

Socorro Isopod
(Thermosphaeroma thermophilum)
5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
New Mexico Ecological Services Field Office
Albuquerque, NM
2022

5-YEAR REVIEW

Socorro Isopod (*Thermosphaeroma thermophilum*)

1.0 GENERAL INFORMATION

1.1 Reviewers:

Lead Regional or Headquarters Office:

Regional Office, Interior Region 7 (NM), Janess Vartanian, Recovery Biologist

Lead Field Office: New Mexico Ecological Services Field Office, Elizabeth Bainbridge, Fish and Wildlife Biologist

Cooperating Regional Office(s): N/A

1.2 Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species once every five years. The purpose of a 5-year review is to evaluate whether the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing as endangered or threatened is based on the species' status considering the five threat factors described in section 4(a)(1) of the Act. These same five factors are considered in any subsequent reclassification or delisting decisions. In the 5-year review, we consider the best available scientific and commercial data on the species and focus on new information since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rulemaking process, including public review and comment.

1.3 The methodology used to complete the review:

This review was conducted through a public review notification in the Federal Register and a comprehensive review of all documents regarding the Socorro isopod (*Thermosphaeroma thermophilum*) that were available to the Service's New Mexico Ecological Services Field Office (NMESFO). The Federal Register notice (86 FR 23976) announced this review on May 5, 2021, and solicited new information about the species biology, habitat conditions, conservation measures, threats, genetic information, and population trends from other agencies, such as Federal, non-governmental organizations, academic, and the general public. New information was received from this request from academics studying the species and from the New Mexico Department of Game and Fish (NMDGF). The information to inform this analysis are the previous 5-year review (Service, 2009), the recovery plan (Service, 1982), recovery plan amendment (Service, 2019), Section 6 reports from NMDGF (NMDGF 2019, 2020a, 2021a), literature on the species published since the

previous review, unpublished reports, and personal communications with Daniel Trujillo (invertebrate biologist with NMDGF), Dr. David Berg (academic researcher at Miami University), and Mary Jones (PhD student and researcher at Miami University). This 5-year review document was written by Elizabeth Bainbridge, Fish and Wildlife Biologist at the NMESFO. This document was reviewed by NMDGF biologists Dan Trujillo and Jill Wick.

1.4 Background:

1.4.1 F.R. Notice citation announcing initiation of this review: 86 FR 23976; May 5, 2021

1.4.2 Listing history:

Original Listing

FR notice: 43 FR 12690

Date listed: March 27, 1978

Entity listed: *Exophaeroma* (sic) *thermophilus* (sic) = *Thermosphaeroma thermophilum*

Classification: Endangered

1.4.3 Associated Rule-makings: None

1.4.4 Review History: A 5-year review was initiated on November 6, 1991 (56 FR 56882) for all species listed before 1991, but no document was prepared for this species. Another 5-year review was initiated on March 20, 2008 (73 FR 14995) and the 5-year review was completed in November of 2009. Since that time, a recovery plan amendment (Service, 2019) was completed to provide measurable recovery criteria for this species. Surveys show that populations have remained stable since the previous 5-year review was published.

Species' Recovery Priority Number at start of 5-year review: 2, indicating a species has a high degree of threat and high recovery potential.

1.4.5 Recovery Plan or Outline

Name of plan or outline: Socorro Isopod Recovery Plan

Date issued: February 2, 1982

Dates of amendment: Recovery criteria were amended in May, 2019

2.0 REVIEW ANALYSIS

Section 4 of the Act (16 U.S.C. 1533) and its implementing regulations (50 C.F.R. part 424) set forth the procedures for determining whether a species meets the definition of “endangered” or “threatened.” The Act defines an “endangered species” as a species that is “in danger of extinction throughout all or a significant portion of its range,” and a “threatened species” as a species that is “likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” The Act requires that we determine whether a species

meets the definition of “endangered” or “threatened” due to any of the five factors described below.

The identification of any threat(s) does not necessarily mean that the species meets the statutory definition of an “endangered” or a “threatened” species. In assessing whether a species meets either definition, we must evaluate all identified threats by considering the expected response of the species, and the effects of the threats—in light of those actions and conditions that will ameliorate the threats—on an individual, population, and species level. We evaluate each threat and its expected effects on the species, then analyze the cumulative effect of all the threats on the species as a whole. We also consider the cumulative effect of the threats considering those actions and conditions that will have positive effects on the species—such as any existing regulatory mechanisms or conservation efforts. The Service recommends whether the species meets the definition of an “endangered” or a “threatened” species only after conducting this cumulative analysis and describing the expected effect on the species now and in the foreseeable future.

2.1 Distinct Population Segment (D.P.S.) policy (1996):

Not applicable; the D.P.S. policy does not apply to invertebrates.

2.2 Updated Information and Current Species Status:

Since the previous status review (Service, 2009), several studies have been conducted which enhance our knowledge of the species (Bleakley et al., 2013; Jones and Berg, 2019; Jones and Berg, 2020; NMDGF, 2013; NMDGF, 2019; NMDGF 2020a; NMDGF 2021a). Genetic data are currently being collected to inform our understanding of population dynamics of the three extant Socorro isopod populations (Jones pers. comm., 2021). These data have not yet been analyzed and will be included in a future status review. In 2019, recovery criteria were revised, ensuring the recovery plan included objective and measurable down and delisting criteria for the species (Service, 2019).

The Socorro isopod is native to a single, thermal spring in Socorro, New Mexico. The native spring, known as Sedillo spring, was converted into a bathhouse in the early 1900s, known as the “Evergreen” facility, and is now abandoned (Appendix: Figure 1)(Shuster, 1981). The Socorro isopod can still be found in the remains of the bathhouse structures (Trujillo pers. comm., 2021). However, the natural habitat does not exist, and we know little about the specific conditions in which the species evolved.

The Socorro isopod population was extirpated from the Evergreen facility in 1988 during a drought. Spring water eventually returned, and the species was repatriated from the captive population kept at the University of New Mexico (Service, 2009; Lang et al., 2012). To protect against future dewatering events, some water was diverted to the Socorro Isopod Propagation Facility (SIPF) outside the city of Socorro, New Mexico (Appendix: Figure 1) to create additional habitat for the isopod.

The SIPF contains two runs of artificial pools that are separated into the North and South series. Gene flow is possible within each series, but there is probably no gene flow between north and south (Appendix: Figure 2). We refer to the constructed habitat features associated with the “Evergreen” water system and the SIPF as “natural” sites since they are sustained by warm water piped from Sedillo spring and all sites contain similar constructed habitat features (Service, 2019). There is no natural gene flow between the SIPF and Sedillo spring (Bleakley et al., 2013).

There is also an extant, captive population of Socorro isopods at the Albuquerque BioPark (ABP) (NMDGF, 2021a). The ABP contains 5 large tanks, with approximately 300 individual isopods between all tanks. These populations are self-sustaining and continually reproduce (Ward pers. comm., 2021).

Sedillo spring, the SIPF, and the ABP comprise the three extant populations of the Socorro isopod. Socorro isopods breed throughout the year, and populations are structured by both age and size (NMDGF, 2019). All isopod populations appear to be healthy during recent bi-annual studies (NMDGF, 2020a).

2.2.1 Biology and Habitat

2.2.1.1 New information on the species’ biology and life history:

Socorro isopods are sexually dimorphic, with males displaying larger body sizes than females in all populations (Jones and Berg, 2020; Service, 2009; Appendix: Table 1). Size differentiation between sexes could be due in part to same-sex interactions (Bleakley et al., 2013). There are significant morphological differences in population structure that have arisen between Sedillo spring and the other two populations (the SIPF and ABP) (Lang et al., 2012). The size of females varies between the three populations more than males. Females in Sedillo spring are the smallest and those at the SIPF are the largest among all populations (Bleakley et al., 2013; Jones and Berg, 2020; Appendix: Table 1). It is unknown if this disparity in size among populations is an indication of genetic drift or the result of phenotypic plasticity in response to environmental variables (See Section 2.2.1.2 below; Jones pers. comm., 2021).

The Socorro isopod is omnivorous, eating both vegetative matter and other invertebrates, including members of the same species (Service, 2009). With few natural predators, cannibalism likely plays an important role in structuring Socorro isopod demographics (Jormalainen and Shuster, 1997). Bleakley et al. (2013) found that same-sex interactions are more likely to result in both aggression and pre-cannibalistic behavior. It is possible that natural selection from cannibalism operates differently on males and females because they experience different predation risk from same sex individuals (Bleakley et al., 2013).

Socorro isopods practice a behavior known as mate guarding, exhibited by males grasping females until they breed. It does not seem that males and females attack one another, even after failed mate guarding attempts. Therefore, cannibalistic interactions are probably not linked to mating behaviors (Bleakley et al., 2013).

Differences in the substrate between the three populations might affect the frequency of antagonistic interactions, thus driving disparity in body size (Shuster et al., 2005). The rate of body size increase for captive populations seems to be inversely proportional to the amount of physical structure present within the habitat (Lang et al., 2012). Both males and females are larger in the SIPF, where there is currently no substrate to provide shelter to smaller individuals (NMDGF, 2021a). Bleakley et al. (2013) found that pre-cannibalistic behavior is more common among individuals from Sedillo spring. The native spring offers the most physical structure, which has been demonstrated to create size-structured populations in which isopods are most likely to interact with similarly sized social partners (Jormalainen and Shuster, 1997; Shuster et al., 2005). When individuals of the same gender and size interact with one another, it seems that cannibalistic behavior is more likely (Bleakley et al., 2013).

It is possible that when individuals cannot avoid cannibalistic interactions, there could be selection pressure for overall larger body size (Jones pers. comm., 2021). Males and females of larger body sizes are more likely to initiate and survive pre-cannibalistic attacks, and relatively larger individuals were more likely to attack than smaller individuals (Bleakley et al., 2013). Therefore, it is possible that same sex competition drives selection towards larger body sizes, especially in manmade systems with little cover, such as the SIPF (NMDGF, 2021a).

2.2.1.2 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

Genetic research is needed for many endemic aquatic invertebrates in the state of New Mexico, including the Socorro isopod (Sivinski, 2018). The SIPF and ABP populations have been continuously maintained for differing lengths of time and were established from Sedillo spring on different occasions. These two populations have likely undergone separate genetic bottlenecks and probably differ in genetic structure (Bleakley et al., 2013). Variation in 57 genetic markers showed that captive populations diverged significantly from the Sedillo spring population. There was minimal genetic divergence between the SIPF and the ABP populations (Lang et al., 2012).

New Mexico Department of Game and Fish is developing a genetics management plan for the Socorro isopod (NMDGF, 2021a). To inform the plan, continuing genetic studies are underway to determine the level of genetic

differentiation among the three populations at the genomic level (NMDGF, 2020a). This study will determine the degree of genetic diversity within each of the three populations and the spatial scale at which population-level divergence is occurring (Jones and Berg, 2020). Genetic specimens were collected from the three populations in 2019. Currently, researchers are working to extract and sequence genetic material from the Socorro isopods (NMGF, 2020a). The DNA extractions are ongoing, as researchers determine an optimal protocol for Socorro isopod genomic analysis (Jones and Berg, 2019).

The Service is currently funding research on the genetic diversity, reproduction, growth, and mortality of Socorro isopods from Sedillo spring, the SIPF, and ABP. These data are still being analyzed and will be used to determine life tables and baseline population structure of each population (NMDGF, 2021a). Researchers have determined that macrophotography can be used to obtain both sex and size data and is a feasible method for monitoring demographics of this species (Jones and Berg, 2020).

2.2.1.3 Taxonomic classification or changes in nomenclature:

There have been no changes for this taxon.

2.2.1.4 Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors, pollinator availability, etc.), or historic range (e.g., corrections to the historical range, change in distribution of the species within its historic range, etc.):

Between 2013 and 2014, populations of Socorro isopods were sampled almost monthly (NMDGF, 2014). Annual surveys were then conducted in 2015 and 2016. All populations were stable between 2013 and 2016 (NMDGF, 2013; NMDGF, 2014; NMDGF, 2016). Socorro isopod populations have been sampled bi-annually for the past three years. Each population has contained all life stages; males, females, adults, and mancas (juveniles) (NMDGF, 2019; NMDGF, 2020a; NMDGF, 2021a). At the SIPF, isopods have been present in all pools during survey efforts (NMDGF, 2020a). Demographics in the pools at the SIPF have changed over the past 12 years. In 2009, NMDGF found that mancas were the most common life stage (NMDGF, 2010). Recent surveys have shown a more even distribution between males, females, and mancas (NMDGF, 2021a).

Density of the species at the Sedillo spring in 2020 was 3040 isopods/m² (NMDGF, 2021a). At the SIPF, density in the North pools averaged 333 isopods/m², and density in the South pools averaged only 42 isopods/m² (NMDGF, 2021a). It is possible that predation and substrate structure have affected population density at these sites (see section 2.2.2.3 Disease and predation) (Trujillo pers. comm., 2021).

2.2.1.5 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Habitat conditions at Sedillo spring remain unchanged. Under ideal conditions, the SIPF has two runs where water flows at a rate of 0.02 m³/min (Lang et al., 2012). When NMDGF biologists visited the SIPF in 2018 and 2019, no maintenance was required at the facility (NMDGF, 2010; NMDGF, 2020a). Repairs were needed at the facility in 2021; the outflow to the leach field in the Northern run was backing up, possibly due to tree roots in the pipes. This, in turn, caused water to contact and subsequently corrode protective screens that cover the pools. Repairs to the screens were made by Service and NMDGF biologists (NMDGF, 2021a). A more permanent solution is needed to ensure that suitable water flow is maintained at the SIPF (See section 2.2.2.5).

In July of 2012, an arsenic treatment facility was constructed for the City of Socorro public drinking water supply which is located immediately adjacent to the SIPF. New Mexico Department of Game and Fish coordinated with City of Socorro's engineers to minimize impacts to the isopod. NMDGF checked the public water supply for isopods that might have entered from Sedillo and Socorro springs, which feed the public water supply. No isopods were found in the sources, and none were taken because of these activities. Flow to the SIPF was restored in less than one hour (NMDGF, 2014).

At the SIPF, vertical habitat structure was added to some of the pools. When structure was added, isopods immediately crawled onto the structures, indicating a positive response (NMDGF, 2014). Vertical habitat provided protective structure and seemed to be effective shelter for females and juveniles (NMDGF, 2013). However, the initial vertical structure (netting) proved to be temporary. More permanent habitat structure is planned to be added to the pools in 2022 (NMDGF, 2021b; See section 2.2.1.6 below).

2.2.1.6 Conservation Measures:

Biologists from NMDGF and the Service plan to partner with the city of Socorro to maintain proper drainage at the SIPF site. Several pipes have become occluded, potentially by tree roots, which need to be cleared using plumbing equipment (NMDGF, 2021b; see Section 2.2.2.1 below). Care will be taken to ensure the population at the SIPF is protected during these activities so there are minimal effects to the animals during the procedure.

By installing structure (rocks and artificial plants) within the habitats at the SIPF, researchers hope to mimic natural habitat for the species and reduce the risk of cannibalistic behavior within the artificial habitat. Isopods seem to respond positively to artificial plants at the ABP, providing justification for using artificial plants at the SIPF.

Monitoring and genetic work are ongoing and needed to ensure the health of all Socorro isopod populations. Genetic data will inform the genetic management plan currently being developed by NMDGF biologists. Once a plan is in place, it will inform the future best management practices for species conservation and recovery. Monitoring is needed to understand trends in population size and sex ratios, which will further inform species management actions into the future.

In 2021, the Service worked internally, and with NMDGF, to develop a more accurate publicly available map for the Socorro isopod range. Through this effort, the Service will be able to provide accurate range data to partners for each species. These range maps will help better inform consultations on the species and ensure adverse impacts to both individuals and habitat are avoided and minimized (Lee pers. comm., 2021).

2.2.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):

2.2.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

In 2020, tree roots began to occlude the outflow to the SIPF facility. This has caused water to back up into the pools within areas of the SIPF. Standing water temporarily degraded the mesh screens which protect the pools from external threats such as predatory dragonflies (See section 2.2.2.3 below). Screens were repaired and replaced by Service and NMDGF biologists, and plans are underway to construct permanent structures (NMDGF, 2021b). There have been several contaminations and dewatering events that have resulted in local extirpations at the SIPF and Sedillo spring. In both cases, the species was successfully repatriated from captive populations. The species remains vulnerable to changes that effect water flow and quality within suitable habitat (Service, 2019).

Socorro isopods are subject to many perturbations that puts this species at risk of extinction. The geologic stability of the area surrounding Sedillo spring is not well understood (Service, 2019). The NMDGF (2013) identified perlite mining as a possible threat to the long-term geologic stability of the Socorro thermal area – including Sedillo spring and the SIPF. Explosive forces could affect the ground water supply in the area. Changes in stream discharge has locally extirpated the Socorro isopod before (Service, 2009). However, the exact effect of local mining on the Socorro isopod's habitat remains undetermined (NMDGF 2013).

2.2.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

When the previous 5-year review was written, there was no utilization of the isopod (Service, 2009). Recent studies have removed individuals from all populations for scientific purposes (Jones and Berg, 2020). These experiments have not affected the status of the Socorro isopod, and numbers remain stable within all populations (NMDGF, 2021a). Data from these experiments have led to a greater understanding of the biology of the species, thus enabling our ability to better conserve and recover the Socorro isopod.

2.2.2.3 Disease or predation:

When flooding degraded the structures protecting the SIPF in 2020, predatory dragonfly (order Odonata) larvae colonized the south run at the SIPF, reducing the density of Socorro isopods at that site. Dragonflies were manually removed, and protective structures were repaired. It is imperative that dragonflies do not colonize either run at the SIPF in the future (NMDGF, 2021a).

2.2.2.4 Inadequacy of existing regulatory mechanisms:

The Socorro isopod is federally listed as endangered (43 FR 12690) and State listed as endangered (NMDGF 2020b). Critical habitat has not been designated for the species. All research activities are regulated by permits and consultation by the Service and NMDGF.

2.2.2.5 Other natural or manmade factors affecting its continued existence:

At the SIPF, continuous monitoring and maintenance of the facility is needed to ensure the artificial habitat does not become degraded. Degradation of this facility has increased the risk of predation (See section 2.2.2.3), and diminished habitat quality. Without human intervention and maintenance, the population at the SIPF could risk extirpation.

There are currently no permanent conservation protections for the Sedillo spring population. State biologists maintain a working relationship with the landowner to secure occasional access to monitor and study the population (NMDGF, 2019). Work continues to ensure protections for the species at this site.

2.3 Synthesis

Since the previous 5-year review was completed, several studies have been completed which enhanced our knowledge of the species' life history and ecology. The Socorro isopod remains a rare crustacean endemic to a single spring in Socorro County, New Mexico. New information underscores the fact that the Socorro isopod occupies a fragile ecosystem, which lacks permanent or long-term habitat protections. Within habitat that lack natural structure,

cannibalistic interactions between individual isopods might affect species demographics. State biologists continue to work on a genetic management plan for the species. Once complete, this management plan will aid further genetic research and recovery efforts for the species. Maintenance at the SIPF is needed to ensure the viability of the species at that site. Until a conservation agreement is successfully executed, down or delisting of the species is inadvisable as the native population of the Socorro isopod faces several threats (NMDGF, 2009; Service, 2009). Additionally, there is a high likelihood of genetic drift between all extant populations (NMDGF, 2021a). Objective and measurable recovery criteria were developed in 2019 (Service, 2019). These criteria should be used to shape management and inform recovery success. Management and monitoring are needed to ensure that this species and maintains viability. Thus, the status of the species remains unchanged since 2009.

3.0 RESULTS

3.1 Recommended Classification:

- Downlist to Threatened**
- Uplist to Endangered**
- Delist** (*Indicate reasons for delisting per 50 CFR 424.11*):
 - Extinction*
 - Recovery*
 - Original data for classification in error*
- No change is needed**

3.2 New Recovery Priority Number (indicate if no change; see 48 FR 43098):

No change recommended.

Brief Rationale:

The recovery priority number of 2 still applies and indicates a species has a high degree of threat and high recovery potential.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

1. Develop permanent land protections for the population at Sedillo spring. Protections could be in the form of any conservation easements, agreements, or acquisition to protect the isopod population in perpetuity.
2. Continue to facilitate working relationship with the landowner of Sedillo spring. The private landowner has contributed to the conservation of the Socorro isopod by maintaining habitat and allowing access for surveys and monitoring.
3. Collect demographic and genetic data regarding genetic diversity, reproduction, sex ratios, growth and mortality of Socorro isopods from Sedillo spring, the Socorro Isopod Propagation Facility, and the Albuquerque BioPark.
4. Once developed, use genetic management plan to maintain genetic diversity and health of all three isopod populations.
5. Determine the level of genetic divergence among the three extant populations.

6. Monitor the response of the species to the addition of structure within habitat. Future experiments should help inform preferred habitat structure of the species to ensure proper management of habitat variables at all sites.
7. Maintain proper flow rates at the SIPF to sustain proper habitat parameters at the site. Monitor the SIPF to ensure future blockages do not threaten the species.
8. Construct permanent, metal hinged screens at the SIPF to reduce the risk of deterioration, which is possible with the current wood and metal screen structures.
9. Continue controlled propagation of the Socorro isopod at the SIPF and the Albuquerque BioPark, with the goal of increasing genetic variation within the species.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of Socorro Isopod (*Thermosphaeroma thermophilum*)

Current Classification: Endangered, Recovery Priority Number: 2

Recommendation resulting from the 5-Year review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: NA

Review Conducted By:

FIELD OFFICE APPROVAL:

**Lead Field Supervisor, U.S. Fish and Wildlife Service, New Mexico Ecological Services
Field Office**

Approve _____

APPENDIX

Figures and Tables

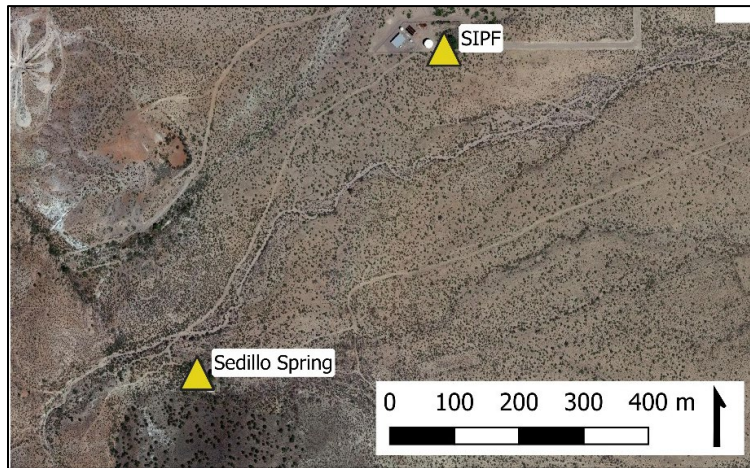


Figure 1. Site of Sedillo spring and the Socorro Isopod Propagation Facility (SIPF), Socorro County, NM (Jones and Berg, 2020).

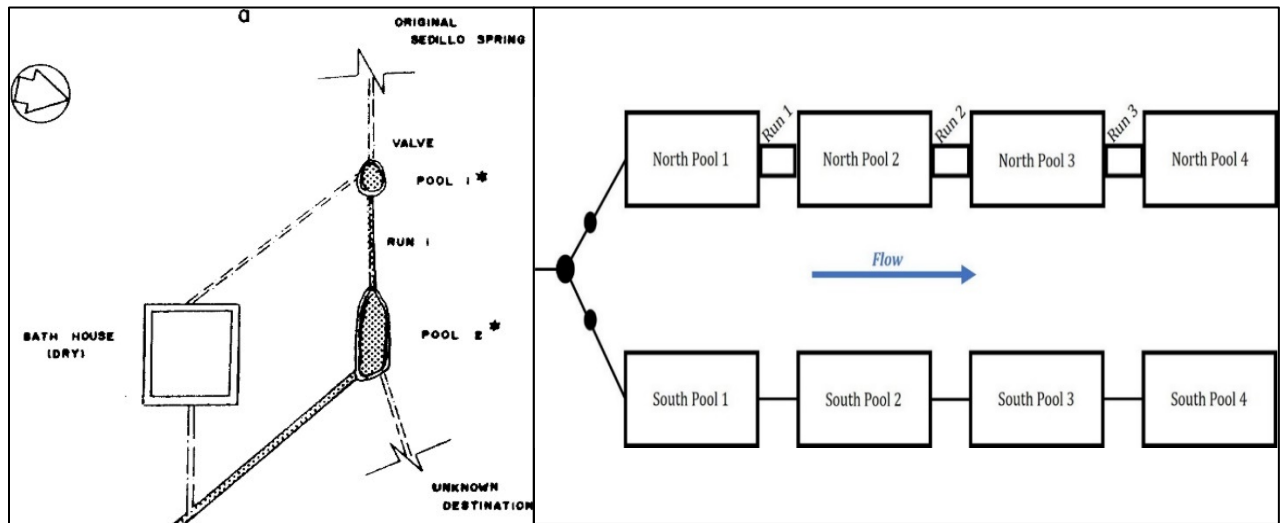


Figure 2. (Left) Sedillo spring habitat diagram; adapted from Shuster 1981. (Right) Diagram of the Socorro Isopod Propagation Facility (SIPF); adapted from Lange et al. 2006.

Table 1. Summary of demographic traits for three populations of Socorro isopod sampled in 2019.

	<i>Sedillo Spring</i>	<i>SIPF</i>	<i>ABQ BioPark</i>
<i>Total (N)</i>	39	86	22
<i>Males n (%)</i>	22(56)	30(35)	13(59)
<i>Mean size, males (mm²)</i>	21.0	41.2	22.0
<i>Standard deviation</i>	7	17	7
<i>Females n (%)</i>	7(18)	29(34)	5(23)
<i>Mean size, females (mm²)</i>	11.2	17.3	13.6
<i>Standard deviation</i>	3	8	4
<i>Immature n (%)</i>	10(26)	27(31)	4(18)
<i>Sex ratio (m/f)</i>	1.4	1.0	2.6