



Springs in the Mojave Desert Network— Surface Water Monitoring at Desert Springs

Standard Operating Procedures, version 1.0

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ON THE COVER

MOJN I&M Field Crew at Bridge Canyon Spring in Lake Mead National Recreation Area. Photograph courtesy of the National Park Service.

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Standard Operating Procedure 1: Staff Training and JHA

Version 1.0

1. Introduction

The current staffing structure includes a Protocol Lead and at least two Science Technicians. Field crews will include at least one employee (typically a Science Technician) and may be supplemented by interns or volunteers. It is the responsibility of the Protocol Lead to ensure that all personnel conducting monitoring for the protocol are properly trained. This Standard Operating Procedure (SOP) describes the training in safety best practices and data collection methods that all field crew members must receive prior to the field season.

2. Safety

Safety training will include formal and on-the-job training in park orientation, map and GPS navigation, communications devices, radio etiquette, check-in procedures, and 4-wheel drive vehicles. Field crew members will read about field work-related incidents that have been reported by the NPS and other agencies. They will discuss with their peers and supervisors the lessons learned from these incidents as well as the specific hazards they may encounter while working in backcountry desert and mountainous environments. The Job Hazard Analysis (JHA) for the protocol can be found at the end of this SOP. Field crew members must sign the JHA indicating that they have read and understand the material before participating in field work.

In addition, field crew members are required to complete a 16-hour wilderness first aid course, either through a certified organization (e.g., Red Cross, NOLS) or a team of LAKE first responders. All personnel, including employees and volunteers, are also required to complete a 16-hour Operational Leadership course, which covers situational awareness and good decision making skills.

Before field crew members are allowed work in the backcountry or travel on overnight trips, they must complete a Green-Amber-Red (GAR) or Severity-Probability-Exposure (SPE) risk assessment with their supervisor. The risk assessment should address factors including road conditions, vehicle status, weather forecasts, length and difficulty of hikes, terrain challenges, team health and fitness, team experience, communications coverage, contingency resources, and any hazards specific to individual parks.

For more information about safety procedures and training, refer to the *Mojave Desert Network Inventory & Monitoring Field Safety Plan*.

3. Data Collection

3.1. Field Training

Most training in hydrology data collection methods can be done in the field, while some vegetation data collection methods must be covered in the office or before going to the field with a formally trained botanist. The Protocol Lead will accompany the field crew members to the first three or four

springs sampled during the field season, and together they will walk through the methods and complete a field data sheet at each spring. Ideally, the springs will be diverse enough that the field crew members are exposed to a variety of spring types and vegetation communities, and they will have the opportunity to ask questions that may arise.

3.2. Spring Vegetation

The network Ecologist (or Botanist) will train field crew members to identify the plant life form categories ranked in this protocol as well as common riparian and invasive plant species found at desert springs. Some of this training should occur in the office and include a fundamental explanation of plant life form categories with many examples of plants that fall into each of the categories. Depending on his or her level of botanical expertise, the Protocol Lead may also train field crew members to identify common riparian plant species while they are learning about data collection methods in the field. While this protocol does not require field crews to identify many plants to species, understanding the fundamentals of botany is required to collect vegetation data for this protocol.

3.3. Water Quality

Recent Inventory and Monitoring Division (IMD) guidance requires at least one staff member per network to complete an approved water quality field methods training course. Training must be kept current with at least one staff member having completed approved training within the last three years. IMD has developed a course in collaboration with the U. S. Geological Survey (USGS) that is designed to promote basic knowledge and core competencies in the skills required to implement water quality monitoring protocols as well as to foster consistency in field methods among networks. The Protocol Lead will complete and maintain this training requirement.

Training personnel on the use of the water quality instrument is relatively straightforward. After one field demonstration, most field crew members should be able to use the instrument with the aid of the SOP. However, this protocol requires more frequent calibrations than is common in many settings, so the Protocol Lead must explain the importance of calibrations to all personnel making measurements.

3.4. Data-Logging Sensors

Field crew members must be trained to understand where and how to deploy the sensors appropriately at a spring. If they incorrectly place a sensor outside of the spring source area or springbrook channel, then the sensor will not be able to record the actual presence or absence of surface water, and the data will be inaccurate. If they improperly secure a sensor to the ground or nearby vegetation, then the sensor may be washed away by flash flooding or removed by animal activity, and the data will be lost.

During the initial training in data collection methods, the Protocol Lead will make sure that at least one of the springs sampled has an iButton humidity sensor. The Protocol Lead will walk through the site assessment and decision-making steps and demonstrate proper sensor placement and installation.

4. QA/QC

The Quality Assurance Plan (QAP) for this protocol is currently in development and will describe how staff are trained in office and field QA/QC procedures. For more information on these QA/QC

procedures, refer to SOP 11: Data Management or to the Data Quality Standards for Desert Springs Monitoring in the Mojave Desert Inventory & Monitoring Network (2018).

Literature Cited

Lehman, M., S. Wright, and J. Bailard. 2018. Data Quality Standards for Desert Springs Monitoring in the Mojave Desert Inventory & Monitoring Network. National Park Service, Fort Collins, Colorado.

JOB HAZARD ANALYSIS (JHA)		Date: January 26, 2018	☒ New JHA ☐ Revised JHA
Park Unit: MOJN I&M	Location of Park Unit: Boulder City, NV	Location(s) of Job Duties: CAMO, DEVA, JOTR, LAKE, MOJA, PARA	
Job Title: Physical Science Technician		JHA Number:	Page: 1 of 6
Job Performed By: Desert Springs Field Crews	Analysis By: Jennifer Bailard	Supervisor: Allen Calvert	Approved By:
Required Standards and General Notes:	Refer to the <i>Mojave Desert Network Inventory & Monitoring Field Safety Plan</i>		
Required Personal Protective Equipment:	Clothing: hiking boots, long pants, hat, sunglasses, sunscreen; rain jacket and warm clothing if necessary Equipment: first aid kit, map and GPS, flashlight / headlamp, radio, satphone, inReach Food and water: 1 gallon of water per person per day, extra food and water		
Sequence of Job Steps	Potential Hazards / Injury sources	Safe Action or Procedure	
Driving in the backcountry	Poor road conditions / unmaintained dirt roads	• Turn around or postpone travel if road is washed out or impassible or if driver is fatigued or feels uncomfortable with the difficulty of 4 wheel drive. • Avoid driving on backcountry dirt roads in the dark, when obstacles or unsafe conditions may be impossible to see. • Be alert and drive slowly when driving on roads known to be frequented by deer, sheep, elk or other large animals.	
	Difficult navigation	• Familiarize yourself with the route and the park before you start driving. • Bring a backcountry road map and GPS with road layer to prevent getting lost or disoriented. • Stay on approved roads.	

	Vehicle problems	• Conduct a basic vehicle check (e.g. fluid levels, tire pressure, full gas tank) before driving in the backcountry. • Ensure vehicle is properly and regularly maintained (e.g. schedule oil changes, replace tires if they become too worn). • Ensure vehicle is equipped at minimum with road flares, shovels, and jack. • Bring at least two spare tires into the backcountry, and know how to change them for every vehicle.
	General best practices	• Safety first. Understand and practice situational awareness and risk management at all times. • Submit a backcountry travel plan to dispatch and pertinent park staff, and observe appropriate call-in / call-out procedures. • Always work in a team of at least two field crew members. Working alone in the backcountry is not permitted.
Hiking and camping in the backcountry	Rugged and remote terrain	• Wear sturdy and broken-in hiking boots with good ankle support. • Turn around if terrain becomes too difficult or dangerous to continue (e.g. large boulders, steep cliffs). If one field crew member feels uncomfortable, then the whole team should turn around. No spring is worth the health and safety of a field crew member. • Do not hike in the dark, especially if the terrain is difficult. Return to the vehicle by sunset. • Every team should have multiple forms of communication with spare batteries and charging equipment. At a minimum: truck radio, handheld radio, satphone, inReach, cellphone. • All field crew members must maintain current certification in CPR / AED and wilderness first aid. • Keep a larger first aid kit in the vehicle and a smaller first aid kit in your backpack. Replace used or expired materials regularly. • Stock the vehicle with enough food and water for the team to camp at least 1 additional night beyond the anticipated plan.
	Slips, trips, falls	
	Patchy communication	
	Long emergency response time	

	Long hikes / overnight trips Difficult navigation / getting lost Hunger and dehydration Heavy backpack	• Bring a map, compass, and GPS with spare batteries. Hiking cross-country over desert terrain can be disorienting. • Ensure that map and GPS have topo lines to bypass steep terrain and find the most accessible routes to springs. • If you park at a different location than suggested on the site information sheet, make a GPS waypoint of where you park. • Hike on trails and closed roads when possible. • Maintain line-of-sight with your fellow field crew members during hikes. • Carry at least 1 gallon of water per person per day. • Rest and take water and snack breaks every so often to keep energy up and stay hydrated. • Bring extra food, in the event that the hike takes longer or is more strenuous than expected. • As there is often no water in the desert even at springs, you must carry all of the water you need on your back. For overnight backpacking trips, tents and other camp gear add to the load. Do not plan trips longer than you have the ability to carry supplies. Generally, field crew members can only carry enough water for a 2-day trip before they must return to a safe water source. • Do not overload yourself and risk back injury with unnecessary gear. Bring what you need to stay safe; you can forgo luxuries for a night or two.
	Illegal activity	• If you see evidence of illegal activity (e.g. marijuana grows, poaching), leave the area immediately. Take a quick photo if you can do so discreetly, but do not linger to investigate. • Do not confront strangers in the backcountry, even (especially) if they are breaking the law. • Report illegal activity or suspicious persons to dispatch or law enforcement when you have reached a safe distance.

	Bad weather Extreme heat Cold / wind / inclement weather Flash floods Lightning	• Wear a wide-brimmed hat, sunglasses, long pants, and long sleeves to avoid sun exposure to skin. • Apply sunscreen to exposed skin regularly. • If possible, conduct field work from late fall to early spring, when temperatures are moderate. • If you must conduct field work in the summer, begin hiking at daybreak and finish by noon to avoid the hottest part of the day. • Drink adequate water. Take rests in the shade, if you are beginning to feel overheated. • Check the weather report before leaving for every trip and plan accordingly to bring a rain jacket or warm clothes (e.g. coat, gloves, hat). • Continue to check weather updates throughout your trip, especially if a storm system is predicted to develop. • Bring a spare set of clothes (especially socks) in case you get wet. • Do not camp in washes or canyons. • Do not hike in canyons during heavy or prolonged rain, or if there is heavy or prolonged rain in the mountains above you. It does not have to be raining where you are in the canyon for a flash flood to descend upon you from higher elevations. • If you see flooding heading toward you, quickly climb to higher ground. • Do not attempt to wade across flowing water. • If you see or hear a thunderstorm developing around you, immediately return to the vehicle. • If you cannot get to your vehicle, move away from high mountain passes and open meadows. Retreat to a forested area. Do not stand next to running water or tall objects like trees, telephone poles, or power lines. • Crouch down on your pack on the balls of your feet, and keep your feet close together. Place your hands on your knees and lower your head. Minimize contact with the ground, and make yourself as small a target as possible.
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	Thorny / spiny plants	• Be careful when hiking around sharp plants, like cacti, yuccas, mesquite, and catclaw, especially on steep or loose terrain where you have a higher risk of falling into them. • Wear long sleeves and pants made of thicker fabric to prevent cuts and provide a barrier. Some spines are barbed and may be painful to remove, while others have irritating properties if they puncture the skin.
	Dangerous wildlife Mountain lions Snakes Bees / wasps Spiders Scorpions	• Stay close to your fellow field crew members as much as possible. Mountain lions are less likely to attack groups of people. • Leave the area immediately if you see a mountain lion or encounter a fresh mountain lion kill. • If a mountain lion becomes aggressive toward you, move together, stand tall, raise your arms in the air, and yell loudly to be intimidating. • If you see a snake, leave it alone. • If you hear rattling, stay calm, identify where the snake is, and move away from it quickly. • Be careful when reaching into handholds or rock crevasses into which you cannot see. • If you receive a snake bite, evacuate immediately and go to a hospital. • Avoid antagonizing bees and wasps. • If you see bees “bumping into you,” they may be marking you with a pheromone and preparing to swarm. Evacuate the area immediately and return to the vehicle. • If you receive a bite from a black widow or other venomous spider, seek medical attention immediately. • Avoid walking barefoot, especially in the dark. • Check the inside of your boots before putting them on.

	Disease transmission Hantavirus from rodents Lyme disease from ticks Mosquito infections Aquatic organism infections	• Do not enter abandoned or unventilated structures where rodent droppings are present. • Check clothing and skin regularly for ticks. • To remove a tick, grasp it with tweezers at its head, and pull it straight out. • Wear long sleeves and long pants, and use bug spray if necessary. Stay vigilant for signs of illness, and see a doctor if you become sick. • Desert springs may contain pathogenic organisms, like the protozoan giardia. Never drink untreated spring water. If you must drink spring water, use a filter or purification tablet. • Warm springs may harbor potentially deadly organisms, like the protozoan <i>Naegleria fowleri</i>, which can enter through the nose and cause lethal brain infection. Never submerge your head in spring water.				
	Prior medical conditions	• At your discretion, alert fellow crew members to any health conditions (e.g. asthma, severe bee allergy, migraines, recent cold or flu) that might affect you in the backcountry. Tell them where you keep your medication in the event you need assistance. • Know and monitor your personal fitness level and that of others in your group. Adjust plans accordingly. • Stay in reasonable shape. • Postpone your trip or find a replacement field crew member if you are too sick to work. Do not expose your colleagues to infection.				
I have read and understood the Job Hazard Analysis (JHA) for Desert Springs Field Crews:						
<table border="0" style="width: 100%;"> <tr> <td style="width: 33%; text-align: center;">_____ Employee Signature</td> <td style="width: 15%; text-align: center;">_____ Date</td> <td style="width: 33%; text-align: center;">_____ Supervisor Signature</td> <td style="width: 15%; text-align: center;">_____ Date</td> </tr> </table>			_____ Employee Signature	_____ Date	_____ Supervisor Signature	_____ Date
_____ Employee Signature	_____ Date	_____ Supervisor Signature	_____ Date			

Standard Operating Procedure 2: Field Mobilization and Demobilization

Version 1.0

1. Introduction

This Standard Operating Procedure (SOP) describes the administrative and logistical actions that must be undertaken before and after field work.

2. Mobilization

2.1. Before the Field Season

The Program Manager will complete an annual Protocol Readiness Review Certification (RRC) for each park where the protocol will be implemented during the field season, which confirms that the MOJN I&M Desert Springs protocol has sufficient resources and support to be implemented with full consideration for field logistics, safety, and supervisory oversight. The RRCs will be signed by the Program Manager, Protocol Lead, and each Superintendent before the field season begins. The Protocol Lead will make sure that Scientific Research and Collecting Permits for the protocol are valid for each park as well.

The Protocol Lead will schedule a meeting with relevant park personnel (e.g., Superintendent, law enforcement rangers, resource managers) at each park where the protocol will be implemented during the field season to discuss the purpose of the field work as well as to provide a tentative monitoring schedule. The Protocol Lead should ask for updates on safety contacts and any specific hazards or areas of concern in the park, which may change from year to year. The Protocol Lead should also work with the park to designate a point of contact for field crews and to determine who will receive backcountry travel plans and daily check-ins. At the end of the meeting, the Superintendent will sign the RRC.

Six to eight weeks before the field season begins, the Protocol Lead will hold a “protocol kickoff meeting”. These meetings can be scheduled on the calendar months in advance to maximize attendance and serve as a reminder for mobilization. The entire MOJN I&M office should be invited to the meeting so that all staff (Program Manager, Hydrology Team, Vegetation Ecology Team, Data Management Team, Science Communicator, etc.) are aware of schedules, personnel needs, technical assistance needs, and opportunities for coordinating field work. The meeting agenda should include all aspects of field season preparation: logistics, permits, gear, personnel, training schedule, office planning, safety issues, and other relevant topics to ensure a smooth start to the field season.

For most overnight trips, field crews will be car camping in the backcountry. At parks where this is not feasible due to access or safety considerations, the Protocol Lead will contact administrative staff to reserve park housing or campsite permits. This should be done as soon as possible, since park housing tends to fill up well in advance.

The Protocol Lead will verify that all required field equipment and supplies are present and in good working condition at least six weeks in advance of the field season, in case additional supplies need to be ordered. The Protocol Lead should also test that field communication devices (e.g., satphone, inReach) are functioning and that service plans have been paid for the duration of the field season.

The Protocol Lead will ensure that field vehicles are in good working condition to travel on potentially rough or challenging backcountry roads. The vehicles should be checked and tested according to their maintenance schedules and outfitted with all necessary safety equipment (e.g., first aid kit, fire extinguisher, two spare tires).

2.2. Week Before Field Work

The Field Crew Lead will assemble site packets for every trip into the field. These site packets will contain daily itineraries, driving and hiking routes, topographic maps, locations of nearest medical services, weather forecasts, and emergency contact numbers. Driving and hiking routes for each spring and the locations of medical services for each park can be found in the *Implementation* folder within the *DS_Water* folder on the MOJN I&M server. Blank backcountry travel plans, which include fields and drop-down menus for daily itineraries, weather forecasts, and emergency contact numbers, can be found in the *1_BACKCOUNTRY_TRAVEL_PLANS* folder within the *Safety* folder on the MOJN I&M server. Topographic maps can be found in the map filing cabinet in the MOJN I&M office.

NPS employees will submit a travel authorization and receive approval in Concur before departing on each multi-day trip. Interns and volunteers will work with their supervisor and sponsor organization (e.g., Student Conservation Association) to ensure that they are properly approved for multi-day trips.

2.3. Day Before Field Work

The Field Crew Lead will submit a completed backcountry travel plan to the dispatch responsible for the park where the field crew will be working. Lake Mead Interagency Communications Center (ICC) dispatch (LAKE, PARA) prefers to receive an emailed copy of the backcountry travel plan. San Bernardino Federal Interagency Communications Center (FICC) dispatch (DEVA, JOTR, MOJA, CAMO) prefers to receive a faxed copy of the backcountry travel plan. The backcountry travel plan for all days of the trip will be submitted at the same time.

In addition to dispatch, some park personnel, such as law enforcement rangers and resource managers, also want to receive an emailed copy of the backcountry travel plan for the days that field crews will be working in their park. These personnel are determined during the pre-season field meeting. The Field Crew Lead will submit the backcountry travel plan to these personnel as well.

Field crew members will ensure that all equipment is assembled in the ready room and set to be loaded into the field vehicle. They should double-check to make sure that all gear is in working order and that the vehicle is fueled and ready to go. They should charge batteries overnight for the communications devices, GPS units, and digital cameras before leaving the next day.

2.4. Mobilization List

Mobilization tasks and responsibilities are summarized in the following list:

Table 2.1. List of activities to be completed before field work.

Timing	Task	Responsibility	Description
Months Before the Field Season	Protocol Readiness Review Certification (RRC) completed	Program Manager	RRC must be signed by Superintendent for each park where protocol will be implemented
	Scientific Research and Collecting Permit renewed	Protocol Lead	Permit must be valid for each park where protocol will be implemented
	Equipment and supplies purchased	Protocol Lead	Replace equipment if broken, restock consumables like pH buffers if running low
	Vehicles inspected	Protocol Lead	Change oil, inspect tires for wear, etc.
	Communication devices tested	Protocol Lead	Activate or renew service plans with the assistance of the Field Logistics Lead
Week Before Field Work	Park housing or campsite reserved	Protocol Lead	If applicable
	Site packet and backcountry travel plan assembled	Field Crew Lead	Must include daily itinerary, topo map, hiking and driving routes, list of emergency contact numbers, address of nearest hospital, weather forecast
	Travel authorization submitted and approved in Concur	Field Crew Members	Required for overnight trips only, field crew members cannot travel until travel authorizations have been approved by supervisor
Day Before Field Work	Equipment and supplies checked and organized	Field Crew Members	Refer to Table 2.2 for equipment list
	Electronic equipment charged	Field Crew Members	–
Morning of Field Work	Backcountry travel plan submitted to dispatch and park contacts	Field Crew Lead	LAKE ICC for LAKE and PARA; San Bernardino FICC for DEVA, JOTR, MOJA, and CAMO

2.5. Equipment List

The following list includes the minimum equipment needed for the protocol at each spring:

Table 2.2. List of field equipment to bring to each spring.

Equipment Type	Item	Description
Safety	Handheld radio w/spare battery	–
	Inmarsat satphone	–
	DeLorme inReach messenger	–
	MOJN I&M cellphone	–
	Backcountry travel plan	–
	Topographic map and aerial imagery of driving and hiking routes	–
	First aid kit	–
Personal	Sturdy hiking boots	–
	Hat and sunscreen	–
	Long-sleeve shirt and pants	To protect against sun, insects, and plants
	Rain or cold weather gear	Depending on weather forecast
	Sufficient water	1 L per person per hour outdoors, 2 L per person per hour outdoors may be necessary for strenuous hikes or work performed in 100+ °F
	Sufficient food	–
Data Collection	Field data sheets	1 complete copy and 1 backup copy
	Sensor re-location notes and photos	If applicable
	Clipboard	–
	Rite-in-the-Rain pen	Black or blue ink
	Programmed iButton sensor	If applicable
	Metal bolt	10-cm (4-inch), for installing sensor, if applicable
	Spool of wire	Insulated, for installing sensor, if applicable
	Scissors or knife	For cutting wire
	YSI 556 MPS w/spare batteries	For temperature, pH, specific conductance, and dissolved oxygen measurements
	pH buffer solutions	At least one 500-mL bottle each of pH 4, pH 7, and pH 10 buffers
	Conductivity standards	At least one 500 mL bottle of 1413 $\mu\text{S}/\text{cm}$ KCl standard
	Rinse water	For cleaning water quality probe
	Container of known volume	For measuring discharge
	Stopwatch	Capable of recording seconds to 2 decimal places, may be on a wristwatch or cellphone
	GPS unit w/spare batteries	Loaded with topo layer and coordinates
	Digital camera	Waterproof, if available

3. Demobilization

3.1. After Field Work

Before leaving a park, field crew members should check their equipment, camping gear, and personal belongings for potentially exotic or invasive pests (i.e., seeds, insects). Muddy boots must be rinsed off. Clothing and backpacks can be brushed out in the field, but should be washed as soon as possible after leaving a park. Refer to SOP 3: Equipment Disinfection for more information.

Upon returning to the office, field crew members will clean the YSI 556 MPS. Generally this means wiping down the external surfaces of the handheld instrument and probe module with a soft cloth and mild soap and then rinsing them with tap water.

Before driving a field vehicle to another park, field crew members must hose down the outside of the vehicle, particularly areas where biological material may have accumulated (i.e., undercarriage, tire treads, wheel wells, truck bed). Vehicles are the largest culprit for spreading invasive plants. Field crew members should also inspect the vehicle for damage as well as for routine maintenance, such as tire pressure and fluid levels. They should remove any trash that may have accumulated in the vehicle during their field work.

NPS employees will submit their travel voucher in Concur within five days of returning from a multi-day trip to ensure reimbursement for lodging and per diems. Interns and volunteers will work with their supervisor and sponsor organization (e.g., Student Conservation Association) to ensure that they are properly reimbursed for lodging and per diems.

3.2. After the Field Season

Field crew members will thoroughly wash and clean the field vehicles. They may hose down the outsides and sweep out or vacuum the insides of the vehicles, or they may take the vehicles to an approved car wash. Field crews should perform a damage inspection and ensure that the vehicles are ready to go for the next people who need to drive them.

Field crew members will clean the YSI 556 MPS and remove its batteries prior to long-term storage. The pH sensor should be removed from the probe module and stored in a vessel containing a solution of 2 M KCl. The vessel should be sealed to prevent evaporation. The empty port on the probe module should be protected with the provided port plug. The probe module with the remaining sensors should be securely fastened to a calibration cup containing 12 mm (1/2 in) of water. The calibration cup should be sealed to prevent evaporation. It is important to keep the sensors moist without actually immersing them in water, as this could cause their readings to drift or result in premature sensor failure.

Field crew members will return pH buffers and conductivity standards to the ready room. The Protocol Lead will check the amounts and expiration dates of these chemicals and order replacement bottles, if necessary. Field crew members should notify the Protocol Lead if any field equipment has been broken or lost, so that the equipment may be repaired or replacements may be ordered before the next field season.

The Protocol Lead and Data Manager will organize a field season debriefing once field work for the protocol has been completed in all parks. Field crew members will have the opportunity to provide feedback on protocol implementation as well as their overall experiences during the field season. The Protocol Lead will incorporate lessons learned from this feedback to improve subsequent field efforts. The Data Manager will attempt to resolve any outstanding questions or concerns about data collected during the field season.

3.3. Demobilization List

Demobilization tasks and responsibilities are summarized in the following list:

Table 2.3. List of activities to be completed after field work.

Timing	Task	Responsibility	Description
After Field Work	Gear checked for invasive pests	Field Crew Members	Brush mud from boots, remove seeds and insects from clothing
	Vehicle inspected and rinsed off	Field Crew Members	Check vehicle for damage sustained during trip, ensure vehicle is in good condition for next trip, rinse off mud from external surfaces
	Water quality instrument cleaned	Field Crew Members	Rinse off contaminants and debris from probe
	Travel voucher submitted in Concur	Field Crew Members	Submit within five days of returning to the office
After Field Season	Water quality instrument cleaned and properly stored	Field Crew Members	–
	Vehicle inspected and thoroughly washed	Field Crew Members	–
	Equipment and supplies inventoried and put away	Field Crew Members	Notify Protocol Lead if equipment or supplies need to be repaired or replaced
	Field season debriefed	Protocol Lead /	–

Standard Operating Procedure 3: Equipment Disinfection

Version 1.0

1. Introduction

Field crew members have the potential to introduce and spread pathogens and invasive organisms as they travel between springs. This Standard Operating Procedure (SOP) describes the disinfection best practices that all personnel must perform after visiting each spring and especially before traveling to a new park unit.

2. Between Springs

The most effective way to prevent the spread of invasive organisms from spring to spring is to minimize the exposure of equipment to potentially contaminated spring water and sediment. Consequently, field crew members should choose paths in riparian areas that avoid getting boots and equipment wet or muddy whenever possible.

Other than boots, the equipment most likely to contact spring water and sediment is the YSI 556 MPS water quality instrument. To reduce the risk of contamination:

- Before use, rinse the probe module with clean water (not spring water).
- To the extent possible, place the probe module in the spring in such a way to avoid or minimize fouling it with sediment, algae, etc. during use.
- Limit the amount of time that the probe module is submerged in water to the duration necessary to record measurements. When the water quality instrument is not in use, keep it stowed in a backpack.
- Immediately after use, rinse the probe module again with clean water, taking care that all sediment, algae, etc. is washed away. Use a small, soft brush if necessary to clean the recesses where debris or organisms may become lodged.

Before traveling to another spring, field crew members should check equipment and personal gear for exotic or invasive organisms (e.g., seeds, insects). Soil and organic matter on footwear and clothing have the potential to contaminate other monitored springs. Muddy boots should be rinsed, and their treads should be brushed out once dry. Clothing and backpacks can also be brushed out in the field, but should be washed as soon as possible after leaving a park.

3. Between Parks

Upon returning to the office, field crews will thoroughly clean the water quality instruments as described in SOP 5: Water Quality.

Other equipment that may have come into contact with spring water or sediments, such as wash bottles or waders, may be disinfected with quaternary ammonium. Quaternary ammonium is lethal to

many pathogens and acts by disrupting the cell membrane and denaturing cell proteins. To disinfect equipment:

1. Dilute the quaternary ammonium detergent disinfectant per label directions.
2. Using the detergent, thoroughly wash all equipment surfaces, internal and external, making sure to remove all soil and organic matter that could retain contaminants, invasive organisms, or residual moisture.
3. Thoroughly rinse all equipment surfaces in tap water and allow to dry.

Quaternary ammonium is a common household cleaning product sold under many brand names. We typically use QD – 64 One Step Germicidal Cleaner and Deodorant. If quaternary ammonium is not available, disinfecting wipes can be used to clean surfaces. When using chemical disinfectants, be sure to read all cautionary labels and directions. Do not mix ammonia- and bleach-based cleaners, as the chemical reaction will release toxic chlorine gas.

Before driving a field vehicle to another park, field crews should hose down the outside of the vehicle, particularly areas where biological material may have accumulated (i.e., undercarriage, tire treads, wheel wells, truck bed). At the end of the field season, field crews will thoroughly wash and clean the field vehicle. They may hose down the outside and sweep out or vacuum the inside of the vehicle, or they may take the vehicle to a GSA-approved car wash.

Standard Operating Procedure 4: Spring Acceptance and Classification

Version 1.0

1. Introduction

This Standard Operating Procedure (SOP) describes how to accept and characterize a spring and how to fill out the corresponding sections on the field data sheet during a spring visit. Field crews will complete and submit a field data sheet for every spring visited.

2. Site Visit Information

On the field data sheet, write in the full **Spring Name** (e.g. Gnome Spring L). Record the four-letter **Park Code** (e.g., DEVA) of the park unit that contains the spring being visited as well as the seven-digit **Spring ID**, which is generally the first three letters of its name followed by a designated series of four numbers (e.g., GNO0080). Record the **Date** of the visit in the format mm/dd/yy (e.g., 04/16/18 for April 16, 2018) and the **Time** of arrival at the spring, using the 24-hour convention for time (e.g., 14:30 instead of 2:30 PM). Use the correct time zone for the date and location. Record the three-letter initials of the **Observers** present during the spring visit. If an observer does not have a middle name, use X as his or her middle initial. If two observers have the same initials, assign one of them to use X as his or her middle initial. In this case, make sure the Data Manager knows which initials correspond to which crew member, so that the metadata can be correctly entered into the database. Write down the **GPS ID** (e.g., MOJN #T3) of the unit collecting geographic data, and record the geodetic **Datum**, which should be NAD83. Circle the correct **UTM Zone**, which is 11N for all park units except PARA, which covers both 11N and 12N.

3. Spring Status

Site visits are classified as one of four **Visit Types**, described in Table 4.1. Circle the type that applies. Upon visiting a spring, the field crew will either monitor the spring or identify a reason for not monitoring. Criteria for not monitoring are listed in Table 4.2. If you monitor the spring, circle Y for **Spring Monitored**. If you do not monitor the spring, circle N for **Spring Monitored** as well as the appropriate criterion for not monitoring. Provide a brief description of the reason in the **Spring Comments** section. Take a representative photograph of the reason (e.g., impassible cliff or evidence of illegal activity), and record the file # (last four digits of the image code) in this section. The image code can be found by pressing the review button (►) on the camera. Even if a spring is not monitored during your visit, it may be monitored by field crews at a later date if conditions change.

Before each field season, the Protocol Lead may decide in the office that certain springs or areas will not be monitored if there are known dangers or access concerns that would prevent a field crew from working there safely. The Protocol Lead will coordinate with the Data Manager to ensure that decisions made in the office are reflected in the database.

Table 4.1. Visit types and descriptions.

Visit Type	Description
Primary	When a spring is visited for the purpose of collecting official data for the protocol.
Training	When a spring is visited purely for the purpose of training or protocol development. If a spring is visited for training, but official protocol data are also collected, then the visit is considered primary.
Calibration	When a spring is visited for the purpose of comparing data collected by two or more different field crews for QA/QC analysis. The visit where official protocol data are collected is considered primary, which is generally led by the Protocol Lead or Field Crew Lead. All other visits are considered calibration.
Replicate	When a spring is visited multiple times in a field season for purposes other than training or calibration. Only one visit is considered primary. The primary visit is not necessarily the chronological first; the primary visit is whichever one is considered to have collected the most complete or accurate protocol data. All other visits are considered replicates.

Table 4.2. Criteria for not monitoring a spring and descriptions.

Criteria for Not Monitoring	Description
Not found	No evidence of flowing or dry spring or riparian vegetation in area
Inaccessible	Spring cannot be physically reached (e.g., washed-out road, impassable cliff, private property boundary)
Unsafe	Spring cannot be safely visited (e.g., illegal activity, active or recent fire)
Potential resource damage	Monitoring would threaten sensitive organisms or cultural sites

4. Spring Classification

Circle the appropriate **Spring Type**. For classifying the spring type, refer to Table 4.3 and Figure 4.1. If you circle **Other**, provide a description of the spring in the **Spring Comments** section.

Table 4.3. Spring types and descriptions. Adapted from Springer and Stevens (2009).

Spring Types	Description
Exposure	Groundwater is exposed at the surface but does not flow
Helocrene	Groundwater emerges from low gradient cienegas (marshy, wet meadows); often has indistinct or multiple sources
Hillslope	Groundwater emerges from non-vertical hillslopes at 30-60° slopes; often has indistinct or multiple sources
Hypocrene	Groundwater does not reach the surface, typically due to low discharge and high evaporation or transpiration
Limnocrene	Groundwater emerges into one or more pools
Rheocrene	Flowing spring, groundwater emerges into one or more stream channels

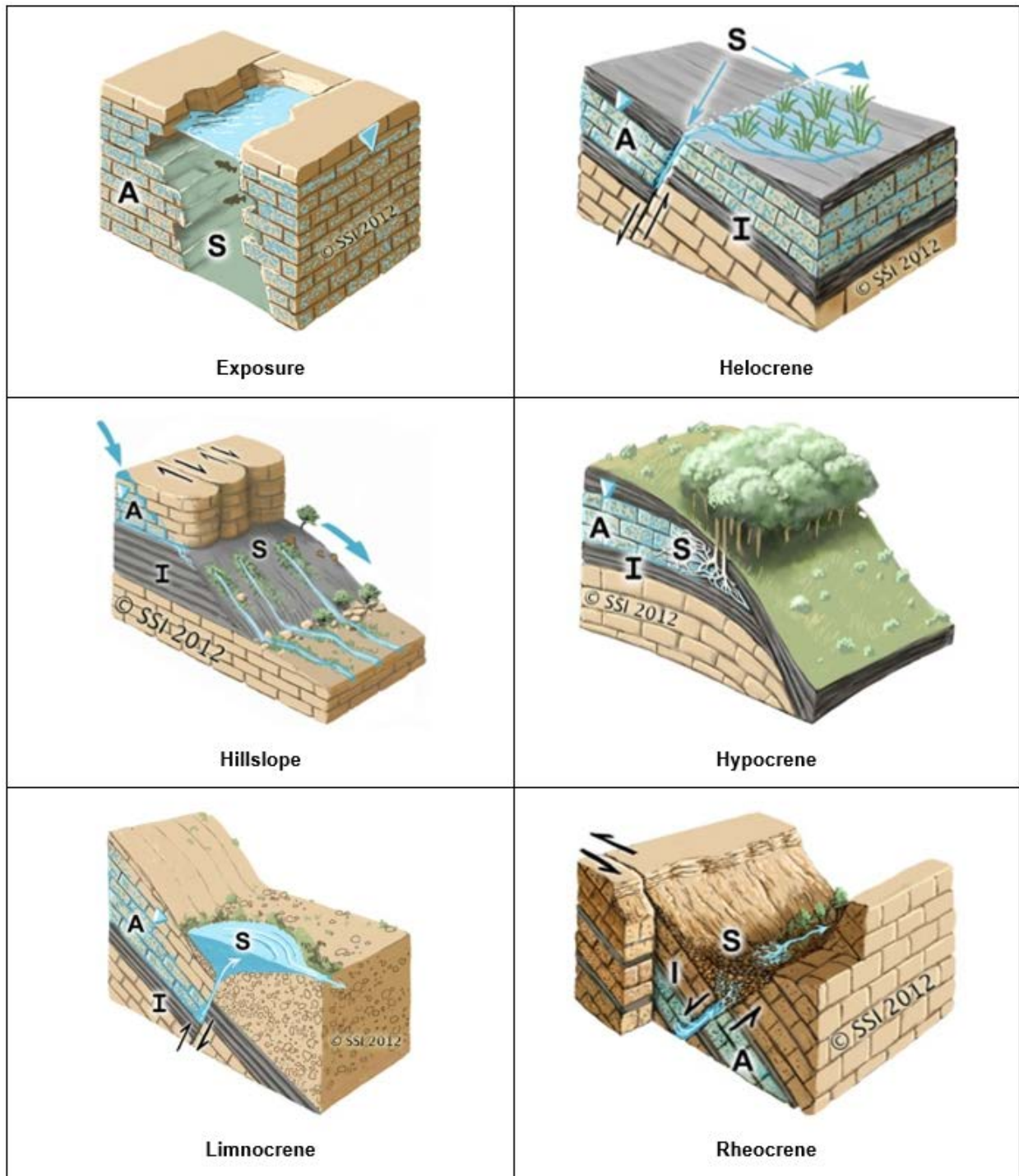


Figure 4.1. Spring types and illustrations. A = aquifer, I = impermeable rock layer; S = spring source. Fault lines indicated by arrows. Illustrations by Victor O. Leshyk from Spring Ecosystem Inventory Protocols (Stevens, Springer, and Ledbetter 2016).

5. General Notes

The **General Notes** section is for any other information about the spring that might be relevant toward understanding or managing the data collected on the field data sheet, or that would be helpful

for future field crews to know during a later site visit. It is better to err on the side of including extra information than to leave out potentially important information. For example, this is the section to write down weather conditions that might influence discharge and water quality measurements or recommendations about the best way to approach a spring that is difficult to access.

Literature Cited

Springer, A. E. and L. E. Stevens. 2009. Spheres of discharge of springs. *Hydrogeology Journal*: Vol. 17, pp. 83-93.

Stevens, L. E., A. E. Springer, and J. D. Ledbetter. 2016. *Springs Ecosystem Inventory Protocols*. Springs Stewardship Institute, Museum of Northern Arizona, Flagstaff, Arizona.

Standard Operating Procedure 5: Water Availability: Flow Condition

Version 1.0

1. Introduction

This Standard Operating Procedure (SOP) describes how to assess the flow condition of a spring and collect discrete water availability data if surface water is present. Discrete water availability data include discharge and surface water length.

2. Flow Condition

Circle the appropriate **Flow Condition** on your field data sheet based on the descriptions in Table 5.1. Depending on flow condition at the spring, either estimate the discharge or use the volumetric method to measure discharge. Circle **Estimated**, **Volumetric**, or **Other** for **Discharge Method**.

Table 5.1. Flow conditions and descriptions. Adapted from NCPN Springs Monitoring Protocol SOP 5: Hydrologic Monitoring (2017).

Flow Condition	Description
Dry	No surface water or dampness present
Wet soil	Substrate visibly damp or damp to the touch, but no standing or flowing surface water
Standing water	Pooled surface water present, but no flow
Flowing water	Flowing surface water present due to active groundwater discharge
Flood	Flowing surface water present due to precipitation run-off; flow measurement not representative of active groundwater discharge
Frozen	Surface water present entirely as solid ice; unable to observe or measure active groundwater discharge

3. Discharge: Visual Estimate

If the spring is dry and there is no water at all, you may write down **0** for **Estimated Discharge**. If wet soil or standing water is present, but there is no flowing water, then the discharge should be reported as less than 1 liter per minute. You may use the > or < symbol in your estimate, so you would write down <1 for **Estimated Discharge**.

If field crew members have made multiple volumetric measurements (described below), and are comfortable in their ability to identify discharges of less than 1 liter per minute, then they may report springs flowing at a trickle as less than 1 liter per minute. Visual estimates are not appropriate for discharges of more than 1 liter per minute.

4. Discharge: Volumetric Method

The volumetric method consists of measuring the time required for spring discharge to fill a container of known volume, such as a 1-liter flask or a 5-gallon bucket. Record the **Volume of the Container** on the field data sheet. The discharge is then calculated by dividing the volume of the container by the time needed to fill it. The method below is taken from Turnipseed and Sauer (2010), who describe the volumetric method as “the most accurate method of measuring small discharges.”

1. Choose a location close to the spring source to make the measurements. If there is a location where all of the flow can be captured in the container without channel modification, attempt this first. Otherwise, build a temporary earthen dam to funnel the flow into the container. (Measure water quality first before disturbing the substrate. See SOP 7: Water Quality.) The location and building materials should be chosen to minimize the transport of sediment downstream.
2. If the container captures the entire flow, record 100 for the **% of Flow Captured**. If the container only captures a portion of a wide channel, or if there are multiple channels, estimate and write down the **% of Flow Captured** by the container.
3. Use a stopwatch to record the amount of time it takes to fill the container. Record a minimum of five **Fill Times** at each spring. In general, the precision of these fill times should be within approximately 1 second of each other, so fill times of less than 10 seconds should be avoided by using a larger container.
4. If you built an earthen dam, carefully restore the channel to its original condition, taking care to minimize sediment released downstream.

5. Discharge: Other Methods

Occasionally, specific conditions at a site may make it desirable to measure discharge using a float, flowmeter, portable flume or weir, or another method. Write the name of the method on the field sheet next to **Other**, and follow the procedures described in the applicable section of Turnipseed and Sauer (2010).

6. Surface Water Dimensions

Measure and record the **Surface Water Length**, either by pacing out the distance or by using a measuring tape. Look at standing and flowing water only, not wet soil. Wherever the surface water that emerges from the spring source ends is the length of the springbrook, even if water reemerges further down the channel. Do not measure the springbrook length beyond 50 meters; if the springbrook is longer, write down >50 on the field data sheet. Visually estimate and record the **Surface Water Width** along the entire length (or 50 m, whichever is shorter) of the springbrook.

If the spring is not rheocrene, then record the dimensions of whatever surface water is present. For example, if water has filled a trough, then record the length and width of the trough. If the spring is dry or there is only wet soil, then write down 0 for the length and width. Record any additional observations, such as channel morphology or substrate, in the **Channel Description** section.

Literature Cited

- Northern Colorado Plateau Network. 2017. Northern Colorado Plateau Network springs monitoring protocol standard operating procedures (SOPs). National Park Service, Fort Collins, Colorado.
- Turnipseed, D. P. and V. B. Sauer. 2010. Discharge measurements at gaging stations. U.S. Geological Survey Techniques and Methods 3-A8. U.S. Geological Survey, Washington, D.C.

Standard Operating Procedure 6: Water Availability: Data-Logging Sensors

Version 1.0

1. Introduction

This Standard Operating Procedure (SOP) describes how to collect continuous water availability data through the use of data-logging sensors, including how to deploy and retrieve sensors in the field and how to program sensors and download temperature and humidity data in the office. Only a subset of springs visited at each park will have sensors deployed at them, but these springs will be visited annually. For a list of these annual springs, refer to Appendix A in the protocol narrative.

2. Humidity Sensors

The data-logging sensors currently being used in this protocol are temperature and humidity Hygrochron iButtons manufactured by Maxim Integrated Products (product ID DS1923, Figure 6.1). These sensors can store up to 4096 paired readings of ambient relative humidity and temperature. The sensors are susceptible to failure if deployed underwater (Wolaver and Sharp 2007), but their waterproofing can be improved by sealing their rims with epoxy. The vent hole on the top each sensor must not be obstructed by epoxy or the unit will be unable to measure humidity.



Figure 6.1. iButton epoxied to a metal disk. Penny for scale.

The sensors should be attached to either a metal disk or a specially-manufactured fob (Maxim product ID DS9093A+) so that they can be more easily labeled and secured in place. In addition to the sensors themselves, a reader (Maxim product ID DS1402D-DR8# or a similar model) and a USB port adapter (Maxim product ID DS9490R#) are needed (Figure 6.2).



Figure 6.2. iButton reader (left) and USB adapter (right).

3. Sensor Programming

A sensor must be programmed to collect data before it can be deployed at a spring. The iButtons can be programmed using OneWireViewer, a Java application distributed by Maxim. The program can be downloaded as part of a package from:

http://www.maxim-ic.com/products/ibutton/software/tmex/download_drivers.cfm.

A complete set of installation instructions with screen shots can be found at:

<http://www.maxim-ic.com/app-notes/index.mvp/id/4373>.

Once the program has been installed, the sensors can be programmed as follows:

1. Connect the iButton reader to the USB adapter, and plug the adapter into a USB port on your computer. Open OneWireViewer.exe. The serial number on the Device List is the USB adapter.
2. Snap a sensor into the reader. When the sensor is properly installed, a serial number that includes the identifier “DS1923” should appear in the Device List. It may be necessary to remove epoxy from the sensor to allow it to communicate with the reader. If the sensor already contains temperature and humidity data, then first download the data (described later in this SOP) before continuing to program the sensor. If this is the first configuration of the sensor, the tag number and serial number should be recorded in the Desert Springs database.

3. Click on the serial number of the sensor in the Device List. The Hygrochron screen should appear.
4. Click the “Mission” tab, then click “Start New Mission.” The Initialize New Mission screen (Figure 6.3) should pop up.

Initialize New Mission

Mission General

☒ Synchronize Clock? Sampling Rate (seconds)

☒ Enable Rollover? Start Delay (minutes)

☐ Use 1-Second Mission Test?

Mission Channel: Temperature

☒ Enable Sampling? ☐ Enable Alarms?

Resolution: Low Alarm? (°C)

 High Alarm? (°C)

☐ Enable SUTA?

Mission Channel: Humidity

☒ Enable Sampling? ☐ Enable Alarms?

Resolution: Low Alarm? (%RH)

 High Alarm? (%RH)

Figure 6.3. Initialize New Mission screen in OneWireViewer.exe.

5. In the Mission General section, check the boxes for “Synchronize Clock” and “Enable Rollover.” Enter a start delay if the time of deployment is known. Uncheck the box for “Use 1-second Mission Test?”
6. The selection of a sampling rate is a trade-off between the value of more frequent data and the memory limitations of the sensor. A sampling rate of 14400 seconds (4 hours) will allow for the collection of one year of temperature and humidity data at low resolution. If a higher sampling frequency is desired, then you may wish to disable temperature sampling.

7. In the Mission Channel sections, check the boxes next to “Enable Sampling?” and uncheck the boxes next to “Enable Alarms?” and “Enable SUTA.” Select the lower resolution (i.e., the larger number) for both temperature and humidity sampling, as the higher resolution data use twice as much memory. Click “OK.”
8. Remove the sensor from the reader. If the sensor has not been previously deployed, or if its epoxy has been degraded or removed, then seal the rim of the sensor with epoxy to improve its waterproofing. Do not allow epoxy to obstruct the vent hole.

4. Sensor Deployment and Retrieval

The purpose of a sensor is to record the availability of surface water at a spring over the course of the year. Therefore, the sensor should be deployed at the location that is the last to dry up as discharge fluctuates at a spring. It may or may not be possible to identify this location in the field, especially if a spring is visited when it is completely dry. In general, the sensor should be placed at the lowest point in the source area.

The sensor should be tied with a corrosion-resistant cord or wire to a 10-centimeter (4-inch) bolt pounded into the substrate (Figure 6.4). If it is not possible to pound a bolt into the substrate (e.g., if the substrate is bedrock, or if the bolt would harm cultural resources), then another method should be used to ensure the sensor is not swept downstream by flooding, such as tying the sensor to the sturdy root of a nearby tree or shrub.



Figure 6.4. Bolt pounded into substrate with tag and sensor attached by electrical wire.

Field crews will relocate a sensor for retrieval using the UTM coordinates and photographs that were taken and recorded on the field data sheet during its deployment. Refer to SOP 11: Repeat Photographs for more information.

Each new sensor should be deployed in the same location as the old one on subsequent visits. If the bolt is still secure, then it may be left in place and the sensors simply swapped out. Changing the location of a sensor makes it impossible to compare data between different deployments, so the original location should be kept unless it found to be inappropriate (e.g., not in the spring).

If a sensor is successfully deployed at a spring, circle **Y** for **Sensor Deployed** on the field data sheet. If a sensor is not deployed because the spring is not an annual spring, circle **N**. If a sensor is not deployed for any other reason, circle **N** and explain this reason in the **Sensor Comments**. If a sensor is successfully retrieved, circle **Y** for **Sensor Retrieved**. If a previously deployed sensor is looked for but not recovered, circle **N**. If there was no sensor previously deployed at the spring, circle **N/A**.

Record the **Sensor Type** and unique MOJN **Sensor ID** for each sensor as appropriate. In the event that a sensor was not recovered or was recovered in a potentially compromised circumstance, circle the **Sensor Problem** that was encountered and elaborate in the **Sensor Comments**. Potential sensor problems are described in Table 6.1. If there was no obvious problem during sensor retrieval, circle **None** for the **Sensor Problem**.

Table 6.1. Sensor problems and descriptions.

Sensor Problem	Description
None	Sensor recovered in the correct location, no obvious problem
Damaged	Sensor recovered in the correct location, but damaged or tampered with
Buried	Sensor recovered in the correct location, but buried under substrate
Outside water	Sensor recovered in the correct location, but laying outside of flowing or standing water
Wrong location	Sensor recovered, but from the wrong location
Missing	Spring location found, but sensor not recovered
Location not found	Spring location not found

5. Sensor Download

Temperature and humidity data should be downloaded from the sensors as soon as possible after they have been removed from the field. To download the data:

1. Connect the iButton reader to the USB adapter, and plug the adapter into a USB port on your computer. Open OneWireViewer.exe.
2. Snap a sensor into the reader, and then click on the serial number of the sensor in the Device List. The Hygrochron screen should appear.
3. Click on the “Mission” tab, and then click “Disable Mission.” This stops the sensor from collecting data.
4. Click on the “Humidity Data Log” tab. A graphical representation of the collected humidity data should appear (Figure 6.5).

5. Right-click anywhere on the graph to open a pop-up menu. Select “Save as .csv file” from the menu. Type in the file name based on network-specific data management protocols.
6. Repeat step 5 for the “Temperature Data Log” tab.
7. The data are now downloaded. Either program the sensor for future collection (described earlier in this SOP) or remove it from the reader.

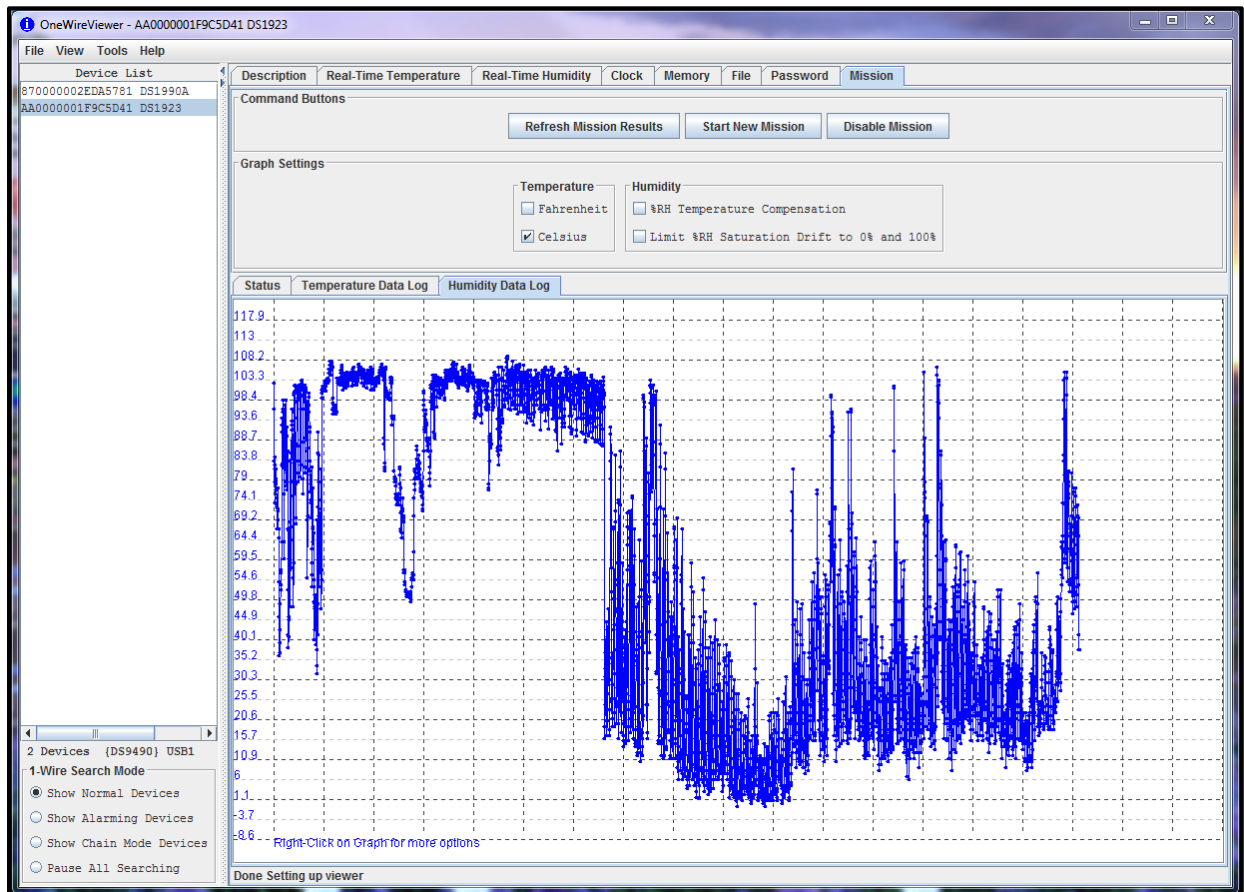


Figure 6.5. Hygrochron Humidity Data Log screen in OneWireViewer.exe.

When iButton humidity sensors are saturated or submerged in water, they can record humidity values that are greater than the actual humidity to which they are being exposed (i.e., >100%). Humidity values >100% are not within the operating range recommended for the iButton humidity sensors, and may be a reason why negative humidity values are sometimes logged. Humidity values >100% or <0% should be adjusted to 100% during data processing and analysis.

Literature Cited

Wolaver, B. D., and J. M. Sharp. 2007. Thermochron iButton: Limitation of this inexpensive and small-diameter temperature logger. *Ground Water Monitoring and Remediation* 27(3):127-128.

Standard Operating Procedure 7: Water Quality

Version 1.0

1. Introduction

This Standard Operating Procedure (SOP) describes how to calibrate the water quality instrument used for this protocol and how to measure water quality parameters in the field. The four “core” parameters measured are temperature, pH, specific conductance, and dissolved oxygen. These parameters are measured using a YSI 556 MPS.

2. YSI 556 MPS

MOJN I&M owns a YSI 556 MPS handheld water quality instrument that measures temperature, pH, specific conductance, and dissolved oxygen. Diagrams of the handheld instrument and probe module are shown in Figures 7.1 and 7.2. Sensor specifications are provided in Table 7.1. The following instructions on calibration and maintenance are adapted from the YSI 556 Multi Probe System Operations Manual (2009) and YSI 556 Multi Probe System Specification Sheet (2009).

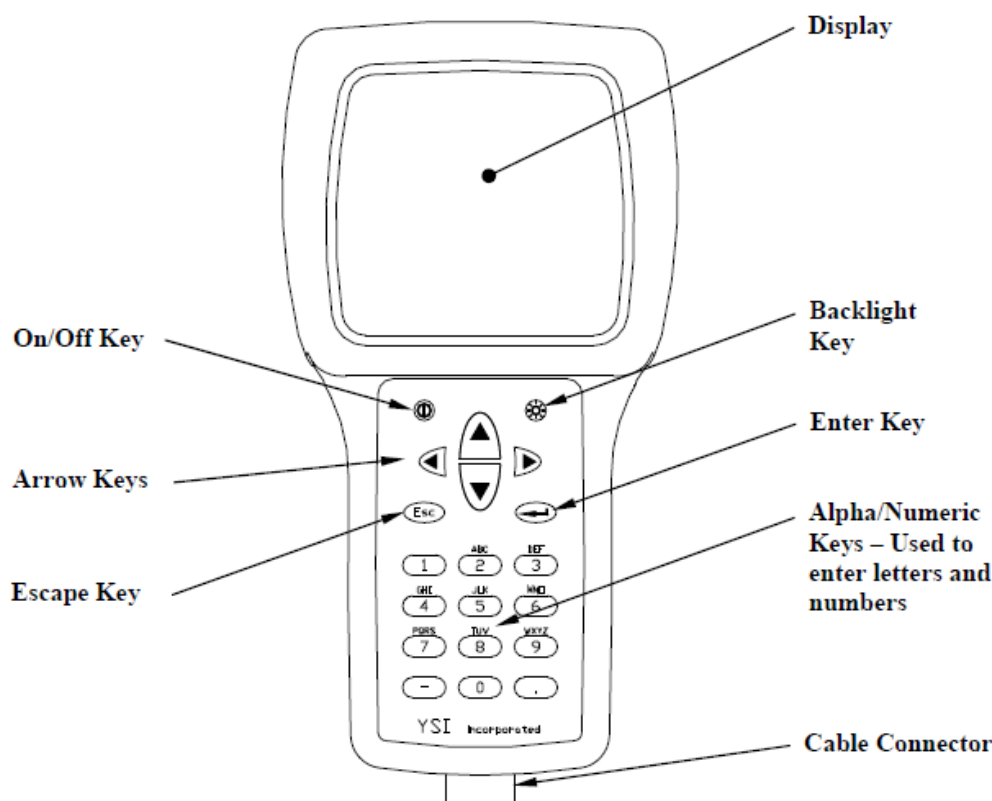


Figure 7.1. Diagram of the YSI 556 MPS handheld instrument from the product operations manual.

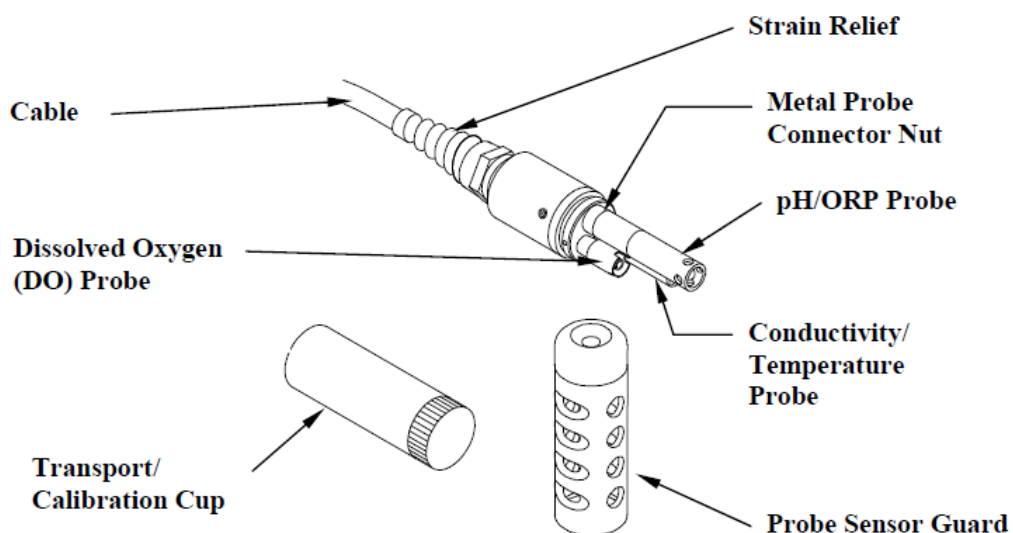


Figure 7.2. Diagram of the YSI 556 MPS probe module from the product operations manual.

Table 7.1. YSI 556 MPS sensor specifications from the product specification sheet.

Water Quality Parameter	Sensor Metric	Sensor Specification
Temperature	Sensor Type	YSI Temperature Precision™ thermistor
	Range	-5 to 45 °C
	Accuracy	± 0.15 °C
	Resolution	0.1 °C
Specific Conductance	Sensor Type	4-electrode cell with autoranging
	Range	0 to 200 mS/cm
	Accuracy	± 0.5 % of reading or ± 0.001 mS/cm; whichever is greater
	Resolution	0.001 mS/cm to 0.1 mS/cm (range-dependent)
pH	Sensor Type	Glass combination electrode
	Range	0 to 14 units
	Accuracy	± 0.2 units
	Resolution	0.01 units
Dissolved Oxygen (% Saturation)	Sensor Type	Steady state polarographic
	Range	0 to 500 % air saturation
	Accuracy	0 to 200 % air saturation, ± 2 % of the reading or ± 2 % air saturation, whichever is greater; 200 to 500 % air saturation, ± 6 % of the reading
	Resolution	0.1 % air saturation
Dissolved Oxygen (mg/L)	Sensor Type	Steady state polarographic
	Range	0 to 50 mg/L
	Accuracy	0 to 20 mg/L, ± 2 % of the reading or ± 0.2 mg/L, whichever is greater; 20 to 50 mg/L, ± 6 % of the reading
	Resolution	0.01 mg/L

3. Calibration

MOJN I&M uses calibration procedures and quality-assurance criteria developed by the USGS. The YSI 556 MPS must be calibrated at least once per day that data are collected. The sensors should be calibrated on site, immediately prior to data collection. If multiple springs will be visited on the same day, then these calibrations should be checked at each subsequent site. If a calibration is outside of the acceptable range (see Table 7.2), then the sensor should be recalibrated.

The temperature sensor does not need to be calibrated in the field; however, its performance should be compared to a separate NIST-traceable thermometer at least once per field season. Because pH buffer solutions have very high conductivities, the specific conductance sensor must be calibrated before the pH sensor, so that the pH buffers do not contaminate the conductivity standard and affect calibration of the sensor.

You will record the pre- and post-calibration readings for specific conductance, dissolved oxygen, and both pH calibrations. Also record the pre- and post-calibration temperatures for the dissolved oxygen and both pH calibrations. Record the atmospheric pressure or elevation used for the dissolved oxygen calibration. Acceptable calibration errors are provided in Table 7.2.

Table 7.2. Acceptable calibration error for water quality parameters. Adapted from USGS criteria (Gibs, Wilde, and Heckathorn 2007).

Water Quality Parameter	Acceptable Calibration Error
Temperature	± 0.2 °C
Specific Conductance	± 5 μ S/cm or $\pm 3\%$, whichever is greater
Dissolved Oxygen	± 0.3 mg/L
pH	± 0.2

3.1. Specific Conductance

Specific conductance is almost always calibrated with a standard solution of 1413 μ S/cm KCl, although a small number of desert springs visited for this protocol may require standards of 10,000 μ S/cm or even 50,000 μ S/cm (whichever is nearest to the expected sample value). These standards are easily contaminated when reused, so fresh standard must be used for each calibration. The calibration should be made at a temperature that is as close as possible to the sample temperature.

1. Rinse the sensor and calibration cup once with clean water and three times with standard. Discard the rinsate.
2. Fill the calibration cup with enough standard to cover the vent hole on the side of the sensor (approximately 200 mL). Allow one minute for the sensor to equilibrate to the temperature of the standard.
3. From the main menu, select “Calibrate”. From the Calibrate Menu, select “Conductivity,” then “SpCond.” Enter the specific conductance of the standard solution.

4. All of the enabled sensor readings will be displayed on the screen. Once the specific conductance reading has been stable (fluctuation within 5 $\mu\text{S}/\text{cm}$ or 3%, whichever is greater) for about 30 seconds, accept the calibration by pressing “Enter.”

3.2. Dissolved Oxygen

Errors in dissolved oxygen calibrations are common, so care should be taken to follow these instructions carefully. The intent of the procedure is to use water-saturated air as a calibration standard. However, the saturation point changes as a function of temperature and pressure. The YSI 556 MPS automatically corrects for temperature, and pressure is measured by a barometer built into the instrument.

Note: The instrument must be on for at least 20 minutes before calibrating DO.

1. Rinse the sensor and calibration cup three times with clean water. Discard the rinsate.
2. Place the sensor in a calibration cup containing 3 mm (1/8 in) of water. Since the intent is to perform the calibration in water-saturated air, the sensor should not be underwater. Loosely thread the calibration cup onto the probe housing to ensure that the air pressure inside the cup is the same as the atmospheric pressure. Wait at least 15 minutes to allow the sensor to equilibrate to the temperature of the water-saturated air.
3. From the main menu, select “Calibrate”. From the Calibrate Menu, select “ODOsat %,” then “1-point.” Accept the barometric pressure displayed as the default option on the instrument.
4. All of the enabled sensor readings will be displayed on the screen. Once the DO reading has been stable (fluctuation within 0.3 mg/L) for 30 seconds, accept the calibration by pressing “Enter.”

3.3. pH

A two point calibration will be made with buffer solutions of pH 7 and either pH 4 or pH 10 (whichever is nearest to the expected sample value). The desert springs visited for this protocol will almost all require pH 7 and pH 10 buffers.

Note: If the response of the pH sensor appears to be slower than normal, then the sensor should be cleaned according to the instructions given in the manual.

1. Rinse the sensor and calibration cup once with clean water and three times with pH 7 buffer. Discard the rinsate.
2. Pour enough pH 7 buffer into the calibration cup to immerse the pH sensor (approximately 125 mL). Do not thread the cup onto the probe. Allow one minute for the sensor to equilibrate to the temperature of the buffer.
3. Read the temperature of the buffer in the cup. Use the table on the buffer bottle to determine the temperature-corrected pH of the buffer.

4. Thread the cup onto the probe. From the main menu, select “Calibrate”. From the Calibrate Menu, select “ISE1 pH,” then “2-point.” Enter the temperature-corrected pH of the buffer.
5. All of the enabled sensor readings will be displayed on the screen. Once the pH reading has been stable (fluctuation within 0.2 pH units) for 30 seconds, accept the first point of the calibration by pressing “Enter.”
6. Rinse the sensor and calibration cup once with clean water and three times with pH 10 (or pH 4) buffer. Discard the rinsate.
7. Pour enough pH 10 (or pH 4) buffer into the calibration to immerse the pH sensor (approximately 125 mL). Do not thread the cup onto the probe. Allow one minute for the sensor to equilibrate to the temperature of the buffer.
8. Read the temperature of the buffer in the cup. Use the table on the buffer bottle to determine the temperature-corrected pH of the buffer.
9. Follow the instructions on the screen to continue the calibration. Enter the temperature-corrected pH of the buffer.
10. Once the pH reading has been stable for 30 seconds, accept the second point of the calibration by pressing “Enter.”

4. Maintenance

Probe maintenance is essential for collecting quality data. The conductivity sensor is generally low-maintenance and should be cleaned according to manufacturer guidelines. The dissolved oxygen sensor requires frequent maintenance. The membrane cap and electrolyte solution must be changed at least once every 30 days during periods of heavy use (generally September through April). The sensor should be inspected each day of use to ensure that there are no cracks or scratches on the membrane. The pH sensor has a lifespan of approximately 12 to 18 months. To ensure that accurate data are collected, the pH sensor should be replaced every 12 months. Refer to the instrument manual for additional cleaning instructions.

5. Measurement

If sufficient water is available, submerge the probe in the spring as close to the source as possible, and allow the instrument to stabilize for approximately two minutes. In springs where only a small amount of water is present near the source, measurements should be collected at the deepest point. Do not dig into the substrate to deepen the pool, as disturbing the sediment will affect the readings. In order to obtain an accurate dissolved oxygen reading, the probe should be continuously stirred.

If you collect any water quality data at a spring, circle **Y** for **Data Collected** and write down the **pH Instrument ID #** and the **WQ Instrument ID #** as applicable. When using the YSI 556 MPS, these IDs are the same. Measure three readings each for **Temp, pH, SpCond, DO (%)**, and **DO (mg/L)** to prevent the inclusion of outlier data, and record these values in the spaces provided on the field data sheet. Median values will be calculated in the office and used for analysis and reporting.

Sometimes, very shallow water will be sufficient for the temperature and pH sensors, but not the specific conductance or dissolved oxygen sensors. In this event, record the temperature and pH readings as normal, and make a note in the **Water Quality Comments** section explaining why the SpCond and DO fields are empty.

If you do not collect any water quality data at a spring for any reason, circle **N** for **Data Collected**, and also circle the appropriate criterion for no data (Table 7.3). You may elaborate on the reason for no data in the **Water Quality Comments**.

Table 7.3. Criteria for no water quality data.

Criteria for No Data	Description
Instrument failure	Hardware damage, software malfunction, dead batteries, etc.
Poor calibration	Problems in calibration resulting in inaccurate or unreliable data
Insufficient water	Spring dry or water not deep enough to submerge sensors
Other	Does not fit into one of the described criteria for no data

Literature Cited

- Gibs, J., F. D. Wilde, and H. A. Heckathorn. 2007. Chapter 6.8: Use of multiparameter instruments for routine field measurements. Section A: National Field Manual for the Collection of Water-Quality Data. Book 9: Handbooks for Water-Resource Investigations. U. S. Geological Survey, Reston, Virginia. Available online: <http://water.usgs.gov/owq/FieldManual/Chapter6/6.8.html>.
- YSI Environmental. 2009. YSI 556 Multi Probe System Operations Manual. Yellow Springs, Ohio. Available online: <https://www.ysi.com/File%20Library/Documents/Manuals/655279-YSI-556-Operations-Manual-RevD.pdf>.
- YSI Environmental. 2009. YSI 556 Multi Probe System Specification Sheet. Yellow Springs, Ohio. Available online: <https://www.ysi.com/File%20Library/Documents/Specification%20Sheets/W11-556-Multiparameter-System.pdf>.

Standard Operating Procedure 8: Site Condition: Spring Vegetation

Version 1.0

1. Introduction

This Standard Operating Procedure (SOP) describes how to define a buffer area to assess spring vegetation and how to identify and rank vegetation life forms within that area.

2. Buffer Area

The first step for assessing spring vegetation is to visually define the buffer area (see Figure 8.1). The area within the estimated spring source and springbrook buffers will be the area used to rank life forms by canopy cover.

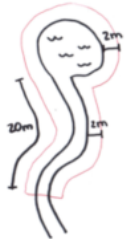
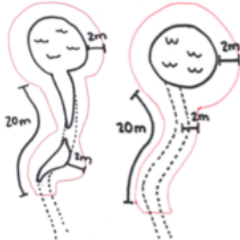
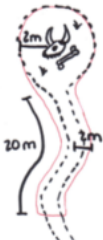
If water is flowing from the spring source and down a springbrook (spring is rheocrene): Visually define a 2-meter buffer around the source and along the channel for 20 meters downstream. The buffer begins at the edge of surface water.	
If water is flowing from the spring source, but the springbrook is partially or completely dry: Visually define a 2-meter buffer around the source and along the channel for 20 meters downstream. The buffer begins at the edge of surface water around the source and where water is present down the springbrook, and at the center of the channel where the springbrook is dry.	
If the spring source and the springbrook are dry: Visually define a 2-meter buffer around the source and along the channel for 20 meters downstream. The buffer around the source centers around the GPS coordinates for the source or at the coordinates determined to be the source based on field observations. The buffer along the channel begins at the center of the channel down the dry springbrook.	
If water is flowing from the spring source, but there is no obvious springbrook (spring is not rheocrene): Visually define a 2-meter buffer around the source. The buffer begins at the edge of surface water. The spring will not have a downstream buffer component.	
If the spring source is dry, and there is no obvious springbrook: Visually define a 2-meter buffer around the GPS coordinates for the source or at the coordinates determined to be the source based on field observations. The spring will not have a downstream buffer component.	

Figure 8.1. Possible scenarios when visually defining the buffer area at a spring.

3. Life Form Rank

You will assign each plant life form present within the buffer area a **Rank** using a method adapted from the U. S. Forest Service (USFS) Groundwater-Dependent Ecosystem (GDE) Level 1 Field Guide (2012). Life form rank is based on canopy cover, which is the total area covered within the buffer area by all species in that life form, even when the canopies of different life forms overlap. Include both dead and living plants in your estimate of canopy cover and life form rank. A rank of 1 indicates the life form with the greatest canopy cover. Two or more life forms may share the same rank if they have approximately the same amount of canopy cover. Figure 8.2 provides a list of the life form categories as well as their definitions. Graminoids have been divided into subcategories because of their particular importance to spring ecology and management.

If **Mistletoe** is present within the buffer area (commonly found on catclaws and mesquites), then check that box on the field data sheet. If there is **No Vegetation** (including the Non-Plant life form category) at all within the buffer area, then check that box on the field data sheet.

Woody >4 m: Woody vascular plant with a single stem (trunk) or multi-stemmed growth form that is greater than 4 m tall. Always perennial. Often corresponds to a large or mature tree.
Woody 2-4 m: Woody vascular plant with a single stem (trunk) or multi-stemmed growth form that is 2 to 4 m tall. Always perennial. Often corresponds to a tree or a large shrub.
Woody <2: Woody vascular plant with a single stem (trunk) or multi-stemmed growth form that is less than 2 m tall. Stems may be woody or herbaceous above the ground, but there is significant woody tissue at the ground. Always perennial. Often corresponds to a young or dwarf tree or a shrub or subshrub.
Forb: Herbaceous vascular plant without significant woody tissue above or at the ground. May be annual or perennial. Graminoids are excluded, but ferns, lycophytes, and horsetails are included.
Graminoid: Herbaceous vascular grass or grass-like plant, including grasses (Poaceae), sedges (Cyperaceae), rushes (Juncaceae), and cattails (Typhaceae). May be annual or perennial. Grass: Graminoid characterized by hollow, round stems in cross-section, solid nodes, alternate leaves, and hairy ligules. Reed: Tall grass characterized by cane-like stems, long leaves, and plume-like inflorescences. Typically <i>Phragmites australis</i> or <i>Arundo donax</i> . Rush: Graminoid characterized by pithy, round stems in cross-section. Sedge: Graminoid characterized by triangular or flattened stems and spirally-arranged leaves. Cattail: Graminoid characterized by brownish, compact, corn-cob-shaped inflorescences.
Bryophyte: Herbaceous nonvascular plant, including mosses, hornworts, and liverworts.
Non-Plant: Organism that may or may not be photosynthetic, including algae, bacteria, fungi, and lichens. Lichens are generally recognized as a single "plant" that consists of a fungus and an alga or cyanobacterium living in symbiotic association.

Figure 8.2. Vegetation life form descriptions. Adapted from USFS GDE Level I Field Guide (2012).

4. Dominant Species

Record the **Dominant Species (If Known)** for each life form present within the buffer area. The dominant species is the species with the highest percent canopy cover in that life form category. If it is not clear which species is dominant, you may record two or more dominant species within a life form if they have approximately the same amount of canopy cover.

When you cannot confidently identify a species, it must be recorded as unknown. In this case, refer to the species as “unks” on the field data sheet followed by a letter (e.g., an unknown conifer species at the spring is called “unks A,” an unknown forb with yellow flowers and triangular leaves is “unks B,” and so on). After recording the species as “unks [appropriate letter]”, describe the plant in the comments section of the datasheet: the fruits, flowers, leaves, bark, height, proximity to water, smell, and other notable features. If you have a “best guess” at what the species is, provide your guess in the comments section as well. Take photographs of identifying structures such as fruits, flowers, and individual leaves (see next section).

Importantly, do not record a species name unless you are confident in your identification. In plant ecology, a useful rule of thumb is to ask yourself if you would bet \$100 on your guess. If you would not, then record the species as unknown. According to MOJN I&M data quality standards, inaccurate data are worse than no data.

If it seems as though an unknown species could be identified in the office (e.g., the species is not senescent and desiccated) and the park permit allows for collection, you may collect a representative individual in the field and store it in a plant press. As stated in SOP 1, the network Ecologist or Protocol Lead may attempt to identify unknown species during office examination.

5. Photographs

Photographing the dominant species within each life form, whether tentatively identified or unknown, is required to provide supplementary evidence for later office examination, as well as to provide a long-term visual record of change. A minimum of two photographs are mandatory for the dominant species within each life form, and generally no more than four photographs are necessary. Figure 8.3 describes the ideal properties that should be photographed for each plant.

Write the **Camera ID #** and **Memory Card #** in the appropriate spaces on the field data sheet. The camera number is the last five digits of the code on the property sticker. The memory card number is labeled on the card itself. In addition, write the **File #** (last four digits of the image code) for each photograph in the appropriate spaces on the field data sheet. The image code can be found by pressing the review button on the camera (►).

Structure/Morphology: The general growth habit and microhabitat of the plant. Include a ruler or some object of known size for scale. <i>Mandatory.</i> In the example of <i>Prosopis pubescens</i> (screwbean mesquite) to the right, note the person standing off to the side of the tree who provides a sense of proportion.	
Leaves/Stems: The photosynthetic structures of the plant. Include as much as you can about leaf and stem size, shape, margin, venation, color, texture, number of leaflets, etc. <i>Mandatory.</i>	
Flowers/Fruits/Seeds: The reproductive structures of the plant. Include as much as you can about flower structure, arrangement, color, number and size of petals, or in the case of fruits or seeds, size, shape, color, texture, etc. May not be present depending on the season of the site visit. <i>Mandatory if present.</i>	
Distinctive Traits: Any other unique or diagnostic features of the plant that would be useful in its identification. <i>Optional.</i> In the example of <i>Prosopis pubescens</i> (screwbean mesquite) to the right, the tree has very characteristic tightly coiled seed pods. Photographs of distinctive traits like this will help personnel to identify an unknown species in the office.	

Figure 8.3. Photographs required for the dominant species within each life form.

6. Other Species of Interest

Additionally, record any other significant plant species or observations in the **Vegetation Comments** of your field data sheet (i.e., a large cottonwood upstream of spring source or an ornamental that appears out-of-place). These plants may be inside or outside the buffer area, as long as they are in the general vicinity of the spring.

Literature Cited

U. S. Forest Service. 2012. Groundwater-Dependent Ecosystems: Level 1 Inventory Field Guide: Inventory Methods for Assessment and Planning. General Technical Report WO-86a.

Standard Operating Procedure 9: Site Condition: Invasive Plants

Version 1.0

1. Introduction

This Standard Operating Procedure (SOP) provides a list of targeted invasive plants found within MOJN park units and describes how to record observations of invasive plants. In addition to recording observations on the field data sheet, field crews will also implement Tier 3 monitoring of the Invasive Plant Species Early Detection (IPSED) plan. This SOP and the associated IPSED monitoring are intended to detect only the presence or absence of invasive plants – not their percent or actual cover.

2. Targeted Species

MOJN parks are interested in monitoring the introduction and proliferation of invasive plants at sensitive spring ecosystems. The 53 invasive plants targeted for identification and documentation by the MOJN parks are found in the MOJN I&M Invasive Plant Guide for National Parks in the Mojave Desert Network (2016), which will be provided to field crew members. Park managers may also request additional species not listed in the invasive plant guide, which should also be included in the targeted invasive plants.

This guide was developed for non-technical users and does not require any special skills or prior training in plant identification. The network Ecologist will train field crew members on how to identify invasive plants and efficiently utilize the guide in the field. For an example page from the guide, see Figure 9.1. Table 9.1 provides a list of the invasive plants found within the MOJN park units as of December 2015, as well as their common names and USDA PLANTS codes.

Giant Reed (*Arundo donax*)

Plant: Forms dense stands; turns from green to tan as it dries in fall/winter

Stems/Branches: Erect, smooth stems, 1-4 cm (½-1½ in) thick

Leaves: Up to 0.5 m (1½ ft) long by 2.5-5 cm (1-2 in) wide; **distinct pale green area where attached to stem**

Flowers: Brown to tan; erect, feathery clusters 0.3-1 m (1-3¼ ft) long of many small flowers

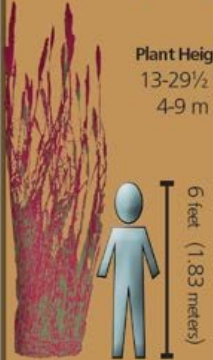
Fruit/Seeds: 10-13 mm (~½ in) long

Known Parks:
DEVA, JOTR,
LAKE, MOJA

Growing Season:
Spring - Summer

Flowering Times:
April - July

Plant Height
13-29½ ft
4-9 m






Giant Reed (*Arundo donax*)

Habitat: Disturbed areas, springs, river banks




Quassia Family - Simaroubaceae

Don't Confuse
Common Reed
(*Phragmites australis*)



All parts ~3 times smaller than giant reed; flowers red to tan & **drooping (non-erect)**



Grass

For full list of photo credits, visit: <http://go.nps.gov/mojn-ipg>

Perennial

Figure 9.1. Example page from the MOJN I&M Invasive Plant Guide for National Parks in the Mojave Desert Network (2015).

Table 9.1. Invasive plants found within MOJN park units.

Family	Species	Common Name	USDA Code	MOJN Parks
Apocynaceae (Dogbane)	<i>Nerium oleander</i>	oleander	NEOL	DEVA LAKE MOJA JOTR
Arecaceae (Palm)	<i>Phoenix dactylifera</i>	date palm	PHDA4	DEVA JOTR LAKE PARA
	<i>Washingtonia filifera</i>	desert fan palm	WAFI	DEVA LAKE PARA
Asteraceae (Sunflower)	<i>Acroptilon repens</i>	Russian knapweed	ACRE3	all except JOTR and MANZ
	<i>Carduus nutans</i>	musk thistle	CANU4	GRBA only
	<i>Centaurea melitensis</i>	Malta starthistle, tocalote	CEME2	all except GRBA and MANZ
	<i>Centaurea solstitialis</i>	yellow starthistle	CESO3	DEVA PARA
	<i>Centaurea stoebe</i> ssp. <i>micranthos</i>	spotted knapweed	CESTM	GRBA PARA
	<i>Cirsium arvense</i>	Canada thistle	CIAR4	GRBA PARA
	<i>Cirsium vulgare</i>	bull thistle	CIVU	GRBA JOTR PARA
	<i>Lactuca serriola</i>	prickly lettuce	LASE	all except MANZ
	<i>Onopordum acanthium</i>	Scotch thistle	ONAC	GRBA PARA
	<i>Sonchus oleraceus</i>	common sowthistle	SOOL	all except MANZ
Brassicaceae (Mustard)	<i>Brassica tournefortii</i>	Sahara mustard	BRTO	all
	<i>Cardaria draba</i>	hoary cress	CADR	DEVA GRBA PARA
	<i>Eruca vesicaria</i> ssp. <i>sativa</i>	arugula, salad rocket	ERVES	JOTR MOJA
	<i>Lepidium latifolium</i>	broadleaved pepperweed	LELA2	GRBA JOTR PARA
	<i>Malcolmia africana</i>	African mustard	MAAF	all except JOTR and MANZ
	<i>Sisymbrium altissimum</i>	tall tumbledmustard	SIAL2	all except MANZ
	<i>Sisymbrium irio</i>	London rocket	SIIR	all except GRBA and MANZ
	<i>Sisymbrium orientale</i>	Indian hedgemustard	SIOR4	all except GRBA and MANZ
Chenopodiaceae (Goosefoot)	<i>Bassia scoparia</i>	burningbush, kochia	BASC5	all except MOJA
	<i>Bassia hyssopifolia</i>	thorn orache, fire-horn smotherweed	BAHY	all except MANZ
	<i>Halogeton glomeratus</i>	halogeton, saltlover	HAGL	all except JOTR and MANZ
	<i>Salsola tragus</i>	Russian thistle	SATR12	all
Convolvulaceae (Morning Glory)	<i>Convolvulus arvensis</i>	field bindweed	COAR4	all except DEVA and JOTR
Elaeagnaceae (Oleaster)	<i>Elaeagnus angustifolia</i>	Russian olive	ELAN	GRBA JOTR PARA
Euphorbiaceae (Spurge)	<i>Euphorbia esula</i>	green spurge	EUES	GRBA only
Fabaceae (Pea)	<i>Spartium junceum</i>	Scotch broom	SPJU2	DEVA PARA

Family	Species	Common Name	USDA Code	MOJN Parks
Geraniaceae (Geranium)	<i>Erodium cicutarium</i>	redstem filaree, redstem storkbill	ERCI6	all
Lythraceae (Loosestrife)	<i>Lythrum salicaria</i>	purple loosestrife	LYSA2	GRBA only
Poaceae (Grass)	<i>Arundo donax</i>	giant cane, giant reed	ARDO4	DEVA LAKE MOJA
	<i>Avena fatua</i>	wild oat	AVFA	JOTR LAKE MOJA
	<i>Bromus diandrus</i>	ripgut brome	BRDI3	all except GRBA and MANZ
	<i>Bromus rubens</i>	red brome	BRRU2	all
	<i>Bromus tectorum</i>	cheatgrass	BRTE	all
	<i>Cortaderia selloana</i>	pampas grass	COSE4	DEVA LAKE
	<i>Cynodon dactylon</i>	Bermudagrass	CYDA	all except GRBA
	<i>Hordeum</i> spp.	barley	HORDE	all
	<i>Pennisetum ciliare</i>	buffel grass	PECI	DEVA JOTR LAKE
	<i>Pennisetum setaceum</i>	fountain grass	PESE3	all except PARA
	<i>Polypogon monspeliensis</i>	annual beard grass, annual rabbitsfoot grass	POMO5	all except MANZ
	<i>Saccharum ravennae</i>	ravennagrass, elephant grass	SARA3	LAKE PARA DEVA MOJA
	<i>Schismus</i> spp.	Mediterranean grass	SCHIS	all
	<i>Sorghum halepense</i>	Johnson grass	SOHA	LAKE only
	<i>Stipa capensis</i>	Mediterranean steppegrass	STCA25	JOTR only
Simaroubaceae (Quassia)	<i>Ailanthus altissima</i>	tree-of-heaven	AIAL	all except GRBA and PARA
Solanaceae (Nightshade)	<i>Nicotiana glauca</i>	tree tobacco	NIGL	all except GRBA and MANZ
Tamaricaceae (Tamarisk)	<i>Tamarix aphylla</i>	Athel tamarisk, saltcedar	TAAP	all except GRBA and MANZ
	<i>Tamarix ramosissima</i>	saltcedar	TARA	all
Verbenaceae (Verbena)	<i>Lantana camara</i>	hedgeflower, wild sage	LACA2	DEVA LAKE
	<i>Vitex agnus-castus</i>	chastetree	VIAG	DEVA LAKE
Zygophyllaceae (Caltrop)	<i>Tribulus terrestris</i>	puncturevine	TRTE	all

3. Field Observations

If you observe any invasive plants, record the **Species (If Known)** and their coordinates in the **UTM Easting** and **UTM Northing** sections of your field data sheet. Also record the **GPS Error** reported on the GPS unit. If any of these plants are observed within the previously defined buffer area (SOP 8: Site Condition: Spring Vegetation), then check the box in the **Rip Veg Buffer** column. If the **Rip Veg Buffer** box is checked, it is not necessary to provide coordinates because the approximate location of the plant is already known. If the plants are only observed in the uplands around a spring or during the hike to or from a spring but not in the buffer area, then leave this box blank. If there is continuous or patchy cover of an invasive plant, record the coordinates of the approximate centroid of the cover. If the cover extends across the spring vegetation buffer area, make sure to check the **Rip Veg Buffer** box, even if the centroid coordinates are outside of the buffer area.

For each species, take one or more photographs for later verification by the network Ecologist or a trained Botanist (see SOP 1: Staff Training and JHA). Record each **File #** (last four digits of the image code) in the appropriate space on the field data sheet. The image code can be found by pressing the review button (►) on the camera. Note any other useful information in the **Invasive Comments**.

4. Invasive Plant Species Early Detection Plan

The Invasive Plant Species Early Detection (IPSED) plan includes five tiers that vary based on personnel training and location risk. Tier 3: Opportunistic Monitoring of High Risk Places focuses on field crews that are familiar with basic plant identification, but are not hired specifically for botany or invasive species work. Field crews for this protocol will be able to use the plant identification training they received from the network Ecologist with the Invasive Plant Guide.

When field crews encounter invasive plants at a spring or during the hike to or from a spring, they will record their observations using the iNaturalist smartphone application in addition to recording them on the field data sheet. If certain field crew members have a stronger background in plant identification, they may instead record their observations using the Arc Collector smartphone application. Arc Collector and ArcGIS Online will be used in conjunction with the National Invasive Species information Management System (NISIMS) maintained by the NPS Exotic Plant Management Team (EPMT).

It is important to record all invasive plants that are encountered at a spring. This can alert EPMT to potentially new infestations and may provide information about whether previous treatments have been successful.

For more detailed information on implementing Tier 3: Opportunistic Monitoring of High Risk Places, refer to the Invasive Plant Species Early Detection Monitoring Plan (Hupp et al. 2017).

Literature Cited

Hupp, N. R., M. Lehman, D. Gundlach, G. Moret, and N. Tallent. 2017. Invasive plant species early detection monitoring plan: A tiered approach for the Mojave Desert Network. Natural Resource Report NPS/MOJN/NRR—2017/1447. National Park Service, Fort Collins, Colorado.

Mojave Desert Network. 2016. MOJN I&M Invasive Plant Guide for National Parks in the Mojave Desert Network. National Park Service, Fort Collins, Colorado.

Standard Operating Procedure 10: Site Condition: Disturbance

Version 1.0

1. Introduction

This Standard Operating Procedure (SOP) describes how to identify and assess both natural and anthropogenic disturbance and how to record observations and evidence of wildlife use at a spring.

2. Flow Modification

Search the area around the spring for evidence of modern or historical flow modifications, and circle the appropriate **Modification Type**. If there are multiple flow modifications, circle all that apply. Modification types are described in Table 10.1.

If at least one of the flow modifications is currently diverting or affecting water at the surface, circle **Yes (One or more active)**. If the spring is dry at the time of the visit, but at least one or more of the flow modifications would most likely affect surface water if it were present, also circle **Yes (One or more active)**. Flow modifications do not have to be recently constructed or maintained for them to be active; they may, in some cases, be abandoned or historical modifications. If none of the flow modifications are currently affecting water at the surface, or would most likely not affect surface water if it were present, then circle **Yes (All inactive)**. If you do not see any evidence of active or inactive flow modifications, then circle **None**.

Table 10.1. Flow modification types and descriptions. Adapted from NCPN Springs Monitoring Protocol SOP 6: Site Condition and Repeat Photopoints (2017).

Flow Modification Type	Description
Pipe diversion	Surface water has been captured and redirected by pipe; pipe may be plastic or metal
Dam diversion	Surface water has been blocked behind an artificial barrier of natural or manmade materials to form a pool or reservoir
Open trough / tank	Surface water has been diverted into a trough or tank for use by livestock
Pumping	Surface water has been raised or groundwater has been extracted through a well with a pump; pump may be manual or externally powered
Encasement	Spring source has been entirely covered or enclosed, often with a concrete box
Excavation	Groundwater has been accessed at the water table through the removal of soil and rock at the surface
Sealed cracks	Surface water has been collected or kept at the surface by sealing faults, joints, or cracks in rock
Other	Does not fit into one of the described modification types

3. Disturbance

Look around for any anthropogenic or natural disturbances within the defined buffer area (see SOP 8: Site Condition: Spring Vegetation). Disturbances are described in Table 10.2. For each type of disturbance present, assess approximately what percent of the buffer area it covers, and assign a

cover class. Cover classes are defined in Table 10.3. Circle the cover class that best represents each type of disturbance. If a type of disturbance is not present, then circle 0 for the cover class. This means that all types of disturbance, even if they are not present, should have a cover class circled.

Assess approximately what percent of the buffer area is covered by any type of disturbance, and assign an **Overall Disturbance Cover Class**. For example, if livestock use covers 40% of the buffer area (cover class 2) and flooding covers 20% of the buffer area (cover class 1), but the areas covered by the disturbances do not overlap, then 60% of the buffer area is covered by disturbance, so the overall disturbance cover class would be 3. However, if the flooding occurs totally within the area affected by livestock use, then only 40% of the buffer area is covered by disturbance, so the overall disturbance cover class would be 2. If there is no disturbance of any type within the buffer area, then circle 0 for the overall disturbance cover class.

Provide any additional information or descriptions about flow modifications or disturbances in the **Disturbance Comments**. If there are nearby flow modifications or disturbances that do not occur within the buffer area but are still relevant to the spring, then discuss them here.

Table 10.2. Anthropogenic and natural disturbances and descriptions. Adapted from NCPN Springs Monitoring Protocol SOP 6: Site Condition and Repeat Photopoints (2017).

Disturbance Type	Disturbance	Description
Anthropogenic	Roads	Paved, dirt, or two-track; may be open or closed
	Hiking trails	Human footpath; may be maintained or social
	Human use	Denoted by campsites, shelters, water diversion, litter, trampling, recreation, illicit activity, etc.
	Livestock	Indicated by the presence of livestock / feral animal or livestock / feral animal manure, trampling, wallowing, or grazing
	Plant management	Indicated by cut stumps, debris piles, dead plants, outplanting, etc.
	Other	Does not fit into one of the described anthropogenic disturbances
Natural	Flooding	Indicated by flattened vegetation, turbidity, and debris lines
	Fire	Indicated by charred or blackened vegetation or ground surfaces
	Wildlife use	Indicated by significant impacts due to the presence of wildlife or wildlife scat, trampling, wallowing, grazing, browsing, or digging
	Other	Does not fit into one of the described natural disturbances

Table 10.3. Disturbance cover classes and descriptions.

Cover Class	Description
0	0% (i.e. no disturbance)
1	>0-25%
2	>25-50%
3	>50-75%
4	>75-100%

4. Wildlife Evidence

Search the defined buffer area (see SOP 8: Site Condition: Spring Vegetation) for any evidence of wildlife use at the spring. Record the type of **Animal** associated with the evidence using the animal codes defined in Table 10.4 and the type of **Evidence** using the evidence codes defined in Table 10.5. Write down the **Species (If Known)**, using either its scientific or common name. The same species may have more than one type of evidence associated with it on the same line. For example, you may write SC and TR if you see both the scat and hoof prints of bighorn sheep. Include any relevant information in the **Notes**, such as the description of an unknown bird or the number of individuals observed.

Table 10.4. Animal codes and descriptions for wildlife.

Animal Code	Description
MAML	Mammal
BIRD	Bird
AMPH	Amphibian
FISH	Fish
AQIN	Aquatic Invertebrate
TEIN	Terrestrial Invertebrate
OTHER	Other Wildlife

Table 10.5. Evidence codes and descriptions for wildlife.

Evidence Code	Description
OB	Direct observation
SC	Scat
TR	Tracks
SH	Shelter
FO	Foraging
VO	Vocalization
OT	Other

Literature Cited

Northern Colorado Plateau Network. 2017. Northern Colorado Plateau Network springs monitoring protocol standard operating procedures (SOPs). National Park Service, Fort Collins, Colorado.

Standard Operating Procedure 11: Site Condition: Repeat Photographs

Version 1.0

1. Introduction

This Standard Operating Procedure (SOP) describes how to compose repeat photographs at a spring. Repeat photographs can be powerful visual tools for recognizing and communicating landscape and ecosystem change over time. Spring photographs are used to monitor coarse changes in vegetation and disturbance. Sensor photographs are used primarily to relocate sensors from year to year.

2. Repeat Photographs

In the appropriate spaces on your field data sheet, record the **Camera ID #** and **Memory Card #**. The camera number is the last five digits of the code on the property sticker. The memory card number is labeled on the card itself.

2.1. Spring Photographs

Take a photograph looking down toward the source from about 20 meters upstream. This is the **Looking Downstream** photograph. Record the **File #** (last four digits of the image code) of the photograph and the **UTM Easting** and **UTM Northing** coordinates where the photograph was taken. The image code can be found by pressing the review button (►) on the camera (see Figure 11.1). The UTM coordinates should be read from the GPS unit, which is more accurate than the camera. Write down any pertinent notes about the location or contents of photograph in the **Comments**. Take another photograph looking up toward the source from about 20 meters downstream and fill out the same image and coordinate information. This is the **Looking Upstream** photograph.

For the **Looking Downstream** and **Looking Upstream** photographs, try to include both the location of discharge and the surrounding riparian vegetation and channel characteristics. Avoid standing directly behind vegetation or other objects that will obscure the image. The intent of these spring photographs is to capture representative and contextual images of site condition that can be compared with past and future visits to the spring. See Figure 11.2 for examples.

Take a photograph looking at the source from a few meters away and fill out the same image and coordinate information. This **Source** photograph should include the location of discharge and its immediate environs, and may also include the sensor if one was deployed at the spring.

2.2. Sensor Photographs

If a sensor was deployed at the spring but not included in the **Source** photograph, then take an additional **Sensor** photograph and fill out the image and coordinate information on the field data sheet as described above. Sensor photographs are primarily to help future field crews locate the sensor for retrieval, especially if those field crew members have never before visited the spring. A year or more may have passed between sensor deployment and retrieval, which means that vegetation may have died or grown back, or that flooding may have scoured the landscape and rearranged even large boulders in the canyon or wash bottom.

Try to incorporate landmarks from multiple distances to help future crews triangulate the sensor location. Distinctive rock layers or contacts on a canyon wall or a large rock outcrop are features that will likely persist until the next visit and are useful to include in the background. If there is a single tree or shrub of a certain species that will be easily recognized by future crews, this may be useful to include in the mid-ground or foreground. Large boulders or particular arrangements of rocks may also be included in the foreground, although there is no guarantee that they will be in the same position during the next visit.

In some cases, it may be helpful to take two **Sensor** photographs: one from farther away showing landmarks to identify the general location, and one from closer up showing exactly where the bolt or wire have been installed in the ground. This second photograph may help field crews know where to dig into the substrate if they suspect that the bolt and wire may have been buried. Make sure that the sensor is indicated in at least one photograph by a field crew member pointing at its location, since the sensor is small and may not appear obvious in photos. See Figure 11.2 for example.

2.3. Other Photographs

The **Other 1** and **Other 2** photographs are optional. If you take additional any photographs at a spring or on the hike to or from a spring, such as the presence of trespass livestock, wildlife, archaeological artifacts, or active or historical flow modifications, then fill out the image and coordinate information on the field data sheet as described above.



Figure 11.1. Location of the last four digits of the image code (indicated by red arrow) on the review screen of the Olympus TG-4 camera.



Figure 11.2. Example repeat photographs. Left: Looking downstream photograph. Center: Source photograph, with crew member pointing at sensor location. Right: Looking upstream photograph.

Standard Operating Procedure 12: Data Analysis and Reporting

Version 1.0

Note: portions of this SOP are adapted from SOP 7 in:

McKinney, S. T., T. Rodhouse, L. Chow, A. Chung-MacCoubrey, G. Dicus, L. Garrett, K. Irvine, S. Mohren, D. Odion, D. Sarr, and L. A. Starcevich. 2013. Monitoring white pine (*Pinus albicaulis*, *P. balfouriana*, *P. flexilis*) community dynamics in the Pacific West Region - Klamath, Sierra Nevada, and Upper Columbia Basin Networks: Standard operating procedures version 1.0 (Appendix A to Narrative Version 1.0). Unpublished protocol revision update, April 2013. National Park Service, Fort Collins, Colorado.

1. Introduction

The statistical methods outlined below are described for implementation with the open-source statistical platform R. R is a powerful system for statistical computations and graphics, which runs on Windows, Unix, and Mac computers. R is a combination of a statistics package and a programming language. It can be downloaded for free from <http://www.r-project.org/>. The R Wiki provides an online forum <http://wiki.rproject.org/rwiki/doku.php> and documentation. R is one of the analytical environments of choice for MOJN I&M. Computational code for procedures outlined in this SOP that are written for R statistical language and environment (<http://www.r-project.org/>) can be provided by request from the involved networks. Direct references to R commands in the text are distinguished by **Courier New Font** rather than Times New Roman, with arguments for the commands noted by closed parentheses ().

2. Status Estimation Analysis

The Data Summary Reports will include summary statistics and graphics to convey information to park managers on the status of the springs in each park. Types of monitoring data include binary data, numerical (real-valued) data, and sensor data. Table 12.1 summarizes the statistical analyses that will be performed on these data.

Table 12.1. Summary statistics and graphics for Data Summary Reports.

Measurable Objective	Parameter	Statistical Analyses	Graphics
Water Availability	Flow Condition Discharge Surface Water Length	Proportion of springs in sample with given condition -- confidence interval determined using hypergeometric distribution; sample mean for discharge; sample mean for surface water length	Maps of key variables (e.g., presence or absence of surface water)
	Sensor Data	Proportion of perennial, seasonal, and ephemeral springs; sample median dates of beginning and end of dry period	Graphical representation of wet and dry periods at each annual spring

Measurable Objective	Parameter	Statistical Analyses	Graphics
Water Quality	Temperature pH Specific Conductance Dissolved Oxygen	Sample mean for each “core” parameter -- confidence interval calculated using finite sample size correction	Maps of “core” parameters, box and whisker plots
Site Condition: Incidental Data	Spring Vegetation Invasive Plants Disturbance Wildlife Use	Proportion of springs in sample with given condition -- confidence interval determined using hypergeometric distribution	Maps of specific variables of management interest (e.g., presence or absence of livestock)

2.1. Binary Data

Many of the observations made for this protocol can be thought of as binary data, that is, data with only two possible outcomes. Examples of this include the presence or absence of surface water, the presence or absence of particular invasive plants, the presence or absence of different vegetation lifeforms, or the presence or absence of different types of disturbance. In these cases, the best park-wide summary statistic is the proportion of springs in which a certain condition is observed (e.g., percentage of springs with surface water). The sample is drawn from a fixed population without replacement, so the confidence interval for this proportion can be determined using the Clopper-Pearson approach for the hypergeometric distribution (Clopper and Pearson 1934). The Clopper-Pearson interval can be calculated in the R with the *PropCIs* R package (Scherer 2014):

```
ConfidenceInterval <- exactci(x, n, conf.level)
#x is the number of data with one particular outcome (e.g., tamarisk is present)
#n is the total number of data points with either outcome
#conf.level is the confidence level (e.g., 0.05 for 95% confidence)
```

The spatial distribution of these parameters can be communicated using maps. The Protocol Lead will determine which parameters should be mapped in each report to best communicate the results of monitoring to the parks.

An important consideration with binary data is ensuring that, when a data point is not collected at a spring, this lack of data is not recorded, analyzed, or displayed as an absence. Where possible, the field data sheets have been designed to prompt field crews to circle either “yes” or “no” or else to circle one or more options from a list when recording data. This built-in quality assurance step allows for the distinction between confirmed absence (e.g., “no” or “none” circled) and missing data (e.g., nothing circled).

2.2. Numerical Data

The measurements of water quality parameters, discharge, and surface water length are numerical data. The relevant summary statistic for the water quality parameters and discharge is the sample mean, with the confidence limits determined using a finite population correction factor (e.g., Jarrell 1994). Surface water lengths are recorded as “>50 m” for all lengths greater than 50 m, so the sample median will be used instead of the sample mean. For all numerical parameters, maps will be used to illustrate geographic distribution of parameter values, and box plots will be used to display the

distribution of the sample data. The Protocol Lead will determine which parameters should be mapped and plotted in each report to best communicate the results of monitoring to the parks.

The following script, which was used to generate Figure 15 in the protocol narrative, shows how boxplots can be generated:

```
temp <- read.csv("DEVAtemperaturedataforboxplots.csv")
temp2011 <- temp[,1:2]
temp2011 <- cbind(temp2011, rep(2011,32))
names(temp2011) <- c("Spring", "Temp.C", "Year")
temp2014 <- temp[,c(1,3)]
temp2014 <- cbind(temp2014, rep(2014,32))
names(temp2014) <- c("Spring", "Temp.C", "Year")
springtemps <- rbind(temp2011,temp2014)
boxplot(Temp.C ~ Year, springtemps, names= c("2011","2013-14"),ylab="Temperature (C)",
xlab="Year")
```

2.3. Sensor Data

The sensor data will be converted into records of wet and dry periods using a threshold of 80% relative humidity. These data will be discussed in the context of precipitation patterns in each park over the period of the record. Although morning dew is very rare in the arid Mojave Desert, moisture recorded only in the early morning hours will be ignored. Summary information derived from these humidity sensor records will include:

- Proportions of perennial springs, seasonally wet springs, and ephemeral springs without an extended wet period.
- Median dates of beginning and end of dry period for seasonally wet springs.
- Graphical representation of when each spring was wet.

3. Trend Analysis

When adequate temporal replication of monitoring data is available, trends in desert spring outcomes will be estimated and tested for statistical significance to assess how water availability and water quality are changing over time. Parametric and nonparametric trend approaches will be considered, and the methods used will depend on the nature of data, underlying model assumptions, and desired inference.

Trend Analysis Reports will include summary statistics and graphics to convey information to park managers on the trends of the springs in each park. Types of monitoring data include binary data, numerical (real-valued) data, censored data, and bounded data. Table 12.2 summarizes the statistical analyses that will be performed on these data. General outlines of trend analysis methods are provided for each data type, with a more detailed example for binary data, since pilot data are currently available.

Table 12.2. Summary statistics and graphics for Trend Analysis Reports. This table describes the parameters in terms of their data type.

Measurable Objective	Parameter	Data Type	Statistical Analyses
Trends in Water Availability	Flow Condition	Categorical	GLMM
	Surface Water Length (m)	Numerical (censored)	GLMM, but correct data using substitution, maximum likelihood methods, regression on order statistics, etc.
	Discharge (L/min)	Numerical (censored)	GLMM, but correct data using substitution, maximum likelihood methods, regression on order statistics, etc.
	Sensor data (presence / absence of surface water)	Binary (bounded)	GLMM, but bounded data must be transformed
Trends in Water Quality	Temperature (°C)	Numerical (continuous)	GLMM, or Regional Kendall Tau test
	pH	Numerical (continuous)	GLMM, or Regional Kendall Tau test
	Specific Conductance (µS/cm)	Numerical (continuous)	GLMM, or Regional Kendall Tau test
	Dissolved Oxygen (mg/L, %)	Numerical (continuous)	GLMM, or Regional Kendall Tau test

3.1. Binary Data

Trends in the probabilities of binary data (e.g., the proportion of springs that were dry at the time of visit) will be analyzed using binomial generalized linear mixed models (GLMM). These models provide a flexible framework to consider trends in a binary outcome while also considering random variation among years and springs (McCulloch et al. 2008). GLMMs may be fit with the *lme4* package (Bates et al. 2014).

The spring permanence data from MOJA are used to demonstrate the trend model selection process. Only springs visited at least 3 times are included in the trend analysis. A subset of the data (an object called “Perm” in R) are provided below, where the variables Spring, X, Y, Year, and WYear are defined as above and Wet is the outcome of interest with “1” indicating that water was present and “0” indicating otherwise. Model checking with residuals is “sort of an art” (Zuur et al. 2009) because the observed data include only zeros and ones, so the residuals are two distinct groups. Some potentially useful plots are provided to evaluate the model fit.

```
# Examine the data
```

```
head(Perm)
```

```

      Spring      X      Y Year Wet WYear
Barnes Spring 618922 3851731 2004   1     0
Basalt Spring 618744 3848851 2004   1     0
Blind Spring 635269 3865644 2004   1     0
Blind Spring West 635022 3865488 2004   1     0
Bolder Spring 632808 3878400 2004   0     0
Bull Canyon Creek 618062 3852372 2004   1     0
```

```
# Plot the raw proportion of wet/dry springs by year
```

```

PermPropbyYear<-aggregate(Perm$Wet, list(WYear=Perm$WYear), mean)
plot(PermPropbyYear$WYear+2004,PermPropbyYear$x, ylim=c(0,1),lwd=2,
col=6,pch=6,xlab="Year", ylab="Proportion of Springs Observed to be Wet")
legend("topright",col=6,pch=6,legend=c("MOJA"),pt.lwd=2)

# Load the lme4 library

require(lme4)

# Fit the full GLMM. The (1|Year) term is the random year effect, and the
# (1+WYear|Spring) term specifies that the random spring intercept and the
# random spring slope are correlated.

fit1.perm<-glmer(Wet ~ WYear + (1|Year) +(1+WYear|Spring), data=Perm, family=binomial)
summary(fit1.perm)

# Examine the estimated random effects variances and fixed effects

Generalized linear mixed model fit by maximum likelihood
(Laplace Approximation) [glmerMod]
Family: binomial ( logit )
Formula: Wet ~ WYear + (1 | Year) + (1 + WYear | Spring)
Data: Perm

      AIC      BIC    logLik deviance df.resid
  858.7    887.6   -423.4    846.7     907

Scaled residuals:
      Min       1Q   Median       3Q      Max
-2.90868  0.08311  0.23535  0.35999  2.07648

Random effects:
Groups Spring          Variance Std.Dev. Corr
Spring (Intercept)  3.188195  1.78555
      WYear          0.004857  0.06969  1.00
Year   (Intercept)  0.737975  0.85905
Number of obs: 913, groups: Spring, 188; Year, 9

Fixed effects:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)    2.6598     0.7231   3.678 0.000235 ***
WYear          -0.1609     0.1425  -1.129 0.258976

# Notice that the correlation between the random spring intercept and the random
spring slope effects is 1.00. This indicates that the model may be overfit.

# Fit a reduced model without the random spring slope.

fit2.perm<-glmer(Wet ~ WYear + (1|Year) +(1|Spring), data=Perm, family=binomial) #
summary(fit2.perm)

# Examine the estimated random effects variances and fixed effects

Generalized linear mixed model fit by maximum likelihood
(Laplace Approximation) [glmerMod]

```

```

Family: binomial ( logit )
Formula: Wet ~ WYear + (1 | Year) + (1 | Spring)
Data: Perm

```

AIC	BIC	logLik	deviance	df.resid
855.1	874.3	-423.5	847.1	909

Scaled residuals:

Min	1Q	Median	3Q	Max
-2.90919	0.06849	0.23223	0.36668	2.09016

Random effects:

Groups	Spring	Variance	Std.Dev.
Spring	(Intercept)	4.3630	2.0888
Year	(Intercept)	0.7802	0.8833

Number of obs: 913, groups: Spring, 188; Year, 9

Fixed effects:

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	2.8814	0.6610	4.359	1.31e-05 ***
WYear	-0.2049	0.1269	-1.615	0.106

This model yields a lower AIC value and the standard error of the trend estimate (indicated by the Estimate and Std. Error for the fixed effect, WYear) is also smaller for this model.

Examine the trend line on the plot of observed proportions

```

EstProp = aggregate(fitted(fit2.perm), list(WYear=Perm$WYear), mean)
lines(EstProp$WYear+2004, EstProp$x)

```

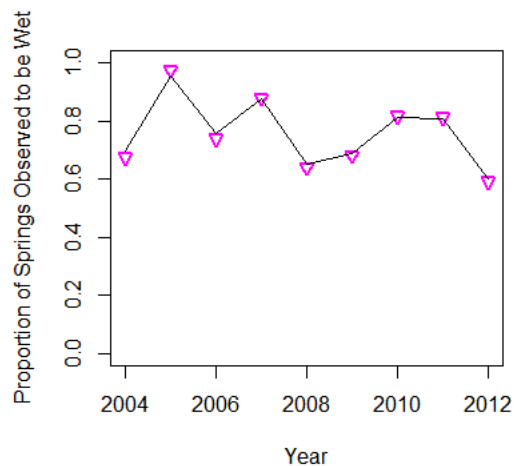


Figure 12.1. Observed (pink) and estimated (black line) proportions of wet springs by year.

Examine the residuals for this trend model.

A useful plot from <http://freakonometrics.hypotheses.org/8210>

```

par(mfrow=c(1,1))
plot(Perm$WYear,residuals(fit2.perm),col=c("blue","red")[1+Perm$Wet], xlab="Year",
ylab="Residuals")
lines(lowess(Perm$WYear,residuals(fit2.perm)),col="black",lwd=2)

```

```
lines(lowess(Perm$WYear[Perm$Wet==0],residuals(fit2.perm)[Perm$Wet==0]),col="blue")
lines(lowess(Perm$WYear[Perm$Wet==1],residuals(fit2.perm)[Perm$Wet==1]),col="red")
abline(h=0,lty=2,col="grey")
```

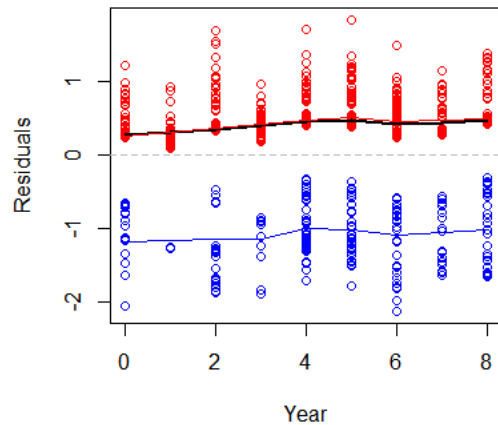


Figure 12.2. Residual plot used to evaluate a trend model. Residuals for outcomes with values of 1 are shown in red, and residuals for outcomes with values of 0 are shown in blue.

We expect the black line to be close to 0 for all years. These residual values are higher than expected.

```
# Bin residuals with the arm package binned plot option.
require(arm)
par(mfrow=c(1,1))
binnedplot(fitted(fit2.perm),resid(fit2.perm), nclass=100)
```

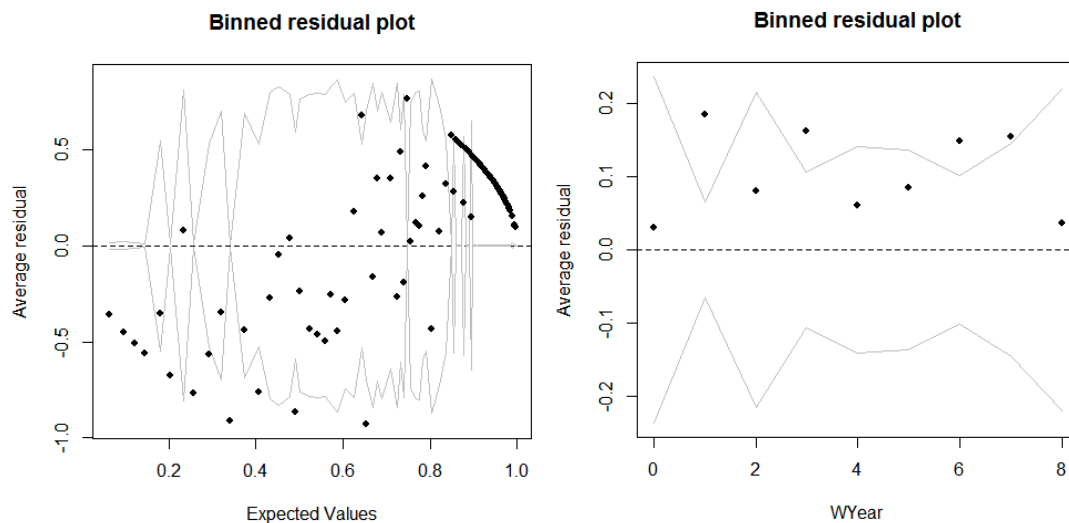


Figure 12.3. Binned residuals plotted as a function of expected value (left) and water year (right).

The gray lines represent the 95%-confidence interval on the points, so we expect that about 95% of the points will fall within those lines. Here we see points outside the confidence interval for expected values close to 0 and 1 and an increasing trend in the residuals as the expected values increase. A plot

of the residuals by WYear indicates that the residuals are high in particular years. Extensive model selection, including other link functions such as the probit and cloglog, could not improve on this model. Assumptions of the random effects may be evaluated graphically following the guidance of Pinheiro and Bates (2004), which is implemented in an example using R by Starceвич (2013).

3.2. Numerical Data

Continuous numerical data that take values on the real-number line may be modeled with linear mixed models, given that parametric assumptions are met. Some numerical data, such as water quality parameters, will only be measured at springs where water is present at the time of the visit. Since measurements cannot be taken for dry springs, trends in water quality parameters may be best interpreted in tandem with trends in the proportion of dry springs.

The linear mixed model of Piepho and Ogutu (2002) is a flexible model for estimating trend as well as the contribution of the variance by components such as spring-to-spring variation, year-to-year variation, and variation among spring-level trend lines. This trend model is implemented in R (2015) with the lme4 (Bates et al. 2014) package. Assume a data set is available and define “Spring” as the spring; X and Y as the longitude and latitude of the spring, respectively; Year as the survey year represented in R as a factor; Y as the outcome of interest; and WYear as an integer variable calculated as Year – minimum(Year) so that the first year of the survey has value 0. The WYear variable provides more stable estimates of trend than if the actual year value was used. The basic R code for the Piepho and Ogutu (2002) linear mixed model is given by:

```
fit = lmer(Y ~ WYear + (1|Year) +(1+WYear|Spring), data=Dataname)
```

If assumptions of the linear mixed model are not met, a nonparametric trend approach such as the Regional Kendall Tau test (Helsel and Frans 2006) may be used. To obtain interpretable p-values for the Regional Kendall Tau test when data are serially correlated, trend-free pre-whitening is recommended to remove serial correlation (Yue et al. 2006) from the time series prior to testing. The following R functions may be used to conduct the Regional Kendall Tau trend test with the R packages *zyp* (Bronaugh and Werner 2013) and *rkt* (Marchetto 2014):

```
TFPW<-function(dat) {
# Conduct trend-free pre-whitening (Yue et al 2002) to prepare for trend analysis with
# Regional Kendall tau trend test (Helsel and Frans 2006)
# LA Starceвич WEST, Inc. 3.27.15
# dat has columns: Site, WYear, y

dat_cast<-cast(dat, Site ~ WYear)
yrs<-ncol(dat_cast)-1
y.TFPW<-data.frame(matrix(NA,nrow(dat_cast),yrs-1))
t.vec<-as.numeric(colnames(dat_cast)[-1])
for (i in 1:nrow(dat_cast)) {
  y<-data.frame(dat_cast)[i,2:(yrs+1)]
  zyp.i<-zyp.yuepilon(y, x=t.vec)
  autocor<-as.numeric(zyp.i[8])
  slope<-as.numeric(zyp.i[2])
  y.detrended<-y-t.vec*slope
  y.nolag<-y.detrended[2:yrs]- autocor* y.detrended[1:(yrs-1)]
}
```

```

      y.TFPW[i,]<-y.nolag + t.vec[2:yrs]*slope
    }
  y.TFPW<-data.frame(Site=dat_cast[,1],y.TFPW)
  Y.TFPW<-melt(y.TFPW, id="Site", measured=names(y.TFPW)[2:(yrs+1)])
  names(Y.TFPW)[2:3]<-c("WYear", "y")
  Y.TFPW$WYear<-as.numeric(gsub("X","",Y.TFPW$WYear))-1
  return(Y.TFPW)
}

require(rkt)
require(zyp)
# Pre-whiten the data to remove serial correlation for a data set named "dataset"
# and outcome of interest, y
Y.TFPW = TFPW(data.frame(Site=dataset$Spring, WYear=dataset$WYear, y=dataset$y))
# Run the Regional Kendall Tau test for trend
rkt(Y.TFPW$WYear, Y.TFPW$y, block=as.numeric(as.factor(Y.TFPW$Site)), correct=T)

```

3.3. Censored Data

Censored data occur when data below or above a certain limit are not measured or reported. Various tools exist for analyzing censored data, and the appropriate methods depend on the direction of the censoring (left-censoring occurs for measurements below a particular limit and right-censoring occurs above a given limit), the proportion of censored data, and sample size of available data (Helsel 2005). Methods such as the Kaplan-Meier (1958) model, robust regression of order statistics (Gilliom and Helsel 1986), and the robust maximum-likelihood estimator (Kroll and Stedinger 1996) may be calculated with the “censtats” function of the NADA (Lee 2013) R package or the censReg (Henningsen 2013) R package.

Parametric models may incorporate a year term for trend estimation, but nonparametric approaches must be used for each set of annual data, and the trend must be estimated from the annual measures (e.g., means or medians) after adjusting for censored values. Monte Carlo simulations may be used to compare methods for known data sets with similar levels of censoring to ensure that trends are detected with appropriate power and test size.

3.4. Bounded Data

Bounded data may be converted to a scale that mirrors a known distribution for convenient trend modeling. For example, the Julian date on which a spring went dry or started flowing will be tracked across years to detect trends in the drying and onset of seasonal flow. These data are bounded in the interval of 0 to 365 days (or 366 for leap years). The day on which a spring becomes wet may be scaled to a proportion of the year by dividing by the number of days in that year. For example, if a spring becomes wet on day 187 of a year with 365 days, the proportion of the year that the spring was dry is calculated as $187/365 = 0.51$. The binomial GLMM may be used to model a two-part response characterized by a column with the day on which the spring became wet and the number of days in the year. The following R code indicates a possible model specification for this proportional data model, where daywet is the day on which the spring became wet and Ndays is the number of days in the year:

```
fit<-glmer(cbind(daywet,Ndays) ~ WYear + (1|Year) +(1|Spring), data=Perm,
family=binomial)
```

If the exact day that water is present at a spring is not recorded, then the data may be interval-censored (the event occurs within a known interval, but the exact day is unknown). In this case, methods used for censoring may be needed to account for the missing data if the interval between visits to each spring is large enough to affect inference.

4. Reporting

There will be three types of reporting for the MOJN I&M Desert Springs protocol:

- Each year, the certified data will be made available to the parks by uploading it to IRMA.
- Every three years, once all springs in the sample have been visited, and annual springs in the sample have been visited three times, MOJN I&M will prepare a Data Summary Report for each park. These reports will not analyze trends in the data, but will present the results of the previous three field seasons of data collection. The reporting will follow the same three-year calendar as the monitoring, beginning with reports for the 2015-16 pilot season at LAKE and MOJA. The Data Summary Reports will be published in the NPS Natural Resource Data Series (NRDS).
- After twelve years, once all springs in the sample have been visited four times, and annual springs have been visited twelve times, MOJN I&M will prepare a Trend Analysis Report for each park. These reports will synthesize the information presented in the Data Summary Reports and provide statistically-rigorous assessments of trends in the data. After the first report for each park, they will be subsequently prepared every nine years. The Trend Analysis Reports will be published in the NPS Natural Resource Report Series (NRR).

The certified data will be provided to parks at the same time following each field season, while the Data Summary Reports and Trend Analysis Reports will be staggered on a three-year calendar that follows the same three-year calendar as monitoring. For more information on this monitoring calendar, refer to the rotating panel design and Table 4 in the protocol narrative. The reporting schedule is given in Table 12.3.

Table 12.3. Reporting schedule for the MOJN I&M Desert Springs protocol.

Data Type	Responsibility	Target Date	Destination
Certified data	Data Manager	July 15	IRMA
Invasive plants data	Data Manager	July 15	Parks, NISIMS, EPMT
Photos and sensor files	Field Crew Lead	June 1	Designated locations on the MOJN I&M shared drive (M:\).
Data Summary Reports (NRDS)	Protocol Lead	August 15, two parks per year	Parks, IRMA
Trend Analysis Reports (NRR)	Protocol Lead	First reports after twelve years, then every nine years for each park	Parks, IRMA

Literature Cited

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Standard Operating Procedure 13: Data Management

Version 1.0

1. Introduction

This Standard Operating Procedure (SOP) describes the ways in which physical and electronic data for the protocol are collected and managed to assure quality. This includes the steps to enter, verify, validate, and certify data as well as the requirements for distributing, reporting, and archiving data. A data dictionary is provided at the end of the SOP.

2. Data Collection and Database Design

2.1. Project File Storage Conventions

All of the files associated with the development and implementation of this protocol will be stored on the MOJN server under the folder \Monitoring\DS_Water or in the read-only archive for the protocol at \Archive\DesertSprings.

The DS_Water folder will contain at a minimum the following folders:

- **Analyses** (Contains R scripts and results)
- **Data**
 - o **Database** (Contains the database front-end, backups of previous versions, backups of the SQL backend database, DSN file for establishing a connection to the SQL database)
 - o **FieldData** (Contains a scan of all field data sheets grouped in folders by hydrologic year.)
 - o **Images** (Contains all photographs taken at a site grouped in folders by spring code.)
 - o **LabData** (Contains results of external laboratory analyses grouped in folders by hydrologic year.)
 - o **LoggerData** (Contains the data downloaded from deployed sensors)
- **Implementation**
 - o **FieldDataForms** (Contains blank field data sheets and lookup code “cheat sheets”)
 - o **GIS_Basedata** (Contains spatial data for navigation and simple map making)
 - o **SitePackets** (Contains a Word file for each spring including navigation waypoints and a map with the suggested access route)

- **ProjectFiles**
 - o **Permits** (Contains copies of permits for conducting field work)
 - o **Protocol** (Contains folders for the published protocol narrative and SOPs, draft revisions of the narrative and SOPs, and files documenting the protocol development process)
 - o **SampleDesign** (Contains files specific to the GRTS draw)
- **Reports** (Contains data and trends reports)

Other parts of this SOP will contain additional information on required file naming procedures that are specific to this protocol. Where file naming procedures are not defined it should be assumed that the MOJN I&M general SOP *MOJN File Naming Conventions* is applicable.

2.2. Data Collection

2.2.1. Collecting and managing discrete data

Discrete data collected in the field will be recorded on paper datasheets until an electronic data collecting system is deemed practical. To minimize potential ambiguity of field data sheets, MOJN I&M has established handwriting best practices which are summarized in Table 13.1.

Table 13.1. Handwriting best practices.

Description	Correct Method
Use a line through the 7	7
Use a line through the 0 (zero)	0
Single line through mistakes Never erase Never scribble out	~~Brito~~ BRTO
Never use "ditto" marks	Line with arrow through the column or row where data are repeated
Clear distinction between P and D	P D
Date format	mm/dd/yyyy
Time format	24 hour, hh:mm (e.g. 13:00)
Fill in every field	Line through the field or N/A (not applicable) if no data
Decimal points	Points should be distinct and unmistakable for commas or dashes
Park or Park Code is always four alpha characters	DEVA, JOTR, LAKE, MOJA, PARA, CAMO

Before leaving a spring, the Field Crew Lead is responsible for ensuring that all forms – whether digital or electronic – have been filled out completely and that the information on each form is

logical and legible. Upon returning from each field trip, datasheets will be filed in the incoming data file cabinet. After data have been entered into the database, the field data sheets will be scanned to 300 dpi or greater PDF files. When retroactive changes are made to paper datasheets, they must be re-scanned. The Protocol Lead is responsible for safekeeping and organization of the datasheets until data entry and verification procedures have been completed, at which point the datasheets are stored, and eventually archived, by the network Data Manager.

2.2.2. Collecting and managing continuous data

Continuous water data (i.e., iButton temperature and relative humidity data) will be stored locally in the native CSV format as well as in Excel files. The data will be uploaded to and processed in the NPS-hosted Aquarius System (springboard and database).

2.2.3. Collecting and managing photographs

Photographs for the protocol are stored in M:\MONITORING\DesertSprings\Data\Images. To import photographs from a MOJN I&M camera memory card, insert the card into a USB card reader and plug the reader into a computer that has access to the MOJN I&M shared drive (M:\). Open Windows Explorer and navigate to the memory card. Run the script titled TransferPhotos.bat and follow the prompts. For devices without a memory card (e.g., phone camera) or memory cards without the TransferPhotos.bat script, consult the Data Management Team.

All incoming photographs can be found in M:\MONITORING_FieldPhotoOriginals_DoNotModify. Photographs in this folder are organized by memory card ID and date and should never be renamed or edited. Monitoring photographs for the protocol should be copied into M:\MONITORING\DesertSprings\Data\Images and organized by spring ID code, at which point they may be renamed according to the following convention:

SpringID_YYYYMMDD_description

Where *SpringID* is the spring ID code, including the “PARK_P_” prefix (e.g., LAKE_P_AZT0072).

Example: LAKE_P_AZT0072_20160303_WOOD2TO4_0001

The *description* should adhere to the following standard, where ##### is a four digit number corresponding to the last four digits of the original photo filename:

Repeat Photos

Looking downstream: DNSTR_####

Source: SOURCE_####

Sensor: SENSOR_####

Looking upstream: UPSTR_####

Other 1: OTHER1_####

Other 2: OTHER2_####

Other n: OTHERn_####

Riparian Vegetation Photos

Woody >4m: WOODGT4_####

Woody 2 – 4m: WOOD2TO4_####

Woody <2m: WOODLT2_####
Forb: FORB_####
Grass: GRASS_####
Rush: RUSH_####
Sedge: SEDGE_####
Cattail: CATT_####
Reed: REED_####
Bryophyte: BRYO_####
Non-Plant: NON_####

Invasive Species Photos

INV_USDAPlantsCode _#### (INV_TARA_0001)

Animal Photos

ANIMAL_####

Spring Rejection Photos

REJECT_####

2.3. Database Design

Discrete data will be stored in a SQL Server relational database that is based on the development work of a multi-network collaborative team. The database design is inspired by the Inventory and Monitoring (I&M) Program’s Natural Resources Database Template (NRDT) but with modifications that bring it in line with the 2015 Inventory and Monitoring Division (IMD) database standards (Frakes et al. 2015).

At its core the database contains a Site table that stores a list of the springs that we monitor, a Visit table that stores each “event”, and tables to store each type of data that is collected during a spring visit. The tables and fields are summarized in Figure 13.1.

Any time a revision is made to the database, a complete copy of the database will be made and stored in an archive directory.

The database will store metadata for photographs taken as part of each site visit. This includes the ID of the camera that was used, the ID number of the memory card, the GPS coordinates from which the photograph was taken, the original camera-assigned filename, and a description of what feature the photograph was intended to capture.

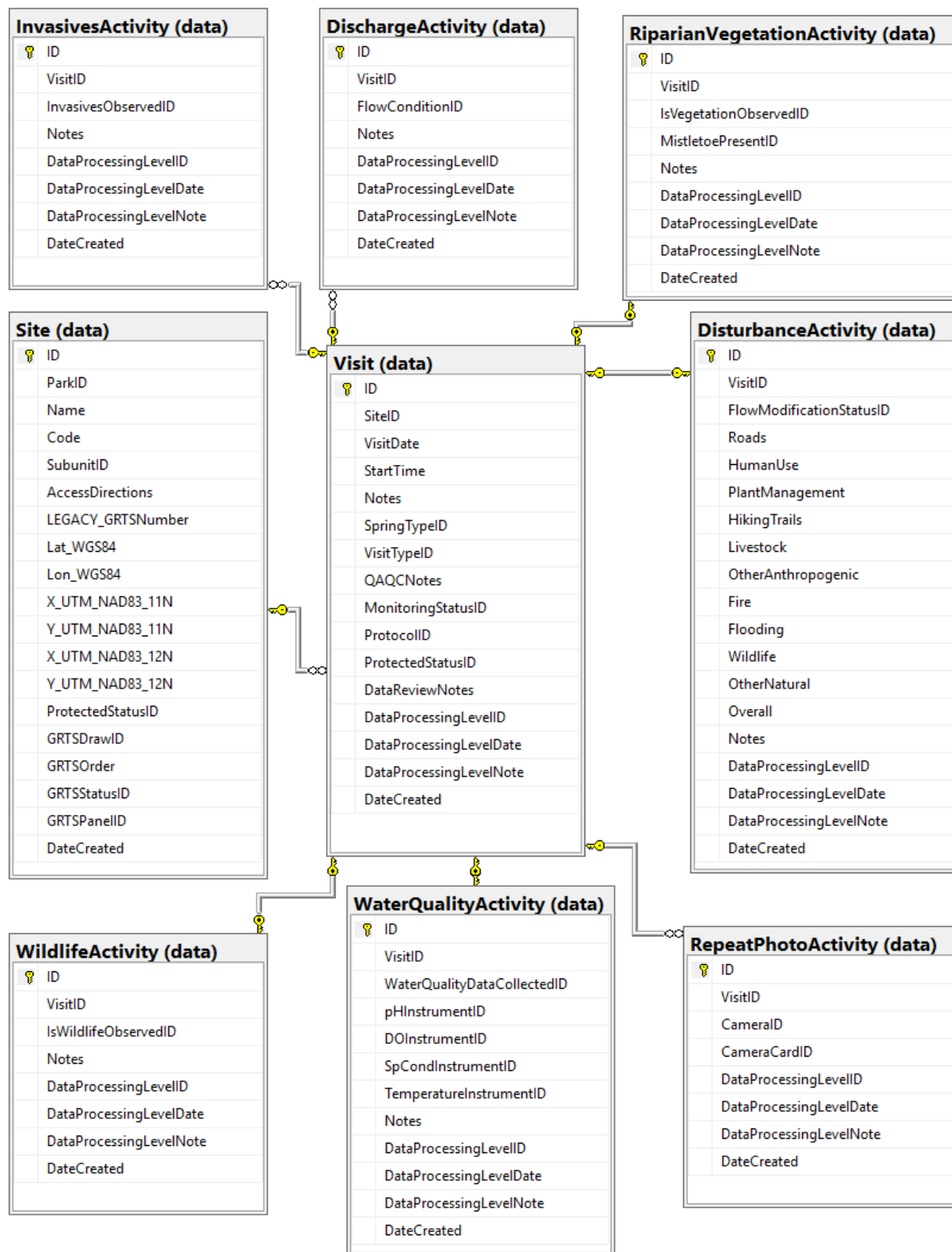


Figure 13.1. Core database tables.

3. Data Entry, Verification, and Validation

3.1. Data entry

Data from paper field data sheets will be entered into the Desert Springs database as soon after data collection as possible through an MS Access front-end. Ideally, this will be undertaken throughout the field season. Otherwise, it should occur immediately following the field season. Data entry should be completed by someone who participated in data collection, or is familiar with the project and data. The primary goal of data entry is to transfer the data from paper into the database with 100% accuracy. The database will be backed up regularly to maximize the ability to recover should irreversible errors or problems occur during the data entry session.

When the person entering the data finds a correctable error or omission on the field data sheet, this correction should be entered in the database and recorded on the field data sheet along with the correction date and the initials of the person who made the correction. Data entry should be viewed as an important step in the overall quality assurance/quality control (QA/QC) process.

3.2. Data verification

The springs database application will incorporate QA/QC strategies to ensure data quality. The database design and the allowable value ranges assigned to individual fields within the data tables help to minimize the potential for data entry errors or the transcription of erroneously recorded data.

After the initial data entry process for a spring is completed, all of the records will be reviewed for consistency with hard-copy datasheets. This task should be completed by someone other than the person who completed the original data entry. The completion of data entry and data verification will be tracked in the database. Any outstanding discrepancies between the database and the field data sheet should be clearly documented in the appropriate comments field in the database.

The Data Management Team will verify the geospatial component of the field data each season by completing a proximity analysis of all newly collected coordinates against the spring locations. Any photopoint that is not closest to the spring that was being monitored when the photo was taken will be flagged for review. Additionally, any point more than 500m from the spring being monitored will be flagged for review.

When data verification is complete, the dataset is considered to have reached the “provisional” data processing level and this will be reflected in the database (Figure 13.2). The data processing levels referred to in this document are more fully described in Certification Guidelines for Inventory and Monitoring Data Products (National Park Service 2016).

Spring Visit

DEVA_P_HUM0793 (Hummingbird Spring)

11/29/2017 3:41:00 PM

Protocol: MOJN DS (Final Draft)

Locked

Intro
Photos
Sensor
Discharge
Quality
Disturbance
Wildlife
Riparian
Invasives

***Status** Sampled

Spring Type Rheocrene

***Protocol** MOJN DS (Final Draft)

***Visit Type** Primary

***Camera** 36781

***Camera Card** MOJN_10 (SD XC)

***Field Crew, Data Entry, and Review Personnel**

Initials	Role
AOW	Field crew
JLB	Data entry
MHS	Field crew
CNW	Data review

Notes

Pipe with flowing water above wash. Shallow flow into wash.

Activity Dashboard

Activity	Status	DPL	DPL Date
Discharge	flowing	Raw	5/10/2018 3:13:48 PM
Disturbance	Yes	Raw	5/10/2018 3:16:39 PM
Invasives	Yes	Raw	5/10/2018 3:27:03 PM
Quality	No - Insufficient water	Raw	5/10/2018 3:15:03 PM
Riparian	Yes	Raw	5/10/2018 3:24:25 PM
Wildlife	Yes	Raw	5/10/2018 3:19:14 PM

Data Processing Level

***DPL** Raw

***DPL Date** 5/10/2018

Notes

This DPL applies only to the information on this tab

* Indicates a required field

Figure 13.2. Data processing level tracking in database.

3.3. Data validation

The Protocol Lead and Data Management Team will collaboratively validate a given field season’s dataset (i.e., ensure that the data make sense). Some validation methods have been incorporated into the database as queries or views. Other, more specific, validation routines are developed in collaboration with the Protocol Lead and will be executed in batch from the R statistical software platform. The Data Management Team will work closely with the Protocol Lead to provide any needed database queries, reports, graphs, R scripts, or export file formats to assist with the overall validation.

4. Data Certification and Documentation

Once the data have been validated, the Data Manager and Protocol Lead will complete the necessary accompanying metadata. Metadata is defined as structured information about the content, quality, condition, and other characteristics of a given dataset. Additionally, metadata provide the means to catalog and search among datasets, thus making these datasets available to a broad range of potential data users.

The Protocol Lead and Data Manager will work collaboratively to fill out the MOJN I&M Metadata Interview form (Figure 13.3). Any records that did not meet the documented quality standards in the

validation process must be clearly identified in the metadata, which will be a Federal Geographic Data Committee (FGDC) and NPS compliant metadata record in XML format.

When this process is complete, the dataset may be said to have reached the “accepted” data processing level. Only upon implementation and application of a Quality Assurance Plan for this protocol will the data be considered “certified.”

5. Data Distribution

Prior to publication of any reports or data, MOJN I&M personnel will work with a staff member from each park represented in the dataset to complete a data sensitivity assessment (Figure 13.4). The results of this assessment will dictate the appropriate audience for the data: Park only, NPS only, or public. Redacted datasets and reports may be created when it is deemed that sensitive information should be obscured for one or more of these audiences. The sensitivity or “protected status” of species and location data will be tracked in the database following the guidance in the IMD document Minimum Standards for Network Projects (Frakes and Kingston 2017). As part of the reporting cycle, summary reports and derived data products will be made available on the IRMA Data Store (<http://irma.nps.gov/DataStore/>).

Discrete water data will be submitted to the NPS Water Resources Division via the NPS Environmental Quality Information System (EQuIS) electronic data deliverable (EDD) specification. The data will undergo a final review by the EQuIS Data Processor before they are incorporated into the Servicewide EQuIS database and automatically transferred to the Environmental Protection Agency’s STORET Data Warehouse and the interagency Water Quality Portal. Data corrections, adjustments, and errors will be documented; corrected data will be updated in the network database and resubmitted via the NPS EQuIS EDD, if necessary.

6. Data Maintenance and Archiving

Secure data archiving is essential for protecting data files from loss or corruption. Once the master project dataset and metadata are considered final for a field season, the Data Manager will place a copy of the dataset and the metadata record into the appropriate folder within the archive directory on the network server. These archived files will be stored in read-only format. Any subsequent changes made to this database must be documented in an edit log and in the metadata. In addition to the database copy in its native format, all tables will be archived in a comma-delimited ASCII format that is platform-independent. Finally, a full copy of the project master dataset will be uploaded to the IRMA Data Store on an annual basis to ensure compliance with the Application Inventory Registry (AIR) requirements. This upload will be consistent with the guidance in Loading / Linking Data for Application Inventory Registry (AIR) Compliance (Dratch and Kingston 2017), including the creation of a link to the data in the NPS Protocol Tracking Tool (<https://irma.nps.gov/protocoltracking>).

Additional digital files to be archived include all digital photos associated with that field season, and any digital files associated with data analysis products and project reporting.

Hard-copy materials (e.g., datasheets, field notebooks) are currently stored in the MOJN I&M office but will eventually be moved to an NPS-approved repository for permanent storage.

Any editing of archived data must be documented in the edit log and accompanied by an explanation that includes pre-and post-edit data descriptions. Datasheets can be reconciled to the database through the use of the edit log.

Prior to any major changes of a dataset, a copy is stored with the appropriate version number to allow for tracking changes over time. Each additional version will be assigned a sequentially higher number. Frequent users of the data are notified of the updates and provided with a copy of the most recent version.

7. Revising the Protocol

The following guidelines ensure that changes to data collection and processing procedures are documented and retained throughout the entire lifespan of the long-term dataset, thus maintaining “line of sight.” Project staff should refer to these instructions when any changes to an approved protocol document are necessary.

Modifications must be reviewed for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by MOJN I&M personnel. An outside review is required for substantive changes in methods. Regional and national staff of the NPS and experts outside the NPS with familiarity in hydrology or riparian ecology monitoring and data analysis will be used to review major changes.

Record all changes to a protocol document (narrative or SOP) in its revision history log, even minor edits like fixing typos or formatting changes. It is not necessary to record the specific edits made, rather just the fact that typos were fixed or formatting changes were made. For minor edits, record the same document version number in the revision history log. For significant protocol changes (e.g., changes in methods, equipment), assign a new version number in the revision history log. Depending on the significance of the changes, it may be okay to combine multiple changes in the same entry in the revision history log. Version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, etc.) for minor changes. Major changes should be designated with the next whole number (e.g., version 2.0, version 3.0, etc.). Record the previous version number, the date of the revision, the author of the revision, and the reason for the changes along with the new version number (if applicable).

If changes have been made to any of the protocol documents since the previous field season, a “protocol package” of all SOPs should be uploaded to the IRMA Data Store as part of the field season kickoff procedure. Data collected using this package of SOPs will be linked to the Data Store reference in the Desert Springs database.

8. Data Management Task Timetable

Table 13.2. Timetable of data management tasks.

Project Stage	Task	Responsibility
Pre-season	Make sure Master Version Table reflects all protocol updates	Data Manager, Protocol Lead
	Make sure database is able to handle any protocol updates	Data Manager
	Add new users to database	Data Manager
	Conduct data management training for field crews	Data Manager
Mid-season	Spot check incoming data	Data Manager, Protocol Lead
	Upload device data (photos, logger files, etc.) to server	Field Crew, Data Manager
	Oversee data entry processes	Data Manager
	Develop, implement, and maintain QA queries	Data Manager
Post-season	Facilitate use of database tools for data verification and validation processes	Data Manager
	Complete metadata for field season	Data Manager /, Protocol Lead
	Accept / certify and publish data products	Data Manager
	Archive field season materials and products	Data Manager

9. Metadata Interview Form

Project Metadata Interview (v 1.0)

- 1) Title of the project or dataset:
- 2) Creator of the dataset:
- 3) Who else should be credited as a contributor to the dataset:
- 4) Brief description or abstract for the dataset:
- 5) Time period represented in the dataset:
- 6) Is it expected that this dataset will be updated, and if so, how frequently?
- 7) Keywords for this dataset:

Thematic	
Place	
Temporal	
Taxonomic	

- 8) List any related datasets that should be cross-referenced to this dataset: *None*
- 9) If species information was collected, what taxonomic authority or field guide was used for identification?:
- 10) If any voucher specimens were collected, please describe:
- 11) If the dataset was developed using an analytical tool or model, please provide a reference or url:
- 12) Describe the FIELD METHODS used in collecting this data, or reference a published protocol or SOP:
- 13) Describe the LABORATORY METHODS used in collecting this data, or reference a published protocol or SOP:
- 14) Describe the STATISTICAL AND ANALYTICAL METHODS used in preparing this data, or reference a published protocol or SOP:
- 15) Describe the QUALITY ASSURANCE AND QUALITY CONTROL MEASURES taken to ensure that the data are accurate, or reference a published protocol or SOP:
- 16) if spatial data is included in this dataset, describe the geospatial data collection and processing steps, or reference a published protocol or SOP:
- 17) Describe the fields in each file or table including field size, data type, and domain (enumerated, range, codeset) or reference a published data dictionary:
- 18) Additional advice or caveats for potential users of this dataset:

Figure 13.3. Metadata Interview Form.

10. Data Sensitivity Assessment Form

Project Data Sensitivity Assessment Form (v 1.0)

All MOJN data and data products must be reviewed to see if they contain any sensitive information. Sensitive information could include information on any of the following things:

- rare, threatened, endangered, or commercially valuable species
- rare habitats or habitats that are essential to an RTE species
- sensitive resources such as caves or wells
- minerals
- paleontological objects
- archeology resources and ethnographic sites

1) Assessment date:

2) Project title:

3) Range of dates for certified data:

4) Description and scope of data being assessed: |

5) Which of the following best describes the sensitivity of this data:

Not Sensitive - Does not contain sensitive information

Operationally Sensitive - Not legally sensitive, but not deemed appropriate for public release

Sensitive - Has one or more FOIA-exempt sensitivities

6) Please identify specific concerns about this dataset and describe potential remedies.

Concerns

Has harm, theft, or destruction occurred to a similar resource on federal, state, or private lands?

Has harm, theft, or destruction occurred to other types of resources of similar commercial value, cultural importance, rarity, or threatened or endangered status on federal, state, or private lands?

Is information about locations of the resource in the park specific enough so that the park resource is likely to be found at these locations at predictable times now or in the future? (For example, raptor nests locations).

Would information about the nature of the park resource, if available in conjunction with other public information, permit determining specific locations of the resource?

Even if relatively outdated, is there information that would reveal locations or characteristics of the park resource such that the information could be used to find the park resource as it exists now or is likely to exist in the future?

Is the NPS unable to protect the park resource if the public knows or can infer its location?

Is the information temporarily critical to some park's operations or negotiations (for a land purchase, water rights issue)?

Remedies

Should this DATA be posted on the IRMA DataStore as Public, NPS-Only, or Private (specified individuals only)?

Should spatial locations be completely removed from the data, "obscured", or released as is?

7) Assessors (Name, Title, Affiliation)

Figure 13.4. Data Sensitivity Assessment Form.

11. Data Dictionary

Table 13.3 provides a list of data tables that specify the types of data that are collected at a site visit and entered into the database. Table 13.4 provides a list of lookup tables that specify how users are able to sort and search through data that has been entered into the database.

Table 13.3. Data tables.

Table	Field	Description
data.CalibrationDO	ID	Primary key for this table
data.CalibrationDO	CalibrationTime	Time of calibration
data.CalibrationDO	CalibrationDate	Date of calibration
data.CalibrationDO	PreCalibrationReading_percent	Pre-calibration dissolved oxygen reading in percent
data.CalibrationDO	PreCalibrationTemperature_C	Pre-calibration temperature in C
data.CalibrationDO	PostCalibrationReading_percent	Post-calibration dissolved oxygen reading in percent
data.CalibrationDO	PostCalibrationTemperature_C	Post-calibration temperature in C
data.CalibrationDO	BarometricPressure_mmHg	Barometric Pressure in mmHg
data.CalibrationDO	DOInstrumentID	Foreign key to ref.WaterQualityInstrument (instrument being calibrated)
data.CalibrationDO	Notes	Notes about this calibration
data.CalibrationDO	DateCreated	Date the record was created
data.CalibrationpH	ID	Primary key for this table
data.CalibrationpH	CalibrationTime	Time of calibration
data.CalibrationpH	CalibrationDate	Date of calibration
data.CalibrationpH	StandardValue_pH	Standard value of pH solution
data.CalibrationpH	TemperatureCorrectedStd_pH	Temperature-corrected standard value of pH solution (only applies to some instruments)
data.CalibrationpH	PreCalibrationReading_pH	Pre-calibration pH value
data.CalibrationpH	PreCalibrationTemperature_C	Pre-calibration temperature in C
data.CalibrationpH	PostCalibrationReading_pH	Post-calibration pH value
data.CalibrationpH	PostCalibrationTemperature_C	Post-calibration temperature in C
data.CalibrationpH	pHInstrumentID	Foreign key to ref.WaterQualityInstrument (instrument being calibrated)
data.CalibrationpH	Notes	Notes about this calibration
data.CalibrationpH	DateCreated	Date the record was created
data.CalibrationSpCond	ID	Primary key for this table
data.CalibrationSpCond	CalibrationDate	Date of calibration
data.CalibrationSpCond	CalibrationTime	Time of calibration
data.CalibrationSpCond	StandardValue_microS_per_cm	Standard value of Specific Conductivity solution in microsiemens per cm
data.CalibrationSpCond	PreCalibrationReading_microS_per_cm	Pre-calibration Specific Conductivity reading in microsiemens per cm

Table	Field	Description
data.CalibrationSpCond	PostCalibrationReading_microS_per_cm	Post-calibration Specific Conductivity reading in microsiemens per cm
data.CalibrationSpCond	SpCondInstrumentID	Foreign key to ref.WaterQualityInstrument (instrument being calibrated)
data.CalibrationSpCond	Notes	Notes about this calibration
data.CalibrationSpCond	DateCreated	Date the record was created
data.DischargeActivity	ID	NULL
data.DischargeActivity	VisitID	Foreign key to data.Visit (information about individual sampling visits)
data.DischargeActivity	FlowConditionID	Foreign key to lookup.FlowCondition (flow condition at time of site visit)
data.DischargeActivity	Notes	Comments for a Discharge Event
data.DischargeActivity	DataProcessingLevelID	Foreign key to lookup.DataProcessingLevel (indicates level of qa/qc that has been applied to data in a given table)
data.DischargeActivity	DataProcessingLevelDate	Date the Data Processing Level was changed
data.DischargeActivity	DataProcessingLevelNote	Notes for Data Processing Level Status
data.DischargeActivity	DateCreated	Date record was created
data.DischargeEstimatedObservation	ID	Primary key for this table
data.DischargeEstimatedObservation	DischargeActivityID	Foreign key to data.DischargeEvent (general discharge information)
data.DischargeEstimatedObservation	Discharge_L_per_min	Estimated discharge in liters per minute
data.DischargeEstimatedObservation	DischargeEstimatedFlagID	Foreign key to lookup.DischargeEstimatedFlag (indicates whether estimated discharge is less than the reported value)
data.DischargeEstimatedObservation	DateCreated	Date the record was created
data.DischargeVolumetricObservation	ID	Primary key for this table
data.DischargeVolumetricObservation	DischargeActivityID	Foreign key to data.DischargeEvent (general discharge information)
data.DischargeVolumetricObservation	ContainerVolume_mL	Volume of container used
data.DischargeVolumetricObservation	FillTime_seconds	How long it took for container to fill
data.DischargeVolumetricObservation	MeasurementTimeOfDay	Not in use
data.DischargeVolumetricObservation	EstimatedCapture_percent	Estimate of percentage of flow captured in container
data.DischargeVolumetricObservation	DateCreated	Date the record was created
data.DisturbanceActivity	ID	Primary key for this table

Table	Field	Description
data.DisturbanceActivity	VisitID	Foreign key to data.Visit (information about individual sampling visits)
data.DisturbanceActivity	FlowModificationStatusID	Foreign key to lookup.FlowModificationStatus (indicates whether spring flow has been modified from its natural course)
data.DisturbanceActivity	Roads	Road disturbance percent class from lookup.DisturbanceClass
data.DisturbanceActivity	HumanUse	Human use disturbance percent class from lookup.DisturbanceClass
data.DisturbanceActivity	PlantManagement	Plant management disturbance percent class from lookup.DisturbanceClass
data.DisturbanceActivity	HikingTrails	Hiking trail disturbance percent class from lookup.DisturbanceClass
data.DisturbanceActivity	Livestock	Livestock disturbance percent class from lookup.DisturbanceClass
data.DisturbanceActivity	OtherAnthropogenic	Other anthropogenic disturbance percent class from lookup.DisturbanceClass
data.DisturbanceActivity	Fire	Fire disturbance percent class from lookup.DisturbanceClass
data.DisturbanceActivity	Flooding	Flooding disturbance percent class from lookup.DisturbanceClass
data.DisturbanceActivity	Wildlife	Wildlife disturbance percent class from lookup.DisturbanceClass
data.DisturbanceActivity	OtherNatural	Other natural disturbance percent class from lookup.DisturbanceClass
data.DisturbanceActivity	Overall	Overall disturbance percent class from lookup.DisturbanceClass
data.DisturbanceActivity	Notes	Additional notes about disturbance at this location
data.DisturbanceActivity	DataProcessingLevelID	Foreign key to lookup.DataProcessingLevel (indicates level of qa/qc that has been applied to data in a given table)
data.DisturbanceActivity	DataProcessingLevelDate	Date Data Processing Level was changed
data.DisturbanceActivity	DataProcessingLevelNote	Note for Data Processing Level Status
data.DisturbanceActivity	DateCreated	Date the record was created
data.DisturbanceFlowModification	ID	Primary key for this table
data.DisturbanceFlowModification	DisturbanceActivityID	Foreign key to data.Disturbance (disturbance observed at spring)
data.DisturbanceFlowModification	ModificationTypeID	Foreign key to lookup.ModificationType (type of modification to natural spring flow)
data.DisturbanceFlowModification	DateCreated	Date the record was created
data.InvasivesActivity	ID	Primary key for this table
data.InvasivesActivity	VisitID	Foreign key to data.Visit (information about individual sampling visits)

Table	Field	Description
data.InvasivesActivity	InvasivesObservedID	Foreign key to lookup.InvasivesObserved (indicates whether invasive species were observed at a spring)
data.InvasivesActivity	Notes	Comments for Invasives Event
data.InvasivesActivity	DataProcessingLevelID	Foreign key to lookup.DataProcessingLevel (indicates level of qa/qc that has been applied to data in a given table)
data.InvasivesActivity	DataProcessingLevelDate	Date the Data Processing Level was changed
data.InvasivesActivity	DataProcessingLevelNote	Notes for Data Processing Level Status
data.InvasivesActivity	DateCreated	Date record was created
data.InvasivesObservation	ID	Primary key for this table
data.InvasivesObservation	InvasivesActivityID	Foreign key to data.InvasivesEvent (general invasives information)
data.InvasivesObservation	TaxonID	Foreign key to ref.Taxon (species list)
data.InvasivesObservation	SpeciesNotes	Notes about this plant
data.InvasivesObservation	RiparianVegetationBufferID	Foreign key to lookup.RiparianVegetationBuffer (indicates whether invasive species observation falls within or outside of riparian veg buffer)
data.InvasivesObservation	UtmX_m	UTM X coordinate for Invasives Observation
data.InvasivesObservation	UtmY_m	UTM Y coordinate for Invasives Observation
data.InvasivesObservation	HorizontalDatumID	Foreign key to lookup.HorizontalDatum (horizontal datum of UTM coordinates)
data.InvasivesObservation	UTMZoneID	Foreign key to lookup.UTMZone (zone associated with utm coordinates)
data.InvasivesObservation	GPSUnitID	–
data.InvasivesObservation	ProtectedStatusID	Foreign key to lookup.ProtectedStatus (protected status of data record)
data.InvasivesObservation	TaxonomicReferenceAuthorityID	Foreign key to lookup.TaxonomicReferenceAuthority (reference or authority used in species identification)
data.InvasivesObservation	DateCreated	Date the record was created
data.InvasivesPhoto	ID	Primary key for this table
data.InvasivesPhoto	InvasivesObservationID	Foreign key to data.InvasivesObservation (invasive species found at site)
data.InvasivesPhoto	PhotoFileNumber	The number of the photo as recorded on the camera
data.InvasivesPhoto	DateCreated	Date the record was created
data.Photo	ID	Primary key for this table

Table	Field	Description
data.Photo	PhotoActivityID	Foreign key to data.PhotoEvent (general photo information)
data.Photo	DateTaken	–
data.Photo	PhotoDescriptionCodeID	Foreign key to ref.PhotoShortDescription (short descriptions of photos (used in photo file naming))
data.Photo	IsLibraryPhotoID	Foreign key to lookup.IsLibraryPhoto (indicates whether photo may be a good candidate for inclusion in newsletters or other communication products)
data.Photo	OriginalFilePath	File path to the original photo on the shared drive
data.Photo	RenamedFilePath	File path to the photo once it has been copied to the appropriate monitoring folder and renamed
data.Photo	GPSUnitID	Foreign key to ref.GPSUnit (gps units, each with a unique identifier)
data.Photo	HorizontalDatumID	Foreign key to lookup.HorizontalDatum (horizontal datum of UTM coordinates)
data.Photo	UTMZoneID	Foreign key to lookup.UTMZone (zone associated with UTM coordinates)
data.Photo	UtmX_m	UTM X coordinate
data.Photo	UtmY_m	UTM Y coordinate
data.Photo	Notes	Notes about the photo
data.Photo	DateCreated	Date the record was created
data.PhotoActivity	ID	Primary key for this table
data.PhotoActivity	VisitID	Foreign key to data.Visit (information about individual sampling visits)
data.PhotoActivity	CameraID	Foreign key to ref.Camera (all cameras used for monitoring, each with a unique identifier)
data.PhotoActivity	CameraCardID	Foreign key to ref.CameraCard (camera memory cards, each with a unique identifier)
data.PhotoActivity	DataProcessingLevelID	Foreign key to lookup.DataProcessingLevel (indicates level of qa/qc that has been applied to data in a given table)
data.PhotoActivity	DataProcessingLevelDate	Date the Data Processing Level was changed
data.PhotoActivity	DataProcessingLevelNote	Notes for Data Processing Level Status
data.PhotoActivity	DateCreated	Date the record was created
data.RepeatPhoto	ID	Primary key for this table
data.RepeatPhoto	RepeatPhotoObservationID	Foreign key to data.RepeatPhotoObservation (repeat photopoint information)

Table	Field	Description
data.RepeatPhoto	PhotoFileNumber	The number of the photo as displayed by the camera and recorded on the field form.
data.RepeatPhoto	DateCreated	Date the record was created
data.RepeatPhotoActivity	ID	Primary key for this table
data.RepeatPhotoActivity	VisitID	Foreign key to data.Visit (information about individual sampling visits)
data.RepeatPhotoActivity	CameraID	Foreign key to ref.Camera (all cameras used for monitoring, each with a unique identifier)
data.RepeatPhotoActivity	CameraCardID	Foreign key to ref.CameraCard (camera memory cards, each with a unique identifier)
data.RepeatPhotoActivity	DataProcessingLevelID	Foreign key to lookup.DataProcessingLevel (indicates level of qa/qc that has been applied to data in a given table)
data.RepeatPhotoActivity	DataProcessingLevelDate	Date the Data Processing Level was changed
data.RepeatPhotoActivity	DataProcessingLevelNote	Notes for Data Processing Level Status
data.RepeatPhotoActivity	DateCreated	Date the record was created
data.RepeatPhotoObservation	ID	Primary key for this table
data.RepeatPhotoObservation	RepeatPhotoActivityID	Foreign key to data.RepeatPhotoEvent (general information about repeat photos)
data.RepeatPhotoObservation	RepeatPhotoTypeID	Foreign key to lookup.RepeatPhotoType (type of repeat photo)
data.RepeatPhotoObservation	UtmX_m	UTM X coordinate
data.RepeatPhotoObservation	UtmY_m	UTM Y coordinate
data.RepeatPhotoObservation	HorizontalDatumID	Foreign key to lookup.HorizontalDatum (horizontal datum of utm coordinates)
data.RepeatPhotoObservation	UTMZone	Foreign key to UTM Zone lookup table
data.RepeatPhotoObservation	GPSUnitID	Foreign key to ref.GPSUnit (gps units, each with a unique identifier)
data.RepeatPhotoObservation	Notes	Notes about this photo observation
data.RepeatPhotoObservation	DateCreated	Date the record was created
data.RiparianVegetationActivity	ID	Primary key for this table
data.RiparianVegetationActivity	VisitID	Foreign key to data.Visit (information about individual sampling visits)
data.RiparianVegetationActivity	IsVegetationObservedID	Foreign key to lookup.IsVegetationObserved (indicates whether riparian vegetation was observed at a spring)
data.RiparianVegetationActivity	MistletoePresentID	Foreign key to lookup.MistletoePresent (indicates whether mistletoe was observed at the spring)

Table	Field	Description
data.RiparianVegetationActivity	Notes	Comments about the riparian vegetation
data.RiparianVegetationActivity	DataProcessingLevelID	Foreign key to lookup.DataProcessingLevel (indicates level of qa/qc that has been applied to data in a given table)
data.RiparianVegetationActivity	DataProcessingLevelDate	Date the Data Processing Level was changed
data.RiparianVegetationActivity	DataProcessingLevelNote	Notes for Data Processing Level Status
data.RiparianVegetationActivity	DateCreated	Date the record was created
data.RiparianVegetationObservation	ID	Primary key for this table
data.RiparianVegetationObservation	RiparianVegetationActivityID	Foreign key to data.RiparianVegetationEvent (overview of riparian vegetation)
data.RiparianVegetationObservation	LifeFormID	Foreign key to lookup.LifeForm (type of riparian vegetation, split into broad and easily identifiable classes)
data.RiparianVegetationObservation	Rank	Integer indicating relative canopy cover of vegetation life form. 1 indicates greatest canopy cover. Ties are allowed.
data.RiparianVegetationObservation	DominantSpecies	Text description or name of the dominant species
data.RiparianVegetationObservation	TaxonID	Foreign key to ref.Taxon (species list)
data.RiparianVegetationObservation	ProtectedStatusID	Foreign key to lookup.ProtectedStatus (protected status of data record)
data.RiparianVegetationObservation	TaxonomicReferenceAuthorityID	Foreign key to lookup.TaxonomicReferenceAuthority (reference or authority used in species identification)
data.RiparianVegetationObservation	DateCreated	Date the record was created
data.RiparianVegetationPhoto	ID	Primary key for this table
data.RiparianVegetationPhoto	RiparianVegetationObservationID	Foreign key to data.RiparianVegetationObservation (observations of riparian vegetation, classified by lifeform and relative abundance)
data.RiparianVegetationPhoto	PhotoFileNumber	The number of the photo as recorded on the camera
data.RiparianVegetationPhoto	DateCreated	Date the record was created
data.SensorDeployment	ID	Primary key for this table
data.SensorDeployment	VisitID	Foreign key to data.Visit (information about individual sampling visits)
data.SensorDeployment	SensorID	Foreign key to ref.Sensor (sensors used to detect presence/absence of water at a spring)
data.SensorDeployment	DeploymentTimeOfDay	Sensor deployment time. Not recorded prior to 1/6/2017.
data.SensorDeployment	Notes	Notes on the sensor deployment

Table	Field	Description
data.SensorDeployment	DateCreated	Date the record was created
data.SensorImport	ID	Primary key for this table
data.SensorImport	SensorImportHeaderID	Foreign key to data.SensorImportHeader (metadata associated with temperature and humidity data imported from ibutton sensors)
data.SensorImport	DateTime	Date and time of measurement
data.SensorImport	UnitOfMeasure	Unit associated with Value column
data.SensorImport	Value	Measured value
data.SensorImportHeader	ID	Primary key for this table
data.SensorImportHeader	SensorRetrievalAttemptID	Foreign key to data.SensorRetrievalAttempt (information about attempts to retrieve ibutton humidity sensors)
data.SensorImportHeader	SensorModel	NULL
data.SensorImportHeader	SerialNumber	NULL
data.SensorImportHeader	MissionInProgress	NULL
data.SensorImportHeader	SUTAMission	NULL
data.SensorImportHeader	WaitingForTempAlarm	NULL
data.SensorImportHeader	SampleRate	NULL
data.SensorImportHeader	MissionStartTime	NULL
data.SensorImportHeader	MissionSampleCount	NULL
data.SensorImportHeader	RolloverEnabled	NULL
data.SensorImportHeader	FirstSampleTimestamp	NULL
data.SensorImportHeader	TotalMissionSamples	NULL
data.SensorImportHeader	TotalDeviceSamples	NULL
data.SensorImportHeader	TemperatureLogging	NULL
data.SensorImportHeader	TemperatureHighAlarm	NULL
data.SensorImportHeader	TemperatureLowAlarm	NULL
data.SensorImportHeader	DataLogging	NULL
data.SensorImportHeader	DataHighAlarm	NULL
data.SensorImportHeader	DataLowAlarm	NULL
data.SensorImportHeader	IsImportSuccess	Indicates whether data import was successful
data.SensorImportHeader	ImportDate	Date data were imported into database
data.SensorImportHeader	username	NULL
data.SensorRetrievalAttempt	ID	Primary key for this table
data.SensorRetrievalAttempt	VisitID	Foreign key to data.Visit (information about individual sampling visits)
data.SensorRetrievalAttempt	SensorDeploymentID	Foreign key to data.SensorDeployment (information about ibutton humidity sensor deployment)
data.SensorRetrievalAttempt	IsSensorRetrievedID	Was sensor retrieved (Y/N)

Table	Field	Description
data.SensorRetrievalAttempt	SensorProblemID	Foreign key to lookup.SensorProblem (problems with retrieved sensor)
data.SensorRetrievalAttempt	RetrievalTimeOfDay	Sensor retrieval time. Not recorded prior to 1/6/2017.
data.SensorRetrievalAttempt	IsDownloadSuccessfulID	Foreign key to lookup.IsDownloadSuccessful (indicates whether sensor data were downloaded successfully)
data.SensorRetrievalAttempt	Notes	Sensor retrieval notes
data.SensorRetrievalAttempt	DateCreated	Date the record was created
data.Site	ID	Primary key for this table
data.Site	ParkID	Foreign key to lookup.Park (the park in which the spring is located)
data.Site	Name	Name of spring
data.Site	Code	Unique spring code, formatted [4-letter park code]_P_[1st 3 letters of spring name][4 digit number, unique within park]
data.Site	SubunitID	Foreign key to lookup.Subunit (management units into which parks are subdivided)
data.Site	AccessDirections	Directions to spring
data.Site	LEGACY_GRTSNumber	Legacy GRTS number; now replaced by GRTSOrder
data.Site	Lat_WGS84	Latitude of spring location. Typically comes from springs inventory.
data.Site	Lon_WGS84	Longitude of spring location. Typically comes from springs inventory.
data.Site	X_UTM_NAD83_11N	UTM Zone 11N X coordinate of spring
data.Site	Y_UTM_NAD83_11N	UTM Zone 11N Y coordinate of spring
data.Site	X_UTM_NAD83_12N	UTM Zone 12N X coordinate of spring
data.Site	Y_UTM_NAD83_12N	UTM Zone 12N Y coordinate of spring
data.Site	ProtectedStatusID	–
data.Site	GRTSDrawID	Foreign key to lookup.GRTSDraw (documents the grts draw that applies to these locations.)
data.Site	GRTSOrder	Order that spring appears in the GRTS draw. Unique for a GRTS frame
data.Site	GRTSStatusID	Foreign key to lookup.GRTSStatus (documents the grts status of this plot)
data.Site	GRTSPanelID	Foreign key to lookup.GRTSPanel (documents the grts sampling panel applied to this location.)
data.Site	DateCreated	Date the record was created

Table	Field	Description
data.SpringbrookDimensions	ID	Primary key for this table
data.SpringbrookDimensions	DischargeActivityID	Foreign key to data.DischargeEvent (general discharge information)
data.SpringbrookDimensions	SpringbrookLength_m	Length of springbrook in meters
data.SpringbrookDimensions	SpringbrookWidth_m	Width of springbrook in meters
data.SpringbrookDimensions	SpringbrookLengthFlagID	Foreign key to lookup.SpringbrookLengthFlag (indicates whether springbrook length is greater than reported length)
data.SpringbrookDimensions	Notes	Notes on springbrook
data.SpringbrookDimensions	DateCreated	Date the record was created
data.Visit	ID	Primary key for this table
data.Visit	SiteID	Foreign key to data.Site (the springs contained in the sampling frame)
data.Visit	VisitDate	Date of spring visit
data.Visit	StartTime	Start time of spring visit
data.Visit	Notes	General comments pertaining to spring visit
data.Visit	SpringTypeID	Foreign key to lookup.SpringType (hydrologic category of spring)
data.Visit	VisitTypeID	Foreign key to lookup.SpringVisitType (type of site visit)
data.Visit	QAQCNotes	Notes for QA/QC
data.Visit	MonitoringStatusID	Foreign key to lookup.AcceptanceRejectionReason (reason spring was accepted or rejected)
data.Visit	ProtocolID	Foreign key to ref.Protocol (reference to each version of the monitoring protocol)
data.Visit	ProtectedStatusID	–
data.Visit	DataReviewNotes	Comments for Data Review
data.Visit	DataProcessingLevelID	Foreign key to lookup.DataProcessingLevel (indicates level of qa/qc that has been applied to data in a given table)
data.Visit	DataProcessingLevelDate	Date the Data Processing Level was changed
data.Visit	DataProcessingLevelNote	Notes for Data Processing Level Status
data.Visit	DateCreated	Date the record was created
data.VisitPersonnel	VisitID	Foreign key to data.Visit (information about individual sampling visits)
data.VisitPersonnel	PersonnelID	Foreign key to ref.Personnel (personnel involved in data collection or management)
data.VisitPersonnel	PersonnelRoleID	Foreign key to lookup.PersonnelRole (data management roles, from collection to qa/qc and certification)

Table	Field	Description
data.VisitPersonnel	DateCreated	Date the record was created
data.WaterQualityActivity	ID	Primary key for this table
data.WaterQualityActivity	VisitID	Foreign key to data.Visit (information about individual sampling visits)
data.WaterQualityActivity	WaterQualityDataCollectedID	Foreign key to lookup.SufficientWater (indicates whether the amount of water at the spring was sufficient for wq measurements)
data.WaterQualityActivity	pHInstrumentID	Foreign key to ref.WaterQualityInstrument (instrument used for measurement)
data.WaterQualityActivity	DOInstrumentID	Foreign key to ref.WaterQualityInstrument (instrument used for measurement)
data.WaterQualityActivity	SpCondInstrumentID	Foreign key to ref.WaterQualityInstrument (instrument used for measurement)
data.WaterQualityActivity	TemperatureInstrumentID	Foreign key to ref.WaterQualityInstrument (instrument used for measurement)
data.WaterQualityActivity	Notes	Not in use
data.WaterQualityActivity	DataProcessingLevelID	Foreign key to lookup.DataProcessingLevel (indicates level of qa/qc that has been applied to data in a given table)
data.WaterQualityActivity	DataProcessingLevelDate	Date Data Processing Level was changed
data.WaterQualityActivity	DataProcessingLevelNote	Note for Data Processing Level status
data.WaterQualityActivity	DateCreated	Date the record was created
data.WaterQualityDO	ID	Unique primary key for Water Quality Dissolved Oxygen
data.WaterQualityDO	WaterQualityActivityID	Foreign key to data.WaterQualityEvent (general information about water quality measurements)
data.WaterQualityDO	DissolvedOxygen_percent	Percent measurement for Dissolved Oxygen
data.WaterQualityDO	DissolvedOxygen_mg_per_L	Measured value of Dissolved Oxygen in milligrams per liter
data.WaterQualityDO	DataQualityFlagID	Foreign key to lookup.DataQualityFlag (indicates type and severity of data quality issue)
data.WaterQualityDO	DataQualityFlagNote	Notes about data quality flag
data.WaterQualityDO	DateCreated	Date record was created
data.WaterQualitypH	ID	Primary key for this table
data.WaterQualitypH	WaterQualityActivityID	Foreign key to data.WaterQualityEvent (general information about water quality measurements)

Table	Field	Description
data.WaterQualitypH	pH	Measurement of pH for Water Quality
data.WaterQualitypH	DataQualityFlagID	Foreign key to lookup.DataQualityFlag (indicates type and severity of data quality issue)
data.WaterQualitypH	DataQualityFlagNote	Notes about data quality flag
data.WaterQualitypH	DateCreated	Date the record was created
data.WaterQualitySpCond	ID	Primary key for this table
data.WaterQualitySpCond	WaterQualityActivityID	Foreign key to data.WaterQualityEvent (general information about water quality measurements)
data.WaterQualitySpCond	SpecificConductance_microS_per_cm	Specific conductance measurement in microsiemens per centimeter
data.WaterQualitySpCond	DataQualityFlagID	Foreign key to lookup.DataQualityFlag (indicates type and severity of data quality issue)
data.WaterQualitySpCond	DataQualityFlagNote	Notes about data quality flag
data.WaterQualitySpCond	DateCreated	Date record was created
data.WaterQualityTemperature	ID	Primary key for this table
data.WaterQualityTemperature	WaterQualityActivityID	Foreign key to data.WaterQualityEvent (general information about water quality measurements)
data.WaterQualityTemperature	WaterTemperature_C	Temperature measurement in degrees C
data.WaterQualityTemperature	DataQualityFlagID	Foreign key to lookup.DataQualityFlag (indicates type and severity of data quality issue)
data.WaterQualityTemperature	DataQualityFlagNote	Notes about data quality flag
data.WaterQualityTemperature	DateCreated	Date record was created
data.WildlifeActivity	ID	Primary key for this table
data.WildlifeActivity	VisitID	Foreign key to data.Visit (information about individual sampling visits)
data.WildlifeActivity	IsWildlifeObservedID	Foreign key to lookup.IsWildlifeObserved (indicates whether evidence of wildlife was observed at a spring)
data.WildlifeActivity	Notes	–
data.WildlifeActivity	DataProcessingLevelID	Foreign key to lookup.DataProcessingLevel (indicates level of qa/qc that has been applied to data in a given table)
data.WildlifeActivity	DataProcessingLevelDate	Date the Data Processing Level was changed
data.WildlifeActivity	DataProcessingLevelNote	Notes for Data Processing Level Status
data.WildlifeActivity	DateCreated	Date record was created

Table	Field	Description
data.WildlifeObservation	ID	Primary key for this table
data.WildlifeObservation	WildlifeActivityID	Foreign key to data.WildlifeEvent (general wildlife information)
data.WildlifeObservation	WildlifeTypeID	Foreign key to lookup.WildlifeType (broad wildlife categories of interest)
data.WildlifeObservation	SpeciesName	Type of wildlife (may be scientific or common name)
data.WildlifeObservation	WildlifeEvidenceID	Foreign key to lookup.WildlifeEvidence (types of evidence of wildlife presence)
data.WildlifeObservation	EvidenceNotes	Notes pertaining to wildlife evidence
data.WildlifeObservation	DateCreated	Date the record was created
ref.Camera	ID	Primary key for this table
ref.Camera	Label	Descriptive label
ref.Camera	Manufacturer	Equipment manufacturer
ref.Camera	Model	Equipment model
ref.Camera	NPSPropertyTag	NPS property tag code
ref.Camera	Summary	Additional details
ref.Camera	SerialNumber	Serial number assigned by manufacturer
ref.Camera	IsActive	Indicates whether this item is a valid option for current data
ref.Camera	SortOrder	Sort order for items in this lookup
ref.CameraCard	ID	Primary key for this table
ref.CameraCard	Label	Numeric label on camera card that field crew writes on field form
ref.CameraCard	Manufacturer	Camera card manufacturer
ref.CameraCard	CardType	Type of camera memory card (e.g. xD, sD, etc)
ref.CameraCard	CardCapacityGB	Capacity of camera memory card
ref.GPSUnit	ID	Primary key for this table
ref.GPSUnit	Label	Label on GPS unit that field crew writes on the field form
ref.GPSUnit	Summary	Additional details
ref.GPSUnit	IsActive	Indicates whether this instrument is currently used to collect data
ref.GPSUnit	Model	GPS unit model
ref.GPSUnit	Manufacturer	GPS unit manufacturer
ref.ParkTaxonProtectedStatus	TaxonID	Foreign key to ref.Taxon (species list)
ref.ParkTaxonProtectedStatus	ParkID	Foreign key to lookup.Park (the park in which the spring is located)
ref.ParkTaxonProtectedStatus	ProtectedStatusID	Foreign key to lookup.ProtectedStatus (protected status of data record)
ref.Personnel	ID	Primary key for this table

Table	Field	Description
ref.Personnel	Initials	Unique initials of staff or participant. For duplicate initials, a number is added at the end (e.g. JLB2)
ref.Personnel	FirstName	First name
ref.Personnel	LastName	Last name
ref.Personnel	MiddleInitial	Middle initial
ref.Personnel	Organization	Organization the participant is associated with
ref.Personnel	Notes	Notes about staff member or participant (e.g. what projects they worked on, if relevant)
ref.Personnel	PersonnelActiveID	Foreign key to lookup.PersonnelActive (indicates whether the individual is currently working for/with MOJN)
ref.Personnel	ProtectedStatusID	Foreign key to lookup.ProtectedStatus (protected status of data record)
ref.PhotoDescriptionCode	ID	Primary key for this table
ref.PhotoDescriptionCode	Code	Descriptive label
ref.PhotoDescriptionCode	Label	Additional details
ref.PhotoDescriptionCode	IsMonitoringPhoto	Indicates whether this photo is of potential scientific value, however anecdotal
ref.PhotoDescriptionCode	PhotoSOPID	Foreign key to lookup.PhotoSOP (the SOP that the photo is associated with)
ref.PhotoDescriptionCode	IsActive	–
ref.Protocol	ID	Protocol Configuration ID autogenerated identifier
ref.Protocol	ProtocolName	Simple name for protocol configuration (should likely include version)
ref.Protocol	Description	Brief description of protocol configuration
ref.Protocol	DataStoreReferenceCode	Data Store reference code that points to full description/content of protocol configuration
ref.Protocol	URL	URL that points to full description/content of protocol configuration
ref.Protocol	BeginImplementationDate	Date that protocol configuration was first used in field
ref.Protocol	EndImplementationDate	Date that protocol configuration was last used in field
ref.Protocol	CreatedDate	Date the record was created
ref.Sensor	ID	Primary key for this table
ref.Sensor	SensorModelID	Foreign key to ref.SensorModel (model of sensor used to detect presence/absence of water)
ref.Sensor	SerialNumber	Sensor serial number

Table	Field	Description
ref.Sensor	Label	Label affixed to sensor that field crew writes on field form
ref.Sensor	Summary	Sensor details
ref.SensorModel	ID	Primary key for this table
ref.SensorModel	Label	Descriptive label
ref.SensorModel	Manufacturer	Sensor manufacturer
ref.SensorModel	Model	Official model name or number
ref.SensorModel	Summary	Additional details
ref.Taxon	ID	Primary key for this table
ref.Taxon	USDAPlantsCode	USDA plant code assigned to taxon
ref.Taxon	ScientificName	Species scientific name
ref.Taxon	CommonName	Species common name
ref.Taxon	Invasive	Indicates whether species is considered invasive
ref.Taxon	TaxonomicReferenceAuthorityID	Foreign key to lookup.TaxonomicReferenceAuthority (reference or authority used in species identification)
ref.Taxon	DateCreated	Date the record was created
ref.WaterQualityInstrument	ID	Primary key for this table
ref.WaterQualityInstrument	Label	Label on water quality instrument that field crew writes on field form
ref.WaterQualityInstrument	Summary	Additional details
ref.WaterQualityInstrument	Model	WQ instrument model
ref.WaterQualityInstrument	Manufacturer	WQ instrument manufacturer
ref.WaterQualityInstrument	NPSPropertyTag	National Park Service property tag number
ref.WaterQualityInstrument	IsActive	Indicates whether this instrument is currently used to collect data

Table 13.4. Lookup tables.

Table	Field	Description
lookup.DataProcessingLevel	ID	Primary key for this table
lookup.DataProcessingLevel	Code	Short code/abbreviation
lookup.DataProcessingLevel	Label	Descriptive label
lookup.DataProcessingLevel	Summary	Additional details
lookup.DataProcessingLevel	IsActive	Indicates whether this item is a valid option for current data
lookup.DataProcessingLevel	ProcessOrder	Order in which DPL should be applied
lookup.DataQualityFlag	ID	Primary key for this table
lookup.DataQualityFlag	Code	Short code/abbreviation
lookup.DataQualityFlag	Label	Descriptive label
lookup.DataQualityFlag	Summary	Additional details
lookup.DataQualityFlag	IsActive	Indicates whether this item is a valid option for current data

Table	Field	Description
lookup.DataQualityFlag	SortOrder	Sort order for items in this lookup
lookup.DischargeEstimatedFlag	ID	Primary key for this table
lookup.DischargeEstimatedFlag	Code	Short code/abbreviation
lookup.DischargeEstimatedFlag	Label	Descriptive label
lookup.DisturbanceClass	ID	Primary key for this table
lookup.DisturbanceClass	Code	Short code/abbreviation
lookup.DisturbanceClass	Label	Descriptive label
lookup.FlowCondition	ID	Primary key for this table
lookup.FlowCondition	Label	Descriptive label
lookup.FlowCondition	Sort	Sort order for items in this lookup
lookup.FlowModificationStatus	ID	Primary key for this table
lookup.FlowModificationStatus	Code	Short code/abbreviation
lookup.FlowModificationStatus	Label	Descriptive label
lookup.GRTSDraw	ID	Primary key for this table
lookup.GRTSDraw	Code	Short code/abbreviation
lookup.GRTSDraw	Label	Descriptive label
lookup.GRTSDraw	Summary	Additional details
lookup.GRTSPanel	ID	Primary key for this table
lookup.GRTSPanel	Code	Short code/abbreviation
lookup.GRTSPanel	Label	Descriptive label
lookup.GRTSStatus	ID	Primary key for this table
lookup.GRTSStatus	Code	Short code/abbreviation
lookup.GRTSStatus	Label	Descriptive label
lookup.GRTSStatus	Summary	Additional details
lookup.HorizontalDatum	ID	Primary key for this table
lookup.HorizontalDatum	Code	Short code/abbreviation
lookup.HorizontalDatum	Label	Descriptive label
lookup.HorizontalDatum	Summary	Additional details
lookup.InvasivesObserved	ID	Unique primary key for Data Processing Level lookup table
lookup.InvasivesObserved	Code	Unique code for Data Processing Level
lookup.InvasivesObserved	Label	Unique name for Data Processing Level lookup table
lookup.IsDownloadSuccessful	ID	Primary key for this table
lookup.IsDownloadSuccessful	Code	Short code/abbreviation
lookup.IsDownloadSuccessful	Label	Descriptive label
lookup.IsLibraryPhoto	ID	Primary key for this table
lookup.IsLibraryPhoto	Code	Short code/abbreviation
lookup.IsLibraryPhoto	Label	Descriptive label
lookup.IsSensorRetrieved	ID	Primary key for this table
lookup.IsSensorRetrieved	Code	Short code/abbreviation
lookup.IsSensorRetrieved	Label	Descriptive label
lookup.IsVegetationObserved	ID	Unique primary key for Protected Status lookup table
lookup.IsVegetationObserved	Code	Unique code for Protected Status

Table	Field	Description
lookup.IsVegetationObserved	Label	Unique name for Protected Status lookup table
lookup.IsWildlifeObserved	ID	Primary key for this table
lookup.IsWildlifeObserved	Code	Unique code for Wildlife evidence
lookup.IsWildlifeObserved	Label	Unique name for wildlife evidence lookup
lookup.LifeForm	ID	Primary key for this table
lookup.LifeForm	Label	Descriptive label
lookup.LifeForm	Summary	Additional details
lookup.LifeForm	Code	Short code/abbreviation
lookup.LifeForm	IsActive	–
lookup.MistletoePresent	ID	Primary key for this table
lookup.MistletoePresent	Code	Short code/abbreviation
lookup.MistletoePresent	Label	Descriptive label
lookup.ModificationType	ID	Primary key for this table
lookup.ModificationType	Code	Short code/abbreviation
lookup.ModificationType	Label	Descriptive label
lookup.ModificationType	Summary	Additional details
lookup.MonitoringStatus	ID	Primary key for this table
lookup.MonitoringStatus	Code	Unique code for Acceptance rejection reason lookup
lookup.MonitoringStatus	IsSampled	Category name/description for acceptance rejection reason
lookup.MonitoringStatus	Label	Descriptive label
lookup.MonitoringStatus	Summary	Additional details
lookup.Park	ID	Primary key for this table
lookup.Park	Code	Short code/abbreviation
lookup.Park	Label	Descriptive label
lookup.Park	ShortLabel	Shortened label (abbreviates National Park to NP, etc.)
lookup.PersonnelActive	ID	Primary key for this table
lookup.PersonnelActive	Code	Short code/abbreviation
lookup.PersonnelActive	Label	Descriptive label
lookup.PersonnelRole	ID	Primary key for this table
lookup.PersonnelRole	Label	Descriptive label
lookup.PersonnelRole	Summary	Additional details
lookup.PhotoSOP	ID	Primary key for this table
lookup.PhotoSOP	Code	Short code/abbreviation
lookup.PhotoSOP	Label	Descriptive label
lookup.PhotoSOP	Summary	Additional details
lookup.PhotoSOP	SortOrder	–
lookup.ProtectedStatus	ID	Primary key for this table
lookup.ProtectedStatus	Code	Short code/abbreviation
lookup.ProtectedStatus	Label	Descriptive label
lookup.ProtectedStatus	Summary	Additional details
lookup.RepeatPhotoType	ID	Primary key for this table

Table	Field	Description
lookup.RepeatPhotoType	Code	–
lookup.RepeatPhotoType	Label	Descriptive label
lookup.RepeatPhotoType	IsActive	–
lookup.RiparianVegetationBuffer	ID	Primary key for this table
lookup.RiparianVegetationBuffer	Code	Short code/abbreviation
lookup.RiparianVegetationBuffer	Label	Descriptive label
lookup.SensorProblem	ID	Primary key for this table
lookup.SensorProblem	Label	Descriptive label
lookup.SensorProblem	Summary	Additional details
lookup.SpringbrookLengthFlag	ID	Primary key for this table
lookup.SpringbrookLengthFlag	Code	Short code/abbreviation
lookup.SpringbrookLengthFlag	Label	Descriptive label
lookup.SpringbrookLengthFlag	Summary	Additional details
lookup.SpringType	ID	Primary key for this table
lookup.SpringType	Code	Short code/abbreviation
lookup.SpringType	Label	Descriptive label
lookup.SpringType	Summary	Additional details
lookup.Subunit	ID	Primary key for this table
lookup.Subunit	ParkID	Foreign key to lookup.Park (the park in which the spring is located)
lookup.Subunit	Code	Short code/abbreviation
lookup.Subunit	Label	Descriptive label
lookup.Subunit	Summary	Additional details
lookup.TaxonomicReferenceAuthority	ID	Primary key for this table
lookup.TaxonomicReferenceAuthority	TaxonomicStandardID	Foreign key to lookup.TaxonomicStandard (type of standard used in species identification)
lookup.TaxonomicReferenceAuthority	Label	d Subject Matter Experts, use shortened position responsible for performing identifications (e.g., crew lead w/ID skill).
lookup.TaxonomicReferenceAuthority	Summary	use full name and organization (e.g., John Doe, University of Georgia). For Field Subject Matter Experts, use full position responsible for performing identifications (e.g., field crew lead with documented identification proficiency).
lookup.TaxonomicStandard	ID	Primary key for this table
lookup.TaxonomicStandard	Code	Short code/abbreviation
lookup.TaxonomicStandard	Label	Descriptive label
lookup.TaxonomicStandard	Summary	Additional details
lookup.UTMZone	ID	Primary key for this table
lookup.UTMZone	Code	Short code/abbreviation
lookup.UTMZone	Label	Descriptive label
lookup.UTMZone	Summary	Additional details
lookup.VisitType	ID	Primary key for this table
lookup.VisitType	Code	Short code/abbreviation
lookup.VisitType	Label	Descriptive label

Table	Field	Description
lookup.VisitType	Summary	Additional details
lookup.WaterQualityDataCollected	ID	Primary key for this table
lookup.WaterQualityDataCollected	Code	Short code/abbreviation
lookup.WaterQualityDataCollected	Label	Descriptive label
lookup.WildlifeEvidence	ID	Primary key for this table
lookup.WildlifeEvidence	Code	Short code/abbreviation
lookup.WildlifeEvidence	Label	Descriptive label
lookup.WildlifeType	ID	Primary key for this table
lookup.WildlifeType	Code	Short code/abbreviation
lookup.WildlifeType	Label	Descriptive label
lookup.WildlifeType	IsActive	–

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National Park Service. 2008. Data Management Guidelines for Inventory and Monitoring Networks. NPS/NRPC/NRR—2008/035 National Park Service, Fort Collins, Colorado.

Appendix A: Field Data Sheet

MOJN Desert Springs Field Data Sheet

Spring Name: _____

Park Code: _____ Spring ID: _____ Date: ____/____/____ Time (24H): ____:____

UTM Zone: 11N / 12N Datum: _____ GPS ID: _____ Observers: _____

Spring Classification

Visit Type: Primary / Replicate / Training / Calibration

Spring Monitored: Y / N If no, why not: Not Found / Inaccessible / Unsafe / Potential Resource Damage

Spring Type: Exposure / Helocrene / Hillslope / Hypocrene / Limnocrene / Rheocrene / Other

Spring Comments: _____

Sensor Information

Sensor Deployed: Y / N Sensor Type: _____ Sensor ID #: _____ Time (24H): ____:____

Sensor Retrieved: Y / N / NA Sensor Type: _____ Sensor ID #: _____ Time (24H): ____:____

Sensor Problem(s): None / Damaged / Buried / Outside Water / Wrong Location / Missing / Location Not Found

Sensor Comments: _____

Repeat Photographs

Camera ID #: _____

Memory Card #: _____

Photo	File #	UTM Easting	UTM Northing	Comments
Looking Downstream				
Source				
Looking Upstream				
Sensor (If Different from Source)				
Other 1				
Other 2				

Water Availability

Flow Condition: Dry / Wet Soil / Standing Water / Flowing Water / Flood

Discharge Method: Estimated / Volumetric / Other _____

Discharge (L/min): _____ or Volume of Container (mL): _____ % of Flow Captured: _____

Fill Time(s): (1) _____ (2) _____ (3) _____ (4) _____ (5) _____ (6) _____

Discharge Comments: _____

(If channel is dry, enter "0" for length and width)

Springbrook Length (m): _____ Springbrook Width (m): _____

Channel Description: _____

Water Quality

Data Collected: Y / N If no, why not: Instrument Failure / Poor Calibration / Insufficient Water / Other

pH Instrument ID #: _____ WQ Instrument ID #: _____

	pH	Temp (°C)	SpCond (µS/cm)	DO (%)	DO (mg/L)
1)					
2)					
3)					

	Pre-Cal Temp	Pre-Cal Reading	Post-Cal Temp	Post-Cal Reading	
pH 7					Acceptable pH error: ±0.10
pH 4 / 10					Acceptable SpCond error: ±15 µS/cm
DO (%)					Corrected pH 7: _____
SpCond					Corrected pH 4/10: _____
					Pressure (mmHg): _____
					Standard (µS/cm): _____

Water Quality Comments: _____

Disturbance

Flow Modification: Yes (One or more Active) / Yes (All Inactive) / None

Modification Type(s):	Pipe	Dam	Trough	Pump	Encasement	Excavation	Sealed Cracks	Other
<i>Anthropogenic Disturbance</i>								
Roads:	0 / 1 / 2 / 3 / 4							
Human Use:	0 / 1 / 2 / 3 / 4							
Plant Mgmt:	0 / 1 / 2 / 3 / 4							
Hiking Trails:	0 / 1 / 2 / 3 / 4							
Livestock:	0 / 1 / 2 / 3 / 4							
Other:	0 / 1 / 2 / 3 / 4							
<i>Natural Disturbance</i>								
Fire:	0 / 1 / 2 / 3 / 4							
Flooding:	0 / 1 / 2 / 3 / 4							
Wildlife:	0 / 1 / 2 / 3 / 4							
Other:	0 / 1 / 2 / 3 / 4							
<i>Overall Disturbance</i>	0 / 1 / 2 / 3 / 4							

Disturbance Comments: _____

Wildlife EvidenceEvidence Codes: OB = observed SC = scat TR = tracks SH = shelter FO = foraging VO = vocalization OT = other
Animal Codes: MAMMAL BIRD AMPHIBIAN FISH AQUATIC INVERT TERRESTRIAL INVERT OTHER Wildlife

Animal	Evidence	Species (If Known) and Notes

Spring Vegetation

Vegetation present? Y / N (If no, skip this section)

Camera ID #: _____

Memory Card #: _____

Life Form	Rank	Dominant Species (If Known)	File #s				
Woody (>4 m)							
Woody (2 - 4 m)							
Woody (<2 m)							
Forb							
Grass							
Reed							
Rush							
Sedge							
Cattail							
Bryophyte							
Non-Plant							
Mistletoe (<i>Phoradendron sp.</i>) present? Y / N							

Vegetation Comments: _____

Invasive Plants

Species (If Known)	Rip Veg Buffer	UTM Easting	UTM Northing	Error (m)	File #s	
	Y / N					
	Y / N					
	Y / N					
	Y / N					

Invasive Comments: _____

Additional Comments: _____

National Park Service
U.S. Department of the Interior



Mojave Desert Network
