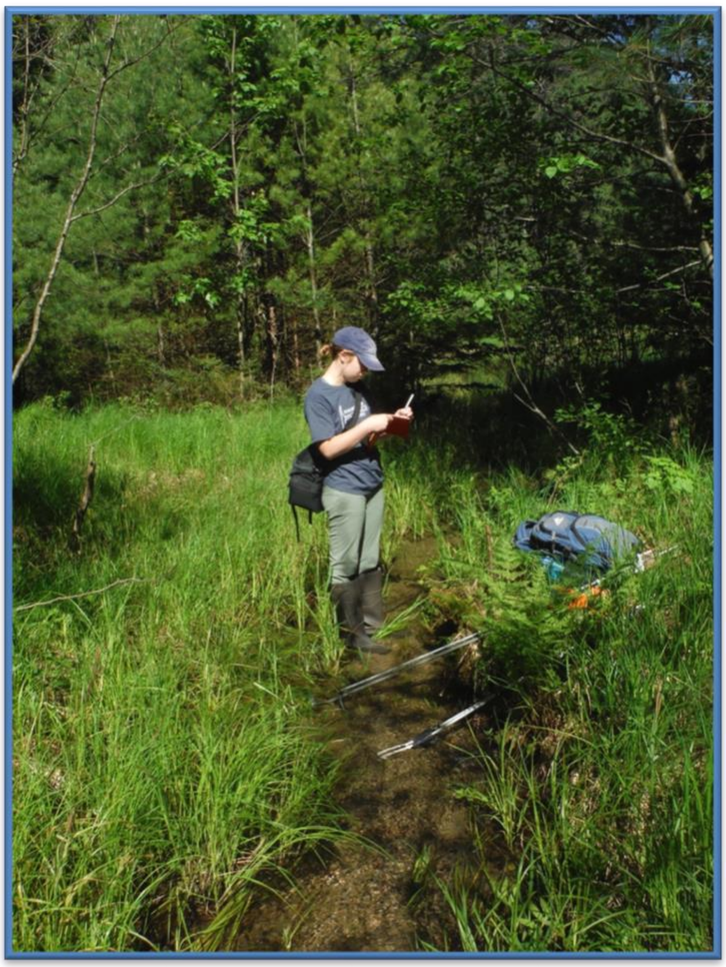
Wisconsin Geological
and Natural History Survey
DIVISION OF EXTENSION
UNIVERSITY OF WISCONSIN–MADISON

Methods and best practices for surveying springs in Wisconsin



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Open-File Report 2019-03 | 2019

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1. Introduction

Springs are a critical natural resource, supplying water for wetlands, lakes, and streams and creating habitat for endangered and threatened species. They are important points of groundwater discharge, sources for chemical analysis, and places to directly measure groundwater elevation. Spring water is typically representative of the surrounding groundwater system, with springs serving as focal points for groundwater discharge. Therefore, springs often serve as windows into the groundwater system and can provide opportunities for improved understanding of groundwater resources.

To improve knowledge of spring positions and their physicochemical characteristics, the Wisconsin Geological and Natural History Survey (WGNHS) undertook an inventory of the largest springs in Wisconsin between July 2014 and August 2017 (Swanson and others, 2019). This report describes the field methods and data management procedures used for the inventory. Use of the methodology resulted in a database of measured and observed variables that provide insight into the hydrogeological conditions that lead to the formation of springs, their habitat quality, and their relative vulnerability to changes in surrounding land use or climate (Swanson and others, 2019). Future use of this methodology by Wisconsin Department of Natural Resources field technicians or other land managers and researchers will ensure consistency of data sets for new springs with existing inventory data.

2. Procedure

This chapter provides information and best practices regarding field preparations, spring surveys, and site departure. Several appendices are referenced throughout this chapter, which provide detailed information about field equipment, field methodology, as well as real-world examples of field conditions. The methods draw heavily from existing spring survey and management practices developed by the National Park Service (Sada and Pohlman, 2006), the Florida Department of Environmental Protection (2007), the USDA Forest Service (2012a, 2012b), and the Springs Stewardship Institute (Stevens and others, 2016).

2.1 Field preparations

Use of the methodology described in this report assumes that the springs have been located and that all permissions to access the springs have been granted.

Collect all necessary equipment (appendix A), calibrate meters, and confirm that instruments are fully charged.

Plan the route and timing of the field activities. Before visiting a spring, compile field maps (topographic or trails) and aerial imagery to identify an efficient route to the spring. Surveyors should plan to spend 1–2 hours at each spring site.

2.2 Spring surveys

All observations and measurements recorded as part of the spring survey are listed in appendix B. During the WGNHS inventory, some field data, such as discharge-related measurements and photo captions, were recorded in a field book. However, nearly all springs-related field data were recorded in a geodatabase that was field-edited on a handheld Trimble Juno GPS unit that operates ArcPad software. The geodatabase was configured with single-select dropdown menus for several of the attributes. Use of a similar geodatabase or data dictionary is highly recommended to ensure consistency in survey syntax and the ability to query records for specific attributes.

Spring surveys should be conducted so as to minimize physical impact to a site. They should always begin with initial site observations, followed by water-quality measurements. All other observations and measurements can be completed in the order considered to be most efficient for a particular site.

Upon arrival, the perimeter of the spring should be fully explored. Check for upstream sources, locate spring orifices, and establish the boundaries of the spring area. These initial observations are very important, particularly where there may be multiple spring orifices. Having a holistic understanding of the site will aid decision-making regarding the size and scale of the site and where and how to make measurements of water quality and spring discharge.

Water quality

Measure spring water pH, temperature (°C), and conductivity (µmho/cm) first to minimize the potential of stirring up sediment or disturbing the natural spring conditions. Water quality measurements should be made at a spring orifice, or as close to the spring orifice as possible, to accurately reflect the groundwater conditions. Stand downstream of the orifice or out of the water to avoid influencing readings. Record measurements only after the readings stabilize; this may take several minutes.

General site description

The general site descriptors provide information on where the spring is located, when the spring was surveyed, and who conducted the survey. This category also involves drawing a site sketch, which documents the morphology of the site, as well as positions of measurements made during the survey. On the site sketch paper (appendix C), draw a map of the spring area approximately to scale. Each map should include a reference scale and north arrow. Use a laser range finder, tape measure, and compass to measure dimensions, orientations, and relative positions of important spring features. Record the locations of observed spring orifices (OR), channels (CH), pools (PL), and indicate the direction of flow. Also mark positions of survey measurements: water quality (WQ), spring discharge (DI), GPS position (GPS), and each photo point numbered consecutively in the order that they are taken (PP#). Include other features on the map that add context, such as vegetation, physical structures, landmarks, or locations of roads or trails. Make consistent use of the abbreviations and avoid creating new ones. An example site sketch is provided in appendix C. For additional guidelines on drawing effective site sketches, refer to Stevens and others (2016).

Other general site descriptors:

Spring ID: This numerical field refers to the order in which springs are surveyed within a county. For example, if six springs have already been surveyed in a county, the spring ID of the next spring surveyed in that county is 7.

County: Note which county contains the spring.

Surveyor(s): List the first and last initials or names of surveyors.

Date and time: The GPS unit will automatically populate these fields.

Easting and northing: The GPS unit will automatically populate these fields, but the surveyor should capture the GPS coordinates as close to the spring source as possible. Easting and northing should be recorded using the Wisconsin Transverse Mercator (WTM) coordinate system and the North American Datum of 1983 (ND83). Set the GPS to record statistics on the locational accuracy of the measurement, including the **Horizontal precision** and **Maximum positional dilution of precision (PDOP)**.

Elevation and Elevation Source: Although the GPS unit may automatically populate a value for this field, most GPS units do not measure elevation accurately enough for the purposes of the survey. Therefore, after uploading the field data back in the office, extract the elevation (meters) from the highest resolution Digital Elevation Model (DEM) available. Then identify the source and horizontal resolution of the DEM used in the Elevation Source field.

Land ownership: Note whether property ownership is *private*, *city*, *county*, *state*, *National Park Service (NPS)*, *U.S. Forest Service (USFS)*, *tribal*, *military*, or *other*. Surveyors should already know this information based on in-office preparations.

Access: Give precise directions to the spring, beginning from an easily located landmark such as an intersection or trailhead. Avoid vague language by using cardinal directions and distances. Distances can be estimated using mapping software (e.g., ArcGIS) before or after the field visit.

Ease of access: Select from: *easy*, *difficult*, or *terrain prohibits access to other potential spring areas*. Springs that are difficult to access may require navigating through unmarked terrain for more 100 feet to more than a mile. This information may be especially helpful in planning future visits to the site.

Land cover: Describe the land cover that immediately surrounds the spring setting. Select from: *urban*, *residential*, *agriculture*, *grassland*, *forest*, *open water*, *wetland*, *barren*, *shrubland,* or *other*.

Photographs: Take at least three photos to document conditions at the spring site. The first photo will be Photo Point 1 (PP1), the second will be PP2, and so on. Record positions of the photos on the site sketch and captions for each photo in the field book. Captions should briefly describe the orientation (e.g. looking upstream, looking downstream) and subject of the photo (e.g., spring orifice, spring pool, channel). Consider including equipment in the photos to document the scale of the photo.

Environmental conditions

The environmental conditions provide information on weather conditions on the day of the survey and general landscape properties of the site.

Air temperature: Measure the air temperature (°F) with a handheld weather meter. Allow time for the thermometer to acclimate and measure in shaded conditions.

Cloud cover: Visually estimate the cloud cover percentage at the time of the survey. Estimate to the nearest 5%.

Wind speed: Measure the average wind speed in miles per hour (mph) using a handheld weather meter.

Aspect: Use a compass to measure in degrees the direction that the spring orifice faces. If there are multiple orifices, record the most representative direction of water flow.

Slope: Measure the average slope in degrees of the spring area or channel using a laser range finder or a compass.

Slope variability: Qualify the variation in surface slope within the spring site as *high, medium*, *low*, or *none*. The spring site should be thought of as the area shown on the site sketch. Examples of different levels of slope variability are shown in appendix D.

Condition: Qualify the level of disturbance as *undisturbed*, *light*, *moderate*, or *high* based on observed impacts to the site. Examples of these levels of disturbance are shown in appendix E. Sites that are undisturbed are pristine. Sites qualified as light, moderate, and high show increasing levels of disturbance by animals or humans. Highly disturbed springs exhibit significant alterations to the natural morphology of the spring environment. For example, sites with highly unnatural land cover conditions or those with a spring house or stone encasement are highly disturbed.

Type of disturbance: List all types of observed disturbances. Spring disturbances include those due to *wildlife*, *livestock*, *recreation*, *diversion*, *residence*, *impoundment*, *dredging*, *flooding*, *trails*, *roadway*, *invasives*, *spring house*, *encased, raceways*, *other human-made structure, trash*, *storm-water*, *drain tile*, *agriculture,* and *other*. Examples of these types of disturbance are shown in appendix F.

Geology and geomorphology

This category provides information on the dimensions of the spring and the type and composition of geomorphic surfaces within the spring area.

Spring area: Use the site sketch to estimate the area of the spring site. The spring site should be thought of as the area shown on the site sketch, which completely encompasses the spring orifices and pools. Select the appropriate area range from: *<2 m^2, 2–10 m^2, 10–100 m^2, 100–1,000 m^2, 1,000–10,000 m^2, or 10,000–100,000 m^2.*

Surface types: List all surface types present within the spring site. Descriptions and examples are provided in table 1 and appendix G.

Table 1. Spring site surface types

Surface type	Description
Pool	Pool of water formed by the spring
Channel	Passage of flowing water
Backwall	Vertical to sloping bedrock behind spring orifice
Sloping bedrock	Sloped bedrock within the spring area
Colluvial slope	Slope of unconsolidated material
Cave	A large natural hole in the side of a hill
Spring mound	Precipitated material accumulated at spring orifice, e.g. tufa
Other	Describe in notes field

Channel or pool width: Measure the representative or average width in feet (ft) of the spring pool or channel. If not present, measure the width of the area of standing water, such as a pond or spring house.

Width location: Note the location of the width measurement. Select from: *pool*, *channel*, *pond*, *spring house*, or *other*.

Channel or pool depth: Measure representative or average water depth in centimeters (cm) of the spring pool or channel. If not present, measure the depth of a different feature, such as a pond or spring house.

Depth location: Note the location of the depth measurement. Select from: *pool*, *channel*, *pond*, *spring house*, or *other*.

Emergence substrate composition: Visually estimate the percentages of organic matter or inorganic grain sizes near the spring source, including *organics, fines* (<0.0625 mm*), sand* (0.625–2 mm)*, gravel* (2–64 mm), *cobble* (64–256 mm), *boulder* (>256 mm)*,* and *bedrock*.

Check to confirm that percentages sum to 100%. See appendix H for two examples of estimated substrate percentages.

Bedrock composition: Identify the bedrock composition near the spring source, if exposed. Select from: *shale, siltstone*, *sandstone*, *conglomerate*, *limestone*, *dolomite*, *igneous or metamorphic*, *other,* or *NA* (if no bedrock observed). Limestone effervesces briskly in dilute hydrochloric acid (HCl) and dolomite effervesces in dilute HCl when powdered or crushed. If unsure of the rock composition, consider collecting a hand sample for later identification.

Hydrological conditions

The hydrological conditions category provides information on the type of spring, the morphology of the spring orifice, and flow characteristics of the spring.

Spring type: This classification describes the natural emergence setting and broad hydrogeologic properties of the spring, which is sometimes referred to as the sphere of discharge (Meinzer, 1923; Hynes, 1970; Springer and Stevens, 2009). Select from: *rheocrene, limnocrene, hillslope springs, helocrene,* or *other.* See appendix I for examples of spring types. Descriptions:

- *Rheocrene* springs (derived from the Latin root *rheo* or “flowing stream”) naturally discharge directly into channels.
- *Limnocrene* springs (from the Latin root *limno* or “lake”) are springs that naturally discharge into a pond and then overflow to a channel.
- *Hillslope* springs emerge from steep slopes.
- *Helocrene* springs emerge into a small basin or depression that is marshy.

In Wisconsin, rheocrene springs are common. However, they are sometimes impounded and discharge to engineered ponds. Surveyors should classify the spring type based on the *natural* emergent environment. If a spring is impounded that detail should be captured in **Type of disturbance** (under Environmental conditions). See appendix J for examples of a free-flowing and an impounded rheocrene spring.

Limnocrenes are also common. Limnocrenes with highly focused discharge are often visible from the shoreline where there is contrast in substrate material or water color. They can also emerge into a deep hole on the bed of a lake, where the focused flow of spring water has displaced lake-bed material.

Spring source: A spring orifice is an opening in lithified or unlithified material through which the majority of the spring water discharges. Select from: *single orifice*, *multiple orifices*, *diffuse flow* (if no concentrated point of flow is present), or *other.* See appendix K for examples of each spring source type.

Orifice geomorphic type: This field describes the morphology, or form, of the spring orifice(s). It can provide important clues as to why water emerges at a particular location. See appendix L for examples of orifice geomorphologies.

- *Seepage/filtration* springs discharge from many small openings in permeable, unlithified material. They often discharge as sandy or organic boils at the base of hillslopes or within wetland environments,
- *Fracture* springs discharge from fractured bedrock,
- *Contact* springs discharge along lithological contacts where the adjacent layers have contrasting permeability,
- *Tubular* springs occur where conduit groundwater flow discharges from large dissolution channels. These are rare in Wisconsin, and no example is shown in appendix L. They often occur in karst environments.

Discharge: Record the spring flow rate (cubic feet per second). Measure spring discharge as close to the spring source as possible to minimize additional baseflow inputs to the spring channel. Ideally, measure within a straight reach of the channel and away from large obstacles that create turbulence. Some sites may require multiple measurements. For example, if there is an upstream source, measure discharge upstream and downstream of the spring and report the difference. If there are two defined channels discharging from the same spring area, make measurements in both channels and report the sum.

Flow accuracy: This field describes the surveyor's confidence that the recorded flow rate is accurate. Qualify the accuracy as *low* or *high*. Low accuracy may result when channel conditions prohibit best practices for a given method (for example, flow direction is non-uniform, channel boundaries not well defined).

How measured: Record the method or primary instrument used to measure spring discharge. Select from: *timed volume*, *float velocity method*, *flume*, *AA meter* (Price-type current meter), *AD meter* (acoustic Doppler meter), or *EM meter* (electromagnetic meter). Use of a stage-discharge relationship, the velocity-area method, and the timed-volume methods are common ways to measure spring flow under different conditions. A portable cutthroat flume is a convenient way to apply a stage-discharge relationship to a range of channel widths. A variety of velocity meters can be used in combination with a wading rod and tape measure when applying the velocity-area method. Many resources on how to make discharge measurements are available (for example, Turnipseed and Sauer, 2010). Table 2 summarizes the preferred spring site conditions for the different methods.

Flow location: Precisely describe the position of the flow measurement(s). Be specific enough that future surveyors could easily make a measurement at the same location(s).

Flow %: Estimate the percentage of spring discharge captured during the measurement.

Table 2. Preferred channel conditions for different methods of measuring spring discharge

Method	Primary instruments	Preferred conditions
stage-discharge relationship	cutthroat flume	Effective in low-gradient, narrow channels with unlithified substrate.
velocity-area method	AD meter (acoustic Doppler meter), electromagnetic, or AA current meter (Price-type current meter)	Best in wide channel cross-sections, or sites where the flow is too high to be routed through the cutthroat flume.
timed volume method	bucket and stopwatch	Useful for catching a small volume of water (<5 gallons) from pipes or rock outcrops over a measured time period.
float-velocity method	stick or plastic ball and stopwatch	Useful when the channel conditions are not conducive to other more accurate methods.

Biological conditions

The biological conditions category provides information on the area covered by vegetation within the spring site. See appendix M for examples of vegetation percentages.

Vegetative bed cover: Estimate the percentage of the channel or pool bed covered by live vegetation.

Vegetative bank cover: Estimate the percentage of the pool or channel bank covered by live vegetation.

Notes

The notes category includes auto-generated fields if a geodatabase is utilized to record spring survey information and offers the opportunity to record supplemental notes about the spring site, as necessary.

Notes: Record any additional information that might affect interpretation of the information collected during the survey.

Global ID: The GPS unit will automatically generate a unique identifier for each spring surveyed.

GPS time and date: The GPS unit will automatically record the time and date of the survey.

Number of satellites: The GPS unit will automatically record the number of satellites utilized to determine position.

2.3 Site departure

Before leaving the property, sterilize boots and aquatic field equipment to prevent transfer of invasive species between spring sites. Spray gear with 1% bleach solution. Scrub with a bristle brush and rinse with water.

3. Data management

After field work is completed, each site sketch should be scanned and saved as a PDF document using the following naming scheme: *CountyName_SpringID.pdf*. Photos should be downloaded and saved using the following naming scheme: *CountyName_SpringID_PP#.jpg*. All photo captions should be entered into a photo-log spreadsheet.

The geodatabase should be downloaded from the handheld GPS unit, and all entries for newly surveyed springs should be reviewed in GIS for quality-control purposes. Finally, extract elevation from a high-resolution digital elevation model (DEM), and enter the DEM source in the Elevation Source field.

4. References

Florida Department of Environmental Protection, 2007, Florida springs initiative—program summary and recommendations: Tallahassee, Florida Department of Environmental Protection, 43 p.

Hynes, H.B.N., 1970, The ecology of running waters: Liverpool University Press, 555 p.

Meinzer, O.E., 1923, Outline of ground-water hydrology: U.S. Geological Survey Water-Supply Paper 494, 71 p.

Sada, D.W., and Pohlman, K.F., 2006 (draft), U.S. National Park Service Mojave inventory and monitoring network spring survey protocols: Level I and level II: Reno and Las Vegas, Nev., Desert Research Institute, Inc., 95 p.

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U.S. Department of Agriculture, Forest Service, 2012b. Groundwater-dependent ecosystems: Level II inventory field guide: Inventory methods for project design and analysis: Washington, DC, Gen. Tech. Report WO-86b, 124 p.

Appendix A. Equipment list

EQUIPMENT	SPRING SURVEY CATEGORY
Waders, knee boots	General use
Scrub brush and 1% bleach solution	General use
Personal flotation device (PFD)	General use
Maps for access	General use
GPS unit with editable springs geodatabase	General use
Field notebook, waterproof recommended	General use
Pen or pencil	General use
Compass	General site description, Environmental conditions
Site sketch paper	General site description
Digital camera, waterproof recommended	General site description
Handheld weather meter (temperature, wind speed)	Environmental conditions
Laser range finder	General site description, Environmental conditions
Metric ruler	Geology and geomorphology
Measuring tape	General site description, Hydrological conditions
Velocity meter (acoustic Doppler meter, electromagnetic meter, or current meter) with wading rod, bank anchors, and clips	Hydrological conditions
8-inch cutthroat flume with flow conversion sheet	Hydrological conditions
5-gallon bucket marked with 1/4-gallon intervals	Hydrological conditions
Stop watch	Hydrological conditions
Dilute HCl solution for rock identification	Geology and geomorphology
pH, temperature, and specific conductance meters, calibrated according to instrument manual(s)	Water quality
Calibration standards for water quality meters	Water quality
Deionized water for rinsing water quality meters	Water quality
Spare batteries and screwdrivers for in-field equipment repairs	General use
Vegetation field guide	Optional

Appendix B. Field protocol

CATEGORY	VARIABLE	WORKING FIELD NAME	DESCRIPTION
WATER QUALITY	pH	pH	Measured as close to spring source as possible.
	Specific Conductance	Conductivity_µS	Measured as close to spring source as possible (µmho/cm).
	Temperature	Water_Temp_C	Measured as close to spring source as possible (°C).
GENERAL SITE DESCRIPTION	Site Sketch	---	Hand drawn with scale, north arrow, photo points (labeled PP#), GPS point (GPS), discharge measurement point (DI), water quality measurements (WQ), orifice(s) (OR), pool (PL), channel (CH), and direction of flow
	Spring ID	SpringID	Unique identifier within county.
	County	County	County where spring is located.
	Surveyor(s)	Surveyor	Who conducted the survey (initials).
	Date	Date	Date of field survey.
	Time	Time	Start time.
	Easting	Easting_WTM	Easting using Wisconsin Transverse Mercator (WTM). As close to the spring source as possible.
	Northing	Northing_WTM	Northing (WTM). As close to the spring source as possible.
	Horizontal Precision	Horz_Precision_m	Horizontal accuracy of GPS position (meters).
	Maximum PDOP	Max_PDOP	Maximum positional dilution of precision (PDOP) during measurement.
	Elevation	Elevation_m	From digital elevation model (DEM) (meters).
	Elevation Source	Elevation_source	DEM source and horizontal resolution of DEM used to extract elevation.
	Land Ownership	Land_Owner	List: private, city, county, state, National Park Service (NPS), U.S. Forest Service (USFS), tribal, military, other.
	Access	Access	Directions to springs.
	Ease of Access	Ease_Access	List: Easy access, Difficult access, Terrain prohibits access to other potential spring areas.
	Land Cover	Land_Cover	List: urban, residential, agriculture, grassland, forest, open water, wetland, barren, shrubland, other.
	Photographs	---	Photos of spring orifice, looking upstream, looking downstream, others as necessary.

CATEGORY	VARIABLE	WORKING FIELD NAME	DESCRIPTION
ENVIRONMENTAL CONDITIONS	Air temperature	Air_temp_f	Air temperature on date surveyed (°F).
	Cloud Cover	Cloud_Cover_percent	Cloud cover at time of survey (%).
	Wind Speed	Wind_Speed_mph	Velocity measurement on date surveyed (mph).
	Aspect	Aspect_degrees	Direction that the spring orifice faces.
	Slope	Slope_degrees	Channel slope (°).
	Slope Variability	Slope_Variability	List: high, medium, low, none.
	Condition	Condition	List: undisturbed, light, moderate, high.
	Type of Disturbance	Type_of_Disturbance	List: wildlife, livestock, recreation, diversion, residence, impounded, dredging, flooding, trails, roadway, invasives, spring house, encased, raceways, human-made structure, trash, storm-water, drain tile, agriculture, other.
GEOLOGY AND GEOMORPHOLOGY	Spring Area	Spring_Area_sqm	List: <2 m^2, 2–10 m^2, 10–100 m^2, 100–1000 m^2, 1000–10,000 m^2, 10,000–100,000 m^2
	Surface Type(s)	Surface_Types	List: pool, channel, backwall, sloping bedrock, colluvial slope, cave, spring mound, other.
	Channel or Pool Width	Width_ft	If a channel or pool exists, the mean width (feet).
	Width Location	Width_Location	List: pool, channel, pond, spring house, other.
	Channel or Pool Depth	Depth_cm	If a channel or pool exists, the mean depth (cm).
	Depth Location	Depth_Location	List: pool, channel, pond, spring house, other.
	Emergence Substrate Composition	Percent_organic, Percent_fines, Percent_sand, Percent_gravel, Percent_cobble, Percent_boulder, Percent_bedrock	Qualitative estimate of the % organics, fines (<0.625 mm), sand (0.625–2 mm), gravel (2–64 mm), cobble (64–256 mm), boulder (>256 mm), or bedrock. Described as close to spring source as possible.
	Bedrock Composition	Bedrock_Comp	List: shale, siltstone, sandstone, conglomerate, limestone, dolomite, igneous or metamorphic, NA, other.

CATEGORY	VARIABLE	WORKING FIELD NAME	DESCRIPTION
HYDROLOGICAL CONDITIONS	Spring Type	Spring_Type	List: rheocrene, limnocrene, hillslope spring, helocrene, other.
	Spring Source	Spring_Source	List: single orifice, multiple orifices, diffuse flow, other.
	Orifice Geomorphic Type	Orifice_Geom	List: seepage/filtration, fracture, contact, tubular.
	Discharge	Discharge_cfs	Spring flow (cubic feet per second, ft^3/s).
	Flow Accuracy	Flow_Accuracy	Level of accuracy of flow measurement, List: low, high
	How Measured	Discharge_Meas	List: timed volume, float velocity method, flume, AA meter (Price-type current meter), AD meter (acoustic Doppler meter), EM meter (electromagnetic meter).
	Flow Location	Flow_Location	Where flow was measured.
	Flow %	Flow_percent	Percent of flow captured (%).
BIOLOGICAL CONDITIONS	Vegetative Bed Cover	Veg_Bed_Cover_percent	The proportion of the spring pool bed or channel bed that is covered by live vegetation (%).
	Vegetative Bank Cover	Veg_Bank_Cover_percent	The proportion of the spring pool banks or channel banks that is covered by live vegetation (%).
NOTES	Notes	Notes	Other notes as necessary.
	Global ID	GlobalID	Automatically generated unique and global ID
	GPS Time and Date	gps_time_date	Automatically generated GPS time and date stamp
	Number of Satellites	sat_signals	Automatically generated number of satellites visible

References used in the development of the field protocol

Florida Department of Environmental Protection, 2007, Florida Springs Initiative, program summary and recommendations: Florida Department of Environmental Protection, 43 p.

Sada, D.W., and Pohlman, K.F., 2006 (draft), U.S. National Park Service Mojave Inventory and Monitoring Network spring survey protocols: Level I and level II: Reno and Las Vegas, NV, Desert Research Institute, Inc., 95 p.

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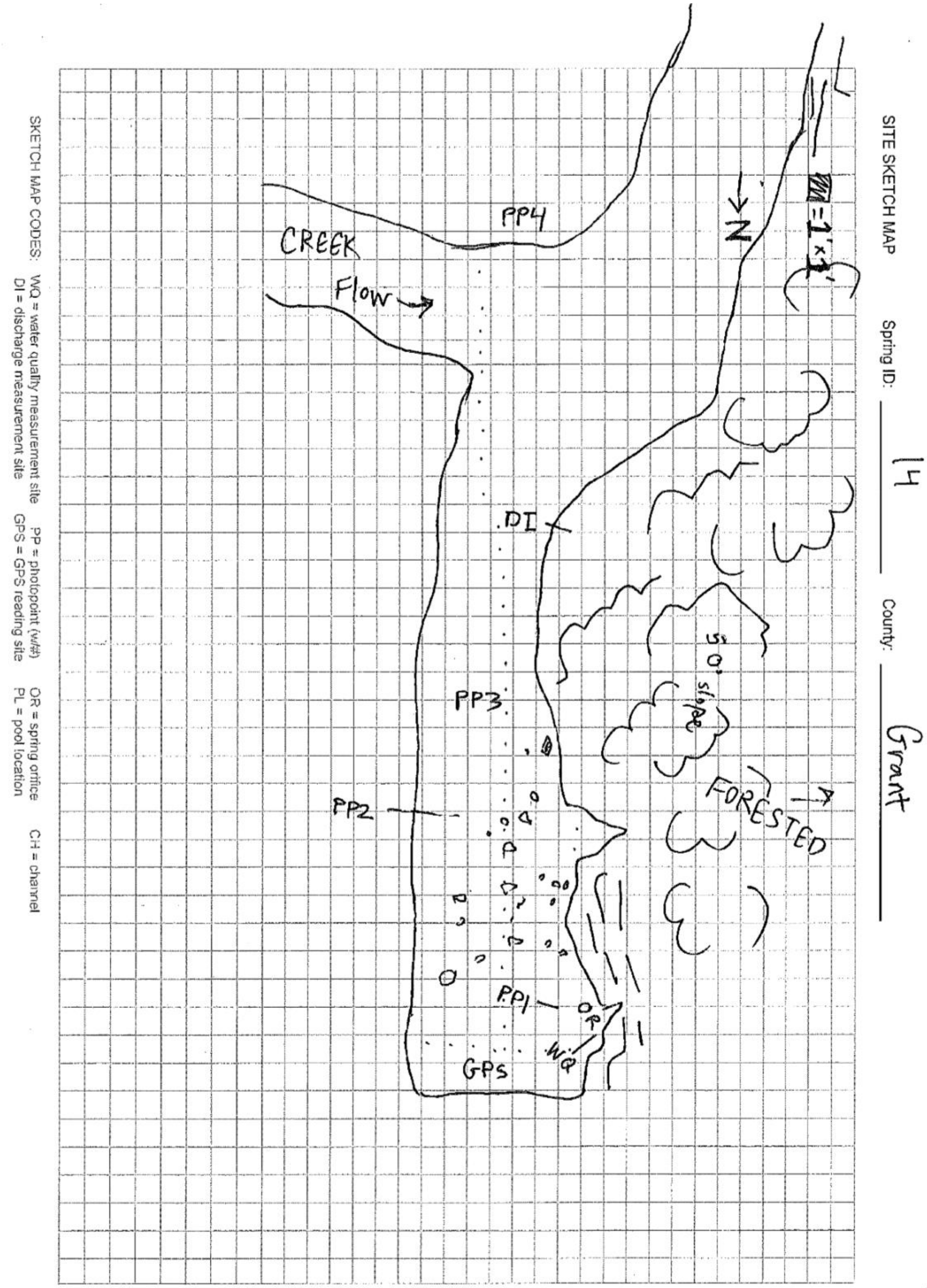
USDA Forest Service, 2012b, Groundwater-dependent ecosystems: Level II inventory field guide: Inventory methods for project design and analysis: Washington, DC, Gen. Tech. Report WO-86b.

Appendix C. Sketch (example) and blank site sketch paper



SITE SKETCH MAP Spring ID: ____________________ County: ______________________________

SKETCH MAP CODES: WQ = water quality measurement site PP = photopoint (w/#) OR = spring orifice CH = channel
DI = discharge measurement site GPS = GPS reading site PL = pool location

Appendix D. Slope variability (examples)

High

Medium

Low

Appendix E. Spring conditions (examples)

Undisturbed

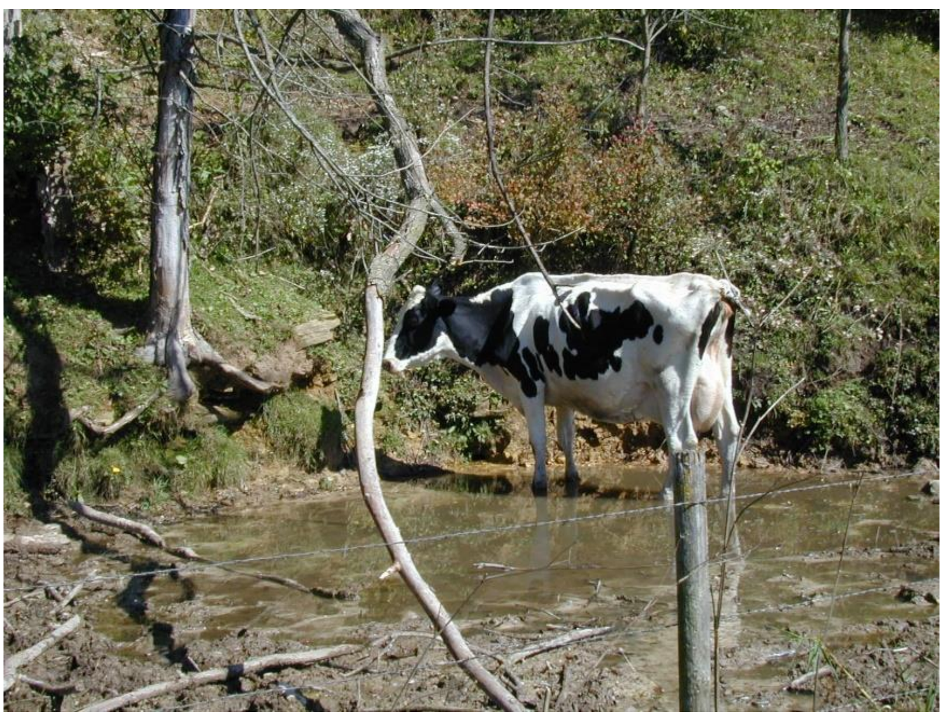
Light: This site shows evidence of light recreational use. Hiking trails lead to the springs and a boardwalk overlooks the surrounding wetland.

Moderate: This site was historically used for grazing livestock.

High: This highly disturbed spring is impacted by surrounding agricultural activity, trampling and grazing by livestock, and the presence of a human-made structure.

Appendix F. Types of disturbances (examples)

Wildlife: Photo shows beaver dam



Livestock

Recreation

Diversion

Residence

Impoundment

Dredging

Flooding: Severe flooding recently washed through this valley.

Trails

Roadway

Invasives: The channel is filled with watercress and reed canary grass covers the banks.

Spring house

Encased

Raceway

Trash

Stormwater

Drain tile

Other human-made structure

Agriculture

Appendix G. Surface types (examples)

Pool

Channel

Backwall

Sloping bedrock

Colluvial slope

Cave

Spring mound

Appendix H. Emergence substrate percentage (examples)

Emergence substrate percentages: 40% sand, 40% gravel, 15% cobble, 5% boulder

Emergence substrate percentages: 90% sand, 5% cobble, 5% organic

Appendix I. Spring types (examples)

Limnocrene

Rheocrene

Hillslope spring

Helocrene

Appendix J. Rheocrene springs, free flowing and impounded (examples)

Free-flowing rheocrene

Impounded rheocrene

Appendix K. Spring source types (examples)

Single orifice

Multiple orifices

Diffuse flow

Appendix L. Orifice geomorphologies (examples)

Seepage-filtration

Fracture

Contact

Appendix M. Vegetation percentages (examples)

Vegetative bed cover: 70%
Vegetative bank cover: 100%

Vegetative bed cover: 5%
Vegetative bank cover: 50%