DEMONSTRATING AND MONITORING THE SUSTAINABLE MANAGEMENT OF NUTRIENTS ON C&H FARM IN BIG CREEK WATERSHED

This research project will evaluate the sustainable management of nutrients from the C&H Farm operation (subsequently referred to as C&H, to include animal facilities and permitted land application fields). The study includes the following major tasks:

1. Monitor the fate and transport of nutrients and bacteria from land-applied swine effluent to pastures.
2. Assess the impact of farming operations (effluent holding ponds and land-application of effluent) on the quality of critical water features on and surrounding the farm including springs, ephemeral streams, creeks and ground water.
3. Determine the effectiveness and sustainability of alternative manure management techniques including solid separation that may enhance transport and export of nutrients out of the watershed.

This plan of work covers equipment purchase, installation, labor, travel, and analytical costs of monitoring for one year. The project will focus on three fields, which give a range in landscape position and soil fertility levels representative of the overall operation (Map 1 and Table 1). Water quality assessment of Big Creek above and below the farm will provide baseline information (Map 2).

To address the long-term sustainability of C&H, the project will measure soil fertility levels of all permitted fields at frequent intervals. This combined with nutrient levels in monitored wells will inform manure management decision and ensure they remain sustainable. The project will assess the feasibility of manure treatment, which is regarded as addressing nutrient imbalance concerns and has the potential to provide the farm with cost-beneficial alternative for the sustainable use and export of treated manures.

This information will be a short-term assessment and it must be noted that funds allocated below will not cover long-term monitoring, sample analysis, and assessment of land use impacts on area waters. Additional funds would be needed for sample collection and labor to continue monitoring for a minimum of five years. This time frame is recognized by NRCS, EPA, and general scientific community to be the minimum required to accurately assess any impacts and overcome annual weather fluctuations.

The plan of research meets the level of funding currently available. Other important methods of investigation, such as the use of dye-tracer tests, will provide valuable information on possible rapid by-pass flow pathways common in karst dominated areas and will be included in years 2 and 3, when water flows on the operation will be better understood. With additional funding, this would be conducted at sites identified from year 1 studies. Finally, a broad pool of expertise from the partner organizations will be brought together for work plan implementation and periodic review.

<u>Field Evaluation - Land Application Sites</u>

Assess water flow directions and risk of nutrient and bacteria losses from three fields (Fields 1, 5, and 12) that will be used to land apply manure (Map 1 and Table 1). On each field;

1. Conduct a detailed topographic survey of the application fields to better understand surface water flow patterns and the most appropriate location for surface runoff collection and monitoring wells / piezometer devices.
2. Utilize GIS/GPS and grid soil sampling to develop initial soil nutrient maps for all application fields. Use results to develop strategic soil fertility sampling that will be repeated twice ayear to track changes in nutrient levels.
3. Conduct inventory of soil physical properties (surface infiltration, subsurface hydraulic conductivity, bulk density, phosphorus sorption isotherms, and particle size analysis in the three application fields.
4. Install bermed surface runoff area (>2 acres) to collect and monitor surface runoff, with weather station (Maps 3 and 4).
5. Install two transects of monitoring wells / piezometers across the two stream-side fields (i.e., #5 and 12) to automatically and continuously determine if subsurface water is moving to or away from the adjacent river (Maps 4 and 5). These will be installed according to standard NRCS protocols and described in more detail in Appendix 1 (see Figures 1 and 2). Piezometers will be installed so that there is minimal piping or equipment above ground that could interfere or influence with day to day farm operations on that field.
6. Collect samples after each rainfall event from the surface runoff areas and monitoring wells, and from monitoring wells at monthly intervals, filter on site, store on ice and ship to the AWRC Laboratory for nitrogen, phosphorus, pH, sediment, and bacteria (E. coli) analysis for one year.
7. Annually measure soil nutrient fertility on every permitted field of C&H by state approved methods to assess the long-term sustainability of implemented measures.
8. Periodically determine plant uptake by collecting plant and hay samples for tissue analysis and determine yield (dry matter mass for a pre-determined area.
9. Determine nutrient application rate by determining nutrient content of swine effluent before land application via manure application and determine volume of effluent being applied to known monitoring area.

<u>Water Quality Assessment of Springs, Ephemeral Streams, and Creeks in the Operation</u>

Measure nutrient, bacteria, and sediment concentrations in: a) an ephemeral stream that drains runoff from around the animal production facility and slurry holding ponds, b) springs connected to land application fields, and c) Big Creek at upstream and downstream of farm (see Map 2).

1. Install two observation wells adjacent to the holding ponds and upslope of the holding ponds to determine any potential seepage of nutrients, nitrogen and phosphorus.
2. Continuously monitor flow and automatically collect water samples at the road culvert draining the subwatershed containing the animal houses and manure holding ponds.

3. Install a calibrated stream gauge for continuous flow measurement and collect Big Creek water samples on a monthly basis.

4. Deploy sondes at the spring and Big Creek sampling locations to continuously determine dissolved oxygen (DO), excess partial pressure of carbon dioxide ($EpCO_2$), electrical conductivity (EC), and temperature of the water. Diurnal, seasonal, and storm event fluctuations of water $EpCO_2$, DO, EC, and temperature can be used to identify possible sources of new and old water at these locations. Similarly, a longitudinal survey downstream between upper and lower sampling points in Big Creek under baseflow, can locate potential sites where water is entering the Creek form the surrounding landscape. That is, $EpCO_2$ will increase (and pH will drop), with the input of spring water into Big Creek.

Manure Treatment via Solids and Chemical Separation: A Case Study to Evaluate Cost Benefits of Alternative Manure Management Options

Work with the owners of the C&H Farm to explore potential long-term, economically viable, options to modify current manure management practices in the general areas of:

1) Separating manure liquids and solids along with their differential management;
2) Retaining sufficient nitrogen to meet crop needs;
3) Exporting excess phosphorus off the farm;
4) Mitigating off site odor; and
5) Not exceeding the current economic, labor, and management resources of the farm.

The project will identify management options to meet the above objectives. It is anticipated that the options will include but not be limited to:

- Mechanical separation manure solids from liquids with or without chemicals as a precursor for off-farm transport of separated solids; and
- Selective application of higher phosphorus content solids and lower phosphorus content liquids to different fields that minimizes any loss of nutrient loss.

For the management options identified, their initial and long-term costs will be estimated and an assessment of their implementation impacts made. Available literature and other information resources will be utilized in this process. However, there will be a need for laboratory and onsite tests/trials. This is especially true when evaluating manure solid-liquid separation and/or chemical use.

Project Outcomes

1. Research project documenting the field and manure management options evaluated and the details of their evaluation.
2. Will provide C&H Farm input for their decision on appropriate options to undertake manure treatment and export, in terms of cost and labor considerations.
3. A sustainable management blueprint for C&H Farm operation.

4. Documentation of any environmental impacts and details of actions taken to eliminate them.
5. A five-year assessment of C&H. If the majority of those five years are abnormal weather years, consideration should be given to extend the assessment in order to obtain a true representation of Operation impacts.

Table 1. Properties of fields where surface and subsurface flow will be determined.

	Field 1	Field 5	Field 12
¼ section	SW	NE	SE
Section	25	26	35
Township	15N	15N	15N
Range	20W	20W	20W
Latitude	35.917	35.928	35.901
Longitude	-93.058	-93.071	-93.069
Available acres	15.6	23.8	23.7
Soil type	Noark very cherty slit loam	Razort loam	Spadra loam
Soil test P, ppm	83	65	19
Field slope, %	5.3	0.2	2.0
Erosion, tons/acre [a]	0.12	0.05	0.05

[a] Erosion estimated by RUSLE 1.

Budget

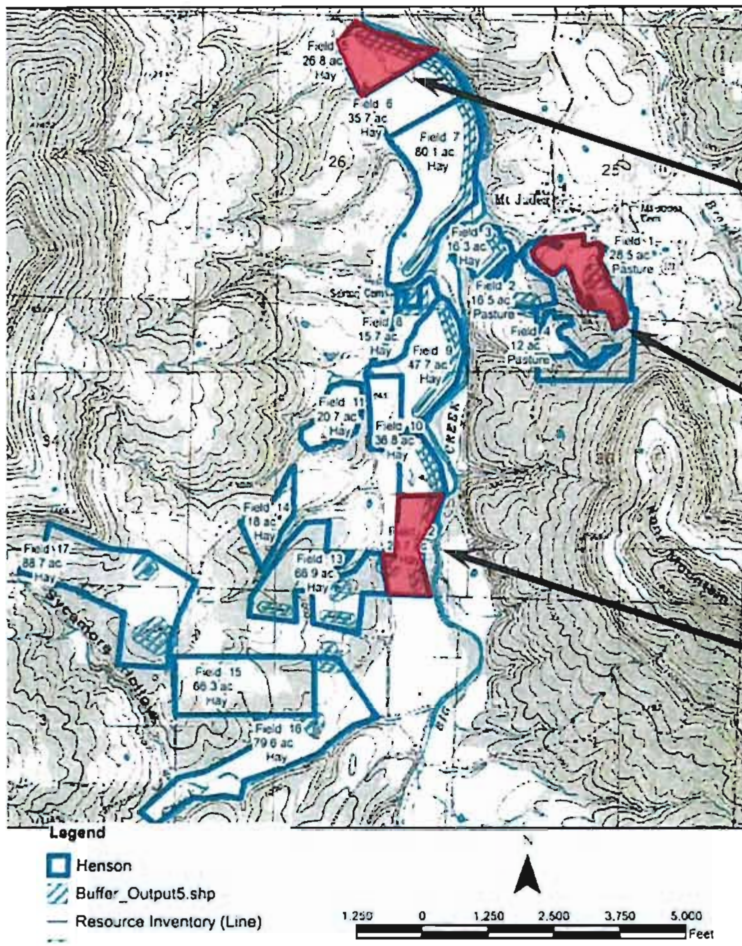
Item	Unit cost	Total cost
Field monitoring		
Detailed topographic survey of application fields	10,000	10,000
Surface runoff plot (installation & flume) @ 3 total	4,000	12,000
Weather station @ 3 total	750	2,250
Piezometers/monitoring wells @ 24 per field / 48 total	950	45,600
Velocity flow meter for culverts	5,000	10,000
ISCO sampler @ 5 total	6,000	30,000
Sample analysis @ ~10 samples per site for 50 sites	110	55,000
Observation well @ 2	5,000	10,000
Subtotal		$174,850
In-stream chemical monitoring		
Sontek Flow Meter @ 2 stream sites	5,000	10,000
Stream gauge, install @ 2 sites	5,000	10,000
Sonde for continuous water quality assessment @ 3 sites [a]	3,000	9,000
Sample analysis @ 24 samples per site for 4 sites [b]	110	10,560
Subtotal		$39,560
Manure treatment		
Chemical treatment: Benchtop test to determine to chemical types and rates. Equipment and sample analysis. 144 samples @ $50 per sample.	10,000	10,000
Physical treatment: Manure separation lab field tests. 30 samples $50 @ per sample	2,500	2,500
Miscellaneous supplies for chemical and physical treatment tests		10,000
Field Technician –$30/hour for 320 hours (2 months)		14,400
Travel for technician and extension researcher		5,000
Subtotal		$41,900

Personnel		
Travel to site from Little Rock and Fayetteville for site inspection and maintenance	10,000	10,000
Charges for shipping samples for analysis	8,000	8,000
Contractual labor – earthwork for installations	20,000	20,000
Field technician – hourly basis @$30/hour half time (1040 hours)	31,200	31,200
Student aides to help with sample processing @ $10 / hour (2@ 15 hours/week/50 weeks each year)	7,500	15,000
Subtotal		$84,200
Project total		**$340,510**

[a] Sondes deployed in Big Creek upstream and downstream and in spring.

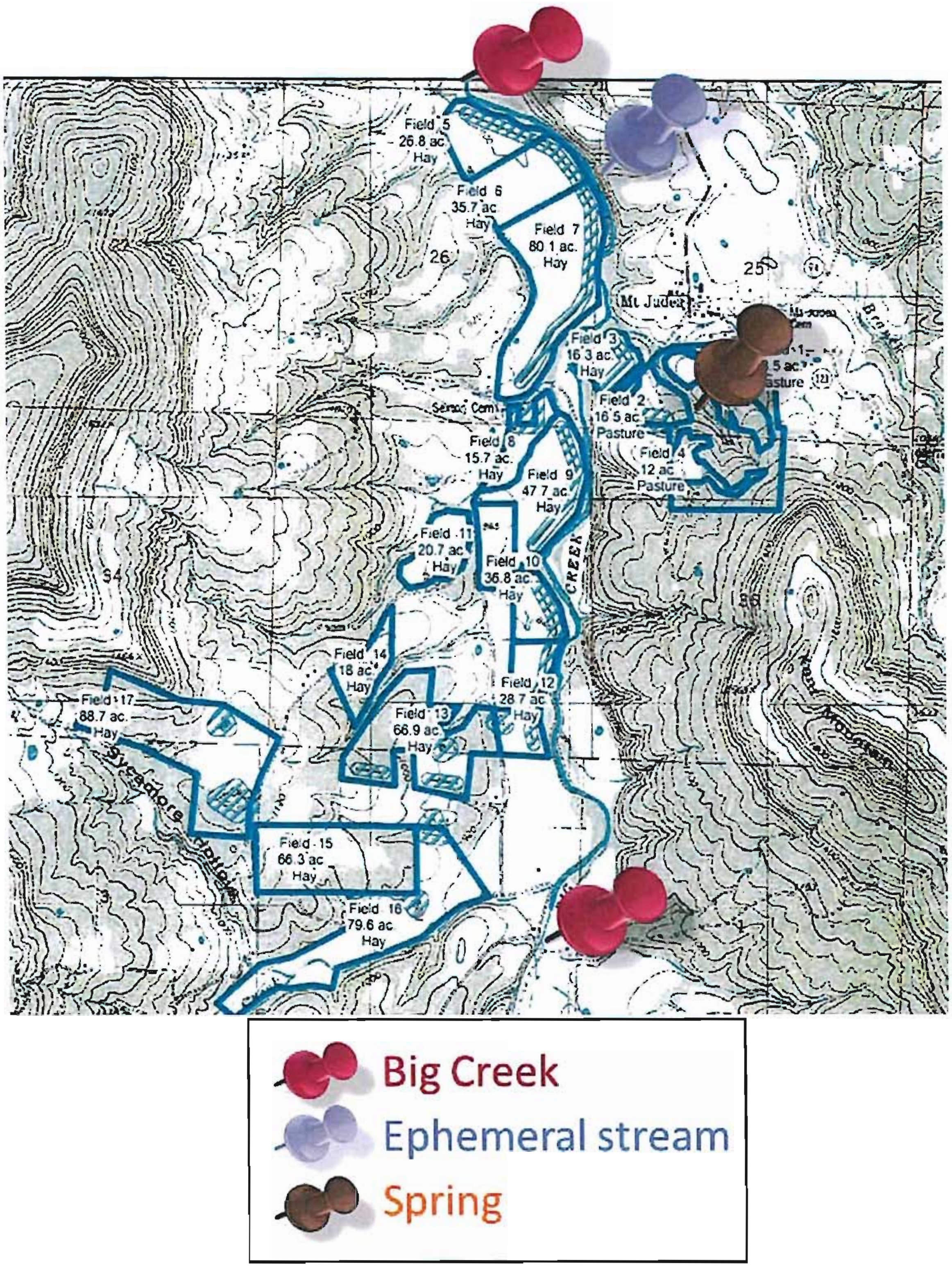
[b] Samples from Big Creek (2 sites), ephemeral stream, and spring.

Map 1. Location of monitored fields on the C&H Farm operation.

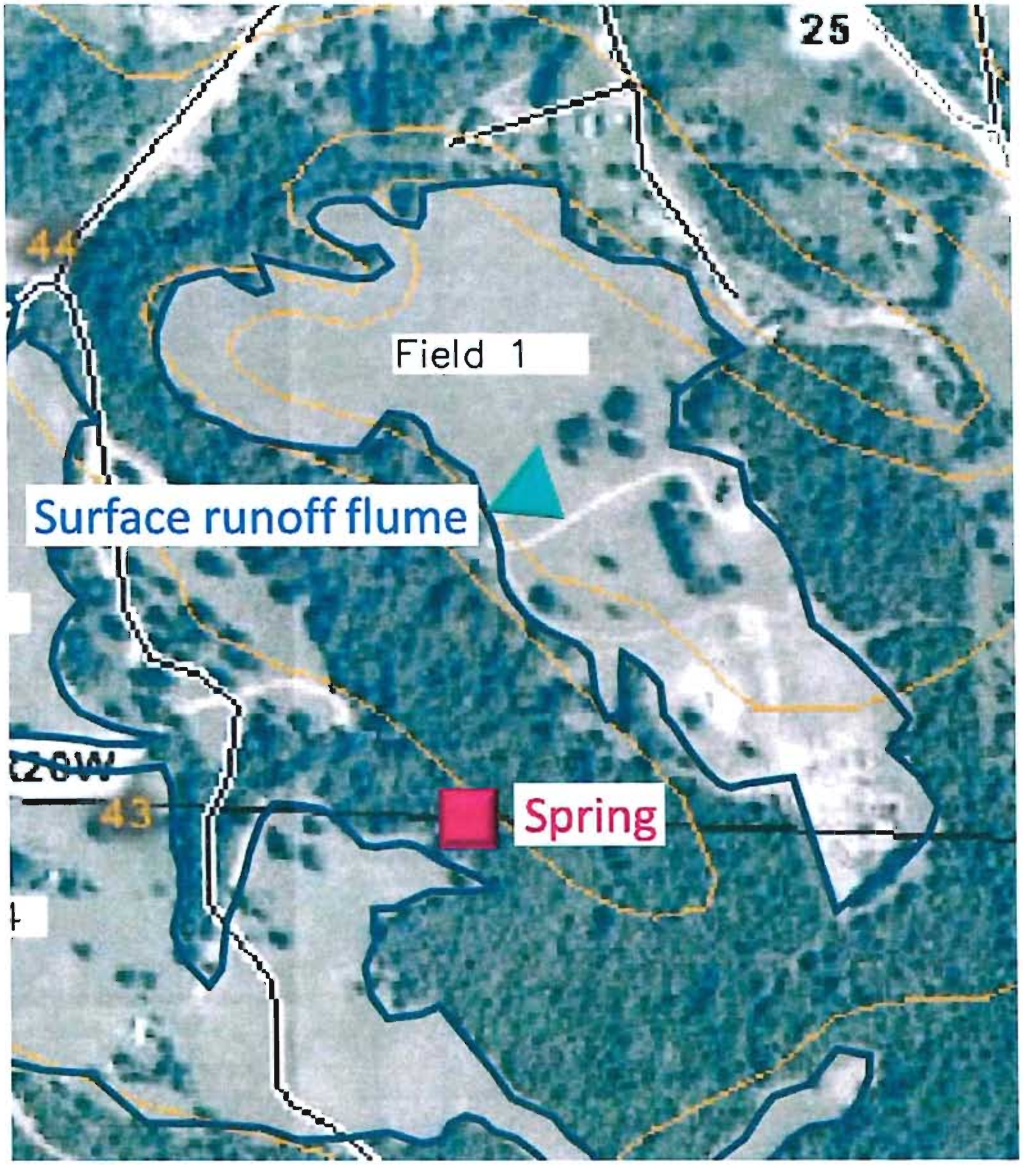


Field #	Area, acres	Soil test P, ppm
5	23.8	65
1	15.6	83
12	23.7	19

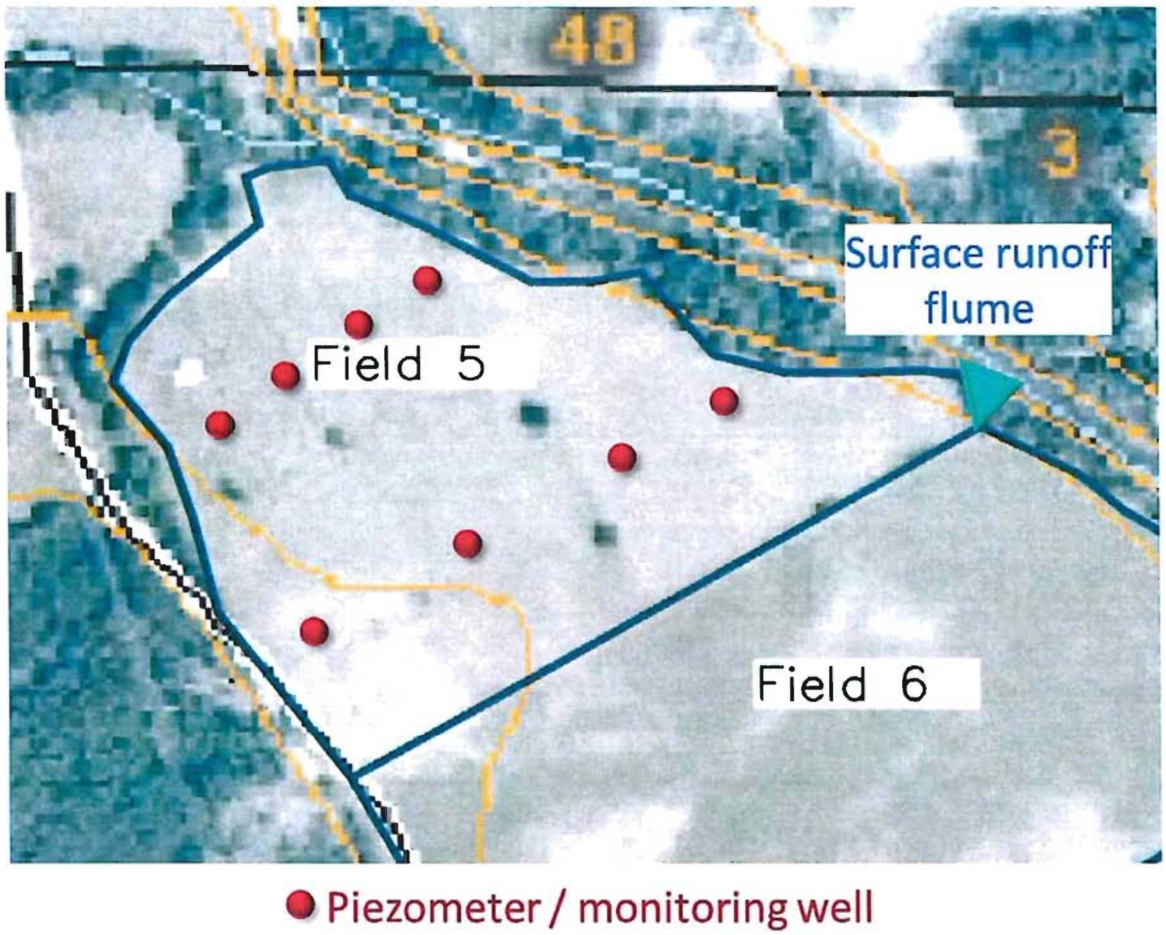
Map 2. Sampling locations for ephemeral stream, spring, and Big Creek.



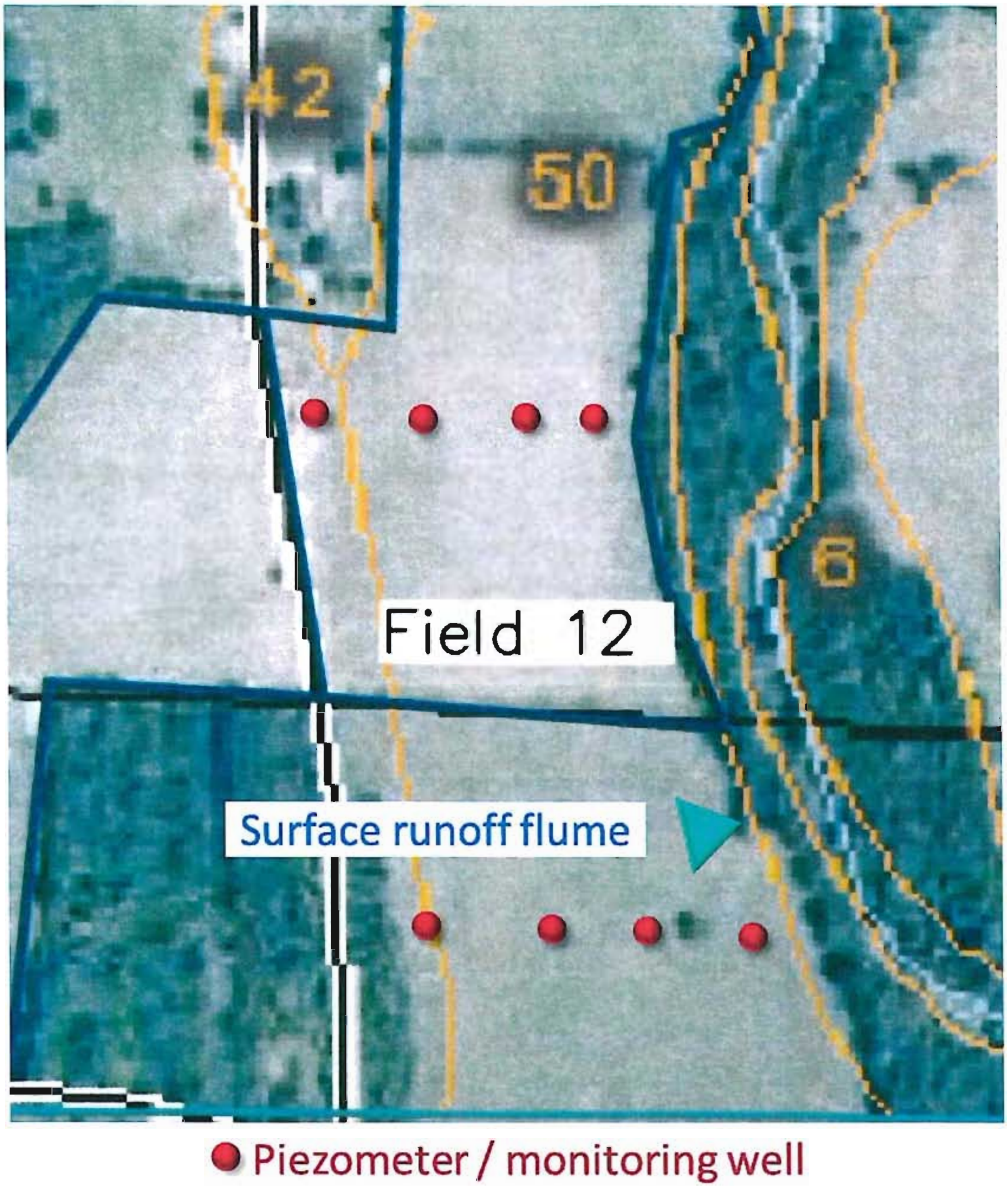
Map 3. Sampling locations for Field 1.



Map 4. Sampling locations for Field 5.



Map 5. Sampling locations for Field 12.



Map 6. Sampling locations for Field 12.

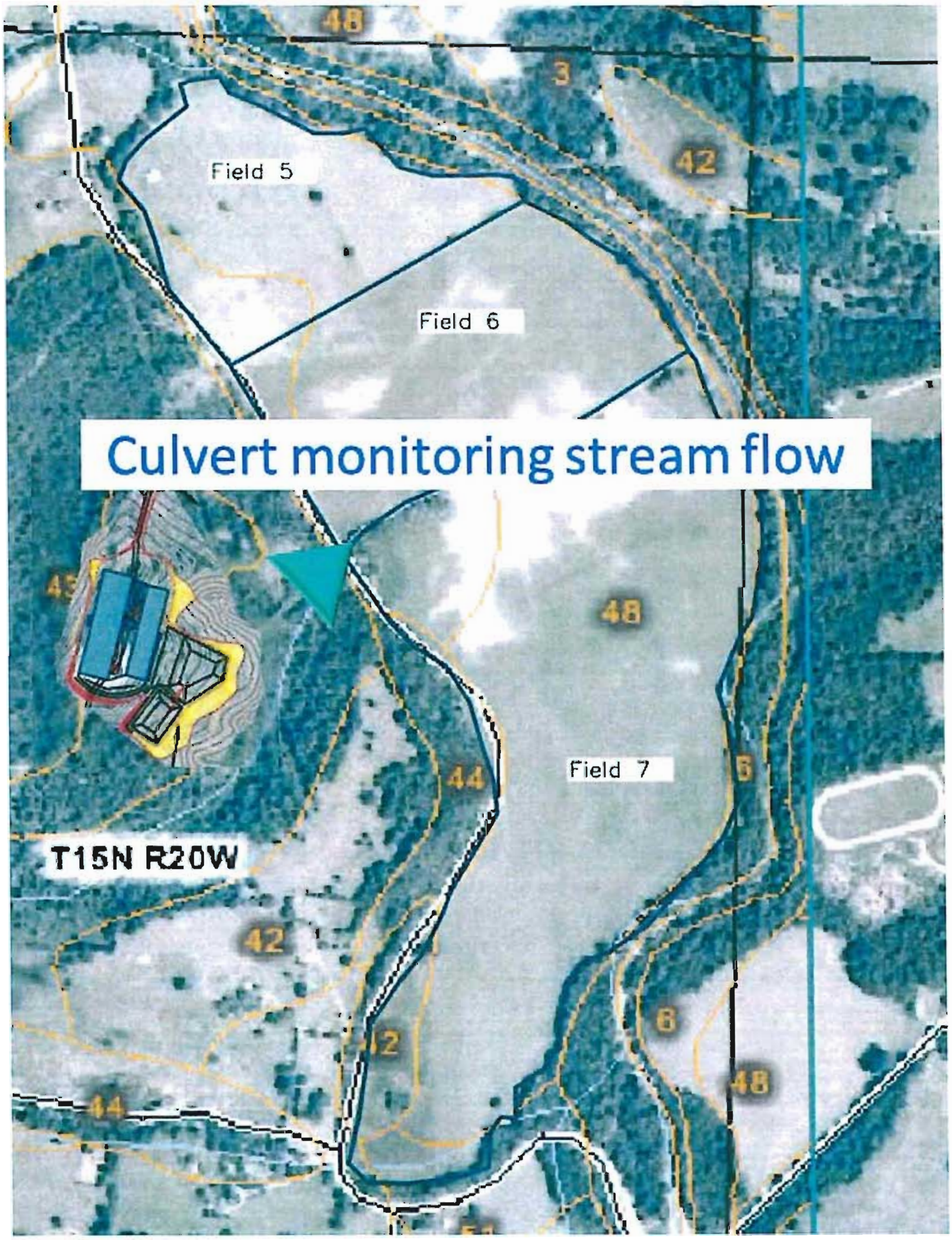


Figure 1. Standard installations for soil studies of (1A) a piezometer and (1B) a water-table well (NRCS, 2008).

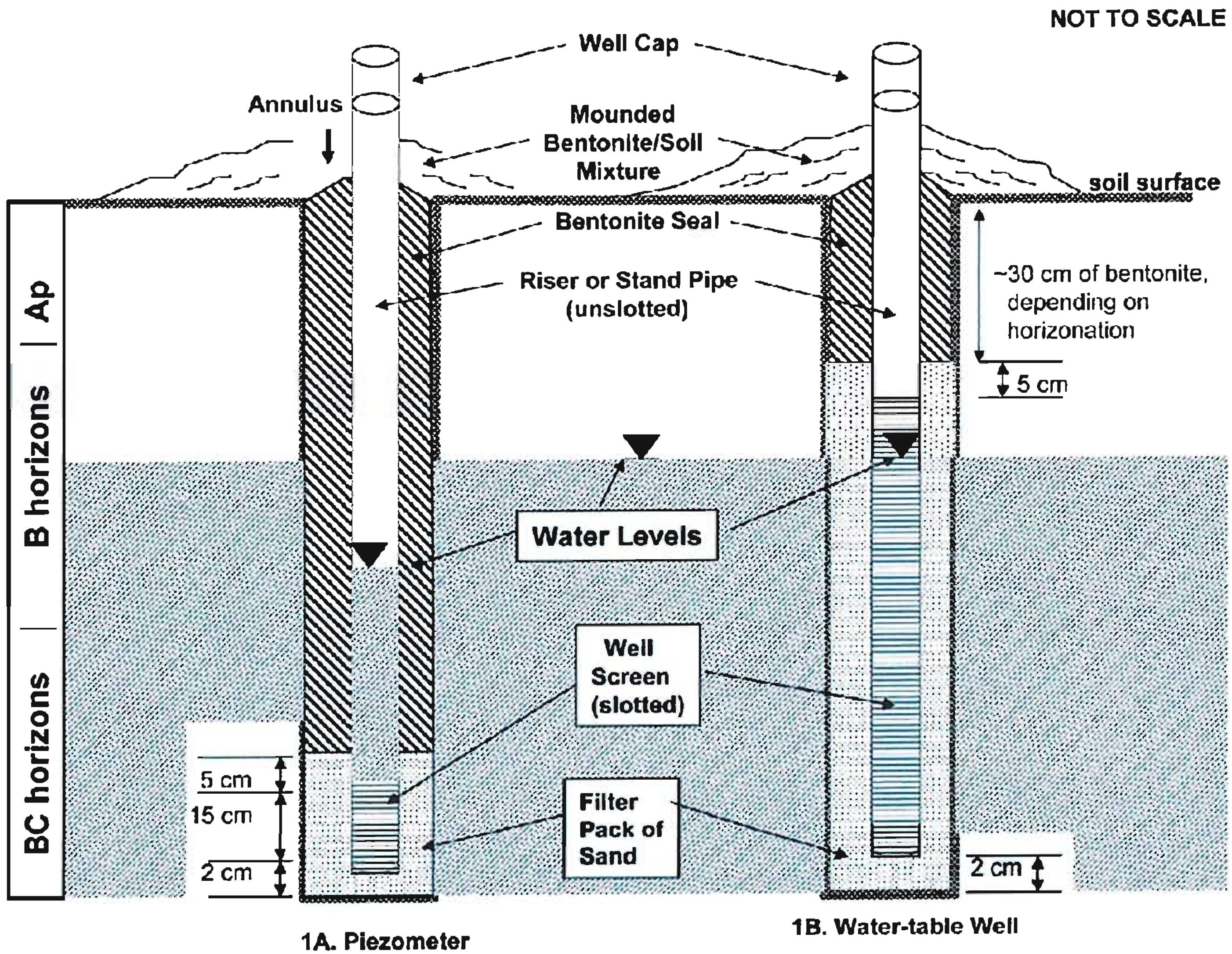
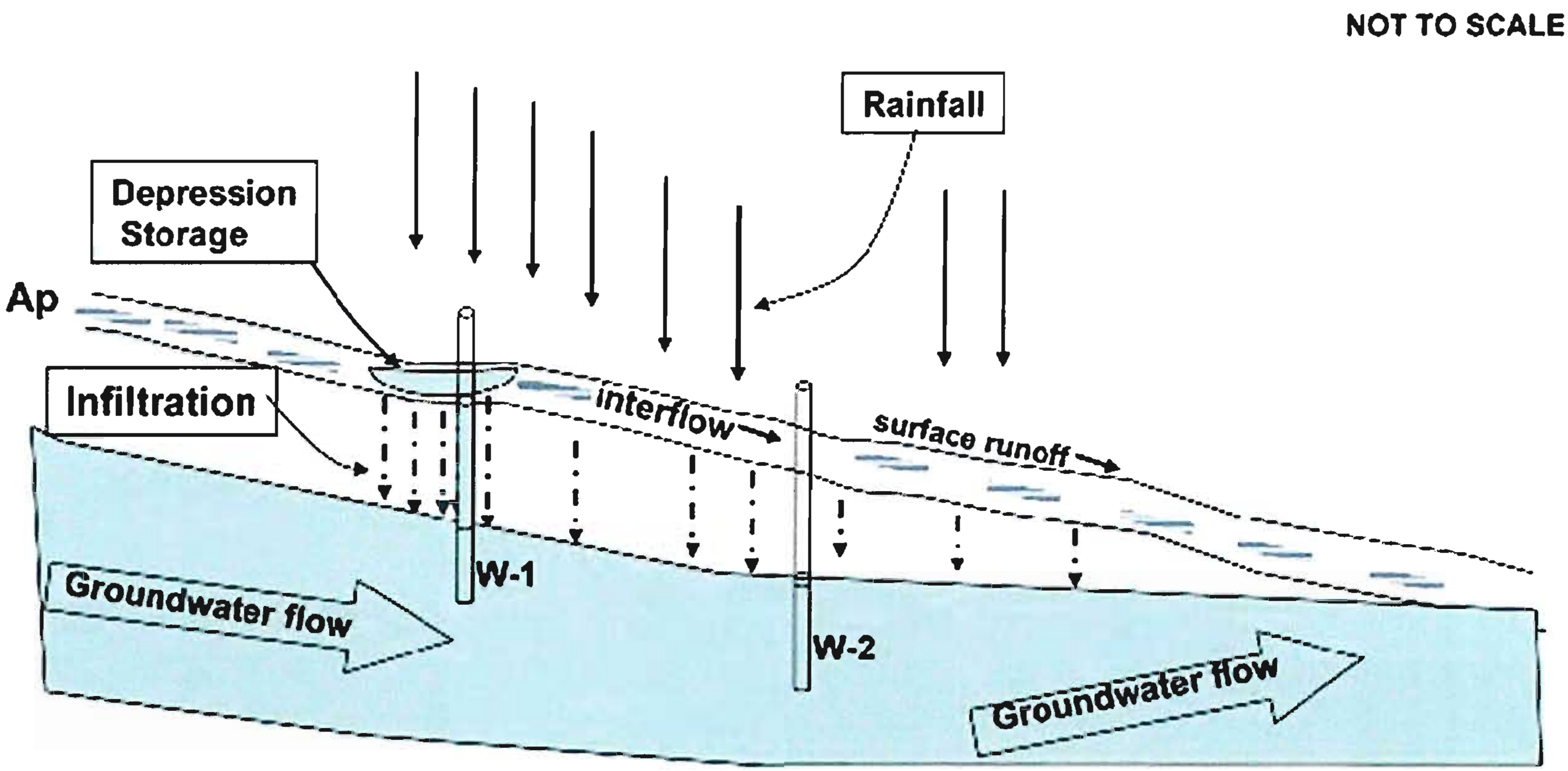


Figure 2. Schematic diagram of paths of water flow significant to shallow water monitoring studies in sloping landscapes. A combination of depression storage and interflow at small scales may be short-lived but can be significant enough to cause bypass flow down poorly protected well risers (W-1). Figure modified from Kirkby (1969).



APPENDIX 1 - PIEZOMETER AND MONITORING WELL INSTALLATION

At each site, a series of three (3) piezometers will be installed. Piezometers containing water-level sensors (Water Logger WL-15 units from Global Water) will be installed near just below the root zone (about 12 inches deep), at approximately the bottom impermeable layer or groundwater level (about 15 feet or approximately at the Big Creek bed elevation), and equidistant from the first two piezometers. A bucket auger will used to describe the soil profile upon excavation to install the deepest piezometers. The piezometers containing the water-level sensors will consist of 5-cm (2-inch) diameter Schedule 40 PVC pipe, which will be slotted in the bottom 10 cm of the pipe to facilitate water flow. Sand will be placed in the bottom of the hole and along the outside of the PVC pipe up to the top level of the slots in the pipe. Bentonite chips will be placed above the sand along the outside of the PVC pipe to the soil surface to ensure no preferential movement of water along the well casing. Data will be downloaded from each WL-15 unit using a laptop computer once approximately every month. Water-table heights will be measured manually each time the datalogger is downloaded to confirm the sensors' accuracy.

NOTE - Piezometers will be installed so that there is minimal piping or equipment above ground that could interfere or influence with day to day farm operations on that field.

APPENDIX 2 – ICP-MS and ICP-OES Analysis

Inductively coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma optical emission spectrometry (ICP-OES) to determine trace metals and cations in waters.

Acidified aqueous solutions analyzed directly on the PerkinElmer DRCII ICP-MS or Perkin Elmer DV 7300 ICP-OES using standard conditions. Providing an analysis of a suite of trace metals that includes Aluminum, Antimony, Barium, Beryllium, Boron, Calcium, Cerium, Cesium, Cobalt, Iron, Lanthanum, Lithium, Magnesium, Manganese, Molybdenum, Potassium, Praseodymium, Rubidium, Silicon, Sodium, Strontium, Sulfur, and Vanadium.