2012 SPRINGSNAIL SURVEY
DEVILS CANYON, PINAL COUNTY, ARIZONA

Prepared for: Resolution Copper Mining

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1. INTRODUCTION

WestLand Resources Inc. (WestLand) was retained by Resolution Copper Mining (RCM) to survey for springsnails (*Pyrgulopsis* spp.; Hydrobiidae) in select springs in Devils Canyon, Pinal County, Arizona (***Figure 1***). Springsnails in Arizona and the arid American West in general, tend to have relatively narrow distributions and can be restricted to isolated springs, spring complexes or drainage basins and may exhibit a high degree of endemism (Hershler and Landye 1988, Hershler and Sada 2002, Hurt 2004). Based on the inherent nature of small, isolated aquatic systems, many of these habitats and the taxa associated with them are threatened by human-mediated impacts such as catastrophic wildfire, spring impoundment and diversion, groundwater pumping, and ungulate grazing (USFWS 2012a, 2012b). Two springsnails in Arizona have recently been listed as Endangered or Threatened with Critical Habitat (*P. trivalis* and *P. bernardiana*; respectively) by the U.S. Fish and Wildlife Service (USFWS 2012a) and two others are considered Candidates (*P. morrisoni* and *P. thompsoni*) (USFWS 2012b).

The objective of this survey was to identify and investigate natural spring habitats that had potential to support springsnail populations in the vicinity of the Resolution Project—a proposed underground mine, ore processing operation, and associated facilities and infrastructure—and through focused survey efforts to determine if springsnails were present.

2. SPRINGSNAIL NATURAL HISTORY

Springsnails are small snails ranging in shell length from approximately 0.04 to 0.3 in (1 to 8 mm) and because of their small size often evade detection (Hershler 1994). They are a completely aquatic, gill-breathing snail that is found in a variety of perennial aquatic environments including lakes, streams, springs, seeps and cienegas (Hershler 1994, Liu et al., 2003). They are often found in close association with the spring orifice or source (i.e., springhead) of relatively undisturbed springs, especially those with a constant, thermally-stable discharge. Abundance of springsnails often decreases with increasing distance from the springhead (Martinez and Rogowski 2011, Tsai et al., 2007).

Habitat studies of individual springsnail species have found a widely varying range of abiotic (e.g., water chemistry, water depth, temperature, dominant substrates) and biotic (e.g., vegetation, aquatic macroinvertebrates) factors associated with presence and/or abundance of springsnails (Obrien and Blinn 1999, Malcom et al, 2005, Sada 2005, Martinez and Thome 2006, Martinez and Myers 2008, Martinez and Rogowski 2011). Few habitat preferences are consistent across species but it appears springsnails are generally not associated with soft, silt substrates composed of fine sediments (O'Brien and Blinn 1999, Malcom et al., 2005). They are more often found associated with more stable substrates such as gravel and cobble (Martinez and Thome 2006, Martinez and Myers 2008) and aquatic macrophytes (Hershler and Landye 1988, Malcom et al., 2005, Sada 2005) which are presumably important for foraging and egg laying (USFWS 2012a). Although springsnails do not occupy all such environments in Arizona, there are springs in Devils Canyon and its tributaries that have potential to provide habitat for springsnail populations.

3. METHODS

WestLand surveyed for springsnails at five springs in Devils Canyon during December 17 through 18, 2012. Springs in the vicinity of the Resolution Project were considered for survey based on results of previous field investigations (Golder 2006, WestLand 2012). The nomenclature used to identify individual springs was adopted from WestLand (2012). None of the springs surveyed are depicted on USGS 7.5 minute topographic maps. Selection criteria included proximity to the Resolution Project, known spring discharge, presence of wetland plants, and accessibility. WestLand followed USFWS and Arizona Game and Fish Department survey protocols and used standard survey datasheets (Cox et al., 2008).

Surveys were initiated as close to the spring orifice as possible. Two surveyors then began a timed search and moved slowly downstream turning any available substrates to which springsnails might be attached. Targeted substrates included large gravel, cobble, leaves, bark, and live vegetation in or immediately adjacent to the aquatic environment. Substrates sampled were visually examined with the naked eye or with the aid of a twenty-power magnification hand lens. All aquatic invertebrates encountered were field-identified to the lowest taxonomic order possible, usually Order or Family. Total search time and linear distance of the spring-run or wetted area sampled were recorded. Following timed springsnail surveys, air and water temperature were measured as well as water chemistry parameters including pH, electrical conductivity, and dissolved oxygen.

4. RESULTS AND DISCUSSION

Sites surveyed, locality information, brief physical descriptions, search parameters, aquatic invertebrate observations, and water chemistry are presented in ***Table 1***. The relative location of the five springs visited in Devils Canyon is illustrated in ***Figure 2***. Additionally, representative photographs from each spring surveyed are presented in ***Appendix A***. All spring surveys, except at Pipe Spring, were initiated at a readily discernible spring source. The springhead of Pipe Spring was indeterminate and likely upslope of the area accessed during this survey. No obvious spring impoundments, diversions or stock watering infrastructure were observed at any of the five sites.

Two of the springs surveyed (Golder 8.2 and Pipe springs) expressed a readily observable and constant discharge that flowed in a moderately discreet channel across a stable soil and root substrate. Gravel was occasionally encountered but was not the dominant substrate. Water temperatures at Golder 8.2 and Pipe springs were the highest of all springs surveyed (≥ 23.3°C) and were warm relative to air temperatures suggesting a connection to a relatively deep, thermally stable aquifer (***Table 1***).

The remaining three springs surveyed (Golder 8.8, Bear, and West Canyon springs) emerge as seeps with a weak but observable discharge and flow unconfined through a soft, muddy substrate. Again, gravel was occasionally encountered but was far from representing the dominant substrate. Golder 8.8 was a very small seep with only ~ 0.3 m^2 area surveyed. Bear and West springs were larger seeps (~ 7.7 m^2 and 16.1 m^2, respectively) and were moderately to heavily impacted by ungulate (e.g., cattle, deer, javelina) and other mammalian use (***Table 1***).

No springsnails were observed at any of the springs visited during this survey (***Table 1***). One individual of an aquatic snail (c.f. *Physa* sp.) was found at one site (Golder 8.8 Spring). Several other taxa of aquatic invertebrates were observed at all sites (***Table 1***), notably riffle beetles (Family Elmidae) at one site (Golder 8.2 Spring). Riffle beetles are a highly specialized aquatic species that may have restricted distributions similar to springsnails, often inhabit similar spring habitats, and can exhibit a high degree of endemism (Brown 1972a, 1972b, Martinez and Sorenson 2007). Taxon identifications were made in the field and have not been verified by experts. Voucher specimens were collected and further investigations in the lab and consultations with experts would be needed to confirm taxa observed.

Selection of springsnail survey sites were based on prior knowledge, access and time constraints, and those springs assumed to have the greatest potential for supporting springsnails. Therefore, the current springsnail survey was not a temporally or spatially exhaustive survey. Survey efforts at individual springs in 2012 do represent baseline data on springsnail and other spring-associated invertebrate distributions in Devils Canyon and its tributaries that can inform the regulatory process in the future.

5. REFERENCES

Brown, H.P. 1972a. Synopsis of the Genus *Heterelmis* in the USA with Description of a New Species from Arizona (Coleoptera, Dryopoidea, Elmidae). Entomological News 83:229–238.

Brown, H.P. 1972b. Aquatic Dryopoid Beetles (Coleoptera) of the United States. Biota of Freshwater Ecosystems Identification Manual No. 6. Environmental Protection Agency, Washington, DC. 82 pp.

Cox, D., M.A. Martinez, and J. Sorenson. 2008. Page springsnail survey and monitoring protocol. *In* Arizona Game and Fish Department. 2009. Candidate conservation agreement with assurances for the Page springsnail.

Golder Associates, Inc. 2006. Resolution Copper Company, Surface Water Baseline Report, October 2002 through February 2006. Golder Associates, Inc. Tucson, Arizona.

Hershler, R. and D.W. Sada. 2002. Biogeography of Great Basin aquatic snails of the genus Pyrgulopsis. Pages 255-276, In R. Hershler, D.B. Madsen, and D.R. Curry (Eds.). Great Basin Aquatic Systems History. Smithsonian Institution Press, Washington, D.C.

Hershler, R. 1994. A review of the North American freshwater snail genus *Pyrgulopsis* (Hydrobiidae). Smithsonian Contributions to Zoology, Number 554. Smithsonian Institution Press. Washington D.C. 115 pp.

Hershler, R. and J.J. Landye. 1988. Arizona Hydrobiidae (Prosobranchia: Rissoacea). Smithsonian Contributions to Zoology. No. 459. 63 pp.

Hurt, C. 2004. Genetic divergence, population structure and historical demography of rare springsnails (*Pyrgulopsis*) in the lower Colorado River basin. Molecular Ecology 13:1173-1187.

Liu, Hsiu-Ping, Hershler, Robert and Clift, K. 2003. Mitochondrial DNA sequences reveal extensive cryptic diversity within a western American springsnail. Molecular Ecology, 12: 2771-2782.

Malcom, J.W., W.R. Radke, and B.K. Lang. 2005. Habitat associations of the San Bernardino springsnail, *Pyrgulopsis bernardina* (Hydrobiidae). Journal of Freshwater Ecology 20(1):71-77.

Martinez, M.A. and D.L. Rogowski. 2011. Use and apparent partitioning of habitat by an imperiled springsnail (Hydrobiidae) and a cosmopolitan pond snail (Physidae). The Southwestern Naturalist 56(2):216-223.

Martinez, M.A. and T.L. Myers. 2008. Associations between aquatic habitat variables and *Pyrgulopsis trivialis* presence/absence. Journal of Freshwater Ecology 23(2):189-194.

Martinez, M.A. and J.A. Sorensen. 2007. Effect of sampling without replacement on isolated populations of endemic aquatic invertebrates in central Arizona. The Journal of the Arizona-Nevada Academy of Science 39(1):28-32.

Martinez, M.A. and D.M. Thome. 2006. Habitat usage by the Page springsnail, *Pyrgulopsis morrisoni* (Gastropoda: Hydrobiidae) from central Arizona. The Veliger. 48(1):8-16.

O'Brien C. and D.W. Blinn. 1999. The endemic spring snail *Pyrgulopsis montezumensis* in a high CO2 environment: importance of extreme chemical habitats as refugia. Freshwater Biology 42:225- 234.

Sada, D.W. 2005. Abundance, distribution, and habitat use of the Grand Wash springsnail (*Pyrgulopsis bacchus*), Grand Canyon-Parashant National Monument, Arizona. 47 pp.

Tsai, Y.J., K. Maloney, and A.E. Arnold. 2007. Biotic and abiotic factors influencing the distribution of the Huachuca springsnail (*Pyrgulopsis thompsoni*). Journal of Freshwater Ecology 22:213-218.

United States Fish & Wildlife Service (USFWS). 2012a. Endangered and Threatened Wildlife and Plants: Determination of Endangered Status for Three Forks Springsnail and Threatened Status for San Bernardino Springsnail Throughout Their Ranges and Designation of Critical Habitat for Both Species. Federal Register 77: 23060–23092.

United States Fish & Wildlife Service (USFWS). 2012b. Endangered and Threatened Wildlife and Plants; Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions. Federal Register 77: 69994–70060.

WestLand Resources Inc. 2012. Wetland Plant Survey of Springs in the Resolution Project Area, September 2012. WestLand Resources, Inc., Tucson, Arizona.

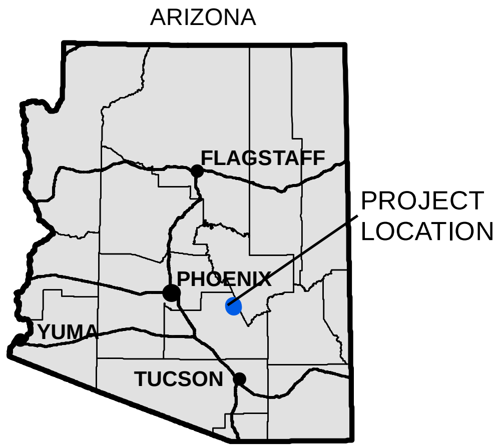
TABLE

Table 1. Springsnail Survey Results at Selected Sites in Devils Canyon, Pinal County, Arizona; December 17-18, 2012.

Spring Name	UTM Coordinate (NAD 83)		Survey Date	Description of Feature	Search Time[1] (min.)	Search Distance (m)	Substrate Searched	Spring Snails	Other Macroinvetrebrates[2]	T_a[4] (°C)	T_w[5] (°C)	pH[6]	EC[6,7] (µS/cm)	DO[6,8] (%)
	Easting	Northing												
Golder 8.2 Spring	497469	3681397	12/17/2012	Spring perched above creek bottom; emerges from a discreet orifice ~ 0.1 m in diameter with a constant discharge and flows down-gradient over a stable soil and root substrate in a discreet channel.	60	1.6	Leaves (primarily), live roots, woody debris, rocks, pebbles	None observed	- aquatic beetles; elmids[3] - leeches - mayfly larvae - caddisfly larvae	10.0	23.3	6.62	283.0	56.1
Golder 8.8 Spring	497367	3681959	12/17/2012	Spring perched above creek bottom; emerges as a seep (0.7 m wide) at base of soil bank with 2 small puddles (0.1 m in diameter) and wet mud.	60	0.7	Leaves (primarily), twigs, small rocks	None observed	- *Physa* spp. (*n*=1) - aquatic beetles - damselfly larvae	8.6	19.3	7.23	292.3	58.7
Bear Spring	497391	3682080	12/17/2012	Spring perched above creek bottom; emerges as a seep (1.3 m wide) at base of soil and rootmass bank; seeping (observable low discharge) ~ 5.9 m down-gradient forming a swath of wet, loose mud. Moderate - high disturbance from cattle and wildlife.	40	5.9	Leaves (primarily), grass, bark	None observed	- damselfly larvae - fly larvae - Ostracoda (ID uncertain) - other (unknown)	6.1	19.0	7.13	269.1	47.4
Pipe Spring	498413	3678970	12/18/2012	Spring perched well above creek bottom; springhead indeterminate and upslope of sampled area. There is a flooded "adit" and riparian vegetation upslope of surveyed area. Initiated survey at base of giant reed stand where constant discharge emerges and flows down-gradient over a relatively stable soil, mud, and root substrate, forming occasional pools.	60	7.0	Leaves, bark, dead wood, rocks	None observed	- aquatic beetles - dragonfly larvae - caddisfly larvae - leech - fly larvae - mayfly larvae	15.0	23.5	6.35	292.8	41.8
West Canyon Spring	497389	3680091	12/18/2012	Spring perched immediately above canyon bottom; emerges as a seep (3.5 m wide) at base of soil bank; seeping (observable low discharge) ~ 4.6 m down-gradient forming a swath of wet, loose mud. Very high disturbance from cattle.	30	4.6	Leaves (primarily), rock	None observed	- aquatic beetles - caddisfly larvae (ID uncertain) - other (unknown)	13.2	13.0	6.76	317.9	20.9

[1] Sites were surveyed by 2 observers and search time represents total effort.
[2] Macroinvertebrates were field identified with 20-X magnification hand-lenses and have not been verified by experts.
[3] Riffle beetles positively identified to family (Family Elmidae) in lab with dissecting microscope.
[4] Air temperature
[5] Water temperature
[6] Water chemistry measured with an Oakton® PCD 650 Waterproof Portable Meter Kit
[7] Electrical conductivity
[8] Dissolved oxygen

FIGURES

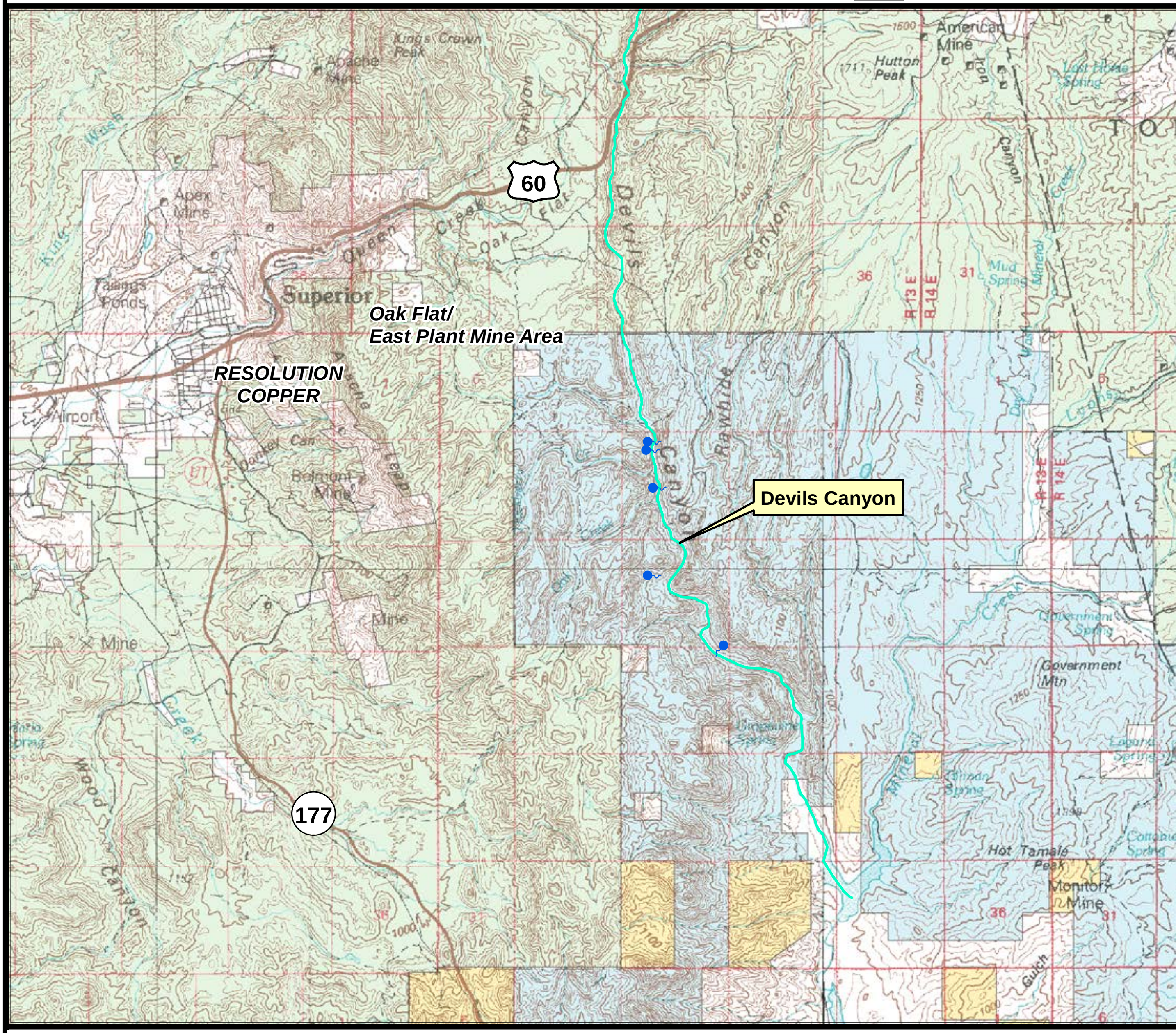


Legend

- Spring

Surface Management

- Bureau of Land Management (BLM)
- Private Land (No Color)
- State Trust Land
- US Forest Service (USFS)



Pinal County, Arizona,
Superior, Pinal Ranch, Teapot Mntn,
& Hot Tomale Peak USGS 7.5' Quadrangles

WestLand Resources, Inc.
Engineering and Environmental Consultants

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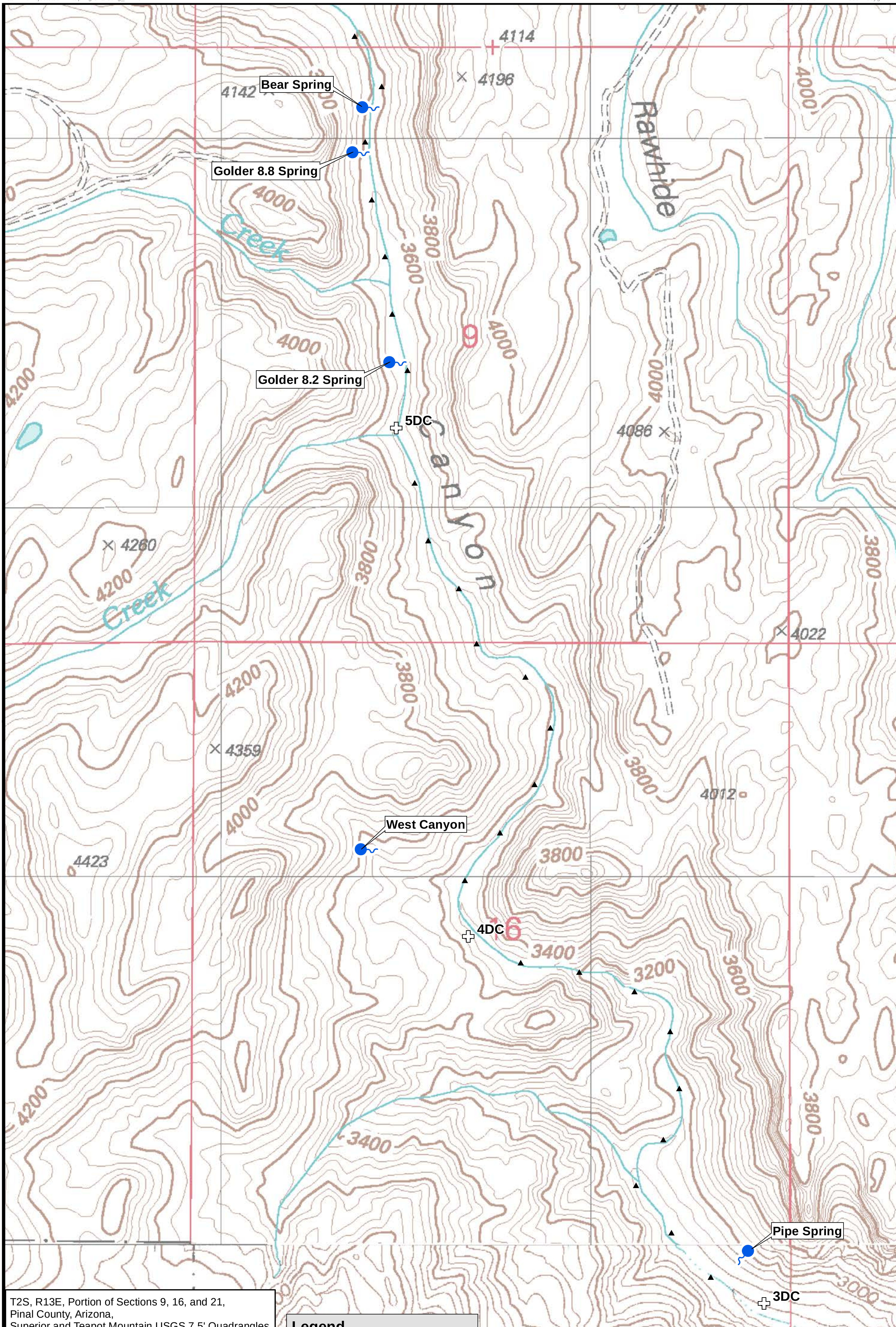
0 8,000 16,000 Feet

RESOLUTION COPPER MINING

2012 Springsnail Survey
Devils Canyon, Pinal County, Arizona

VICINITY MAP
Figure 1



T2S, R13E, Portion of Sections 9, 16, and 21,
Pinal County, Arizona,
Superior and Teapot Mountain USGS 7.5' Quadrangles

Legend

Spring

Markers

Mile Marker

One Tenth Mile Markers

N

0 400 800 Feet

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RESOLUTION COPPER MINING
2012 Springsnail Survey
Devils Canyon, Pinal County, Arizona

MAP OF SPRINGS
Figure 2

APPENDIX A

Representative Photographs

Photo 1.
Golder 8.2 Spring. Overview of area sampled.
12/17/2012.

Photo 2.
Golder 8.2 Spring. Close-up of spring orifice.
12/17/2012.

Photo 3.
Golder 8.8 Spring. Overview of area sampled.
12/17/2012.

Photo 4.
Golder 8.8 Spring. Close-up of seep emergence.
12/17/2012.

Photo 5.
Bear Spring. Overview of area sampled.
12/17/2012.

Photo 6.
Bear Spring. Overview of area sampled.
12/17/2012.

Photo 7.
Bear Spring. Close-up of seep emergence. 12/17/2012.

Photo 8.
Pipe Spring. Downstream view of area sampled. 12/18/2012.

Photo 9.
Pipe Spring. Close-up of point where sample was initiated. 12/18/2012.

Photo 10.
Pipe Spring. Close-up of flow and pool at ash tree rootmass below point where sample start point. 12/18/2012.

Photo 11.
West Canyon Spring. Overview of area sampled. 12/18/2012.