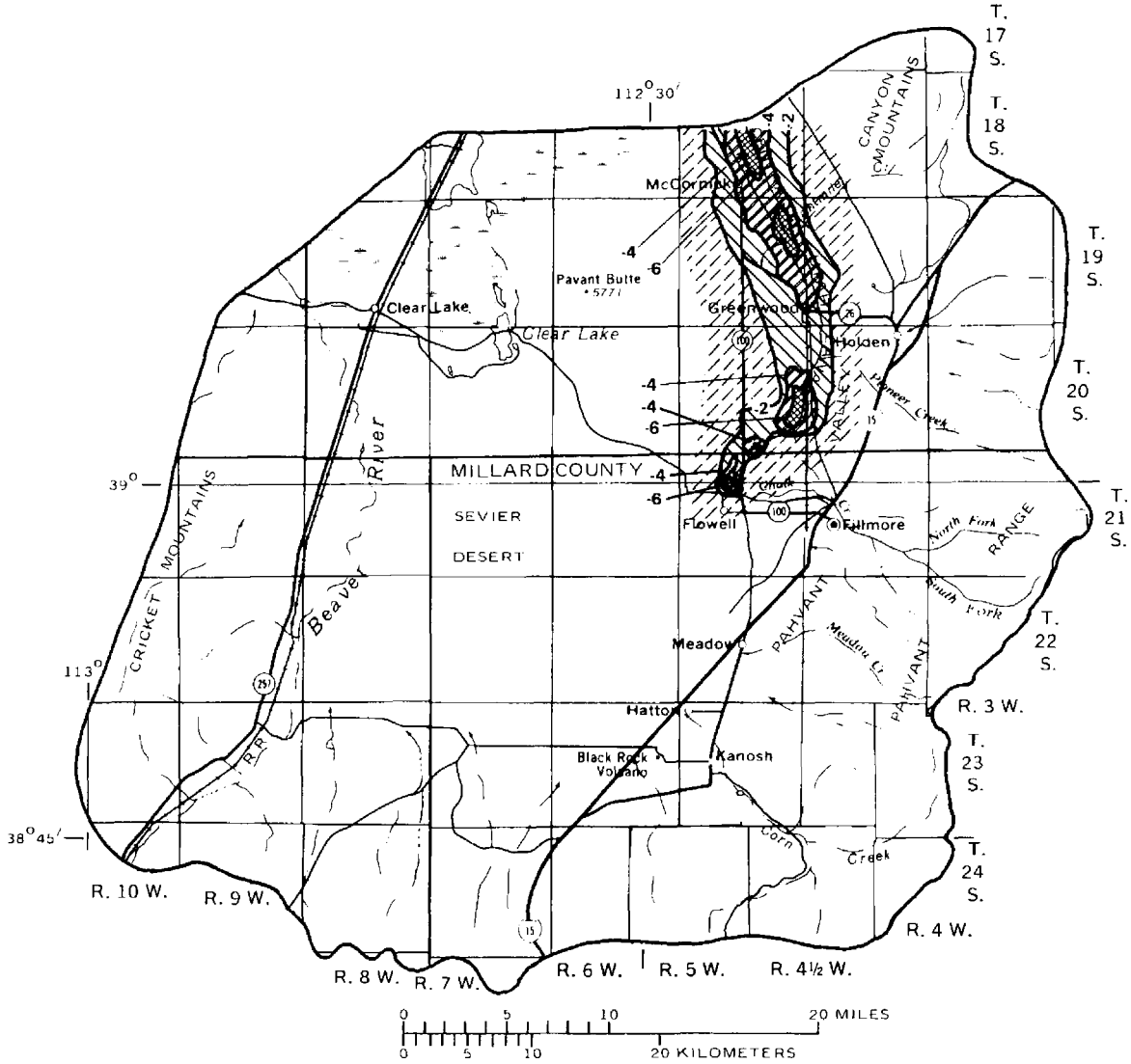
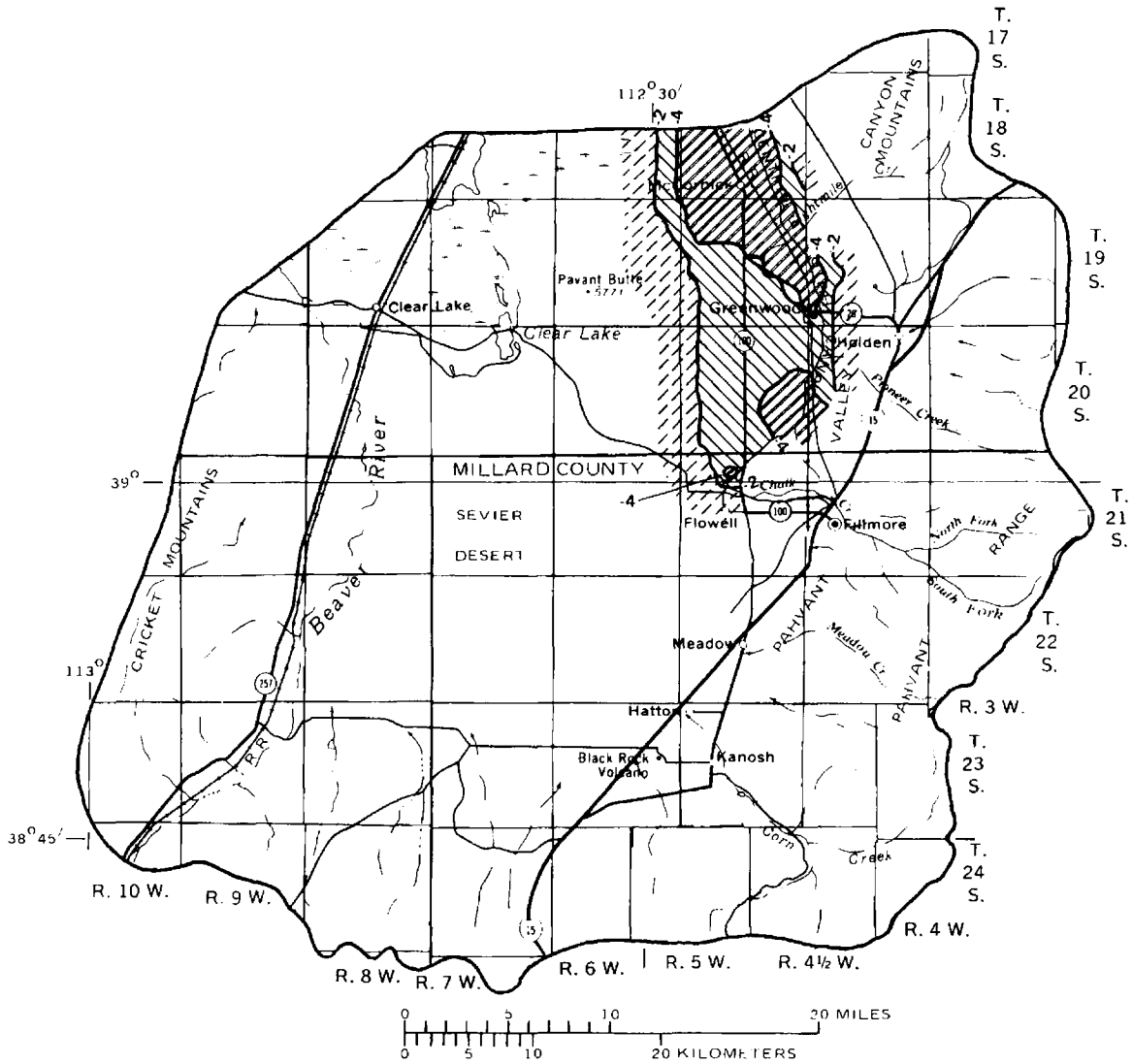


Figure 30.--Projected water-level declines in layer 2 assuming the elimination of recharge from the Central Utah Canal for a period of 20 years, 1985-2005.



EXPLANATION

—— -2 —— LINE OF EQUAL WATER-LEVEL DECLINE, IN FEET--Contour interval is 2 feet

DECLINE (feet)

- 0 - 2
- 2 - 4
- 4 - 6

Figure 31.--Projected water-level declines in layer 3 assuming elimination of recharge from the Central Utah Canal for a period of 20 years, 1985-2005.

SUMMARY

The primary ground-water system in Pahvant Valley and adjacent areas is that within the unconsolidated basin fill and interbedded basalt. The thickness of the unconsolidated basin fill varies from a few feet near the mountain fronts to at least 1,400 feet in the central part of the area.

Recharge to the basin fill in 1959, primarily from seepage from streams, canals, and unconsumed irrigation water and infiltration of precipitation, was estimated to be about 70,000 acre-feet. Movement of ground water is generally from recharge areas near the mountains on the east toward discharge areas in the central part of the study area. Some ground water moves out of the area along the northwestern boundary. Discharge from the ground-water system, primarily by discharge from springs, evapotranspiration, and wells, was estimated to be about 109,000 acre-feet in 1959.

Water-level declines of as much as 45 feet occur on a seasonal basis as a result of ground-water withdrawals for irrigation during the summer months. Water levels recover most of their decline during the winter and spring but spring water-level declines of more than 50 feet occurred between the early 1950's and 1980 due to extensive pumping and less-than-normal precipitation. Water levels recovered most of their declines between 1983 and 1986 because of record quantities of precipitation and reduced withdrawals for irrigation.

The quality of ground water is generally good, although west of Kanosh the quality of ground water in some wells has deteriorated from a dissolved-solids concentration of about 2,000 to more than 6,000 milligrams per liter. The deterioration in ground-water quality is probably caused by poor quality water from the southwest and possibly the west moving into the area during periods of large ground-water withdrawals and from the recycling of irrigation water.

A digital-computer model was used to project the effects of ground-water withdrawals and changes in recharge on water levels; discharge from Clear Lake Springs, drains, and evapotranspiration; and changes in ground-water storage. Ground-water withdrawals of about 96,000 acre-feet per year for 20 years are projected to cause water-level declines of more than 80 feet in some parts of Pahvant Valley, while withdrawals of about 48,000 acre-feet per year for 20 years are projected to cause water-level rises of as much as 58 feet and declines of as much as 47 feet. The elimination of recharge from the Central Utah Canal for 20 years is projected to cause water-level declines of up to 8 feet near the canal.

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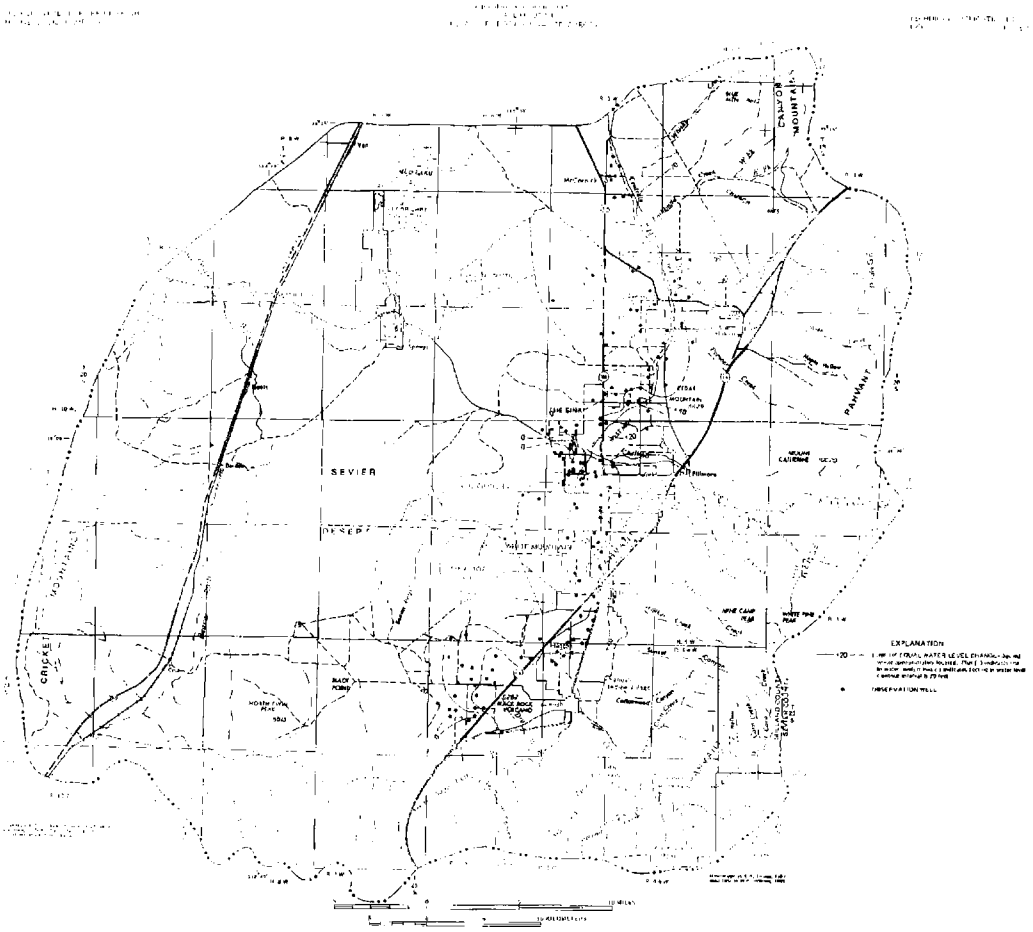
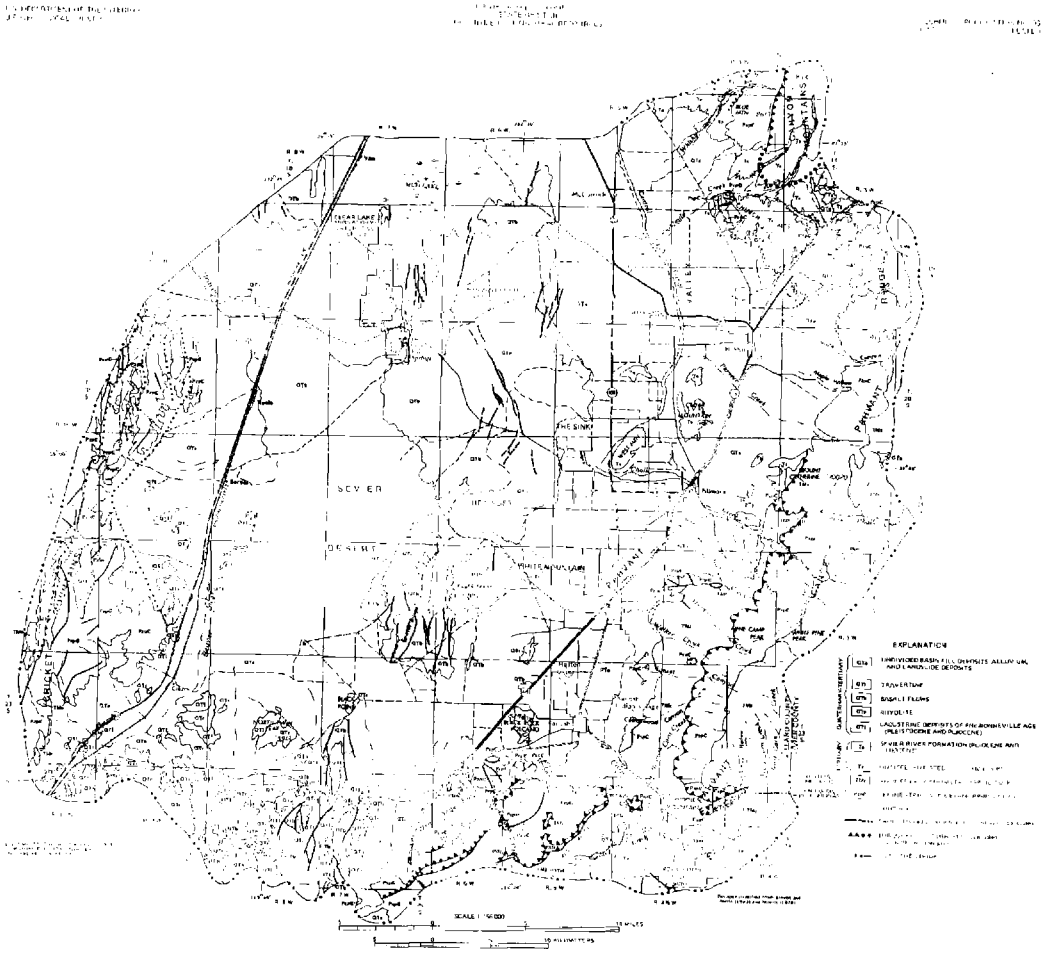
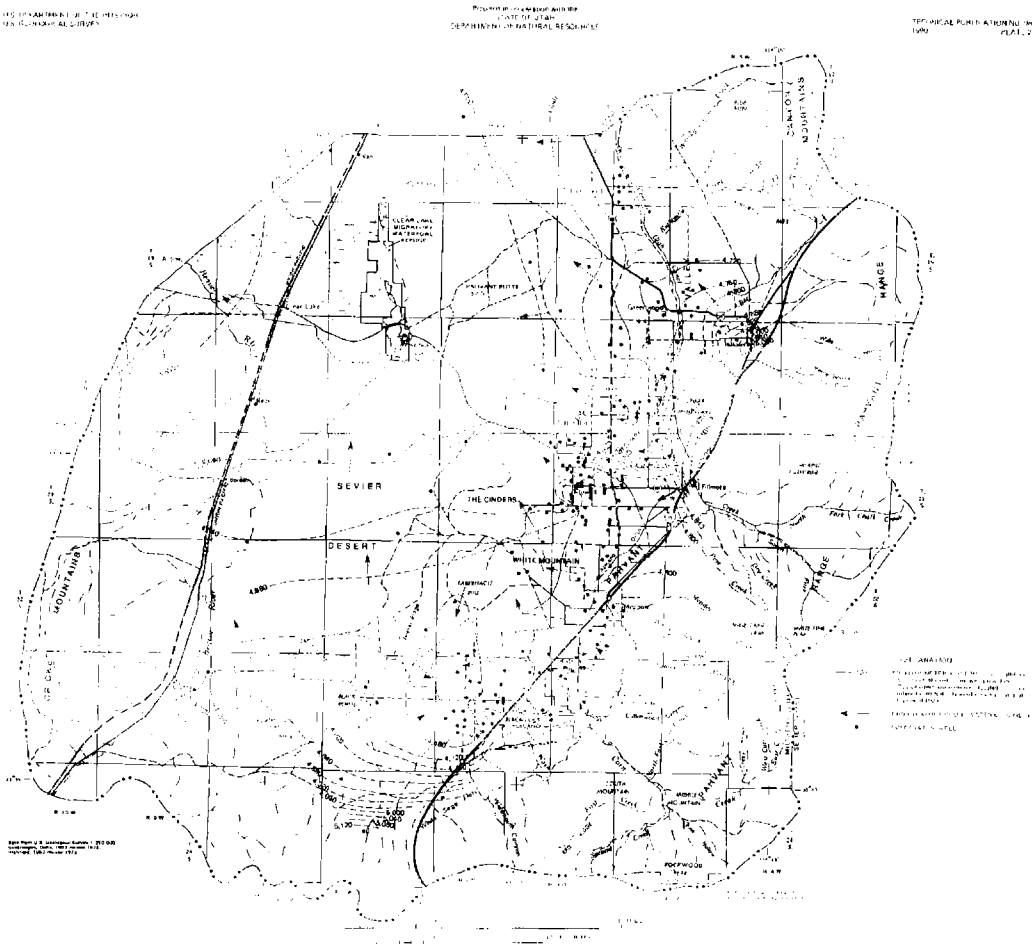


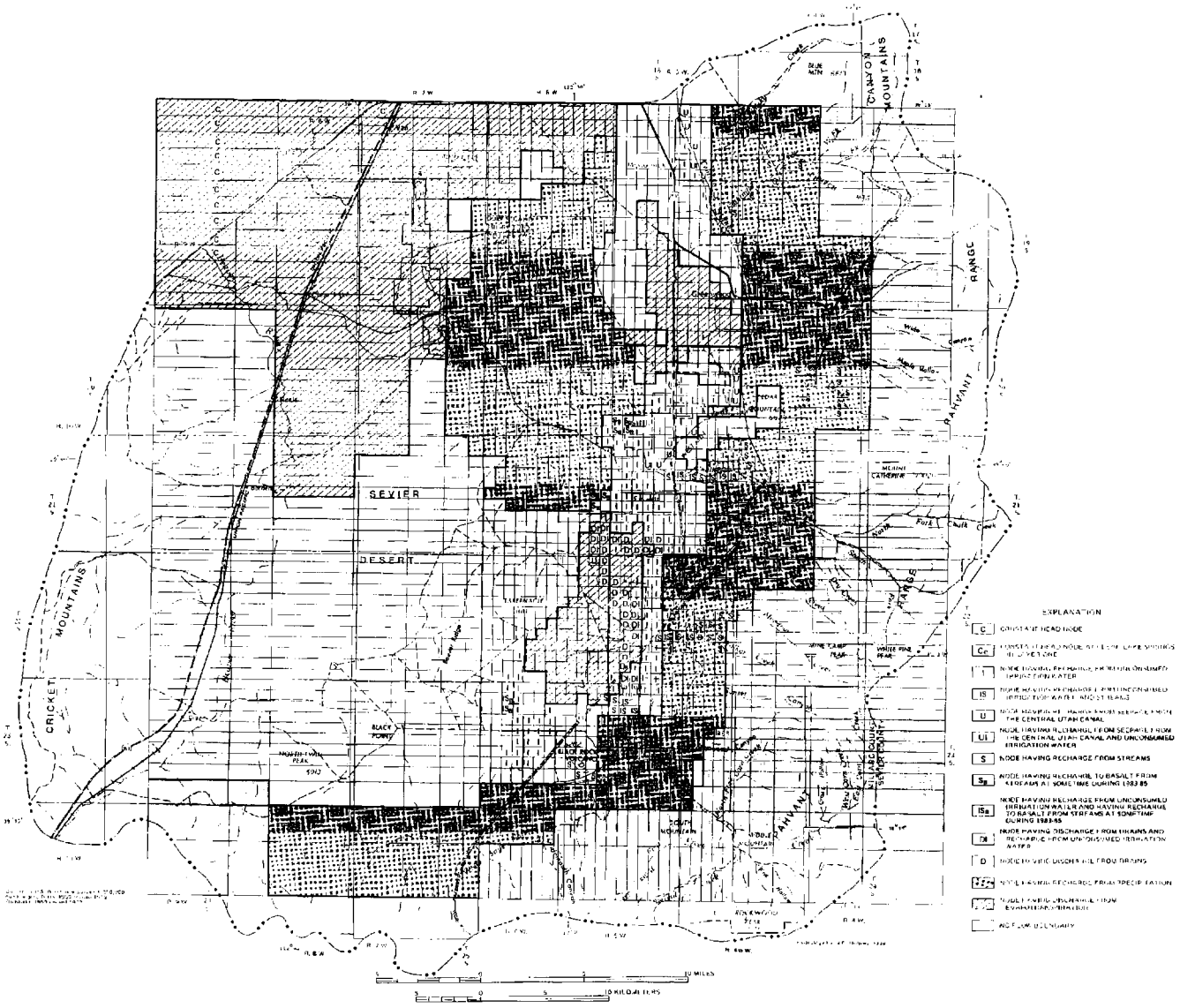
MAP SHOWING WATER-LEVEL CHANGES FROM SPRING 1960 TO SPRING 1986, PAHVANT VALLEY AND ADJACENT AREAS, UTAH



MAP SHOWING GENERALIZED GEOLOGY OF PAHVANT VALLEY AND ADJACENT AREAS, UTAH



MAP SHOWING POTENTIOMETRIC-SURFACE CONTOURS, SPRING 1986,
PAHVANT VALLEY AND ADJACENT AREAS, UTAH



MAP SHOWING DIGITAL-COMPUTER MODEL GRID AND INFORMATION ON THE UPPERMOST MODEL LAYER, PAHVANT VALLEY AND ADJACENT AREAS, UTAH

Attachment F – Water Quality Handling & Analysis Plan

WATER QUALITY SAMPLING, HANDLING, AND ANALYSIS PLAN

A Compliance Document for

Groundwater Discharge Permit Application

FOR:

CHRISTENSEN FINISHER SITES

MILLARD COUNTY, UTAH

January 4, 2018

Prepared For:

J and J Swine, LLC

1065 East 150 North

Springville, Utah 84663

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Figure A-1	**Monitor Well Water Level Measurements Log**
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Figure A-4	**Field Water Sample Chain-of-Custody Record**

Water Quality Handling and Analysis Plan

1.0 INTRODUCTION

The following **Water Quality Sampling, Handling and Analysis Plan** (The Plan) presents the organization and procedures for water quality investigations near Delta, Utah. This plan is required by the Utah State Department of Environmental Quality (DEQ), Division of Water Quality as a condition of the Final Ground Water Discharge Permit for the Christensen Finisher Hog Production Sites.

1.1 Implementation

The Plan is submitted as a Compliance Document for the Utah Ground Water Discharge Permit ("the Permit"). The Plan has been approved by Christensen and Smithfield Farms.

2.0 PROJECT DESCRIPTION

2.1 Purpose

Specific objectives of the Groundwater Monitoring Plan:

A. To evaluate background water quality at the Christensen Finisher Site approximately 8 miles northwest of Fillmore, Utah.

B. To provide information for the DEQ to establish ground water protection levels for the facility.

C. To establish procedures for groundwater monitoring and sample collection at the facility.

2.2 Methodology

Engineering Activities for Achieving the Specific Objectives: Water quality data reports will be submitted to the DEQ on a regular schedule, in accordance with the requirements of the Groundwater Quality Discharge Permit for the facility.

A. Installation of monitoring wells in the most shallow aquifer, upgradient and downgradient from the facility.

B. Measurement of groundwater elevations at the monitor wells.

C. Evaluation of hydrologic gradients in all aquifers penetrated by monitor wells.

D. Collection and analysis of ground water quality samples from the monitor wells according to a schedule recommended by the Utah State Division of Water Quality in the Permit.

E. Preparation and submission of quarterly "Groundwater Sampling Reports" during the one year accelerated background monitoring period.

3.0 PROJECT ORGANIZATION AND RESPONSIBILITY

3.1 Organization

Organization for studies and field investigations required by this Plan

A. **Construction Management Company:**
Christensen Finisher Sites
Contact: Andrade Christensen - Owner
Construction Manager (CM) will be appointed by Andrade Christensen.

B. **Quality Assurance Company:**
GEM Engineering, Inc.
Contact: Joel A. Myers, P.E. – President
Quality Assurance Officer (QAO) will be appointed by GEM Engineering.

C. **Department of Environmental Quality Official:**
Ed Hickey. P.G. – Environmental Scientist
State of Utah – Department of Environmental Quality
Division of Water Quality

3.2 Responsibilities

A. The CM and the QAO review and conduct or oversee the field activities described in the Plan. They will review all data generated during the investigation and will be responsible for validating and submitting data to the DEQ.

B. Analytical results of each completed sampling round will be submitted to the Division of Water Quality.

C. The CM and the QAO will review and approve the Plan, review all quality control data and identify problems, if any. The QAO will report directly to the CM and recommend corrective measures.

D. The state official will advise the owner of any comments, or objections to the Plan, its implementation, or any proposed changes to the Plan.

4.0 MONITOR WELL INSTALLATION

4.1 Site

Monitor wells are installed in the shallowest aquifer where unconsolidated quaternary sand and gravel contain unconfined water.

4.2 Construction

Requirements for monitor wells constructed for the Christensen Finisher facilities are included in the section of the Groundwater Discharge Permit Report. Unless required by the Division of Environmental Quality additional specifications will not be included as part of this Plan.

4.3 Published Standards

Well construction conforms to the EPA RCRA Groundwater Monitoring Technical Enforcement Guidance Document and the National Water Well Association's Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells.

5.0 ANALYTICAL PARAMETERS AND QA OBJECTIVES

Required analytical parameters and holding times are given in Tables A-1 and A-2. Specific conductance, temperature and pH will be measured in the field. Table A-1 provides parameters which will be analyzed on a quarterly basis, until the State official determines an adequate base

line has been established. After this the samples will be analyzed on a semi-annual or annual basis, as determined by the state, for the parameters listed in Table A-2.

5.1 Procedures

A. Check analyses for the field parameters pH and specific conductance will be run in the laboratory. Chemical analysis for all certified constituents will be performed by a commercial laboratory certified under either, The Clean Water Act, The Safe Drinking Water Act or The Resource Conservation and Recovery Act.

5.2 Quality Assurance

A. Internal quality assurance for this project will be in accordance with the Utah DEQ protocol. Laboratory certification will be monitored by the QAO.

B. Routine analysis of samples will be performed in accordance with standard EPA procedures. Special analyses will be performed according to EPA methods for chemical analyses of water and wastes.

C. Specific analytical methodologies and references are listed in Table A-1. These methodologies specify the documentation needed to complete and evaluate the data. They also define acceptable accuracy and precision criteria that must be met for the data to be considered valid.

1. Accuracy: defined by the EPA as the percent recovery of a spiked sample. Laboratory matrix spikes are actual field samples spiked in the laboratory with a representative group from the list of required parameters as per Table A-1. One sample per alternate set of field samples will be split for matrix spike analysis.

2. Precision: defined by the EPA as the relative percent difference of duplicate sample analyses f similar matrix.

D. Re-sampling will be required if contaminant concentration in a trip blank (to be submitted on alternate sampling rounds) are within one order of magnitude of actual field sample concentrations.

5.3 Data Quality Objectives

A. The data collected as part of this investigation is intended for use by the State of Utah DEQ and by Blue Mountain Christensen Finisher and its consultants.

B. Laboratory and field procedures have been designed to provide a high confidence level in the analytical results based on precision, accuracy, completeness and comparability.

5.4 Data Quality Control Management

A. Field data quality control will be managed by the QAO in consultation with the State DEQ official for each type of data defined in this Plan.

B. Field data will be compared to previously collected data at the site to test for probable consistency. Historic data will also be assessed for accuracy to assure consistency and comparability of all data taken at the site.

C. Data will be compared in the same area and / or at similar depths during this study to determine whether or not the results are reasonable and consistent.

D. Unreasonable data points will be evaluated by technical personnel who will decide whether re-sampling or retesting are required.

6.0 FIELD PROCEDURES

This section presents the water quality research methods for water level measurements, sample collection and handling.

6.1 Water Level Measurements

A. Static water level measurements are to be made in all monitor wells during this investigation. Water levels will be measured before sampling with a steel tape or electric sounding device to the nearest 0.01 foot. The measuring device and reel will be cleaned with distilled water before and after each measurement.

B. Measurements will be made from a standard reference point at the top of the well casing.

C. Interpolation will be used to estimate the depth to the nearest 0.01 foot. Sufficient "runs" to the top of the ground water will be attempted to assure accuracy of the measurements. The total depth of each well will be measured after the water level is determined to verify the integrity of the well.

D. Water levels will be reported as depths below the standard reference point and as elevations relative to mean seal level.

1. Measurements obtained while drilling and immediately after completion of each monitor well will be reported on the boring logs.

2. Measurements obtained during the water quality sampling program will be recorded on a field log (Figure A-1) and will be transferred to permanent records.

E. All field and office records will be retained for reference.

6.2 Groundwater Sampling for Laboratory Analysis

A. Collection Methods

1. Groundwater samples will be collected following monitor well development.

2. Development will continue until water removed from the well is reasonably free of sand, silt and clay so that the well can be sampled without damage to the pump or bailer.

3. If possible, turbidity will be less than 5 NTU.

4. Analytes will be sampled in order of decreasing volatility.

5. Teflon, PVC or stainless steel bailers will be used to sample wells that do not yield adequate quantities of water to be purged by pumping. Each well will be ailed until the field parameters (temperature, pH and conductance) have stabilized, thus assuring that the sample will be representative of groundwater conditions.

6. Any abnormal sampling conditions that may have an effect on sampling will be recorded in the field sampling notes. Examples of such conditions would include, but would not be limited to; equipment malfunctions, unusual recharge rates of the well, unusual pumping rates, or conditions which could lead to contamination of the sample. Field notes will also record:

   a. Whether high (pump) or low (bailer) yield procedures for well evacuation were followed.

b. The types of samples taken during a particular sampling event.

c. The sample numbers.

B. Measurements

1. Field measurements and observations will be recorded on field logs which will be copied and stored for reference. A field log from for groundwater sampling is included with this Plan as Figure A-2.

2. Water Levels will be measured before sampling. The height of the water column above the screened completed interval will be used to determine three casing volumes for evacuation prior to sampling.

3. Estimated discharge rates and pumping durations necessary for ensuring evacuation of three casing volumes will be prepared to guide sampling personnel after completion of the monitor well drilling program.

C. Equipment

1. A Groundfos MP1 submersible pump will be used to pump wells. Alternatively a stainless steel PVC or Teflon bailer may be used.

2. Pumping and bailing shall be conducted to ensure that three casing volumes are evacuated before sample retention. A work sheet showing water column calculations for each of the monitor wells is enclosed as Figure A-2. Pump or bailer discharge shall be measured to verify the evacuation volume.

D. Calibration

1. Field instruments for pH and specific conductivity will be calibrated according to manufacturer's recommendations before sampling begins. Cole-Parmer pH and conductivity meter or their functional equivalents will be used.

2. Calibration standards for pH and conductivity will be chosen to be representative of values expected in the naturally occurring waters.

3. Calibrations will be rechecked after sample collection, and all calibration procedures will be documented on the sampling field log. Measurements of pH,

conductivity and temperature will be made at the beginning and just before the end of voiding three casing volumes.

E. Storage and Handling

1. Groundwater samples will be bottled directly from the discharge of the pump or bailer. Bottles will be labeled prior to filling and stored on ice immediately after collection.

2. Sample bottles of appropriate size and with the required preservative will be obtained from the selected certified laboratory.

6.3 Procedures to Avoid Contaminating Groundwater Samples

A. Restrict pump and bailing discharge rates so that drawdown does not cause sample aeration.

B. Decontaminate sampling equipment prior to utilization at another site. Decontamination methods will include:

1. Cleaning with a non phosphate detergent.
2. Rinsing pump and hose with culinary water
3. Rinsing bailers with deionized or distilled water.

6.4 Sample Handling

A. Sample containers will be (1) stored out of direct sunlight and (2) preserved, shipped and analyzed within the maximum allowable holding times as specified in Tables A-1 & A-2.

B. Samples will be shipped to the appropriate laboratory as soon as possible on the same day as collection, but in all cases within the time required by the accepting laboratory.

C. Other specific laboratory requirements and EPA guidelines will be observed for each parameter, including container type, preservation dosages and refrigeration.

7.0 SAMPLE CUSTODY

7.1 Field Operations

A. Documentation of field collection procedures and sample integrity from collection to reporting are essential parts of the Plan.

B. Documentation of sample possession assures that samples may be traced from the time of collection through analysis and final statistical evaluation.

1. Documentation of the history of the sample is referred to as chain-of-custody.

7.2 Necessary Records and Actions

A. Sample Labels: prevent misidentification of samples. The sample label shown as Figure A-3 or its equivalent will be filled out and attached to each sample bottle before collection.

B. Field Sampling and Analysis Records will be maintained. Pertinent field measurements and observation will be recorded.

C. Equipment used to measure the field parameters shall be calibrated before the collection of each sample.

D. Appropriate forms such as Figure A-2 will be filled out for each sample site. Documentation of the sources of buffers, standards, reagents, sample containers and so forth will be recorded on these forms.

E. A chain-of-custody record (equivalent to Figure A-4) will be filled out for each set of samples. A copy will accompany every sample shipment from the time of collection through receipt by the analytical results for inclusion in the yearly reports.

F. A copy of the form sent to the laboratory with each sample shipment will be retained with the analytical results for inclusion in the yearly reports.

G. Andrade Christensen, at his option may elect to protect sample integrity by use of seals applied in the field immediately after sampling. Such seals may be required by the State of Utah in the event that sampling is related to enforcement issues.

7.3 Laboratory Operations

A. The analytical laboratory will acknowledge receipt of the samples by signing and dating in the appropriate box in the form shown as Figure A-4. This form will be returned to Andrade Christensen with the analytical results.

B. The laboratory will maintain internal chain-of-custody control in accordance with protocol as per the Utah DEQ.

8.0 CALIBRATION PROCEDURES AND FREQUENCY

8.1 General

A. Meters used to measure pH and specific conductance will be calibrated as outlined below prior to and during use. Source and identification of standards used to calibrate will be recorded on the form as presented in Figure A-2.

8.2 Field pH

A. Field pH will be determined via a Cole Parmer pH Tester Meter (or equivalent). The meter has automatic temperature correction capabilities.

B. Field personnel will follow the manufacturer's instructions for operation and standardization of instruments.

8.3 Standardization

A. Standardization will utilize a buffer of 7 pH units.

B. The meter will be sterilized prior to each sample collection and checked against the standard after each sample collection. Where sample pH values vary widely, the meter will be standardized with buffers having pH of 7 and 10.

8.4 Equipment Storage and Cleaning

A. The pH meter electrode will be stored in accordance with the manufacturer's recommendation.

B. Any oil on the electrodes shall be cleaned with methanol f HCL as needed.

8.5 Field Specific Conductance

A. Field specific conductance will be measured with a Col-Parmer Model 0481-40, or equivalent. This meter automatically indicates specific conductance normalized to 25°C.

B. Calibration will be accomplished according to manufacturer's instruction before each measurement.

8.6 Temperature and Water Levels

A. Temperature will be measured using a good grade mercury thermometer. Temperatures will be reported to the nearest o degree Fahrenheit.

B. Water level measurements will be made with a steel tape or electronic sounding device capable of accuracy to within 0.01 feet.

C. Water levels will be recorded in the field on the form shown as Figure A-1 along with pertinent observations.

9.0 INTERNAL QUALITY CONTROL

9.1 Field Operations

A. At least one blind field groundwater duplicate sample will be prepared and submitted to the laboratory during alternate sampling events.

B. Obtaining Water Samples for Duplicates:

1. Water samples will be obtained directly from the pump discharge line.

2. One field equipment blank will also be collected during alternate sampling events.

C. Preparing Field Equipment Blank Sample (one of the following methods):

1. Pump distilled water through the submersible pump.

2. Fill sample containers from the bailer in the same manner as is done for a typical sample.

9.2 Preservation

A. Preservatives are planned for use in sample bottles.

B. A trip blank for each one of the preserved sample bottle types will be included for alternate sampling events.

C. Each of these trip blank bottles will be prepared by the laboratory (filled with distilled water and appropriate preservatives) and be subjected to the same field conditions and laboratory analytical tests as required for ground water samples.

9.3 Laboratory Operations

A. The laboratory will conduct quality control checks in accordance with the State of Utah certification requirements.

B. This quality control check will include running at least 5 percent duplicated and spike samples.

C. The laboratory will summarize the results of these quality control checks and submit them with the analytical results.

D. At least one groundwater sample from alternate sampling events will be utilized for laboratory matrix spike duplicate analyses. Field personnel will ensure that sufficient sample material is provided to the appropriate laboratory for the matrix spike.

9.4 Summary of Quality Control Samples

A. The following "extra samples" will be analyzed during alternate sampling events.

1. Groundwater duplicate samples from each upgradient well.
2. One field equipment blank.
3. One trip blank for each of the preserved bottle types (prepared by the laboratory).
4. One laboratory matrix spike duplicate sample.

10.0 DATA REDUCTION MANAGEMENT, VALIDATION, AND REPORTING

All field data and chain-of-custody forms generated from sampling will be appropriately identified and included in each water quality data report.

10.1 Standardization

A. Use of standardization forms will enable consistent presentation of the data throughout the project life. Therefore, standardization data forms will be used by all field personnel as well as by the laboratory during the project.

10.2 Validation

A. Validation of all analytical data will be performed. Laboratory will be required to submit results which are supported by sufficient back up data and QA/QC reports to enable the Quality Assurance Officer to determine the quality of the data.

B. Validity of all data will be determined from the precision and accuracy assessments outlined in Section 5.0 of this Plan. All data will be stored and maintained according to the procedures outlined.

10.3 Data Processing

A. Data will be processed through an orderly, easily traceable and logical sequence. Field data will be assessed for accuracy.

B. Subsequent analysis, interpretation and reporting of results will be conducted by trained professionals, using documents which are initialed and dated whenever appropriate.

C. Backup copies of electronic media will be prepared daily. Any calculations will be checked and all assumptions necessary for calculations will be approved by the QAO.

D. Results will be reported with all necessary supporting documentation after proper review.

11.0 AUDIT PROCEDURES

The CM and the QAO will monitor and audit performance of the quality assurance procedures outlined in this report. The QAO will conduct random field and office audits which will assure that the information being gathered is reliable and of good quality. This information will be provided to the DEQ Official.

11.1 Field Audits

A. The CM or his representative will conduct unscheduled field activity audits during each sampling event. Audits will evaluate the execution of (1) sample identification, (2) sample control, (3) chain-of-custody procedures, (4) field documentation, (5) equipment calibration and (6) sampling operations.

B. Evaluation: The following list of items will be used to evaluate the water sampling and handling:

1. Field documents pertaining to sample identification and control will be examined for completeness and accuracy.

2. Field documents will be reviewed to see that (1) all entries are dated and signed with waterproof ink or pencil and that (2) the contents are legible, accurate and inclusive.

3. The field documents form the basis for reports and will contain all measurements and observations.

4. Field instruments will be checked for proper calibration and completely prepared calibration documentation.

C. Conformance and Security

1. Sampling operations will be evaluated for conformance to Section 6.0 of this Plan. The proper number of samples will be collected at the assigned locations in proper containers with correct labels and appropriate preservatives.

2. Required field measurements and quality assurance checks will be performed and documented as directed by the CM and the QAO.

3. The CM or his representative will check chain-of-custody procedures and confirm that samples are kept in secure custody at all times.

11.2 Office Audits

A. Upon completion of each sampling event, the individual files will be assembled, organized and securely stored.

B. Documents will be examined to determine that all necessary signatures, dates and project numbers are included. The CM or his representative will examine all documents and determine if they have been handled and stored in the proper manner. Such files will be maintained by Andrade Christensen or a member of his company.

C. The CM or his representative will review product quality to assure that the project is being performed in accordance with approved quality assurance procedures.

D. Prior to the production of the draft Background Groundwater Quality Report, all work products will undergo review by the QAO.

E. QAO assessment will include review of calculation, test analysis, graphs, tables, computer input/outputs and any other document which involves interpretation of the field data.

12.0 CORRECTIVE ACTION

12.1 Criteria

A. Corrective action will be undertaken if sample collection deficiencies or unreliable analytical results prevent QA objectives for the project from being met.

B. Specific criteria for acceptable data collection are given in section 5.0. The QA program(s) of the selected laboratory will provide the criteria for acceptable analytical results.

C. Analytical results supplied by the laboratory will have been subjected to the internal QA plan and will be considered to be acceptable unless the results significantly contradict previously acquired data.

D. If significant contradiction occurs, the QAO will request that the laboratory review the quality control documentation for the sample or analysis in question.

E. Further corrective action will be based on the results of the documentation review.

12.2 Correction

A. The principal corrective action that may be required as a result of deficiencies in sample collection is re-sampling. Re-sampling will be required if one or more of the following problems occur:

1. Contaminating samples due to collection procedure errors which result in a sample not representative of site conditions.
2. Loosing sample in transit to the laboratory.
3. Surpassing holding times for required parameters.
4. Trip blank showing contaminant concentrations within one order of magnitude of the original field sample.
5. Ion balance in error (either plus or minus) by more than 5%.

B. Variations between duplicate analyses, which are outside control limits, will be evaluated by the CM QAO and DEQ Official to determine whether re-sampling is required.

C. Re-analysis may be substituted for re-sampling if the holding time has not expired and sample condition is satisfactory.

D. A request for corrective action (RCA) may be initiated by the CM, the QAO or the DEQ Official.

13.0 QUALITY ASSURANCE REPORTS

Water quality data reports will be submitted every three months during the initial background groundwater quality report study period and annually thereafter. Quarterly sampling reports will document any deviations from field, handling or laboratory procedures contained in the approved plan.

QA reports will be prepared annually and submitted in conjunction with water quality data reports to the DEQ, Division of Water Quality.

13.1 Contents

A. Quality Assurance reports will contain:

1. Results of system and / or performance audits of sample collection activities.
2. A summary of the laboratory QA report(s), including notation of QA modifiers.
3. Listing and basis for any unacceptable data.
4. Discussion of significant QA problems and recommended solutions.

13.2 Format

A. The QA report will be prepared by the QAO and the CM or his representative and distributed to the DEQ Official.

B. The final background groundwater quality report will contain a separate QA section which will summarize the data quality information.

14.0 MONITORING STATIONS

A map of the monitor wells to be sampled is included as Figure A-5. The map shows the physical location of the wells with respect to the proposed facility location.

ATTACHMENTS

Christensen Finsher Sites

Table A-1 -- Base Line Water Sample Analysis Parameters

Parameters	Units	Analytical Methods		Preservation	Max Holding Time
		EPA	Std Methods		
Alkalinity, Carbonate as CaCO3	mg/l		2320 B	Cool, ≤ 6°C	14 days
Ammonia-nitrogen as N	mg/l	350.1	4500-NH3	Cool, ≤ 6°C, H_2SO_4 to pH<2	28 days
Bicarbonate	mg/l	310.2	2320 B	Cool, ≤ 6°C	14 days
Bromide	mg/l	300.0		None Req'd	28 days
Calcium	mg/l	215.1	3111 B	HNO_3 to pH<2	6 months
Carbon dioxide	mg/l				--
Carbonate	mg/l	310.2	2320 B	Cool, ≤ 6°C	14 days
Chloride	mg/l		4500-Cl-B	None Req'd	28 days
Hardness, Ca + Mg	mg/l		2340 B or C	HNO_3, H_2SO_4 to pH<2	14 days
Hydroxide	mg/l				--
Inorganic nitrogen (nitrate and nitrite) as N	mg/l	353.2	4500--NO3-F	Cool, ≤ 6°C, H_2SO_4 to pH<2	28 days
Magnesium	mg/l	242.1	3111 B	HNO_3 to pH<2	6 months
pH					on site
Phosphate-phosphorus as P	mg/l	365.3	4500-P-E	Cool, ≤ 6°C, H_2SO_4 to pH<2	28 days
Potassium	mg/l	258.1	3111 B	HNO_3 to pH<2	6 months
Sodium	mg/l	273.1	3111 B	HNO_3 to pH<2	6 months
Solids, Total Dissolved	mg/l	160.1	2540-C	Cool, ≤ 6°C	7 days
Solids, Total Suspended (TSS)	mg/l	160.1	2540-C	Cool, ≤ 6°C	7 days
Specific conductance	uS/cm	120.1	2510 B	Cool, ≤ 6°C	7 days
Sulfur, sulfate (SO4) as SO4	mg/l	375.2		Cool, ≤ 6°C	28 days
Turbidity	NTU	180.1	2130 B	Cool, ≤ 6°C	48 hours

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Table A-2 -- Steady State Water Sample Analysis Parameters

Parameters	Units	Analytical Methods		Preservation	Max Holding Time
		EPA	Std Methods		
Alkalinity, Carbonate as CaCO3	mg/l		2320 B	Cool, ≤ 6°C	14 days
Ammonia-nitrogen as N	mg/l	350.1	4500-NH3	Cool, ≤ 6°C, H_2SO_4 to pH<2	28 days
Bicarbonate	mg/l	310.2	2320 B	Cool, ≤ 6°C	14 days
Bromide	mg/l	300.0		None Req'd	28 days
Carbon dioxide	mg/l				--
Carbonate	mg/l	310.2	2320 B	Cool, ≤ 6°C	14 days
Chloride	mg/l		4500-Cl-B	None Req'd	28 days
Hydroxide	mg/l				--
Inorganic nitrogen (nitrate and nitrite) as N	mg/l	353.2	4500--NO3-F	Cool, ≤ 6°C, H_2SO_4 to pH<2	28 days
Kjeldahl Nitrogen, Total (TKN)	mg/l		4500-Norg B or C and 4500-NH3B	Cool, ≤ 6°C	28 days
pH					on site
Phosphate-phosphorus as P	mg/l	365.3	4500-P-E	Cool, ≤ 6°C, H_2SO_4 to pH<2	28 days
Solids, Total Dissolved	mg/l	160.1	2540-C	Cool, ≤ 6°C	7 days
Solids, Total Suspended (TSS)	mg/l	160.1	2540-C	Cool, ≤ 6°C	7 days
Specific conductance	uS/cm	120.1	2510 B	Cool, ≤ 6°C	7 days
Sulfur, sulfate (SO4) as SO4	mg/l	375.2		Cool, ≤ 6°C	28 days
Turbidity	NTU	180.1	2130 B	Cool, ≤ 6°C	48 hours

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Christensen Finisher Sites
Monitor Well Water Level Measurements Log

Well	Date	Time	Reference Point	Ref. Pt. Elevation	Depth (ft)	Depth to Water (ft)	Water Elevation	By:

Figure A-1

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Christensen Finisher Sites
Water Quality Sampling Field Record

Well Name: _____ **Date:** _____

Sampling Personnel: _____

Instrument Calibrations

pH meter Calibrated? ☐ **Yes**

Conductivity Meter Calibrated? ☐ **Yes**

Field Measurements

Time	Volume Evacuated	Temp. (F)	pH	Conductivity	Comments

Base intake slots (feet below ground) _____

Top water surface (feet below ground) _____

Water Column (feet): _____ Casing - Inside Diameter: _____

Gallons of Water in Casing: _____ Gallons X 3: _____

Note: One gallon - 231 cubic inches. Height of water column in inches is obtained by multiplying the water column in feet by 12; this column height is then multiplied by the area of the casing to obtain the volume of water in cubic inches. This volume is then divided by 231 to obtain the volume of water in gallons.

Pump Started - Time: _____ Pump Stoped - Time: _____

Pump Started - Time: _____ Pump Stoped - Time: _____

Pump Started - Time: _____ Pump Stoped - Time: _____

Pump Started - Time: _____ Pump Stoped - Time: _____

Pump Rate (gpm): _____ Total Time Pumped (min): _____

Volume evacuated before sampling (gal): _____

Notes:

_____

_____

_____

Figure A-2

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Christensen Finisher Sites
Field Water Sample Label

Well Name: _____

Sample Number: _____

Analytical parameter(s): dfsd

Date Sampled: _____

Time Sampled: _____

Sampler: _____

Preservative: ☐ Acid ☐ Base ☐ Filtered

Destination Laboratory: _____

Figure A-3

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Christensen Finisher Sites
Field Water Sample - Chain-of-Custody Record

Sampler Signature: _____

Sample ID	Sample Source	Sampled Date & Time:	# of Containers	Parameters to Analyze		
				Group 1 Characteristics	Group 2 Characteristics	Other

Group 1 Characteristics:

Alkalinity, Carbonate as CaCO3	Ammonia-nitrogen as N	Bicarbonate	Carbon Dioxide
Carbonate	Chloride	Hydroxide	Inorganic nitrogen (nitrate & nitrite) as N
pH	Phosphate-phosphorus as P	Solids, Dissolved	Solids, Total Suspended (TSS)
Specific Conductance	Sulfur, sulfate (SO4) as SO4	Turbidity	

Group 2 Characteristics:

Calcium	Hydroxide	Magnesium	Potassium	Sodium

Relinquished By:	Date & Time	Sent Via	Received By:	Date & Time

Notes:

_____

_____

_____

Figure A-4

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