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Forest Service

Southwestern Region

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Supplemental Information Report

Rosemont Copper Project

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Introduction and Background

In December 2013, a final environmental impact statement (FEIS[1]) and draft record of decision (draft ROD) were published by the Coronado National Forest (Coronado) for the Rosemont Copper Project. The draft ROD described the Selected Action (Alternative 4 – Barrel Alternative, as described in the FEIS) and the rationale for its selection.

The Administrative Review Objection Period was held from January 1 through February 14, 2014. After determining that 101 objectors were eligible, the Regional Office proceeded to review and respond to these objections. This review was extended due to the content and complexity of the objections, but also because of information coming from the U.S. Fish and Wildlife Service (USFWS) regarding the sighting of a protected species (ocelot) within the analysis area. Additionally, as explained in the Regional Forester's objection response letter, a number of Objectors introduced what they presented to be "new information" not previously considered (U.S. Forest Service 2014).

In May 2014, the Coronado decided to reinitiate formal consultation under the Endangered Species Act (ESA), based on the sightings of ocelot within the project area. As part of these discussions, the Coronado made an effort to enhance the existing analysis completed for the USFWS in the previous biological assessment (BA) and in several supplemental BAs (SBAs). Both the Coronado and USFWS were striving to improve the accuracy or reduce the uncertainty of the analysis associated with the biological opinion (BO) that was prepared for the FEIS, and specifically uncertainty related to impacts within the Las Cienegas National Conservation Area (NCA), in riparian areas along Empire Gulch and Cienega Creek. A number of agencies were invited to participate in meetings and a renewed effort to exchange information, in order to better document baseline conditions and refine the hydrologic analyses related to riparian areas. This exchange brought forward numerous documents, field data, and analyses not previously provided to the Coronado, which constituted new information under National Environmental Policy Act (NEPA) regulations.

This report is informed by a number of sources of new information. One was the review of potential new information presented in objections to the FEIS and draft ROD. The Coronado conducted a review of all eligible objections for attached documents and referenced sources of information that could potentially provide new information that had not previously been considered by the interdisciplinary (ID) team. All such information was screened to determine whether the new information could reasonably result in changes to the analysis or conclusion of impacts disclosed in the FEIS. Any new information that passed this screening review was brought into this report for further evaluation. Additional sources of new information addressed in this report include materials supplied by Federal, State, and county agencies; results of additional field data collection; revised analysis using pertinent new information; and updated status of past, present, and reasonably foreseeable actions.

The new information is listed in appendix A and summarized in the "New Information" section of this report. In light of the new information, the Coronado conducted a review to determine the adequacy of the EIS. In accordance with Forest Service Handbook (FSH) 1909.15, chapter 10, section 18.1, "If new information or changed circumstances relating to the environmental impacts of a proposed action come to the attention of the responsible official after a decision has been made and prior to completion of the approved program or project, the responsible official must review the information

[1] Available at: http://www.rosemonteis.us/final-eis. Further mention of the FEIS in this report will not be accompanied by a formal citation.

carefully to determine its importance." The responsible official would then determine whether a "correction, supplement, or revision to an environmental document is necessary."

As part of the Section 7 reinitiation discussions, a number of field trips and meetings were held in 2014 and 2015 that involved all of the cooperating Federal agencies. The list in appendix A includes those meetings/field trips for which documentation is in the project record, which generally are those that involved coordination with multiple agencies and group discussion of new information and the hydrology/biology analysis. Note that other internal phone calls or communications may have taken place that are not captured in appendix A.

The objective of this supplemental information report (SIR) is to determine whether or not the new information or changed circumstances are within the scope and range of effects considered in the original analysis (40 Code of Federal Regulations (CFR) 1502.9(c); and FSH 1909.15, section 18). If the new information or changed conditions are beyond the scope and range of effects considered in the original analysis, the responsible official will determine whether the original analysis should be corrected, supplemented, or revised. If new information or changed conditions are within the scope and range of effects considered in the original analysis, the responsible official will determine whether a correction of the FEIS is needed. This report documents the ID team's review of new information and comparison of impacts with the original analysis presented in the Rosemont Copper Project FEIS.

Summary of New Information Received or Changed Conditions

A complete summary of new information received or changed conditions to be considered in this SIR is included in appendix A. The following is a summary of the general categories of information received.

The FEIS for the Rosemont Copper Project was published on December 13, 2013. In June 2012 and October 2013, the Coronado requested from the Bureau of Land Management (BLM) and other cooperators any available hydrologic information related to aquatic resources on the Las Cienegas NCA. This information was not made available with sufficient time to incorporate into the FEIS before it went to publication, but a series of items was provided by the BLM in November 2013 and is considered in this SIR.

The objection period for the FEIS took place in January and February 2014. Objections were processed and reviewed between February and May 2014, with final direction being provided to the Coronado by the Regional Forester on June 13, 2014 (U.S. Forest Service 2014). Directions to the Coronado included ensuring that all materials submitted during the objection period were fully reviewed and considered. These materials were reviewed and those containing new information are considered in this SIR. This ID team review found one document that was brought forward for consideration in this SIR: additional detail regarding the potential development of the Charles Seel mineral lease of State land.

In March 2014, staff from the Coronado visited the Caterpillar, Inc. (Caterpillar), proving grounds to discuss equipment emissions and the potential for reduction of those emissions. Additional information was provided by Caterpillar at that time and is considered in this SIR.

In May 2014, the Coronado Forest Supervisor indicated the intention to reinitiate consultation with the USFWS under Section 7 of the ESA, based on several factors, including the sighting of an ocelot in the analysis area. The Forest Supervisor requested that discussions be undertaken with BLM, USFWS, U.S. Geological Survey (USGS), and other cooperators to ensure that all pertinent information had been obtained regarding baseline conditions on Las Cienegas NCA and other aquatic resources. In addition to discussions of baseline conditions, the analysis methodologies used in the FEIS were reviewed, and possible refinements or alternative analysis methodologies were discussed. Information was received by the Coronado as part of these discussions from approximately May through November 2014 and is considered in this SIR. In particular, a large portion of this SIR discusses new information or changed conditions related to biological resources, as well as refinements to the analysis of aquatic impacts.

The list of past, present, and future reasonably foreseeable actions that informed the FEIS has been reviewed and updated, and changes are considered in this SIR.

Past, Present, and Reasonably Foreseeable Actions

For preparation of the FEIS, the ID team identified past, present, and reasonably foreseeable actions that were pertinent to the proposed project and addressed those that were applicable to specific resource analyses. Past and present actions were taken into consideration in the description of existing conditions and addressed in the analysis of direct and indirect effects, whereas reasonably foreseeable actions were considered in cumulative effects analyses. The project record contains a document that lists the past, present, and reasonably foreseeable actions considered by the ID team in their analyses. In addition, the introduction to chapter 3 of the FEIS included a list of reasonably foreseeable actions. The master list of past, present, and reasonably foreseeable actions was reviewed for changed or new information in December 2014 and January 2015. Changes to the list of past, present, and reasonably foreseeable actions are described below and addressed for pertinent resource analysis throughout this SIR.

Past Actions

All past actions considered in the FEIS remain valid. The following actions have been added to the list of past actions:

- Exploratory drilling on Rosemont private property occurred in 2014. All ground-disturbing activities occurred within the footprint of the open pit. The pit and all areas within the security fence were considered disturbed land for the purpose of impact analysis in the FEIS; therefore, the drilling adds no additional ground disturbance for any analysis.
- An estimated 33 additional wildfires occurred between 2012 and 2014 in the area that constitutes the Nogales Ranger District, the southern portion of Santa Catalina Ranger District, and the western portion of the Sierra Vista Ranger District. These wildfires ranged in size from 0.1 to 66 acres, with the majority being smaller than 10 acres in size. Only six of these fires were greater than 10 acres in size.
- Gardner Canyon Hazardous Fuels Reduction Project. A project titled Hog and Gardner Canyon Fuel Reduction Project was listed as a reasonably foreseeable action in the FEIS. The Gardner Canyon portion of this project has been completed. The Hog Canyon portion remains a foreseeable action.
- Reintroduction and augmentation of Chiricahua leopard frog, Gila topminnow, desert pupfish, Gila chub, New Mexico gartersnake, and Huachuca water umbel at various locations within the Las Cienegas NCA. This action constitutes implementation of a portion of a reasonably foreseeable action that was listed in the FEIS, and continues to be listed as foreseeable since similar reintroductions are expected in the future.

- Project segments 2A and 2B of the Sahuarita Road Phase II Project have been implemented. These involve improvements to Sahuarita Road between La Villita Road and the realigned Nogales Highway (completed August 2014); and a new alignment of Nogales Highway approximately 1 mile north and 1 mile south of Sahuarita Road (completed August 2014). The Sahuarita Road Phase II Project was considered as a present action in the FEIS, and the uncompleted segments of the project remain in the current listing as a present action.
- Noxious weed surveys and treatment in the Greaterville Fire area. This was listed as a foreseeable action in the FEIS and has since been completed.
- Designation of Santa Rita Mountains as a Traditional Cultural Place. This was listed as a foreseeable action in the FEIS and has since been completed.
- Fred Lawrence Whipple Observatory. Installation of a Cherenkov telescope dish within the permitted area. This was listed as a foreseeable action in the FEIS and has since been completed.
- Minerals Exploration Project. Blue Fire Gem Company to hand-drill shallow, 3.5-foot-deep holes to fracture rock for sampling/assay on its unpatented mining claim to obtain evidence of mineralization. Located on the Nogales Ranger District. This was listed as a foreseeable action in the FEIS and has since been completed.
- Arizona Department of Transportation (ADOT) State Route (SR) 83 right-of-way (ROW) location, milepost 40, road in place. This project, which was identified by the BLM, was considered as a present action in the FEIS and has since been completed.
- Interchange of ROW Easements between ASARCO, Inc. (ASARCO), and U.S. Government (Coronado) for National Forest System Roads (NFSRs) 4064 and 231. As part of the interchange, ASARCO acquired a Federal Land Policy and Management Act (FLPMA) easement on April 30, 1993, which was terminated by the Coronado on August 1, 2005. This was listed as a foreseeable action in the FEIS but has since been completed.
- Reconstruction of a segment of the Arizona National Scenic Trail (Arizona Trail) through the project area. This project refers to a reconstruction project that took place prior to release of the Rosemont Copper Project draft EIS (DEIS). It should not be confused with the relocation of segments of the Arizona Trail that are part of the action alternatives described in the FEIS. While this was mistakenly listed as a foreseeable action in the FEIS, it has in fact been completed.
- Road repair (pavement preservation) from Sonoita to milepost 43. This project was listed as foreseeable in the FEIS. It was scheduled to start in October 2012 and is assumed to have been completed.

Present Actions

The following changes have been made to the list of present actions:

- Project segment 2C of the Sahuarita Road Phase II Project includes the portion of Sahuarita Road between the new Nogales Highway and the eastern town limits. Construction started in January 2014, with completion anticipated for the summer of 2015. Three segments of this project were considered as present action in the FEIS; however, segments 2A and 2B have been completed (see “Past Actions” above).
- Rancho Sahuarita: Rancho Sahuarita is a 3,048-acre master-planned community located within the town of Sahuarita, adjacent to the northwestern portions of the Sahuarita Farms property. This project was listed as a foreseeable action in the FEIS. However, research

indicates that this development is now selling real estate and constructing houses and infrastructure. Therefore, it has been reclassified as a present action.

- Quail Creek. Quail Creek is a 1,700-acre master-planned retirement community located northeast of Sahuarita Farm's southernmost specific plan parcel. This project was listed as a foreseeable action in the FEIS. However, research indicates that this development is now selling real estate and constructing houses and infrastructure. Therefore, it has been reclassified as a present action.
- Madera Highlands. Madera Highlands is adjacent to the eastern boundary of the Sahuarita Farms' southernmost development parcel. It is a 920-acre master-planned community with 1,500 single-family-home sites. This project was listed as a foreseeable action in the FEIS. However, research indicates that this development is now selling real estate and constructing houses and infrastructure. Therefore, it has been reclassified as a present action.
- Madera Canyon Bridge Replacement. This project replaces two single-lane existing bridges within Madera Canyon with two 2-lane bridges and will not result in additional through-traffic on Madera Canyon or Box Canyon Roads. The bridge replacement is a safety project and should not draw additional visitors in and of itself. This project was not foreseeable at the time the FEIS was released but is now ongoing.
- Mt. Lemmon Recreation Area Improvements. This project involves installation of three tables, a bulletin board, and a fee tube at the Mt. Lemmon Recreation Site, in addition to new parking bumpers and procured trail signs at the Mt. Lemmon Recreation Area and Summit Trailheads parking. This project was not foreseeable at the time the FEIS was released but is now ongoing.
- Forestwide planting for traditional uses and pollinators on the Coronado National Forest. Implement a series of plantings to (1) increase the availability of traditional use plants for use by the Tribes and protect; and (2) expand upon the availability of habitat for pollinators that increase the sustainability of our forests. This project was not foreseeable at the time the FEIS was released but is now ongoing.
- A new document published after release of the FEIS provides results and planned future actions of the Frog and Fish Restoration Outreach Group Conservation Project (FROG Project), which was intended to restore Chiricahua leopard frogs into a large landscape in southeastern Arizona, including portions of the analysis area.

Reasonably Foreseeable Actions

The following changes have been made to the list of reasonably foreseeable actions:

- Hog Canyon, Hazardous Fuels Reduction Project. The District proposes to remove hazardous fuels on 2,500 acres in Hog Canyon on the Nogales Ranger District. Note that this originally included Gardner Hazardous Fuels Reduction Project, which has been completed and is now listed as a past action.
- In May 2010, a lease was granted to Charles Seel for mining purposes for 240 acres of Arizona State Land Department (ASLD) State Trust land (from State land commissioner) in Section 29, Township 17 South, Range 17 East, adjacent to CalPortland leases in Davidson Canyon. A mineral development plan has been submitted to and accepted by the State.
  No ground-disturbing activities have occurred, and it is not known whether or when ground-disturbing activities may occur. Although this project was listed as a foreseeable action in the FEIS, the existence and content of the mineral development plan was not known at that time. The new information contained in the mineral development plan is addressed in this SIR.

- Continued programmatic aquatic special status species reintroductions at Las Cienegas NCA (May 2012). The BLM proposes to approve a decision for programmatic aquatic special status species reintroductions at Las Cienegas NCA. A new document provided by BLM after publication of the FEIS provides updated information and documentation of the BLM proposal to reintroduce aquatic special status species at Las Cienegas NCA. This project was listed as foreseeable in the FEIS. However, it has recently come to light that the BLM has implemented a portion of this program (see past actions). The remainder of this program is still foreseeable.
- Permit Reissue. Archaeology Investigating Companies, William Self Associates, Inc., Desert Archaeology, Statistical Research, Inc., Environmental Planning Group, Inc., Jacobs Engineering Group, Inc., Gulf South Research Corporation, EnviroSystems Management, Inc., and EcoPlan Associates. This is a new project that is in the planning stages and was not considered for the FEIS.
- Madera Waterline Replacement. Modify the existing Madera water supply system to provide a reliable source of water for the residents and visitors to Madera Canyon. Water usage from three springs will cease and be replaced with a well on private property on the Nogales Ranger District. This is a new project that is in the planning stages and was not considered for the FEIS.
- Mt. Hopkins Re-Entry Thinning Project. Nogales Ranger District is coordinating with the Smithsonian Institution to thin and chip near structures on the Mt. Hopkins Observatory site. This is to maintain defensible space around the structures in the event of a wildfire. This is a new project that is in the planning stages and was not considered for the FEIS.
- Road Construction (5 miles). U.S. Customs and Border Protection (CBP). Provide improved access to the U.S.–Mexico border on the Coronado National Forest by constructing approximately 5 miles of roads that will enable CBP to safely and effectively execute its mission while protecting the forest natural resources to the degree possible. New road construction would occur in three different locations: the Fresnal Wash area, Cantinas Reservoir area, and Sycamore Canyon area.

  Newly constructed roads would be closed to public motorized use and available only for administrative use. In addition, approximately 1.2 miles of existing roads in the Fresnal Wash and Sycamore Canyon areas would be closed to motorized travel by earthen berm barriers to foster resource protection. Additionally, some of the road mileage may be claimed under the Department of Homeland Security Waiver—particularly the portion crossing the Inventoried Roadless Area (IRA). This is a new project that is in the planning stages and was not considered for the FEIS.
- Improvements at Marshall Gulch Picnic Area and Trailhead. Replace restrooms, renovate picnic sites and trailheads, install vehicular bridges over stream, naturalize stream channel, and improve roads and parking areas. This is a new project that is in the planning stages and was not considered for the FEIS.
- Grazing Permit Amendment, Papago Allotment. The District proposes to change the number of livestock authorized on the Papago allotment on the Sierra Vista Ranger District, 10 miles southeast of Sonoita, Arizona. This is a new project that is in the planning stages and was not considered for the FEIS.
- Mowry Allotment Analysis. The proposed action is to authorize continued livestock grazing on the Mowry Allotment using an adaptive management strategy. This is a new project that is in the planning stages and was not considered for the FEIS.

- Plan of Operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. The District proposes to authorize the operator to conduct 5-hole exploratory drilling activities on the Sierra Vista Ranger District, approximately 2 miles southeast of Washington-Duquesne, Arizona. This is a new project that is in the planning stages and was not considered for the FEIS.
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River, as part of its 5-year Capital Improvement Plan. Ultimately, the project will correct the structural deficiencies of the existing bridge structure and provide for additional travel lanes, bicycle lanes, sidewalks, and new waterline crossings. The project limits extend approximately 1,000 feet on either side of the Santa Cruz River.

  The remaining design efforts are anticipated to be complete within the next 4 months, with major construction of the new bridge anticipated to begin in the spring of 2015. Construction is anticipated to take 12 to 18 months, but those details will be confirmed as the final design plans are prepared and a construction contract is awarded for the project. This is a new project that is in the planning stages. It was not considered for the FEIS.
- Camp Tatiyee Land Exchange. This is a new project and was not considered in the FEIS. Nine tracts on the Coronado National Forest are proposed to be conveyed to the U.S. Forest Service (Forest Service). These parcels are scattered across the Santa Catalina, Douglas, Safford, Nogales, and Sierra Vista Ranger Districts. National Forest System (NFS) lands proposed for conveyance to a private party are not located on the Coronado National Forest.
  - The Happy Valley 40, West, and East (West in Pima County and East in Cochise County) tracts consist of approximately 359.08 record acres and are located in the Happy Valley area within the Rincon Mountains, Santa Catalina Ranger District. The Happy Valley 40 parcel is located approximately 1.5 miles east of Saguaro National Park East's Rincon Mountain Wilderness area. The Happy Valley West and East parcel is just over 1 mile east of the Happy Valley 40 parcel. The vegetative types include desert scrub, grassland, chaparral, and woodland.
  - The Stronghold tract is on parcel totaling approximately 1.10 record acres, located approximately 9 miles northwest of Pearce, Arizona, in East Stronghold Canyon in the Dragoon Mountains. The Rucker tract consists of two separate parcels totaling approximately 320.00 record acres, located along NFSR 74 approximately 30 miles north of Douglas, Arizona, in Rucker Canyon in the Chiricahua Mountains. Both tracts are located on the Douglas Ranger District. The vegetative types include undeveloped grasslands, desert scrub, chaparral, woodland, and coniferous forest, with some riparian areas that have high attraction to recreationists.
  - The Ronstadt Highway tract is a parcel totaling approximately 135.08 record acres, located in the Stockton Pass area along SR 266, approximately 3 miles southeast of the Arizona State Prison at Fort Grant. The Ronstadt Tank tract consists of a parcel totaling approximately 80.00 record acres, located in Bar-X Canyon, Pinaleño Mountains, on the Safford Ranger District. The vegetative types include desert scrub, grassland, chaparral, and woodland.
  - The Mansfield tract is a parcel totaling approximately 182.41 record acres, consisting of nine patented lode mining claims located approximately 7 miles northwesterly of Patagonia, Arizona, in Mansfield Canyon within the Santa Rita Mountains on the Nogales Ranger District. The parcel contains six small areas of concern (mine adits and waste rock material sites, one site of which is greater than 1,000 cubic yards and is located on the Mansfield Canyon stream bank) that may be restored during the Mansfield Canyon Mines Site removal action under the authority of a Watershed Restoration and

Enhancement Act (Wyden Amendment). Vegetative types include desert scrub, grassland, chaparral, and woodland.

  - The Harshaw Creek tract is a parcel totaling approximately 75.64 record acres, located approximately 6 miles southeast of Patagonia, Arizona, along Harshaw Creek between the Patagonia Mountains and the Canelo Hills within the Sierra Vista Ranger District. Vegetative types include desert scrub, grassland, chaparral, and woodland with a lower-elevation, intermittent stream extending into oak and mesquite in the bottom.
  - The Babcock tract is a parcel totaling approximately 11.15 record acres on the Prescott National Forest. It is a patented lode mining claim located approximately 3 miles south of Crown King, Arizona, on the Bradshaw Ranger District. Vegetative types include primarily chaparral with interspersed pinyon/juniper.
- Helicopter use by the Arizona Game and Fish Department (AGFD) within Pusch Ridge Wilderness to capture and investigate mortalities of desert bighorn sheep. To increase the potential for successful reintroduction of desert bighorn sheep, AGFD requires the intermittent use of helicopters for the first 4 years of the reintroduction and restoration process. This is a new project and was not considered in the FEIS.
- Bear Canyon Bark Beetle Sanitation Project. Fell and remove bark beetle infested trees to reduce bark beetle populations, to protect surrounding trees and stands, and to mitigate fire hazard associated with beetle-killed trees on the Santa Catalina Ranger District. Developed recreation sites and surrounding areas, including Cypress, Middle Bear, and Chihuahua Pine Picnic Areas and General Hitchcock Campground. Generally, canyon bottom and north-facing slopes.

In addition, the following projects have been removed from the list of reasonably foreseeable actions:

- The Loma Linda Hazardous Fuels Reduction Project located south of Summerhaven, Arizona, was listed as a foreseeable action in the FEIS. However, it was subsequently incorporated into the Catalina-Rincon FireScape Project proposed on the Santa Catalina Ranger District. The Catalina-Rincon FireScape Project was listed as and remains a foreseeable action that was considered in the FEIS.
- The Forest Service proposes to approve a mine plan of operations (MPO) for Javelina Minerals Exploration for mineral exploration drilling of eight holes in an area located approximately 3 miles southeast of Patagonia, Arizona. Activities would occur for a maximum of 1 year. This project has been cancelled.
- The Forest Service proposes to approve an MPO to OZ Exploration Proprietary Ltd. for mineral exploration drilling in the East Paymaster and Guajolote Flats areas in the Patagonia Mountains. Activities would occur for a maximum of 1 year. This project has been cancelled.
- The Forest Service proposes to approve an MPO for minerals exploration drilling on the Helix Margarita property for a maximum of 1 year. This property is located near Arivaca in Santa Cruz County, Arizona, about 75 miles south of Tucson, Arizona. This project has been cancelled.

Analysis of New Information

Geology, Minerals, and Paleontology

Summary of Applicable New Information and/or Changed Conditions

Other than the following item, no new information or changed conditions were identified that would occur within the analysis area and pertain to geology, minerals, and paleontology.

Past Actions

- Exploratory drilling on Rosemont private property. All ground-disturbing activities are within the footprint of the open pit. The pit and all areas within the security fence were considered disturbed land for the purpose of impact analysis in the FEIS; therefore, the drilling adds no additional ground disturbance for any analysis.

Present Actions

- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions was listed as a reasonably foreseeable action in the FEIS. These projects have since been initiated, and the status has changed to present actions.

Baseline Conditions Considering New Information and Changed Conditions

Baseline conditions described in the FEIS pertain primarily to geological rock types, disturbance, and known sites of cave and paleontology artifacts. The identified new information would result in no change to the current baseline conditions, as the disturbance related to recent mineral exploration drilling took place within the footprint of the mine pit, which was considered a disturbed area in the analysis in the FEIS.

Summary of FEIS Analysis Methodology and Impact Conclusions

The analysis for geology, minerals, and paleontology considered impacts of geology and groundwater and those implications on cave and paleontological resources. The following factors were addressed in the analysis:

- Tons of rock removed.
- Quantitative assessment of the potential for loss of paleontological resources using the Potential Fossil Yield Classification (PFYC) System.
- Qualitative assessment of geotechnical and seismic stability of the pit.
- Qualitative assessment of the potential for disturbance of cave resources.

Impact Conclusions

Direct and Indirect Impacts

- For all action alternatives, the operation would excavate and relocate approximately 1.8 billion to 1.9 billion tons of geological material of both sulfide and oxide rock types, as outlined in table 13 of the FEIS.
- The level of disturbance of moderate to high PFYC classes of rock for the action alternatives ranges from 2,449 acres for the Scholefield-McCleary Alternative to 3,541 acres for the Barrel Trail Alternative.
- For all action alternatives, the qualitative assessment of geotechnical and seismic stability of the pit show that failure is unlikely because of the design criteria for expected seismic activity.
- For all action alternatives, there is no disturbance to known caves expected, and the geological formations have low potential for caves. Therefore, it is unlikely that unknown resources would be impacted.

Cumulative Impacts

No impacts to geology, minerals, or cave resources are expected from any of the action alternatives. Therefore, foreseeable actions would not contribute to cumulative impacts for those resources. The four projects that were considered to have the potential to disturb paleontologically significant geological formations are listed below:

- The BLM proposes to approve an MPO to expand the Andrada Mine limestone quarry in the Davidson Canyon drainage system north and northeast of the Santa Rita Mountains. The Andrada Mine is located approximately 4 miles from the Tucson, Arizona, city limits and 1 mile from the Vail, Arizona, city limits. This expansion has the potential to impact paleontological resources should they exist in the areas proposed for disturbance.
- In late 2009, Freeport-McMoRan bought 8,900 acres of the long-closed Twin Buttes Mine site, near Sahuarita. Required permits for reopening the mine have not been issued to date, but it is reasonable to assume that this mine could be reopened at some point in the future. Activities associated with reopening and operating this mine have the potential to impact paleontological resources through ground disturbance.
- Development of the Farmers Investment Company property within the Town of Sahuarita's jurisdiction over the next 40 to 50+ years for residential and commercial mixed use is proposed, along with the enhancement of more than 12 miles of the Santa Cruz River in both the town of Sahuarita and Pima County. Much of this land has been actively managed for agriculture for many decades; however, the potential for development activities still exists.
- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions could have an impact. Ground-disturbing activities associated with these subdivision expansions have the potential to further impact paleontological resources.

No effects from climate change are expected for geological or paleontological resources from any of the action alternatives. Because most caves in southeastern Arizona are seasonally wet to some degree, climate change would result in less moisture available to caves, thus impacting this resource.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

There are no changes to the analysis methodology or conclusion of impacts for geology, minerals, and paleontology. As noted, the recent Rosemont Copper Company (Rosemont Copper) exploration activity was located in an area analyzed in the FEIS as disturbed; therefore, there are no changes to the analysis disclosed in the FEIS.

The expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions was addressed as a reasonably foreseeable action in the FEIS. The impacts described therein remain applicable, and no change in the analysis or conclusion of impacts disclosed in the FEIS is warranted.

Summary of Findings

No new information or changed conditions were identified that would result in changes to the description of baseline conditions, the analysis methodology, or the conclusions of impacts presented in the FEIS for geology, minerals, and paleontology.

Soils and Revegetation

Summary of Applicable New Information and/or Changed Conditions

Other than the following item, no new information or changed conditions were identified that would occur within or pertain to the analysis area for soils and revegetation.

Past Actions

- Exploratory drilling on Rosemont private property. All ground-disturbing activities are within the footprint of the open pit. The pit and all areas within the security fence were considered disturbed land for the purpose of impact analysis in the FEIS; therefore, the drilling adds no additional ground disturbance for any analysis.

Baseline Conditions Considering New Information and Changed Conditions

Baseline conditions described in the FEIS pertain primarily to current levels of soil disturbance and to potential plant community and soil conditions. The identified new information would result in no change to the current baseline conditions, as the disturbance related to recent mineral exploration drilling took place within the footprint of the mine pit, which was considered a disturbed area in the FEIS analysis.

Summary of FEIS Analysis Methodology and Impact Conclusions

The analysis for soils and revegetation considered impacts on land stability and soil productivity. The following factors were addressed in the analysis:

- Qualitative assessment of long-term stability of tailings and waste rock facilities, including expected results of reclamation.
- Acres and quantitative level of disturbance leading to lost soil productivity.
- Qualitative assessment of the potential for revegetation of tailings and waste rock facilities.
- Qualitative evaluation of alteration of soil productivity and soil development.
- Tons per year of sediment delivery to Davidson Canyon, Cienega Creek, or other streams and washes, compared with background sediment loading.

Impact Conclusions

Direct and Indirect Impacts

- For all action alternatives, modeling indicates that waste rock and tailings would be more stable than required by regulations.
- The level of disturbance leading to lost soil productivity for the action alternatives ranges from 5,431 acres for the Barrel Alternative, to 6,197 acres for the Scholefield-McCleary Alternative.
- For all action alternatives, onsite test plots and greenhouse studies indicate that revegetation can produce a vegetation volume that is similar to historic climax conditions under proper management.
- For all action alternatives, soil productivity would be reclaimed following placement of soil or soil/rock cover and revegetation, with the exception of the 955-acre mine pit.

- Tons of sediment delivery to Davidson Canyon, Cienega Creek, or other streams and washes, compared with background sediment loading, would range from 16,000 tons for the proposed action to 24,200 tons for the Scholefield-McCleary Alternative.

Cumulative Impacts

None of the reasonably foreseeable actions as identified on the Coronado ID team's list of reasonably foreseeable future actions fall within the analysis area for soils; therefore, these actions are not analyzed for their effect on soil or soil productivity. Trends in past and present actions, such as increased recreation from an increasing population, are expected to affect areas that have already been impacted; these areas have been analyzed as part of the affected environment.

Expected climate change conditions could have an effect on the success rate of revegetation and therefore on long-term soil stability. Revegetation could become more difficult due to the potential for more variable temperatures and precipitation. Some models predict higher temperatures and prolonged droughts, whereas other models predict warmer and wetter conditions in the Southwest.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

There are no changes to the analysis methodology or conclusion of impacts for soils and revegetation.

Summary of Findings

No new information or changed conditions were identified that would result in changes to the description of baseline conditions, the analysis methodology, or the conclusions of impacts presented in the FEIS for soils and revegetation.

Air Quality and Climate Change

Summary of Applicable New Information and/or Changed Conditions

In March 2014, representatives from the Coronado met with representatives of Caterpillar at the Tinaja Hills testing facility in Green Valley, Arizona. Caterpillar is the manufacturer of much of the mobile mine equipment to be purchased by Rosemont Copper, and the purpose of the meeting was to discuss timing and phasing of more stringent emission requirements (specifically, Tier IV engines). As part of this discussion, Caterpillar provided updated emission factors for particulate matter (PM), nitrogen oxides (NO_x), or carbon monoxide (CO), for Tier 2 equipment currently available (Kistner 2014a, 2014b).

Additional calculations based on these emission factors were requested from Rosemont Copper by the Forest Service and provided on January 16, 2015, with a clarification provided on February 3, 2015 (Hudbay Minerals 2015b, 2015e; SWCA Environmental Consultants 2015a).

The Council on Environmental Quality (CEQ) has issued draft guidance on Consideration of Greenhouse Gas Emissions and the Effect of Climate Change in NEPA Reviews (Council on Environmental Quality 2014). This draft guidance is intended to help explain how agencies of the Federal government should analyze the environmental effects of greenhouse gas (GHG) emissions and climate change when they describe the environmental effects of a proposed agency action. A review of the draft guidance indicates that the FEIS analysis of climate change meets the guidance provided by CEQ. The draft guidance does not constitute new information that would result in any changes to the analysis or conclusion of impacts disclosed in the FEIS.

The following new information and changed conditions were noted.

Past Actions

- Exploratory drilling on Rosemont Copper private property. All ground-disturbing activities are within the footprint of the open pit. The pit and all areas within the security fence were considered disturbed land for the purpose of impact analysis in the FEIS; therefore, the drilling adds no additional ground disturbance for any analysis.
- Additional wildfires that occurred between 2012 and 2014.
- Hazardous fuels treatment in Gardner Canyon has been accomplished.

Present Actions

- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions has been reclassified from a reasonably foreseeable action, as presented in the FEIS, to a present action. These developments are actively selling real estate and constructing homes and associated infrastructure.

Reasonably Foreseeable Actions

- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes.
- Plan of operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. The Forest Service proposes to authorize the operator to conduct a five-hole exploratory drilling activities on the Sierra Vista Ranger District.
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River, as part of its 5-year Capital Improvement Plan.

Baseline Conditions Considering New Information and Changed Conditions

Baseline conditions for air quality and climate change remain essentially the same as described in the FEIS. Additional mining exploration and residential development have occurred in the analysis area since the release of the FEIS, but these are a continuation of past and present actions and the whole impacts described in the FEIS. Mineral exploration projects are typically short-term, isolated projects that result in little ground disturbance and no air quality impacts once the project is completed and drilling equipment is removed. The description of baseline conditions for air resources in the FEIS remains accurate.

Summary of FEIS Analysis Methodology and Impact Conclusions

The FEIS used a variety of methodologies to assess air quality impacts, including emission inventory estimates, AERMOD modeling of potential exceedances of National Ambient Air Quality Standards (NAAQS) at the perimeter fenceline, and CALPUFF modeling of impacts to Class I areas in the vicinity of the mine.

The only alternative that met all NAAQS at the perimeter fenceline was the Barrel Alternative. Other alternatives exceeded NAAQS for PM, either particulate matter 10 (PM_{10}) or particulate matter 2.5 ($PM_{2.5}$). All alternatives increased emissions of GHGs (an increase of approximately 1 percent of Pima County total GHG emissions) and NO_x (an increase of approximately 3.4 to 3.9 percent of Pima County total NO_x emissions). All alternatives also potentially would contribute to degradation of air quality related values (visibility and deposition) in nearby Class I areas, including Saguaro National Park East, Saguaro National Park West, and the Galiuro Wilderness Area.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

The air quality modeling and emissions calculations used in the FEIS assumed that most equipment would meet Tier 4 engine standards, with the exception of haulage trucks. Haulage trucks represent the largest amount of emissions from the mine equipment (roughly 80 to 90 percent), and the FEIS modeling and calculations assumed that haulage trucks would be a mix of Tier 2 and Tier 4 equipment, depending on availability at the time the equipment is ordered and received from Caterpillar. Specifically, for each alternative, the analysis assumed the first 25 haulage trucks would have Tier 2 engines and the remaining trucks would have Tier 4 engines.

The emission factors provided by Caterpillar in March/April 2014 represent updates to the Tier 2 emission factors used in the FEIS analysis. Compared with the emission factors used in the FEIS for the first 25 haulage trucks, the most recent data from Caterpillar indicate that all emission factors are reduced:

- The NO_x/VOC emission factor changed from 4.8 grams pollutant per horsepower-hour (g/hp-hr) to 4.55 g/hp-hr.
- The CO emission factor changed from 2.6 g/hp-hr to 1.72 g/hp-hr.
- The PM emission factor changed from 0.15 g/hp-hr to 0.142 g/hp-hr.

Table 42 in the FEIS summarizes the total annualized emissions for each alternative. The Coronado requested that this table be updated using the most recent emission factors.[2] These results show that, as expected based on the reduced emission factors, total annual emissions for each alternative are also slightly reduced. For instance, for the Barrel Alternative:

- PM_{10} particulate emissions are reduced from 1,037.7 tons/year to 1,036.3 tons/year.
- $PM_{2.5}$ particulate emissions are reduced from 147.8 tons/year to 146.4 tons/year.
- NO_x emissions are reduced from 1,190.2 tons/year to 1,151.1 tons/year.
- CO emissions are reduced from 1,475.1 tons/year to 1,320.7 tons/year.
- SO_2 and lead emissions remain the same.

Past Actions

- Exploratory drilling on Rosemont Copper private property. *This action consisted of minor disturbance on private property to facilitate exploration temporary drilling. The disturbance is minor and would not contribute toward air quality impacts during mine operations.*
- Additional wildfires that occurred between 2012 and 2014. *Wildfires occur in the analysis area annually. During the period from 2012 to 2014, an estimated 33 wildfires occurred, ranging in size from 0.1 acre to 66 acres. The majority were less than 10 acres in size. While wildfires have air quality impacts, these would not contribute toward air quality impacts during mine operations. No changes in the overall impacts disclosed in the FEIS have resulted from these wildfires.*

[2] Note that there are two letters from Rosemont regarding this issue (January 16, 2015, and February 3, 2015). The first letter mistakenly replaces all haulage trucks with the revised Tier 2 emission factors, which is not a scenario that would occur. The second letter corrects this mistake.

- Hazardous fuels treatment in Gardner Canyon has been accomplished. *Hazardous fuels treatments also have minor air quality impacts but would not contribute toward air quality impacts during mine operations.*

Present Actions

- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions is currently underway. The developments are actively selling real estate and constructing homes and associated infrastructure. *These actions were considered as reasonably foreseeable in the FEIS and addressed in the cumulative effects analysis. The impacts disclosed remain valid.*

Reasonably Foreseeable Actions

- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes. *While this project was listed as reasonably foreseeable in the FEIS, no information regarding plans for mining was known. Subsequently, a mineral development plan was discovered that was submitted to the ASLD. While no ground-disturbing activity has occurred on the site, the mineral development plan outlines the plan of operations for the proposed mining activity and provides an environmental assessment of potential impacts. Operations of this proposed mining activity would have air impacts, but it would not modify the air quality analysis or change the conclusion of impacts to air resources disclosed in the FEIS. It should be noted that there is no indication whether or when ground-disturbing activities may occur for this project.*
- Plan of operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. *This is a short-term use that would cause minimal surface disturbance. Drilling equipment would cause some air quality impacts in the short term while activities are ongoing. However, due to the small area impacted, expected reclamation, and short duration of these activities, this action would not change the conclusion of impacts to air quality disclosed in the FEIS.*
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River. *This is a short-term use that would cause minimal surface disturbance and air emissions at the bridge site only. It would not change the conclusion of impacts to air quality resources disclosed in the FEIS.*

Summary of Findings

Based on the revised emission inventory from Rosemont Copper, the revised emission factors received from Caterpillar result in fewer emissions overall than those disclosed in the FEIS.

Some of the reasonably foreseeable actions have changed that could have local, short-term impacts. The change in timing of these impacts suggests that they are going to be unlikely to overlap those of the proposed Rosemont Copper Project and would not result in cumulative impacts.

Groundwater Quantity

Summary of Applicable New Information and/or Changed Conditions

A letter was received from Mr. Don Pressnall identifying a new well and spring located east of the mine pit on private property not owned by Rosemont Copper (Pressnall 2014).

In January 2015, Rosemont Copper provided updated monitoring results for groundwater wells, springs, and surface water monitoring, including groundwater levels (Hudbay Minerals 2015e).

Several modeling issues were reviewed as part of the Section 7 discussions between May and November 2014. None of these were pertinent to the overall groundwater quantity analysis, as they focused specifically on distant water sources at Empire Gulch. These modeling documents are explicitly reviewed in the “Seeps, Springs, and Riparian Areas” section.

The following new information and changed conditions were noted.

Present Actions

- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions has been reclassified from a reasonably foreseeable action, as presented in the FEIS, to a present action. These developments are actively selling real estate and constructing homes and associated infrastructure.

Baseline Conditions Considering New Information and Changed Conditions

The baseline conditions for groundwater quantity described in the FEIS remain valid, with no changes or modifications. Wells were not analyzed individually, as explained in the FEIS (see p. 291, FEIS), and the presence of another individual well does not change the baseline conditions disclosed.

Additional groundwater levels were obtained from Rosemont Copper. Groundwater contours were disclosed in the FEIS; these contours are based on analysis of a large number of wells and groundwater levels throughout the basin. The updated groundwater levels obtained from Rosemont Copper are similar in nature to those observed previously and, when considered with all other groundwater levels, would not change the overall groundwater depths and flow directions disclosed in the FEIS.

Summary of FEIS Analysis Methodology and Impact Conclusions

Impacts to groundwater quantity were largely analyzed using four numerical groundwater models: three of these were conducted in the area of the mine site itself on the east side of the Santa Rita Mountains, and one was conducted in the area of the mine water supply pumping on the west side of the Santa Rita Mountains.

Measurement factors included:

- Direction and feet of change in water table level, including annual average, range, and rate, compared with background
- Impairment of mountain-front groundwater recharge function
- Geographic extent in which water resources may be impacted
- Duration of the effect (in years)
- Comparison of mine pit water loss by evaporation with overall basin water balance
- Potential reduction in subsurface groundwater outflow from Davidson Canyon to Cienega Creek
- Approximate number of wells within the geographic extent of the impact
- Water needed for operations from the Santa Cruz Valley and comparison with other water uses and basin water balance, measured in acre-feet
- Potential for subsidence to occur as a result of groundwater withdrawal near the mine water supply pumping
- Approximate number of wells within the geographic extent of the impact

For all alternatives, a cone of depression would develop near the mine site due to the development of the mine pit, and near the mine water supply wells due to pumping. The total dewatering loss near the mine site during active mining ranges from 13,000 to 18,500 acre-feet. There is also an annual water loss in perpetuity of 170 to 370 acre-feet due to the presence of the mine pit lake, which is equivalent to approximately 3 percent of basin recharge. The total water use pumped from the mine water supply wells is 99,600 acre-feet, with permitted water use up to 120,000 acre-feet. Annual water use of 5,400 acre-feet during first 8 years represents an increase of 6.7 percent in area pumping. A total of 360 to 370 wells are estimated to be impacted because of the drawdown near the mine site, and 500 to 550 wells are estimated to be impacted because of drawdown near the mine water supply wells. In the Davidson Canyon/Cienega Creek basin, there would also be impacts to mountain front recharge (estimated as a reduction of 35 acre-feet per year) and subsurface outflow from Davidson Canyon (ranging from 4.4 to 11.7 percent reduction).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

Analysis of impact to individual wells was not undertaken in the FEIS, as inadequate information exists to do so in a credible manner. Instead, the overall number of wells that would be impacted by certain levels of drawdown was estimated (see table 66, FEIS, p. 353). These numbers remain valid.

The additional data points represented by new groundwater levels would not affect the overall modeling results, which are developed based on the entire period of record throughout the Cienega Creek Basin. The results disclosed in the FEIS remain valid.

Present Actions

- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions is currently underway. The developments are actively selling real estate and constructing homes and associated infrastructure. *These actions were considered reasonably foreseeable in the FEIS and addressed in the cumulative effects analysis. The impacts disclosed remain valid.*

Summary of Findings

The identification of an additional well in the area, and the availability of more recent groundwater levels does not change the findings from those presented in the FEIS.

Some of the reasonably foreseeable actions have changed to ongoing activities that could have long-term impacts on groundwater quantity. Use of water by these developments in the Santa Cruz groundwater subbasin would overlap those of the proposed Rosemont Copper Project and would result in similar cumulative impacts to those disclosed in the FEIS.

Groundwater Quality

Summary of Applicable New Information and/or Changed Conditions

Several new pieces of information were received pertinent to groundwater quality. The Coronado received additional isotope and geochemistry data for area wells and springs in June and July 2014 (Rosemont Copper Company 2014c, 2014d). In January 2015, the Coronado also received additional groundwater quality data based on regular monitoring conducted during 2014 (Hudbay Minerals 2015e).

Present Actions

- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands residential developments has been reclassified from a reasonably foreseeable action, as presented in the FEIS, to a present action. These developments are actively selling real estate and constructing homes and associated infrastructure.

Baseline Conditions Considering New Information and Changed Conditions

Baseline groundwater quality is disclosed in the FEIS based on sampling results available at the time of publication and is presented as the median, along with a range of results encountered either in wells or springs (see tables 71 and 72, FEIS, pp. 380–381).

The new information provided since the FEIS (roughly, data from July 2013 through the present) was reviewed for consistency with the ranges of ambient groundwater quality disclosed in the FEIS. Multiple new samples contained concentrations higher than those disclosed in the FEIS. These include:

- Antimony. Both dissolved and total antimony exceeded the range of ambient groundwater quality indicated in the FEIS in well DC-3B in February 2014.
- Arsenic. Total arsenic exceeded the range of ambient groundwater quality indicated in the FEIS in well RP-2B (July 2013) and Zackendorf Spring (April 2014).
- Barium. Total barium exceeded the range of ambient groundwater quality indicated in the FEIS in well RP-2B for five samples between July 2013 and October 2014, in Empire Gulch Spring (June 2014), and in Rosemont Spring (August 2013).
- Beryllium. Total beryllium exceeded the range of ambient groundwater quality indicated in the FEIS in well RP-2B in two samples (July 2013 and January 2014).
- Chromium. Total chromium exceeded the range of ambient groundwater quality indicated in the FEIS in numerous wells (DC-3B, RP-5, RP-3A, RP-2B, HC-6, HC-5B, HC-1B) and springs (Helvetia, Zackendorf) between July 2013 and October 2014.
- Lead. Total lead exceeded the range of ambient groundwater quality indicated in the FEIS in six samples from well RP-2B (July 2013 to October 2014) and in multiple springs (Helvetia, Peligro Adit, Rosemont, Zackendorf) between September 2013 and October 2014.
- Selenium. Total or dissolved selenium exceeded the range of ambient groundwater quality indicated in the FEIS in numerous wells (DC-3B, HC-5B, HC-1B, P-899, Pc-2, RP-2C) and springs (Papago, Questa, Zackendorf, Mulberry) between November 2013 and October 2014.
- Concentrations of cadmium, mercury, nickel, and thallium were all within the range of ambient groundwater quality indicated in the FEIS.

Summary of FEIS Analysis Methodology and Impact Conclusions

Analysis of impacts to groundwater quality made use of geochemical models to evaluate the likely concentrations of metals and other constituents in tailings seepage, waste rock seepage, and heap leach seepage. The geochemical models were based on a variety of static and kinetic tests for different types of waste rock. Additional analyses looked at expected water quality in the mine pit lake and at the potential for the occurrence of technologically enhanced naturally occurring radioactive materials (TENORM) and explosive residue. Details of control technologies (such as pond liners) were evaluated to help determine the potential fate and transport of contaminants. Potential impacts on the Sierrita sulfate plume due to pumping of mine water supply wells were also evaluated.

Analysis for all alternatives indicates that modeled water quality for potential seepage from tailings and waste rock would meet aquifer water quality standards. Water quality from the lined heap leach pad (for all alternatives except Barrel) would exceed standards for some metals but would not be discharged to the aquifer without treatment. Water quality analyses indicate the mine pit lake would exceed some regulatory standards (thallium, potentially ammonia); however, the mine pit lake is not regulated under either surface water or aquifer water quality standards.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

The additional baseline information obtained suggests that existing groundwater quality for some constituents could be greater than anticipated and disclosed. It should be noted that the new baseline information represents the most recent samples from a sampling protocol that began in approximately 2008; for any analysis, the entire period of record for water quality samples has to be considered together. The revised baseline conditions would not affect the analysis of tailings, waste rock, or heap leach seepage. The modeling conducted to analyze these effects does not rely on the ambient groundwater quality, nor are any conclusions drawn based on the ambient groundwater quality.

Unlike the geochemical modeling for the tailings and waste rock seepage, the predicted water quality of the mine pit lake does take into account the background groundwater quality, and specifically uses the average water quality for monitoring wells PC-1 through PC-8. The samples that were used to calculate this average water quality were collected during the first round of monitoring in 2008. Two more samples were collected from well PC-2 in 2012 and 2014, and one more sample was collected from well PC-8 in 2014.

- The additional samples were below laboratory detection limits for total and dissolved concentrations of the following constituents. If incorporated into the average groundwater quality from wells PC-1 through PC-8, these sample results would reduce the overall concentrations used in the pit lake analysis for these constituents: aluminum, antimony, arsenic, barium, beryllium, cadmium, carbonate, cobalt, copper, mercury, nickel, silver, thallium, uranium, and zinc.
- The average bicarbonate concentration used in the pit lake geochemical modeling was 187 milligrams per liter (mg/L). The additional samples range from 110 to 190 mg/L. If incorporated into the average groundwater quality from wells PC-1 through PC-8, these additional samples would reduce the average bicarbonate concentration (and also alkalinity) to 184 mg/L.
- The average calcium concentration used in the pit lake geochemical modeling was 131 mg/L. The additional samples range from 47 to 74 mg/L. If incorporated into the average groundwater quality from wells PC-1 through PC-8, these additional samples would reduce the average calcium concentration to 123 mg/L.
- The average chloride concentration used in the pit lake geochemical modeling was 8.36 mg/L. The additional samples range from 6.4 to 9.5 mg/L. If incorporated into the average groundwater quality from wells PC-1 through PC-8, these additional samples would reduce the average chloride concentration to 8.31 mg/L.
- The average fluoride concentration used in the pit lake geochemical modeling was 0.85 mg/L. The additional samples range from 0.72 to 1.9 mg/L. If incorporated into the average groundwater quality from wells PC-1 through PC-8, these additional samples would increase the average fluoride concentration to 0.90 mg/L.

- The average chromium concentration used in the pit lake geochemical modeling was <0.01 mg/L. All additional samples are less than this and if incorporated into the average groundwater quality from wells PC-1 through PC-8, these sample results would reduce the overall concentrations used in the pit lake analysis.
- The average iron concentration used in the pit lake geochemical modeling was 0.554 mg/L. The one additional sample is less than this and if incorporated into the average groundwater quality from wells PC-1 through PC-8, this sample result would reduce the average iron concentration to 0.546 mg/L.
- The average lead concentration used in the pit lake geochemical modeling was 0.00092 mg/L. All additional samples are less than this and if incorporated into the average groundwater quality from wells PC-1 through PC-8, these sample results would reduce the average lead concentration to 0.0089 mg/L.
- The average manganese concentration used in the pit lake geochemical modeling was 0.174 mg/L. The one additional sample is less than this and if incorporated into the average groundwater quality from wells PC-1 through PC-8, this sample result would reduce the average manganese concentration to 0.171 mg/L.
- The average molybdenum concentration used in the pit lake geochemical modeling was 0.121 mg/L. The additional sample for molybdenum is 0.25 mg/L, and if incorporated into the average groundwater quality from wells PC-1 through PC-8, this sample result would increase the average molybdenum concentration to 0.126 mg/L.
- The average nitrate concentration used in the pit lake geochemical modeling was 0.49 mg/L. The additional samples range from 0.52 to 0.54 mg/L, and if incorporated into the average groundwater quality from wells PC-1 through PC-8, these sample results would not change the average nitrate concentration (still 0.49 mg/L).
- The average selenium concentration used in the pit lake geochemical modeling was 0.00212 mg/L. The additional samples are all below laboratory detection limits, and if incorporated into the average groundwater quality from wells PC-1 through PC-8, these samples would increase the average selenium concentration to 0.00285 mg/L.
- The average sulfate concentration used in the pit lake geochemical modeling was 300 mg/L. The additional samples ranged from 7.7 to 120 mg//L, and if incorporated into the average groundwater quality from wells PC-1 through PC-8, these additional samples would reduce the average sulfate concentration to 276 mg/L.

The addition of any samples will mathematically change the average concentrations. For most of the constituents listed, the additional samples collected from wells PC-1 through PC-8 since the first round of data collection in 2008 would not change or would reduce the average ambient groundwater quality, and therefore when incorporated into the pit lake geochemical model would reduce the concentrations of these constituents predicted to occur in the pit lake. Concentrations of three constituents in post-2008 groundwater samples would increase the average ambient groundwater quality (see SWCA (2015e) for details of calculations). These constituents include fluoride (a potential increase from 0.85 mg/L to 0.89 mg/L), molybdenum (a potential increase from 0.121 mg/L to 0.126 mg/L), and selenium (a potential increase from 0.00212 mg/L to 0.00285 mg/L). In addition, the overall alkalinity of the ambient groundwater also decreased from 187 mg/L to 184 mg/L, which would have a mathematical effect on the pit lake acidity. Potentially, these additional groundwater samples could change the overall output of the geochemical pit lake model if incorporated into the average ambient groundwater quality.

The FEIS analysis disclosed the potential for elevated metal concentrations in the pit lake that exceed state surface water standards for wildlife, and although these standards are not applicable by regulation to the pit lake, they indicate there could be potential impacts to wildlife species due to pit lake water quality. As a result, during the preparation of the FEIS, mitigation and monitoring measures were considered for the pit lake, informed both by public comments received on the DEIS and discussions with cooperating agencies. A specific measure (FS-GW-04) was developed and incorporated into the mitigation and monitoring plan (see appendix B in FEIS).

Measure FS-GW-04 anticipated the situation that additional water quality or geochemical testing data would be made available that could affect the outcome of the pit lake model. Because the pit lake will not exist until after closure of the mine, geochemical modeling is the only method to determine future pit lake water quality. It was recognized that estimates of pit lake water quality would likely change over time as more and better information becomes available. Measure FS-GW-04 requires Rosemont Copper to assess all available new information and rerun the pit lake geochemical model every 5 years during operations. By reassessing data and rerunning the model, predictions of pit lake water quality at the time of mine closure will be based on an extensive database of pertinent information and would allow for effective mitigation measures to be developed during mine closure.

Present Actions

- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions is currently underway. The developments are actively selling real estate and constructing homes and associated infrastructure. *These actions were considered reasonably foreseeable in the FEIS and addressed in the cumulative effects analysis. The impacts disclosed remain valid.*

Summary of Findings

The new information received changes the overall baseline conditions with respect to ambient groundwater quality but does not factor into the analysis for the potential for tailings, waste rock, or heap leach seepage to impact groundwater quality. The ambient groundwater quality does play a large role in the pit lake geochemical modeling and incorporation of new groundwater sampling information would change future predictions of pit lake water quality. Periodic changes to the pit lake geochemical model due to the receipt of new water quality and geochemical information were anticipated and addressed in the FEIS through mitigation and monitoring measure FS-GW-04, and will occur during mine operations.

Some of the reasonably foreseeable actions have changed to ongoing activities that could have long-term impacts on groundwater quality by changing flow directions within the Santa Cruz groundwater subbasin. Use of water by these developments in the Santa Cruz groundwater subbasin would overlap the proposed Rosemont Copper Project and would result in the cumulative impacts that are disclosed in the FEIS.

Surface Water Quantity

Summary of Applicable New Information and/or Changed Conditions

As a result of the Section 7 discussions between May and November 2014, several new sources of stream flow data were provided to the Coronado, including monitoring on Empire Gulch and Cienega Creek from the BLM and Pima Association of Governments (PAG). This information is discussed in detail in the "Seeps, Springs, and Riparian Areas" section.

In January 2015, Rosemont Copper provided additional information regarding monitoring of stormwater in the Barrel and Davidson Canyon watersheds (Hudbay Minerals 2015c; Water and Earth Technologies 2014).

The following new information and changed conditions were noted.

Past Actions

- Exploratory drilling on Rosemont Copper private property. All ground-disturbing activities are within the footprint of the open pit. The pit and all areas within the security fence were considered disturbed land for the purpose of impact analysis in the FEIS; therefore, the drilling adds no additional ground disturbance for any analysis.
- Additional wildfires that occurred between 2012 and 2014.
- Hazardous fuels treatment in Gardner Canyon has been accomplished.

Reasonably Foreseeable Actions

- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes.
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River, as part of its 5-year Capital Improvement Plan.

Baseline Conditions Considering New Information and Changed Conditions

The surface water quantity section of the FEIS discloses baseline stream flow conditions for several drainages, including those downstream of the mine site (Barrel, Davidson, Lower Cienega Creek) and those that potentially could be impacted by mine drawdown (Upper Cienega Creek).

The additional information obtained provides additional baseline stream flow data for Cienega Creek in two locations (Upper Cienega Creek above Gardner Canyon, and Lower Cienega Creek at Marsh Station Road), as well as Empire Gulch. No information was available for Empire Gulch when the FEIS was published.

The additional information includes new surface flow monitoring stations in Barrel and Davidson Canyons. These stations provide detail on the current frequency of flows that occur in Barrel Canyon and Davidson Canyon. In Barrel Canyon, a total of 23 days of storm flow occurred in 2013; most of these were related to monsoon events between July and September, with several additional days of flow occurring in November. In Davidson Canyon, a total of 2 days of storm flow occurred in 2013 related to monsoon events. The baseline conditions used in the “Surface Water Quantity” analysis remain unchanged; however, the additional information has been used extensively in the “Seeps, Springs, and Riparian Areas” analysis.

Summary of FEIS Analysis Methodology and Impact Conclusions

The surface water quantity analysis includes analysis of impacts to stock tanks, potential impacts to downstream surface water rights, and predicted impacts to the volume of stormwater runoff. Predictions of change in stormwater runoff were made using pre- and post-mine stormwater runoff models to analyze the change in mine site topography and runoff characteristics.

Overall, none of the alternatives were determined to have negative effects on beneficial use of surface water. Impacts to stock tanks varies by alternative, ranging from 5 to 15 stock tanks directly lost because of surface disturbance from the mine, and from 5 to 6 stock tanks potentially affected indirectly by changes in runoff conditions; however, the analysis concluded that indirect impacts on the stock tanks were likely to be negligible. All of the alternatives impact surface water flows during operation, with estimated reductions from 30 to 50 percent. Postclosure, the reductions in surface water runoff vary by alternative. The greatest impact was predicted from the proposed action alternative, with a 45.8 percent reduction in annual surface water volume, as measured at the Barrel Canyon gage. The least impact was predicted from the Barrel Alternative, with a 17.2 percent reduction. The percentage of reduction grows less with distance downstream; reductions at the confluence of Davidson Canyon with Cienega Creek range from 11.1 to 4.3 percent.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

The additional information extends the period of record available for downstream stormwater flows, but with just over 1 year of monitoring, it is not yet of sufficient length to change the overall baseline condition for stormwater flows in Barrel and Davidson Canyons. The peak flows that occurred in 2013 were substantially less than the 100-year, 24-hour peak flow predicted in the FEIS, and do not change any conclusions regarding future runoff conditions.

Past Actions

- Exploratory drilling on Rosemont Copper private property. *This action consisted of minor disturbance on private property to facilitate exploration temporary drilling. The disturbance is minor, and surface disturbance would not be likely to substantially contribute to changes in watershed runoff characteristics.*
- Additional wildfires that occurred between 2012 and 2014. *Wildfires occur in the analysis area annually. During the period from 2012 to 2014, an estimated 33 wildfires occurred, ranging in size from 0.1 acre to 66 acres. The majority were less than 10 acres in size. New fires do have an effect on watershed runoff characteristics, but in the context of the whole watershed, these fires are generally a small percentage of the drainage area. Past wildfires have been recovering over time, and these newer fires will also recover over time. No changes in the overall impacts disclosed in the FEIS have resulted from these wildfires.*
- Hazardous fuels treatment in Gardner Canyon has been accomplished. *Hazardous fuel treatments are similar to wildfires in that they both result in removal of vegetation to various degrees, changes watershed characteristics such as surface cover, and, depending on magnitude, typically only involve a small percentage of the drainage area. The discussion above regarding additional wildfires pertains to this action as well.*

Reasonably Foreseeable Actions

- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes. *While this project was listed as reasonably foreseeable in the FEIS, no information regarding plans for mining was known. Subsequently, a mineral development plan was discovered that was submitted to the ASLD. While no ground-disturbing activity has occurred on the site, the mineral development plan outlines the plan of operations for the proposed mining activity and provides an environmental assessment of potential impacts. This project would contribute to ground disturbance within the Davidson Canyon drainage and affect watershed runoff characteristics. The cumulative impacts disclosed in the FEIS remain valid. It should be noted that there is no indication whether or when ground-disturbing activities may occur for this project.*

- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River. *This is a short-term use that would cause minimal surface disturbance at the bridge site only. It would not change the conclusion of impacts to surface water resources disclosed in the FEIS.*

Summary of Findings

A review of new information and changed conditions indicates that no changes to the description of baseline conditions, analysis methodology, or the conclusions of impacts presented in the FEIS for surface water quantity are warranted.

While some of the reasonably foreseeable actions could have impacts on the watershed, the impacts are similar to those disclosed in the FEIS.

Surface Water Quality

Summary of Applicable New Information and/or Changed Conditions

At the time of publication of the FEIS in December 2013, the Arizona Department of Environmental Quality (ADEQ) had not yet issued the State water quality certification under Section 401 of the Clean Water Act (CWA). The 401 water quality certification was issued by ADEQ on February 3, 2015 and was reviewed, as well as the basis for decision previously published by ADEQ in ADEQ (Arizona Department of Environmental Quality 2014, 2015). Pima County also reviewed and commented on the basis for decision (Pima County 2014a).

In January 2015, Rosemont Copper provided additional information concerning stormwater quality samples collected in Barrel Canyon. Stormwater sampling data that were used in the FEIS analysis had been made available through September 2011; the additional information provided extends that period of record through 2014.

The following new information and changed conditions were noted.

Past Actions

- Exploratory drilling on Rosemont private property. All ground-disturbing activities are within the footprint of the open pit. The pit and all areas within the security fence were considered disturbed land for the purpose of impact analysis in the FEIS; therefore, the drilling adds no additional ground disturbance for any analysis.
- Additional wildfires that occurred between 2012 and 2014.
- Hazardous fuels treatment in Gardner Canyon has been accomplished.

Reasonably Foreseeable Actions

- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes.
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River, as part of its 5-year Capital Improvement Plan.

Baseline Conditions Considering New Information and Changed Conditions

Baseline surface water quality conditions were included in the surface water quality section for stormwater in Barrel Canyon (see table 105, FEIS, p. 475). The additional information substantially extends the period of record for stormwater samples, which is used for comparison with predicted stormwater runoff from the mine site. The following baseline changes were noted:

- The concentrations included in the additional stormwater samples are not any greater than the range disclosed in the FEIS for aluminum (total), antimony (total), arsenic (total), barium (total), beryllium (total), boron (total), cadmium (total), calcium (total), chloride (total), copper (total), iron (total), lead (total), manganese (total), magnesium (total), mercury (dissolved), molybdenum (dissolved), nickel (total and dissolved), selenium (total), silver (total and dissolved), thallium (total), and zinc (total).
- For arsenic (dissolved), one sample was included in the additional information that has a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from 0.029 to 0.0603 mg/L.
- For cadmium (dissolved), one sample was included in the additional information that has a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from below laboratory detection limits to 0.0092 mg/L.
- For copper (dissolved), two samples were included in the additional information that have a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from 0.152 to 3.3 mg/L.
- For fluoride (total), seven samples were included in the additional information that have a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from 0.17 to 1.4 mg/L.
- For lead (dissolved), two samples were included in the additional information that have a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from 0.0748 to 1.2 mg/L.
- For mercury (total), two samples were included in the additional information that have a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from 0.00176 to 0.0029 mg/L.
- For molybdenum (total), one sample was included in the additional information that has a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from 0.0229 to 0.024 mg/L.
- For nitrates, two samples were included in the additional information that have a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from 8.3 to 140 mg/L.
- For potassium (total), 64 samples were included in the additional information that have a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from 13 to 132 mg/L.
- For sodium (total), two samples were included in the additional information that have a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from 69 to 100 mg/L.
- For sulfate three samples were included in the additional information that have a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from 42 to 66 mg/L.
- For total dissolved solids, 26 samples were included in the additional information that have a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from 436 to 1,600 mg/L.

- For zinc (dissolved), three samples were included in the additional information that have a concentration greater than the range disclosed in the FEIS, increasing the high end of the range from below laboratory detection limits to 2.7 mg/L.

Additional baseline surface water quality was included in the FEIS for Davidson Canyon and Cienega Creek; however, these were for base flow samples, not for stormwater samples. The additional information now provides stormwater quality samples in Davidson Canyon that were not previously available. These are analyzed in the "Seeps, Springs, and Riparian Areas" section of this report as part of the analysis of the Outstanding Arizona Waters (OAWs).

Summary of FEIS Analysis Methodology and Impact Conclusions

The measurement factors used in the "Surface Water Quality" section include the ability to meet Arizona surface water quality standards (specifically in Barrel Canyon at the point of discharge), change in geomorphology downstream of the mine, the acres and location of areas that could be indirectly impacted by surface water quality changes, and the acres of potentially jurisdictional waters of the U.S. (WUS) that could be impacted.

The ability to meet Arizona surface water quality standards in Barrel Canyon was analyzed by using geochemical tests from waste rock and soil samples to estimate what surface water runoff quality might look like. This prediction was then compared with water quality standards, as well as the existing stormwater quality observed in Barrel Canyon. The possibility that tailings seepage might "daylight" into Barrel Canyon was also analyzed by comparing the modeled water quality of the tailings seepage with surface water quality standards and existing stormwater quality observed in Barrel Canyon. Overall, it was found that existing stormwater quality exceeds water quality standards for silver, arsenic, copper, lead, selenium, and thallium. Predictions of waste rock runoff indicate that it could exceed the surface water quality standard for dissolved silver; however, this prediction could be mitigated by the waste rock segregation techniques that would be implemented.

Geomorphology was analyzed by modeling of pre-mine and post-mine sediment loads, as well as in two independent geomorphological expert reports. The results indicate that the sediment load would decrease overall for all alternatives but that given the geomorphology of the channel, scour due to the lower sediment load was unlikely to occur.

The downstream waters that could be indirectly impacted by stormwater quality changes remains the same for all alternatives, including 2.5 miles of Barrel Canyon and 14 miles of Davidson Canyon. The acres of jurisdictional waters directly impacted by the mine footprint varies among alternatives, ranging from 48.9 acres for the Scholefield-McCleary Alternative to 84.1 acres for the Barrel Trail Alternative.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

The additional information received changes the baseline conditions for stormwater quality in Barrel Canyon, which formed part of the analysis of expected runoff water quality. However, the measurement factor for this issue is the compliance with surface water quality standards, which are independent of the ambient stormwater quality and rely solely on geochemistry tests conducted on waste rock samples.

Some of the constituents found in existing stormwater have a substantially greater range of concentrations once the extended period of record is included. This does not change analysis of impacts, except to reinforce the analysis that under the no action alternative, some surface water quality standards are likely exceeded under current conditions.

The documents concerning the 401 water quality certification technically do not have any bearing on the FEIS analysis. The ADEQ conducted its own analysis and estimates of potential surface water quality impacts, independent of the approach and techniques used in the FEIS, and ultimately issued a water quality certification that Arizona surface water quality would not degrade water quality in Barrel Canyon or in downstream waters, including the OAWs in Davidson Canyon and Cienega Creek. The analysis in the FEIS did not rely on the ADEQ 401 water quality certification.

Past Actions

- Exploratory drilling on Rosemont private property. *This action consisted of minor disturbance on private property to facilitate exploration temporary drilling. The disturbance is minor, and surface disturbance would not be likely to substantially contribute to changes in watershed runoff characteristics.*
- Additional wildfires that occurred between 2012 and 2014. *Wildfires occur in the analysis area annually. During the period from 2012 to 2014, an estimated 33 wildfires occurred, ranging in size from 0.1 acre to 66 acres. The majority were less than 10 acres in size. New fires do have an effect on watershed runoff characteristics, but in the context of the whole watershed, these fires are generally a small percentage of the drainage area. Past wildfires have been recovering over time, and these newer fires will also recover over time. No changes in the overall impacts disclosed in the FEIS have resulted from these wildfires.*
- Hazardous fuels treatment in Gardner Canyon has been accomplished. *Hazardous fuel treatments are similar to wildfires in that they both result in removal of vegetation to various degrees and in changes to watershed characteristics such as surface cover, and, depending on magnitude, typically only involve a small percentage of the drainage area. The discussion above regarding additional wildfires pertains to this action as well.*

Reasonably Foreseeable Actions

- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes. *It should be noted that there is no indication whether or when ground-disturbing activities may occur for this project. While this project was listed as reasonably foreseeable in the FEIS, no information regarding plans for mining was known. Subsequently, a mineral development plan was discovered that was submitted to the ASLD. While no ground-disturbing activity has occurred on the site, the mineral development plan outlines the plan of operations for the proposed mining activity and provides an environmental assessment of potential impacts. This project would contribute to ground disturbance within the Davidson Canyon drainage and affect watershed runoff characteristics. The cumulative impacts disclosed in the FEIS remain valid.*
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River. *This is a short-term use that would cause minimal surface disturbance at the bridge site only. It would not change the conclusion of impacts to surface water resources disclosed in the FEIS.*

Summary of Findings

The new information received changes the overall baseline conditions with respect to ambient stormwater quality in Barrel Canyon, but does not change the analysis of predicted runoff water quality from mine facilities and does not change the conclusions in the FEIS.

While some of the reasonably foreseeable actions could have impacts on the watershed, the cumulative impacts are similar to those disclosed in the FEIS.

Seeps, Springs, and Riparian Areas

Summary of Applicable New Information and/or Changed Conditions

Most of the new information received since publication of the FEIS was related either to biological resources or to riparian areas and aquatic systems. The following section is organized into several categories:

- Cooperative reviews of predictive analysis techniques,
- Additional information concerning physical hydrology,
- Additional scientific and technical literature reviewed, and
- Changes to past, present, and reasonably foreseeable actions.

Note that many of the meetings listed in appendix A, including several field trips to Las Cienegas NCA with BLM biologists, were also pertinent to this resource section; these are not repeated here.

Cooperative Reviews of Predictive Analysis Techniques

As noted earlier, as part of reinitiation of Section 7 consultation, between May and November 2014, the Coronado engaged various Federal agencies (BLM, USFWS, USGS), cooperators (Pima County, AGFD), and Rosemont Copper to solicit additional information concerning baseline conditions of aquatic systems, and to critique and evaluate available approaches for predicting impacts to the Empire Gulch and Cienega Creek[3] aquatic systems. This resulted in a series of memos from various parties, containing proposed approaches, critiquing proposed approaches, and suggesting refinements to proposed approaches.

Rosemont Copper/WestLand Resources – Probabilistic Wet/Dry Mapping Approach

Rosemont Copper and their contractor, WestLand Resources, Inc. (WestLand), provided a critique of the existing FEIS analysis as well as proposing a different approach for assessing impacts to Cienega Creek and Empire Gulch based on the results of annual wet/dry mapping (Hudbay Minerals 2015d; Rosemont Copper Company 2014a, 2014b; WestLand Resources Inc. 2014a, 2015g). This approach was further reviewed and commented upon by the USGS (U.S. Geological Survey 2014f), as well as Dr. Tom Myers at the request of Pima County (Myers 2014; Pima County 2014b). Additionally, WestLand had prepared a memorandum in 2012 as part of the Section 7 consultation process that described statistical relationships between groundwater levels and flow conditions on Lower Cienega Creek. While this does not constitute new information as it was available and considered during preparation of the FEIS, this memorandum was also reviewed by Dr. Tom Myers at the request of Pima County, and the review does constitute new information.

[3] For the purposes of this document, the terms “Lower Cienega Creek” and “Upper Cienega Creek” are sometimes used. “Lower Cienega Creek” refers to that portion of Cienega Creek that lies approximately between I-10 and Pantano Dam, which is largely located within the Pima County Cienega Creek Natural Preserve. “Upper Cienega Creek” refers to that portion of Cienega Creek that lies upstream of I-10; much of this area lies within the BLM Las Cienegas NCA.

SWCA Environmental Consultants – FEIS Analysis Approach

Preliminary critiques in May and June 2014 focused on perceived shortcomings in the FEIS approach for predicting stream flow impacts on Empire Gulch and Cienega Creek. In a series of memoranda and meetings, SWCA Environmental Consultants (SWCA) further evaluated the approach used in the FEIS and, based on new information received, also refined the approach to respond to some concerns and make full use of newly available information (Garrett 2014a, 2014b).

The refined approach was further reviewed and commented upon by the USGS (U.S. Geological Survey 2014e), as well as Dr. Tom Myers at the request of Pima County (Myers 2014; Pima County 2014b). Additionally, SWCA had prepared a memorandum in 2013 providing details of the FEIS analysis of stream flow impacts. While this does not constitute new information as it was available and considered during preparation of the FEIS, this memorandum was also reviewed by Dr. Tom Myers at the request of Pima County, and the review does constitute new information.

Pima County – Statistical Correlations on Lower Cienega Creek

Pima County attended a meeting on June 10 and 11, 2014, and presented a statistical analysis of correlations between groundwater levels, stream flow, and wet/dry mapping on Lower Cienega Creek (Postillion 2014; Powell 2014c). A written report covering these same topics was also submitted later by Pima County (Powell et al. 2014). The Pima County analysis was further reviewed and commented upon by the USGS (U.S. Geological Survey 2014d).

SWCA – StreamStats Approach

During the June 10 and 11, 2014, meeting, the USGS suggested the potential use of the USGS StreamStats website to extend existing measured stream flow records to other locations in the watershed where measurements have not been made. SWCA reviewed and documented the potential use of this data source (Garrett 2014e; U.S. Geological Survey 2014a, 2014b).

USGS – Generic Stream Flow Interaction Modeling

During the June 10 and 11, 2014, meeting, the USGS suggested the potential use of a generic and simplified groundwater flow model to explore the mathematical relationship between drawdown in the aquifer and changes in stream flow. Modeling files were later provided by Dr. Stan Leake of the USGS (Leake 2014; SWCA Environmental Consultants 2015d).

Rosemont Copper/Hydro-Logic – Revised Empire Gulch Modeling

Stream flow within Empire Gulch was not explicitly modeled in any of the three groundwater models used for the FEIS analysis. During the June 10 and 11, 2014, meeting, it was discussed whether such modeling could be explored for Empire Gulch using the Hydro-Logic groundwater flow model (referred to in the FEIS as the "Tetra Tech" model). Hydro-Logic conducted additional modeling and presented those results in a memorandum (O'Brien 2014a). The refined approach was further reviewed and commented upon by the USGS (U.S. Geological Survey 2014c).

Additional Information Concerning Physical Hydrology

Arizona Department of Environmental Quality – Physical Integrity Survey

Several cooperators identified a study that had been conducted by Hans Huth and Lin Lawson of ADEQ in 2000–2001, surveying and recording the physical characteristics of Cienega Creek (Huth 2002, 2006, 2014a, 2014b; Lawson and Huth 2003; SWCA Environmental Consultants 2015c).

Rosemont Copper/WestLand Resources – Cross Sections

As a response to the meetings conducted on June 10 and 11, 2014, WestLand conducted fieldwork to survey several cross-sections along Empire Gulch (WestLand Resources Inc. 2014b).

Pima County – Drought Conditions

Pima County provided an update from the PAG on the ongoing drought conditions on Cienega Creek (Pima Association of Governments 2014).

Rosemont Copper – Isotope and Geochemistry Data

During the meetings conducted on June 10 and 11, 2014, the availability of isotope and geochemistry data for Empire Gulch was discussed. Rosemont Copper subsequently provided a summary spreadsheets of all available isotope and geochemistry data for the project area (Rosemont Copper Company 2014c, 2014d). Much of this information was previously disclosed and used in the FEIS, but the isotope samples on Empire Gulch had not been previously seen and thus constitutes new information. Other isotope samples collected within the Las Cienegas National Conservation Area were also made available by BLM (Desert Botanical Gardens 2014).

As discussed in the “Groundwater Quality” section, in January 2015 Rosemont Copper also provided additional monitoring data that included water quality samples for groundwater and surface water/stormwater, including isotope samples (Hudbay Minerals 2015e). Stormwater quality monitoring in Barrel Canyon was already discussed under the “Surface Water Quality” section of this SIR. Stormwater quality monitoring conducted in Davidson Canyon is also pertinent to the OAW analysis contained in the FEIS and is therefore discussed under this resource section, as well.

BLM – Precipitation and Temperature Data

In November 2013, BLM provided precipitation data for 11 rain gages, for the period from November 2012 through April 2013 (Garrett 2014d). BLM also provided data for temperature data collected from sensors placed within the Las Cienegas NCA (Bureau of Land Management 2012).

BLM – Groundwater Levels and Well Data

In November 2013, the BLM provided a variety of information on groundwater levels and wells within the Las Cienegas NCA. Information includes photos of wells, details of well construction, and maps of well locations (Bureau of Land Management 2014b; Garrett 2014d; Haney 2005).
In addition, a database of groundwater levels was provided that contained data for over 50 wells. Older water levels date back to the 1950s, with more frequent water-level measurements starting around 2011. These files also include groundwater levels from piezometers, some of which are coupled with stream flow monitoring locations (described below).

BLM – Stream Flow

In November 2013, the BLM provided flow monitoring data for two locations on Las Cienegas NCA (Bureau of Land Management 2013b). One location is located on Cienega Creek, upstream of Gardner Canyon. The other location is in Empire Gulch, downstream of the Upper Empire Gulch Springs. Stream flow has been monitored every few months since approximately 2006–2007. Additional stream flow measurements at these two locations were also provided by the BLM in 2014, encompassing the most recent monitoring (Bureau of Land Management 2014a).

USGS – Stream Flow

At the time the FEIS was prepared, only one stream gage location was known on Upper Cienega Creek (USGS stream gage 09484550, Cienega Creek near Sonoita). Stream flow and water-level data from this gaging station were used in the FEIS analysis. The most recent data at this gaging station have been obtained for 2014 (U.S. Geological Survey 2015).

BLM – Wet/Dry Mapping

Several entities conduct wet/dry mapping on Cienega Creek every year during the low-flow period in May and June. The wet/dry mapping conducted by Pima County on Lower Cienega Creek in the Cienega Creek Natural Preserve (CCNP) was known to exist and was used in preparation of the FEIS. BLM also conducts similar wet/dry mapping on the Las Cienegas NCA, including both Cienega Creek and Empire Gulch. This information was provided by BLM after completion of the FEIS, originally in November 2013 (Bureau of Land Management 2013b), but also updated later to include the most recent mapping in 2014 (Bureau of Land Management 2014a). Procedures used for wet/dry mapping were also provided (Bureau of Land Management 2014c).

SWCA – Pool Depth Surveys

As part of the discussions with other federal agencies, and in response to criticisms of the FEIS analysis approach, it became clear that an important aspect of the hydrologic system is the continued presence of water in the stream during the critical low-flow season of May and June. Even if stream flow ceases during these times, there typically are standing pools. The presence of these refugia pools is deemed critical to the ability of aquatic species to survive prior to the onset of monsoon rains.

Several approaches for addressing this aspect of the hydrologic system were discussed, and eventually a data collection protocol and scope of work were developed. This data collection took place in November and December 2014 and involved the pedestrian survey of nine key reaches[4] on Empire Gulch and Cienega Creek, the identification of standing pools, and the measurement and recording of key characteristics of the pools, including length, width, and depths.

These data were processed and summarized in a memorandum (SWCA Environmental Consultants 2015b).

Additional Temperature/Precipitation Data

Additional information was compiled to better analyze ongoing trends in the aquatic system and estimate potential impacts from climate change. These include temperature and precipitation data for three monitoring locations (Tucson, Green Valley, and Vail) (National Oceanic and Atmospheric Administration National Climatic Data Center 2014).

EPA STORET Flow Measurements

Several historic stream flow measurements on Cienega Creek were available in the U.S. Environmental Protection Agency (EPA) STORET database; these were obtained and used in the analysis (U.S. Environmental Protection Agency 2014).

Lower Cienega Creek Stream flow Measurements and Groundwater Levels

Upon review of the Pima County and WestLand analyses of water levels on Lower Cienega Creek, raw data were requested and received from both parties (Cerasale 2014; Powell 2014a, 2014b).

WestLand Riparian Extent Analysis

At the request of the Coronado, WestLand Resources conducted an analysis of satellite imagery along Cienega Creek and Empire Gulch between 1995 and 2014 (Hudbay Minerals 2015a; WestLand

[4] The key reaches used for the analysis are described later in the "Seeps, Springs, and Riparian Areas" section of the SIR.

Resources Inc. 2015f). The purpose of this analysis was to evaluate potential impacts from the ongoing drought on the riparian gallery.

Additional Observations of Aquatic Environment

Several pieces of information were submitted to the Coronado that reflect various observations or summaries of the riparian or aquatic environment; note that some of these were also available and reviewed during the FEIS (Leidy 2013; Pima Association of Governments 2011; Powell 2013b; Simms 2014d; U.S. Environmental Protection Agency 2013a, 2013b). A large series of photos from BLM was also reviewed that describe riparian conditions at certain cross sections within the Las Cienegas NCA (Bureau of Land Management 2007a). Several other documents concerning riparian and aquatic environments were also reviewed (Bureau of Land Management 2004, 2007c; Simms 2004a, 2004b).

Additional Technical and Scientific Literature Reviewed

Several additional publications were reviewed for use in the refined aquatic analysis, particularly with respect to effects on riparian vegetation. These include the following.

- A thesis prepared by Hans Huth was brought to the attention of the Coronado by the EPA. The thesis, prepared in 1996, concerns geochemical analysis of mountain front recharge in the Cienega Creek basin and the potential sources of water to Cienega Creek (Huth 1996).
- Additional literature review was conducted regarding vegetation responses to hydrologic changes (Busch and Smith 1995; Capon 2003; Cooper and Merritt 2012; Cooper et al. 1999; Elmore et al. 2003; Gitlin et al. 2006; Gitlin and Whitham 2007; Grady et al. 2011; Hendrickson and Minckley 1984; Horton and Clark 2001; Horton et al. 2001; Leenhouts et al. 2006; Lite 2004; Lite and Stromberg 2005; Nilsson and Svedmark 2002; Parmesan 2006; Rains et al. 2004; Rehfeldt et al. 2006; Scott et al. 1999; Shafroth et al. 1998; Shafroth et al. 2000; Stella et al. 2010; Stromberg 1997; Stromberg et al. 1993; Stromberg et al. 1996).
- Additional literature review was conducted regarding climate change and future water availability (Anderson and Woosley Jr. 2005; Barlow and Leake 2012; Foti et al. 2012; Garrick et al. 2011; Nadeau and Medgal 2011a; Nadeau and Megdal 2011b).
- Additional literature was reviewed regarding groundwater/surface water interactions (Barlow and Leake 2012).
- A series of technical reports and information was reviewed dating from the 1970s, related to development of water resources for the Empire Ranch. These were primarily pertinent to understanding of the groundwater system, and were discussed during some meetings (Anamax Mining Company 1980, n.d. [1971], n.d. [1975]-a, n.d. [1975]-b; Harshbarger and Associates 1975, n.d. [1975]).

Past, Present, and Reasonably Foreseeable Actions

In addition to the above, the following new information and changed conditions were noted.

Past Actions

- Additional wildfires that occurred between 2012 and 2014.
- Hazardous fuels treatment in Gardner Canyon has been accomplished.

Reasonably Foreseeable Actions

- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes.

- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River, as part of its 5-year Capital Improvement Plan.

Baseline Conditions Considering New Information and Changed Conditions

Information That Does Not Reflect New Information or Changed Conditions

The following does not represent new information about baseline conditions, or reflect changed conditions since publication of the FEIS. The latter category includes several analysis approaches that were proposed and thoroughly discussed during agency meetings and calls between May and November 2014, but were not determined to include any useful tools for refining predictions of aquatic impacts.

- USGS StreamStats Website. The potential to use this website to fill gaps in hydrologic data was investigated, but found that it provided no additional baseline information or predictive capability (Garrett 2014e).
- USGS Generic Stream Flow Modeling. This approach was offered as an alternative to using a 1:1 relationship between water levels in the aquifer and water levels in a stream. This relationship has indeed been revised in the refined predictions of aquatic impacts contained in this SIR, but the revised relationship is based on empirical field data, which were determined to be more applicable and suitable than theoretical mathematical modeling.
- Hydro-Logic Revised Empire Gulch Modeling. This revised modeling was conducted at the request of the Coronado with the intent of better understanding the expected changes in stream flow in Empire Gulch. This modeling approach was thoroughly discussed, including a written review by the USGS. However, it was determined that the underlying hydrologic assumption about the connection between Upper Empire Gulch Springs and the regional aquifer was insufficient to describe likely real-world hydrologic conditions (Garrett 2014c).

New Information or Changed Conditions

The following information represents either new information regarding baseline conditions in the project area, or changed conditions since publication of the FEIS. The latter category includes several analysis approaches that were proposed, thoroughly discussed during agency meetings between May and November 2014, and contained certain key aspects that were useful to help refine predictions of aquatic impacts.

- WestLand Probabilistic Wet/Dry Mapping Approach. Overall, this proposed approach was not determined to be appropriate for use in refining predictions of aquatic impacts. However, this approach was designed in part to fill a gap in the FEIS analysis—namely, the presence of water that remains in the stream, even if stream flow falls to zero (as was predicted in the FEIS). An analysis of pools remaining when stream flow ceases has been incorporated into the refined prediction of aquatic impacts included in this SIR.
- SWCA Refined FEIS Approach. This approach was developed to make use of new information obtained since publication of the FEIS and to respond to criticisms of the FEIS approach, primarily regarding the assumed mathematical relationship between drawdown in the aquifer and flow in the stream. Specifically, instead of assuming impacts based solely on water level—i.e., 1 foot of drawdown in the aquifer would equal 1 foot of drawdown in the stream—the refined approach uses stream flow data and piezometer water levels to develop an empirical relationship between aquifer drawdown and changes in stream flow. This refinement has been carried through into the refined prediction of aquatic impacts included in

this SIR. An additional refinement is the use of multiple stream flow data sources, instead of only making use of the USGS stream gage on Upper Cienega Creek.

- Pima County Statistical Correlations on Lower Cienega Creek. This proposed approach was developed to describe correlations of stream flow and flow extent on Lower Cienega Creek with groundwater levels. While these relationships and information were not used in the form presented by Pima County, other analyses were conducted for this SIR that are of a similar nature and were informed by the data and results presented by Pima County.
- ADEQ Physical Integrity Survey and WestLand Empire Gulch Cross-Sections. Very little information was available during preparation of the FEIS regarding the physical topography of the Cienega Creek and Empire Gulch stream channels (width, depth, presence of pools). Both of these information sources provide additional details that better describe baseline conditions of the aquatic environment.
- Pima County Drought Conditions; BLM Temperature and Precipitation Data; Updated Temperature and Precipitation Records. While this type of climatic information was available and used in the FEIS (see chapter 3, “Air Quality” section, FEIS, pp. 229–238; see chapter 3, “Seeps, Springs, and Riparian Areas” section, FEIS, pp. 505–506, 525–526), these records represent updated information with either greater detail, greater geographic coverage, or extension of data coverage through 2014.
- Rosemont Copper Isotope/Geochemistry Data. Most of this information was available during preparation of the FEIS and was used in the analysis (see chapter 3, “Seeps, Springs, and Riparian Areas” section, FEIS, pp. 493, 519–520, 534–535). However, isotopic and geochemical data regarding some water sources, including Empire Gulch, were not previously available. In addition, stormwater quality samples in Davidson Canyon were not available at the time the FEIS was prepared and are pertinent to the analysis of OAWs.
- BLM Groundwater Levels; PAG Groundwater Levels. Groundwater levels throughout the Cienega Creek basin were used in construction of the groundwater flow models and were incorporated throughout the FEIS analysis (see chapter 3, “Groundwater Quantity” section, FEIS, pp. 288–361). However, some of the BLM groundwater levels were not previously known, particularly those associated with piezometers installed alongside the Empire Gulch and Cienega Creek stream channels. Similarly, the groundwater levels measured by PAG in wells on Lower Cienega Creek were not previously available. These water levels have been incorporated into the refined analysis of aquatic impacts contained in this SIR.
- BLM Stream Flow; USGS Stream Flow; EPA STORET Stream Flow Measurements; PAG Stream Flow Measurements. The USGS stream gage data on Cienega Creek were central to the analysis of aquatic impacts in the FEIS. The period of record for the USGS stream gage is now extended through 2014. The BLM and PAG stream flow measurements were previously unknown to the Coronado and were not incorporated into the FEIS. These measurements are highly important to the refined FEIS analysis. The previous FEIS analysis made the assumption—lacking any other available data—that the stream flow and channel conditions at the USGS Cienega Creek stream gage were similar to those elsewhere on Cienega Creek and Empire Gulch. The BLM and PAG stream flow measurements demonstrate that this is not an accurate assumption. Instead of estimating changes in stream flow due to drawdown at a single gage location, the refined analysis of aquatic impacts contained in this SIR now estimates changes in stream flow at multiple different locations, and in conjunction with other scattered flow data, can also more reasonably extrapolate those hydrographs to different reaches without permanent monitoring of stream flow.
- BLM Wet/Dry Mapping. The wet/dry mapping on Las Cienegas NCA represents a new piece of information describing baseline conditions on Cienega Creek and Empire Gulch,

specifically during the most critical time of year, during low-flow conditions in May and June. The wet/dry mapping has been incorporated into the refined analysis of aquatic impacts contained in this SIR.

- SWCA Pool Depth Survey. The pool depth survey represents a new piece of information describing baseline conditions on Cienega Creek and Empire Gulch. Prior to this survey and the wet/dry mapping, very little was known about the number, extent, and depth of pools on Cienega Creek and Empire Gulch. Analysis of these pool depths has been incorporated into the refined analysis of aquatic impacts contained in this SIR.
- Additional Observations of Aquatic Environment; WestLand Riparian Extent Analysis. The various qualitative observations made of the riparian and aquatic systems were useful in assessing baseline conditions. While most of this information is not used directly for quantitative analysis, it was incorporated into the refined analysis of aquatic impacts contained in this SIR. The WestLand analysis of riparian extent was incorporated into baseline conditions as a quantitative assessment of current ongoing riparian trends.
- Additional Technical/Scientific Literature. Many technical documents were also available and incorporated into the FEIS, particularly with respect to vegetation impacts (see FEIS, pp. 497–501). Review of the additional literature helped refine and validate these impacts. The Huth thesis provides an analysis that supports an assumption already used in the FEIS analysis and this SIR analysis: that the regional aquifer, shallow alluvial stream aquifer, and the stream itself are likely in hydrologic connection.

Analysis of Baseline Trends

Data plots for the following baseline trends are included in appendices B through D.

Temperature/Precipitation

Long-term meteorological stations are located in Green Valley, Vail, and Tucson. The average daily June high temperature has been plotted for Green Valley (see appendix B, figure B1) and Tucson (see appendix B, figure B2); the Vail station had inadequate temperature information for plotting. Each plot shows the long-term historical average, the 3-year moving average, a linear regression trend line, and the range predicted in the future due to climate change. There are two conclusions that can be reached regarding temperature:

- Based on this metric, while there is no statistically strong upward trend, 11 of the past 12 years have had higher than average temperatures.
- The temperatures experienced during the current drought cycle are lower than those predicted due to climate change. Care needs to be taken with this conclusion, because the generic results of climate change modeling are being applied to a very specific metric (June high temperatures) that may not be perfectly comparable.

Annual precipitation has been plotted for Green Valley (see appendix B, figure B3), Vail (see appendix B, figure B4), and Tucson (see appendix B, figure B5); each plot shows the long-term historical average, the 3-year moving average, a linear regression trend line, and the range predicted in the future due to climate change. There are two conclusions that can be reached regarding precipitation:

- There is a statistically significant trend toward lower precipitation. As with temperature, 11 of the past 13 years have had lower than expected precipitation.

- Unlike temperature, the precipitation experienced in the past decade is actually within the approximate range expected due to climate change.

Statistical analysis of the precipitation and temperature trends is summarized in table 1 below.

Table 1. Summary of temperature and precipitation trends

Station	Parameter	P value	R^2	Comments
Green Valley	Temperature – Average June Daily High	0.32	0.075	No statistically significant trend
Tucson	Temperature – Average June Daily High	0.88	0.001	No statistically significant trend
Green Valley	Precipitation – Annual Total	0.015	0.378	Statistically significant trend; decrease in precipitation of 0.36 inch/year
Tucson	Precipitation – Annual Total	0.002	0.371	Statistically significant trend; decrease in precipitation of 0.23 inch/year
Vail	Precipitation – Annual Total	0.24	0.137	No statistically significant trend

Stream Flow

Stream flow measurements have been collected at various locations in the past along Cienega Creek, but there are only five reasonably long-term hydrographs available: the Cienega Creek USGS stream gage station 09484550 (Cienega Creek Reach 4 (also called CC4)), BLM monitoring on Cienega Creek above Gardner Canyon (Cienega Creek Reach 2), BLM monitoring on Empire Gulch (Empire Gulch Reach 1 (also called EG1)), PAG monitoring at Marsh Station Road (Cienega Creek Reach 13), and the Pantano Wash USGS stream gage station 90484600 (Cienega Creek Reach 15). These stream flow measurements are shown in appendix C.

- Stream flow measurements on Cienega Creek Reach 2 have been taken manually by the BLM since April 2006, approximately monthly. June stream flow shows a downward trend (see appendix C, figure C1), while October/November stream flow (see appendix C, figure C2) and overall stream flow (see appendix C, figure C3) remain steady with no statistically significant trend.
- Daily stream flow measurements at the USGS stream gage in Cienega Creek Reach 5 have been taken automatically since 2001. Mean monthly June stream flow (see appendix C, figure C4), mean monthly November stream flow (see appendix C, figure C5), and overall mean monthly stream flow (see appendix C, figure C6) all remain steady at this gage, with no statistically significant trend.
- Stream flow measurements on Empire Gulch Reach 1 have been taken manually by the BLM since June 2007, approximately monthly. June stream flow (see appendix C, figure C7) shows a downward trend, while October/November stream flow (see appendix C, figure C8) and overall stream flow (see appendix C, figure C9) remain steady, with no statistically significant trend.
- Regular stream flow measurements on Lower Cienega Creek at Marsh Station Road (Cienega Creek Reach 13) have been taken manually by the PAG since about 2001, approximately quarterly. June stream flow (see appendix C, figure C10) shows a downward trend, as does the overall stream flow (see appendix C, figure C11).
- Daily stream flow measurements at the USGS stream gage in Cienega Creek Reach 15 have been taken automatically since 1959; for consistency with other data sets, only data since 2001 were used in this analysis. Mean monthly June stream flow (see appendix C, figure

C12), mean monthly November stream flow (see appendix C, figure C13), and overall mean monthly stream flow (see appendix C, figure C14) all remain steady at this gage, with no statistically significant trend.

Statistical analysis of the stream flow trends is summarized in table 2 below.

Table 2. Summary of stream flow trends

Location	Parameter	P value	R^2	Comments
BLM Key Reach CC2	June stream flow	0.044	0.589	Statistically significant trend; decrease of 7.5 gallons per minute per year (gpm/year)
BLM Key Reach CC2	October/November stream flow	0.999	0.000	No statistically significant trend
BLM Key Reach CC2	All stream flow	0.651	0.003	No statistically significant trend
USGS Stream Gage – Cienega Creek at Sonoita (CC5)	Mean June stream flow	0.750	0.009	No statistically significant trend
USGS Stream Gage – Cienega Creek at Sonoita (CC5)	Mean November stream flow	0.270	0.109	No statistically significant trend
USGS Stream Gage – Cienega Creek at Sonoita (CC5)	All mean monthly stream flow	0.817	0.000	No statistically significant trend
BLM Key Reach EG1	June stream flow	0.045	0.515	Statistically significant trend; decrease of 1.37 gpm/year
BLM Key Reach EG1	October/November stream flow	0.184	0.209	No statistically significant trend
BLM Key Reach EG1	All stream flow	0.540	0.006	No statistically significant trend
PAG Cienega Creek at Marsh Station Road (CC13)	June stream flow	0.005	0.463	Statistically significant trend; decrease of 0.044 cubic feet per second per year (cfs/year) (19.7 gpm/year)
PAG Cienega Creek at Marsh Station Road (CC13)	All stream flow	0.001	0.168	Statistically significant trend; decrease of 0.048 cfs/year (21.5 gpm/year)
USGS Stream gage – Pantano Wash at Vail (CC15)	Mean June stream flow	0.664	0.016	No statistically significant trend
USGS Stream gage – Pantano Wash at Vail (CC15)	Mean November stream flow	0.531	0.037	No statistically significant trend
USGS Stream gage – Pantano Wash at Vail (CC15)	All mean monthly stream flow	0.694	0.001	No statistically significant trend
BLM Key Reach EG1	Stream flow vs. temperature	<0.001	0.212	Statistically significant trend; increase of 0.77 degrees Celsius (°C) per 10-gpm reduction in stream flow
BLM Key Reach EG1	Stream flow vs. dissolved oxygen	0.400	0.012	No statistically significant trend
BLM Key Reach CC2	Stream flow vs. temperature	<0.001	0.275	Statistically significant trend; increase of 0.36°C per 10-gpm reduction in stream flow

Location	Parameter	P value	R^2	Comments
BLM Key Reach CC2	Stream flow vs. dissolved oxygen	<0.001	0.187	Statistically significant trend; decrease of 0.54 parts per million (ppm) dissolved oxygen per 10-gpm reduction in stream flow
Wet/Dry Mapping on Cienega Creek/Empire Gulch	Time vs. wetted length	0.509	0.076	No statistically significant trend

Wet/Dry Mapping

Wet/dry mapping has been conducted on Empire Gulch and Cienega Creek from 2006 through present. The past 2 years of mapping (2012 and 2013) have had the least amount of measured wetted stream length, suggesting a trend toward degrading aquatic habitat. However, when analyzed, there is no statistically significant trend (see table 2 and appendix C, figure C18).

Dissolved Oxygen/Temperature

The BLM also monitored temperature and dissolved oxygen along with stream flow at their monitoring locations on Empire Gulch and Cienega Creek. Trend analysis for these parameters are included in appendix C.

While the relationships are not strongly predictive, as shown in table 2, there is a statistically significant relationship between reductions in stream flow, increases in temperature, and decreases in dissolved oxygen.

Temperature increases with reductions in stream flow by about 0.36 to 0.77 degrees Celsius (°C) for every 10-gallon-per-minute (gpm) reduction (see appendix C, figures C15 and C17). Dissolved oxygen decreases with reductions in stream flow by about 0.54 parts per million (ppm) for every 10-gpm reduction.

Aquifer Water Levels

Reasonably long records of aquifer water-level measurements exist for approximately 25 wells or piezometers (table 3) along Cienega Creek and Empire Gulch, and are included in appendix D. These include 10 piezometers installed by BLM (denoted as "WP-"); many of the BLM piezometers have very frequent water levels using continually recording pressure transducers; however, these measurements only extend a few years in duration. Most of the longer-term water levels in other wells are fairly sporadic and not regularly measured, with the exception of three wells that are regularly monitored on Lower Cienega Creek (Jungle, Cienega, Del Lago).

Table 3. Summary of groundwater levels for selected wells/piezometers

Well/ Piezometer	Location	Aquifer	Period of Record	Number of Observations	Median Depth to Groundwater (feet below ground surface)	Seasonal Fluctuation (feet)
WP-2	Cienega Creek, 2.4 miles below Empire Gulch confluence	Shallow alluvial	6/1998–2/2012	22	8.6	–
WP-4	Cienega Creek, 1.2 miles below Empire Gulch confluence	Shallow alluvial	6/1998–2/2000	9	16.8	–
WP-7	Gardner Canyon headwaters	Shallow alluvial	2/2012–10/2013	4,883	12.1	2 – 2.5

Well/ Piezometer	Location	Aquifer	Period of Record	Number of Observations	Median Depth to Groundwater (feet below ground surface)	Seasonal Fluctuation (feet)
WP-8	Gardner Canyon near confluence with Cienega Creek	Shallow alluvial	3/2012–10/2013	4,818	5.6	2.7 – 2.8
WP-9	Empire Gulch	Shallow alluvial	2/2012–10/2013	4,962	5.8	1.9
WP-10	Cienega Creek headwaters	Shallow alluvial	3/2011–10/2013	15	17.4	–
WP-11	Cienega Creek, 2.2 miles above Empire Gulch	Shallow alluvial	7/2011–10/2013	21	11.6	–
WP-12	Cienega Creek, 1.9 miles above Empire Gulch	Shallow alluvial	2/2012–10/2013	4,958	2.3	2 – 2.4
WP-13	Cienega Creek, 1.4 miles above Empire Gulch	Shallow alluvial	2/2012–10/2013	4,973	3.8	0.9
WP-14	Cienega Creek, 0.1 mile below Empire Gulch	Shallow alluvial	7/2011–10/2013	19	0.3	3.2
Adobe Barn Well	Cienega Creek floodplain, 1.5 miles below Empire Gulch	Shallow alluvial	3/1982–10/2011	22	6.2	–
Anamax E-12; Lower Springwater Well	Outside of floodplain, 1.4 miles east of Cienega Creek	Regional aquifer	3/1982–10/2013	30	63.6	–
Anamax E-5; Sando Well	Gardner Canyon headwaters	Regional aquifer	3/1982–9/2013	30	19.4	–
Anamax E-7; Road Well	Outside of floodplain, 1.3 miles west of Cienega Creek	Regional aquifer	3/1982–10/2013	38	54.1	–
Box Well	Cienega Creek, 0.4 mile above Empire Gulch	Shallow alluvial	3/1982–10/2013	30	2.6	1.2 – 1.4
Frog Well	Cienega Creek 0.5 mile above USGS stream gage	Shallow alluvial	3/1998–6/2013	21	35.7	1.1 – 1.8
GAC-3; Antelope Well	Cienega Creek headwaters	Regional aquifer	5/1970–10/2013	26	42.9	–
Mary Cane Well	Outside of floodplain, 4.7 miles west of Cienega Creek	Regional aquifer	9/1941–9/2013	25	32.0	–
Mattie Well	Outside of floodplain, 2.3 miles east of Cienega Creek	Regional aquifer	11/1972–10/2013	15	81.4	–
Upper Hilton Windmill	Cienega Creek headwaters near Sonoita	Regional aquifer	11/1972–10/2013	29	32.4	–
Upper Springwater Windmill	Outside of floodplain, 3.7 miles east of Cienega Creek	Regional aquifer	3/1982–10/2013	27	54.2	–
Wood Canyon Well	Outside of floodplain, 2.2 miles east of Cienega Creek	Regional aquifer	2/1951–11/2013	20	79.9	–

Well/ Piezometer	Location	Aquifer	Period of Record	Number of Observations	Median Depth to Groundwater (feet below ground surface)	Seasonal Fluctuation (feet)
Jungle Well	Lower Cienega Creek, 4 miles above Davidson Canyon	Shallow alluvial	7/1994–4/2011	191	31.3	–
Cienega Well	Lower Cienega Creek, 2 miles above Davidson Canyon	Shallow alluvial	7/1994–4/2011	202	16.1	4.5 – 4.9
Del Lago Well	Lower Cienega Creek, at Pantano Dam	Regional aquifer	7/1994–4/2011	199	75.2	–

Ongoing Trends in Riparian Vegetation

Trends in riparian vegetation at Cienega Creek result from changes in channel morphology, past and present management actions, the ongoing drought, and other activities within the basin. Cattle were excluded in CCNP in 1988 and excluded from year-round residence on the Las Cienegas NCA in 1990. As a result, riparian areas have gone from bare, open areas to cottonwood (*Populus fremontii*)-willow (*Salix gooddingii*) gallery forests. Bodner and Simms (2008:figures 17-22) used repeated photo points to document the expansion of riparian forests within the Las Cienegas NCA, and used aerial photography to illustrate the widening of riparian forests from 1972 to 2002 (2008:figure 23); Powell (2013b:figure 3) shows the succession of vegetation within the CCNP from 1988 to 2003. Cienega Creek and its tributaries on Las Cienegas NCA support approximately 20 linear miles of riparian forest and marshland, which is often flanked by sacaton (*Sporobolus wrightii*) flats or mesquite (*Prosopis velutina*) bosque vegetation communities; additionally, many miles of xeroriparian and shrub communities occur (Bodner and Simms 2008). Within the Las Cienegas NCA, the Riparian Area Condition Evaluation (RACE) for Cienega Creek and its tributaries showed a marked increase in the percentage of linear miles of riparian habitat rated satisfactory, from 46 percent in 1989 to 93 percent in 2000 (Bodner and Simms 2008). For all areas of Las Cienegas NCA combined, comparing 1993 with 2006, there are more mature trees, saplings, and seedlings per acre; overall, ash and cottonwood density increased, though cottonwood to a lesser extent than ash, and willow density decreased; and, different locations at Las Cienegas NCA have shifting age classes and species composition over time (Bureau of Land Management 2007b). Additionally, some marshy areas are trending toward “woody swamp” vegetation community, likely because of reduced disturbance (Bodner and Simms 2008).

In contrast to long-term trends showing overall increase in riparian forest extent and health due to changes in land management, there are other trends that are specific to the recent drought. By most measures, the ongoing drought began in the late 1990s. During riparian monitoring from 1998 to 2005, BLM has shown a shifting in species composition, with ash (*Fraxinus velutina*) coming to dominate many reaches in place of cottonwoods or willow; Bodner and Simms (2008) speculate that this may be due to the system reaching a climax community, the effects of reduced disturbance (e.g., from cattle or fire), or the effects of drought or lowering of the water table. The vegetation surrounding Cienega Creek consists of mostly native plants, with some Bermuda grass (*Cynodon dactylon*), Johnsongrass (*Sorghum halepense*), and tamarisk (*Tamarix* spp.) occurring (Bodner and Simms 2008), and with tamarisk abundances increasing in recent years (Powell 2013b).

Powell (2013b) states that since 2005, there has only been a slight increase in extent of cottonwood canopies at CCNP, and the extent and vigor of the mesquite bosque vegetation community has apparently declined. The current drought is blamed for a thinning of cottonwood canopy at CCNP

(Powell 2013b:figure 40; Powell et al. 2014:figure 12) and death of cottonwoods at CCNP (Pima Association of Governments 2014). On Las Cienegas NCA downstream of the “Cienega Ranch” wetlands, Simms (2014d) noted and photographed segments of Cienega Creek that currently have low and declining riparian function, likely due to drought and loss of groundwater. Simms (2014d:appendix B) provided photographs of head cutting and bank erosion attributed to loss of riparian plants due to dry conditions. These areas show a loss of soil stability due to the loss of root systems, and they currently have a channel that is bordered by deer grass in poor health and dead and dying willow trees, reportedly indicating that these areas are transforming as seepwillow (*Baccharis salicifolia*) comes in to replace cottonwood, willow, and ash (Simms 2014d). A head cut at CCNP resulted in the loss of cottonwood and mesquite (Powell 2013b:figure 34).

In January 2015, in order to better quantify the anecdotal observations from other sources, the Coronado requested that Rosemont Copper evaluate whether the ongoing drought has had noticeable effects on the extent and density of the riparian corridors along Cienega Creek and Empire Gulch using analysis of satellite imagery. WestLand conducted an assessment of Landsat imagery between 1995 and 2014 using a technique known as Normalized Difference Vegetation Index (NDVI) (WestLand Resources Inc. 2015f). Using this technique, the color of pixels in the satellite image is correlated with vegetation density (the darker the pixel, the more vegetation is assumed to be present). WestLand Resources concluded that “a plot of NDVI values for each segment through time shows that there was no apparent trend in the data from 1995 through 2014” (WestLand Resources Inc. 2015f:4). It should be noted that this approach does not differentiate between different types of vegetation and does not correlate to field observations. This technique only reflects the overall relative amount of vegetation present, and how that amount changes year to year.

Summary of FEIS Analysis Methodology and Impact Conclusions

All flow data along Cienega Creek and Empire Gulch that were known and available at the time were used for the riparian analysis contained in the “Seeps, Springs, and Riparian Areas” section of chapter 3 of the FEIS. The analysis is also presented in more detail in “Review of Available Depth of Flow Information on Cienega Creek and Empire Gulch and Protocol for Estimating Impacts to Streamflow” (SWCA Environmental Consultants 2013e). The riparian analysis relied on the following basic assumptions:

- That the flow observed at the USGS stream gage on upper Cienega Creek during the period from 2001 to 2013 (a period of severe drought) was a reasonable representation of flow conditions in the future;
- That the cross-section at the gage location was similar in nature to elsewhere along upper Cienega Creek, Empire Gulch, and Gardner Canyon; and
- That predicted (i.e., modeled) groundwater drawdown could be superimposed directly on the historic observed stream hydrograph, and that the resulting new hydrograph could then be compared statistically with the historic observed hydrograph.

Drawdown predictions for various time frames (50, 150, and 1,000 years after closure), various modeling scenarios (lowest modeled drawdown, highest modeled drawdown, and best-fit modeled drawdown), and various locations (Upper Cienega Creek, Empire Gulch, Gardner Canyon) were superimposed on the historic Cienega Creek hydrograph to predict future conditions. Additional adjustments (i.e., reductions) were made for contribution to Cienega Creek from Empire Gulch and Gardner Canyon; lacking quantified flow data for these tributaries, these adjustments were based on the watershed size, as a percentage of the overall Cienega Creek watershed. The predicted effects resulting from drawdown at the USGS gage site were then extrapolated elsewhere in the watershed to predict effects elsewhere along Cienega Creek, in Empire Gulch, and in Gardner Canyon.

Using this approach, several statistical measures were calculated for the historic and predicted stream hydrographs. These measurements included amount of time with no flow (as both a percentage of time and as a number of days per year), and amount of time with extremely low flow (also as both a percentage of time and as a number of days per year). The predicted statistical measures were compared with existing statistical measures to determine the potential effects that drawdown could have on the various perennial stream areas. It should be noted that the substantial uncertainty associated with this analysis is thoroughly described in the FEIS.

The statistical flow results were also interpreted into more understandable terminology: ephemeral, intermittent, perennial. The criteria for this were as follows: perennial (predicted stream is dry less than 30 days per year), intermittent (predicted stream is dry from 30 to 350 days per year), and ephemeral (predicted stream is dry more than 350 days per year). These definitions were developed based on analysis of the historic flow record between 2001 and 2013 at the Cienega Creek gage.

Results from the FEIS are summarized in table 4, presented below.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

Overview of Refined Analysis of Aquatic Impacts

The information gathered since publication of the FEIS includes new information affecting baseline conditions, which also enables refined analysis techniques. The refined analysis discussed here makes use of these revised techniques and baseline conditions.

The refined analysis includes three parts: (1) analysis of impacts to stream flow; (2) analysis of impacts to refugia pools; and (3) analysis of impacts to riparian vegetation. Parts 1 and 3 were part of the FEIS analysis, but have been refined to reflect new information and techniques. Part 2 was not part of the FEIS; it has been added in response to the discussions with federal agencies between May and November 2014 and is based on fieldwork conducted in November and December 2014.

Refinements to Analysis of Impacts to Stream Flow

The overall approach for impacts to stream flow remains similar in concept to that used in the FEIS, in which impacts from drawdown are superimposed on a real-world hydrograph, and the resulting predicted change is compared with baseline conditions using flow statistics (number of days of zero flow per year), as well as being translated into a narrative description (perennial, intermittent, ephemeral).

Three important refinements have been incorporated:

- Previously, the existing hydrograph was analyzed as depth of water, not as stream flow, and the predicted aquifer drawdown was directly superimposed using a 1:1 relationship (i.e., 1 foot of aquifer drawdown equals 1 foot loss in stream depth). In this refined analysis, the existing hydrograph is analyzed as stream flow, not depth. In order to superimpose the predicted aquifer drawdown, that drawdown must be translated into a change in stream flow. This is accomplished using linear regression analysis of newly obtained field data collected from nearby piezometers to correlate measured aquifer water levels with stream flow.
- There are now five real-world hydrographs that are analyzed, instead of a single hydrograph.

Table 4. Summary of stream flow analysis presented in FEIS

Location	Parameter	Current Condition	50 Years					150 Years					1,000 Years				
			Low	Best-Fit	Best-Fit	Best-Fit	High	Low	Best-Fit	Best-Fit	Best-Fit	High	Low	Best-Fit	Best-Fit	Best-Fit	High
Empire Gulch	Days with no flow	3	3	3	4	283	361	3	32	32	363	365	363	364	365	365	365
Upper Cienega Creek	Days with no flow	3	3	3	3	3	4	3	3	3	32	313	3	3	125	351	351
Gardner Canyon	Days with no flow	3	3	3	3	3	3	3	3	3	4	146	3	3	283	363	363
Empire Gulch	Days with low flow	4	4	4	146	352	362	4	283	283	364	365	363	364	365	365	365
Upper Cienega Creek	Days with low flow	4	4	4	4	4	146	4	88	88	283	352	88	88	339	354	354
Gardner Canyon	Days with low flow	4	4	4	4	4	88	4	4	32	146	349	4	4	352	363	363
Empire Gulch	Flow status	Perennial	Perennial	Perennial	Perennial	Intermittent	Ephemeral	Perennial	Intermittent	Intermittent	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
Upper Cienega Creek	Flow status	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Intermittent	Perennial	Perennial	Intermittent	Ephemeral	Ephemeral
Gardner Canyon	Flow status	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Perennial	Perennial	Intermittent	Ephemeral	Ephemeral

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- The analysis has been divided into nine key reaches. These key reaches represent critical areas on Cienega Creek and Empire Gulch that have a persistent water presence that supports an aquatic ecosystem, including threatened and endangered species. The hydrologic controls for each key reach have been estimated independently based on information and discussions compiled between May and November 2014. Note that one reach analyzed in the FEIS has been dropped; new information indicates that Gardner Canyon does not have consistent surface flow, as was indicated during the FEIS.

New Analysis of Impacts to Refugia Pools

Refugia pools are assumed to have three possible sources of water: filling by runoff during precipitation events, filling from upstream base flow, and intersection with the shallow alluvial aquifer. During the critical low-flow period in May and June, there is very little or no precipitation. Further, in some areas there is virtually no upstream base flow to support the pools, or base flow from these upstream areas that currently exists may cease to exist due to predicted mine drawdown. Therefore, the contribution to these pools from groundwater is likely the most critical aspect to their continued presence as refugia for threatened and endangered species.

Presence, depth, and approximate topography of refugia pools were surveyed and recorded in November and December 2014. An approximate topographic model was constructed for each pool, and from this topographic model the change in pool depth, surface area, and volume was calculated for various incremental changes in aquifer water level. Corrections were also incorporated into the analysis to reflect measurement during November instead of during the critical low-flow season in May and June.

While the topography and effects on the individual pools are analyzed independently, the results are presented as an overall total for each key reach. The reason for this is the long time delay between the current field measurements and the predicted onset of groundwater drawdown from the mine. Impacts along Cienega Creek are not estimated to occur for at least 70 to 75 years after the start of mining. It is not reasonable to expect that the specific individual pools measured would still exist in their current configuration at that time. However, the overall geomorphology of each key reach is assumed to remain similar, since substrate, slope, and bedrock controls would remain similar. In other words, even if the pools change or migrate, the overall number of pools per reach should remain similar.

Refinements to Analysis of Impacts to Riparian Vegetation

In the FEIS, impacts to riparian vegetation were based on an extensive review of available literature about the responses of riparian vegetation to hydrologic changes. The FEIS analysis focused primarily on the continued presence of the hydroriparian corridor along Cienega Creek and Empire Gulch. The discussions between May and November 2014 indicated that even small changes in vegetation health could trigger negative feedback loops with large consequences (i.e., loss of root mass, leading to channel erosion and downstream siltation of pools). The refined analysis discussed here makes use of literature review as before, but with additional sources. Further, the analysis has been quantified to the extent possible, with a focus on capturing changes from smaller increments of drawdown. The analysis of impacts to riparian vegetation also takes into account current ongoing negative trends related to the aquatic ecosystem.

Refinement to Time Period Analyzed

While predicted impacts in the FEIS were taken to 1,000 years after mine closure, the FEIS also identified limitations in relying upon the groundwater models beyond 300 years. The refined analysis discussed here will disclose similar impacts to 1,000 years. However, it should be noted that the use of this information is subject to the same limitations, and that the time period relied upon for during

Section 7 consultation with the USFWS to assess impacts to threatened and endangered species may differ.

Incorporation of Other System Stresses

Climate change has been incorporated into the analysis by analyzing trends over the past decade and incorporating additional groundwater drawdown due to expected future changes in temperature. Expected changes in precipitation have not been incorporated, since the trend analysis indicates that the hydrographs analyzed already reflect precipitation conditions similar to those expected to be experienced in the future. More detail on the climate change scenario is included later in this SIR.

Refined Analysis of Aquatic Impacts

Identification of Key Reaches

As part of the collaboration with other federal agency biologists and hydrologists between May and November 2014, several key reaches were identified along Empire Gulch and Cienega Creek. These key reaches are those that are considered core biological areas that have persistent presence of water and are of critical importance to aquatic species. Each key reach is analyzed independently. Key reaches are summarized in table 5. While the key reaches are refinements of what was analyzed in the FEIS, there are two changes that should be noted:

- In the FEIS, Gardner Canyon was analyzed as a stream reach. Based on information collected between May and November 2014, it does not appear that Gardner Canyon has perennial flow that supports a core aquatic system similar to those seen on Cienega Creek and Empire Gulch. No key reaches were identified on Gardner Canyon during the collaboration.
- In the FEIS, wetland areas adjacent to Cienega Creek were analyzed as part of the overall riparian corridor. The collaboration identified one wetland area of particular importance not only from a biological standpoint, but because of its closer proximity to Empire Gulch and higher levels of predicted mine drawdown, as well as the importance for species reintroductions. Cieneguita Wetlands, which are located within the Empire Gulch floodplain upstream from the confluence with Cienega Creek, have been identified as a key reach.

Analysis of Impacts to Stream Flow

General Geological Framework

Both Empire Gulch and Cienega Creek are associated with stream channels composed of young alluvial materials, as shown in figure 1. For Empire Gulch, the shallow alluvial material is underlain entirely by older alluvial basin deposits. For Cienega Creek, the shallow alluvial materials are underlain by older alluvial basin deposits upstream from Mattie Canyon. However, below Mattie Canyon, sedimentary bedrock units appear at the surface and underlie the stream and shallow alluvium for some distance downstream.

Supporting Evidence for General Geological Framework
1) Regional geological map (see figure 1). *2) Field observations during field trips.*

Table 5. Information for key reaches

Key Reach	Location	Available Hydrologic Information			Analysis Assumptions			
		Stream Monitoring	Wet/Dry Mapping	Nearest Groundwater Levels	Overall Assumption for Key Reach	Specific Technique to Analyze Impact of Drawdown on Stream flow	Hydrograph to Be Used for Predictions	Specific Technique to Analyze Impact of Upstream Flow Losses
Cienega Creek Reach 2 (CC2)	Approximately 0.75 mile in length, located on Upper Cienega Creek, within the Las Cienegas NCA, immediately upstream from Gardner Canyon.	BLM hydrograph (2006–2014)	2006–2014	WP-8 (2011-13, within reach) WP-13 (2011-13, within reach) Box (1982-2013, 0.7 mile below reach) WP-14 (2011-13, 1.2 miles north of reach) WP-12 (2011-13, 0.3 mile above reach) WP-11 (2011-13, 0.6 mile above reach)	Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer.	Predict using empirical relationship derived from BLM flow measurements and BLM piezometer groundwater level measurements (location WP-13)	BLM measurements (2006–2014)	None. Typically no base flow occurs upstream of this reach.
Cienega Creek Reach 4 (CC4)	Approximately 0.8 mile in length, located on Upper Cienega Creek, within the Las Cienegas NCA, immediately upstream of Mattie Canyon.	One isolated flow measurement (1998)	2006–2014	WP-2 (1998-2012, 0.6 miles above reach) WP-4 (2011-12, 1.6 miles above reach) Adobe (1982-2011, 1.2 miles above reach)	Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer.	Predict using empirical relationship derived from BLM flow measurements and BLM piezometer groundwater level measurements (location WP-13)	BLM measurements from CC2 (2006–2014), increased by factor of 2	Upstream flow from Cienega Creek Reach 2 and Empire Gulch Reach 2 are assumed to contribute to Reach 4. Impacts to those upstream flows are incorporated into the analysis.
Cienega Creek Reach 5 (CC5)	Approximately 0.8 mile in length, located on Upper Cienega Creek, within the Las Cienegas NCA, downstream of Mattie Canyon and containing the USGS Sonoita stream gage.	USGS gage (2001–2014)	2006–2014	WP-2 (1998-2012, 1.4 miles above reach) WP-4 (2011-12, 2.4 miles above reach) Adobe (1982-2011, 2.0 miles above reach) Frog Well (1998-2013, within reach)	Assumes flow in channel is primarily the result of bedrock controls forcing upgradient shallow groundwater to surface near Cold Water Spring, and maintaining that flow in the channel until the Narrows.	None. Due to presence of bedrock control immediately below, no direct influence from regional aquifer is assumed.	USGS stream gage (2001–2014)	Upstream flow from Cienega Creek Reach 4 is assumed to contribute to Reach 5. Impacts to those upstream flows are incorporated into the analysis.
Cienega Creek Reach 7 (CC7)	Approximately 0.6 mile in length, located on Upper Cienega Creek, within the Las Cienegas NCA, at the beginning of the Narrows.	Six flow measurements (2001–2002); one flow measurement (2012)	2006–2014	WP-2 (1998-2012, 2.3 miles above reach) WP-4 (2011-12, 3.3 miles above reach) Adobe (1982-2011, 2.9 miles above reach) Frog Well (1998-2013, 0.9 mile above reach)	Assumes flow in channel is primarily the result of bedrock controls forcing upgradient shallow groundwater to surface near Cold Water Spring, and maintaining that flow in the channel until the Narrows.	None. Due to presence of bedrock control immediately below, no direct influence from regional aquifer is assumed.	USGS stream gage (2001–2014)	Upstream flow from Cienega Creek Reach 5 is assumed to contribute to Reach 7. Impacts to those upstream flows are incorporated into the analysis.
Empire Gulch Reach 1 (EG1)	Approximately 0.3 mile in length, located within the Las Cienegas NCA immediately downstream from the Upper Empire Gulch Springs, near the Empire Ranch Headquarters.	BLM hydrograph (2007–2014)	2006–2014	WP-9 (2011-14, within reach)	Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer.	Predict using empirical relationship derived from BLM flow measurements and BLM piezometer groundwater level measurements (location WP-9)	BLM measurements (2006–2014)	None. Typically no base flow occurs upstream of this reach.
Empire Gulch Reach 2 (EG2)	Approximately 1 mile in length, located within the Las Cienegas NCA immediately upstream from the Cienega Creek confluence.	None	2006–2014	Box (1982-2013, 0.1 mile from reach) WP-14 (2011-13, 0.1 mile below reach)	Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer.	Predict using empirical relationship derived from BLM flow measurements and BLM piezometer groundwater level measurements (location WP-9)	BLM measurements from EG1 (2006–2014)	There is a substantial reach of ephemeral stream channel between Empire Gulch Reach 1 and 2; overall this ephemeral reach is approximately 3 miles in length. For this reason, impacts in upstream flows are not incorporated into the analysis for Empire Gulch Reach 2.

Key Reach	Location	Available Hydrologic Information			Analysis Assumptions			
		Stream Monitoring	Wet/Dry Mapping	Nearest Groundwater Levels	Overall Assumption for Key Reach	Specific Technique to Analyze Impact of Drawdown on Stream flow	Hydrograph to Be Used for Predictions	Specific Technique to Analyze Impact of Upstream Flow Losses
Cieneguita Wetlands (CGW)	Located on the Las Cienegas NCA, within the floodplain of Empire Gulch, near the confluence of Empire Gulch and Cienega Creek.	Not applicable	None	Box (1982-2013, 0.5 mile away) WP-8 (2011-13, 0.8 mile away)	Assumes direct hydraulic connection with regional aquifer.	Not applicable. With respect to the water level in the wetlands, drawdown in regional aquifer is assumed to occur equally in wetland ponds.	Not applicable	Not applicable
Cienega Creek Reach 13 (CC13)	Approximately 2.5 miles in length, located on Lower Cienega Creek, within the Pima County CCNP, upstream and downstream of Davidson Canyon confluence.	PAG hydrograph (1990–2013)	1999–2014	Jungle (1994 – 2011, 2.5 miles upstream) Cienega (1994-2011, 1 mile upstream) Del Lago (1994-2011, 1.5 miles downstream)	Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer.	Predict using empirical relationship derived from PAG flow measurements at Marsh Station Road and nearby groundwater level measurements in Cienega Well	PAG measurements at Marsh Station Road (2001–2014)	Ephemeral/intermittent reach extends approximately 13 miles between Reach 7 (Narrows) and Reach 13. For this reason, impacts in upstream flows are not incorporated into the analysis for Reach 13.
Cienega Creek Reach 15 (CC15)	Approximately 0.5 mile in length, located on Lower Cienega Creek, within the Pima County CCNP, upstream of Pantano Dam.	USGS stream gage (1959–2014)	1999–2014	Jungle (1994–2011, 5.5 miles upstream) Cienega (1994–2011, 3.5 miles upstream) Del Lago (1994–2011, within reach)	Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer.	Predict using empirical relationship derived from USGS stream gage at Pantano Wash and nearby groundwater level measurements (Del Lago Well) Or Predict using rating curve	USGS stream gage (2001–2014)	Upstream flow from Cienega Creek Reach 13 is assumed to contribute to Reach 15. Impacts to those upstream flows are incorporated into the analysis.

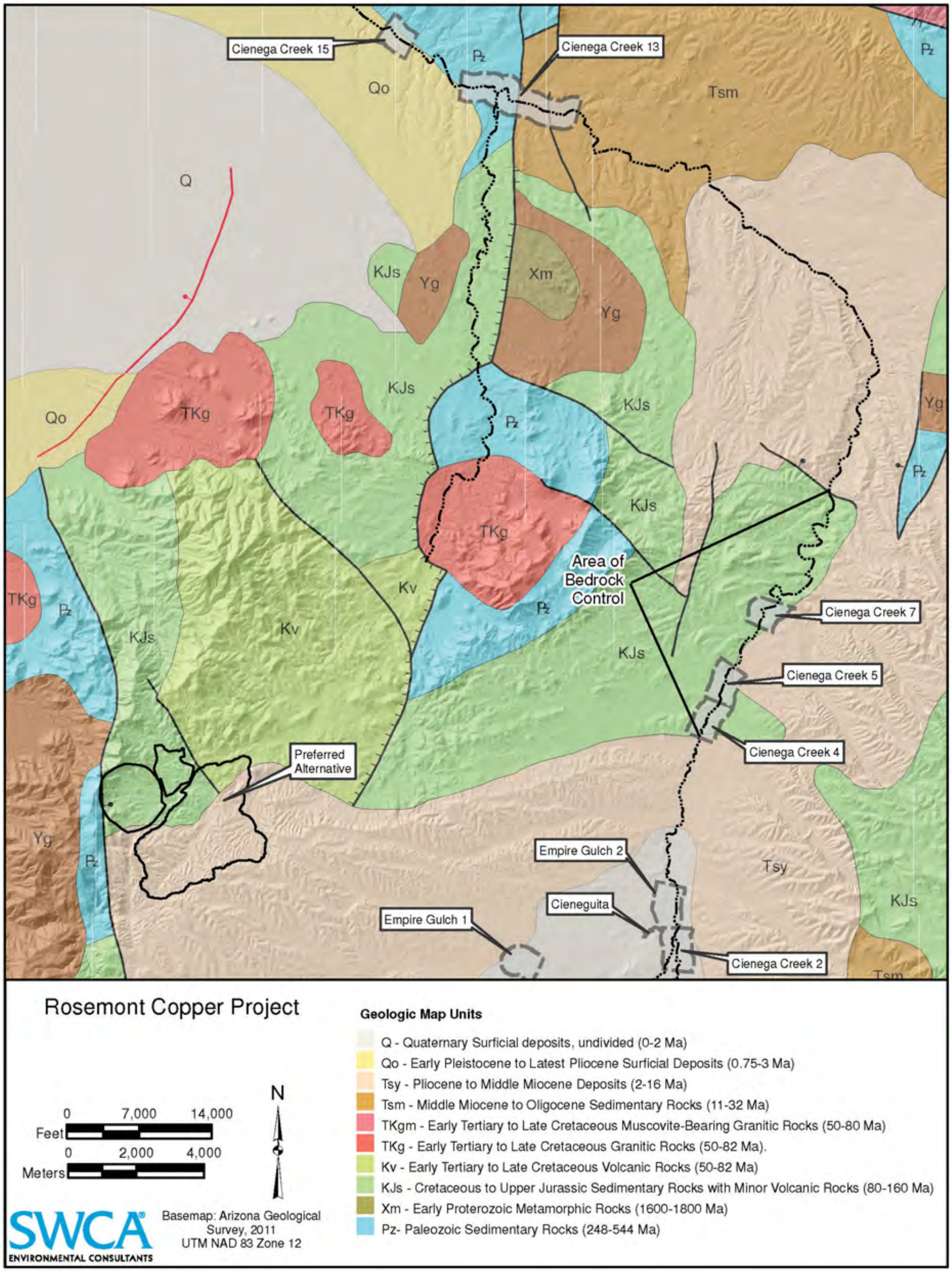

Figure 1. Hydrogeologic framework of key reaches

Conceptual Hydrologic Framework

Conceptually, the hydrologic framework of the aquifer/stream system consists of five components:

- Known geological controls.
- The flowing stream itself.
- The shallow alluvial aquifer through which the stream flows, which is approximately identical in area to the riparian gallery or corridor.
- The regional aquifer, consisting of the older alluvial basin materials, as well as fractured igneous and sedimentary bedrock units. This regional aquifer extends to the mine site and is the aquifer from which groundwater will be lost due to the mine pit.
- Wetland areas that lie outside the alluvial riparian corridor.

This analysis assumes that unless there is a clear indication that stream flow is controlled by local geological conditions, the flowing stream, the shallow alluvial aquifer, and the regional aquifer are all in complete hydraulic connection. Similarly, any off-channel adjacent wetland areas are also assumed to be in complete hydraulic connection with the regional aquifer.

This is consistent with general Forest Service policy and with the approach used in the FEIS, and also is the most conservative approach for estimating impacts due mine drawdown. In reality, a portion of the groundwater in the shallow alluvial aquifer is derived locally from ephemeral flow events. This groundwater is stored in the shallow alluvial material, where it is available to riparian vegetation and contributes to base flow in the stream. This groundwater component, which is derived from local flow events, would not be expected to change due to drawdown from the mine site. However, the amount of groundwater derived locally and not regionally is difficult to estimate, and the persistence of these stream systems suggests there is some hydraulic connection to a larger regional source of water. Assuming a complete connection with the regional aquifer is a reasonable, if conservative, approach.

There is one exception to the above assumption that complete connection exists between the stream, the shallow alluvial aquifer, and the regional aquifer. The 3- to 4-mile reach of Cienega Creek that extends from approximately Cold Water Spring above the confluence with Mattie Canyon, downstream to the Narrows, is one of the most persistently flowing reaches. Bedrock is evident at the surface along much of the reach. The flow in the channel appears to largely arise from Cold Water Spring, which is slightly off-channel and appears to be the result of an unspecified bedrock control.

For approximately 3 miles upstream of Cold Water Spring, Cienega Creek is typically dry during the early summer, while flow or water persists below Cold Water Spring. Conceptually, flow in the reach below Cold Water Springs is assumed to consist primarily of shallow alluvial groundwater from upstream that is forced to the surface by geological controls, discharges at Cold Water Spring, and then persists as stream flow through this bedrock-dominated reach downstream with relatively little loss to the shallow or regional aquifers.

Supporting Evidence for Conceptual Hydrologic Framework
1) Observed contraction of wet/dry mapping during the present drought cycle suggests that local precipitation plays some role in supplying water to the shallow alluvial aquifer and flowing stream above Cold Water Spring. *2) Persistent flow below Cold Water Spring (includes location of USGS gage site) even during drought cycles suggests that hydrologic controls are different than those above this point.*

Supporting Evidence for Conceptual Hydrologic Framework
3) *Isotopes are largely mixed, suggesting contribution from both regional and local sources.* 4) *June and November stream flows at USGS gage below Cold Water Spring have not varied during the recent drought, while the BLM gaging stations on Cienega Creek above Gardner Canyon and in Empire Gulch show an overall trend toward lower June stream flow.* 5) *Observations of bedrock at or near surface in reach downstream of Cold Water Spring, along with informal interpretations of Las Cienegas NCA personnel, suggest bedrock control of the stream hydrology.* 6) *Stream flow in Cienega Creek upstream of Mattie Canyon appears to arise along the entire channel from diffuse sources, rather than a single source like Cold Water Spring.*

Application of Conceptual Hydrologic Framework to Key Reaches

In summary, the above conceptual framework is translated to each of the key reaches as follows. There are assumed to be two sources that will contribute to base flow in any given key reach: inflow from groundwater, and surface flow from upstream. For each reach, assumptions are made for how the stream is envisioned to connect (or not) with the regional aquifer, and whether or not impacts to upstream flow contributions need to be considered. These are also summarized in table 5.

- Cienega Creek Reach 2 – Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer. Cienega Creek is generally dry upstream from CC2; therefore, no upstream flow impacts are considered.
- Cienega Creek Reach 4 – Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer. During the critical dry season, there is a significant dry reach between CC2 and CC4; however, most of the year, there is still likely a reasonably close flow connection either through surface flow or subsurface flow through the shallow alluvial aquifer. For this reason, upstream flow from both Cienega Creek Reach 2 and Empire Gulch Reach 2 are both assumed to contribute to Reach 4, and impacts to those upstream flows are incorporated into the analysis.
- Cienega Creek Reach 5 – Assumes flow is the result of bedrock controls forcing upgradient shallow groundwater to surface; no direct influence from drawdown in regional aquifer is assumed. However, there is likely a close flow connection between CC4 and CC5, and impacts to those upstream flows are incorporated into the analysis.
- Cienega Creek Reach 7 – Assumes flow is the result of bedrock controls forcing upgradient shallow groundwater to surface; no direct influence from drawdown in regional aquifer is assumed. However, there is likely a close flow connection between CC5 and CC7, and impacts to those upstream flows are incorporated into the analysis.
- Cienega Creek Reach 13 – Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer. There is a substantial reach of ephemeral stream channel between CC7 and CC13 (with some limited segments that have persistent water); overall, this ephemeral reach is approximately 13 miles between CC7 and CC13. For this reason, impacts in upstream flows are not incorporated into the analysis for CC13.
- Cienega Creek Reach 15 – Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer. During the critical dry season,

there is a significant dry reach between CC13 and CC15; however, most of the year, there is still likely a reasonably close flow connection either through surface flow or subsurface flow through the shallow alluvial aquifer. For this reason, upstream flow from Cienega Creek Reach 13 is assumed to contribute to CC15, and impacts to those upstream flows are incorporated into the analysis.

- Cieneguita Wetlands – Assumes direct hydraulic connection with regional aquifer.
- Empire Gulch Reach 1 – Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer. Additional discussion of the hydrology of Upper Empire Gulch Springs is provided in the next section. Empire Gulch is generally dry upstream from EG1; therefore, no upstream flow impacts are considered.
- Empire Gulch Reach 2 – Assumes complete and direct hydraulic connection between flowing stream, shallow alluvial aquifer, and regional aquifer. There is a substantial reach of ephemeral stream channel between Empire Gulch Reaches 1 and 2; overall, this ephemeral reach is approximately 3 miles in length. For this reason, impacts in upstream flows are not incorporated into the analysis for Empire Gulch Reach 2.

Discussion of Upper Empire Gulch Springs

The hydrologic framework controlling Upper Empire Gulch Springs was a topic of discussion between May and November 2014, including an interpretation proposed by Rosemont Copper contractor Hydro-Logic in a modeling memo dated June 27, 2014 (O'Brien 2014a). The Hydro-Logic interpretation assumes that Upper Empire Gulch Springs is ultimately tied to and reliant upon an artesian portion of the regional aquifer. This interpretation is supported by the presence of a nearby artesian well drilled in the 1970s. Because the piezometric head at this location (based on the artesian well) is 28 feet above ground surface, and predicted drawdown of head due to the mine pit is less than 6 feet even after 1,000 years, this interpretation leads to the conclusion that the springs will have a reduced flow but will not entirely dry up.

After consideration and discussion, the Coronado did not find this interpretation to be sufficient for the analysis. The presence of the Upper Empire Gulch Springs, in an area where most drainages at similar elevations are ephemeral without spring flow, suggests that there is indeed a unique connection to the regional aquifer at this location, similar to the connection proposed by Hydro-Logic; however, there is no evidence at the spring location itself that the flow is under considerable artesian head. In addition, isotopic signatures suggest—like many of the water sources in the area—that a mix of both regional and local water sources supports Upper Empire Gulch Springs. There are many possible conceptual models in which Upper Empire Gulch Springs is connected to the regional aquifer, even artesian in nature, but would still be heavily impacted or dried by a drawdown of several feet. At this time, we do not understand enough about Upper Empire Gulch Springs to develop an accurate conceptual model specific to the springs.

A conservative approach would be to consider Upper Empire Gulch Springs to be an unconfined water source in which the spring flows until drawdown falls below the ground surface (bgs); this is the conceptual approach used in this SIR. For the purposes of this analysis, all interpretations of impacts to flow in Empire Gulch Reach 1 are based on the stream flow and shallow water level monitoring conducted by BLM just downstream from the headwaters. The predictive techniques used are more fully described later.

Supporting Evidence for Empire Gulch Approach
1) Observed wet/dry mapping during the present drought cycle indicates a relatively steady reach just below Upper Empire Gulch Springs, which suggests that a regional water source may be dominant. *2) BLM gaging station on Empire Gulch shows an overall trend toward lower June and November stream flow. This is not consistent with item 1 and suggests that locally derived precipitation may play a dominant role.* *3) Isotopes are largely mixed, suggesting contribution from both regional and local sources.* *4) Observations of Upper Empire Gulch Springs suggest that piezometric head of 28 feet is not present, and even if a direct connection to a regional artesian source exists, there must be some head loss before water exits into the channel.*

Extrapolation of Hydrographs to other Reaches

Five hydrographs exist that can be used for this refined analysis of aquatic impacts: Empire Gulch Reach 1 (BLM monitoring 2006 to present), Cienega Creek Reach 2 (BLM monitoring 2006 to present), Cienega Creek Reach 5 (USGS gage 2001 to present), Cienega Creek Reach 13 (PAG monitoring 1990 to present), and Cienega Creek Reach 15 (USGS gage 1959 to present). For each key reach without dedicated stream flow measurements (CC4, CC7, EG2), a hydrograph needs to be assumed for the analysis. The following is also summarized in table 5.

- Cienega Creek Reach 2 – This reach contains hydrograph from BLM monitoring on Cienega Creek above Gardner Canyon.
- Cienega Creek Reach 4 – A summary of the median of all available stream flow measurements is depicted in figure 2, including not only the five hydrograph locations but other temporary monitoring locations for which more than one stream flow measurement exists. In terms of conceptual hydrology, CC4 should be similar to CC2. However, based on the few available measurements, the magnitude of flow is greater at CC4 (median of 0.49 cubic feet per second (cfs)) than at CC2 (median of 0.18 cfs), which would be expected from a measurement location farther downstream and after receiving stream flow contributions from Empire Gulch. In order of magnitude, CC4 (median of 0.49 cfs) is more similar to CC5 (median of 0.65 cfs), but the conceptual hydrology is different (CC5 is assumed to be bedrock controlled, whereas CC4 is not). For the purposes of this analysis, an artificial hydrograph has been constructed for CC4 by multiplying the CC2 hydrograph stream flows by a factor of two. This method should preserve the characteristics of the conceptual hydrology, but better replicate the magnitude of flow expected in CC4.
- Cienega Creek Reach 5 – This reach contains the USGS Sonoita stream gage (09484550).
- Cienega Creek Reach 7 – Conceptually, this reach has bedrock control and receives no inflow from the regional aquifer, similar to CC5. Available stream flow measurements show stream flow magnitudes (median of 0.51 cfs) are approximately those of the USGS gaging station in CC5 (median of 0.65 cfs). For these reasons, the conditions in Cienega Creek Reach 7 are similar to those in Reach 5, and for the purposes of this analysis, the USGS Sonoita stream gage hydrograph from Cienega Creek Reach 5 has also been used for Cienega Creek Reach 7.

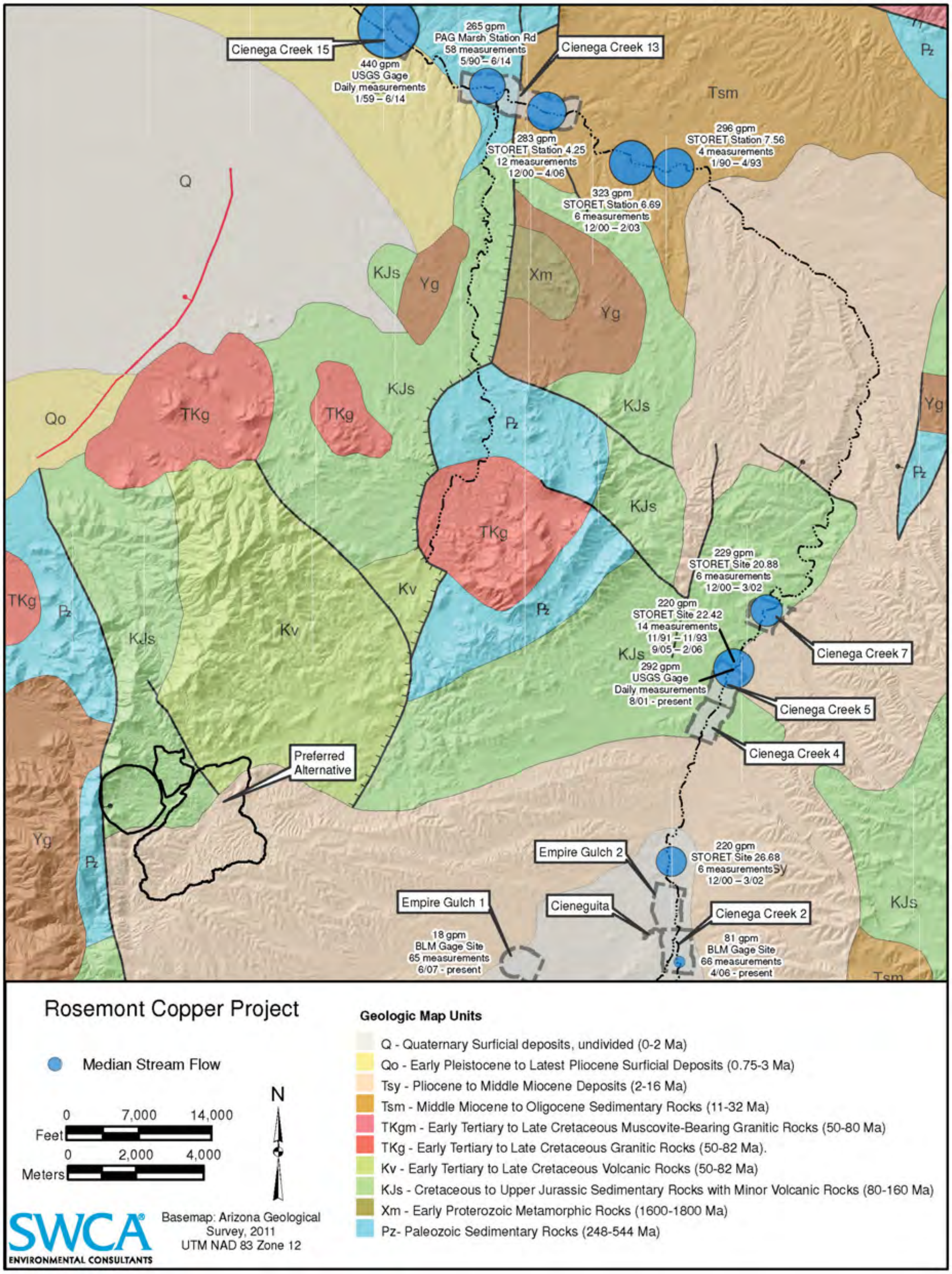

Figure 2. Median values of available stream flow measurements

- Cienega Creek Reach 13 – This reach contains flow measurements conducted by PAG between 1990 and 2014. In order to better match the period of record for other gages, which occurs primarily during the current drought period, only those measurements since 2001 have been used. This is a conservative approach, to ensure that impacts are not diluted by wetter periods prior to the current drought period.
- Cienega Creek Reach 15 – This reach contains the USGS Pantano Wash stream gage (09484600). Note that this stream gage includes stream flow measurements since 1959. In order to better match the period of record for other gages, which occurs primarily during the current drought period, only those measurements since 2001 will be used. This is a conservative approach, to ensure that impacts are not diluted by wetter period prior to the current drought period.
- Empire Gulch Reach 1 – This reach contains hydrograph from BLM monitoring on Empire Gulch.
- Empire Gulch Reach 2 – Little information exists about the magnitude of stream flow in Empire Gulch near the confluence with Cienega Creek. For the purposes of this analysis, the hydrograph from Empire Gulch Reach 1 will be used for Empire Gulch Reach 2, as well.

Selection of Incremental Drawdown and Depth to Groundwater

Discussions between May and November 2014 made clear the desire by biologists and hydrologist for the analysis to include the incremental impacts of groundwater drawdown, rather than solely focusing only on the results of the groundwater models. This approach provides flexibility in that the analysis is conducted once, but the results can be applied to any given modeling scenario. For impacts to riparian vegetation, relative drawdown and absolute depth to groundwater are both important, and ranges and increments were selected for both parameters. The following ranges were selected for analysis:

- Groundwater drawdown (feet): 0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0.
- Absolute depth to groundwater (feet bgs): 0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0.

Methodology for Predicting Impacts to Stream Hydrographs

For each key reach, the hydrograph is modified in three ways if applicable:

1. Make changes to measured hydrograph in order to extrapolate to a different key reach. Cienega Creek Reach 4 is the only hydrograph extrapolated in this manner.
2. Make changes to hydrograph due to groundwater drawdown occurring in the key reach. This step requires a method of converting drawdown (in feet) to loss in stream flow (in cfs or gpm); the exact nature of this conversion varies by key reach.
3. Change to hydrograph due to loss of upstream surface flow, if applicable.

The specific methods to be applied to each key reach are summarized in table 5.

Methodology for Translating Groundwater Drawdown to Stream flow Loss

One substantial change between the analysis presented in the FEIS and the analysis presented in this SIR is the manner in which groundwater drawdown is translated to impacts on stream flow. In the FEIS analysis, this translation was accomplished by directly assuming any drawdown of groundwater would appear identically in the stream channel, i.e., 1 foot of drawdown in the aquifer would equal 1 foot of lowering of the water surface of the flowing stream. The drawbacks of this approach were one of the main points of discussion between May and November 2014, specifically the high likelihood that a 1:1 relationship exists only in certain hydrologic settings, such as a standing pool, but is not necessarily applicable to a flowing stream.

The additional information obtained between May and November 2014 allows a different approach to determining the relationship between groundwater levels and stream flow. Several data sets are now available for Empire Gulch and Cienega Creek that pair stream flow measurements (as measured in gpm or cfs) with groundwater levels (as measured in feet below land surface). These data sets have been used to define a statistical relationship between groundwater level and stream flow. This empirical stream flow/groundwater level relationship replaces the assumed 1:1 stream depth/groundwater level relationship.

It needs to be made clear that this empirical relationship is not based on the same stresses that will occur in the future, due to the presence of the mine pit. The empirical data set consists of stream flow measured in the stream channel, matched up with groundwater levels measured in nearby piezometers in the shallow alluvial aquifer. Both the stream flow and piezometer water level measurements fluctuate seasonally. This seasonal fluctuation occurs primarily because the shallow alluvial aquifer is stressed by the evapotranspiration of groundwater by riparian vegetation during the growing season. The empirical correlation between stream flow and groundwater levels is possible because both parameters are responding to the stress of evapotranspiration directly on the shallow alluvial aquifer.

When future drawdown occurs due to creation of the mine pit, it will result in a different stress entirely. There will be a stress placed directly on the regional aquifer, not on the shallow alluvial aquifer. As previously discussed and summarized in table 5, this SIR analysis assumes for many key reaches that there is a complete hydraulic connection between the regional aquifer, the shallow alluvial aquifer, and surface flow in the stream channel. Thus, it is expected that the stress placed on the regional aquifer by the mine pit will result in drawdown in the regional aquifer, which will in turn result in drawdown in the shallow alluvial aquifer, which will in turn result in reduced stream flow. In other words, the physical action that will cause a reduction in stream flow in the future—dropping shallow aquifer water levels—is the same physical action that occurs now seasonally, but the stress that causes that physical action will be different.

As summarized in table 5, there are four different data sets that allow development of an empirical stream flow/groundwater level relationship. Different statistical techniques were considered to develop each of these relationships. For instance, in June 2014 Rosemont Copper presented the results of statistical correlation between wet/dry mapping and stream flow, using a variety of statistical techniques (Rosemont Copper Company 2014b). Similarly, in July 2014 Pima County presented the results of statistical correlations between wet/dry mapping, stream flow, and groundwater levels, also using a variety of statistical techniques (Powell et al. 2014). After consideration of these techniques, and others, it was determined that using a linear regression model with two variables, groundwater level (explanatory variable) and stream flow (response variable), was the most appropriate technique to translate groundwater drawdown into stream flow loss.

The least useful relationship between groundwater levels and stream flow was found for key reach CC15 on Lower Cienega Creek. In this case, while statistically significant, the water levels in the Del Lago well do not explain much of the variation. An alternative approach considered was use of the rating curve for the USGS stream gage at this location. The comparison of the rating curve to the linear regression is shown in appendix E. For the lowest range of flows, the relationship between water level and stream flow is similar to that developed from the regression analysis. The regression analysis has been used for predictions in this SIR.

Use of Statistical Analysis

Evaluation of Linear Regressions

There are several components of the refined analysis presented in this SIR that rely on linear regression to identify statistically significant trends. This includes analysis of changes over time (i.e., the relationship of time versus temperature or precipitation), and analysis of how two variables relate to each other (i.e., the relationship between stream flow and groundwater levels, or the relationship between temperature and groundwater levels). In each case, a linear regression line is calculated that defines the best-fit relationship between the explanatory variable (also known as the independent variable, which appears on the x-axis) and the response variable (also known as the dependent variable, which appears on the y-axis).

When using linear regression, it is incumbent on the statistician to analyze whether the results are statistically significant. For the purposes of this analysis, two statistics were calculated and reviewed for each linear regression.

The first statistic is commonly known as the P value. The P value can be described as the probability that the linear regression line would occur as calculated, if in reality there is no relationship between the explanatory and the response variables (i.e., the “null hypothesis” is true). In other words, the lower the P-value, the less likely the linear regression line is to have occurred purely by accident. Commonly, the P-value is used to determine significance as follows:

- $P \leq 0.01$. Very strong presumption against null hypothesis.
- $0.01 < P \leq 0.05$. Strong presumption against null hypothesis.
- $0.05 < P \leq 0.1$. Low presumption against null hypothesis.
- $P > 0.01$. No presumption against the null hypothesis.

<u>For the purposes of this analysis, any P value less than or equal to 0.05 is considered statistically significant.</u>

The second statistic is known as R-squared, or R^2. R^2 is a measure of how well the linear regression explains the relationship between the explanatory and response variables. R^2 varies between 0 and 1, and represents the percentage of variability explained by the linear regression. An R^2 of 0 indicates that the prediction from the linear regression explains none of the variability in the real-world data; conversely, an R^2 of 1 indicates that the prediction from the linear regression explains all of the variability in the real-world data. For example, we can look at the relationship between stream flow and groundwater levels in Empire Gulch. The relationship described by the linear regression shows a slope of −10.9, indicating that for every 1-foot decrease in groundwater, stream flow will also decrease by 10.9 gpm. The regression has a P value of <0.001, which is less than 0.05, meaning that it is considered statistically significant. The R^2 for the linear regression is 0.709, which means that about 71 percent of the variability in stream flow can be accurately predicted by groundwater level. It is expected that the rest of the variability may be random or due to variables other than groundwater level.

Unlike the P value, for this analysis there is no cut-off below which R^2 is considered unacceptable. Rather, R^2 is considered a descriptive statistic that helps put the linear regression in context.

USGS Review of Linear Regression Analysis

The USGS reviewed an early version of the regression analysis (Garrett 2014b) and offered several cautions regarding use of the regression.

- Consideration of multiple water-level sources. The USGS suggested that additional distant wells be considered in the analysis, instead of relying on a single nearby piezometer. All available water-level data were reviewed. For the stream flow measured by BLM on Cienega Creek and Empire Gulch, except for the nearby piezometers no other wells had appropriate water-level measurements (i.e., taken on the same day that stream flow was measured). Therefore, for these two locations, the water levels in nearby piezometers were necessarily the data set used for the linear regression. Multiple wells were identified with water-level records overlapping that of the USGS stream gage on Cienega Creek; all of these were evaluated for potential correlation. However, note that the direct influence of drawdown on stream flow for key reaches CC5 and CC7 was not determined to be appropriate due to geological controls. Therefore, this correlation was ultimately not used in the analysis. On Lower Cienega Creek (key reaches CC13 and CC15), three wells with water levels were identified (Jungle, Cienega, and Del Lago Wells). All of these were evaluated for potential predictive ability.
- Consideration of other parameters, such as geology, climatic variables, and antecedent hydrologic conditions. Several of these parameters have been incorporated into the analysis (geology, climate variables), but have not been incorporated mathematically into the regression, which describes how stream flow changes due to changes in groundwater level.
- Extrapolation of drawdown past existing range. It is acknowledged that the use of this linear regression will be to predict the effects of groundwater drawdown beyond the levels of drawdown currently experienced. This is unavoidable for several reasons. Empire Gulch may experience drawdown of several feet. There are currently no seasonal stresses of this magnitude. The drawdown that may be experienced on Cienega Creek is substantially less, and likely within the same range as that experienced seasonally. But since the analysis is cumulative—that is, the drawdown imposed by the mine pit is considered on top of the seasonal changes already experienced—even on Cienega Creek by definition the analysis will have to be extrapolated beyond the existing range of the data.
- Confidence intervals. A key tenet of the entire FEIS analysis, as well as the refined analysis in this SIR, is the consideration of a range of impact scenarios and not reliance on any single groundwater model, any single modeling scenario, or any single predictive technique. The key statistical parameter used in this analysis is the slope of the linear regression line that defines the relationship between stream flow and groundwater levels. This calculated slope indicates the change in stream flow that will occur for any change in groundwater level.

  For instance, on Empire Gulch, the empirical relationship yields a linear regression with a slope of −10.9 gpm/foot. In other words, for every 1-foot decline in groundwater level, stream flow will decline by 10.9 gpm. However, there could be many possible lines drawn through the data with many possible slopes, some fitting the data better than others. This universe of possible slopes has its own probability distribution, and −10.9 gpm/foot actually represents the mean of this probability distribution, which also represents the slope with the best fit to the data. Because there is a probability distribution for the regression slope, rather than rely on just the best-fit slope, it is also possible to apply confidence intervals to the calculated slope of the regression line. For instance, on Empire Gulch, there is 95 percent confidence that the slope will lie between −7.6 and −14.2 gpm/foot, or put another way, −10.9 ± 3.3 gpm/foot. The refined analysis in this SIR includes analysis of the best-fit relationship between stream flow and groundwater levels (−10.9 gpm/foot for Empire Gulch), as well as disclosure of impacts from the high (−14.2 gpm/foot) and low (−7.6 gpm/foot) ends of the 95 percent confidence interval.

Comparison with Pima County Analysis of Water Levels on Lower Cienega Creek

In July 2014, as part of the discussion related to reinitiation of consultation, Pima County conducted an analysis of correlations between groundwater levels, stream flow, and wetted stream length on Lower Cienega Creek (Powell et al. 2014). Pima County used linear regression to calculate a predictive relationship between the natural log of stream flow and groundwater levels in nearby wells (Powell 2014a).

These same calculations were conducted for the analysis contained in this SIR. Stream flow measured at Marsh Station Road was analyzed against groundwater levels from three wells (Cienega, Jungle, and Del Lago Wells). The natural log of stream flow was also analyzed against groundwater levels from the Cienega Well (similar to what Pima County conducted). These results are included in appendix E.

Similar to the results obtained by Pima County, while all of the wells showed statistically significant relationships with stream flow, the Cienega Well groundwater levels correlate most closely with stream flow in Lower Cienega Creek, and therefore this relationship is used in this SIR. The natural log of stream flow offered a slightly better correlation with groundwater levels (R^2 of 0.62 for stream flow, and R^2 of 0.68 for the natural log of stream flow), but for consistency with the other linear regressions, the non-log relationship was selected for use.

Results of Stream Flow/Groundwater Level Linear Regressions

Full information regarding the following regression analyses is included in appendix E. Table 6 presents a summary of the results.

Table 6. Summary of linear regressions for stream flow/groundwater level

Key Reach*	Source of Groundwater Levels	Source of Stream flow	Number of Data Points	Slope	95% Confidence Interval for Slope	P Value	R^2
EG1	BLM Piezometer WP-9	BLM measurements	21	−10.9 (gpm/foot)	−7.6 to −14.2	<0.001	0.709
CC2	BLM Piezometer WP-13	BLM measurements	19	−117.6 (gpm/foot)	−168.0 to −67.2	<0.001	0.588
CC13†	Cienega Well	PAG measurements	41	−108.6 (gpm/foot)	−136 to −81.2	<0.001	0.622
CC15‡	Del Lago Well	USGS Gage	198	−166 (gpm/foot)	−293.0 to −38.6	0.011	0.033

* Analysis was also conducted on CC5, with a variety of wells. But due to the conceptual hydrology and presence of geological controls, these relationships were not used in the analysis, and are not included in appendix E.

† Analysis included in appendix E also looked at correlation with Del Lago Well, Jungle Well, as well as log of stream flow.

‡ Analysis included in appendix E also looked at correlation with Jungle Well and Cienega Well.

Incremental Predicted Impacts to Stream flow for Key Reaches.

Predictions of impact to each of the key reaches based on increasing increments of theoretical drawdown are included in appendix F and summarized in tables 7 through 10.

Table 7. Predicted stream flow reduction (gpm)*

Key Reach	Additional Drawdown (feet)									
	Baseline (zero drawdown)	0.2	0.4	0.6	0.8	1.0	1.5	2.0	3.0	4.0	5.0
CC2	0.0	23.5	47.0	70.6	94.1	117.6	177.4	235.2	352.8	470.4	588.0
CC4	0.0	49.2	98.4	147.7	196.9	246.1	371.2	492.2	738.3	984.4	1230.5
CC5	0.0	49.2	98.4	147.7	196.9	246.1	371.2	492.2	738.3	984.4	1230.5
CC7	0.0	49.2	98.4	147.7	196.9	246.1	371.2	492.2	738.3	984.4	1230.5
CC13	0.0	21.7	43.4	65.2	86.9	108.6	162.9	217.2	325.8	434.4	543.0
CC15	0.0	54.9	109.8	164.8	219.7	274.6	411.9	549.2	823.8	1098.4	1373.0
EG1	0.0	2.2	4.4	6.5	8.7	10.9	17.4	21.8	32.7	43.6	54.5
EG2	0.0	2.2	4.4	6.5	8.7	10.9	17.4	21.8	32.7	43.6	54.5

* Includes flow reduction from direct drawdown in the reach, as well as flow reductions from upstream reaches, where applicable.

Table 8. Predicted number of days of zero stream flow per year

Key Reach	Additional Drawdown (feet)									
	Baseline (zero drawdown)	0.2	0.4	0.6	0.8	1.0	1.5	2.0	3.0	4.0	5.0
CC2	0	0	22	133	271	326	359	365	365	365	365
CC4	0	0	44	155	277	332	359	365	365	365	365
CC5	2	3	20	60	109	150	244	315	350	352	353
CC7	2	3	20	60	109	150	244	315	350	352	353
CC13	0	0	23	46	68	84	144	183	236	274	304
CC15	0	37	94	143	200	234	285	304	323	333	337
EG1	0	0	0	6	19	26	128	205	339	365	365
EG2	0	0	0	6	19	26	128	205	339	365	365

Table 9. Predicted number of days of low stream flow per year

Key Reach	Additional Drawdown (feet)									
	Baseline (zero drawdown)	0.2	0.4	0.6	0.8	1.0	1.5	2.0	3.0	4.0	5.0
CC2	0	61	160	277	332	343	359	365	365	365	365
CC4	0	72	166	282	332	348	365	365	365	365	365
CC5	3	18	55	106	146	181	279	329	351	352	354
CC7	3	18	55	106	146	181	279	329	351	352	354
CC13	0	23	46	68	84	114	152	205	251	274	312
CC15	0	57	108	166	210	241	288	304	323	333	337
EG1	0	19	26	58	90	128	237	301	352	365	365
EG2	0	19	26	58	90	128	237	301	352	365	365

Table 10. Predicted flow status

Key Reach	Additional Drawdown (feet)										
	Baseline (zero drawdown)	0.2	0.4	0.6	0.8	1.0	1.5	2.0	3.0	4.0	5.0
CC2	P	P	P	I	I	I	E	E	E	E	E
CC4	P	P	I	I	I	I	E	E	E	E	E
CC5	P	P	P	I	I	I	I	I	E	E	E
CC7	P	P	P	I	I	I	I	I	E	E	E
CC13	P	P	P	I	I	I	I	I	I	I	I
CC15	P	I	I	I	I	I	I	I	I	I	I
EG1	P	P	P	P	P	P	I	I	I	E	E
EG2	P	P	P	P	P	P	I	I	I	E	E

P = Perennial (<30 no flow days per year); I = Intermittent (30–350 no-flow days per year); E = Ephemeral (>350 no-flow days per year).

Selected Modeling Scenarios to Be Evaluated

Groundwater Modeling Scenarios

As with the FEIS, five groundwater modeling scenarios have been evaluated. These include the best-fit modeling results (or base model) for each of the three groundwater models: Tetra Tech, Montgomery, and Dr. Myers. In addition to these, the least-impactful and most-impactful results are analyzed from the entire range of model scenarios, including any runs conducted during the sensitivity analysis.

In the FEIS, analysis was limited to only drawdowns greater than 0.1 foot. For the refined analysis, detailed numeric drawdown results for each key reach were requested by the Coronado for each key reach (Montgomery and Associates Inc. 2014; O'Brien 2014b), and are used as received and not rounded (most of these results are reported to three or four decimal places).

The following time steps were analyzed: end of mining, and 10, 20, 50, 100, 150, 200, 300, 400, 500, 600, 700, 800, 900, and 1,000 years after end of mining.

Results are analyzed for scenarios including only mine-related drawdown, as well as mine-related drawdown combined with predicted climate change stresses.

Climate Change Stress

Climate change is expected to have three primary consequences: decreased precipitation, change in precipitation patterns, and increased temperature. With respect to precipitation amount, review of the current trends (see appendix B) indicates that during the current ongoing drought, between 2001 and 2014, precipitation has already been in the overall range predicted by climate change (see appendix B, figures B3, B4, and B5). As indicated in the FEIS, one driving factor behind adopting the hydrograph analysis technique used in the FEIS and this SIR is that it incorporates a period of severe drought into future predictions: “The patterns seen in Southern Arizona in the past few decades, and particularly on Cienega Creek, provide a template for what long-term climate change could look like. Prolonged droughts brought on by climate change could result in similar shifts from perennial to intermittent flow along upper Cienega Creek and Empire Gulch” (FEIS, p. 566).

However, review of the ongoing climatic trends indicates that while the current drought has reduced precipitation to levels predicted in the future due to climate change, the same is not true for temperature. Estimates are that climate change will drive increases in mean annual temperature between 5 to 8 degrees Fahrenheit (°F). Analysis of current trends shows that while temperatures for 11 of the past 12 years have been hotter than average, they have not reached the range expected due to climate change. Therefore, it is reasonable to assume that additional climate change stresses, above and beyond those reflected in the current hydrographs, could occur.

Review of literature related to climate change indicates that conclusions often focus on the effect that both precipitation and temperature will have on plant communities, including overall mortality, shifts in range, and conversion to more drought-tolerant species. Fewer studies focus on the question at hand: how can we estimate the overall increase or decrease in water use of the riparian corridor under higher temperature conditions? It must be acknowledged that it is not possible to approach this question with any certainty, because there are many interacting variables. If temperatures reached a threshold at which significant mortality occurs, water use could decrease. In addition to individual mortality, climate change is widely expected to increase the risk of both disease outbreaks and fires; either of these outcomes could significantly alter the riparian corridor and reduce water use. However, if more drought-tolerant tamarisk began to take over from cottonwood/willow riparian forest, or even expand the overall riparian footprint, then water use could substantially increase.

For the purposes of this SIR, the climate change scenario can be simplified with some basic assumptions. First, the scenario assumes that no catastrophic events will occur, including major disease outbreak and wildfire, and that the overall vegetative makeup of the riparian corridor will remain similar. Second, it is assumed that increasing temperatures will not reach a level that causes complete transition or mortality of the primary woody species. Cottonwood and willow are adaptable species, as long as sufficient water is available, and there are examples in the Southwest of similar riparian corridors that exist under higher temperature regimes than at Cienega Creek, such as along the Salt, Verde, Gila, and Colorado Rivers.

Given those assumptions, and the fact that reduced precipitation is already factored into the hydrographs used in the analysis, it is necessary to isolate just the effects of increased temperature. Increased temperature is assumed to have a wide range of effects; the primary effect to be considered in this analysis is that increased temperatures will drive increases in transpiration by riparian vegetation, as well as increases in direct evaporation from surface water sources. This would be expected to lead to a decrease in availability of shallow groundwater and further reductions in stream flow along Empire Gulch and Cienega Creek.

The amount of water that could be lost is difficult to estimate, particularly since predicted temperature changes may or may not occur during the growing season, during the critical low-flow season, or during the day during periods of greatest transpiration. However, in order to incorporate climate change stresses into this analysis, a rough estimate of additional stress can be gained by looking at seasonal stream flow fluctuations. On average, there is a temperature swing of approximately 25 degrees between November and June. These months were selected as being those with the highest likelihood of representing base flow conditions not directly influenced by runoff from precipitation. The increase due to climate change (5 to 8 degrees) represents 20 to 32 percent of this seasonal range.

Analysis of the stream flow used in this analysis yields the approximate change in stream flow during these same periods. In order to make a rough estimate of additional climate change stress due to increased temperatures, it is assumed that the additional reduction in surface water flow due to increased temperature is roughly 25 percent of the annual fluctuation, as shown in table 11. For those scenarios incorporating climate change, this additional stress was applied equally to all time periods and was not phased over time.

Table 11. Estimated climate change stress for each key reach

Key Reach	Median November Flow (gpm)	Median June Flow (gpm)	Seasonal Fluctuation (gpm)	Estimated 25% Stream Flow Reduction due to Future Temperature Increases (gpm)
CC2	73	56	17	4.3
CC4	146	112	34	8.5
CC5	278	108	170	43
CC7	278	108	170	43
CC13	278	103	175	44
CC15	157	110	47	12
EG1	26	13	13	3.3
EG2	26	13	13	3.3

An alternative method for estimating stream flow impacts from increased temperature could be to look at historic data and develop linear regression equations between measured stream flow and measured temperature (see appendix G). As shown in appendix G, the relationships developed by linear regression analysis are statistically significant, but show that seasonal temperature variation does not explain a large percentage of the variation in stream flow (i.e., low R^2 values). Overall, linear regression suggests that a 5 to 8 degree temperature increase would result in a stream flow reduction of approximately 2 to 3 gpm in key reach EG1 (appendix G, figures G1 and G2), and in key reach CC2, the linear regression suggests that a 5 to 8 degree temperature increase would result in a stream flow reduction of 6 to 12 gpm (see appendix G, figures G3 and G4). This alternative method was not used in any of the scenarios incorporating climate change.

Additional Basin Stresses

Between May and November 2014, ongoing discussions included the potential for growth of water use and pumpage in the Sonoita basin from residential or irrigation uses. The Coronado determined that incorporating additional stresses due to basin growth would be speculative and is not warranted. The two primary factors determining the impact a new water use might have on Cienega Creek are the quantity pumped and the proximity to the creek. While the overall trend of population growth and development is expected to continue, neither of these factors is known, and it would not be feasible to accurately estimate additional impacts on stream flow due to other basin water uses.

Sources of Uncertainty and 95th Percentile Analysis

A key tenet of the discussion between May and November 2014 was the desire to include explicit quantitative analysis of the uncertainty of predictions, to the extent possible. There are several main sources of uncertainty in the analysis; some of these are able to be assessed quantitatively, whereas others are not, as shown in table 12.

Using the high and low ends of the sensitivity analyses to predict impacts allows disclosure of the overall possible range of effects, which supplements the use of just the three best-fit model scenarios (Tetra Tech, Montgomery, and Myers). However, it is also useful to condense the very large number of modeling scenarios and parameters into a single useful prediction that incorporates all sources of uncertainty. Often, the 95 percent confidence interval is used to consolidate all sources of uncertainty into a single statistic.

For this SIR analysis, two different factors were incorporated to create a single range that would be expected to represent 95 percent of the possible outcomes. For each key reach, for each time step, there are predictions of drawdown from 37 to 38 individual modeling scenarios, including the Myers best-fit model (1 scenario, only available for key reaches EG1, CC2, and CC5, and only for certain time steps), the Tetra Tech best-fit model (1 scenario), the Montgomery best-fit model (1 scenario), the Tetra Tech sensitivity analyses (8 scenarios), and the Montgomery sensitivity analyses (27 scenarios). The drawdown from these outcomes was ranked, and the 95th percentile range was calculated. In other words, a low value of drawdown was selected where 2.5 percent of the model scenarios would predict a smaller drawdown, and a high value of drawdown was selected where 2.5 percent of the model scenarios would predict a higher drawdown. Thus, the drawdown predicted by 95 percent of all available model scenarios falls within this range.

As previously discussed, there is also statistical uncertainty also in the translation of groundwater drawdown into reductions in stream flow, which was developed using linear regression of available field data. In this case, the 95 percent confidence interval[5] can be calculated within which we know that 95 percent of the possible regression slopes would fall.

By combining these two factors, a single low and a single high scenario can be analyzed; 95 percent of all outcomes fall within the range of these two scenarios.

Table 12. Strategies to analyze sources of uncertainty

Source of Uncertainty	Strategy to Assess Uncertainty
Inherent uncertainty in groundwater models, due to long distances, long time frames, and prediction of stresses greater than currently observed.	• Use of three individual models, instead of a single model • Disclosure of predictions using high and low ends of model sensitivity analyses (quantitative) • Disclosure of predictions using 95th percentile results (quantitative)
Seasonal and drought-related changes in flow patterns	• Use of real-world hydrographs for entire period of record, rather than relying on average or median flow
Spatial differences along riparian corridor	• Use multiple key reaches, with hydrologic framework assessed independently for each reach, and analyze each separately
Climate change	• Disclose predictions of impact with mine-drawdown alone, as well as predictions combining mine drawdown with climate change • Incorporate ongoing riparian trends into baseline analysis
Translation from groundwater drawdown to reductions in stream flow	• Disclosure of predictions using 95 percent confidence intervals for regression slope, in addition to best-fit regression slope (quantitative)

[5] It should be noted that there is a difference between the 95th percentile used with the model results, and the 95 percent confidence intervals used with the regression slope. In the case of the modeling results, each model run is based on different underlying assumptions. Therefore, they are not technically replicates of each other, and they would not necessarily be expected to be similar to each other. Statistically speaking, they do not belong to the same population and should not be used to create a probability distribution. The 95th percentile is a measure that is independent of the probability distribution, and simply represents the range within which 95 percent of the results fall, regardless of whether they are replicates of the same process. The population of likely regression slopes, on the other hand, forms a true probability distribution, as it represents different outcomes for the same underlying data. The 95 percent confidence interval is a statistical construct, based on the assumption that the many different regression slopes that could occur would follow a normal distribution.

Predicted Impacts to Stream Flow for Key Reaches for Modeling Scenarios

Mine Drawdown Only

Predicted impacts on stream flow for each modeling scenario without climate change, as well as the baseline without climate change, are shown for each key reach in tables 13 through 16. Predicted flow loss is shown in table 13. Annual predicted days with zero stream flow are shown in table 14. Annual predicted days with extremely low stream flow are shown in table 15. The predicted flow status of each key reach (i.e., perennial, intermittent, ephemeral) is shown in table 16. The same results are shown graphically in figures H1-A through H8-A in appendix H.

Tables 14 through 16 also show a comparison of the results disclosed in the FEIS to the refined stream flow analysis.

Climate Change Only

Predicted impacts on stream flow due solely to climate change are shown for each key reach in table 17.

Combined Mine Drawdown and Climate Change

Predicted impacts on stream flow for each modeling scenario combined with climate change are shown for each key reach in tables 18 through 21. Predicted flow loss is shown in table 18. Annual predicted days with zero stream flow are shown in table 19. Annual predicted days with extremely low stream flow are shown in table 20. The predicted flow status of each key reach (i.e., perennial, intermittent, ephemeral) is shown in table 21. The same results are shown graphically in figures H1-B through H8-B in appendix H.

Tables 19 through 21 also show a comparison of the results disclosed in the FEIS with the refined stream flow analysis.

95th Percentile – Mine Only and Combined Mine/Climate Change

The predicted impacts for the 95th percentile range are shown for each key reach, both with and without climate change, in tables 22 through 25. Predicted flow loss is shown in table 22. Annual predicted days with zero stream flow are shown in table 23. Annual predicted days with extremely low stream flow are shown in table 24. The predicted flow status of each key reach (i.e., perennial, intermittent, ephemeral) is shown in table 25. The same results are shown graphically in figures H1-C through H8-C in appendix H.

Analysis of Impacts to Refugia Pools

Methodology for Predicting Impacts to Refugia Pools

During November and December 2014, field surveys were conducted of all key reaches, with the intent of collecting information on standing pools. During these surveys, all pools were identified, their locations mapped, and characteristics recorded. The locations of all pools identified during the field surveys are shown in figures 3a through 3e. Measurements included total length, width at multiple locations, depth at multiple locations, and presence of inflow/outflow.

An approximate three-dimensional model of each pool was created using the Surfer software package. Using this three-dimensional model, the depth, volume, and pool surface area were calculated for each of the incremental drawdown scenarios.

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Table 13. Results of stream flow analysis for modeling scenarios without climate change – predicted stream flow loss (gpm)

Key Reach	Baseline without Climate Change	End of Mine					10					20					50					100					150					500					1,000				
		L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	0.0	−0.4	0.0	0.0	-	0.4	0.0	0.4	0.1	-	4.2	0.0	0.4	0.1	-	4.2	0.0	0.4	0.1	0.0	4.2	0.0	0.8	0.1	-	4.2	0.0	1.5	0.1	11.8	11.8	0.0	4.2	1.4	-	5.6	0.0	4.6	2.8	258.7	258.7
CC4	0.0	−0.4	0.0	0.0	-	0.5	0.0	0.4	0.2	-	7.2	0.0	0.5	0.2	-	7.2	0.0	0.6	0.2	-	7.9	0.0	1.5	0.2	-	9.0	0.0	2.8	0.3	-	17.8	0.3	7.5	2.1	-	13.5	0.5	8.0	3.9	-	266.7
CC5	0.0	−0.4	0.0	0.0	-	0.5	0.0	0.4	0.2	-	7.2	0.0	0.5	0.2	-	7.2	0.0	0.6	0.2	0.0	7.9	0.0	1.5	0.2	-	9.0	0.0	2.8	0.3	11.8	17.8	0.3	7.5	2.1	-	13.5	0.5	8.0	3.9	258.7	266.7
CC7	0.0	−0.4	0.0	0.0	-	0.5	0.0	0.4	0.2	-	7.2	0.0	0.5	0.2	-	7.2	0.0	0.6	0.2	-	7.9	0.0	1.5	0.2	-	9.0	0.0	2.8	0.3	-	17.8	0.3	7.5	2.1	-	13.5	0.5	8.0	3.9	-	266.7
CC13	0.0	0.0	0.0	0.0	-	0.4	0.0	0.4	0.1	-	3.9	0.0	0.4	0.1	-	3.9	0.0	1.1	0.1	-	3.9	0.0	1.4	0.1	-	3.9	0.0	2.1	0.1	-	3.9	0.0	3.2	1.3	-	5.2	0.0	3.6	2.6	-	6.6
CC15	0.0	0.0	0.0	0.0	-	0.9	0.0	0.9	0.1	-	8.6	0.0	0.9	0.1	-	8.7	0.0	3.2	0.1	-	8.6	0.0	6.3	0.1	-	12.6	0.0	10.9	0.1	-	17.5	0.0	21.2	1.3	-	25.4	0.0	23.2	2.6	-	26.2
EG1	0.0	0.0	0.1	0.0	-	2.0	0.0	0.6	0.0	-	5.0	0.0	1.5	0.0	-	9.2	0.0	6.5	0.0	23.8	24.2	0.0	18.7	0.7	-	45.0	0.2	31.9	3.1	35.7	58.8	12.9	69.2	23.5	-	73.3	27.0	70.8	38.7	51.2	70.8
EG2	0.0	0.0	0.0	0.0	-	0.1	0.0	0.0	0.1	-	0.2	0.0	0.1	0.1	-	0.3	0.0	0.3	0.1	-	0.9	0.0	0.7	0.1	-	1.8	0.0	1.3	0.2	-	2.4	0.3	2.9	0.7	-	3.1	0.5	3.0	1.0	-	3.0

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

Table 14. Results of stream flow analysis for modeling scenarios without climate change – number of days with zero flow per year

Key Reach	Baseline without Climate Change	End of Mine					10					20					50					100					150					500					1,000				
		L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	-	0	0	0	0	365	365
CC4	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	332
CC5	2	0	2	2	-	2	2	2	2	-	3	2	2	2	-	3	2	2	2	2	3	2	2	2	-	3	2	2	2	3	3	2	3	2	-	3	2	3	2	160	166
CC7	2	0	2	2	-	2	2	2	2	-	3	2	2	2	-	3	2	2	2	-	3	2	2	2	-	3	2	2	2	-	3	2	3	2	-	3	2	3	2	-	166
CC13	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0
CC15	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	1	0	-	3	0	3	0	-	3
EG1	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	26	0	6	0	237	269	0	160	0	-	365	0	333	0	339	365	58	365	237	-	365	295	365	352	365	365
EG2	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0
FEIS Disclosure – Empire Gulch		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	283	361	-	-	-	-	-	3	32	32	363	365	-	-	-	-	-	363	364	365	365	365
FEIS Disclosure – Cienega Creek		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3	3	4	-	-	-	-	-	3	3	3	32	313	-	-	-	-	-	3	3	125	351	351

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

Table 15. Results of stream flow analysis for modeling scenarios without climate change – number of days with extremely low flow per year

Key Reach	Baseline without Climate Change	End of Mine					10					20					50					100					150					500					1,000				
		L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	0	0	0	0	-	6	0	6	0	-	6	0	6	0	-	6	0	6	0	0	6	0	6	0	-	6	0	6	0	11	11	0	6	6	-	6	0	6	6	365	365
CC4	0	0	0	0	-	0	0	0	0	-	6	0	0	0	-	6	0	6	0	-	6	0	6	0	-	6	0	6	0	-	11	0	6	6	-	6	0	6	6	-	354
CC5	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	3	3	3	3	3	-	3	3	3	3	4	5	3	3	3	-	4	3	3	3	190	195
CC7	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	5	3	3	3	-	4	3	3	3	-	195
CC13	0	0	0	0	-	0	0	0	0	-	8	0	0	0	-	8	0	8	0	-	8	0	8	0	-	8	0	8	0	-	8	0	8	8	-	15	0	8	8	-	15
CC15	0	0	0	0	-	0	0	0	0	-	3	0	0	0	-	3	0	1	0	-	3	0	3	0	-	6	0	6	0	-	9	0	13	1	-	18	0	13	1	-	18
EG1	0	0	6	0	-	6	0	6	0	-	26	0	6	0	-	102	0	58	0	314	333	0	269	6	-	365	6	339	26	365	365	160	365	314	-	365	339	365	365	365	365
EG2	0	0	6	0	-	6	0	6	6	-	6	0	6	6	-	6	0	6	6	-	6	0	6	6	-	6	0	6	6	-	19	6	19	6	-	26	6	19	6	-	19
FEIS Disclosure – Empire Gulch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	146	352	362	-	-	-	-	-	4	283	283	364	365	-	-	-	-	-	363	364	365	365	365
FEIS Disclosure – Cienega Creek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4	4	146	-	-	-	-	-	4	88	88	283	352	-	-	-	-	-	88	88	339	354	354

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

Table 16. Results of stream flow analysis for modeling scenarios without climate change – flow status

Key Reach	Baseline without Climate Change	End of Mine					10					20					50					100					150					500					1,000				
		L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	P	P	P	P	P	-	P	P	P	P	P	P	P	P	P	-	P	P	P	P	E	E
CC4	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	I
CC5	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	P	P	P	P	P	-	P	P	P	P	P	P	P	P	P	-	P	P	P	P	I	I
CC7	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	I
CC13	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P
CC15	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P
EG1	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	I	I	P	I	P	-	E	P	I	P	I	E	I	E	I	-	E	I	E	E	E	E
EG2	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P
FEIS Disclosure – Empire Gulch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	P	P	I	E	-	-	-	-	-	P	I	I	E	E	-	-	-	-	-	E	E	E	E	E
FEIS Disclosure – Cienega Creek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	P	P	P	P	-	-	-	-	-	P	P	P	I	I	-	-	-	-	-	P	P	I	E	E

Notes: P = Perennial (<30 no flow days per year); I = Intermittent (30–350 no-flow days per year); E = Ephemeral (>350 no-flow days per year)

L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

Table 17. Refined stream flow analysis for climate change only

Key Reach	Current Conditions			Climate Change Scenario			
	Days per Year with Zero Stream Flow	Days per Year with Extremely Low Flow	Flow Status	Predicted Flow Reduction (gpm)	Days per Year with Zero Stream Flow	Days per Year with Extremely Low Flow	Flow Status
CC2	0	0	Perennial	4.3	0	6	Perennial
CC4	0	0	Perennial	8.5	0	6	Perennial
CC5	2	3	Perennial	43	5	23	Perennial
CC7	2	3	Perennial	43	23	60	Perennial
CC13	0	0	Perennial	44	23	46	Perennial
CC15	0	0	Perennial	12	37	57	Intermittent
EG1	0	0	Perennial	3.3	0	26	Perennial
EG2	0	0	Perennial	3.3	0	26	Perennial

Table 18. Results of stream flow analysis for modeling scenarios combined with climate change – predicted stream flow loss (gpm)

Key Reach	Baseline with Climate Change	End of Mine					10					20					50					100					150					500					1,000				
		L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	4.3	3.9	4.3	4.3	-	4.7	4.3	4.7	4.4	-	8.5	4.3	4.7	4.4	-	8.5	4.3	4.7	4.4	4.3	8.5	4.3	5.1	4.4	-	8.5	4.3	5.8	4.4	16.1	16.1	4.3	8.5	5.7	-	9.9	4.3	8.9	7.1	263.0	263.0
CC4	16.1	15.7	16.1	16.1	-	16.6	16.1	16.5	16.3	-	23.3	16.1	16.6	16.3	-	23.3	16.1	16.7	16.3	-	24.0	16.1	17.6	16.3	-	25.1	16.1	18.9	16.4	-	33.9	16.4	23.6	18.2	-	29.6	16.6	24.1	20.0	-	282.8
CC5	59.1	58.7	59.1	59.1	-	59.6	59.1	59.5	59.3	-	66.3	59.1	59.6	59.3	-	66.3	59.1	59.7	59.3	59.1	67.0	59.1	60.6	59.3	-	68.1	59.1	61.9	59.4	70.9	76.9	59.4	66.6	61.2	-	72.6	59.6	67.1	63.0	317.8	325.8
CC7	102.1	101.7	102.1	102.1	-	102.6	102.1	102.5	102.3	-	109.3	102.1	102.6	102.3	-	109.3	102.1	102.7	102.3	-	110.0	102.1	103.6	102.3	-	111.1	102.1	104.9	102.4	-	119.9	102.4	109.6	104.2	-	115.6	102.6	110.1	106.0	-	368.8
CC13	44.0	44.0	44.0	44.0	-	44.4	44.0	44.4	44.1	-	47.9	44.0	44.4	44.1	-	47.9	44.0	45.1	44.1	-	47.9	44.0	45.4	44.1	-	47.9	44.0	46.1	44.1	-	47.9	44.0	47.2	45.3	-	49.2	44.0	47.6	46.6	-	50.6
CC15	56.0	56.0	56.0	56.0	-	56.9	56.0	56.9	56.1	-	64.6	56.0	56.9	56.1	-	64.7	56.0	59.2	56.1	-	64.6	56.0	62.3	56.1	-	68.6	56.0	66.9	56.1	-	73.5	56.0	77.2	57.3	-	81.4	56.0	79.2	58.6	-	82.2
EG1	3.3	3.3	3.4	3.3	-	5.3	3.3	3.9	3.3	-	8.3	3.3	4.8	3.3	-	12.5	3.3	9.8	3.3	27.1	27.5	3.3	22.0	4.0	-	48.3	3.5	35.2	6.4	39.0	62.1	16.2	72.5	26.8	-	76.6	30.3	74.1	42.0	54.5	74.1
EG2	3.3	3.3	3.3	3.3	-	3.4	3.3	3.3	3.4	-	3.5	3.3	3.4	3.4	-	3.6	3.3	3.6	3.4	-	4.2	3.3	4.0	3.4	-	5.1	3.3	4.6	3.5	-	5.7	3.6	6.2	4.0	-	6.4	3.8	6.3	4.3	-	6.3

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses
- Indicates no data available for this model/time step.

Table 19. Results of stream flow analysis for modeling scenarios combined with climate change – number of days with zero flow per year

Key Reach	Baseline without Climate Change	End of Mine					10					20					50					100					150					500					1,000				
		L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	-	0	0	0	0	365	365
CC4	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	343
CC5	5	5	5	5	-	5	5	5	5	-	6	5	5	5	-	6	5	5	5	5	6	5	5	5	-	8	5	5	5	8	11	5	6	5	-	9	5	6	6	197	201
CC7	23	23	23	23	-	23	23	23	23	-	28	23	23	23	-	28	23	23	23	-	28	23	25	23	-	28	23	25	23	-	35	23	28	25	-	31	23	28	25	-	244
CC13	23	23	23	23	-	23	23	23	23	-	23	23	23	23	-	23	23	23	23	-	23	23	23	23	-	23	23	23	23	-	23	23	23	23	-	23	23	23	23	-	23
CC15	37	37	37	37	-	37	37	37	37	-	46	37	37	37	-	46	37	42	37	-	46	37	42	37	-	50	37	46	37	-	57	37	63	37	-	66	37	63	42	-	66
EG1	0	0	0	0	-	0	0	0	0	-	19	0	0	0	-	58	0	26	0	301	301	0	205	0	-	365	0	339	6	359	365	128	365	295	-	365	333	365	365	365	365
EG2	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	6	0	-	6	0	6	0	-	6
FEIS Disclosure – Empire Gulch		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4	283	361	-	-	-	-	-	3	32	32	363	365	-	-	-	-	-	363	364	365	365	365
FEIS Disclosure – Cienega Creek		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3	3	4	-	-	-	-	-	3	3	3	32	313	-	-	-	-	-	3	3	125	351	351

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses
- Indicates no data available for this model/time step

Table 20. Results of stream flow analysis for modeling scenarios combined with climate change – number of days with extremely low flow per year

Key Reach	Baseline without Climate Change	End of Mine					10					20					50					100					150					500					1,000				
		L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	6	6	6	6	-	6	6	6	6	-	6	6	6	6	-	6	6	6	6	6	6	6	6	6	-	6	6	6	6	17	17	6	6	6	-	11	6	11	6	365	365
CC4	6	6	6	6	-	6	6	6	6	-	11	6	6	6	-	11	6	6	6	-	11	6	6	6	-	11	6	11	6	-	17	6	11	11	-	11	6	11	11	-	359
CC5	23	23	23	23	-	25	23	25	25	-	28	23	25	25	-	28	23	25	25	23	28	23	25	25	-	28	23	25	25	31	35	25	28	25	-	31	25	28	25	234	244
CC7	60	60	60	60	-	60	60	60	60	-	68	60	60	60	-	68	60	60	60	-	68	60	60	60	-	68	60	65	60	-	79	60	68	65	-	73	60	68	65	-	276
CC13	46	46	46	46	-	46	46	46	46	-	61	46	46	46	-	61	46	46	46	-	61	46	61	46	-	61	46	61	46	-	61	46	61	46	-	61	46	61	61	-	61
CC15	57	57	57	57	-	57	57	57	57	-	66	57	57	57	-	66	57	57	57	-	66	57	63	57	-	72	57	66	57	-	77	57	77	57	-	80	57	80	57	-	85
EG1	26	26	26	26	-	26	26	26	26	-	83	26	26	26	-	160	26	102	26	339	339	26	301	26	-	365	26	365	58	365	365	231	365	339	-	365	339	365	365	365	365
EG2	26	26	26	26	-	26	26	26	26	-	26	26	26	26	-	26	26	26	26	-	26	26	26	26	-	26	26	26	26	-	26	26	58	26	-	58	26	58	26	-	58
FEIS Disclosure – Empire Gulch		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	146	352	362	-	-	-	-	-	4	283	283	364	365	-	-	-	-	-	363	364	365	365	365
FEIS Disclosure – Cienega Creek		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4	4	146	-	-	-	-	-	4	88	88	283	352	-	-	-	-	-	88	88	339	354	354

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

Table 21. Results of stream flow analysis for modeling scenarios combined with climate change – flow status

Key Reach	Baseline without Climate Change	End of Mine					10					20					50					100					150					500					1,000				
		L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	P	P	P	P	P	-	P	P	P	P	P	P	P	P	P	-	P	P	P	P	E	E
CC4	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	I
CC5	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	P	P	P	P	P	-	P	P	P	P	P	P	P	P	P	-	P	P	P	P	I	I
CC7	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	I	P	P	P	-	I	P	P	P	-	I
CC13	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P
CC15	I	I	I	I	-	I	I	I	I	-	I	I	I	I	-	I	I	I	I	-	I	I	I	I	-	I	I	I	I	-	I	I	I	I	-	I	I	I	I	-	I
EG1	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	I	P	P	P	I	I	P	I	P	-	E	P	I	P	E	E	I	E	I	-	E	I	E	E	E	E
EG2	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P	P	P	P	-	P
FEIS Disclosure – Empire Gulch		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	P	P	I	E	-	-	-	-	-	P	I	I	E	E	-	-	-	-	-	E	E	E	E	E
FEIS Disclosure – Cienega Creek		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	P	P	P	P	-	-	-	-	-	P	P	P	I	I	-	-	-	-	-	P	P	I	E	E

Notes: P = Perennial (<30 no-flow days per year); I = Intermittent (30–350 no-flow days per year); E = Ephemeral (>350 no-flow days per year)

L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

Table 22. Results of stream flow analysis for 95th percentile range – predicted stream flow loss (gpm)

Key Reach	Scenario	End of Mine	10	20	50	100	150	200	300	400	500	600	700	800	900	1,000
CC2	Mine Only	0	0-4.8	0-4.8	0-4.8	0-4.8	0-6.9	0-5.6	0-6.1	0-6.7	0-7.3	0-7.7	0-8	0-8.5	0-8.7	0-46.2
CC2	Climate Change	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
CC2	Mine and Climate Change	4.3	4.3-9.1	4.3-9.1	4.3-9.1	4.3-9.1	4.3-11.2	4.3-9.9	4.3-10.4	4.3-11	4.3-11.6	4.3-12	4.3-12.3	4.3-12.8	4.3-13	4.3-50.5
CC4	Mine Only	0-0.1	0-8.5	0-8.5	0-9	0-10.3	0-13.2	0-12.7	0-14.2	0.1-15.2	0.2-16.1	0.3-16.6	0.3-17	0.4-17.7	0.4-17.8	0.4-55.5
CC4	Climate Change*	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1
CC4	Mine and Climate Change	16.1-16.2	16.1-24.6	16.1-24.6	16.1-25.1	16.1-26.4	16.1-29.3	16.1-28.8	16.1-30.3	16.2-31.3	16.3-32.2	16.4-32.7	16.4-33.1	16.5-33.8	16.5-33.9	16.5-71.6
CC5	Mine Only	0-0.1	0-8.5	0-8.5	0-9	0-10.3	0-13.2	0-12.7	0-14.2	0.1-15.2	0.2-16.1	0.3-16.6	0.3-17	0.4-17.7	0.4-17.8	0.4-55.5
CC5	Climate Change*	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1
CC5	Mine and Climate Change	59.1-59.2	59.1-67.6	59.1-67.6	59.1-68.1	59.1-69.4	59.1-72.3	59.1-71.8	59.1-73.3	59.2-74.3	59.3-75.2	59.4-75.7	59.4-76.1	59.5-76.8	59.5-76.9	59.5-114.6
CC7	Mine Only	0-0.1	0-8.5	0-8.5	0-9	0-10.3	0-13.2	0-12.7	0-14.2	0.1-15.2	0.2-16.1	0.3-16.6	0.3-17	0.4-17.7	0.4-17.8	0.4-55.5
CC7	Climate Change*	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1
CC7	Mine and Climate Change	102.1-102.2	102.1-110.6	102.1-110.6	102.1-111.1	102.1-112.4	102.1-115.3	102.1-114.8	102.1-116.3	102.2-117.3	102.3-118.2	102.4-118.7	102.4-119.1	102.5-119.8	102.5-119.9	102.5-157.6
CC13	Mine Only	0-0.4	0-3.9	0-3.9	0-3.9	0-3.9	0-3.9	0-4.1	0-4.6	0-5.1	0-5.7	0-6.2	0-6.5	0-6.9	0-7	0-7.3
CC13	Climate Change	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
CC13	Mine and Climate Change	44-44.4	44-47.9	44-47.9	44-47.9	44-47.9	44-47.9	44-48.1	44-48.6	44-49.1	44-49.7	44-50.2	44-50.5	44-50.9	44-51	44-51.3
CC15	Mine Only	0-0.8	0-15.4	0-15.4	0-15.4	0-15.4	0-15.4	0-15.6	0-16.1	0-16.6	0-17.2	0-17.7	0-18	0-18.4	0-18.5	0-18.8
CC15	Climate Change*	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
CC15	Mine and Climate Change	56-56.8	56-71.4	56-71.4	56-71.4	56-71.4	56-71.4	56-71.6	56-72.1	56-72.6	56-73.2	56-73.7	56-74	56-74.4	56-74.5	56-74.8
EG1	Mine Only	0-2.3	0-4.2	0-6.5	0-28.4	0-33.4	0.3-49.1	1.1-62	3.5-76.7	6.2-82.8	9.1-84.6	11.8-85.2	14.2-85.1	15.9-84.7	16.7-84.3	17.3-83.9
EG1	Climate Change	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
EG1	Mine and Climate Change	3.3-5.6	3.3-7.5	3.3-9.8	3.3-31.7	3.3-36.7	3.6-52.4	4.4-65.3	6.8-80	9.5-86.1	12.4-87.9	15.1-88.5	17.5-88.4	19.2-88	20-87.6	20.6-87.2
EG2	Mine Only	0-0.1	0-0.3	0-0.3	0-0.6	0-1.4	0-2.2	0-2.8	0-3.5	0.1-3.8	0.2-3.9	0.3-4	0.3-3.9	0.4-3.9	0.4-3.9	0.4-3.9
EG2	Climate Change	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
EG2	Mine and Climate Change	3.3-3.4	3.3-3.6	3.3-3.6	3.3-3.9	3.3-4.7	3.3-5.5	3.3-6.1	3.3-6.8	3.4-7.1	3.5-7.2	3.6-7.3	3.6-7.2	3.7-7.2	3.7-7.2	3.7-7.2

* Includes climate change reductions from all applicable upstream reaches as well

Table 23. Results of stream flow analysis for 95th percentile range – number of days with zero flow per year

Key Reach	Scenario	End of Mine	10	20	50	100	150	200	300	400	500	600	700	800	900	1,000
CC2	Mine Only	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0-22
CC2	Climate Change	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CC2	Mine and Climate Change	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0-55
CC4	Mine Only	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CC4	Climate Change	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CC4	Mine and Climate Change	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0-6
CC5	Mine Only	0-2	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-4

Key Reach	Scenario	End of Mine	10	20	50	100	150	200	300	400	500	600	700	800	900	1,000
CC5	Climate Change	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
CC5	Mine and Climate Change	5	5-8	5-8	5-8	5-8	5-9	5-8	5-9	5-9	5-9	5-9	5-9	5-11	5-11	5-31
CC7	Mine Only	0-2	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-4
CC7	Climate Change	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
CC7	Mine and Climate Change	23	23-28	23-28	23-28	23-31	23-31	23-31	23-31	23-35	23-35	23-35	23-35	23-35	23-35	23-73
CC13	Mine Only	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CC13	Climate Change	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
CC13	Mine and Climate Change	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
CC15	Mine Only	0	0	0	0	0	0	0	0	0	0	0	0-1	0-1	0-1	0-1
CC15	Climate Change	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37
CC15	Mine and Climate Change	37	37-50	37-50	37-50	37-50	37-50	37-50	37-57	37-57	37-57	37-57	37-57	37-57	37-57	37-57
EG1	Mine Only	0	0	0-6	0-307	0-339	0-365	0-365	0-365	6-365	26-365	26-365	83-365	102-365	128-365	128-365
EG1	Climate Change	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EG1	Mine and Climate Change	0	0-6	0-26	0-333	0-339	0-365	0-365	6-365	26-365	58-365	102-365	128-365	166-365	166-365	199-365
EG2	Mine Only	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EG2	Climate Change	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EG2	Mine and Climate Change	0	0	0	0	0	0	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6

Table 24. Results of stream flow analysis for 95th percentile range – number of days with extremely low flow per year

Key Reach	Scenario	End of Mine	10	20	50	100	150	200	300	400	500	600	700	800	900	1,000
CC2	Mine Only	0	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-155
CC2	Climate Change	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
CC2	Mine and Climate Change	6	6-11	6-11	6-11	6-11	6-11	6-11	6-11	6-11	6-11	6-11	6-11	6-11	6-11	6-171
CC4	Mine Only	0	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-6	0-11	0-11	0-94
CC4	Climate Change	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
CC4	Mine and Climate Change	6	6-11	6-11	6-11	6-11	6-11	6-11	6-17	6-17	6-17	6-17	6-17	6-17	6-17	6-116
CC5	Mine Only	3	3-3	3-3	3-3	3-4	3-4	3-4	3-4	3-5	3-5	3-5	3-5	3-5	3-5	3-23
CC5	Climate Change	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
CC5	Mine and Climate Change	23	23-28	23-28	23-28	23-31	23-31	23-31	23-35	23-35	25-35	25-35	25-35	25-35	25-35	25-73
CC7	Mine Only	3	3-3	3-3	3-3	3-4	3-4	3-4	3-4	3-5	3-5	3-5	3-5	3-5	3-5	3-23
CC7	Climate Change	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
CC7	Mine and Climate Change	60	60-68	60-68	60-68	60-68	60-73	60-73	60-73	60-73	60-79	60-79	60-79	60-79	60-79	60-114
CC13	Mine Only	0-8	0-8	0-8	0-8	0-8	0-8	0-8	0-8	0-15	0-15	0-15	0-15	0-15	0-15	0-15
CC13	Climate Change	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
CC13	Mine and Climate Change	46	46-61	46-61	46-61	46-61	46-61	46-61	46-61	46-61	46-61	46-61	46-61	46-61	46-61	46-61
CC15	Mine Only	0	0-9	0-9	0-9	0-9	0-9	0-9	0-9	0-9	0-9	0-9	0-9	0-9	0-9	0-9

Key Reach	Scenario	End of Mine	10	20	50	100	150	200	300	400	500	600	700	800	900	1,000
CC15	Climate Change	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57
CC15	Mine and Climate Change	57	57-72	57-72	57-72	57-72	57-72	57-72	57-72	57-72	57-77	57-77	57-77	57-77	57-77	57-77
EG1	Mine Only	0-19	0-26	0-58	0-339	0-359	6-365	6-365	26-365	58-365	102-365	128-365	192-365	205-365	231-365	237-365
EG1	Climate Change	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
EG1	Mine and Climate Change	26	26-64	26-102	26-339	26-365	26-365	26-365	58-365	102-365	160-365	205-365	237-365	288-365	288-365	295-365
EG2	Mine Only	0-6	0-6	0-6	0-6	0-6	0-19	0-19	6-26	6-26	6-26	6-26	6-26	6-26	6-26	6-26
EG2	Climate Change	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
EG2	Mine and Climate Change	26	26	26	26	26	26	26-58	26-58	26-64	26-64	26-64	26-64	26-64	26-64	26-64

Table 25. Results of stream flow analysis for 95 percentile range – flow status

Key Reach	Scenario	End of Mine	10	20	50	100	150	200	300	400	500	600	700	800	900	1,000
CC2	Mine Only	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC2	Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC2	Mine and Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P-I
CC4	Mine Only	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC4	Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC4	Mine and Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC5	Mine Only	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC5	Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC5	Mine and Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P-I
CC7	Mine Only	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC7	Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC7	Mine and Climate Change	P	P	P	P	P-I	P-I	P-I	P-I	P-I	P-I	P-I	P-I	P-I	P-I	P-I
CC13	Mine Only	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC13	Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC13	Mine and Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC15	Mine Only	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
CC15	Climate Change	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
CC15	Mine and Climate Change	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
EG1	Mine Only	P	P	P	P-I	P-I	P-E	P-E	P-E	P-E	P-E	P-E	I-E	I-E	I-E	I-E
EG1	Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
EG1	Mine and Climate Change	P	P	P	P-I	P-I	P-E	P-E	P-E	P-E	I-E	I-E	I-E	I-E	I-E	I-E
EG2	Mine Only	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
EG2	Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
EG2	Mine and Climate Change	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

Notes: P = Perennial (<30 no-flow days per year); I = Intermittent (30–350 no-flow days per year); E = Ephemeral (>350 no-flow days per year)

L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

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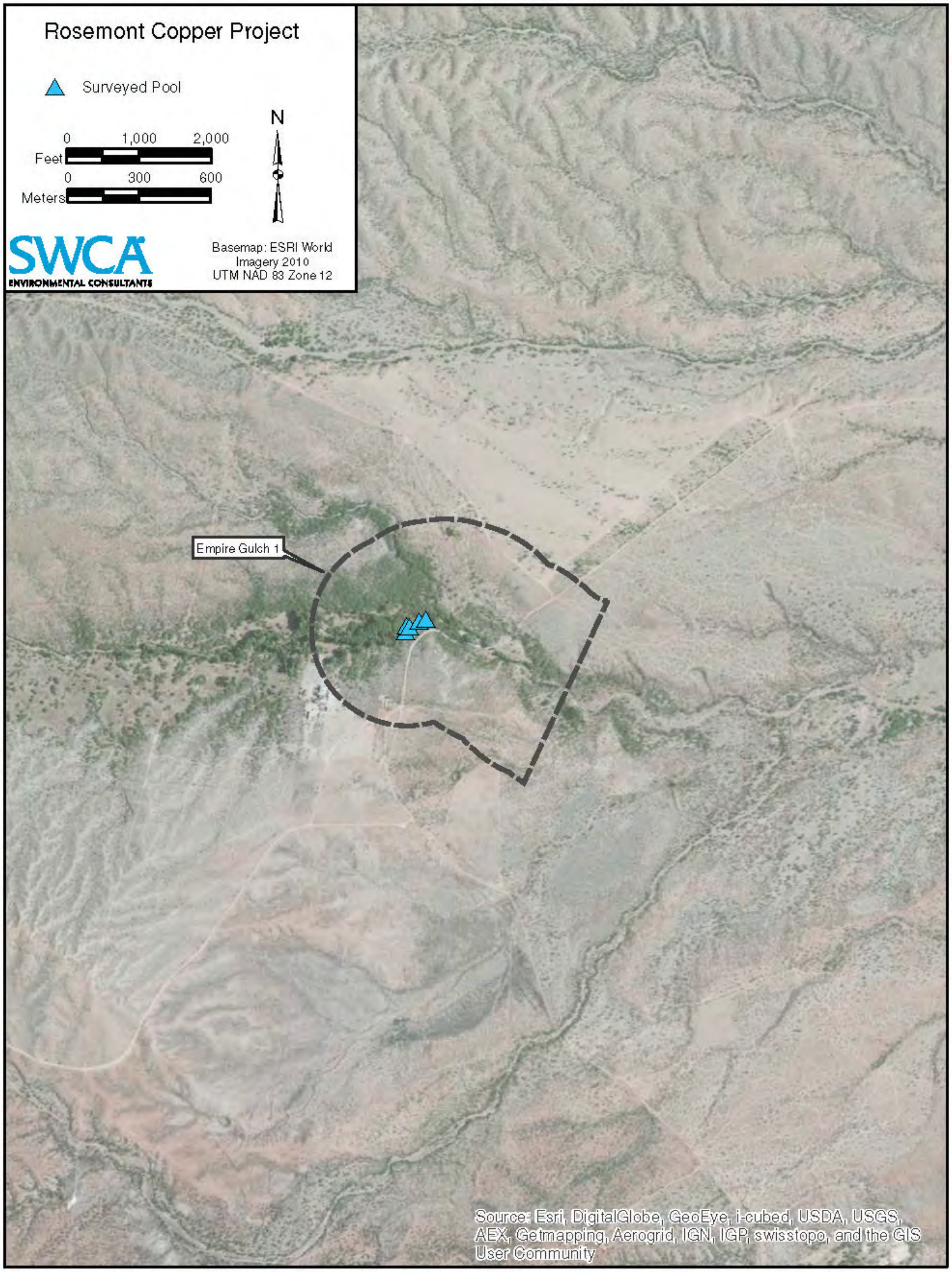

Figure 3a. Pool survey – November/December 2014

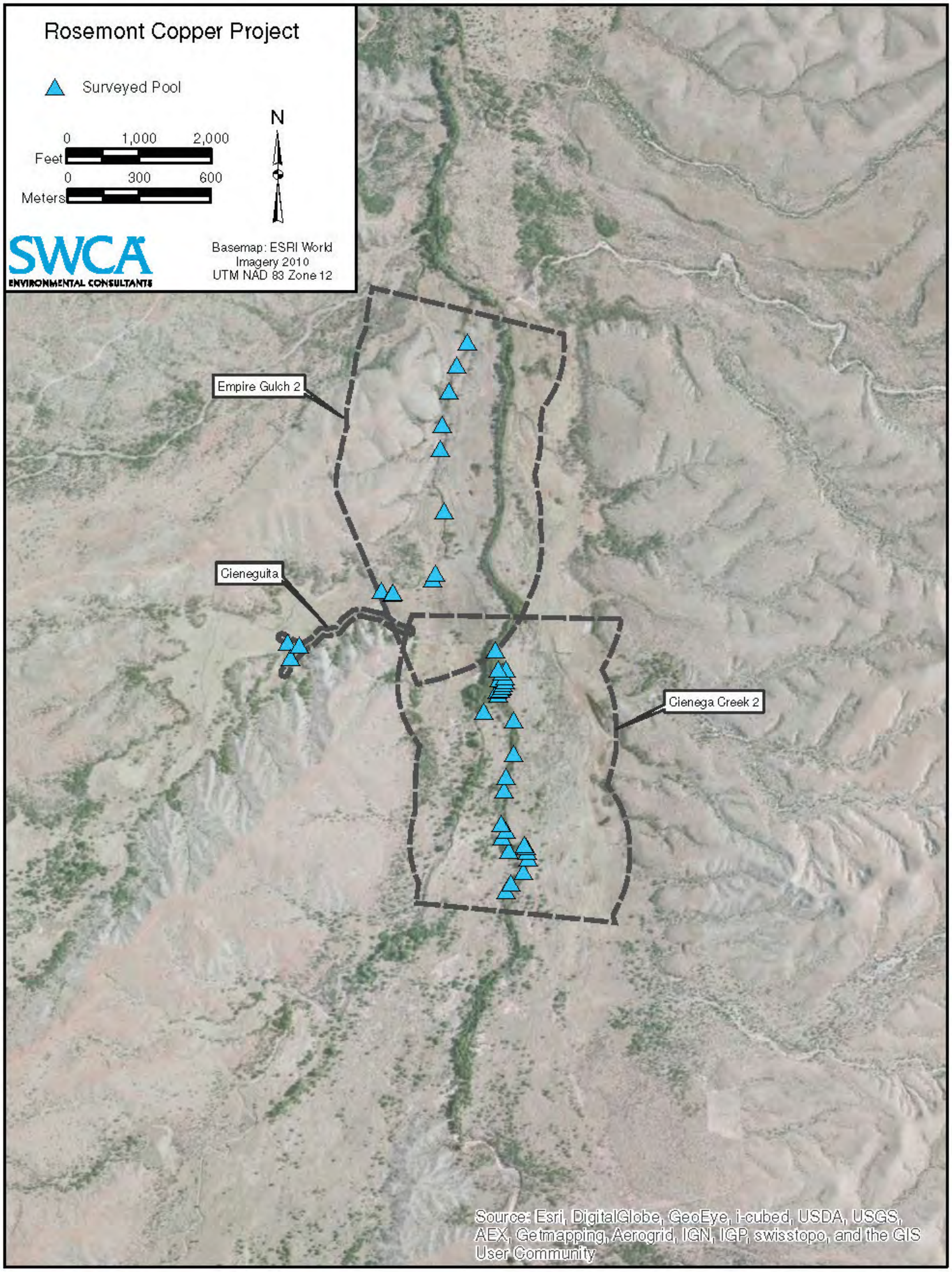

Figure 3b. Pool survey – November/December 2014

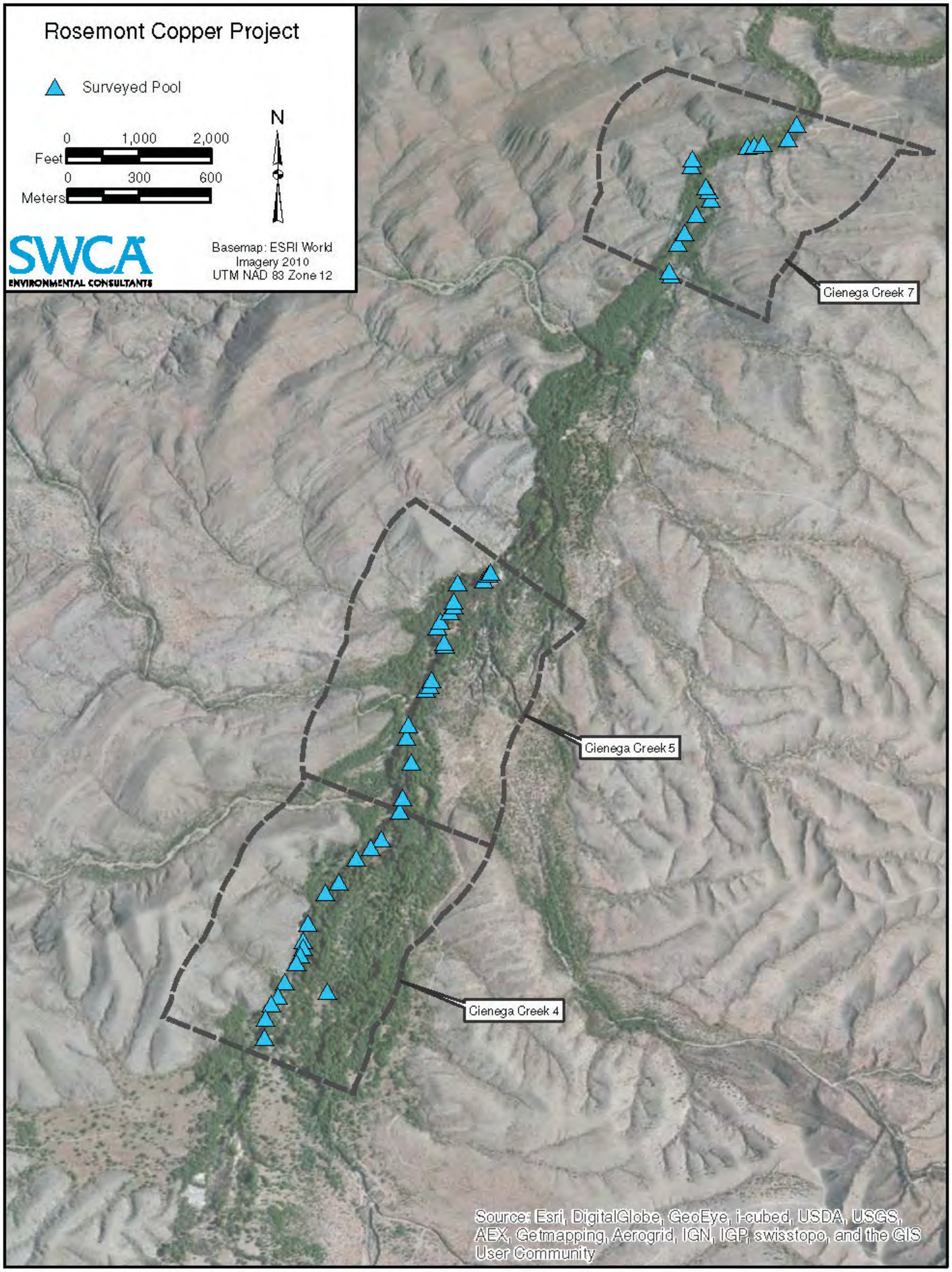

Figure 3c. Pool survey – November/December 2014

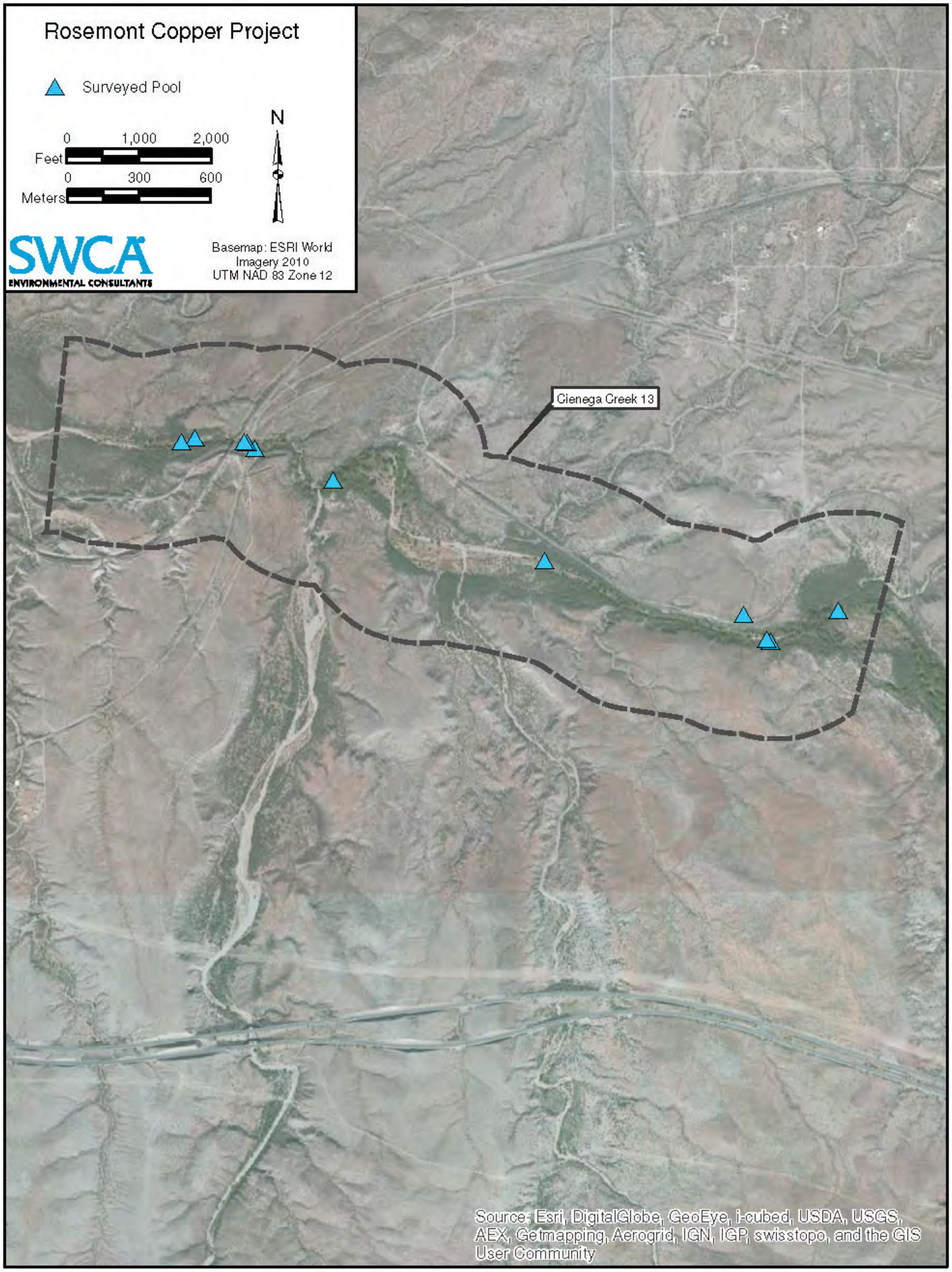

Figure 3d. Pool survey – November/December 2014

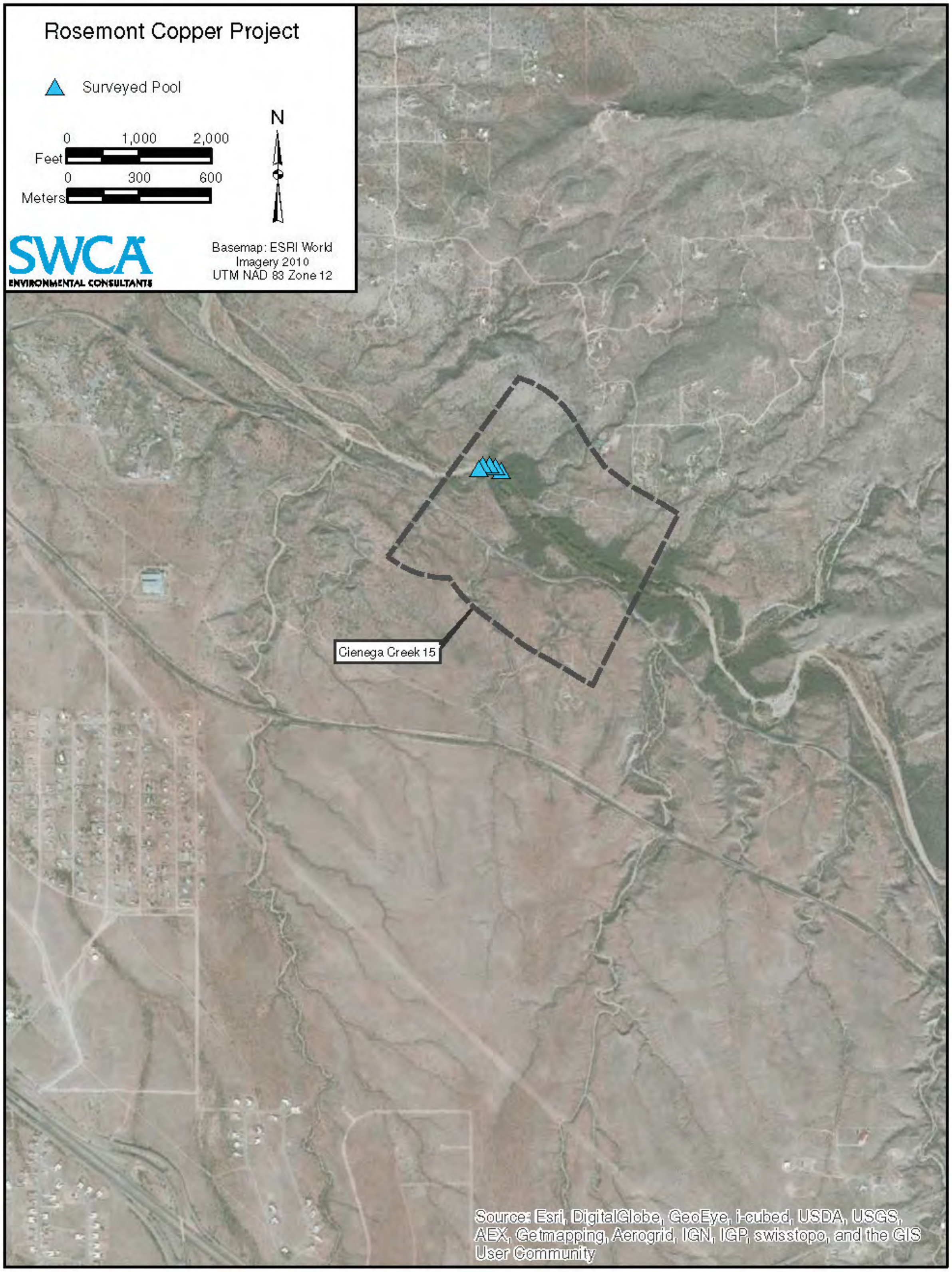

Figure 3e. Pool survey – November/December 2014

Summary of Pool Characteristics for Key Reaches

A summary of the baseline pool characteristics as measured or calculated in November and December 2014 is shown in table 26.

Table 26. Summary of pool characteristics for key reaches in November/December 2014

Key Reach	Number of Pools	Median Pool Depth (feet)	Maximum Pool Depth (feet)	Median Pool Volume (cubic feet)	Median Pool Surface Area (square feet)
CC2	31	1.0	8.5	99	309
CC4	16	1.4	10.4	369	612
CC5	19	2.2	9.0	281	193
CC7	15	1.8	7.0	666	657
CC13	11	0.6	3.8	57	169
CC15	5	0.5	3.0	10	84
EG1	5	1.3	3.7	455	490
EG2	11	2.1	5.6	395	423
CGW	3	1.0	4.6	463	958

Incremental Predicted Impacts to Refugia Pools for Key Reaches

The change in the number and characteristics of pools in each key reach was calculated for each of the incremental drawdown scenarios (tables 27–30). The same results are shown graphically in appendix I.

Table 27. Number of pools for given drawdown based on November/December measurements

Key Reach	Additional Drawdown (feet)										
	Baseline (zero drawdown)	0.2	0.4	0.6	0.8	1.0	1.5	2.0	3.0	4.0	5.0
CC2	31	27	27	26	22	19	13	10	9	6	6
CC4	16	16	16	16	16	15	14	11	8	5	1
CC5	19	19	19	19	19	19	19	19	13	4	1
CC7	15	15	15	15	15	15	15	14	11	5	4
CC13	11	11	9	8	8	8	4	2	1	0	0
CC15	5	5	4	4	4	3	2	2	0	0	0
EG1	5	5	5	5	5	5	5	2	2	0	0
EG2	11	11	11	11	11	10	9	8	4	3	3
CGW	3	3	3	3	3	3	3	3	2	2	0

Table 28. Median pool depth (feet) for given drawdown based on November/December measurements

Key Reach	Additional Drawdown (feet)										
	Baseline (zero drawdown)	0.2	0.4	0.6	0.8	1.0	1.5	2.0	3.0	4.0	5.0
CC2	1.0	1	1.3	1.8	2.0	2.4	2.5	2.3	1.7	1.5	1.3
CC4	1.4	1.3	1.3	1.3	1.3	1.2	0.9	0.6	0.9	0.7	4.1
CC5	2.2	2	1.8	1.6	1.5	1.4	1.1	0.9	0.7	0.4	3.1
CC7	1.8	1.6	1.4	1.4	1.4	1.4	1.2	1.0	1.1	0.9	0.9
CC13	0.6	0.5	0.4	0.4	0.5	0.4	0.3	1.3	0.8	-	-
CC15	0.5	0.5	0.7	0.8	0.6	0.4	0.6	0.7	-	-	-

Key Reach	Additional Drawdown (feet)										
	Baseline (zero drawdown)	0.2	0.4	0.6	0.8	1.0	1.5	2.0	3.0	4.0	5.0
EG1	1.3	1.1	1.0	0.8	0.7	0.6	0.7	0.8	0.3	-	-
EG2	2.1	1.9	1.7	1.5	1.4	1.3	1.3	1.3	1.0	0.8	0.5
CGW	1.0	0.8	0.7	0.7	0.5	0.4	0.5	0.4	1.5	0.5	-

Table 29. Median pool volume (cubic feet) for given drawdown based on November/December measurements

Key Reach	Additional Drawdown (feet)										
	Baseline (zero drawdown)	0.2	0.4	0.6	0.8	1.0	1.5	2.0	3.0	4.0	5.0
CC2	99	54	28	13	6	2	1	0	0	0	0
CC4	369	283	230	165	128	102	60	15	1	0	0
CC5	281	245	213	185	159	137	89	37	3	0	0
CC7	666	542	434	338	255	184	100	23	2	0	0
CC13	57	20	8	3	1	0	0	0	0	0	0
CC15	10	2	1	1	0	0	0	0	0	0	0
EG1	455	365	273	129	63	29	14	0	0	0	0
EG2	395	318	254	199	148	98	51	4	0	0	0
CGW	463	306	194	122	86	58	32	2	0	0	0

Table 30. Median pool surface area (square feet) for given drawdown based on November/December measurements

Key Reach	Additional Drawdown (feet)										
	Baseline (zero drawdown)	0.2	0.4	0.6	0.8	1.0	1.5	2.0	3.0	4.0	5.0
CC2	309	191	94	53	26	12	6	0	0	0	0
CC4	612	394	269	208	167	128	83	30	6	0	0
CC5	193	169	151	134	118	103	79	54	14	0	0
CC7	657	554	433	335	297	263	183	49	5	0	0
CC13	169	76	37	17	7	2	1	0	0	0	0
CC15	84	21	4	2	1	1	0	0	0	0	0
EG1	490	413	336	266	193	125	63	0	0	0	0
EG2	423	349	296	216	175	137	105	18	0	0	0
CGW	958	658	464	284	196	137	69	8	0	0	0

Selected Impact Scenarios to Be Evaluated

Groundwater Modeling Scenarios

Pool depth is analyzed for the same groundwater modeling scenarios as those for stream flow.

Seasonal Correction

It is recognized that this pool survey was not conducted during the same time of year that is of interest for the presence of refugia pools. Although the pool survey was conducted in November and December during a period that generally is not influenced by runoff, similar to the critical low-flow period in May and June, groundwater levels potentially sustaining the pools during May and June would likely be lower. Several of the wells or piezometers have an adequate period of record to calculate the typical difference in groundwater levels between June and November (see appendix D, figures D4, D5, D8, D9, and D24).

Groundwater levels in the shallow alluvial aquifer typically reach their maximum depth around August or September, and then begin to recover as evapotranspiration begins to decline in the fall. In November, groundwater levels are generally higher than those in June, but full recovery of the aquifer does not occur until January or February. As shown in table 31, for those wells with adequate periods of record, groundwater levels in November are typically 0.7 foot higher than those during the critical low-flow period in June.

For analysis of impacts to standing pools, water levels were reduced 0.7 foot from those measured in November and December 2014, to better simulate pool levels in May and June.

Table 31. Estimated difference in groundwater levels between November and June

Well/ Piezometer	Average January Groundwater Level (feet bgs)	Average June Groundwater Level (feet bgs)	Average November Groundwater Level (feet bgs)	November–June Difference (feet)	January–June Difference (feet)
WP-8	4.8	6.3	5.6	0.7	1.5
WP-9	5.1	6.3	5.7	0.6	1.2
WP-12	1.7	3.1	2.4	0.7	1.4
WP-13	3.7	4.0	3.9	0.1	0.3
Cienega	15.4	18.2	17.5	0.7	2.8

Climate Change Stress

Similar to the approach for stream flow, an additional climate change stress can be estimated for the groundwater levels supporting standing pools. As with the stream flow analysis, there is an approximately 25 degree difference between January and June; the typical change in groundwater levels over this same period is shown in table 31. The expected increase in temperature due to climate change is approximately 25 percent of the seasonal change, and we can estimate that the climate change stress would be 25 percent of the seasonal water-level change. This represents an additional drawdown of approximately 0.4 foot that would be experienced in the standing pools, above and beyond that experienced from the modeling scenarios.

Predicted Impacts to Refugia Pools for Key Reaches for Selected Impact Scenarios

Mine Drawdown Only

Predicted impacts on standing pools for each modeling scenario without climate change are shown for each key reach in tables 32 through 34. The predicted number of pools is shown in table 32. The predicted volume of pools, compared with the estimated May/June pool current pool volume, is shown in table 33. The predicted top surface area of pools, compared with the estimated May/June current pool surface area, is shown in table 34. The same results are shown graphically in appendix J, figures J1A through J9A.

Climate Change Only

The predicted impacts on standing pools due solely to climate change are shown for each key reach in table 35.

Table 32. Results of refugia pool analysis for modeling scenarios without climate change – number of pools remaining under no-flow conditions

	End of Mine					10					20					50					100					150					500					1,000				
Key Reach	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	26	22	22	22	22	22	22	22	-	22	22	22	22	22	22	22	22	22	22	22	22	22	22	-	22	22	22	22	22	22	22	22	22	-	22	22	22	22	10	10
CC4	16	16	16	-	16	16	16	16	-	16	16	16	16	-	16	16	16	16	-	16	16	16	16	-	16	16	16	16	-	16	16	16	16	-	16	16	16	16	-	16
CC5	19	19	19	19	19	19	19	19	-	19	19	19	19	19	19	19	19	19	19	19	19	19	19	-	19	19	19	19	19	19	19	19	19	-	19	19	19	19	19	19
CC7	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15
CC13	8	8	8	-	8	8	8	8	-	8	8	8	8	-	8	8	8	8	-	8	8	8	8	-	8	8	8	8	-	8	8	8	8	-	8	8	8	8	-	8
CC15	4	4	4	-	4	4	4	4	-	4	4	4	4	-	4	4	4	4	-	4	4	4	4	-	4	4	4	4	-	4	4	4	4	-	4	4	4	4	-	4
EG1	5	5	5	5	5	5	5	5	-	5	5	5	5	5	5	5	5	5	2	2	5	2	5	-	0	5	1	5	0	0	3	0	2	-	0	2	0	0	0	0
EG2	11	11	11	-	11	11	11	11	-	11	11	11	11	-	11	11	11	11	-	11	11	11	11	-	11	11	11	11	-	10	11	10	11	-	10	11	10	11	-	10
CGW	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

Table 33. Results of refugia pool analysis for modeling scenarios without climate change – median percent reduction* in volume of pools

	End of Mine					10					20					50					100					150					500					1,000				
Key Reach	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	100%	99%	99%	99%	98%	99%	98%	98%	-	84%	99%	98%	98%	99%	84%	99%	98%	98%	99%	84%	99%	96%	98%	-	84%	99%	93%	98%	58%	58%	99%	84%	94%	-	79%	99%	83%	89%	0%	0%
CC4	100%	100%	100%	-	100%	100%	100%	100%	-	97%	100%	100%	100%	-	97%	100%	100%	100%	-	97%	100%	100%	100%	-	96%	100%	100%	100%	-	96%	100%	100%	100%	-	94%	100%	100%	100%	-	94%
CC5	100%	99%	99%	99%	99%	99%	99%	99%	-	97%	99%	99%	99%	99%	97%	99%	99%	99%	99%	97%	99%	99%	99%	-	97%	99%	99%	99%	99%	97%	99%	99%	99%	-	96%	99%	99%	99%	80%	80%
CC7	100%	100%	100%	-	100%	100%	100%	100%	-	97%	100%	100%	100%	-	97%	100%	99%	100%	-	97%	100%	97%	100%	-	95%	100%	95%	100%	-	91%	100%	89%	100%	-	88%	100%	88%	100%	-	88%
CC13	100%	100%	100%	-	99%	100%	99%	100%	-	85%	100%	99%	100%	-	85%	100%	96%	100%	-	85%	100%	95%	100%	-	85%	100%	92%	100%	-	85%	100%	87%	95%	-	80%	100%	86%	90%	-	74%
CC15	100%	100%	100%	-	99%	100%	100%	100%	-	89%	100%	100%	100%	-	89%	100%	100%	100%	-	89%	100%	100%	100%	-	89%	100%	100%	100%	-	89%	100%	99%	100%	-	89%	100%	99%	100%	-	89%
EG1	100%	98%	100%	100%	64%	100%	88%	100%	-	32%	100%	71%	100%	100%	14%	100%	25%	100%	0%	0%	100%	0%	85%	-	0%	97%	0%	46%	0%	0%	4%	0%	0%	-	0%	0%	0%	0%	0%	0%
EG2	100%	100%	100%	-	99%	100%	100%	99%	-	97%	100%	99%	99%	-	97%	100%	97%	99%	-	89%	100%	91%	99%	-	79%	100%	84%	98%	-	73%	97%	67%	92%	-	65%	94%	67%	87%	-	67%
CGW	100%	100%	100%	-	98%	100%	99%	100%	-	91%	100%	97%	100%	-	84%	100%	86%	100%	-	58%	100%	65%	100%	-	37%	100%	42%	99%	-	31%	87%	26%	73%	-	24%	70%	25%	57%	-	25%

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

* In this case, 100% indicates that the pool retains all of its original volume; lower percentages indicate the percentage left of the original volume. For instance, a statistic of 80% would mean that the pool retains 80% of its original volume, and has lost or shrunk by 20%.

Table 34. Results of refugia pool analysis for modeling scenarios without climate change – median percent reduction* in top surface area of pools

	End of Mine					10					20					50					100					150					500					1,000				
Key Reach	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	100%	99%	99%	99%	98%	99%	98%	99%	-	90%	99%	98%	99%	99%	90%	99%	98%	99%	99%	90%	99%	97%	99%	-	90%	99%	96%	99%	73%	73%	99%	90%	96%	-	87%	99%	89%	93%	0%	0%
CC4	100%	100%	100%	-	100%	100%	100%	100%	-	98%	100%	100%	100%	-	98%	100%	100%	100%	-	98%	100%	100%	100%	-	97%	100%	100%	100%	-	97%	100%	100%	100%	-	96%	100%	100%	100%	-	96%
CC5	100%	99%	99%	99%	99%	99%	99%	99%	-	98%	99%	99%	99%	99%	98%	99%	99%	99%	99%	98%	99%	99%	99%	-	98%	99%	99%	99%	99%	98%	99%	99%	99%	-	97%	99%	99%	99%	86%	86%
CC7	100%	100%	100%	-	100%	100%	100%	100%	-	98%	100%	100%	100%	-	98%	100%	99%	100%	-	98%	100%	97%	100%	-	96%	100%	96%	100%	-	93%	100%	91%	100%	-	90%	100%	90%	100%	-	90%
CC13	100%	100%	100%	-	99%	100%	99%	100%	-	89%	100%	99%	100%	-	89%	100%	97%	100%	-	89%	100%	96%	100%	-	89%	100%	94%	100%	-	89%	100%	91%	96%	-	86%	100%	90%	93%	-	82%
CC15	100%	100%	100%	-	100%	100%	100%	100%	-	91%	100%	100%	100%	-	91%	100%	100%	100%	-	91%	100%	100%	100%	-	91%	100%	100%	100%	-	91%	100%	99%	100%	-	91%	100%	99%	100%	-	91%
EG1	100%	98%	100%	100%	78%	100%	92%	100%	-	50%	100%	82%	100%	100%	20%	100%	39%	100%	0%	0%	100%	0%	90%	-	0%	98%	0%	66%	0%	0%	5%	0%	0%	-	0%	0%	0%	0%	0%	0%
EG2	100%	100%	100%	-	99%	100%	100%	99%	-	98%	100%	99%	99%	-	98%	100%	98%	99%	-	94%	100%	95%	99%	-	89%	100%	91%	99%	-	85%	98%	82%	96%	-	81%	97%	81%	93%	-	81%
CGW	100%	100%	100%	-	99%	100%	99%	100%	-	93%	100%	98%	100%	-	88%	100%	90%	100%	-	69%	100%	74%	100%	-	50%	100%	57%	99%	-	42%	90%	35%	79%	-	32%	78%	34%	68%	-	34%

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

* In this case, 100% indicates that the pool retains all of its original volume; lower percentages indicate the percentage left of the original volume. For instance, a statistic of 80% would mean that the pool retains 80% of its original volume, and has lost or shrunk by 20%.

Table 35. Refugia pool analysis for climate change only

Key Reach	Current Conditions – Modified to Reflect May/June Status			Climate Change Scenario		
	Number of Pools	Median Pool Volume (cubic feet)	Median Pool Area (square feet)	Number of Pools	Median Percentage of Original Pool Volume	Median Percentage of Original Pool Area
CC2	26	10	39	19	52	57
CC4	16	147	187	15	62	68
CC5	19	173	126	19	67	75
CC7	15	297	309	15	67	71
CC13	8	10	29	7	12	29
CC15	4	39	51	3	35	45
EG1	5	96	229	5	33	52
EG2	11	175	195	10	59	73
CGW	3	104	240	3	38	51

Combined Mine Drawdown and Climate Change

Predicted impacts on standing pools for each modeling scenario combined with climate change are shown for each key reach in tables 36 through 38. Predicted number of pools is shown in table 37. The predicted volume of pools, compared to the estimated May/June pool current pool volume, is shown in table 37. The predicted top surface area of pools, compared with the estimated May/June current pool surface area, is shown in table 38. The same results are shown graphically in figures J1B through J9B.

95th Percentile – Mine Only and Combined Mine/Climate Change

The predicted impacts for the 95th percentile range are shown for each key reach, both with and without climate change, in tables 39 through 41. The predicted number of pools is shown in table 39. The predicted volume of pools, compared with the estimated May/June pool current pool volume, is shown in table 40. The predicted top surface area of pools, compared with the estimated May/June current pool surface area, is shown in table 41. The same results are shown graphically in figures J1C through J9C.

Analysis of Impacts to Riparian Vegetation

Methodology for Predicting Impacts to Riparian Vegetation

Based on discussions between May and November 2014, it was identified that relatively minor changes in riparian vegetation could have consequences for the aquatic system. In particular, negative feedback loops were identified in which small changes in root density near the active stream channel could result in soil loss, culminating in a head cut that would advance upstream until reaching some channel control (bedrock or manmade control structure). The head cut would also effectively dewater part of the shallow stream aquifer, lowering the overall water table and further stressing vegetation. This occurrence has been documented by BLM as currently or historically occurring at several locations along Cienega Creek. The need to assess relatively small changes in riparian vegetation resulted in the goal of assessing vegetation changes quantitatively if possible, rather than qualitatively as was done in the FEIS.

Available literature was reviewed in order to identify research connecting hydrologic changes to changes in vegetation conditions. In general, research has focused on three general hydrologic parameters: relative change in groundwater depth or rate of change in groundwater depth, absolute depth of groundwater below ground surface, and stream flow permanence. A total of 19 studies was reviewed. The results of the review are summarized in appendix K. It should be noted that the focus of the literature review was not to identify general relationships between hydrology and vegetation; these general relationships were previously identified and used in the FEIS to disclose potential impacts to riparian vegetation. Instead, the focus was on identifying quantitative predictive techniques.

Of the 19 studies, five studies yielded useful predictors of absolute groundwater depth versus vegetation community type or vegetation characteristics; these studies are summarized in appendix K, table K1. Six studies yielded useful predictors of total groundwater drawdown or rate of groundwater drawdown versus vegetation community type or vegetation characteristics; these studies are summarized in appendix K, table K2. Two studies yielded useful predictors of stream flow permanence versus vegetation community type or vegetation characteristics; these studies are summarized in appendix K, table K3. The most common woody species analyzed were cottonwood, willow, and tamarisk, and overall research also analyzed effects on different age classes of these species (seedlings, saplings, mature trees).

It should be noted that the results of these studies vary widely in their presentation and detail. The tables in appendix K attempt to capture the pertinent details of each study but also graphically display the results in a consistent format, organized by the same drawdown/depth to groundwater ranges to be analyzed in the SIR. The tables in appendix K also attempt to capture pertinent details of statistical significance or reliability; consistent with other results used in this SIR, a P value of less than 0.05 was considered to be statistically significant for determining relationships. However, recall that the P value is a measure of the likelihood of the null hypothesis being true (that there is no relationship between two variables). In the case of the available research, the fact that no statistically significant trend was established is also of interest and is included in the narrative descriptions below.

Some of the studies looked at rates of change in groundwater level, rather than overall drawdown. In these cases, it was necessary to convert the incremental drawdowns to a rate. The earliest time step for predicting impacts to the riparian system is at mine closure (22 years after operations begin). Therefore, to convert expected drawdowns to rate of change in order to make use of these studies, a period of 20 years was used; these instances are identified in the footnotes of the tables in appendix K. This results in a conservative estimate, as most of the expected impacts actually take place later in time and the rate of change would be even less.

It should also be noted that during discussions between May and November 2014, numeric thresholds that might trigger negative feedback loops were not identified, except that very small increments of change were significant.

Incremental Predicted Impacts to Riparian Vegetation

Narrative descriptions of predicted changes are provided in the following tables (tables 42 and 43). Note that many of the metrics given in the reviewed literature are percentages, for instance percent increase in basal area or percent survivorship. All percentages shown in the table below refer to the expected percent change from the baseline condition of zero drawdown, regardless of the original metric used in the study.[6] All percentages are rounded to the nearest whole number.

The research concerning absolute depth to groundwater is not as directly useful as that for changes in groundwater depth. Much of the available research reviewed focuses on the range of groundwater depth in which species are most likely to occur (Leenhouts et al. 2006; Shafroth et al. 1998; Stromberg et al. 1996); these studies are difficult to use predictively to indicate presence or absence, unless the depth of groundwater happens to be in the specific range studied. In the following table, the likelihood of presence is noted if the groundwater depth is within one standard deviation of the mean; it is not noted if the groundwater depth is outside of the range studied.

Several studies allow for prediction of vegetation metrics (canopy dieback, basal area, stem density) for any groundwater depth (Horton and Clark 2001; Leenhouts et al. 2006; Lite and Stromberg 2005); however, these metrics are largely not useful unless comparing two different groundwater depths. In the following table, the metrics calculated from the research studies are noted without comparison with other groundwater depths.

[6] For instance, results from Shafroth (2000) indicate that at zero drawdown, over the course of 2 years the basal area of a cottonwood/willow sapling would be 363 percent of the original basal area, whereas at 1 foot of drawdown it would only be 314 percent of the original basal area. The change between zero and 1 foot of drawdown is 49 percentage points (363 minus 314), which represents a 13 percent change from baseline conditions of zero drawdown (49 divided by 363). The percentage shown in the table is therefore 13 percent.

Table 36. Results of refugia pool analysis for modeling scenarios combined with climate change – number of pools remaining under no-flow conditions

	End of Mine					10					20					50					100					150					500					1,000				
Key Reach	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	19	19	19	19	19	19	19	19	-	19	19	19	19	19	19	19	19	19	19	19	19	19	19	-	19	19	19	19	17	17	19	19	19	-	19	19	19	19	8	8
CC4	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15
CC5	19	19	19	19	19	19	19	19	-	19	19	19	19	19	19	19	19	19	19	19	19	19	19	-	19	19	19	19	19	19	19	19	19	-	19	19	19	19	19	19
CC7	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15	15	15	15	-	15
CC13	7	7	7	-	7	7	7	7	-	7	7	7	7	-	7	7	7	7	-	7	7	7	7	-	7	7	7	7	-	7	7	7	7	-	7	7	7	7	-	7
CC15	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3
EG1	5	5	5	5	5	5	5	5	-	5	5	5	5	5	3	5	4	5	2	2	5	2	5	-	0	5	0	5	0	0	2	0	2	-	0	1	0	0	0	0
EG2	10	10	10	-	10	10	10	10	-	10	10	10	10	-	10	10	10	10	-	10	10	10	10	-	10	10	10	10	-	10	10	10	10	-	10	10	10	10	-	10
CGW	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3	3	3	3	-	3

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

Table 37. Results of refugia pool analysis for modeling scenarios combined with climate change – median percent reduction* in volume of remaining pools

	End of Mine					10					20					50					100					150					500					1,000				
Key Reach	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	52%	52%	52%	52%	51%	52%	51%	52%	-	50%	52%	51%	52%	52%	50%	52%	51%	52%	52%	50%	52%	51%	52%	-	50%	52%	51%	52%	47%	47%	52%	50%	51%	-	49%	52%	50%	50%	0%	0%
CC4	62%	62%	62%	-	62%	62%	62%	62%	-	60%	62%	62%	62%	-	60%	62%	62%	62%	-	60%	62%	62%	62%	-	60%	62%	62%	62%	-	60%	62%	61%	62%	-	60%	62%	61%	62%	-	59%
CC5	67%	67%	67%	67%	67%	67%	67%	67%	-	66%	67%	67%	67%	67%	66%	67%	67%	67%	67%	66%	67%	67%	67%	-	66%	67%	67%	67%	67%	66%	67%	67%	67%	-	65%	67%	67%	67%	56%	56%
CC7	67%	67%	67%	-	67%	67%	67%	67%	-	65%	67%	67%	67%	-	65%	67%	66%	67%	-	65%	67%	65%	67%	-	64%	67%	64%	67%	-	62%	67%	61%	67%	-	60%	67%	60%	67%	-	60%
CC13	12%	12%	12%	-	12%	12%	12%	12%	-	11%	12%	12%	12%	-	11%	12%	12%	12%	-	11%	12%	11%	12%	-	11%	12%	11%	12%	-	11%	12%	11%	11%	-	10%	12%	11%	11%	-	10%
CC15	35%	35%	35%	-	35%	35%	35%	35%	-	32%	35%	35%	35%	-	32%	35%	35%	35%	-	32%	35%	35%	35%	-	32%	35%	35%	35%	-	32%	35%	34%	35%	-	32%	35%	34%	35%	-	32%
EG1	33%	33%	33%	33%	24%	33%	31%	33%	-	13%	33%	26%	33%	33%	1%	33%	8%	33%	0%	0%	33%	0%	30%	-	0%	33%	0%	19%	0%	0%	0%	0%	0%	-	0%	0%	0%	0%	0%	0%
EG2	59%	58%	59%	-	58%	59%	58%	58%	-	57%	59%	58%	58%	-	57%	59%	57%	58%	-	54%	59%	55%	58%	-	49%	59%	51%	58%	-	45%	57%	42%	55%	-	41%	56%	42%	53%	-	42%
CGW	38%	38%	38%	-	37%	38%	38%	38%	-	36%	38%	37%	38%	-	35%	38%	35%	38%	-	29%	38%	31%	38%	-	20%	38%	25%	38%	-	14%	36%	9%	33%	-	7%	32%	8%	29%	-	8%

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

* In this case, 100% indicates that the pool retains all of its original volume; lower percentages indicate the percentage left of the original volume. For instance, a statistic of 80% would mean that the pool retains 80% of its original volume, and has lost or shrunk by 20%.

Table 38. Results of refugia pool analysis for modeling scenarios combined with climate change – median percent reduction* in top surface area of remaining pools

	End of Mine					10					20					50					100					150					500					1,000				
Key Reach	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	57%	57%	57%	57%	57%	57%	57%	57%	-	55%	57%	57%	57%	57%	55%	57%	57%	57%	57%	55%	57%	56%	57%	-	55%	57%	56%	57%	52%	52%	57%	55%	56%	-	54%	57%	55%	56%	0%	0%
CC4	68%	68%	68%	-	68%	68%	68%	68%	-	67%	68%	68%	68%	-	67%	68%	68%	68%	-	67%	68%	68%	68%	-	67%	68%	68%	68%	-	67%	68%	68%	68%	-	66%	68%	68%	68%	-	66%
CC5	75%	75%	75%	75%	75%	75%	75%	75%	-	74%	75%	75%	75%	75%	74%	75%	75%	75%	75%	74%	75%	75%	75%	-	74%	75%	75%	75%	75%	74%	75%	75%	75%	-	74%	75%	75%	75%	65%	65%
CC7	71%	71%	71%	-	71%	71%	71%	71%	-	69%	71%	71%	71%	-	69%	71%	70%	71%	-	69%	71%	69%	71%	-	68%	71%	68%	71%	-	66%	71%	65%	71%	-	64%	71%	64%	71%	-	64%
CC13	29%	29%	29%	-	29%	29%	29%	29%	-	27%	29%	29%	29%	-	27%	29%	29%	29%	-	27%	29%	29%	29%	-	27%	29%	28%	29%	-	27%	29%	28%	29%	-	27%	29%	28%	28%	-	26%
CC15	45%	45%	45%	-	45%	45%	45%	45%	-	42%	45%	45%	45%	-	42%	45%	45%	45%	-	42%	45%	45%	45%	-	42%	45%	45%	45%	-	42%	45%	45%	45%	-	42%	45%	45%	45%	-	42%
EG1	52%	51%	52%	52%	38%	52%	48%	52%	-	16%	52%	41%	52%	52%	1%	52%	10%	52%	0%	0%	52%	0%	47%	-	0%	51%	0%	29%	0%	0%	0%	0%	0%	-	0%	0%	0%	0%	0%	0%
EG2	73%	73%	73%	-	73%	73%	73%	73%	-	72%	73%	73%	73%	-	72%	73%	72%	73%	-	68%	73%	69%	73%	-	63%	73%	66%	72%	-	59%	72%	56%	69%	-	55%	70%	56%	67%	-	56%
CGW	51%	51%	51%	-	51%	51%	51%	51%	-	49%	51%	51%	51%	-	48%	51%	48%	51%	-	40%	51%	42%	51%	-	28%	51%	34%	51%	-	19%	48%	13%	45%	-	10%	44%	11%	40%	-	11%

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

* In this case, 100% indicates that the pool retains all of its original volume; lower percentages indicate the percentage left of the original volume. For instance, a statistic of 80% would mean that the pool retains 80% of its original volume, and has lost or shrunk by 20%.

Table 39. Results of refugia pool analysis for 95th percentile range – number of pools remaining under no-flow conditions

Key Reach	Scenario	End of Mine	10	20	50	100	150	200	300	400	500	600	700	800	900	1,000
CC2	Mine Only	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
CC2	Climate Change	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
CC2	Mine and Climate Change	19	19	19	19	19	19	19	19	19	19	19	19	19	19	14-19
CC4	Mine Only	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
CC4	Climate Change	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
CC4	Mine and Climate Change	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
CC5	Mine Only	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
CC5	Climate Change	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
CC5	Mine and Climate Change	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
CC7	Mine Only	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
CC7	Climate Change	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
CC7	Mine and Climate Change	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
CC13	Mine Only	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
CC13	Climate Change	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
CC13	Mine and Climate Change	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
CC15	Mine Only	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
CC15	Climate Change	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CC15	Mine and Climate Change	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EG1	Mine Only	5	5	5	2-5	2-5	0-5	0-5	0-5	0-5	0-2	0-2	0-2	0-2	0-2	0-2

Key Reach	Scenario	End of Mine	10	20	50	100	150	200	300	400	500	600	700	800	900	1,000
EG1	Climate Change	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
EG1	Mine and Climate Change	5	5	5	2-5	1-5	0-5	0-5	0-5	0-2	0-2	0-2	0-2	0-2	0-2	0-1
EG2	Mine Only	11	11	11	11	11	11	11	10-11	10-11	10-11	10-11	10-11	10-11	10-11	10-11
EG2	Climate Change	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
EG2	Mine and Climate Change	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
CGW	Mine Only	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CGW	Climate Change	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CGW	Mine and Climate Change	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Table 40. Results of refugia pool analysis for 95 percentile range – median percent remaining volume of pools

Key Reach	Scenario	End of Mine	10	20	50	100	150	200	300	400	500	600	700	800	900	1,000
CC2	Mine Only	99	87-99	87-99	87-99	87-99	82-99	85-99	84-99	82-99	81-99	80-99	79-99	78-99	78-99	24-99
CC2	Climate Change	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
CC2	Mine and Climate Change	15	14-15	14-15	14-15	14-15	13-15	14-15	13-15	13-15	13-15	13-15	13-15	13-15	13-15	5-15
CC4	Mine Only	100	97-100	97-100	97-100	97-100	96-100	96-100	96-100	96-100	96-100	96-100	96-100	96-100	96-100	95-100
CC4	Climate Change	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62
CC4	Mine and Climate Change	57	56-57	56-57	56-57	56-57	56-57	56-57	56-57	56-57	56-57	56-57	56-57	56-57	56-57	56-57
CC5	Mine Only	99	97-99	97-99	97-99	97-99	97-99	97-99	97-99	97-99	97-99	97-99	97-99	97-99	97-99	95-99
CC5	Climate Change	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67
CC5	Mine and Climate Change	67	66-67	66-67	66-67	66-67	66-67	66-67	66-67	66-67	66-67	66-67	66-67	66-67	66-67	65-67
CC7	Mine Only	100	98-100	98-100	97-100	95-100	93-100	91-100	89-100	88-100	88-100	88-100	88-100	88-100	88-100	88-100
CC7	Climate Change	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67
CC7	Mine and Climate Change	67	66-67	66-67	65-67	64-67	63-67	62-67	61-67	61-67	61-67	60-67	60-67	60-67	60-67	60-67
CC13	Mine Only	99-100	88-100	88-100	88-100	88-100	88-100	87-100	86-100	84-100	82-100	81-100	80-100	79-100	78-100	77-100
CC13	Climate Change	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
CC13	Mine and Climate Change	12	11-12	11-12	11-12	11-12	11-12	11-12	11-12	11-12	10-12	10-12	10-12	10-12	10-12	10-12
CC15	Mine Only	100	89-100	89-100	89-100	89-100	89-100	89-100	89-100	89-100	89-100	89-100	89-100	89-100	89-100	89-100
CC15	Climate Change	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
CC15	Mine and Climate Change	35	33-35	33-35	33-35	33-35	33-35	33-35	33-35	33-35	33-35	33-35	33-35	33-35	33-35	33-35
EG1	Mine Only	64-100	40-100	30-100	0-100	0-100	0-90	0-67	0-30	0-13	0	0	0	0	0	0
EG1	Climate Change	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
EG1	Mine and Climate Change	24-33	17-33	11-33	0-33	0-33	0-31	0-25	0-11	0	0	0	0	0	0	0
EG2	Mine Only	99-100	97-100	97-100	94-100	87-100	81-100	76-100	70-99	67-98	66-96	66-95	66-94	66-93	67-92	67-92
EG2	Climate Change	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59
EG2	Mine and Climate Change	57	56-57	56-57	54-57	51-57	48-57	45-57	42-57	41-56	40-55	40-55	40-54	40-54	40-54	40-53
CGW	Mine Only	98-100	92-100	90-100	75-100	52-100	38-100	34-100	28-97	25-92	25-86	24-81	24-76	25-73	25-71	25-70
CGW	Climate Change	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
CGW	Mine and Climate Change	37-38	36-38	36-38	33-38	28-38	21-38	17-38	11-37	9-36	8-35	8-35	8-34	8-33	8-32	8-32

Table 41. Results of refugia pool analysis for 95 percentile range – median percent remaining surface area of pools

Key Reach	Scenario	End of Mine	10	20	50	100	150	200	300	400	500	600	700	800	900	1,000
CC2	Mine Only	99	92-99	92-99	92-99	92-99	88-99	91-99	89-99	89-99	88-99	87-99	87-99	86-99	85-99	32-99
CC2	Climate Change	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57
CC2	Mine and Climate Change	22	20-22	20-22	20-22	20-22	20-22	20-22	20-22	20-22	20-22	19-22	19-22	19-22	19-22	6-22
CC4	Mine Only	100	98-100	98-100	98-100	98-100	97-100	97-100	97-100	97-100	97-100	97-100	97-100	97-100	97-100	97-100
CC4	Climate Change	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
CC4	Mine and Climate Change	67	66-67	66-67	65-67	65-67	65-67	65-67	65-67	65-67	65-67	65-67	65-67	65-67	65-67	65-67
CC5	Mine Only	99	98-99	98-99	98-99	98-99	98-99	98-99	98-99	98-99	98-99	98-99	98-99	98-99	98-99	96-99
CC5	Climate Change	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
CC5	Mine and Climate Change	75	74-75	74-75	74-75	74-75	74-75	74-75	74-75	74-75	74-75	74-75	74-75	74-75	74-75	73-75
CC7	Mine Only	100	98-100	98-100	98-100	96-100	94-100	93-100	91-100	90-100	90-100	90-100	90-100	90-100	90-100	90-100
CC7	Climate Change	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71
CC7	Mine and Climate Change	71	69-71	70-71	69-71	68-71	67-71	66-71	65-71	65-71	65-71	64-71	64-71	64-71	64-71	64-71
CC13	Mine Only	99-100	91-100	91-100	91-100	91-100	91-100	91-100	90-100	89-100	88-100	86-100	86-100	85-100	85-100	84-100
CC13	Climate Change	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
CC13	Mine and Climate Change	22	20-22	20-22	20-22	20-22	20-22	20-22	20-22	20-22	19-22	19-22	19-22	19-22	19-22	19-22
CC15	Mine Only	100	92-100	92-100	92-100	92-100	92-100	92-100	92-100	92-100	92-100	92-100	92-100	92-100	92-100	92-100
CC15	Climate Change	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
CC15	Mine and Climate Change	45	42-45	42-45	42-45	42-45	42-45	42-45	42-45	42-45	42-45	42-45	42-45	42-45	42-45	42-45
EG1	Mine Only	78-100	61-100	47-100	0-100	0-100	0-93	0-80	0-47	0-16	0	0	0	0	0	0
EG1	Climate Change	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
EG1	Mine and Climate Change	38-52	26-52	14-52	0-52	0-52	0-48	0-39	0-14	0	0	0	0	0	0	0
EG2	Mine Only	100	98-100	98-100	97-100	93-100	89-100	86-100	83-100	82-99	81-98	81-97	81-97	81-96	81-96	81-96
EG2	Climate Change	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73
EG2	Mine and Climate Change	72	71-72	71-72	69-72	66-72	62-72	59-72	55-72	54-71	53-71	53-70	53-69	53-69	53-69	53-68
CGW	Mine Only	99-100	94-100	93-100	81-100	64-100	52-100	46-100	38-97	35-94	34-89	33-86	33-82	33-80	34-78	34-77
CGW	Climate Change	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
CGW	Mine and Climate Change	51	50-51	49-51	45-51	38-51	29-51	23-51	15-51	12-50	11-48	11-47	11-46	11-45	11-44	11-44

Table 42. Predicted changes in vegetation characteristics for given drawdown or change in groundwater depth

Incremental Drawdown	Expected Changes
0.2 foot	*Seedlings:* Research indicates there would be no difference in the presence/absence of cottonwood, willow, tamarisk, or seep willow seedlings (Shafroth et al. 1998). No statistical trend was found between groundwater change and cottonwood seedling survivorship (Shafroth et al. 2000). *Saplings:* Research indicates that cottonwood/willow saplings would experience 3% decrease in stem density and a 3% decrease in basal area (Shafroth et al. 2000). No statistical trend was found between groundwater change and tamarisk sapling vegetation characteristics (Shafroth et al. 2000). *Mature:* Research indicates there would be no change in the survivorship or plant height of willow or tamarisk (Horton et al. 2001). No statistical difference was found in survivorship, change in live crown volume, leaf area, leaf mass, or incremental stem grown of mature cottonwood for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999). Research indicates that mature cottonwoods could experience a reduction in branch elongation of roughly 30% for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999); note that this percentage is estimated graphically based on the average of large ranges of data points. *Stream Flow Permanence:* At this drawdown there would be no change in stream flow permanence or resulting effects on riparian vegetation.
0.4 foot	*Seedlings:* Research indicates there would be no difference in the presence/absence of cottonwood, willow, tamarisk, or seep willow seedlings (Shafroth et al. 1998). No statistical trend was found between groundwater change and cottonwood seedling survivorship (Shafroth et al. 2000). *Saplings:* Research indicates that cottonwood/willow saplings would experience 6% decrease in stem density and a 6% decrease in basal area (Shafroth et al. 2000). No statistical trend was found between groundwater change and tamarisk sapling vegetation characteristics (Shafroth et al. 2000). *Mature:* Research indicates there would be no change in the survivorship or plant height of willow or tamarisk (Horton et al. 2001). No statistical difference was found in survivorship, change in live crown volume, leaf area, leaf mass, or incremental stem grown of mature cottonwood for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999). Research indicates that mature cottonwoods could experience a reduction in branch elongation of roughly 30% for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999); note that this percentage is estimated graphically based on the average of large ranges of data points. *Stream Flow Permanence:* CC2, CC4, CC5, CC7, CC13, EG1, EG2: No change in stream flow presence predicted. CC15: At this drawdown, stream flow permanence is reduced from 100% to 90%. Quantitative research on effects of stream flow permanence are mixed, are grouped in wide categories, and are difficult to use predictively. Overall, research indicates the shift to a less permanent stream flow system is associated with reduced basal area, size classes, stem density, and vegetation height for cottonwood/willow, and increased basal area and stem density for tamarisk.

Incremental Drawdown	Expected Changes
0.6 foot	*Seedlings:* Research indicates there would be no difference in the presence/absence of cottonwood, willow, tamarisk, or seep willow seedlings (Shafroth et al. 1998). No statistical trend was found between groundwater change and cottonwood seedling survivorship (Shafroth et al. 2000). *Saplings:* Research indicates that cottonwood/willow saplings would experience 9% decrease in stem density and an 8% decrease in basal area (Shafroth et al. 2000). No statistical trend was found between groundwater change and tamarisk sapling vegetation characteristics (Shafroth et al. 2000). *Mature:* Research indicates there would be no change in the survivorship or plant height of willow or tamarisk (Horton et al. 2001). No statistical difference was found in survivorship, change in live crown volume, leaf area, leaf mass, or incremental stem grown of mature cottonwood for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999). Research indicates that mature cottonwoods could experience a reduction in branch elongation of roughly 30% for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999); note that this percentage is estimated graphically based on the average of large ranges of data points. *Stream Flow Permanence:* EG1, EG2: No change in stream flow presence predicted. CC2, CC4, CC5, CC7, CC13, CC15: At this drawdown, stream flow permanence is reduced in all Cienega Creek reaches, ranging from 95% (CC5, CC7) to 74% (CC15). Quantitative research on effects of stream flow permanence are mixed, are grouped in wide categories, and are difficult to use predictively. Overall, research indicates the shift to a less permanent stream flow system is associated with reduced basal area, size classes, stem density, and vegetation height for cottonwood/willow, and increased basal area and stem density for tamarisk.
0.8 foot	*Seedlings:* Research indicates there would be no difference in the presence/absence of cottonwood, willow, tamarisk, or seep willow seedlings (Shafroth et al. 1998). No statistical trend was found between groundwater change and cottonwood seedling survivorship (Shafroth et al. 2000). *Saplings:* Research indicates that cottonwood/willow saplings would experience 12% decrease in stem density and an 11% decrease in basal area (Shafroth et al. 2000). No statistical trend was found between groundwater change and tamarisk sapling vegetation characteristics (Shafroth et al. 2000). *Mature:* Research indicates there would be no change in the survivorship or plant height of willow or tamarisk (Horton et al. 2001). No statistical difference was found in survivorship, change in live crown volume, leaf area, leaf mass, or incremental stem grown of mature cottonwood for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999). Research indicates that mature cottonwoods could experience a reduction in branch elongation of roughly 30% for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999); note that this percentage is estimated graphically based on the average of large ranges of data points. *Stream Flow Permanence:* At this drawdown, stream flow permanence is reduced in all Cienega Creek reaches, ranging from 87% (CC13) to 58% (CC4), and reduced slightly in both Empire Gulch reaches (from 100% to 98%). Quantitative research on effects of stream flow permanence are mixed, are grouped in wide categories, and are difficult to use predictively. Overall, research indicates the shift to a less permanent stream flow system is associated with reduced basal area, size classes, stem density, and vegetation height for cottonwood/willow, and increased basal area and stem density for tamarisk.

Incremental Drawdown	Expected Changes
1.0 foot	*Seedlings:* Research indicates there would be no difference in the presence/absence of cottonwood, willow, tamarisk, or seep willow seedlings (Shafroth et al. 1998). No statistical trend was found between groundwater change and cottonwood seedling survivorship (Shafroth et al. 2000). *Saplings:* Research indicates that cottonwood/willow saplings would experience 15% decrease in stem density and a 13% decrease in basal area (Shafroth et al. 2000). No statistical trend was found between groundwater change and tamarisk sapling vegetation characteristics (Shafroth et al. 2000). *Mature:* Research indicates there would be no change in the survivorship or plant height of willow or tamarisk (Horton et al. 2001). No statistical difference was found in survivorship, change in live crown volume, leaf area, leaf mass, or incremental stem grown of mature cottonwood for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999). Research indicates that mature cottonwoods could experience a reduction in branch elongation of roughly 30% for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999); note that this percentage is estimated graphically based on the average of large ranges of data points. *Stream Flow Permanence:* At this drawdown, stream flow permanence is reduced in all Cienega Creek reaches, ranging from 81% (CC13) to 24% (CC4), and reduced slightly in both Empire Gulch reaches to 95%. Quantitative research on effects of stream flow permanence are mixed, are grouped in wide categories, and are difficult to use predictively. Overall, research indicates the shift to a less permanent stream flow system is associated with reduced basal area, size classes, stem density, and vegetation height for cottonwood/willow, and increased basal area and stem density for tamarisk.
1.5 feet	*Seedlings:* Research indicates there would be no difference in the presence/absence of cottonwood, willow, tamarisk, or seep willow seedlings (Shafroth et al. 1998). No statistical trend was found between groundwater change and cottonwood seedling survivorship (Shafroth et al. 2000). *Saplings:* Research indicates that cottonwood/willow saplings would experience 21% decrease in stem density and a 20% decrease in basal area (Shafroth et al. 2000). No statistical trend was found between groundwater change and tamarisk sapling vegetation characteristics (Shafroth et al. 2000). *Mature:* Research indicates there would be no change in the survivorship or plant height of willow or tamarisk (Horton et al. 2001). No statistical difference was found in survivorship, change in live crown volume, leaf area, leaf mass, or incremental stem grown of mature cottonwood for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999). Research indicates that mature cottonwoods could experience a reduction in branch elongation of roughly 30% for drawdown less than 1.7 feet (0.5 m) (Scott et al. 1999); note that this percentage is estimated graphically based on the average of large ranges of data points. *Stream Flow Permanence:* At this drawdown, stream flow permanence is reduced in all Cienega Creek reaches, ranging from 77% (CC13) to 9% (CC4), and reduced in both Empire Gulch reaches to 93%. Quantitative research on effects of stream flow permanence are mixed, are grouped in wide categories, and are difficult to use predictively. Overall, research indicates the shift to a less permanent stream flow system is associated with reduced basal area, size classes, stem density, and vegetation height for cottonwood/willow, and increased basal area and stem density for tamarisk.

Incremental Drawdown	Expected Changes
2 feet	*Seedlings:* Research indicates there would be no difference in the presence/absence of cottonwood, willow, tamarisk, or seep willow seedlings (Shafroth et al. 1998). No statistical trend was found between groundwater change and cottonwood seedling survivorship (Shafroth et al. 2000). *Saplings:* Research indicates that cottonwood/willow saplings would experience 27% decrease in stem density and a 27% decrease in basal area (Shafroth et al. 2000). No statistical trend was found between groundwater change and tamarisk sapling vegetation characteristics (Shafroth et al. 2000). *Mature:* Research indicates there would be no change in the survivorship or plant height of willow or tamarisk (Horton et al. 2001). *Stream Flow Permanence:* At this drawdown, stream flow permanence is reduced in all Cienega Creek reaches, ranging from 50% (CC13) to 0% (CC2, CC4), and reduced in both Empire Gulch reaches to 44%. Quantitative research on effects of stream flow permanence are mixed, are grouped in wide categories, and are difficult to use predictively. Overall, research indicates the shift to a less permanent stream flow system is associated with reduced basal area, size classes, stem density, and vegetation height for cottonwood/willow, and increased basal area and stem density for tamarisk.
3 feet	*Seedlings:* Research indicates there would be no difference in the presence/absence of cottonwood, willow, tamarisk, or seep willow seedlings (Shafroth et al. 1998). No statistical trend was found between groundwater change and cottonwood seedling survivorship (Shafroth et al. 2000). *Saplings:* Research indicates that cottonwood/willow saplings would experience 42% decrease in stem density and a 40% decrease in basal area (Shafroth et al. 2000). No statistical trend was found between groundwater change and tamarisk sapling vegetation characteristics (Shafroth et al. 2000). *Mature:* Research indicates there would be no change in the survivorship or plant height of willow or tamarisk (Horton et al. 2001). *Stream Flow Permanence:* At this drawdown, stream flow permanence is reduced in all Cienega Creek reaches, ranging from 35% (CC13) to 0% (CC2, CC4), and reduced in both Empire Gulch reaches to 7%. Quantitative research on effects of stream flow permanence are mixed, are grouped in wide categories, and are difficult to use predictively. Overall, research indicates the shift to a less permanent stream flow system is associated with reduced basal area, size classes, stem density, and vegetation height for cottonwood/willow, and increased basal area and stem density for tamarisk.
4 feet	*Seedlings:* Research indicates there would be no difference in the presence/absence of cottonwood, willow, tamarisk, or seep willow seedlings (Shafroth et al. 1998). No statistical trend was found between groundwater change and cottonwood seedling survivorship (Shafroth et al. 2000). *Saplings:* Research indicates that cottonwood/willow saplings would experience 55% decrease in stem density and a 53% decrease in basal area (Shafroth et al. 2000). No statistical trend was found between groundwater change and tamarisk sapling vegetation characteristics (Shafroth et al. 2000). *Mature:* Research indicates there would be no change in the survivorship or plant height of willow or tamarisk (Horton et al. 2001). Research indicates that for mature cottonwoods there could roughly be an 88% reduction in survivorship, a 38% reduction in live crown volume, and a 64% reduction in stem diameter of mature cottonwoods for drawdown greater than 3.3 feet (1 m) (Scott et al. 1999); note that these percentages were estimated graphically based on the average of large ranges of data points. *Stream Flow Permanence:* At this drawdown, stream flow permanence is reduced in all Cienega Creek reaches, ranging from 25% (CC13) to 0% (CC2, CC4), and reduced in both Empire Gulch reaches to 0%. Quantitative research on effects of stream flow permanence are mixed, are grouped in wide categories, and are difficult to use predictively. Overall, research indicates the shift to a less permanent stream flow system is associated with reduced basal area, size classes, stem density, and vegetation height for cottonwood/willow, and increased basal area and stem density for tamarisk.

Incremental Drawdown	Expected Changes
5 feet	*Seedlings:* Research indicates there would be no difference in the presence/absence of cottonwood, willow, tamarisk, or seep willow seedlings (Shafroth et al. 1998). No statistical trend was found between groundwater change and cottonwood seedling survivorship (Shafroth et al. 2000). *Saplings:* Research indicates that cottonwood/willow saplings would experience 70% decrease in stem density and a 67% decrease in basal area (Shafroth et al. 2000). No statistical trend was found between groundwater change and tamarisk sapling vegetation characteristics ((Shafroth et al. 2000). *Mature:* Research indicates there would be no change in the survivorship or plant height of willow or tamarisk (Horton et al. 2001). Research indicates that for mature cottonwoods there could roughly be an 88% reduction in survivorship, a 38% reduction in live crown volume, and a 64% reduction in stem diameter of mature cottonwoods for drawdown greater than 3.3 feet (1 m) (Scott et al. 1999); note that these percentages were estimated graphically based on the average of large ranges of data points. *Stream Flow Permanence:* At this drawdown, stream flow permanence is reduced in all Cienega Creek reaches, ranging from 17% (CC13) to 0% (CC2, CC4), and reduced in both Empire Gulch reaches to 0%. Quantitative research on effects of stream flow permanence are mixed, are grouped in wide categories, and are difficult to use predictively. Overall, research indicates the shift to a less permanent stream flow system is associated with reduced basal area, size classes, stem density, and vegetation height for cottonwood/willow, and increased basal area and stem density for tamarisk.

Table 43. Predicted changes in vegetation characteristics for absolute groundwater depths

Absolute Depth to Groundwater	Expected Conditions
0	One study indicates that this groundwater depth is associated with the presence of juvenile willows (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, willow, and tamarisk (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 square meters per hectare (m^2/ha) (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 281 stems/ha (cottonwood) and 164 stems/ha (willow) (Leenhouts et al. 2006).
0.2 foot	One study indicates that this groundwater depth is associated with the presence of juvenile willows (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, willow, and tamarisk (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 277 stems/ha (cottonwood) and 162 stems/ha (willow) (Leenhouts et al. 2006).
0.4 foot	One study indicates that this groundwater depth is associated with the presence of juvenile willows (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, willow, and tamarisk (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 273 stems/ha (cottonwood) and 160 stems/ha (willow) (Leenhouts et al. 2006).

Absolute Depth to Groundwater	Expected Conditions
0.6 foot	Studies indicate that this groundwater depth is associated with the presence of cottonwood, willow, and tamarisk seedlings (Shafroth et al. 1998) and juvenile willows (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, willow, and tamarisk (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 269 stems/ha (cottonwood) and 158 stems/ha (willow) (Leenhouts et al. 2006).
0.8 foot	Studies indicate that this groundwater depth is associated with the presence of cottonwood, willow, and tamarisk seedlings (Shafroth et al. 1998) and juvenile willows (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, willow, and tamarisk (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 265 stems/ha (cottonwood) and 156 stems/ha (willow) (Leenhouts et al. 2006).
1.0 foot	Studies indicate that this groundwater depth is associated with the presence of cottonwood and tamarisk seedlings (Shafroth et al. 1998) juvenile willows (Stromberg et al. 1996), and seepwillow (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, willow, and tamarisk (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 262 stems/ha (cottonwood) and 154 stems/ha (willow) (Leenhouts et al. 2006).
1.5 feet	Studies indicate that this groundwater depth is associated with the presence of juvenile and mature cottonwood, juvenile willows, and seepwillow (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, willow, and tamarisk (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 252 stems/ha (cottonwood) and 149 stems/ha (willow) (Leenhouts et al. 2006).
2 feet	Studies indicate that this groundwater depth is associated with the presence of juvenile and mature cottonwood, juvenile and mature willows, and seepwillow (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, willow, and tamarisk (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 242 stems/ha (cottonwood) and 143 stems/ha (willow) (Leenhouts et al. 2006).
3 feet	Studies indicate that this groundwater depth is associated with the presence of juvenile and mature cottonwood (Stromberg et al. 1996), juvenile and mature willows (Leenhouts et al. 2006; Stromberg et al. 1996), juvenile and mature tamarisk (Stromberg et al. 1996), and seepwillow (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, and tamarisk, and 1.1% canopy dieback in willow (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 223 stems/ha (cottonwood) and 133 stems/ha (willow) (Leenhouts et al. 2006).

Absolute Depth to Groundwater	Expected Conditions
4 feet	Studies indicate that this groundwater depth is associated with the absence of willow and tamarisk seedlings (Shafroth et al. 1998), and the presence of juvenile and mature cottonwood (Leenhouts et al. 2006; Stromberg et al. 1996) , mature willows (Leenhouts et al. 2006; Stromberg et al. 1996), juvenile and mature tamarisk (Stromberg et al. 1996), and seepwillow (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood and tamarisk, and 2% canopy dieback in willow (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 203 stems/ha (cottonwood) and 123 stems/ha (willow) (Leenhouts et al. 2006).
5 feet	Studies indicate that this groundwater depth is associated with the absence of cottonwood and tamarisk seedlings (Shafroth et al. 1998), and the presence of mature cottonwood (Leenhouts et al. 2006; Stromberg et al. 1996), young cottonwood (Leenhouts et al. 2006), mature willows (Leenhouts et al. 2006; Stromberg et al. 1996), young willow (Leenhouts et al. 2006), juvenile and mature tamarisk (Stromberg et al. 1996), and seepwillow (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood and tamarisk, and 3.6% canopy dieback in willow (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 184 stems/ha (cottonwood) and 112 stems/ha (willow) (Leenhouts et al. 2006).
6 feet	Studies indicate that this groundwater depth is associated with the presence of mature cottonwood (Leenhouts et al. 2006; Stromberg et al. 1996), young cottonwood (Leenhouts et al. 2006), mature willows (Leenhouts et al. 2006; Stromberg et al. 1996), young willow (Leenhouts et al. 2006), juvenile and mature tamarisk (Stromberg et al. 1996), and seepwillow (Stromberg et al. 1996); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, 6.4% canopy dieback in willow, and 1.7% canopy dieback in tamarisk (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 165 stems/ha (cottonwood) and 102 stems/ha (willow) (Leenhouts et al. 2006).
7 feet	Studies indicate that this groundwater depth is associated with the presence of mature cottonwood (Leenhouts et al. 2006; Stromberg et al. 1996), young cottonwood (Leenhouts et al. 2006), mature willows (Leenhouts et al. 2006; Stromberg et al. 1996), young willow (Leenhouts et al. 2006), and mature tamarisk (Leenhouts et al. 2006); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, 11% canopy dieback in willow, and 4.2% canopy dieback in tamarisk (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 145 stems/ha (cottonwood) and 92 stems/ha (willow) (Leenhouts et al. 2006).
8 feet	Studies indicate that this groundwater depth is associated with the presence of old cottonwood (Leenhouts et al. 2006), mature cottonwood (Leenhouts et al. 2006; Stromberg et al. 1996), young cottonwood (Leenhouts et al. 2006), mature and young willow (Leenhouts et al. 2006), and mature and young tamarisk (Leenhouts et al. 2006); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, 18% canopy dieback in willow, and 9.2% canopy dieback in tamarisk (Horton and Clark 2001). Basal area for groundwater depths less than 8.25 feet is 10.46 m^2/ha (cottonwood), 2.31 m^2/ha (willow), and 3.75 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 126 stems/ha (cottonwood) and 82 stems/ha (willow) (Leenhouts et al. 2006).

Absolute Depth to Groundwater	Expected Conditions
9 feet	Studies indicate that this groundwater depth is associated with the presence of old cottonwood and mature cottonwood, mature and young willow, and mature and young tamarisk (Leenhouts et al. 2006); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with <1% canopy dieback in cottonwood, 28% canopy dieback in willow, and 17% canopy dieback in tamarisk (Horton and Clark 2001). Basal area for groundwater depths between 8.25 and 11.55 feet is 13.89 m^2/ha (cottonwood), 1.48 m^2/ha (willow), and 6.07 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 106 stems/ha (cottonwood) and 71 stems/ha (willow) (Leenhouts et al. 2006).
10 feet	Studies indicate that this groundwater depth is associated with the presence of old cottonwood and mature cottonwood, mature willow, and mature and young tamarisk (Leenhouts et al. 2006); this groundwater depth is not within the range of other studies reviewed, and no conclusions can be drawn regarding presence/absence. One study found that this groundwater depth is associated with 1.5% canopy dieback in cottonwood, 39% canopy dieback in willow, and 26% canopy dieback in tamarisk (Horton and Clark 2001). Basal area for groundwater depths between 8.25 and 11.55 feet is 13.89 m^2/ha (cottonwood), 1.48 m^2/ha (willow), and 6.07 m^2/ha (tamarisk) (Lite and Stromberg 2005). Stem density for this groundwater depth is 87 stems/ha (cottonwood) and 61 stems/ha (willow) (Leenhouts et al. 2006).

Selected Impact Scenarios to Be Evaluated

Groundwater Modeling Scenarios

Impacts to riparian vegetation are analyzed for the same groundwater modeling scenarios as those for stream flow and pool depth.

Climate Change Stress

Similar to the approach for pool depths an additional climate change stress can be estimated for the groundwater levels supporting riparian vegetation. As before, there is an approximate 25 degree difference between January and June, and the typical change in groundwater levels over this same period is shown in table 31. The expected increase in temperature due to climate change is approximately 25 percent of the seasonal change, and we can estimate that the climate change stress would be 25 percent of the seasonal water level change. This represents an additional drawdown of approximately 0.4 foot that would be experienced by riparian vegetation, above and beyond that experienced from the modeling scenarios.

Predicted Impacts to Riparian Vegetation for Selected Impact Scenarios

The predicted drawdown or change in groundwater levels below riparian vegetation for the selected modeling scenarios, including climate change, is shown in table 44; the predicted absolute depths to groundwater, including climate change, are shown in table 45.

All Cienega Creek Reaches

A total of 65 individual scenarios was reviewed for each key reach; these scenarios include 15 time steps (ranging from end of mining to 1,000 years after mine closure), the best-fit modeling results for three different models (Tetra Tech, Montgomery, Myers), and the low and high ends of all modeling sensitivity runs. The modeled drawdown in all key reaches along Cienega Creek is 0.12 foot or less for 63 of these 65 scenarios, except for the Myers model at 1,000 years. With climate change adding 0.4 foot of drawdown, the overall drawdown ranges from 0.4 to 0.5 foot. With respect to absolute depth to groundwater, the expected changes do not shift the key reaches into a different category, as shown in table 42.

Table 44. Expected change in groundwater levels below riparian vegetation for modeling scenarios and climate change

	End of Mine					10					20					50					100					150					500					1,000				
Key Reach	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
Drawdown from modeling scenarios (feet)																																								
CC2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	2.2	2.2
CC4	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0
CC5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.2	0.2
CC7	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.1	0.0	0.1	0.0	-	0.1	0.0	0.1	0.0	-	0.1	0.0	0.1	0.0	-	0.1
CC13	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.1
CC15	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.1	0.0	0.1	0.0	-	0.1	0.0	0.1	0.0	-	0.1	0.0	0.1	0.0	-	0.1
EG1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	-	0.4	0.0	0.1	0.0	0.0	0.8	0.0	0.5	0.0	2.0	2.0	0.0	1.6	0.1	-	3.8	0.0	2.7	0.3	3.0	4.9	1.1	5.8	2.0	-	6.2	2.3	6.0	3.2	4.3	6.0
EG2	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.1	0.0	0.1	0.0	-	0.2	0.0	0.1	0.0	-	0.2	0.0	0.3	0.1	-	0.3	0.0	0.3	0.1	-	0.3
CGW	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.1	0.0	0.1	0.0	-	0.2	0.0	0.2	0.0	-	0.4	0.0	0.3	0.0	-	0.6	0.1	0.7	0.1	-	0.7	0.1	0.7	0.2	-	0.7
Drawdown, including an additional 0.4-foot reduction expected from climate change (feet)																																								
CC2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	2.6	2.6
CC4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4
CC5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	0.6	0.6
CC7	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.5	0.4	0.5	0.4	-	0.5	0.4	0.5	0.4	-	0.5	0.4	0.5	0.4	-	0.5
CC13	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.5
CC15	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.5	0.4	0.5	0.4	-	0.5	0.4	0.5	0.4	-	0.5	0.4	0.5	0.4	-	0.5
EG1	0.4	0.4	0.4	0.4	0.6	0.4	0.4	0.4	-	0.8	0.4	0.5	0.4	0.4	1.2	0.4	0.9	0.4	2.4	2.4	0.4	2.0	0.5	-	4.2	0.4	3.1	0.7	3.4	5.3	1.5	6.2	2.4	-	6.6	2.7	6.4	3.6	4.7	6.4
EG2	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.5	0.4	0.5	0.4	-	0.6	0.4	0.5	0.4	-	0.6	0.4	0.7	0.5	-	0.7	0.4	0.7	0.5	-	0.7
CGW	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.4	0.4	0.4	0.4	-	0.5	0.4	0.5	0.4	-	0.6	0.4	0.6	0.4	-	0.8	0.4	0.7	0.4	-	1.0	0.5	1.1	0.5	-	1.1	0.5	1.1	0.6	-	1.1

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

Table 45. Expected change in groundwater levels below riparian vegetation for modeling scenarios and climate change

		End of Mine					10					20					50					100					150					500					1,000				
Key Reach	Current Median DTW*	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H	L	TT	M	MY	H
CC2	5.6 (WP-13)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	-	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	-	6.0	6.0	6.0	6.0	6.1	6.1	6.0	6.0	6.0	-	6.0	6.0	6.0	6.0	8.2	8.2
CC4	8.6 (WP-2)	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	-	9.0
CC5	8.6 (WP-2)	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	9.2	9.2
CC7	8.6 (WP-2)	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	-	9.0	9.0	9.0	9.0	-	9.1	9.0	9.1	9.0	-	9.1	9.0	9.1	9.0	-	9.1	9.0	9.1	9.0	-	9.1
CC13	16.1 (Cienega)	16.5	16.5	16.5	-	16.5	16.5	16.5	16.5	-	16.5	16.5	16.5	16.5	-	16.5	16.5	16.5	16.5	-	16.5	16.5	16.5	16.5	-	16.5	16.5	16.5	16.5	-	16.5	16.5	16.5	16.5	-	16.5	16.5	16.5	16.5	-	16.6
CC15	16.1 (Cienega)	16.5	16.5	16.5	-	16.5	16.5	16.5	16.5	-	16.5	16.5	16.5	16.5	-	16.5	16.5	16.5	16.5	-	16.5	16.5	16.5	16.5	-	16.6	16.5	16.6	16.5	-	16.6	16.5	16.6	16.5	-	16.6	16.5	16.6	16.5	-	16.6
EG1	5.8 (WP-9)	6.2	6.2	6.2	6.2	6.4	6.2	6.2	6.2	-	6.6	6.2	6.3	6.2	6.2	7.0	6.2	6.7	6.2	8.2	8.2	6.2	7.8	6.3	-	10.0	6.2	8.9	6.5	9.2	11.1	7.3	12.0	8.2	-	12.4	8.5	12.2	9.4	10.5	12.2
EG2	2.6 (Box)	3.0	3.0	3.0	-	3.0	3.0	3.0	3.0	-	3.0	3.0	3.0	3.0	-	3.0	3.0	3.0	3.0	-	3.1	3.0	3.1	3.0	-	3.2	3.0	3.1	3.0	-	3.2	3.0	3.3	3.1	-	3.3	3.0	3.3	3.1	-	3.3
CGW	2.6 (Box)	3.0	3.0	3.0	-	3.0	3.0	3.0	3.0	-	3.0	3.0	3.0	3.0	-	3.1	3.0	3.1	3.0	-	3.2	3.0	3.2	3.0	-	3.4	3.0	3.3	3.0	-	3.6	3.1	3.7	3.1	-	3.7	3.1	3.7	3.2	-	3.7

Notes: L = Low End of All Sensitivity Analyses; TT = Tetra Tech Base or Best-Fit Model; M = Montgomery Base or Best-Fit Model; MY = Myers Base or Best-Fit Model; H = High End of All Sensitivity Analyses

- Indicates no data available for this model/time step

* Source piezometer/well(s) shown in parentheses

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Overall, some research shows that drawdown in this range could result in some changes to riparian vegetation (see table 42). This includes an estimated 6 to 9 percent decrease in stem density and basal area of cottonwood/willow saplings (Shafroth et al. 2000), and a study in which a 30 percent reduction in mature cottonwood branch elongation was observed for drawdowns less than 1.7 feet/0.5 m (Scott et al. 1999). However, most research found no statistical trend in presence/absence, survivorship, live crown volume, leaf area, leaf mass, or incremental stem growth.

In all cases, these effects would be due mostly to climate change (0.4-foot drawdown), and not from the groundwater drawdown associated with the mine (up to 0.12-foot drawdown). Qualitatively, changes in stream flow permanence are associated with vegetation changes; however, this level of drawdown also does not cause major shifts in stream flow permanence along Cienega Creek.

Empire Gulch – Key Reach EG1

By 1,000 years, the predicted impacts are unambiguous with drawdowns estimated anywhere from 2.7 to 6.6 feet. At these drawdowns, available pertinent research finds major impacts to vegetation, not least of which would be a shift in stream flow permanence from perennial to ephemeral, with associated major changes in riparian vegetation.

An important question for key reach EG1 is how early predicted effects could occur. One general measure that can be looked at is the shift from perennial to intermittent stream flow; it should be noted that the definition used here (where perennial flow is anywhere from 0 to 30 days of no flow per year) does not necessarily match the definition used in many of the studies (where perennial flow means 0 days of no flow per year). The best-fit modeling scenarios place the shift from perennial to intermittent in key reach EG1 anywhere from 50 to 300 years after mine closure. The worst-case scenarios (i.e., the high end of all model sensitivity analyses) have this shift occurring as early as 20 years after mine closure.

It would be expected that at these drawdowns and with this shift in stream flow permanence, impacts to riparian vegetation would follow. While research differs on exact thresholds, roughly speaking, once absolute depth to groundwater exceeds 7 feet, willow experiences canopy dieback greater than 10 percent, there is a reduction in the likely presence of younger cottonwood and willow specimens, and there is an overall reduction in stem density and basal area of cottonwood and willow. This threshold begins to be exceeded as early as 20 years, and by 150 years the majority of scenarios show depth to groundwater over 8 feet. This level of change in riparian vegetation density and health would also be likely to trigger negative feedback loops, resulting in head cuts, erosion, and downstream sedimentation.

The best-fit models put the final transition from intermittent flow to ephemeral flow anywhere from 150 to 800 years after mine closure. By the time this transition occurs, major shifts in riparian vegetation in key reach EG1 would be expected to be well underway, with complete loss of the hydroriparian corridor and transition to xeroriparian vegetation.

Empire Gulch – Key Reach EG2 and Cieneguita Wetlands

For up to 50 years after closure of the mine, predicted drawdowns in key reach EG2 and the Cieneguita Wetlands are very similar to that described for Cienega Creek, with most scenarios showing drawdown in the range of 0.4 to 0.5 foot.

After 50 years, drawdowns increase to a maximum of 0.7 foot for key reach EG2 and 1.1 feet for the Cieneguita Wetlands. With these drawdowns, the results are similar to those described for Cienega Creek, except that the estimated decrease in stem density and basal area of cottonwood/willow saplings increases to 11 to 15 percent along the riparian corridor, which is sparse but still exists at a lower density along key reach EG2. The shift in stream flow permanence is relatively minor and would not be expected to drive major vegetation changes.

While woody riparian vegetation would not experience major transitions in Lower Empire Gulch (key reach EG2) or the Cieneguita Wetlands, aquatic vegetation and wetland obligate plants likely would experience greater impact. Drawdown of 0.5 foot would lower groundwater levels below some root depths, and contraction of pools in volume and surface area would affect near-edge wetland species.

Consideration of Ongoing Trends

As described previously, the current drought is believed to be contributing to negative trends with respect to the riparian habitat along both Empire Gulch and Cienega Creek. Much of the impact to riparian vegetation is anecdotal in nature, however statistical negative trends have been identified with stream flow, precipitation, and annual wet/dry mapping, although not with overall riparian extent. The estimate of climate change used in this SIR analysis for riparian vegetation (an additional drawdown of 0.4 foot) is one technique meant to analyze what would happen if the currently occurring negative trends continue. While this technique suggests that vegetation would not be overly stressed by an additional drop of 0.4 foot due to climate change, it must be acknowledged that much of the literature does not allow for detailed predictions for small incremental changes in groundwater depth. A more likely scenario is to acknowledge that the currently observed negative trends would continue.

The estimate of impacts included in this SIR analysis does suggest, however, that mine drawdown would not be the driving factor for declines in riparian vegetation along Cienega Creek. In 95 percent of possible analysis scenarios, drawdown along Cienega Creek does not exceed 0.2 foot even after 1,000 years.

Upper Empire Gulch shows the opposite effect: mine drawdown is of such magnitude that negative trends are likely to intensify, regardless of the stresses experienced from climate change. The modeling scenarios are consistent in that a change to ephemeral status would occur at some point in time; however, the results vary widely on when that transition would occur, ranging from as early as 20 years to 1,000 years.

Outstanding Arizona Waters Analysis

As described in the “Seeps, Springs, and Riparian Areas” section of the FEIS, the Forest Service does not have the jurisdiction to determine whether or not runoff from the mine site to the OAW in Davidson Canyon would meet Arizona surface water quality standards. This jurisdiction lies with ADEQ through issuance of the 401 water quality certification. The 401 water quality certification was issued by ADEQ on February 3, 2015, and indicates that runoff from the mine is not expected to violate Arizona surface water quality standards. However, as noted in the FEIS, the Forest Service still has a responsibility under NEPA to disclose potential impacts to lower Davidson Canyon.

A screening analysis was used in the FEIS to identify which constituents could pose concerns in surface water runoff, without drawing conclusions about whether or not these concentrations would violate Arizona surface water quality standards. One reason stated in the FEIS that limited the screening analysis was the lack of any available stormwater samples in Davidson Canyon, in order to compare potential runoff water quality. The screening analysis found that most constituents in runoff from either waste rock or soil cover on the waste rock were estimated to be less than ambient stormwater quality, with several exceptions. Samples from Barrel Canyon had to be used instead to estimate Davidson Canyon water quality.

Based on the new information received, there is now some record of runoff water quality in Davidson Canyon. Almost without exception, average concentrations in Davidson Canyon are less than those in Barrel Canyon. This is true for aluminum (total), antimony (total), arsenic (total), barium (total), beryllium (total), cadmium (total and dissolved), calcium (total), chloride (total), chromium (total and dissolved), copper (total and dissolved), fluoride (total), iron (total), lead (total and dissolved), magnesium (total), manganese (total), molybdenum (total), nickel (total and dissolved), nitrate, selenium (total), silver (total and dissolved), sodium (total), sulfate (total), thallium (total), and zinc (total and dissolved). Two constituents have higher average concentrations in Davidson Canyon than Barrel Canyon: total dissolved solids, and potassium (total). Several constituents are unable to be compared due to laboratory detection limits, including arsenic (dissolved), iron (dissolved), and mercury (total and dissolved). Two conclusions can be drawn from this comparison:

- The screening analysis used in the FEIS that substitutes Barrel Canyon stormwater quality for Davidson Canyon stormwater quality is likely not an accurate estimate of potential impacts downstream in Davidson Canyon. Barrel Canyon and Davidson Canyon stormwater quality is substantially different.
- The new stormwater quality also illustrates the infeasibility of estimating impacts on Davidson Canyon water quality due to runoff from the mine site. Stormwater quality clearly changes greatly in the intervening 12 miles between the mine site and lower Davidson Canyon. Just as runoff in Barrel Canyon is empirically demonstrated to be dissimilar to Davidson Canyon stormwater runoff, it is reasonable to assume that mine site runoff would be equally dissimilar to Davidson Canyon, and it would be inappropriate to directly compare mine runoff that far downstream.

As noted previously, the determination as to whether the mine is likely to violate anti-degradation standards in the OAW in Davidson Canyon belongs with ADEQ. ADEQ has issued the 401 water quality certification and determined that Arizona state water quality standards would not be violated. ADEQ came to similar conclusions in their basis of determination for the 401 permit:

> ADEQ finds that if the applicant adheres to the conditions of the CWA §404 permit, the conditions and mitigations required in this State 401Certification, the mitigations required in the FEIS and requirements of the 2010 MSGP, the Rosemont Copper Project should not cause or contribute to exceedances of surface water quality standards nor cause water quality degradation in the downstream receiving waters including Davidson Canyon Wash and Cienega Creek. (Arizona Department of Environmental Quality 2014)

These conclusions were based in part on the same conclusions drawn above: “Ambient stormwater quality, representing background conditions pre-mining, exceeds surface water quality standards for several parameters including copper, lead, and silver. Under current conditions, these exceedances do not appear to be impacting water quality in the downstream OAWs” (Arizona Department of Environmental Quality 2014).

Past Actions

Past actions were incorporated into the description of existing conditions in the FEIS. The following past actions are the result of changes in their status, and were not addressed in the FEIS:

- Additional wildfires that occurred between 2012 and 2014. *Wildfires occur in the analysis area annually. During the period from 2012 to 2014, an estimated 33 wildfires occurred ranging in size from 0.1 acre to 66 acres. The majority were less than 10 acres in size. New fires do have an effect on watershed runoff characteristics and potentially downstream riparian areas, but in the context of the whole watershed, these fires are generally a small percentage of the drainage area. Past wildfires are recovering over time, and these newer fires will also recover over time. No changes in the overall impacts disclosed in the FEIS have resulted from these wildfires.*
- Hazardous fuels treatment in Gardner Canyon has been accomplished. *Hazardous fuels treatments are similar to wildfires in that they both result in removal of vegetation to various degrees and to changes watershed characteristics such as surface cover, and, depending on magnitude, typically only involve a small percentage of the drainage area. The discussion above regarding additional wildfires pertains to this action as well.*

These additional past actions affect a minor portion of the analysis area and would not result in any substantive change to the description of existing conditions or environmental baseline disclosed in the FEIS.

Reasonably Foreseeable Actions

Reasonably foreseeable actions were addressed in the "Cumulative Effects" sections of the FEIS. The following changes to reasonably foreseeable actions are pertinent to water resources.

- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes. *While this project was listed as reasonably foreseeable in the FEIS, no information regarding plans for mining was known. Subsequently, a mineral development plan was discovered that was submitted to the ASLD. While no ground-disturbing activity has occurred on the site, the mineral development plan outlines the plan of operations for the proposed mining activity and provides an environmental assessment of potential impacts. This project would contribute to ground disturbance within the Davidson Canyon drainage and affect watershed runoff characteristics, potentially downstream riparian areas, and would result in direct loss of xeroriparian vegetation. The cumulative impacts disclosed in the FEIS remain valid. It should be noted that there is no indication whether or when ground-disturbing activities may occur for this project.*
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River. *This is a short-term use that would cause minimal surface disturbance at the bridge site only. It would not change the conclusion of impacts to riparian resources disclosed in the FEIS.*

The changes to reasonably foreseeable actions noted above would not result in changes to the cumulative impacts disclosed in the FEIS.

Summary of Findings

Reasonably Expected Impacts to Stream Flow and Standing Pools

The analysis included in this SIR covers a wide variety of scenarios, but certain patterns stand out that can be considered reasonably expected to occur, based on the assumptions in the analysis.

With respect to time frames, the cautions contained in the FEIS are still valid:

> As a whole, it was found that the artifical boundary conditions—and particularly the western boundary—did have a quantifiable effect on the model results, but this effect was highly dependent on time . . . . Roughly speaking, effects from the boundaries remained minimal until about 300 years after closure of the mine. After this time, the change in flow from the artificial boundaries becomes a larger and larger percentage of the groundwater entering the pit, which in turn could cause a reduction in modeled impacts elsewhere in the model domain. (FEIS, p. 300)

For this reason, this summary of reasonably expected impacts is limited in time to only 300 years after closure of the mine; this time frame may be reduced further when considering the uncertainties associated with individual species.

The most succinct way to evaluate reasonably expected impacts is to rely on the 95th percentile results (tables 22 through 25 for predicted stream flow impacts, and tables 39 through 41 for predicted pool impacts). The results shown in these tables reflect the impacts that would occur from 95 percent of the possible scenarios, which account for the variabililty in the model results as well as variability in the relationship used to translate groundwater drawdown into reduced stream flow. There are three basic questions that can be asked: what impacts are predicted from the mine drawdown alone, what impacts are predicted as a result of increasing temperatures associated with climate change, and when climate change is considered, will the mine drawdown have a different impact than when considered by itself?

Cienega Creek

The results for all key reaches along Cienega Creek are consistent and clear: for 95 percent of the possible scenarios, mine drawdown by itself has no or little effect on drying of the stream (measured by days with zero stream flow) and does not change the stream flow status from perennial (as defined in this analysis). Mine drawdown by itself would have some effect on water quality (measured by days with extremely low stream flow), in some reaches up to 9 days of extremely low flow per year. Since stream flow does not fall to zero, standing pools would not be expected to be impacted. However, even if drawdown impacts are imposed on the pools the results are similar along Cienega Creek: for 95 percent of the possible scenarios, mine drawdown by itself does not change the number of pools, and pools retain at least 82 percent of their original volume.

By contrast, the climate change scenario by itself has a substantial effect on both stream flow and pools along Cienega Creek. The upper reaches of Cienega Creek (CC2, CC4, CC5) are relatively stable, with no or little increase in days with zero stream flow. Farther downstream, however, the analysis indicates a greater susceptibility to climate change. Cienega Creek Reaches 7 and 13 both reach a maximum of 23 days per year with zero stream flow, and Cienega Creek Reach 15 reaches a maximum of 37 days per year with zero stream flow, which pushes this reach from perennial to intermittent status. Because stream flow begins to fall to zero more often, the effects on standing pools in these lower reaches become more important. For the most part, the reaches along Cienega Creek do not lose substantial numbers of pools due to climate change, in most cases only a single pool or less. Though the pools remain, the volume of the pools is substantially affected by climate change. Upper reaches (CC2, CC4, CC5, CC7) see pool reductions up to about half of their original volume. However, recall that stream flow is not expected to change in some of these reaches, and pools would not be expected to be impacted by drawdown. Lower reaches (CC13, CC15) see greater reductions, with Cienega Creek Reach 13 pools retaining only 12 percent of their original size, and Cienega Creek Reach 15 pools retaining 35 percent of their original size. Climate change also has a substantial effect on water quality, especially in lower reaches (CC7, CC13, CC15), which see up to 60 days per year with extremely low stream flow.

When considered on top of climate change, mine drawdown still makes little difference to some reaches (CC2, CC4, CC5, CC13), but mine drawdown does have greater influence on Cienega Creek Reach 7, which increases days with zero stream flow from 23 to 31, and Cienega Creek Reach 15, which increases days with zero stream flow, from 37 up to 57. In both these cases, when superimposed on climate change, the mine drawdown changes flow status from perennial to intermittent (as defined in this analysis). With respect to pools, when considered on top of climate change, mine drawdown does not change the number of pools, and for the most part does not change the volume of the pools substantially. The exception is Cienega Creek Reach 2, which sees pool volumes reduced to 13 percent of their original volume. However, recall that stream flow is not expected to change in this reach, and pools would not be expected to be impacted by drawdown. With respect to water quality, in all reaches, when considered on top of climate change, mine drawdown does increase the number of days with extremely low stream flow.

To summarize, for Cienega Creek:

- Mine drawdown by itself has little to no effect on stream drying or pools, and minimal impact on water quality due to extremely low stream flow.
- Climate change by itself would mostly impact the lower reaches of Cienega Creek. Periods without stream flow from 23 to 37 days could occur in Cienega Creek Reaches 7, 13, and 15, and though the number of pools would not change, their volume would decrease substantially.
- When mine drawdown is considered on top of climate change, Cienega Creek Reaches 7 and 15 experience an increase in days with zero stream flow per year, most reaches experience an increase in days with extremely low flow, but relatively little impact is seen on pool number or volume.

Lower Empire Gulch and Cieneguita Wetlands

Lower Empire Gulch (reach EG2) and the Cieneguita Wetlands show similar results as those along Cienega Creek, but with greater expected impacts to water quality and pools. Lower Empire Gulch does not see a large increase in days with zero stream flow from either mine drawdown or climate change, although taken together, the number of days with zero stream flow increase as high as 6. Impacts to water quality are more variable, with mine drawdown alone resulting in anywhere from zero to 26 extremely low flow days, which, when combined with climate change (26 days with extremely low flow by itself), increases to 26 to 58 extremely low flow days per year. The number of pools in Lower Empire Gulch does not change under any scenario. Pool volume in Lower Empire Gulch can decrease to 70 percent of the original volume from mine drawdown alone, and, when combined with the climate change scenario (which reduces pools to 59 percent of original volume), pool volumes can decrease to 42 to 57 percent of original volume.

The number of pools associated with the Cieneguita Wetlands also do not change under any scenario. However, impacts to pool volume are substantial and highly variable. Mine drawdown alone could result in pools being anywhere from 25 to 92 percent of their original volume. When combined with the climate change scenario (which reduces pools to 38 percent of original volume), volumes can reach as low as 11 to 37 percent of their original volume.

Upper Empire Gulch

Upper Empire Gulch (reach EG1) experiences the greatest impact of all reaches, but also the greatest variability in impact and timing. It is difficult to point to any one scenario as being reasonably expected to occur. However, there are patterns that emerge from the highly variable scenarios. Upper Empire Gulch generally sees no or little changes through 20 years after closure of the mine. At this point, the modeling scenarios diverge regarding the timing and magnitude of impacts. The high end of the sensitivity analyses indicates that reach EG1 would be ephemeral by 100 years after mine closure. The Tetra Tech and Myers models both come close to ephemeral status by 150 years after mine closure, and reach ephemeral status by 200 years after mine closure. The Montgomery model does not reach ephemeral status by 300 years, but has shifted from perennial to intermittent flow, as defined by this analysis. The low end of the sensitiity analyses shows no change in flow status even at 300 years. Adding the effects of climate change does not change the overall pattern described.

Pools and water quality impacts (as measured by extremely low stream flow) also follow similar patterns, with wide variability. The number of pools remains unimpacted even at 300 years, or they completely disappear, depending on the model scenario.

Reasonably Expected Impacts to Riparian Vegetation

Overall, the literature reviewed does not provide the tools needed to assess changes in vegetation health or density due to small increments of groundwater drawdown. A more reasonable assessment is to assume that negative trends in riparian habitat observed during the current drought are likely to continue into the future due to climate change.

However, the analysis does provide some basis to evaluate the relative importance of stresses and impacts. In 95 percent of possible scenarios, the mine drawdown does not exceed 0.2 foot along Cienega Creek. This level of drawdown is half of what is estimated from climate change, and available literature indicates such an increment is unlikely to lead to substantial shifts in vegetation health along Cienega Creek. Nor are there substantial shifts in stream flow permanence along most reaches of Cienega Creek that would be expected to drastically alter the riparian corridor.

Upper Empire Gulch, on the other hand, is almost certain to experience major shifts in riparian vegetation due to mine drawdown, regardless of climate change stresses. Scenarios differ widely on when this transition might begin to occur.

Outstanding Arizona Waters

Review of additional baseline information indicates that the screening analysis used in the FEIS to assess the potential for mine site runoff to impact downstream OAWs was not reasonable, as stormwater quality in Barrel Canyon does not adequately represent stormwater quality in Davidson Canyon. However, this information also highlights the infeasibility of estimating impacts 12 miles downstream from the mine site, and does not suggest a better or more valid method of estimating impacts. Separate from the analysis conducted by the Coronado, the ADEQ has issued the 401 water quality certification and identified that mine runoff is not expected to violate Arizona state surface water qualtiy standards.

Summary of Refined Aquatic Analysis and Comparison to FEIS Conclusions

Overall, the conclusions contained in the revised SIR analysis are similar to FEIS conclusions, and in most cases show slightly less impact. It should be noted that climate change was not incorporated quantitatively into the FEIS analysis, and therefore the comparisons made below are for mine-only drawdown.

- Comparison of "Empire Gulch" in the FEIS with key reaches EG1 and EG2 shows that in most cases the FEIS disclosed more days with zero stream flow (see table 14), more days with extremely low flow (see table 15), and similar shifts from perennial status to intermittent or ephemeral status (see table 16).
- Comparison of "Upper Cienega Creek" in the FEIS with key reaches CC2, CC4, CC5, and CC7 shows that in all cases the FEIS disclosed more days with zero stream flow (see table 14), and in most cases more days with extremely low flow (see table 15). Shifts away from perennial status were not predicted in either the FEIS or this SIR analysis.
- Impacts disclosed to "Gardner Canyon" in the FEIS would be greater than indicated in this SIR analysis, as the FEIS assumed perennial flow in this area, and more recent discussions suggest it is an intermittent reach.

Impacts to riparian vegetation are also similar to those disclosed in the FEIS:

- For Cienega Creek, the FEIS disclosed: "[It] would not be likely to result in widespread changes to riparian vegetation, even up to 1,000 years after mine closure. However, while total conversion from a hydroriparian to a xeroriparian corridor is unlikely, there is likely to be contraction of the hydroriparian area, with conversion occurring at the transitional margins of the habitat." This is similar to the effects described in this SIR analysis.
- For Empire Gulch, the FEIS disclosed: "In the near term [<=50 years] . . . would be unlikely to cause widespread mortality or transition from hydroriparian to xeroriparian habitat, but cottonwood/willow forest would experience stress . . . decrease in canopy height and vegetation volume. In the long term [150+ years] . . . would contribute to mortality and transition from hydroriparian to xeroriparian habitat." This is similar to the effects described in this SIR analysis.

With respect to OAWs, the FEIS concludes, "Some water quality constituents potentially elevated in runoff, but potential is reduced by waste rock segregation procedures" (FEIS, p. 508). In the light of new information, the analysis itself is not supportable, but also does not point to a contrary or different conclusion. The reduction in potential for elevated metal concentrations due to waste rock segregation procedures is still valid. Despite the inability to analyze the issue quantitatively, in light of the ADEQ technical basis for their 401 determination and their issuance of the 401 water quality certification for the project, the overall conclusion that the mine runoff is unlikely to impact the downstream OAWs is likely still valid.

Biological Resources

Introduction

The organization of the "Biological Resources" section differs somewhat from the other sections of this SIR. Instead of addressing new information and how that affects baseline conditions, analysis, and impact conclusions made in the FEIS for biological resources as a whole, this section will address these items on a species by species basis. While the direct and indirect impact conclusions follow this format, cumulative impacts on the species and on biological resources as a whole, including those from climate change, will be discussed in the “Cumulative Effects” section following the individual species accounts.

Beyond considering new information, the information presented here is also being used to prepare a supplement to the June 2012 BA (SWCA Environmental Consultants 2012a), and the October 2012 (SWCA Environmental Consultants 2012b) and February 2013 (U.S. Forest Service and SWCA Environmental Consultants 2013) SBAs.

During a meeting between the Coronado, USFWS, SWCA, Rosemont Copper, and WestLand, on May 12, 2014, the following reasons were identified as the need for a supplement to the BA:

1. There are five species for which listing status has changed or is expected to change in the near future:

    - Proposed critical habitat for the jaguar (*Panthera onca*) was designated as critical habitat after the BO was issued (U.S. Fish and Wildlife Service 2014c).
    - Two species that were recently listed as threatened were not conferenced or consulted on in the BO: the northern Mexican gartersnake (*Thamnophis eques megalops*) and the western yellow-billed cuckoo (*Coccyzus americanus occidentalis*). In July 2013, the USFWS proposed to list northern Mexican gartersnake as threatened and concurrently proposed to designate critical habitat (U.S. Fish and Wildlife Service 2013a, 2013c), and in July 2014, the USFWS determined that threatened species status is warranted for this species, effective August 2014 (U.S. Fish and Wildlife Service 2014g); the final designation for critical habitat is anticipated to be published in 2015. In October 2013, the USFWS proposed to list the western yellow-billed cuckoo as a threatened species in the western United States, Canada, and Mexico (U.S. Fish and Wildlife Service 2013b). In August 2014, the USFWS proposed critical habitat for this species (U.S. Fish and Wildlife Service 2014d), and in October 2014, the USFWS determined that threatened species status is warranted for this species (U.S. Fish and Wildlife Service 2014e).
    - The status of the Sonoran desert tortoise (*Gopherus morafkai*) may change from candidate to proposed listed within the next year (U.S. Fish and Wildlife Service 2014f); however, the Forest Service is currently working with USFWS and other land management agencies in Arizona to create a Candidate Conservation Agreement that may prevent the listing of this species.
    - The Mexican gray wolf (*Canis lupus baileyi*) gained its own listing with ESA separate from the gray wolf (*Canis lupus*); concurrently, the regulations for the nonessential experimental population of that species changed, and the 10J reintroduction area for that species expanded to include the entire analysis area (U.S. Fish and Wildlife Service 2015b).

2. There are five species that were included in the BO for which baseline conditions have changed and/or new information about baseline conditions have become available; and one species that was not included in previous consultation for this project for which or new information has become available:

    - Chiricahua leopard frog (*Lithobates chiricahuensis*). In February 2013, numerous dead Chiricahua leopard frogs were detected floating in a tank within the analysis area of the proposed project, and of the 22 frogs that were sampled for the chytridiomycete skin fungus, *Batrachochytrium dendrobatidis* (*Bd*), 10 of these samples tested positive (Crawford 2014).

- Huachuca water umbel (*Lilaeopsis schaffneriana* ssp. *recurva*). The USFWS recently published the 5-Year Review for the Huachuca water umbel (U.S. Fish and Wildlife Service 2014h), and updated information from this review is included herein.
- Mexican spotted owl (*Strix occidentalis lucida).* An observation of the Mexican spotted owl was made by wildlife cameras in November 2014 north of Box Canyon in Sycamore Canyon approximately 1 mile west of project area (Douglas 2015).
- Ocelot (*Leopardus pardalis*). A single male ocelot was detected multiple times on wildlife cameras in the Santa Rita Mountains within the analysis area of the proposed project in April–May 2014 (U.S. Fish and Wildlife Service 2014i); the ocelot was previously assumed to be present within the analysis area for impact analysis and Section 7 consultation purposes, but there were no documented occurrences of this species in the Santa Rita Mountains prior to these photographs.
- Jaguar (*Panthera onca*). The individual male that was previously detected within in the Santa Rita Mountains within the analysis area of the proposed project has been observed as recently as January 2015 (SWCA Environmental Consultants 2015f).
- Desert pupfish (*Cyprinodon macularius*). The BLM recently (Simms 2013a) reintroduced desert pupfish into the Las Cienegas NCA in several locations, some of which are within the analysis area for this project.

3. Finally, the USFWS is requesting the opportunity to reassess their analysis of impacts on aquatic and riparian threatened and endangered species from the proposed project using the revised interpretations of the groundwater models that were used in the FEIS but were not available for consideration prior to completion of the BO. The USFWS has also requested further details from the project proponent regarding two proposed conservation measures for aquatic species (i.e., Sonoita Creek Ranch and the severance and transfer of water rights of Cienega Creek at Pantano Dam) and the certainty of water available for these conservation measures.

In addition to new information and baseline changes for threatened and endangered species, new information and other changes for other special status species addressed in the FEIS have become available, and this information is summarized below.

No new data or information pertinent to the species described in table 46 has been identified. Thus, the most up-to-date analysis for these species can be found in the FEIS.

Table 46. Summary of special status plant and animal species that are specifically addressed in the FEIS and for which no new data are available

Scientific Name	Common Name	USFWS	Forest Service	BLM	State	County
Plants						
Amoreuxia gonzalezii	Santa Rita yellowshow		S		HS	
Carex ultra	Arizona (=Cochise) giant sedge		S	S		
Coryphantha scheeri var. *robustispina*	Pima pineapple cactus	E			HS	CS
Erigeron arisolius	Arid throne fleabane		S			
Graptopetalum bartramii	Bartram stonecrop	PL	S	S	SR	
Heterotheca rutteri	Huachuca golden aster		S	S		

Scientific Name	Common Name	USFWS	Forest Service	BLM	State	County
Hexalectris colemanii	Coleman's coral-root	PL*	S	S	SR	
Lilium parryi	Lemon lily		S			
Manihot davisiae	Arizona manihot		S			
Muhlenbergia elongata (= M. xerophila)	Sycamore Canyon (Weeping) muhly		S			
Muhlenbergia palmeri (= M. dubioides)	Southwestern (Box Canyon) muhly		S			
Pectis imberbis	Beardless chinchweed	PL	S			
Samolus vagans	Chiricahua mountain brookweed		S			
Stevia lemmonii	Lemmon's stevia		S			
Tragia laciniata	Sonoran noseburn		S			
Reptiles						
Senticolis triaspis	Green ratsnake		S		SGCN	
Birds						
Ammodramus savannarum ammolegus	Arizona grasshopper sparrow		S		SGCN	
Megascops trichopsis	Whiskered screech-owl		S		SGCN	
Passerina versicolor	Varied bunting		S		SGCN	
Invertebrates						
Sonorella magdalenensis	Sonoran talussnail	PL				CS
Sonorella walkeri walkeri (formerly *S. rosemontensis*)	Santa Rita talussnail (formerly Rosemont talussnail)			S		
Mammals†						
Baiomys taylori ater	Northern pygmy mouse		S			
Mephitis macroura milleri	Hooded skunk		S			
Nyctinomops femorosaccus	Pocketed free-tailed bat		S	S	SGCN	
Reithrodontomys fulvescens	Fulvous harvest mouse		S		SGCN	
Reithrodontomys montanus	Plains harvest mouse		S		SGCN	
Sigmodon ochrognathus	Yellow-nosed cotton rat		S		SGCN	

* On December 18, 2013, USFWS determined that this species does not warrant protection under ESA (U.S. Fish and Wildlife Service 2013d).

† With the exception of the lesser long-nosed bat, all sensitive bat species are discussed together.

Status Key:

USFWS (U.S. Department of the Interior)

E – Endangered. Any species that is in danger of extinction throughout all or a significant portion of its range.

PL – Petitioned for Listing. A formal request suggesting that a species, with supporting biological data, be listed under the ESA.

Forest Service (U.S. Department of Agriculture, Southwestern Region)

S – Sensitive. Those taxa occurring on national forests in Arizona that are identified as sensitive by the Regional Forester for the Southwestern Region of the Forest Service (U.S. Forest Service 2007).

BLM (U.S. Department of the Interior)

S – Sensitive. Those taxa occurring on BLM field office lands in Arizona that are considered sensitive "that require special management consideration to avoid potential future listing under the ESA" (Bureau of Land Management 2008).

State (Arizona Native Plant Law, Arizona Department of Agriculture)

HS – Highly Safeguarded. No collection allowed.

SR – Salvage Restricted. Collection only with permit.

State (Species of Greatest Conservation Need in Arizona, AGFD)

SGCN – Species of Greatest Conservation Need in Arizona. Those species that were identified as most in need of conservation actions in Arizona (Arizona Game and Fish Department 2012).

County (Covered Species, Pima County "Sonoran Desert Conservation Plan")

CS – Covered Species. The "Multi-species Conservation Plan," which is part of the "Sonoran Desert Conservation Plan," identifies 44 species that are proposed for coverage under the forthcoming Section 10 permit.

Summary of Applicable New Information and/or Changed Conditions

New information and changed conditions are described for each species addressed in this section. However, changes in the status of past and present actions have occurred that apply to all species. These are as follows.

Past Actions

- Exploratory drilling on Rosemont Copper private property.
- Additional wildfires that occurred between 2012 and 2014.
- Hazardous fuels treatment in Gardner Canyon has been accomplished.
- Reintroduction and augmentation of Chiricahua leopard frog; Gila topminnow (*Poeciliopsis occidentalis*); desert pupfish; Gila chub (*Gila intermedia*), New Mexico gartersnake, and Huachuca water umbel at various locations within the Las Cienegas NCA.

Present Actions

- The BLM proposes to approve a decision for programmatic aquatic special status species reintroductions at Las Cienegas NCA. This was addressed as a reasonably foreseeable action in the FEIS; however, it is currently being implemented. A new document provided by BLM after publication of the FEIS provides updated information and documentation of the BLM proposal to reintroduce aquatic special status species at Las Cienegas NCA.
- Forestwide planting for traditional uses and pollinators on the Coronado National Forest, all districts. Implement a series of plantings to (1) increase the availability of traditional use plants for use by the Tribes and protect; and (2) expand upon the availability of habitat for pollinators that increase the sustainability of our forests.
- A new document published after release of the FEIS provides results and planned future actions of the FROG Project, which was intended to restore Chiricahua leopard frogs into a large landscape in southeastern Arizona, including portions of the analysis area.

Summary of FEIS Analysis Methodology

The analysis area for biological resources is defined as the project area (i.e., the area that is composed of the open pit, waste rock facility, tailings facility, heap leach facility,[7] plant site and ancillary facilities, fenced area around the mine (perimeter fence), and mine primary access road), including roads that would be decommissioned and constructed, plus a larger surrounding analysis area that

[7] This applies to all action alternatives except the Barrel Alternative.

may experience direct or indirect temporal and spatial impacts from the proposed project. Temporally, the potential onsite and offsite impacts resulting from the proposed project encompass all the activities associated with premining (18 to 24 months), active mining (20 to 25 years), final reclamation and closure (3 years), and postclosure (indefinite). The analysis area, which was delineated to consider the impacts of vibration and noise, dust and air pollutants, artificial night lighting, increased traffic on SR 83 and other roads, groundwater drawdown, and surface water alteration, totals approximately 146,163 acres. The analysis area includes vegetation communities, surface water drainages, and onsite physical and topographic features (e.g., mountains, caves and mine adits/shafts, seeps and springs, stock tanks, rocky outcrops, etc.) that may be directly or indirectly impacted by the project. The analysis area also includes the indirect downgradient impacts on the surface water and groundwater environments that would result from the onsite diversion and impoundment of surface water; the impacts on springs and seeps outside the project area; and the impacts of vibration, noise, dust and air pollutants, artificial night lighting, and increased traffic volumes on SR 83 and other roads resulting from the construction and operations of the mine and the connected actions.

Analysis of special status plants and animals discussed in this FEIS and its supporting documents began with a review of the legal requirements for disclosure of effects. Special status species include those afforded protection (or are petitioned/proposed for listing) under the ESA, Forest Service and BLM sensitive species, forest-specific management indicator species, migratory birds of conservation concern, AGFD's Species of Greatest Conservation Need and Species of Economic and Recreational Importance, and Pima County's "Sonoran Desert Conservation Plan"/"Multi-species Conservation Plan" covered species. In all, approximately 700 species were considered for further analysis (SWCA Environmental Consultants 2013b), only some of which were specifically addressed in this FEIS. These approximately 700 species were analyzed in a series of documents: "Biologists' Report on the Affected Environment and Identification of Species for Disclosure of Effects, Rosemont Copper Mine Project, Pima County, Arizona" ("biologists' report") (SWCA Environmental Consultants 2013b), biological evaluation (SWCA Environmental Consultants 2013a), management indicator species report (SWCA Environmental Consultants 2013c), migratory bird analysis (SWCA Environmental Consultants 2013d), and BA (SWCA Environmental Consultants 2012a, 2012b; U.S. Forest Service and SWCA Environmental Consultants 2013).

Analysis of direct and indirect impacts focused on the following issues, and measurement factors, which are presented in the FEIS:

Issue 5: Impact on Plants and Animals
This group of issues focuses on the effects on plant and animal populations and habitats. Many aspects of the mine operations have the potential to affect individuals, populations, and habitat for plants and animals, including special status species. This issue includes the potential for impacts on wildlife as a result of landscape alteration, and as a result of light, noise, vibration, traffic, and other disturbance from the proposed mine operations.

Issue 5A: Vegetation
The pit, plant, tailings and waste rock facilities, road and utility corridors, and other facilities have the potential to permanently change vegetation, and reclamation may not restore vegetation to preproject conditions.

Issue 5A Factor for Alternative Comparison

1. Acres of terrestrial vegetation permanently lost or altered, by vegetation type.

Issue 5B: Habitat Loss

The mine and ancillary facilities could result in a loss or alteration of habitat for numerous plant and animal species. Potential impacts could impact upland and riparian habitat and fragmentation of riparian habitat and corridors, including Cienega Creek.

Issue 5B Factors for Alternative Comparison

1. Acres by type of terrestrial and aquatic habitat lost, altered, or indirectly impacted.
2. Qualitative assessment of impacts on aquatic habitats and surface water that supports wildlife and plants such as stock tanks, seeps, and springs.
3. Qualitative assessment of how changes in the function of riparian areas could impact wildlife habitat.

Issue 5C: Nonnative Species

The mine and its operations have the potential to create conditions conducive to the introduction, establishment, and/or spread of nonnative species, which may out-compete native plants and animals. Forest Service and other Federal, State, and local laws, regulations, policies, and plans contain management direction for invasive plants.

Issue 5C Factor for Alternative Comparison

1. Acres of disturbance that could create conditions conducive for invasive species

Issue 5D: Wildlife Movement

The mine and its operations could potentially modify and/or fragment wildlife habitats and/or reduce connectivity between habitats. Increased traffic could correspondingly increase wildlife mortality and injury.

Issue 5D Factors for Alternative Comparison

1. Qualitative assessment of the change in movement corridors and connectivity between wildlife habitats
2. Qualitative assessment of mortality of various animal species resulting from increased volume of traffic related to mine operations

Issue 5E: Special Status Species

The mine and its operations have the potential to impact habitat for special status species (see the “Analysis Methodology, Assumptions, Uncertain and Unknown Information” part of the FEIS, “Biological Resources” section, for a description of special status species).

Issue 5E Factors for Alternative Comparison

1. Acres of habitat disturbed for each special status species, including impacts to designated and proposed critical habitat
2. Potential to affect the population viability of any species

Issue 5F: Animal Behavior

Mine construction, closure and operations, including drilling and blasting, may result in noise and vibration, which could impact animal behavior and result in negative impacts on wildlife. Nocturnal and other animals may be adversely affected by the light glow in night skies.

Issue 5F Factors for Alternative Comparison

1. Acres of habitat impacted from noise, vibration, and light
2. Qualitative assessment of effects on wildlife behavior from noise, vibration, and light

As noted earlier, the "Biological Resources" section differs organizationally from many other resource areas in this SIR in how it presents consideration of new information and changed conditions in analysis methodology and impact conclusions. For resource areas where consideration of new information can be addressed for the overall resource, issues, factors, and impact conclusion summaries are addressed. However, the summary table for biological resources in the FEIS (see table 116) refers the reader to other tables and impact descriptions contained within the text for individual species. Therefore, the following section, titled "Summary of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions," is presented in paragraph form, rather than being organized by issue and factor.

Summary of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

Only the new information listed above under past and present actions will be addressed here. Other new information is addressed on a species by species basis below.

Past Actions

- Exploratory drilling on Rosemont Copper private property. *All ground-disturbing activities are within the footprint of the proposed open pit. The pit and all areas within the proposed security fence were considered disturbed land for the purpose of impact analysis in the FEIS; therefore, the drilling adds no additional ground disturbance for any analysis. This action does not result in any change or modification to the analysis for biological resources presented in the FEIS.*
- Additional wildfires that occurred between 2012 and 2014. *Wildfires occur in the analysis annually. During the period from 2012 to 2014, an estimated 33 wildfires occurred, ranging in size from 0.1 acre to 66 acres. The majority were less than 10 acres in size. Past wildfires have been recovering over time, and these newer fires will also recover over time. The fire locations and relative sizes were reviewed against known habitat for special-status species in the analysis area; none of these fires would have substantial impacts on species or habitats within the analysis area. No changes in the overall impacts disclosed in the FEIS have resulted from these wildfires.*
- Hazardous fuels treatment in Gardner Canyon has been accomplished. *This project reduced fuels by removing dead-standing juniper and oak trees less than 20 inches in diameter using chainsaws and hand tools. Fuelwood was removed and offered to the public. The remaining slash was lopped using hand tools. The District Biologist determined that the activities would have no effect on threatened or endangered species, designated critical habitat, or species or habitat proposed for Federal listing.*
- Reintroduction and augmentation of Chiricahua leopard frog, Gila topminnow, desert pupfish, Gila chub, New Mexico gartersnake, and Huachuca water umbel at various locations

within the Las Cienegas NCA. *These reintroductions were not known when the FEIS analysis was conducted. They result in changes in the environmental baseline and are addressed in the analysis disclosed in this report.*

Present Actions

- A new document published after release of the FEIS provides results and planned future actions of the FROG Project, which was intended to restore Chiricahua leopard frogs into a large landscape in southeastern Arizona, including portions of the analysis area. *The FROG Project was not previously mentioned in the FEIS. The FROG Project has successfully reduced or eliminated nonnative species (i.e., bullfrogs), restored aquatic habitats, and introduced Chiricahua leopard frogs, native fish, and northern Mexican gartersnakes within portions of the analysis area in the Santa Rita Mountains and Las Cienegas NCA. Future actions (through 2015 and beyond) for this project include: ensuring invasive species eradication, completing more site restorations and establishing frog populations there, monitoring the new Chiricahua frog populations for presence of the chytrid fungus pathogen, and monitoring the bullfrog buffer zone and removing bullfrogs. The expected work on this project would benefit these special status species and their habitats within the analysis area.*
- The BLM proposes to approve a decision for programmatic aquatic special status species reintroductions at Las Cienegas NCA. This was addressed as a reasonably foreseeable action in the FEIS; however, it is currently being implemented, with some reintroductions having already occurred and others planned for the future. A new document provided by BLM after publication of the FEIS provided updated information and documentation of the BLM proposal to reintroduce aquatic special status species at Las Cienegas NCA. *In Simms (2013a), the reintroductions of Chiricahua leopard frog, Gila topminnow, desert pupfish, northern Mexican gartersnake, and Huachuca water umbel to wildlife ponds and wetlands within Las Cienegas NCA from 2013 to 2014 are documented. These introductions have been included within the new baseline. More reintroductions are planned for the Las Cienegas NCA in the future.*
- Forestwide planting for traditional uses and pollinators on the Coronado National Forest. *One goal of this project is to protect and expand upon the availability of habitat for pollinators that increase the sustainability of our forests CNF will plant wildflowers, forbs, grasses, and shrubs to improve habitat for pollinators, including bees, monarch butterflies, and hummingbirds. While this would not result in changes to the analysis of any species addressed in the FEIS or this SIR, it would be beneficial for pollinators over the long term.*

Species for Which New Information Is Available or Baseline Conditions Have Changed

Huachuca water umbel (Lilaeopsis schaffneriana var. *recurva)*

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the USFWS provide updated information and documentation of the Huachuca water umbel:

- USFWS (2014h) provides a draft of the 5-year review of this species that includes updated information and distribution of the species.
- USFWS (2014b) provides a distribution map that shows the general locations of both historic and current Huachuca water umbel occurrences as of April 2014; these generalized locations occur within upper Cienega Creek.

- USFWS (2014a) provides a distribution map that shows a close-up view of the Huachuca water umbel occurrences within upper Cienega Creek; these generalized locations occur within upper Cienega Creek on the Las Cienegas NCA, and they may extend to Empire Gulch Reach 2 and Cieneguita Wetlands.

Since the USFWS provided the new documents described above, the final 5-year review of this species was released in August 2014. To ensure that the most current information is being used, the final 5-year review will be used in SBA and SIR analyses when appropriate:

- USFWS (2014h) is the final 5-year review of the Huachuca water umbel, which includes updated information and distribution of this species; these generalized locations occur within upper Cienega Creek and may extend into lower Empire Gulch (EG2).

New documents provided by the BLM provide updated documentation of the Huachuca water umbel within Cienega Creek and other aquatic locations within the analysis area. They also provide the professional opinion of Jeff Simms (BLM) about baseline conditions at the Las Cienegas NCA and thresholds he proposed:

- BLM (2013b) documents the presence of this species (giving Universal Transverse Mercator (UTM) coordinates) in Cienega Creek Reaches 3, 5, 6, 7, and 8 and in Mattie Canyon.
- Polm (2014) documents the presence of this species in the Empire Gulch Reach 2, Cieneguita Wetlands, Mattie Canyon, and all Cienega Creek reaches except Cienega Creek Reaches 3, 10, and 11.
- Simms (2014b) includes a summary of a meeting and field trip where Jeff Simms (BLM) presented his professional opinion of current, baseline conditions at Las Cienegas NCA and proposed analysis thresholds he would like considered for the SBA.
- Simms (2013a) documents 49 plants of this species being reintroduced to Cieneguita Wetlands Pond #3, with pending plantings at many other locations within Las Cienegas NCA.
- Bodner and Simms (2008) document Huachuca water umbel trends at Las Cienegas NCA, including their conclusion that populations had expanded between 2002 and 2008 and that this species appears to do better in areas with moderate disturbance.
- BLM (2014d) contains data sheets for surface flow mapping at Las Cienegas NCA, UTMs for this species are provided (but some data sheets prior to 2014 appear to be repeats of BLM (2013b)); the presence of this species was noted in upper Cienega Creek.
- BLM (2014d) gives results of yellow-billed cuckoo surveys and bird mapping at Las Cienegas NCA headwaters to narrows; it also contains some wet/dry mapping data sheet repeats where the presence of this species was noted in upper Cienega Creek.
- Simms (2014d) contains a field trip report with BLM and USFWS staff at riparian areas within Las Cienegas NCA; includes pictures, narrative, and locations. This species was not observed at Empire Gulch Spring but was observed in Upper Cienega Creek (photographs of current conditions included).

New documents provided by the Pima County Office of Sustainability and Conservation provide location of the species and potential impacts to the species:

- Powell (2013b) notes the presence of this species as being along Cienega Creek in CCNP.
- Powell et al. (2014) note that the Huachuca water umbel has not been observed within CCNP for a number of years, with a dedicated search for this species being conducted in 2013.

Baseline Conditions Considering New Information and Changed Conditions

Although this species was known to occur within the analysis area at the time of FEIS publication, the new documents provide specific locations for this plant. This species was observed in lower Empire Gulch (EG2), Cieneguita Wetlands, and upper Cienega Creek, but the Huachuca water umbel has not been identified within CCNP for a number of years, with a dedicated search for this species occurring in 2013. Further, Simms (2013a) documents 49 plants of this species being reintroduced to Cieneguita Wetlands Pond #3, with pending future plantings at many other locations within Las Cienegas NCA. Other new information includes documented Huachuca water umbel trends at Las Cienegas NCA (Bodner and Simms 2008); this species appeared to undergo a population expansion between 2002 and 2008 and seems to do well in areas with moderate disturbance. Simms (2014b) included a summary of a meeting and field trip where Jeff Simms (BLM) presented his professional observations and opinion of current, baseline conditions at Las Cienegas NCA, which may be relevant to this species and include lack of surface water, wetland desiccation, head cutting, excessive sedimentation, riparian vegetation change, soil moisture variation, and the observation that some stream reaches (EG1, EG2, CC1, and CC2, and Mattie Canyon) appear to be stable and functioning well in that they show little or no disruption of riparian or aquatic habitat characteristics or function.

Summary of FEIS Impact Conclusions

Direct effects on Huachuca water umbel are not anticipated as a result of the proposed project because this species is not known to occur within the project area, no direct impacts on upper Cienega Creek have been identified, and no direct impacts resulting from connected actions are anticipated. Impacts could occur to the Huachuca water umbel populations located within the analysis area in Empire Gulch and Cienega Creek, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. Based on this, all action alternatives may affect and are likely to adversely affect the Huachuca water umbel (SWCA Environmental Consultants 2012a, 2012b, 2013a; U.S. Forest Service and SWCA Environmental Consultants 2013). After reviewing the current status of Huachuca water umbel, the environmental baseline for the analysis area, the effects of the proposed action, and the cumulative effects, the USFWS's biological opinion as of October 2013 was that the proposed project is not likely to jeopardize the continued existence of the Huachuca water umbel (U.S. Fish and Wildlife Service 2013e) (see FEIS, vol. 3, p. 678).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. New information and changed conditions about the Huachuca water umbel in the analysis area include more specific known locations where this species occurs and has been reintroduced, the fact that the species has not been located within CCNP for a number of years despite a dedicated search for this species in 2013, a documented trend of population expansion of the species at Las Cienegas NCA, and current baseline conditions at Las Cienegas NCA that affect this species. Current baseline conditions on Las Cienegas NCA as documented in Simms (2014b) may be affecting the populations at Las Cienegas NCA; however, these conditions are not measured quantitatively and so can only be applied to our analysis of impacts in a qualitative fashion.

Direct and Indirect Effects. Because there have been no new occurrences within the project area as a result of this new information, no direct impacts are expected. However, new occurrence records do occur within the analysis area. The indirect effects as stated in the FEIS are still expected to occur;

this new information merely refines our knowledge of precise locations of this species. This species has not been observed at Empire Spring (within reach EG1). However, it was documented at reach EG2 and has been transplanted to the Cieneguita Wetlands. The aquatic analysis in the “Seeps, Springs, and Riparian Areas” section of this SIR indicates that reach EG2 is likely to have an increase in zero-flow and low-flow days, and a reduction in pool volume and water quality as a result of mine drawdown alone; however, the number of pools does not change under any scenario. The number of pools at Cieneguita Wetlands does not change under any scenario, but impacts to pool volume are substantial and highly variable, with pools being from 25 to 92 percent of their original volume from mine drawdown alone. Thus, when taken out to 1,000 years, Huachuca water umbel in reach EG2 and the Cieneguita Wetlands is expected to experience impacts through loss of habitat as the extent of surface water decreases.

Most new occurrence records for the Huachuca water umbel in the analysis area occur within upper Cienega Creek; according to the aquatic analysis in the “Seeps, Springs, and Riparian Areas” section of this SIR, in 95 percent of the possible scenarios, mine drawdown by itself would have little or no effect with regard to increasing the days with zero stream flow or changing the stream flow status from perennial, though mine drawdown would have some effect on water quality (measured by days of extremely low stream flow). In fact, for 95 percent of the possible scenarios, mine drawdown by itself does not change the number of pools, and pools retain at least 82 percent of their original volume even out to 1,000 years. While some habitat may be lost for this aquatic to semi-aquatic species as a result of the Barrel Alternative, the most recent analysis suggests that it would not result in widespread absence of flow within Cienega Creek or widespread loss of pool habitat; thus, habitat for this species would continue to occur and not be greatly reduced within Cienega Creek.

Several areas containing Huachuca water umbel within Cienega Creek also contain stream reaches that are apparently stable and functioning well (i.e., reaches CC1 and CC2). Further, although current conditions at Las Cienegas NCA may show negative trends to Huachuca water umbel habitat, including wetland desiccation from declining groundwater, head cutting, and lack of surface water, the most recent analysis along Cienega Creek indicates that the Barrel Alternative would not result in widespread absence of flow and the drawdown associated with the proposed mine would not exceed 0.2 foot along Cienega Creek. Thus, the Barrel Alternative by itself is not expected to further negative processes that may already be occurring.

The re-evaluated impacts based on new information do not differ substantially from those disclosed in the BA and FEIS, specifically, that mine drawdown would occur within Empire Gulch and that widespread absence of flow in Cienega Creek was not anticipated. Although Huachuca water umbel habitat would likely be impacted within reach EG2 owing to reduction in flow, pool volume, and reduced water quality and Cieneguita Wetlands owing to pool volume reduction, adequate habitat for Huachuca water umbel is expected to remain along Cienega Creek, where absence of flow is not widespread and the stream’s status is not expected to change from perennial.

Thus, the effects determination should not change: *the Barrel Alternative may affect and is likely to adversely affect the Huachuca water umbel*.

Chiricahua Leopard Frog (Lithobates chiricahuensis)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM after the publication of the FEIS provide documentation of the Chiricahua leopard frog in Cienega Creek and other aquatic locations within the analysis area:

- BLM (2013b) documents the presence of this species (giving UTMs) in Mattie Canyon, and the presence of frogs was noted in upper Cienega Creek (while the observer was not able to identify to species, they did note that it was not likely bullfrogs).
- Polm (2014) documents this species as occurring in reaches CC1 through CC8 and Cieneguita Wetlands, reaches EG1 and EG2, and in Mattie Canyon.
- Simms (2013a) documents both tadpoles and adults of this species being stocked at many locations within Las Cienegas NCA from 1986 to 2014 (including upper Cienega Creek, Cieneguita Wetlands ponds, Empire Wildlife Pond, Maternity Wildlife Pond, and other wildlife ponds), with other stocking locations pending.
- Simms (2013b) is the draft Empire Gulch monitoring report 2004–2013. Chiricahua leopard frog tadpoles had a high catch rate at Empire Gulch (in EG1) within Las Cienegas NCA, and appear to be increasing; catch rates of tadpoles are inversely related to abundances of *Abetis* and *Lethocerus*, invertebrate predators on these tadpoles.
- Simms (2014c) is the final Empire Gulch monitoring report 2004–2013, which contains the same information as Simms (2013b); however, a map of the study area has been added and the discussion section modified.
- Simms (2004c) is a compilation of wildlife sightings at Las Cienegas NCA from 1988 to 2004 from J.R. Simms's field notes, fall fish count forms, riparian assessment forms (RACE), and fish habitat inventory forms; "leopard frog" or "frog" observed at upper Cienega Creek, Mattie Canyon, EG1 and EG2 and "Chiricahua leopard frog" observed at EG1.
- Bodner and Simms (2008) document the presence of this species as Las Cienegas NCA. BLM (2014d) contains data sheets for surface flow mapping at Las Cienegas NCA, UTMs for this species are provided (but some data sheets prior to 2014 appear to be repeats of BLM (2013b)); the presence of this species is documented in upper Cienega Creek.
- BLM (2014d) gives the results of yellow-billed cuckoo surveys and bird mapping at Las Cienegas NCA headwaters to narrows. It also contains some wet/dry mapping data sheet repeats where "leopard frogs" are documented as occurring in upper Cienega Creek.
- Simms (2014d) contains a field trip report with BLM and USFWS staff at riparian areas within Las Cienegas NCA; it has pictures, narrative, and locations. This species was observed at Empire Pond; this species was observed at Empire Spring (reach EG1), upper Cienega Creek, and Empire Wildlife Pond.

New location data were provided by Dr. David Hall (University of Arizona) on July 30, 2014:

- Hall (2014) documents the presence (giving UTMs) of breeding Chiricahua leopard frogs in both lotic and lentic locations at within Cienega Creek and at several springs nearby within the analysis area; this species was documented breeding at Empire Spring (EG1), Cienega Creek Reaches 1 and 5, and several wildlife ponds at Las Cienegas NCA.

New photographs of Las Cienegas NCA were made available by EPA after the publication of the FEIS:

- EPA (2013a) contains photographic documentation of this species (adult and larval) occurring at Upper Empire Gulch Spring (EG1), Las Cienegas NCA on July 27, 2013.

On August 14, 2014, a draft report outlining baseline conditions and the proposing analysis thresholds for aquatic species at Cienega Creek, Empire Spring, and Cieneguita ponds following field trips with Jeff Simms (BLM), Marc Stamer (Forest Service), and Mike Hatch (SWCA):

- Simms (2014b) includes a summary of a meeting and field trip where Jeff Simms (BLM) presented his professional opinion of current, baseline conditions at Las Cienegas NCA and proposed analysis thresholds he would like considered for the SBA.

On July 29, 2013, "Restoring Leopard Frogs and Habitat in Sky Island Grasslands (Arizona): Final Report 2010-2012" was published by the FROG Project: Frog and Fish Restoration Outreach Group for National Fish and Wildlife Foundation–Keystone Initiative–Wildlife and Habitat Project 2010-0023-000:

- Rosen et al. (2013) contains the full FROG Project report, including sites where Chiricahua leopard frogs are known to occur, and where they have been released. Many of these sites are in Las Cienegas NCA and on other sites in the Santa Rita Mountains within the analysis area, including CC 1 through CC6, EG1 and EG2, Cieneguita Wetlands.
- Rosen (2013) consists of figure 29 from the FROG Project report and shows Chiricahua leopard frog restoration sites, management sites, and other sites mentioned in Rosen et al. (2013). Some of these locations are within the analysis area (Las Cienegas NCA, Gardner Canyon, Empire Gulch, and Box Canyon), and some are located outside the analysis area.

In an email, Cat Crawford, USFWS, confirmed the presence of *Bd*-positive Chiricahua leopard frog among those found dead floating in West Tank, which is within the analysis area, about 1 mile south of the project area:

- Crawford (2014)

New ranid surveys of the Rosemont holdings and vicinity have been completed:

- WestLand (2013a) contains the results of the "2012 Ranid Survey of the Rosemont Holdings and Vicinity," plus the mitigation parcels, Sonoita Creek Ranch and Fullerton Ranch. No Chiricahua leopard frogs were observed in the mitigation parcels, but because the mitigation parcels are not within the analysis area, they will not be considered in the analysis of effects.
- WestLand (2015b) contains the 2013 pre-disturbance ranid survey results for the Rosemont holdings and vicinity.
- WestLand (2015d) contains the 2014 pre-disturbance ranid survey results for the Rosemont holdings and vicinity.

Baseline Conditions Considering New Information and Changed Conditions

This species is more widespread on the analysis area than previously known. Several of the aforementioned sources of new information provide previously unknown occurrences of the Chiricahua leopard frogs in the analysis area, some of which are due to reintroductions at wildlife ponds in the analysis area and at Cienega Creek (Polm 2014; Rosen 2013; Rosen et al. 2013; Simms 2013a, 2014d). During predisturbance monitoring surveys, Chiricahua leopard frogs were observed at Barrel Tank in 2014, within the project area, where they had never been observed before, though other locations within the project area that previously contained this species (East Dam and Lower Stock Tank) did not contain frogs during the 2012–2014 surveys. Further, Chiricahua leopard frogs were documented at Deering Spring, a site within the perimeter fence in 2013 and 2014, where they had never been observed before. Chiricahua leopard frogs continue to be found in many locations within the analysis area where they were documented to occur in the FEIS, such as California Gulch Tank East and West, Bowman Tank, and along Box Canyon; thus, the baseline does not change in these areas. In 2012, the Greaterville Tank dried out as a result of sedimentation from the Greaterville Fire, but the tank was subsequently renovated and restored in June 2012 (WestLand Resources Inc.

2013a), and tadpoles were released into this tank in October 2012 (Rosen et al. 2013). Additionally, invasive species (i.e., bullfrogs and crayfish) have been removed from portions of the analysis area and habitat restored at locations throughout the analysis area.

Simms (2014b) includes a summary of a meeting and field trip where Jeff Simms (BLM) presented his professional opinion of current, baseline conditions, and trends at Las Cienegas NCA that may be relevant to this species, including lack of surface water, head cutting and erosion, excessive sedimentation, riparian vegetation change, poor water quality in areas, tadpoles exposed to increased predation by being confined to pools that have declined rapidly pre-monsoon, perennial stream segments acting as a migration corridor for individuals, threat of bullfrog invasion from source ponds on private lands, long-distance dispersal (3 to 5 miles), and the observation that some stream reaches (EG1, EG2, CC1 and CC2, and Mattie Canyon) show little or no disruption of riparian or aquatic habitat characteristics or function. Additionally, *Bd*-positive Chiricahua leopard frogs were confirmed among those found dead in West Tank, which is within the analysis area, about 1 mile south of the project area (Crawford 2014). Prior to this die-off chytridiomycosis was not noted as an imminent threat in the Santa Rita Mountains (U.S. Fish and Wildlife Service 2012a), though the presence of chytridiomycosis had been confirmed at one location in the Santa Rita Mountains (Big Casa Blanca Canyon) outside the analysis area (Sredl 2013).

Summary of FEIS Impact Conclusions

All action alternatives would result in permanent, direct impacts to Chiricahua leopard frogs: one aquatic site (Lower Stock Tank) within the project area was known to have been occupied by Chiricahua leopard frogs in 2008 (WestLand Resources Inc. 2009a) and would be removed as a result of mine construction and operations. Although frogs have not been documented in this location since 2008, if individual frogs (eggs/embryos, tadpoles, juveniles, and adults) are present, mine construction and operation activities would result in direct impacts in the form of mortality or other disruptions to behavior that could influence growth and survivorship. Additionally, although these sites have not been occupied since 2008, the three nearest occurrences of Chiricahua leopard frogs were less than 1 mile from the security fence of all action alternatives, which is within the overland dispersal range of this species. Therefore, direct impacts to frogs dispersing to and from aquatic sites from within the analysis area into the project area could range from increased risk to mortality (e.g., crushed on roads or in other areas of mining related activities) to behavioral avoidance (e.g., reluctance to move across disturbed areas).

Any individual frogs, tadpoles, and/or eggs present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from noise, vibration, and artificial night lighting. Additional impacts could occur to Chiricahua leopard frogs populations located within the analysis area in Cienega Creek and Empire Gulch, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. A range of outcomes was assessed for Empire Gulch as well and are highly uncertain. The most likely scenarios suggest that noticeable reductions in stream flow would occur, gradually increasing until widespread absence of flow occurred in Empire Gulch. Impacts to Chiricahua leopard frogs could also result from prey species of the Chiricahua leopard frog experiencing the same impacts as the frog from proposed project activities, hence altering their predator-prey relationships. Additionally, because the mine pit lake water quality could exceed wildlife standards for three contaminants that are known to bioaccumulate (i.e., cadmium, mercury, and selenium), impacts to this species could occur from eating aquatic invertebrates originating from the mine pit lake.

Within the portions of the analysis area that include designated critical habitat for the Chiricahua leopard frog, it is possible that the proposed project could impact some of the primary constituent elements of critical habitat for this species within those areas. Chiricahua leopard frogs are known to occur at seven locations within proposed critical habitat within the analysis area, and some of these locations are supported by groundwater. Therefore, designated critical habitat for this species could be impacted by groundwater drawdown. It is possible that the proposed mine and associated disturbances could also result in increases in populations of nonnative species and could create conditions suitable for the presence of chytridiomycosis. When critical habitat was designated for this species (March 2012), chytridiomycosis had been documented from Las Cienegas NCA but not was noted as an imminent threat in the Santa Rita Mountains (U.S. Fish and Wildlife Service 2012a). However, there is speculation that chytridiomycosis may have been present in Tarahumara frogs (*Lithobates tarahumarae*) in the Santa Rita Mountains in the past (Hale et al. 2005; Rorabaugh et al. 2005), and the AGFD provided a comment on the Preliminary Administrative Review Draft FEIS that the presence of chytridiomycosis in the Santa Rita Mountains has been confirmed at one location (Big Casa Blanca Canyon) outside the analysis area (Sredl 2013).

In addition to the impacts described as common to all action alternatives, Chiricahua leopard frogs could experience additional impacts associated with the Barrel Alternative from the rerouting of the Arizona National Scenic Trail where it would cross SR 83 in Oak Tree Canyon, where this species was documented at two locations in 2008. The construction and use of the rerouted Arizona National Scenic Trail and a new trailhead on the west side of SR 83 in Oak Tree Canyon could result in additional noise impacts to this species (SWCA Environmental Consultants 2012a). The Barrel Trail Alternative would result in direct impacts to an additional known location where Chiricahua leopard frogs were documented in 2008 and 2009 (East Dam). Impacts described as common to all action alternatives could occur to Chiricahua leopard frogs at this location. As with the Barrel Alternative, Chiricahua leopard frogs could experience additional impacts from the rerouting of the Arizona National Scenic Trail where it would cross SR 83 in Oak Tree Canyon. This species was documented at two locations in Oak Tree Canyon in 2008, and the construction and use of the rerouted Arizona National Scenic Trail and a new trailhead on the west side of SR 83 in Oak Tree Canyon could result in additional noise impacts to this species (SWCA Environmental Consultants 2012a). As with the Barrel and Barrel Trail Alternatives, Chiricahua leopard frogs could experience additional impacts from the rerouting of the Arizona National Scenic Trail associated with the Scholefield-McCleary Alternative, where it would cross SR 83 in Oak Tree Canyon. This species was documented at two locations in Oak Tree Canyon in 2008, and the construction and use of the rerouted Arizona National Scenic Trail and a new trailhead on the west side of SR 83 in Oak Tree Canyon could result in additional noise impacts to this species.

Based on this, all action alternatives may affect and are likely to adversely affect the Chiricahua leopard frog and designated critical habitat for the Chiricahua leopard frog (SWCA Environmental Consultants 2012a, 2012b, 2013a; U.S. Forest Service and SWCA Environmental Consultants 2013). After reviewing the current status of Chiricahua leopard frog, the environmental baseline for the analysis area, the effects of the proposed action, and the cumulative effects, the USFWS's biological opinion as of October 2013 was that the proposed project is not likely to jeopardize the continued existence of the Chiricahua leopard frog or to adversely modify its designated critical habitat (U.S. Fish and Wildlife Service 2013e).

Key conservation measures and terms and conditions from the BO are included in the mitigation and monitoring measures in appendix B of the FEIS. Key measures related to Chiricahua leopard frogs include the following: measure FS-BR-03, which requires actions to erect frog barriers if needed for exclusion from process areas; measure FS-BR-05, which requires the construction, management, and maintenance of up to 30 new water features; the purchase of Sonoita Creek Ranch (measure FS-BR-08), which includes management of the property to benefit Chiricahua leopard frogs; measure FS-BR-11, which requires monitoring and control of actions to reduce or prevent impacts to Chiricahua leopard frog from invasive aquatic species; measure FS-BR-12, which allows for relocation of Chiricahua leopard frogs; measure FS-BR-26, which requires annual monitoring of Chiricahua leopard frogs; and measure FS-BR-28, which requires monitoring of water quality in some potential Chiricahua leopard frog habitat (see FEIS, vol. 3, pp. 680–683).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. New information and changed conditions about the Chiricahua leopard frog include a new occurrence of this species in the project area at Barrel Tank. New occurrences of this species are also documented within analysis area (some of which are due to reintroductions); this species has been observed at Deering Spring, Empire Spring (in reach EG1), Empire Gulch Reach 2, Cieneguita Wetlands, and upper and lower Cienega Creek, as well as many of the wildlife ponds within the Las Cienegas NCA (i.e., Maternity Wildlife Pond, Empire Wildlife Pond). The FROG Project has conducted recent work to restore a metapopulation of Chiricahua leopard frogs to a large (approximately 444-square-mile) area centered on the Empire Valley, including Las Cienegas NCA, CCNP, and portions of the Santa Rita Mountains; specifically, they have removed bullfrogs on a landscape level, restored ponds to create Chiricahua leopard frog habitat, and released captive-bred Chiricahua leopard frogs (Rosen et al. 2013). Thus, this species is more widespread within the analysis area and has higher-quality habitat than was known at the time of publication of the FEIS. The baseline environmental conditions and trends at Las Cienegas NCA documented in Simms (Simms 2014b) are not quantified, so they are included in a qualitative discussion of possible current trends: these frogs appear to be doing well in some areas Las Cienegas NCA where the stream reaches are functioning well, though in some areas they may be impacted from lack of pool volume or lack of surface water due to the current drought.

While the overall number and habitat quality of ponds within the analysis area has increased due to restoration and reintroduction efforts by the FROG Project and BLM, *Bd*-positive individuals that were found dead floating in West Tank, in an area where die-offs from chytridiomycosis had not been observed before.

Direct and Indirect Impacts. The direct and indirect impacts for the Chiricahua leopard frog populations that were already known remain the same as stated in the FEIS. This species would also experience effects due to the rerouting of the Arizona National Scenic Trail for the Barrel Alternative – Preferred Alternative that were already discussed in the FEIS. Impacts for the new locations are as follows: the Barrel Alternative is still expected to result in permanent, direct impacts to Chiricahua leopard frogs at the aquatic sites they occur in within the project area (the previously known Lower Stock Tank, though no frogs have been documented in this location since 2008, and Barrel Tank, a new location). If individual frogs (eggs/embryos, tadpoles, juveniles, and adults) are present, mine construction and operation activities would result in direct impacts in the form of mortality or other disruptions to behavior that could influence growth and survivorship. Additionally, a new occurrence location has been observed within the perimeter fence, which is within the overland dispersal range of this species. Therefore, direct impacts to frogs dispersing to and from this new site and all the previously known aquatic sites from within the analysis area into the project area could range from increased risk to mortality (e.g., crushed on roads or in other areas of mining related activities) to behavioral avoidance (e.g., reluctance to move across disturbed areas). Any individual frogs, tadpoles, and/or eggs present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from noise, vibration, and artificial night lighting.

The re-evaluated impacts based on new information do not differ substantially from those disclosed in the BA, SBAs, and FEIS, specifically, that mine drawdown would occur within Empire Gulch and that widespread absence of flow in Cienega Creek was not anticipated. According to the updated aquatic analysis in the “Seeps, Springs, and Riparian Areas” section of this SIR, Empire Gulch would see little or no change through 20 years after mine closure, with some variability in magnitude and timing of impacts following that; however, most scenarios indicate a change to ephemeral or intermittent flow by 300 years after mine closure with pools and water quality impacts showing high variability; under at least one scenario pools completely disappear within 300 years. Thus, Chiricahua leopard frogs at Empire Gulch Reach 1 are expected to experience impacts due to loss of habitat. With the reduction in water within Empire Gulch, some connectivity between the Chiricahua leopard frog metapopulations occurring in Cienega Creek and the Santa Rita Mountains may be impaired in the future; however, these frogs are known to disperse relatively long distances, and the Empire and Maternity Wildlife ponds upstream of Empire Gulch Spring, where Chiricahua leopard frogs were recently introduced, are not expected to be dewatered. Both of these wildlife ponds currently receive water from surface runoff as well as being supplemented by groundwater pumping. Groundwater modeling indicates that in the first 150 years after mine closure, drawdown greater than 10 feet is unlikely to occur at these locations (see FEIS, pp. 341–345) (Montgomery and Associates Inc. 2010; Tetra Tech 2010). The exact depth of the wells is not known; however, drawdown less than 10 feet was not considered in the FEIS to impact nearby wells (FEIS, p. 294). There also are not expected to be any changes in surface runoff due to the mine in this watershed (FEIS, p. 398). Therefore, the Chiricahua leopard frogs in these locations are not expected to experience habitat loss or degradation.

This species was documented as occurring and being reintroduced into Empire Gulch Reach 2 and Cieneguita Wetlands. The aquatic analysis in the “Seeps, Springs, and Riparian Areas” section of this SIR indicates that Empire Gulch Reach 2 is likely to have an increase in zero-flow and low-flow days and a reduction in pool volume and water quality as a result of mine drawdown alone; however, the number of pools does not change under any scenario. The number of pools at Cieneguita Wetlands does not change under any scenario, but impacts to pool volume are substantial and highly variable with pools being from 25 to 92 percent of their original volume from mine drawdown alone. Thus, individuals occurring in Empire Gulch Reach 2 or Cieneguita Wetlands are expected to experience impacts due to habitat loss, habitat degradation, and increased predation as pool size shrinks.

Within Cienega Creek, for 95 percent of all possible scenarios, mine drawdown by itself has little or no effect on drying of the stream, does not change stream flow status from perennial, may have some effect on water quality, and does not change the number of pools, with the pools retaining at least 82 percent of their original volume even out to 1,000 years (see “Seeps, Springs, and Riparian Areas” section of this SIR). Thus, in Cienega Creek, adequate Chiricahua leopard frog habitat is expected to remain.

Prior to the documentation of a die-off at West Tank where individual dead Chiricahua leopard frogs were subsequently found to be *Bd*-positive, chytridiomycosis was not known to be an imminent threat in the Santa Rita Mountains, though it had been documented at Las Cienegas NCA, and at Big Casa Blanca Canyon in the Santa Rita Mountains outside the analysis area. Given the dispersal range of this species and the presence of invasive species, particularly bullfrogs, which act as reservoirs of *Bd*, it is unlikely that any given location would remain *Bd* free over the long term.

Current baseline conditions on Las Cienegas NCA as documented in Simms (Simms 2014b) may be affecting the populations at Las Cienegas NCA; however, these conditions are not measured quantitatively and so can only be applied to our analysis of impacts in a qualitative fashion. Due to current hydrologic conditions or the ongoing drought, this species may be experiencing lack of surface water, poor water quality in areas, and tadpoles exposed to increased predation by being confined to pools that have declined rapidly pre-monsoon, though some reaches where this species occurs appear to be stable and functioning well; further, this species may disperse along perennial stretches during times of increased precipitation, and may disperse up to approximately 3 to 5 miles. Populations occurring in Empire Gulch would likely see an increase of these baseline trends; however, the most recent analysis along Cienega Creek shows that the Barrel Alternative would not result in widespread absence of flow, reduction in pool number, and would result in a minor reduction in pool size.

The new information shows that this species is more widespread on the analysis area than previously known, but whether these newly observed and newly reintroduced populations would persist has not been evaluated. Negative trends for this species include the observation of *Bd* in the analysis area at West Tank. The expected impacts for this species are not different in scope from the FEIS, only detail. Thus, the effects determination does not change from the FEIS: *the Barrel Alternative may affect and is likely to adversely affect the Chiricahua leopard frog and may affect and is likely to adversely affect designated critical habitat for the Chiricahua leopard frog*.

Lowland leopard frog (Lithobates yavapaiensis)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of the lowland leopard frog in Cienega Creek and other aquatic locations within the analysis area:

- Polm (2014) documents this species as occurring in reaches 7 through 10 along Cienega Creek.
- Simms (2004c) is a compilation of wildlife sightings at Las Cienegas NCA from 1988 to 2004 from J.R. Simms's field notes, fall fish count forms, riparian assessment forms (RACE data), and fish habitat inventory forms; "leopard frog" identified at many locations in Las Cienegas NCA, lowland leopard frog at Nogales Spring.
- Bodner and Simms (2008) document the presence of this species at the Las Cienegas NCA.

A document providing species accounts for the June 13, 2014, wet/dry mapping of Pima County CCNP was provided after the publication of the FEIS:

- Caldwell (2014) notes that during PAG's wet/dry mapping of CCNP, both larval and adult members of this species were observed in the "head cut" reach.

After the publication of the FEIS, the transcribed field notes of Robert A. Leidy, EPA, pertaining to observations made within Cienega Creek Watershed from March 2012 to June 2013, were made available:

- Leidy (2013) documents an adult of this species occurring at Cienega Creek at Pantano Dam in June 2013.

New location data were provided by Dr. David Hall (University of Arizona) on July 30, 2014:

- Hall (2014) documents breeding of this species at the Narrows (within CC7 and CC8).

After publication of the FEIS, Pima County Office of Sustainability and Conservation made available an unpublished report by Brian Powell examining water resource trends in CCNP:

- Powell (2013b) states that lowland leopard frogs occur at CCNP.

On July 29, 2013, "Restoring Leopard Frogs and Habitat in Sky Island Grasslands (Arizona): Final Report 2010-2012" was published by the FROG Project:

- Rosen et al. (2013) document the currently known locations of lowland leopard frog within the analysis area in CCNP; occurrences of this species have been recorded at lower Cienega Creek and upper Cienega Creek (CC3 through CC11), but this document lists them extant at Road Canyon Tank (an introduced population that was extirpated when the well was turned off) and at Lower Cienega Creek.

New ranid surveys of the Rosemont holdings and vicinity have been completed:

- WestLand (2013a) contains the results of the "2012 Ranid Survey of the Rosemont Holdings and Vicinity," plus the mitigation parcels, Sonoita Creek Ranch and Fullerton Ranch. No lowland leopard frogs were observed in the mitigation parcels, but because the mitigation parcels are not within the analysis area, they will not be considered in the analysis of effects.

Baseline Conditions Considering New Information and Changed Conditions

The documents listed above contain more detailed information about the extent of occurrences of this species in the analysis area than was provided in the FEIS. Quantitative trends for populations of this species are not provided, but Powell (2013b) cites sources that state that lowland leopard frog populations at CCNP were "never abundant" and that their numbers "appeared to decline" recently.

Summary of FEIS Impact Conclusions

Direct impacts on lowland leopard frogs are not anticipated as a result of the proposed project because this species is typically found at elevations below the project area and there are no confirmed records of this species within the project area. Any individual frogs, tadpoles, and/or eggs present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area (i.e., in Davidson Canyon and Cienega Creek) could experience indirect impacts from decreased surface water flow in Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Additional impacts could occur on lowland leopard frog populations located within the analysis area in Cienega Creek where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. Indirect impacts on lowland leopard frogs could also result from prey species of the lowland leopard frog experiencing the same impacts as the frog from proposed project activities, hence altering their predator-prey relationships. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a) (see FEIS, vol. 3, p. 682).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. New information and changed conditions about the lowland leopard frog includes more detailed information about the extent of occurrences of this species in the analysis area than was provided in the FEIS. The most recent observation records show that this species occurs at CCNP and Cienega Creek Reaches 7 through 10 at Las Cienegas NCA, and breeds in Cienega Creek Reaches 7 and 8 at Las Cienegas NCA and at CCNP. Because no abundance estimations or quantitative trends are provided, we have no way to evaluate the apparent trend of declining lowland leopard frogs at CCNP. The 2012 (WestLand) ranid surveys provide further occurrence records of lowland leopard frogs in lower Cienega Creek and Davidson Canyon near the confluence of the two.

Direct and Indirect Impacts. The new occurrence records show that these frogs occur on the analysis area within upper Cienega Creek (reaches CC3 through C11, with breeding confirmed in reaches CC7 and CC8) and lower Cienega Creek but not within Empire Gulch (EG1 and EG2). Within Cienega Creek, for 95 percent of all possible scenarios, mine drawdown by itself has little or no effect on drying of the stream, does not change stream flow status from perennial, and may have some effect on water quality, and does not change the number of pools with the pools retaining at least 82 percent of their original volume even out to 1,000 years (see “Seeps, Springs, and Riparian Areas” section of this SIR). Thus, this species may experience some impacts from loss of habitat but is not likely to experience widespread habitat loss as a result of the proposed project.

The FEIS already took into account some water loss at Cienega Creek without widespread absence of flow; thus, the direct and indirect effects on lowland leopard frogs as a result of the proposed project are not expected to change from those detailed in the FEIS, and adequate habitat is expected to remain for this species within the analysis area. Thus, based on the new information and the FEIS, *the Barrel Alternative may impact individuals but is not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability*.

Giant spotted whiptail (Aspidoscelis stictogramma)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of the giant spotted whiptail in Las Cienegas NCA:

- BLM (2013b) contains data sheets for surface flow mapping at Las Cienegas NCA, UTMs for this species are provided (CC6). BLM (2014d) contains a copy of the same data sheet with the giant spotted whiptail record from BLM (2013b).

Baseline Conditions Considering New Information and Changed Conditions

This species was known to occur within Las Cienegas NCA when the FEIS analysis was conducted; thus, this new occurrence record does not change baseline conditions of this species. However, the new location data and aquatic analysis allow a refinement of expected impacts to this species.

Summary of FEIS Impact Conclusions

For all action alternatives, any individuals present within the project area or in the path of either the water or transmission lines or the reroute of the Arizona National Scenic Trail would be directly impacted (e.g., crushed or trampled) as a result of project activities. Any individuals present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience indirect impacts from decreased surface water flow in

Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads.

Additional impacts could occur on giant spotted whiptail populations located within the analysis area in Cienega Creek, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. Prey species of the giant spotted whiptails are likely to experience the same direct impacts as this lizard, hence altering their predator-prey relationships. Additionally, because the mine pit lake water quality could exceed wildlife standards for three contaminants that are known to bioaccumulate (i.e., cadmium, mercury, and selenium), indirect impacts to this species could occur from eating aquatic invertebrates originating from the mine pit lake. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a; WestLand Resources Inc. 2013b) (see FEIS, vol. 3, pp. 682–683).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. This species was known to occur within the analysis area prior to the receipt of new information, and the new data shows that this species occurs at Cienega Creek Reach 6, within Cienega Creek.

Direct and Indirect impacts. Because this species was already known to occur within the analysis area, the analysis of impacts in the FEIS took into account their presence within the analysis area when considering possible impacts to this species. The aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR) for Cienega Creek indicates that in 95 percent of possible scenarios for mine drawdown by itself does not change the stream flow status from perennial, the number of pools does not change, pools retain at least 82 percent of their volume even out to 1,000 years; and that the xeroriparian or mesoriparian habitat near streams that this species prefers would not be lost. Minor impacts are expected to occur to this species or its habit at this location as already discussed in the FEIS.

Thus, there will be no change in the conclusion of impacts considering new information: *the Barrel Alternative may impact individuals but is not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability*.

Sonoran Desert tortoise (Gopherus morafkai)

Summary of Applicable New Information and/or Changed Conditions

The Sonoran desert tortoise is currently a Candidate species under ESA (U.S. Fish and Wildlife Service 2010b). The status of this species has not yet changed; however, after the publication of the FEIS the USFWS published the annual Candidate Notice of Review in which it continued to find that listing the Sonoran desert tortoise is warranted but precluded. Further, USFWS is currently working on a proposed listing determination that is expected to be published prior to the next annual resubmitted petition 12-month finding. In USFWS (2014f), as of December 2014, the USFWS is working to change the status of the Sonoran desert tortoise from candidate to proposed listing within the next year prior to the next annual Candidate Notice of Review. In addition, the USFS is currently working with the USFWS and other land management agencies in Arizona to create a Candidate Conservation Agreement that may prevent the listing of this species.

Baseline Conditions Considering New Information and Changed Conditions

There is no new information regarding the distribution of this species within the analysis area, and the status of this species has not changed as of the writing of this SIR.

Summary of FEIS Impact Conclusions

Direct impacts to this species, in the form of mortality or other disruptions to behavior, could result from the construction and placement of the mine infrastructure or the water or electric transmission lines and utility maintenance road. Any individuals present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow, groundwater drawdown, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a) (see FEIS, vol. 3, p. 683).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. No new occurrence records have been identified. However, the Sonoran desert tortoise's status under the ESA may change within the next year. If the status of the Sonoran desert tortoise does change to proposed, effects determinations will be made at that time. If a Candidate Conservation Agreement is made, any specific regulations will be followed.

As of the writing of the SIR, the status of this species has not changed; the baseline conditions or expected impacts to this species have also not changed. Thus, the impact determination will not change: *the Barrel Alternative may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability.*

Northern Mexican Gartersnake (Thamnophis eques megalops)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the Pima County Office of Sustainability and Conservation provide species location and potential impacts to this species:

- Powell (2013b) documents the presence of this species along lower Cienega Creek at CCNP.
- Powell et al. (2014) document the rarity of this species historically on the CCNP and mentioned the occurrence found in the above document.

New documents provided by the BLM provide general species' locations, professional opinions about baseline conditions at Las Cienegas NCA and proposed thresholds:

- In Polm (2014), the potential to occur for this species was noted along Cienega Creek (CC1 through CC10), Empire Gulch Reach 2, and Mattie Canyon.
- Simms (2014b) includes a summary of a meeting and field trip where Jeff Simms (BLM) presented his professional opinion of current, baseline conditions at Las Cienegas NCA and proposed analysis thresholds he would like considered for the SBA.
- Simms (2013a) documents this species being reintroduced into Empire Wildlife Pond and Maternity Wildlife Pond at Las Cienegas NCA in 2014, with other stocking locations

pending at the Cieneguita Wetlands, and in other wildlife ponds, some of which are within the analysis area of the proposed project.

- Simms (2004c) is a compilation of wildlife sightings at Las Cienegas NCA from 1988 to 2004 from J.R. Simms's field notes, fall fish count forms, riparian assessment forms (RACE), and fish habitat inventory forms; this species was observed at headwaters of Cienega Creek in 1994 (CC1) and confluence of Empire Gulch and Cienega Creek in 1989 (CC3 or EG2, location unspecified).
- BLM (2004) includes the Las Cienegas NCA RACE data; in 1989, this species was observed in Empire Gulch in a marsh near the confluence of Cienega Creek (EG2). This is likely the same observation as Simms (2004c) because Simms is a compilation of herpetofauna sightings, which includes those observations found in the RACE forms (Bureau of Land Management 2004).
- Bodner and Simms (2008) document the presence of this species as Las Cienegas NCA.
- Simms (2014d) contains a field trip report with BLM and USFWS staff at riparian areas within Las Cienegas NCA; this includes pictures, narrative, and locations. This species was said to occur at Empire Wildlife Pond.

New documents received from Dennis Caldwell provide species' locations:

- Caldwell (2014) documents the presence of this species (giving UTMs) in Lower Cienega Creek Reach 13 at CCNP.

New documents received from Dr. David Hall provide species' locations:

- Hall (2014) documents the presence of this species in what he calls the "Headwaters" reach (in CC1) and the "Narrows" reach (in CC7 and CC8) of upper Cienega Creek; exact locations are not given.

On July 29, 2013, "Restoring Leopard Frogs and Habitat in Sky Island Grasslands (Arizona): Final Report 2010-2012" was published by the FROG Project:

- Rosen et al. (2013) mention that northern Mexican gartersnake populations have been declining along Cienega Creek and that reintroductions are planned, but should be delayed until leopard frogs, their native prey, are abundant.

After publication of the FEIS, the northern Mexican gartersnake was designated threatened by the USFWS.

- USFWS (2014g) lists the northern Mexican gartersnake as threatened under ESA and documents threats to the northern Mexican gartersnake, including habitat loss from dewatering, loss of native frog prey base, and nonnative species. Known locations include Las Cienegas NCA and Cienega Creek, but the conclusion was that the population is likely not viable there.

Baseline Conditions Considering New Information and Changed Conditions

Several of the aforementioned new sources of information provide previously unknown occurrences of the northern Mexican gartersnakes in the analysis area, some of which are due to reintroductions. This species was documented at lower Cienega Creek, upper Cienega Creek (specifically, CC1 and a location within "the narrows reach" which consists of most of CC7 and CC8), Mattie Canyon, lower Empire Gulch (EG2), and has been reintroduced at Maternity and Empire Wildlife Ponds. Jeff Simms

(BLM) presented his professional observations and opinion of current, baseline conditions at Las Cienegas NCA, which may be relevant to this species, including dispersal over distances potentially greater than 5 miles, especially during summer rainy season and any of the baseline trends that may affect its native frog prey base (see baseline conditions discussion for Chiricahua leopard frog, above). This species is known to be highly dependent upon its native frog prey base to persist at a site (Rosen et al. 2013; U.S. Fish and Wildlife Service 2014g). Additionally, after the publication of the FEIS, the northern Mexican gartersnake was designated as threatened (U.S. Fish and Wildlife Service 2014g).

Summary of FEIS Impact Conclusions

All action alternatives have the potential to directly impact the northern Mexican gartersnake because any individuals present within the project area or in the path of either of the connected actions could be crushed or trampled as a result of project activities. Any individuals present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Additional impacts could occur on northern Mexican gartersnake populations located within the analysis area in Cienega Creek, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. Prey species of the northern Mexican gartersnake are likely to experience the same direct impacts as the snake, hence altering their predator-prey relationships. Additionally, because the mine pit lake water quality could exceed wildlife standards for three contaminants that are known to bioaccumulate (i.e., cadmium, mercury, and selenium), indirect impacts to this species could occur from eating vertebrates that eat aquatic invertebrates originating from the mine pit lake.

There is no proposed critical habitat for the northern Mexican gartersnake within the project area; therefore, there would be no impacts to proposed critical habitat for the northern Mexican gartersnake within the project area. Within the portions of the analysis area that include proposed critical habitat for the northern Mexican gartersnake, it is possible that the proposed project could impact some of the primary constituent elements of critical habitat for this species within those areas. Northern Mexican gartersnakes are known to occur within proposed critical habitat within the analysis area in Cienega Creek, which is supported by groundwater; therefore, proposed critical habitat for this species could be impacted by groundwater drawdown. It is possible that the proposed mine and associated disturbances could also result in impacts to prey species and increases in populations of nonnative species, hence altering predator-prey relationships. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a) (see FEIS, vol. 3, pp. 683–684).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. New information and changed conditions about the northern Mexican gartersnake in the analysis area include previously unknown occurrences of this species (some of which are due to reintroductions), and a change in status to listed threatened under ESA. The new occurrence record data can be used with the aquatic analysis (see “Seeps, Springs, and Riparian Areas” section of this SIR) to refine the expected impacts on this species as a result of the Barrel Alternative.

Direct and Indirect Impacts. The possible direct impacts found within the FEIS for any northern Mexican gartersnakes within the project area and as a result of water quality in the mine pit lake are not expected to change as a result of this information, though none of the new occurrence records are within the project area. Direct and indirect impacts to any individuals in the project area or analysis area may still occur as a result of the Barrel Alternative, as outlined in the FEIS. This species relies upon the presence of riparian habitat and presence of healthy populations of its preferred prey, native ranids, particularly Chiricahua and lowland leopard frogs, and to a lesser extent native fishes.

No impacts are expected on the northern Mexican gartersnakes that have been introduced into Empire Wildlife Pond and Maternity Wildlife Pond because both sites currently receive water from surface runoff as well as being supplemented by groundwater pumping. Groundwater modeling indicates that in the first 150 years after mine closure, drawdown greater than 10 feet is unlikely to occur at these locations (FEIS, pp. 341–345) (Montgomery and Associates Inc. 2010; Tetra Tech 2010). The exact depth of the wells is not known; however, drawdown less than 10 feet was not considered in the FEIS to impact nearby wells (FEIS, p. 294). There also are not expected to be any changes in surface runoff due to the mine in this watershed (FEIS, p. 398).

Although the FEIS indicated that impacts could occur within the analysis area at Cienega Creek, new information in the aquatic analysis (see “Seeps, Springs, and Riparian Areas” section of this SIR) clarifies the impacts expected for this species at that location. This species relies upon healthy populations of its preferred prey, native ranids, particularly Chiricahua and lowland leopard frogs, and to a lesser extent native fishes; thus, this species experiences the same impacts as its prey species.

This species has not been observed in upper Empire Gulch (EG1), where aquatic analysis (see “Seeps, Springs, and Riparian Areas” section of this SIR) suggests the most severe impacts on groundwater would be observed. However, because their native prey occurs there, it is possible that they occur there (or could occur there in the future due to the proximity to the introduction sites at Empire Wildlife and Maternity Wildlife Ponds which are less than 4 miles from EG1) but were not observed. EG2 would see little or no change through 20 years after mine closure, with some variability in magnitude and timing of impacts following that; however, most scenarios indicate a change to ephemeral or at least intermittent flow by 300 years after mine closure with pools and water quality impacts showing huge variability but under at least one scenario pools completely disappear within 300 years. Because this reach would be impacted by ceasing to be perennial, water quality would be impacted and the number of pools may decrease or they may disappear entirely (there is high variation among the models for this reach), this area would likely no longer be suitable habitat for Chiricahua leopard frogs or native fishes, and thus this species would experience impacts through loss of prey base in addition to loss of riparian habitat. The loss of water at Empire Gulch Reach 1 may impair the connectivity of northern Mexican gartersnakes at Empire and Maternity Wildlife ponds to those in upper Cienega Creek; however, it is unknown whether the reintroduced populations of northern Mexican gartersnakes would persist. Further, the dispersal range for this species is unknown (U.S. Fish and Wildlife Service 2014g) but may be more than 5 miles (Simms 2014b).

This species was documented as occurring at Lower Empire Gulch (EG2). The expected impacts to this area (see “Seeps, Springs, and Riparian Areas” section of this SIR) include a small increase in days with zero stream flow, increasing the number extremely low flow days per year, and reduction of pool volume, though the number of pools do not change under any scenario. The northern Mexican gartersnake would experience impacts due to loss of its native frog prey source and loss of riparian habitat at lower Empire Gulch (EG2).

Within Cienega Creek, for 95 percent of all possible scenarios, mine drawdown by itself has little or no effect on drying of the stream, does not change stream flow status from perennial, may have some negative effect on water quality, and does not change the number of pools with the pools retaining at least 82 percent of their original volume, even out to 1,000 years (as noted in "Seeps, Springs, and Riparian Areas" section of this SIR). The most recent analysis suggests Cienega Creek would retain perennial segments; thus, habitat for this species and aquatic habitat for its native prey would continue to occur, though it may experience some impacts there.

The re-evaluated impacts based on new information do not differ substantially from those disclosed in the FEIS, specifically, that mine drawdown would occur within Empire Gulch and that widespread absence of flow in Cienega Creek was not anticipated. This species occurs in the analysis area and may experience impacts due to the proposed project. Although the impacts in Empire Gulch Reach 1 are likely to be most severe with the species possibly losing all of its habitat and prey base by 300 years after mine closure, this species is likely to retain most of its habitat and prey base in the Cienega Creek reaches. Individuals within Empire Gulch Reach 2 would experience impacts to habitat and prey base similar to those along Cienega Creek with greater expected impacts to their native prey due to reduction of size and water quality of pools. Maternity and Empire Wildlife Ponds, where this species has been introduced, are expected to show no impacts as a result of mine drawdown.

In the FEIS, it was determined that the proposed project may impact individuals but is not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability. Since the FEIS was published, the northern Mexican gartersnake has been listed as threatened under ESA (U.S. Fish and Wildlife Service 2014g), and an effects determination must be made. Based on the FEIS and new information presented here, *the Barrel Alternative may affect and is likely to adversely affect the northern Mexican gartersnake.*

Proposed Critical Habitat: There is no proposed critical habitat for the northern Mexican gartersnake within the project area; therefore, there would be no direct impacts to proposed critical habitat for the northern Mexican gartersnake. A portion of the Cienega Creek Subbasin Unit of proposed critical habitat for the northern Mexican gartersnake is located within the analysis area (U.S. Fish and Wildlife Service 2013a). The Cienega Creek Subbasin Unit is located east of the Santa Rita Mountains, north of the Canelo Hills, and west of the Whetstone Mountains, in Pima and Santa Cruz Counties.

Within the portions of the analysis area that include proposed critical habitat for the northern Mexican gartersnake, it is likely that the proposed project could impact some of the primary constituent elements (i.e., riparian habitat that includes perennial water and shoreline habitat of adequate space and complexity, a native prey base, and absence of crayfish or nonnative fish) of critical habitat for this species within those areas. As stated above, different locations of northern Mexican gartersnake proposed critical habitat on Las Cienegas NCA would be impacted differently. The proposed critical habitat at Empire Gulch Reach 1 would be the most impacted, potentially losing all or most of its pools and riparian vegetation; however, Cienega Creek is projected to be the least impacted, retaining its flow, its perennial pools, having comparatively minor impacts on water quality, and retaining its riparian vegetation. Lower Empire Gulch (EG2) and the Cieneguita Wetlands would be impacted less than Empire Gulch Reach 1 but more than Cienega Creek, retaining its stream flow but with greater expected impacts to water quality, pools, and riparian vegetation than in Cienega Creek.

Based on the above, *the Barrel Alternative is not likely to destroy or adversely modify northern Mexican gartersnake proposed critical habitat.*

Northern gray hawk (Buteo nitidus maximus)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of the northern gray hawk in Cienega Creek and other aquatic locations within the analysis area:

- BLM (2013b) states that northern gray hawks and nests were observed during wet/dry mapping of Las Cienegas NCA; this species was observed in upper Cienega Creek (reaches CC1–CC5, CC7, and CC10), Mattie Canyon, and Empire Gulch Reach 1.
- BLM (2014f) states that northern gray hawks were observed during yellow-billed cuckoo surveys at Empire Gulch and Mattie Canyon in August 2014.
- Simms (2004c) is a compilation of wildlife sightings at Las Cienegas NCA from 1988 to 2004 from J.R. Simms's field notes, fall fish count forms, riparian assessment forms (RACE), and fish habitat inventory forms; this species noted at many locations along upper Cienega Creek.
- BLM (2004) is the Las Cienegas NCA RACE data; this species was observed in Empire Gulch (EG1).
- Bodner and Simms (2008) document the presence of this species as Las Cienegas NCA, including nests, and note that the species' preferred habitat occurs at Las Cienegas NCA.
- BLM (2014d) contains data sheets for surface flow mapping at Las Cienegas NCA in 2014 and previous years (but some data sheets prior to 2014 appear to be repeats of BLM (2013b)); this species was observed in upper Cienega Creek.
- BLM (2014d) has results of yellow-billed cuckoo surveys and bird mapping at Las Cienegas NCA headwaters to narrows; it also contains some wet/dry mapping data sheet repeats. This species was observed within Empire Gulch Reach 1, Mattie Canyon, and upper Cienega Creek.

A document providing species accounts for the June 13, 2014, wet/dry mapping of Pima County CCNP was provided after the publication of the FEIS:

- Caldwell (2014) states that two northern gray hawks were observed during PAG's June 2014 wet/dry mapping of CCNP.

Baseline Conditions Considering New Information and Changed Conditions

The new information supports the previously documented occurrences of this species within the analysis area, including at Las Cienegas NCA. As this species was known to occur within the analysis area, these documents do not substantially change the baseline condition of this species; they only give us more specific occurrence locations in upper Cienega Creek, Mattie Canyon, and upper Empire Gulch (EG1).

Summary of FEIS Impact Conclusions

Direct impacts on the northern gray hawk are not anticipated as a result of the proposed project or the construction of the connected actions because there are no known occurrences of this species within these areas. Any individuals present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Additional impacts could occur on northern gray hawk populations located within the analysis area in Cienega Creek and Empire Gulch, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. A range of outcomes was assessed for Empire Gulch as well, and are also highly uncertain. The most likely scenarios suggest that noticeable reductions in stream flow would occur, gradually increasing until widespread absence of flow occurred in Empire Gulch. Indirect impacts on northern gray hawks could also result from prey species of the northern gray hawk experiencing the same impacts as the hawk from proposed project activities, hence altering their predator-prey relationships. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a; WestLand Resources Inc. 2013b) (see FEIS, vol. 3, pp. 684–685).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information: New information and changed conditions about the northern gray hawk in the analysis area include more specific known locations for this species within the analysis area at Las Cienegas NCA. This species was known to occur within the analysis area prior to the receipt of new information. Thus, the analysis of impacts in the FEIS took into account their presence within the analysis area when considering possible impacts to this species. This species is now known to occur within upper Empire Gulch (EG1) and upper Cienega Creek at the Las Cienegas NCA.

Direct and Indirect impacts: The new information does not substantially change the impacts expected to this species. Because there have been no new occurrences within the project area as a result of this new information, no direct impacts area expected on this species, and the indirect impacts from dust, air pollutants, increased traffic volume on SR 83, and water drawdown in Barrel and Davidson Canyons are not expected to change. The re-evaluated impacts based on new information do not differ substantially from those disclosed in and FEIS, specifically, that mine drawdown would occur within Empire Gulch and that widespread absence of flow in Cienega Creek was not anticipated. According to the recent aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR), this species is expected to experience impacts from loss of much of its woodland riparian habitat in Empire Gulch Reach 1 and impacts through reduction of habitat area at Lower Empire Gulch (EG2); however, impacts to this species from loss of riparian woodland habitat at Cienega Creek are expected to be minor. Although this species may lose a portion of its habitat on the analysis area because of the Barrel Alternative, it would still retain the majority of its habitat along Cienega Creek.

Given that habitat for this species is likely to remain in Cienega Creek and that this species occurs in a larger range that includes southern Arizona, southern New Mexico, southern Texas, portions of Mexico, and into Central and South America, the loss of riparian habitat for this species at Empire Gulch counts as only a small portion of loss of total habitat for this species. Thus, the new information does not change the effects determination for this species: *the Barrel Alternative may impact individuals but is not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability.*

Common black-hawk (Buteogallus anthracinus)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of the common black-hawk in upper Cienega Creek (CC1–CC9):

- BLM (2014d) contains data sheets for surface flow mapping at Las Cienegas NCA, UTMs for this species are provided; this species was observed in upper Cienega Creek Reach 4.
- BLM (2014d) provides results of all species observed during yellow-billed cuckoo surveys and bird mapping (including common black-hawk) at Las Cienegas NCA headwaters to narrows; it also contains some wet/dry mapping data sheet repeats. This species was observed in upper Cienega Creek.

Baseline Conditions Considering New Information and Changed Conditions

This species was known to occur within the analysis area prior to the receipt of new information and the new documents provide specific occurrence locations for this bird. This species is now known to occur in upper Cienega Creek (CC1–CC9).

Summary of FEIS Impact Conclusions

Direct impacts on the common black-hawk are not anticipated as a result of the proposed project or the construction of the connected actions because there are no known occurrences of this species within these areas. The reroute of the Arizona National Scenic Trail for all action alternatives, however, would put the trail closer to a known common black-hawk nest in Mulberry Canyon (within approximately 200 feet of the nest for the Barrel, Barrel Trail, and Scholefield-McCleary Alternatives to 800 feet of the nest for the proposed action and Phased Tailings Alternative). The common black-hawks nesting in this area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Additional impacts could occur on common black-hawk populations located within the analysis area in Cienega Creek where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. Further, the construction and use of the rerouted Arizona National Scenic Trail could result in additional noise impacts to this species. Indirect impacts on common black-hawk could also result from prey species of the common black-hawk experiencing the same impacts as the hawk from proposed project activities, hence altering their predator-prey relationships. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a; WestLand Resources Inc. 2013b) (see FEIS, vol. 3, p. 685).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New information. New information and changed conditions about the common black-hawk in the analysis area include occurrence records within upper Cienega Creek (CC1–CC9).

Direct and Indirect Impacts. This species was known to occur within the analysis area prior to the receipt of new information. Thus, the analysis of impacts in the FEIS took into account their presence within the analysis area when considering possible impacts to this species. The only change to impacts would be a refinement of expected impacts to this species' habitat due to the recent aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR). The re-evaluated impacts based on new information do not differ substantially from those disclosed in the BA and FEIS, specifically, that mine drawdown would occur within Empire Gulch and that widespread absence of flow in Cienega Creek was not anticipated. This species is expected to experience impacts from loss of much of its woodland riparian habitat in Empire Gulch Reach 1 and impacts through reduction of habitat area at Lower Empire Gulch (EG2); however, impacts to this species from loss of riparian woodland habitat at Cienega Creek are expected to be minor. Although this species may lose a portion of its habitat in the analysis area because of the Barrel Alternative, it would still retain the majority of its riparian woodland habitat along Cienega Creek.

Given that habitat for this species is likely to remain in Cienega Creek and that this species occurs in a larger range that includes Arizona, Utah, New Mexico, Texas, Mexico, and into South and Central America, the loss of riparian habitat for this species at Empire Gulch counts as only a small portion of loss of total habitat for this species. Based both on the FEIS and new information provided, the impacts determination for this species will not change: *the Barrel Alternative may impact individuals but is not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability.*

Northern beardless-tyrannulet (Camptostoma imberbe)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of the northern beardless-tyrannulets in Cienega Creek and other aquatic locations within the analysis area:

- BLM (2013b) states that northern beardless-tyrannulets were observed in upper Cienega Creek during wet/dry mapping of Las Cienegas NCA.
- BLM (2014f) states that northern beardless-tyrannulets were observed during yellow-billed cuckoo surveys at Empire Gulch (EG1) and Mattie Canyon in August 2014.
- BLM (2014d) contains data sheets for surface flow mapping at Las Cienegas NCA during 2014 and previous years, UTMs for this species are provided (but some data sheets prior to 2014 appear to be repeats of BLM (2013b)); this species was observed in upper Cienega Creek.
- BLM (2014d) gives results of yellow-billed cuckoo surveys and bird mapping at Las Cienegas NCA headwaters to narrows; it also contains some wet/dry mapping data sheet repeats. This species was observed in Empire Gulch Reach 1, Mattie Canyon, and along upper Cienega Creek.

Baseline Conditions Considering New Information and Changed Conditions

This species was known to occur in the analysis area; the new documents provide further evidence that northern beardless-tyrannulets habitat occurs within the analysis area at Las Cienegas NCA, specifically within upper Cienega Creek, Empire Gulch, and Mattie Canyon (Bureau of Land Management 2013b, 2014f).

Summary of FEIS Impact Conclusions

Direct impacts on the northern beardless-tyrannulet could occur as a result of the proposed project because this species was documented in lower Barrel Canyon within the project area in the 1970s. Any individuals present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Additional impacts could occur on northern beardless-tyrannulet populations located within the analysis area in Cienega Creek where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. Prey species of the northern beardless-tyrannulet could experience the same impacts as the northern beardless-tyrannulet, hence altering their predator-prey relationships. Additionally, because the mine pit lake water quality could exceed wildlife standards for three contaminants that are known to bioaccumulate (i.e., cadmium, mercury, and selenium), impacts to this species could occur from eating aquatic invertebrates originating from the mine pit lake. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a; WestLand Resources Inc. 2013b) (see FEIS, vol. 3, pp. 685–686).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New information. New information and changed conditions about the northern beardless-tyrannulet in the analysis area include more detailed information about the extent of occurrences than was provided in the FEIS (i.e., Empire Gulch and Mattie Canyon).

Direct and Indirect Impacts: This species was known to occur within the analysis area prior to the receipt of new information. Thus, the analysis of impacts in the FEIS took into account their presence within the analysis area when considering possible impacts to this species. The only change to impacts would be a refinement of expected impacts to this species' habitat due to the recent aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR). This species is expected to experience impacts from loss of much of its woodland riparian habitat in Empire Gulch Reach 1 and impacts through reduction of habitat area at Lower Empire Gulch (EG2); however, impacts to this species from loss of riparian woodland habitat at Cienega Creek are expected to be minor. Although this species may lose a portion of its habitat on the analysis area because of the Barrel Alternative, it would still retain the majority of its riparian woodland habitat along Cienega Creek.

Given that habitat for this species is likely to remain in Cienega Creek and that this species occurs in a larger range that includes Arizona, New Mexico, Texas, large portions of Mexico, and into Central America, the loss of riparian habitat for this species at Empire Gulch counts as only a small portion of loss of total habitat for this species. Based both on the FEIS and the new information provided, the impact determination will not change for this species: *the Barrel Alternative may impact individuals but is not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability* (SWCA Environmental Consultants 2013a; WestLand Resources Inc. 2013b).

Western yellow-billed cuckoo (Coccyzus americanus occidentalis)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of the western yellow-billed cuckoo in Cienega Creek and other aquatic locations within the analysis area:

- BLM (2013b) states that western yellow-billed cuckoos were observed during wet/dry mapping of Las Cienegas NCA; this species was observed at Empire Gulch Reach 1 and in Upper Cienega Creek (CC1 and CC3).
- Polm (2014) documents this species as having the potential to occur in Cienega Creek Reaches 1 through 10, Empire Gulch Reaches 1 and 2, and Mattie Canyon.
- BLM (2014f) states that western yellow-billed cuckoos were observed during surveys for this species at Empire Gulch (EG1) and Mattie Canyon (Mattie Canyon) in August 2014.
- Simms (2004c) is a compilation of wildlife sightings at Las Cienegas NCA from 1988 to 2004 from J.R. Simms's field notes, fall fish count forms, RACE, and fish habitat inventory forms; this species was observed on upper Cienega Creek near a canal and between Oak Tree Canyon and Empire Gulch.
- Bodner and Simms (2008) document the presence of this species at Las Cienegas NCA, though the sample size there was too small to determine a population trend.
- BLM (2014d) contains data sheets for surface flow mapping at Las Cienegas NCA in 2014 and previous years, UTMs for this species are provided (but some data sheets prior to 2014 appear to be repeats of BLM (2013b)); no new records for this species are contained in the 2014 data sheets, all records contained in BLM (2013b).
- BLM (2014d) gives results of 2001 yellow-billed cuckoo surveys and bird mapping at Las Cienegas NCA along approximately 10.5 miles of Cienega Creek from the Headwaters to the Narrows; it also contains some wet/dry mapping data sheet repeats. This species was observed in Cienega Creek Reaches 1 through 4, 7, and 8. An estimated 23 pairs and 3 single birds occur there, and this species occurred more often in areas with >30-m-high vegetation and areas with greater cover in the 0.25- to 2-m range.

After publication of the FEIS, Pima County Office of Sustainability and Conservation made available a report by Brian Powell detailing the results western yellow-billed cuckoo surveys at CCNP.

- In 2013, at least 11 individual yellow-billed cuckoos were observed at CCNP in lower Cienega Creek, as documented in Powell (2013a).

In 2011, models were created to predict avian responses to changes in groundwater and riparian floodplain vegetation along the upper San Pedro River, Arizona.

- Brand et al. (2011) note that western yellow-billed cuckoo responded strongly to both vegetation structure and surface water availability.

A report was prepared by Pima County in 2014 and sent to the Coronado National Forest Supervisor to discuss the environmental baseline of CCNP and impacts of the Rosemont Copper Mine on listed species and hydrology of the CCNP:

- Powell et al. (2014) state that the status of western yellow-billed cuckoo populations at CCNP is not certain. This report also contains photographs of cottonwoods and riparian woodland vegetation that show thinning of canopy (attributed to the current drought though no data are presented) to the extent that they would not be considered nesting habitat for this species.

In 2013 and 2014, surveys for western yellow-billed cuckoos were completed in the project area inside the perimeter fence by WestLand. WestLand also provided its analysis of impacts of the proposed project on this species; however, the Forest Service has conducted its own analysis on the data and survey reports that were provided.

- WestLand (2015c) contains the results of the 2013 western yellow-billed cuckoo surveys: western yellow-billed cuckoos were observed along two of nine transects surveyed during an 8-week period, though they were observed in areas without mature riparian vegetation communities and no breeding was observed.
- WestLand (2015e) contains the results of the 2014 western yellow-billed cuckoo surveys: this species was observed along two of six transects, and although no direct evidence of breeding was observed, there was evidence of probable breeding at two locations.
- WestLand (2015h) lists potential effects of the Barrel Alternative on the western yellow-billed cuckoo and its proposed critical habitat. As stated above, the Forest Service has conducted its own analysis and did use the analysis provided in WestLand (2015h).

After the publication of the FEIS, the USFWS listed the western yellow-billed cuckoo as threatened under ESA and proposed approximately 6,127 acres of critical habitat within the analysis area:

- USFWS (2014e)—species is threatened under ESA on November 3, 2014.
- USFWS (2014d)—proposed critical habitat with primary constituent elements within the analysis area on August 15, 2014.
- USFWS (2013b)—species proposed threatened on October 3, 2013.

Baseline Conditions Considering New Information and Changed Conditions

This species was known to occur within the project and analysis areas prior to the receipt of new information; however, the most recent documented occurrence of this species in the project area was in 1975. The documents listed above contain more detailed information about the extent of occurrences of this species in the analysis area than was provided in the FEIS. This species occurs along Cienega Creek, where it has been incidentally observed along reaches 1 through 7, Empire Gulch Reach 1, and Mattie Canyon, and observed through species-specific surveys from Cienega Creek Reaches 1 through 9. In 2001, an estimated 23 mated pairs and 3 single birds occurred along surveyed portions of Cienega Creek. In 2011, at least 11 individual birds were observed along lower Cienega Creek at CCNP. In 2013, western yellow-billed cuckoo were observed within the perimeter fence (at Lower Barrel Canyon and Wasp Canyon transects), but no evidence of breeding was observed, and no breeding was inferred based on behavior or repeat observations. In 2014, this species was observed within the perimeter fence (at both Lower and Upper Barrel Canyon and Wasp Canyon transects); although no evidence of breeding was observed, “probable” breeding was inferred based on bird behavior.

Population trends have not been determined for either Lower or Upper Cienega Creek. This bird has been associated with areas with vegetation structure and surface water availability (Brand et al. 2011); farther along upper Cienega Creek, the birds were associated with vegetation with a height greater than 30 m and with areas with greater vegetative cover at 0.25 to 2 m in height. The birds observed within the perimeter fence in 2013 and 2014 were observed in areas that did not support perennial water and were associated with habitats containing oak, Arizona walnut, velvet mesquite, desert willow, and alligator juniper. The current drought may be contributing to removing nesting habitat by causing cottonwood canopies to thin at CCNP, though no data are available on the amount of nesting habitat removed or whether this loss is driving any population trends. Monitoring is planned for the future.

Finally, after the publication of the FEIS, the USFWS proposed this species for listing, listed the western yellow-billed cuckoo as threatened under ESA, and proposed approximately 6,127 acres of critical habitat within the analysis area (U.S. Fish and Wildlife Service 2013b, 2014d, 2014e). The USFWS has proposed to designate approximately 546,335 acres of critical habitat in Arizona, California, Colorado, Idaho, Nevada, New Mexico, Texas, Utah, and Wyoming (U.S. Fish and Wildlife Service 2014d). There are approximately 6,127 acres of proposed critical habitat for the western yellow-billed cuckoo in the analysis area of the proposed project: 4,219 acres in unit 33 (AZ-25 Upper Cienega Creek), and 1,908 acres in unit 38 (AZ-30 Lower Cienega Creek). Primary constituent elements in proposed critical habitat for western yellow-billed cuckoo are as follows (U.S. Fish and Wildlife Service 2014d): riparian woodlands (willow-cottonwood, mesquite thornforest, or a combination of these) in contiguous or nearly contiguous patches of at least 200 acres in extent and at least 325 feet wide, with at least one nesting grove (often willow dominated with average canopy closure of more than 70 percent), and a cooler, more humid environment than surrounding areas; adequate prey base, including large insects (e.g., cicadas, caterpillars, katydids, grasshoppers, large beetles, and dragonflies) and treefrogs in breeding areas and post-breeding dispersal areas; and dynamic riverine processes, especially including river system having hydrologic processes that promote regular habitat regeneration (sediment movement, seedling germination, plant vigor and growth), which leads to patches of old and new riparian vegetation. Formal designation of critical habitat has not occurred as of the writing of this SIR.

Summary of FEIS Impact Conclusions

There are documented occurrences of the western yellow-billed cuckoos within the project area in Barrel Canyon (in 1975) and more recently in the analysis area outside the project area in Box Canyon, Davidson Canyon, Empire Gulch, and Cienega Creek. Direct impacts on western yellow-billed cuckoos could result from the construction of the mine and related facilities in Barrel Canyon. Any individuals present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Additional impacts could occur on western yellow-billed cuckoo populations located within the analysis area in Cienega Creek and Empire Gulch, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. A range of outcomes was assessed for Empire Gulch, as well, and are also highly uncertain. The most likely scenarios suggest that noticeable reductions in stream flow would occur, gradually increasing until widespread absence of flow occurred in Empire Gulch.

Prey species of the western yellow-billed cuckoo are likely to experience the same direct impacts as the bird, hence altering their predator-prey relationships. Additionally, because the mine pit lake water quality could exceed wildlife standards for three contaminants that are known to bioaccumulate (i.e., cadmium, mercury, and selenium), impacts to this species could occur from eating aquatic invertebrates originating from the mine pit lake. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a; U.S. Forest Service and SWCA Environmental Consultants 2013) (see FEIS, vol. 3, p. 686).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New information: New information and changed conditions about the western yellow-billed cuckoo in the analysis area include more detailed information about the extent of occurrences of this species, which allows for a more refined analysis than conducted in the FEIS. However, neither the analysis methodology nor the impact conclusions differ substantially from the FEIS. This species was known to occur within the project area, though it was not documented there since 1975. It still occurs there, with evidence of "probable" breeding. This species was already also known to occur and breed within Empire Gulch and both upper and lower Cienega Creek prior to this new information.

The population trends for this species at the Las Cienegas NCA and CCNP are currently unknown, thus cannot be used in the analysis of impacts. Any reduction in woodlands is likely to reduce abundance of this species as in Brand et al. (2011); however, the amount of riparian canopy lost is not quantified or linked to a decline in abundance in the analysis area. Thus, only a qualitative assessment of this species' baseline condition due to the effects of the current drought can be made. Photographs in Powell et al. (2014) suggest this bird may currently be losing habitat through riparian woodland canopy thinning or riparian woodland loss at CCNP.

In the project area, this species is associated with atypical habitat types: sites without mature riparian gallery woodlands or perennial water. Few individuals were observed within the project area, and while no breeding was confirmed, breeding was noted as probable during the 2014 transects within the project area. Within Las Cienegas NCA and CCNP, this species is associated with more typical habitats: riparian woodlands near perennial water sources.

This species' status under the ESA has changed to threatened and critical habitat has been proposed within the analysis area; thus, effects determinations will have to be made.

Direct and Indirect Impacts: This species was known to occur within the project and analysis areas prior to the receipt of new information. Thus, the analysis of impacts in the FEIS took into account their presence within the analysis area when considering possible impacts to this species, and the impacts outlined in the FEIS have not changed. Specifically, direct impacts on western yellow-billed cuckoos could result from the construction of the mine and related facilities in Barrel and Wasp Canyons. Any individuals present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Further, prey species of the western yellow-billed cuckoo are likely to experience the same direct impacts as the bird, hence altering their predator-prey relationships. Additionally, because the mine pit lake water quality could exceed wildlife standards for three contaminants that are known to bioaccumulate (i.e., cadmium, mercury, and selenium), impacts to this species could occur from eating aquatic invertebrates originating from the mine pit lake.

Additional impacts are still expected to occur on western yellow-billed cuckoo populations located within the analysis areas in Cienega Creek and Empire Gulch as a result of the proposed project, and the new aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR) and more detailed location data allow for more refined analysis of impacts to this species. However, these impacts do not differ substantially from what was stated in the FEIS, specifically that mine drawdown would occur within Empire Gulch and that widespread absence of flow in Cienega Creek was not anticipated. According to the most recent aquatic analysis, this species is projected to be impacted through habitat loss in Empire Gulch as a result of mine drawdown as upper Empire Gulch (EG1) would potentially lose all or most of its pools and riparian vegetation. However, along Cienega Creek, the mine drawdown alone is not expected to remove riparian habitat, pools, and flow regime this species relies upon; thus, the impacts to this species' habitat or prey base are expected to be minimal.

In the FEIS, it was determined that the proposed project may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability. However, the western yellow-billed cuckoo has been listed as threatened under ESA (U.S. Fish and Wildlife Service 2014e) after publication of the FEIS, and an effects determination must be made. This species occurs in the project and analysis areas and is expected to experience direct and indirect impacts due to the proposed project; however, this species also occurs within riparian areas in Arizona, California, Colorado, Montana, Nevada, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming and the loss of Empire Gulch represents a small portion of its habitat. Further, adequate habitat is expected to remain for this species where it occurs near Cienega Creek.

Based on the FEIS and new information presented here, *the Barrel Alternative may affect and is likely to adversely affect the western yellow-billed cuckoo.*

Proposed Critical Habitat: There is no proposed critical habitat for the western yellow-billed cuckoo within the project area; therefore, there would be no direct impacts to proposed critical habitat for the western yellow-billed cuckoo.

The effects on primary constituent elements in different locations of the proposed critical habitat within the analysis area would be impacted differently. The proposed critical habitat at Empire Gulch would be the most impacted, potentially losing all or most of its riparian woodlands of differing ages and prey base; however, the proposed critical habitat at Cienega Creek is projected to be the less impacted, retaining its flow, its perennial pools (which may provide the humidity and prey base necessary for this species), and riparian woodlands. However, *the Barrel Alternative is not likely to destroy or adversely modify western yellow-billed cuckoo proposed critical habitat.*

Broad-billed hummingbird (Cynanthus latirostris)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of the broad-billed hummingbird in Cienega Creek and other aquatic locations within the analysis area:

- BLM (2014d) gives results of yellow-billed cuckoo surveys and bird mapping at Las Cienegas NCA at the Headwaters of Cienega Creek to the Narrows; it also contains some wet/dry mapping data sheet repeats. This species was observed along upper Cienega Creek.

Baseline Conditions Considering New Information and Changed Conditions

This species was known to occur within the analysis area prior to the receipt of new information; however, the documents listed above contain more detailed information about the extent of occurrences of this species in the analysis area than was provided in the FEIS. This species was confirmed in upper Cienega Creek.

Summary of FEIS Impact Conclusions

Direct impacts on the broad-billed hummingbird are not anticipated as a result of the proposed project because there are no known occurrences of this species within the project area, and no direct impacts resulting from connected actions are anticipated. Any individuals present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Additional impacts could occur on broad-billed hummingbird populations located within the analysis area in Cienega Creek, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. Prey species of the broad-billed hummingbird could experience the same impacts as the broad-billed hummingbird, hence altering their predator-prey relationships. Additionally, because the mine pit lake water quality could exceed wildlife standards for three contaminants that are known to bioaccumulate (i.e., cadmium, mercury, and selenium), impacts to this species could occur from eating aquatic invertebrates originating from the mine pit lake. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a; WestLand Resources Inc. 2013b) (see FEIS, vol. 3, pp. 686–687).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New information: New information and changed conditions about the broad-billed hummingbird in the analysis area include more detailed information about the extent of occurrences than was provided in the FEIS and an updated aquatic analysis (see “Seeps, Springs, and Riparian Areas” section of this SIR) that clarifies expected impacts to water within the analysis area.

Direct and Indirect Impacts. This species was known to occur within the analysis area prior to the receipt of new information. Thus, the analysis of impacts in the FEIS took into account their presence within the analysis area when considering possible impacts to this species. The direct and indirect impacts discussed in the FEIS remain unchanged with the exception of a clarified species location record along upper Cienega Creek. The recent aquatic analysis (see “Seeps, Springs, and Riparian Areas” section of this SIR) predicts that as a result of mine drawdown even out to 1,000 years, in 95 percent of possible scenarios, Cienega Creek would retain its flow and perennial pools, have comparatively minor impacts on water quality, and retain its riparian vegetation, though some areas may experience increased dry days per year and loss of water quality. Thus, some impacts are expected on this species’ habitat or prey along Cienega Creek as a result of the proposed project, but habitat would remain present and impacts are expected to be minimal.

The determination of impacts for this species will not change as a result of the incorporation of this new information because the new information does not substantially change our understanding of the occurrences of this species in the analysis area or the impacts on this species: *the Barrel Alternative may impact individuals but is not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability.*

Southwestern willow flycatcher (Empidonax traillii extimus)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of the southwestern willow flycatcher in Cienega Creek and other aquatic locations within the analysis area:

- Polm (2014) documents this species as occurring along Cienega Creek Reaches 1, 2, 3, and 5 and Empire Gulch Reach 1.
- BLM (2014e) contains bird banding data and a southwestern willow flycatcher report from 2003, UTMs for one bird observed along Cienega Creek Reach 3.

Baseline Conditions Considering New Information and Changed Conditions

This species was known to occur within the analysis area prior to the receipt of new information; however, the documents listed above contain more detailed information about the extent of occurrences of this species in the analysis area than was provided in the FEIS.

Summary of FEIS Impact Conclusions

Direct impacts on the southwestern willow flycatcher are not anticipated as a result of the proposed project because there are no known occurrences of this species within the project area, and no direct impacts resulting from connected actions are anticipated. Additional impacts could occur on southwestern willow flycatcher populations located within the analysis area in Cienega Creek and Empire Gulch, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. A range of outcomes was assessed for Empire Gulch as well, and are also highly uncertain. The most likely scenarios suggest that noticeable reductions in stream flow would occur, gradually increasing until widespread absence of flow occurred in Empire Gulch. Impacts on southwestern willow flycatchers could also result from prey species experiencing the same impacts as the southwestern willow flycatchers from groundwater drawdown, hence altering their predator-prey relationships. Additionally, because the mine pit lake water quality could exceed wildlife standards for three contaminants that are known to bioaccumulate (i.e., cadmium, mercury, and selenium), impacts to this species could occur from eating aquatic invertebrates originating from the mine pit lake. Changes to food sources could also result in changes in dispersal and hunting success. The proposed project could impact both primary constituent elements of proposed critical habitat for this species (in Cienega Creek): riparian vegetation and insect prey.

Based on this, all action alternatives may affect and are likely to adversely affect the southwestern willow flycatcher and designated critical habitat for the southwestern willow flycatcher (SWCA Environmental Consultants 2012a, 2012b, 2013a; U.S. Forest Service and SWCA Environmental Consultants 2013). After reviewing the current status of southwestern willow flycatcher, the environmental baseline for the analysis area, the effects of the proposed action, and the cumulative effects, the USFWS's biological opinion as of October 2013 is that the proposed project is not likely to jeopardize the continued existence of the southwestern willow flycatcher and is not likely to destroy or adversely modify designated critical habitat (U.S. Fish and Wildlife Service 2013e) (see FEIS, vol. 3, p. 697).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New information. New information and changed conditions about the southwestern willow flycatcher in the analysis area include more detailed information about the extent of occurrences than was provided in the FEIS. Specifically, this bird was observed in upper Empire Gulch (EG1) and Reaches 1, 2, 3, and 5 along Cienega Creek, allowing the use of the new aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR) for more refined impact analysis in those areas.

Direct and Indirect Impacts. This species was known to occur within the analysis area prior to the receipt of new information. Thus, the analysis of impacts in the FEIS took into account their presence within the analysis area when considering possible impacts to this species. The direct and indirect impacts outlined in the FEIS within the project area have not changed; further, the impacts on its prey species have not changed. Impacts are still expected to occur to southwestern willow flycatcher populations located within the analysis areas in Cienega Creek and upper Empire Gulch as a result of the Barrel Alternative.

According to new information, this species occurs within upper Empire Gulch (EG1), which would be the most impacted of the areas studied, potentially losing all or most of its pools and riparian vegetation; however, Cienega Creek (where this species was observed along CC1, CC2, CC3, and CC5) is projected even out to 1,000 years to be the least impacted, retaining its flow, its perennial pools, having comparatively minor impacts on water quality, and retaining its riparian vegetation. While the species may lose habitat in Empire Gulch as a result of mine drawdown, it is not expected that mine drawdown alone would remove the riparian habitat, surface water, and flow regime that this species relies upon along Cienega Creek, and thus impacts to this species due to the proposed project are expected to be minimal in that area. The new location data and projected loss of habitat for this species do not change any of the conditions already accounted for in the FEIS, specifically, that this species would lose much or all of its riparian habitat in Empire Gulch, but would retain much of its habitat along Cienega Creek.

Thus, the determination is not expected to change: *the Barrel Alternative may affect and is likely to adversely affect the southwestern willow flycatcher and designated critical habitat.*

Abert's towhee (Pipilo [=Melozone] aberti)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of Abert's towhee in Cienega Creek and other aquatic locations within the analysis area:

- BLM (2014f) states that Abert's towhees were observed during western yellow-billed cuckoo surveys at Empire Gulch (EG1) and Mattie Canyon in August 2014.
- BLM (2014d) gives results of yellow-billed cuckoo surveys and bird mapping at Las Cienegas NCA headwaters to narrows; it also contains some wet/dry mapping data sheet repeats. This species was observed in Empire Gulch Reach 1, Mattie Canyon, and along upper Cienega Creek.

In 2011, models were created to predict avian responses to changes in groundwater and riparian floodplain vegetation along the upper San Pedro River, Arizona:

- The groundwater drawdown model used by Brand et al. (2011) noted that Abert's towhees, like other mid- and understory nesting species, may increase in density due to the increased salt cedar that occurs with reduced groundwater.

Baseline Conditions Considering New Information and Changed Conditions

The new documents provide further evidence that this species occurs within the analysis area in Las Cienegas NCA at Empire Gulch and also in Mattie Canyon (Bureau of Land Management 2014f). Also, a new paper refines understanding of Abert's towhee density in relation to vegetation type; when tamarisk invades an area as a result of groundwater drawdown replacing the native riparian vegetation, Abert's towhee density may increase (Brand et al. 2011).

Summary of FEIS Impact Conclusions

Direct impacts on the Abert's towhee are not anticipated as a result of the proposed project because there are no known occurrences of this species within the project area, and no direct impacts resulting from connected actions are anticipated. Any individuals present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Additional impacts could occur on Abert's towhee populations located within the analysis area in Cienega Creek and Empire Gulch, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. A range of outcomes was assessed for Empire Gulch as well, and are also highly uncertain. The most likely scenarios suggest that noticeable reductions in stream flow would occur, gradually increasing until widespread absence of flow occurred in Empire Gulch. Indirect impacts on Abert's towhees could also result from prey species of the Abert's towhee experiencing the same impacts as the towhee from proposed project activities, hence altering their predator-prey relationships. Additionally, because the mine pit lake water quality could exceed wildlife standards for three contaminants that are known to bioaccumulate (i.e., cadmium, mercury, and selenium), impacts to this species could occur from eating aquatic invertebrates originating from the mine pit lake. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a; WestLand Resources Inc. 2013b) (see FEIS, vol. 3, pp. 688–689).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. This species was known to occur within the analysis area (near Box Canyon, Empire Gulch, and Cienega Creek) prior to the receipt of new information. Thus, the analysis methodology in the FEIS took into account their presence within the analysis area when considering possible impacts to this species, with these new occurrence records providing further documentation that they occur in the analysis area in Empire Gulch (EG1) and upper Cienega Creek.

Direct and Indirect Impacts. The direct and indirect impacts outlined in the FEIS within the project area have not changed. The FEIS already noted that effects to groundwater were expected to be more severe in Empire Gulch than in Cienega Creek; the updated analysis reinforces that conclusion. The updated aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR) shows that upper Empire Gulch (EG1) would be the most impacted, potentially losing all or most of its pools and riparian vegetation; however, Cienega Creek is projected to be the least impacted, retaining its flow, its perennial pools, having comparatively minor impacts on water quality, and retaining its riparian vegetation. Lower Empire Gulch (EG2) and the Cieneguita Wetlands would be impacted less than Empire Gulch Reach 1 but more than Cienega Creek, retaining its stream flow but with greater expected impacts to water quality, pools, and riparian vegetation than in Cienega Creek. Thus this species is expected to be impacted through loss of all or most of its riparian habitat along Empire Gulch, but impacts through habitat loss are expected to be minimal along Cienega Creek. Although researchers have shown that Abert's towhee population densities may increase when tamarisk invades an area due to loss of groundwater (Brand et al. 2011), it is far from certain whether the effects of tamarisk would be beneficial to this species. Further, Las Cienegas NCA is being managed by BLM to reduce the incidence of tamarisk, ensuring that it remains a minor component of the riparian woodland vegetation (Bodner and Simms 2008; Bureau of Land Management 2003b). Thus, this area is unlikely to become a dense stand of tamarisk like those described to be beneficial in Brand et al. (2011); therefore, increases in tamarisk are not expected to offset loss of other habitat for this species.

Given that habitat for this species is likely to remain in Cienega Creek and that this species occurs in a larger range that includes portions of Arizona, Nevada, California, New Mexico, and Sonora, Mexico, the loss of habitat for this species at Empire Gulch represents only a small portion of loss of total habitat for this species.

Based on the FEIS and this new information, the impact determination for this species will not change*: the Barrel Alternative may impact individuals but is not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability.*

Mexican spotted owl (Strix occidentalis lucida)

Summary of Applicable New Information and/or Changed Conditions

A new document provided by USFWS provides documentation of Mexican spotted owl north of Box Canyon, within the analysis area, approximately 1 mile west of the project footprint:

- Douglas (2015) is a record of this species taken from a wildlife camera near Box Canyon.

Baseline Conditions Considering New Information and Changed Conditions

This species was not known to occur within the analysis area prior to the receipt of new information.

Summary of FEIS Impact Conclusions

Direct impacts on Mexican spotted owls are not anticipated as a result of the proposed project because the project and analysis areas are in desert, semidesert grasslands, and Madrean encinal woodlands, and Mexican spotted owls occur at elevations above these vegetation communities, in mixed pine-oak woodlands to conifer forests. Further, the project area does not contain typical Mexican spotted owl habitat of mixed conifers, pine-oak, ponderosa pine, and pinyon-juniper required for foraging and nesting/roosting. The project area is located approximately 4.8 miles to the northeast of the nearest protected activity center, and the analysis area is located approximately 0.7 mile to the northeast of the nearest protected activity center. All mining and mine related construction activities (e.g., clearing of vegetation, vehicular traffic, and associated noise (i.e., no new access roads or mine activities)) would occur within the project area, approximately 4.8 miles from the nearest known Mexican spotted owl protected activity centers.

Although the nearest known Mexican spotted owl protected activity center is approximately 4.8 miles from the proposed project area and approximately 1 mile from the analysis area (where the noise levels are predicted to be 55 A-weighted decibels (dBA)), it is difficult to predict how the noise would be perceived by Mexican spotted owls in or near the analysis area. The impacts and responses can vary; however, given the distance from the proposed project area to the nearest known Mexican spotted owl protected activity centers, these impacts are likely to be insignificant and discountable. Adverse impacts on Mexican spotted owl critical habitat are also not anticipated as a result of the proposed project, although the analysis area (including the impacts of vibration, noise, and artificial night lighting) includes 430 acres of critical habitat unit BR-W-12. It is expected that an increase of vibration, noise, and artificial night lighting would occur within this area of critical habitat; however, these increases would not alter any primary constituent elements for this species. Based on this, all action alternatives may affect but are not likely to adversely affect the Mexican spotted owl and would have no effect on designated critical habitat for the Mexican spotted owl (SWCA Environmental Consultants 2012a, 2012b, 2013a). The USFWS concurred with this effects determination (see appendix F) (see FEIS, vol. 3, p. 689).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information: The effects of the proposed project on this species were re-evaluated taking into consideration this new occurrence record within the analysis area because the presence of a Mexican spotted owl within the analysis area was unknown at the time of publication of the FEIS.

New information and changed conditions about the Mexican spotted owl in the analysis area include a new occurrence record north of Box Canyon approximately 1 mile west of project area (i.e., footprint) (Douglas 2015). There is no new information regarding Mexican spotted owl designated critical habitat.

Direct and Indirect Impacts. Impacts to this species remain similar to those already accounted for in the FEIS. Direct impacts on Mexican spotted owl are still not anticipated from the construction of the mine and related facilities in Barrel Canyon, as this species is not known to occur within the project area. Any individuals present in the analysis area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. It is difficult to predict how the noise resulting from the proposed project would be perceived by Mexican spotted owls in or near the analysis area. The impacts and responses can vary; however, given the lack of preferred habitat and nesting habitat for this species and the infrequency of occurrences in this area, these impacts are likely to be minimal. Prey species of the Mexican spotted owl are likely to experience the same impacts as the bird, hence altering their predator-prey relationships.

The analysis area is not located within typical foraging or nesting habitat for this species, and the scarcity of occurrence records shows that while this species may use the area, it is not commonly encountered there. In the FEIS, it was determined that the proposed project may affect but is not likely to adversely affect the Mexican spotted owl and would have no effect on designated critical habitat for the Mexican spotted owl. Because the new information does not substantially change the baseline for this species within the analysis area, the effects determination does not change: *the Barrel Alternative may affect but is not likely to adversely affect the Mexican spotted owl and would have no effect on designated critical habitat for the Mexican spotted owl.*

Desert pupfish (Cyprinodon macularius)

Summary of Applicable New Information and/or Changed Conditions

Although it was known that the BLM was proposing to establish populations of aquatic special status species (i.e., Chiricahua leopard frog, Gila topminnow, desert pupfish, Gila chub, northern Mexican gartersnake, Sonora mud turtle, and Huachuca water umbel) into multiple (up to 16) earthen stock tanks and modified large aboveground water storage tanks at Las Cienegas NCA (Bureau of Land Management 2003a; U.S. Fish and Wildlife Service 2012b), it was not known until after the publication of the FEIS that populations of the desert pupfish had been reintroduced into the analysis area; thus, this species was not considered in the FEIS.

New documents received by the BLM after publication of the FEIS provide species' locations:

- Polm (2014) notes that the species is located within the Cieneguita Wetlands.

- Simms (2013a) documents this species being reintroduced at many locations within Las Cienegas NCA in 2012 to 2013 (Cinco Canyon Wildlife Pond, Road Canyon Wildlife Pond, Cottonwood Wildlife Pond, Empire Wildlife Pond, Cieneguita Wetlands Pond #4, Cieneguita Wetlands Pond #3, Antelope Wildlife Pond and Bald Hill Wildlife Pond), with other reintroductions at Las Cienegas NCA pending.
- Simms (2014d) contains a field trip report with BLM and USFWS staff at riparian areas within Las Cienegas NCA; it contains pictures, narrative, and locations. This species was observed at Empire Wildlife Pond.

On July 29, 2013, "Restoring Leopard Frogs and Habitat in Sky Island Grasslands (Arizona): Final Report 2010-2012" was published by the FROG Project:

- Rosen et al. (2013) document the reintroduction of desert pupfish into Road Canyon Tank.

Baseline Conditions Considering New Information and Changed Conditions

As mentioned above, the desert pupfish was not considered in the FEIS because it was not known until after the publication of the FEIS that this species had been reintroduced into the analysis area.

Summary of FEIS Impact Conclusions

Not applicable; this species was not analyzed in the FEIS.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. New information and changed conditions about the desert pupfish include the reintroduction of this species into the analysis area.

Listing Status. The desert pupfish was listed as endangered with critical habitat on April 30, 1986 (U.S. Fish and Wildlife Service 1986).

Taxonomy. In the time since listing, researchers have used DNA evidence to split *C. macularius* into three separate species: *C. macularius*, *C. eremus*, and *C. arcuatus* (Echelle et al. 2000; Koike et al. 2008; Minckley et al. 2002; Page et al. 2013). Currently, the USFWS is in the process of correcting this list in the CFR (50 CFR 17.11) to reflect contemporary taxonomic understanding. Herein, legal references to *C. macularius* will generally make reference to the taxonomic understanding at the time of listing and will generally make common reference to the "desert pupfish complex."

Critical Habitat. Critical habitat for "desert pupfish complex" occurs in four specific areas in Pima County, Arizona, and Imperial County, California: (1) Quitobaquito Spring plus a 100-foot riparian buffer zone in Organ Pipe Cactus National Monument in Pima County, Arizona, approximately 25 miles west-northwest of Lukeville, Arizona; (2) approximately 8.5 stream miles and 100 feet on either side of San Felipe Creek in Imperial County, California; (3) approximately 1.75 steam miles plus 100 feet on either side of Carrizo Wash in Imperial County, California; and (4) approximately three-fourths of a stream mile with 100-foot buffer on either side of Fish Creek Wash in Imperial County, California. No "desert pupfish complex" critical habitat occurs within the analysis area.

The constituent elements of critical habitat include the following habitat components (U.S. Fish and Wildlife Service 1986): small, slow-moving streams and spring pools with marshy backwater areas, clean, unpolluted water, and water that is relatively free of exotic organisms (especially exotic fishes). Cienega Creek, Empire Gulch, and many restored ponds on the Las Cienegas NCA contain one or more of the constituent elements for "the desert pupfish complex."

Primary threats. The primary threats to the "desert pupfish complex" include habitat alteration from stream bank erosion, surface water diversion and groundwater pumping and withdrawals; and predation by, and competition with, nonindigenous organisms, including other fish species, bullfrogs, and crayfish (U.S. Fish and Wildlife Service 1986). The effects of climate change (i.e., decreased precipitation and water resources and increased evapotranspiration) are a threat to many species (Lenart 2007), including the "desert pupfish complex."

Range and habitat. No natural populations of the "desert pupfish complex" remain in Arizona, although numerous captive and wild, reestablished populations currently exist (U.S. Fish and Wildlife Service 2010a). The "desert pupfish complex" is normally found at elevations ranging between 1,200 to 3,450 feet above mean sea level in shallow waters of springs, marshes, and streams, often associated with clear water and soft substrates (Arizona Game and Fish Department 2001).

Historical collections of specimens of the "desert pupfish complex" are known from Baja California and Sonora, Mexico, and in the United States in California and Arizona. Historical distribution of "desert pupfish complex" in Arizona included the Gila, San Pedro, Salt, and Santa Cruz Rivers. Representatives of the "Desert Pupfish Complex" were also found in the Lower Colorado River, Rio Sonoyta basin, Salton Sink basin, and Laguna Salada basin (Black 1980; Evermann 1916; Garman 1895; Gilbert and Scofield 1898; Miller 1943; Miller and Fuiman 1987; Turner 1983; U.S. Fish and Wildlife Service 1993). More recently, the historical range of *C. macularius* has been redefined due to the taxonomic revisions. The recognition of *C. eremus* and *C. arcuatus* as separate species removed the Rio Sonoyta and Santa Cruz River basins from the previously known historical range of the desert pupfish.

In a recent assessment of status, subpopulations of the "desert pupfish complex" were described collectively as stable, although environmental and demographic stochasticity could result in local extirpations (U.S. Fish and Wildlife Service 2010a). Local populations may be far more variable due to a variety of factors such as the number of habitat with independent fates, habitat area, presence of nonnative species, and other threats. The consequence of these threats can result if extinction or extirpation as is exemplified by *C. arcuatus* that perished in Monkey Spring (Santa Cruz County, Arizona) in the late 1960s or early 1970s (Minckley et al. 2002).

Eleven natural populations of the "desert pupfish complex" persist, five of which are in Mexico (U.S. Fish and Wildlife Service 2010a). About 16 transplanted populations exist in the wild, all in Arizona. No natural populations of the "desert pupfish complex" remain in Arizona, although numerous captive and wild, reestablished populations currently exist. Five natural populations persist in California, and no reestablished wild populations exist in California or Mexico. There is a total of 15 refuge populations in California.

Desert pupfish abundance in the Salton Sea is relatively low and distributed in fragmented patches (U.S. Fish and Wildlife Service 2010a). While populations in irrigation drains entering the Salton Sea can be abundant (U.S. Fish and Wildlife Service 2010a), fish populations there are still dominated by nonnative species (Martin and Saiki 2005).

The desert pupfish population in Salt Creek is stable to increasing, and currently has few nonnative species (U.S. Fish and Wildlife Service 2010a). A stable to increasing population exists in San Felipe Creek, and no nonnative fish species have been found there in recent surveys. Desert pupfish do occur in other areas of the Salton Sink when conditions are suitable, and currently do occur in a wash near Hot Mineral Spa.

Status in analysis area. There is no habitat, or known occurrences of this species, within the project area, and surveys for this species have not been conducted within the analysis area for the purposes of the proposed project. Desert pupfish have been reintroduced into six Wildlife Ponds (Cinco Canyon, Road Canyon, Cottonwood, Empire, Antelope, and Bald Hill) and two Cieneguita Wetlands ponds at Las Cienegas NCA. Dead fish that resembled *C. macularius* were observed (not collected or handled) in one of the ponds during a September 2014 site visit. The status of the species in these ponds has not been assessed since that site visit although Jeff Simms (Simms 2014a) made the observation late in 2014 that the water level in the ponds was sufficiently low to factor prominently in reducing the species' ability to overwinter at these sites.

Direct and Indirect Impacts. Direct impacts on the desert pupfish are not anticipated as a result of the proposed project because there is no habitat or known occurrences of this species within the project area. No impacts are expected to the desert pupfish in the Empire Wildlife Pond into which they have been reintroduced because the Empire site currently receives water from surface runoff as well as being supplemented by groundwater pumping. Groundwater modeling indicates that in the first 150 years after mine closure, drawdown greater than 10 feet is unlikely to occur at this location (FEIS, pp. 341–345) (Montgomery and Associates Inc. 2010; Tetra Tech 2010). The exact depth of the well is not known; however drawdown less than 10 feet was not considered in the FEIS to impact nearby wells (FEIS, p. 294). There also are not expected to be any changes in surface runoff due to the mine in this watershed (FEIS, p. 398).

Some impacts to the desert pupfish are expected where they have been released into the Cieneguita Wetlands ponds. New aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR) suggests that while the number of pools in the Cieneguita Wetlands do not change under any scenario, the impacts to pool volume are substantial (and highly variable), with pools being reduced to 24 to 92 percent of their original volume by mine drawdown alone, though the number of pools does not change under any scenario. Thus, impacts could occur on desert pupfish populations located within the analysis area in the Cieneguita Wetlands ponds because of habitat loss, habitat degradation, or increased predation. Impacts on desert pupfish could also result from prey species of the desert pupfish experiencing the same impacts as the fish from groundwater drawdown, hence altering their predator-prey relationships.

This species was only recently reintroduced into the analysis area; thus, it was not evaluated in the BA or FEIS and an effects determination must be made. The desert pupfish occurs in the analysis area and the proposed project is likely to impact their habitat at some locations in the Las Cienegas NCA; however, this species has been reintroduced in many locations in Arizona and California, and it is not yet certain whether the introduced populations on Las Cienegas NCA would become self-sustaining. Based on the information in this document, *the Barrel Alternative may affect and is likely to adversely affect the desert pupfish.*

Longfin Dace (Agosia chrysogaster)

Summary of Applicable New Information and/or Changed Conditions

New documents received by the BLM provide species' locations:

- Polm (2014) notes that the species has been observed in Cienega Creek Reaches 2 and 4 through 10 and in Mattie Canyon.
- BLM (2013b) states that the species has been observed in pools in upper Cienega Creek and within Mattie Canyon.

- Simms (2004b) notes that this species occurs in the upper pools of the Empire Gulch Spring area (EG1) during a survey in June 2004.
- Simms (2013b) is the draft Empire Gulch monitoring report 2004-2013; the final Empire Gulch monitoring report, Simms (Simms 2014c) contains the same information as this draft with the addition of a map of the study site and a modified discussion; therefore, it is reasonable to only use the Simms (Simms 2014c) document for the SBA and SIR analyses. Longfin dace were not collected at Empire Gulch (EG1) after 2010 and had only been observed in the headspring of that area.
- BLM (2004) includes the Las Cienegas NCA riparian assessment forms (RACE data); this species was observed in many pools in upper Cienega Creek.
- Foster and Simms (2005) document the presence of longfin dace in the “lower” reach of Cienega Creek (CC4–CC8).
- BLM (2014d) contain data sheets for surface flow mapping at Las Cienegas NCA. Some data sheets prior to 2014 appear to be repeats of BLM (2013b), and the new data sheets from 2014 show this species as occurring within upper Cienega Creek.
- Simms (2014d) contains a field trip report with BLM and USFWS staff at riparian areas within Las Cienegas NCA; it has pictures, narrative, and locations. This species has been documented as occurring within upper Cienega Creek at Cienega Creek Reach 5 and other locations, though in several locations the pools had dried out and the fish were absent.
- Simms (2015) states that in fall 2014, Empire Gulch Reach 1 was surveyed with a seine, and no longfin dace were collected. Simms further indicates that because the headspring is too deep to seine, that the possibility of a few fish being present cannot be ruled out, and that if they occur there would be little or no reproduction or dispersal into the brook downstream of Empire Spring.
- Simms and Ehret (2014) is a draft report on Gila chub monitoring in Cienega Creek in 2005, 2007, 2008, 2011, and 2012, with notes on Gila topminnow, longfin dace, Sonora mud turtle, and Huachuca water umbel.

New documents received by the USGS Arizona Cooperative Fish and Wildlife Research Unit provide habitat information for this species:

- Bonar et al. (2010) estimate habitat suitability criteria for water depth, water velocity, substrate, and water temperature for the fishes (including the longfin dace) outside the analysis area at Cherry Creek, which runs through the Tonto National Forest. Overall, it was found that the longfin dace tends to be a habitat generalist.
- Schultz and Bonar (2006) mention that at the time the longfin dace was extant in Bonita Creek (which is within Gila Box Riparian NCA and not within the analysis area) and Cienega Creek.

A new document received by the USGS provides habitat information for this species:

- Waddle and Bovee (2010) document an instream flow assessment that was conducted at Cherry Creek in order to determine habitat for native and introduced fish (including longfin dace).

A new document submitted to the Department of Justice and BLM provides habitat information for this species:

- Miller (2006) gives the results of a study conducted to determine changes in habitat availability for fish in the San Pedro River (not within analysis area) as a function of changes in stream flow (the longfin dace was included in this study).

A new document submitted by Dennis Caldwell provides species' locations:

- Caldwell (2014) notes that this species was observed in lower Cienega Creek, in the CCNP.

A new document by the ADEQ provides species' locations:

- Lawson and Huth (2003) state that this species was observed in lower Cienega Creek in 2002.
- Huth (2014b) documents the presence of this species in both lower and upper Cienega Creek.

A new document by EPA provides species' locations:

- Leidy (2013) notes that the longfin dace was observed at multiple locations along lower Cienega Creek near its confluence with Davidson Canyon.

On July 29, 2013, "Restoring Leopard Frogs and Habitat in Sky Island Grasslands (Arizona): Final Report 2010-2012" was published by the FROG Project:

- Rosen et al. (2013) document the presence of longfin dace in upper and lower Cienega Creek.

In a recent technical memorandum, the annual fall count survey data (conducted by Simms and Ehret (2014)) were used to estimate a mean growth rate and model current demographic processes of this species where it is found in below Spring Water Canyon in Cienega Creek:

- Hatch (2015) analyzes fish counts conducted by BLM periodically from 2005 through 2012.

Baseline Conditions Considering New Information and Changed Conditions

This species was known to occur within the analysis area prior to the receipt of new information; however, most of the documents listed above contain more detailed information about the extent of occurrences of this species in the analysis area than was provided in the FEIS. Most of these new documents provide further evidence that this species occurs within the analysis area in Las Cienegas NCA in Cienega Creek and Mattie Canyon as well as in CCNP. This species has not occurred at Empire Gulch Springs (EG1) since 2010. Additionally, some of the documents listed above provides more information about this species' habitat (Bonar et al. 2010; Miller 2006; Waddle and Bovee 2010).

Hatch (2015) analyzes fish counts conducted by BLM periodically from 2005 through 2012, and based on these counts estimated positive mean growth rates for this species in one population on Cienega Creek. Positive mean growth rates indicate that this specific population on Cienega Creek is tending to increase, not shrink. However, because of the variability inherent in fish count data, the population data have substantial uncertainty, which can be analyzed by looking at the probability distribution of the data. By evaluating this probability distribution, it was determined that the lower bound of the 95 percent confidence intervals include growth rates that are negative. This means that even though mean growth rate is positive, there is still the possibility of long-term population decline due to environmental stresses. The probability that the extirpation threshold (which is defined in Hatch (2015) as a catch per unit of 1 fish over a 24-hour period) is reached was calculated for this species below Spring Water Canyon as 0.1832, meaning that there is an approximately 18 percent chance that this specific population of this species would be functionally extirpated at some point in the future. It should be noted that extirpation is not the same as extinction; extirpation refers only to the local population analyzed by this study.

These estimates are only probabilistic and cannot be interpreted as certainty. These estimates take into account this species' fitness in its environment but cannot fully account for random variability in the environment, future conditions that may be different from those experienced in the past, or density-dependent processes that may affect this species. It should be noted that the analysis only describes the sensitivity of this particular fish population to environmental change, but does not consider the cause of those stresses. The potential environmental stresses on the aquatic system from climate change and mine drawdown are fully assessed in the "Seeps, Springs, and Riparian Areas" section of this SIR. The conclusion that this fish species is sensitive to environmental stresses—whether natural or manmade—and that local populations could face extirpation because of those stresses, is consistent with the status of longfin dace as a Forest sensitive species.

Summary of FEIS Impact Conclusions

Direct impacts on the longfin dace are not anticipated as a result of the proposed project because there is no habitat or known occurrences of this species within the project area, no direct impacts on Cienega Creek have been modeled, and no direct impacts resulting from connected actions are anticipated. Additional impacts could occur on longfin dace populations located within the analysis area in Cienega Creek and Empire Gulch, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. A range of outcomes was assessed for Empire Gulch as well and are also highly uncertain. The most likely scenarios suggest that noticeable reductions in stream flow would occur, gradually increasing until widespread absence of flow occurred in Empire Gulch. Indirect impacts on longfin dace could also result from prey species of the longfin dace experiencing the same indirect impacts as the fish from groundwater drawdown, hence altering their predator-prey relationships. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a) (see FEIS, vol. 3, pp. 689–690).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. New information and changed conditions about the longfin dace in the analysis area include more detailed information about the extent of occurrences in Las Cienegas NCA and CCNP than was provided in the FEIS and more information about this species' habitat. The new analysis of demographic parameters for longfin dace in Cienega Creek shows that under current conditions, this species has a positive growth rate, which generally indicates increasing population trajectories. The probability that the extirpation threshold is reached for this species below Spring Water Canyon is 0.1832; however, this model of demographic processes give insight into the fitness of this species in this environment, but cannot predict with certainty that this fish would continue to occur at this location, or when or if extirpation would occur.

Direct and Indirect Impacts. As in the FEIS, direct impacts on this species are not anticipated because it does not occur within the project area. However, new occurrence records do occur within the analysis area. The indirect effects as stated in the FEIS are still expected to occur; this new information merely refines our knowledge of precise locations of this species.

In the FEIS, this species was documented as occurring in lower and upper Cienega Creek and Empire Gulch; however, these new documents suggest that the population within Empire Gulch has not persisted. In 2010, only one individual was caught, and no further individuals were caught between 2011 and 2014 (Simms 2014c; Simms 2015). Simms (2014c) indicates that Empire Gulch Reach 1 may have shifted so that it is no longer suitable habitat for Gila topminnow (some of which may also apply to longfin dace because of its similar size and life history): the area has shifted to a trophic structure driven by detritus instead of algae; duckweed covers the surface, leading to low light levels, which may make it hard for these fish to feed; and the predator load is heavy in this area, including Chiricahua leopard frogs and predatory invertebrates.

The new occurrence records for the longfin dace in the analysis area occur within upper Cienega Creek; according to aquatic analysis (see “Seeps, Springs, and Riparian Areas” section of this SIR) in 95 percent of the possible scenarios, mine drawdown by itself has little or no effect with regard to increasing the days with zero stream flow or changing the stream flow status from perennial, though mine drawdown would have some effect on water quality (measured by days of extremely low stream flow). In fact, for 95 percent of the possible scenarios, mine drawdown by itself does not change the number of pools, and pools retain at least 82 percent of their original volume even out to 1,000 years. While some habitat may be lost for this aquatic species as a result of the Barrel Alternative, the most recent analysis suggests that it would not result in widespread absence of flow within Cienega Creek or widespread loss of pool habitat; thus, habitat for this species would continue to occur and not be greatly reduced within Cienega Creek.

Given that habitat for this species is likely to remain in Cienega Creek and that this species occurs in a larger range that includes Arizona, New Mexico, Utah, Nevada, and Mexico, the loss of its habitat in the analysis area counts as only a small portion of loss of total habitat for this species. Thus, the impact determination does not change from what was stated in the FEIS: *the Barrel Alternative may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability.*

Gila chub (Gila intermedia)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of Gila chub in Cienega Creek and other aquatic locations within the analysis area:

- BLM (2013b) documents the presence of Gila chub within upper Cienega Creek observed during wet/dry mapping of Las Cienegas NCA.
- Polm (2014) documents this species as occurring in Cienega Creek Reaches 2 and 4 through 9 and in Mattie Canyon.
- Simms (2013a) documents many locations at Las Cienegas NCA as “pending” for being stocked with this species, including Wildlife Ponds, Cieneguita Wetlands, and Cienega Creek above Mattie Canyon (approximately CC4).
- BLM (2004) are the Las Cienegas NCA riparian assessment forms (RACE data); this species was observed in Mattie Canyon.
- Bodner and Simms (2008) document the presence of this species at Las Cienegas NCA.
- According to Bodner et al. (2007), Gila chub are known to occur in upper Cienega Creek.
- Foster and Simms (2005) document the presence of Gila chub in upper Cienega Creek (CC1–CC8) and give an abundance estimate of approximately 6,291 Gila chub in upper Cienega Creek in 2005.

- BLM (2013a; 2014d) contain data sheets for surface flow mapping at Las Cienegas NCA; UTMs for this species are provided (but some data sheets prior to 2014 appear to be repeats of BLM (2013b)). New data sheets for 2014 document occurrences of this species in upper Cienega Creek.
- Simms (2014d) contains a field trip report with BLM and USFWS staff at riparian areas within Las Cienegas NCA; it has pictures, narrative, and locations. This species occurs in upper Cienega Creek and was noted particularly at the confluence of Mattie Canyon and Cienega Creek (CC5).
- Simms and Ehret (2014) is a draft report on Gila chub monitoring in Cienega Creek in 2005, 2007, 2008, 2011, and 2012, with notes on Gila topminnow, longfin dace, Sonora mud turtle, and Huachuca water umbel

A document providing species accounts for the June 13, 2014, wet/dry mapping of Pima County CCNP was provided after the publication of the FEIS:

- Caldwell (2014) documents this species in three pools in the “head cut” reach of lower Cienega Creek at CCNP.

After publication of the FEIS, a new document was made available by the ADEQ. This document investigates developing quantitative methods for assessing stream channel physical condition by evaluating the lower Cienega Creek restoration project:

- Lawson and Huth (2003) document this species in two pools in the “head cut” reach of lower Cienega Creek at CCNP in 2001.

A report was prepared by Pima County in 2014 and sent to the Coronado National Forest Supervisor, Jim Upchurch, to discuss the environmental baseline and impacts of the Rosemont Copper Mine on listed species and hydrology of the CCNP:

- Powell et al. (2014) state that the Gila chub prefer deeper waters and are currently generally restricted to three Pima County ponds on the CCNP, within the lower Cienega Creek.

On August 14, 2014, Jeff Simms (BLM) drafted a report regarding the conditions at Las Cienegas NCA:

- Simms (2014b) includes a summary of a meeting and field trip where Jeff Simms (BLM) presented his professional opinion of current, baseline conditions at Las Cienegas NCA and then proposed thresholds he would like to be considered for the SBA.

In a report to BLM, Gila chub habitat preferences, reproduction, and movement were studied; habitat and demographic research was conducted on Gila chub in Cienega Creek:

- Schultz and Bonar (2006) document the habitat requirements, reproduction, movement patterns, and the locations of tagged Gila chub in upper Cienega Creek. In Cienega Creek, Gila chub were strongly associated with pools, and spawning occurs typically in individuals >75 mm and begins in late February to early March, with a smaller fall spawning possible after monsoon rains, and many recaptured individual are near their initial capture site.

On July 29, 2013, “Restoring Leopard Frogs and Habitat in Sky Island Grasslands (Arizona): Final Report 2010-2012” was published by the FROG Project:

- Rosen et al. (2013) document the presence of Gila chub in upper Cienega Creek and Mattie Canyon; and document the threat crayfish and nonnative fishes would have on this species.

In a recent technical memorandum, the annual fall count survey data (conducted by Simms and Ehret (2014)) were used to estimate a mean growth rate and model current demographic processes of this species where it is found in two populations in Cienega Creek:

- Hatch (2015) analyzes fish counts conducted by BLM periodically from 2005 through 2012.

Baseline Conditions Considering New Information and Changed Conditions

This species was known to occur within the analysis area prior to the receipt of new information; however, most of the documents listed above contain more detailed information about the extent of occurrences of this species in the analysis area than was provided in the FEIS. Most of these new documents provide further evidence that this species occurs within the analysis area in Las Cienegas NCA (i.e., Cienega Creek and Mattie Canyon) as well as in CCNP. Additionally, some of the documents listed above provide more information about this species' habitat preferences at Cienega Creek: this species was strongly associated with pools, tended not to move far from initial capture site, and may spawn twice per year in some cases (Schultz and Bonar 2006).

Simms (Simms 2014b) includes a summary of a meeting and field trip where Jeff Simms (BLM) presented his professional observations and opinion of current, baseline conditions at Las Cienegas NCA, which may be relevant to this species, including lack of surface water, head cutting, excessive sedimentation, poor water quality in some areas, high predation rates in pools that shrink rapidly in June and July, and the observation that some stream reaches (CC1 and CC2; Mattie Canyon) appear to be stable and functioning well in that they show little or no disruption of riparian or aquatic habitat characteristics or function.

Hatch (2015) analyzes fish counts conducted by BLM periodically from 2005 through 2012, and based on these counts estimated positive mean growth rates for this species in two populations on Cienega Creek. Positive mean growth rates indicate that this specific population on Cienega Creek is tending to increase, not shrink. However, because of the variability inherent in fish count data, the population data have substantial uncertainty, which can be analyzed by looking at the probability distribution of the data. By evaluating this probability distribution, it was determined that the lower bound of the 95 percent confidence intervals include growth rates that are negative. This means that even though mean growth rate is positive, there is still the possibility of long-term population decline due to environmental stresses. The probability that the extirpation threshold (which is defined in Hatch (2015) as a catch per unit of 1 fish over a 24-hour period) is reached was calculated for this species above Spring Water Canyon as 0.4637, meaning that there is an approximately 46 percent chance that this specific population of this species would be functionally extirpated at some point in the future. It should be noted that extirpation is not the same as extinction; extirpation refers only to the local population analyzed by this study. Below Spring Water canyon the probability is 0.8228, meaning there is an approximately 82 percent chance this species would be functionally extirpated at some point in the future.

These estimates are only probabilistic and cannot be interpreted as certainty; these estimates take into account this species' fitness in its environment but cannot fully account for random variability in the environment, future conditions that may be different from those experienced in the past, or density-dependent processes which may affect this species. It should be noted that the analysis only describes the sensitivity of this particular fish population to environmental change, but does not consider the cause of those stresses. The potential environmental stresses on the aquatic system from climate change and mine drawdown are fully assessed in the "Seeps, Springs, and Riparian Areas" section of this SIR. The conclusion that this fish species is sensitive to environmental stresses—whether natural or manmade—and that local populations could face extirpation because of those stresses, is consistent with the status of Gila chub as endangered, with limited habitat and reduced populations.

There is no new information regarding designated critical habitat for Gila chub.

Summary of FEIS Impact Conclusions

Direct impacts on the Gila chub are not anticipated as a result of the proposed project because there is no habitat or known occurrences of this species within the project area, no direct impacts on upper Cienega Creek have been modeled (this species has only been documented in Cienega Creek upstream of the confluence with Davidson Canyon), and no direct impacts resulting from connected actions are anticipated. Additional impacts could occur on Gila chub populations located within the analysis area in Cienega Creek, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. Impacts on Gila chub could also result from prey species of the Gila chub experiencing the same impacts as the fish from groundwater drawdown, hence altering their predator-prey relationships. The analysis area also includes portions of designated critical habitat for the Gila chub, and it is possible that within those areas, the proposed project could indirectly impact two of the three primary constituent elements of critical habitat for this species that are present within the analysis area (at two locations in designated critical habitat that are supported by groundwater—Empire Gulch and Cienega Creek): vegetative cover and water quantity.

Based on this, all action alternatives may affect and are likely to adversely affect the Gila chub and may affect and are likely to adversely affect designated critical habitat for the Gila chub (SWCA Environmental Consultants 2012a, 2012b, 2013a; U.S. Forest Service and SWCA Environmental Consultants 2013). After reviewing the current status of the Gila chub, the environmental baseline for the analysis area, the effects of the proposed action, and the cumulative effects, the USFWS's biological opinion as of October 2013 was that the proposed project is not likely to jeopardize the continued existence of the Gila chub and is not likely to destroy or adversely modify designated critical habitat (U.S. Fish and Wildlife Service 2013e) (see FEIS, vol. 3, p. 690).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. New information and changed conditions about the Gila chub in the analysis area include more detailed information about the extent of occurrences in Las Cienegas NCA and CCNP than was provided in the FEIS and more information about this species' habitat. The new analysis of demographic parameters for two populations of this species in Cienega Creek shows that under current conditions, this species has a positive growth rate, which generally indicates increasing population trajectories. The probability that the extirpation threshold is reached for this species above Spring Water Canyon is 0.4634; below Spring Water Canyon it is 0.8228. However, this model of demographic processes give insight into the fitness of this species in this environment, but cannot predict with certainty that this fish would continue to occur at this location, or when or if extirpation would occur.

Direct and Indirect Impacts. As in the FEIS, direct impacts on this species are not anticipated because it does not occur within the project area. However, new occurrence records do occur within the analysis area. The indirect effects as stated in the FEIS are still expected to occur; this new information merely refines our knowledge of precise locations of this species. The new occurrence records for the Gila chub in the analysis area occur within upper and lower Cienega Creek; according to aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR) in 95 percent of the possible scenarios, mine drawdown by itself has little or no effect with regard to increasing the days with zero stream flow or changing the stream flow status from perennial, though mine drawdown would have some effect on water quality (measured by days of extremely low stream flow). In fact, for 95 percent of the possible scenarios, mine drawdown by itself does not change the number of pools, and pools retain at least 82 percent of their original volume, even out to 1,000 years. While some habitat may be lost for this aquatic species as a result of the Barrel Alternative, the most recent analysis suggests that it would not result in widespread absence of flow within Cienega Creek or widespread loss of pool habitat that this species is strongly associated with in Cienega Creek; thus, habitat for this species would continue to occur and not be greatly reduced within Cienega Creek. The re-evaluated impacts based on new information do not differ substantially from those disclosed in the BA and FEIS, specifically, that mine drawdown would occur within Empire Gulch and that widespread absence of flow in Cienega Creek was not anticipated.

While the new analysis of demographic parameters provides insight into the sensitivity of this fish population to environmental change, it cannot take into account the causes of environmental change or future conditions, which may be different from the past. Thus, the impact determination does not change from what was stated in the FEIS: *the Barrel Alternative may affect and is likely to adversely affect the Gila chub and may affect and is likely to adversely affect designated critical habitat for the Gila chub.*

Gila topminnow (Poeciliopsis occidentalis occidentalis)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of Gila topminnow in Cienega Creek and other aquatic locations within the analysis area:

- BLM (2013b) documents the presence of Gila topminnow observed in upper Cienega Creek during wet/dry mapping of Las Cienegas NCA.
- Polm (2014) documents this species as occurring in Cienega Creek Reaches 2 and 4, Cieneguita Wetlands, and Mattie Canyon.
- Simms (2013a) documents this species as being stocked at many locations within Las Cienegas NCA (including many Wildlife Ponds and Cieneguita Wetlands ponds) from 2012 to 2014, with other stocking locations pending.
- Simms (2013b) is the draft Empire Gulch monitoring report 2004–2013. The final Empire Gulch monitoring report, Simms (Simms 2014c), contains the same information as this draft with the addition of a map of the study site and modified discussion; therefore, it is reasonable to only use the Simms (2014c) document for the SBA and SIR analyses.
- Simms (2014c) is the final Empire Gulch monitoring report 2004–2013; despite being established at Empire Gulch in 2001 and further augmented in 2002, 2003, and 2006, the Gila topminnow population at Empire Gulch has not persisted.
- BLM (2004) consists of the Las Cienegas NCA riparian assessment forms (RACE data); this species was observed in upper Cienega Creek, Empire Gulch near the confluence of Cienega Creek (EG2), and Mattie Canyon.
- Bodner and Simms (2008) document the presence of this species at Las Cienegas NCA. Bodner et al. (2007) note that Gila topminnow are found throughout locations in upper

Cienega Creek; populations in perennial sections of CC1 through CC3 appear to be declining, but those in perennial sections of CC5 through CC7 and Mattie Canyon may be stable.

- Foster and Simms (2005) document the presence of Gila topminnow at Cienega Creek. Gila topminnow were present in the "upper" reach of Cienega Creek (CC1 through CC3) but less commonly observed there than Gila chub, and they were also present and considered common in the "lower" reach (CC4 through CC8).
- BLM (2014d) contains data sheets for surface flow mapping at Las Cienegas NCA; UTMs for this species are provided (but some data sheets prior to 2014 appear to be repeats of BLM (2013b)). New data sheets from 2014 document this species as occurring in upper Cienega Creek.
- Simms (2014d) contains a field trip report with BLM and USFWS staff at riparian areas within Las Cienegas NCA; it has pictures, narrative, and locations. This species occurs at Empire Wildlife Pond, within pools in upper Cienega Creek, including some at the confluence of Cienega Creek and Mattie Canyon (CC5).
- Simms (2015) states that in the fall 2014, Empire Gulch Reach 1 was surveyed with a seine, and no Gila topminnow were collected. Simms further indicates that because the headspring is too deep to seine, the possibility of a few fish being present cannot be ruled out, and that if they occur there would be little or no reproduction or dispersal into the brook downstream of Empire Spring.
- Simms and Ehret (2014) is a draft report on Gila chub monitoring in Cienega Creek in 2005, 2007, 2008, 2011, and 2012, with notes on Gila topminnow, longfin dace, Sonora mud turtle, and Huachuca water umbel.

A document providing species accounts for the June 13, 2014, wet/dry mapping of Pima County CCNP was provided after the publication of the FEIS:

- Caldwell (2014) documents this species as being abundant at the "head cut" reach at CCNP, within the lower Cienega Creek.

A new document by the ADEQ provides species' locations:

- Huth (2014b) documents this species as occurring in upper Cienega Creek at approximately the dividing line between Cienega Creek Reaches 7 and 8.

A report was prepared by Pima County in 2014 and sent to the Coronado National Forest Supervisor, Jim Upchurch, to discuss the environmental baseline and impacts of the Rosemont Copper Mine on listed species and hydrology of the CCNP:

- Powell (2013b) indicates that Gila topminnow occur at CCNP within fragmented shallow water habitats.

On August 14, 2014, Jeff Simms (BLM) drafted a report regarding the conditions at Las Cienegas NCA.

- Simms (2014b) includes a summary of a meeting and field trip where Jeff Simms (BLM) presented his professional opinion of current, baseline conditions at Las Cienegas NCA and then proposed thresholds he would like to be considered for the SBA.

On July 29, 2013, "Restoring Leopard Frogs and Habitat in Sky Island Grasslands (Arizona): Final Report 2010-2012" was published by the FROG Project:

- Rosen et al. (2013) document the presence of Gila topminnow at both upper and lower Cienega Creek, and reintroduction at Road Tank; they also state that nonnative mosquitofish are the biggest threat to this species and that this species can coexist with leopard frog tadpoles.

In a recent technical memorandum, the annual fall count survey data (conducted by Simms and Ehret (2014)) were used to estimate a mean growth rate and model current demographic processes of this species where it is found in two populations in Cienega Creek.

- Hatch (2015) analyzes fish counts conducted by BLM periodically from 2005 through 2012.

Baseline Conditions Considering New Information and Changed Conditions

This species was known to occur within the analysis area prior to the receipt of new information; however, most of the documents listed above contain more detailed information about the extent of occurrences of this species in the analysis area than was provided in the FEIS. Most of these new documents provide further evidence that this species occurs within the analysis area in Las Cienegas NCA in Cienega Creek, Cieneguita Wetlands, and at reintroduction sites (Road Canyon, Empire, Gaucho, Spring Water, Nogales Spring, Little Nogales Spring Wildlife Ponds and Cieneguita Wetlands Ponds #1 and #3 between 2012 and 2014; in summer 2010, this species naturally immigrated to Cinco Wetlands Pond #1), as well as in CCNP.

Simms (2014b) includes a summary of a meeting and field trip where Jeff Simms (BLM) presented his professional observations and opinion of current, baseline conditions at Las Cienegas NCA, which may be relevant to this species, including lack of surface water, head cutting, excessive sedimentation, poor water quality in some areas, high predation rates in pools that shrink rapidly in June and July, and the observation that some stream reaches (CC1 and CC2; Mattie Canyon) appear to be stable and functioning well in that they show little or no disruption of riparian or aquatic habitat characteristics or function.

Hatch (2015) analyzes fish counts conducted by BLM periodically from 2005 through 2012, and based on these counts estimates positive mean growth rates for this species in two populations on Cienega Creek. Positive mean growth rates indicate that this specific population on Cienega Creek is tending to increase, not shrink. However, because of the variability inherent in fish count data, the population data have substantial uncertainty, which can be analyzed by looking at the probability distribution of the data. By evaluating this probability distribution, it was determined that the lower bound of the 95 percent confidence intervals include growth rates that are negative for population found below Spring Water Canyon. This means that even though mean growth rate is positive, there is still the possibility of long-term population decline due to environmental stresses. The probability that the extirpation threshold (which is defined in Hatch (2015) as a catch per unit of 1 fish over a 24-hour period) is reached was calculated for this species above Spring Water Canyon as 0.0000064156, meaning that there is a less than 0.01 percent chance that this specific population of this species would be functionally extirpated at some point in the future. It should be noted that extirpation is not the same as extinction; extirpation refers only to the local population analyzed by this study. Below Spring Water Canyon the probability is 0.9609, meaning there is an approximately 96 percent chance this species would be functionally extirpated at some point in the future.

These, estimates are only probabilistic and cannot be interpreted as certainty; these estimates take into account this species' fitness in its environment but cannot fully account for random variability in the environment, future conditions that may be different from those experienced in the past, or density-dependent processes that may affect this species. It should be noted that the analysis only describes the sensitivity of this particular fish population to environmental change, but does not consider the cause of those stresses. The potential environmental stresses on the aquatic system from climate change and mine drawdown are fully assessed in the "Seeps, Springs, and Riparian Areas" section of this SIR. The conclusion that this fish species is sensitive to environmental stresses—whether natural or manmade—and that local populations could face extirpation because of those stresses, is consistent with the status of Gila topminnow as endangered, with limited habitat and reduced populations.

Summary of FEIS Impact Conclusions

Direct impacts on the Gila topminnow are not anticipated as a result of the proposed project because there is no habitat or known occurrences of this species within the project area, no direct impacts on Cienega Creek have been modeled, and no direct impacts resulting from connected actions are anticipated. Additional impacts could occur on Gila topminnow populations located within the analysis area in Cienega Creek and Empire Gulch, where groundwater drawdown is modeled to occur as a result of all action alternatives. A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. A range of outcomes was assessed for Empire Gulch as well, and are also highly uncertain. The most likely scenarios suggest that noticeable reductions in stream flow would occur, gradually increasing until widespread absence of flow occurred in Empire Gulch. Impacts on Gila topminnow could also result from prey species of the Gila topminnow experiencing the same impacts as the fish from groundwater drawdown, hence altering their predator-prey relationships.

Based on this, all action alternatives may affect and are likely to adversely affect the Gila topminnow (SWCA Environmental Consultants 2012a, 2012b, 2013a; U.S. Forest Service and SWCA Environmental Consultants 2013). After reviewing the current status of the Gila topminnow, the environmental baseline for the analysis area, the effects of the proposed action, and the cumulative effects, the USFWS's biological opinion as of October 2013 is that the proposed project is not likely to jeopardize the continued existence of the Gila topminnow (U.S. Fish and Wildlife Service 2013e) (see FEIS, vol. 3, pp. 690–691).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. New information and changed conditions about the Gila topminnow in the analysis area include more detailed information about the extent of occurrences in Las Cienegas NCA and CCNP than was provided in the FEIS and more information about this species' habitat. The new analysis of demographic parameters for two populations of this species in Cienega Creek shows that under current conditions, this species has a positive growth rate, which generally indicates increasing population trajectories. The probability that the extirpation threshold is reached for this species above Spring Water Canyon is 0.0000064156; below Spring Water Canyon it is 0.9609. However, this model of demographic processes give insight into the fitness of this species in this environment, but cannot predict with certainty that this fish would continue to occur at this location, or when or if extirpation would occur.

Direct and Indirect Impacts. As in the FEIS, direct impacts on this species are not anticipated because it does not occur within the project area. However, new occurrence records do occur within the analysis area. The indirect effects as stated in the FEIS are still expected to occur; this new information merely refines our knowledge of precise locations of this species.

In the FEIS, this species was documented as occurring in lower and upper Cienega Creek and Empire Gulch; however, these new documents suggest that the population within Empire Gulch has not persisted, despite being augmented several times. This species was last observed in Empire Gulch Reach 1 in 2008 when two individuals were caught (Simms 2014c; Simms 2015). Simms (2014c) indicates that Empire Gulch Reach 1 may have shifted so that it is no longer suitable habitat for Gila topminnow: the area has shifted to a trophic structure driven by detritus instead of algae; duckweed covers the surface, leading to low light levels, which may make it hard for these fish to feed; and the predator load is heavy in this area, including Chiricahua leopard frogs and predatory invertebrates.

The re-evaluated impacts based on new information do not differ substantially from those disclosed in the BA and FEIS, specifically, that mine drawdown would occur within Empire Gulch and that widespread absence of flow in Cienega Creek was not anticipated. New occurrence records for the Gila topminnow in the analysis area occur within upper and lower Cienega Creek. According to aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR) in 95 percent of the possible scenarios, mine drawdown by itself has little or no effect with regard to increasing the days with zero stream flow or changing the stream flow status from perennial, though mine drawdown would have some effect on water quality (measured by days of extremely low stream flow). In fact, for 95 percent of the possible scenarios, mine drawdown by itself does not change the number of pools, and pools retain at least 82 percent of their original volume even out to 1,000 years. While some habitat may be lost for this aquatic species as a result of the Barrel Alternative, the most recent analysis suggests that it would not result in widespread absence of flow within Cienega Creek or widespread loss of pool habitat; thus, habitat for this species would continue to occur and not be greatly reduced within Cienega Creek.

Empire Wildlife Pond currently receives water from surface runoff as well as being supplemented by groundwater pumping. Groundwater modeling indicates that in the first 150 years after mine closure, drawdown greater than 10 feet is unlikely to occur at this location (FEIS, pp. 341–345) (Montgomery and Associates Inc. 2010; Tetra Tech 2010). The exact depth of the wells is not known; however, drawdown less than 10 feet was not considered in the FEIS to impact nearby wells (FEIS, p. 294). There also are not expected to be any changes in surface runoff due to the mine in this watershed (FEIS, p. 398). Therefore, the Gila topminnows in this location are not expected to experience habitat loss or degradation.

This species was documented as occurring and being reintroduced into the Cieneguita Wetlands. According to the new aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR) the number of pools at Cieneguita Wetlands does not change under any scenario, but impacts to pool volume are substantial and highly variable with pools being from 25 to 92 percent of their original volume from mine drawdown alone, after 1,000 years. Shorter time frames show similar impact, with pools being from 35 to 100 percent of their original volume at 100 years. Thus, Gila topminnow at Cieneguita Wetlands are expected to experience impacts due to habitat loss, habitat degradation, and increased predation as pool size shrinks.

While the new analysis of demographic parameters provides insight into the sensitivity of this fish population to environmental change, it cannot take into account the causes of environmental change or future conditions which may be different than the past.

Because the impacts are not substantially different than those expected in the FEIS, the impact determination does not change from what was stated in the FEIS: *the Barrel Alternative may affect and is likely to adversely affect the Gila topminnow.*

Ocelot (Leopardus pardalis)

Summary of Applicable New Information and/or Changed Conditions

After publication of the FEIS, a single male ocelot has been documented in the analysis area by wildlife cameras:

- USFWS (2014i) is a letter from Steven Spangle, Field Supervisor, USFWS, to Jim Upchurch, Forest Supervisor, Forest Service, that confirms the presence of an ocelot in the Santa Rita Mountains within the analysis area, April 2014.

Baseline Conditions Considering New Information and Changed Conditions

A single male ocelot was detected on wildlife cameras within the analysis area of the proposed project in April 2014, and there were no documented occurrences of this species in the Santa Rita Mountains prior to these photographs (SWCA Environmental Consultants 2015f).

Summary of FEIS Impact Conclusions

Ocelots in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow, groundwater drawdown, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Impacts on ocelots could also result from prey species experiencing the same impacts as the ocelots, hence altering their predator-prey relationships. Changes to food sources could also result in changes in dispersal and hunting success. Based on this, all action alternatives may affect and are likely to adversely affect the ocelot (SWCA Environmental Consultants 2012a, 2013a; U.S. Forest Service and SWCA Environmental Consultants 2013). After reviewing the current status of the ocelot, the environmental baseline for the analysis area, the effects of the proposed action, and the cumulative effects, the USFWS's biological opinion as of October 2013 is that the proposed project is not likely to jeopardize the continued existence of the ocelot (U.S. Fish and Wildlife Service 2013e) (see FEIS, vol. 3, pp. 691–692).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. New information and changed conditions about the ocelot include the documented occurrences of one individual in the analysis area. In the FEIS, the ocelot was assumed present for purposes of impact analysis, and thus the only difference with the new information is a change in certainty.

Direct and Indirect Impacts. Although ocelots were not known to occur within the analysis area prior to the receipt of new information, they were presumed present because they are an often cryptic and wide-ranging species, and the analysis area is within the range of the ocelot and contains suitable habitat for that species. Thus, the impacts to this species are expected and will not change from what is already contained in the FEIS: ocelots in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow, groundwater drawdown, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Impacts on ocelots could also result from prey species experiencing the same impacts as the ocelots, hence altering their predator-prey relationships. Changes to food sources could also result in changes in dispersal and hunting success.

Thus, the impact determination will not change from what was stated in the FEIS; *the Barrel Alternative may affect and is likely to adversely affect the ocelot.*

Lesser long-nosed bat (Leptonycteris curasoae yerbabuenae)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of lesser long-nosed bat forage species in Las Cienegas NCA within the analysis area:

- BLM 2012 provides data about agave density monitoring at core use areas for lesser long-nosed bats at Las Cienegas NCA during 2011; locations and results are given.

A new survey report for 2013 lesser long-nosed bat roost monitoring was provided by WestLand.

- WestLand (2015a) provides the results of the 2013 lesser long-nosed bat roost monitoring and surveys in the Rosemont area; 81 abandoned mine features were surveyed, 24 inside the perimeter fence, 52 outside but within 1-mile buffer of perimeter fence, and 5 mine openings in the Helena Mine Complex, outside the buffer.

Baseline Conditions Considering New Information and Changed Conditions

The new information provided includes a new inventory of possible forage plants for lesser long-nosed bats within the Las Cienegas NCA but outside the analysis area, east of Cienega Creek; this does not change the baseline for this species within the analysis area, however. WestLand (2015a) changes the baseline for this species by surveying new locations, confirming that abandoned mine features still contain lesser-long nosed bats, and providing updated counts for several known lesser long-nosed bat colonies. In 2013, 81 abandoned mine features were surveyed: 24 inside the perimeter fence, 52 were outside the perimeter fence but within a 1-mile buffer (23 of these were previously unsurveyed), and 5 were mine openings in the Helena Mine Complex, located outside the buffer. T he known lesser-long nosed bats roosts still contain this species (Helena Mine Complex, Chicago Mine, and Adit R-2); further in 2013, exit counts were competed for Helena Mine (with counts of 7,800, 5,700, and 2,700) and Adit R-2 showed a “considerable” amount of lesser long-nosed bat activity. Two of the 23 new abandoned mine features contained evidence of “nectivorous” bat use (which could be either lesser-long nosed bat or Mexican long-tongued bat), three had evidence of insectivorous bat use, and one was a vertical shaft that was not surveyed; the rest contained no evidence of bat usage. Of the previously surveyed mines, seven had signs of “nectivorous bats” not identified to species (three within the perimeter fence).

Summary of FEIS Impact Conclusions

All action alternatives would directly impact and result in the permanent loss of at least one known lesser long-nosed bat postmaternity roost site (Site 9/Chicago Mine) within the project area, which contained roosting lesser long-nosed bats in 2008, 2009, and 2011.[8] While any individuals present within mine adits or shafts the project area would either perish or be forced to relocate, Rosemont Copper would close the Chicago Mine (and any newly discovered sites, based on predisturbance surveys) when lesser long-nosed bat are not present; therefore, no lesser long-nosed bats would be killed by the construction of the mine pit, provided that no individuals are in the mine during closure. Given the anticipated levels of project related activity and associated disturbance from vibration, noise, and artificial night lighting, two additional lesser long-nosed bat postmaternity roosts adjacent to the project area could be impacted: lesser long-nosed bats were detected at Site R-2 in 2008, 2009, and 2011 and at the Helena Mine complex in 2008, 2009, 2010, and 2011.

[8] This site was not surveyed in 2010.

The magnitude of impacts from vibration, noise, artificial night lighting, and increased traffic volumes to these bat roosts is uncertain, but impacts are expected to be higher the closer the mine facilities are to the roosts (which would vary by alternative). All action alternatives would include the relocation of the Las Colinas portion of the Arizona National Scenic Trail, which could reduce the impacts of noise from the trail to the roost: the reroute would reconnect the trail, regardless of action alternative, to the existing trail at approximately the same location, and the closest the trail would come to the roost is approximately 1,265 feet, whereas the trail currently comes as close as approximately 685 feet to the roost. Any individuals present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from groundwater drawdown, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads.

The proposed project would impact lesser long-nosed bats through the removal of forage plants (i.e., paniculate agaves) in the project area that are in the late summer range of the species. Based on surveys, it was estimated that between 196,268 and 306,209 Palmer's agave rosettes would be impacted as a result of the proposed project (WestLand Resources Inc. 2009b). To minimize impacts to this species from the removal of forage plants, agaves would be salvaged and replanted as part of the design for all action alternatives, but the number of agaves planted would be only about 35,000. There would also be some agave seeds added to the seed mix if possible, but the results are untested. Rosemont Copper would also restrict grazing on mitigation lands for which they would record a restrictive covenant (Davidson Canyon parcels; Helvetia Ranch Annex North parcel; and Sonoita Creek Ranch parcel). Impacts on lesser long-nosed bat forage plants also could result from an increase in fugitive dust and air pollutants in the project area and adjacent to access roads and the proposed utility corridor. Reduced food sources could result in reduced reproduction success or could result in the abandonment of the analysis area and nearby roosts by lesser long-nosed bats. Known lesser long-nosed bat maternity roosts are more than 75 miles from the proposed project area; therefore, no impacts on lesser long-nosed bat maternity roosts are anticipated.

Based on this, all actions may affect and are likely to adversely affect the lesser long-nosed bat (SWCA Environmental Consultants 2012a, 2012b, 2013a; U.S. Forest Service and SWCA Environmental Consultants 2013). After reviewing the current status of the lesser long-nosed bat, the environmental baseline for the analysis area, the effects of the proposed action, and the cumulative effects, the USFWS's biological opinion as of October 2013 is that the proposed project is not likely to jeopardize the continued existence of the lesser long-nosed bat (U.S. Fish and Wildlife Service 2013e) (see FEIS, vol. 3, pp. 692–693).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. Because the location of the surveyed agave plants in BLM 2012 is outside the analysis area, this document did not contain any change to the baseline of this species; this document does not change the expected impacts to the forage plants of this species within the analysis area. WestLand 2015a provides survey and monitoring data showing two new potential roost locations, and that lesser long-nosed bats continue to occur in the previously known roost sites.

Direct and Indirect Impacts: Lesser long-nosed bats were already known to roost at the Helena Mine Complex, Chicago Mine, and Adit R-2; this new information indicates that they still occur there. As no change in the Barrel Alternative has been made, Chicago Mine, within the project area, is still expected to be permanently lost, with individuals occurring within the mine features either forced to relocate or be killed, though it is planned to close the mine when this species is not present prior to mine construction to minimize the individuals killed. The other two postmaternity roosts are within the analysis area and, as they are still occupied, still expected to experience impacts due to project related activities as a result of dust, artificial night lighting, vibration, and noise.

The 10 abandoned mine features containing signs of nectivorous bat use would be impacted by the Barrel Alternative. Although the bats were not positively identified as lesser long-nosed bats, it cannot be ruled out that this species occurs at these locations because this species occurs within the analysis area. Eight of these locations were previously known to contain bats, and thus there is no change in impacts to these locations, those in the project area would experience direct impacts from being removed and those outside the Barrel Alternative, but inside the analysis area would experience impacts due to project activities. Both of the two new roosts are located within the 1-mile buffer of the perimeter fence, and thus individuals using these roosts are expected to experience impacts due to project related activities associated with noise, vibration, and artificial night lighting.

Overall, the change in baseline was small, two new potential roosting sites have been discovered within the analysis area. The species of bat using these abandoned mine features has not been confirmed, and it is unknown how many bats use these new locations. Even assuming that both are used by lesser long-nosed bats, the survey results did not indicate large numbers of bats using these locations; whereas Chicago Mine, and Adit R-2, and Helena Mine Complex either qualitatively or quantitatively indicated use by many individuals. Because these new locations are likely to be used by few individuals and are not anticipated to be removed, the increase in expected impacts does not change the impacts analysis substantially.

As in the FEIS: *the Barrel Alternative may affect and is likely to adversely affect the lesser long-nosed bat.*

White-nosed coati (Nasua narica)

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of the white-nosed coati in Cienega Creek and other aquatic locations within the analysis area:

- BLM (2013b) documents the presence of coati observed during wet/dry mapping of Las Cienegas NCA; individuals were observed in Mattie Canyon and the stretch between Headwaters and Gardner Canyon (Cienega Creek Reaches 1 and 2). This species was observed along upper Cienega Creek, and along Mattie Canyon.
- BLM (2014d) contains data sheets for surface flow mapping at Las Cienegas NCA; individuals were observed in Mattie Canyon and CC1 and CC2 (but some data sheets prior to 2014 appear to be repeats of BLM (2013b)).

A document providing species accounts for the June 13, 2014, wet/dry mapping of Pima County CCNP was provided after the publication of the FEIS:

- Caldwell (2014) documents the presence of seven coati at lower Cienega Creek during the June 2014 wet/dry mapping of CCNP.

Baseline Conditions Considering New Information and Changed Conditions

The documents provided after the publication of the FEIS provide further evidence that the white-nosed coati occurs within the analysis area, along upper Cienega Creek (at unspecified locations as well as Reaches 1 and 2) and along Cienega Creek at CCNP.

Summary of FEIS Impact Conclusions

Direct impacts on the white-nosed coati could occur as a result of the proposed project because this species has been documented within the project area. Any individuals present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, groundwater drawdown, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Indirect impacts on white-nosed coatis could also result from prey species of the white-nosed coati experiencing the same impacts as the coati from proposed project activities, hence altering their predator-prey relationships. Additionally, because the mine pit lake water quality could exceed wildlife standards for three contaminants that are known to bioaccumulate (i.e., cadmium, mercury, and selenium), impacts to this species could occur from eating aquatic invertebrates originating from the mine pit lake. Based on this, all action alternatives may impact individuals but are not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability (SWCA Environmental Consultants 2013a) (see FEIS, vol. 3, p. 693).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. This species was known to occur within the analysis area prior to the receipt of new information; however, the new information provides specific location data, which allows for a more detailed analysis in the SIR.

Direct and Indirect Impacts. Because this species was known to occur within the project and analysis areas, the analysis of impacts in the FEIS already took into account their presence within the project and analysis areas when considering possible impacts to this species; therefore, the direct and indirect impacts outlined in the FEIS within the project area have not changed. However, the new aquatic analysis (see “Seeps, Springs, and Riparian Areas” section of this SIR) indicates that the surface water and woodland area this species requires are not expected to be greatly reduced along Cienega Creek as it is projected to retain its flow, perennial pools, and have comparatively minor impacts on water quality, and is not likely to see major shifts in riparian vegetation health or extent, even out to 1,000 years. Thus, some minor impacts to habitat and prey and forage plants are expected to this species along Cienega Creek as a result of the proposed project.

Based on the FEIS and the new information provided, *the Barrel Alternative may impact individuals but is not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability.*

Jaguar (Panthera onca)

Summary of Applicable New Information and/or Changed Conditions

After the publication of the FEIS, USFWS designated critical habitat for the jaguar. On March 5, 2014, the USFWS announced the final designation of approximately 764,207 acres of critical habitat for the jaguar in Pima, Santa Cruz, and Cochise Counties in Arizona and Hidalgo County in New Mexico (U.S. Fish and Wildlife Service 2014c). A total of 59,492 acres of designated critical habitat occurs in the analysis area: 53,498 acres in Unit 3 – Patagonia and 5,994 acres in Unit 4 – Whetstone (subunit 4b – Whetstone-Santa Rita):

- USFWS (U.S. Fish and Wildlife Service 2014c)

A male jaguar has been documented in the analysis area multiple times, and as recently as January 2015, with the use of wildlife cameras:

- SWCA (2015f)

Baseline Conditions Considering New Information and Changed Conditions

This new information includes the designation of critical habitat for the jaguar, and includes the continued documentation of a single, male jaguar whose home range occurs within the analysis area.

Summary of FEIS Impact Conclusions

All action alternatives could impact the jaguar because this species was recently (fall 2012 through spring 2013) documented in the analysis area adjacent to the project area. Jaguars in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, groundwater drawdown, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Impacts on jaguars could also result from prey species experiencing the same impacts as the jaguars, hence altering their predator-prey relationships. Changes to food sources could also result in changes in dispersal and hunting success.

Two units of proposed critical habitat occur within the analysis area, for a total of approximately 59,492 acres (approximately 6.9 percent of the total acreage proposed as critical habitat for this species), and all action alternatives would directly impact one unit (3 – Patagonia) of jaguar proposed critical habitat (table 47). The direct impacts in this table include areas within the security fence and areas impacted by the construction of the primary access road, all other new roads, the electrical transmission line and a water supply pipeline (and associated utility maintenance road), and the rerouted Arizona National Scenic Trail. The primary constituent elements specific to jaguars within the analysis area include expansive open spaces that provide connectivity to Mexico; contain adequate levels of native prey species; include surface water sources; contain Madrean evergreen woodland or semidesert grassland vegetation communities; are characterized by rugged terrain; are characterized by minimal to no human population density, no major roads, or no stable nighttime lighting; and are below 6,562 feet in elevation. As discussed below, all action alternatives will negatively impact most primary constituent elements in the short term, and some primary constituent elements will be impacted indefinitely.

Table 47. Direct impacts (acres and percent lost by unit and total) to jaguar proposed critical habitat resulting from each action alternative and connected actions

Unit	Proposed Action	Phased Tailings	Barrel	Barrel Trail	Scholefield-McCleary
3 – Patagonia	4,518 (1.2% and 0.5%)	4,390 (1.2% and 0.5%)	4,013 (1.1% and 0.5%)	4,041 (1.1% and 0.5%)	5,383 (1.5% and 0.6%)

Note: The calculations of direct impacts in this table do not include the areas of roads that would be decommissioned because it is assumed that the decommissioning of roads would not negatively impact primary constituent elements of proposed critical habitat but rather would convert roads that currently lack primary constituent elements to areas that may provide primary constituent elements.

Connectivity to Mexico would likely be affected for areas beyond (north and northeast) of the project area in unit 3 because of activity and disturbance by the proposed project. It is anticipated that during most of the mine operation and during postclosure, prey species density and diversity are expected to decrease, both in the project area (unit 3) and, to a lesser degree, the analysis area (unit 3 and possibly unit 4b). During and after operations, the open pit would not provide suitable habitat for prey species, and during operations, the facilities would not provide habitat for any prey species. Because of the amount of human activity during the life of the mine and impacts from direct ground disturbance, noise, vibration, dust, artificial night lighting, and traffic, most jaguar prey species would likely avoid the project area and could be impacted by these activities outside the project area within the analysis area. Postclosure is more difficult to predict, but the area of the open pit and the canyons and rocky habitats within the project area would be permanently altered or lost as wildlife habitat; after closure, the tailings facility would likely become revegetated with grasses and shrubs, so some prey species would reinhabit these areas.

The project would impact surface water sources through groundwater drawdown and alteration of surface water flow patterns: some surface water, seeps, and springs would be lost owing to direct surface disturbance or falling groundwater levels, and several naturally occurring drainages would be lost owing to direct surface disturbance or altered as a result of reduced surface water flow. Early in the process, the project area would be cleared of most vegetation (i.e., Madrean evergreen woodland, semidesert grassland, and riparian vegetation), which would eliminate the primary constituent element of 1 to 50 percent cover in semidesert grasslands and Madrean evergreen woodland. There would be phased reclamation using a native species seed mix (composed of grasses, herbs, and small shrubs) beginning at year 1, but about 50 percent of the reclamation would be during years 16 to 22 and at closure (CDM Smith 2012). In the long term, the exact structure and composition of native vegetation within the reclaimed areas are largely unknown.

The project would result in a change to the terrain within the project area: some of the moderate to highly rugged terrain would become less so (e.g., some canyons would be filled), while the project would actually alter the topography to become more rugged terrain (e.g., creation of waste rock facility). One of the most obvious changes to be caused by the proposed copper mine in the proposed jaguar critical habitat is the transformation from a relatively undisturbed landscape to one that shows extensive evidence of human activity. At first, there would be activity from the mining operation; later, there would be an altered landscape. These changes would be the result of a functionally increased population density and an increase in artificial night lighting.

As mentioned in the “Impacts from Increased Traffic Volumes on SR 83 and Other Roads” section of the FEIS, roads result in predominantly negative impacts on large mammals (Fahrig and Rytwinski 2009). Little is known, however, about the level of impacts to jaguars caused by vehicle strikes in the United States. Increased traffic, especially large trucks for the life of the mine, on roads, including SR 83, and possibly non-mine-related traffic on Box Canyon would lead to an increased risk of jaguars being struck by vehicles. However, because jaguars in Arizona are scarce and no jaguars are known to have been struck by a vehicle in Arizona, it is unlikely that there is a great risk of vehicles striking jaguars on either road. Increased traffic on these roads could also result in prey species experiencing the same impacts as the jaguars, hence altering their predator-prey relationships.

Based on this, all action alternatives may affect and are likely to adversely affect the jaguar and may affect and are likely to adversely affect jaguar proposed critical habitat (SWCA Environmental Consultants 2012a, 2012b, 2013a; U.S. Forest Service and SWCA Environmental Consultants 2013). After reviewing the current status of the jaguar, the environmental baseline for the analysis area, the effects of the proposed action, and the cumulative effects, the USFWS’s biological opinion is that the proposed project is not likely to jeopardize the continued existence of the jaguar and will not destroy or adversely modify proposed critical habitat (U.S. Fish and Wildlife Service 2013e) (see FEIS, vol. 3, pp. 693–695).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information: The additional documented occurrence of this species within the analysis area will not change the analysis methodology in the FEIS, because this species was already known to be present within the analysis area. The proposed critical habitat was known to occur in the analysis area and was considered in the FEIS; however, the designated critical habitat is not identical to the proposed for this species and must be considered in this document. After analysis of refined habitat features, some areas that were included in the proposed critical habitat no longer contained jaguar primary constituent elements and were excluded from the designated critical habitat (U.S. Fish and Wildlife Service 2014c) and thus the percentage of designated critical habitat that occurs within the analysis area has changed.

Direct and Indirect Impacts. The jaguar was known to occur within the analysis area, and the new occurrence records confirm its continued presence. Thus, direct and indirect impacts to this species as a result of the Barrel Alternative are expected to occur as discussed in the FEIS and have not changed. Thus, the effects determination will not change from what was stated in the FEIS: *the Barrel Alternative may affect and is likely to adversely affect the jaguar.*

Critical habitat. Even though the Barrel Alternative has not changed in terms of acres of direct and indirect impact to critical habitat (59,492 acres), the percentage of impacted acres of total designated critical habitat (approximately 7.8 percent) has increased from the percentage of total proposed critical habitat described in the FEIS (approximately 6.9 percent) because some areas of proposed critical habitat outside the project area were not designated as critical habitat. Two units of designated critical habitat occur within the analysis area, for a total of 59,492 acres of critical habitat: 53,498 acres in Unit 3 – Patagonia; and 5,994 acres in Unit 4 – Whetstone (subunit 4b – Whetstone-Santa Rita). The Barrel Alternative would directly impact one unit (3 – Patagonia) of jaguar designated critical habitat with the project area, resulting in loss of 4,013 acres of jaguar critical habitat (approximately 0.5 percent of total jaguar designated critical habitat and 1.1 percent of unit 3). Impacts to jaguar critical habitat were known to occur in the FEIS. While the percentage of acres of jaguar critical habitat occurring in the analysis area increased from 6.9 percent as proposed to 7.8 percent as designated, the total change is less than one percentage point. This change is due to areas outside the analysis area that were proposed but did not become designated, and not due to any change in the Barrel Alternative.

There is no percent change in directly impacted acres of designated jaguar critical habitat in comparison with proposed critical habitat for the Barrel Alternative. The direct and indirect impacts as analyzed in the FEIS are not expected to change because no changes have been made to the size of the analysis area or scope of project. Because of the small changes in the extent of impact to jaguar designated critical habitat, the conclusions presented in the FEIS are still valid. Based on this new information, the effects determination will not change from what was stated in the FEIS: *the Barrel Alternative may affect and is likely to adversely affect jaguar designated critical habitat.*

Mexican gray wolf (Canis lupus baileyi)

Summary of Applicable New Information and/or Changed Conditions

This species has not been evaluated in any of the prior documents regarding this proposed project (SBA, biologists' report, FEIS) because it is not known to occur within Pima or Santa Cruz Counties, Arizona. However, new conditions for this species have occurred since the publication of the FEIS.

New information for background/baseline/impact conclusions:

- USFWS (2015b) publishes the final rule, effective February 17, 2015, to determine endangered status for the Mexican gray wolf, revising the ESA list of threatened and endangered wildlife, which will make a separate entry for this subspecies and thereby separating it from the proposal regarding the delisting of the gray wolf (*Canis lupus*). At the same time, the regulations for the nonessential experimental population of this species were revised and expanded to include an increased 10J area and modifying regulations allowing for more effective management of wolves.
- USFWS (2015c) revises the regulations for the nonessential, experimental population of the gray wolf. The 2015 action expands the geographic boundaries of the Mexican Wolf Experimental Population Area (MWEPA), or 10J area, where individuals from the Mexican gray wolf experimental population will be allowed to occur. The 10J area has expanded south of Interstate 10 (I-10) to the International boundary with Mexico, and now includes the entire analysis area. The analysis area occupies Zone 2 of the MWEPA, where wolves may naturally disperse (from northern populations or from populations occurring in Sonora, Mexico) into or be translocated into in the future; however, this species is not currently known to occur in this area.
- USFWS (2015a) documents the results of the annual Mexican gray wolf population survey: a minimum of 109 wolves occur in the wild in Arizona and New Mexico.

Baseline Conditions Considering New Information and Changed Conditions

As mentioned above, the Mexican gray wolf was not considered in the FEIS because it is not known to occur within the analysis area and the 10J area had not been expanded to cover the entire analysis area until after publication of the FEIS.

Summary of FEIS Impact Conclusions

Not applicable; this species was not analyzed in the FEIS because it is not known to occur in Pima or Santa Cruz Counties.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. New information and changed conditions about the Mexican gray wolf include the creation of a separate entry for this subspecies to determine its endangered status under ESA and separate it from the delisting proposal for the gray wolf; further new information has revised the regulations for nonessential, experimental populations, and to expand the 10J area to include all of southern Arizona south of I-40, including the analysis area.

Listing Status and Federal Actions. Gray wolf subspecies or populations by region were originally listed individually. On April 28, 1976, the Mexican gray wolf subspecies was listed as endangered in the southwestern United States and Mexico (41 Federal Register (FR) 17736). On March 9, 1978 the gray wolf was listed as an endangered population at the species level (43 FR 9607, March 9, 1978), reflecting changes in understanding in wolf taxonomy and the fact that wolves in the wild often disperse across subspecies boundaries; however, the 1978 rule made clear that subspecies would continue to be maintained and conserved (U.S. Fish and Wildlife Service 2015b). The USFWS proposed a rule on June 13, 2013 (78 FR 35664) to delist the gray wolf and maintain protections to the Mexican gray wolf, listing it as an endangered subspecies. On February 17, 2015, the Mexican gray wolf subspecies was listed as endangered under the ESA (U.S. Fish and Wildlife Service 2015b), and the USFWS finalized revisions to the regulation for the nonessential experimental population Mexican gray wolf (U.S. Fish and Wildlife Service 2015c).

Taxonomy. Since the subspecies was first described in 1929 as *Canis nubilus baileyi*, Mexican gray wolf taxonomy has undergone major revision; however, morphological and genetic studies have continued to conclude that the Mexican gray wolf is a valid subspecies of gray wolf (U.S. Fish and Wildlife Service 2015b). The Mexican gray wolf is the smallest extant subspecies of gray wolf in North America with adults weighing 50 to 90 pounds (23 to 41 kg) and a shoulder height of 25 to 32 inches (63 to 81 cm); they are typically patchy black, brown, or cinnamon and cream color, but solid black or white color, as seen in other gray wolf subspecies, does not occur (U.S. Fish and Wildlife Service 2015b).

Historical Range. Historically, Mexican wolves occurred in the Santa Rita, Tumacacori, Atascosa-Pajarito, Patagonia, Chiricahua, Huachuca, Pinaleño, and Catalina Mountains, west to the Baboquivari Mountains in southern Arizona, and east into New Mexico. Historical population estimates are generally not available or reliable as they are based on accounts from ranchers or trapping records; however, by 1942, breeding populations of Mexican gray wolves were thought extirpated from the United States as a result of government and private efforts to kill predators such as wolves, though reports of wolves crossing into the United States from Mexico persisted into the 1960s. By the time the Mexican gray wolf was listed in 1976, no wild populations were known to remain in the United States or Mexico. Several Mexican wolf individuals captured in the wild in Mexico became the basis for the captive breeding program (U.S. Fish and Wildlife Service 2015b).

Current Range. In 1998, the USFWS established the MWEPA in central Arizona, New Mexico, and a portion of Texas, and 11 wolves from the captive-breeding program were released into the Blue Range Wolf Recovery Area (BRWRA) within the MWEPA (U.S. Fish and Wildlife Service 2015b). Additional releases and translocations have occurred and by 2014, a population count indicates that at least 109 Mexican gray wolves inhabit the MWEPA (U.S. Fish and Wildlife Service 2015a). In 2015, the USFWS revised the regulations for the nonessential experimental population of this subspecies by expanding the boundaries of the 10J area south of I-10 in Arizona, modifying the regulations that govern release, translocation, removal and take of this subspecies, and issuing a permit for management of this subspecies both inside and outside of the MWEPA (U.S. Fish and Wildlife Service 2015c).

Life History. Historically, Mexican gray wolves were associated with montane woodlands, consisting of evergreen oaks (*Quercus* spp.), pinyon (*Pinus edulis*) or juniper (*Juniperus* spp.) to higher elevation pine (*Pinus* spp.) or mixed conifer forests and adjacent grasslands at elevations of 4,000 to 5,000 feet above mean sea level. Mexican gray wolves likely selected these vegetation communities based on the availability of ungulate prey, water, cover, and den sites; these wolves were thought to avoid desert scrub and semidesert grasslands. Currently, Arizona wolves inhabit pine-oak woodlands, pinyon-juniper woodlands, and mixed conifer forest. Historical diet probably consisted of white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), elk (*Cervus elaphus*), collared peccaries (javelina) (*Tayassu tajacu*), pronghorn (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), jackrabbits (*Lepus* spp.), cottontails (*Sylvilagus* spp.), and small rodents; in Arizona, they show a strong preference to elk, compared with other ungulates, though deer and small animals are also preyed upon (U.S. Fish and Wildlife Service 2015b).

Status in analysis area. This species is not known to occur in the analysis area. The nearest U.S. population is more than 100 miles northeast of the analysis area. A single pair with pups is known to occur in the San Luis Mountains just south of the border (approximately 30 miles southwest of the analysis area) (U.S. Fish and Wildlife Service 2015c), though more animals may be released in the future. However, the regulations for the nonessential experimental population of the Mexican gray wolf were recently revised to allow greater area for the population to achieve necessary population growth and distribution to become self-sustaining, allow for the possibility that wolves from Sonora and Chihuahua, Mexico, to disperse into the United States, and increase the flexibility of management of the experimental population of Mexican gray wolves (U.S. Fish and Wildlife Service 2015b, 2015c). The term BRWRA has been discontinued, and the analysis area has been placed into Zone 2 of the MWEPA. In Zone 2, which Mexican gray wolves will be allowed to naturally disperse into and occupy, they may be translocated into in the future in a phased approach.

Direct and Indirect Impacts

Because this species is not known from the analysis area, and the nearest known populations are distant from the analysis area and separated from the analysis area by interstate freeways, border fence, human activities, and areas of vegetation (i.e. desert scrub and semidesert grassland) that this species is likely to avoid, *the Barrel Alternative would have no effect on the Mexican gray wolf.*

Forest Service and BLM sensitive bat species

Summary of Applicable New Information and/or Changed Conditions

New documents provided by the BLM provide documentation of western red bat (*Lasiurus blossevillii*) in Cienega Creek and other aquatic locations within the analysis area:

- Bodner and Simms (2008) document the presence of this species at Las Cienegas NCA; this species has been observed along upper Cienega Creek.

New documents provided by WestLand provide further documentation of these sensitive bat species within the perimeter fence and within a 1-mile buffer of the perimeter fence:

- WestLand (2015a) documents the continued presence of sensitive bat species in abandoned mine features where they were known to occur (11, 13, 15, 17, 33, 38, 39, 40, 49, 59, 62, DR-01, R-8A, R-44, R-49, R-54, R-55, and DR-06) and abandoned mine features where they had not been known to occur prior to FEIS publication (R-11, NS-4, NS-15, and NS-18).

Baseline Conditions Considering New Information and Changed Conditions

These species were known to occur within the analysis area prior to the receipt of new information; however, the new documents provide new or more specific locations. Bodner and Simms (2008) document western red bats along upper Cienega Creek at Las Cienegas NCA. In WestLand (2015a), sensitive bat species were documented in many abandoned mine features in the project and analysis areas (both within the perimeter fence and within a 1-mile buffer of the perimeter fence) where they had been known to occur at the time of FEIS publication. However, one previously surveyed feature (R-11) in the analysis area that had never contained bats prior to 2013, contained Mexican long-tongued bats (*Choeronycteris mexicana*) in 2013. Several newly surveyed abandoned mine features within the 1-mile buffer contained sensitive bat species in 2013: NS-4 contained pale Townsend's big-eared bats (*Corynorhinus townsendii pallescens*); NS-15 contained Mexican long-tongued bats, fringed myotis (*Myotis thysanodes*), and cave myotis (*M. velifer*); and, NS-18 contained Mexican long-tongued bats. Several other features within the analysis area that were newly surveyed in 2013 contained evidence of bat use, but bats were not identified to species.

Summary of FEIS Impact Conclusions

For the six special status bat species (Mexican long-tongued bat, pale Townsend's big-eared bat, western red bat, fringed myotis, cave myotis, and pocketed free-tailed bat), in addition to lesser long-nosed bat, that have been observed in the analysis area foraging on plant or insect resources and/or using mines and adits for day, night, and/or maternity roosts, similar impacts are expected as those listed above for other special status animal species. Because adits and shafts within the project area would be lost, all action alternatives could directly impact roosts for these sensitive bat species. Any individuals present within mine adits or shafts the project area would either perish or be forced to relocate. Sensitive bat species present in the project area could experience impacts from fugitive dust and air pollutants, and any individuals present in the analysis area could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, groundwater drawdown,[9] noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Any bats roosting near the project area could abandon those roost sites after project inception owing to impacts from artificial night lighting, noise, and vibration.

The proposed project would indirectly impact Mexican long-tongued bats through the removal of forage plants (i.e., paniculate agaves) in the project area. The other five sensitive bat species (western red bat, cave myotis, fringed myotis, pale Townsend's big-eared bat, and pocketed free-tailed bat) feed on insects, and because the mine pit lake water quality could exceed wildlife standards for three contaminants that are known to bioaccumulate (i.e., cadmium, mercury, and selenium), indirect impacts on these species could occur from eating aquatic invertebrates originating from the mine pit lake, which could alter their predator-prey relationships. Bats that drink pit lake water could also be negatively impacted by these contaminants. Based on this, the biological evaluation for this project determined that, for all action alternatives, the proposed project may impact individuals of these sensitive bat species but is not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability of these species (see FEIS, vol. 3, pp. 696–697).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

New Information. New information and changed conditions about the sensitive bat species in the analysis area include more detailed information about the extent of occurrences in the analysis area within 1 mile of the perimeter fence and at Las Cienegas NCA than was provided in the FEIS.

Direct and Indirect Impacts. The four sensitive bat species observed during 2013 bat surveys in the analysis area (Mexican long-tongued bat, pale Townsend's big-eared bat, fringed myotis, and cave myotis) were already known to occur in the project area and within the analysis area; thus, the analysis of impacts to these species to not change substantially from what was stated in the FEIS. The 4 new locations where sensitive bat species occur are not in the project area so no additional direct effects are anticipated; however, individuals using these abandoned mine features could experience impacts from decreased surface water flow in Barrel and Davidson Canyons, noise, vibration, artificial night lighting, and increased traffic volumes on SR 83 and other roads. Any bats roosting near the project area could abandon those roost sites after project inception owing to impacts from artificial night lighting, noise, and vibration.

The new aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR) gives a refinement of expected impacts to the riparian woodland habitat of the western red bat where it occurs along upper Cienega Creek. Specifically, Cienega Creek would not experience widespread

[9] A range of outcomes was assessed for Cienega Creek, all of which have high levels of uncertainty due to the long time frames, long distances, and small amounts of drawdown involved. The most likely scenario suggests that noticeable reductions in stream flow in Cienega Creek would not occur for hundreds of years after closure and, once occurring, would not result in widespread absence of flow along Cienega Creek. A range of outcomes was assessed for Empire Gulch as well, and are also highly uncertain. The most likely scenarios suggest that noticeable reductions in stream flow would occur, gradually increasing until widespread absence of flow occurred in Empire Gulch.

loss of flow or loss of pools and pool volume. Further, this species' riparian woodland gallery habitat is not predicted to be drastically altered. These new occurrences provide more specific location data for analysis, but they do not change the expected impacts or the likely magnitude of impact. Thus, based on the FEIS and this new information, *the proposed project may impact individuals but is not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability of these species.*

Cumulative Effects

Summary of Applicable New Information and/or Changed Conditions

Reasonably Foreseeable Actions

- Hog Canyon, Hazardous Fuels Reduction Project.
- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes.
- Continued programmatic aquatic special status species reintroductions at Las Cienegas NCA (May 2012). This project was listed as foreseeable in the FEIS. However, it has recently come to light that the BLM has implemented a portion of this program (see "Past Actions"). The remainder of this program is still foreseeable.
- Madera Waterline Replacement. Modify the existing Madera water supply system to provide a reliable source of water for the residents and visitors to Madera Canyon. Water usage from three springs will cease and be replaced with a well on private property.
- Mt. Hopkins Re-Entry Thinning Project. Nogales Ranger District is coordinating with the Smithsonian Institute to thin and chip near structures on the Mt. Hopkins Observatory site. This is to maintain defensible space around the structures in the event of a wildfire. This is a new project that is in the planning stages and was not considered for the FEIS.
- Camp Tatiyee Land Exchange.

Baseline Conditions Considering New Information and Changed Conditions

In terms of new baseline conditions, two actions listed as present actions have a component that has yet to occur, and thus are foreseeable: Simms (Simms 2013a) documents the reintroduction of desert pupfish into the Las Cienegas NCA in several locations, and additional reintroductions are planned. This action may increase the number of locations where this species occurs in the analysis area. Rosen et al. (2013) provide new information about sites where Chiricahua leopard frogs are known to occur, and where they have been released that was not mentioned in the cumulative effects section of the FEIS, but that would impact biological resources within the analysis area by increasing the number of locations where this species occurs within the analysis area, increasing the habitat quality for native frogs and other species within the analysis area, and continuing to remove invasive species (i.e. bullfrogs and crayfish) within the analysis area. Finally, the updated aquatic analysis provides more detailed information about the expected cumulative impacts of climate change on the biological resources located within the analysis area (see "Seeps, Springs and Riparian Areas" section of this SIR).

Summary of FEIS Impact Conclusions

This cumulative effects discussion addresses the cumulative impacts of the action alternatives and any applicable reasonably foreseeable actions as identified on the Coronado ID team's list of reasonably foreseeable future actions, provided in the introduction to chapter 3 of the FEIS. The following reasonably foreseeable actions from that list were determined to contribute to a cumulative impact to biological resources within the analysis area:

- A hazardous fuels reduction project is planned on more than 2,500 acres in Hog and Gardner Canyons. The Coronado proposes to thin up to 2,500 acres of dead standing juniper and oak trees in upper Hog and Gardner Canyons, about 10 miles northwest of the town of Sonoita in Santa Cruz and Pima Counties, Arizona. In the past several years, vegetation has deteriorated because of the 2005 Florida wildfire and a continuing drought, leaving dead standing trees and shrubs throughout the project area. The Coronado proposes to reduce fuels in the project area by mechanically removing (e.g., using chainsaws and hand tools) dead standing oaks and junipers that are less than 20 inches in diameter at breast height. Treatment areas would be accessed by truck using NFSRs; in some locations, off-road travel may be necessary, but no temporary or permanent roads would be constructed. Firewood would be removed from the area in trucks or off-highway vehicles and offered to the public. The remaining slash would be lopped using hand tools and scattered at the site. The project is expected to take 2 to 4 months to complete. Impacts to biological resources from fuels reduction projects can be negative and/or beneficial. In the short term, activities associated with this project would likely displace animals from the area and could disturb vegetative recovery that has occurred since the 2005 wildfire. In the long term, however, these types of projects reduce the risk of severe, large-scale wildfires that are outside the range of natural variability, and create conditions that are generally more sustainable than without the treatment.
- The BLM proposes to approve a decision for programmatic aquatic special status species reintroductions at Las Cienegas NCA. In coordination with the USFWS and AGFD, the project proposes to establish populations of Chiricahua leopard frog, Gila topminnow, desert pupfish, Gila chub, Mexican gartersnake, Sonora mud turtle, and Huachuca water umbel into multiple (up to 16) earthen stock tanks and modified large aboveground water storage tanks. This project would conserve the aforementioned imperiled aquatic species through establishment of new populations in strategically located livestock and wildlife watering ponds, and the conversion of these habitats to perennial ponds with dual use of these habitats would benefit these aquatic species within the analysis area.
- The AGFD and BLM are planning to reintroduce beavers into Cienega Creek at Las Cienegas NCA. While the planning for this reintroduction is ongoing and a final decision has yet to be made, future beaver reintroduction could affect surface water flow and riparian vegetation in the reintroduction area, which could impact (beneficially or negatively) a variety of riparian associated species. Because a reintroduction decision has not yet been made and information regarding the rate of reintroduction and monitoring and response activities has not been identified, it is not currently possible to draw further conclusions about potential cumulative impacts.
- The Forest Service proposes to add, decommission, close, or change the designation of roads in the NFSR database and prohibit off-road motorized travel for dispersed camping in certain areas on the Nogales Ranger District. Additional roads could result in impacts to vegetation and wildlife due to habitat removal, vehicular mortality of wildlife, and increased fugitive dust and noise; however, additional road restrictions and decommissioning could reduce motorized use, which would benefit most wildlife species.
- The Coronado proposes to reauthorize the Grazing Permit Reauthorization for the Gardner Allotment, which is located 5 miles north of Sonoita. This is a continuation of an existing use and, provided that no changes are proposed, the reauthorization would result in no additional impacts to biological resources within the analysis area.
- Expansion of the Andrada Mine limestone quarry in the Davidson Canyon drainage system north and northeast of the Santa Rita Mountains has been proposed. The Andrada Mine is located approximately 4 miles from the Tucson city limits and 1 mile from Vail. The mining

of calcium carbonate (limestone) and the associated blasting, road construction, and transportation of the mined materials could result in impacts to upland and riparian vegetation and wildlife species and animal movement corridors in or near the project area due to habitat removal, fugitive dust and air pollutants, noise, and vibration.

- Southline Transmission, LLC, proposes constructing, operating, and maintaining a high-voltage power line. One segment that would upgrade and rebuild about 130 miles of existing transmission lines would cross through the north end of the analysis area. The line would cross Federal lands managed by the BLM and other agencies. It also would cross State and private lands. Although rebuilding of this existing line has the potential to disturb wildlife and impact vegetation, it is located in the I-10 corridor, in an area of high human use. Because of the amount of traffic and other disturbances in this area, impacts to wildlife would be negligible.

When considered together, these foreseeable actions, when combined with the expected impacts from the proposed project (no matter which action alternative is selected), and with climate change and human population growth and associated development, would cumulatively contribute to impacts such as loss or fragmentation of habitat, vibration, noise, dust and air pollutants, and artificial night lighting. The overall result would be a continuation of the long-occurring trend of reduced habitat quantity and quality; distribution of movement and genetic flow; and continued increase in risk and threats to sensitive species (see FEIS, vol. 3, pp. 711–712).

Climate Change

The impacts of climate change (i.e., increased annual temperature, decreased precipitation, increased drought, and increased evapotranspiration) are a threat to many species (Lenart 2007). For example, temperatures rose in the 20th century, and warming is predicted to continue over the 21st century. Although climate models are less certain about predicted trends in precipitation, the southwestern United States is expected to become warmer and drier. In addition, precipitation is expected to decrease in the southwestern United States, and many semiarid regions will suffer a decrease in water resources from climate change as a result of less annual mean precipitation and reduced length of snow season and snow depth. Approximately half of the precipitation within the project area typically falls in the summer months; however, the impacts of climate change on summer precipitation are not well understood. Drought conditions in the southwestern United States have increased over time and have likely contributed to loss of plant and animal populations. Climate change trends are likely to continue, and the impacts on species will likely be complicated by interactions with other factors (e.g., interactions with nonnative species and disease). Overall, the project would exacerbate the effects of climate change, which would add to the cumulative impacts to the biological resources. As such, the stressor effects of the project could shorten the time intervals to modeled effects or increase groundwater drawdown and decrease surface water perenniality (see FEIS, vol. 3, p. 713).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

Reasonably Foreseeable Actions

- Hog Canyon, Hazardous Fuels Reduction Project. *This project was addressed in the FEIS, where it included the Gardner Canyon Fuels Reduction Project. The Gardner Canyon portion has since been completed. There are no changes to the conclusion of impacts noted in the FEIS for the remaining portion of this project.*
- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes. *While this project was listed as reasonably foreseeable in the FEIS, no information regarding plans for mining was known. Subsequently, a mineral development plan was discovered that*

was submitted to the ASLD. While no ground-disturbing activity has occurred on the site, the mineral development plan outlines the plan of operations for the proposed mining activity and provides an environmental assessment of potential impacts. Operations of this proposed mining activity would have impacts to biological resources, but it would not modify the analysis or change the conclusion of impacts to biological resources disclosed in the FEIS, as this would be a small relatively short-term project. The environmental assessment (EA) for this project states, "Some species of animals will experience short-term loss of habitat at the quarry site. The existing habitat will be largely undisturbed and upon completion of quarrying operation and reclamation of the site, there should be no habitat loss." "The quarrying operation may well displace some species onto adjacent land. The small area of disturbance should have little effect on wildlife. Reclamation of the site will mitigate or totally negate the impact." "Biological and botanical studies for threatened and endangered species will be conducted prior to the commencement of quarrying operations." It should be noted that there is no indication if or when ground-disturbing activities may occur for this project.

- Continued programmatic aquatic special status species reintroductions at Las Cienegas NCA (May 2012). This project was listed as foreseeable in the FEIS. However, it has recently come to light that the BLM has implemented a portion of this program (see "Past Actions"). *As noted this project was addressed in the FEIS. No changes are noted that would modify the conclusion of impacts disclosed in the FEIS.*
- Madera Waterline Replacement. *Water usage from three springs will cease and be replaced with a well on private property. While this project may cause minor short-term displacement to local wildlife, it occupies a small site and is of limited duration. It would not change the conclusion of impacts to biological resources disclosed in the FEIS.*
- Mt. Hopkins Re-Entry Thinning Project. *As mentioned for other fuels reduction projects in the FEIS, impacts to biological resources from fuels reduction projects can be negative and/or beneficial. In the short term, activities associated with this project would likely displace animals from the area and could disturb vegetative recovery that has occurred since the 2005 wildfire. In the long term, however, these types of projects reduce the risk of severe, large-scale wildfires that are outside the range of natural variability, and create conditions that are generally more sustainable than without the treatment.*
- Camp Tatiyee Land Exchange. *This project would result in select parcels of private land within the analysis area being becoming NFS lands managed under the direction of the Coronado Forest Plan. This would be generally beneficial for biological resources, as these lands are currently available for development with fewer safeguards that would be in place once they become NFS lands.*

Climate Change

The expected general impacts of climate change as summarized in the FEIS, are not expected to change as a result of this new information; overall, the indirect impacts from the project on aquatic and riparian systems would exacerbate the ongoing and future effects of climate change, which would add to the cumulative impacts to the biological resources. The updated aquatic analysis (see "Seeps, Springs, and Riparian Areas" section of this SIR) provides a refined understanding of the impacts of climate change on water resources within the specific reaches at Las Cienegas NCA, which clarifies understanding of impacts to biological resources within the analysis area, such as impacts aquatic species and their habitat and impacts to riparian obligate species and their habitat.

Recent analysis of the extent of riparian vegetation over the recent drought period does not indicate widespread changes. However, anecdotal reports and observations on the ground suggest that the riparian vegetation is currently experiencing negative trends (i.e., loss of canopy cover, loss of vigor, changes in species composition) due to the current drought and these negative trends are likely to continue into the future due to climate change; thus species that use riparian woodlands or mesquite bosques may be impacted by the loss of habitat. Further, the loss of this vegetation and its root structure may accelerate the sedimentation or head cutting which is already occurring and which may impact pool habitat for aquatic species.

The water resources at Las Cienegas NCA are expected to have effects from climate change (see “Seeps, Springs, and Riparian” section of this SIR), thus habitat for aquatic species and those terrestrial species that require perennial water or riparian vegetation may be lost; loss of stream flow, and decreases in water quality or pool volume may have the effect of increasing disease, encouraging nonnative species, reducing success of native species, or decreasing the amount of habitat available.

Upper Empire Gulch: The magnitude of potential mine-related impacts is expected to be greatest in Upper Empire Gulch. While climate change would have an impact on stream flow and pool volume, the effects of climate change on the water resources in this area would not substantially add to the effects of the Barrel Alternative due to the magnitude of the potential mine-related impacts. Therefore, no substantial additional impacts to biological resources or species known to occur in Empire Gulch Reach 1 (i.e., Chiricahua leopard frog, northern gray hawk, northern beardless tyrannulet, western yellow-billed cuckoo, southwestern willow flycatcher, and Abert’s towhee) are expected in this location as a result of climate change.

Lower Empire Gulch and Cieneguita Wetlands: In the new aquatic analysis for Empire Gulch Reach 2, when the effects of climate change on water resources are combined with the effects of the Barrel Alternative, the number of pools would remain constant but pool volume would decrease; the number of days with zero stream flow could increase from 0 to 6; and, the water quality would lower due to the occurrence of more extremely low-flow days. When mine drawdown is combined with climate change, the Cieneguita Wetlands pools volumes can reach as low as 11 to 37 percent of their original volume, but the number of pool does not decrease. Thus, aquatic species occurring at these locations (Huachuca water umbel, Chiricahua leopard frog, northern Mexican gartersnake, Gila chub, desert pupfish, or Gila topminnow) would experience further impacts beyond what is expected from the project impacts alone. These impacts would include loss of habitat, reduction of habitat through the loss of pool size and increase of days with zero stream flow (for Empire Gulch Reach 2), the possibility of increased predation, and the lowering of water quality. When the effects of climate change are added to the effects of the Barrel Alternative, additional impacts to the riparian vegetation in this area are expected. The riparian woodlands and other riparian vegetation types may decrease in extent or species composition as a result of the reduction in available water, which, in turn, may impact species that depend upon riparian vegetation for all or part of their life cycles (i.e., western yellow-billed cuckoo, and other special-status species that may occur but were not observed at this location though they were observed nearby in upper Empire Gulch or Cienega Creek). More severe impacts would be experienced by aquatic plant species or wetland obligate species, due to drawdown of water levels below the root zone and the contraction of pool volume, surface area, and wetted perimeter.

Cienega Creek: The mine drawdown alone is expected to have no or little effect on drying of the stream. However, the climate change scenario by itself would have a substantial effect on stream flow and pools, particularly in the downstream reaches of Cienega Creek, where days of zero flow would increase, and though the number pools are not expected to decrease, their volume would. Further, the lower reaches would see greater reductions than higher reaches. Thus, climate change by itself is likely to reduce the habitat extent and quality for aquatic species at Cienega Creek. Impacts to aquatic species occurring here (Huachuca water umbel, Chiricahua leopard frog, lowland leopard frog, northern Mexican gartersnake, longfin dace, Gila chub, and Gila topminnow) are expected to include the loss of habitat, reduction of habitat quality, and increased predation, particularly in lower reaches of Cienega Creek. Analysis of riparian vegetation using available literature and predicted drawdown does not suggest major changes would occur due to climate change. However, anecdotal observations of riparian vegetation change and statistical analysis of stream flow and climate data suggest that there are ongoing negative trends due to the current drought. These negative trends are reasonably likely to continue as a result of climate change. Riparian vegetation along Cienega Creek may decrease in extent or species composition as a result of the reduction in available water, which, in turn, may impact species that depend upon riparian vegetation for all or part of their life cycles (including giant spotted whiptail, northern gray hawk, common black-hawk, northern beardless-tyrannulet, western yellow-billed cuckoo, broad-billed humming bird, southwestern willow flycatcher, Abert's towhee, western red bat, and white-nosed coati).

When the effects of the mine drawdown are added to the effects of climate change, additional impacts to biological resources in this area are expected. Specifically, Cienega Creek Reaches 7 and 15 would experience further increase in days with zero stream flow per year and most reaches would have lower water quality from an increased number of extremely low flow days per year, though relatively little impact on pool number or volume is expected. Thus, the impacts to aquatic habitats due to the combined effects of mine drawdown and climate change would be largely the same as those from climate change alone, with the impacts being more pronounced on biological resources or species that occur in Cienega Creek Reaches 7 and 15. When mine drawdown is considered on top of climate change, riparian vegetation along Cienega Creek may further decrease in extent, health, or species composition (particularly along CC7 and CC15) along Cienega Creek as a result of the reduction in available water. Species which depend upon riparian vegetation would be expected to experience additional impacts beyond those expected from climate change alone.

Thus, the overall conclusions from the FEIS are still valid: overall, the project would exacerbate the effects of climate change, which would add to the cumulative impacts to the biological resources. However, the effects of climate change would drive most of the expected impact in Cienega Creek whereas the effects of mine drawdown would drive most of the expected impacts in Empire Gulch.

Summary of Findings

The changes to impact determinations as a result of new information are summarized in table 48.

Table 48. Summary of special-status species for which new information was available and new impact determinations were made

Species Common Name (scientific name)	New Impact Determination	Change from FEIS
Huachuca water umbel (*Lilaeopsis schaffneriana* var. *recurva*)	May affect, likely to adversely affect	No change
Chiricahua leopard frog (*Lithobates chiricahuensis*)	May affect, likely to adversely affect	No change
Lowland leopard frog (*Lithobates yavapaiensis*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change

Species Common Name (scientific name)	New Impact Determination	Change from FEIS
Giant spotted whiptail (*Aspidoscelis stictogramma*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Sonoran Desert tortoise (*Gopherus morafkai*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Northern Mexican gartersnake (*Thamnophis eques megalops*)	May affect, likely to adversely affect	Species listed after publication of FEIS
Northern Mexican gartersnake (*Thamnophis eques megalops*)—Proposed Critical Habitat	Not likely to destroy or result in adverse modification	No change
Northern gray hawk (*Buteo nitidus maximus*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Common black-hawk (*Buteogallus anthracinus*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Northern beardless-tyrannulet (*Camptostoma imberbe*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*)	May affect**,** likely to adversely affect	Species listed after publication of FEIS
Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*) Proposed critical habitat	Not likely to destroy or result in adverse modification	Critical habitat proposed within analysis area after publication of FEIS
Broad-billed hummingbird (*Cynanthus latirostris*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Southwestern willow flycatcher (*Empidonax traillii extimus*)	May affect**,** likely to adversely affect	No change
Southwestern willow flycatcher (*Empidonax traillii extimus*) Designated critical habitat	May affect**,** likely to adversely affect	No change
Abert's towhee (*Pipilo* [=*Melozone*] *aberti*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Mexican spotted owl *(Strix occidentalis lucida*)	May affect, not likely to adversely affect	No change
Mexican spotted owl *(Strix occidentalis lucida*) Designated critical habitat	No effect	No change

Species Common Name (scientific name)	New Impact Determination	Change from FEIS
Desert pupfish (*Cyprinodon macularius*)	May affect**,** likely to adversely affect	Species was not considered in FEIS
Longfin dace (*Agosia chrysogaster*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Gila chub (*Gila intermedia*)	May affect**,** likely to adversely affect	No change
Gila chub (*Gila intermedia*) Designated critical habitat	May affect**,** likely to adversely affect	No change
Gila topminnow (*Poeciliopsis occidentalis occidentalis*)	May affect**,** likely to adversely affect	No change
Mexican long-tongued bat (*Choeronycteris mexicana*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Western red bat (*Lasiurus blossevillii*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*)	May affect**,** likely to adversely affect	No change
Fringed myotis (*Myotis thysanodes)*	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Cave myotis (*Myotis velifer*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
White-nosed coati (*Nasua narica*)	May impact individuals, but not likely to result in a downward trend toward Federal listing as threatened or endangered or in a loss of population viability	No change
Jaguar (*Panthera onca*)	May affect**,** likely to adversely affect	No change
Jaguar (*Panthera onca*) Designated critical habitat	May affect, likely to adversely affect	Critical habitat was designated after publication of FEIS
Mexican gray wolf (*Canis lupus baileyi)*	No effect	Subspecies was given own listing and 10J reintroduction area expanded to cover entire analysis area after publication of FEIS

Landownership and Boundary Management

Summary of Applicable New Information and/or Changed Conditions

No new information or changed conditions were identified that would affect the analysis of landownership or boundary management presented in the FEIS.

Baseline Conditions Considering New Information and Changed Conditions

The baseline conditions described in the FEIS remain valid as written.

Summary of FEIS Analysis Methodology and Impact Conclusions

There are no changes to the analysis methodology or conclusion of impacts for landownership and boundary management from those described in the FEIS.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

No new information or changed conditions were identified that would affect the analysis of landownership or boundary management presented in the FEIS.

Summary of Findings

No new information or changed conditions was identified that would result in changes to the description of baseline conditions, the analysis methodology, or the conclusions of impacts presented in the FEIS for landownership and boundary management.

Livestock Grazing

Summary of Applicable New Information and/or Changed Conditions

No new information or changed conditions were identified that would affect the analysis of livestock grazing presented in the FEIS.

Baseline Conditions Considering New Information and Changed Conditions

The baseline conditions described in the FEIS remain valid as written.

Summary of FEIS Analysis Methodology and Impact Conclusions

There are no changes to the analysis methodology or conclusion of impacts for livestock grazing from those described in the FEIS.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

No new information or changed conditions were identified that would affect the analysis of livestock grazing presented in the FEIS.

Summary of Findings

No new information or changed conditions was identified that would result in changes to the description of baseline conditions, the analysis methodology, or the conclusions of impacts presented in the FEIS for livestock grazing.

Dark Skies

Summary of Applicable New Information and/or Changed Conditions

The following changed conditions were noted.

Past Actions

- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions has been reclassified from a reasonably foreseeable action, as presented in the FEIS, to a present action. The developments are actively selling real estate and constructing homes and associated infrastructure.

Baseline Conditions Considering New Information and Changed Conditions

Baseline conditions related to dark skies remain substantially as described in the FEIS. While the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions are currently being developed, they are subject to the Pima County Outdoor Lighting Code that is designed for and has been effective in reducing impacts of urban development on night skies. While impacts associated with these actions are now part of the existing conditions, overall impacts are not expected to exceed those described under “Direct, Indirect and Cumulative Impacts” in the FEIS.

Summary of FEIS Analysis Methodology and Impact Conclusions

The method used in the FEIS to quantify the potential impacts of project area lighting on the region’s existing dark sky conditions is based on a computer model that calculates sky glow or sky brightness caused by artificial outdoor lighting. The model accounts for the effects of light dispersion or reflection caused by grounded objects such as buildings, terrain, and vegetation. The model also accounts for light emitted by nearby cities and towns, housing developments, industrial areas, and shopping centers, with the capability of accounting for spatial distribution, shielding, and intensities of light sources. The physical model, along with all input parameters for the computer code, are given in “An Assessment of the Impact of Potential Mining Operations at the Rosemont Copper Mine on the Night Sky of Southern Arizona” and references therein (Dark Sky Partners LLC 2012).

Impact Conclusions

- Impacts from the action alternatives on fractional increase in sky brightness from mine facility and vehicle lighting at Whipple Observatory are as follows: the proposed action would result in a 524 percent increase in sky brightness at horizon; a 28 percent increase at 10 degrees above horizon; a 10 percent increase at 20 degrees above horizon; and a 1 percent increase at 90 degrees. The Barrel Alternative would result in an 83 percent increase in sky brightness at horizon; an 8 percent increase at 10 degrees above horizon; a 3.3 percent increase at 20 degrees above horizon; and a 0.4 percent increase at 90 degrees above horizon. The remaining action alternatives would result in a slight increase over the Barrel Alternative due to inclusion of heap leach facilities.

- Impacts from the action alternatives on fractional increase in sky brightness from mine facility and vehicle lighting at Jarnac Observatory are as follows: the proposed action would result in an undetermined increase at horizon due to overlap with light from city of Nogales; a 63 percent increase at 10 degrees above horizon; a 22 percent increase at 20 degrees above horizon; and a 2 percent increase at 90 degrees. The Barrel Alternative would result in an undetermined increase at horizon due to overlap with light from city of Nogales; a 21 percent increase at 10 degrees above horizon; an 8 percent increase at 20 degrees above horizon; and a 0.7 percent increase at 90 degrees above horizon. The remaining action alternatives would result in a slight increase over the Barrel Alternative due to inclusion of heap leach facilities.
- Impacts from the action alternatives on fractional increase in sky brightness from mine facility and vehicle lighting at Sonoita are as follows: the proposed action would result in a 363 percent increase in sky brightness at horizon; a 31 percent increase at 10 degrees above horizon; a 12 percent increase at 20 degrees above horizon; and a 1 percent increase at 90 degrees above horizon. The Barrel Alternative would result in a 76 percent increase in sky brightness at horizon; a 10 percent increase at 10 degrees above horizon; a 4 percent increase at 20 degrees above horizon; and a 0.1 percent increase at 90 degrees above horizon. The remaining action alternatives would result in a slight increase over the Barrel Alternative due to inclusion of heap leach facilities.
- Impacts from the action alternatives on fractional increase in sky brightness from mine facility and vehicle lighting at Corona de Tucson are as follows: the proposed action would result in a 425 percent increase at 5 degrees above horizon; a 119 percent increase at 10 degrees above horizon; a 31 percent increase at 20 degrees above horizon; and a 3 percent increase at 90 degrees above horizon. The project area is blocked by terrain and is therefore provided for closest degree visible above horizon. The Barrel Alternative would result in a 28 percent increase at 10 degrees above horizon; an 11 percent increase at 20 degrees above horizon; and a 0.1 percent increase at 90 degrees above horizon. The project area is blocked by terrain and is therefore provided for closest degree visible above horizon. The remaining action alternatives would result in a slight increase over the Barrel Alternative due to inclusion of heap leach facilities.
- Impacts from the action alternatives on fractional increase in sky brightness from mine facility and vehicle lighting at SR 83 are as follows: for the proposed action, the project area was determined to be below the horizon and therefore not measured at horizon; a 400 percent increase at 10 degrees above horizon; a 141 percent increase at 20 degrees above horizon; and a 25 percent increase at 90 degrees above horizon. The Barrel Alternative would result in a 4,000 percent increase in sky brightness at horizon; a 117 percent increase at 10 degrees above horizon; a 39 percent increase at 20 degrees above horizon; and a 9 percent increase at 90 degrees above horizon. The remaining action alternatives would result in a slight increase over the Barrel Alternative due to inclusion of heap leach facilities.
- Impacts from the action alternatives on fractional increase in sky brightness from mine facility and vehicle lighting at Empire Ranch are as follows: the proposed action would result in a 2,530 percent increase in sky brightness at horizon; a 105 percent increase at 10 degrees above horizon; a 32 percent increase at 20 degrees above horizon; and a 4 percent increase at 90 degrees above horizon. The Barrel Alternative would result in a 1,200 percent increase in sky brightness at horizon; a 24 percent increase at 10 degrees above horizon; a 10 percent increase at 20 degrees above horizon; and a 1 percent increase at 90 degrees above horizon. The remaining action alternatives would result in a slight increase over the Barrel Alternative due to inclusion of heap leach facilities.

Direct and Indirect Impacts

The FEIS predicted that all action alternatives would have direct, adverse, long-term impacts to night sky viewing until mine closure.

Cumulative Impacts

Anticipated changes to the climate of southern Arizona are not expected to contribute to impacts to dark skies.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

The ongoing expansion of Rancho Sahuarita, Quail Creek and Madera Highlands is likely contributing to a slight increase in existing sky brightness in the general Sahuarita area. However, because the development must comply with Pima County Outdoor Lighting Code, and because the developments are in early phases, it is unlikely that the existing condition has resulted in measurable changes to overall sky brightness. The computer modeling conducted for the FEIS remains valid and adequately describes the current conditions, as well as impacts from the developments. Additionally, impact conclusions for "Direct, Indirect and Cumulative Impacts" disclosed in the FEIS remain accurate and valid.

Summary of Findings

The ongoing expansion of Rancho Sahuarita, Quail Creek, and Madera Highlands has not resulted in changes to baseline conditions, the analysis conducted for the FEIS, or the conclusions of impacts to dark skies.

Visual Resources

Summary of Applicable New Information and/or Changed Conditions

The following new information and changed conditions were noted.

Past Actions

- Exploratory drilling on Rosemont private property occurred in 2014. All ground-disturbing activities occurred within the footprint of the open pit. The pit and all areas within the security fence were considered disturbed land for the purpose of impact analysis in the FEIS; therefore, the drilling adds no additional ground disturbance for any analysis.
- Additional wildfires that occurred between 2012 and 2014.
- Hazardous fuels treatment in Gardner Canyon has been accomplished.

Present Actions

- Expansion of the Rancho Sahuarita, Quail Creek and Madera Highlands subdivisions has been reclassified from a reasonably foreseeable action, as presented in the FEIS, to a present action. The developments are actively selling real estate and constructing homes and associated infrastructure.

Reasonably Foreseeable Actions

- Hog Canyon, Hazardous Fuels Reduction Project. The District proposes to remove hazardous fuels over 2500 acres in Hog Canyon on the Nogales Ranger District. Note that in the FEIS this originally included Gardner Hazardous Fuels Reduction Project, which has been completed and is now listed as a past action.
- Charles Seel lease of State Trust Land (from State land commissioner) for mining purposes.
- Mt. Lemmon Recreation Area Improvements. This project involves installation of three tables, a bulletin board, and a fee tube at the Mt. Lemmon Recreation Site, in addition to new parking bumpers and procured trail signs at the Mt. Lemmon Recreation Area and Summit Trailheads parking.
- Madera Waterline Replacement. Modify the existing Madera water supply system to provide a reliable source of water for the residents and visitors to Madera Canyon. Water usage from three springs will cease and be replaced with a well on private property.
- Mt. Hopkins Re-Entry Thinning Project. Nogales Ranger District is coordinating with the Smithsonian Institution to thin and chip near structures on the Mt. Hopkins Observatory site. This is to maintain defensible space around the structures in the event of a wildfire.
- Road Construction (5 miles). CBP. Provide improved access to the U.S.–Mexico border on the Coronado National Forest by constructing approximately 5 miles of roads that will enable CBP to safely and effectively execute its mission while protecting the forest natural resources to the degree possible. New road construction would occur in three different locations: the Fresnal Wash area, Cantinas Reservoir area, and Sycamore Canyon area.

  Newly constructed roads would be closed to public motorized use and available only for administrative use. In addition, approximately 1.2 miles of existing roads in the Fresnal Wash and Sycamore Canyon areas would be closed to motorized travel by earthen berm barriers to foster resource protection. Additionally, some of the road mileage may be claimed under the Department of Homeland Security Waiver—particularly the portion crossing the IRA.
- Improvements at Marshall Gulch Picnic Area and Trailhead. Replace restrooms, renovate picnic sites and trailheads, install vehicular bridges over stream, naturalize stream channel, and improve roads and parking areas.
- Grazing Permit Amendment, Papago Allotment. The Forest Service proposes change the number of livestock authorized on the Papago Allotment.
- Mowry Allotment Analysis. The proposed action is to authorize continued livestock grazing on the Mowry Allotment using an adaptive management strategy.
- Plan of Operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. The District proposes to authorize the operator to conduct 5-hole exploratory drilling activities on the Sierra Vista Ranger District.
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River, as part of its 5-year Capital Improvement Plan.
- Camp Tatiyee Land Exchange. Nine tracts within the Coronado National Forest are proposed to be conveyed to the Forest Service. These parcels are scattered across the Santa Catalina, Douglas, Safford, Nogales, and Sierra Vista Ranger Districts. NFS lands proposed for conveyance to a private party are not located on the Coronado National Forest.
- Helicopter use by AGFD within Pusch Ridge Wilderness to capture and investigate mortalities of desert bighorn sheep.
- Bear Canyon Bark Beetle Sanitation Project. Fell and remove bark beetle infested trees to reduce bark beetle populations, to protect surrounding trees and stands, and to mitigate fire

hazard associated with beetle-killed trees on the Santa Catalina Ranger District. Developed recreation sites and surrounding area, including Cypress, Middle Bear, and Chihuahua Pine Picnic Areas, and General Hitchcock Campground. Generally, canyon bottom and north-facing slopes.

Baseline Conditions Considering New Information and Changed Conditions

Baseline conditions for visual resources remain essentially the same as described in the FEIS. Additional wildfires and mineral exploration activities have occurred in the analysis area since release of the FEIS, but these are a continuation of past and present actions described in the FEIS. As new wildfires occur annually, past fires continue to recover. Similarly, mineral exploration project are typically short term, isolated projects that result in little ground disturbance or visual impact once the project is completed and drilling equipment is removed. The description of baseline conditions for visual resources in the FEIS remains accurate.

Summary of FEIS Analysis Methodology and Impact Conclusions

The analysis of visual resources in the FEIS focused upon describing changes from proposed and reasonably foreseeable actions on scenic conditions from nine specific viewpoints.

Impacts were predicted for four issues and two additional factors:

- Acres that would no longer meet current forest plan scenic integrity objectives designations;
- Degree of change in landscape character from analysis viewpoints over time;
- Miles of SR 83 with direct line-of-sight views of the project area;
- Miles of project area visibility along concern level 1 and 2 roads and trails;
- Acres of project area regional visibility;
- Miles of realigned Arizona National Scenic Trail with direct line-of-sight views of the project area.

Impact Conclusions

Direct and Indirect Impacts

- Acres that would no longer meet current forest plan scenic integrity objectives for the action alternatives range from 4,228 acres for the Barrel Alternative to 5,045 acres for the Scholefield-McCleary Alternative.
- For the action alternatives, the degree of change in landscape character of the open-pit are all permanent and adverse, with more of the pit area visible from selected viewpoints for some action alternatives.
- For the action alternatives, the degree of change in landscape character of the waste rock and tailings are permanent, major impacts visible from piles.
- For the action alternatives, the degree of change in landscape character of the processing facilities range from the processing facility being visible for 7 years under the proposed action, to being visible for the entire life of the mine under the Scholefield-McCleary Alternative.
- For the action alternatives, the degree of change in landscape character of the power transmission line is adversely visible on the west side of the Santa Rita Mountains and over the ridgeline for the life of the project for all action alternatives.

- Miles of SR 83 with direct line-of-sight views of the project area range from 3.4 miles with the proposed action to 4.9 miles with the Barrel Trail Alternative.
- Miles of project area visibility along concern level 1 and 2 roads and trails ranges from 28.5 for the proposed action to 42.5 for the Barrel Alterative.
- Acres of project area regional visibility range from 187,893 acres for the proposed action to 763,295 for the Scholefield-McCleary Alternative.
- Miles of Arizona National Scenic Trail (west side of SR 83) with direct line-of-sight views of the project area are 2.8 miles for the proposed action and Phased Tailings Alternatives.
- Miles of realigned Arizona National Scenic Trail (east side of SR 83) with direct line-of-sight views of the project area are 7.9 miles for the Scholefield-McCleary Alternative; 8.1 miles for the Barrel Trail Alternative, and 8.7 miles for the Barrel Alternative.

Cumulative Impacts

The proposed project, when added to past, present, and future actions and combined with trends that impact visual quality, would result in cumulatively adverse, permanent impacts on scenic quality within the region because of the surface disturbances and landscape contrasts associated with these activities. Additionally, fugitive dust production from the proposed mine, when added to ongoing mining related surface disturbances, would increase the adverse impacts to long-distance scenic viewing of the Santa Rita Mountains and other scenic mountain ranges within the region in the short and long term.

Climate change may impact visual quality as a result of lower precipitation, warmer temperatures, and more frequent drought cycles, which could result in less successful or slower revegetation, as well as more bare soil and rock being visible on the mine areas requiring revegetation. Also, higher frequency of heavy rains and flooding could cause damage to slopes and revegetated areas, which could increase impacts further. Climate change may result in less winter rain, which could impact the ability of grasses and desert scrub vegetation to grow. In addition, climate change may contribute to the mortality of large oak and deciduous trees, including those located within drainages, which would affect scenic quality within the region and revegetation efforts on waste rock and tailings facilities (FEIS, pp. 827–829).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

All new information pertaining to visual resources relates to changed status for past, present and new reasonably foreseeable actions. A review of all of these actions indicates that they would not individually or cumulatively result in changes to the issues or additional factors described above. The rationale for this conclusion follows:

Past Actions

- Exploratory drilling on Rosemont private property. *This action consisted of minor disturbance on private property to facilitate exploration temporary drilling. The disturbance is minor and would not contribute toward visual impacts from any of the designated viewpoints.*
- Additional wildfires that occurred between 2012 and 2014. *Wildfires occur in the analysis annually. During the period from 2012 to 2014 an estimated 33 wildfires occurred ranging in size from 0.1 acre to 66 acres. The majority were less than 10 acres in size. While new wildfires are apparent on the landscape, they do not violate forest plan scenic integrity*

objectives. Past wildfires are recovering over time, and these newer fires will also recover over time. No changes in the overall impacts disclosed in the FEIS have resulted from these wildfires.

- Hazardous fuels treatment in Gardner Canyon has been accomplished. *This project may slightly change the appearance of vegetation in the area of treatment; however, this type of treatment resembles natural conditions and would not be considered to be a visual impact.*

Present Actions

- The Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions are actively selling real estate and constructing homes and associated infrastructure. *These actions were considered as reasonably foreseeable in the FEIS and addressed in the cumulative effects analysis. The impacts disclosed remain valid.*

Reasonably Foreseeable Actions

- Hog Canyon, Hazardous Fuels Reduction Project. *This project may slightly change the appearance of vegetation in the area of treatment; however, this type of treatment resembles natural conditions and would not be considered to be a visual impact.*
- Charles Seel lease of State Trust Land (from State land commissioner) for mining purposes. *While this project was listed as reasonably foreseeable in the FEIS, no information regarding plans for mining was known. Subsequently, a mineral development plan was discovered that was submitted to the ASLD. While no ground-disturbing activity has occurred on the site, the mineral development plan outlines the plan of operations for the proposed mining activity and provides an environmental assessment of potential impacts. According to the EA, which has been accepted by the ASLD, "The quarry site is well screened by topography from surrounding view. There are no residents or residences near the quarry site. The quarry site is not visible from I-10 or from State Highway 83, and it cannot be seen from the two ranch houses in the area. It may be partially visible from a residence built high on a hillside in Sec. 33 T 17 S R 17 E, a little more than ½ mile southeast of the prospect."*

  While this project may have some visual impact from one private residence, it would not change the conclusion of impacts to visual resources disclosed in the FEIS. It should be noted that there is no indication if or when ground-disturbing activities may occur for this project.
- Mt. Lemmon Recreation Area Improvements. *This project will have no impact on visual resources.*
- Madera Waterline Replacement. *Water usage from three springs will cease and be replaced with a well on private property. While this project may cause minor short-term visual impacts to areas disturbed, which would occupy a small site, it would not change the conclusion of impacts to visual resources disclosed in the FEIS.*
- Mt. Hopkins Re-Entry Thinning Project. This is to maintain defensible space around the structures in the event of a wildfire. *This project may slightly change the appearance of vegetation surrounding the Mt. Hopkins Observatory; however, this type of treatment resembles natural conditions and would not be considered to be a visual impact.*
- Road Construction (5 miles). CBP. *The roads to be constructed would affect the visual resource in the immediate area of construction. This project proposes to construct 8 road segments totaling 4.7 miles in length, which would disturb an estimated 16.5 acres of native vegetation. The proposed roads would be unpaved 1 to 2 lanes wide, and would look visually similar to typical NFSRs. These are located in remote areas. In addition, the project*

proposes to close 1.2 miles of existing road for resource protection. While the new road segments would have local impacts to visual quality, and would continue the trend of impacts described in the FEIS: "The proposed project, when added to past, present, and future actions and combined with trends that impact visual quality, would result in cumulatively, adverse, permanent impacts on scenic quality within the region because of the surface disturbance and landscape contrasts associated with those activities." While this foreseeable action would continue this trend of visual impacts, it would not change the conclusion of impacts to visual resources disclosed in the FEIS.

- Improvements at Marshall Gulch Picnic Area and Trailhead. *These actions may have small scale temporary visual effects while construction is occurring, but would recover rapidly. They would not change the conclusion of impacts to visual resources disclosed in the FEIS.*
- Grazing Permit Amendment, Papago Allotment. *Changing the number of livestock on this active grazing allotment would have no impact on visual resources.*
- Mowry Allotment Analysis. *Changing the grazing strategy on an active grazing allotment would have no impact on visual resources.*
- Plan of Operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. *This is a short-term use that would cause minimal surface disturbance. Drilling equipment would be visible during the short term that activities are ongoing. However, due to the small area impacted, expected reclamation, and short duration of these activities this action would not change the conclusion of impacts to visual resources disclosed in the FEIS.*
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River. *This is a short-term use that would cause minimal surface disturbance at the bridge site only. It would not change the conclusion of impacts to visual resources disclosed in the FEIS.*
- Camp Tatiyee Land Exchange. *This project proposes to transfer 9 parcels totaling about 764 acres of private land within the boundaries of the Coronado National Forest to NFS ownership. These parcels are currently available for development. Transfer of ownership of these parcels to the Forest Service would result in their being managed according to the Coronado forest plan, where management activities take scenic quality objectives and potential impacts to visual resources into consideration. The overall effect would be positive for visual resources, with a lower risk of development that could negatively impact visual resources that currently exists.*
- Helicopter use by AGFD within Pusch Ridge Wilderness to capture and investigate mortalities of desert bighorn sheep. *This action would result in limited, short-term helicopter use by AGFD. The noise and visual conditions could be dominated by this helicopter use in the immediate vicinity of landing and takeoff. However, because the use would be limited in duration and number of trips, and the disturbance is temporary in nature no long-term effects are expected.*
- Bear Canyon Bark Beetle Sanitation Project. *Felling and removing bark beetle infested trees in select developed recreation sites and surrounding areas would have visual effects. However, because these actions are generally in canyon bottom and north-facing slopes and consist of individual tree removal, impacts would be localized. Visual changes are expected to blend in with natural surroundings and would not result in any changes to baseline conditions, analysis, or impact conclusions disclosed in the FEIS.*

Summary of Findings

All new information and changed conditions were reviewed to determine whether they would impact visual resources. Those that have the potential to impact visual resources were considered in light of the description of baseline conditions, the analysis methodology, and the conclusions of impacts presented in the FEIS.

Inclusion of new information and changed conditions into the analysis does not result in any changes to the conclusions of impacts to visual resources. While some of the reasonably foreseeable actions could have local, short-term impacts, they would not modify visual conditions to the extent that changes would be necessary for the baseline conditions, analysis methodology, or impact analysis conclusions disclosed in the FEIS.

Recreation and Wilderness

Summary of Applicable New Information and/or Changed Conditions

The following new information and changed conditions were noted.

Past Actions

- Exploratory drilling on Rosemont private property occurred in 2014. All ground-disturbing activities occurred within the footprint of the open pit. The pit and all areas within the security fence were considered disturbed land for the purpose of impact analysis in the FEIS; therefore, the drilling adds no additional ground disturbance for any analysis.
- Additional wildfires that occurred between 2012 and 2014.
- Hazardous fuels treatment in Gardner Canyon has been accomplished.

Reasonably Foreseeable Actions

- Hog Canyon, Hazardous Fuels Reduction Project. The District proposes to remove hazardous fuels over 2500 acres in Hog Canyon on the Nogales Ranger District. Note that this originally included Gardner Hazardous Fuels Reduction Project, which has been completed and is now listed as a past action.
- Charles Seel lease of State Trust Land (from State land commissioner) for mining purposes.
- Mt. Lemmon Recreation Area Improvements. This project involves installation of three tables, a bulletin board, and a fee tube at the Mt. Lemmon Recreation Site, in addition to new parking bumpers and procured trail signs at the Mt. Lemmon Recreation Area and Summit Trailheads parking.
- Madera Waterline Replacement. Modify the existing Madera water supply system to provide a reliable source of water for the residents and visitors to Madera Canyon. Water usage from three springs will cease and be replaced with a well on private property on the Nogales Ranger District.
- Mt. Hopkins Re-Entry Thinning Project. Nogales Ranger District is coordinating with the Smithsonian Institution to thin and chip near structures on the Mt. Hopkins Observatory site. This is to maintain defensible space around the structures in the event of a wildfire.
- Road Construction (5 miles). CBP. Provide improved access to the U.S.–Mexico border on the Coronado National Forest by constructing approximately 5 miles of roads that will enable CBP to safely and effectively execute its mission while protecting the forest natural resources

to the degree possible. New road construction would occur in three different locations: the Fresnal Wash area, Cantinas Reservoir area, and Sycamore Canyon area.

Newly constructed roads would be closed to public motorized use and available only for administrative use. In addition, approximately 1.2 miles of existing roads in the Fresnal Wash and Sycamore Canyon areas would be closed to motorized travel by earthen berm barriers to foster resource protection. Additionally, some of the road mileage may be claimed under the Department of Homeland Security Waiver—particularly the portion crossing the IRA.

- Improvements at Marshall Gulch Picnic Area and Trailhead. Replace restrooms, renovate picnic sites and trailheads, install vehicular bridges over stream, naturalize stream channel, and improve roads and parking areas.
- Grazing Permit Amendment, Papago Allotment. The District proposes to change the number of livestock authorized on the Papago Allotment on the Sierra Vista Ranger District, 10 miles southeast of Sonoita, Arizona.
- Mowry Allotment Analysis. The proposed action is to authorize continued livestock grazing on the Mowry Allotment using an adaptive management strategy.
- Plan of Operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. The District proposes to authorize the operator to conduct 5-hole exploratory drilling activities on the Sierra Vista Ranger District, approximately 2 miles southeast of Washington-Duquesne, Arizona.
- Camp Tatiyee Land Exchange. Nine tracts on the Coronado National Forest are proposed to be conveyed to the Forest Service. These parcels are scattered across the Santa Catalina, Douglas, Safford, Nogales, and Sierra Vista Ranger Districts. NFS lands proposed for conveyance to a private party are not located on the Coronado National Forest.
- Helicopter use by AGFD within Pusch Ridge Wilderness to capture and investigate mortalities of desert bighorn sheep. To increase the potential for successful reintroduction of desert bighorn sheep, AGFD requires the intermittent use of helicopters for the first 4 years of the reintroduction and restoration process.
- Bear Canyon Bark Beetle Sanitation Project. Fell and remove bark beetle infested trees to reduce bark beetle populations, to protect surrounding trees and stands, and to mitigate fire hazard associated with beetle-killed trees on the Santa Catalina Ranger District. Developed recreation sites and surrounding areas, including Cypress, Middle Bear, and Chihuahua Pine Picnic Areas and General Hitchcock Campground. Generally, canyon bottom and north-facing slopes.

Baseline Conditions Considering New Information and Changed Conditions

Baseline conditions for recreation and wilderness remain essentially the same as described in the FEIS. Additional wildfires and mineral exploration activities have occurred in the analysis area since release of the FEIS, but these are a continuation of past and present actions described in the FEIS. As new wildfires occur annually, past fires continue to recover. Similarly, mineral exploration projects are typically short-term, isolated projects that result in little ground disturbance or disruption once the project is completed and drilling equipment is removed. The description of baseline conditions for recreation and wilderness in the FEIS remains accurate.

Summary of FEIS Analysis Methodology and Impact Conclusions

The analysis of recreation and wilderness resources in the FEIS focused on describing changes from proposed and reasonably foreseeable actions on recreation opportunities and experiences and wilderness characteristics within the defined analysis area.

Impacts were predicted for seven issues:

- Acres that would no longer meet current forest plan Recreation Opportunity Spectrum designations.
- Acres of the Coronado National Forest that would be unavailable for recreational use and miles of NFSRs lost.
- Qualitative assessment of potential for noise to reach recreation areas, i.e., audio "footprint."
- Qualitative assessment of impacts on solitude in designated wilderness and other backcountry areas.
- Hunter-days lost (quantity based on number of permits available and number of days in season).
- Miles of Arizona National Scenic Trail relocated.
- Qualitative assessment of increased pressure on other areas, including roads and trails/trailheads.

Impact Conclusions

Direct and Indirect Impacts

- For the action alternatives, acres that would no longer meet current forest plan Recreation Opportunity Spectrum designations range from 6,073 acres. Acres for the Phased Tailings Alternative, to 8,885 acres for the Scholefield-McCleary Alternative.
- For the action alternatives, acres of the Coronado National Forest that would be unavailable for recreational use range from 6,073 with the Phased Tailings Alternative, to 8,885 for the Scholefield-McCleary Alternative. Miles of NFS road lost ranges from 17.5 for the proposed action and Phased Tailings Alternative, to 28.5 for the Scholefield-McCleary Alternative.
- The potential for noise to reach recreation areas exists for all action alternatives. Industrial noise would be noticed near the perimeter fence and along much of the Arizona National Scenic Trail for the proposed action and Phased Tailing Alternative; while industrial noise would be noticed near the perimeter fence but not evident from most of the Arizona National Scenic Trail for the remaining action alternatives.
- Little or no change in solitude in designated wilderness and other backcountry areas is anticipated with any of the action alternatives.
- A total of 775 annual hunter-days lost per year is expected for each of the action alternatives.
- For the action alternatives, 7.3 miles of the Arizona National Scenic Trail would be relocated with the proposed action and Phased Tailings Alternative, while the remaining action alternatives would relocate 12.8 miles of the trail.
- The potential to displace recreational use from the project area and increase pressure on other areas is the same for all action alternatives: moderate increase of use is expected in nearby areas such as Happy Valley, Gardner Canyon, Louisiana Gulch, Ophir Gulch, and Carouleau Gap.

Cumulative Impacts

Cumulatively, these foreseeable actions would contribute and add to the direct and indirect recreation impacts described earlier. Actions associated with the Oracle Ridge Mine would contribute to displacement of recreational uses from this area of the Coronado National Forest. Changes to NFSR designation in the Santa Rita Management Area on the Nogales Ranger District could continue to decrease access for motorized recreation opportunities. Hazardous fuels treatment in Hog and Gardner Canyons would likely displace recreational use for the immediate area for a short amount of time. The overall result would be fewer areas of the forest available for recreation, thus displacing use to other public lands.

Climate change would impact recreation and visual quality if lower precipitation, warmer temperatures, and more frequent drought cycles result in less successful or slower revegetation and more bare soil and rock being visible on the waste rock and tailings facilities, postmine plant site, and other areas allotted for revegetation. Should these conditions occur, they would increase impacts to both recreation settings and visual quality because revegetation is critical to reducing mine impacts (FEIS, p. 870).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

All new information pertaining to recreation and wilderness relates to changed status for past and new reasonably foreseeable actions. A review of all of these actions indicates that they would not individually or cumulatively result in changes to the issues or additional factors described above. The rationale for this conclusion follows:

Past Actions

- Exploratory drilling on Rosemont private property. *This action consisted of temporary use of NFSRs to move equipment to and from the drilling sites on private property, and minor disturbance on private property to facilitate exploration temporary drilling. The use of roads was temporary and short term; and the disturbance is minor. This project may have temporarily displaced recreational use from the area of the activities. However, impacts were limited to the short time in which activities were occurring.*
- Additional wildfires that occurred between 2012 and 2014. *Wildfires occur in the analysis area annually. During the period from 2012 to 2014 an estimated 33 wildfires occurred ranging in size from 0.1 to 66 acres. The majority were less than 10 acres in size. Wildfires may temporarily displace recreational use from the area of the activities while fire suppression activities are ongoing, and, depending on the area, may decrease recreational use until some vegetative recovery has occurred. The fires that occurred between 2012 and 2014 are unlikely to result in any substantive change in recreation use or use patterns in the analysis area.*
- Hazardous fuels treatment in Gardner Canyon has been accomplished. *This project likely temporarily displaced recreational use from the area of the activities while activities were ongoing, but would not have long-term impacts on recreational use.*

Reasonably Foreseeable Actions

- Hog Canyon, Hazardous Fuels Reduction Project. *Impacts would be similar to those described for the Gardner hazardous fuel reduction treatment project described above.*

- Charles Seel lease of State Trust Land (from State land commissioner) for mining purposes. *While this project was listed as reasonably foreseeable in the FEIS, no information regarding plans for mining was known. Subsequently, a mineral development plan was discovered that was submitted to the ASLD. While no ground-disturbing activity has occurred on the site, the mineral development plan outlines the plan of operations for the proposed mining activity and provides an environmental assessment of potential impacts. According to the EA, which has been accepted by the ASLD, the marble quarrying operation should not impact open space, recreation areas or wildlife refuges. While the EA does not include specific analysis of noise resulting from the marble quarry, it is anticipated that noise from the operation could displace dispersed recreational use from the immediate vicinity of the project. It should be noted that this area is currently state grazing land, with no developed recreation sites. Dispersed recreational use is assumed to be light to non-existent. It is also important to note that there is no information about if or when this project will commence.*
- Mt. Lemmon Recreation Area Improvements. *This project will have a minor net beneficial impact for recreation. Impacts are very localized and temporary, and would not contribute to cumulative impacts.*
- Madera Waterline Replacement. *While this project may cause minor short-term displacement of recreational use in the immediate vicinity of activities, it would be short-term and impacts would be limited to a very small area. Impacts are very localized and temporary, and would not contribute to cumulative impacts.*
- Mt. Hopkins Re-Entry Thinning Project. *This project may create some noise and disturbance in the immediate vicinity of thinning activities. While some local, temporary displacement may occur, impacts are very localized and temporary, and would not contribute to cumulative impacts.*
- Road Construction (5 miles). CBP. *The roads to be constructed would have minimal impact on recreational resources. The proposed newly constructed road segments would be closed to public motorized use; and 1.2 miles of existing road would also be closed for resource protection. These net result would be a reduction of 1.2 miles of existing road that is currently open for public motorized use. While this would have local impacts in terms of motorized access, it would not change the conclusion of impacts disclosed in the FEIS that changes to NFSR designation on the Nogales Ranger District could continue to decrease access for motorized recreation opportunities.*

  About 1 mile of the Cantinas Connector portion of the road proposed for construction may be located within an IRA. At this time, the CBP is reevaluating its proposal regarding this segment of road. However, should road construction occur in an IRA, it would impact the roadless characteristics of that area and not meet the Recreation Opportunity Spectrum setting semi-primitive non-motorized recreation in the Coronado forest plan. It is important to note that the Rosemont Copper Project is not projected to impact any IRA; therefore, impacts to the IRA from this road construction proposal would not overlap with similar impacts from the Rosemont Copper proposal (since it has no effects on IRAs); therefore, no cumulative impacts would occur.
- Improvements at Marshall Gulch Picnic Area and Trailhead. *This project will have a minor net beneficial impact for recreation. Impacts are very small and localized and would not contribute to cumulative impacts.*
- Plan of Operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. *This action would consist of temporary use of NFSRs to move equipment to and from the drilling sites, and minor disturbance to facilitate exploration temporary drilling. The use of roads would be temporary and short term, and the disturbance would be minor. This project may*

temporarily displace recreational use from the area of the activities. However, impacts would likely be limited to the short time in which activities are occurring. While some local, temporary displacement may occur, impacts would not overlap with those of the proposed Rosemont Copper Project and thus would not contribute to cumulative impacts.

- Camp Tatiyee Land Exchange. *This project proposes to transfer about 764 acres of private land within the boundaries of the Coronado National Forest to NFS ownership. These parcels are currently available for development. Transfer of ownership of these parcels to the Forest Service would result in their being managed according to the Coronado forest plan, where the parcels would be open to public access. The overall effect would be positive for recreation resources, with a lower risk of development that could negatively impact recreation resources that currently exists.*
- Helicopter use by AGFD within Pusch Ridge Wilderness to capture and investigate mortalities of desert bighorn sheep. *This action would result in limited, short-term helicopter use by AGFD. The noise created by this helicopter use in the immediate vicinity of landing and takeoff could displace some recreational use for short periods of time (typically, a few hours). However, because the use would be limited in duration and number of trips, and the disturbance is temporary in nature, no long-term or cumulative effects are expected.*
- Bear Canyon Bark Beetle Sanitation Project. *Felling and removing bark beetle infested trees in select developed recreation sites and surrounding areas could temporarily displace some recreational use of the areas where activities are occurring. However, because these actions are limited in scope and will occur over a limited amount of time, impacts would not result in any changes to baseline conditions, analysis, or impact conclusions disclosed in the FEIS.*

Summary of Findings

All new information and changed conditions were reviewed to determine whether they would impact recreation and wilderness. Those that have the potential to impact recreation and wilderness were considered in light of the description of baseline conditions, the analysis methodology, and the conclusions of impacts presented in the FEIS.

Inclusion of new information and changed conditions into the analysis does not result in any changes to the conclusions of impacts to recreation and wilderness. While some of the reasonably foreseeable action could have local, short term impacts such as displacing recreational use for short periods, these impacts would not result in any changes in baseline conditions, analysis methodology, or impact analysis conclusions disclosed in the FEIS.

Hazardous Materials

Summary of Applicable New Information and/or Changed Conditions

No new information or changed conditions pertinent to the analysis of hazardous materials in the FEIS were identified.

Baseline Conditions Considering New Information and Changed Conditions

The baseline conditions for hazardous materials described in the FEIS remain valid, with no changes or modifications.

Summary of FEIS Analysis Methodology and Impact Conclusions

There are no changes to the analysis methodology or conclusion of impacts for hazardous materials from those described in the FEIS.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

No new information or changed conditions were identified that would affect the analysis of hazardous materials presented in the FEIS.

Summary of Findings

No new information or changed conditions was identified that would result in changes to the description of baseline conditions, the analysis methodology, or the conclusions of impacts presented in the FEIS for hazardous materials.

Fuels and Fire Management

Summary of Applicable New Information and/or Changed Conditions

The following new information or changed conditions were identified:

- The Greaterville fire occurred within the analysis area for fire and fuels management in 2014. This fire was 0.1 acre in size.
- The Coronado conducted a more detailed cruise of trees that would be removed to facilitate construction of the mine in 2013, after the release of the FEIS.

Baseline Conditions Considering New Information and Changed Conditions

The FEIS description of baseline conditions in the fire and fuels management analysis area describes wildfire conditions and history, and vegetation communities. The one fire that has occurred in the analysis area since release of the FEIS was very small, and has resulted in no change or modification to baseline conditions described in the FEIS.

Summary of FEIS Analysis Methodology and Impact Conclusions

The analysis of fire and fuels management in the FEIS focused on the following:

- Qualitative assessment of the potential for activities to increase the risk of wildfire ignition, including blasting, increased vehicle traffic, storage and transportation of flammable materials, and construction activities.
- Effect of activities on fuel loading, including clearing of vegetation, noxious weeds, and decreases in groundwater level.

Impact Conclusions

Direct and Indirect Impacts

- For all action alternatives:
    - o There is an increased risk of accidental ignition along transportation routes from increased traffic attributable to the mine project;

- There is an increased risk of accidental ignition along transportation routes from s transportation of flammable materials associated with mine operations;
    - Risk of increased ignition from construction activities would be low;
- For all action alternatives:
    - Effects of vegetation clearing on fuel loading would be low;
    - Minor additional fuel loading from noxious weeds (after mitigations) would occur;
    - Decrease in groundwater level (and subsequent impacts to live vegetation) would be minor.

Cumulative Impacts

No reasonably foreseeable future actions are expected to have a cumulative effect on fuels and fire management within the analysis area.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

The pertinent new information results in no change to analysis methodology or impact conclusions for fire and fuels management. The one wildfire that has occurred in the analysis area since the release of the FEIS totaled 0.1 acre in size, which would result in no measurable change to any analysis factor or impact conclusion. The post-FEIS cruise of trees to be cut for construction of the mine provided data on species and size of trees, with the purpose of arriving at a value to be charged to the mine proponent. The FEIS reported an estimated 66,000 tons of woody material would be cut, while the cruise report listed volumes in hundred cubic feet of merchantable volume. While the cruise report provides additional information that was not contained in the FEIS, that information has no effect on the analysis methodology or conclusion of impacts disclosed in the FEIS.

Summary of Findings

A review of new information and changed conditions indicates that no changes to the description of baseline conditions, analysis methodology, or the conclusions of impacts presented in the FEIS for fire and fuels management are warranted.

Transportation/Access

Summary of Applicable New Information and/or Changed Conditions

The following new information and changed conditions were noted.

Past Actions

- Exploratory drilling on Rosemont private property occurred in 2014. All ground-disturbing activities occurred within the footprint of the open pit. The pit and all areas within the security fence were considered disturbed land for the purpose of impact analysis in the FEIS; therefore, the drilling adds no additional ground disturbance for any analysis.

Reasonably Foreseeable Actions

- Charles Seel lease of State Trust Land (from State land commissioner) for mining purposes.
- Plan of Operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. The District proposes to authorize the operator to conduct five-hole exploratory drilling

activities on the Sierra Vista Ranger District, approximately 2 miles southeast of Washington-Duquesne, Arizona.

- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River, as part of its 5-year Capital Improvement Plan.

Baseline Conditions Considering New Information and Changed Conditions

Baseline conditions described in the FEIS focused on describing the existing transportation system in the analysis area, access management, and current conditions such as type and amount of use and existing service levels.

Summary of FEIS Analysis Methodology and Impact Conclusions

The FEIS transportation and access analysis focused on the impact of increased mine-related traffic during premining, active mining, and final reclamation and closure.

Measurement factors were:

- Change in type and pattern of traffic by road and vehicle type.
- Quantitative assessment of the change in level of service on potential highway routes.
- Quantitative assessment of roads decommissioned by the mine and roads whose access is restricted by mine operations.

Impact Conclusions

Direct and Indirect Impacts

- For all action alternatives, there would be an increase in truck and passenger car traffic from mine related traffic on analyzed highway routes.
- For all action alternatives, there would be a decrease in level of service for some intersections and roadway segments, but would not decrease to an unacceptable level of service. Mitigation measures would reduce the impacts of mine related traffic.
- For the action alternatives, roads decommissioned by the mine and roads whose access is restricted by mine operations range from 32.7 miles for the proposed action to 46.9 miles for the Scholefield-McCleary Alternative.

Cumulative Impacts

The two minerals exploration projects (Hermosa and Patagonia/Sunnyside) could result in minor increases in traffic in the vicinity of Patagonia and Nogales, respectively. While these traffic increases would be minor in and of themselves, they could contribute to increased traffic resulting from the proposed Rosemont Copper Project, should mine product shipment be routed through these towns.

Implementation of the Forest Service "Travel Management Rule" on the Nogales Ranger District could result in changes to the established system of roads and trails in the Santa Rita Mountains. It is anticipated that those changes would include closure of some unauthorized roads and some existing NFSRs, prohibitions on some motor vehicle use, and addition of some unauthorized roads to the current road system. The Santa Rita Mountains would continue to be closed to cross-country motorized vehicle travel. Road closures and vehicle prohibitions would contribute to a decrease in motorized access to NFS lands in the analysis area in the long term. The designation/addition of currently unauthorized roads that are used for hunter access, hiking, and dispersed camping as part of the NFSR inventory may increase access to some NFS lands by legalizing use of those roads by the public and ensuring maintenance and management of those roads (FEIS, p. 955).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

All new information pertaining to transportation and access relates to changed status for past and new reasonably foreseeable actions. A review of all of these actions indicates that they would not individually or cumulatively result in changes to the issues or additional factors described above. The rationale for this conclusion follows below.

Past Actions

- Exploratory drilling on Rosemont private property. *This project included use of roads in the analysis area to move equipment into and out of the drilling sites. The total amount of traffic generated by this project was minimal, limited to move-in and move-out and commuting of a few employees. Impacts for this level of use would not have affected any aspect of the baseline conditions described in the FEIS.*

Reasonably Foreseeable Actions

- Charles Seel lease of State Trust Land (from State land commissioner) for mining purposes. *This potential project is located east of Davidson Canyon and SR 83. Access is provided by SR 83 and an unimproved road. No federal land or NFS roads are involved with this project.*

  The EA prepared for this project states, "The number of truckloads of marble hauled per day will vary depending upon quarry production. The crushed marble will be loaded from the stockpile into 25-ton trucks to the processing plant." The location of the processing plan is not specified, other that it would be "off-site." The MPO included a 10-year estimate of quarry operating costs, therefore it is assumed that haul trucks would be operating for this 10-year period of time. The loading equipment specified in the MPO is limited to one excavator and two haul trucks. The entire lease area totals 240 acres, with the marble outcrop covering an area of approximately 120 acres. There is no indication about daily production, however given the number of employees estimated ("at least 4 people employed full time at the quarry site"), it is assumed the operation will operate one shift per day, 5 days per week.

  Based on the above information, which is all the information that is available for this proposed project, the following analysis was conducted:

  120 acres of marble deposit mined over 10 years = 12 acres per year mined

  12 acres per year / 260 work days per year = 0.046 acres per day mined

  0.046 acre is about 2010 square feet, or an area that is 45 feet x 45 feet.

  Given this production schedule and the loading and hauling equipment listed in the MPO, it is estimated that haul truck trips would total 4 to 8 per day (2 haul trucks making 1 to 2 round trips per day), 5 days per week. A total of 6 employees (4 at the quarry and 2 truck drivers) would result in 6 or fewer commuter trips per day, 5 days per week.

  This level of traffic would not change the impact conclusion for transportation and access described in the FEIS. If this project is developed, it would slightly contribute to the overall increase in truck and passenger car traffic from mine-related traffic on SR 83 and potentially other highways, depending on the location of the processing plant. The decrease in traffic *service level would remain as described in the FEIS. This proposed project would not decommission any roads or otherwise affect access for the general public.*

- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River. *While this project could result in temporary traffic delays while construction is occurring, it is not anticipated that any traffic related to the Rosemont Copper Project would occur on this road.*

Summary of Findings

A review of new information and changed conditions indicates that no changes to the description of baseline conditions, analysis methodology, or the conclusions of impacts presented in the FEIS for transportation and access are warranted.

Noise

Summary of Applicable New Information and/or Changed Conditions

No new information or changed conditions pertinent to the analysis of noise in the FEIS were identified.

Baseline Conditions Considering New Information and Changed Conditions

The baseline conditions for noise described in the FEIS remain valid, with no changes or modifications.

Summary of FEIS Analysis Methodology and Impact Conclusions

There are no changes to the analysis methodology or conclusion of impacts for noise from those described in the FEIS.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

No new information or changed conditions were identified that would affect the analysis of noise presented in the FEIS. While many of the project listed as present and reasonably foreseeable actions under the new information section earlier in this document would result in differing degrees of noise, none of them occur within or near the analysis area for noise described in the FEIS.

Summary of Findings

No new information or changed conditions was identified that would result in changes to the description of baseline conditions, the analysis methodology, or the conclusions of impacts presented in the FEIS for noise.

Public Health and Safety

Summary of Applicable New Information and/or Changed Conditions

No new information or changed conditions pertinent to the analysis of public health and safety in the FEIS were identified.

Baseline Conditions Considering New Information and Changed Conditions

The baseline conditions for public health and safety described in the FEIS remain valid, with no changes or modifications.

Summary of FEIS Analysis Methodology and Impact Conclusions

There are no changes to the analysis methodology or conclusion of impacts for public health and safety from those described in the FEIS.

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

No new information or changed conditions were identified that would affect the analysis of public health and safety presented in the FEIS.

Summary of Findings

No new information or changed conditions was identified that would result in changes to the description of baseline conditions, the analysis methodology, or the conclusions of impacts presented in the FEIS for public health and safety.

Cultural Resources

Summary of Applicable New Information and/or Changed Conditions

The following new information and changed conditions were noted.

Past Actions

- Exploratory drilling on Rosemont private property occurred in 2014. All ground-disturbing activities occurred within the footprint of the open pit. The pit and all areas within the security fence were considered disturbed land for the purpose of impact analysis in the FEIS; therefore, the drilling adds no additional ground disturbance for any analysis.
- Additional wildfires that occurred between 2012 and 2014.
- Hazardous fuels treatment in Gardner Canyon has been accomplished.

Present Actions

- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions has been reclassified from a reasonably foreseeable action, as presented in the FEIS, to a present action. The developments are actively selling real estate and constructing homes and associated infrastructure.

Reasonably Foreseeable Actions

- Hog Canyon, Hazardous Fuels Reduction Project. The District proposes to remove hazardous fuels over 2500 acres in Hog Canyon on the Nogales Ranger District. Note that this originally included Gardner Hazardous Fuels Reduction Project, which has been completed and is now listed as a past action.
- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes.

- Mt. Lemmon Recreation Area Improvements. This project involves installation of three tables, a bulletin board, and a fee tube at Mt. Lemmon Recreation Site, in addition to new parking bumpers and procured trail signs at the Mt. Lemmon Recreation Area and Summit Trailheads parking.
- Madera Waterline Replacement. Modify the existing Madera water supply system to provide a reliable source of water for the residents and visitors to Madera Canyon. Water usage from three springs will cease and be replaced with a well on private property on the Nogales Ranger District.
- Mt. Hopkins Re-Entry Thinning Project. Nogales Ranger District is coordinating with the Smithsonian Institution to thin and chip near structures on the Mt. Hopkins Observatory site. This is to maintain defensible space around the structures in the event of a wildfire.
- Road Construction (5 miles). CBP. Provide improved access to the U.S.–Mexico border on the Coronado National Forest by constructing approximately 5 miles of roads that will enable CBP to safely and effectively execute its mission while protecting the forest natural resources to the degree possible. New road construction would occur in three different locations: the Fresnal Wash area, Cantinas Reservoir area, and Sycamore Canyon area.

  Newly constructed roads would be closed to public motorized use and available only for administrative use. In addition, approximately 1.2 miles of existing roads in the Fresnal Wash and Sycamore Canyon areas would be closed to motorized travel by earthen berm barriers to foster resource protection. Additionally, some of the road mileage may be claimed under the Department of Homeland Security Waiver—particularly the portion crossing the IRA.
- Improvements at Marshall Gulch Picnic Area and Trailhead. Replace restrooms, renovate picnic sites and trailheads, install vehicular bridges over stream, naturalize stream channel, and improve roads and parking areas.
- Grazing Permit Amendment, Papago Allotment. The District proposes to change the number of livestock authorized on the Papago Allotment on the Sierra Vista Ranger District, 10 miles southeast of Sonoita, Arizona.
- Mowry Allotment Analysis. The proposed action is to authorize continued livestock grazing on the Mowry Allotment using an adaptive management strategy.
- Plan of Operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. The District proposes to authorize the operator to conduct five-hole exploratory drilling activities on the Sierra Vista Ranger District, approximately 2 miles southeast of Washington-Duquesne, Arizona.
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River, as part of its 5-year Capital Improvement Plan. Ultimately, the project will correct the structural deficiencies of the existing bridge structure and provide for additional travel lanes, bicycle lanes, sidewalks, and new waterline crossings. The project limits extend approximately 1,000 feet on either side of the Santa Cruz River.
- Camp Tatiyee Land Exchange. Nine tracts on the Coronado National Forest are proposed to be conveyed to the Forest Service. These parcels are scattered across the Santa Catalina, Douglas, Safford, Nogales, and Sierra Vista Ranger Districts. NFS lands proposed for conveyance to a private party are not located on the Coronado National Forest.
- Bear Canyon Bark Beetle Sanitation Project. Fell and remove bark beetle infested trees to reduce bark beetle populations, to protect surrounding trees and stands, and to mitigate fire hazard associated with beetle-killed trees on the Santa Catalina Ranger District. Developed recreation sites and surrounding areas, including Cypress, Middle Bear, and Chihuahua Pine

Picnic Areas and General Hitchcock Campground. Generally, canyon bottom and north-facing slopes.

- Forestwide planting for traditional uses and pollinators on the Coronado National Forest. Implement a series of plantings to (1) increase the availability of traditional use plants for use by the Tribes and protect; and (2) expand upon the availability of habitat for pollinators that increase the sustainability of our forests.

Baseline Conditions Considering New Information and Changed Conditions

Baseline conditions for cultural resources remain essentially the same as described in the FEIS. Additional wildfires and mineral exploration activities have occurred in the analysis area since release of the FEIS, but these are a continuation of past and present actions described in the FEIS. As new wildfires occur annually, past fires continue to recover. Similarly, mineral exploration projects are typically short-term, isolated projects that result in little ground disturbance and avoid archaeological sites. The description of baseline conditions for cultural resources in the FEIS remains accurate.

Summary of FEIS Analysis Methodology and Impact Conclusions

The analysis of cultural resources in the FEIS focused upon describing changes from proposed and reasonably foreseeable actions on cultural properties, springs, and resource collection areas.

Impacts were predicted using the following factors:

- Number of historic properties buried, damaged or destroyed;
- Qualitative assessment of potential damage from vibration;
- Qualitative assessment of impacts on historic properties;
- Number of historic and prehistoric sites known/likely to have human remains;
- Number of sacred springs impacts;
- Qualitative assessment of impact on Native Americans of desecration of land, springs, burials, and sacred sites;
- Acres of traditional resource collection areas impacted;
- Qualitative assessment of impacts on other non-tribal communities in the region.

Impact Conclusions

Direct and Indirect Impacts

- Number of historic properties buried, damaged or destroyed ranged from 76 for Scholefield-McCleary Alternative to 106 for Barrel Trail Alternative;
- Potential damage from vibrations to historic properties is very unlikely;
- Notable impacts on historic properties;
- Three historic sites known/likely to have human remains impacted; prehistoric sites impacted ranged from 15 for Scholefield-McCleary Alternative to 36 for Barrel Trail Alternative;
- Number of sacred springs impacted ranged from 16 for Barrel and Barrel Trail Alternatives to 22 for Scholefield-McCleary Alternative;
- Notable impacts on Native Americans of desecration of land, springs, burials, and sacred sites;

- Traditional resource collection areas impacted ranged from 6,073 acres for the Phased Tailings Alternative to 8,889 acres for Scholefield-McCleary Alternative;
- Notable impacts on other non-tribal communities in the region.

Cumulative Impacts

Two of the actions listed in the introduction to chapter 3 would have little or no impact on cultural resources: the issuance of a special-use permit for nondisturbing noncollecting archaeological research, and the issuance of a special-use permit for bat research. These actions do not entail or authorize ground disturbance or disturbance of plants or animals and would not affect human burials or springs.

One of the reasonably foreseeable actions listed is likely to protect or enhance cultural resources rather than impact them:

- Pima County may propose specific actions related to its "Sonoran Desert Conservation Plan," including acquisition of archaeological and historical sites and traditional use sites for conservation and heritage education purposes, tours, monitoring, and other uses of sites by Pima County staff and others. Specific sites or actions are not currently known.

This action does not in itself authorize ground disturbance and in fact may provide for consideration of cultural resources and implementation of protection and enhancement measures in future development.

Two other listed foreseeable future actions do have the potential to impact cultural resources in that they involve ground disturbance and potential changes to the water table. These are as follows:

- The Community Water Company of Green Valley is proposing delivery and recharge of groundwater with water from the Central Arizona Project in the Green Valley area.
- The Farmers Investment Company is proposing extension of Central Arizona Project water into actively farmed pecan groves and activation of a groundwater savings facility near Sahuarita.

The extent of these two projects to cause direct or indirect impacts to cultural resources likely depends on the extent of new ground disturbance associated with the developments. Recharging of the water table is not likely to impact cultural resources, but increased irrigation of the Farmers Investment Company's groves may have the potential to decrease the amount of water available to the San Xavier District of the Tohono O'odham Nation.

The following listed foreseeable actions, ground disturbance, and changes in the water table that could affect cultural resources are projected to be very limited, do not apply, or are not developed to the extent that impacts can be determined. Adherence to existing laws, regulations, and policies can be expected to minimize direct and indirect impacts. Efforts would be made to design these actions to avoid impacts to cultural resources:

- The Forest Service is proposing landscape-level fire management and fuels reduction projects in two areas of the Coronado National Forest. The Catalina-Rincon FireScape Project is proposed on the Santa Catalina Ranger District and adjacent lands in Pima, Pinal, and Cochise Counties, Arizona. The Chiricahua FireScape Project is proposed for the Chiricahua, Dragoon, and Dos Cabezas Mountains.

- The BLM and AGFD are proposing reintroduction of beaver into Cienega Creek at Las Cienegas NCA.
- The Forest Service is proposing to reauthorize the grazing permit for the Gardner Allotment, located 5 miles north of Sonoita.
- The Forest Service proposes to add, decommission, close, or change designation of roads in the NFSR database and prohibit off-road motorized travel for dispersed camping in certain areas on the Nogales Ranger District.
- The Sierra Vista and Santa Catalina Ranger Districts are proposing to make changes to their District motorized travel systems. Actions could include additions to the NFSR database, decommissioning, change in maintenance level, and other actions to meet administrative and user needs.
- The Nogales Ranger District proposes to remove hazardous fuels on 2,500 acres in Hog and Gardner Canyons on the Nogales Ranger District.
- In May 2010, a lease was granted to Charles Seel for mining purposes for 240 acres of ASLD State Trust land (from State land commissioner) in Township 17 South, Range 17 East, Section 29, adjacent to CalPortland leases in Davidson Canyon. There are no known plans to explore for or develop mineral resources on this lease in the foreseeable future.
- The Forest Service proposes to approve an MPO for Javelina Minerals Exploration for mineral exploration drilling of eight holes in an area located approximately 3 miles southeast of Patagonia, Arizona. Activities would occur for a maximum of 1 year. This project has been cancelled.
- The Forest Service proposes to approve an MPO to OZ Exploration Proprietary Ltd. for mineral exploration drilling in the East Paymaster and Guajolote Flats areas in the Patagonia Mountains. Activities would occur for a maximum of 1 year. This project has been cancelled.
- The Forest Service proposes to approve an MPO for Arizona Minerals Inc. for proposed minerals exploration (referred to as Hermosa minerals exploration) on the Sierra Vista Ranger District, approximately 6 miles southeast of Patagonia, Arizona. The proposal involves drilling for core samples and water monitoring wells. Drilling would occur for a maximum of 2 years, with monitoring to continue for up to 10 years.
- The Forest Service proposes to approve an MPO for Regal Resources for minerals exploration drilling of five holes to obtain evidence of mineralization over a 2-acre area for a maximum of 1 year. The Patagonia/Sunnyside minerals exploration project is located near Nogales, Arizona, about 45 miles south of Tucson, Arizona.
- The Forest Service proposes to approve an MPO for minerals exploration drilling on the Helix Margarita property for a maximum of 1 year. This property is located near Arivaca in Santa Cruz County, Arizona, about 75 miles south of Tucson, Arizona. This project has been cancelled.
- The Santa Catalina Ranger District proposes to authorize drilling to explore for minerals approximately 10 miles southeast of Summerhaven, Arizona. The Korn Kob Minerals Exploration project involves short-term (1 year or less) mineral, energy, or geophysical investigations and their incidental support activities, which may require cross-country travel by vehicles and equipment, construction of less than 1 mile of low-standard road, or use and minor repair of existing roads.
- The Forest Service proposes to issue a special use permit to Oracle Ridge Mining, LLC, authorizing the use of forest roads, a parking area, and a utility corridor during operation of the existing Oracle Ridge Mine, which is located on private land.

- The BLM proposes to approve a decision for programmatic aquatic special status species reintroductions at Las Cienegas NCA. The purpose of this project is to conserve imperiled aquatic species through the establishment of new populations in strategically located livestock and wildlife watering ponds. The project would include: species translocations for federally listed Chiricahua leopard frog, desert pupfish, Gila topminnow, and Gila chub; release of Mexican gartersnakes into stock ponds and modified storage tanks; release of Sonora mud turtles into stock ponds from sources in the Cienega and O'Donnell Creek basins; planting of Huachuca water umbel at suitable pond locations; and protection of native leopard frog, fish, and reptile populations from invasive species. Activities would occur over a 10-year period.

However, applicability of NEPA and the National Historic Preservation Act is not likely to protect cultural resources in all cases where Federal land, funding, or permits are involved. In some cases, conflicting laws and perceived or demonstrated public need give land managers little leeway in approving or disapproving proposals. These actions could result in disturbance to cultural resources. Foreseeable actions that fall into this category include:

- Tucson Electric Power proposes two expansions of 138-kV power transmission lines that may be within one or more Rosemont Copper Project analysis areas. The first expansion project would involve the Vail substation–Cienega substation–Spanish Trail substation. It would use the existing Vail–Fort Huachuca/Vail–Spanish Trail 138-kV corridor between Vail substation and seven spans east of Wentworth Road, and then would involve construction of a new double-circuit 138-kV line northeast approximately 2 miles from Tucson Electric Power's proposed Cienega site. The second expansion project would involve the South substation–Hartt substation–Green Valley substation. It would tap into the existing South–Green Valley 138-kV circuit and drop into a new station adjacent to the ROW located approximately 1 mile south of Old Nogales Highway and Duval Mine Road.
- The BLM is preparing an EIS for the Southline Transmission Line Project, proposed to be built in southern New Mexico and Arizona. Southline Transmission, LLC, proposes to construct, operate, and maintain a high-voltage power line in two segments totaling approximately 360 miles. The first segment would be a new double-circuit 345-kV line from a substation in Afton, New Mexico (south of Las Cruces), to a substation in Apache, Arizona (south of Willcox). This 225-mile segment would provide up to 1,500 megawatts of capacity. The second segment would be an upgrade and rebuild of about 130 miles of existing transmission lines between the Apache substation and the Saguaro substation northwest of Tucson. It would provide capacity for an additional 1,000 megawatts of electricity. The line would cross Federal lands managed by the BLM and other agencies. It also would cross State and private lands.
- The BLM proposes to approve an MPO to expand the Andrada Mine limestone quarry in the Davidson Canyon drainage system north and northeast of the Santa Rita Mountains. The Andrada Mine is located approximately 4 miles from the Tucson, Arizona, city limits and 1 mile from the Vail, Arizona, city limits.
- The Forest Service proposes to approve two MPOs for the Moore and Moore No. 4 Placer Mine and the Dice No. 8 Placer Mine, both located 2 miles southwest of Washington/Duquesne, Arizona. Actions for each project would include trenching and washing of excavated material in a 1- to 2-acre area for a maximum of 1 year.
- In late 2009, Freeport-McMoRan bought 8,900 acres of the long-closed Twin Buttes Mine site, near Sahuarita. Required permits for reopening the mine have not been issued to date, but it is reasonable to assume that this mine could be reopened at some point in the future.

- The former Oracle Ridge Mine, located on private property within the Santa Catalina Ranger District, is an inactive, small-scale underground copper mine in the permitting and detail design stage for resuming operations. The proposed mine operation would use the same surface footprint as previous operations to the extent possible.

Urban and suburban development can involve direct impacts on cultural resources from ground disturbance during the construction of housing, roads, and utilities, but also indirect impacts caused by increases in population. For example, the demand for groundwater in the Sahuarita area is anticipated to increase by 200 percent by the year 2030; changes to the water table can affect traditional plants, resource collection, and springs. Increases in population are likely to lead to increases in recreation and other demands on public lands. The foreseeable developments in and near the town of Sahuarita listed in the introduction to chapter 3 include:

- Development of the Farmers Investment Company property within the Town of Sahuarita's jurisdiction over the next 40 to 50+ years for residential and commercial mixed use is proposed, along with the enhancement of more than 12 miles of the Santa Cruz River in both the town of Sahuarita and Pima County.
- Rancho Sahuarita is a proposed 3,048-acre planned community located within the Town of Sahuarita's jurisdiction adjacent to the northwestern portions of the Sahuarita Farms property. The plan allows for 11,680 residential dwelling units, or 3.8 residents per acre. The plan also includes about 1,000 acres of mixed-use and/or other non-residential land uses.
- Quail Creek is a proposed 1,700-acre master planned retirement community located northeast of Sahuarita Farms' southernmost specific plan parcel. The community is within the Town of Sahuarita's jurisdiction and is entitled for approximately 5,000 housing units and a limited amount of non-residential uses adjacent to Old Nogales Highway.
- Madera Highlands is a proposed 920-acre community located within the Town of Sahuarita's jurisdiction. The plan allows for approximately 3,500 units, or approximately 3.8 residents per acre. It is located adjacent to the eastern boundary of Sahuarita Farms' southernmost development parcel.
- Demand for groundwater in the Sahuarita area is expected to increase by 200 percent by the year 2030.

The overall forecast is one of continued degradation and loss of cultural resources from land disturbance, vegetation changes, and depletion of the water table. These foreseeable future actions exacerbate the destruction of cultural resources that has occurred in the analysis area over the past century: modern development has already destroyed an untold number of archaeological sites and places where human remains were buried; the depletion of the water table has altered vegetation and affected traditional plants and springs; and current landownership patterns have restricted traditional collecting areas. As one of the "islands in the desert" of southeastern Arizona, removed from the public domain in the early 20th century, the Santa Rita Mountains have been largely excluded from intensive development. The project area is rich in a diverse array of cultural resources and has the additional cultural significance of the open spaces, heights, and natural resources of the Santa Rita Mountains (FEIS, pp. 1044–1048).

Climate Change

The expected climate changes that are occurring and will continue to evolve include an increase in mean annual temperature, a more frequent drought cycle, decrease in winter precipitation, and increased frequency of heavy rains and flooding. The projected increase in flood events due to climate change could result in the washing away of artifacts and features and/or the burial of sites in the Santa Rita Mountains and other culturally important areas. Changes in mean annual temperature and a decrease in winter precipitation could affect the distribution and availability of traditionally important plants. Over time, upland areas such as the Santa Rita Mountains could become refuges for some species, although if wildfires increase in size and intensity with climate change, as discussed in the "Fuels and Fire Management" resource section, traditionally important species are likely to decline (FEIS, p. 1048).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

All new information pertaining to cultural resources relates to changed status for past and new reasonably foreseeable actions. A review of all of these actions indicates that they would not individually or cumulatively result in changes to the issues or additional factors described above. The rationale for this conclusion follows.

Past Actions

- Exploratory drilling on Rosemont private property. *This action consisted of minor disturbance on private property to facilitate exploration temporary drilling. The disturbance was minor and there were monitors to be sure no archaeological sites were disturbed.*
- Additional wildfires that occurred between 2012 and 2014. *Wildfires occur in the analysis area annually. During the period from 2012 to 2014 an estimated 33 wildfires occurred ranging in size from 0.1 acre to 66 acres. The majority were less than 10 acres in size. Past wildfires are recovering over time, and these newer fires will also recover over time. Because of this recovery, it is not likely that any Traditional Cultural Properties or cultural landscapes were permanently impacted. While these fires could be considered ground disturbance, without previous archaeological surveys in those areas, it would be impossible to understand what, if any, sites were damaged or destroyed. Some of these wildfires may have removed resource collecting areas, but based on the acreage, it is not expected that any resource was deemed completely eliminated as a result. No changes in the overall impacts disclosed in the FEIS have resulted from these wildfires.*
- Hazardous fuels treatment in Gardner Canyon has been accomplished. *These actions were considered as reasonably foreseeable in the FEIS and addressed in the cumulative effects analysis. The impacts disclosed remain valid.*

Present Actions

- The Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions are actively selling real estate and constructing homes and associated infrastructure. *These actions were considered as reasonably foreseeable in the FEIS and addressed in the cumulative effects analysis. The impacts disclosed remain valid.*

Reasonably Foreseeable Actions

- Hog Canyon, Hazardous Fuels Reduction Project. *These actions were considered as reasonably foreseeable in the FEIS and addressed in the cumulative effects analysis. The impacts disclosed remain valid.*
- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes. *While this project was listed as reasonably foreseeable in the FEIS, no information regarding*

plans for mining was known. Subsequently, a mineral development plan was discovered that was submitted to the ASLD. While no ground-disturbing activity has occurred on the site, the mineral development plan outlines the plan of operations for the proposed mining activity and provides an environmental assessment of potential impacts.

This action were considered as reasonably foreseeable in the FEIS and addressed in the cumulative effects analysis. The impacts disclosed remain valid. It should be noted that there is no indication whether or when ground-disturbing activities may occur for this project.

- Mt. Lemmon Recreation Area Improvements. *While this project is on NFS land, adherence to existing laws regulation and policies can be expected to avoid direct impacts to cultural resources. It would not change the conclusion of impacts to cultural resources disclosed in the FEIS.*
- Madera Waterline Replacement. *Water usage from three springs will cease and be replaced with a well on private property. Because this project would be conducted by the Forest Service, there would be avoidance of cultural sites and monitoring to avoid impacts on cultural resources. With the known significance of springs to Tribes, this project could be a benefit by preserving springs. This project would not change the conclusion of impacts to cultural resources disclosed in the FEIS.*
- Mt. Hopkins Re-Entry Thinning Project. *This is to maintain defensible space around the structures in the event of a wildfire. While this project is on NFS land, adherence to existing laws regulation and policies can be expected to avoid direct impacts to cultural resources. It would not change the conclusion of impacts to cultural resources disclosed in the FEIS.*
- Road Construction (5 miles). CBP. *In the Fresnal Wash area, CBP currently access the border fence for patrol operations from spur roads that may potentially impact adjacent cultural sites. This project proposes to close these spurs, totaling 0.6 mile, and construct three new road segments totaling 0.7 mile. The project also proposes to construct four road segments in the Cantinas Reservoir area totaling 3.4 miles; and construct one segment of new road totaling 0.6 mile, while closing 0.6 mile of an existing road to protect the Sonoran chub. This new foreseeable action would fit under this grouping of foreseeable actions discussed in the FEIS (FEIS, pp. 1045–1046): "The following listed foreseeable actions, ground disturbance, and changes in the water table that could affect cultural resources are projected to be very limited, do not apply, or are not developed to the extent that impacts can be determined. Adherence to existing laws, regulations, and policies can be expected to minimize direct and indirect impacts. Efforts would be made to design these actions to avoid impacts to cultural resources." The overall conclusion of cumulative impacts to cultural resources specified in the FEIS would not change: "The overall forecast is one of continued degradation and loss of cultural resources from land disturbance, vegetation changes, and depletion of the water table. These foreseeable future actions exacerbate the destruction of cultural resources that has occurred in the analysis area over the past century: modern development has already destroyed an untold number of archaeological sites and places where human remains were buried; the depletion of the water table has altered vegetation and affected traditional plants and springs; and current landownership patterns have restricted traditional collecting areas" (FEIS, p. 1048).*
- Improvements at Marshall Gulch Picnic Area and Trailhead. *While this project is on NFS land, adherence to existing laws regulation and policies can be expected to avoid direct impacts to cultural resources. It would not change the conclusion of impacts to cultural resources disclosed in the FEIS.*
- Grazing Permit Amendment, Papago Allotment. *Changing the number of livestock on this active grazing allotment would have no impact on cultural resources.*

- Mowry Allotment Analysis. *Changing the grazing strategy on an active grazing allotment would have no impact on cultural resources.*
- Plan of Operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. *This is a short-term use that would cause minimal surface disturbance. While this project is on NFS land, adherence to existing laws regulation and policies can be expected to avoid direct impacts to cultural resources. However, due to the small area impacted, expected reclamation, and short duration of these activities this action would not change the conclusion of impacts to cultural resources disclosed in the FEIS.*
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River. *This is a short-term use that would cause minimal surface disturbance at the bridge site only. It is expected that the Town would abide by adhere to existing laws regulation and policies to avoid direct impacts to cultural resources. It would not change the conclusion of impacts to cultural resources disclosed in the FEIS.*
- Camp Tatiyee Land Exchange. *The parcels that come into NFS ownership would provide a level of protection to cultural sites, if they exist, that does not exist while they are in private ownership. Overall this would constitute a net benefit for cultural resources.*
- Bear Canyon Bark Beetle Sanitation Project. *This is a short-term use that would cause minimal surface disturbance at the locations where activities are occurring, which are primarily developed recreation sites. This project is on NFS land, and adherence to existing laws regulation and policies can be expected to avoid direct impacts to cultural resources. Due to the small area impacted and short duration of these activities, this action would not change the conclusion of impacts to cultural resources disclosed in the FEIS.*
- Forestwide planting for traditional uses and pollinators on the Coronado National Forest. Implement a series of plantings to (1) increase the availability of traditional use plants for use by the Tribes and protect; and (2) expand upon the availability of habitat for pollinators that increase the sustainability of our forests. *This project would have a positive overall effect due to increasing the availability of traditional use plants for use by Tribes. However, it is not expected that this would offset the impacts to traditional plants caused by the Rosemont Copper Project.*

Summary of Findings

All new information and changed conditions were reviewed to determine whether they would impact cultural resources. Those that have the potential to impact cultural resources were considered in light of the description of baseline conditions, the analysis methodology, and the conclusions of impacts presented in the FEIS.

Inclusion of new information and changed conditions into the analysis does not result in any changes to the conclusions of impacts to cultural resources. While some of the reasonably foreseeable actions could have local, short-term impacts, these impacts would not result in any changes in baseline conditions, analysis methodology, or impact analysis conclusions disclosed in the FEIS.

Socioeconomics and Environmental Justice

Summary of Applicable New Information and/or Changed Conditions

The following new information and changed conditions were noted as being pertinent to socioeconomics and environmental justice:

Present Actions

- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands subdivisions has been reclassified from a reasonably foreseeable action, as presented in the FEIS, to a present action. The developments are actively selling real estate and constructing homes and associated infrastructure.

Reasonably Foreseeable Actions

- Charles Seel lease of State Trust land (from State land commissioner) for mining purposes.
- Mt. Lemmon Recreation Area Improvements. This project involves installation of three tables, a bulletin board, and a fee tube at the Mt. Lemmon Recreation Site, in addition to new parking bumpers and procured trail signs at the Mt. Lemmon Recreation Area and Summit Trailheads parking.
- Madera Waterline Replacement. Modify the existing Madera water supply system to provide a reliable source of water for the residents and visitors to Madera Canyon. Water usage from three springs will cease and be replaced with a well on private property on the Nogales Ranger District.
- Mt. Hopkins Re-Entry Thinning Project. Nogales Ranger District is coordinating with the Smithsonian Institution to thin and chip near structures on the Mt. Hopkins Observatory site. This is to maintain defensible space around the structures in the event of a wildfire.
- Road Construction (5 miles). CBP. Provide improved access to the U.S.–Mexico border on the Coronado National Forest by constructing approximately 5 miles of roads that will enable CBP to safely and effectively execute its mission while protecting the forest natural resources to the degree possible. New road construction would occur in three different locations: the Fresnal Wash area, Cantinas Reservoir area, and Sycamore Canyon area.

  Newly constructed roads would be closed to public motorized use and available only for administrative use. In addition, approximately 1.2 miles of existing roads in the Fresnal Wash and Sycamore Canyon areas would be closed to motorized travel by earthen berm barriers to foster resource protection. Additionally, some of the road mileage may be claimed under the Department of Homeland Security Waiver—particularly the portion crossing the IRA.
- Plan of Operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. The District proposes to authorize the operator to conduct five-hole exploratory drilling activities on the Sierra Vista Ranger District, approximately 2 miles southeast of Washington-Duquesne, Arizona.
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River, as part of its 5-year Capital Improvement Plan.
- Camp Tatiyee Land Exchange. Nine tracts on the Coronado National Forest are proposed to be conveyed to the Forest Service. These parcels are scattered across the Santa Catalina, Douglas, Safford, Nogales, and Sierra Vista Ranger Districts. NFS lands proposed for conveyance to a private party are not located on the Coronado National Forest.
- Bear Canyon Bark Beetle Sanitation Project. Fell and remove bark beetle infested trees to reduce bark beetle populations, to protect surrounding trees and stands, and to mitigate fire hazard associated with beetle-killed trees on the Santa Catalina Ranger District. Developed recreation sites and surrounding areas, including Cypress, Middle Bear, and Chihuahua Pine Picnic Areas and General Hitchcock Campground. Generally, canyon bottom and north-facing slopes.

Baseline Conditions Considering New Information and Changed Conditions

The baseline conditions described in the FEIS included population and demographics; housing; property values; employment; income characteristics; quality of life conditions; and environmental justice. All pertinent new information is related to changes in present and reasonably foreseeable actions. These actions are not substantive enough from a socioeconomic or environmental justice perspective to modify the baseline conditions described in the FEIS.

Summary of FEIS Analysis Methodology and Impact Conclusions

The analysis for socioeconomics and environmental justice in the FEIS focused on three issues and one additional factor.

Regional Socioeconomics: The mine facilities and operation may result in changes over time to local employment, property values, tax base, tourism revenue, and demand and cost for road maintenance and emergency services. There may be costs to the alternative elements and mitigation measures that influence the present net value of the mine operations and, thus, its economic profile. Factors used to measure impacts are:

- Change in employment over time
- Change in property values over time
- Change in tax base per year over time
- Change in demand and cost for State road maintenance over time
- Change in demand and cost for emergency services over time
- Quantitative assessment of change in tourism and recreation revenue over time
- Qualitative assessment of economic effect on the astronomy industry

Rural Landscapes: The mine operation may not conform to the quality of life expectations as expressed by the forest plan and Federal, State, and local regulations and ordinances. Commenters expressed concerns about modification of rural historic landscapes and local ranching traditions, which are important to local residents and visitors. Commenters also expressed a need to assess impacts on quality of life, including the economic nature of these rural landscapes. Factors used to measure impacts are:

- Qualitative assessment of the ability to meet rural landscape expectations as expressed by Federal, State, and local plans.
- Quantitative assessment of economic effects on amenity-based relocation.

Other Effects Considered: Environmental Justice: impacts to populations protected by Title VI of the Civil Rights.

Impact Conclusions

Direct and Indirect Impacts

- For all action alternatives, regional increase in employment are estimated to be as follows. Premining phase: Pima County – 594 direct jobs and 443 indirect jobs per year; three-county analysis area – 768 direct and 453 indirect jobs per year. Active mining and reclamation/closure: Pima County – 434 direct jobs and 1,260 indirect jobs per year; three-county analysis area – 434 direct jobs and 512 indirect jobs per year.

- For all action alternatives, there would be a potential decrease in property values between 4 and 11 percent within 5 miles of the project area. Potential impacts include more than 6.4 million in losses to property values.
- For all action alternatives, regional increases in tax base are expected. These include $11 million in construction sales tax during construction. The total direct local and State revenues over the life of the mine are estimated at $136.7 million.
- For all action alternatives, there would be an increase in funding needs for state roads during the mine operation phase. This is partially offset by increased tax dollars from more fuel computation by heavy trucks.
- For all alternatives, potential change in population is not expected to result in dramatic demands for public services and emergency services costs. However, the increase in overall traffic could lead to more accidents and an increase in demand for emergency services over time.
- The change in tourism and recreation revenue over time range ranges from $1.0 million to $3.6 million reduction in visitor spending, and $472,600 to $1.6 million reduction in output per year, and a 15 to 50 percent decrease in nature based tourism from 0 to 10 miles from the mine per year for the Phased Tailings Alternative; to $1.6 million to $5.5 million reduction in visitor spending, and $731,400 to $2.4 million reduction in output per year, and a 15 to 50 percent decrease in nature based tourism from 0 to 10 miles from the mine per year for the Scholefield-McCleary Alternative.
- For all alternatives, increased sky brightness could result in an impairment of observatories near the project area, which could result in a decrease in State revenues generated from astronomy, space, and planetary research and tourism. The negative public perception of having a copper mine next to an observatory may impact observatory revenues.
- For all action alternatives, there would be potential impacts to area quality of life resulting from altered landscapes.
- The economic effects on amenity-based relocation would range as follows:
    - Proposed Action and Phased Tailings Alternatives – 0.08 percent decrease in net migration to Santa Cruz County as a percentage of county population. 6 to 33 percent decrease in the rate of population growth in the Patagonia Census County Division (CCD). However, the decrease in amenity-based migration may be offset by the increase in mine staff relocation. Impacts on amenity migration in Pima County and the greater Tucson area are expected to be negligible owing to the more dynamic nature of the metropolitan economy.
    - Barrel and Barrel Trail Alternatives – same as the proposed action, except for a 0.09 percent decrease in net migration to Santa Cruz County as a percentage of county population, and a 6 to 37 percent decrease in the rate of population growth in Patagonia CCD.
    - Scholefield-McCleary Alternative – same as the proposed action, except for a 0.09 percent decrease in net migration to Santa Cruz County as a percentage of county population, and a 6 to 38 percent decrease in the rate of population growth in Patagonia CCD.
- For all action alternatives, there would be a possible disproportionate effects on the Tohono O’odham Nation, as well as the other consulting tribes, with regard to disturbance to cultural resources.

Cumulative Impacts

Cumulatively, foreseeable actions would contribute to the direct and indirect socioeconomic impacts described above. Mineral exploration and development and new commercial and residential land development would produce additional jobs but could also result in negative impacts to tourism and amenity-based economies in local areas because of the effects that the developments would have on the natural landscape and rural setting. As housing becomes more available and people move into new developments, demands for resources and services would continue to grow. Quality of life could be both positively and negatively affected, depending on proximity to these actions and intangible personal values (FEIS, p. 1128).

Climate change may indirectly affect socioeconomic conditions in the region by affecting the quality of recreation and visual resources. Because of the expected lower precipitation, warmer temperatures, and more frequent drought cycles, revegetation may be slower or less successful, as well as there being more bare soil and rock visible on the waste rock and tailings facilities, postmine plant site, and other areas allotted for revegetation (Karl et al. 2009; U.S. Environmental Protection Agency 2012). This would increase impacts to both recreation and visual quality settings because revegetation is critical to reducing mine impacts. Thus, nature-based tourism in the region may be affected. Also, higher frequency of heavy rains and flooding may cause damage to slopes and revegetated areas, which would increase impacts to recreation and visual quality settings further, potentially impacting nature-based tourism. The lower precipitation, warmer temperatures, and more frequent drought cycles may also have an adverse impact on quality of life in the region (FEIS, p. 1128).

Consideration of New Information and Changed Conditions in Analysis Methodology and Impact Conclusions

Present Actions

- Expansion of the Rancho Sahuarita, Quail Creek, and Madera Highlands residential developments. *These projects were addressed in the FEIS as reasonably foreseeable actions. Development has since started and they have been reclassified as present actions. The FEIS stated this conclusion of impact regarding these projects under "Cumulative Effects:" These projects would add cumulatively to the population if people choose to relocate to {these developments} from outside the three-county analysis area. However, since the majority of employees at the proposed Rosemont Copper Mine are expected to come from the local workforce, the cumulative effects are not expected to be substantial.*

  The current development of these residential areas is not expected to have impacts that would change the analysis methodology or the impact conclusions discussed in the FEIS.

Reasonably Foreseeable Actions

- Charles Seel lease of State Trust Land (from State land commissioner) for mining purposes. *This would result in a slight increase the number of mining jobs within the analysis area, as well as nominally contribute to natural resources impacts that could affect tourism and amenity-based migration. These potential impacts would add cumulatively to the potential socioeconomic impacts of the proposed Rosemont Copper Mine.*
- Mt. Lemmon Recreation Area Improvements. *This is a minor project that would improve recreational facilities at this location. While impacts would be beneficial, they would be limited to recreational users of this particular site only.*

- Madera Waterline Replacement. *This would potentially increase or maintain water system jobs within the analysis area. However, the project is short-term and localized, and the overall impact be minor.*
- Mt. Hopkins Re-Entry Thinning Project. *This would potentially increase or maintain forest-related jobs within the analysis area. However, the project is short-term and localized, and the overall impact be minor.*
- Road Construction (5 miles). CBP. *This would potentially increase or maintain road construction jobs within the analysis area. However, the project is short-term and localized, and the overall impact would be minor. While some impacts to cultural resources could occur, the project also include a proposal to close an existing road to protect a known cultural site. Overall, the cumulative impact to environmental justice disclosed in the FEIS would not change: "For all action alternatives, there would be a possible disproportionate effects to the Tohono O'odham Nation, as well as the other consulting tribes, with regard to disturbance to cultural resources" (FEIS, p. 1062).*
- Improvements at Marshall Gulch Picnic Area and Trailhead. *This is a minor project that would improve recreational facilities at this location. While impacts would be beneficial, they would be limited to recreational users of this particular site only.*
- Plan of Operations, CH Exploratory Drilling Project, MinQuest Minerals Exploration. *This would potentially increase or maintain the number of mining jobs within the analysis area. However, the impacts would likely be of a small magnitude, as these exploration activities are generally small scale, temporary actions and are not typically visually evident.*
- The Town of Sahuarita is currently designing a new Pima Mine Road Bridge across the Santa Cruz River. *This would potentially increase or maintain construction jobs within the analysis area. However, the project is short term and localized, and the overall impact would be minor.*
- Camp Tatiyee Land Exchange. *This project would add a minor amount of acres to the Coronado National Forest that would contribute to recreational opportunities and quality of life. However, due to the amount of acres and scattered nature of the parcels involved, the impacts would be positive but minor.*
- Bear Canyon Bark Beetle Sanitation Project. *This project would have limited, short-term impacts to visual and recreation resources and would not change quality of life issues discussed in the FEIS. It may create a few short-term jobs, but overall impacts would not modify baseline conditions, analysis methods, or conclusions of impacts disclosed in the FEIS.*

Summary of Findings

A review of new information and changed conditions indicates that no changes to the description of baseline conditions, analysis methodology, or the conclusions of impacts presented in the FEIS for socioeconomics and environmental justice are warranted.

Participants in Review

This Rosemont Copper Project SIR was prepared under the supervision of the U.S. Forest Service (Forest Service). The individuals who contributed to the preparation of this document are listed below.

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Conclusions and Determination

This report has identified and evaluated new information and changed circumstances that are applicable to the analysis conducted for the Rosemont Copper Project FEIS. The ID team review conducted for this report considered all resource areas addressed in the FEIS. New information was compared to that addressed in the FEIS, and determinations made as to whether incorporation of the new information would result in changes to baseline conditions, analysis methodology or the conclusion of impacts.

While consideration of some new information resulted in changes to some baseline conditions and analysis methodologies, it did not result in major changes to any of the conclusions of impacts disclosed in the FEIS. The scope and range of effects considered in the analysis disclosed in the FEIS remain valid.

Based upon the results of the ID team review of new information, I have determined that a supplement or revision of the Rosemont Copper Project EIS is not warranted. However, there are a number of changes and additions that warrant correction of the FEIS. This correction will be noted in one or more errata to the FEIS.

JIM UPCHURCH

Forest Supervisor

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———. 2015e. *2014 Yellow-billed Cuckoo (Coccyzus americanus) Survey: Rosemont Project*. Project No. 1049.60. Prepared for Hudbay. Tucson, Arizona: WestLand Resources Inc. February.

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A. New Information

Table A1. Summary of Meetings and Conference Calls to Gather Input

Date	Attendees*	General Topics
3/21/2014	USFWS; CNF	Discussion of predicted aquatic effects with respect to Biological Opinion
4/24/2014	CNF; USFWS	Discussion of new data and changes to species status
5/8/2014	CNF; USFWS	Discussion of new data; prepare for 5/12 meeting
5/12/2014	CNF; Region 3; USFWS; Rosemont Copper	Project status update; discussion of need for reinitiation
5/14/2014	CNF; USFWS; Rosemont Copper	Discussion/critique of FEIS analysis approach
5/19/2014	CNF; USFWS	Discussion of SBA format and approach
5/27/2014	CNF; USFWS	Discussion of SBA format and approach
6/4/2014	CNF; USFWS; EPA; USGS; BLM; AGFD; Rosemont Copper	Discussion of SBA format and approach; prepare for 6/10–11/14 meeting
6/9/2014	CNF; CNO; BLM	Field trip to Cienega Creek and Empire Gulch
6/10-11/14	CNF; CNO; BLM; USFWS; EPA; USGS; Pima County; AGFD; Rosemont Copper	Hydrology/biology working group meeting to discuss hydrology and biology analyses in SBA, as well as new information
6/25/2014	CNF; USFWS	Discuss hydrology working group
6/26/2014	CNF; USFWS; USGS	Discuss USGS involvement
7/14/2014	CNF; USFWS	Hydrology working group call
7/16/2014	CNF; USGS	Call to discuss upcoming meetings
7/21/2014	CNF; BLM; USGS	Field trip to Cienega Creek and Empire Gulch
7/22/2014	CNF; USFWS	Hydrology working group call
7/23/2014	CNF; USFWS; BLM; EPA; USGS	Hydrology/biology working group meeting
7/31/2014	CNF; USFWS; BLM; USGS	Hydrology/biology working group call
8/12/2014	CNF; BLM	Field trip to Cienega Creek and Empire Gulch
8/12/2014	CNF; BLM; USGS; USFWS	Biology working group meeting
8/19/2014	CNF; BLM; USGS; USFWS	Biology working group meeting
8/22/2014	CNF; BLM; USGS; USFWS	Call to discuss utility of PHABSIM
8/22/2014	CNF; USFWS; USGS	Call to discuss groundwater modeling review
9/4/2014	Congressional field trip	Field trip to mine site and Empire Gulch
9/10/2014	CNF; USFWS; BLM; EPA; USGS	Hydrology/biology working group meeting
9/15/2014	CNF; USFWS	Discussion of species effects
9/17/2014	CNF; BLM; USFWS; USGS	Discussion of aquatic habitat modeling
10/3/2014	CNF; USGS; Rosemont Copper	Discuss Empire Gulch modeling approach
10/27/2014	CNF; BLM; USFWS	Federal agency manager meeting; discussion of potential fieldwork approach

* Note that when CNF was present, meetings also usually included SWCA as the third-party NEPA contractor, and when Rosemont Copper was present, meetings also usually included various first-party contractors.

Table A2. New Information Received by the Coronado

Date	Type of Record	Title	Author
1975/07/07	Report	Preliminary Draft – Analysis of Groundwater Development Program in the Empire Ranch Area	Harshbarger and Associates
1980/06/27	Data Sheet	Oil Well Test	Anamax Mining Company
1984/01/01	Journal	Cienegas: Vanishing climax communities of the American southwest. In *Desert Plants.*	Dean A. Hendrickson, W.L. Minckley, Arizona State University
1993/01/01	Photo	Empire Gulch Cross Sections: EG - 1993 - us	BLM
1993/01/01	Photo	Empire Gulch Cross Sections: EG1 - 1993 - cross	BLM
1993/01/01	Photo	Empire Gulch Cross Sections: EG1 - 1993 - ds	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photo (1993) CC0	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) Ag3	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) Ag4	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) Ag5	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) Ag6	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) Ag7	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) Ag8	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) CC1	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) CC2	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) CC3	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) CC5	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) CC6	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) EG1	BLM
1993/01/01	Photo	LCNCA Riparian Monitoring Cross Section Photos (1993) GC1	BLM
2002/08/01	Report	Cienega Creek Physical Integrity Survey: Appendix Version 1.00	Hans Huth, Hydrologist/GIS Technician, ADEQ
2003/11/01	Report	Lower Cienega Creek Restoration Evaluation Project: An Investigation into Developing Quantitative Methods for Assessing Stream Channel Physical Condition.	Lin Lawson, Hans Huth, ADEQ
2004/01/01	Data	LCNCA: Field Records – Herp Sightings: 1988–2004	Jeff Simms, BLM
2004/01/01	Data	Riparian Data: LCNCA RACE BLM data entry(2)	BLM
2004/06/30	Data	Aquatic Habitat Survey – Empire Springs	J.R. Simms
2004/09/28	Data	Empire Spring Habitat Inventory	Jeff Simms, BLM
2005/01/01	Report	Cienega Creek Fish Surveys 2005 – Gila Chub, *Gila intermedia*, Status Investigation	Foster, D.K., J. Simms

Date	Type of Record	Title	Author
2005/01/01	Report	Las Cienegas National Conservation Area: Water Use Study. Phase IA – ADWR Well Database Inventory	J. Haney, The Nature Conservancy
2005/01/01	Report	Water Availability for the Western United States – Key Scientific Challenges	Mark T. Anderson; Lloyd H. Woolsey
2006/01/01	Photo	LCNCA Riparian Monitoring Stream Cross Sections – XS_Ag	BLM
2006/01/01	Photo	LCNCA Riparian Monitoring Stream Cross Sections – XS_Ag5	BLM
2006/01/01	Photo	LCNCA Riparian Monitoring Stream Cross Sections – XS_Ag7	BLM
2006/01/01	Photo	LCNCA Riparian Monitoring Stream Cross Sections – XS_Ag8	BLM
2006/01/01	Photo	LCNCA Riparian Monitoring Stream Cross Sections – XS_CC0	BLM
2006/01/01	Photo	LCNCA Riparian Monitoring Stream Cross Sections – XS_CC7	BLM
2006/01/01	Photo	LCNCA Riparian Monitoring Stream Cross Sections – XS_EG	BLM
2006/01/01	Photo	LCNCA Riparian Monitoring Stream Cross Sections – XS_EG_DS	BLM
2006/01/01	Photo	LCNCA Riparian Monitoring Stream Cross Sections – XS_EG_US	BLM
2006/01/01	Photo	LCNCA Riparian Photo Points (2006) CCAA	BLM
2006/01/01	Photo	LCNCA Riparian Photo Points (2006) CCC – CC_59C_PPA	BLM
2006/01/01	Photo	LCNCA Riparian Photo Points (2006) CCD – CC_59D_PPA	BLM
2006/04/06	Photo	LCNCA Riparian Photo Points CCK (2006) Oak Tree to Spring Water	BLM
2006/04/25	Photo	LCNCA Riparian Photo Points CCI (2006) Ag Fields CC AgIa	BLM
2006/04/25	Photo	LCNCA Riparian Photo Points CCI (2006) Ag Fields CC AgIb	BLM
2006/04/25	Photo	LCNCA Riparian Photo Points CCM (2006) Headwaters	BLM
2006/05/09	Photo	LCNCA Riparian Photo Points (2006) CCF Fresno Gap	BLM
2006/05/09	Photo	LCNCA Riparian Photo Points (2006) CCF Fresno Gap – PPTa	BLM
2006/05/09	Photo	LCNCA Riparian Photo Points (2006) CCF Fresno Gap – RipPasturePt_crossing lane	BLM
2006/05/09	Photo	LCNCA Riparian Photo Points (2006) CCF Fresno Gap – RipPasturePt_USofCrossingLane	BLM
2006/05/10	Photo	LCNCA Riparian Photo Points (2006) Empire Gulch Ega	BLM
2006/05/10	Photo	LCNCA Riparian Photo Points (2006) Empire Gulch Ega1	BLM
2006/05/10	Photo	LCNCA Riparian Photo Points (2006) Empire Gulch Ega2	BLM
2006/05/10	Photo	LCNCA Riparian Photo Points (2006) Empire Gulch Ega3	BLM
2006/05/31	Photo	LCNCA Riparian Photo Points (2006) CCC – CCc	BLM

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Date	Type of Record	Title	Author
2006/05/31	Photo	LCNCA Riparian Photo Points (2006) CCD – CCC	BLM
2006/06/01	Report	Selected Aspects of the Natural History of Gila Chub: Final Report to the Bureau of Land Management	Andrew A. Schulzt; Scott A. Bonar
2006/09/14	Report	Quantification of Habitat Requirements for Aquatic Species in the San Pedro River through the San Pedro Riparian National Conservation Area – Privileged and Confidential Attorney Work Product	William J. Miller, Miller Ecological Consultants, Inc.
2006/10/26	Letter	Re: Cienega Creek Physical Integrity Survey	Hans Huth, Border Program Hydrologist, ADEQ
2007/01/01	Photo	LCNCA Riparian Monitoring Photos (2007) CC_59A	BLM
2007/01/01	Photo	LCNCA Riparian Monitoring Photos (2007) CC_59D	BLM
2007/01/01	Photo	LCNCA Riparian Monitoring Photos (2007) CC_59K	BLM
2007/01/01	Photo	LCNCA Riparian Monitoring Photos (2007) CC_59M	BLM
2007/01/01	Data	Riparian Tree Monitoring: LCNCA Woody Belt Transects: 1993–2006	BLM
2007/07/01	Report	State of the Las Cienegas National Conservation Area: Gila Topminnow Population Status and Trends 1989–2005	Bodner, G., J. Simms, and D. Gori
2008/01/01	Report	State of the Las Cienegas National Conservation Area; Part 3: Condition and Trend of Riparian Target Species	Bodner, G., and K. Simms
2009/10/28	Report	Groundwater Flow Modeling Conducted for Simulation of Proposed Rosemont Pit Dewatering and Post-Closure, Rosemont Project, Pima County, Arizona	Errol L. Montgomery & Associates Inc.
2010/01/01	Report	Environmental Flow Studies of the Fort Collins Science Center – Cherry Creek, Arizona	T.J. Waddle; K.D. Bovee
2010/01/01	Data	Surface Water Monitoring: Flows Cienega Creek – Empire Gulch	BLM
2010/2/18	Letter	Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions	Nancy H. Sutley, Chair, Council on Environmental Quality
2010/06/01	Report	Instream Flow Requirements for Maintenance of Wildlife Habitat and Riparian Vegetation: Cherry Creek, Tonto National Forest, Arizona	David M. Merritt, Forest Service; Heather L. Bateman, Arizona State University; Christopher D. Peltz, USFS
2010/09/01	Report	Habitat use by the fishes of a southwestern desert stream: Cherry Creek, Arizona	Scott A. Bonar; Norman Mercado-Silva; David Rogowski
2010/11/01	Report	Regional Groundwater Flow Model Rosemont Copper Project	Tetra Tech
2011/01/01	Report	Arizona Environmental Water Needs Assessment Report	Joanna Nadeau; Sharon B. Megdal
2011/01/01	Report	Arizona Environmental Water Needs Methodology Guidebook	Joanna Nadeau; Sharon B. Megdal
2011/01/01	Map	Davidson Canyon Flow Reach	Pima Association of Governments

Date	Type of Record	Title	Author
2011/01/01	Journal	Projecting avian response to linked changes in groundwater and riparian floodplain vegetation along a dryland river: a scenario analysis. In *Ecohydrology*	L. Arrianna Brand; Juliet Stromberg; David C. Goodrich; Mark D. Dixon; Kevin Lansey; Doosun Kang; David S. Brookshire; David J. Cerasale
2011/06/01	Report	Market-Based Responses to Arizona's Water Sustainability Challenges: The Cornerstones Report	Dustin Garrick, Amy McCoy, Bruce Aylward, Ecosystem Economics
2012/01/01	Data	LCNCA T and E data: Lesser long-nosed bat (2009–2012)	BLM
2012/01/01	Report	Streamflow Depletion by Wells – Understanding and Managing the Effects of Groundwater Pumping on Streamflow	P.M. Barlow; S.A. Leake
2012/01/01	Report	Vulnerability of U.S. water supply to shortage: a technical document supporting the Forest Service 2010 RPA Assessment	Romano Foti; Jorge A. Ramirez; Thomas C. Brown, Forest Service
2012/02/01	Data	Cienega Creek and Empire Springs Hobo Temp Data: Winter 2009 and February 2012	BLM
2012/08/01	Report	Water Resource Trends in the Cienega Creek Natural Preserve, Pima County, Arizona	Brian Powell, Pima County Office of Sustainability and Conservation
2012/09/12	Email	Info request	Mindy Sue Vogel, Minerals and Geology Program Manager/Forest Geologist, CNF
2012/11/30	Report	Summary of Additional Modeling Analyses Conducted at the Request of the U.S. Forest Service Following Submittal of the August 30th, 2010 Rosemont Mine EIS Modeling Report	Hale W. Barter, Montgomery and Associates
2013/01/01	Map	Chiricahua Leopard Frog Recovery Unit 2: Las Cienegas and Santa Rita Mtns Regions	Rosen
2013/01/01	Map	November 21 DVD	BLM
2013/01/01	Memo	Results of Yellow-billed Cuckoo Surveys at the Cienega Creek Natural Preserve: 2013	Brian Powell, Pima County Office of Sustainability and Conservation
2013/01/11	Report	External Groundwater Model Boundary Analysis and Summary of Groundwater Model Analyses	Grady O'Brien, Hydro-Logic, LLC
2013/05/06	Report	2012 Ranid Survey of the Rosemont Holdings and Vicinity, Sonoita Creek Ranch, and Fullerton Ranch	WestLand Resources, Inc.
2013/06/28	PowerPoint Presentation	Lower Cienega Creek near Confluence with Davidson Canyon, including Lower Davidson Canyon and Pantano Dam, Pima County, AZ: March 5–6 2012, June 208, 2013	EPA
2013/06/28	Field Notes	Transcribed Field Notes pertaining to observations made within the Cienega Creek Watershed, including Davidson Canyon and Empire Gulch, Pima Co., AZ	Robert A. Leidy, EPA
2013/07/27	PowerPoint Presentation	Las Cienegas National Conservation Area	EPA
2013/07/29	Report	Restoring Leopard Frogs and Habitat in Sky Island Grasslands (Arizona): Final Report	Philip C. Rosen, University of Arizona; Netzin Steklis, Cienega Watershed Partnership; Dennis J. Caldwell, Caldwell Design; David H. Hall, University of Arizona
2013/08/26	Table	Aquatic Species Reintroduction Table	Jeff Simms, BLM

A. New Information

Date	Type of Record	Title	Author
2013/11/21	Letter to File – Electronic Files Unable to Print	Wet/dry mapping data received from BLM	Dan Moore, BLM
2013/12/02	Report	Rosemont Mine Timber Settlement, Cruise Report and Appraisal	CNF
2014/01/01	Report	Draft – *Lilaeopsis schaffneriana* ssp. *recurva;* Huachuca water umbel. 5-Year Review: Summary and Evaluation	USFWS
2014/01/01	Data	LCNCA T and E data: Chiricahua Leopard Frog (2011–2014)	BLM
2014/01/01	Data	LCNCA T and E data: Gila chub (2012–2014)	BLM
2014/01/01	Data	LCNCA T and E data: Gila topminnow (2009–2014)	BLM
2014/01/01	Data	LCNCA T and E data: Huachuca water umbel (2009–2014)	BLM
2014/01/01	Data	LCNCA T and E data: Southwestern willow Flycatcher (2006–2014)	BLM
2014/01/01	Data	LCNCA T and E data: Yellow-billed cuckoo (2008–2014)	BLM
2014/01/01	Memo	LCNCA Wet-Dry Procedures	BLM
2014/01/06	Memo	Analysis of Barrel Canyon and Davidson Canyon Instrumentation Data December 1, 2013 – December 31, 2013	Water and Earth Technologies
2014/02/01	Memo	Basis for State 401 Certification Decision, Rosemont Copper Project, ACOE Application No. SPL-2008-00816-MB	ADEQ
2014/02/13	Letter	New information regarding a well not previously known to the Forest Service	Don C. Pressnall
2014/04/01	Map	Distribution of Lilaeopsis schaffneriana subsp. Recurva by watershed in southern Arizona and northern Sonora, Mexico	USFWS
2014/04/04	Letter	Re: Arizona Department of Environmental Quality 401 Certification for Rosemont Copper, Public Notice 27-14AZ LTF 55425	C.H. Huckelberry, Pima County Administrator
2014/06/01	Info Sheet	Cienega Creek: After 3 Consecutive Years of Record Breaking Drought Conditions	Pima Association of Governments
2014/06/01	Report	Trip Report: USFWS Tour of Aquatic, Wetland and Riparian Areas within the LCNCA	Jeff Simms, BLM
2014/06/02	Email	Desert Botanical Garden's Cienega Water Isotope Summary Graph	Desert Botanical Garden
2014/06/06	Memo	Review of USFS Model and an Alternative Approach to Inform the Effects of Groundwater Drawdown on Cienega Creek	Rosemont Copper
2014/06/10	Powerpoint Presentation	Probability Presentation	WestLand Resources, Inc.
2014/06/13	Webpage	Basin Characteristics Report – Empire Gulch	USGS.gov
2014/06/13	Webpage	Basin Delineation Map – Empire Gulch	USGS.gov
2014/06/17	Letter to file - Electronic files unable to print	Groundwater Modeling files	Stan Leake, USGS
2014/06/17	Memo	Species Accounts for the 6/13/2014 Wet/Dry Mapping: Pima County Cienega Creek Natural Preserve	Dennis Caldwell
2014/06/18	Technical Memorandum	Review of USGS StreamStats Website	Chris Garrett, SWCA Project Manager

Date	Type of Record	Title	Author
2014/06/25	Map	2014 Las Cienegas Creek Wet-Dry Mapping	BLM
2014/06/25	Technical Memorandum	Review of Surface Water/Groundwater Relations Memoranda in the Cienega Creek Watershed	Tom Myers
2014/06/26	Memo	Draft – Empire Gulch Monitoring Report: 2004–2013	Jeff Simms, BLM
2014/06/27	Map	Draft – Registered Wells and Monitoring Locations in the Cienega Creek Groundwater Basin	BLM
2014/06/27	Memo	Revised Review of SWCA Model and an Alternative Approach to Inform the Effects of Groundwater Drawdown on Cienega Creek	Rosemont Copper
2014/06/27	Memo	Rosemont Copper Project: Empire Gulch Cross Sections	WestLand Resources, Inc.
2014/06/27	Memo	Simulated Empire Gulch Spring Discharge and Stream Flows based on the Tetra Tech (2010) Groundwater Flow Model	Grady O'Brien, Hydro-Logic, LLC
2014/06/27	Technical Memorandum	Supplemental Water Quality and Isotope Data for Wells and Springs in the Rosemont Area	Rosemont Copper
2014/07/01	Excel table	Empire Gulch Cross Section Properties	
2014/07/02	Email	Well about 1 mile NW of Empire/Cienega Creek Confluence	Frank Postillion, Chief Hydrologist, Water Resources Division, Pima County Regional Flood Control District
2014/07/09	Memo	Empire Spring Monitoring Report: 2004–2013	Jeff Simms, BLM
2014/07/10	PowerPoint Presentation		Brian Powell, Pima County Office of Sustainability and Conservation
2014/07/14	Report	Impacts of the Rosemont Mine on Hydrology and Threatened and Endangered Species of the Cienega Creek Natural Preserve	Brian Powell, Lynn Orchard, Julia Fonseca, Frank Postillion, Pima County
2014/07/16	Letter	Rosemont Mine Supplemental Information Report	C.H. Huckelberry, Pima County Administrator
2014/07/30	Map	Close-up of upper Cienega Creek LISC occurrences	USFWS
2014/07/30	Memo	Lentic sites on the LCNCA with breeding *Lithobates chiricahuensis* populations (WGS 84)	David Hall
2014/08/07	Data Sheet	Yellow-billed Cuckoo Survey Data Form	BLM
2014/08/14	Memo	Current Conditions and Potential Effect Thresholds for the Rosemont Copper Project Supplemental BA (draft 08-14-2014)	Jeff Simms, BLM
2014/08/20	Map	FBIG reach mapping – Draft	BLM
2014/08/21	Report	Huachuca water umbel (*Lilaeopsis schaffneriana* ssp. *recurva*). 5-Year Review: Summary and Evaluation	USFWS
2014/09/12	Report	Appendix – Raw Data to "Lower Cienega Creek Restoration Evaluation Project: An Investigation into Developing Quantitative Methods for Assessing Stream Channel Physical Condition"	Hans Huth, Hydrologist, ADEQ
2014/09/15	Memo	Addendum	Hans Huth
2014/09/30	Letter	Technical Review of Hydro-Logic technical memorandum "Simulated Empire Gulch Spring Discharge and Stream Flows based on the Tetra Tech (2010) Groundwater Flow Model"	James Leenhouts, Director, USGS Arizona Water Science Center

Date	Type of Record	Title	Author
2014/09/30	Letter	Technical Review of Pima County report "Impacts of the Rosemont Mine on Hydrology and Threatened and Endangered Species of the Cienega Creek Natural Preserve"	James Leenhouts, Director, USGS Arizona Water Science Center
2014/09/30	Letter	Technical Review of SWCA draft memorandum "Refined approaches to streamflow predictions"	James Leenhouts, Director, USGS Arizona Water Science Center
2014/09/30	Letter	Technical Review of WestLand Resources report "Rosemont Copper Project: Potential Effects of the Rosemont Copper Project on Lower Cienega Creek"	James Leenhouts, Director, USGS Arizona Water Science Center
2014/12/18	Letter	Confirmation of drilling activity disturbance locations	Hudbay Minerals
2015/01/15	Report	Review of Powell et al. (2014) "Impacts of the Rosemont Mine on Hydrology and Threatened and Endangered Species of Cienega Creek Natural Preserve, Pima County, Arizona, July 14, 2014"	WestLand Resources, Inc.
2015/01/15	Report	Review of Predicted Impacts to Aquatic Habitat in Cienega Creek and Empire Gulch	WestLand Resources, Inc.
2015/01/15	Report	Review of SWCA (2014), "Refined Approach to Streamflow Predictions"	WestLand Resources, Inc.
2015/01/15	Report	Revised Review of SWCA Model and an Alternative Approach to Inform the Effects of Groundwater Drawdown on Cienega Creek	Rosemont Copper Company
2015/01/15	Report	Response to Myers (2014) "Review of Surface Water/Groundwater Relations Memoranda in the Cienega Creek Watershed"	WestLand Resources, Inc.
2015/1/16	PowerPoint Presentation	Overview of the Council on Environmental Quality's Revised Draft Guidance on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews	Horst Greczmiel, Associate Director for NEPA Oversight, Council on Environmental Quality
2015/01/16	Memo	Water Quality/Water Level Data for U.S. Forest Service	Hudbay Minerals
2015/01/20	Report	2013 Lesser Long-Nosed Bat Roost Monitoring and Reconnaissance-Level Surveys in the Rosemont Area	WestLand Resources, Inc.
2015/01/20	Report	2013 Pre-Disturbance Ranid Survey of the Rosemont Holdings and Vicinity	WestLand Resources, Inc.
2015/01/20	Report	2014 Pre-Disturbance Ranid Survey of the Rosemont Holdings and Vicinity	WestLand Resources, Inc.
2015/01/20	Letter	Revised Emission Summary: Rosemont Copper Project	Stantec Consulting Services
2015/1/28	Letter	Analysis of air emissions using update emissions factors provided by Caterpillar	Hudbay Minerals
2015/1/30	Report	NDVI Comparison for Select Riparian Areas in Empire Gulch and Cienega Creek	WestLand Resources, Inc.
2015/2/3	Letter	Clarification of revised emissions totals using revised emission factors	Hudbay Minerals
2015/2/4	Report	2013 Yellow-billed Cuckoo (*Coccyzus americanus*) Survey: Rosemont Copper Project	WestLand Resources, Inc.
2015/2/4	Report	2014 Yellow-Billed Cuckoo (*Coccyzus americanus*) Survey: Rosemont Project	WestLand Resources, Inc.
2015/2/4	Report	Rosemont Project: Potential Effects to Yellow-billed Cuckoo and its Proposed Critical Habitat	WestLand Resources, Inc.

Date	Type of Record	Title	Author
n.d. [1971]	Memo	Hydrology – Helvetia Water Prospects and Wells	C.F. Barter
n.d. [1971]	Memo	Test Well Program	Anamax Mining Company
n.d. [1975]	Memo	Helvetia Water Invest – Empire Ranch Invest	Harshbarger and Associates
n.d. [1975]	Memo	Production Well EP-1 Empire Ranch	Anamax Mining Company
n.d. [1975]	Memo	Test Wells E-1 Through E-14 Empire Ranch	Anamax Mining Company
	Access Database	All Daily Mean Streamflow Records on Cienega Creek	

B. Precipitation/Temperature Trend Analysis

List of Figures and Tables

Figures

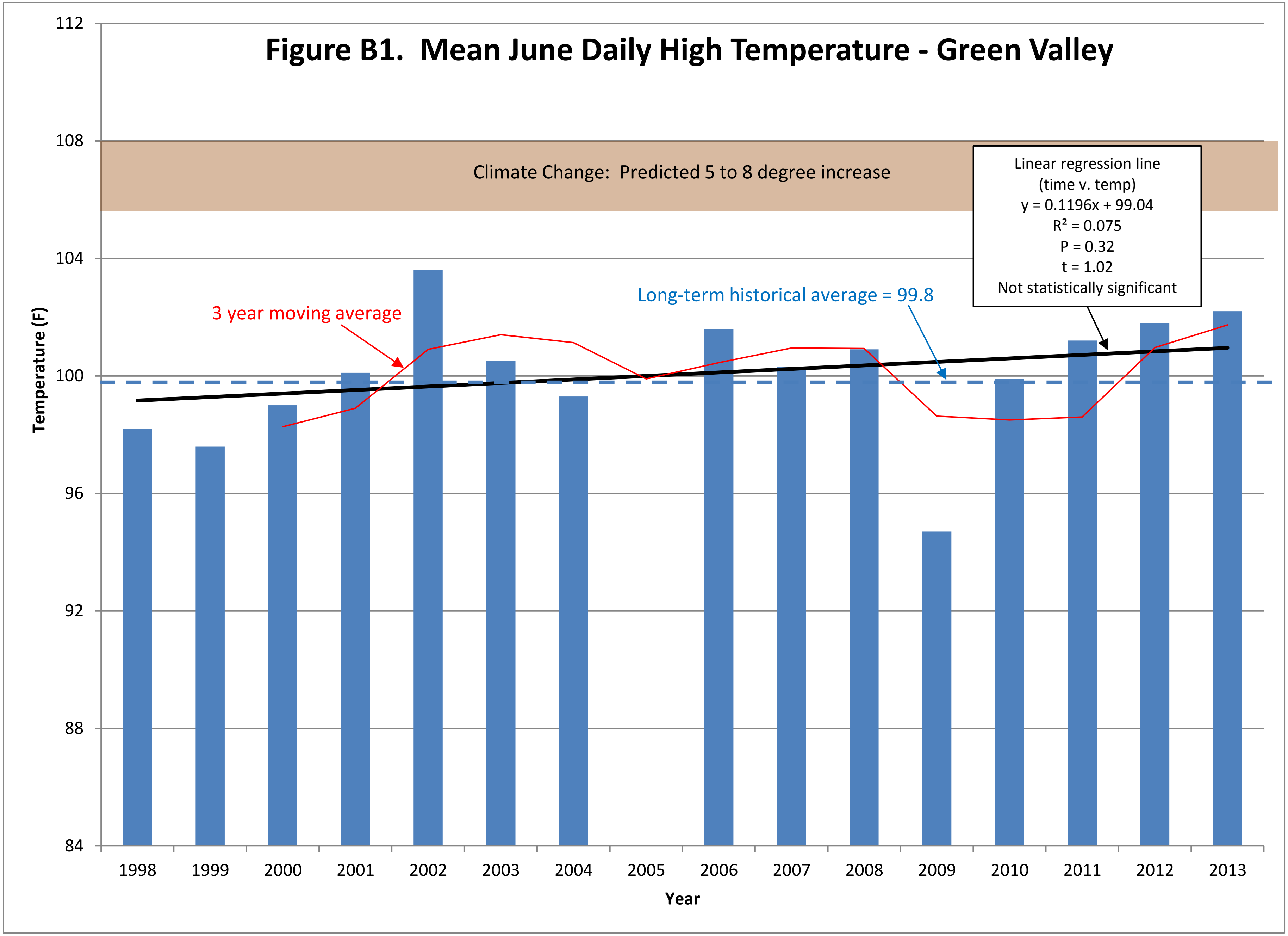
Figure B1. Mean June Daily High Temperature - Green Valley
Climate Change: Predicted 5 to 8 degree increase
Linear regression line
(time v. temp)
y = 0.1196x + 99.04
R² = 0.075
P = 0.32
t = 1.02
Not statistically significant
Long-term historical average = 99.8
3 year moving average
Temperature (F)
112
108
104
100
96
92
88
84
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year

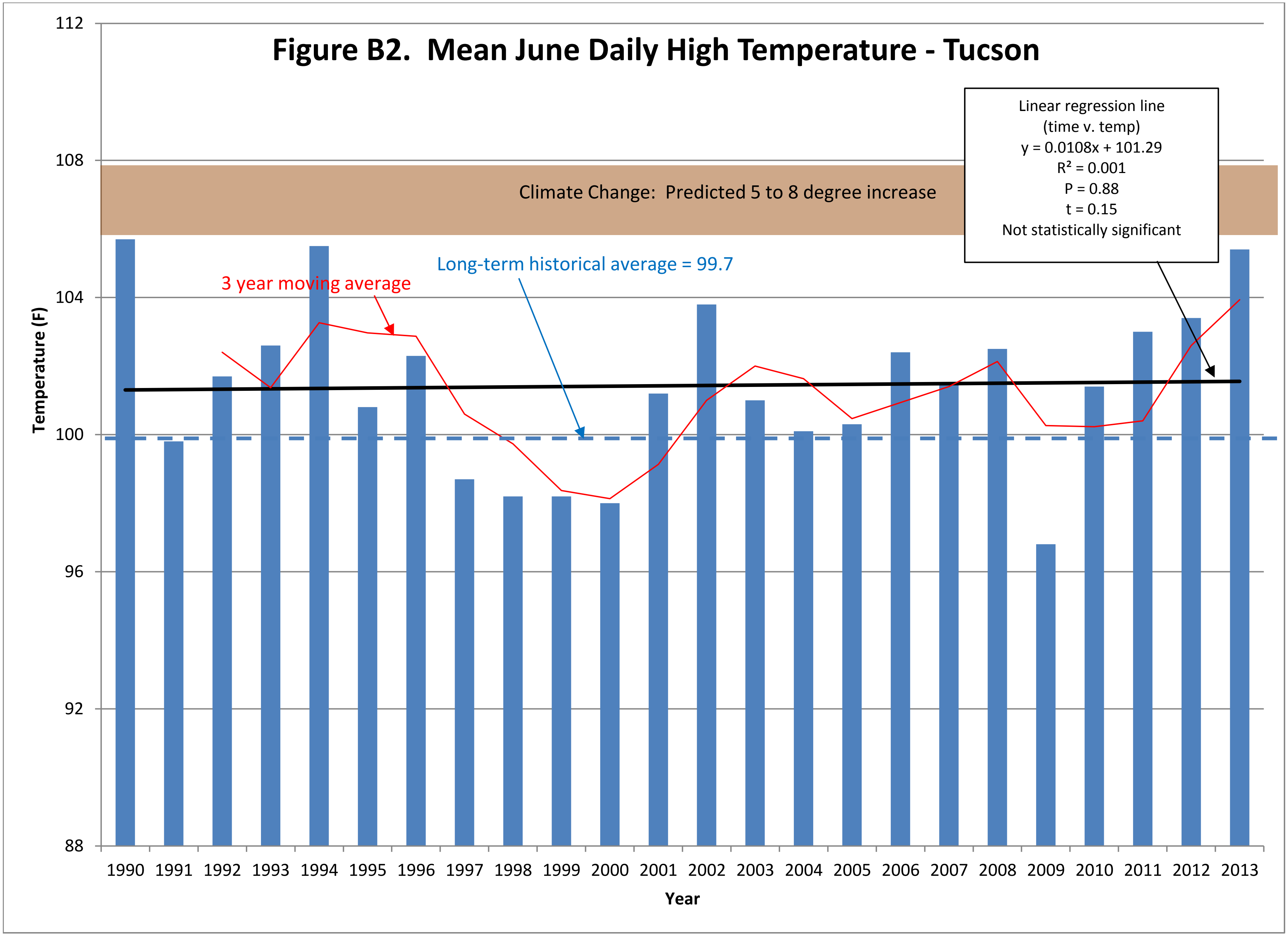

Figure B2. Mean June Daily High Temperature - Tucson
Linear regression line
(time v. temp)
y = 0.0108x + 101.29
R² = 0.001
P = 0.88
t = 0.15
Not statistically significant
Climate Change: Predicted 5 to 8 degree increase
Long-term historical average = 99.7
3 year moving average
Temperature (F)
112
108
104
100
96
92
88
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year

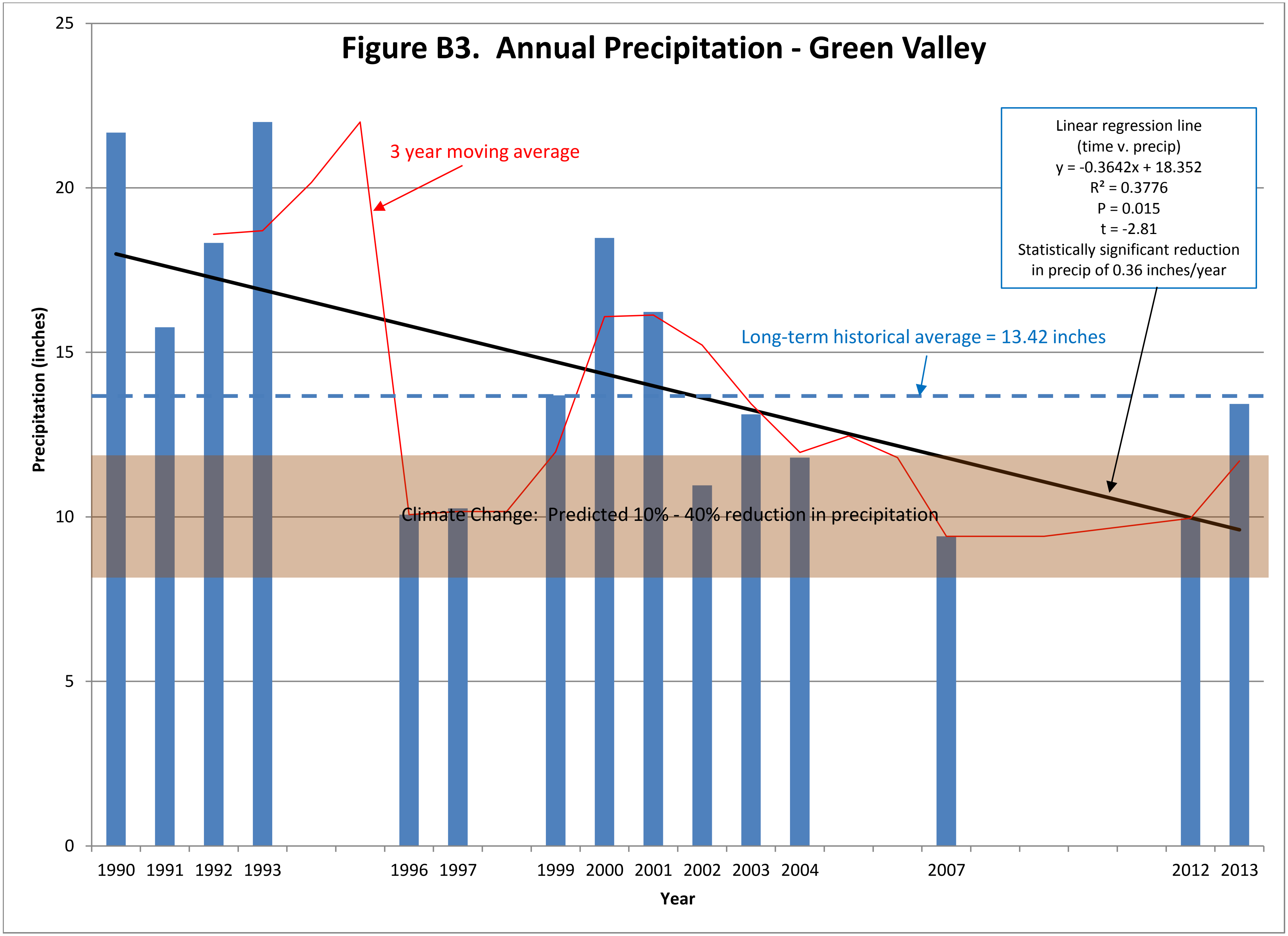
Figure B3. Annual Precipitation - Green Valley
25
20
15
10
5
0
Precipitation (inches)
3 year moving average
Linear regression line
(time v. precip)
y = -0.3642x + 18.352
R² = 0.3776
P = 0.015
t = -2.81
Statistically significant reduction
in precip of 0.36 inches/year
Long-term historical average = 13.42 inches
Climate Change: Predicted 10% - 40% reduction in precipitation
1990
1991
1992
1993
1996
1997
1999
2000
2001
2002
2003
2004
2007
2012
2013
Year

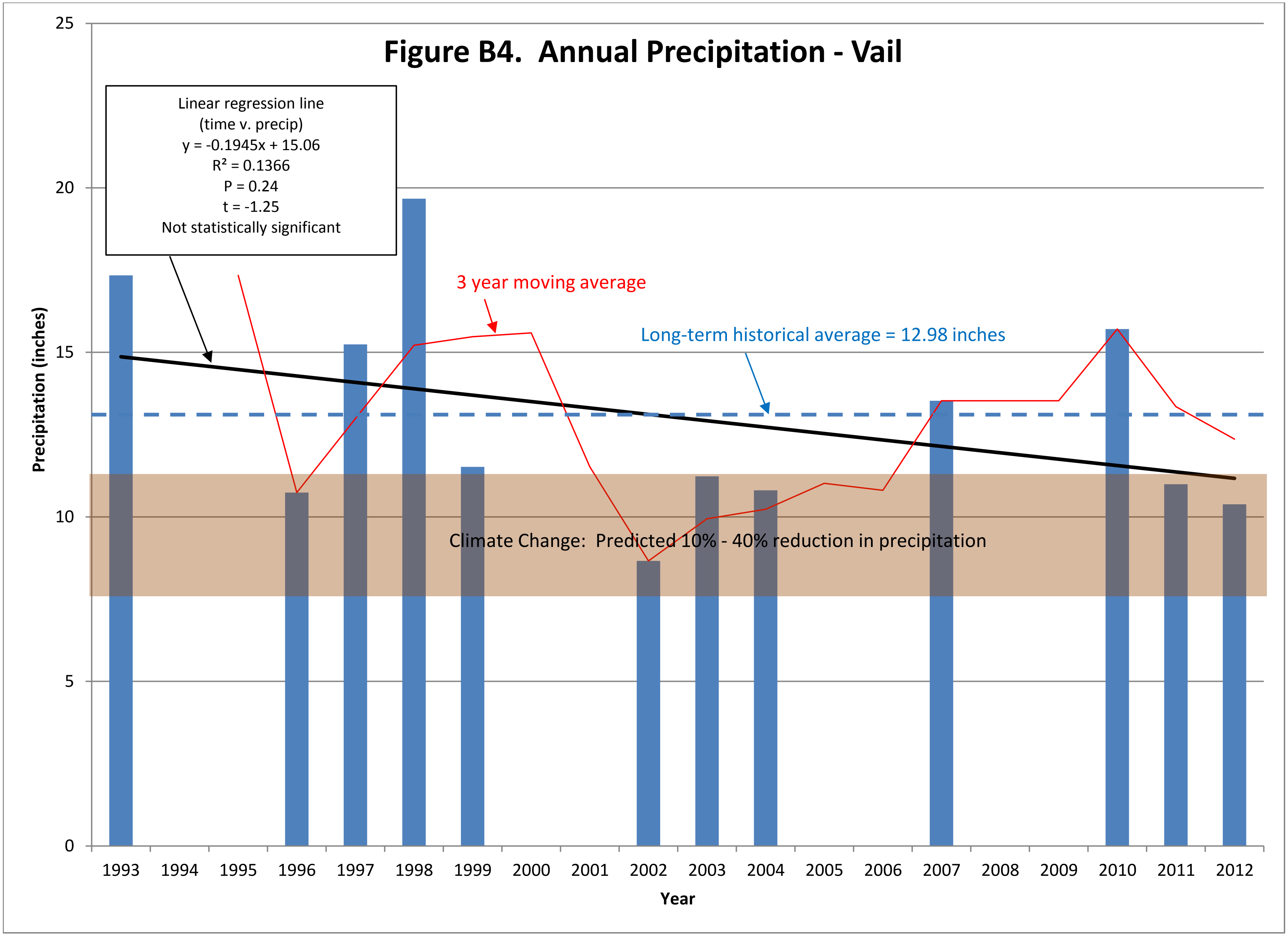
Figure B4. Annual Precipitation - Vail
Linear regression line
(time v. precip)
y = -0.1945x + 15.06
R² = 0.1366
P = 0.24
t = -1.25
Not statistically significant
3 year moving average
Long-term historical average = 12.98 inches
Climate Change: Predicted 10% - 40% reduction in precipitation
Precipitation (inches)
Year
0
5
10
15
20
25
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

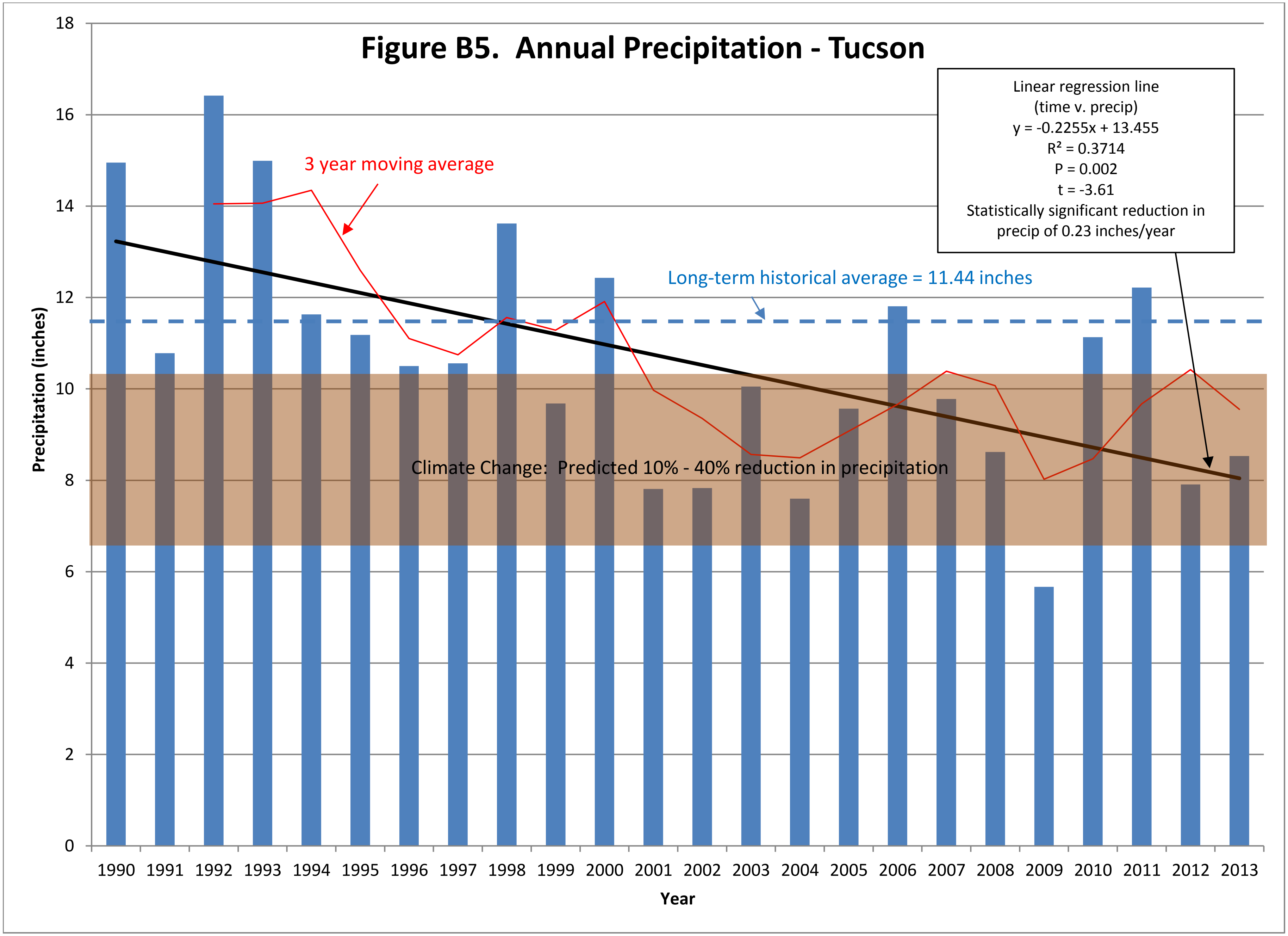
Figure B5. Annual Precipitation - Tucson
Linear regression line
(time v. precip)
y = -0.2255x + 13.455
R² = 0.3714
P = 0.002
t = -3.61
Statistically significant reduction in
precip of 0.23 inches/year
3 year moving average
Long-term historical average = 11.44 inches
Climate Change: Predicted 10% - 40% reduction in precipitation
Precipitation (inches)
Year
18
16
14
12
10
8
6
4
2
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

C. Streamflow Trend Analysis

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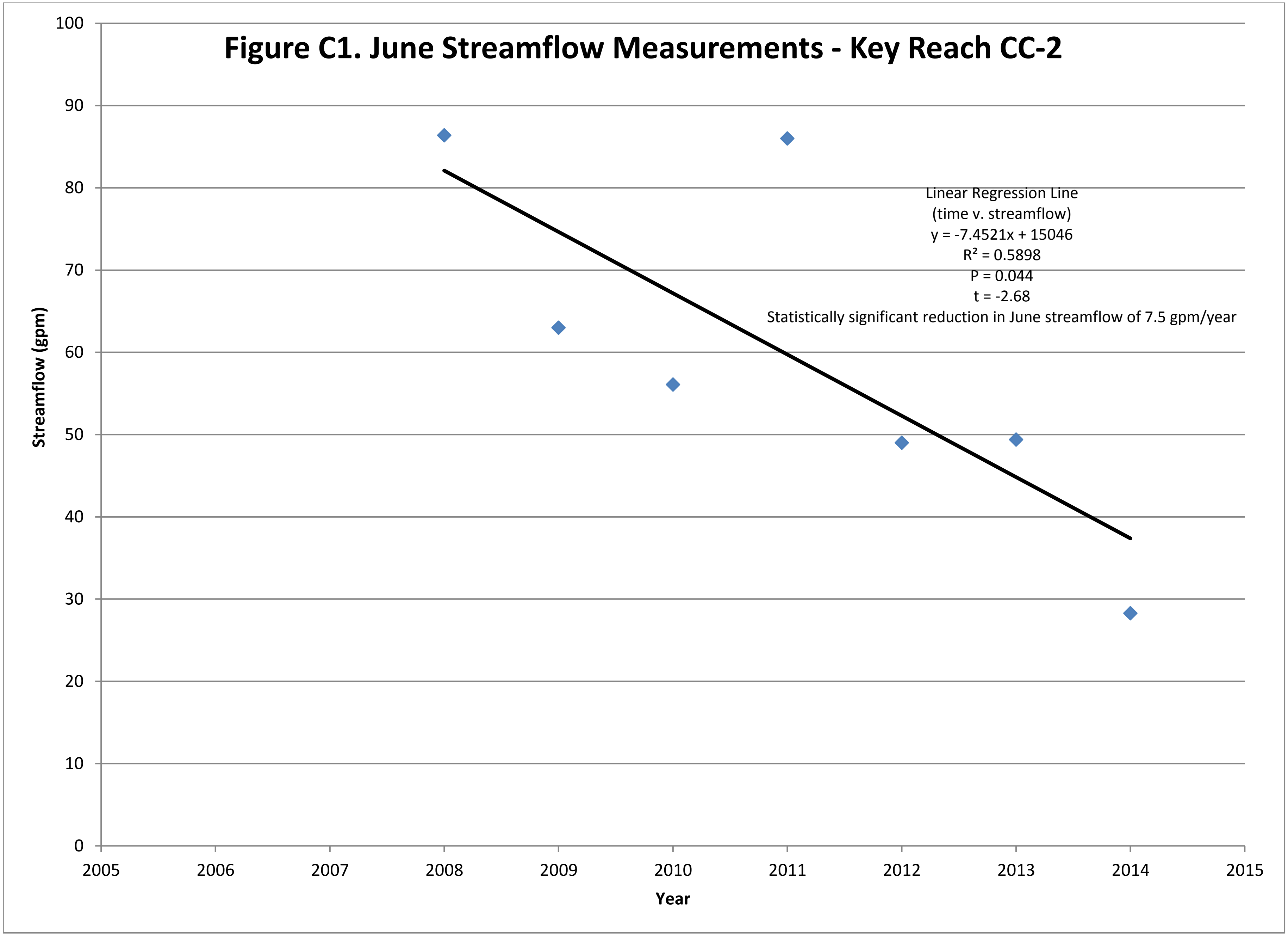
Figure C1. June Streamflow Measurements - Key Reach CC-2
Linear Regression Line
(time v. streamflow)
y = -7.4521x + 15046
R² = 0.5898
P = 0.044
t = -2.68
Statistically significant reduction in June streamflow of 7.5 gpm/year
Streamflow (gpm)
Year
0
10
20
30
40
50
60
70
80
90
100
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

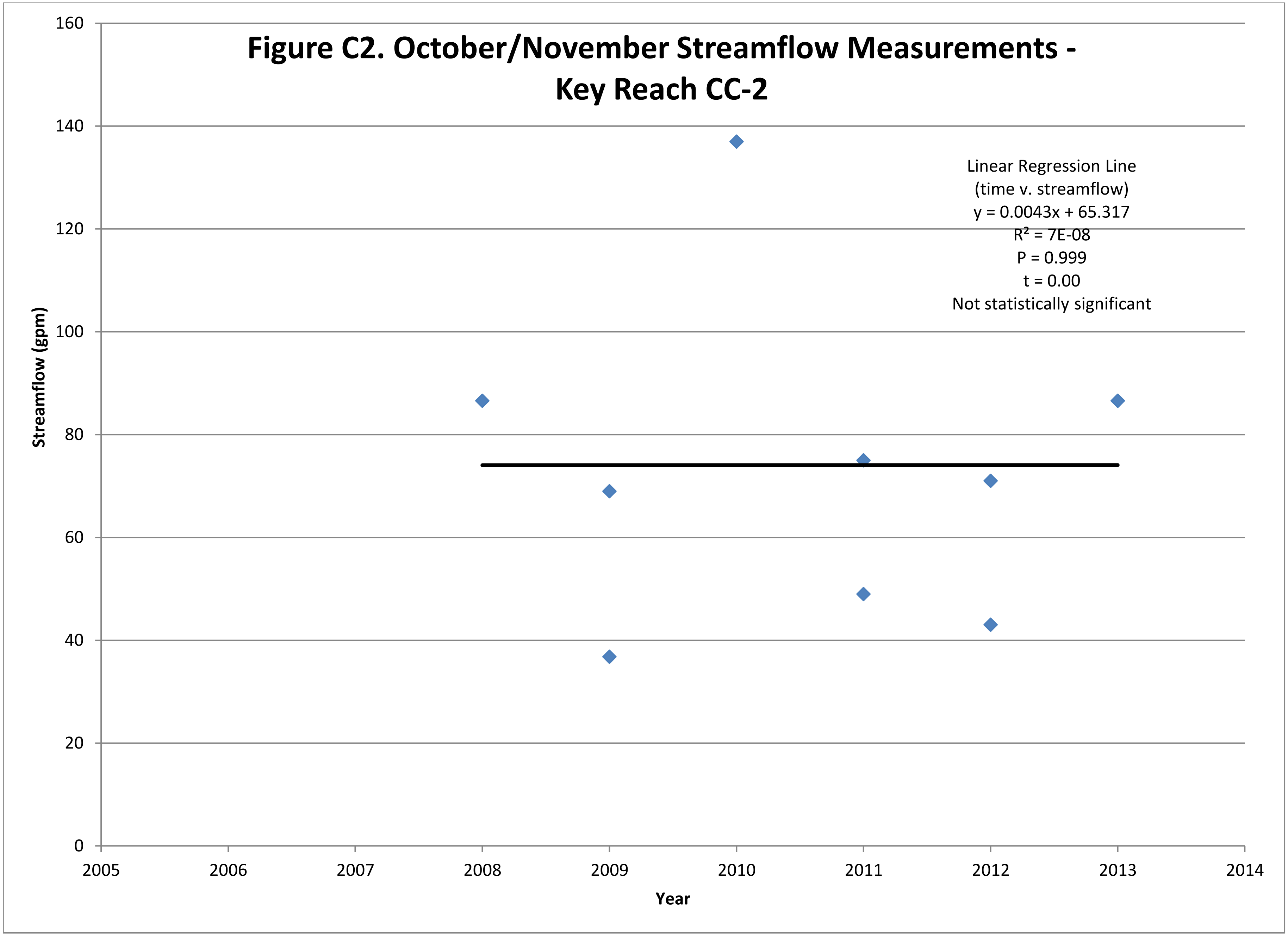
Figure C2. October/November Streamflow Measurements -
Key Reach CC-2
Linear Regression Line
(time v. streamflow)
y = 0.0043x + 65.317
R² = 7E-08
P = 0.999
t = 0.00
Not statistically significant
Streamflow (gpm)
Year
160
140
120
100
80
60
40
20
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

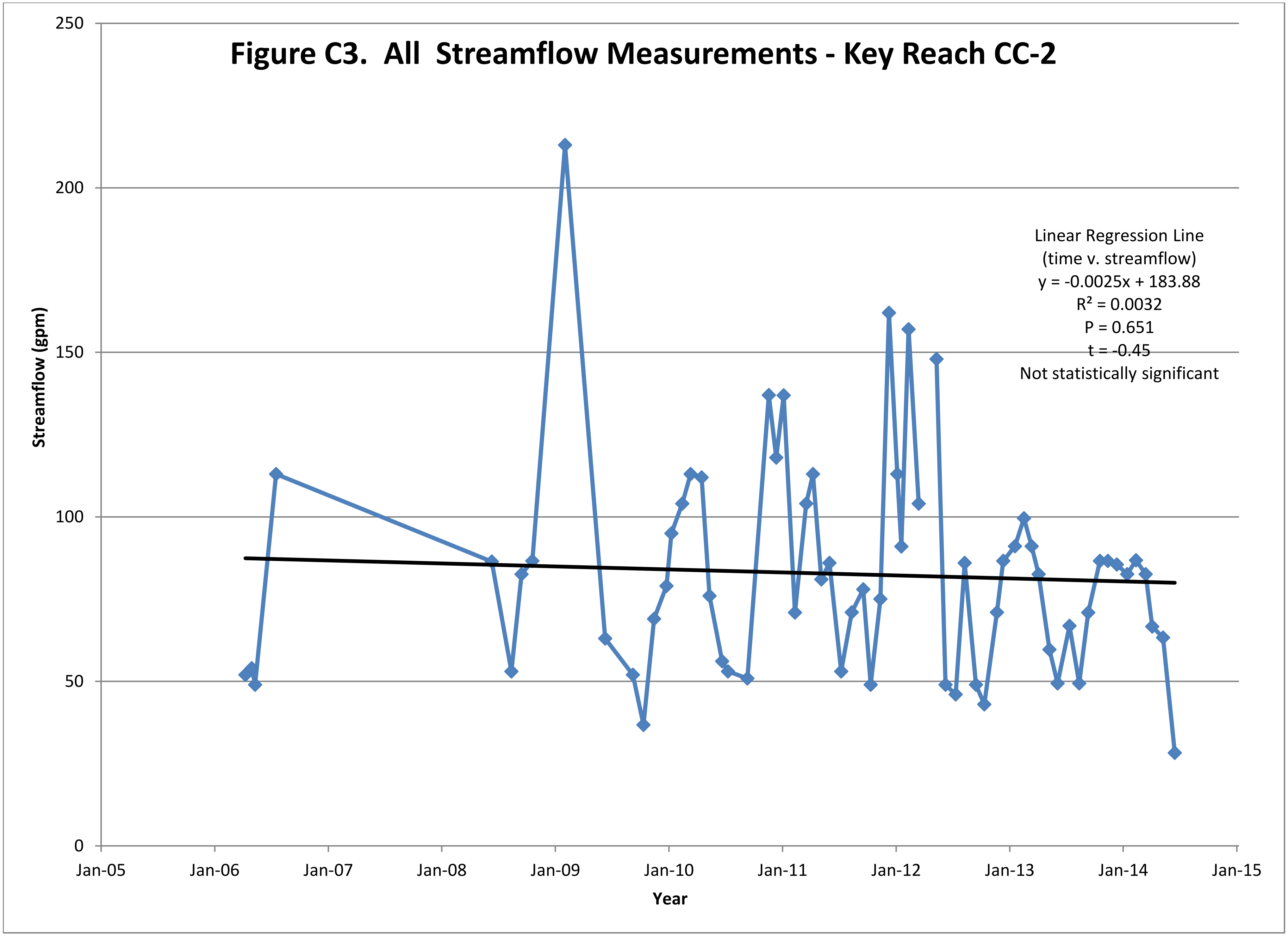
Figure C3. All Streamflow Measurements - Key Reach CC-2
250
200
150
100
50
0
Streamflow (gpm)
Linear Regression Line
(time v. streamflow)
y = -0.0025x + 183.88
R² = 0.0032
P = 0.651
t = -0.45
Not statistically significant
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Year

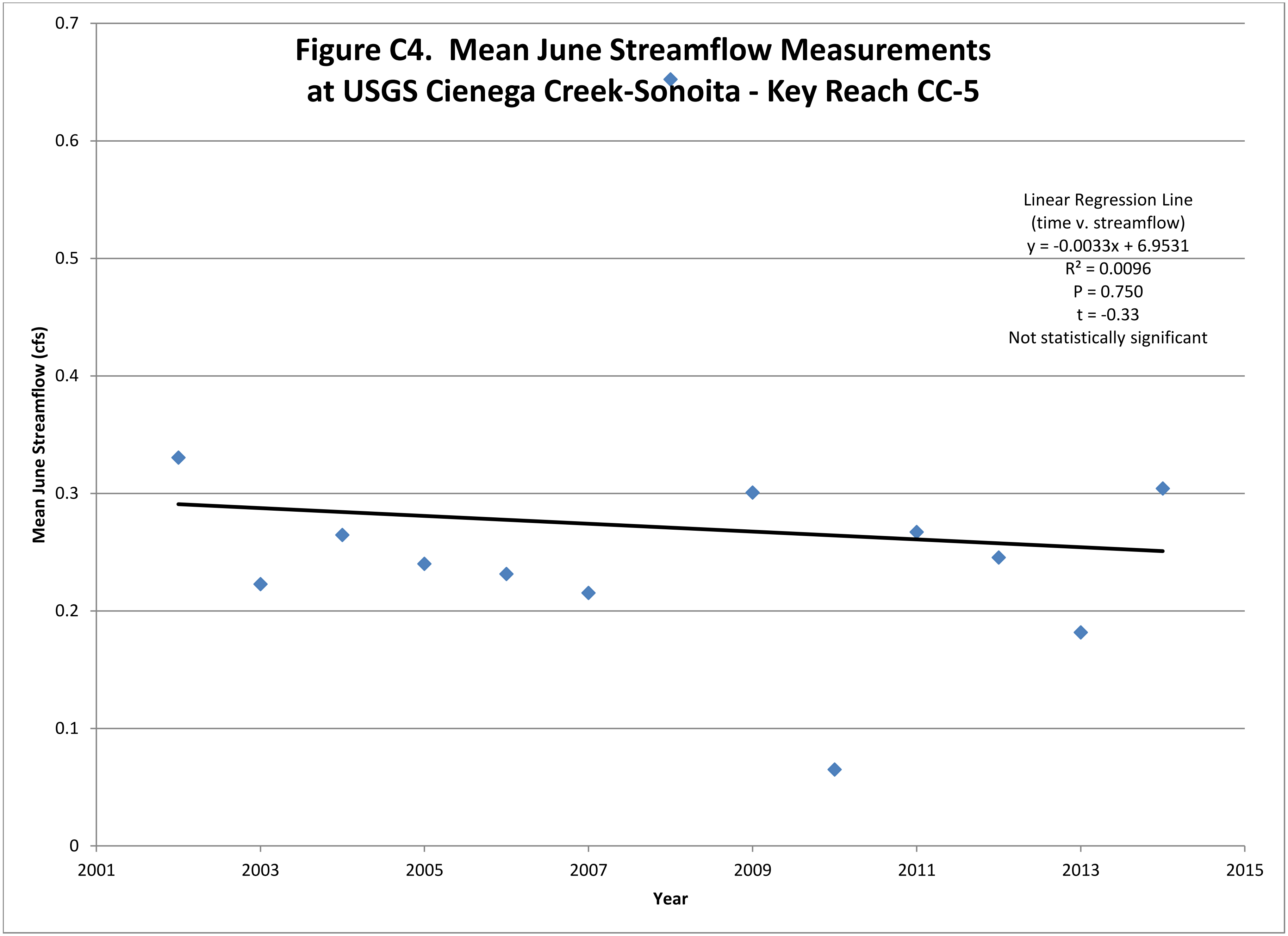
Figure C4. Mean June Streamflow Measurements
at USGS Cienega Creek-Sonoita - Key Reach CC-5
Linear Regression Line
(time v. streamflow)
y = -0.0033x + 6.9531
R² = 0.0096
P = 0.750
t = -0.33
Not statistically significant
Mean June Streamflow (cfs)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2001
2003
2005
2007
2009
2011
2013
2015
Year

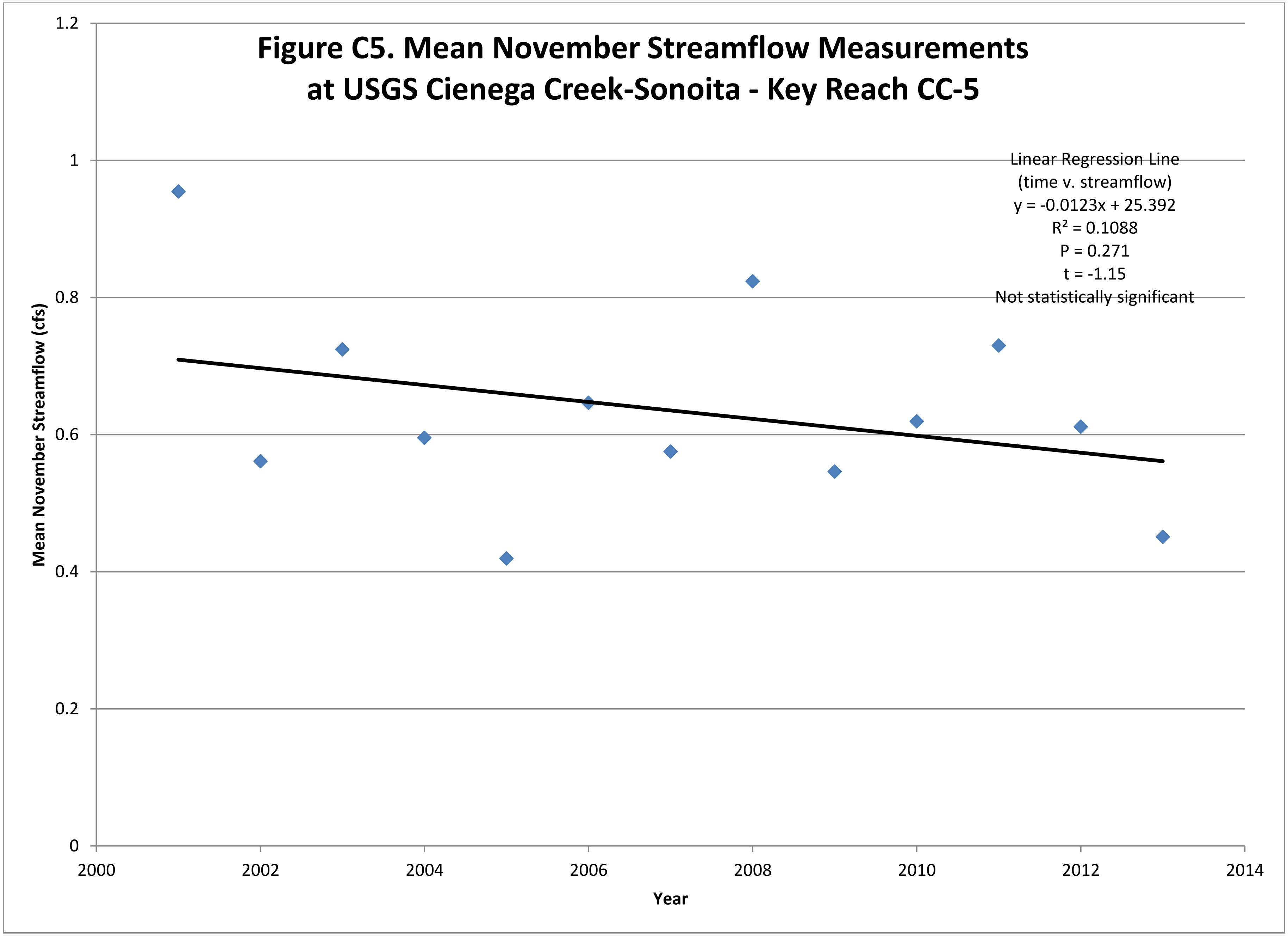
Figure C5. Mean November Streamflow Measurements
at USGS Cienega Creek-Sonoita - Key Reach CC-5
Linear Regression Line
(time v. streamflow)
y = -0.0123x + 25.392
R² = 0.1088
P = 0.271
t = -1.15
Not statistically significant
Mean November Streamflow (cfs)
1.2
1
0.8
0.6
0.4
0.2
0
2000
2002
2004
2006
2008
2010
2012
2014
Year

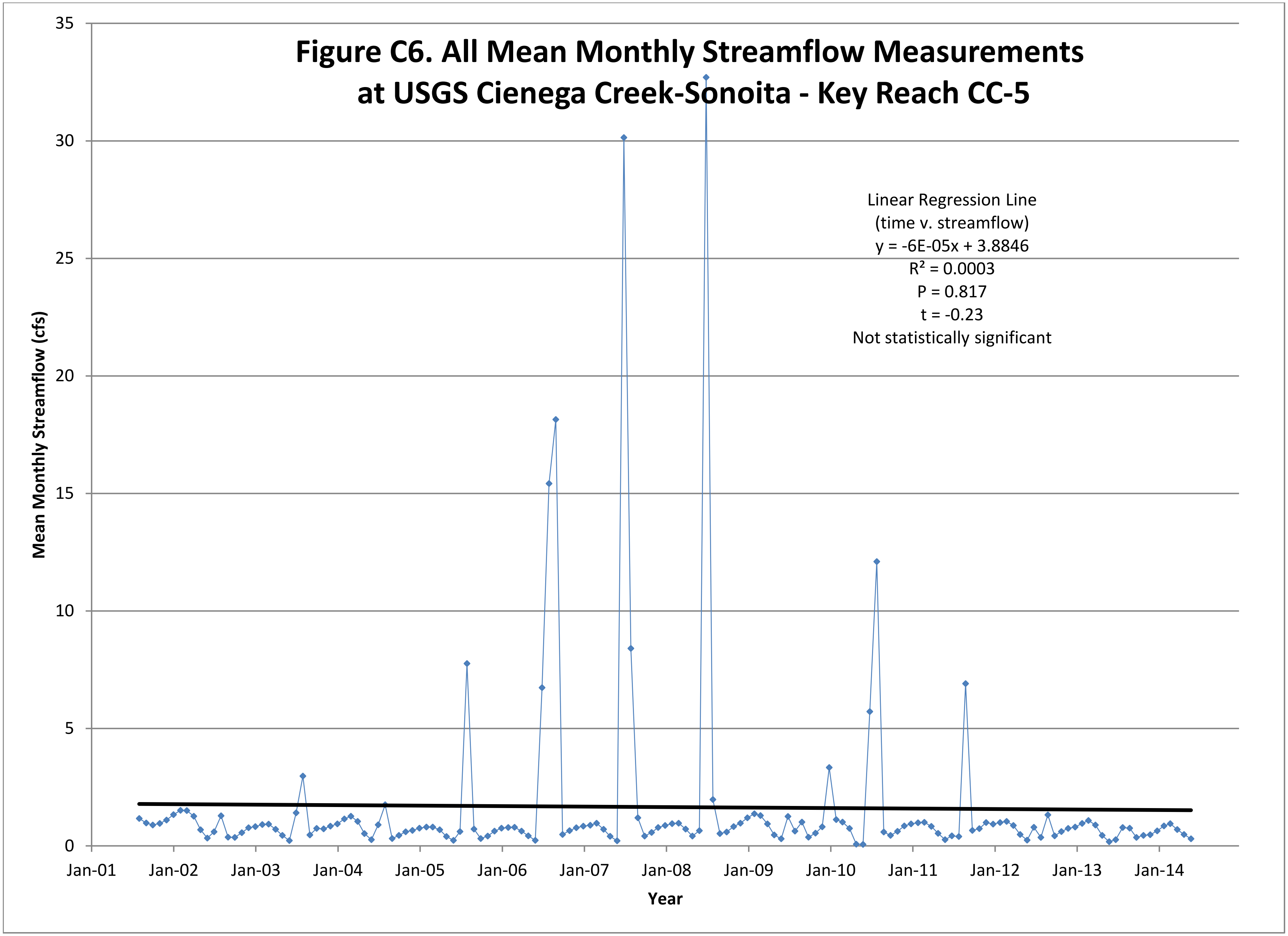
Figure C6. All Mean Monthly Streamflow Measurements
at USGS Cienega Creek-Sonoita - Key Reach CC-5
Linear Regression Line
(time v. streamflow)
y = -6E-05x + 3.8846
R² = 0.0003
P = 0.817
t = -0.23
Not statistically significant
Mean Monthly Streamflow (cfs)
Year
0
5
10
15
20
25
30
35
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14

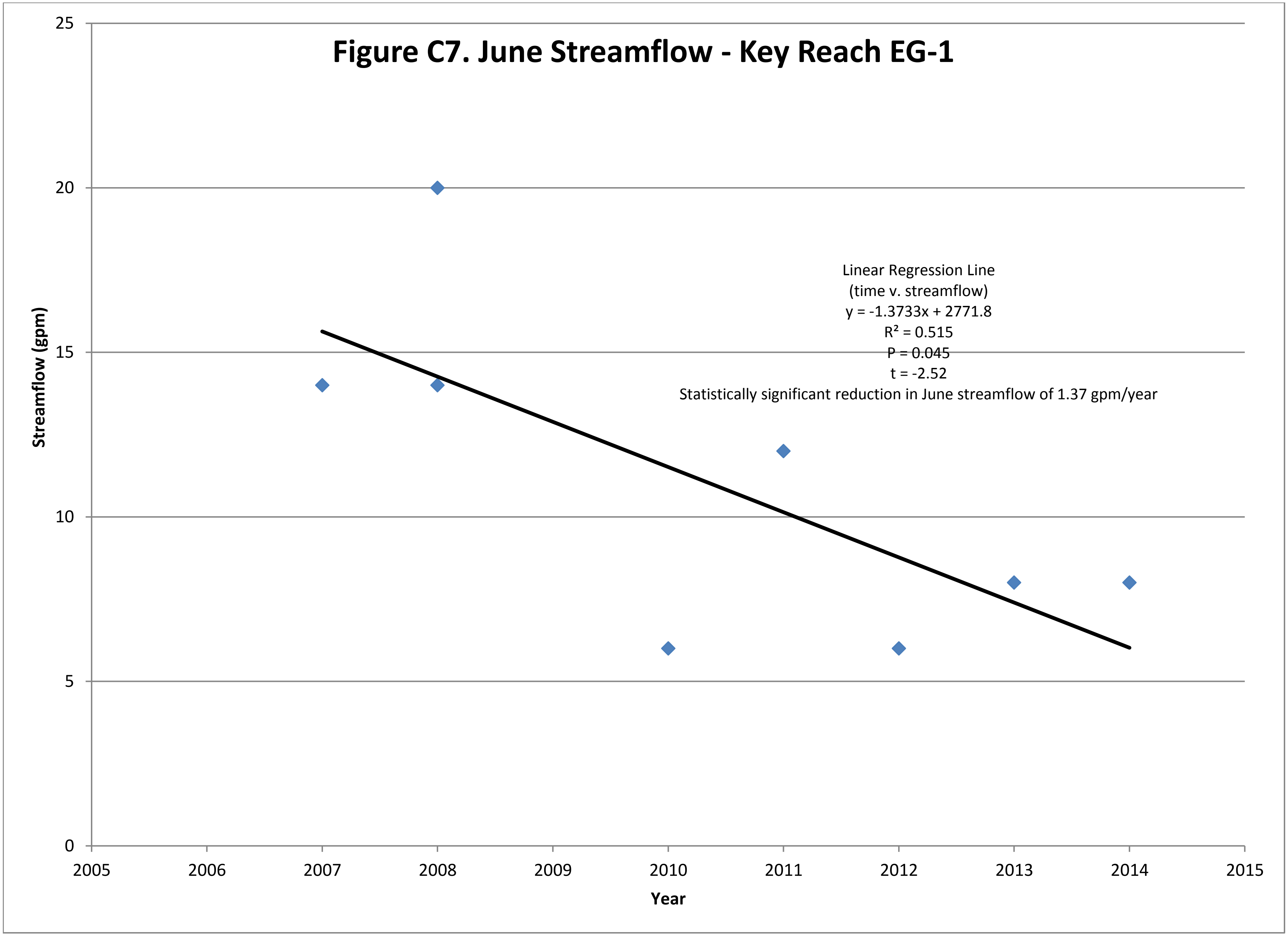
Figure C7. June Streamflow - Key Reach EG-1
Linear Regression Line
(time v. streamflow)
y = -1.3733x + 2771.8
R² = 0.515
P = 0.045
t = -2.52
Statistically significant reduction in June streamflow of 1.37 gpm/year
Streamflow (gpm)
25
20
15
10
5
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year

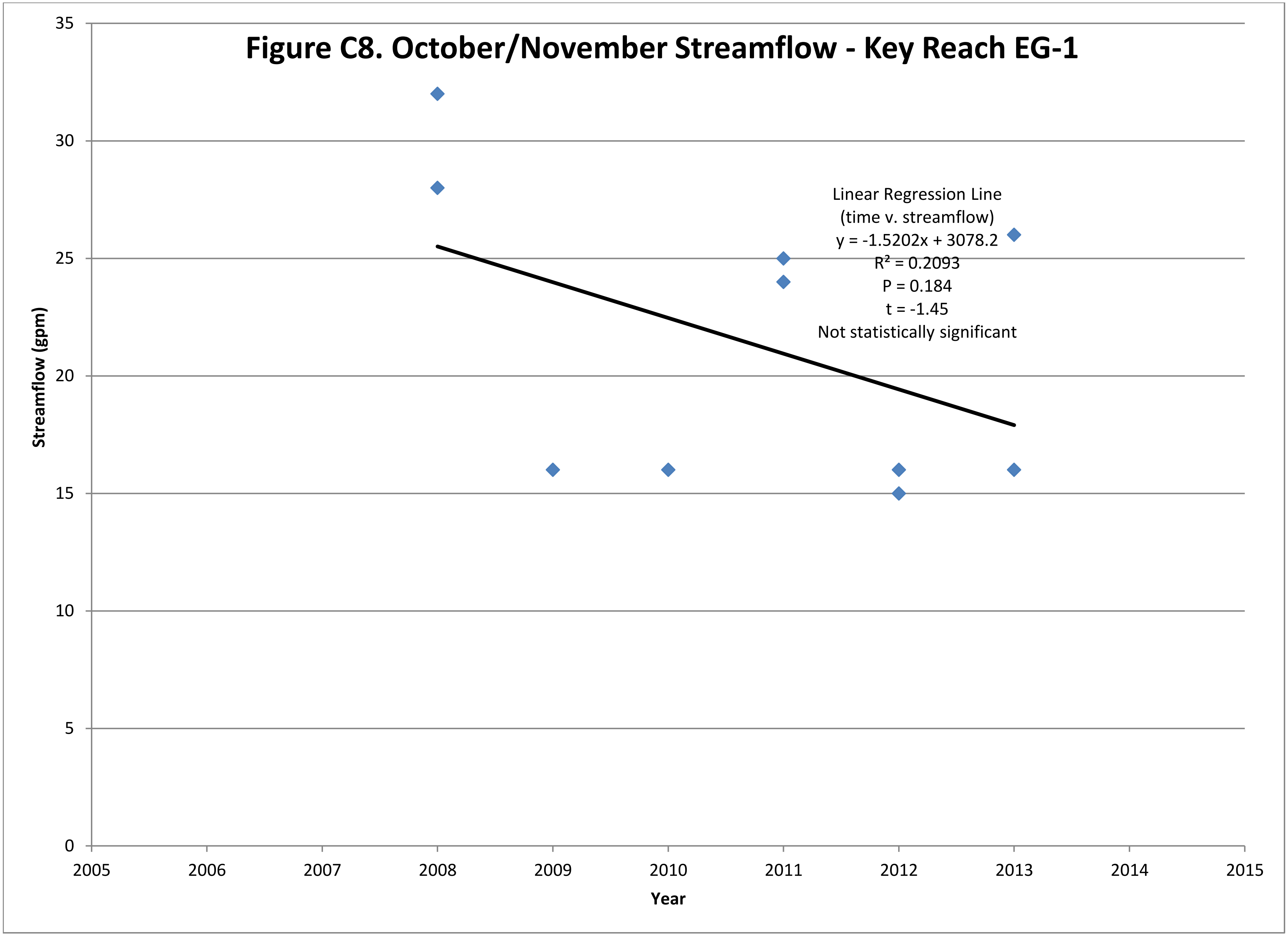
Figure C8. October/November Streamflow - Key Reach EG-1
Linear Regression Line
(time v. streamflow)
y = -1.5202x + 3078.2
R² = 0.2093
P = 0.184
t = -1.45
Not statistically significant
Streamflow (gpm)
Year
35
30
25
20
15
10
5
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

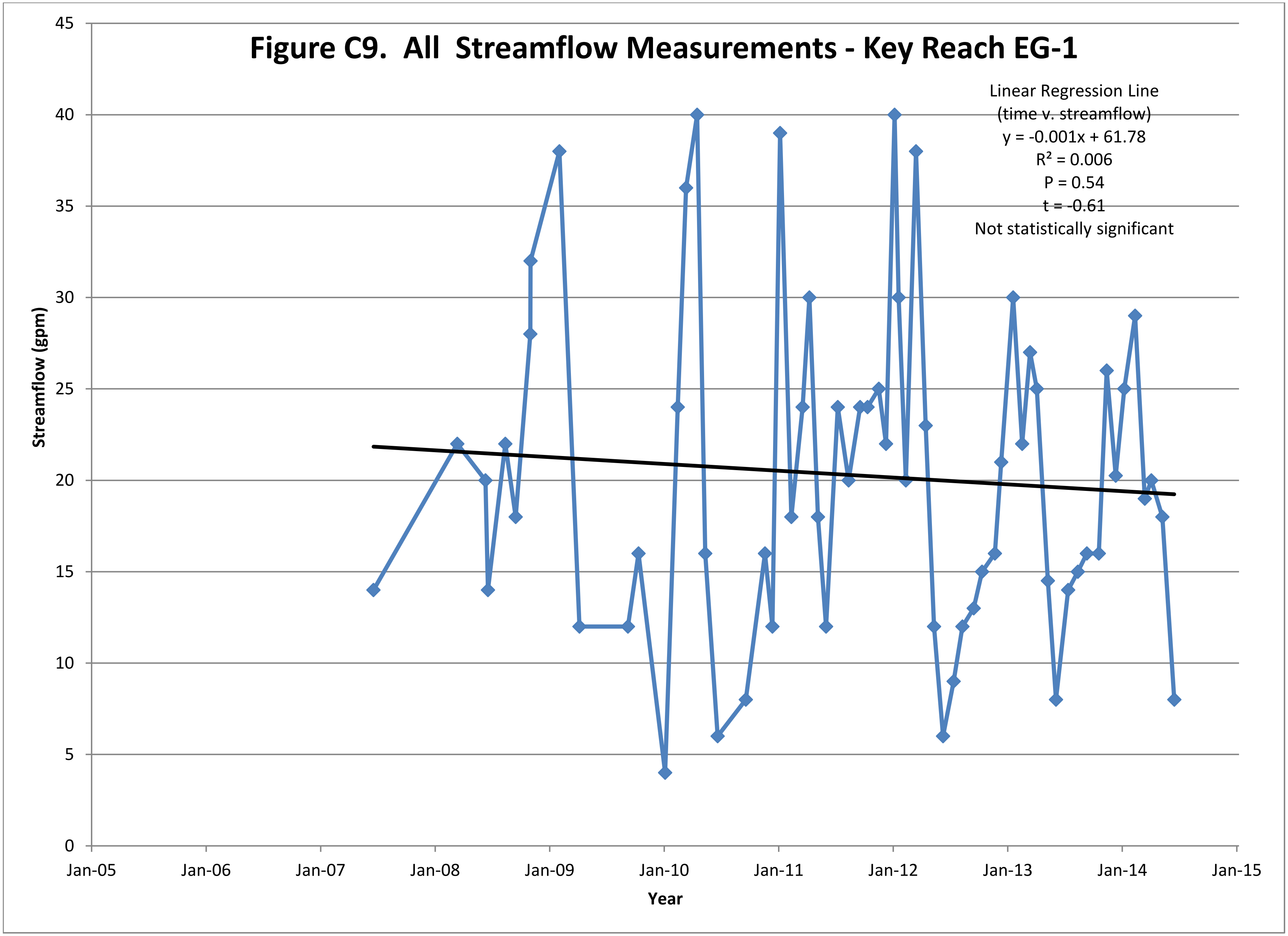
Figure C9. All Streamflow Measurements - Key Reach EG-1
Linear Regression Line
(time v. streamflow)
y = -0.001x + 61.78
R² = 0.006
P = 0.54
t = -0.61
Not statistically significant
Streamflow (gpm)
0
5
10
15
20
25
30
35
40
45
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Year

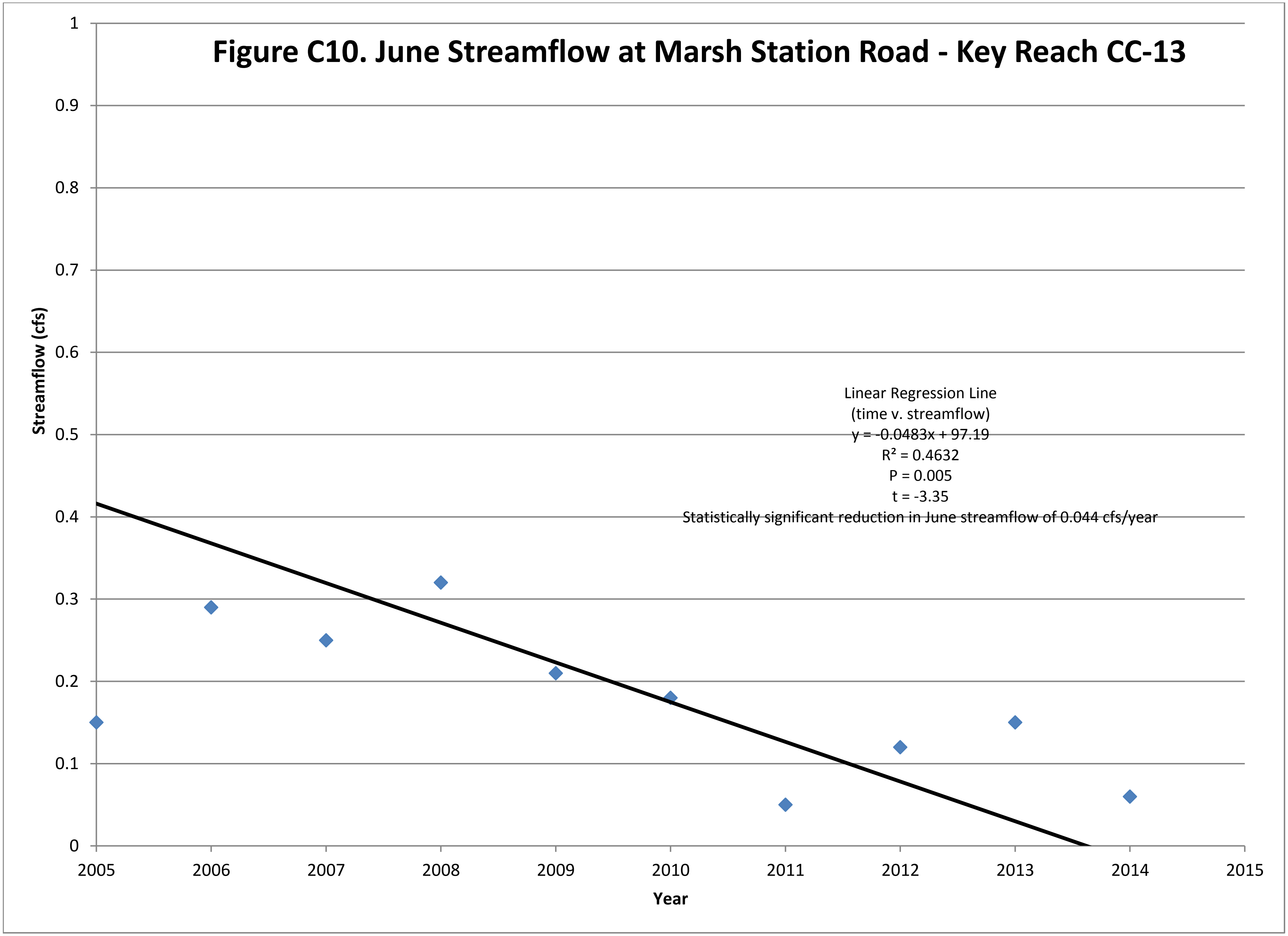

Figure C10. June Streamflow at Marsh Station Road - Key Reach CC-13
Streamflow (cfs)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Linear Regression Line
(time v. streamflow)
y = -0.0483x + 97.19
R² = 0.4632
P = 0.005
t = -3.35
Statistically significant reduction in June streamflow of 0.044 cfs/year
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year

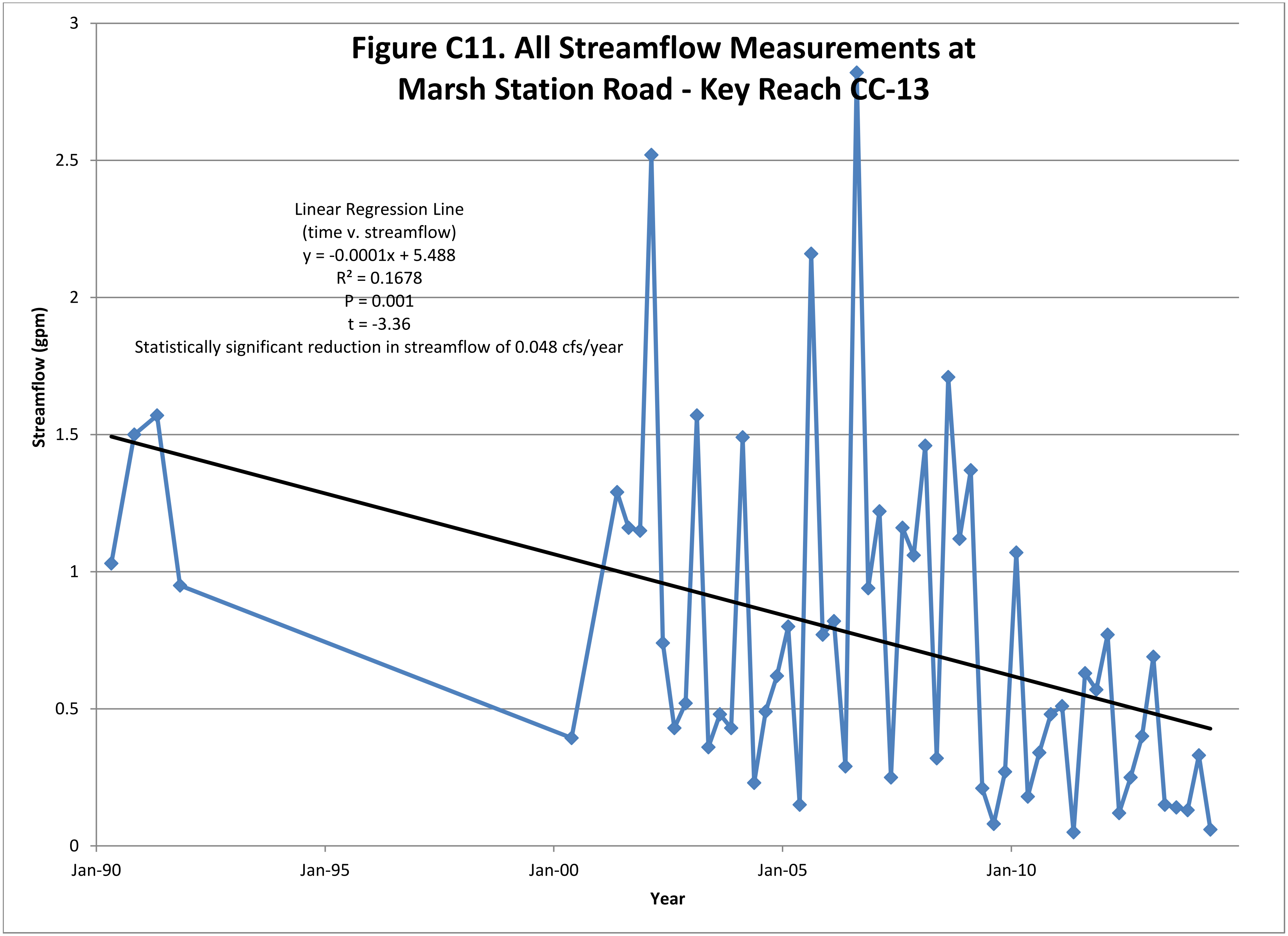
Figure C11. All Streamflow Measurements at
Marsh Station Road - Key Reach CC-13
Linear Regression Line
(time v. streamflow)
y = -0.0001x + 5.488
R² = 0.1678
P = 0.001
t = -3.36
Statistically significant reduction in streamflow of 0.048 cfs/year
Streamflow (gpm)
3
2.5
2
1.5
1
0.5
0
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Year

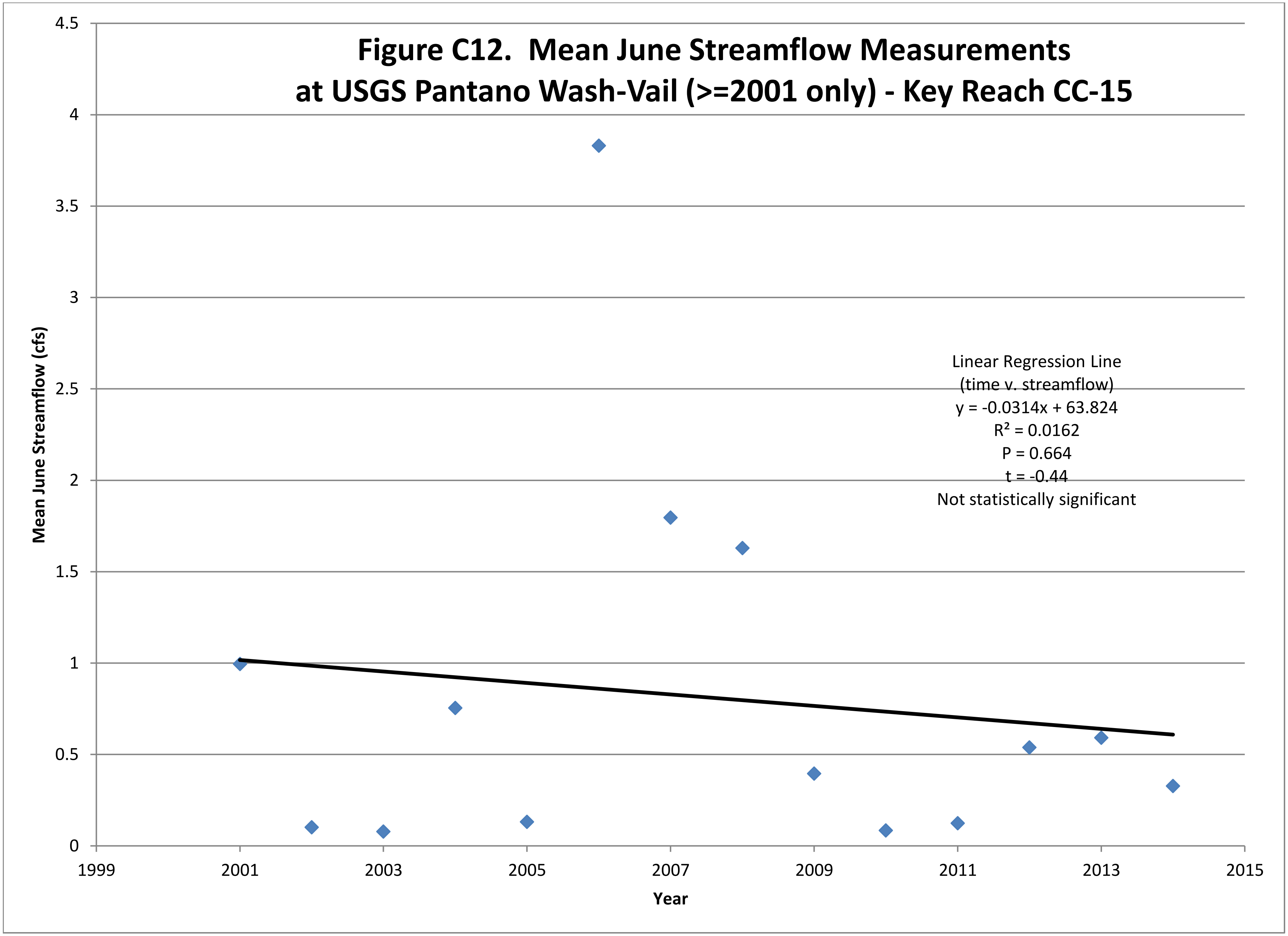
Figure C12. Mean June Streamflow Measurements
at USGS Pantano Wash-Vail (>=2001 only) - Key Reach CC-15
Mean June Streamflow (cfs)
Year
Linear Regression Line
(time v. streamflow)
y = -0.0314x + 63.824
R² = 0.0162
P = 0.664
t = -0.44
Not statistically significant
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1999
2001
2003
2005
2007
2009
2011
2013
2015

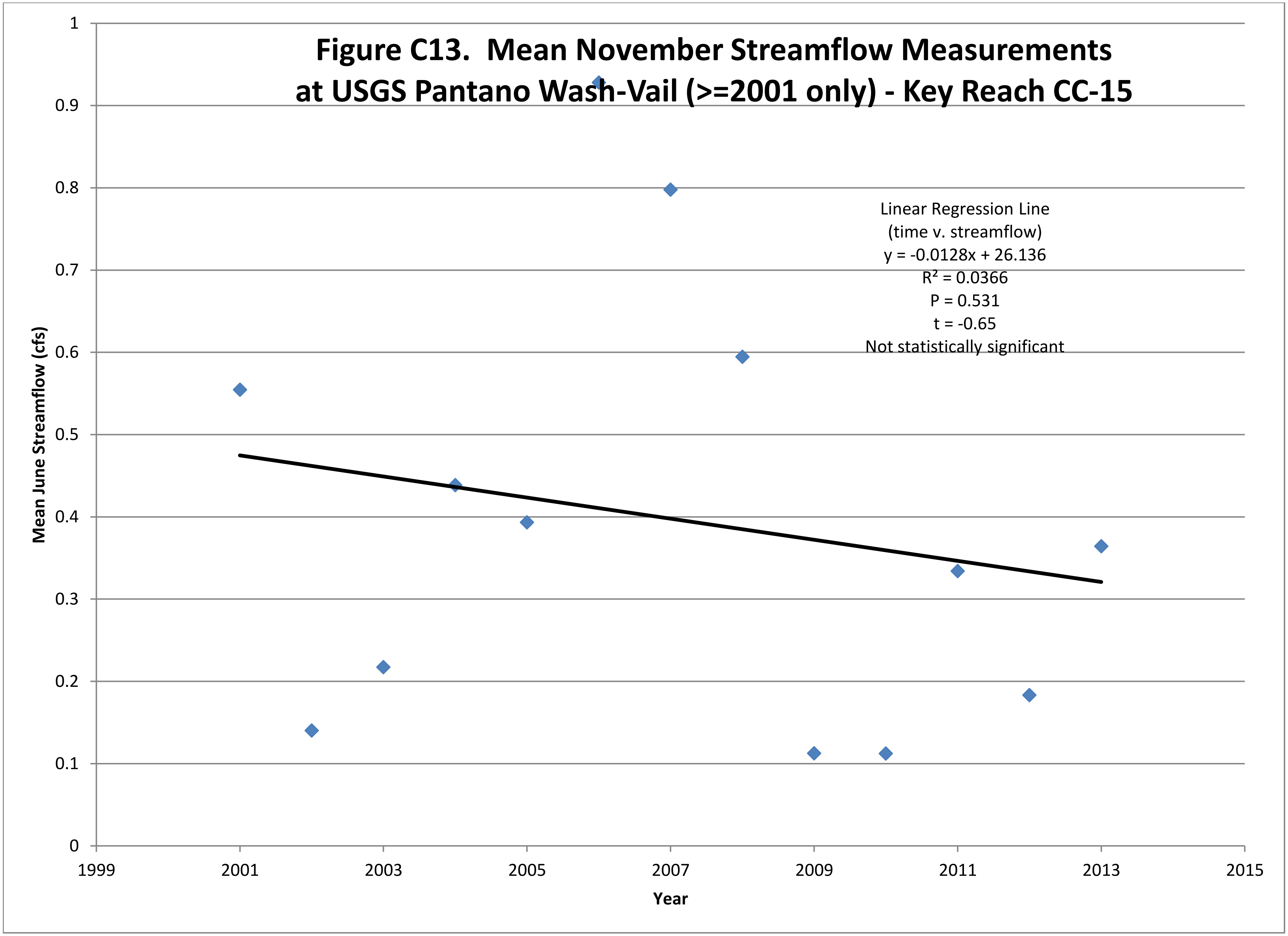

Figure C13. Mean November Streamflow Measurements
at USGS Pantano Wash-Vail (>=2001 only) - Key Reach CC-15
Linear Regression Line
(time v. streamflow)
y = -0.0128x + 26.136
R² = 0.0366
P = 0.531
t = -0.65
Not statistically significant
Mean June Streamflow (cfs)
Year
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1999
2001
2003
2005
2007
2009
2011
2013
2015

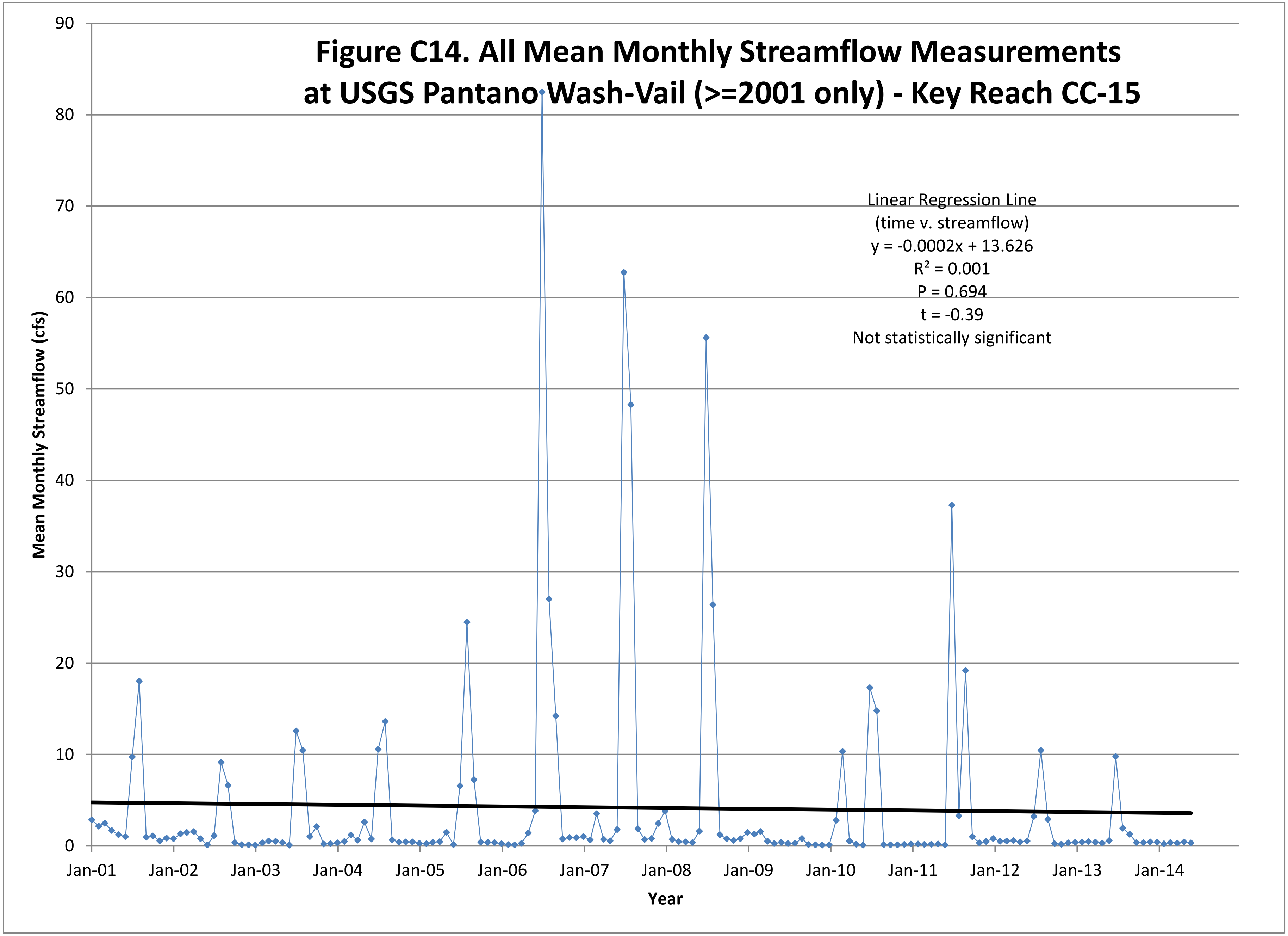

Figure C14. All Mean Monthly Streamflow Measurements
at USGS Pantano Wash-Vail (>=2001 only) - Key Reach CC-15
Linear Regression Line
(time v. streamflow)
y = -0.0002x + 13.626
R² = 0.001
P = 0.694
t = -0.39
Not statistically significant
Mean Monthly Streamflow (cfs)
Year
90
80
70
60
50
40
30
20
10
0
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14

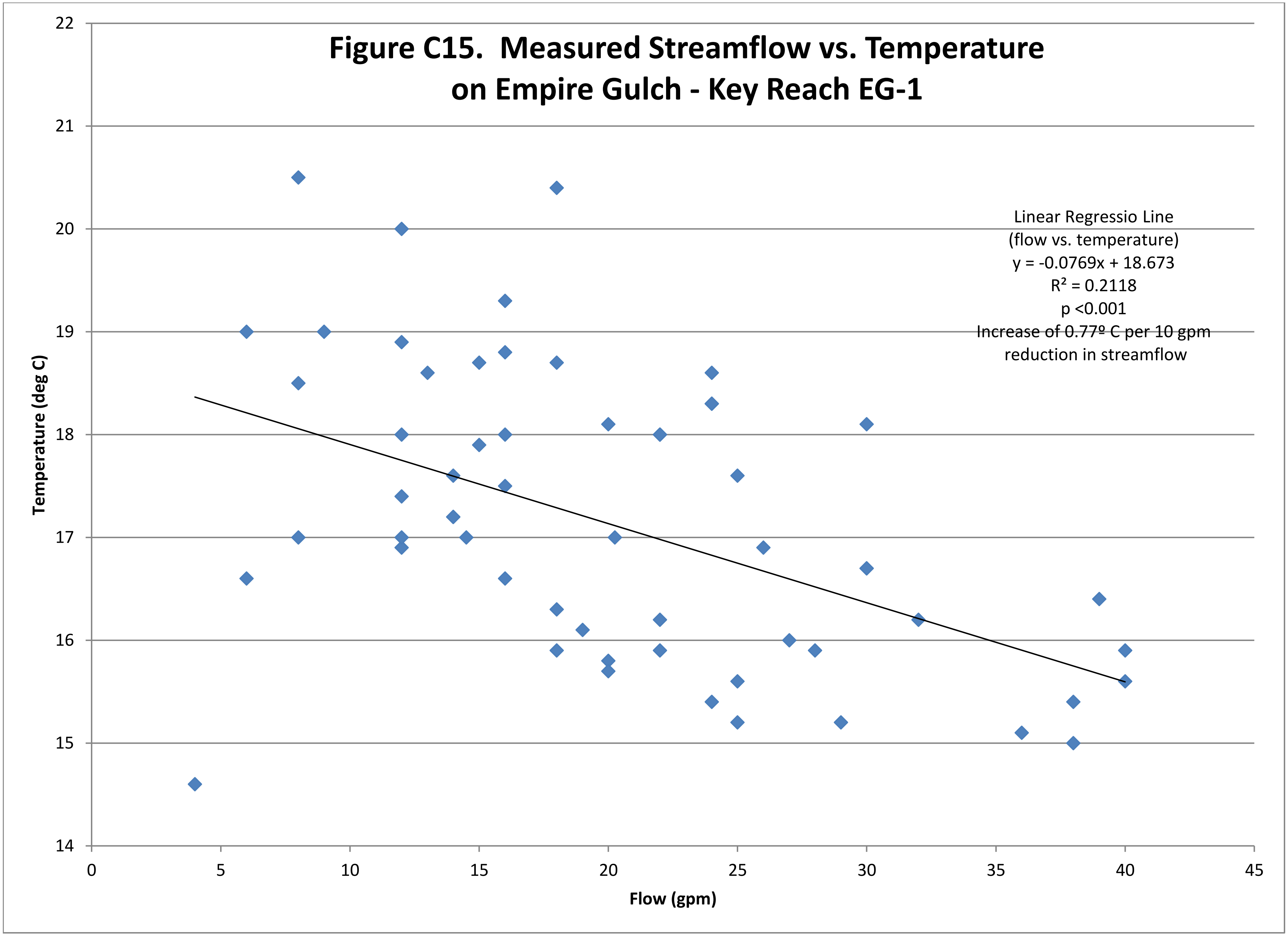
Figure C15. Measured Streamflow vs. Temperature
on Empire Gulch - Key Reach EG-1
Linear Regressio Line
(flow vs. temperature)
y = -0.0769x + 18.673
R² = 0.2118
p <0.001
Increase of 0.77º C per 10 gpm
reduction in streamflow
Temperature (deg C)
Flow (gpm)
22
21
20
19
18
17
16
15
14
0
5
10
15
20
25
30
35
40
45

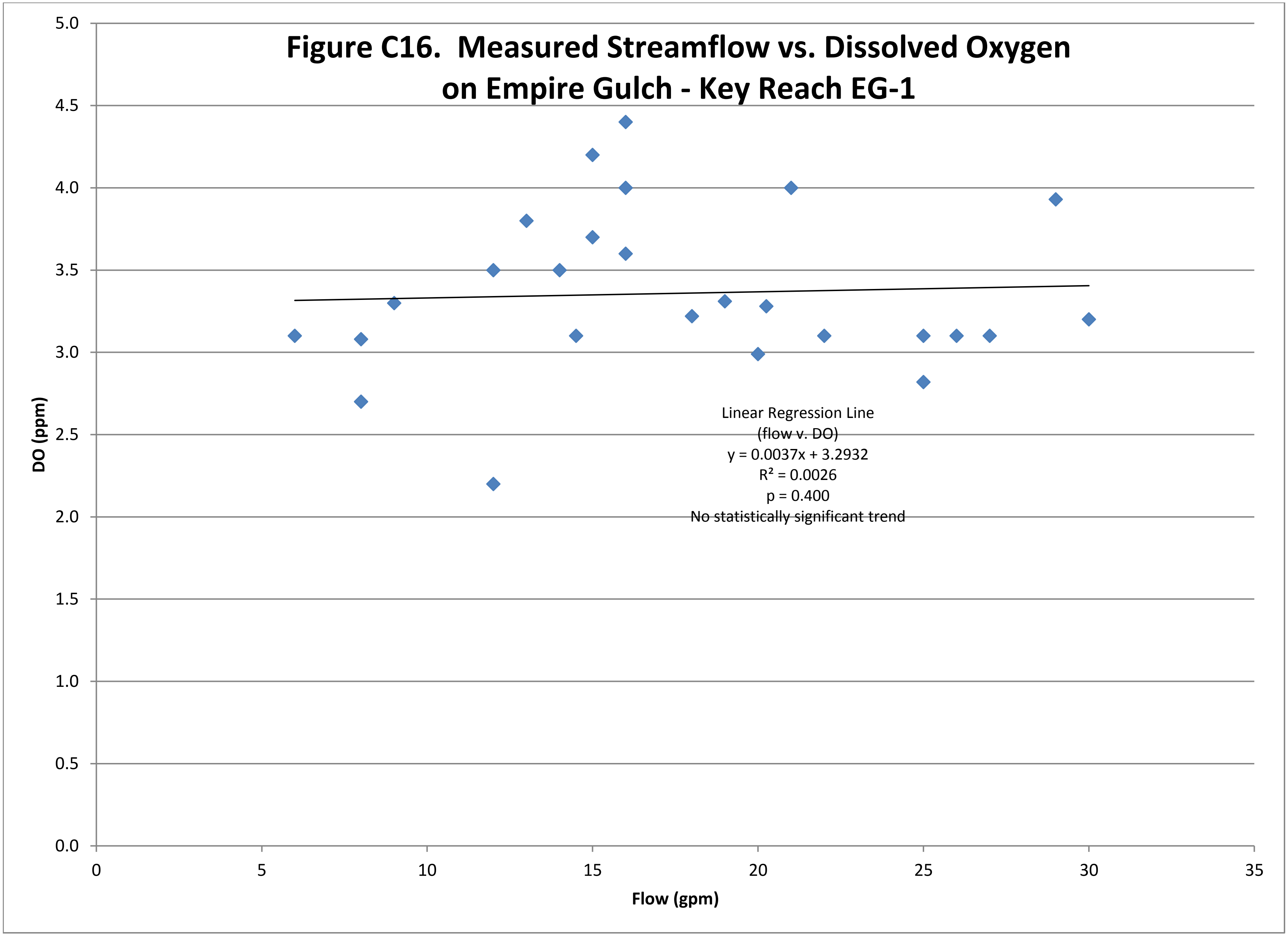
Figure C16. Measured Streamflow vs. Dissolved Oxygen
on Empire Gulch - Key Reach EG-1
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
DO (ppm)
0
5
10
15
20
25
30
35
Flow (gpm)
Linear Regression Line
(flow v. DO)
y = 0.0037x + 3.2932
R² = 0.0026
p = 0.400
No statistically significant trend

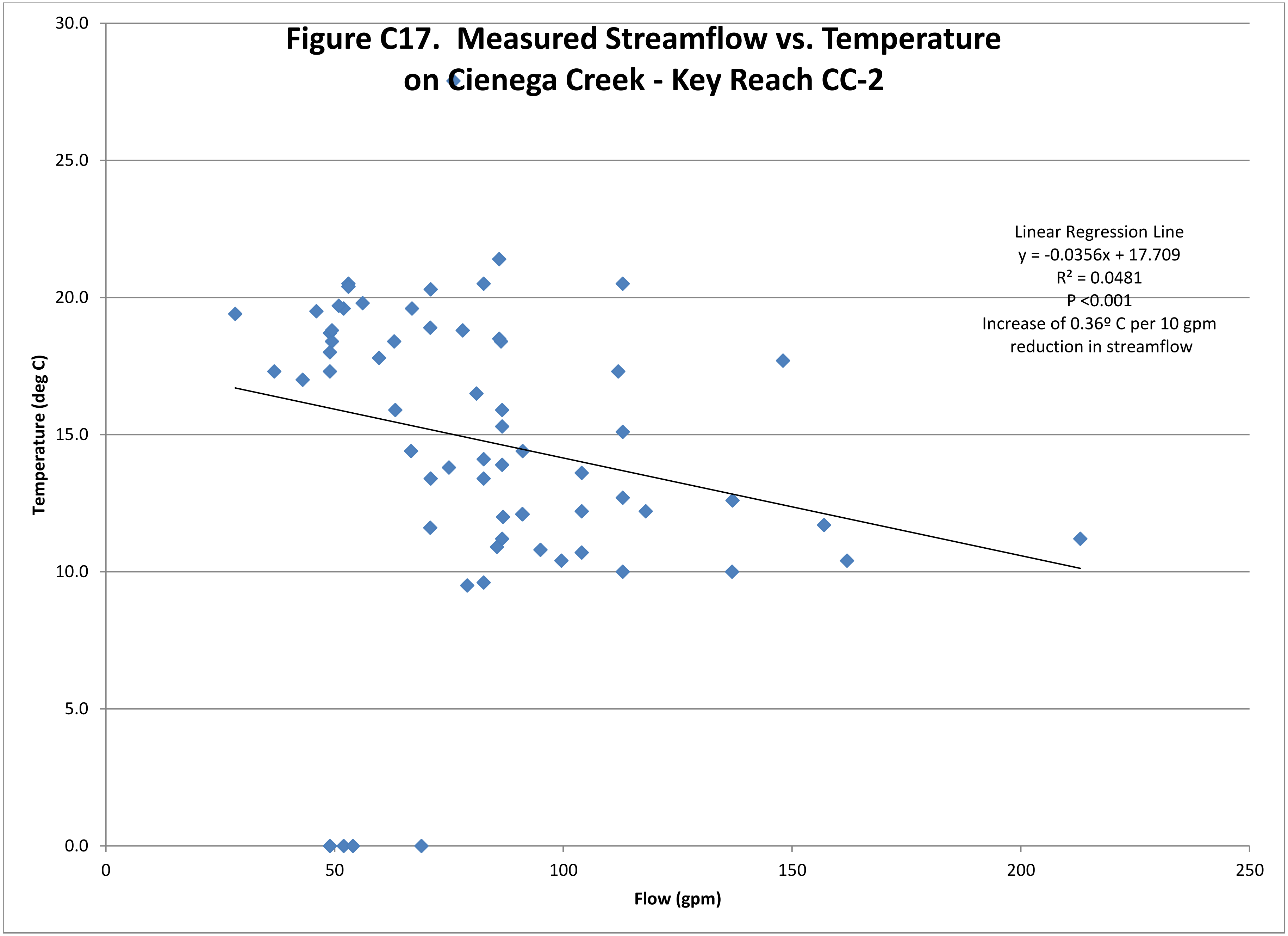
Figure C17. Measured Streamflow vs. Temperature
on Cienega Creek - Key Reach CC-2
Linear Regression Line
y = -0.0356x + 17.709
R² = 0.0481
P <0.001
Increase of 0.36º C per 10 gpm
reduction in streamflow
Temperature (deg C)
Flow (gpm)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
50
100
150
200
250

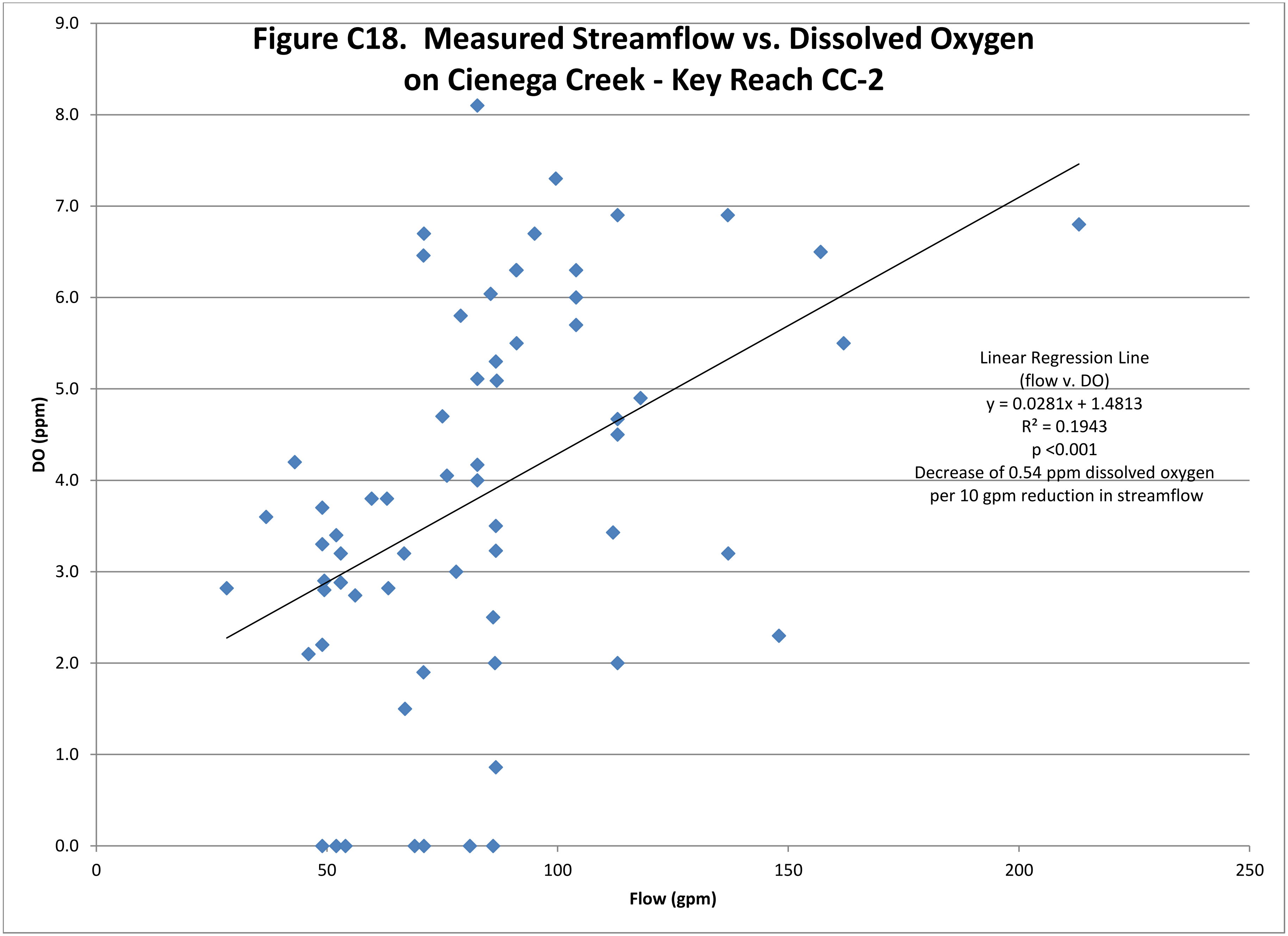
Figure C18. Measured Streamflow vs. Dissolved Oxygen
on Cienega Creek - Key Reach CC-2
DO (ppm)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
50
100
150
200
250
Flow (gpm)
Linear Regression Line
(flow v. DO)
y = 0.0281x + 1.4813
R² = 0.1943
p <0.001
Decrease of 0.54 ppm dissolved oxygen
per 10 gpm reduction in streamflow

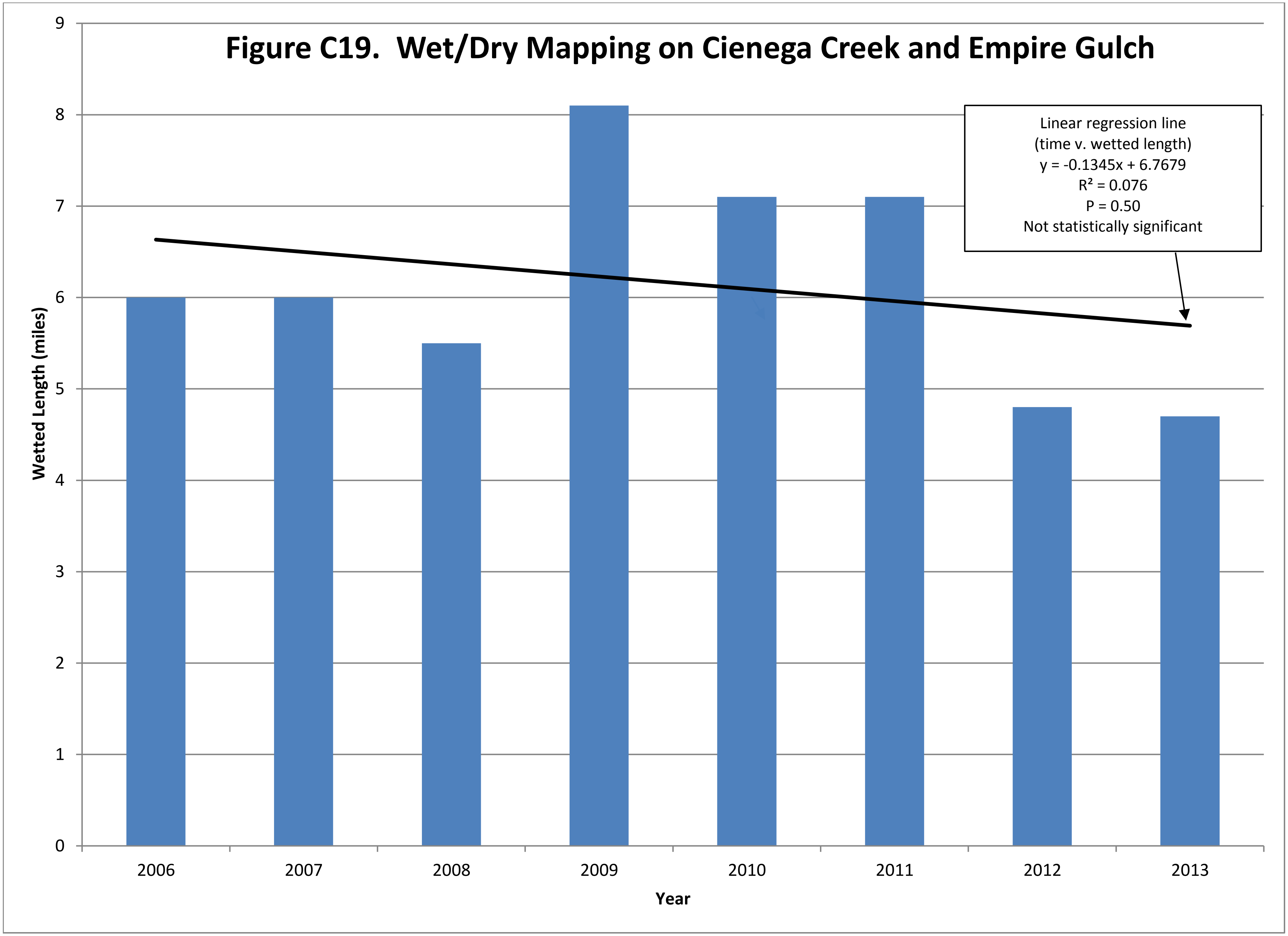
Figure C19. Wet/Dry Mapping on Cienega Creek and Empire Gulch
Linear regression line
(time v. wetted length)
y = -0.1345x + 6.7679
R² = 0.076
P = 0.50
Not statistically significant
Wetted Length (miles)
Year
0
1
2
3
4
5
6
7
8
9
2006
2007
2008
2009
2010
2011
2012
2013

D. Well/Piezometer Groundwater Levels

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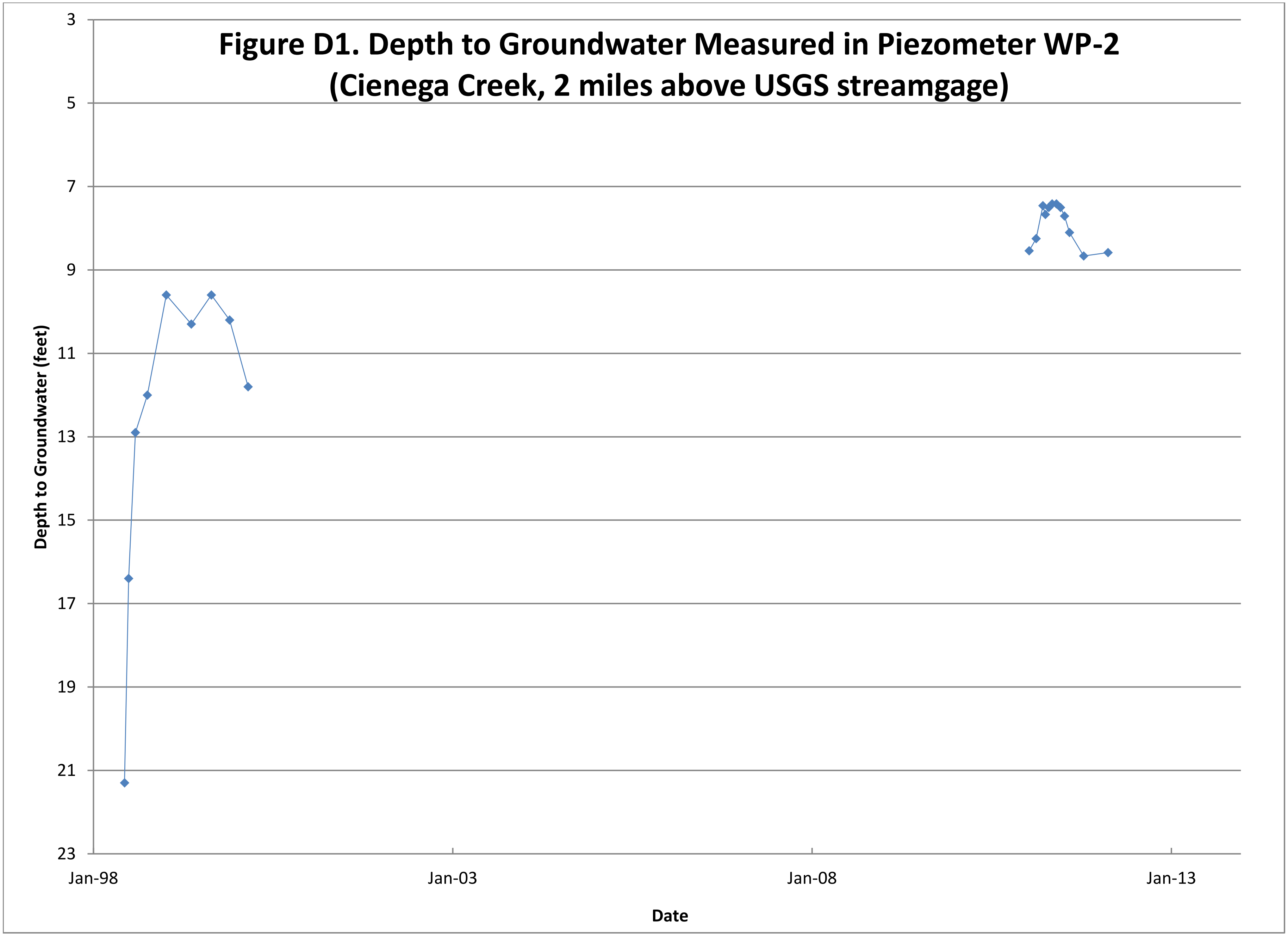
Figure D1. Depth to Groundwater Measured in Piezometer WP-2
(Cienega Creek, 2 miles above USGS streamgage)
Depth to Groundwater (feet)
3
5
7
9
11
13
15
17
19
21
23
Jan-98
Jan-03
Jan-08
Jan-13
Date

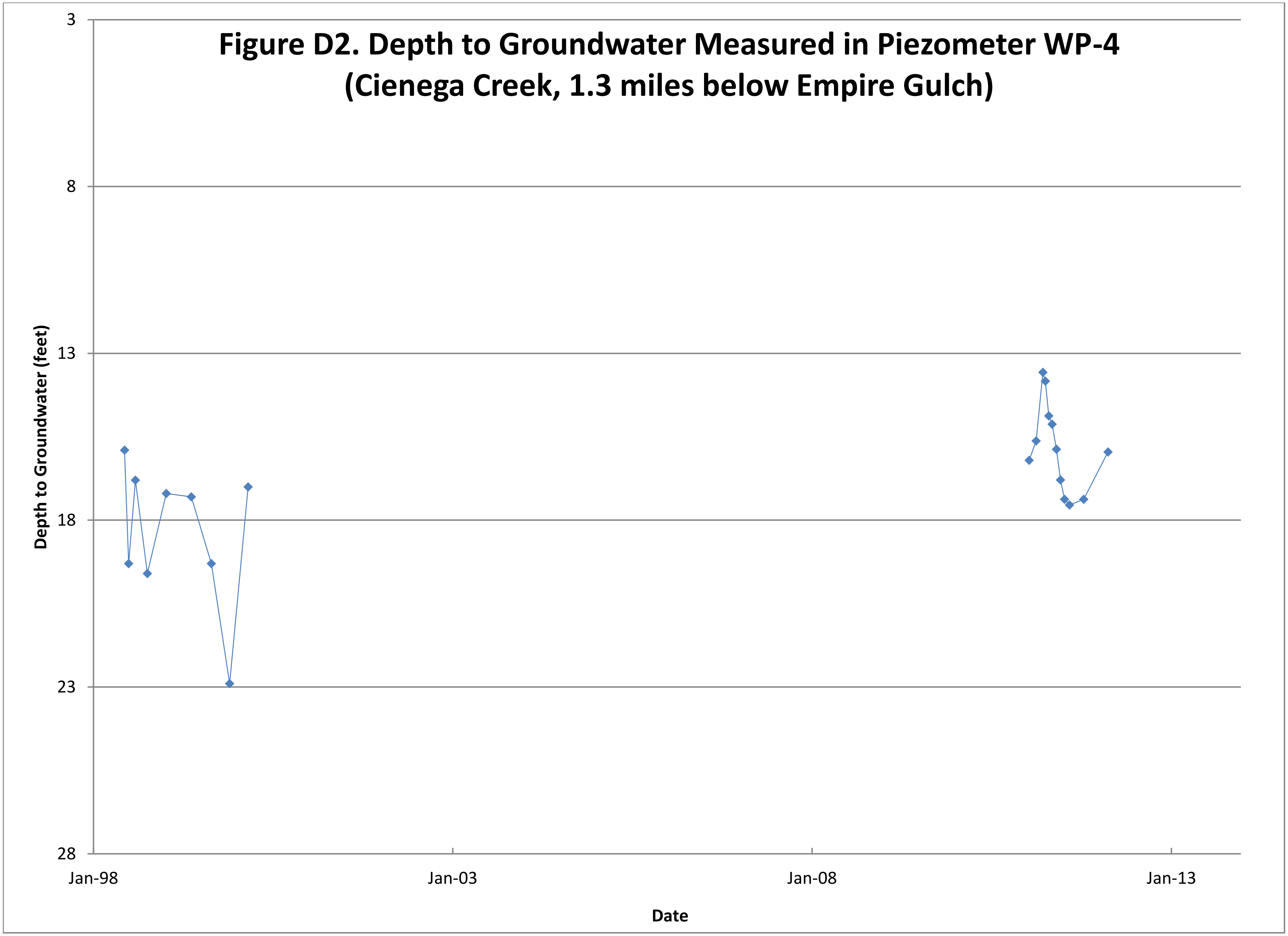
Figure D2. Depth to Groundwater Measured in Piezometer WP-4
(Cienega Creek, 1.3 miles below Empire Gulch)
Depth to Groundwater (feet)
3
8
13
18
23
28
Jan-98
Jan-03
Jan-08
Jan-13
Date

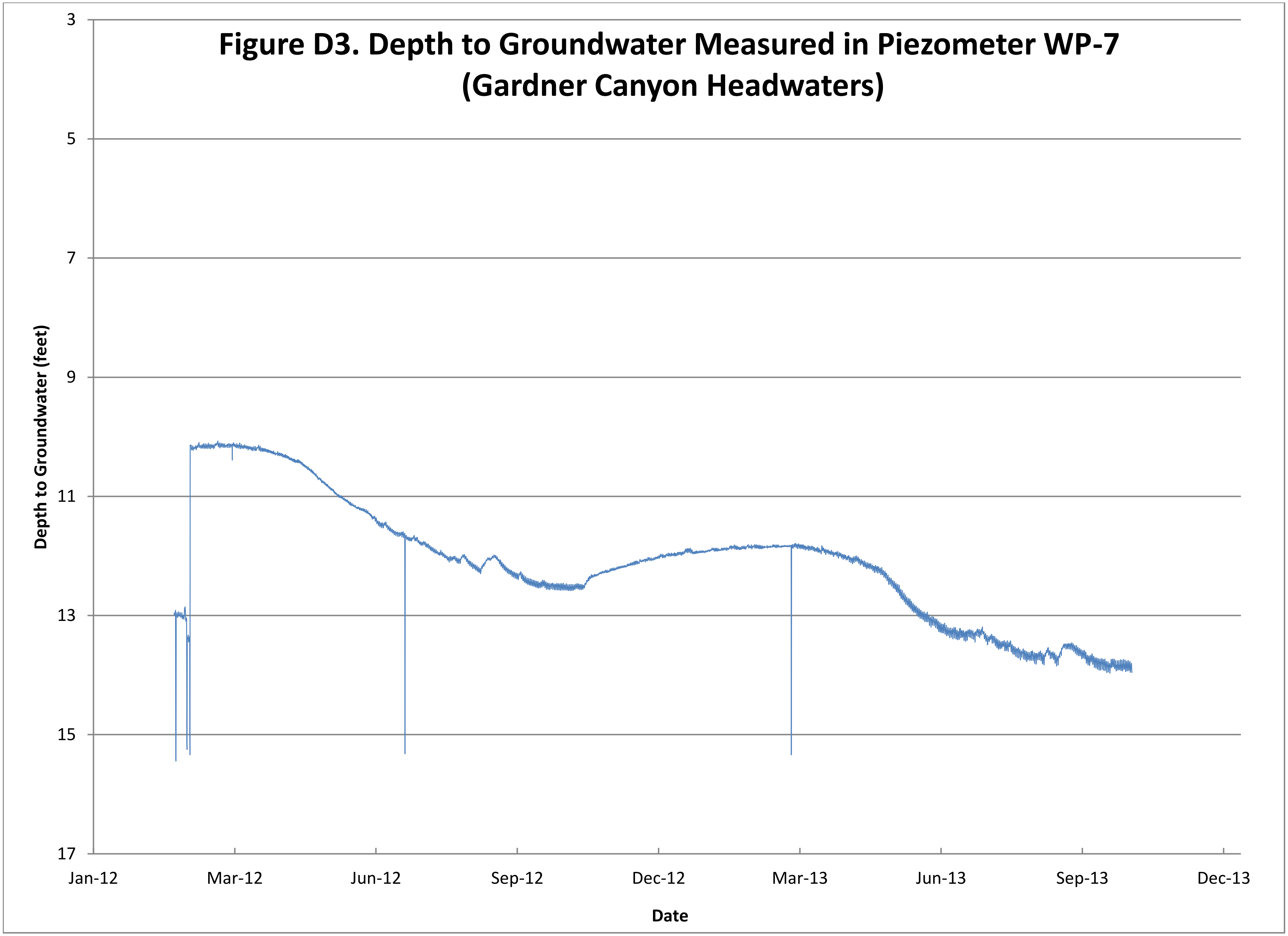
Figure D3. Depth to Groundwater Measured in Piezometer WP-7
(Gardner Canyon Headwaters)
Depth to Groundwater (feet)
3
5
7
9
11
13
15
17
Jan-12
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Date

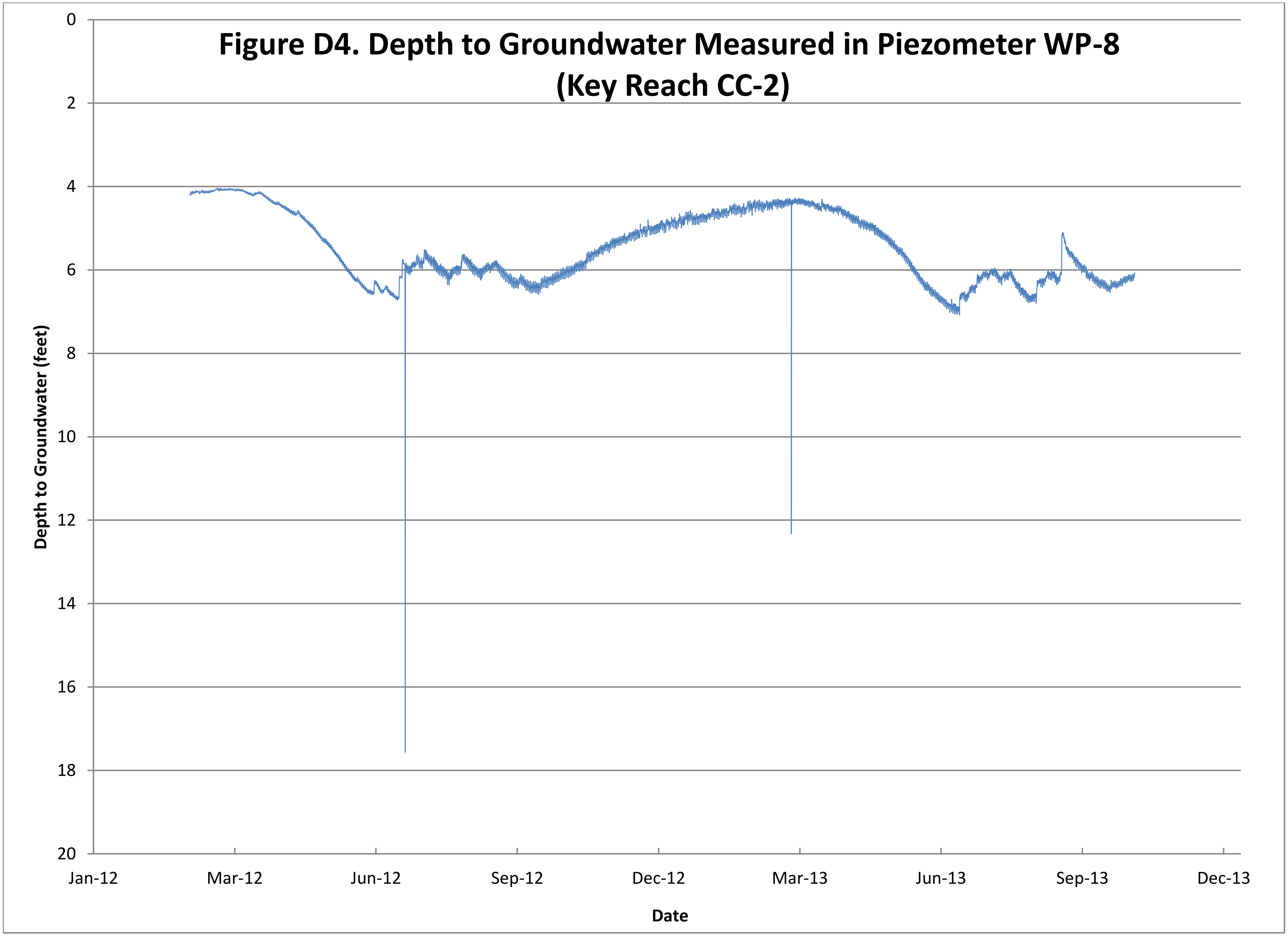
Figure D4. Depth to Groundwater Measured in Piezometer WP-8
(Key Reach CC-2)
0
2
4
6
8
10
12
14
16
18
20
Depth to Groundwater (feet)
Jan-12
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Date

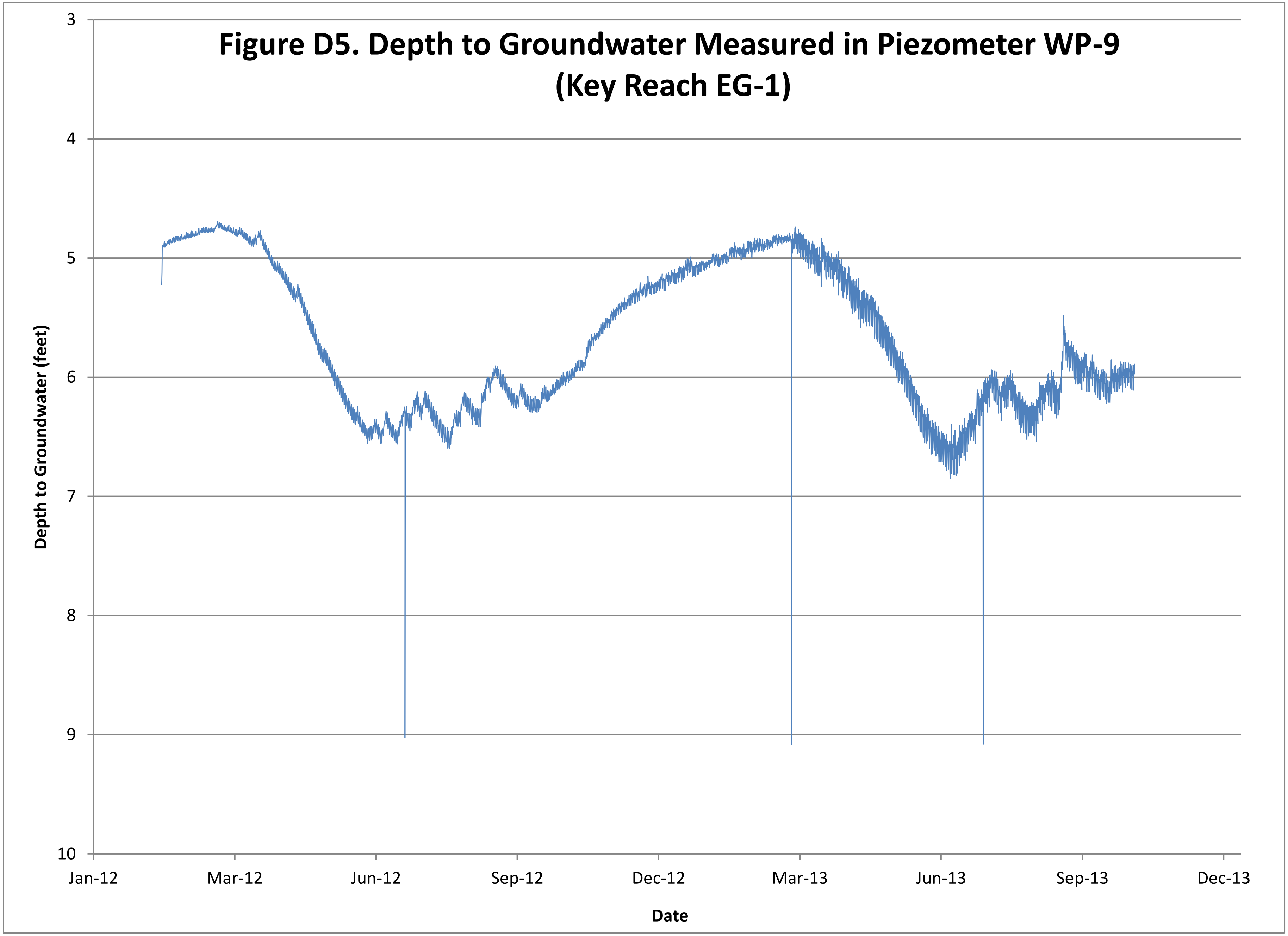
Figure D5. Depth to Groundwater Measured in Piezometer WP-9
(Key Reach EG-1)
Depth to Groundwater (feet)
3
4
5
6
7
8
9
10
Jan-12
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Date

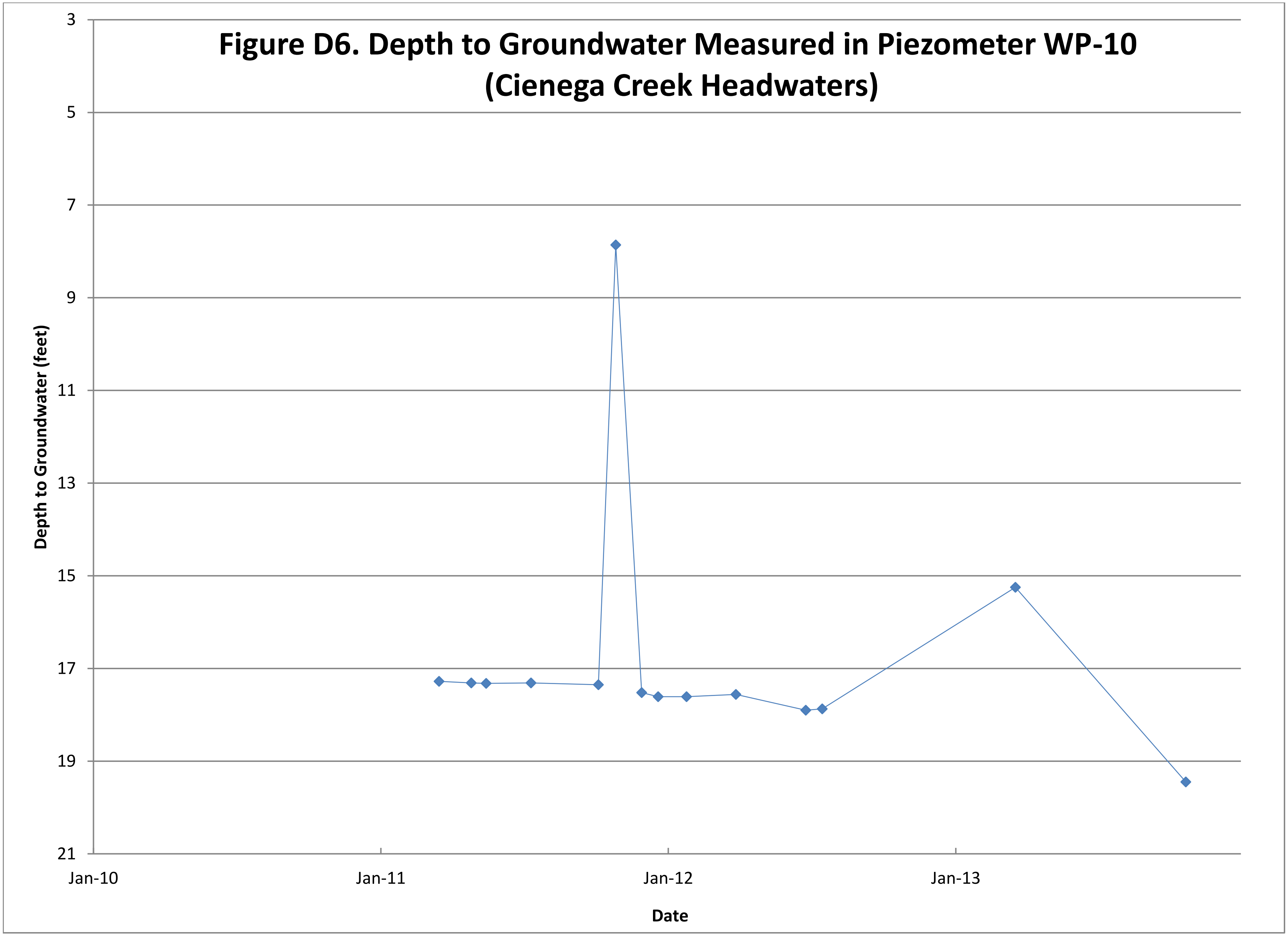
Figure D6. Depth to Groundwater Measured in Piezometer WP-10
(Cienega Creek Headwaters)
Depth to Groundwater (feet)
3
5
7
9
11
13
15
17
19
21
Jan-10
Jan-11
Jan-12
Jan-13
Date

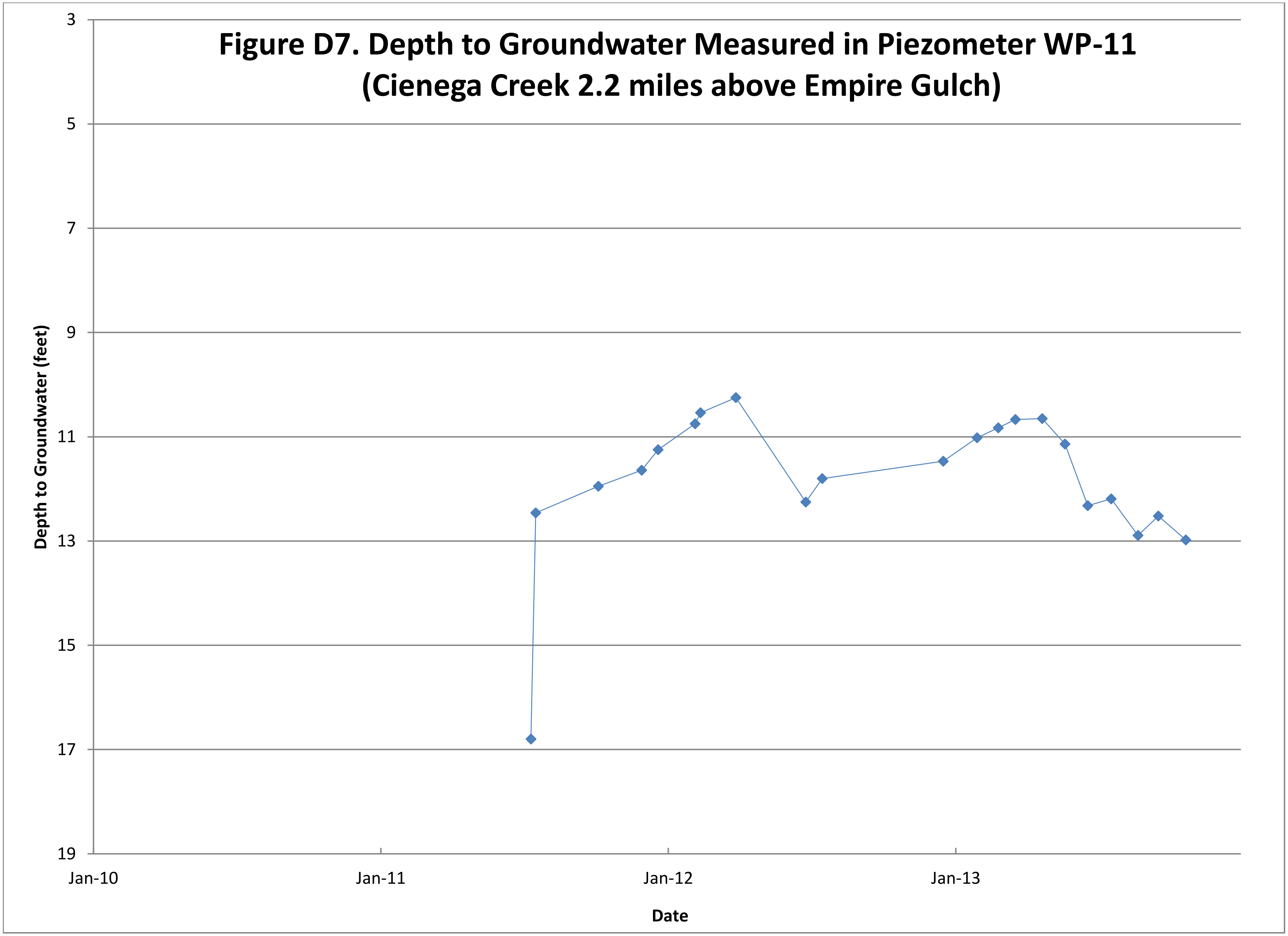

Figure D7. Depth to Groundwater Measured in Piezometer WP-11
(Cienega Creek 2.2 miles above Empire Gulch)
Depth to Groundwater (feet)
3
5
7
9
11
13
15
17
19
Jan-10
Jan-11
Jan-12
Jan-13
Date

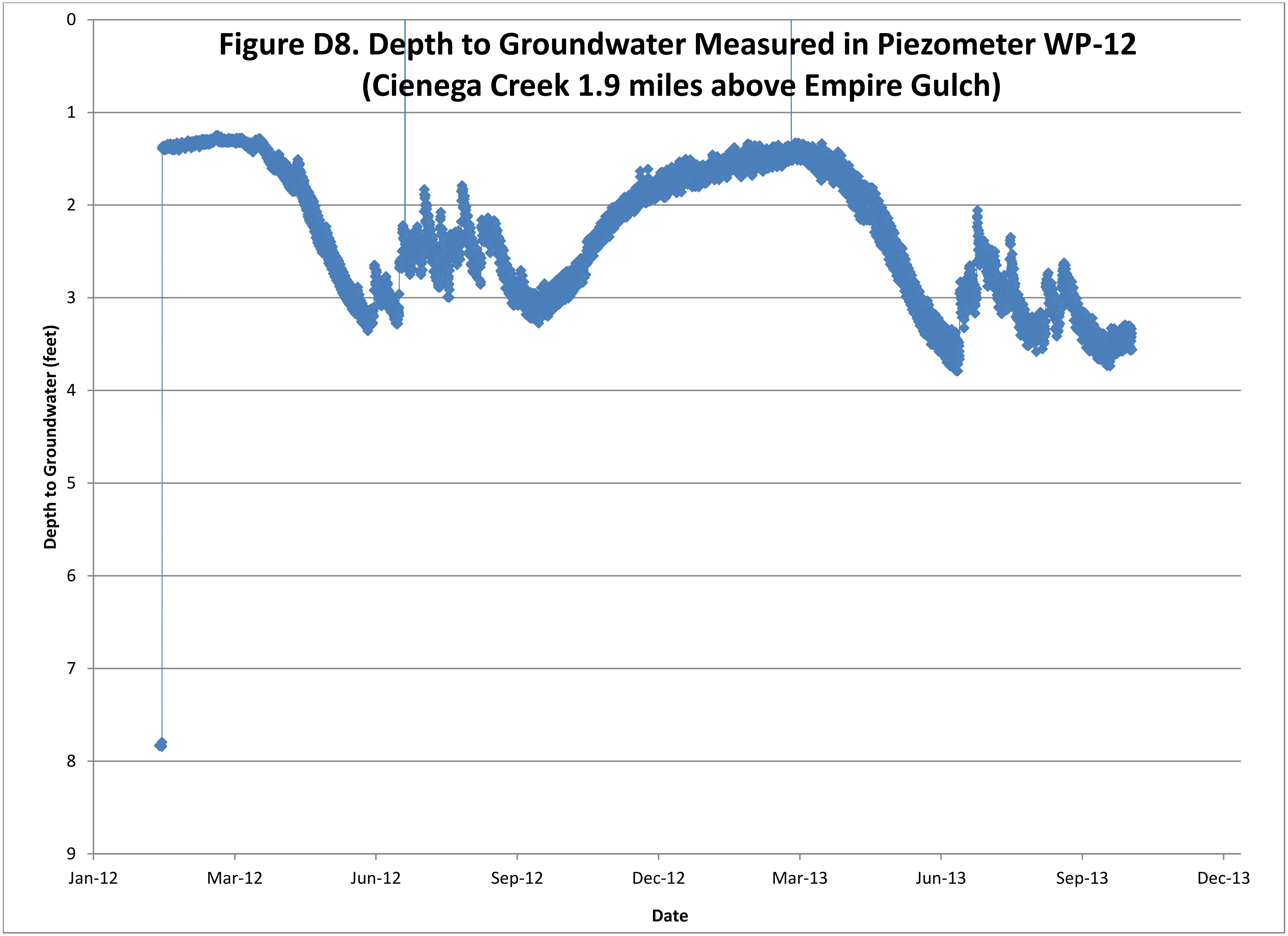
Figure D8. Depth to Groundwater Measured in Piezometer WP-12
(Cienega Creek 1.9 miles above Empire Gulch)
Depth to Groundwater (feet)
0
1
2
3
4
5
6
7
8
9
Jan-12
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Date

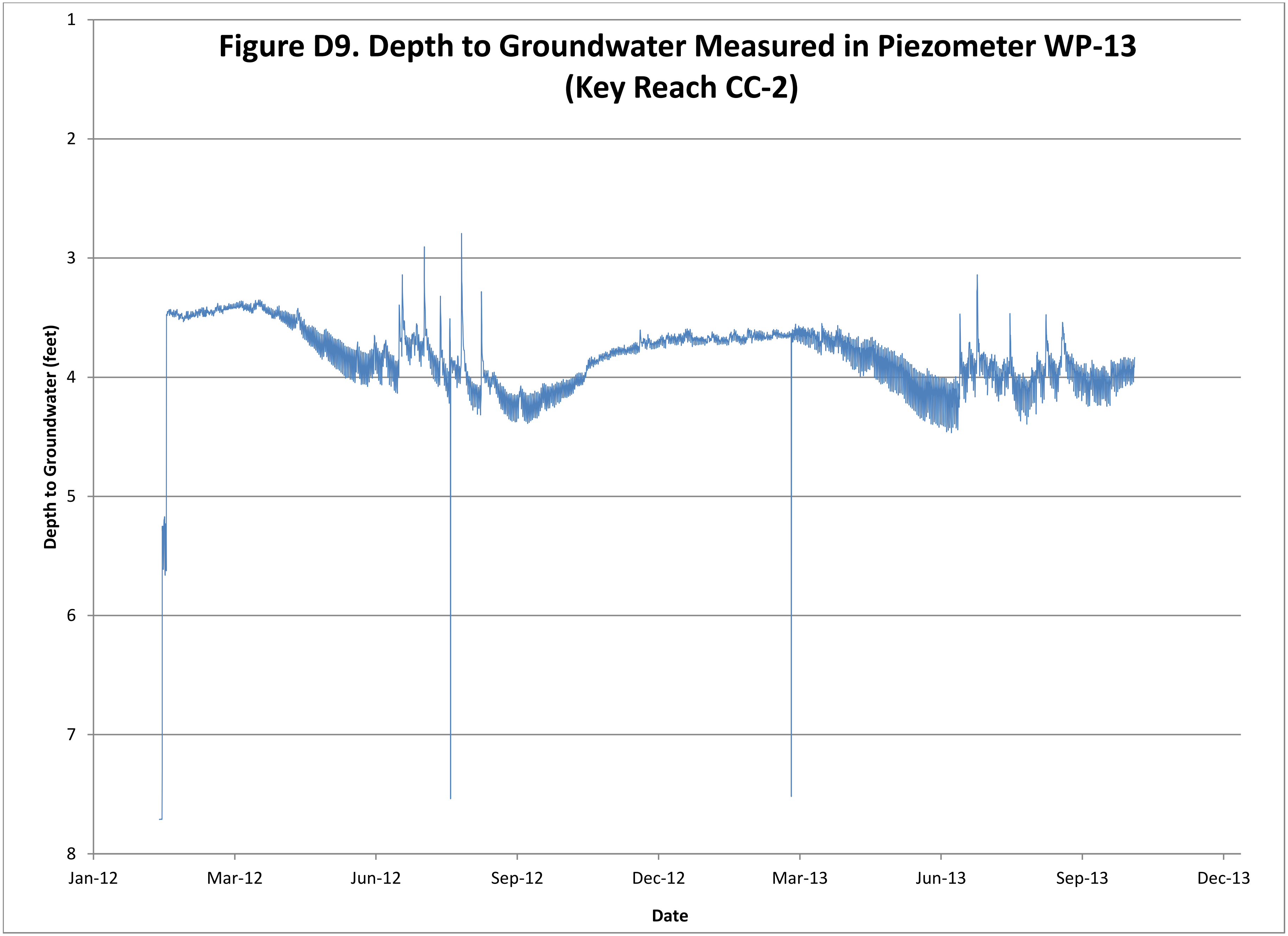
Figure D9. Depth to Groundwater Measured in Piezometer WP-13
(Key Reach CC-2)
Depth to Groundwater (feet)
1
2
3
4
5
6
7
8
Jan-12
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Date

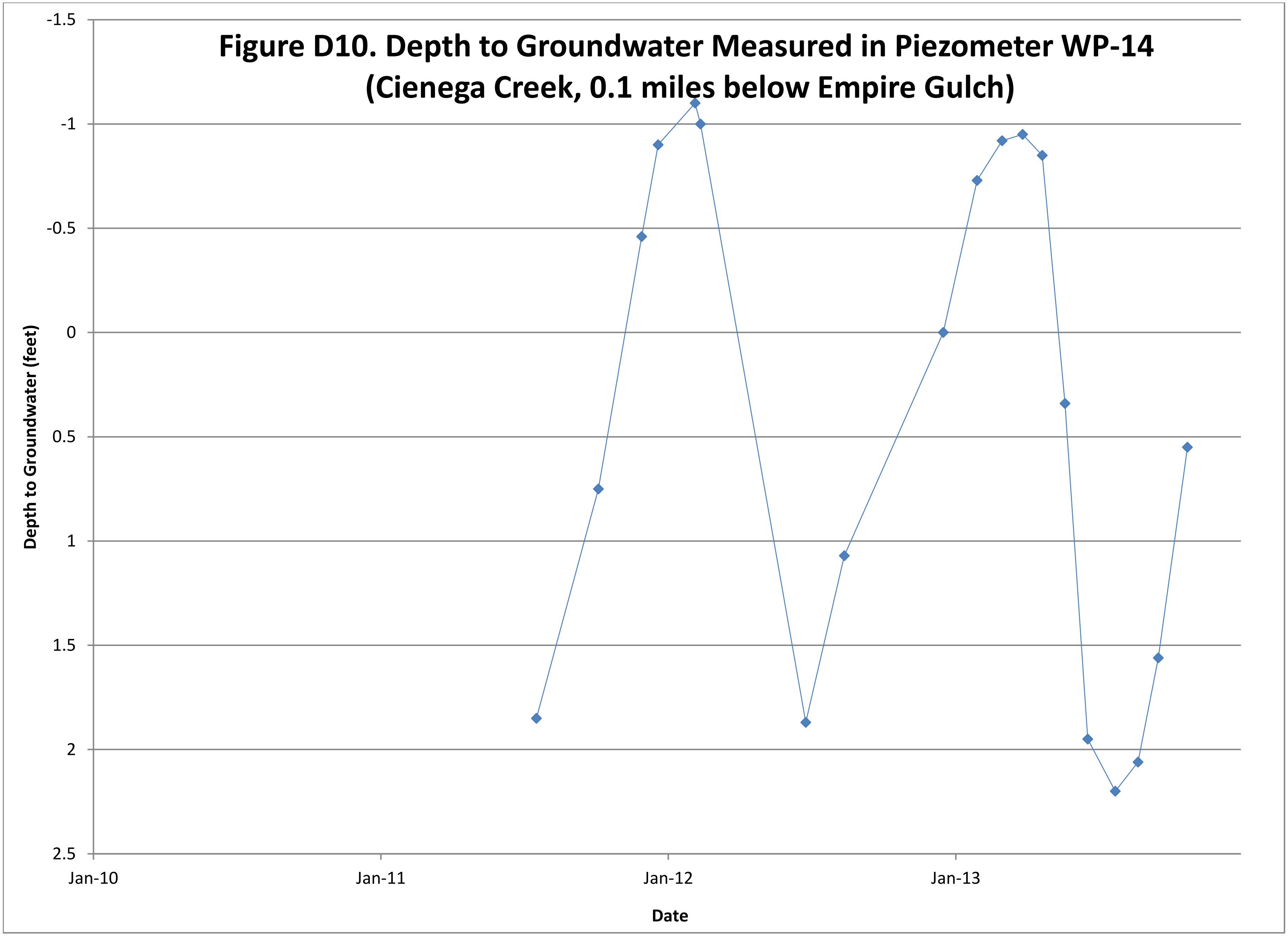
Figure D10. Depth to Groundwater Measured in Piezometer WP-14
(Cienega Creek, 0.1 miles below Empire Gulch)
Depth to Groundwater (feet)
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
Jan-10
Jan-11
Jan-12
Jan-13
Date

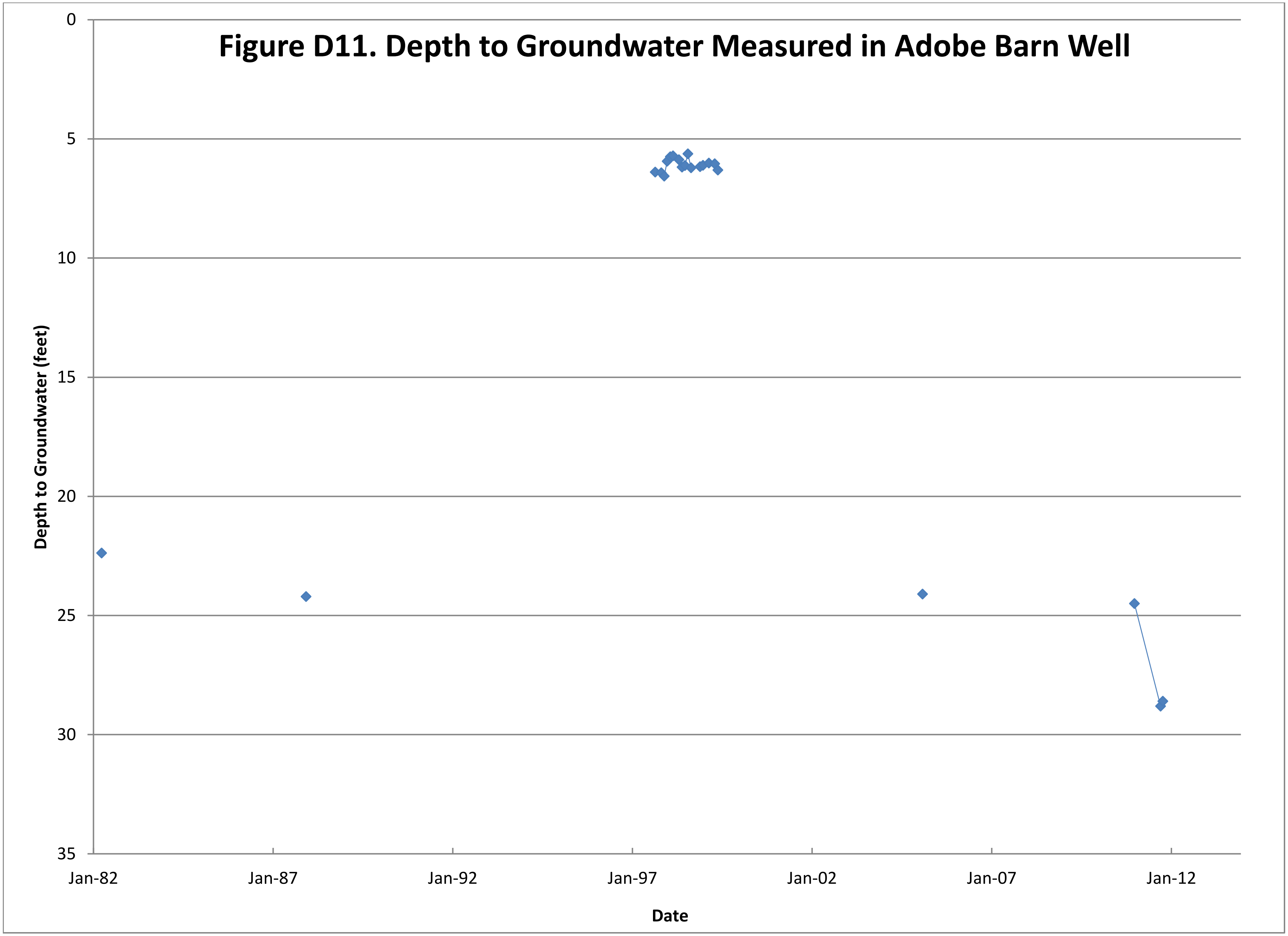
Figure D11. Depth to Groundwater Measured in Adobe Barn Well
Depth to Groundwater (feet)
0
5
10
15
20
25
30
35
Jan-82
Jan-87
Jan-92
Jan-97
Jan-02
Jan-07
Jan-12
Date

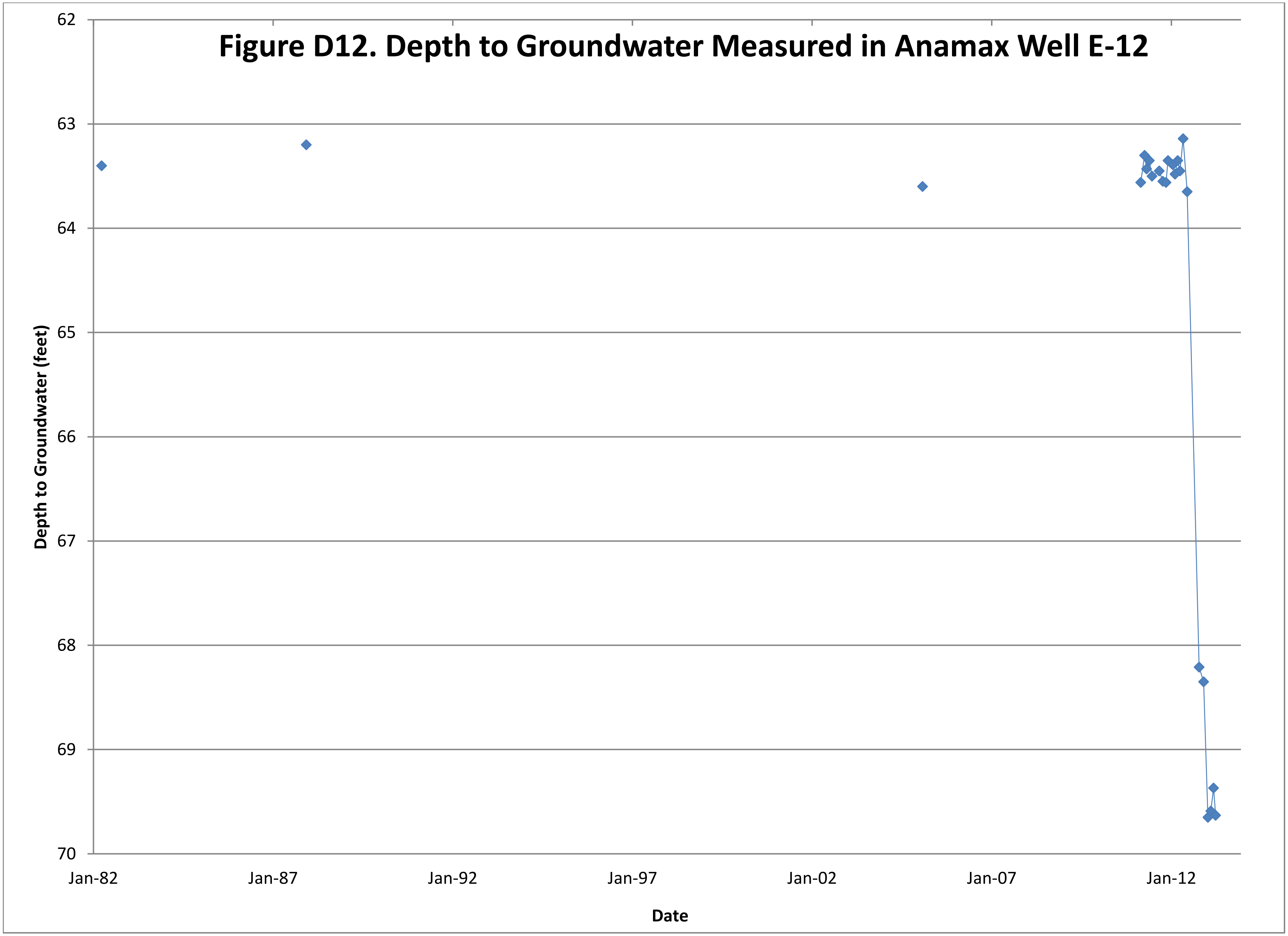

Figure D12. Depth to Groundwater Measured in Anamax Well E-12
62
63
64
65
66
67
68
69
70
Depth to Groundwater (feet)
Jan-82
Jan-87
Jan-92
Jan-97
Jan-02
Jan-07
Jan-12
Date

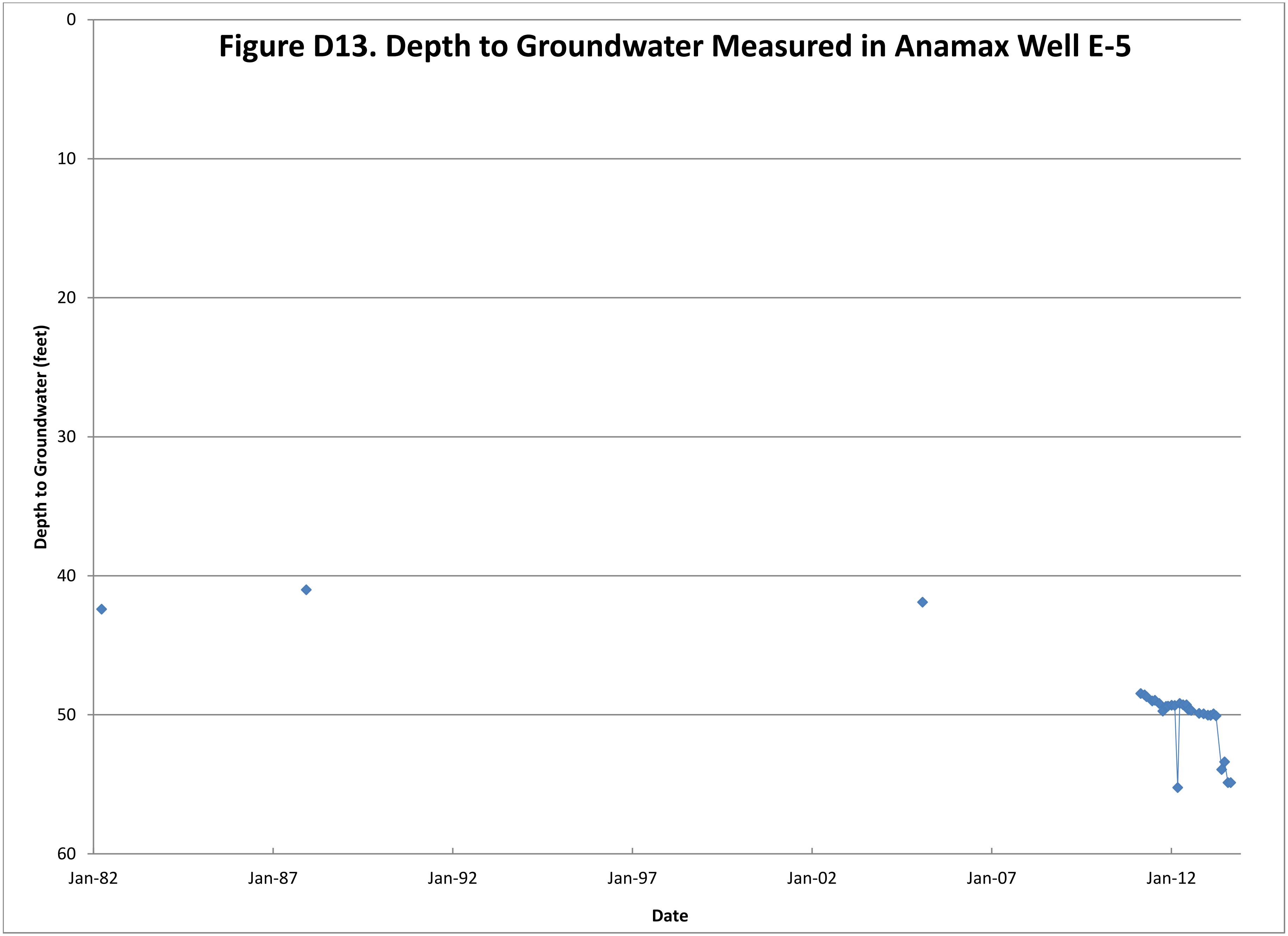
Figure D13. Depth to Groundwater Measured in Anamax Well E-5
Depth to Groundwater (feet)
0
10
20
30
40
50
60
Jan-82
Jan-87
Jan-92
Jan-97
Jan-02
Jan-07
Jan-12
Date

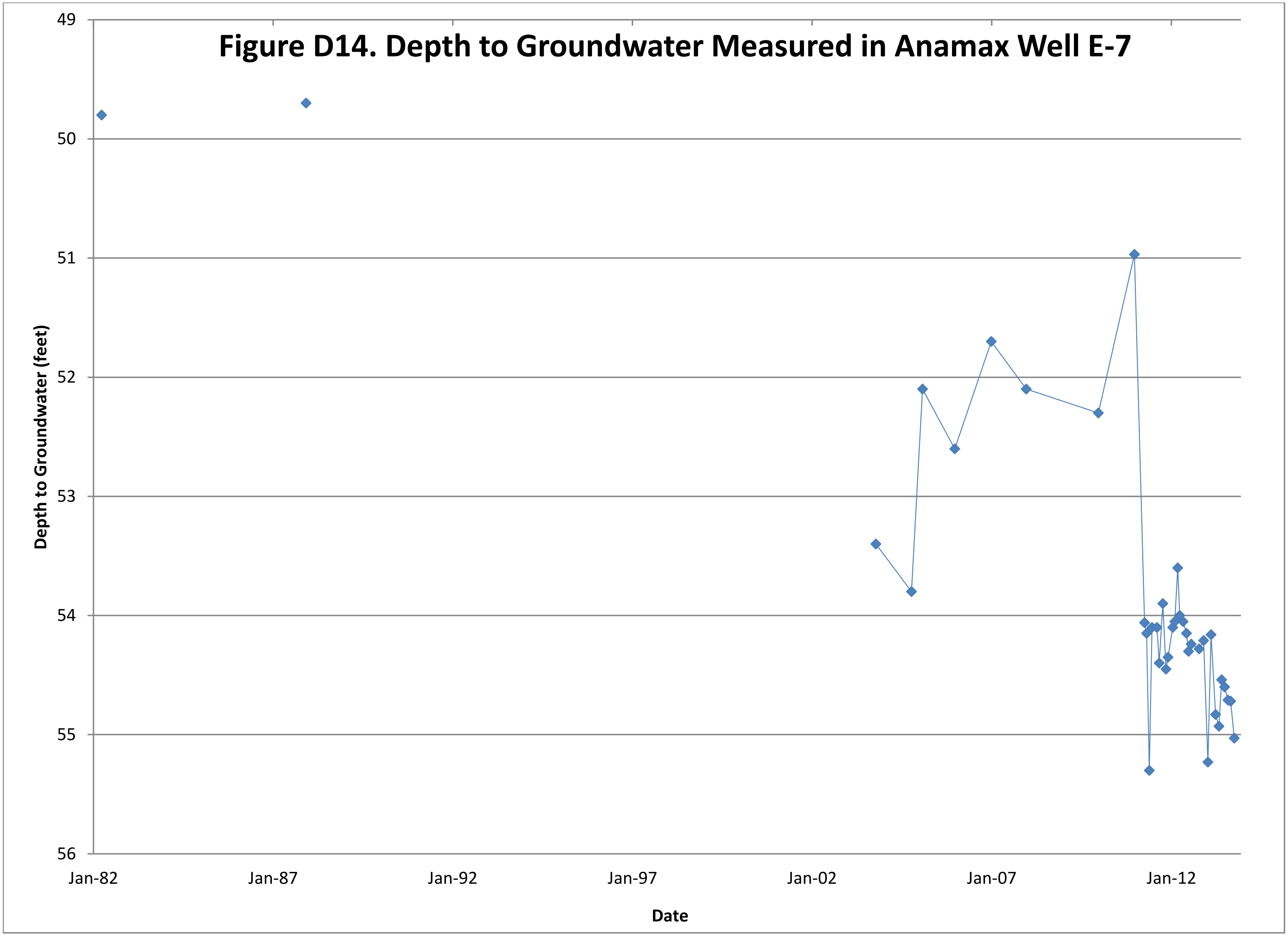
Figure D14. Depth to Groundwater Measured in Anamax Well E-7
Depth to Groundwater (feet)
49
50
51
52
53
54
55
56
Jan-82
Jan-87
Jan-92
Jan-97
Jan-02
Jan-07
Jan-12
Date

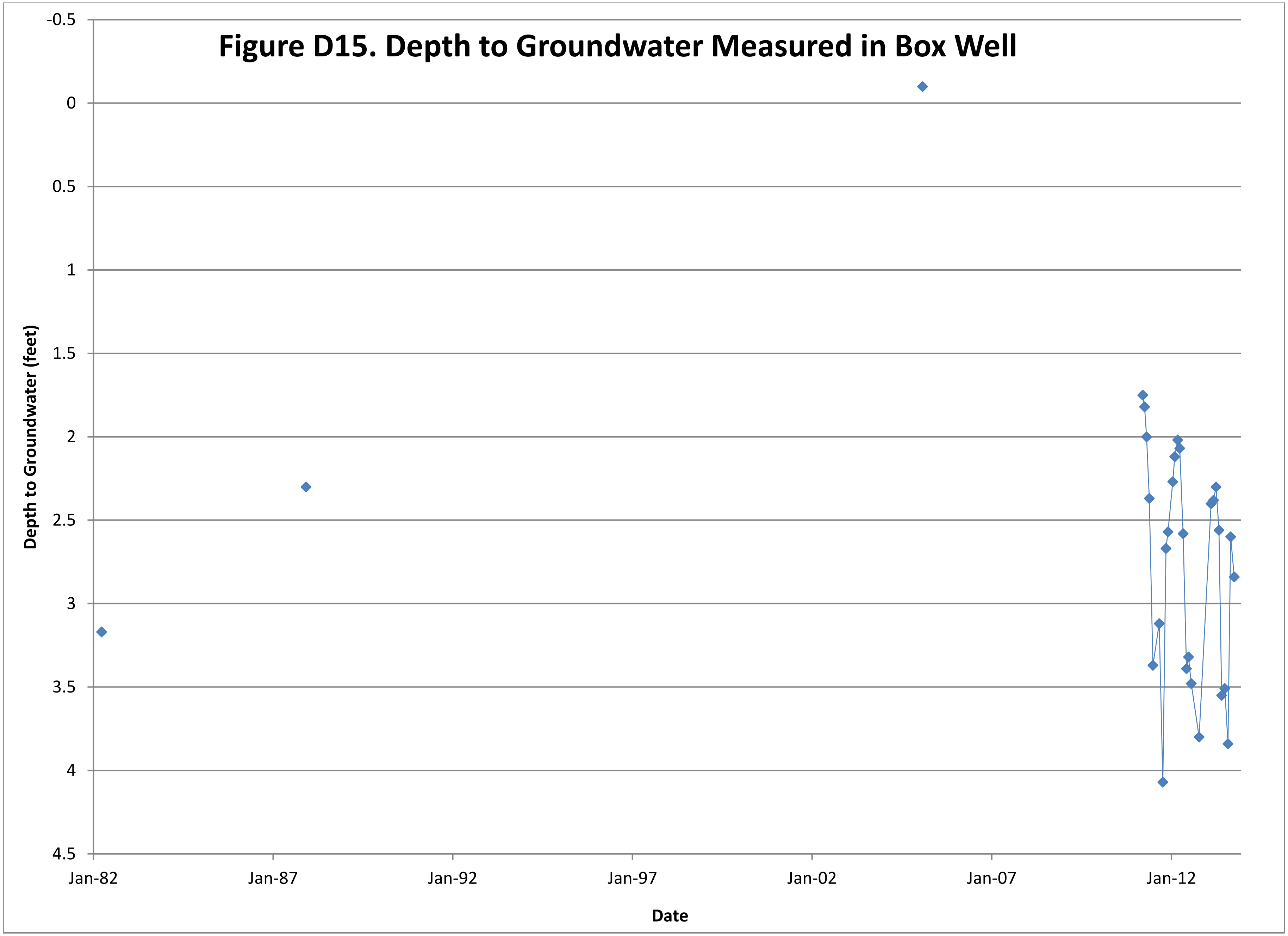

Figure D15. Depth to Groundwater Measured in Box Well
Depth to Groundwater (feet)
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Jan-82
Jan-87
Jan-92
Jan-97
Jan-02
Jan-07
Jan-12
Date

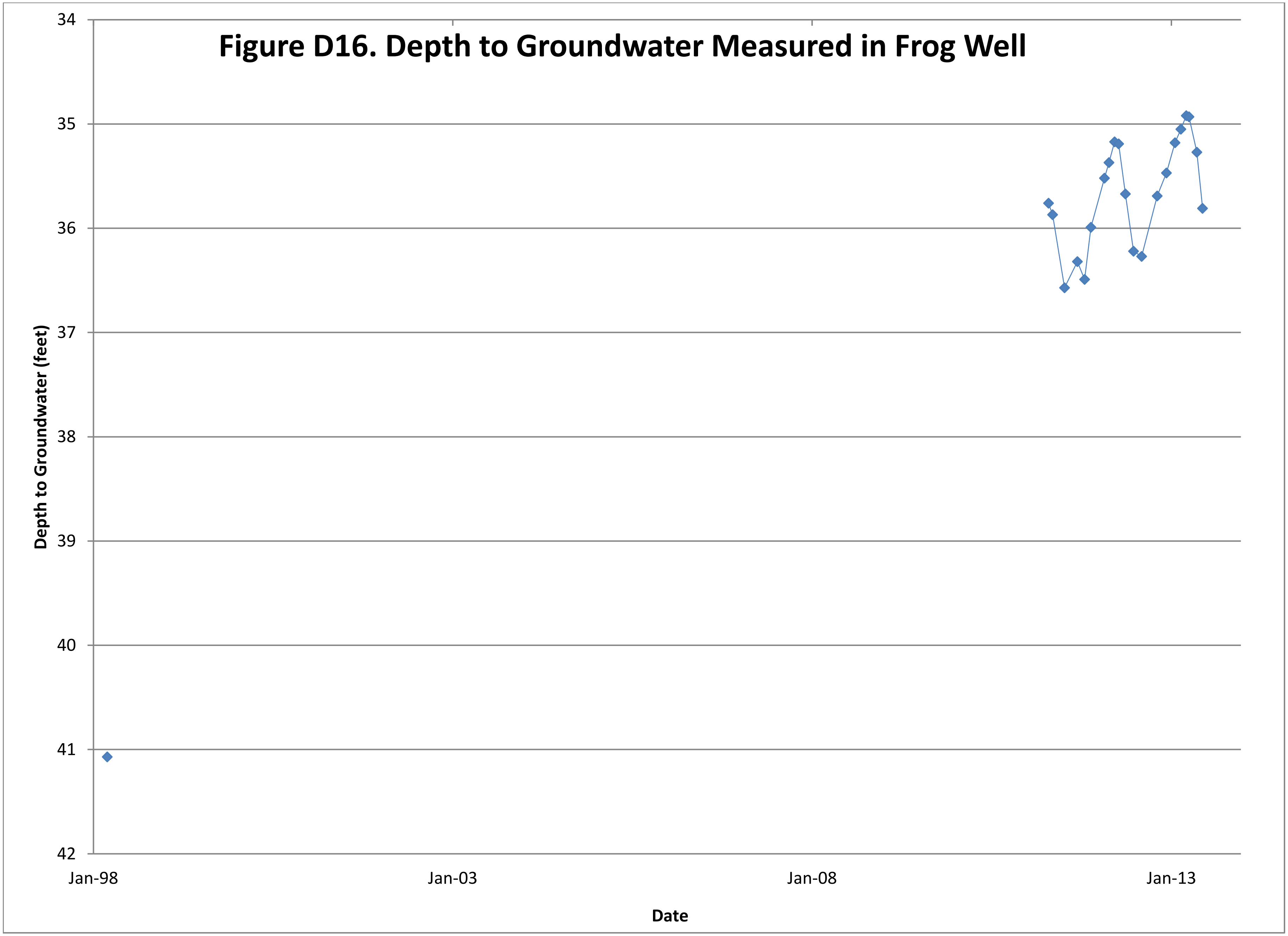
Figure D16. Depth to Groundwater Measured in Frog Well
34
35
36
37
38
39
40
41
42
Depth to Groundwater (feet)
Jan-98
Jan-03
Jan-08
Jan-13
Date

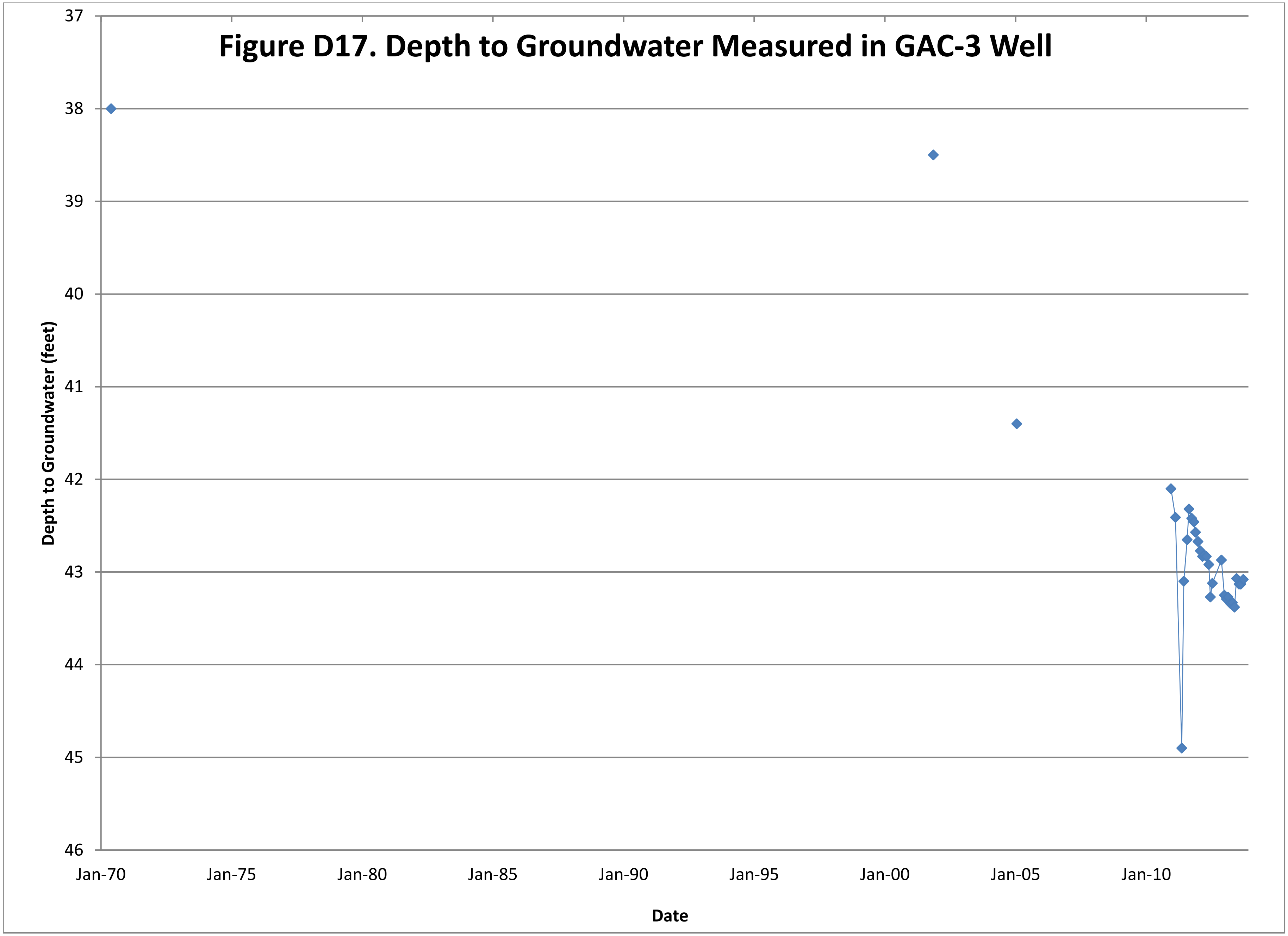

Figure D17. Depth to Groundwater Measured in GAC-3 Well
Depth to Groundwater (feet)
37
38
39
40
41
42
43
44
45
46
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Date

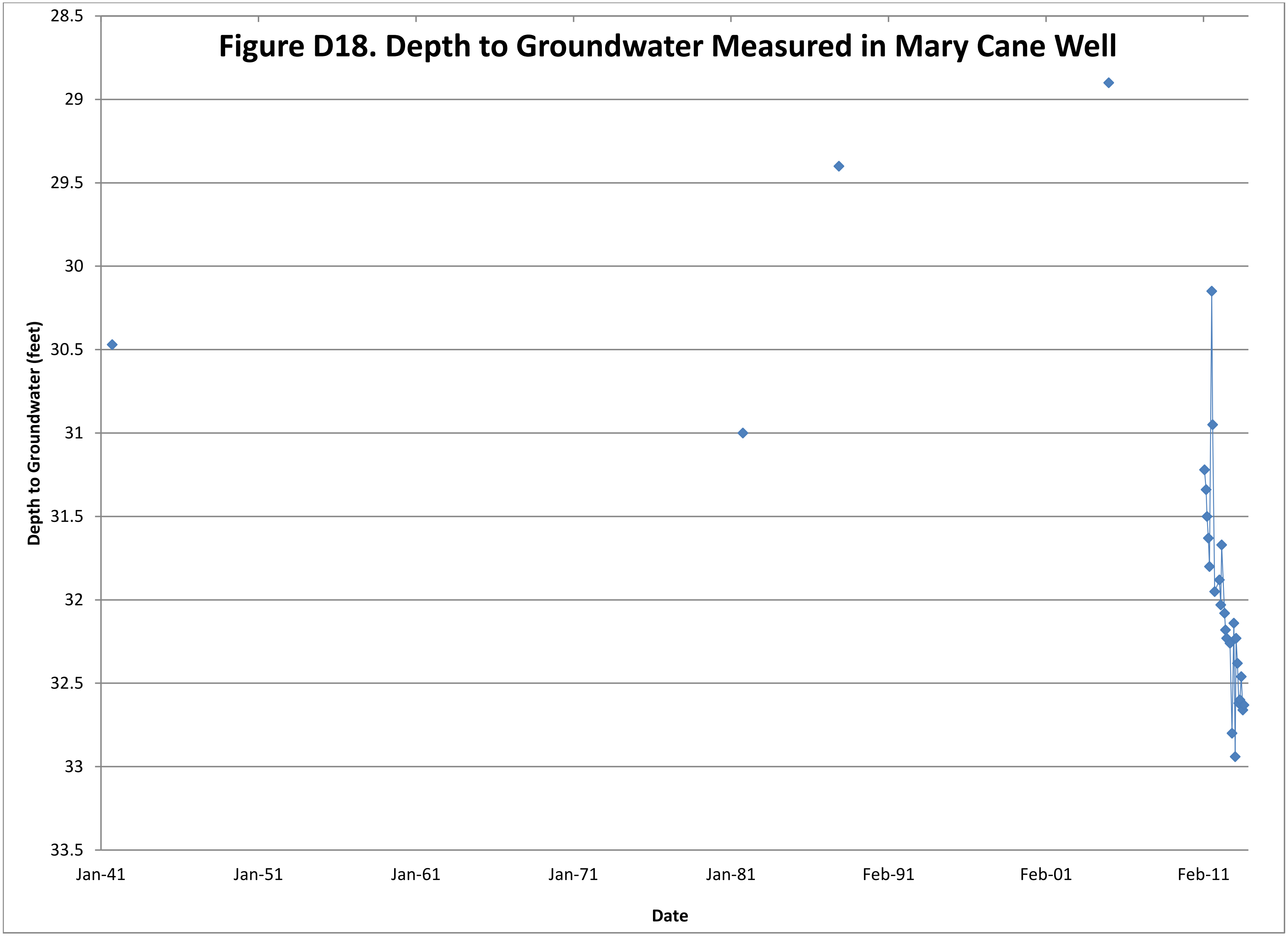
Figure D18. Depth to Groundwater Measured in Mary Cane Well
Depth to Groundwater (feet)
28.5
29
29.5
30
30.5
31
31.5
32
32.5
33
33.5
Jan-41
Jan-51
Jan-61
Jan-71
Jan-81
Feb-91
Feb-01
Feb-11
Date

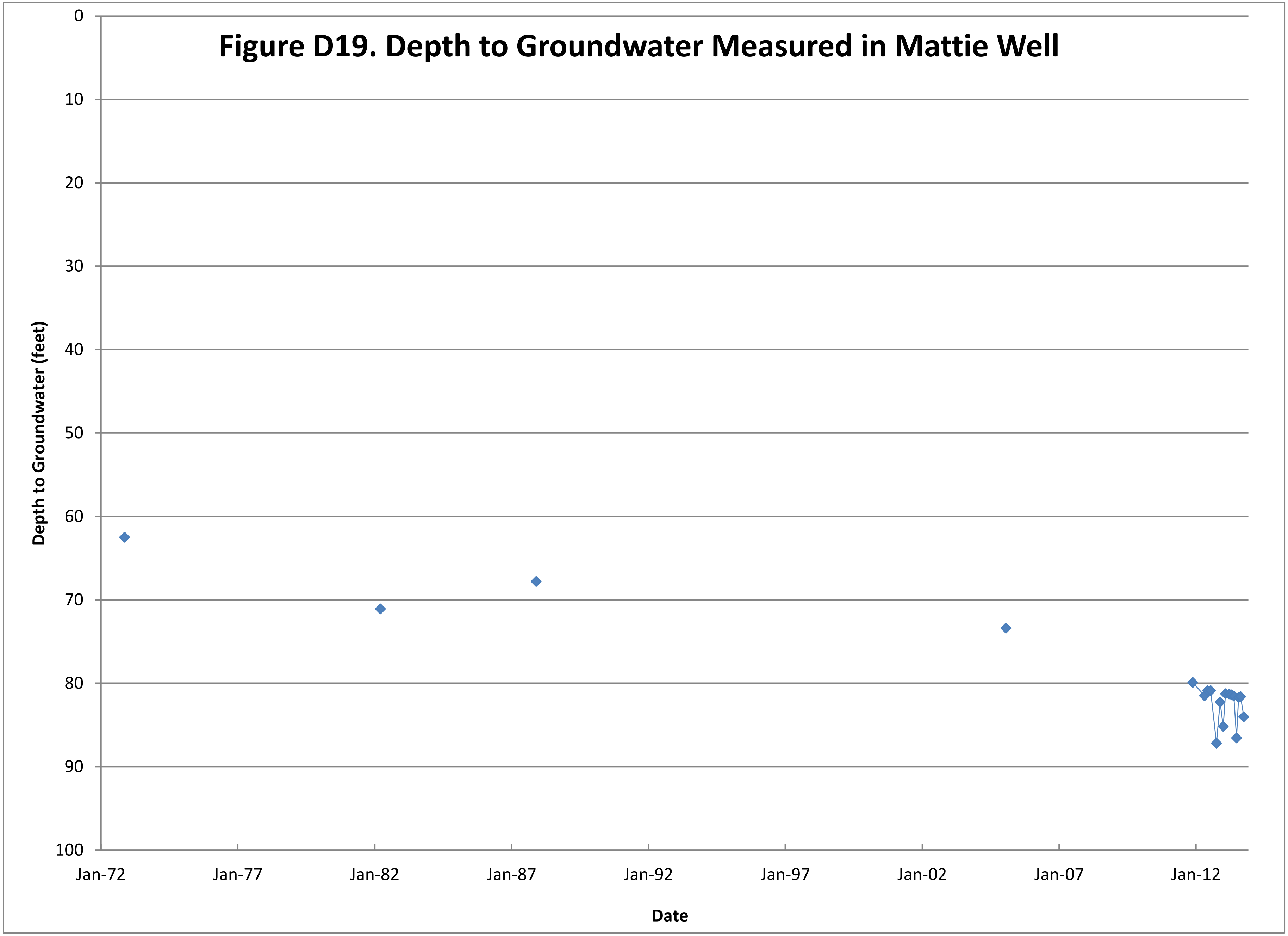
Figure D19. Depth to Groundwater Measured in Mattie Well
Depth to Groundwater (feet)
0
10
20
30
40
50
60
70
80
90
100
Jan-72
Jan-77
Jan-82
Jan-87
Jan-92
Jan-97
Jan-02
Jan-07
Jan-12
Date

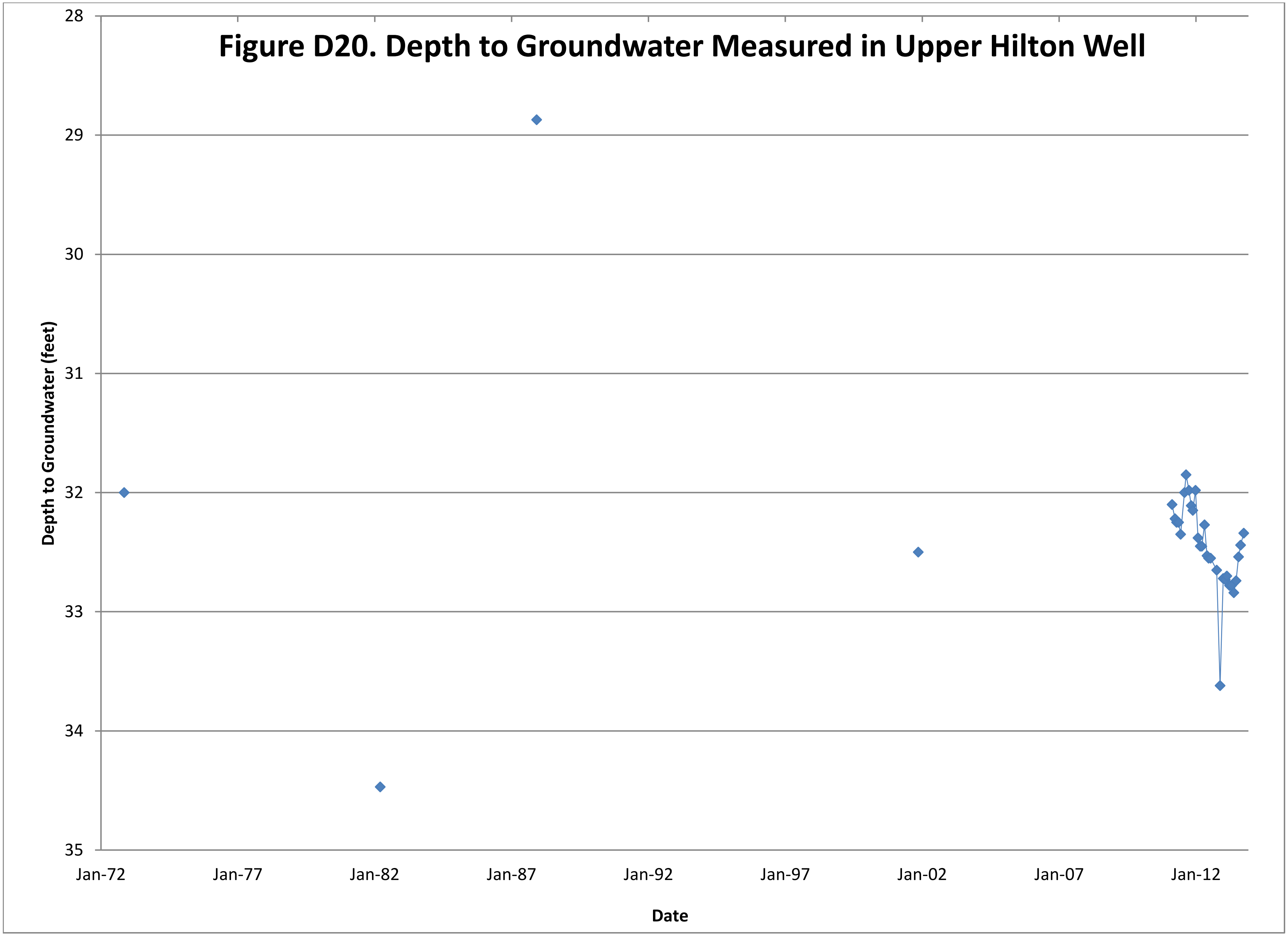
Figure D20. Depth to Groundwater Measured in Upper Hilton Well
Depth to Groundwater (feet)
28
29
30
31
32
33
34
35
Jan-72
Jan-77
Jan-82
Jan-87
Jan-92
Jan-97
Jan-02
Jan-07
Jan-12
Date

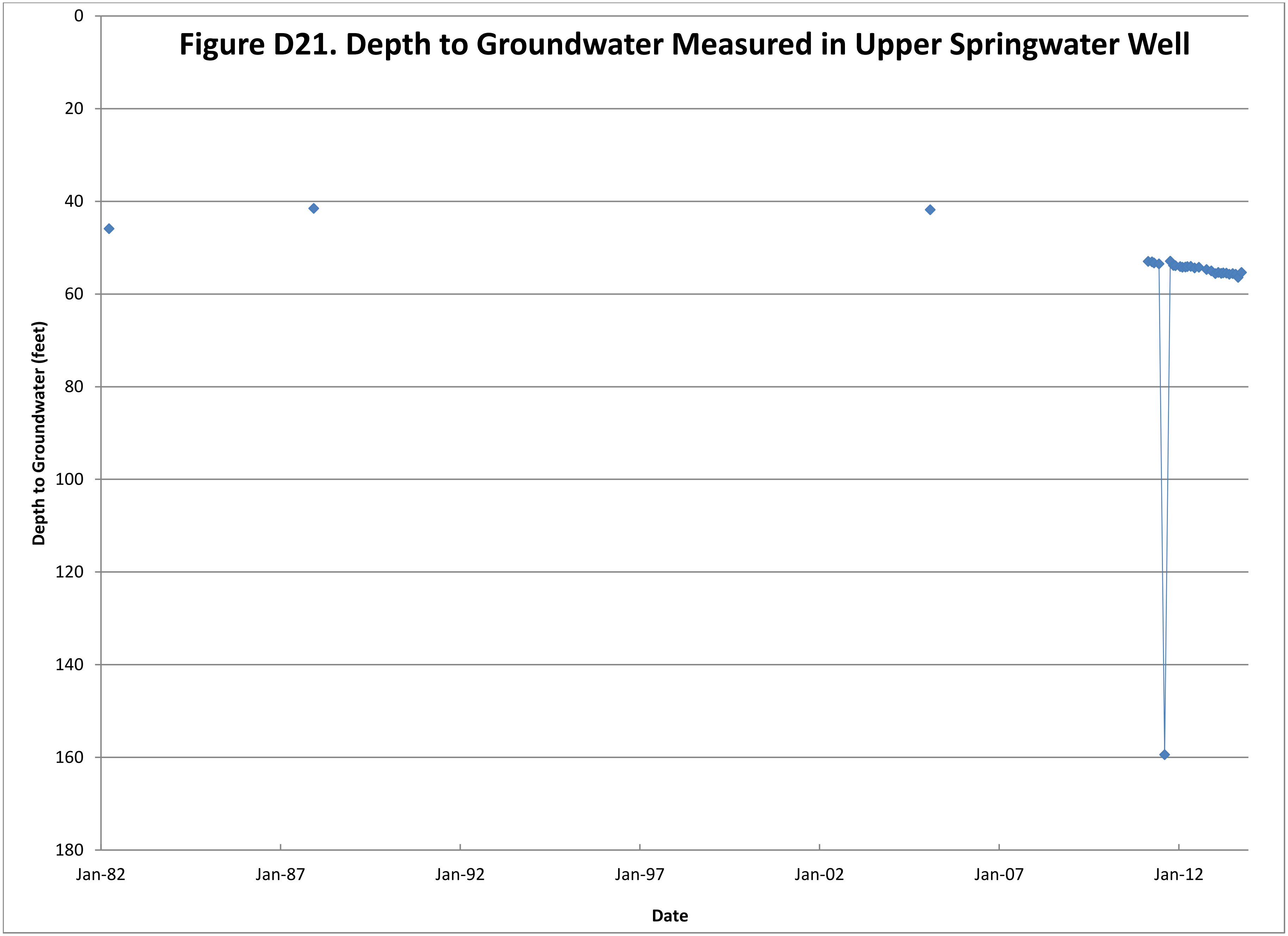
Figure D21. Depth to Groundwater Measured in Upper Springwater Well
Depth to Groundwater (feet)
0
20
40
60
80
100
120
140
160
180
Jan-82
Jan-87
Jan-92
Jan-97
Jan-02
Jan-07
Jan-12
Date

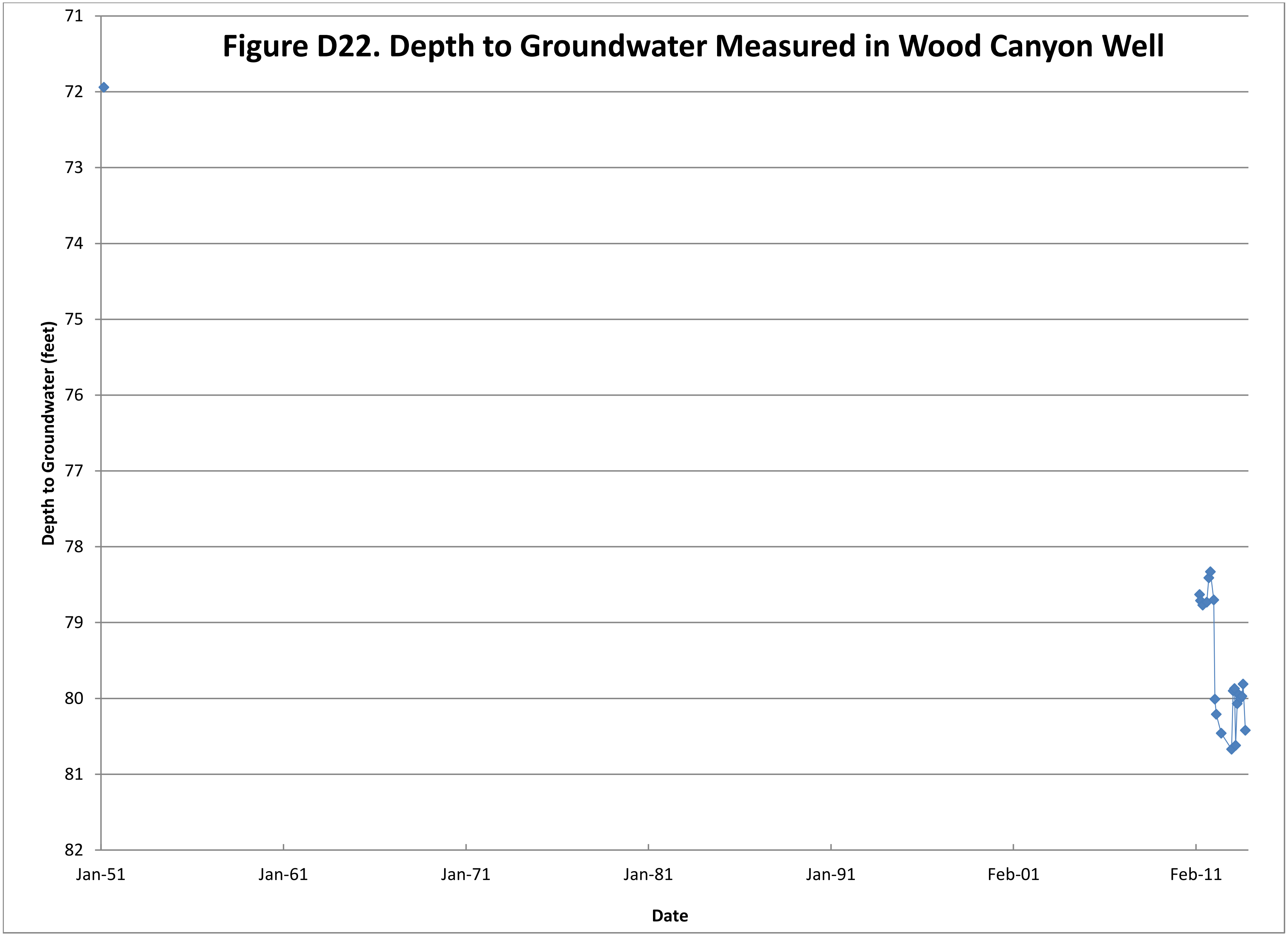
Figure D22. Depth to Groundwater Measured in Wood Canyon Well
Depth to Groundwater (feet)
71
72
73
74
75
76
77
78
79
80
81
82
Jan-51
Jan-61
Jan-71
Jan-81
Jan-91
Feb-01
Feb-11
Date

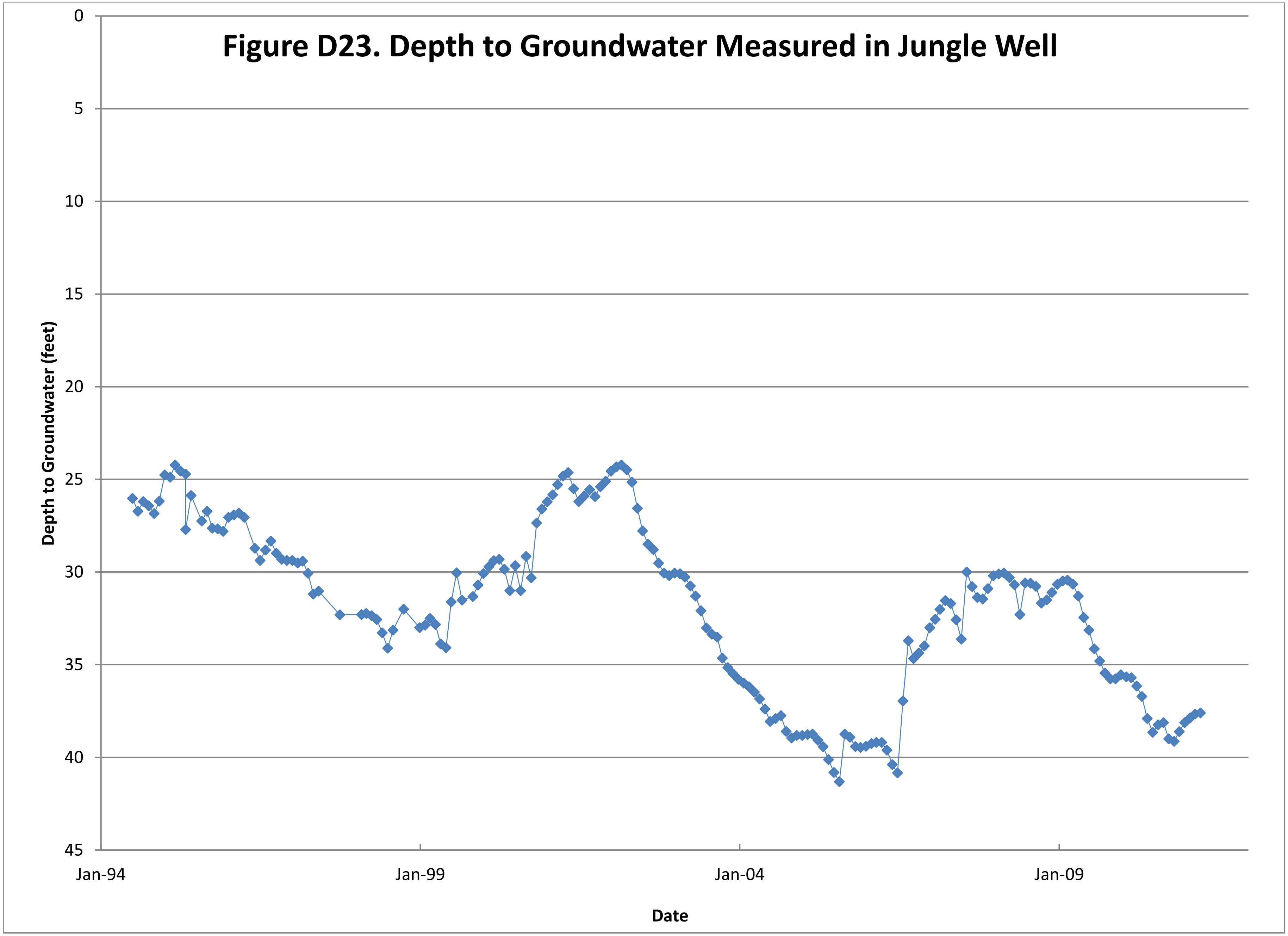
Figure D23. Depth to Groundwater Measured in Jungle Well
Depth to Groundwater (feet)
0
5
10
15
20
25
30
35
40
45
Jan-94
Jan-99
Jan-04
Jan-09
Date

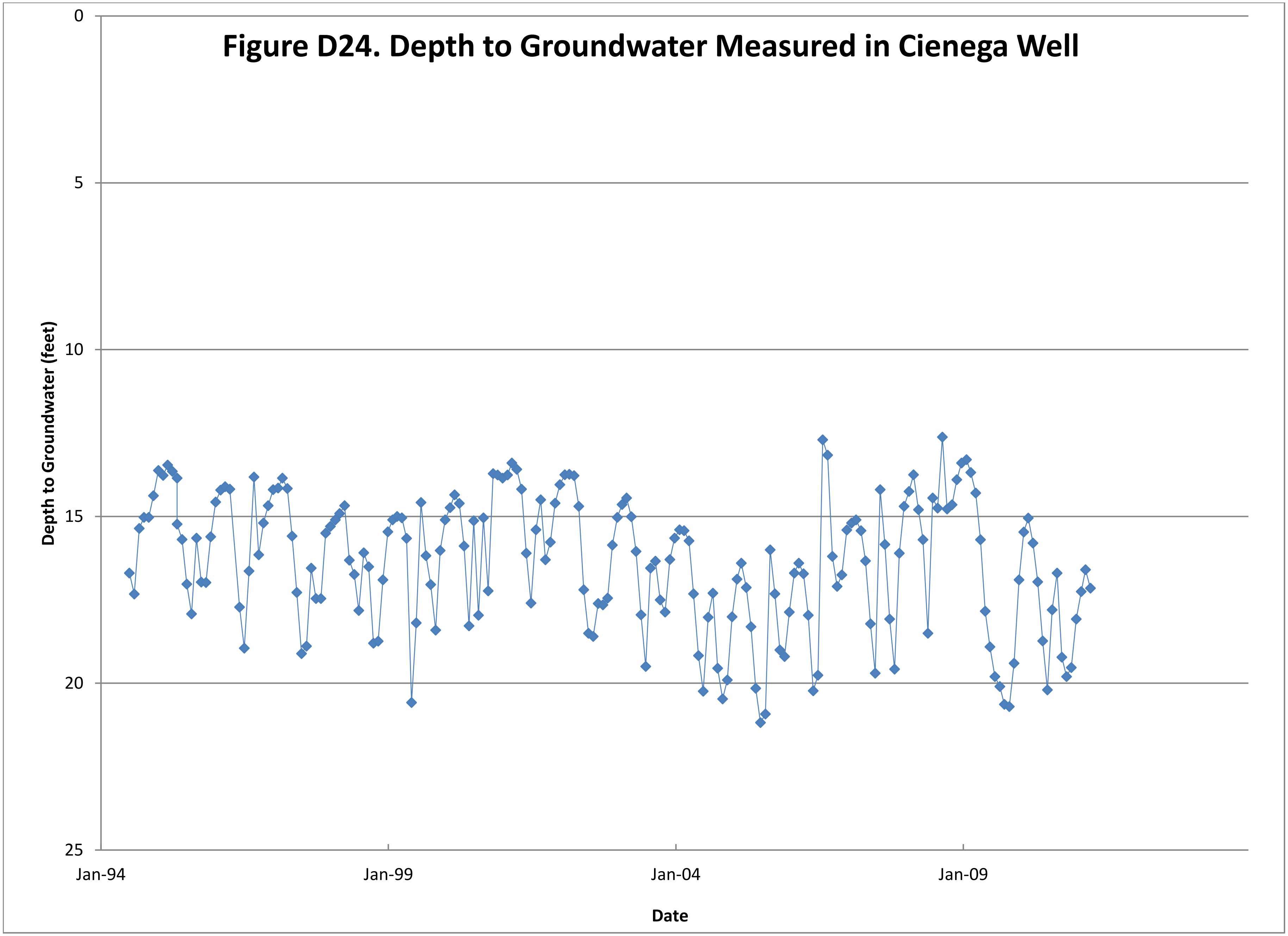

Figure D24. Depth to Groundwater Measured in Cienega Well
Depth to Groundwater (feet)
0
5
10
15
20
25
Jan-94
Jan-99
Jan-04
Jan-09
Date

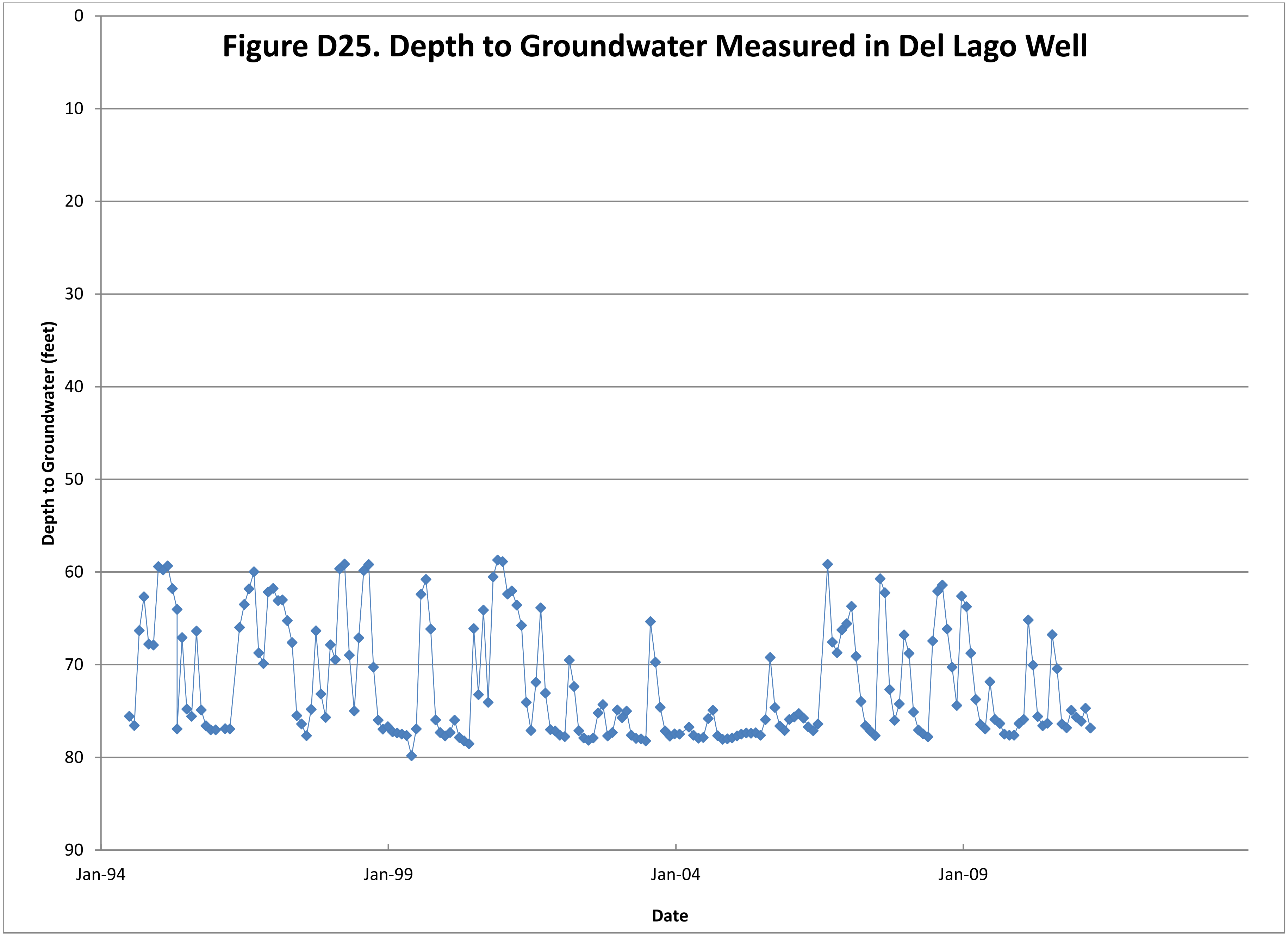
Figure D25. Depth to Groundwater Measured in Del Lago Well
Depth to Groundwater (feet)
0
10
20
30
40
50
60
70
80
90
Jan-94
Jan-99
Jan-04
Jan-09
Date

E. Linear Regression Analysis for Groundwater Depth versus Streamflow

List of Figures and Tables

Figures

Tables

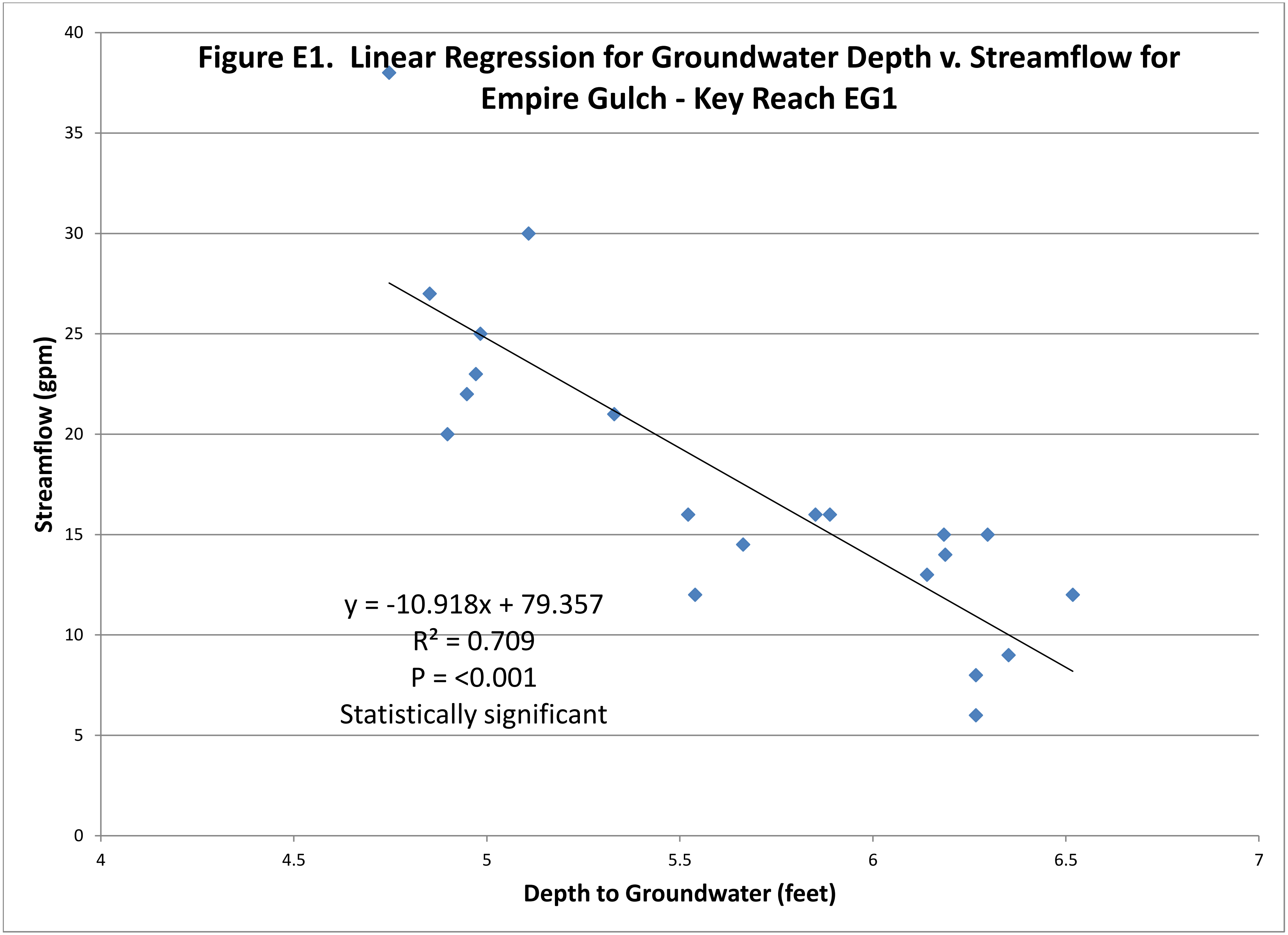
Figure E1. Linear Regression for Groundwater Depth v. Streamflow for Empire Gulch - Key Reach EG1
Streamflow (gpm)
Depth to Groundwater (feet)
y = -10.918x + 79.357
R² = 0.709
P = <0.001
Statistically significant
40
35
30
25
20
15
10
5
0
4
4.5
5
5.5
6
6.5
7

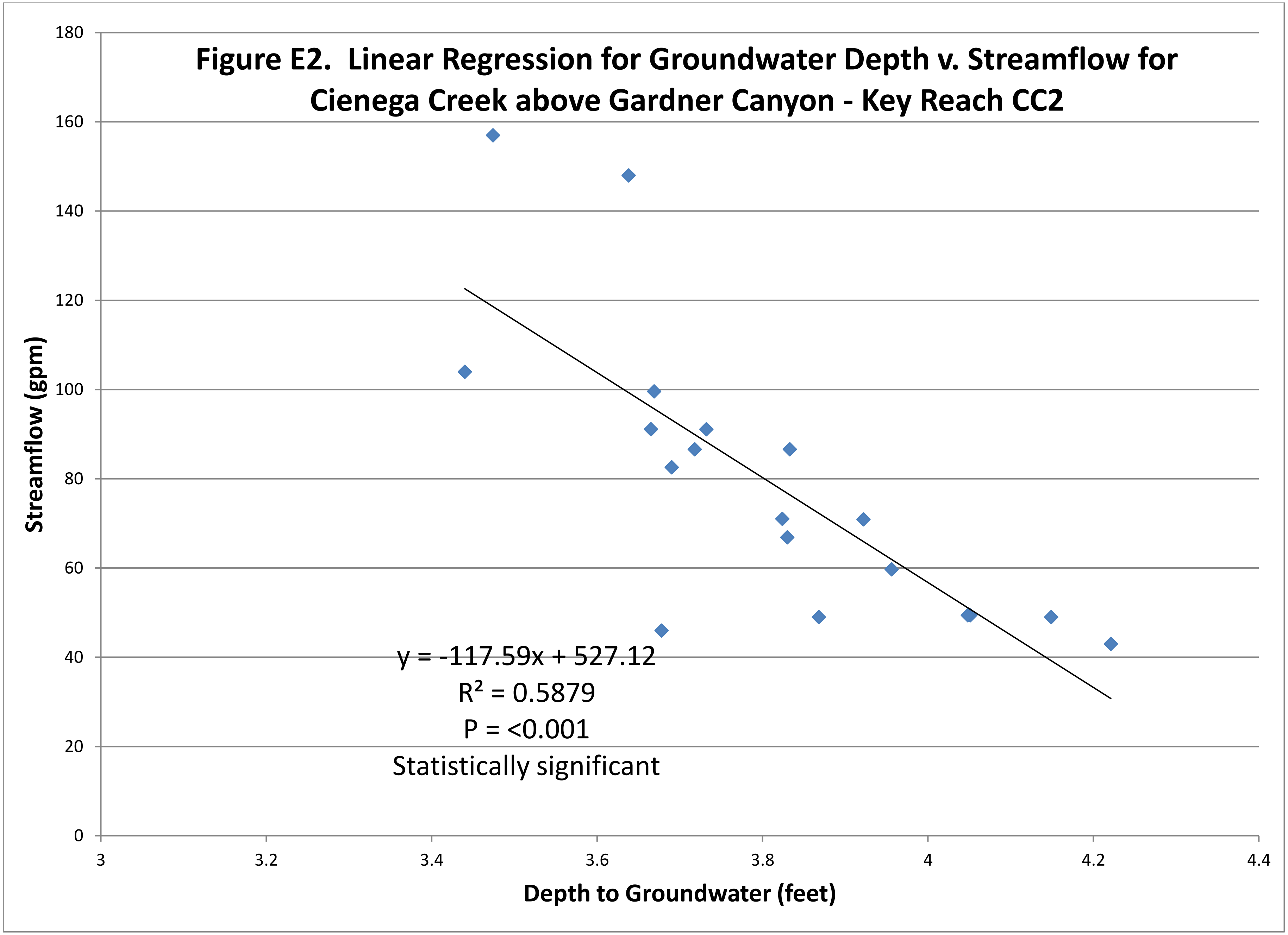

Figure E2. Linear Regression for Groundwater Depth v. Streamflow for Cienega Creek above Gardner Canyon - Key Reach CC2
Streamflow (gpm)
180
160
140
120
100
80
60
40
20
0
3
3.2
3.4
3.6
3.8
4
4.2
4.4
Depth to Groundwater (feet)
y = -117.59x + 527.12
R² = 0.5879
P = <0.001
Statistically significant

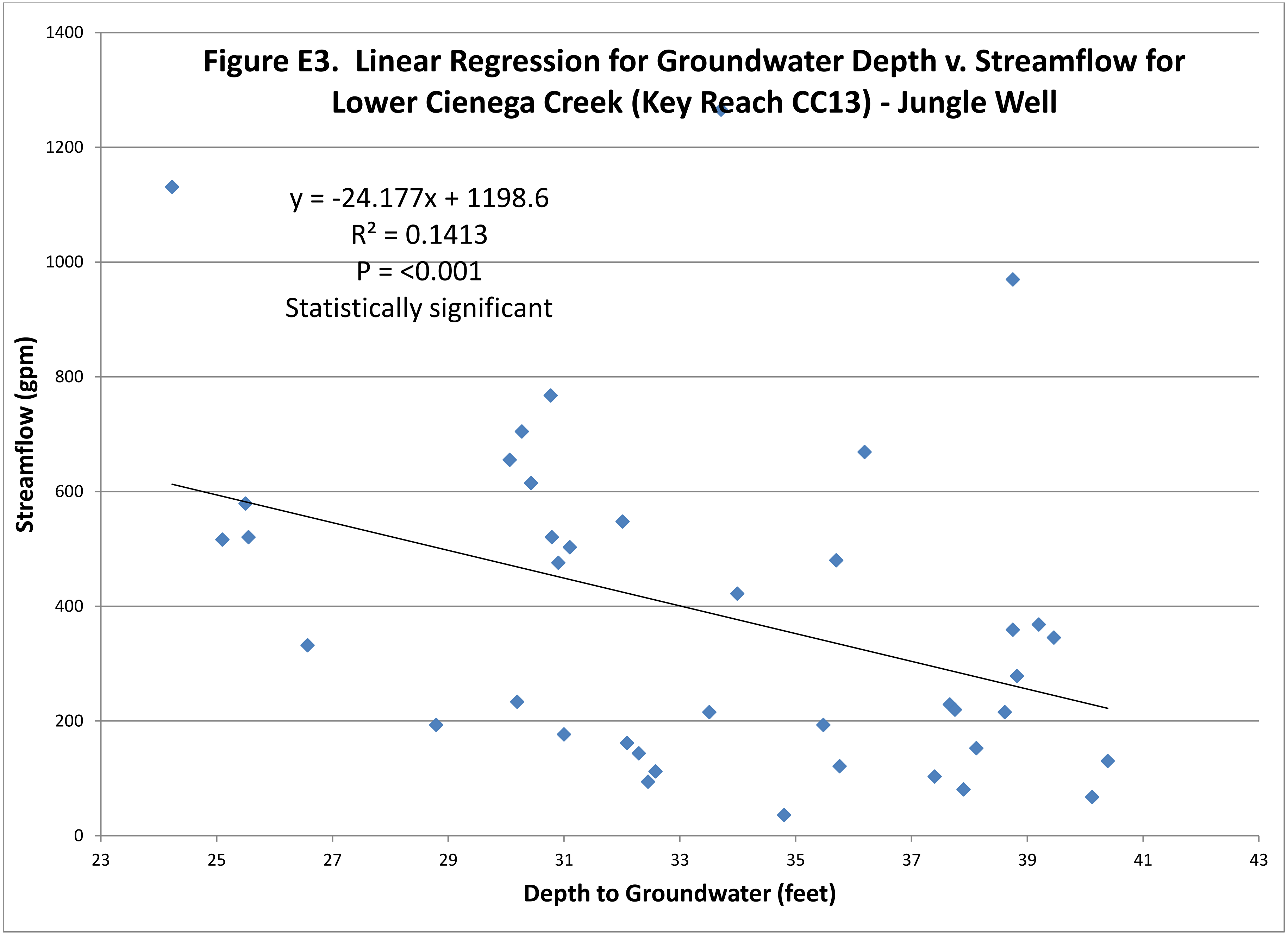
Figure E3. Linear Regression for Groundwater Depth v. Streamflow for Lower Cienega Creek (Key Reach CC13) - Jungle Well
y = -24.177x + 1198.6
R² = 0.1413
P = <0.001
Statistically significant
Streamflow (gpm)
Depth to Groundwater (feet)
1400
1200
1000
800
600
400
200
0
23
25
27
29
31
33
35
37
39
41
43

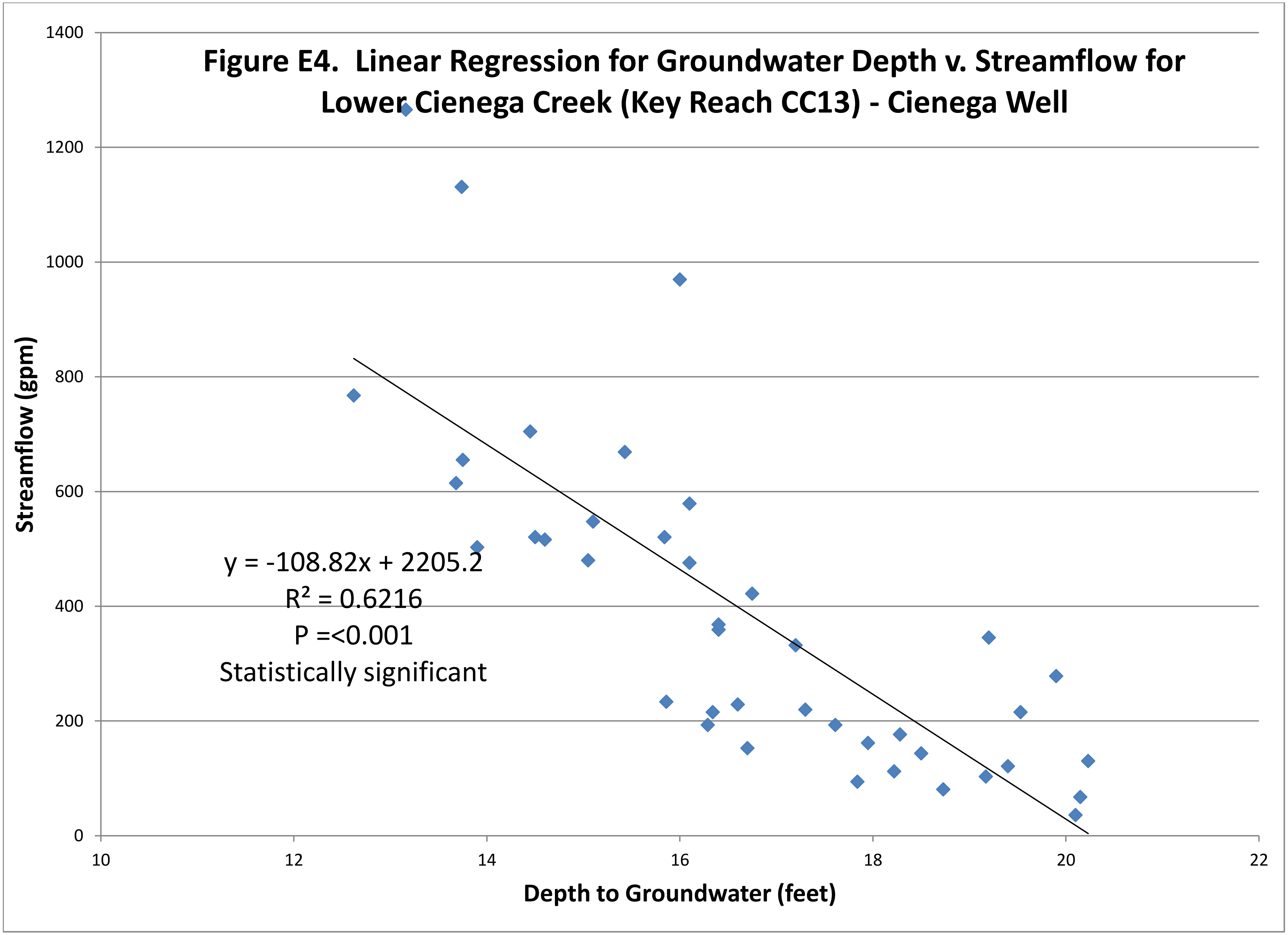
Figure E4. Linear Regression for Groundwater Depth v. Streamflow for Lower Cienega Creek (Key Reach CC13) - Cienega Well
1400
1200
1000
800
600
400
200
0
10
12
14
16
18
20
22
Streamflow (gpm)
Depth to Groundwater (feet)
y = -108.82x + 2205.2
R² = 0.6216
P =<0.001
Statistically significant

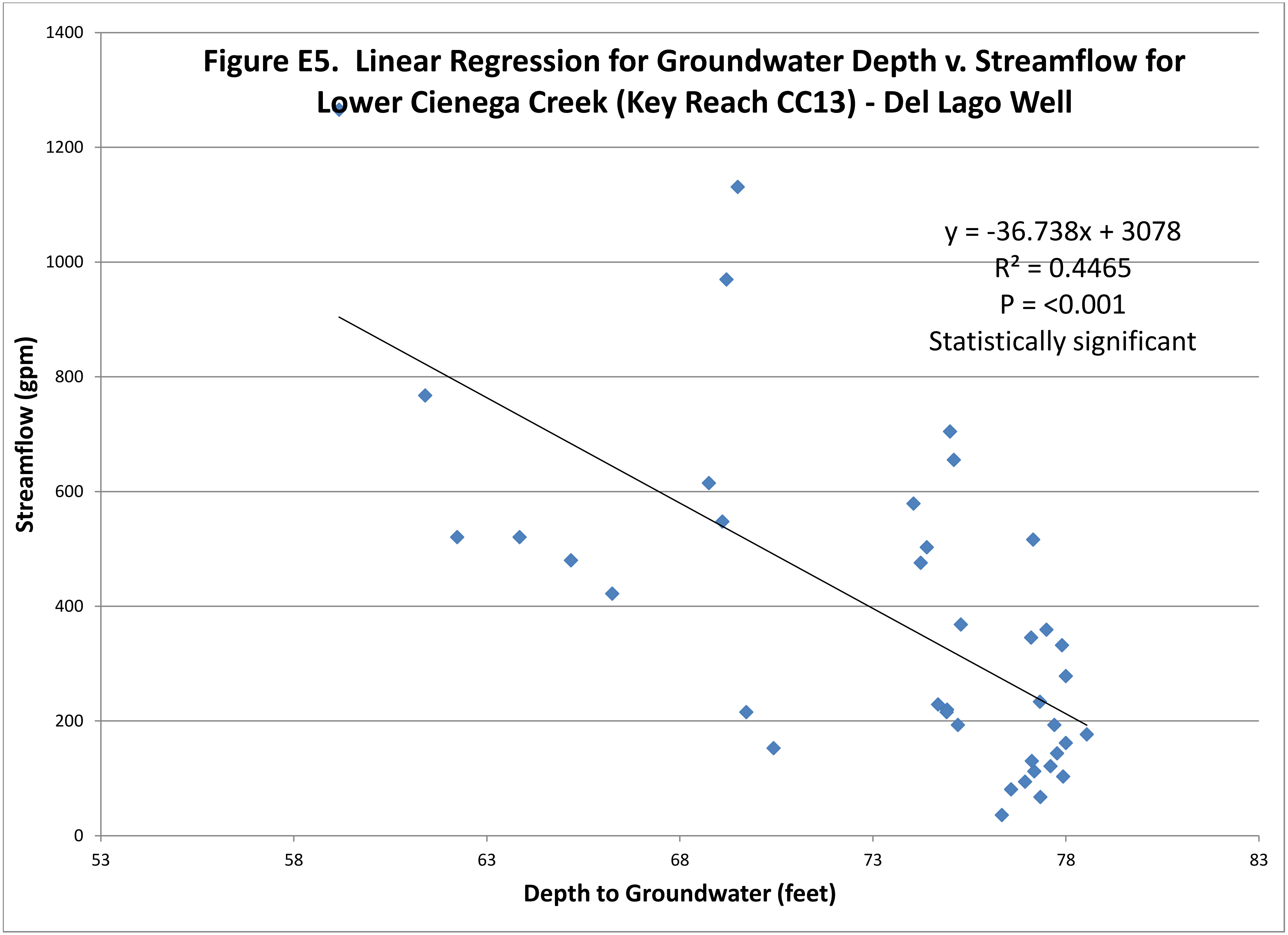
Figure E5. Linear Regression for Groundwater Depth v. Streamflow for Lower Cienega Creek (Key Reach CC13) - Del Lago Well
y = -36.738x + 3078
R^2 = 0.4465
P = <0.001
Statistically significant
Streamflow (gpm)
Depth to Groundwater (feet)
0
200
400
600
800
1000
1200
1400
53
58
63
68
73
78
83

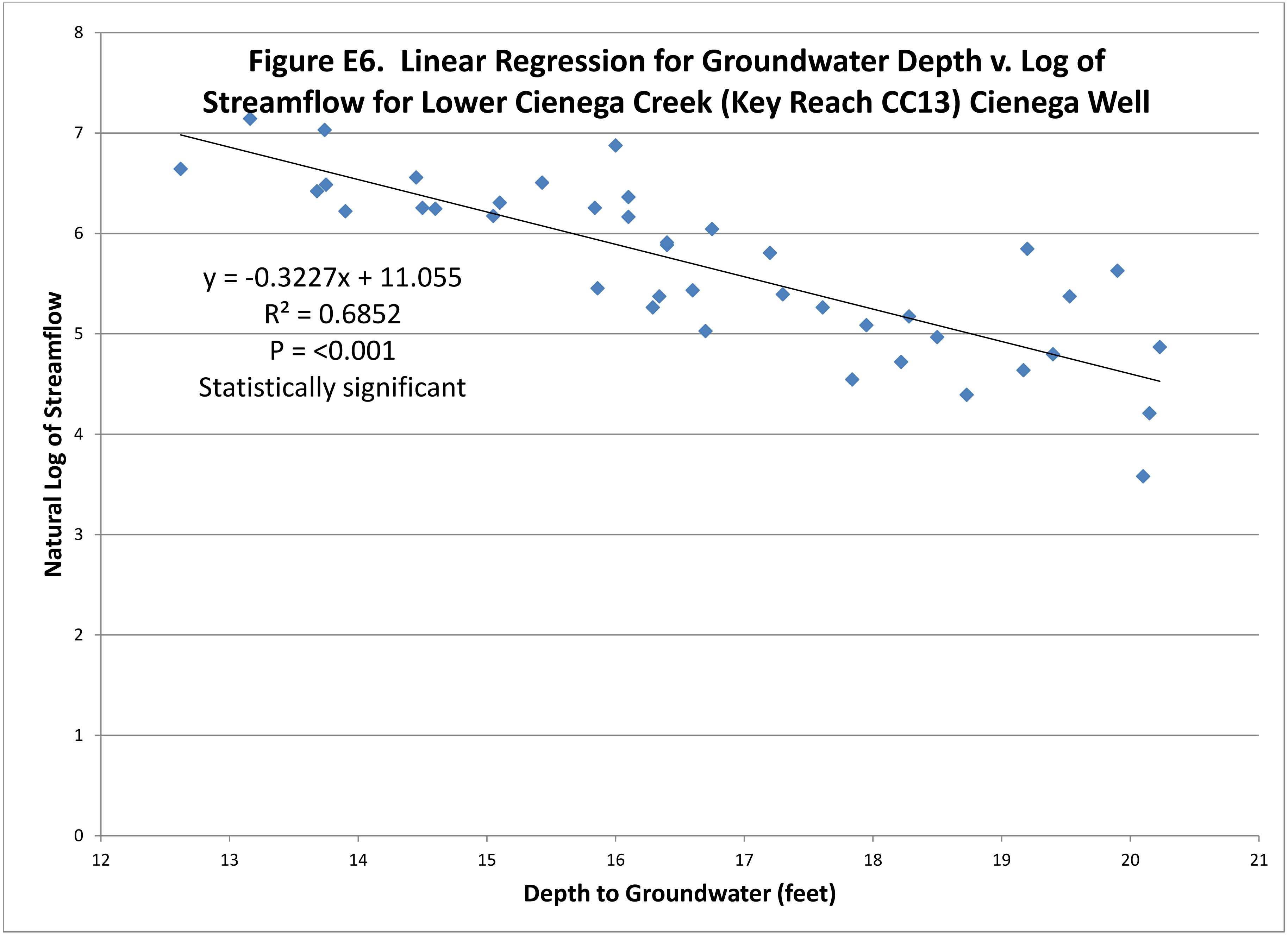
Figure E6. Linear Regression for Groundwater Depth v. Log of Streamflow for Lower Cienega Creek (Key Reach CC13) Cienega Well
y = -0.3227x + 11.055
R² = 0.6852
P = <0.001
Statistically significant
Natural Log of Streamflow
Depth to Groundwater (feet)
0
1
2
3
4
5
6
7
8
12
13
14
15
16
17
18
19
20
21

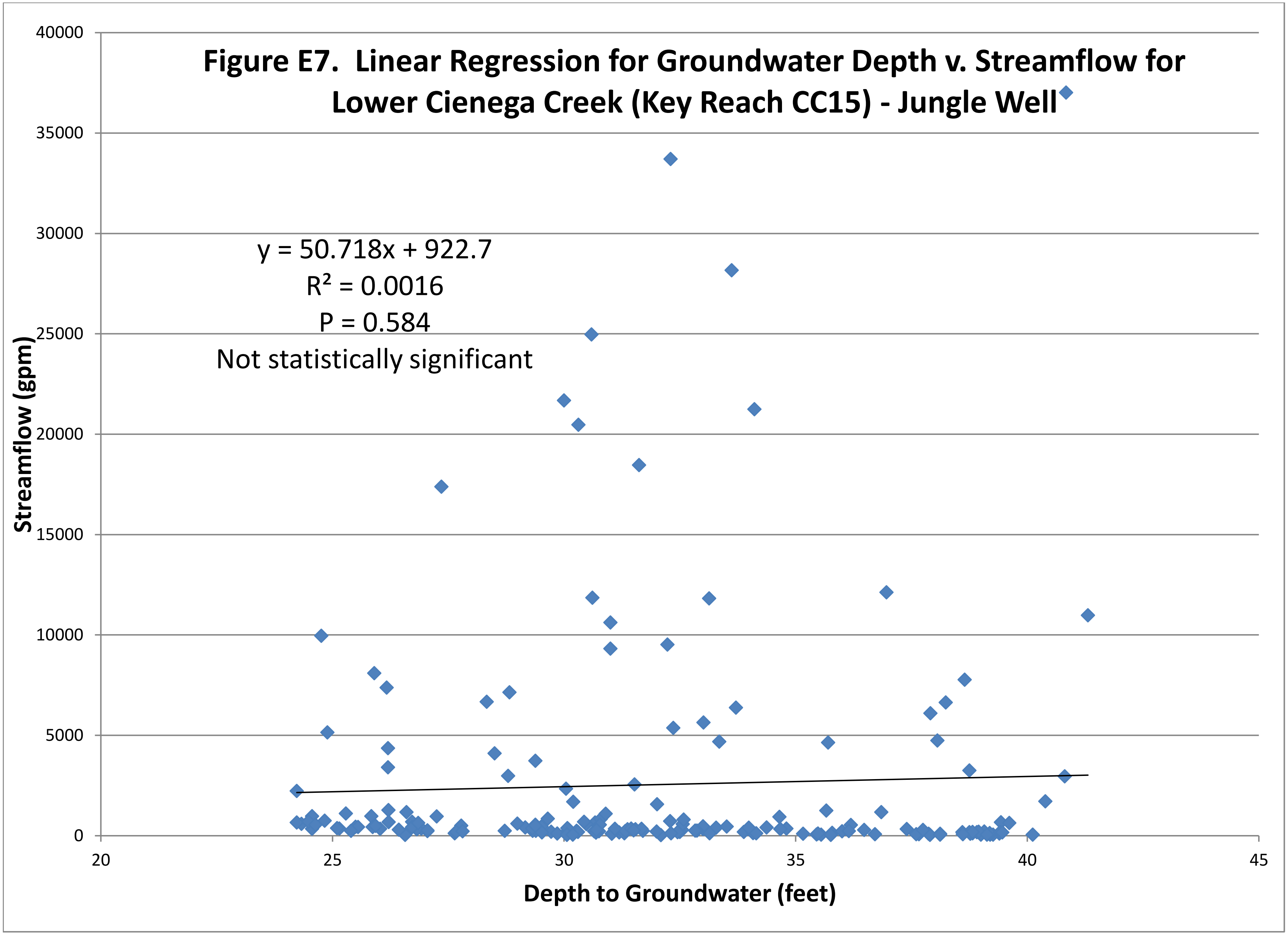
Figure E7. Linear Regression for Groundwater Depth v. Streamflow for Lower Cienega Creek (Key Reach CC15) - Jungle Well
y = 50.718x + 922.7
R^2 = 0.0016
P = 0.584
Not statistically significant
Streamflow (gpm)
Depth to Groundwater (feet)
40000
35000
30000
25000
20000
15000
10000
5000
0
20
25
30
35
40
45

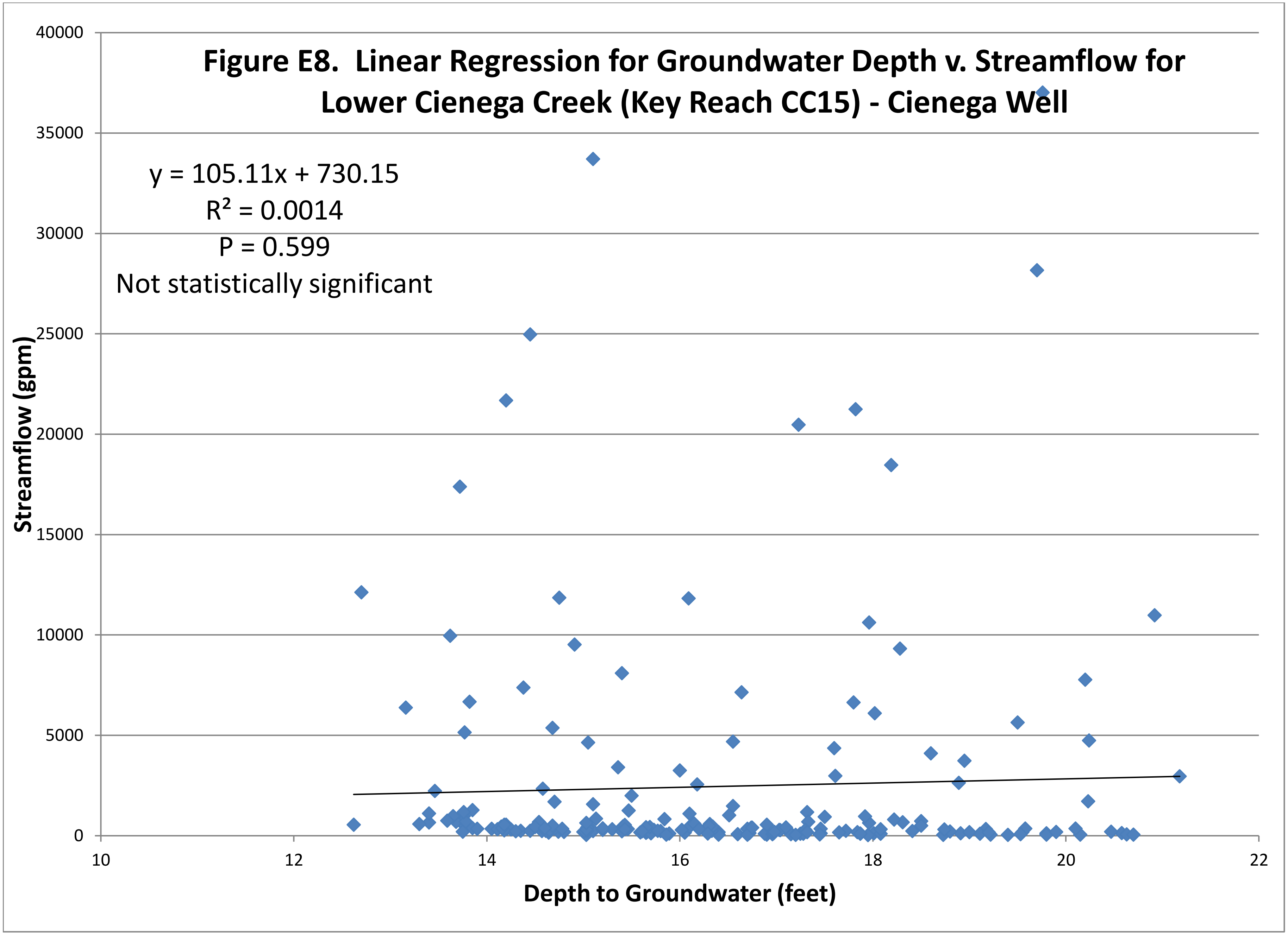
Figure E8. Linear Regression for Groundwater Depth v. Streamflow for Lower Cienega Creek (Key Reach CC15) - Cienega Well
y = 105.11x + 730.15
R² = 0.0014
P = 0.599
Not statistically significant
Streamflow (gpm)
Depth to Groundwater (feet)
40000
35000
30000
25000
20000
15000
10000
5000
0
10
12
14
16
18
20
22

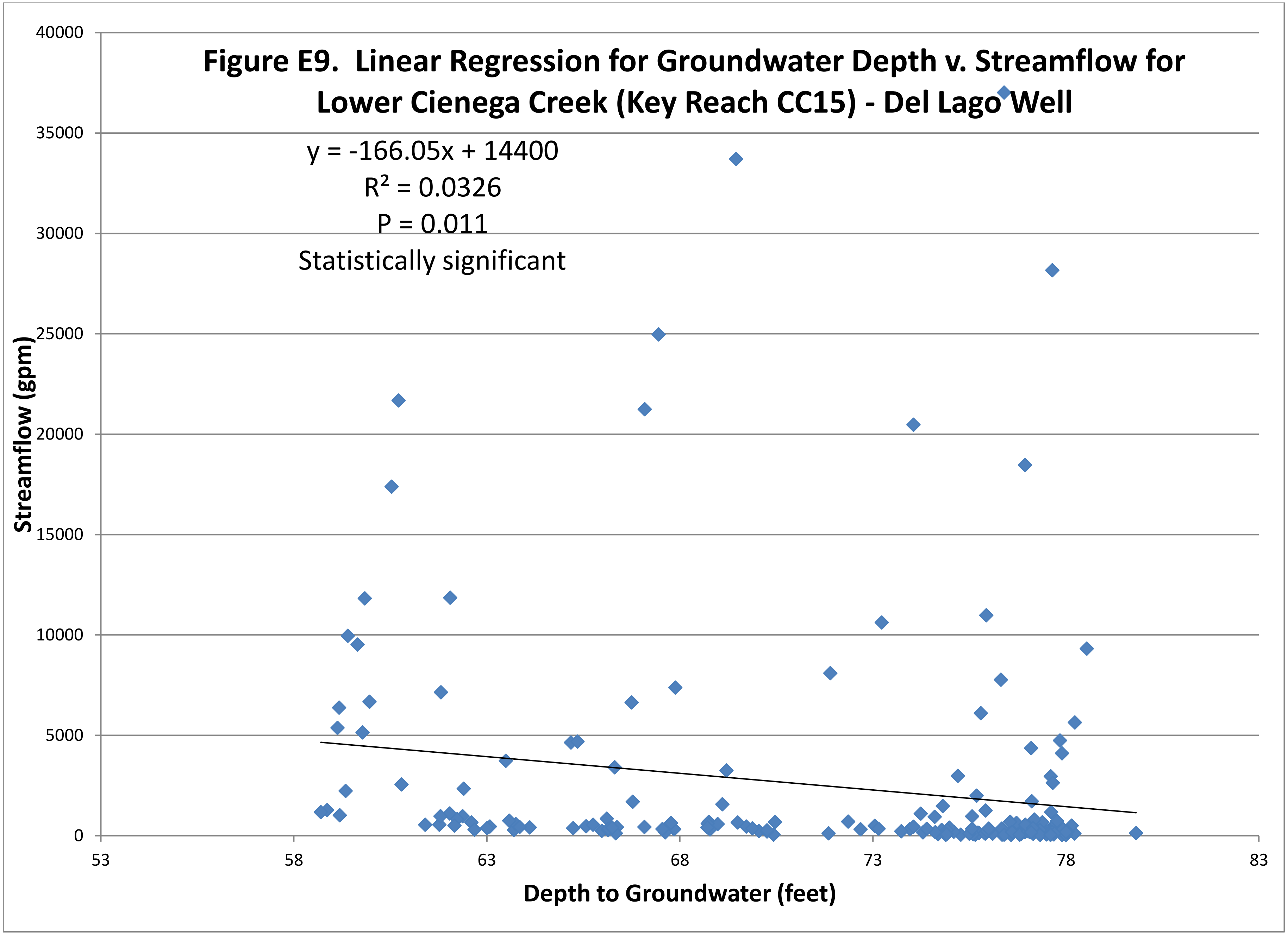
Figure E9. Linear Regression for Groundwater Depth v. Streamflow for Lower Cienega Creek (Key Reach CC15) - Del Lago Well
y = -166.05x + 14400
R^2 = 0.0326
P = 0.011
Statistically significant
Streamflow (gpm)
40000
35000
30000
25000
20000
15000
10000
5000
0
53
58
63
68
73
78
83
Depth to Groundwater (feet)

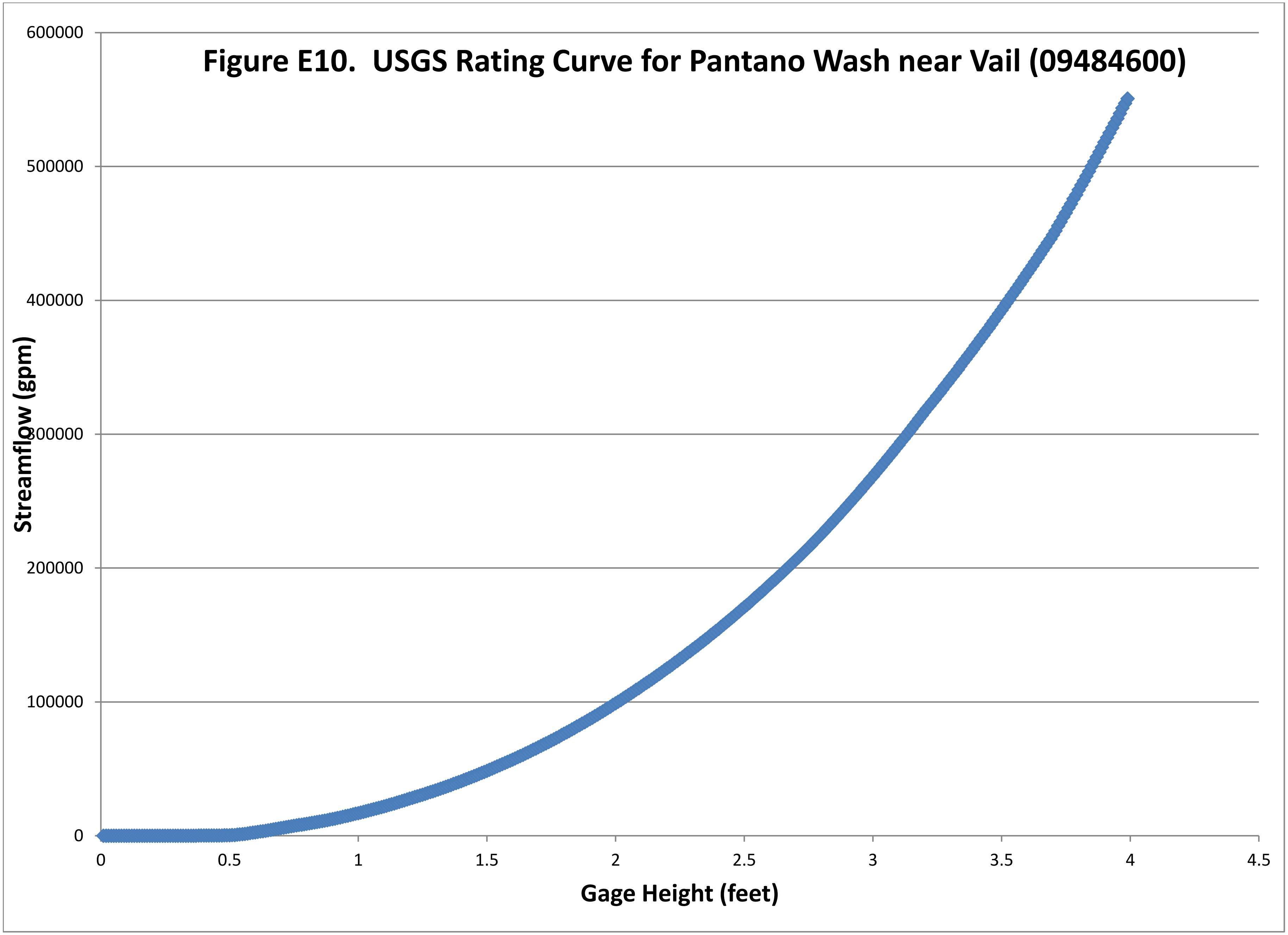
Figure E10. USGS Rating Curve for Pantano Wash near Vail (09484600)
Streamflow (gpm)
600000
500000
400000
300000
200000
100000
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Gage Height (feet)

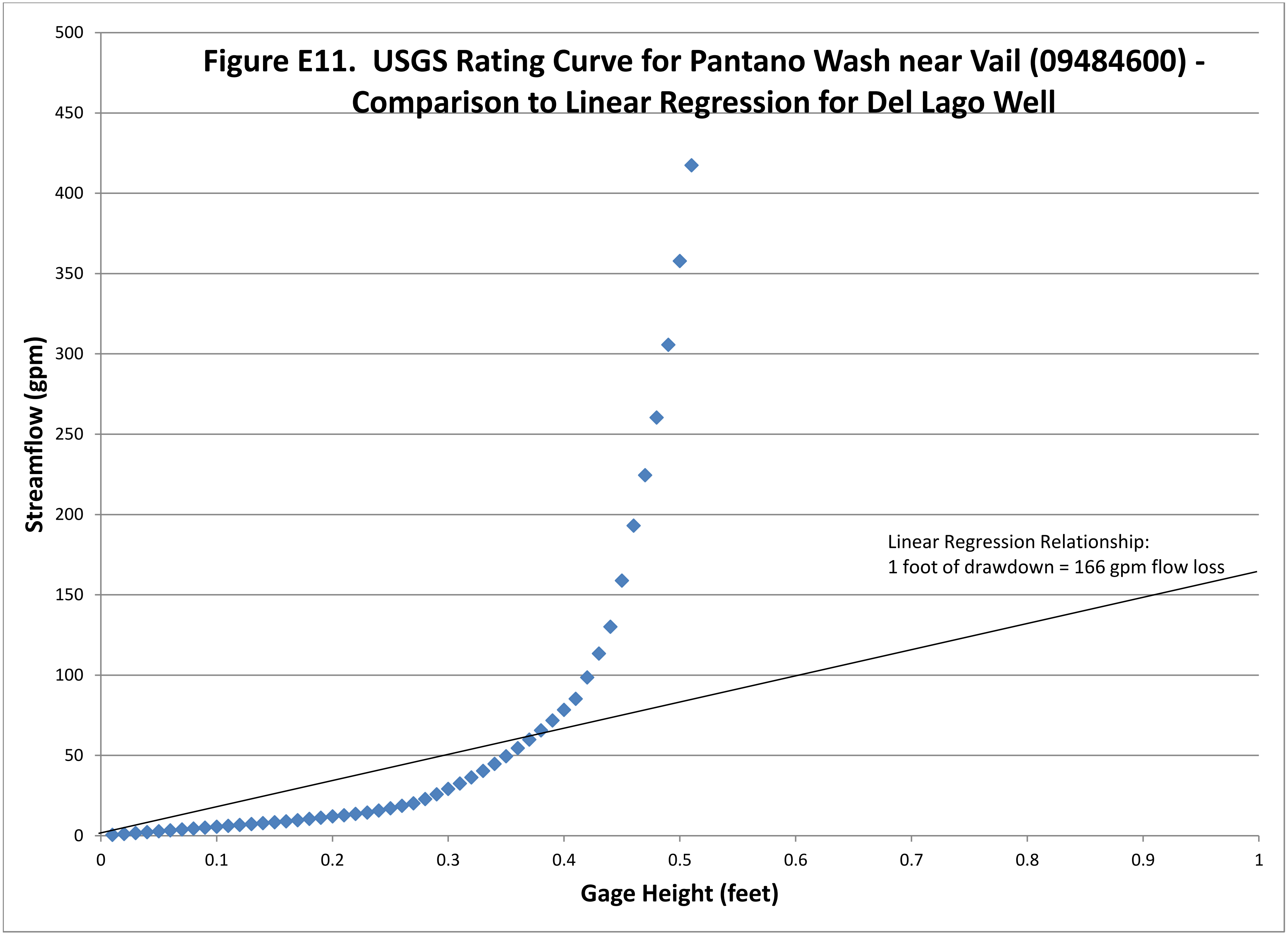
Figure E11. USGS Rating Curve for Pantano Wash near Vail (09484600) - Comparison to Linear Regression for Del Lago Well
Streamflow (gpm)
500
450
400
350
300
250
200
150
100
50
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Gage Height (feet)
Linear Regression Relationship:
1 foot of drawdown = 166 gpm flow loss

Table E1. Summary of Regression Analysis Output for Empire Gulch (Key Reach EG1)

Regression Statistics	
Multiple R	0.842005251
R Square	0.708972843
Adjusted R Square	0.693655624
Standard Error	4.299414556
Observations	21

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 80.0%*	*Upper 80.0%*
Intercept	-20.00006438	5.625755138	-3.555089742	0.002113648	-31.77490518	-8.22522358	-27.46953818	-12.53059059
X Variable 1	10.91834267	1.604840511	6.803381769	1.70122E-06	7.559372889	14.27731246	8.787550657	13.04913469

RESIDUAL OUTPUT

Observation	*Actual Depth to Groundwater (ft) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*	*Standard Residuals*
1	4.8978	20	25.88	-5.88	-1.40
2	4.7469	38	27.53	10.47	2.50
3	4.9716	23	25.08	-2.08	-0.50
4	5.5395	12	18.87	-6.87	-1.64
5	6.2672	6	10.93	-4.93	-1.18
6	6.3516	9	10.01	-1.01	-0.24
7	6.5179	12	8.19	3.81	0.91
8	6.1406	13	12.31	0.69	0.16
9	6.1839	15	11.84	3.16	0.75
10	5.5217	16	19.07	-3.07	-0.73
11	5.3297	21	21.17	-0.17	-0.04
12	5.1083	30	23.58	6.42	1.53
13	4.9483	22	25.33	-3.33	-0.79
14	4.8518	27	26.38	0.62	0.15
15	4.9835	25	24.95	0.05	0.01
16	5.664	14.5	17.52	-3.02	-0.72
17	6.2669	8	10.93	-2.93	-0.70
18	6.1874	14	11.80	2.20	0.52
19	6.2972	15	10.60	4.40	1.05
20	5.8512	16	15.47	0.53	0.13
21	5.8886	16	15.06	0.94	0.22

Table E2. Summary of Regression Analysis Output for Cienega Creek above Gardner Canyon (Key Reach CC2)

Regression Statistics	
Multiple R	0.766726652
R Square	0.587869759
Adjusted R Square	0.563626803
Standard Error	21.40625997
Observations	19

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	527.1208295	91.13473037	5.783973106	2.20162E-05	334.8433557	719.3983033	334.8433557	719.3983033
X Variable 1	-117.5924062	23.8798447	-4.92433714	0.000128413	-167.9744745	-67.21033782	-167.9744745	-67.21033782

RESIDUAL OUTPUT

Observation	*Actual Depth to Groundwater (ft) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*	*Standard Residuals*
1	3.474	157	118.605	38.395	1.846
2	3.44	104	122.603	-18.603	-0.894
3	3.638	148	99.320	48.680	2.340
4	3.868	49	72.273	-23.273	-1.119
5	3.678	46	94.616	-48.616	-2.337
6	4.149	49	39.230	9.770	0.470
7	4.221	43	30.763	12.237	0.588
8	3.824	71	77.447	-6.447	-0.310
9	3.718	86.6	89.912	-3.312	-0.159
10	3.732	91.1	88.266	2.834	0.136
11	3.669	99.6	95.674	3.926	0.189
12	3.665	91.1	96.145	-5.045	-0.242
13	3.69	82.6	93.205	-10.605	-0.510
14	3.956	59.7	61.925	-2.225	-0.107
15	4.051	49.4	50.754	-1.354	-0.065
16	3.83	66.9	76.742	-9.842	-0.473
17	4.048	49.4	51.107	-1.707	-0.082
18	3.922	70.9	65.923	4.977	0.239
19	3.833	86.6	76.389	10.211	0.491

Table E3. Summary of Regression Analysis Output for Cienega Creek at Marsh Station Road (Key Reach CC13) - Jungle Well

Regression Statistics	
Multiple R	0.375900555
R Square	0.141301227
Adjusted R Square	0.11928331
Standard Error	273.4383232
Observations	41

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	479831.177	479831.177	6.417556464	0.015432241
Residual	39	2915972.147	74768.5166		
Total	40	3395803.324			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1198.568099	322.8354135	3.712628939	0.00063982	545.5718391	1851.564358	545.5718391	1851.564358
X Variable 1	-24.17665249	9.543580009	-2.533289653	0.015432241	-43.48036512	-4.872939856	-43.48036512	-4.872939856

RESIDUAL OUTPUT

Observation	*Actual Depth to Groundwater (ft) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*	*Standard Residuals*
1	35.7	480.2802	335.461605	144.818595	0.536367728
2	30.27	704.7102	466.740828	237.969372	0.881372254
3	39.2	368.0652	250.8433213	117.2218787	0.43415718
4	24.23	1131.1272	612.767809	518.359391	1.919858765
5	30.43	614.9382	462.8725636	152.0656364	0.563208751
6	32.01	547.6092	424.6734527	122.9357473	0.455319757
7	37.66	228.9186	288.0753661	-59.15676612	-0.21910018
8	38.75	359.088	261.7228149	97.36518509	0.360613519
9	30.06	655.3356	471.817925	183.517675	0.679698339
10	36.19	668.8014	323.6150453	345.1863547	1.278474086
11	32.29	143.6352	417.90399	-274.26879	-1.015815185
12	32.58	112.215	410.8927608	-298.6777608	-1.106219212
13	25.5	579.0294	582.0634604	-3.034060354	-0.011237314
14	40.39	130.1694	222.0731048	-91.90370484	-0.340385718
15	37.9	80.7948	282.2729695	-201.4781695	-0.746219007
16	26.57	332.1564	556.1944422	-224.0380422	-0.82977449
17	37.4	103.2378	294.3612958	-191.1234958	-0.70786818
18	31	176.62641	449.0918717	-272.4654617	-1.009136159
19	32.09	161.5896	422.7393205	-261.1497205	-0.967225806
20	32.45	94.2606	414.0357256	-319.7751256	-1.184357973
21	40.12	67.329	228.600801	-161.271801	-0.597305819

22	33.71	1265.7852	383.5731434	882.2120566	3.267467666
23	28.79	193.0098	502.5222737	-309.5124737	-1.14634797
24	30.79	520.6776	454.1689687	66.5086313	0.24632944
25	25.55	520.6776	580.8546277	-60.17702773	-0.222878945
26	34.8	35.9088	357.2205922	-321.3117922	-1.190049358
27	33.51	215.4528	388.4084739	-172.9556739	-0.640579629
28	37.75	219.9414	285.8994674	-65.9580674	-0.244290305
29	30.77	767.5506	454.6525018	312.8980982	1.15888738
30	38.75	969.5376	261.7228149	707.8147851	2.621548761
31	38.12	152.6124	276.954106	-124.341706	-0.460527036
32	38.61	215.4528	265.1075463	-49.65474626	-0.183907346
33	35.48	193.0098	340.7804685	-147.7706685	-0.547301386
34	33.99	421.9284	376.8036807	45.12471925	0.167129388
35	30.9	475.7916	451.5095369	24.28206307	0.089933996
36	38.82	278.2932	260.0304492	18.26275076	0.067640141
37	30.19	233.4072	468.6749602	-235.2677602	-0.871366236
38	31.1	502.7232	446.6742064	56.04899357	0.207589856
39	35.76	121.1922	334.0110058	-212.8188058	-0.788221564
40	39.46	345.6222	244.5573916	101.0648084	0.374315893
41	25.1	516.189	591.7341213	-75.54512135	-0.279798082

Table E4. Summary of Regression Analysis Output for Cienega Creek at Marsh Station Road (Key Reach CC13) - Cienega Well

Regression Statistics	
Multiple R	0.788407383
R Square	0.621586201
Adjusted R Square	0.611883283
Standard Error	181.5191475
Observations	41

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2110784.489	2110784.489	64.06178088	9.35391E-10
Residual	39	1285018.835	32949.20091		
Total	40	3395803.324			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2205.193851	228.8126867	9.63755062	7.20317E-12	1742.376507	2668.011195	1742.376507	2668.011195
X Variable 1	-108.8236188	13.59639146	-8.003860373	9.35391E-10	-136.3249163	-81.32232126	-136.3249163	-81.32232126

RESIDUAL OUTPUT

Observation	*Actual Depth to Groundwater (ft) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*	*Standard Residuals*
1	16.4	359.088	420.4865027	-61.39850275	-0.342557144
2	15.05	480.2802	567.3983881	-87.11818813	-0.48605351
3	16.4	368.0652	420.4865027	-52.42130275	-0.292471167
4	14.45	704.7102	632.6925594	72.01764059	0.401803891
5	13.68	614.9382	716.4867459	-101.5485459	-0.566563977
6	15.43	668.8014	526.045413	142.755987	0.796470289
7	13.75	655.3356	708.8690926	-53.53349257	-0.298676344
8	15.1	547.6092	561.9572072	-14.34800719	-0.080051013
9	16.6	228.9186	398.721779	-169.803179	-0.947373136
10	13.74	1131.1272	709.9573288	421.1698712	2.349808903
11	20.15	67.329	12.39793225	54.93106775	0.306473755
12	18.5	143.6352	191.9569033	-48.32170327	-0.269598507
13	20.23	130.1694	3.692042744	126.4773573	0.705647864
14	18.22	112.215	222.4275165	-110.2125165	-0.614902371
15	17.84	94.2606	263.7804917	-169.5198917	-0.945792607
16	17.95	161.5896	251.8098936	-90.22029361	-0.503360909
17	18.73	80.7948	166.9274709	-86.13267094	-0.48055507
18	19.17	103.2378	119.0450787	-15.80727867	-0.088192643
19	18.28	176.62641	215.8980994	-39.2716894	-0.219106284
20	16.1	579.0294	453.1335884	125.8958116	0.70240328
21	17.2	332.1564	333.4276077	-1.271207708	-0.007092376

22	14.5	520.6776	627.2513785	-106.5737785	-0.594600969
23	16.7	152.6124	387.8394171	-235.2270171	-1.312388603
24	13.16	1265.7852	773.0750277	492.7101723	2.748949601
25	16	969.5376	464.0159503	505.5216497	2.820427942
26	17.3	219.9414	322.5452458	-102.6038458	-0.572451751
27	12.62	767.5506	831.8397818	-64.28918181	-0.358684944
28	17.61	193.0098	288.809924	-95.800124	-0.534492136
29	16.34	215.4528	427.0159199	-211.5631199	-1.180361979
30	20.1	35.9088	17.83911319	18.06968681	0.100815167
31	15.84	520.6776	481.4277293	39.24987072	0.218984552
32	19.53	215.4528	79.8685759	135.5842241	0.756457284
33	16.75	421.9284	382.3982362	39.53016383	0.220548375
34	19.2	345.6222	115.7803701	229.8418299	1.282343337
35	16.1	475.7916	453.1335884	22.65801161	0.126414544
36	14.6	516.189	616.3690166	-100.1800166	-0.55892862
37	19.4	121.1922	94.01564635	27.17655365	0.151624587
38	19.9	278.2932	39.60383695	238.6893631	1.331705871
39	13.9	502.7232	692.5455497	-189.8223497	-1.059064947
40	16.29	193.0098	432.4571008	-239.4473008	-1.33593459
41	15.86	233.4072	479.2512569	-245.8440569	-1.371623644

Table E5. Summary of Regression Analysis Output for Cienega Creek at Marsh Station Road (Key Reach CC13) - Del Lago Well

Regression Statistics	
Multiple R	0.66821308
R Square	0.446508721
Adjusted R Square	0.431943161
Standard Error	219.7359777
Observations	40

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1480147.857	1480147.857	30.6551016	2.45919E-06
Residual	38	1834788.197	48283.89991		
Total	39	3314936.054			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3078.001574	488.3691308	6.302612879	2.19051E-07	2089.349955	4066.653192	2089.349955	4066.653192
X Variable 1	-36.7377864	6.635315913	-5.53670494	2.45919E-06	-50.17028121	-23.30529159	-50.17028121	-23.30529159

RESIDUAL OUTPUT

Observation	*Actual Depth to Groundwater (ft) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*	*Standard Residuals*
1	75.28	368.0652	312.3810136	55.68418638	0.256726803
2	69.5	1131.1272	524.725419	606.401781	2.795759458
3	69.1	547.6092	539.4205336	8.188666449	0.037753091
4	75	704.7102	322.6675938	382.0426062	1.761372185
5	77.5	359.088	230.8231278	128.2648722	0.591353358
6	74.69	228.9186	334.0563076	-105.1377076	-0.4847277
7	65.18	480.2802	683.4326562	-203.1524562	-0.936615654
8	68.75	614.9382	552.2787588	62.65944121	0.288885572
9	75.1	655.3356	318.9938152	336.3417848	1.550672765
10	78	161.5896	212.4542346	-50.86463462	-0.234506705
11	78.54	176.62641	192.61583	-15.98941997	-0.073717745
12	77.18	112.215	242.5792195	-130.3642195	-0.601032205
13	74.05	579.0294	357.5684909	221.4609091	1.021025087
14	77.93	103.2378	215.0258797	-111.7880797	-0.515388627
15	76.94	94.2606	251.3962882	-157.1356882	-0.724459591
16	77.9	332.1564	216.1280133	116.0283867	0.534938171
17	76.58	80.7948	264.6218913	-183.8270913	-0.847517843
18	77.77	143.6352	220.9039255	-77.26872549	-0.356240329
19	77.12	130.1694	244.7834867	-114.6140867	-0.528417671
20	77.34	67.329	236.7011736	-169.3721736	-0.780874779
21	76.34	35.9088	273.43896	-237.53016	-1.095110886

22	75.2	193.0098	315.3200365	-122.3102365	-0.56390006
23	69.72	215.4528	516.643106	-301.190306	-1.388610115
24	74.92	219.9414	325.6066167	-105.6652167	-0.487159732
25	61.4	767.5506	822.3014888	-54.7508888	-0.252423921
26	70.43	152.6124	490.5592776	-337.9468776	-1.558072897
27	62.23	520.6776	791.8091261	-271.1315261	-1.250026884
28	59.17	1265.7852	904.2267525	361.5584475	1.666931861
29	63.85	520.6776	732.2939121	-211.6163121	-0.975637481
30	69.21	969.5376	535.379377	434.158223	2.001646427
31	77.15	516.189	243.6813531	272.5076469	1.256371362
32	77.6	121.1922	227.1493492	-105.9571492	-0.48850566
33	77.1	345.6222	245.5182424	100.1039576	0.46152006
34	78	278.2932	212.4542346	65.83896538	0.303544475
35	77.33	233.4072	237.0685515	-3.661351508	-0.016880323
36	74.24	475.7916	350.5883115	125.2032885	0.577238209
37	66.25	421.9284	644.1232248	-222.1948248	-1.024408738
38	77.7	193.0098	223.4755705	-30.46577054	-0.140459624
39	74.91	215.4528	325.9739946	-110.5211946	-0.50954777
40	74.4	502.7232	344.7102656	158.0129344	0.728504054

Table E6. Summary of Regression Analysis Output for Cienega Creek at Marsh Station Road (Key Reach CC13) - Cienega Well - Log of Streamflow

Regression Statistics	
Multiple R	0.8277401
R Square	0.685153673
Adjusted R Square	0.67708069
Standard Error	0.467602019
Observations	41

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	18.55695522	18.55695522	84.86995369	2.4769E-11
Residual	39	8.527414264	0.218651648		
Total	40	27.08436949			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	11.05466123	0.589432441	18.75475536	4.06647E-21	9.862421589	12.24690088	9.862421589	12.24690088
X Variable 1	-0.322667019	0.035024956	-9.212489006	2.4769E-11	-0.393511679	-0.251822359	-0.393511679	-0.251822359

RESIDUAL OUTPUT

Observation	*Actual Depth to Groundwater (ft) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*	*Standard Residuals*
1	16.4	5.883567484	5.762922126	0.120645358	0.2612955
2	15.05	6.174369684	6.198522601	-0.024152918	-0.052310746
3	16.4	5.908260096	5.762922126	0.145337971	0.314775126
4	14.45	6.557786654	6.392122813	0.165663842	0.358797199
5	13.68	6.421521775	6.640576417	-0.219054642	-0.474431783
6	15.43	6.505487155	6.075909134	0.429578021	0.930386431
7	13.75	6.485147471	6.617989726	-0.132842255	-0.28771172
8	15.1	6.305561894	6.18238925	0.123172644	0.266769133
9	16.6	5.433366482	5.698388722	-0.26502224	-0.573989087
10	13.74	7.030969937	6.621216396	0.409753541	0.887450278
11	20.15	4.20959105	4.552920805	-0.343329755	-0.743588661
12	18.5	4.967276752	5.085321386	-0.118044634	-0.255662815
13	20.23	4.868836679	4.527107444	0.341729235	0.740122232
14	18.22	4.720416674	5.175668152	-0.455251478	-0.985990383
15	17.84	4.546063287	5.298281619	-0.752218332	-1.629165587
16	17.95	5.085059788	5.262788247	-0.177728459	-0.384926925
17	18.73	4.391912607	5.011107972	-0.619195365	-1.341062478
18	19.17	4.637035065	4.869134484	-0.232099419	-0.502684353
19	18.28	5.174036824	5.15630813	0.017728694	0.038397067
20	16.1	6.361353253	5.859722231	0.501631022	1.086439886
21	17.2	5.805605942	5.504788511	0.300817432	0.651514842

22	14.5	6.25513104	6.375989462	-0.120858421	-0.261756956
23	16.7	5.027901374	5.66612202	-0.638220646	-1.382267714
24	13.16	7.14344792	6.808363267	0.335084653	0.725731297
25	16	6.876819257	5.891988933	0.984830323	2.132960079
26	17.3	5.393361147	5.472521809	-0.079160662	-0.171447332
27	12.62	6.643204406	6.982603457	-0.339399051	-0.735075485
28	17.61	5.262740965	5.372495033	-0.109754068	-0.237706984
29	16.34	5.37274186	5.782282147	-0.409540287	-0.88698841
30	20.1	3.580982391	4.569054156	-0.988071765	-2.139980442
31	15.84	6.25513104	5.943615656	0.311515384	0.674684625
32	19.53	5.37274186	4.752974357	0.619767503	1.342301624
33	16.75	6.044835631	5.649988669	0.394846962	0.85516539
34	19.2	5.845346271	4.859454473	0.985891798	2.135259036
35	16.1	6.164979943	5.859722231	0.305257712	0.661131666
36	14.6	6.246472977	6.34372276	-0.097249782	-0.210625017
37	19.4	4.797377715	4.794921069	0.002456646	0.00532064
38	19.9	5.628675234	4.63358756	0.995087674	2.155175601
39	13.9	6.22003972	6.569589673	-0.349549953	-0.757060457
40	16.29	5.262740965	5.798415498	-0.535674533	-1.160171826
41	15.86	5.452784568	5.937162316	-0.484377748	-1.049072491

Table E7. Summary of Regression Analysis Output for Cienega Creek at Pantano Dam (Key Reach CC15) - Jungle Well

Regression Statistics	
Multiple R	0.039995026
R Square	0.001599602
Adjusted R Square	-0.003711038
Standard Error	5787.837402
Observations	190

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	10090152	10090152	0.301207003	0.583777933
Residual	188	6297823617	33499061.8		
Total	189	6307913769			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	922.6986578	2987.261135	0.308877804	0.757756504	-4970.159935	6815.55725	-4970.159935	6815.55725
X Variable 1	50.7183367	92.41287258	0.548823289	0.583777933	-131.5810893	233.0177627	-131.5810893	233.0177627

RESIDUAL OUTPUT

Observation	*Actual Depth to Groundwater (ft) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*	*Standard Residuals*
1	24.76	9958.900258	2178.484674	7780.415584	1.34784034
2	27.05	231.0905032	2294.629665	-2063.539162	-0.357477219
3	29.38	550.3602774	2412.80339	-1862.443113	-0.322640344
4	33	330.8532581	2596.403769	-2265.550511	-0.392472656
5	30.08	232.1040581	2448.306226	-2216.202168	-0.383923796
6	26.21	1279.974968	2252.026263	-972.0512949	-0.168393312
7	24.56	351.5587355	2168.341007	-1816.782272	-0.314730288
8	30.06	38.51508387	2447.291859	-2408.776775	-0.417284459
9	35.79	147.3998323	2737.907928	-2590.508096	-0.448766686
10	38.82	126.2599742	2891.584488	-2765.324514	-0.479051009
11	39.4	110.3326839	2921.001124	-2810.66844	-0.486906164
12	33	464.9320839	2596.403769	-2131.471685	-0.36924551
13	30.2	1695.532452	2454.392426	-758.8599744	-0.131461112
14	30.67	657.6522968	2478.230044	-1820.577747	-0.315387797
15	35.55	52.27047097	2725.735527	-2673.465056	-0.463137735
16	38.12	95.56374194	2856.081653	-2760.517911	-0.478218337
17	24.89	5150.6685	2185.078058	2965.590442	0.513744078
18	26.92	352.587269	2288.036282	-1935.449013	-0.335287521
19	29.51	456.5547429	2419.396774	-1962.842031	-0.340032951
20	32.3	33703.61494	2560.900933	31142.71401	5.395008249
21	32.87	255.0486643	2589.810385	-2334.761721	-0.404462461

22	29.72	197.6531793	2430.047624	-2232.394445	-0.386728865
23	25.84	974.6674286	2233.260478	-1258.593049	-0.218032374
24	24.33	590.7318214	2156.67579	-1565.943968	-0.271276313
25	30.09	152.9330143	2448.813409	-2295.880395	-0.397726854
26	36	218.8579448	2748.558779	-2529.700834	-0.438232739
27	38.77	103.7187214	2889.048572	-2785.32985	-0.482516633
28	39.26	58.99302857	2913.900556	-2854.907528	-0.494569923
29	32.55	294.0033	2573.580517	-2279.577217	-0.394902573
30	30.1	313.7376621	2449.320592	-2135.58293	-0.369957722
31	30.48	579.6706286	2468.59356	-1888.922932	-0.327227575
32	35.66	1258.411071	2731.314544	-1472.903473	-0.255158442
33	37.87	98.58889286	2843.402068	-2744.813176	-0.475497727
34	24.23	2229.820645	2151.603956	78.21668922	0.013549869
35	26.82	323.3239935	2282.964448	-1959.640454	-0.339478326
36	29.41	375.3048774	2414.32494	-2039.020063	-0.353229653
37	32.23	9518.872665	2557.35065	6961.522015	1.205979308
38	32.5	185.0461548	2571.0446	-2385.998446	-0.413338455
39	29.39	244.5563032	2413.310573	-2168.75427	-0.375704159
40	25.29	1112.014452	2205.365393	-1093.350941	-0.189406657
41	24.23	662.5752774	2151.603956	-1489.028679	-0.257951892
42	30.27	242.6739871	2457.94271	-2215.268722	-0.38376209
43	36.19	539.3559677	2758.195263	-2218.839295	-0.384380639
44	38.75	173.6074645	2888.034205	-2714.42674	-0.470233733
45	39.2	53.71840645	2910.857456	-2857.13905	-0.4949565
46	32.01	1573.326697	2546.192615	-972.8659187	-0.168534433
47	30.06	201.6974129	2447.291859	-2245.594446	-0.389015567
48	30.43	698.3392839	2466.057643	-1767.71836	-0.306230701
49	35.7	4642.949923	2733.343278	1909.606645	0.330810719
50	37.66	73.84470968	2832.751218	-2758.906508	-0.477939186
51	24.56	969.5376	2168.341007	-1198.803407	-0.207674715
52	27.05	271.5603	2294.629665	-2023.069365	-0.350466434
53	30.07	379.73556	2447.799042	-2068.063482	-0.35826099
54	32.36	5372.70458	2563.944033	2808.760547	0.48657565
55	32.83	257.49602	2587.781652	-2330.285632	-0.403687045
56	29.32	245.67604	2409.76029	-2164.08425	-0.374895148
57	24.83	754.0848	2182.034958	-1427.950158	-0.247370954
58	24.48	707.10412	2164.28354	-1457.17942	-0.252434486
59	30.75	223.83152	2482.287511	-2258.455991	-0.391243637
60	36.48	287.2704	2772.90358	-2485.63318	-0.430598679
61	39.07	207.07408	2904.264073	-2697.189993	-0.467247725
62	39.19	129.72054	2910.350273	-2780.629733	-0.481702408
63	31.54	322.58072	2522.354997	-2199.774277	-0.38107791
64	30.3	189.2693	2459.46426	-2270.19496	-0.393277237
65	30.65	224.87886	2477.215678	-2252.336818	-0.390183582
66	36.15	238.19504	2756.166529	-2517.971489	-0.436200806
67	37.6	79.59784	2829.708118	-2750.110278	-0.47641537
68	26.215	681.9776129	2252.279854	-1570.302241	-0.272031318
69	31.19	171.4355613	2504.603579	-2333.168018	-0.404186376

70	32.56	586.5586645	2574.087701	-1987.529036	-0.344309605
71	33.88	184.6117742	2641.035905	-2456.424131	-0.425538649
72	29.85	107.2920194	2436.641008	-2329.348989	-0.403524786
73	24.63	544.4237419	2171.891291	-1627.467549	-0.281934351
74	25.15	354.3098129	2198.264826	-1843.955013	-0.319437558
75	31.3	159.2729032	2510.182596	-2350.909693	-0.407259855
76	36.85	1174.275677	2791.669365	-1617.393688	-0.280189205
77	39.43	674.882729	2922.522674	-2247.639945	-0.389369919
78	39.61	639.4083097	2931.651974	-2292.243665	-0.397096845
79	31.7	249.0449032	2530.469931	-2281.425028	-0.395222678
80	30.69	161.0104258	2479.244411	-2318.233985	-0.401599278
81	31.3	121.6265806	2510.182596	-2388.556016	-0.413781516
82	36.71	82.82190968	2784.568798	-2701.746888	-0.468037138
83	25.87	434.6461	2234.782028	-1800.135928	-0.311846558
84	28.72	249.26692	2379.329288	-2130.062368	-0.369001367
85	31.03	95.30794	2496.488645	-2401.180705	-0.415968554
86	33.28	400.38312	2610.604903	-2210.221783	-0.382887784
87	34.08	131.06712	2651.179572	-2520.112452	-0.436571696
88	31	9323.42068	2494.967095	6828.453585	1.182927198
89	25.5	446.46608	2216.016244	-1769.550164	-0.306548033
90	26.57	45.78372	2270.284864	-2224.501144	-0.385361469
91	32.09	35.45994	2550.250082	-2514.790142	-0.435649685
92	37.4	338.59006	2819.56445	-2480.97439	-0.429791613
93	40.12	59.24952	2957.518326	-2898.268806	-0.502081614
94	40.39	1719.43304	2971.212277	-1251.779237	-0.216851984
95	32.58	806.15256	2575.102067	-1768.949507	-0.306443979
96	32.29	731.34256	2560.39375	-1829.05119	-0.316855694
97	32.45	177.2997	2568.508684	-2391.208984	-0.414241103
98	37.9	38.00348	2844.923619	-2806.920139	-0.486256827
99	26.03	347.9388968	2242.896962	-1894.958065	-0.328273072
100	29.38	3734.080819	2412.80339	1321.277429	0.228891503
101	34.11	21241.21355	2652.701123	18588.51243	3.220181062
102	31.62	18465.08685	2526.412464	15938.67438	2.761136352
103	29.65	852.1100323	2426.497341	-1574.387309	-0.272738995
104	26.2	4365.525484	2251.519079	2114.006405	0.366219912
105	27.78	503.7367548	2331.654051	-1827.917296	-0.316659264
106	33.01	5644.776484	2596.910952	3047.865532	0.527997004
107	38.06	4744.305406	2853.038552	1891.266854	0.327633625
108	40.81	2955.236323	2992.513978	-37.27765579	-0.006457795
109	40.84	37021.9728	2994.035528	34027.93727	5.894829918
110	33.62	28162.20037	2627.849138	25534.35123	4.423443489
111	30.59	24963.85568	2474.172577	22489.6831	3.896000387
112	33.14	117.1379806	2603.504336	-2486.366355	-0.430725691
113	38.65	7772.372884	2882.962371	4889.410513	0.84701706
114	26.72	690.8100194	2277.892614	-1587.082595	-0.274938263
115	27.25	964.3250323	2304.773333	-1340.448301	-0.232212569
116	28.82	7139.914665	2384.401121	4755.513543	0.823821417
117	33.13	11816.60148	2602.997153	9213.604331	1.596118802

118	30.04	2345.07631	2446.277492	-101.2011825	-0.017531587
119	31	10617.8557	2494.967095	8122.888601	1.407168656
120	25.9	8092.511419	2236.303578	5856.207841	1.014500201
121	28.5	4102.5804	2368.171254	1734.409146	0.300460379
122	33.35	4693.193284	2614.155187	2079.038097	0.360162177
123	37.91	6105.364761	2845.430802	3259.933959	0.564734679
124	41.31	10984.32817	3017.873147	7966.455021	1.380068883
125	36.96	12122.11587	2797.248382	9324.867489	1.615393475
126	30	21677.04213	2444.248759	19232.79337	3.331793075
127	30.61	11850.33838	2475.186944	9375.151437	1.624104415
128	34.15	123.7984839	2654.729856	-2530.931372	-0.438445911
129	38.24	6639.073781	2862.167853	3776.905928	0.654292321
130	26.2	3404.6031	2251.519079	1153.084021	0.199754517
131	26.72	423.57422	2277.892614	-1854.318394	-0.321232858
132	28.33	6675.74516	2359.549136	4316.196024	0.747716244
133	31.52	2561.79364	2521.34063	40.45300954	0.007007877
134	29.16	415.79398	2401.645356	-1985.851376	-0.344018975
135	25.55	430.60636	2218.55216	-1787.9458	-0.309734801
136	28.79	2979.53268	2382.879571	596.6531087	0.103361205
137	33.51	458.73492	2622.27012	-2163.5352	-0.374800033
138	37.75	289.36508	2837.315868	-2547.950788	-0.44139427
139	38.75	3256.62892	2888.034205	368.5947152	0.063853508
140	33.71	6383.98616	2632.413788	3751.572372	0.649903662
141	30.79	832.78492	2484.316245	-1651.531325	-0.286103039
142	30.77	543.56946	2483.301878	-1939.732418	-0.336029557
143	34.8	356.24522	2687.696775	-2331.451555	-0.403889024
144	38.12	58.3518	2856.081653	-2797.729853	-0.484664748
145	26.43	303.3424839	2263.184297	-1959.841813	-0.339513208
146	27.64	119.3098839	2324.553484	-2205.2436	-0.382025388
147	28.99	602.3411613	2393.023239	-1790.682077	-0.31020882
148	32.31	124.088071	2561.408116	-2437.320045	-0.422229153
149	32	209.0818839	2545.685432	-2336.603548	-0.40478153
150	30.31	20470.91187	2459.971443	18010.94043	3.120125373
151	25.93	487.9542581	2237.825128	-1749.87087	-0.303138891
152	29.52	163.6167097	2419.903957	-2256.287247	-0.390867935
153	34.65	945.7914581	2680.089024	-1734.297566	-0.300441049
154	38.6	180.7023484	2880.426454	-2699.724106	-0.467686722
155	38.91	180.2679677	2896.149139	-2715.881171	-0.470485691
156	34.67	335.6314452	2681.103391	-2345.471946	-0.406317847
157	31.37	321.1520903	2513.73288	-2192.58079	-0.379831746
158	31.67	344.3190581	2528.948381	-2184.629323	-0.378454274
159	35.45	63.1299871	2720.663694	-2657.533707	-0.460377868
160	39	54.58716774	2900.713789	-2846.126621	-0.493048762
161	26.85	637.08196	2284.485998	-1647.404038	-0.285388048
162	27.67	188.37158	2326.075034	-2137.703454	-0.370325071
163	29.31	374.19962	2409.253106	-2035.053486	-0.352542503
164	31.32	230.4148	2511.196963	-2280.782163	-0.395111312
165	27.35	17390.48222	2309.845166	15080.63705	2.612494251

166	25.4	248.96768	2210.94441	-1961.97673	-0.339883051
167	30.06	62.99002	2447.291859	-2384.301839	-0.413044543
168	35.16	97.55224	2705.955376	-2608.403136	-0.451866733
169	38.95	196.89992	2898.177872	-2701.277952	-0.467955902
170	39.41	176.5516	2921.508307	-2744.956707	-0.475522592
171	34.37	416.54208	2665.88789	-2249.34581	-0.389665435
172	31.45	358.04066	2517.790347	-2159.749687	-0.37414425
173	31.5	266.92208	2520.326264	-2253.404184	-0.390368487
174	35.76	50.57156	2736.386378	-2685.814818	-0.465277146
175	39.13	50.42194	2907.307173	-2856.885233	-0.49491253
176	26.17	7381.575097	2249.997529	5131.577568	0.888968871
177	27.81	220.0861935	2333.175601	-2113.089408	-0.366061056
178	29.38	508.9493226	2412.80339	-1903.854067	-0.329814171
179	30.7	288.2839548	2479.751594	-2191.46764	-0.37963891
180	26.6	1171.379806	2271.806414	-1100.426607	-0.19063241
181	25.1	377.6215742	2195.728909	-1818.107335	-0.314959835
182	30.19	49.95377419	2453.885243	-2403.931468	-0.416445082
183	35.48	107.7264	2722.185244	-2614.458844	-0.452915794
184	38.82	190.9826903	2891.584488	-2700.601798	-0.467838769
185	39.46	165.7886129	2924.044224	-2758.255611	-0.477826427
186	33.99	400.3541613	2646.614922	-2246.260761	-0.389130996
187	30.9	1099.417413	2489.895262	-1390.477849	-0.240879438
188	31.1	344.4638516	2500.038929	-2155.575077	-0.373421061
189	35.76	38.51508387	2736.386378	-2697.871294	-0.46736575
190	38.61	76.0166129	2880.933638	-2804.917025	-0.485909818

Table E8. Summary of Regression Analysis Output for Cienega Creek at Pantano Dam (Key Reach CC15) - Cienega Well

Regression Statistics	
Multiple R	0.037329048
R Square	0.001393458
Adjusted R Square	-0.003624666
Standard Error	5642.6473
Observations	201

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	8841344.396	8841344.396	0.277685049	0.59880947
Residual	199	6336054241	31839468.55		
Total	200	6344895586			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	730.150838	3293.557839	0.221690607	0.824782071	-5764.602096	7224.903772	-5764.602096	7224.903772
X Variable 1	105.1120268	199.4693449	0.526958299	0.59880947	-288.2328533	498.4569069	-288.2328533	498.4569069

RESIDUAL OUTPUT

Observation	*Actual Depth to Groundwater (ft) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*	*Standard Residuals*
1	13.62	9958.900258	2161.776643	7797.123615	1.385287687
2	14.57	231.0905032	2261.633068	-2030.542565	-0.360759397
3	14.2	550.3602774	2222.741618	-1672.381341	-0.297126145
4	15.3	319.2697742	2338.364848	-2019.095074	-0.358725561
5	15.46	330.8532581	2355.182772	-2024.329514	-0.359655546
6	15.1	232.1040581	2317.342442	-2085.238384	-0.370477012
7	13.85	1279.974968	2185.952409	-905.9774412	-0.160961844
8	14.05	351.5587355	2206.974814	-1855.416079	-0.329645287
9	15.03	38.51508387	2309.984601	-2271.469517	-0.403564046
10	15.65	147.3998323	2375.154057	-2227.754225	-0.395797303
11	18.01	126.2599742	2623.21844	-2496.958466	-0.443625879
12	17.87	110.3326839	2608.502757	-2498.170073	-0.443841141
13	15.41	464.9320839	2349.927171	-1884.995087	-0.334900486
14	14.7	1695.532452	2275.297632	-579.7651801	-0.103004852
15	13.4	657.6522968	2138.651997	-1480.9997	-0.263124038
16	16.9	52.27047097	2506.544091	-2454.27362	-0.436042212
17	18.08	95.56374194	2630.576282	-2535.01254	-0.450386813
18	13.77	5150.6685	2177.543447	2973.125053	0.528224732
19	14.21	352.587269	2223.792739	-1871.20547	-0.332450532
20	14.15	456.5547429	2217.486017	-1760.931274	-0.312858502
21	15.1	33703.61494	2317.342442	31386.2725	5.576289282

22	15.1	255.0486643	2317.342442	-2062.293778	-0.366400524
23	14.74	197.6531793	2279.502113	-2081.848934	-0.36987482
24	13.76	974.6674286	2176.492327	-1201.824898	-0.213524027
25	13.75	590.7318214	2175.441206	-1584.709385	-0.281549775
26	14.64	152.9330143	2268.99091	-2116.057896	-0.375952607
27	15.4	218.8579448	2348.876051	-2130.018106	-0.378432868
28	16.88	103.7187214	2504.44185	-2400.723129	-0.426528083
29	16.7	58.99302857	2485.521685	-2426.528657	-0.431112861
30	15.2	294.0033	2327.853645	-2033.850345	-0.361347079
31	14.25	313.7376621	2227.99722	-1914.259558	-0.340099802
32	13.3	579.6706286	2128.140794	-1548.470166	-0.27511128
33	15.47	1258.411071	2356.233892	-1097.822821	-0.195046342
34	17.25	98.58889286	2543.3333	-2444.744407	-0.43434919
35	13.46	2229.820645	2144.958719	84.86192663	0.015077122
36	14.11	323.3239935	2213.281536	-1889.957542	-0.335782148
37	13.85	375.3048774	2185.952409	-1810.647532	-0.321691415
38	14.91	9518.872665	2297.371157	7221.501507	1.28301892
39	15	185.0461548	2306.83124	-2121.785085	-0.376970136
40	14.35	244.5563032	2238.508422	-1993.952119	-0.3542585
41	13.4	1112.014452	2138.651997	-1026.637545	-0.182399103
42	13.74	662.5752774	2174.390086	-1511.814809	-0.26859885
43	14.45	242.6739871	2249.019625	-2006.345638	-0.356460414
44	15.43	539.3559677	2352.029411	-1812.673444	-0.322051352
45	16.4	173.6074645	2453.988077	-2280.380613	-0.405147249
46	16.4	53.71840645	2453.988077	-2400.269671	-0.426447519
47	15.1	1573.326697	2317.342442	-744.0157457	-0.132186676
48	13.75	201.6974129	2175.441206	-1973.743793	-0.350668158
49	13.68	698.3392839	2168.083364	-1469.744081	-0.261124291
50	15.05	4642.949923	2312.086841	2330.863081	0.414116293
51	16.6	73.84470968	2475.010483	-2401.165773	-0.426606726
52	13.65	969.5376	2164.930004	-1195.392404	-0.212381188
53	14.18	271.5603	2220.639378	-1949.079078	-0.346286064
54	14.16	379.73556	2218.537137	-1838.801577	-0.326693446
55	14.68	5372.70458	2273.195391	3099.509189	0.550678959
56	15.04	257.49602	2311.035721	-2053.539701	-0.364845218
57	14.61	245.67604	2265.837549	-2020.161509	-0.358915031
58	13.59	754.0848	2158.623282	-1404.538482	-0.249539441
59	13.78	707.10412	2178.594567	-1471.490447	-0.261434562
60	15.01	223.83152	2307.88236	-2084.05084	-0.370266025
61	15.73	287.2704	2383.563019	-2096.292619	-0.372440979
62	17.13	207.07408	2530.719857	-2323.645777	-0.41283402
63	16.72	129.72054	2487.623926	-2357.903386	-0.418920449
64	15.43	322.58072	2352.029411	-2029.448691	-0.360565052
65	14.8	189.2693	2285.808834	-2096.539534	-0.372484848
66	14.3	224.87886	2233.252821	-2008.373961	-0.356820779
67	15.8	238.19504	2390.920861	-2152.725821	-0.382467269
68	17.15	79.59784	2532.822097	-2453.224257	-0.435855775
69	14.54	681.9776129	2258.479707	-1576.502095	-0.280091614

70	15.59	171.4355613	2368.847336	-2197.411774	-0.390406466
71	16.31	586.5586645	2444.527995	-1857.96933	-0.330098914
72	15.66	184.6117742	2376.205177	-2191.593403	-0.389372736
73	15.89	107.2920194	2400.380944	-2293.088924	-0.407405091
74	14.18	544.4237419	2220.639378	-1676.215636	-0.297807371
75	14.7	354.3098129	2275.297632	-1920.987819	-0.341295188
76	16.05	159.2729032	2417.198868	-2257.925965	-0.401157811
77	17.32	1174.275677	2550.691142	-1376.415465	-0.244542922
78	18.31	674.882729	2654.752048	-1979.869319	-0.351756459
79	17.96	639.4083097	2617.962839	-1978.554529	-0.351522865
80	16.33	249.0449032	2446.630235	-2197.585332	-0.390437301
81	15.7	161.0104258	2380.409659	-2219.399233	-0.394312901
82	15.7	121.6265806	2380.409659	-2258.783078	-0.401310091
83	16.96	82.82190968	2512.850812	-2430.028903	-0.431734738
84	15.69	434.6461	2379.358538	-1944.712438	-0.345510259
85	17.72	249.26692	2592.735953	-2343.469033	-0.416355948
86	17.28	95.30794	2546.486661	-2451.178721	-0.435492352
87	16.74	400.38312	2489.726166	-2089.343046	-0.371206273
88	20.58	131.06712	2893.356349	-2762.289229	-0.490766268
89	18.28	9323.42068	2651.598688	6671.821992	1.185359283
90	16.1	446.46608	2422.454469	-1975.988389	-0.351066947
91	17.2	45.78372	2538.077699	-2492.293979	-0.442797156
92	17.95	35.45994	2616.911719	-2581.451779	-0.458637511
93	19.17	338.59006	2745.148391	-2406.558331	-0.427564803
94	20.15	59.24952	2848.158178	-2788.908658	-0.495495649
95	20.23	1719.43304	2856.56714	-1137.1341	-0.202030639
96	18.22	806.15256	2645.291966	-1839.139406	-0.326753467
97	18.5	731.34256	2674.723334	-1943.380774	-0.345273666
98	17.84	177.2997	2605.349396	-2428.049696	-0.431383099
99	18.73	38.00348	2698.8991	-2660.89562	-0.47275202
100	16.7	347.9388968	2485.521685	-2137.582789	-0.379776859
101	17.03	294.3652839	2520.208654	-2225.84337	-0.395457808
102	18.95	3734.080819	2722.023746	1012.057074	0.179808641
103	19.11	98.7492	2738.84167	-2640.09247	-0.469055997
104	17.82	21241.21355	2603.247155	18637.96639	3.311342315
105	18.19	18465.08685	2642.138605	15822.94824	2.811207883
106	15.13	852.1100323	2320.495803	-1468.385771	-0.260882965
107	17.6	4365.525484	2580.122509	1785.402974	0.317206303
108	18.5	503.7367548	2674.723334	-2170.986579	-0.385711594
109	19.5	5644.776484	2779.83536	2864.941124	0.509004071
110	20.24	4744.305406	2857.61826	1886.687146	0.335201108
111	21.18	2955.236323	2956.423565	-1.187242762	-0.000210933
112	19.76	37021.9728	2807.164487	34214.80831	6.078825349
113	19.7	28162.20037	2800.857766	25361.3426	4.505861055
114	14.45	24963.85568	2249.019625	22714.83605	4.035665491
115	18.91	117.1379806	2717.819265	-2600.681284	-0.46205395
116	20.2	7772.372884	2853.413779	4918.959105	0.873934263
117	17.33	690.8100194	2551.742262	-1860.932243	-0.330625324

118	17.92	964.3250323	2613.758358	-1649.433326	-0.293049051
119	16.64	7139.914665	2479.214964	4660.699701	0.828050218
120	18.89	2637.26969	2715.717024	-78.44733367	-0.013937463
121	16.09	11816.60148	2421.403349	9395.198135	1.669211999
122	14.58	2345.07631	2262.684189	82.39212114	0.01463832
123	17.96	10617.8557	2617.962839	7999.892858	1.42131299
124	15.4	8092.511419	2348.876051	5743.635369	1.020451611
125	18.6	4102.5804	2685.234536	1417.345864	0.251814883
126	16.55	4693.193284	2469.754881	2223.438403	0.395030526
127	18.02	6105.364761	2624.269561	3481.095201	0.618474011
128	20.92	10984.32817	2929.094438	8055.233729	1.431145209
129	12.7	12122.11587	2065.073578	10057.04229	1.786799536
130	14.2	21677.04213	2222.741618	19454.30051	3.456377543
131	14.75	11850.33838	2280.553233	9569.785148	1.700230263
132	19.8	123.7984839	2811.368968	-2687.570485	-0.47749125
133	17.8	6639.073781	2601.144915	4037.928866	0.717404702
134	15.36	3404.6031	2344.671569	1059.931531	0.188314329
135	15.65	423.57422	2375.154057	-1951.579837	-0.346730365
136	13.82	6675.74516	2182.799048	4492.946112	0.798246025
137	16.55	1477.19826	2469.754881	-992.5566213	-0.176344064
138	16.51	1014.12436	2465.5504	-1451.42604	-0.257869789
139	16.18	2561.79364	2430.863431	130.9302086	0.023261912
140	15.04	415.79398	2311.035721	-1895.241741	-0.336720973
141	14.5	430.60636	2254.275226	-1823.668866	-0.32400487
142	17.61	2979.53268	2581.17363	398.3590503	0.070775059
143	16.34	458.73492	2447.681356	-1988.946436	-0.353369158
144	17.3	289.36508	2548.588901	-2259.223821	-0.401388396
145	16	3256.62892	2411.943267	844.6856534	0.150072346
146	13.16	6383.98616	2113.42511	4270.56105	0.758735648
147	15.84	832.78492	2395.125342	-1562.340422	-0.27757556
148	12.62	543.56946	2056.664616	-1513.095156	-0.268826325
149	20.1	356.24522	2842.902576	-2486.657356	-0.441795717
150	16.7	58.3518	2485.521685	-2427.169885	-0.431226786
151	15.03	303.3424839	2309.984601	-2006.642117	-0.356513088
152	16.97	119.3098839	2513.901933	-2394.592049	-0.425438796
153	16.15	602.3411613	2427.710071	-1825.368909	-0.324306911
154	17.46	124.088071	2565.406826	-2441.318755	-0.433740566
155	18.8	209.0818839	2706.256942	-2497.175058	-0.44366436
156	17.04	279.885929	2521.259774	-2241.373845	-0.398217053
157	17.23	20470.91187	2541.23106	17929.68081	3.185503692
158	16.3	487.9542581	2443.476875	-1955.522617	-0.347430865
159	17.65	163.6167097	2585.378111	-2421.761401	-0.43026588
160	17.5	945.7914581	2569.611307	-1623.819849	-0.288498394
161	19.55	180.7023484	2785.090962	-2604.388613	-0.462712618
162	17.32	180.2679677	2550.691142	-2370.423174	-0.421144796
163	16.2	335.6314452	2432.965672	-2097.334227	-0.372626038
164	18.08	321.1520903	2630.576282	-2309.424192	-0.41030732
165	14.78	344.3190581	2283.706594	-1939.387536	-0.344564202

166	20.63	63.1299871	2898.611951	-2835.481964	-0.503770165
167	19.22	54.58716774	2750.403993	-2695.816825	-0.478956348
168	15.03	637.08196	2309.984601	-1672.902641	-0.297218762
169	16.98	188.37158	2514.953053	-2326.581473	-0.413355595
170	15.2	374.19962	2327.853645	-1953.654025	-0.347098879
171	17.46	352.05586	2565.406826	-2213.350966	-0.393238326
172	18.74	314.65086	2699.95022	-2385.29936	-0.423787796
173	18.41	230.4148	2665.263251	-2434.848451	-0.43259101
174	13.72	17390.48222	2172.287845	15218.19437	2.703763379
175	15.77	248.96768	2387.7675	-2138.79982	-0.379993085
176	17.45	62.99002	2564.355705	-2501.365685	-0.444408894
177	17.87	97.55224	2608.502757	-2510.950517	-0.446111798
178	20.47	196.89992	2881.794026	-2684.894106	-0.477015747
179	19	176.5516	2727.279347	-2550.727747	-0.453178879
180	17.1	416.54208	2527.566496	-2111.024416	-0.375058326
181	19.58	358.04066	2788.244322	-2430.203662	-0.431765787
182	14.65	266.92208	2270.04203	-2003.11995	-0.355887317
183	20.7	50.57156	2905.969792	-2855.398232	-0.507308619
184	19.8	50.42194	2811.368968	-2760.947028	-0.490527804
185	14.38	7381.575097	2241.661783	5139.913314	0.913190425
186	15.61	220.0861935	2370.949576	-2150.863383	-0.382136376
187	14.68	508.9493226	2273.195391	-1764.246069	-0.31344743
188	15.5	1990.766497	2359.387253	-368.6207564	-0.065491561
189	16.9	553.5457355	2506.544091	-1952.998355	-0.346982388
190	16.02	288.2839548	2414.045507	-2125.761552	-0.377676622
191	13.76	1171.379806	2176.492327	-1005.11252	-0.178574827
192	14.6	377.6215742	2264.786429	-1887.164855	-0.335285981
193	15.86	49.95377419	2397.227583	-2347.273809	-0.41703193
194	16.29	107.7264	2442.425754	-2334.699354	-0.41479787
195	19.9	190.9826903	2821.880171	-2630.897481	-0.467422356
196	19.2	165.7886129	2748.301752	-2582.513139	-0.458826079
197	16.75	400.3541613	2490.777287	-2090.423125	-0.371398167
198	16.1	1099.417413	2422.454469	-1323.037056	-0.235059367
199	13.9	344.4638516	2191.20801	-1846.744159	-0.328104577
200	19.4	38.51508387	2769.324158	-2730.809074	-0.485173299
201	19.53	76.0166129	2782.988721	-2706.972108	-0.480938269

Table E9. Summary of Regression Analysis Output for Cienega Creek at Pantano Dam (Key Reach CC15) - Del Lago Well

Regression Statistics	
Multiple R	0.180420006
R Square	0.032551378
Adjusted R Square	0.027615416
Standard Error	5551.220108
Observations	198

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	203223740.7	203223740.7	6.594737993	0.010972656
Residual	196	6039944759	30816044.69		
Total	197	6243168500			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	14399.93565	4679.97275	3.076927243	0.002390631	5170.368476	23629.50283	5170.368476	23629.50283
X Variable 1	-166.0454097	64.65886863	-2.568022195	0.010972656	-293.5618299	-38.52898956	-293.5618299	-38.52898956

RESIDUAL OUTPUT

Observation	*Actual Depth to Groundwater (ft) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*	*Standard Residuals*
1	59.4	9958.900258	4536.838314	5422.061944	0.97922187
2	77.02	231.0905032	1611.118195	-1380.027691	-0.24923236
3	61.77	550.3602774	4143.310693	-3592.950415	-0.648885177
4	67.85	319.2697742	3133.754602	-2814.484828	-0.508294653
5	76.69	330.8532581	1665.91318	-1335.059922	-0.241111202
6	77.69	232.1040581	1499.86777	-1267.763712	-0.228957538
7	58.86	1279.974968	4626.502835	-3346.527867	-0.604381379
8	77.62	351.5587355	1511.490949	-1159.932213	-0.209483219
9	74.89	38.51508387	1964.794917	-1926.279833	-0.347885244
10	77.46	147.3998323	1538.058214	-1390.658382	-0.251152258
11	77.91	126.2599742	1463.33778	-1337.077806	-0.241475631
12	75.92	110.3326839	1793.768145	-1683.435461	-0.304027663
13	65.57	464.9320839	3512.338136	-3047.406052	-0.550360118
14	66.78	1695.532452	3311.42319	-1615.890739	-0.291829117
15	62.6	657.6522968	4005.493003	-3347.840706	-0.604618478
16	76.35	52.27047097	1722.368619	-1670.098148	-0.30161895
17	75.67	95.56374194	1835.279498	-1739.715756	-0.314191858
18	59.78	5150.6685	4473.741058	676.9274418	0.122252782
19	63.08	456.5547429	3925.791206	-3469.236463	-0.626542495
20	69.46	33703.61494	2866.421492	30837.19345	5.569182823
21	77.24	255.0486643	1574.588204	-1319.53954	-0.238308228

22	77.33	197.6531793	1559.644118	-1361.990938	-0.245974931
23	62.37	974.6674286	4043.683447	-3069.016018	-0.554262868
24	77.75	590.7318214	1489.905046	-899.1732241	-0.162390267
25	75.72	152.9330143	1826.977227	-1674.044213	-0.302331608
26	77.5	218.8579448	1531.416398	-1312.558453	-0.237047447
27	77.68	103.7187214	1501.528224	-1397.809503	-0.252443747
28	75.65	58.99302857	1838.600406	-1779.607377	-0.321396266
29	63.7	294.0033	3822.843052	-3528.839752	-0.637306821
30	68.78	313.7376621	2979.332371	-2665.594709	-0.481405167
31	63.75	579.6706286	3814.540782	-3234.870153	-0.584216048
32	75.92	1258.411071	1793.768145	-535.3570739	-0.096685239
33	76.1	98.58889286	1763.879972	-1665.291079	-0.300750796
34	59.34	2229.820645	4546.801039	-2316.980393	-0.418445584
35	76.9	323.3239935	1631.043644	-1307.71965	-0.236173562
36	63.01	375.3048774	3937.414385	-3562.109507	-0.643315324
37	59.65	9518.872665	4495.326962	5023.545703	0.907250022
38	77.37	185.0461548	1553.002301	-1367.956146	-0.247052245
39	75.98	244.5563032	1783.805421	-1539.249117	-0.277987676
40	62.04	1112.014452	4098.478432	-2986.463981	-0.539354009
41	69.5	662.5752774	2859.779676	-2197.204398	-0.396814094
42	75	242.6739871	1946.529922	-1703.855935	-0.307715591
43	77.5	173.6074645	1531.416398	-1357.808933	-0.245219663
44	75.28	53.71840645	1900.037208	-1846.318801	-0.333444318
45	69.1	1573.326697	2926.19784	-1352.871143	-0.2443279
46	75.1	201.6974129	1929.925381	-1728.227968	-0.312117169
47	68.75	698.3392839	2984.313733	-2285.974449	-0.412845924
48	65.18	4642.949923	3577.095846	1065.854077	0.192492752
49	74.69	73.84470968	1998.003999	-1924.15929	-0.347502275
50	61.8	969.5376	4138.329331	-3168.791731	-0.572282316
51	76.93	271.5603	1626.062281	-1354.501981	-0.244622429
52	65.24	379.73556	3567.133121	-3187.397561	-0.57564252
53	59.13	5372.70458	4581.670575	791.0340054	0.142860374
54	77.49	257.49602	1533.076852	-1275.580832	-0.230369306
55	77.86	245.67604	1471.64005	-1225.96401	-0.221408531
56	63.58	754.0848	3842.768501	-3088.683701	-0.557814843
57	72.36	707.10412	2384.889804	-1677.785684	-0.303007316
58	77.6	223.83152	1514.811857	-1290.980337	-0.23315045
59	76.74	287.2704	1657.610909	-1370.340509	-0.24748286
60	77.38	207.07408	1551.341847	-1344.267767	-0.242774135
61	75.75	129.72054	1821.995865	-1692.275325	-0.305624138
62	73.96	322.58072	2119.217148	-1796.636428	-0.324471705
63	77.06	189.2693	1604.476378	-1415.207078	-0.255585741
64	73.74	224.87886	2155.747138	-1930.868278	-0.348713915
65	70.05	238.19504	2768.4547	-2530.25966	-0.45696372
66	76.83	79.59784	1642.666822	-1563.068982	-0.282289533
67	70.47	681.9776129	2698.715628	-2016.738015	-0.364221949
68	67.62	171.4355613	3171.945046	-3000.509485	-0.54189062
69	68.98	586.5586645	2946.123289	-2359.564624	-0.426136276

70	77.63	184.6117742	1509.830495	-1325.21872	-0.239333886
71	78.22	107.2920194	1411.863703	-1304.571684	-0.235605041
72	65.75	544.4237419	3482.449962	-2938.02622	-0.530606172
73	77.12	354.3098129	1594.513654	-1240.203841	-0.223980238
74	77.95	159.2729032	1456.695964	-1297.42306	-0.234314002
75	77.62	1174.275677	1511.490949	-337.2152713	-0.060900921
76	77.39	674.882729	1549.681393	-874.798664	-0.157988233
77	76.72	639.4083097	1660.931818	-1021.523508	-0.184486671
78	76.6	249.0449032	1680.857267	-1431.812363	-0.258584648
79	77.46	161.0104258	1538.058214	-1377.047789	-0.248694191
80	76.45	121.6265806	1705.764078	-1584.137497	-0.286094497
81	75.6	82.82190968	1846.902676	-1764.080767	-0.318592168
82	67.08	434.6461	3261.609567	-2826.963467	-0.51054829
83	65.98	249.26692	3444.259518	-3194.992598	-0.57701418
84	75.5	95.30794	1863.507217	-1768.199277	-0.319335969
85	74.98	400.38312	1949.85083	-1549.46771	-0.279833149
86	79.82	131.06712	1146.191047	-1015.123927	-0.18333091
87	78.54	9323.42068	1358.729172	7964.691508	1.438419589
88	74.05	446.46608	2104.273061	-1657.806981	-0.299399171
89	77.9	45.78372	1464.998234	-1419.214514	-0.256309482
90	78	35.45994	1448.393693	-1412.933753	-0.25517518
91	77.93	338.59006	1460.016872	-1121.426812	-0.202529162
92	77.34	59.24952	1557.983663	-1498.734143	-0.270670691
93	77.12	1719.43304	1594.513654	124.9193864	0.022560383
94	77.18	806.15256	1584.550929	-778.398369	-0.140578384
95	77.77	731.34256	1486.584137	-755.2415773	-0.136396278
96	76.94	177.2997	1624.401827	-1447.102127	-0.261345972
97	76.58	38.00348	1684.178175	-1646.174695	-0.297298386
98	75.57	347.9388968	1851.884039	-1503.945142	-0.271611795
99	74.78	294.3652839	1983.059912	-1688.694629	-0.304977466
100	63.49	3734.080819	3857.712588	-123.6317688	-0.02232784
101	76.4	98.7492	1714.066349	-1615.317149	-0.291725527
102	67.09	21241.21355	3259.949113	17981.26444	3.247408011
103	76.94	18465.08685	1624.401827	16840.68502	3.041419897
104	66.11	852.1100323	3422.673615	-2570.563582	-0.46424259
105	77.1	4365.525484	1597.834562	2767.690922	0.499843696
106	78.15	503.7367548	1423.486882	-919.7501268	-0.166106446
107	78.23	5644.776484	1410.203249	4234.573235	0.764761961
108	77.85	4744.305406	1473.300505	3271.004902	0.590741967
109	77.61	2955.236323	1513.151403	1442.08492	0.260439867
110	76.4	37021.9728	1714.066349	35307.90645	6.376591516
111	77.65	28162.20037	1506.509586	26655.69078	4.814005382
112	67.45	24963.85568	3200.172766	21763.68291	3.930511032
113	71.85	117.1379806	2469.572963	-2352.434982	-0.424848666
114	76.32	7772.372884	1727.349981	6045.022902	1.09172833
115	76.56	690.8100194	1687.499083	-996.6890637	-0.180001582
116	75.57	964.3250323	1851.884039	-887.5590064	-0.160292745
117	61.81	7139.914665	4136.668877	3003.245788	0.542384795

118	77.66	2637.26969	1504.849132	1132.420558	0.204514627
119	59.84	11816.60148	4463.778334	7352.82315	1.327916448
120	62.4	2345.07631	4038.702085	-1693.625775	-0.305868029
121	73.23	10617.8557	2240.430297	8377.425399	1.512959139
122	71.9	8092.511419	2461.270692	5631.240727	1.016999461
123	77.9	4102.5804	1464.998234	2637.582166	0.476346115
124	65.35	4693.193284	3548.868126	1144.325158	0.206664592
125	75.8	6105.364761	1813.693594	4291.671167	0.775073821
126	75.94	10984.32817	1790.447237	9193.880931	1.660410629
127	60.71	21677.04213	4319.318827	17357.7233	3.134796771
128	62.05	11850.33838	4096.817978	7753.520402	1.400282186
129	75.9	123.7984839	1797.089053	-1673.29057	-0.3021955
130	66.75	6639.073781	3316.404552	3322.669228	0.60007252
131	66.31	3404.6031	3389.464533	15.13856726	0.002734018
132	66.37	423.57422	3379.501808	-2955.927588	-0.53383915
133	59.96	6675.74516	4443.852884	2231.892276	0.403078709
134	74.81	1477.19826	1978.07855	-500.8802901	-0.090458748
135	59.19	1014.12436	4571.70785	-3557.58349	-0.642497927
136	60.79	2561.79364	4306.035194	-1744.241554	-0.315009215
137	64.11	415.79398	3754.764434	-3338.970454	-0.603016514
138	63.85	430.60636	3797.936241	-3367.329881	-0.608138213
139	75.2	2979.53268	1913.32084	1066.21184	0.192557363
140	69.72	458.73492	2823.249686	-2364.514766	-0.427030269
141	74.92	289.36508	1959.813555	-1670.448475	-0.301682219
142	69.21	3256.62892	2907.932845	348.6960755	0.062974349
143	59.17	6383.98616	4575.028758	1808.957402	0.326696867
144	62.23	832.78492	4066.929804	-3234.144884	-0.584085065
145	61.4	543.56946	4204.747494	-3661.178034	-0.661207054
146	76.34	356.24522	1724.029073	-1367.783853	-0.247021129
147	70.43	58.3518	2705.357445	-2647.005645	-0.478047991
148	62.68	303.3424839	3992.20937	-3688.866886	-0.666207647
149	74.88	119.3098839	1966.455371	-1847.145488	-0.333593618
150	68.72	602.3411613	2989.295095	-2386.953934	-0.431082773
151	66.34	124.088071	3384.48317	-3260.395099	-0.588825842
152	70.26	209.0818839	2733.585164	-2524.50328	-0.455924121
153	66.14	279.885929	3417.692252	-3137.806323	-0.566686366
154	74.05	20470.91187	2104.273061	18366.63881	3.317006444
155	73.05	487.9542581	2270.318471	-1782.364213	-0.32189415
156	74.3	163.6167097	2062.761709	-1899.144999	-0.342984705
157	74.6	945.7914581	2012.948086	-1067.156628	-0.192727992
158	77.65	180.7023484	1506.509586	-1325.807238	-0.239440172
159	74.62	180.2679677	2009.627178	-1829.35921	-0.330381424
160	67.55	335.6314452	3183.568225	-2847.93678	-0.51433606
161	72.68	321.1520903	2331.755273	-2010.603182	-0.363114001
162	66.15	344.3190581	3416.031798	-3071.71274	-0.554749895
163	77.5	63.1299871	1531.416398	-1468.286411	-0.265171844
164	76.4	54.58716774	1714.066349	-1659.479181	-0.29970117
165	67.77	637.08196	3147.038235	-2509.956275	-0.453296938

166	76.6	188.37158	1680.857267	-1492.485687	-0.269542222
167	69.88	374.19962	2796.68242	-2422.4828	-0.437499269
168	73.15	352.05586	2253.71393	-1901.65807	-0.343438565
169	75.99	314.65086	1782.144967	-1467.494107	-0.265028754
170	75.95	230.4148	1788.786783	-1558.371983	-0.281441257
171	60.53	17390.48222	4349.207001	13041.27522	2.355248251
172	77	248.96768	1614.439103	-1365.471423	-0.246603505
173	77.69	62.99002	1499.86777	-1436.87775	-0.259499455
174	77.15	97.55224	1589.532291	-1491.980051	-0.269450905
175	78.04	196.89992	1441.751877	-1244.851957	-0.224819686
176	76.61	176.5516	1679.196813	-1502.645213	-0.271377028
177	68.71	416.54208	2990.955549	-2574.413469	-0.464937878
178	76	358.04066	1780.484513	-1422.443853	-0.2568927
179	70.26	266.92208	2733.585164	-2466.663084	-0.445478208
180	77.6	50.57156	1514.811857	-1464.240297	-0.264441118
181	76.8	50.42194	1647.648185	-1597.226245	-0.288458318
182	67.88	7381.575097	3128.773239	4252.801857	0.768054041
183	77.02	220.0861935	1611.118195	-1391.032001	-0.251219734
184	62.16	508.9493226	4078.552983	-3569.603661	-0.644668764
185	75.69	1990.766497	1831.95859	158.8079072	0.028680634
186	76.95	553.5457355	1622.741373	-1069.195638	-0.193096236
187	77.33	288.2839548	1559.644118	-1271.360163	-0.229607055
188	58.7	1171.379806	4653.070101	-3481.690294	-0.628791651
189	77.15	377.6215742	1589.532291	-1211.910717	-0.218870513
190	77.33	49.95377419	1559.644118	-1509.690343	-0.272649375
191	77.7	107.7264	1498.207316	-1390.480916	-0.251120208
192	78	190.9826903	1448.393693	-1257.411003	-0.227087843
193	77.1	165.7886129	1597.834562	-1432.045949	-0.258626834
194	66.25	400.3541613	3399.427257	-2999.073096	-0.541631209
195	74.24	1099.417413	2072.724434	-973.3070207	-0.175778796
196	74.4	344.4638516	2046.157168	-1701.693316	-0.307325023
197	77.6	38.51508387	1514.811857	-1476.296773	-0.266618512
198	74.91	76.0166129	1961.474009	-1885.457396	-0.340512731

F. Refined Streamflow Analysis for Incremental Drawdowns

List of Figures and Tables

Tables (provided in electronic format only)

Table F8-B. Refined Streamflow Analysis for Incremental Drawdowns for Key Reach EG2 - Low End of 95% Regression Confidence Interval

Table F8-C. Refined Streamflow Analysis for Incremental Drawdowns for Key Reach EG2 - High End of 95% Regression Confidence Interval

G. Linear Regression Analysis for Temperature versus Streamflow and Groundwater Depth

List of Figures and Tables

Figures

Tables

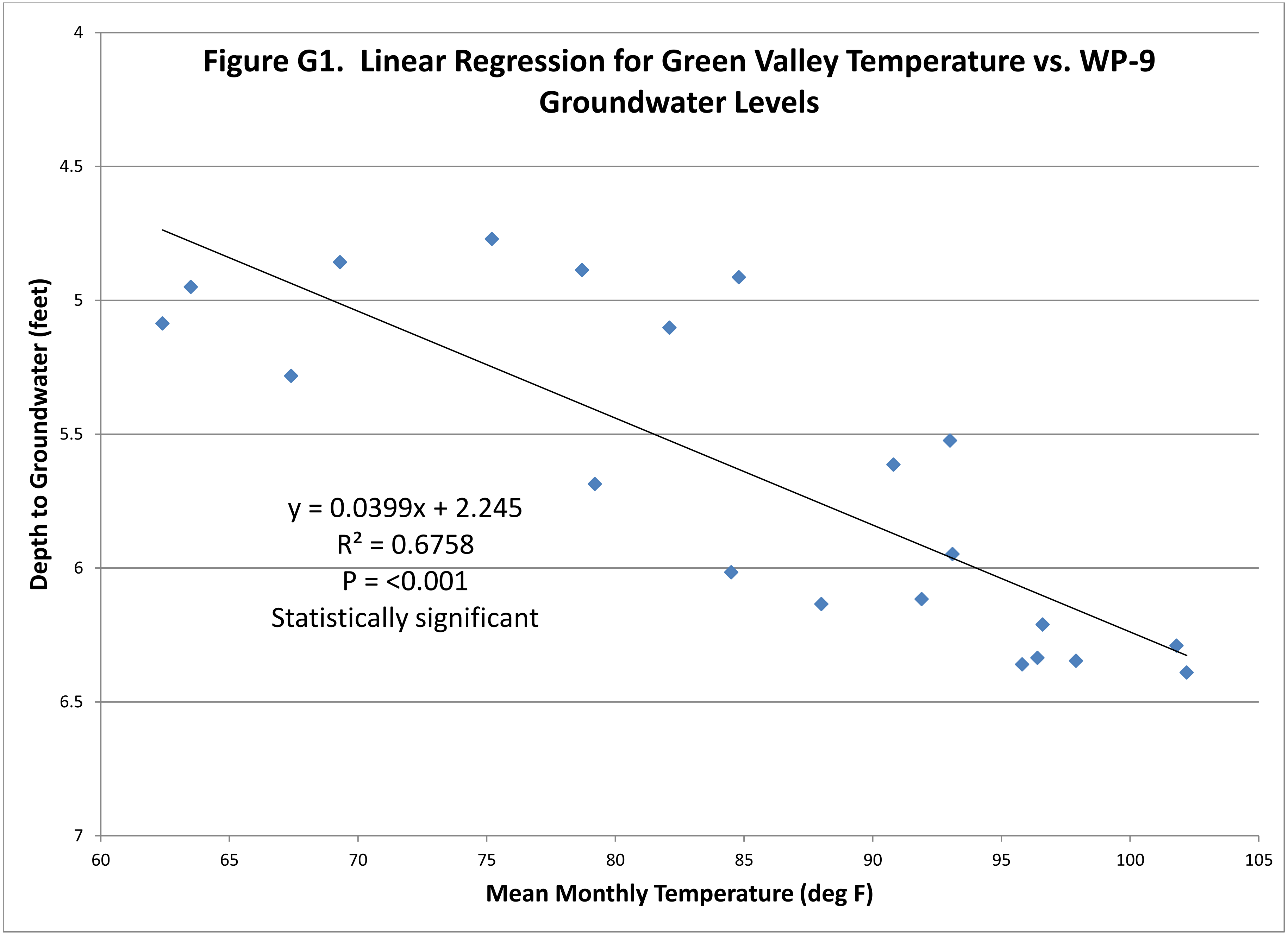
Figure G1. Linear Regression for Green Valley Temperature vs. WP-9 Groundwater Levels
y = 0.0399x + 2.245
R² = 0.6758
P = <0.001
Statistically significant
Depth to Groundwater (feet)
4
4.5
5
5.5
6
6.5
7
Mean Monthly Temperature (deg F)
60
65
70
75
80
85
90
95
100
105

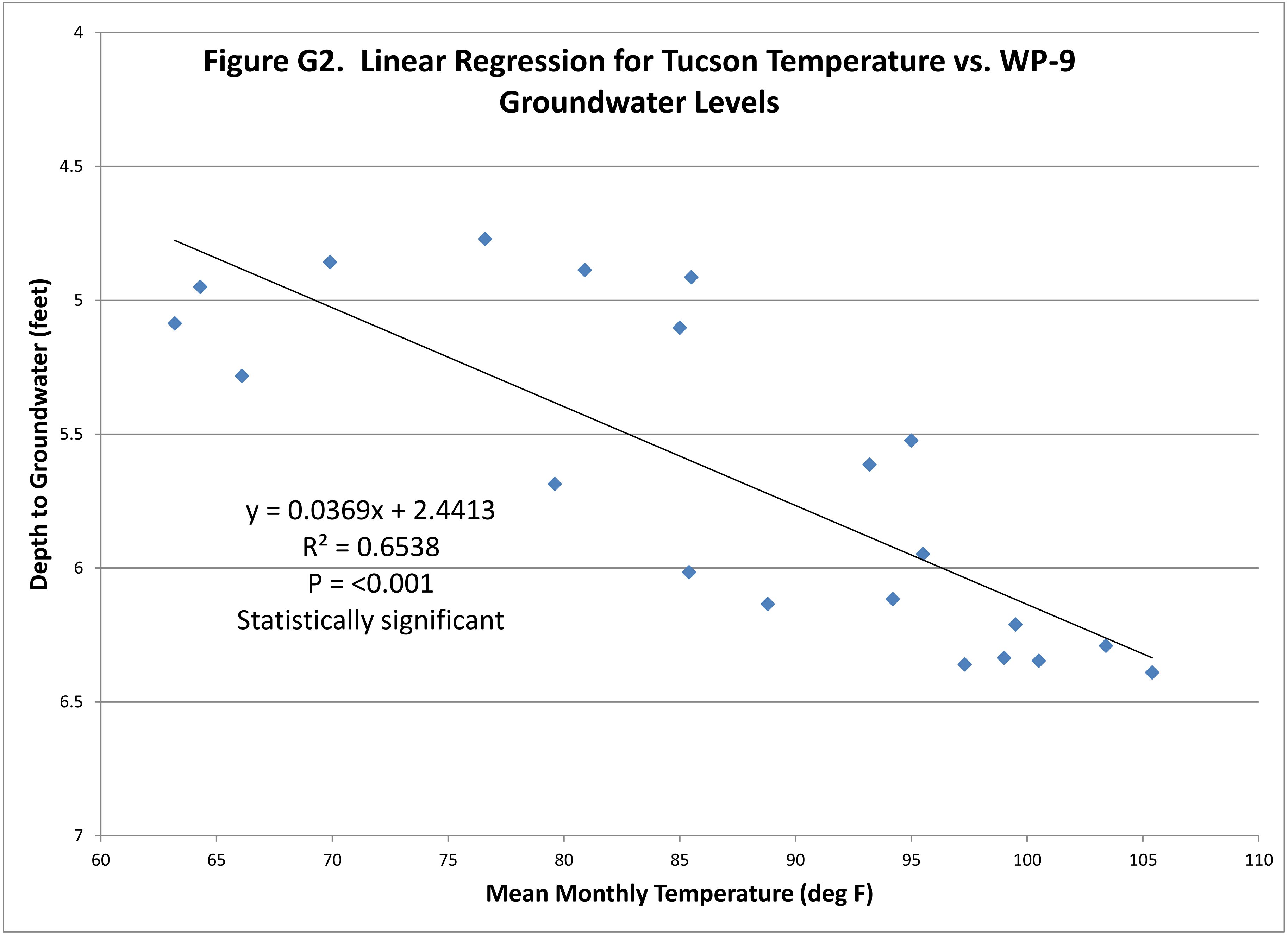
Figure G2. Linear Regression for Tucson Temperature vs. WP-9 Groundwater Levels
Depth to Groundwater (feet)
Mean Monthly Temperature (deg F)
y = 0.0369x + 2.4413
R² = 0.6538
P = <0.001
Statistically significant
4
4.5
5
5.5
6
6.5
7
60
65
70
75
80
85
90
95
100
105
110

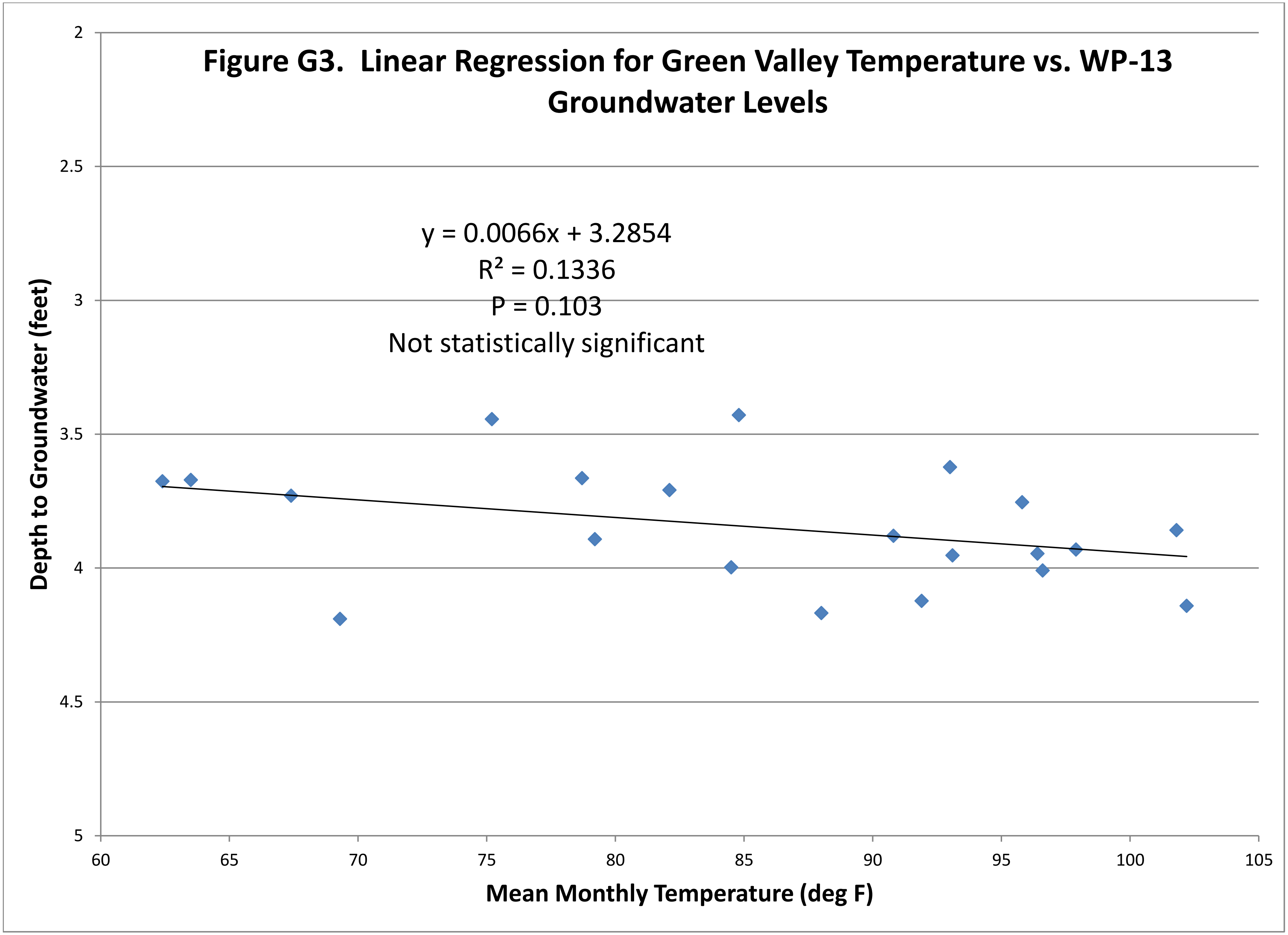

Figure G3. Linear Regression for Green Valley Temperature vs. WP-13 Groundwater Levels
y = 0.0066x + 3.2854
R² = 0.1336
P = 0.103
Not statistically significant
Depth to Groundwater (feet)
2
2.5
3
3.5
4
4.5
5
60
65
70
75
80
85
90
95
100
105
Mean Monthly Temperature (deg F)

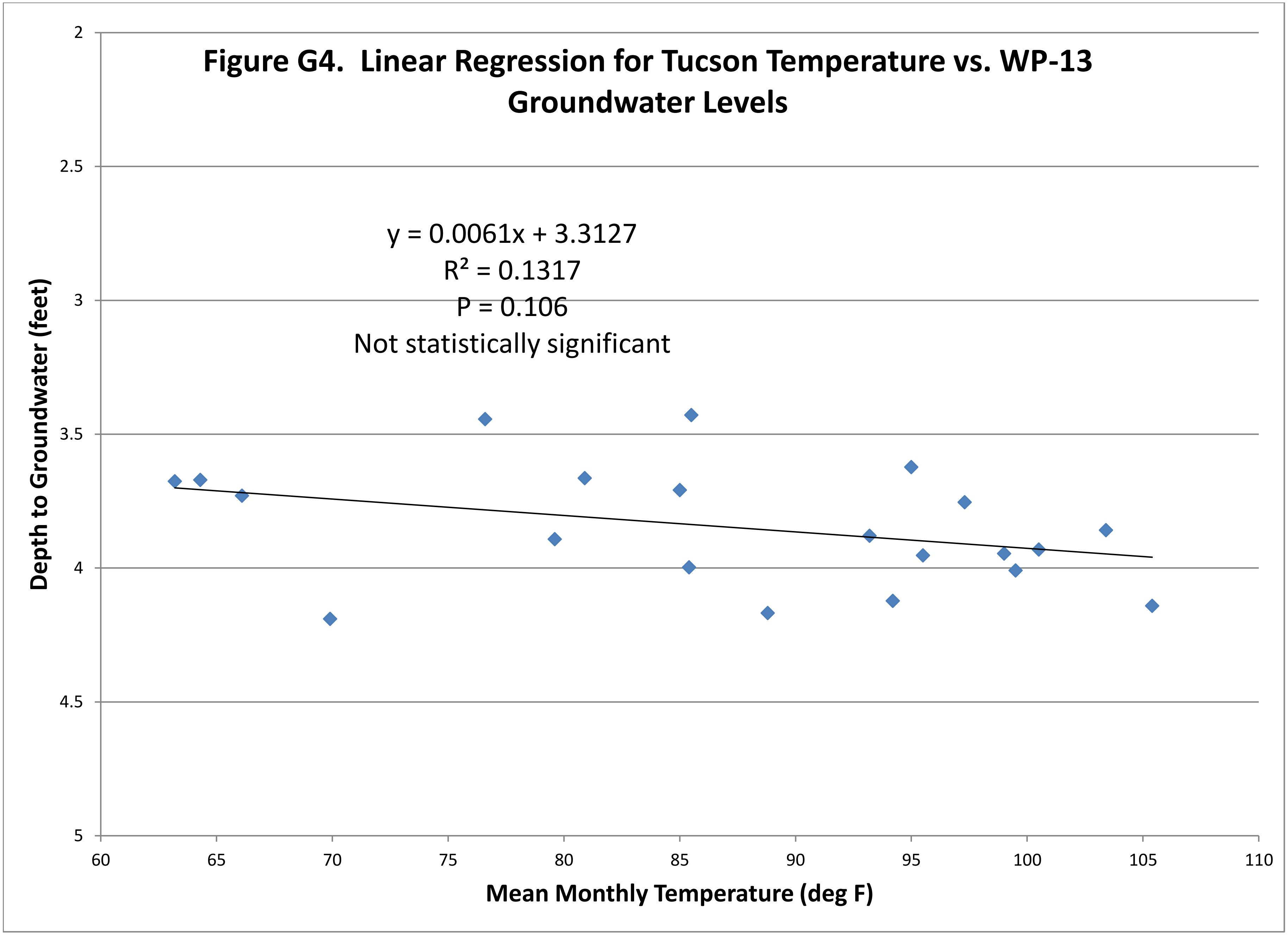
Figure G4. Linear Regression for Tucson Temperature vs. WP-13 Groundwater Levels
y = 0.0061x + 3.3127
R² = 0.1317
P = 0.106
Not statistically significant
Depth to Groundwater (feet)
2
2.5
3
3.5
4
4.5
5
60
65
70
75
80
85
90
95
100
105
110
Mean Monthly Temperature (deg F)

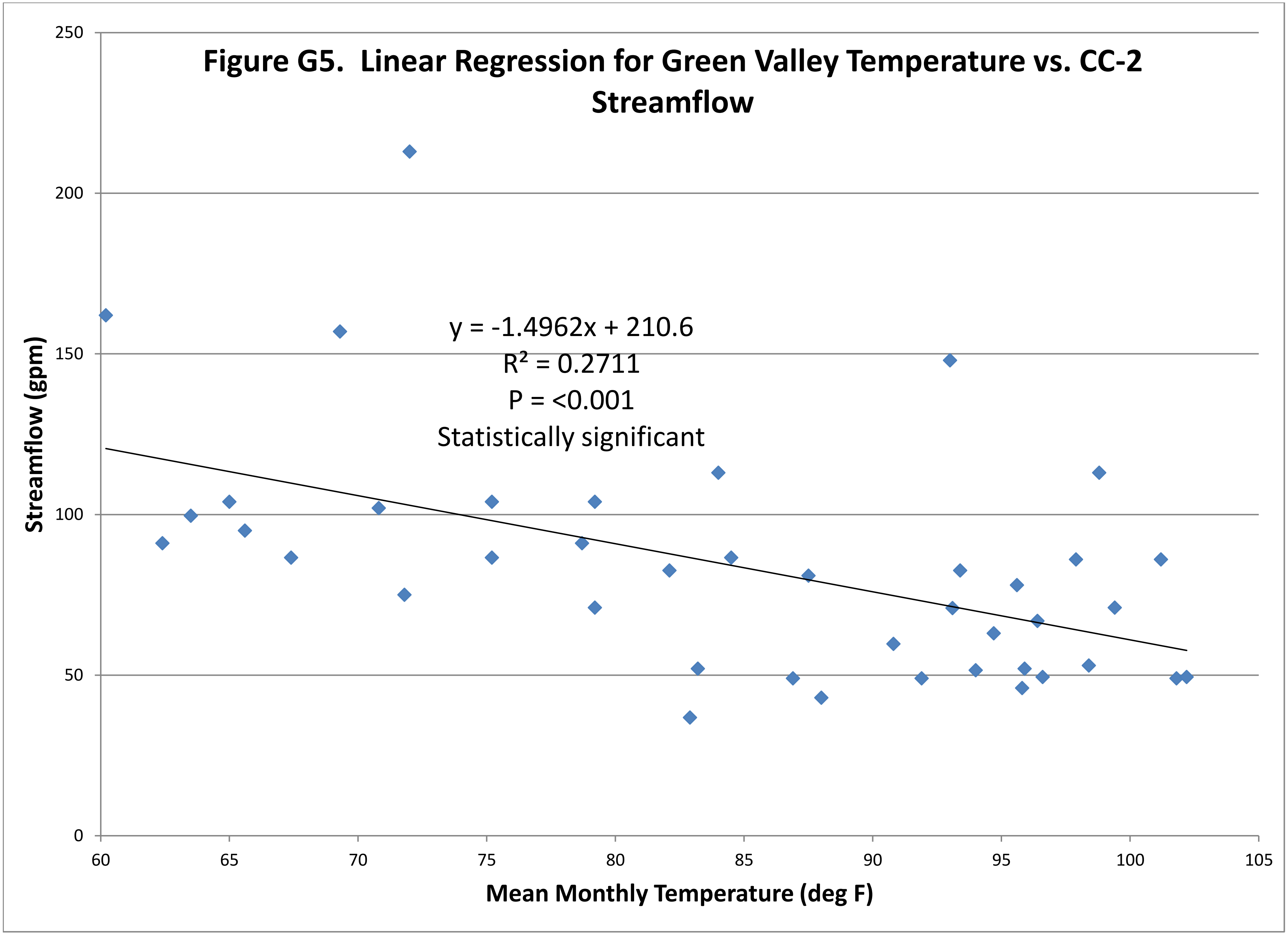
Figure G5. Linear Regression for Green Valley Temperature vs. CC-2 Streamflow
y = -1.4962x + 210.6
R² = 0.2711
P = <0.001
Statistically significant
Streamflow (gpm)
Mean Monthly Temperature (deg F)
0
50
100
150
200
250
60
65
70
75
80
85
90
95
100
105

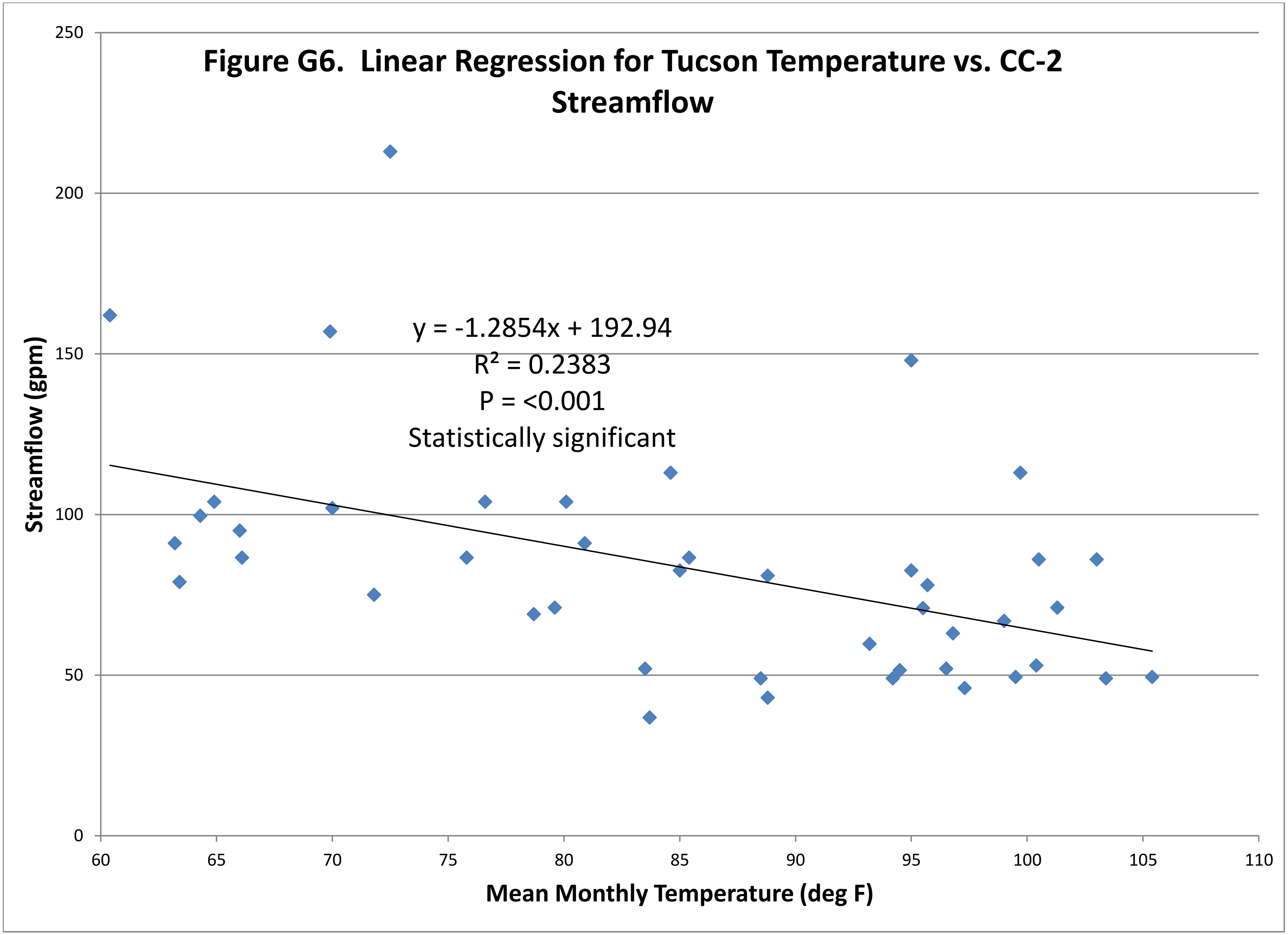
Figure G6. Linear Regression for Tucson Temperature vs. CC-2 Streamflow
y = -1.2854x + 192.94
R² = 0.2383
P = <0.001
Statistically significant
Streamflow (gpm)
Mean Monthly Temperature (deg F)
250
200
150
100
50
0
60
65
70
75
80
85
90
95
100
105
110

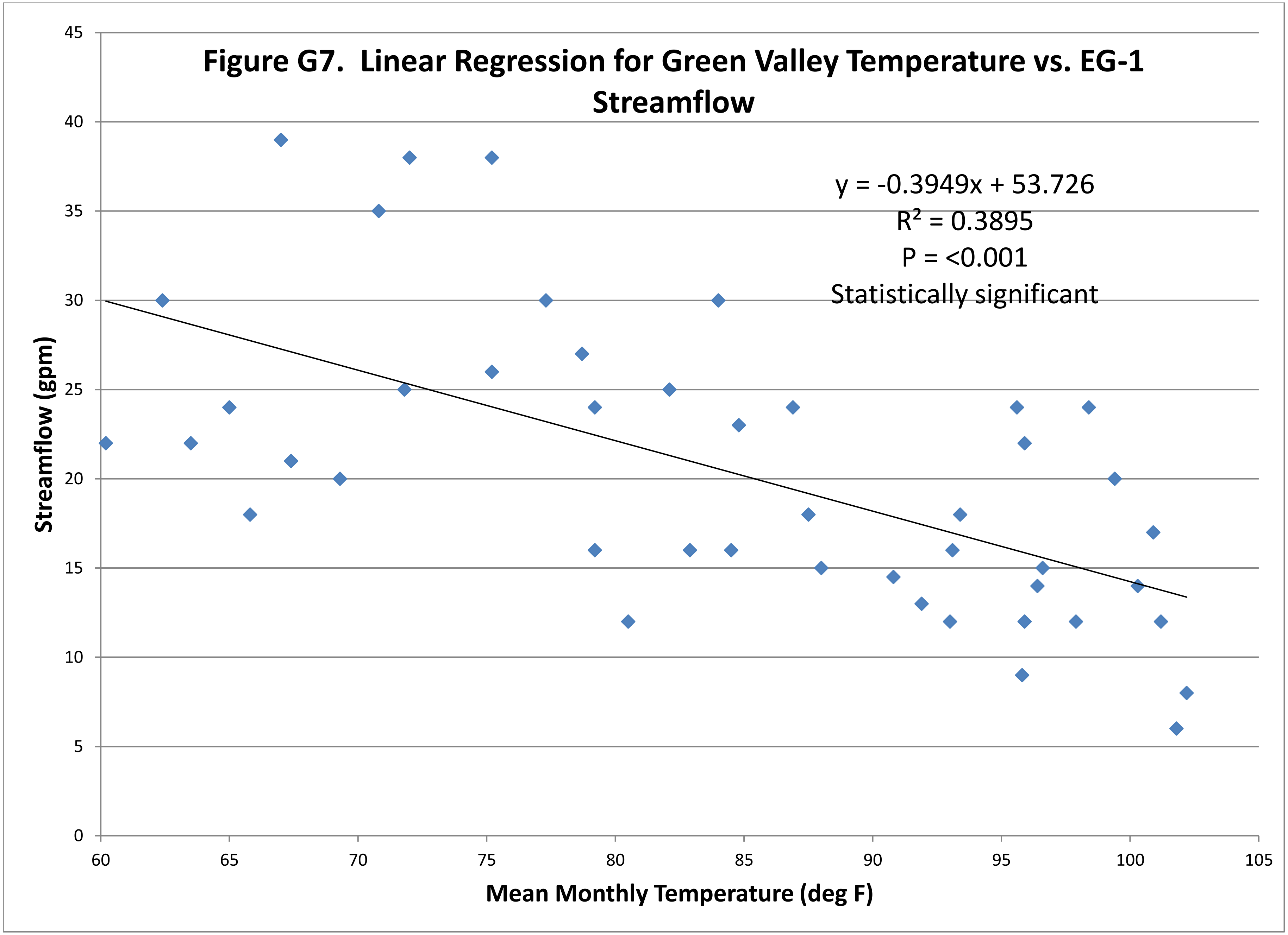
Figure G7. Linear Regression for Green Valley Temperature vs. EG-1 Streamflow
y = -0.3949x + 53.726
R² = 0.3895
P = <0.001
Statistically significant
Streamflow (gpm)
Mean Monthly Temperature (deg F)
45
40
35
30
25
20
15
10
5
0
60
65
70
75
80
85
90
95
100
105

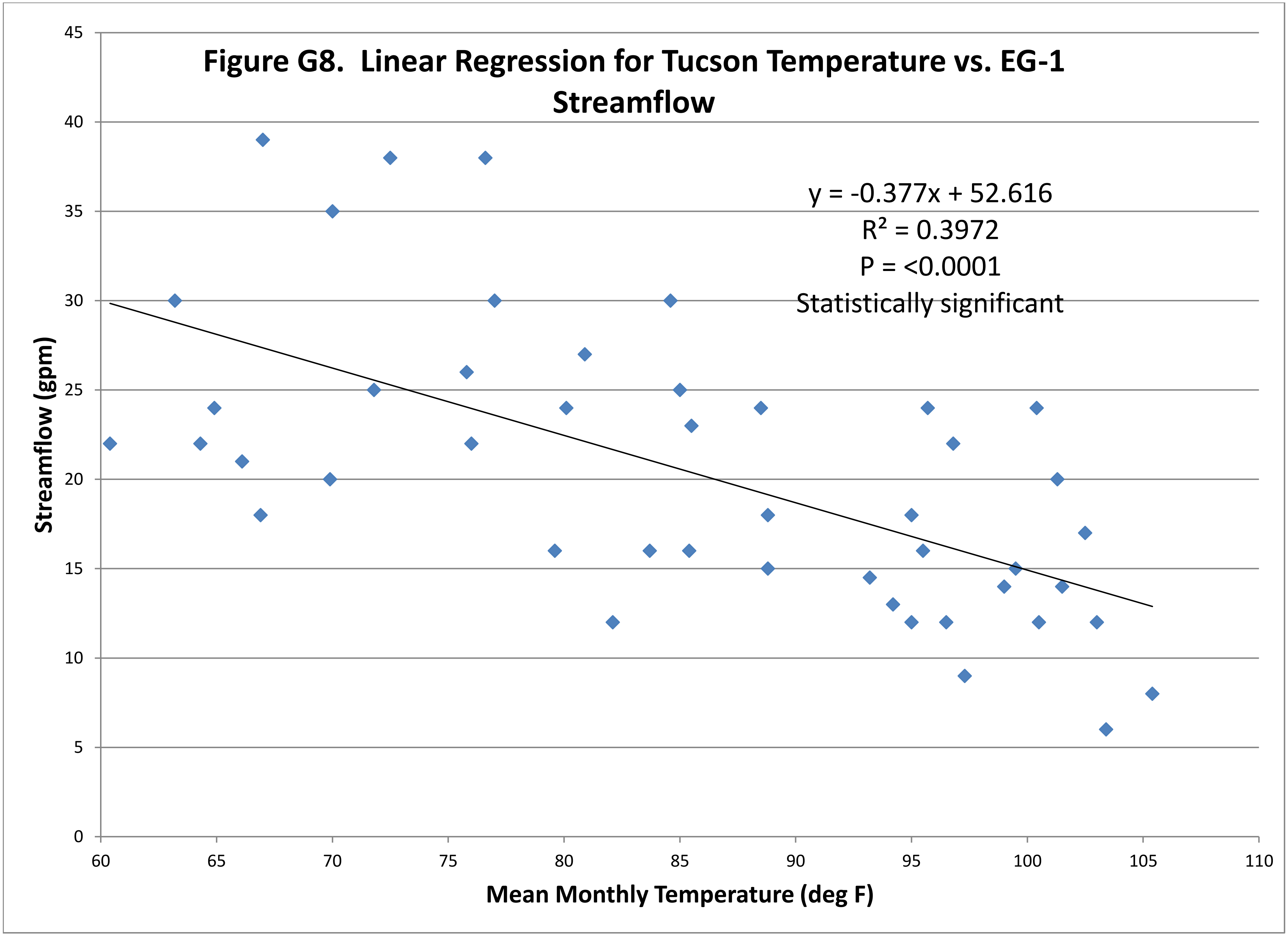
Figure G8. Linear Regression for Tucson Temperature vs. EG-1 Streamflow
y = -0.377x + 52.616
R² = 0.3972
P = <0.0001
Statistically significant
Streamflow (gpm)
Mean Monthly Temperature (deg F)
0
5
10
15
20
25
30
35
40
45
60
65
70
75
80
85
90
95
100
105
110

Table G1. Summary of Regression Analysis Output for Green Valley Temperatures versus WP9 Groundwater Depths

Regression Statistics	
Multiple R	0.822074627
R Square	0.675806692
Adjusted R Square	0.658743886
Standard Error	0.350369674
Observations	21

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.862113129	4.862113129	39.60700855	4.8431E-06
Residual	19	2.332419257	0.122758908		
Total	20	7.194532385			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.245014204	0.547657775	4.099301258	0.00061072	1.098753308	3.3912751	1.098753308	3.3912751
X Variable 1	0.039936766	0.006345807	6.29340993	4.8431E-06	0.026654839	0.053218693	0.026654839	0.053218693

RESIDUAL OUTPUT

Observation	*Actual Mean Monthly Temperature (F) [X]*	*Actual Groundwater Depth (gpm) [Y]*	*Predicted Y*	*Residuals*
1	69.3	4.856875	5.012632064	-0.155757064
2	75.2	4.770561694	5.248258981	-0.477697288
3	84.8	4.91329625	5.631651932	-0.718355682
4	93	5.523437097	5.95913341	-0.435696313
5	101.8	6.290385833	6.310576948	-0.020191114
6	95.8	6.359640562	6.070956354	0.288684208
7	97.9	6.346616532	6.154823562	0.191792971
8	91.9	6.115706667	5.915202968	0.200503699
9	88	6.134093548	5.759449582	0.374643967
10	79.2	5.686002917	5.408006044	0.277996873
11	67.4	5.282324597	4.936752209	0.345572387
12	62.4	5.085678226	4.737068381	0.348609845
13	63.5	4.949676339	4.780998823	0.168677516
14	78.7	4.886646988	5.388037661	-0.501390673
15	82.1	5.101779583	5.523822664	-0.422043081
16	90.8	5.613572984	5.871272526	-0.257699542
17	102.2	6.390190417	6.326551654	0.063638763
18	96.4	6.335418145	6.094918413	0.240499732
19	96.6	6.211083065	6.102905766	0.108177298
20	93.1	5.947477917	5.963127087	-0.01564917
21	84.5	6.015353571	5.619670902	0.395682669

Table G2. Summary of Regression Analysis Output for Tucson Temperatures versus WP9 Groundwater Depths

Regression Statistics	
Multiple R	0.808558658
R Square	0.653767103
Adjusted R Square	0.635544319
Standard Error	0.362083429
Observations	21

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.703548598	4.703548598	35.87635689	9.17803E-06
Residual	19	2.490983787	0.13110441		
Total	20	7.194532385			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.441252738	0.542811706	4.497420948	0.000246624	1.30513478	3.577370696	1.30513478	3.577370696
X Variable 1	0.036946623	0.006168372	5.989687545	9.17803E-06	0.024036071	0.049857174	0.024036071	0.049857174

RESIDUAL OUTPUT

Observation	*Actual Mean Monthly Temperature (F) [X]*	*Actual Groundwater Depth (gpm) [Y]*	*Predicted Y*	*Residuals*
1	69.9	4.856875	5.02382167	-0.16694667
2	76.6	4.770561694	5.271364043	-0.50080235
3	85.5	4.91329625	5.600188986	-0.686892736
4	95	5.523437097	5.951181902	-0.427744806
5	103.4	6.290385833	6.261533534	0.0288523
6	97.3	6.359640562	6.036159135	0.323481427
7	100.5	6.346616532	6.154388328	0.192228205
8	94.2	6.115706667	5.921624604	0.194082063
9	88.8	6.134093548	5.722112841	0.411980707
10	79.6	5.686002917	5.382203911	0.303799005
11	66.1	5.282324597	4.883424504	0.398900093
12	63.2	5.085678226	4.776279298	0.309398928
13	64.3	4.949676339	4.816920583	0.132755756
14	80.9	4.886646988	5.430234521	-0.543587533
15	85	5.101779583	5.581715675	-0.479936091
16	93.2	5.613572984	5.884677981	-0.271104997
17	105.4	6.390190417	6.335426779	0.054763637
18	99	6.335418145	6.098968393	0.236449752

19	99.5	6.211083065	6.117441705	0.09364136
20	95.5	5.947477917	5.969655214	-0.022177297
21	85.4	6.015353571	5.596494324	0.418859248

Table G3. Summary of Regression Analysis Output for Green Valley Temperatures versus WP13 Groundwater Depths

Regression Statistics	
Multiple R	0.365463116
R Square	0.133563289
Adjusted R Square	0.087961357
Standard Error	0.211992294
Observations	21

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.131626706	0.131626706	2.928895405	0.103283405
Residual	19	0.853873925	0.044940733		
Total	20	0.985500631			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.285441075	0.331362092	9.914957534	6.0382E-09	2.591892245	3.978989905	2.591892245	3.978989905
X Variable 1	0.006571014	0.003839551	1.711401591	0.103283405	-0.001465259	0.014607286	-0.001465259	0.014607286

RESIDUAL OUTPUT

Observation	*Actual Mean Monthly Temperature (F) [X]*	*Actual Groundwater Depth (gpm) [Y]*	*Predicted Y*	*Residuals*
1	69.3	4.189827083	3.740812318	0.449014765
2	75.2	3.443986828	3.779581299	-0.335594471
3	84.8	3.428731667	3.842663029	-0.413931363
4	93	3.623207796	3.896545341	-0.273337545
5	101.8	3.85815375	3.954370261	-0.096216511
6	95.8	3.754342169	3.914944179	-0.160602011
7	97.9	3.931038153	3.928743308	0.002294845
8	91.9	4.122484583	3.889317226	0.233167357
9	88	4.167699731	3.863690273	0.304009458
10	79.2	3.892390833	3.805865353	0.08652548
11	67.4	3.729975538	3.728327393	0.001648145
12	62.4	3.67625578	3.695472325	-0.019216545
13	63.5	3.670476042	3.70270044	-0.032224398
14	78.7	3.663961022	3.802579846	-0.138618825
15	82.1	3.708639583	3.824921293	-0.116281709
16	90.8	3.879427554	3.882089111	-0.002661557
17	102.2	4.140845	3.956998666	0.183846334
18	96.4	3.94609207	3.918886787	0.027205283

19	96.6	4.009331183	3.92020099	0.089130193
20	93.1	3.952254167	3.897202442	0.055051724
21	84.5	3.997483077	3.840691725	0.156791352

Table G4. Summary of Regression Analysis Output for Tucson Temperatures versus WP13 Groundwater Depths

Regression Statistics	
Multiple R	0.362841267
R Square	0.131653785
Adjusted R Square	0.085951352
Standard Error	0.212225766
Observations	21

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.129744888	0.129744888	2.880673475	0.105969071
Residual	19	0.855755743	0.045039776		
Total	20	0.985500631			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.312742577	0.318154936	10.41235637	2.73433E-09	2.646836642	3.978648511	2.646836642	3.978648511
X Variable 1	0.006136307	0.003615431	1.697254688	0.105969071	-0.001430877	0.01370349	-0.001430877	0.01370349

RESIDUAL OUTPUT

Observation	*Actual Mean Monthly Temperature (F) [X]*	*Actual Groundwater Depth (gpm) [Y]*	*Predicted Y*	*Residuals*
1	69.9	4.189827083	3.741670413	0.44815667
2	76.6	3.443986828	3.782783668	-0.33879684
3	85.5	3.428731667	3.837396798	-0.408665131
4	95	3.623207796	3.895691711	-0.272483915
5	103.4	3.85815375	3.947236687	-0.089082937
6	97.3	3.754342169	3.909805216	-0.155463048
7	100.5	3.931038153	3.929441398	0.001596755
8	94.2	4.122484583	3.890782666	0.231701918
9	88.8	4.167699731	3.85764661	0.310053122
10	79.6	3.892390833	3.801192588	0.091198245
11	66.1	3.729975538	3.718352448	0.01162309
12	63.2	3.67625578	3.700557159	-0.024301379
13	64.3	3.670476042	3.707307096	-0.036831054
14	80.9	3.663961022	3.809169787	-0.145208765
15	85	3.708639583	3.834328644	-0.125689061
16	93.2	3.879427554	3.884646359	-0.005218805
17	105.4	4.140845	3.9595093	0.1813357
18	99	3.94609207	3.920236938	0.025855132
19	99.5	4.009331183	3.923305091	0.086026092
20	95.5	3.952254167	3.898759864	0.053494302
21	85.4	3.997483077	3.836783167	0.16069991

Table G5. Summary of Regression Analysis Output for Green Valley Temperatures versus CC-2 Streamflow

Regression Statistics	
Multiple R	0.520647625
R Square	0.271073949
Adjusted R Square	0.252850798
Standard Error	31.16352081
Observations	42

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	14446.32359	14446.32359	14.87525102	0.000408176
Residual	40	38846.60117	971.1650293		
Total	41	53292.92476			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	210.5960256	33.28159546	6.327702224	1.63636E-07	143.3314121	277.8606391	143.3314121	277.8606391
X Variable 1	-1.496180921	0.387928745	-3.856844697	0.000408176	-2.28021416	-0.712147683	-2.28021416	-0.712147683

RESIDUAL OUTPUT

Observation	*Actual Mean Monthly Temperature (F) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*
1	83.2	52	86.11377294	-34.11377294
2	94	51.5	69.95501899	-18.45501899
3	98.8	113	62.77335057	50.22664943
4	93.4	82.6	70.85272754	11.74727246
5	72	213	102.8709993	110.1290007
6	94.7	63	68.90769234	-5.907692344
7	95.9	52	67.11227524	-15.11227524
8	82.9	36.8	86.56262722	-49.76262722
9	65.6	95	112.4465572	-17.44655716
10	65	104	113.3442657	-9.344265712
11	79.2	104	92.09849663	11.90150337
12	84	113	84.9168282	28.0831718
13	87.5	81	79.68019498	1.319805021
14	101.2	86	59.18251635	26.81748365
15	98.4	53	63.37182293	-10.37182293
16	99.4	71	61.87564201	9.124357987
17	95.6	78	67.56112951	10.43887049
18	86.9	49	80.57790353	-31.57790353
19	71.8	75	103.1702354	-28.17023545
20	60.2	162	120.5259341	41.47406587
21	70.8	102	104.6664164	-2.666416367

22	69.3	157	106.9106877	50.08931225
23	75.2	104	98.08322031	5.916779687
24	93	148	71.45119991	76.54880009
25	101.8	49	58.2848078	-9.284807802
26	95.8	46	67.26189333	-21.26189333
27	97.9	86	64.1199134	21.8800866
28	91.9	49	73.09699892	-24.09699892
29	88	43	78.93210452	-35.93210452
30	79.2	71	92.09849663	-21.09849663
31	67.4	86.6	109.7534315	-23.1534315
32	62.4	91.1	117.2343361	-26.13433611
33	63.5	99.6	115.5885371	-15.98853709
34	78.7	91.1	92.84658709	-1.746587087
35	82.1	82.6	87.75957195	-5.159571954
36	90.8	59.7	74.74279794	-15.04279794
37	102.2	49.4	57.68633543	-8.286335433
38	96.4	66.9	66.36418478	0.535815222
39	96.6	49.4	66.06494859	-16.66494859
40	93.1	70.9	71.30158182	-0.401581818
41	84.5	86.6	84.16873774	2.431262257
42	75.2	86.6	98.08322031	-11.48322031

Table G6. Summary of Regression Analysis Output for Tucson Temperatures versus CC-2 Streamflow

Regression Statistics	
Multiple R	0.488116491
R Square	0.238257708
Adjusted R Square	0.220120987
Standard Error	31.15516191
Observations	44

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	12751.11633	12751.11633	13.13675749	0.000775906
Residual	42	40767.05276	970.6441134		
Total	43	53518.16909			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	192.9410274	30.65484306	6.293981899	1.4994E-07	131.0770495	254.8050053	131.0770495	254.8050053
X Variable 1	-1.285388784	0.354642202	-3.624466511	0.000775906	-2.001085722	-0.569691845	-2.001085722	-0.569691845

RESIDUAL OUTPUT

Observation	*Actual Mean Monthly Temperature (F) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*
1	83.5	52	85.61106394	-33.61106394
2	94.5	51.5	71.47178732	-19.97178732
3	99.7	113	64.78776565	48.21223435
4	95	82.6	70.82909293	11.77090707
5	72.5	213	99.75034056	113.2496594
6	96.8	63	68.51539312	-5.515393118
7	96.5	52	68.90100975	-16.90100975
8	83.7	36.8	85.35398618	-48.55398618
9	78.7	69	91.7809301	-22.7809301
10	63.4	79	111.4473785	-32.44737849
11	66	95	108.1053677	-13.10536765
12	64.9	104	109.5192953	-5.519295313
13	80.1	104	89.9813858	14.0186142
14	84.6	113	84.19713628	28.80286372
15	88.8	81	78.79850339	2.201496613
16	103	86	60.54598266	25.45401734
17	100.4	53	63.8879935	-10.8879935
18	101.3	71	62.73114359	8.268856407
19	95.7	78	69.92932078	8.07067922
20	88.5	49	79.18412002	-30.18412002
21	71.8	75	100.6501127	-25.65011271

22	60.4	162	115.3035448	46.69645516
23	70	102	102.9638125	-0.963812517
24	69.9	157	103.0923514	53.9076486
25	76.6	104	94.48024655	9.519753454
26	95	148	70.82909293	77.17090707
27	103.4	49	60.03182715	-11.03182715
28	97.3	46	67.87269873	-21.87269873
29	100.5	86	63.75945462	22.24054538
30	94.2	49	71.85740396	-22.85740396
31	88.8	43	78.79850339	-35.79850339
32	79.6	71	90.6240802	-19.6240802
33	66.1	86.6	107.9768288	-21.37682877
34	63.2	91.1	111.7044562	-20.60445624
35	64.3	99.6	110.2905286	-10.69052858
36	80.9	91.1	88.95307478	2.146925224
37	85	82.6	83.68298076	-1.082980764
38	93.2	59.7	73.14279274	-13.44279274
39	105.4	49.4	57.46104958	-8.06104958
40	99	66.9	65.68753779	1.212462205
41	99.5	49.4	65.0448434	-15.6448434
42	95.5	70.9	70.18639854	0.713601463
43	85.4	86.6	83.16882525	3.431174749
44	75.8	86.6	95.50855757	-8.908557572

Table G7. Summary of Regression Analysis Output for Green Valley Temperatures versus EG-1 Streamflow

Regression Statistics	
Multiple R	0.624085066
R Square	0.389482169
Adjusted R Square	0.37528408
Standard Error	6.341279675
Observations	45

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1103.091399	1103.091399	27.43201333	4.63353E-06
Residual	43	1729.108601	40.21182792		
Total	44	2832.2			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	53.72615203	6.439049127	8.343802163	1.55333E-10	40.74057189	66.71173218	40.74057189	66.71173218
X Variable 1	-0.394869885	0.075391984	-5.237557955	4.63353E-06	-0.546912311	-0.242827459	-0.546912311	-0.242827459

RESIDUAL OUTPUT

Observation	*Actual Mean Monthly Temperature (F) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*
1	100.3	14	14.12070258	-0.120702576
2	100.9	17	13.88378065	3.116219355
3	95.9	22	15.85813007	6.14186993
4	93.4	18	16.84530478	1.154695218
5	77.3	30	23.20270993	6.797290071
6	72	38	25.29552032	12.70447968
7	80.5	12	21.9391263	-9.939126297
8	95.9	12	15.85813007	-3.85813007
9	82.9	16	20.99143857	-4.991438573
10	65	24	28.05960951	-4.059609513
11	67	39	27.26986974	11.73013026
12	65.8	18	27.74371361	-9.743713605
13	79.2	24	22.45245715	1.547542852
14	84	30	20.5570817	9.4429183
15	87.5	18	19.1750371	-1.175037103
16	101.2	12	13.76531968	-1.76531968
17	98.4	24	14.87095536	9.129044643
18	99.4	20	14.47608547	5.523914528
19	95.6	24	15.97659104	8.023408965
20	86.9	24	19.41195903	4.588040966
21	71.8	25	25.3744943	-0.374494296

22	60.2	22	29.95498496	-7.954984961
23	70.8	35	25.76936418	9.230635819
24	69.3	20	26.36166901	-6.361669008
25	75.2	38	24.03193669	13.96806331
26	84.8	23	20.24118579	2.758814208
27	93	12	17.00325274	-5.003252736
28	101.8	6	13.52839775	-7.528397749
29	95.8	9	15.89761706	-6.897617058
30	97.9	12	15.0683903	-3.0683903
31	91.9	13	17.43760961	-4.437609609
32	88	15	18.97760216	-3.97760216
33	79.2	16	22.45245715	-6.452457148
34	67.4	21	27.11192179	-6.11192179
35	62.4	30	29.08627121	0.913728786
36	63.5	22	28.65191434	-6.651914341
37	78.7	27	22.64989209	4.35010791
38	82.1	25	21.30733448	3.692665519
39	90.8	14.5	17.87196648	-3.371966483
40	102.2	8	13.37044979	-5.370449795
41	96.4	14	15.66069513	-1.660695127
42	96.6	15	15.58172115	-0.58172115
43	93.1	16	16.96376575	-0.963765747
44	84.5	16	20.35964676	-4.359646758
45	75.2	26	24.03193669	1.968063313

Table G8. Summary of Regression Analysis Output for Tucson Temperatures versus EG-1 Streamflow

Regression Statistics	
Multiple R	0.630207878
R Square	0.39716197
Adjusted R Square	0.383461105
Standard Error	6.232121969
Observations	46

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1125.878636	1125.878636	28.98809593	2.68739E-06
Residual	44	1708.931146	38.83934423		
Total	45	2834.809783			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	52.61610686	6.053352734	8.692060281	4.18577E-11	40.41637605	64.81583768	40.41637605	64.81583768
X Variable 1	-0.376953249	0.070012832	-5.384059429	2.68739E-06	-0.51805484	-0.235851657	-0.51805484	-0.235851657

RESIDUAL OUTPUT

Observation	*Actual Mean Monthly Temperature (F) [X]*	*Actual Streamflow (gpm) [Y]*	*Predicted Y*	*Residuals*
1	101.5	14	14.35535213	-0.355352127
2	76	22	23.96765997	-1.967659967
3	102.5	17	13.97839888	3.021601122
4	96.8	22	16.1270324	5.872967605
5	95	18	16.80554824	1.194451757
6	77	30	23.59070672	6.409293282
7	72.5	38	25.28699634	12.71300366
8	82.1	12	21.66824515	-9.66824515
9	96.5	12	16.24011837	-4.24011837
10	83.7	16	21.06511995	-5.065119952
11	64.9	24	28.15184103	-4.151841027
12	67	39	27.3602392	11.6397608
13	66.9	18	27.39793453	-9.397934529
14	80.1	24	22.42215165	1.577848352
15	84.6	30	20.72586203	9.274137971
16	88.8	18	19.14265838	-1.142658384
17	103	12	13.78992225	-1.789922254
18	100.4	24	14.7700007	9.2299993
19	101.3	20	14.43074278	5.569257223
20	95.7	24	16.54168097	7.458319031
21	88.5	24	19.25574436	4.744255641

22	71.8	25	25.55086361	-0.550863611
23	60.4	22	29.84813065	-7.848130645
24	70	35	26.22937946	8.770620541
25	69.9	20	26.26707478	-6.267074783
26	76.6	38	23.74148802	14.25851198
27	85.5	23	20.3866041	2.613395895
28	95	12	16.80554824	-4.805548243
29	103.4	6	13.63914095	-7.639140955
30	97.3	9	15.93855577	-6.938555771
31	100.5	12	14.73230538	-2.732305376
32	94.2	13	17.10711084	-4.107110842
33	88.8	15	19.14265838	-4.142658384
34	79.6	16	22.61062827	-6.610628272
35	66.1	21	27.69949713	-6.699497128
36	63.2	30	28.79266155	1.207338451
37	64.3	22	28.37801298	-6.378012976
38	80.9	27	22.12058905	4.879410951
39	85	25	20.57508073	4.424919271
40	93.2	14.5	17.48406409	-2.984064091
41	105.4	8	12.88523446	-4.885234457
42	99	14	15.29773525	-1.297735249
43	99.5	15	15.10925862	-0.109258624
44	95.5	16	16.61707162	-0.617071619
45	85.4	16	20.42429943	-4.42429943
46	75.8	26	24.04305062	1.956949383

H. Refined Streamflow Analysis

List of Figures and Tables

Figures

Tables (provided in electronic format only)

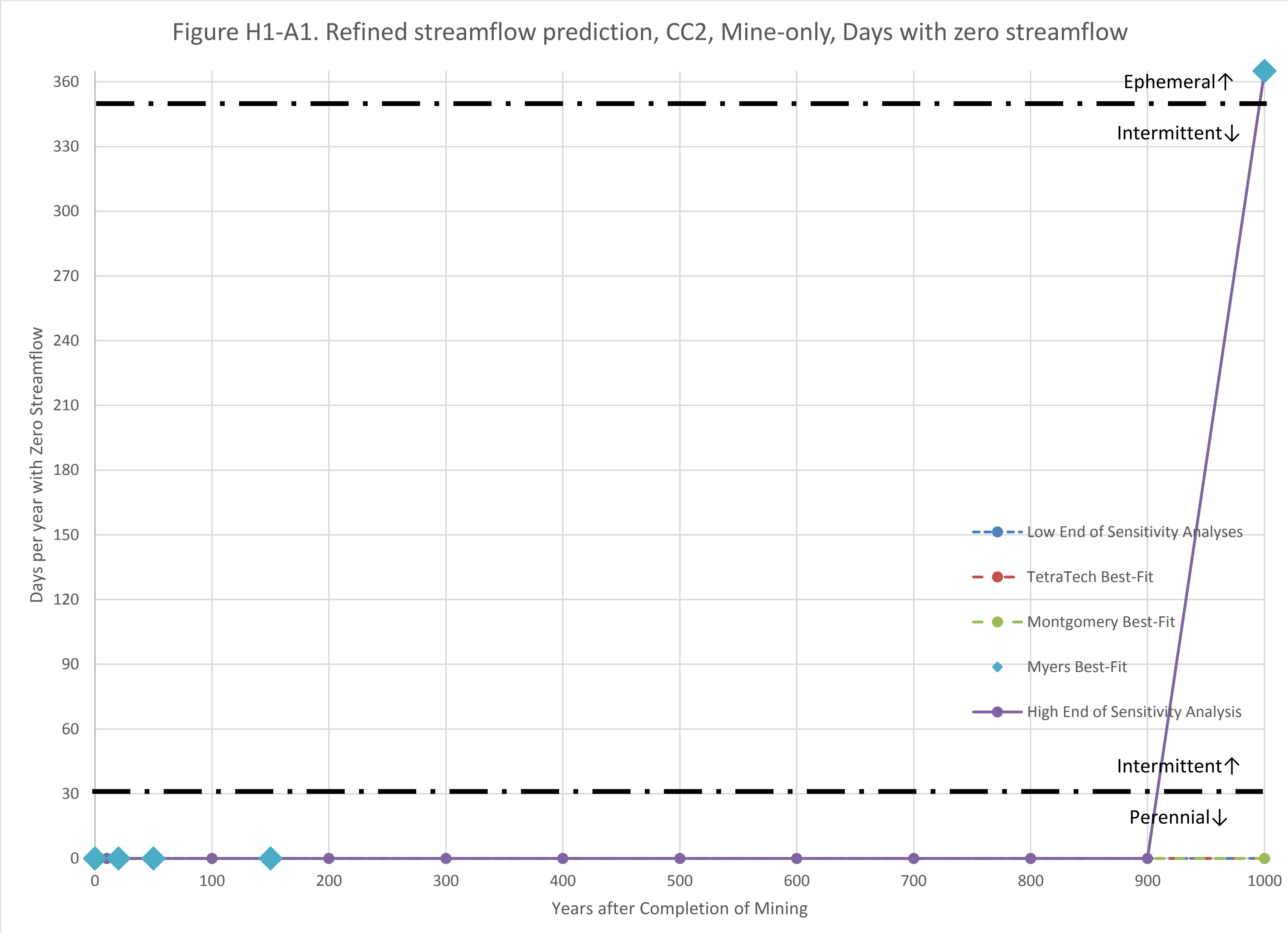

Figure H1-A1. Refined streamflow prediction, CC2, Mine-only, Days with zero streamflow
Days per year with Zero Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

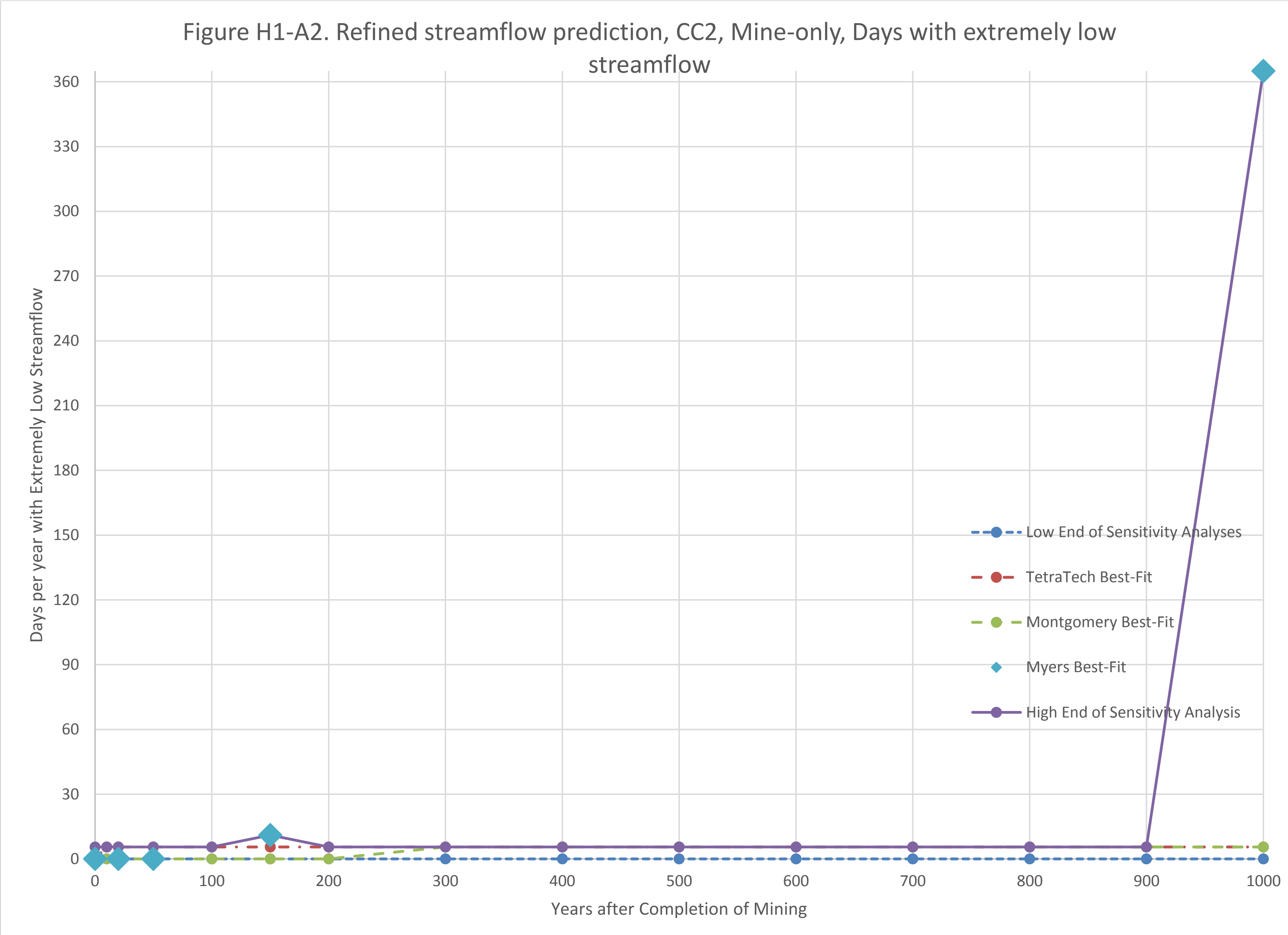
Figure H1-A2. Refined streamflow prediction, CC2, Mine-only, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
0
30
60
90
120
150
180
210
240
270
300
330
360
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

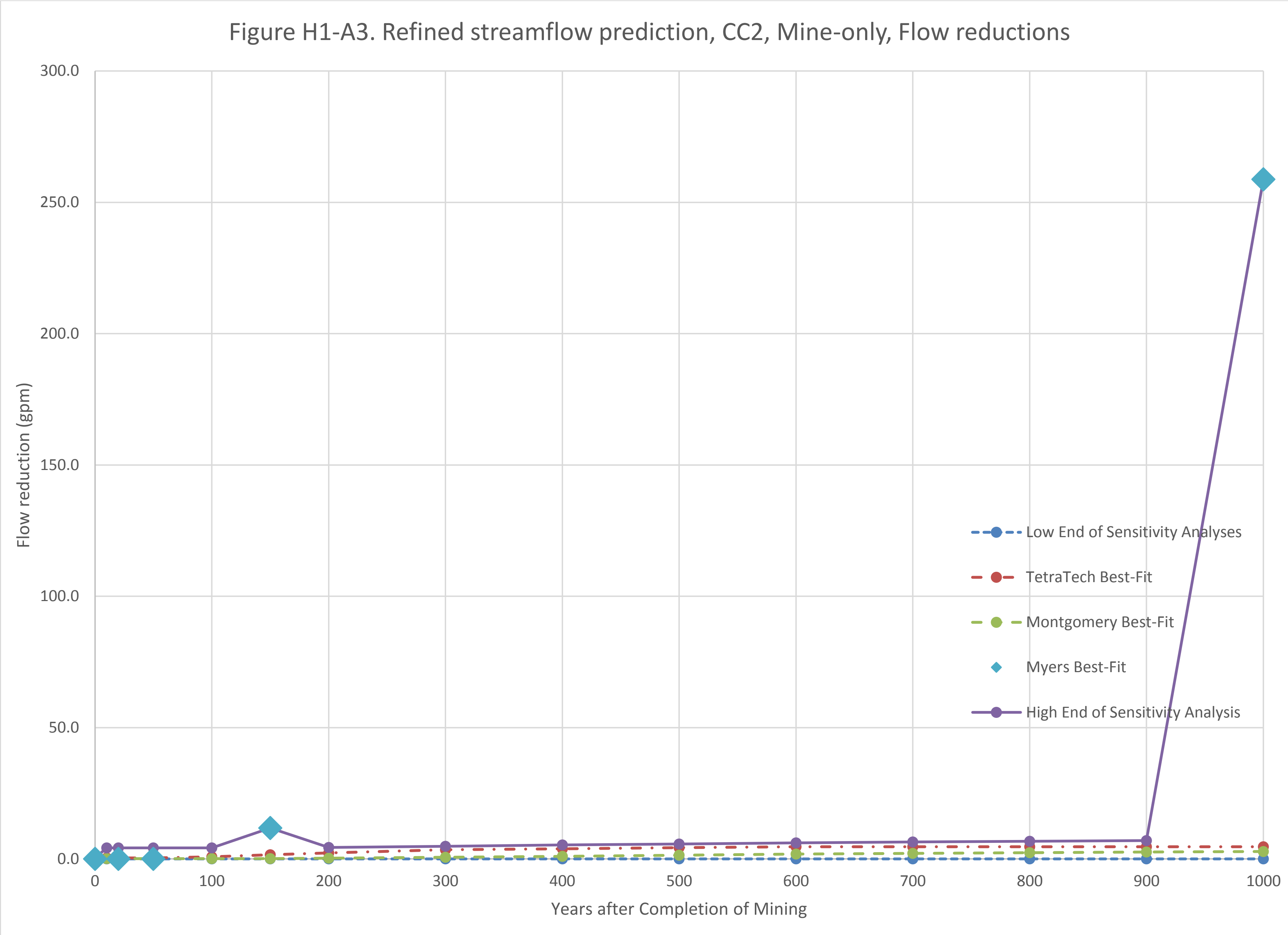
Figure H1-A3. Refined streamflow prediction, CC2, Mine-only, Flow reductions
Flow reduction (gpm)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
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TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
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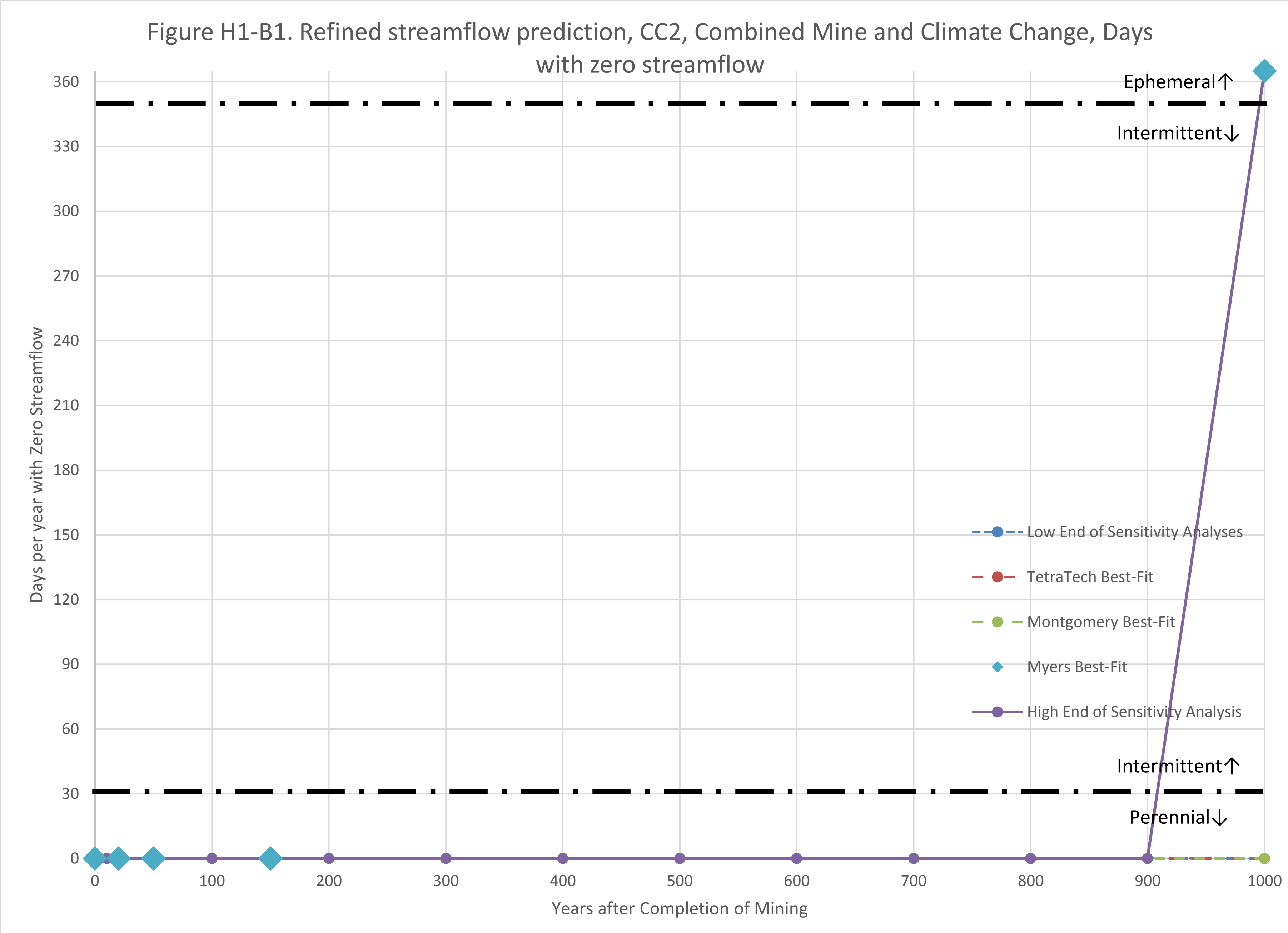
Figure H1-B1. Refined streamflow prediction, CC2, Combined Mine and Climate Change, Days with zero streamflow
Days per year with Zero Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
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Myers Best-Fit
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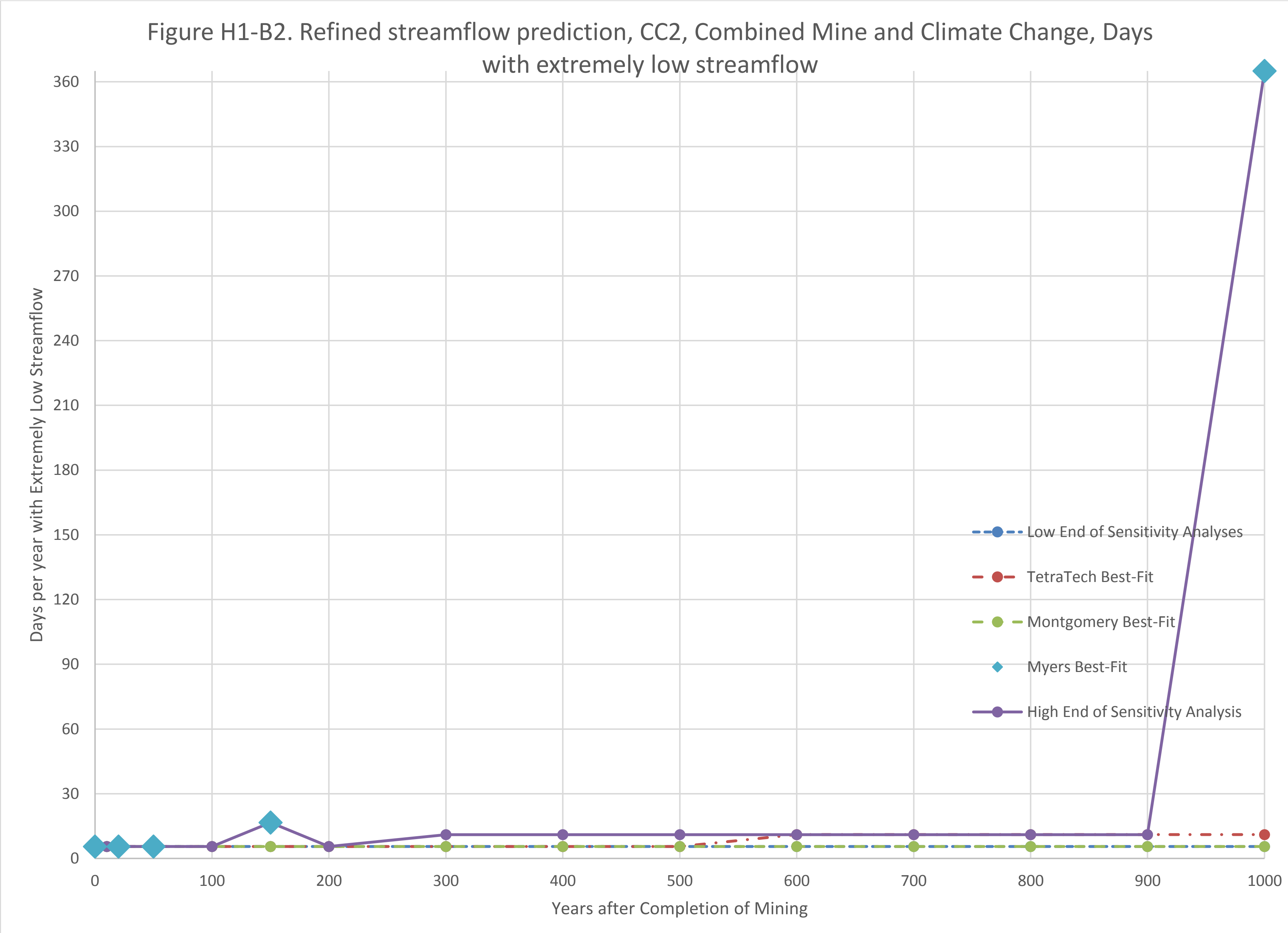
Figure H1-B2. Refined streamflow prediction, CC2, Combined Mine and Climate Change, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
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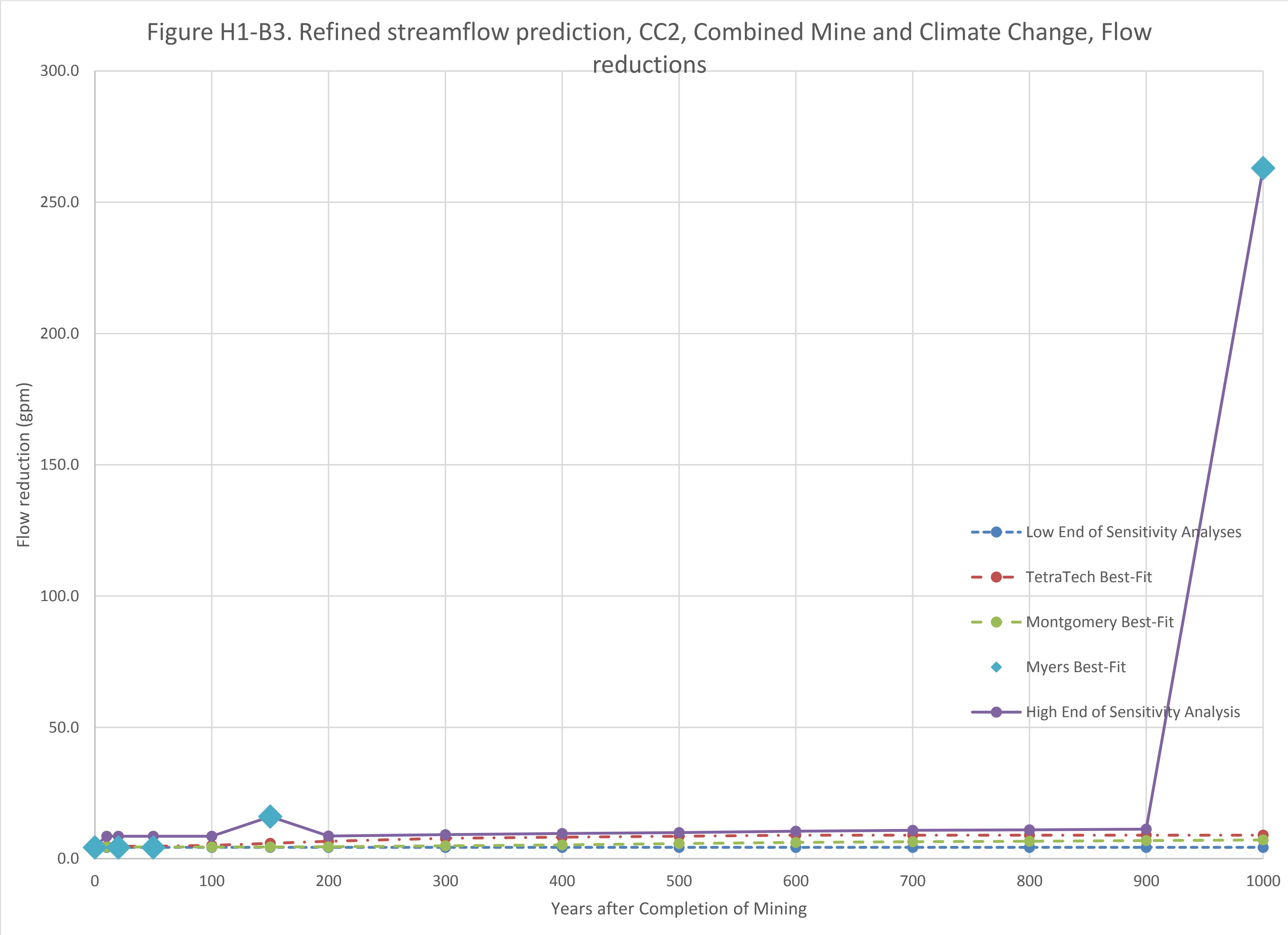
Figure H1-B3. Refined streamflow prediction, CC2, Combined Mine and Climate Change, Flow reductions
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Flow reduction (gpm)
0
100
200
300
400
500
600
700
800
900
1000
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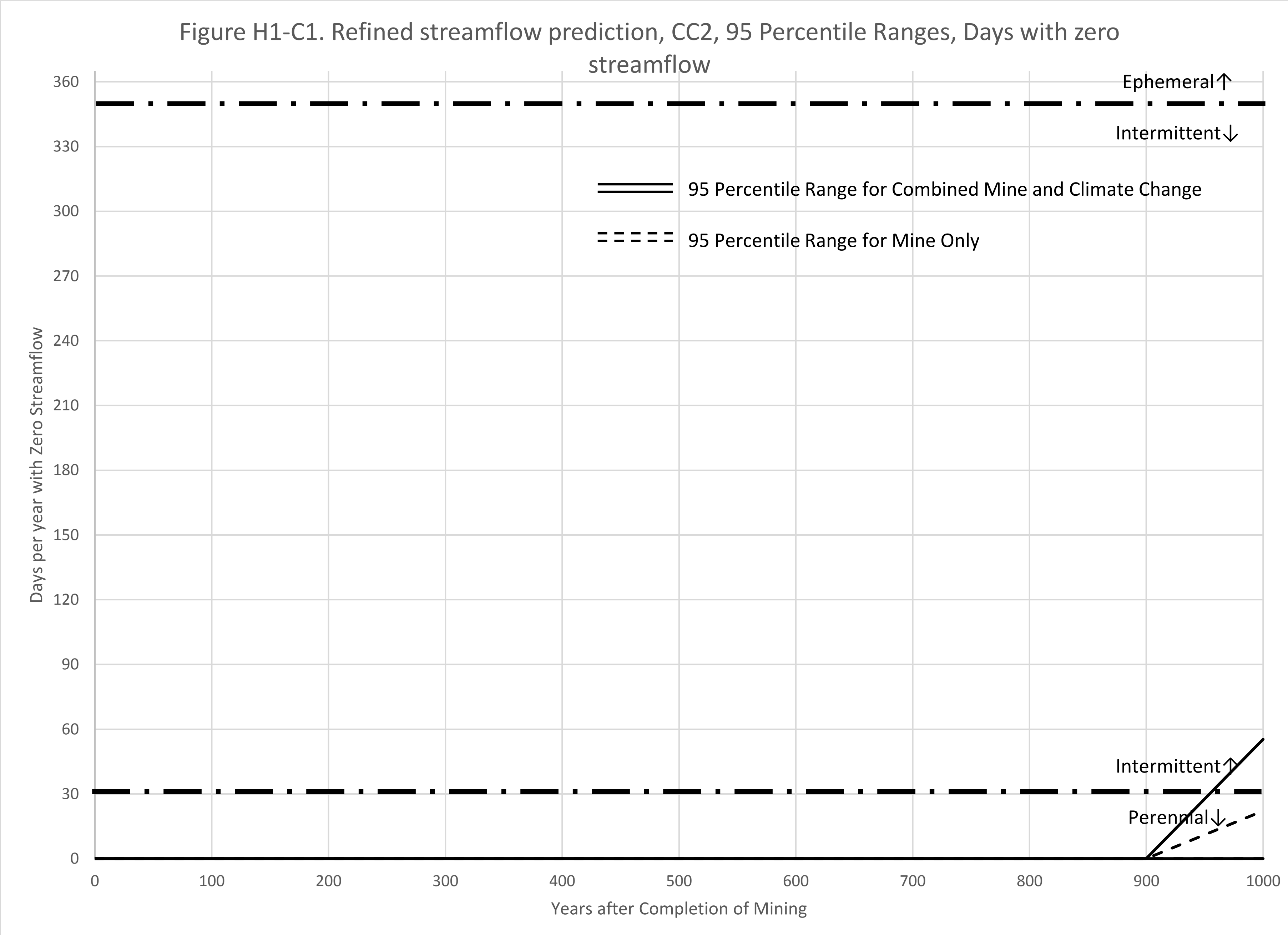

Figure H1-C1. Refined streamflow prediction, CC2, 95 Percentile Ranges, Days with zero streamflow
Ephemeral↑
Intermittent↓
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
Years after Completion of Mining
0
30
60
90
120
150
180
210
240
270
300
330
360
0
100
200
300
400
500
600
700
800
900
1000

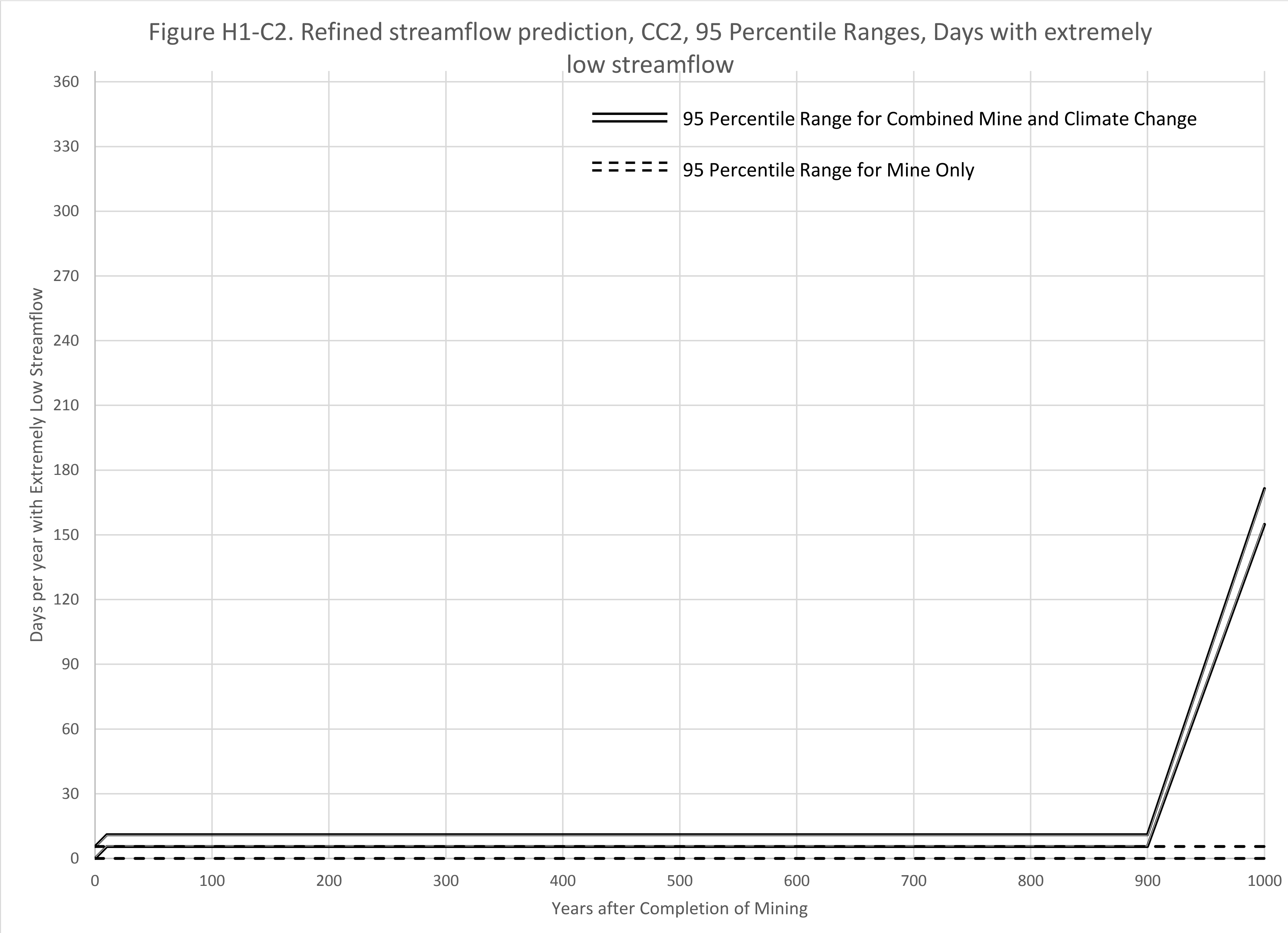
Figure H1-C2. Refined streamflow prediction, CC2, 95 Percentile Ranges, Days with extremely low streamflow
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

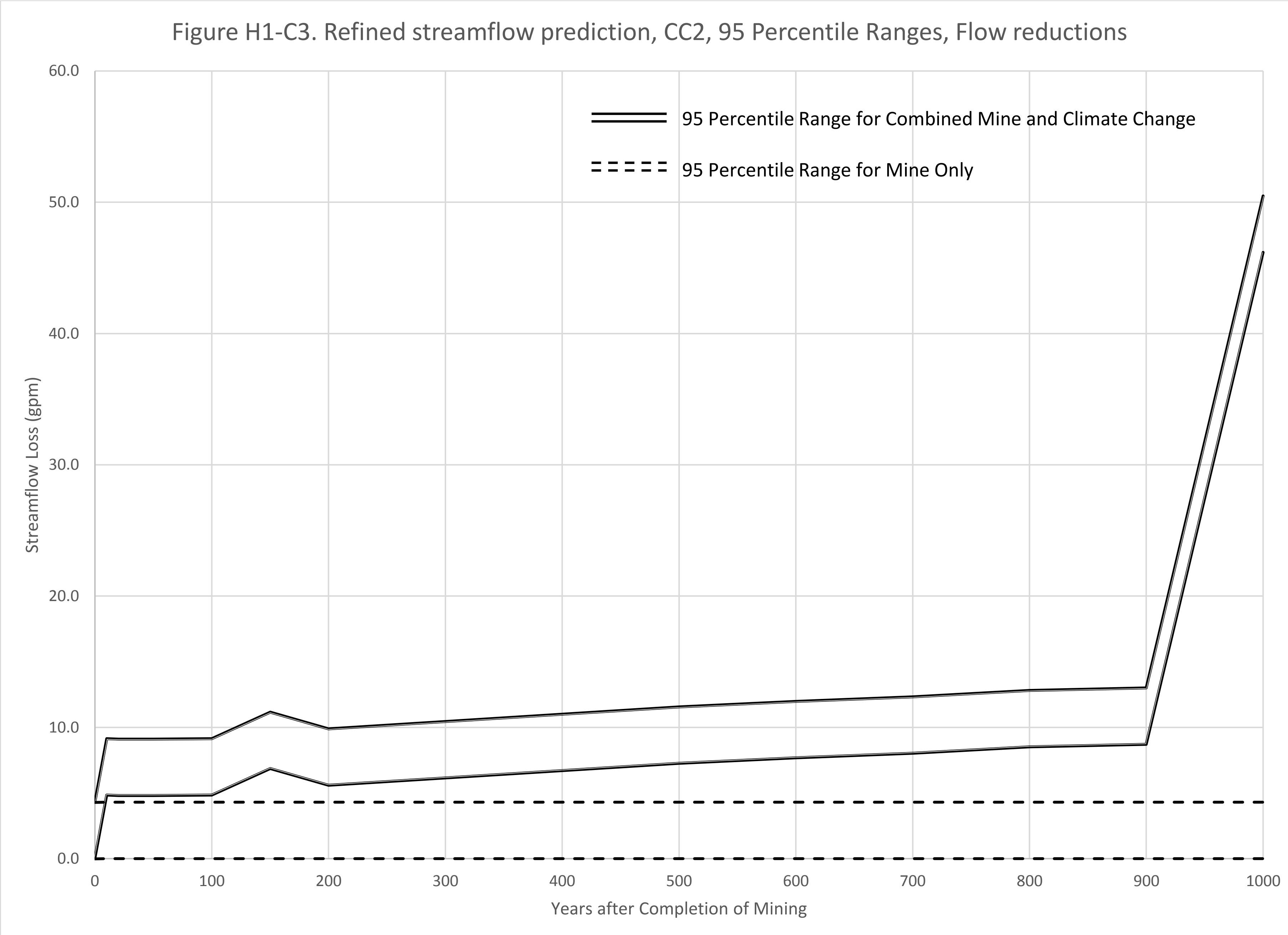
Figure H1-C3. Refined streamflow prediction, CC2, 95 Percentile Ranges, Flow reductions
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Streamflow Loss (gpm)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

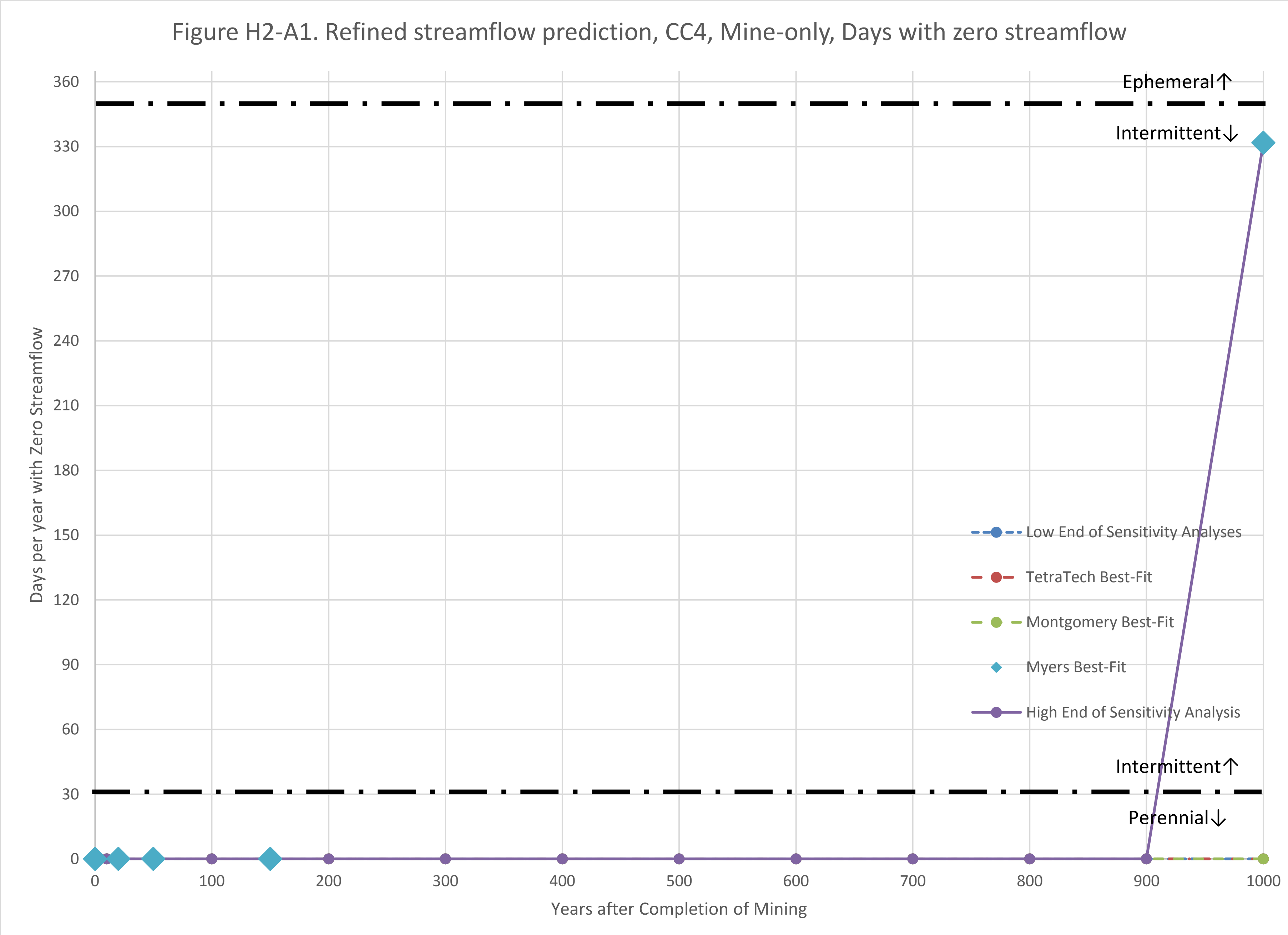

Figure H2-A1. Refined streamflow prediction, CC4, Mine-only, Days with zero streamflow
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis
Days per year with Zero Streamflow
Years after Completion of Mining
0
30
60
90
120
150
180
210
240
270
300
330
360
100
200
300
400
500
600
700
800
900
1000

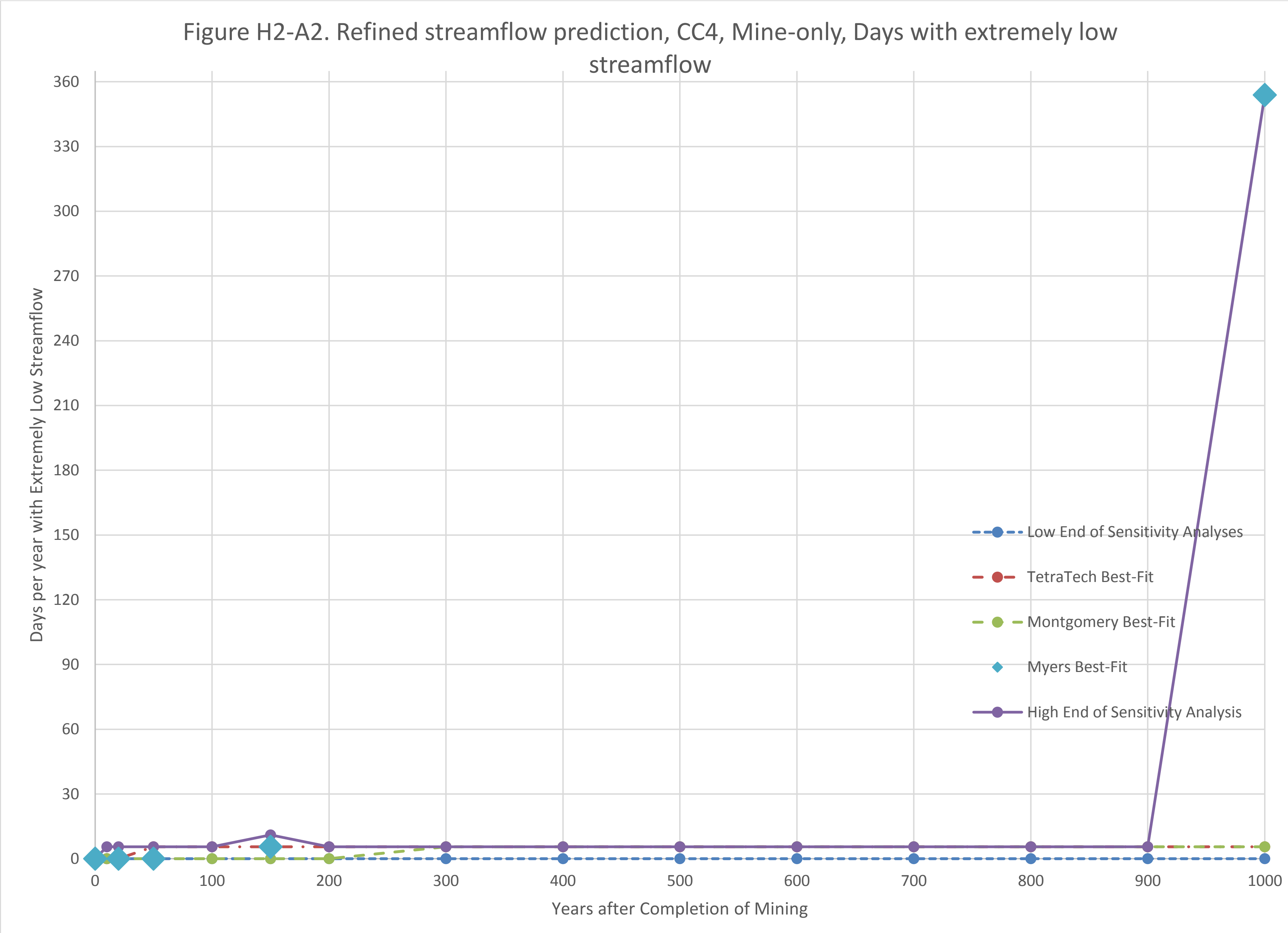

Figure H2-A2. Refined streamflow prediction, CC4, Mine-only, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
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600
700
800
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1000
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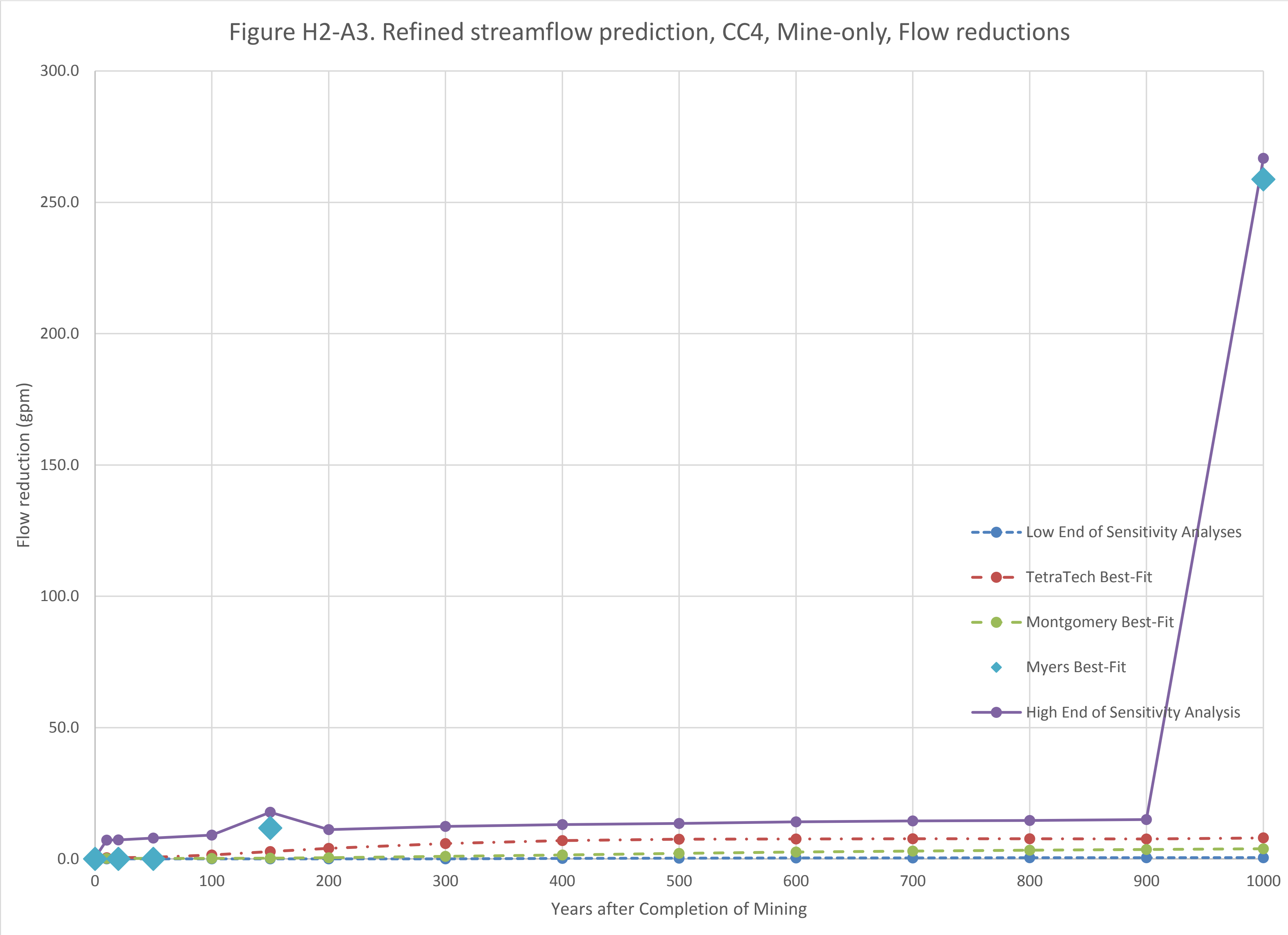
Figure H2-A3. Refined streamflow prediction, CC4, Mine-only, Flow reductions
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Flow reduction (gpm)
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
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TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
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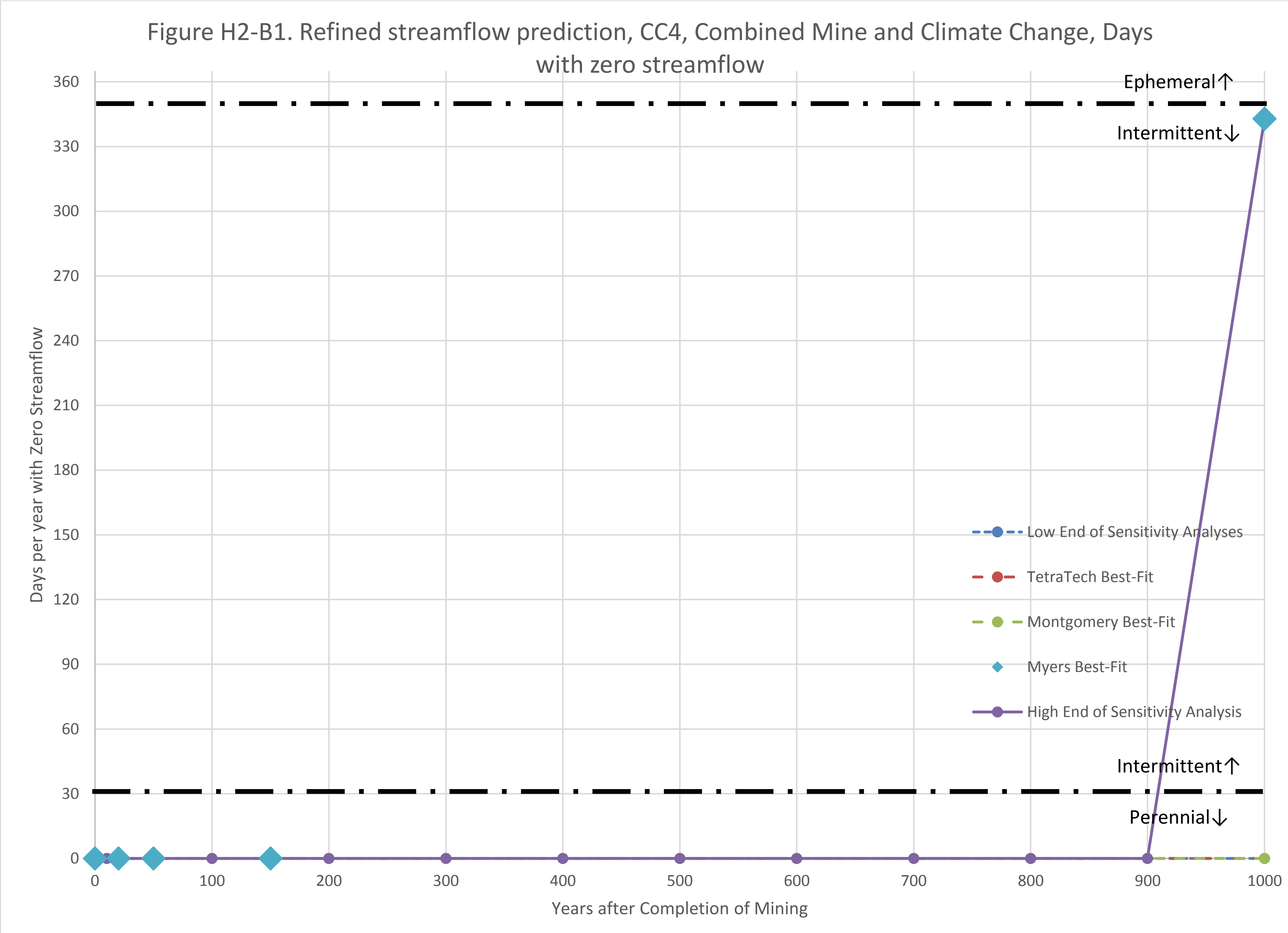

Figure H2-B1. Refined streamflow prediction, CC4, Combined Mine and Climate Change, Days with zero streamflow
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
Years after Completion of Mining
0
30
60
90
120
150
180
210
240
270
300
330
360
0
100
200
300
400
500
600
700
800
900
1000
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

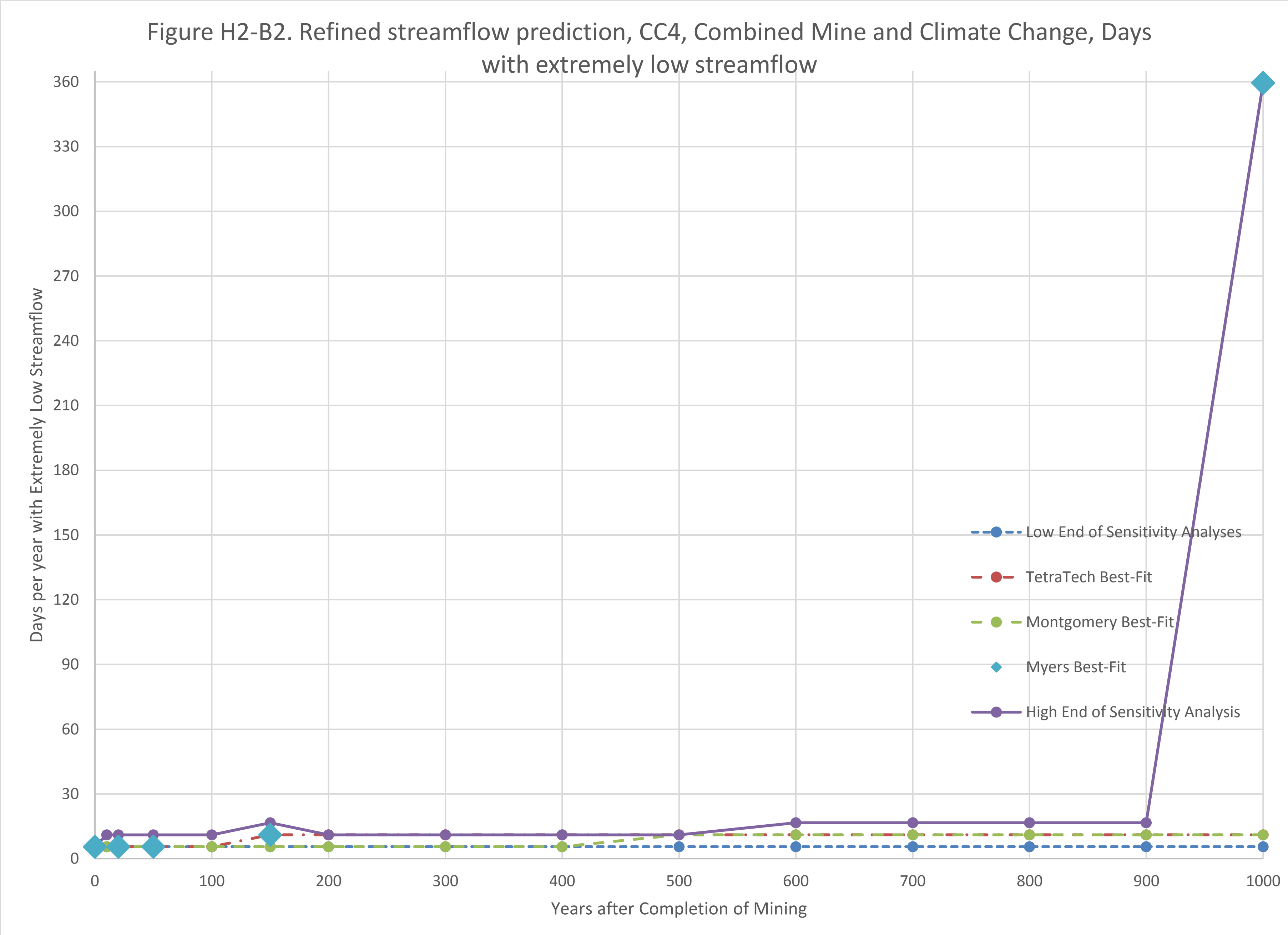
Figure H2-B2. Refined streamflow prediction, CC4, Combined Mine and Climate Change, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
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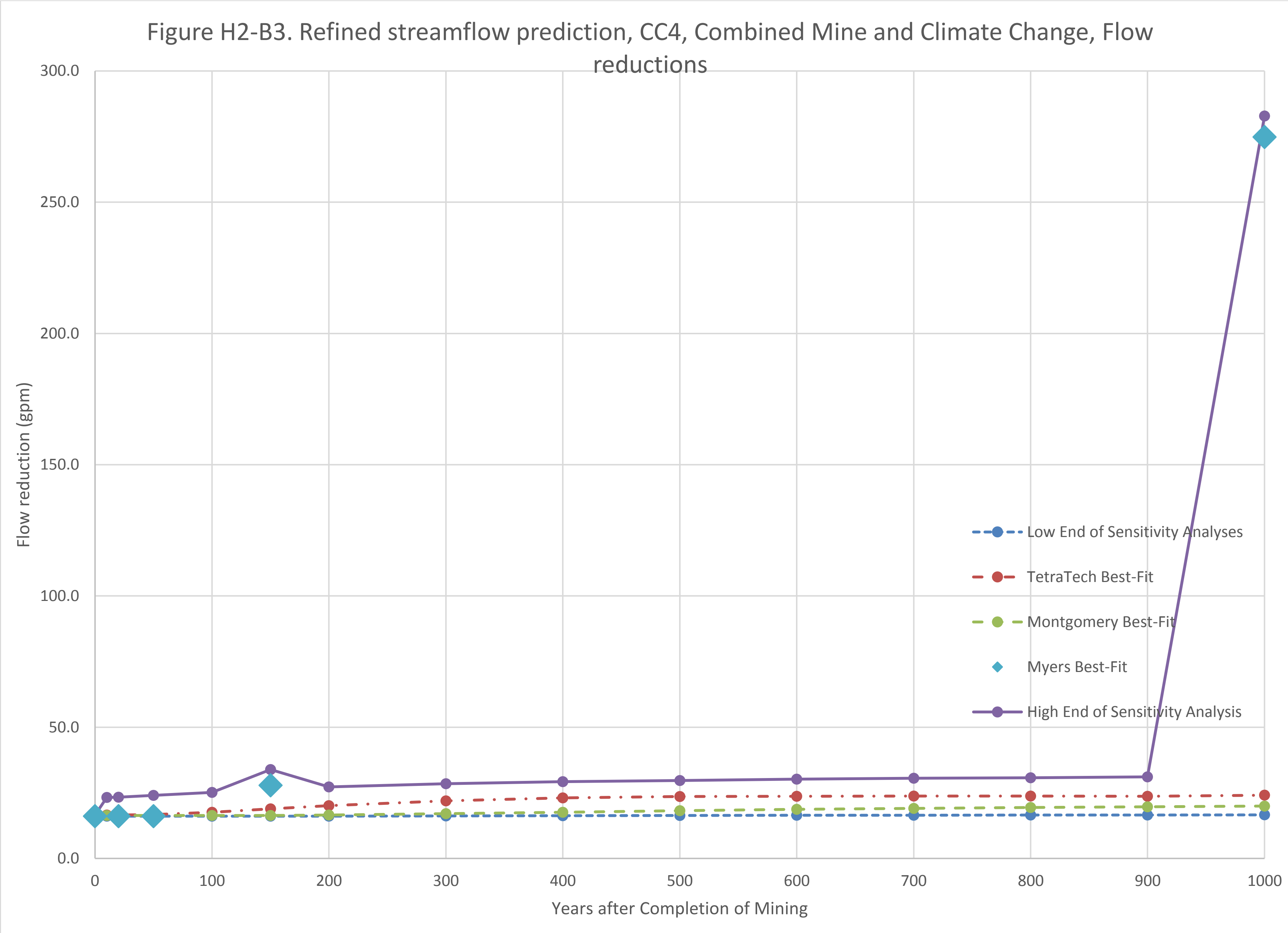
Figure H2-B3. Refined streamflow prediction, CC4, Combined Mine and Climate Change, Flow reductions
Flow reduction (gpm)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
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TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
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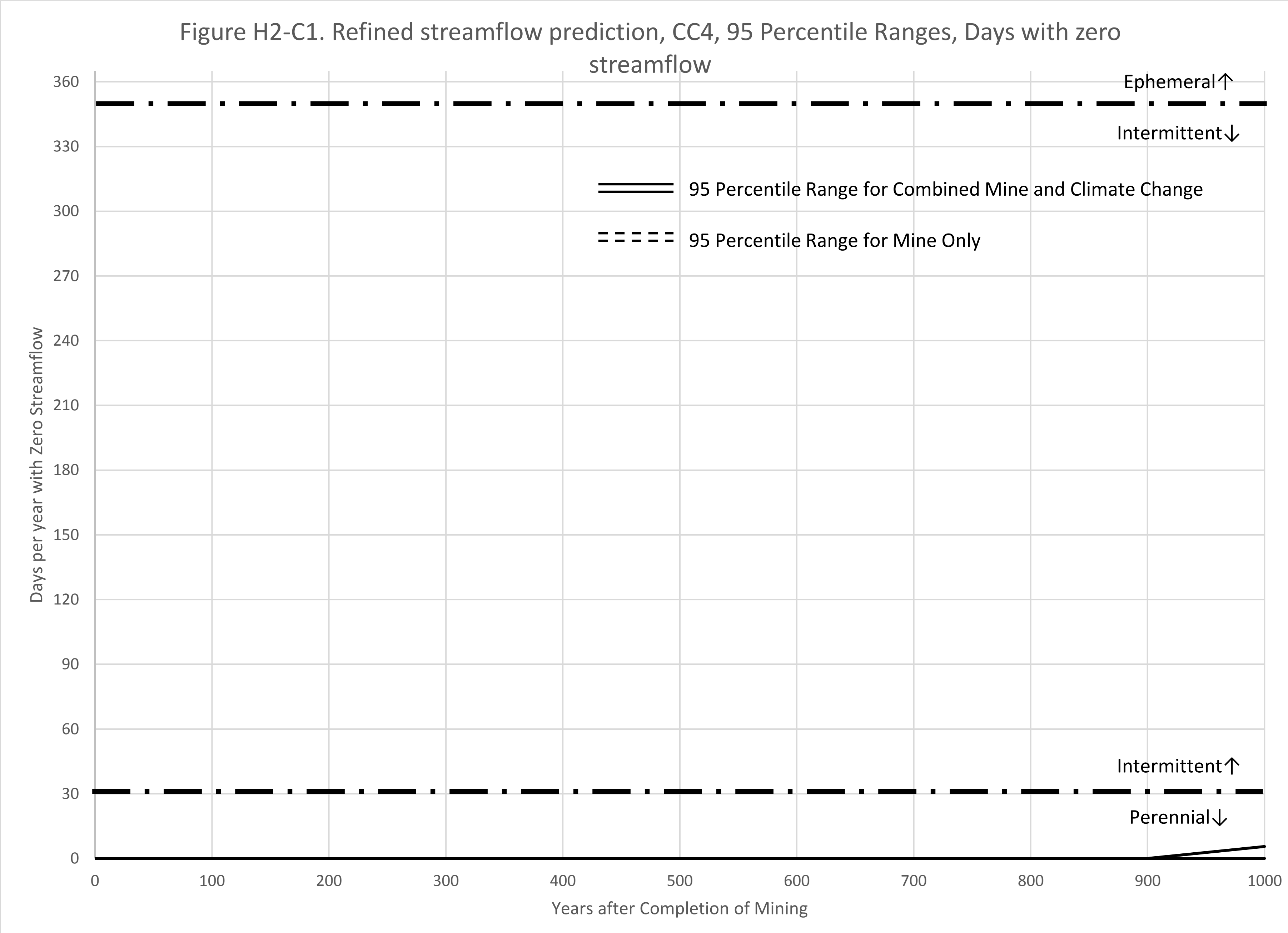
Figure H2-C1. Refined streamflow prediction, CC4, 95 Percentile Ranges, Days with zero streamflow
Ephemeral↑
Intermittent↓
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
Years after Completion of Mining
360
330
300
270
240
210
180
150
120
90
60
30
0
100
200
300
400
500
600
700
800
900
1000

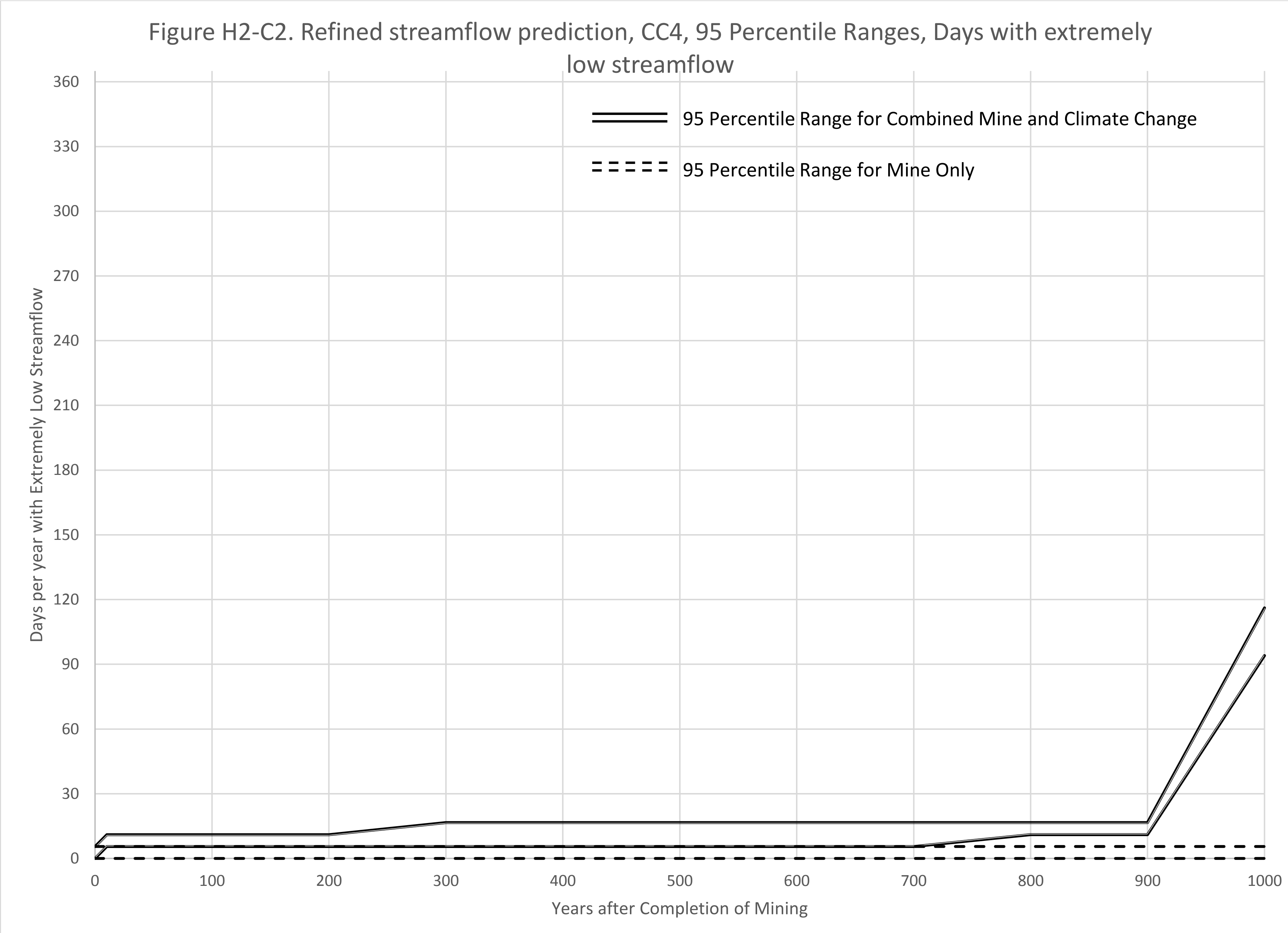
Figure H2-C2. Refined streamflow prediction, CC4, 95 Percentile Ranges, Days with extremely low streamflow
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

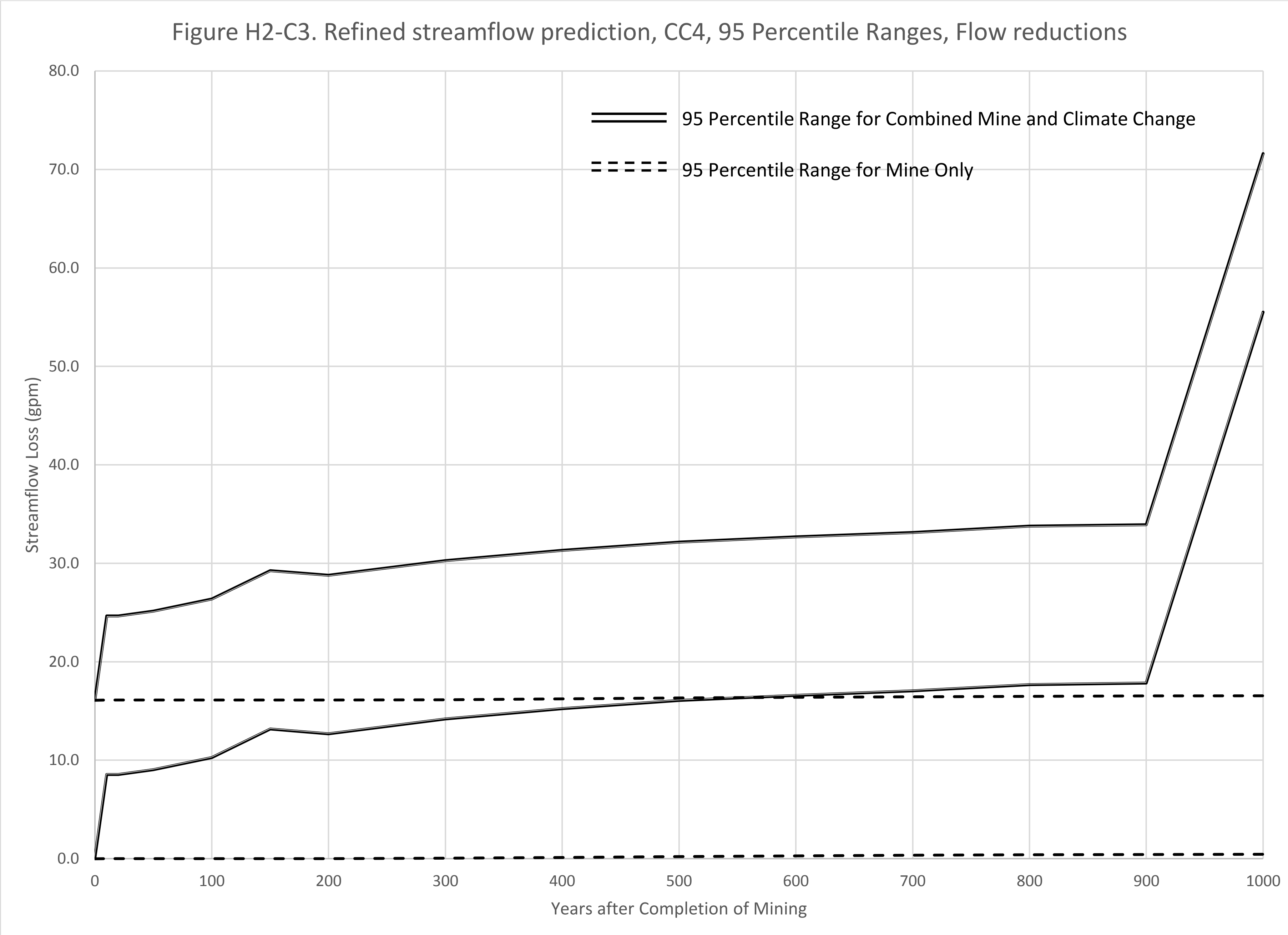
Figure H2-C3. Refined streamflow prediction, CC4, 95 Percentile Ranges, Flow reductions
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Streamflow Loss (gpm)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

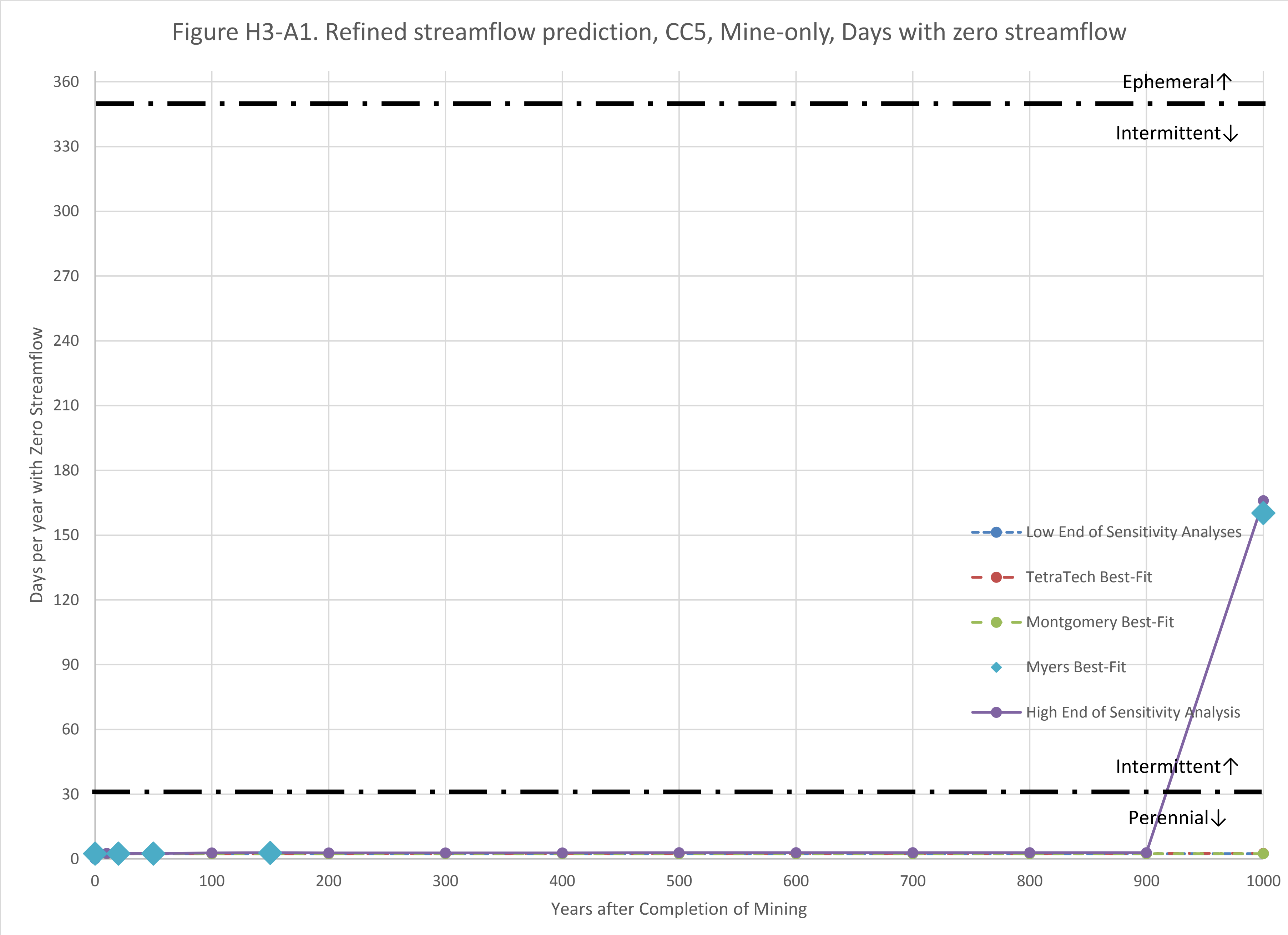
Figure H3-A1. Refined streamflow prediction, CC5, Mine-only, Days with zero streamflow
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

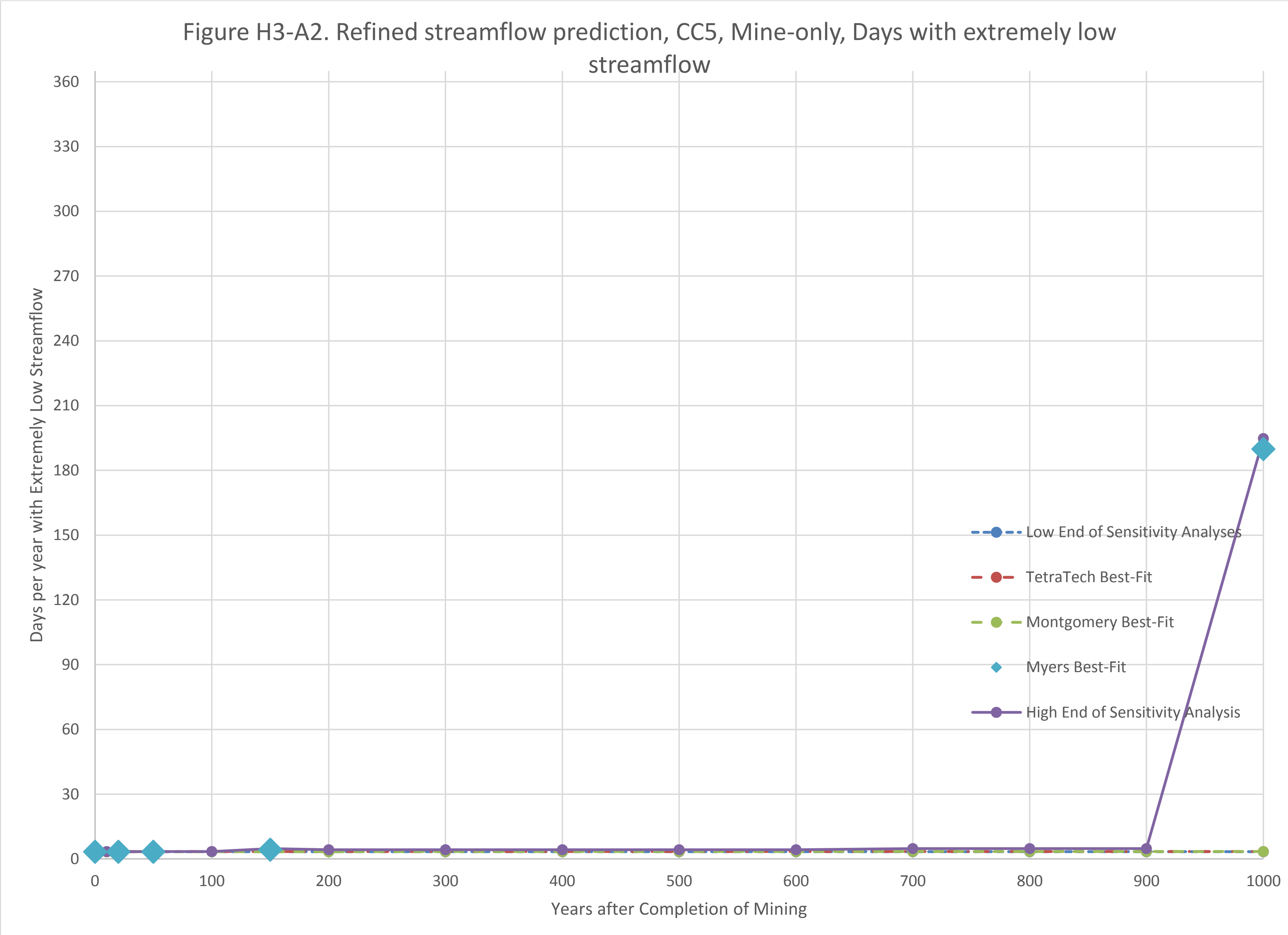

Figure H3-A2. Refined streamflow prediction, CC5, Mine-only, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
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1000
Years after Completion of Mining
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TetraTech Best-Fit
Montgomery Best-Fit
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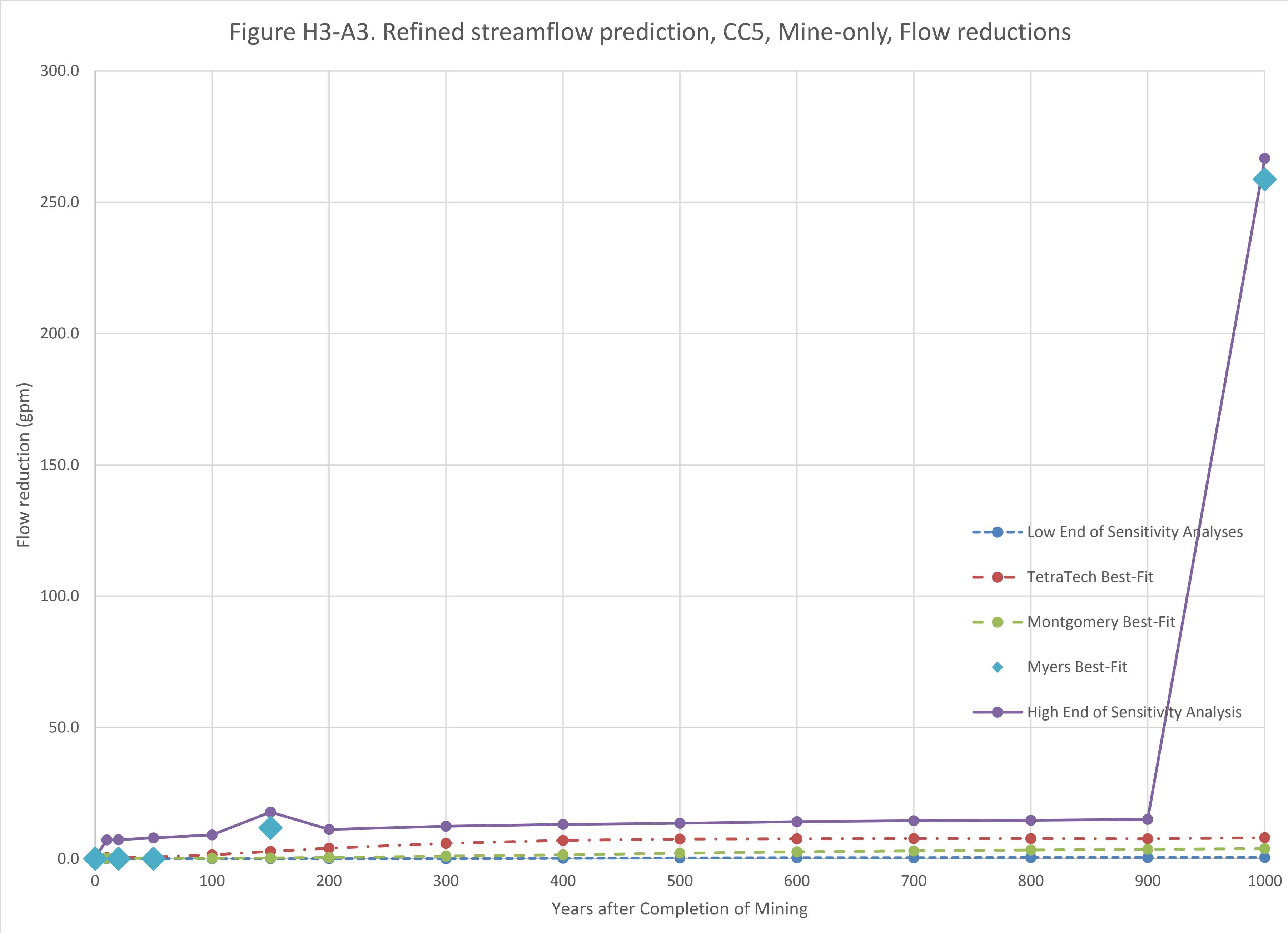
Figure H3-A3. Refined streamflow prediction, CC5, Mine-only, Flow reductions
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Flow reduction (gpm)
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
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TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

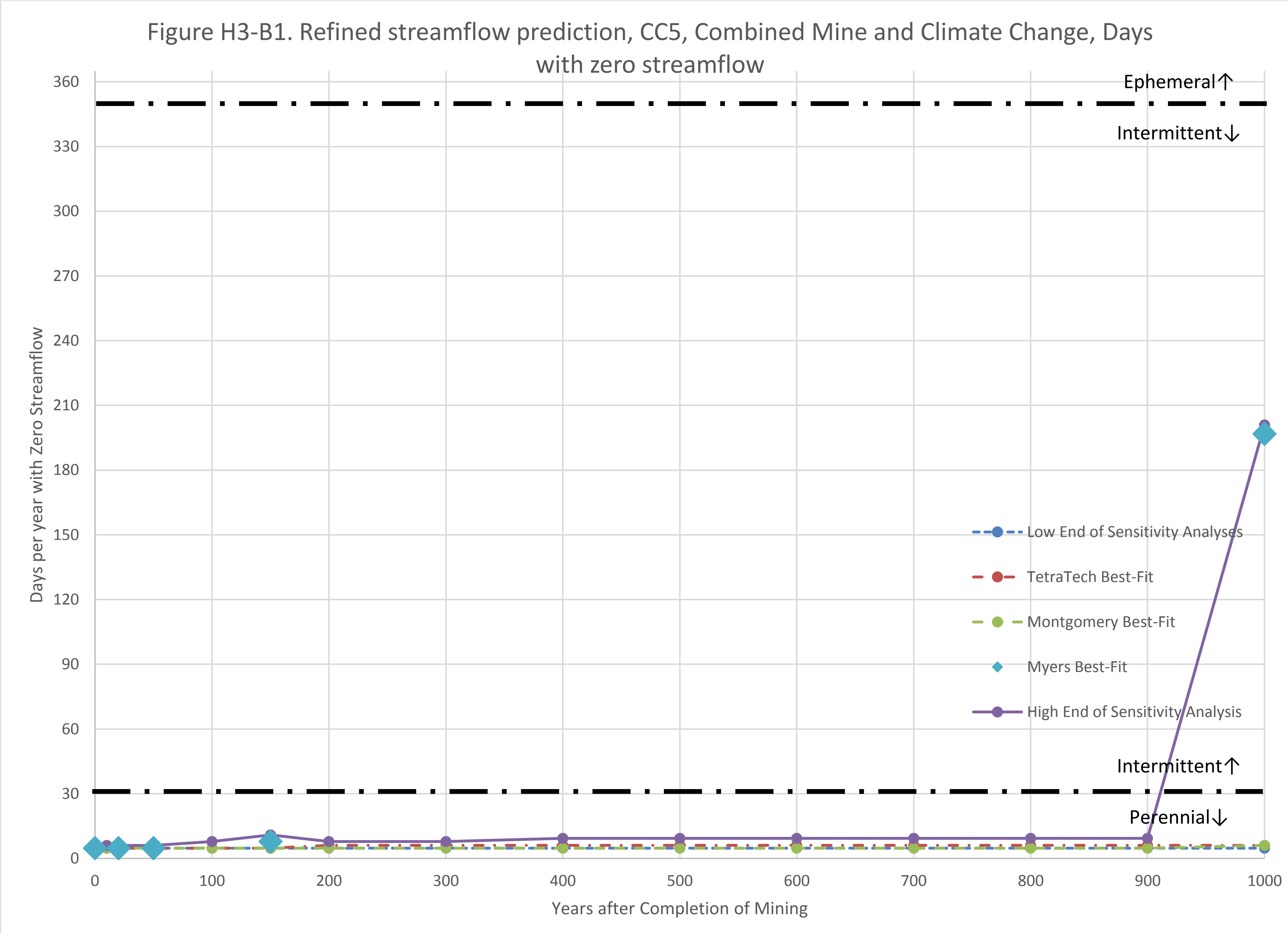
Figure H3-B1. Refined streamflow prediction, CC5, Combined Mine and Climate Change, Days with zero streamflow
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
Years after Completion of Mining
0
30
60
90
120
150
180
210
240
270
300
330
360
0
100
200
300
400
500
600
700
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900
1000
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TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
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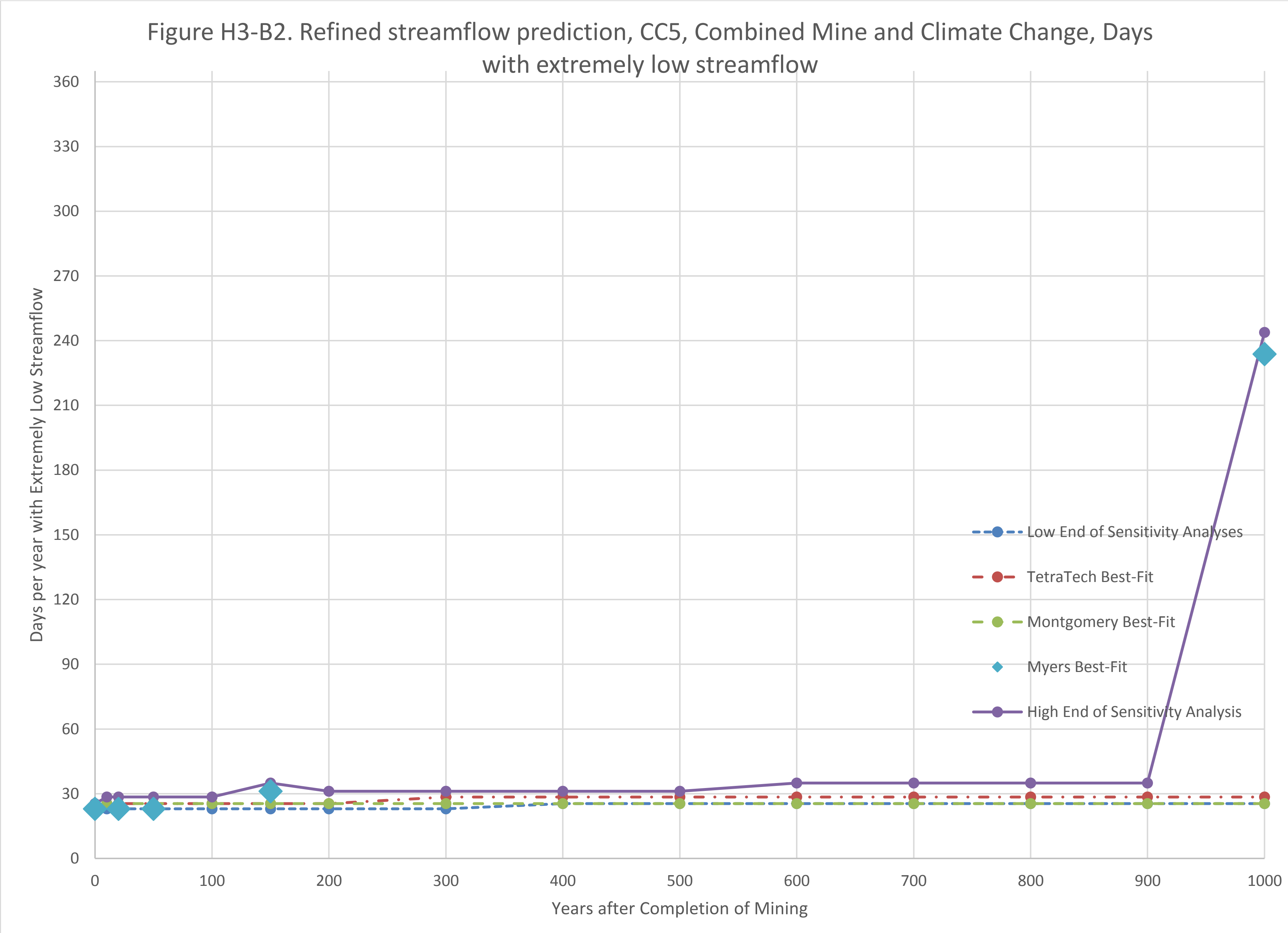
Figure H3-B2. Refined streamflow prediction, CC5, Combined Mine and Climate Change, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
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600
700
800
900
1000
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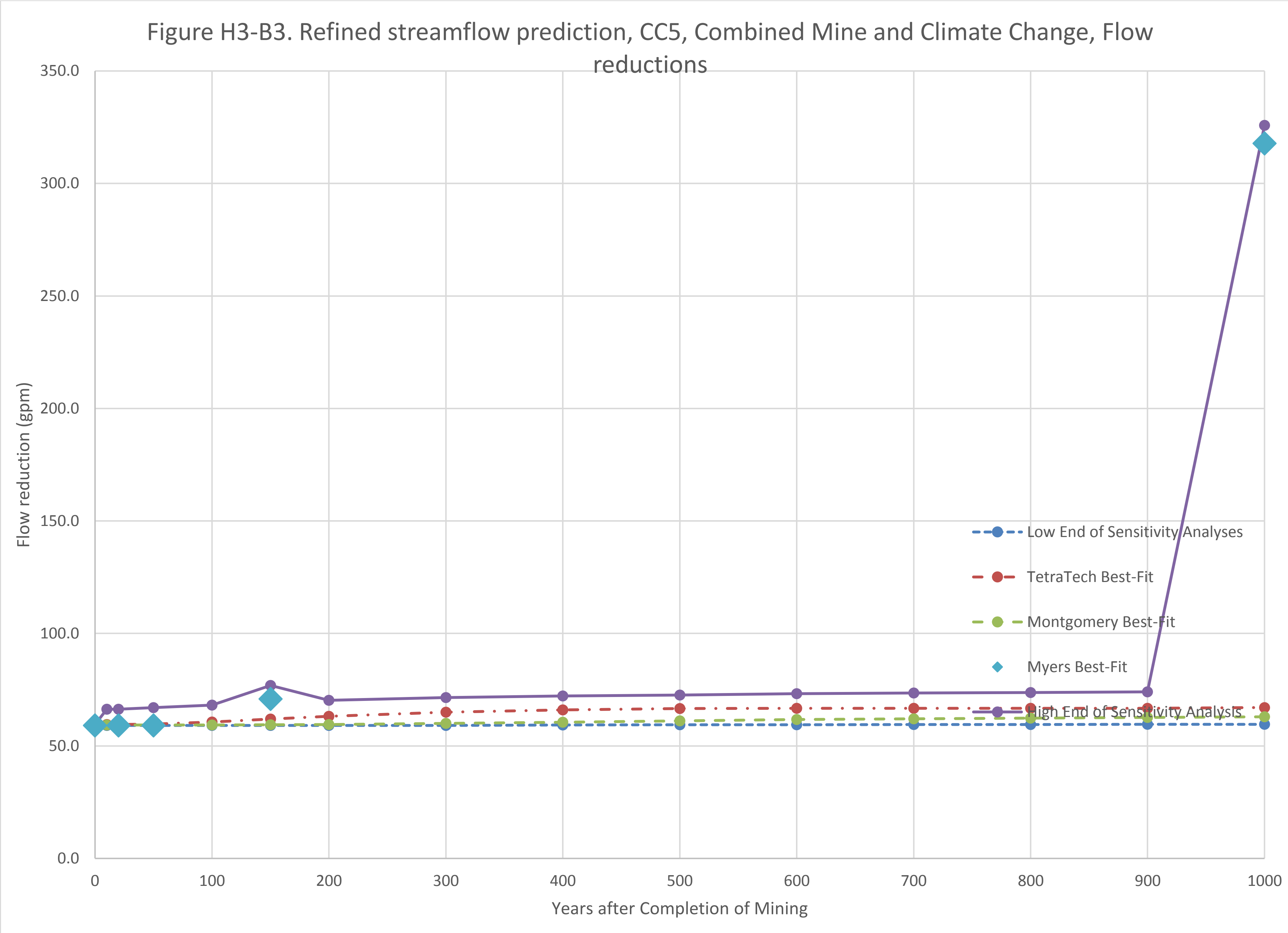
Figure H3-B3. Refined streamflow prediction, CC5, Combined Mine and Climate Change, Flow reductions
Flow reduction (gpm)
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
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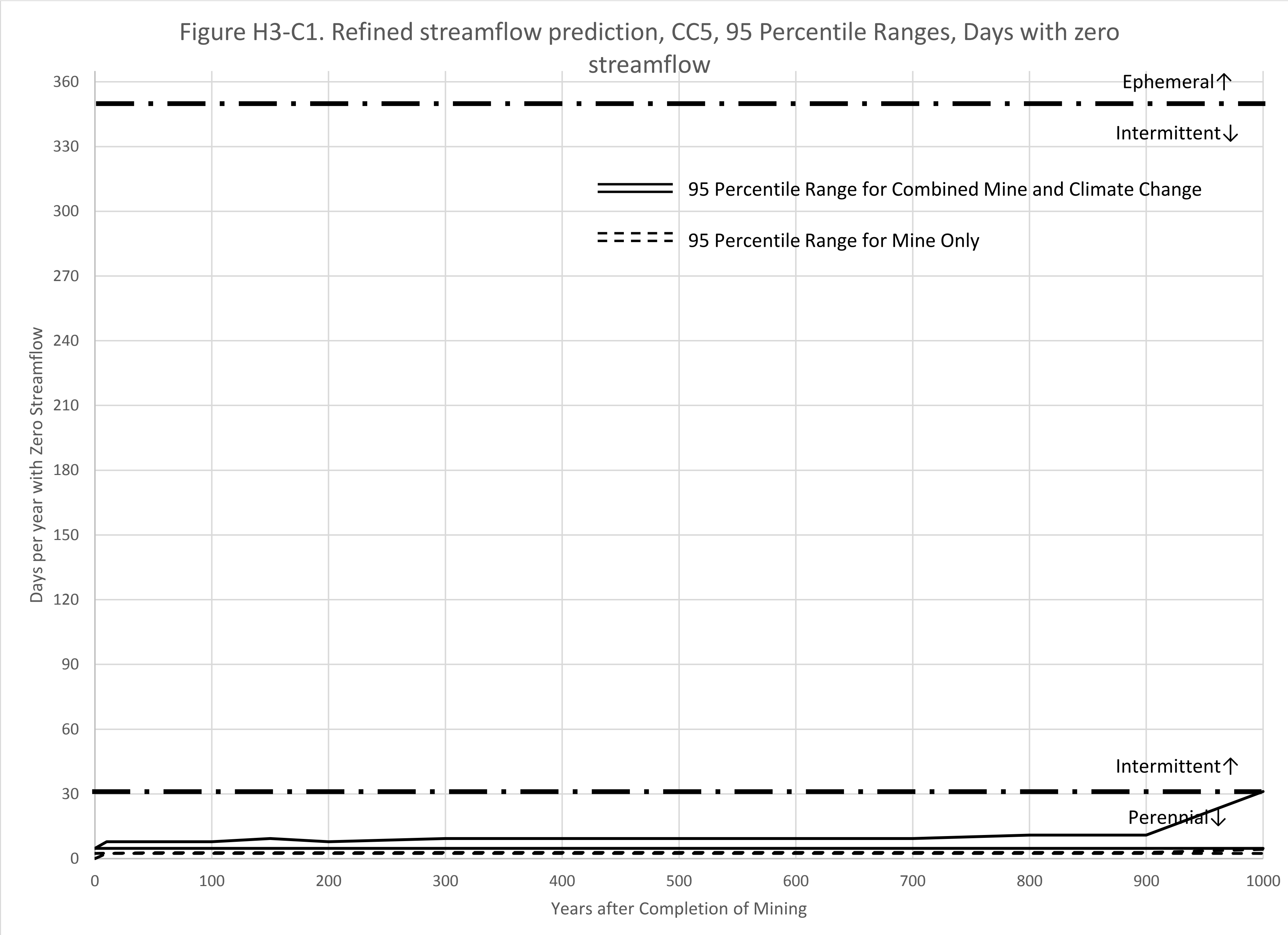
Figure H3-C1. Refined streamflow prediction, CC5, 95 Percentile Ranges, Days with zero streamflow
Ephemeral↑
Intermittent↓
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
Years after Completion of Mining
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000

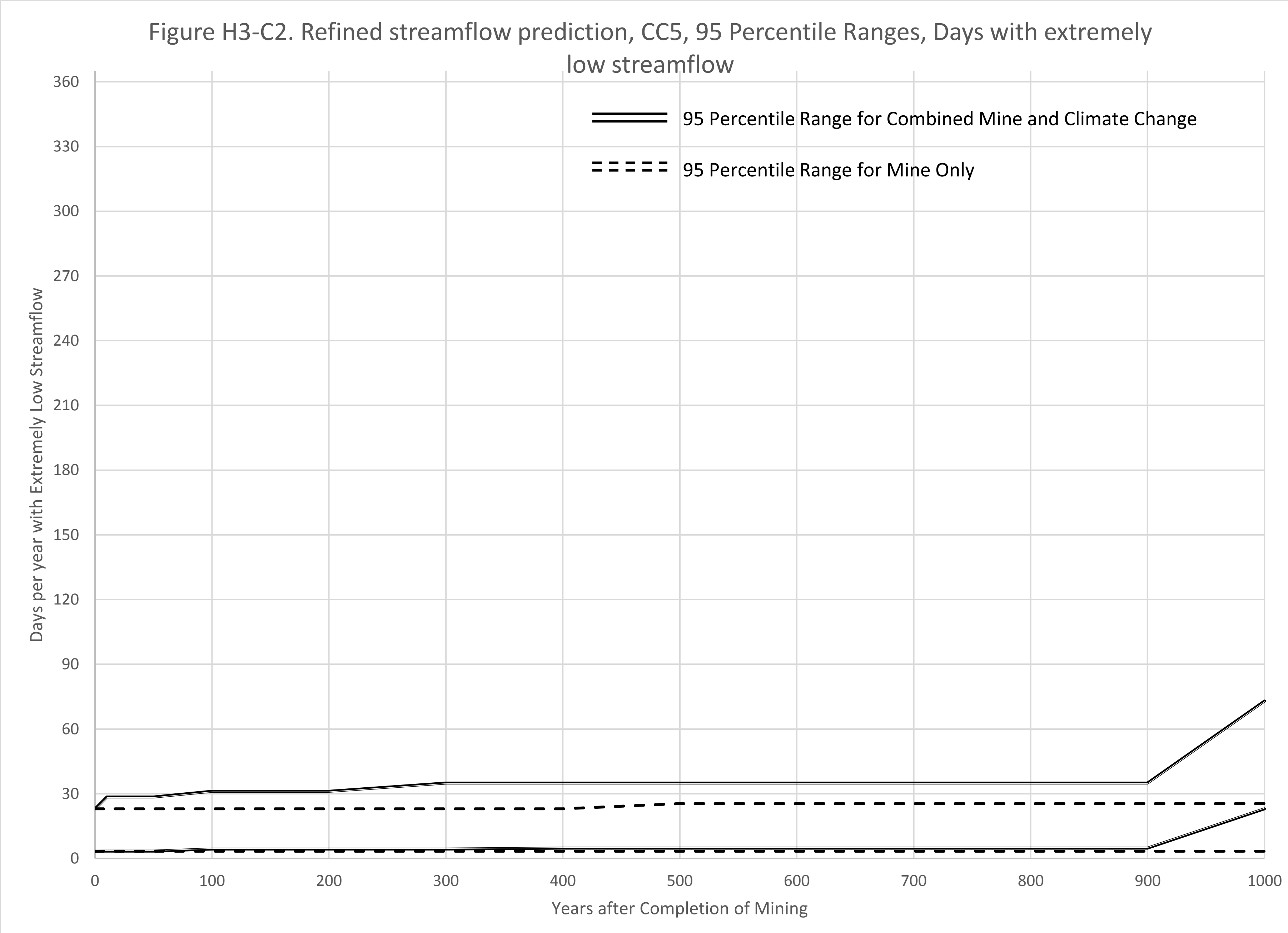

Figure H3-C2. Refined streamflow prediction, CC5, 95 Percentile Ranges, Days with extremely low streamflow
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

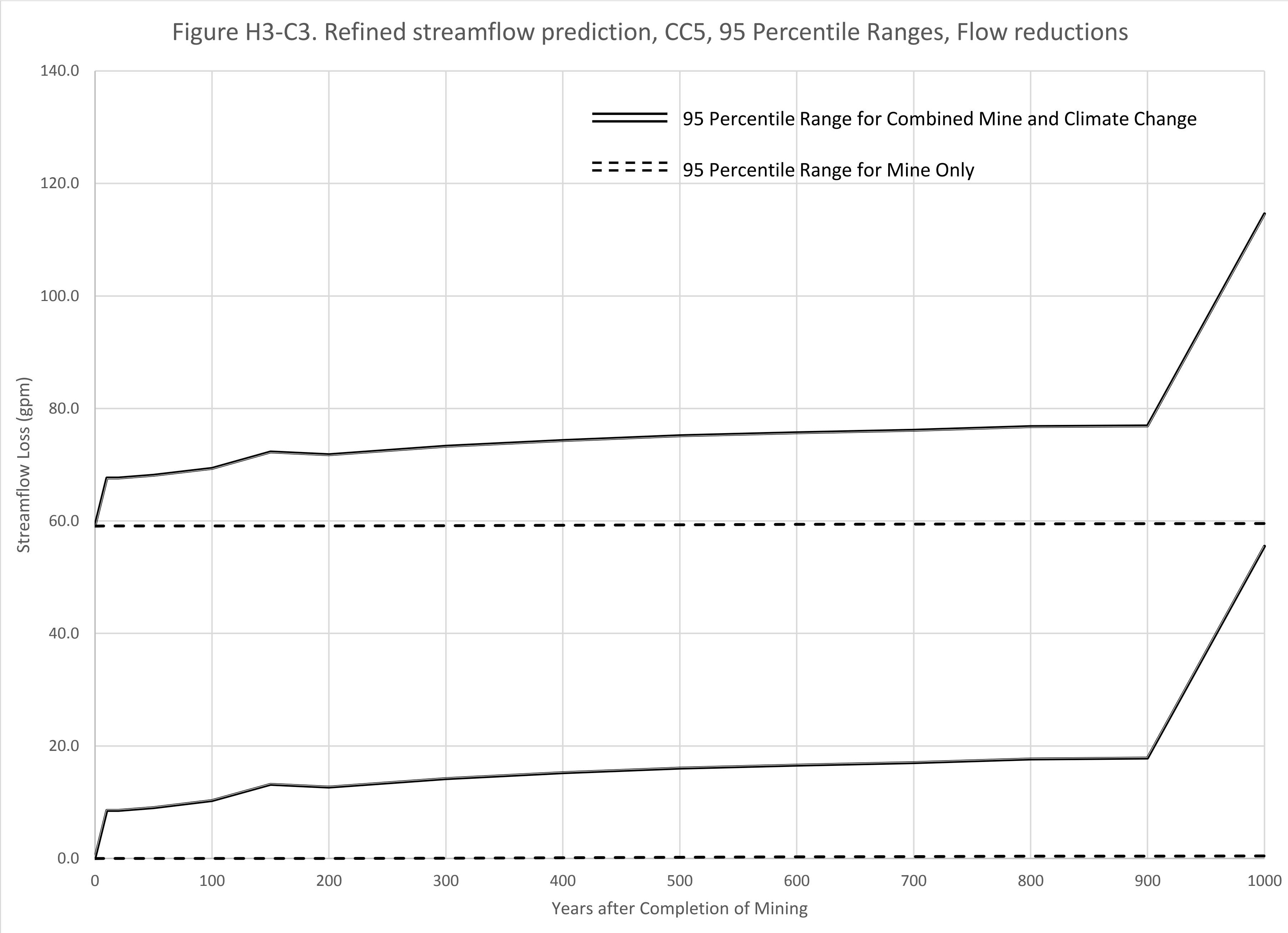
Figure H3-C3. Refined streamflow prediction, CC5, 95 Percentile Ranges, Flow reductions
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Streamflow Loss (gpm)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

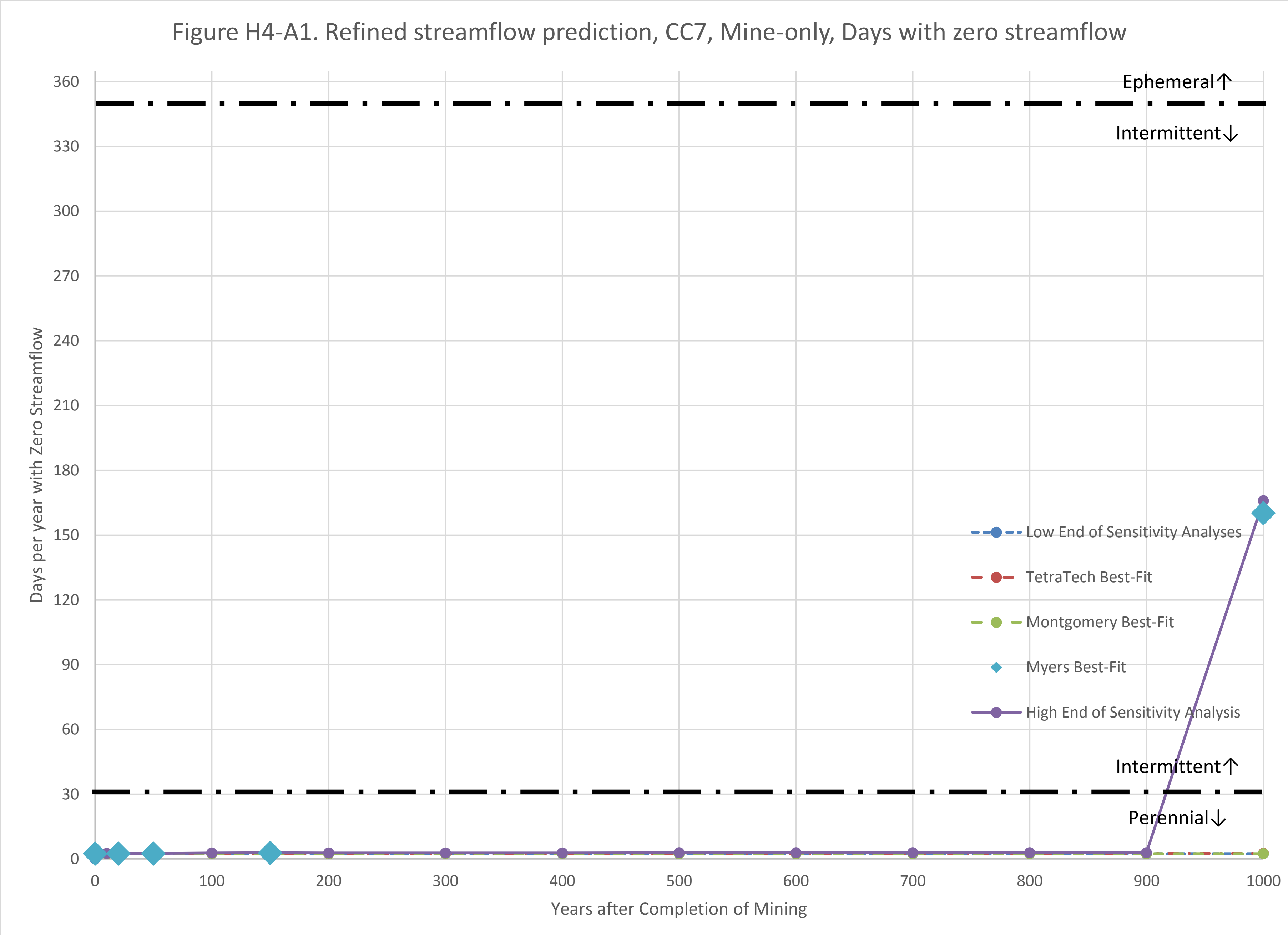
Figure H4-A1. Refined streamflow prediction, CC7, Mine-only, Days with zero streamflow
Days per year with Zero Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
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TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

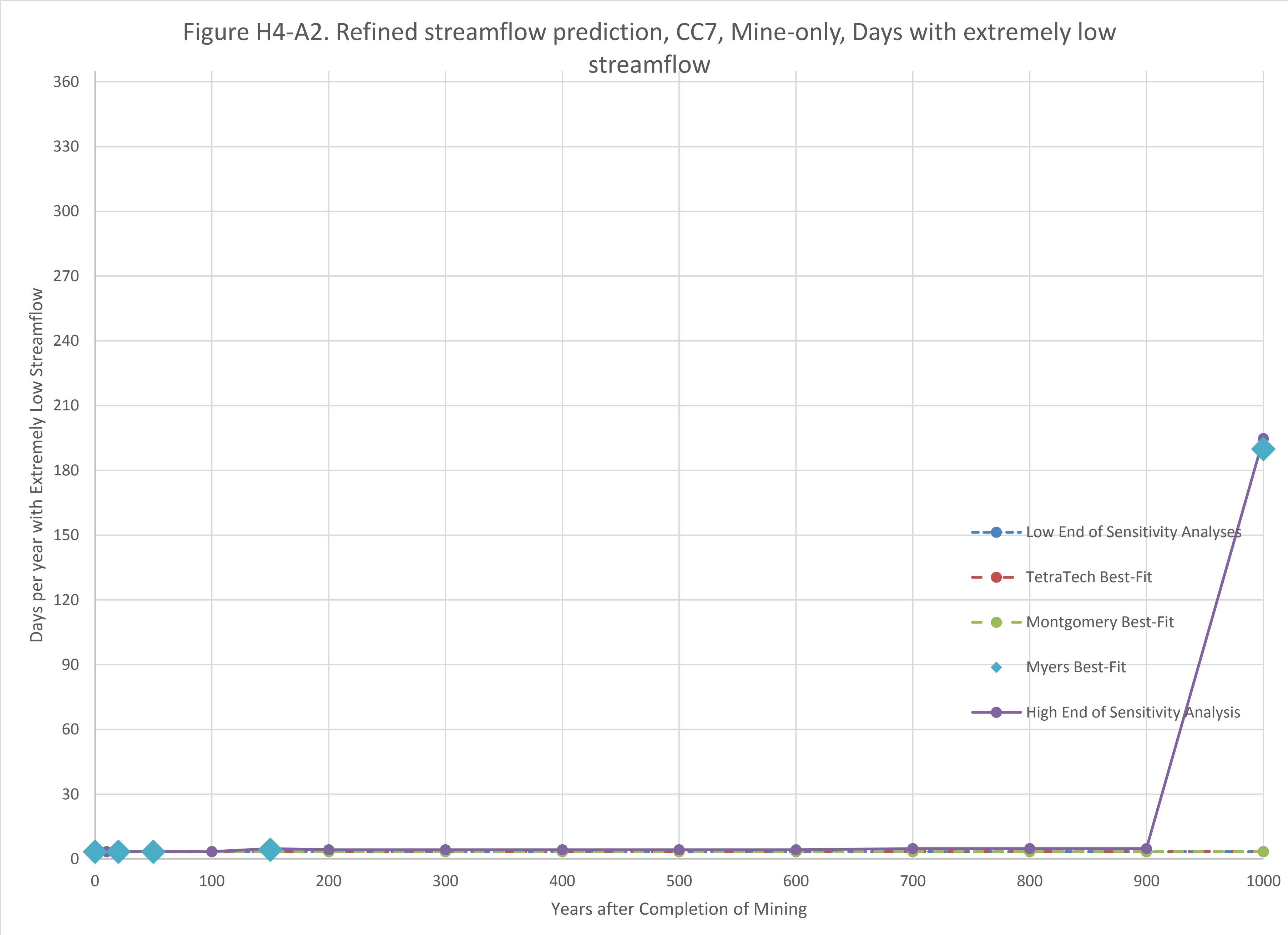


Figure H4-A2. Refined streamflow prediction, CC7, Mine-only, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

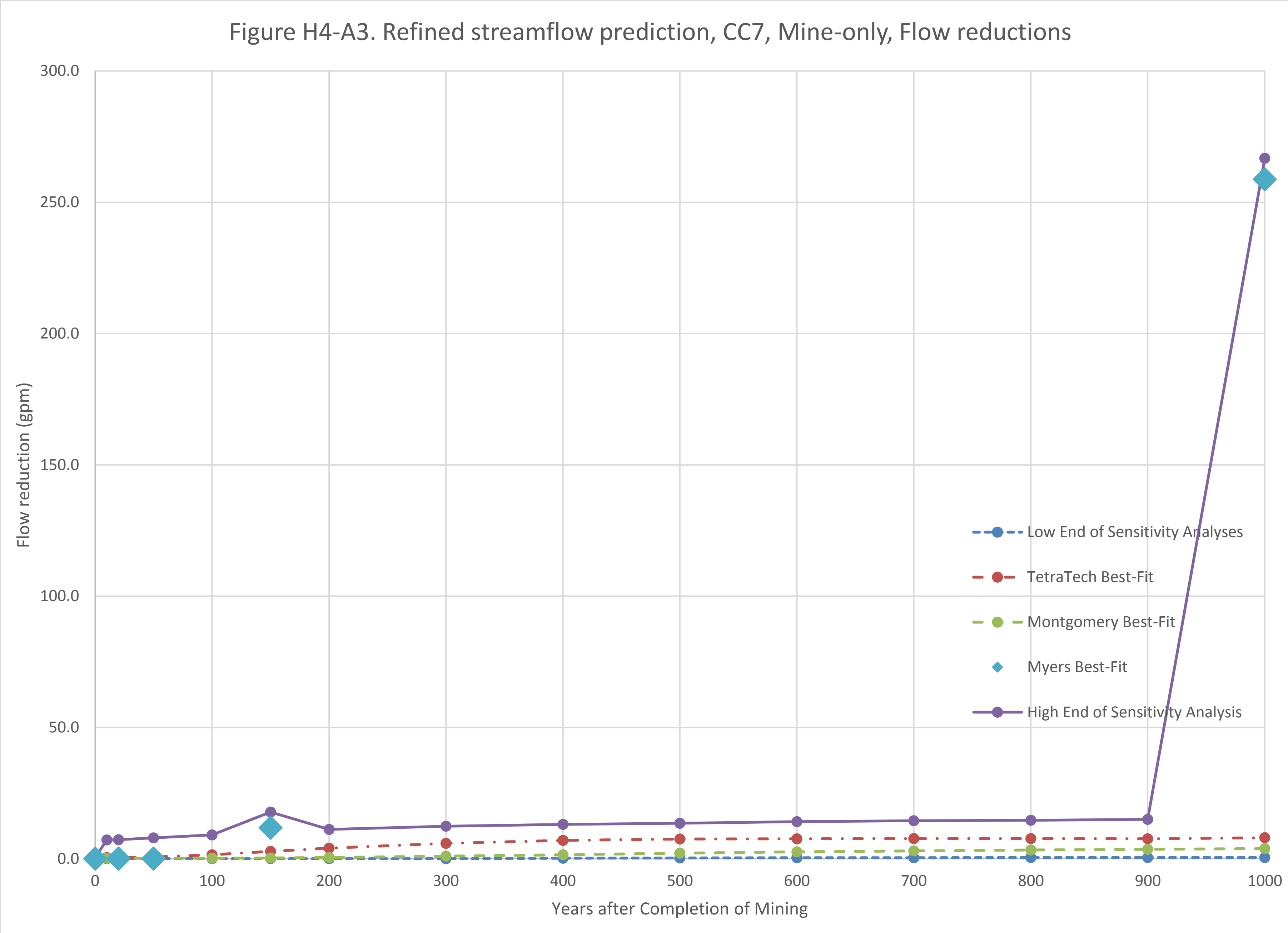


Figure H4-A3. Refined streamflow prediction, CC7, Mine-only, Flow reductions
Flow reduction (gpm)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

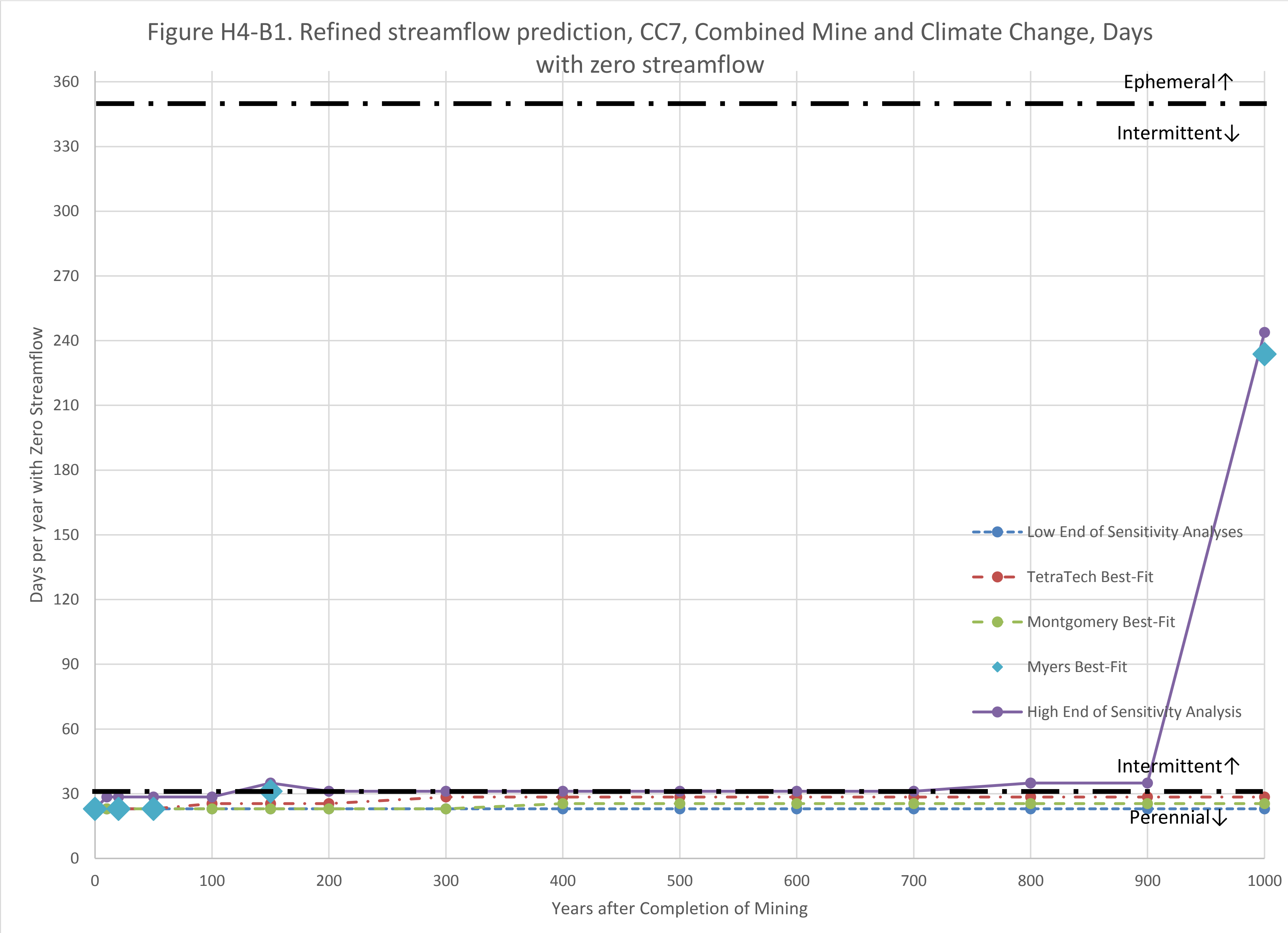


Figure H4-B1. Refined streamflow prediction, CC7, Combined Mine and Climate Change, Days with zero streamflow
Days per year with Zero Streamflow
Years after Completion of Mining
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis
0
30
60
90
120
150
180
210
240
270
300
330
360
0
100
200
300
400
500
600
700
800
900
1000

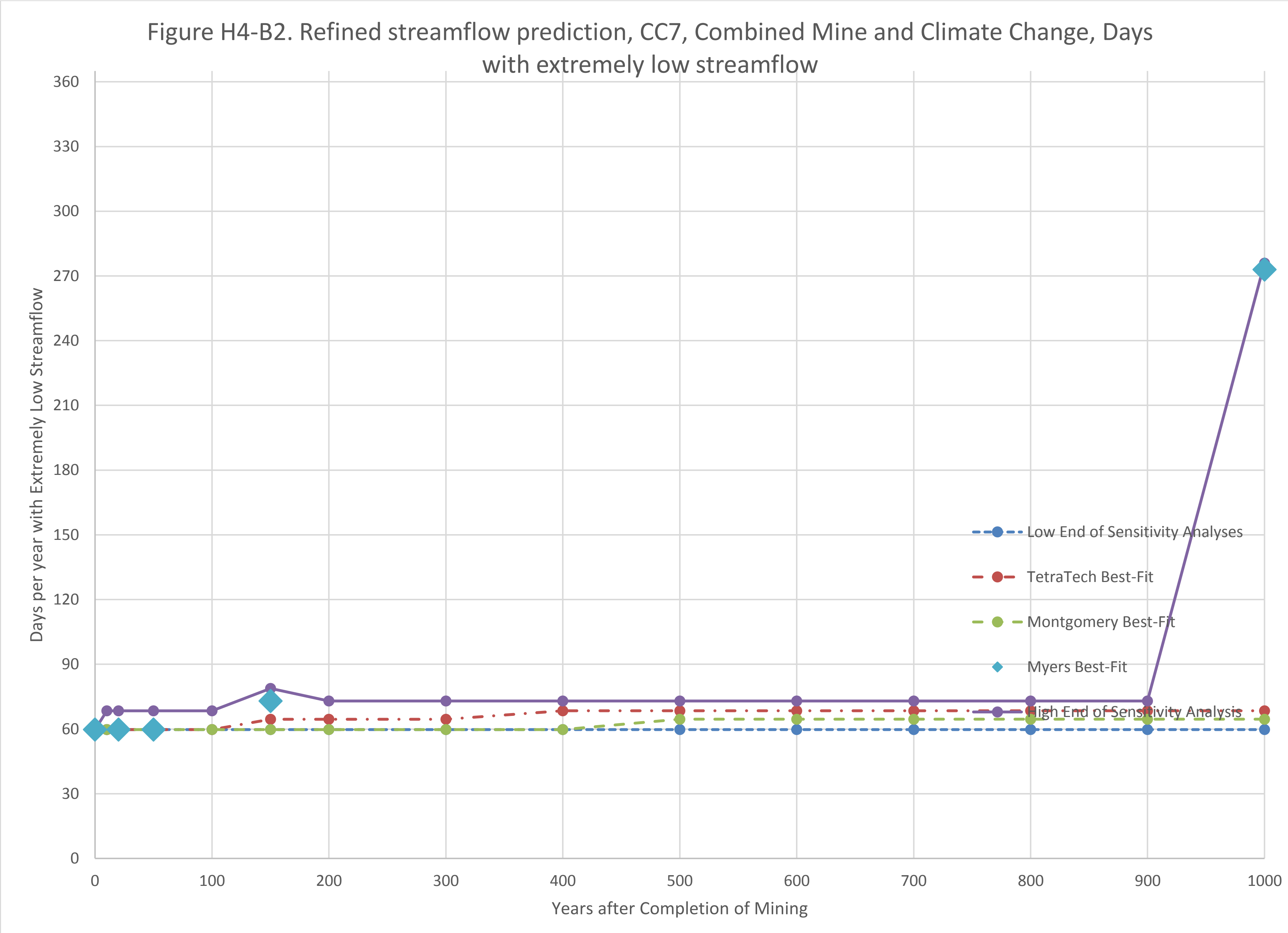


Figure H4-B2. Refined streamflow prediction, CC7, Combined Mine and Climate Change, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

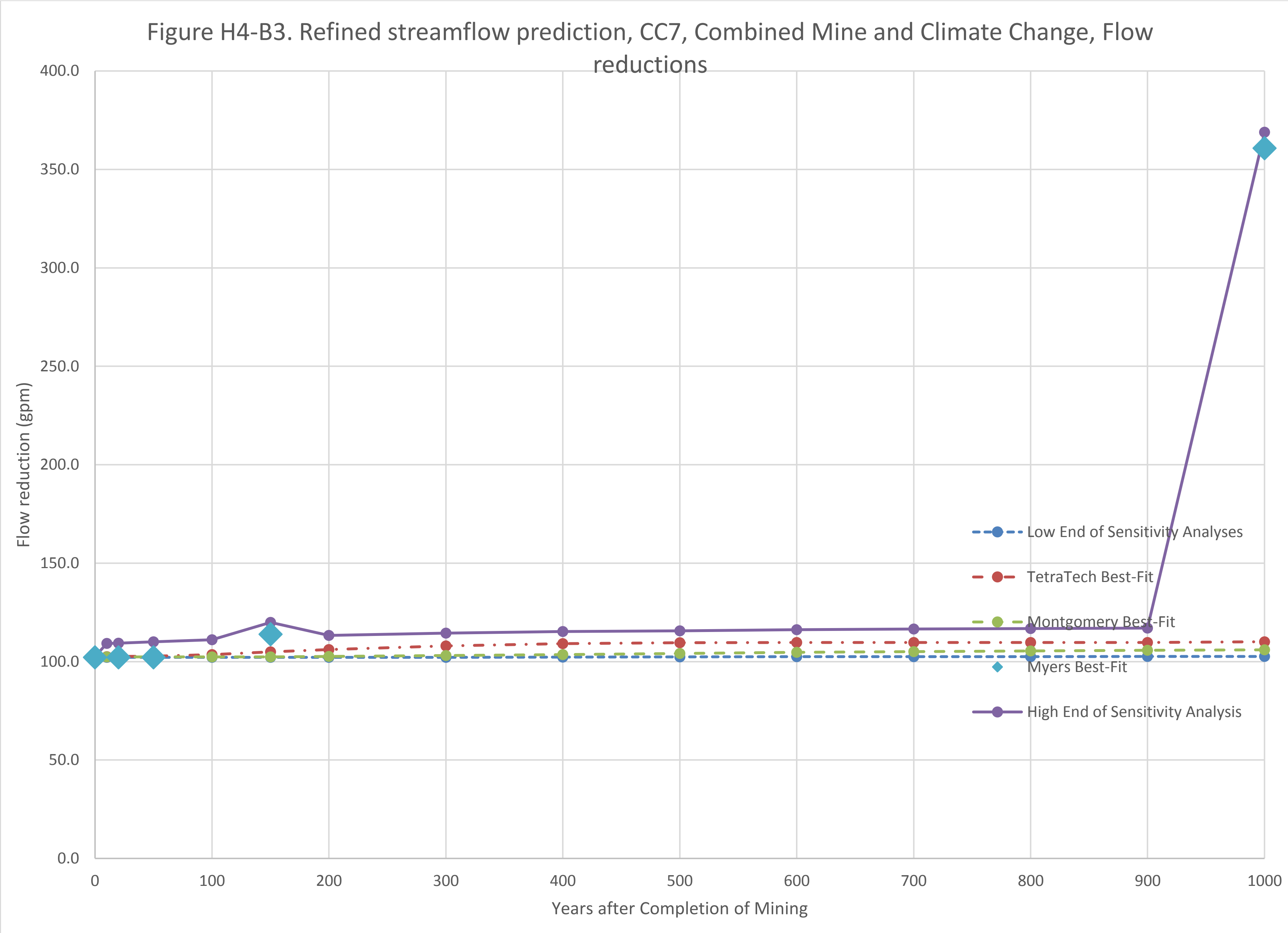


Figure H4-B3. Refined streamflow prediction, CC7, Combined Mine and Climate Change, Flow reductions
Flow reduction (gpm)
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

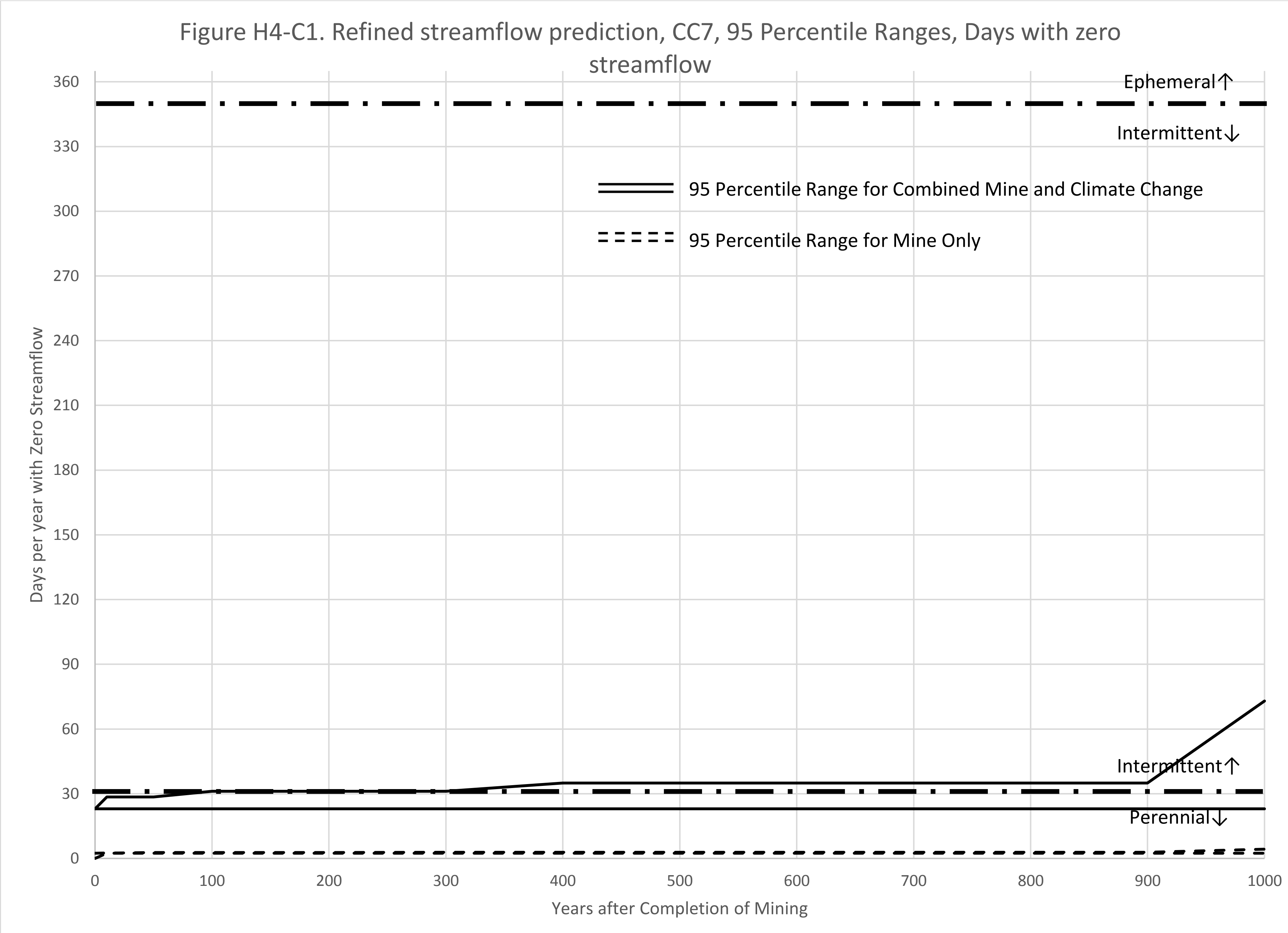


Figure H4-C1. Refined streamflow prediction, CC7, 95 Percentile Ranges, Days with zero streamflow
Ephemeral↑
Intermittent↓
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
Years after Completion of Mining
0
30
60
90
120
150
180
210
240
270
300
330
360
0
100
200
300
400
500
600
700
800
900
1000

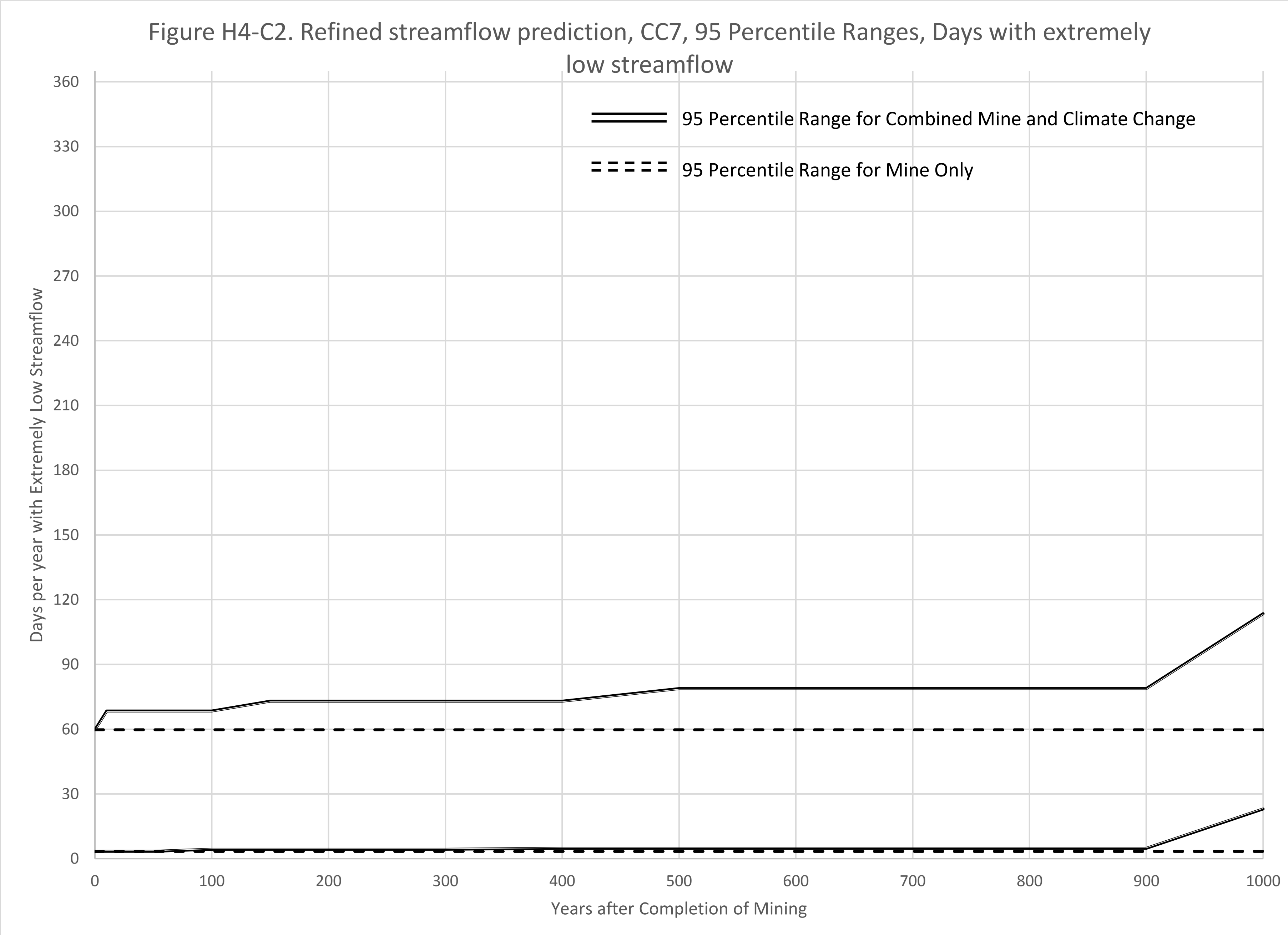


Figure H4-C2. Refined streamflow prediction, CC7, 95 Percentile Ranges, Days with extremely low streamflow
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

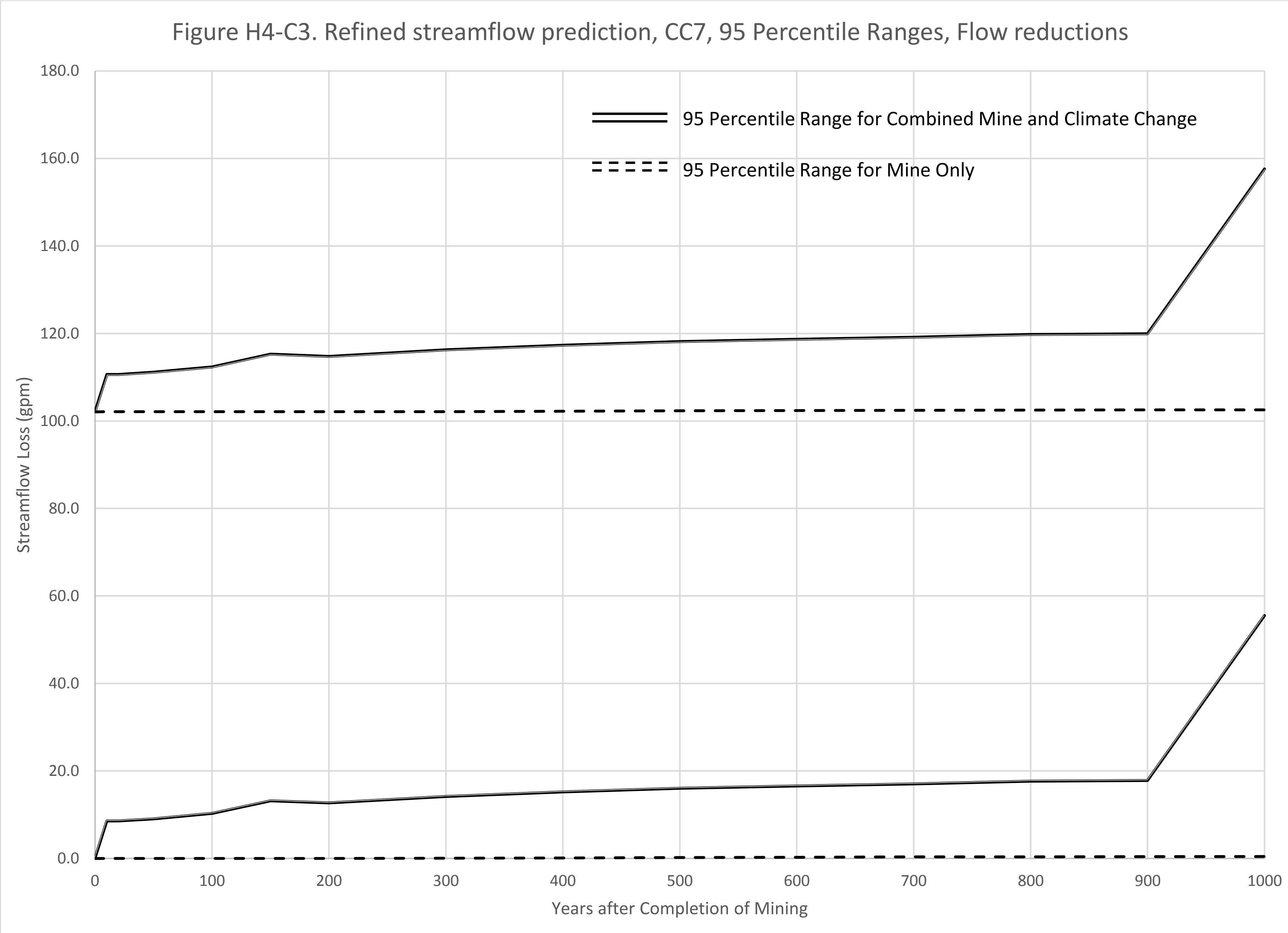


Figure H4-C3. Refined streamflow prediction, CC7, 95 Percentile Ranges, Flow reductions
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Streamflow Loss (gpm)
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only

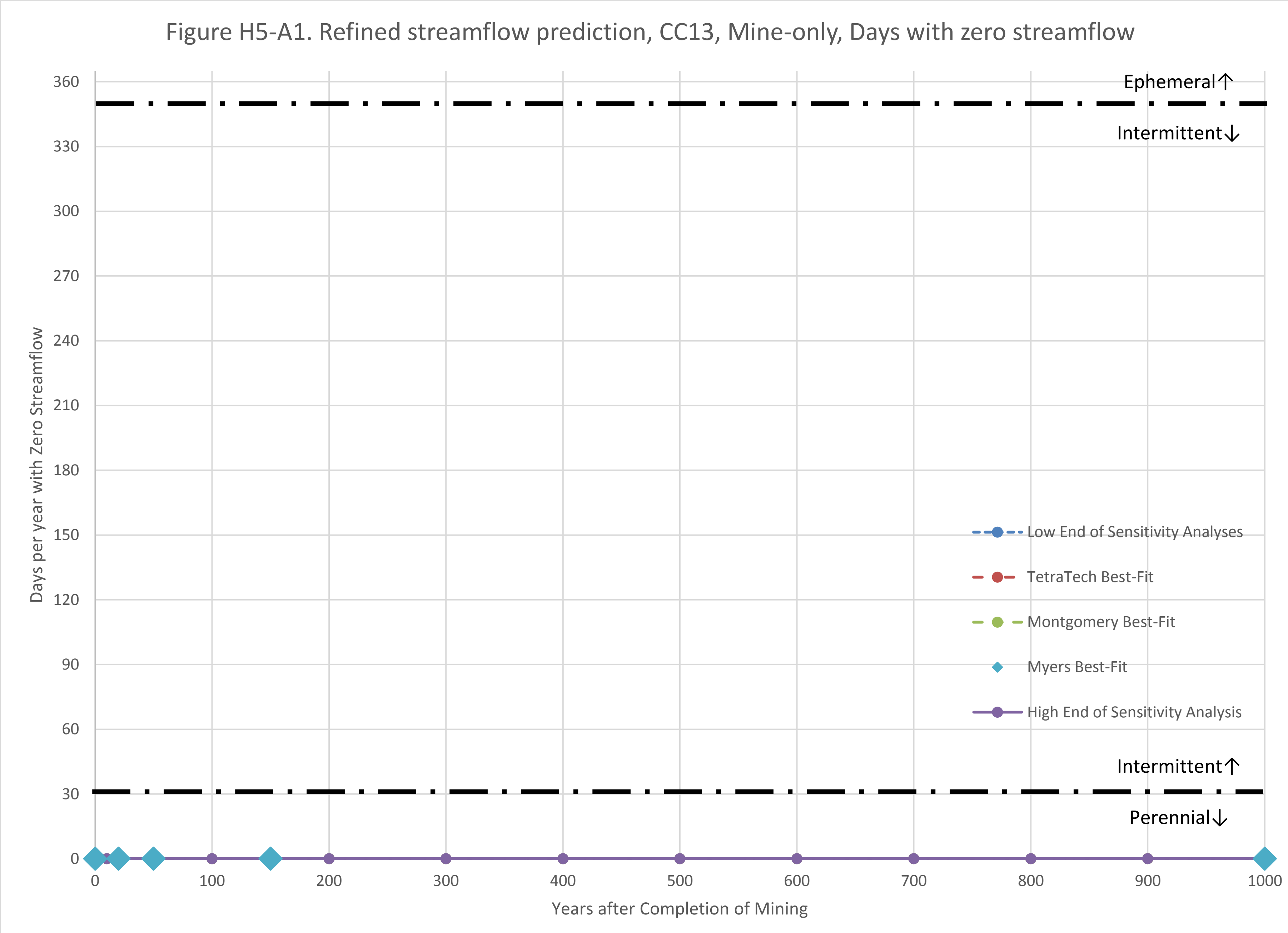


Figure H5-A1. Refined streamflow prediction, CC13, Mine-only, Days with zero streamflow
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

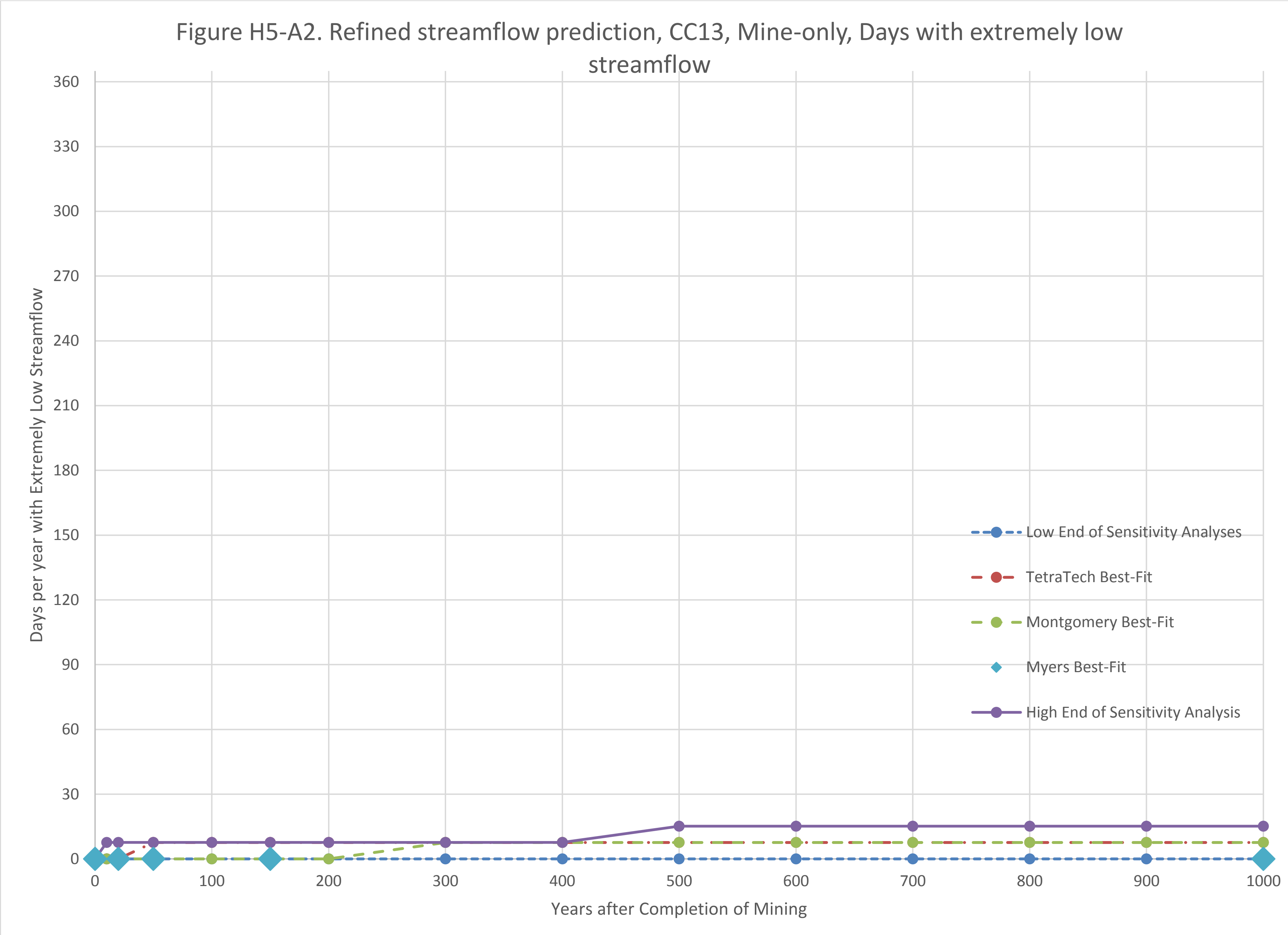


Figure H5-A2. Refined streamflow prediction, CC13, Mine-only, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

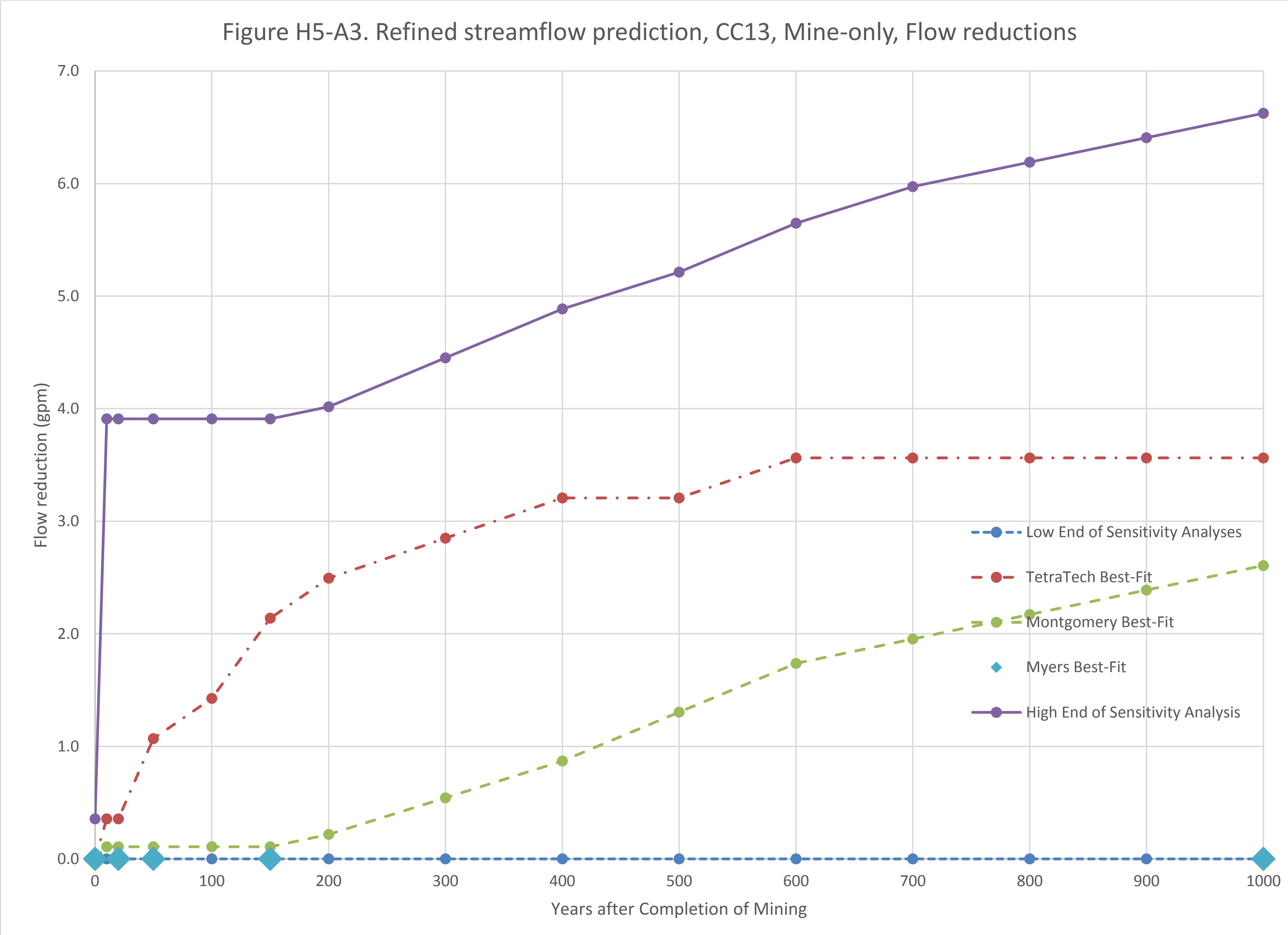


Figure H5-A3. Refined streamflow prediction, CC13, Mine-only, Flow reductions
Flow reduction (gpm)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

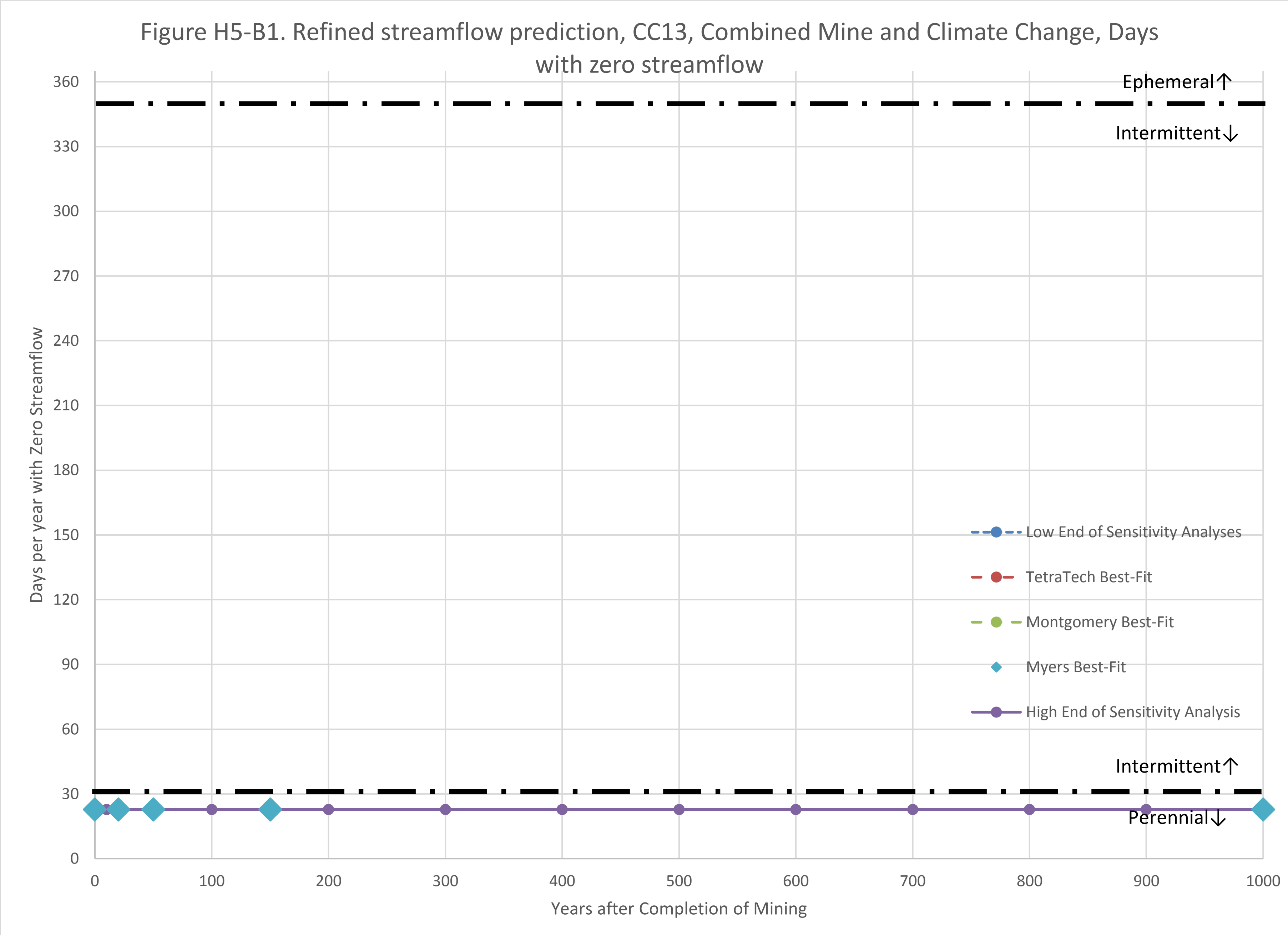


Figure H5-B1. Refined streamflow prediction, CC13, Combined Mine and Climate Change, Days with zero streamflow
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

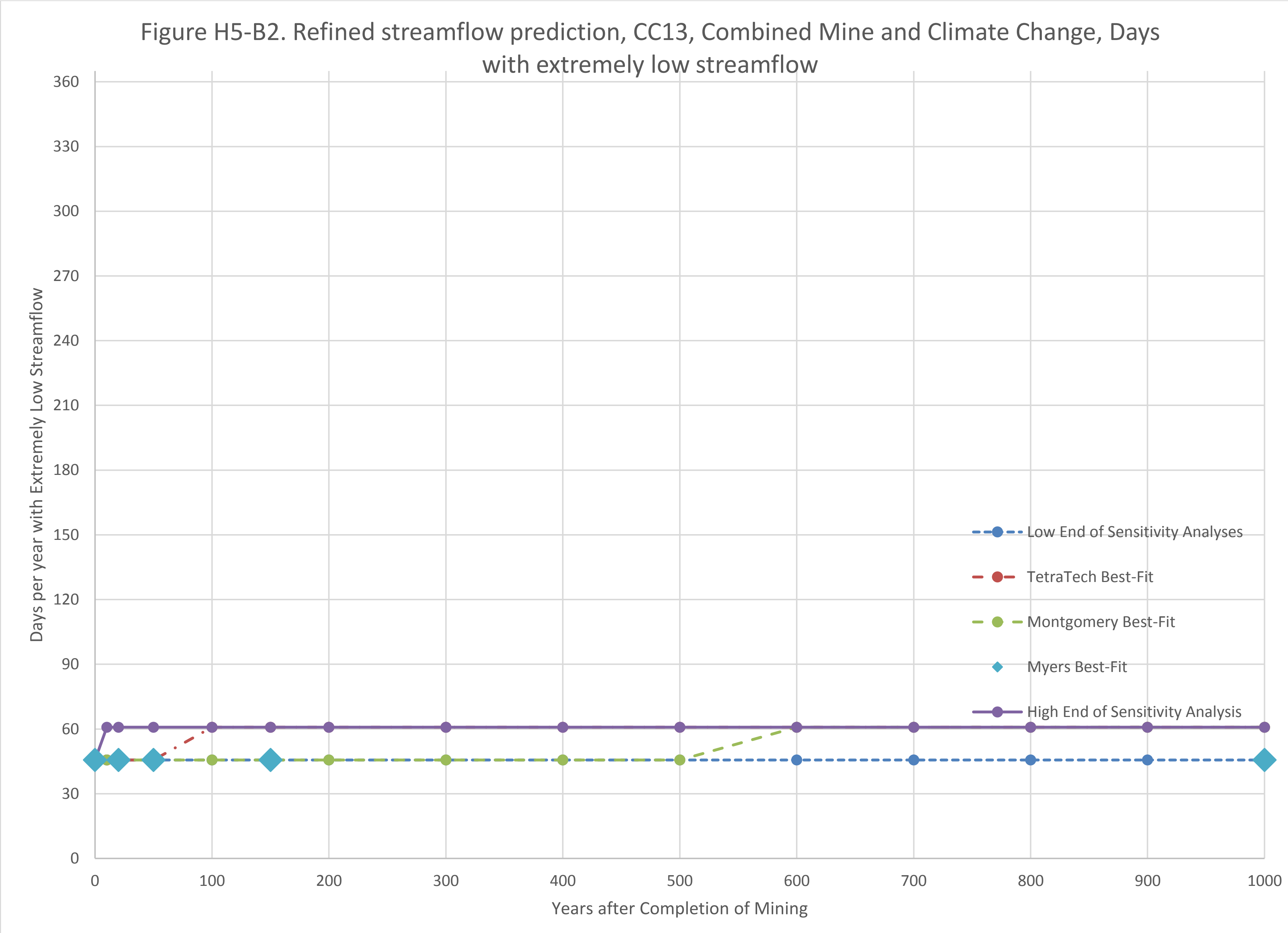


Figure H5-B2. Refined streamflow prediction, CC13, Combined Mine and Climate Change, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

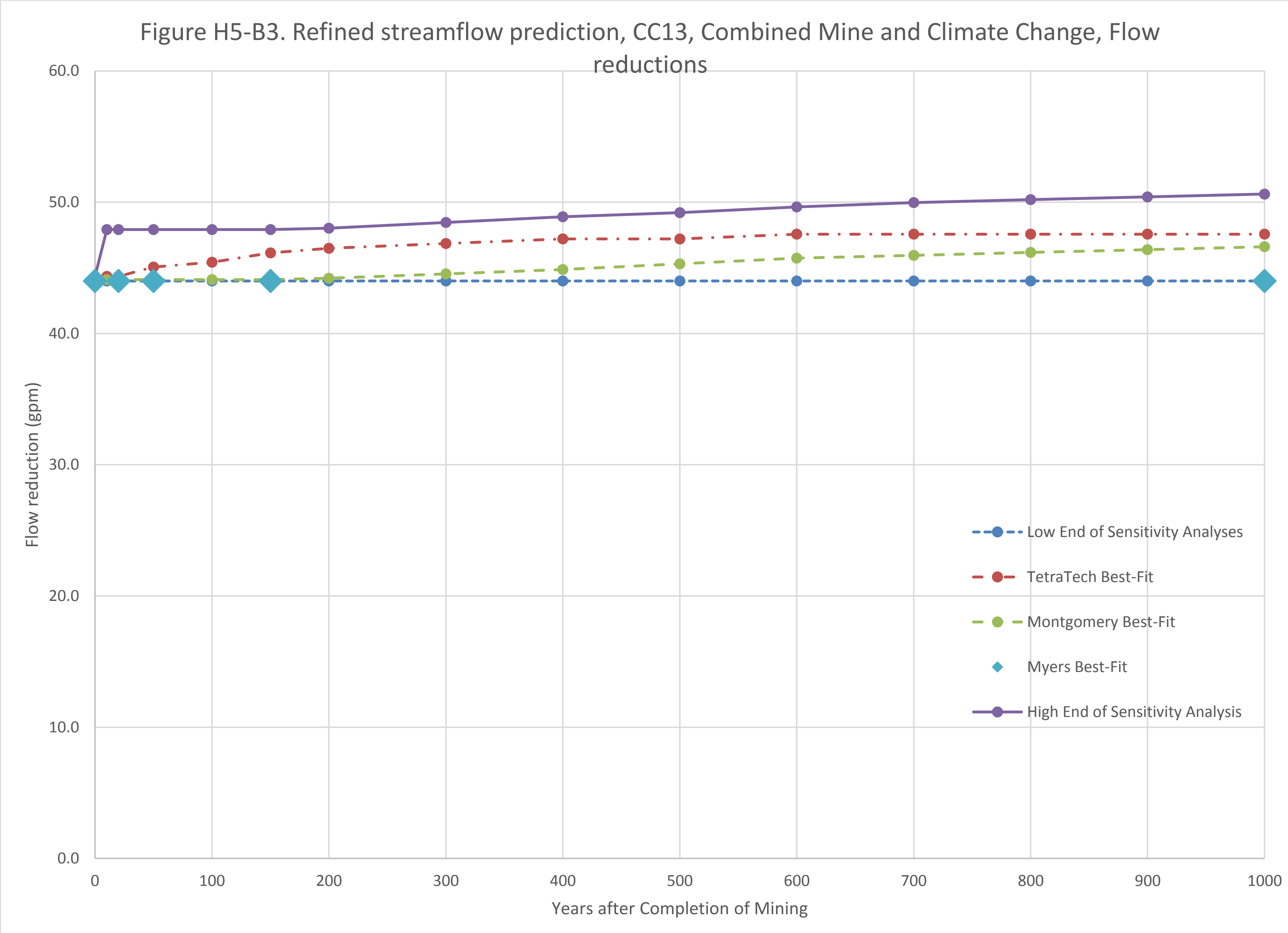


Figure H5-B3. Refined streamflow prediction, CC13, Combined Mine and Climate Change, Flow reductions
Flow reduction (gpm)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

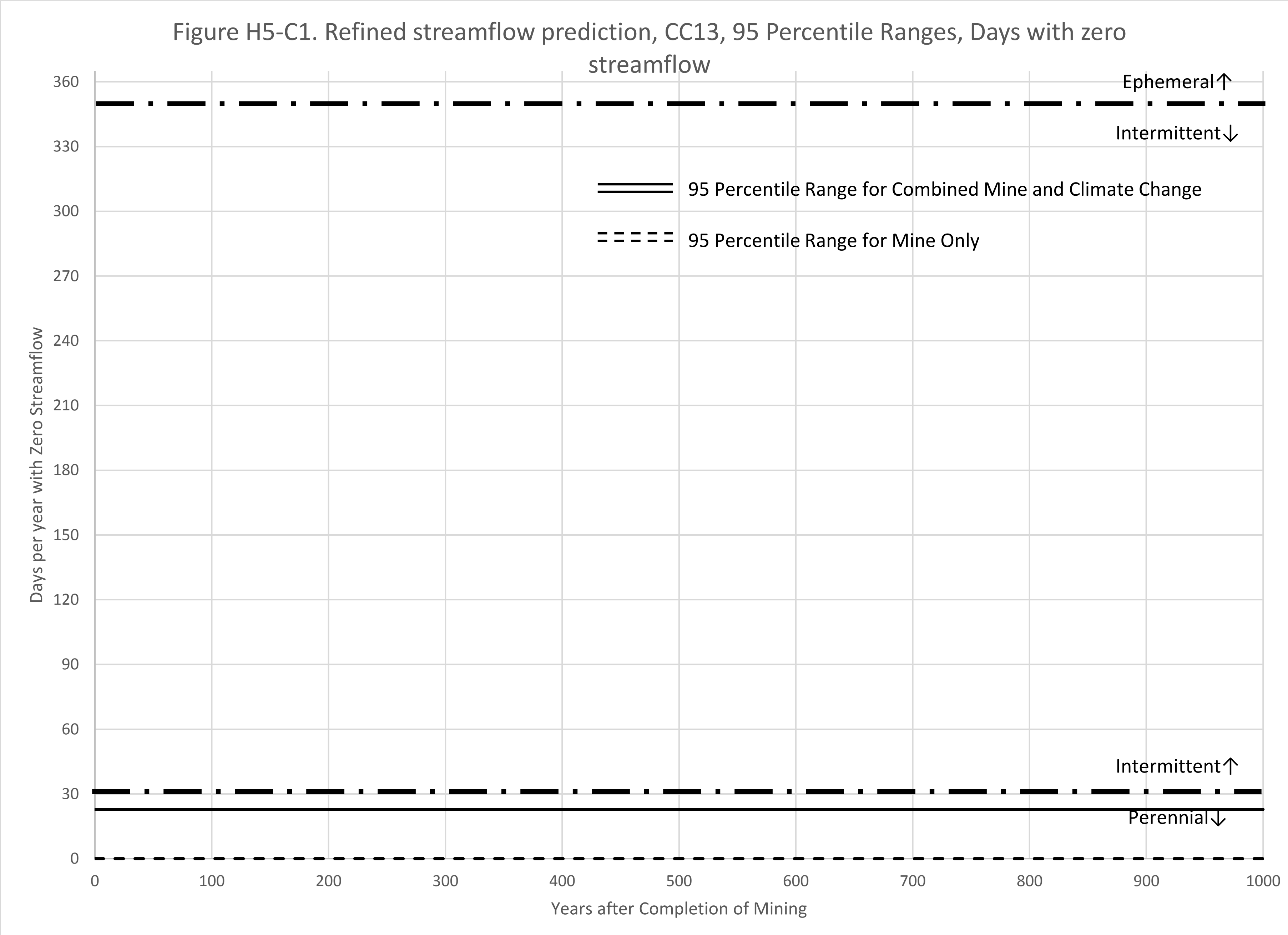


Figure H5-C1. Refined streamflow prediction, CC13, 95 Percentile Ranges, Days with zero streamflow
Ephemeral↑
Intermittent↓
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
Years after Completion of Mining
0
30
60
90
120
150
180
210
240
270
300
330
360
100
200
300
400
500
600
700
800
900
1000

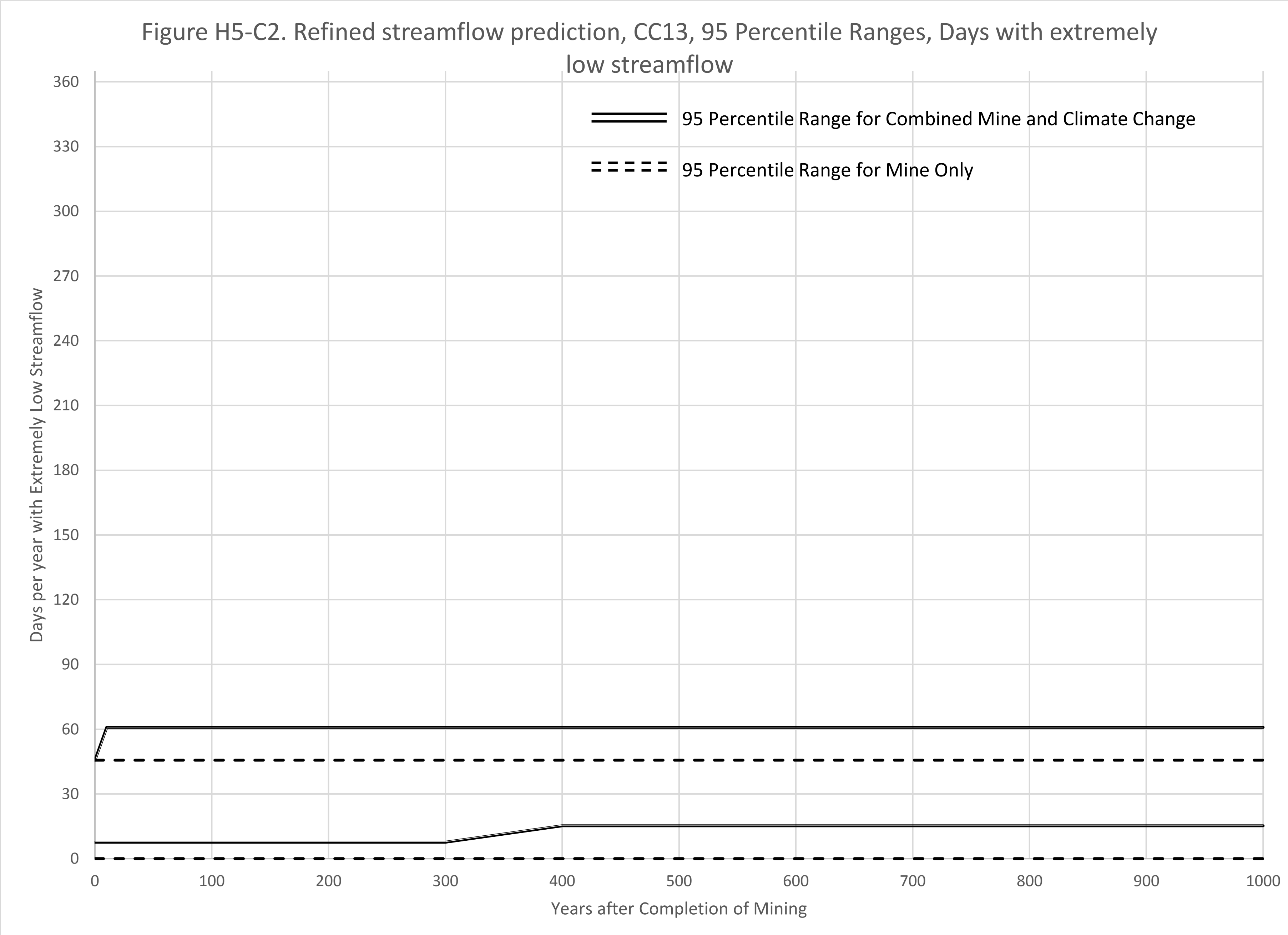


Figure H5-C2. Refined streamflow prediction, CC13, 95 Percentile Ranges, Days with extremely low streamflow
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Days per year with Extremely Low Streamflow
Years after Completion of Mining
0
30
60
90
120
150
180
210
240
270
300
330
360
0
100
200
300
400
500
600
700
800
900
1000

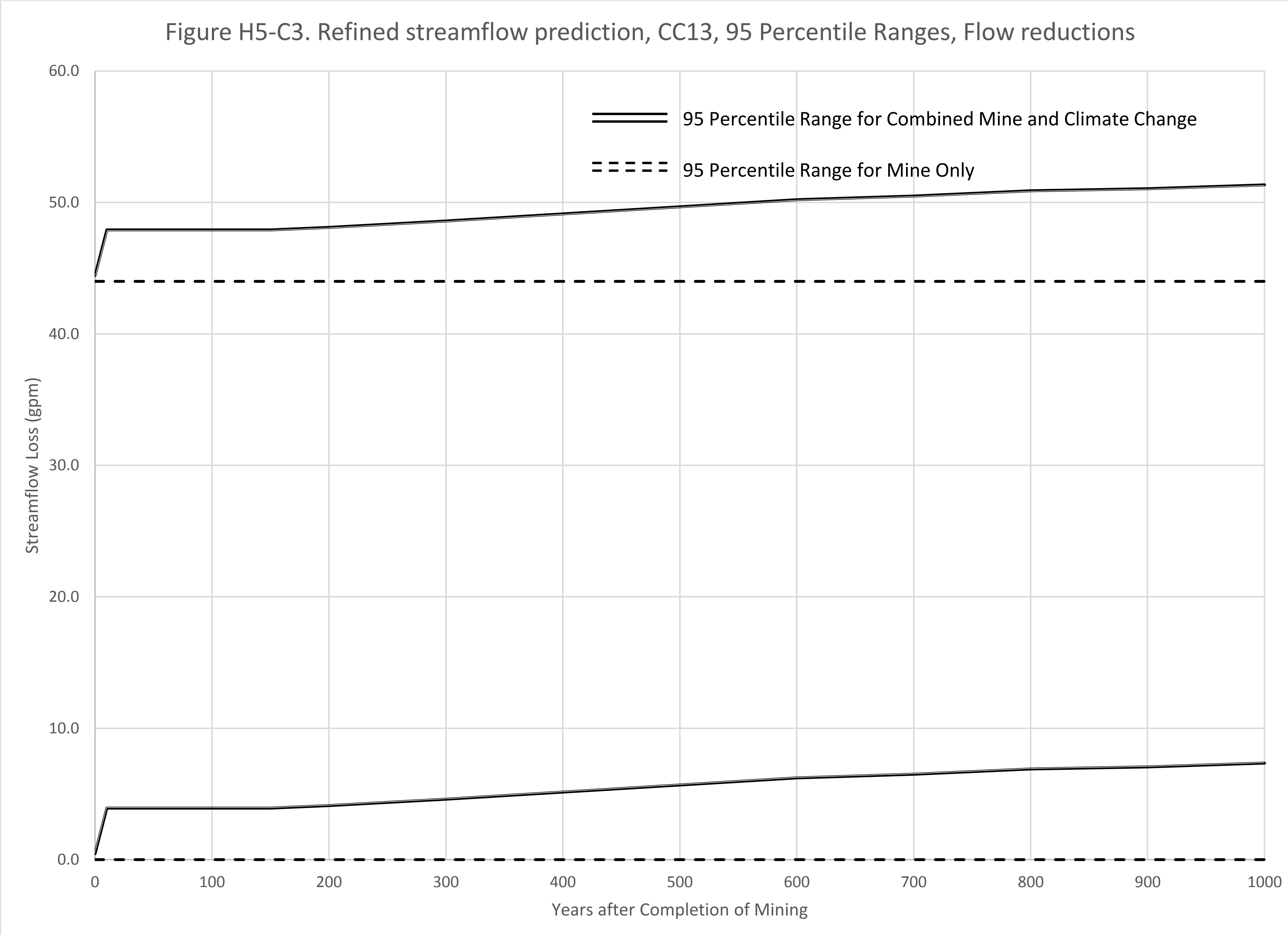


Figure H5-C3. Refined streamflow prediction, CC13, 95 Percentile Ranges, Flow reductions
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Streamflow Loss (gpm)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

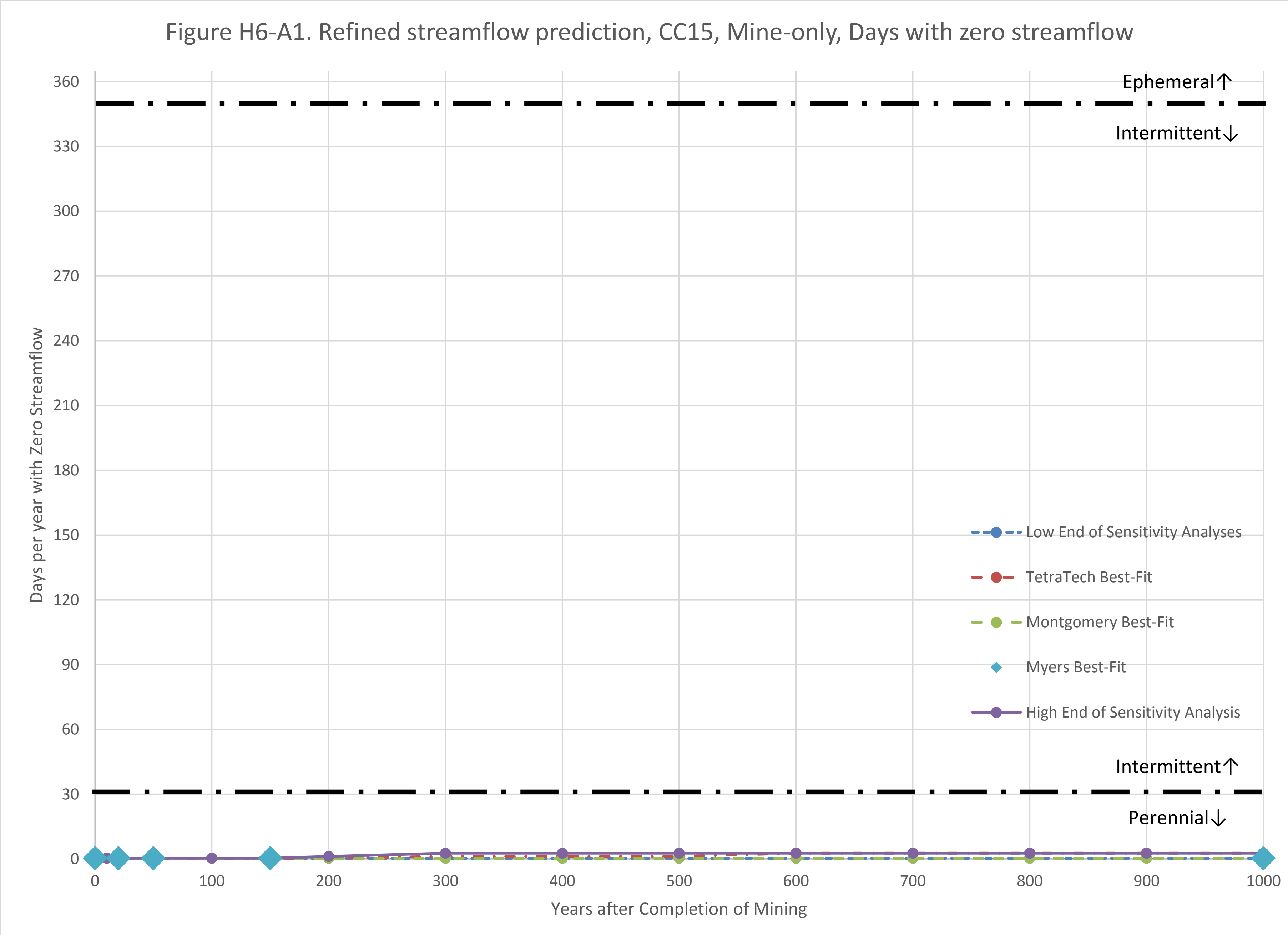


Figure H6-A1. Refined streamflow prediction, CC15, Mine-only, Days with zero streamflow
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

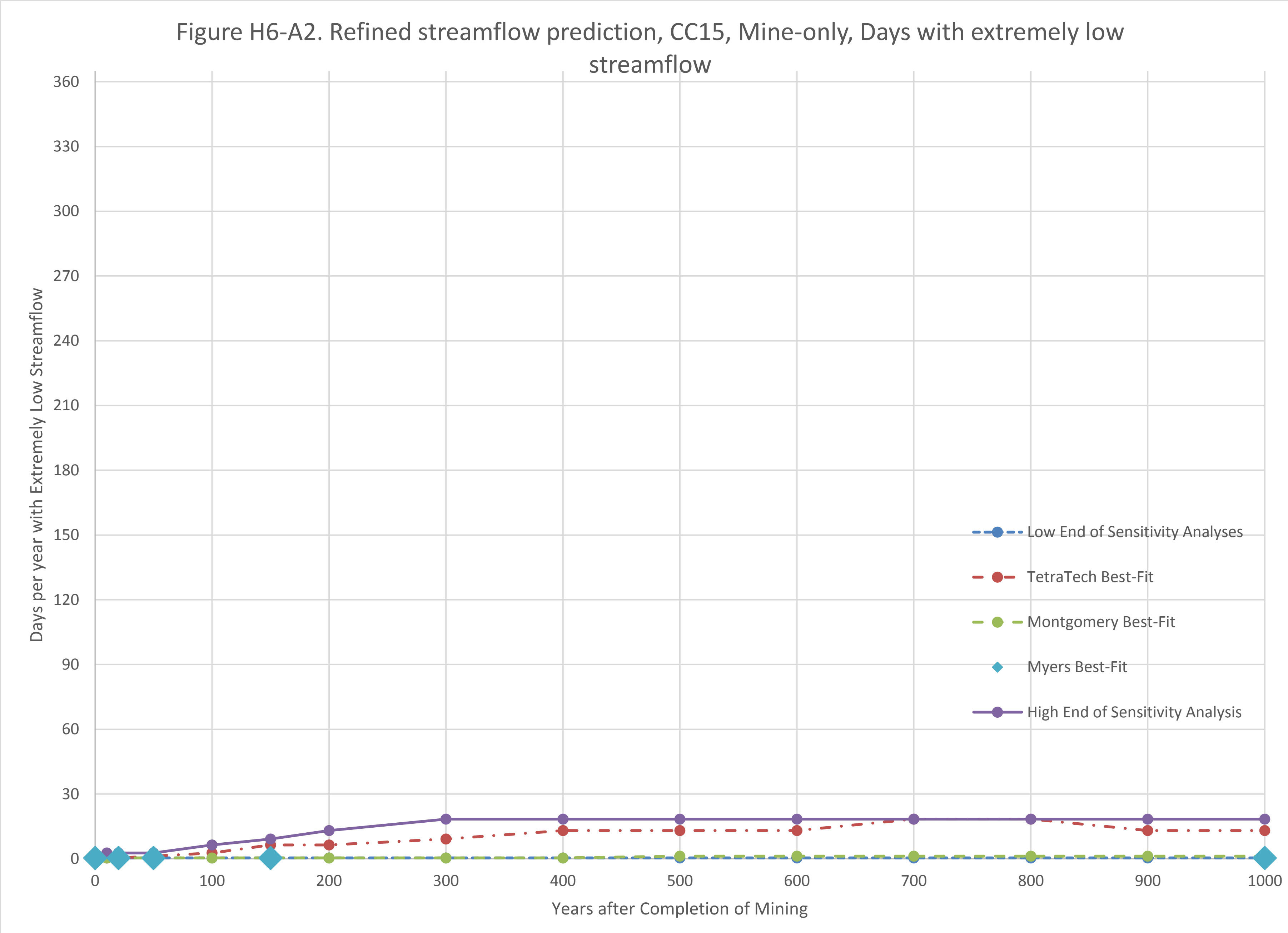


Figure H6-A2. Refined streamflow prediction, CC15, Mine-only, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

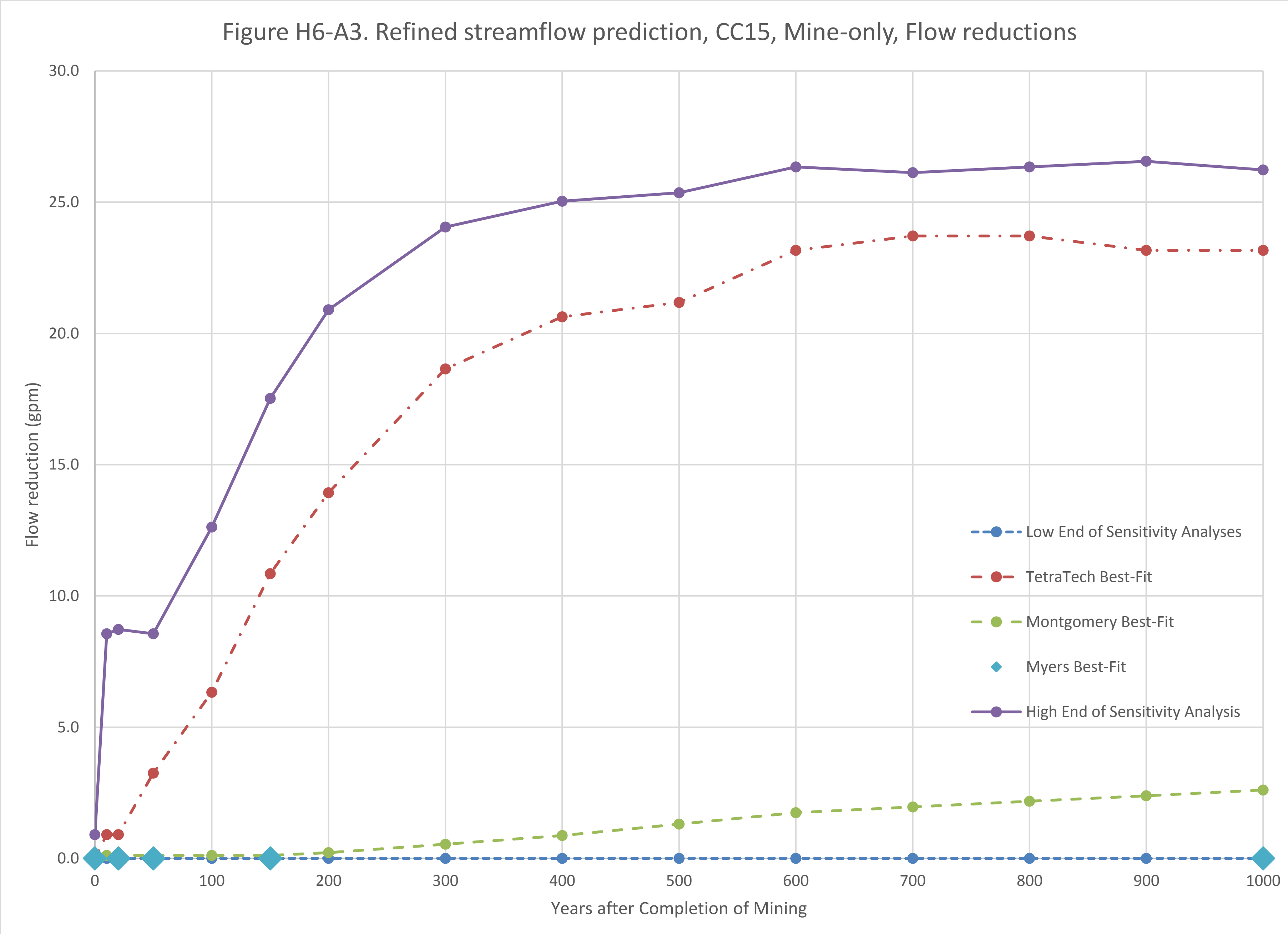


Figure H6-A3. Refined streamflow prediction, CC15, Mine-only, Flow reductions
Flow reduction (gpm)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

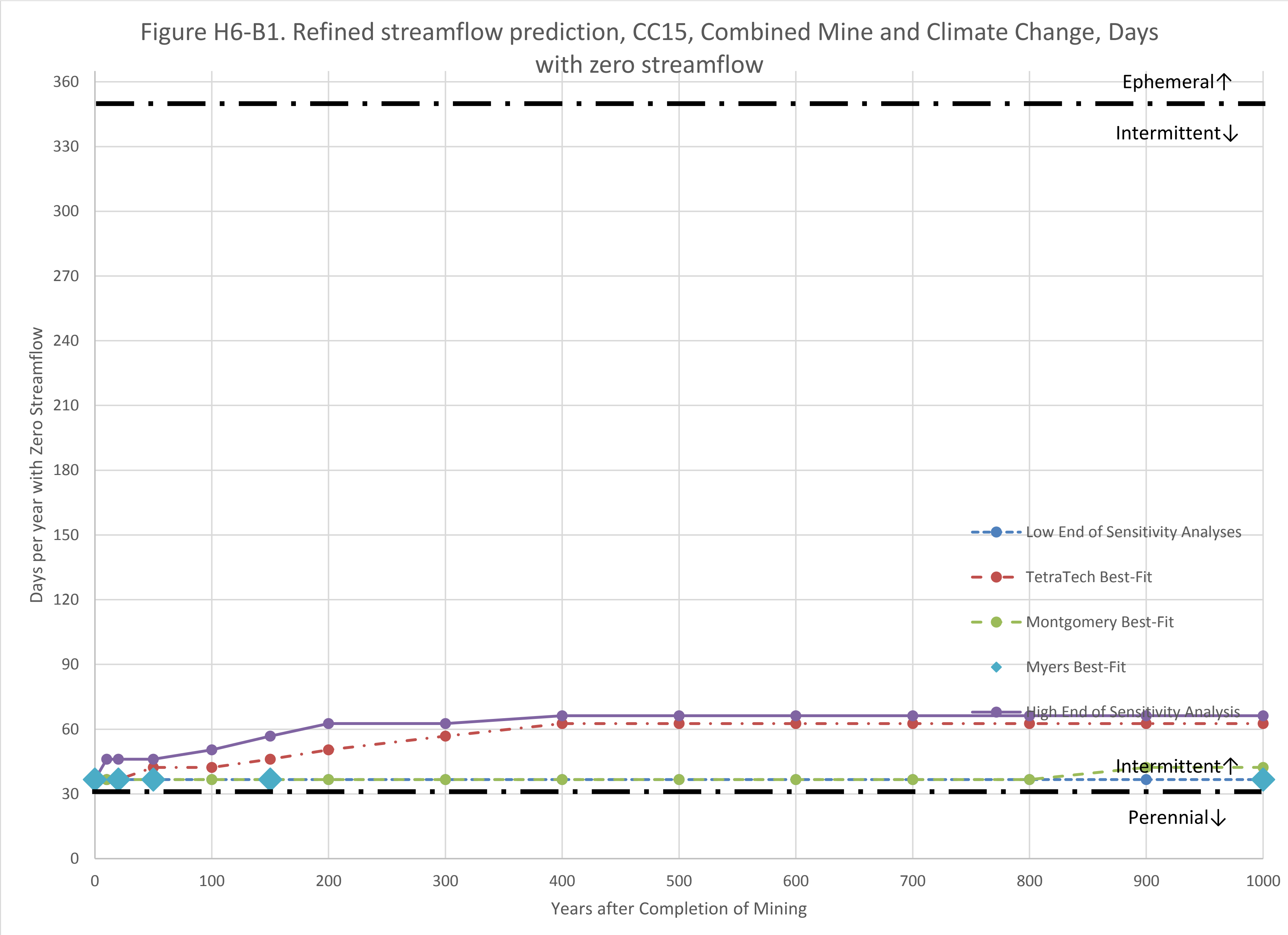


Figure H6-B1. Refined streamflow prediction, CC15, Combined Mine and Climate Change, Days with zero streamflow
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis
0
30
60
90
120
150
180
210
240
270
300
330
360
100
200
300
400
500
600
700
800
900
1000

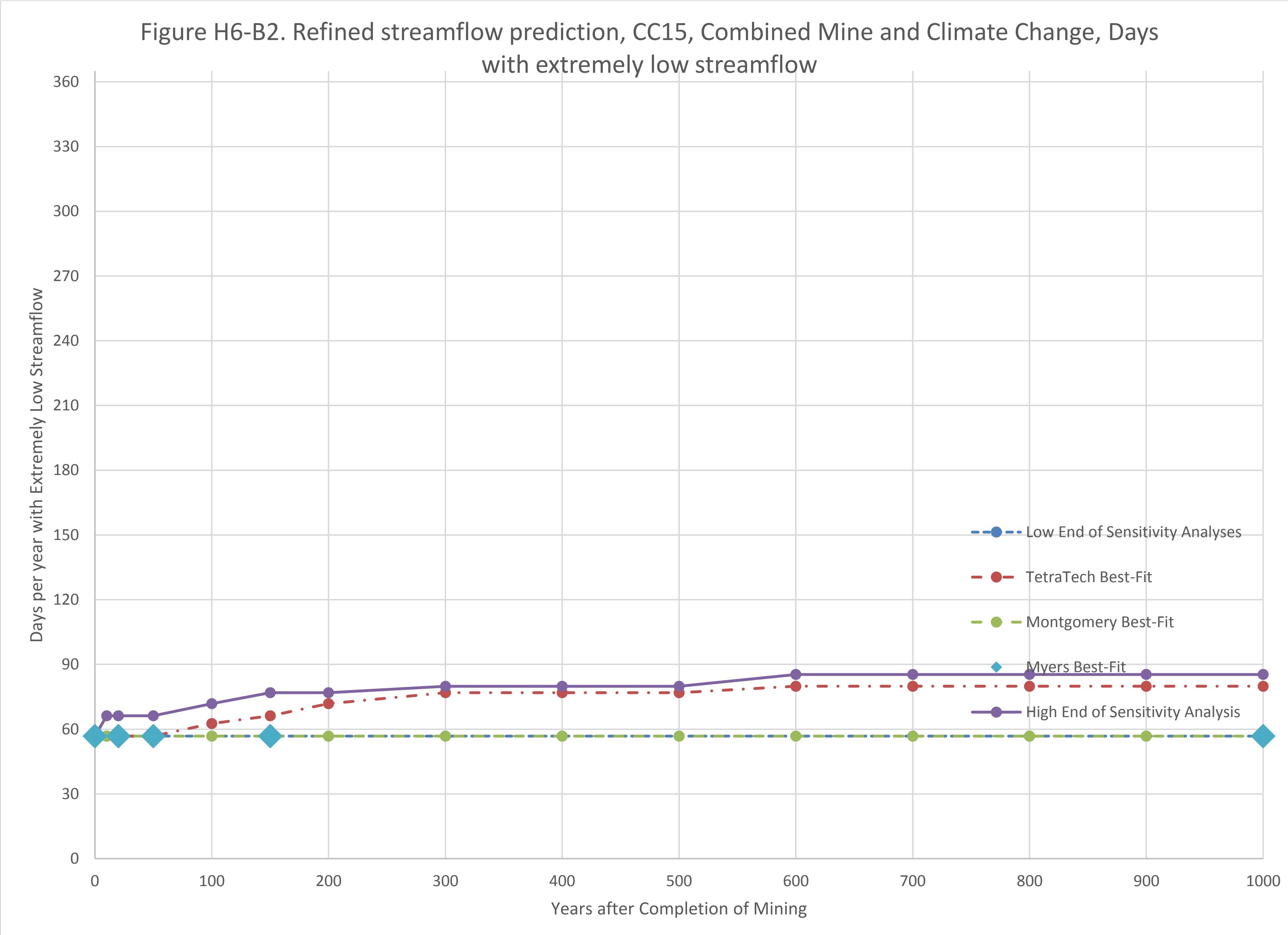


Figure H6-B2. Refined streamflow prediction, CC15, Combined Mine and Climate Change, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

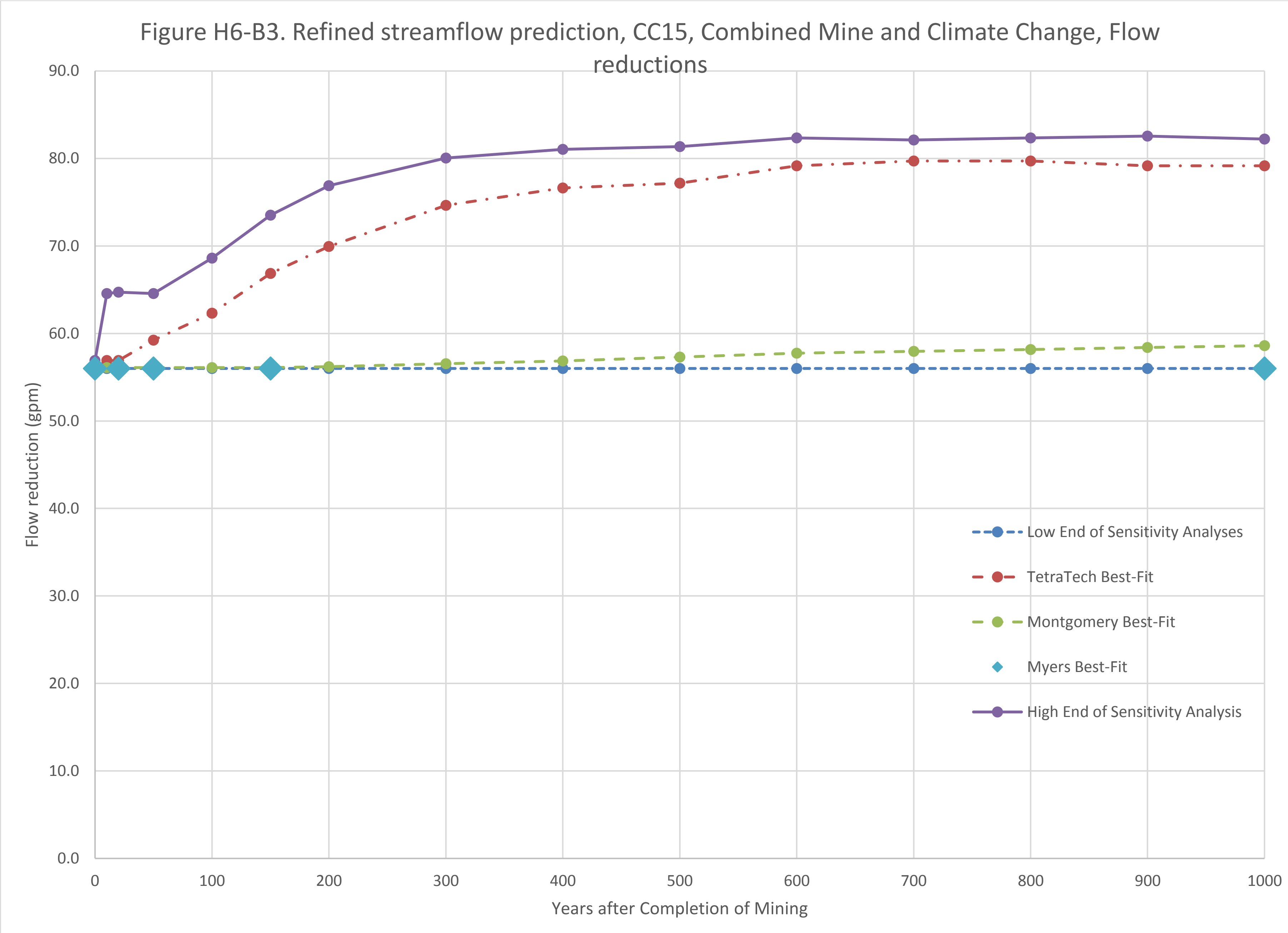


Figure H6-B3. Refined streamflow prediction, CC15, Combined Mine and Climate Change, Flow reductions
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Flow reduction (gpm)
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

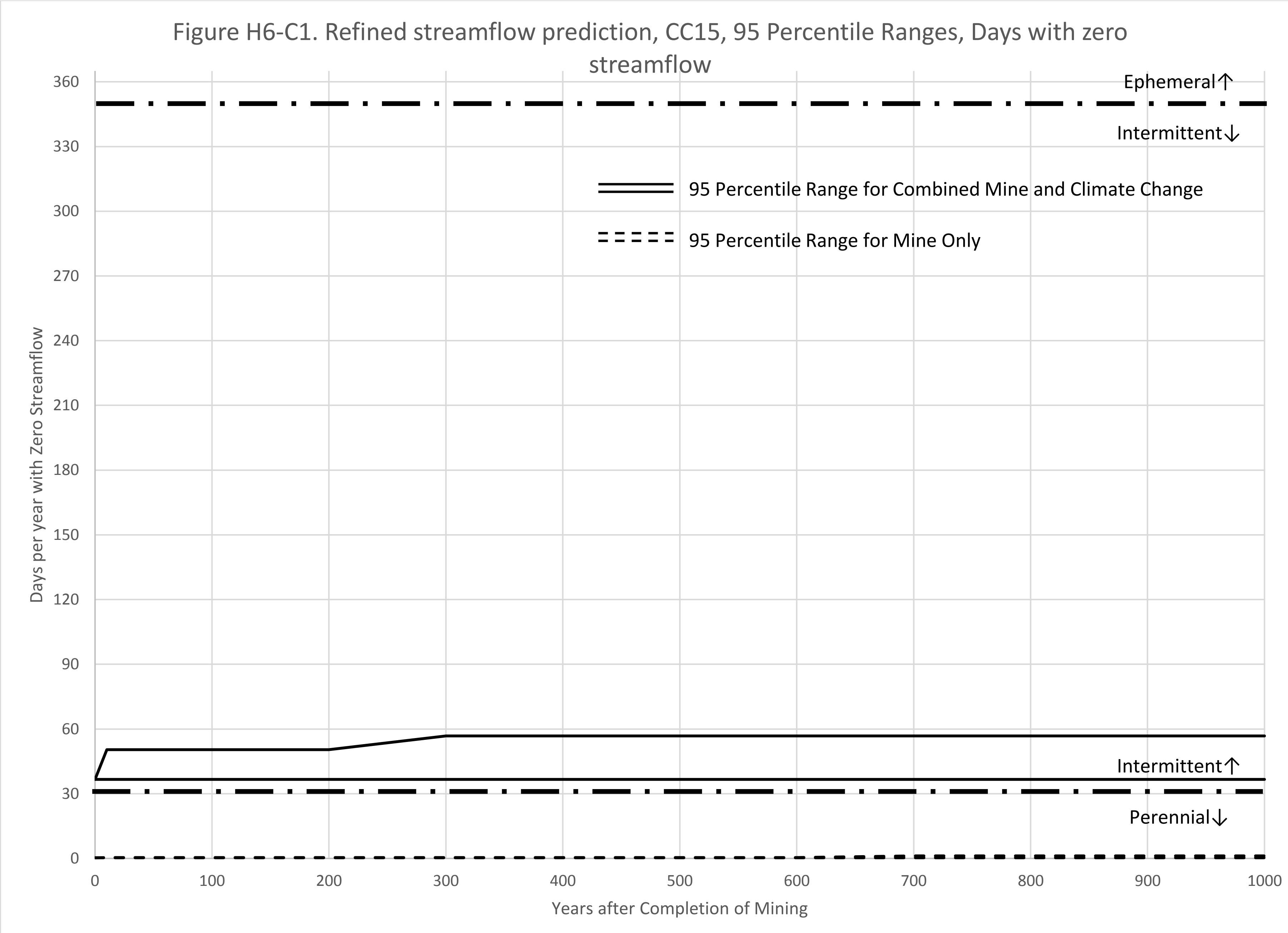


Figure H6-C1. Refined streamflow prediction, CC15, 95 Percentile Ranges, Days with zero streamflow
Ephemeral↑
Intermittent↓
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
0
30
60
90
120
150
180
210
240
270
300
330
360
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

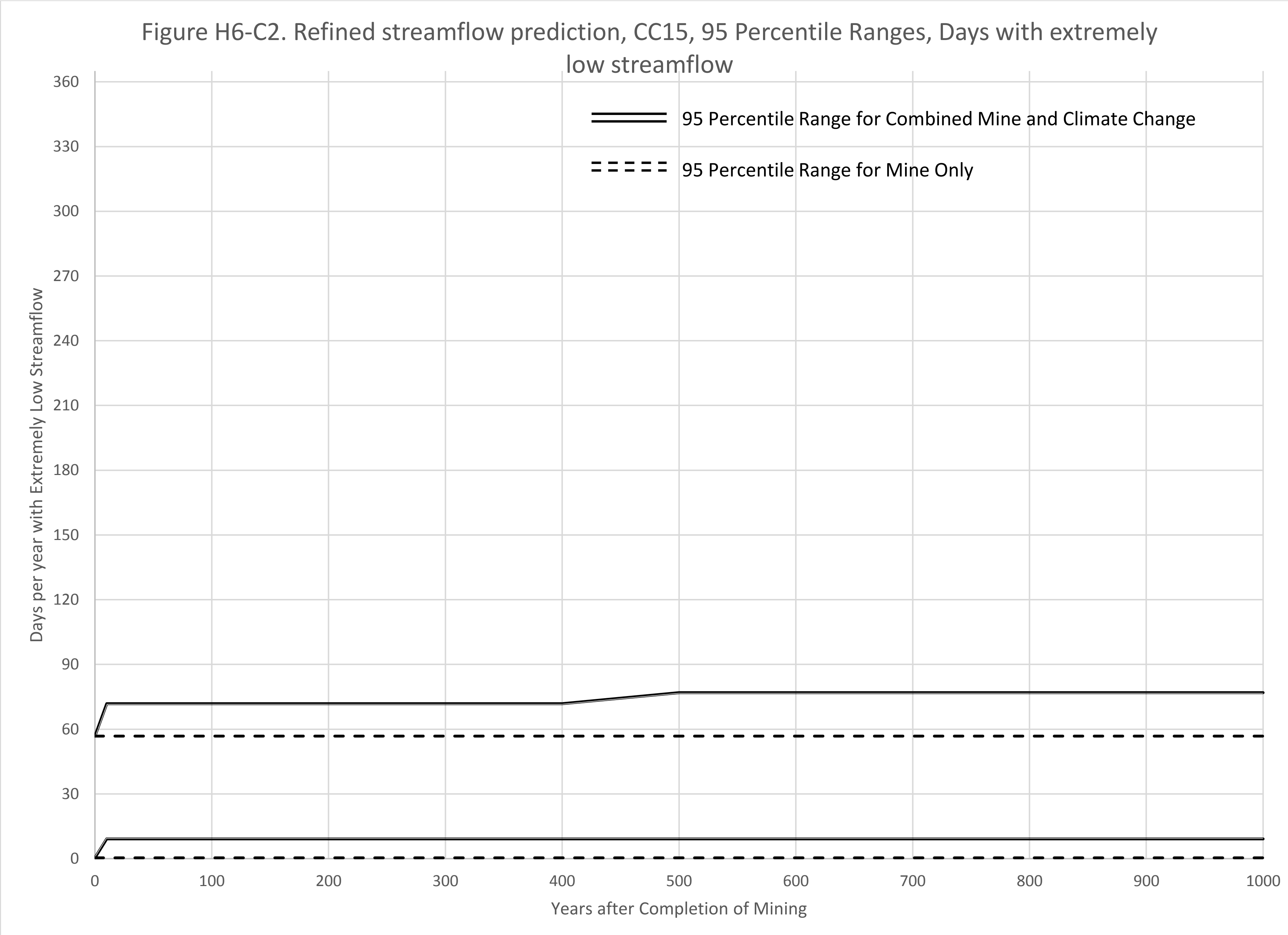


Figure H6-C2. Refined streamflow prediction, CC15, 95 Percentile Ranges, Days with extremely low streamflow
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

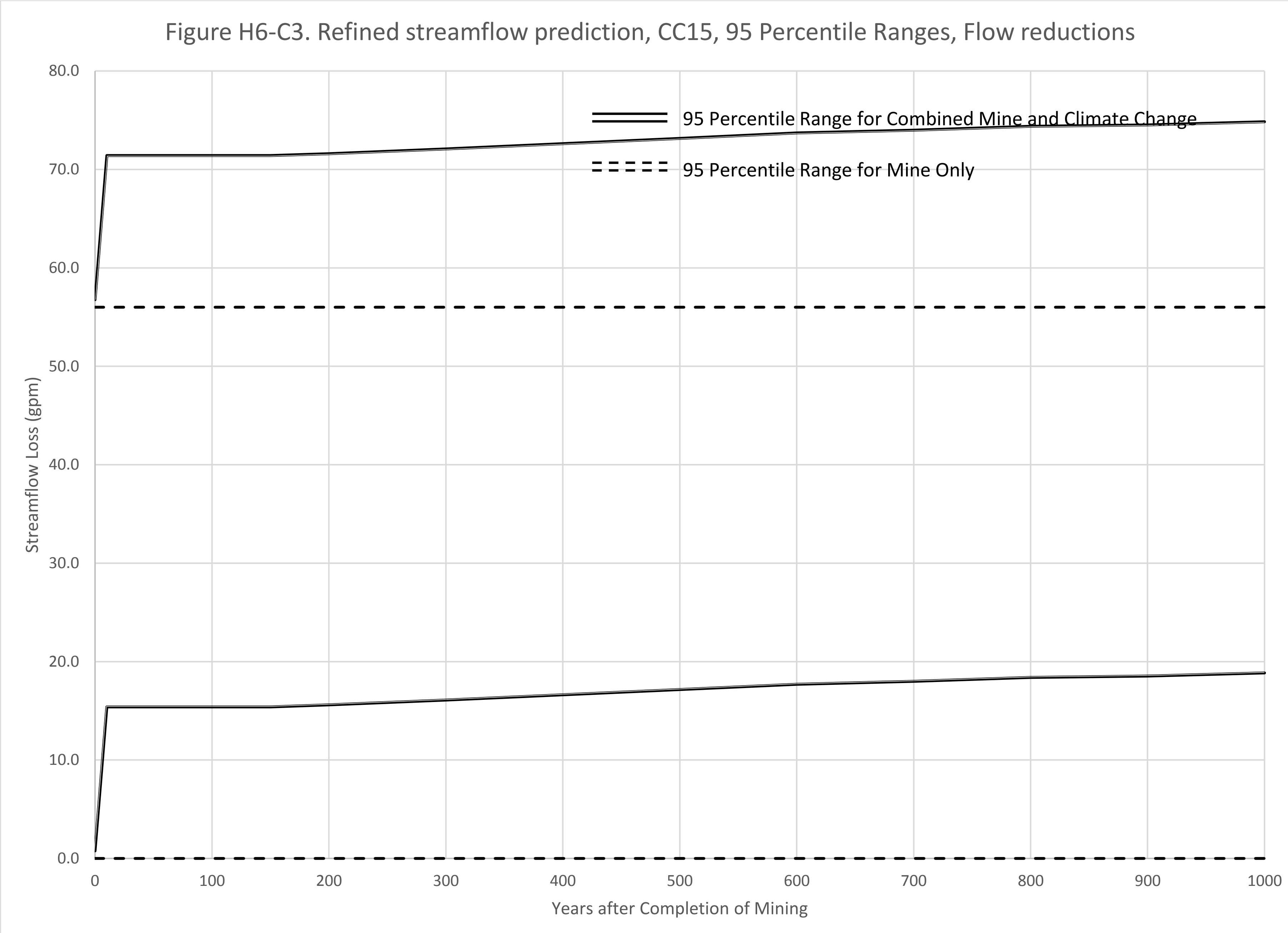


Figure H6-C3. Refined streamflow prediction, CC15, 95 Percentile Ranges, Flow reductions
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Streamflow Loss (gpm)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

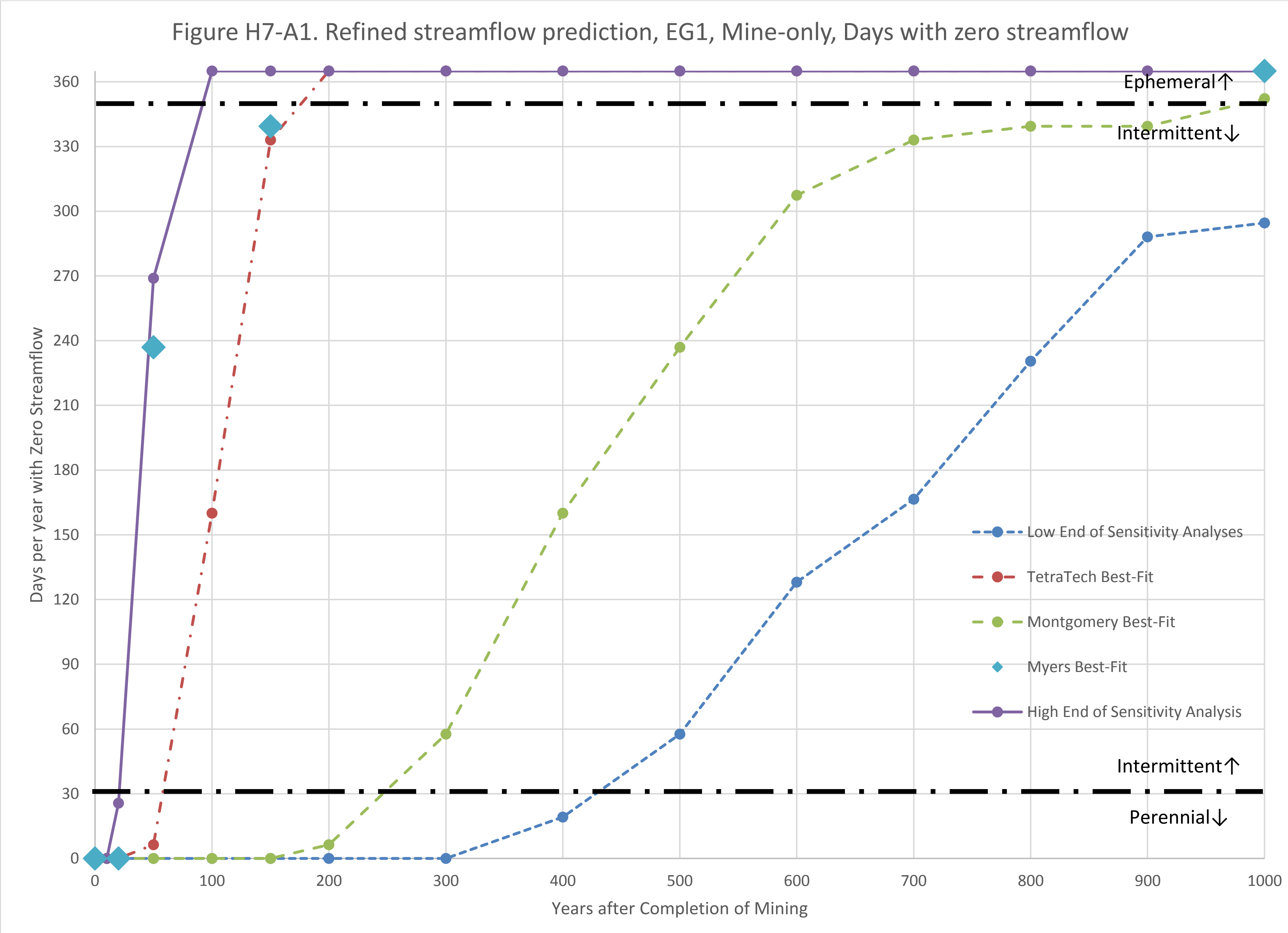


Figure H7-A1. Refined streamflow prediction, EG1, Mine-only, Days with zero streamflow
Days per year with Zero Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

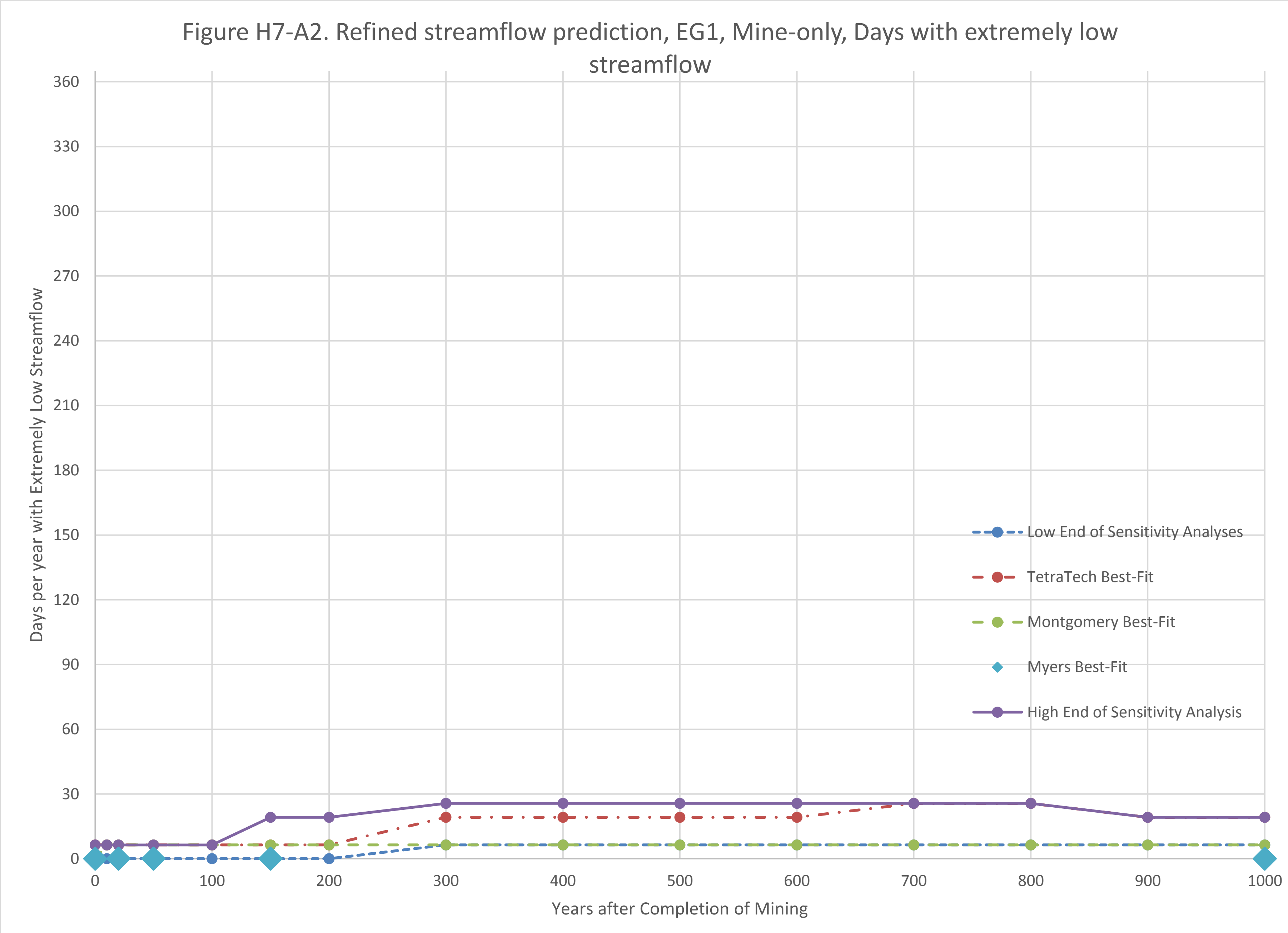


Figure H7-A2. Refined streamflow prediction, EG1, Mine-only, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
Years after Completion of Mining
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

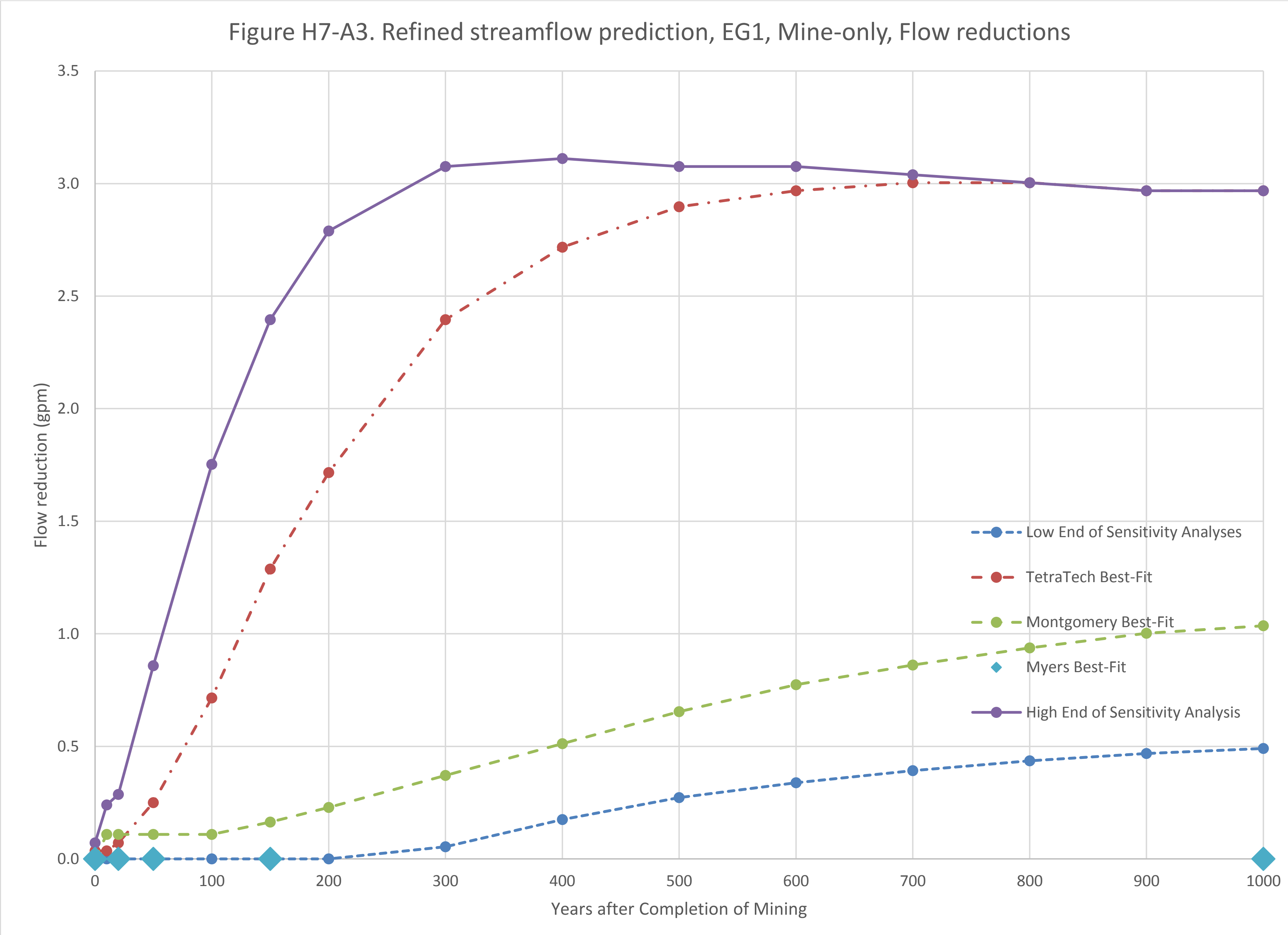


Figure H7-A3. Refined streamflow prediction, EG1, Mine-only, Flow reductions
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow reduction (gpm)
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

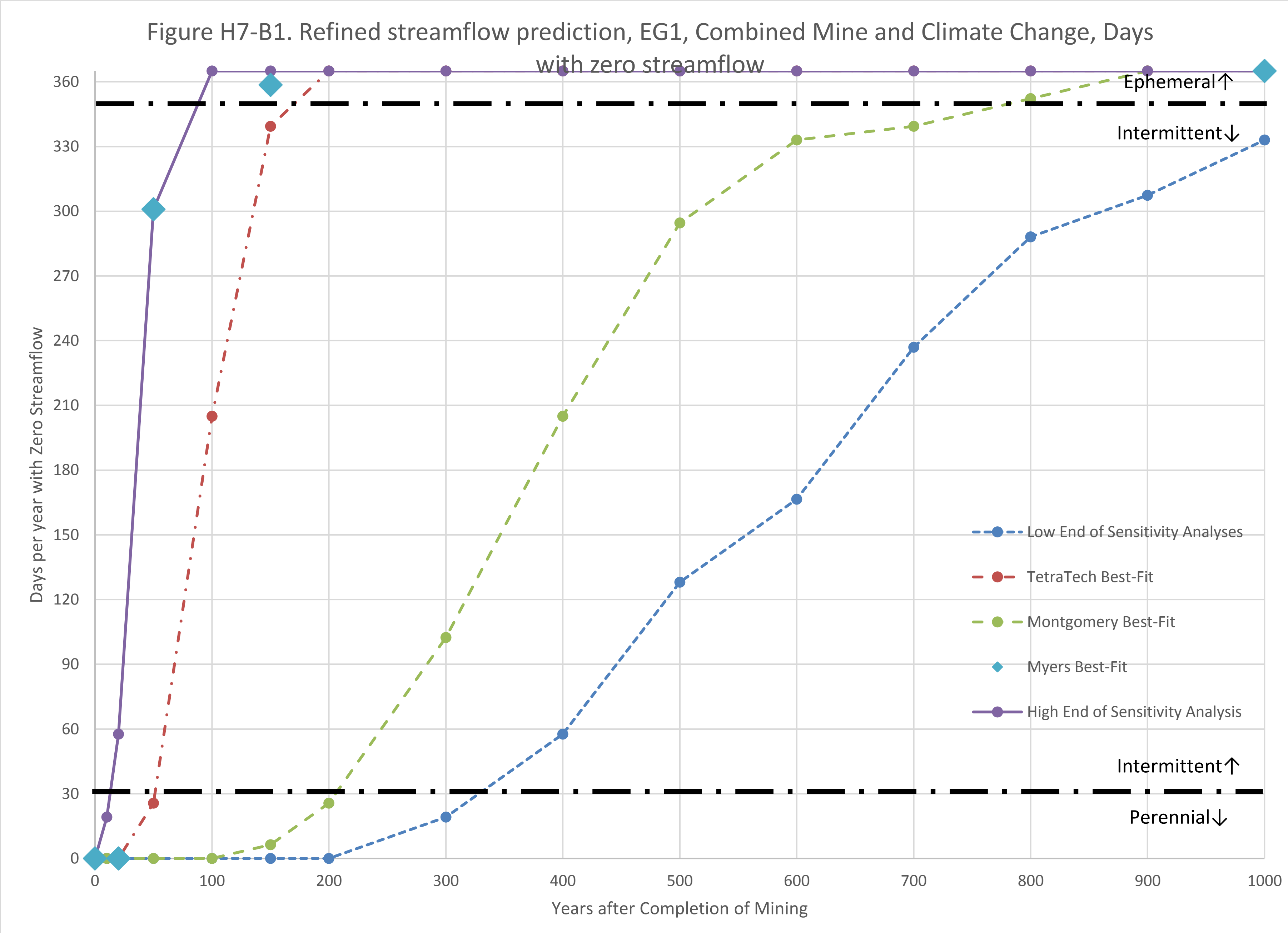


Figure H7-B1. Refined streamflow prediction, EG1, Combined Mine and Climate Change, Days with zero streamflow
Days per year with Zero Streamflow
Years after Completion of Mining
0
30
60
90
120
150
180
210
240
270
300
330
360
0
100
200
300
400
500
600
700
800
900
1000
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

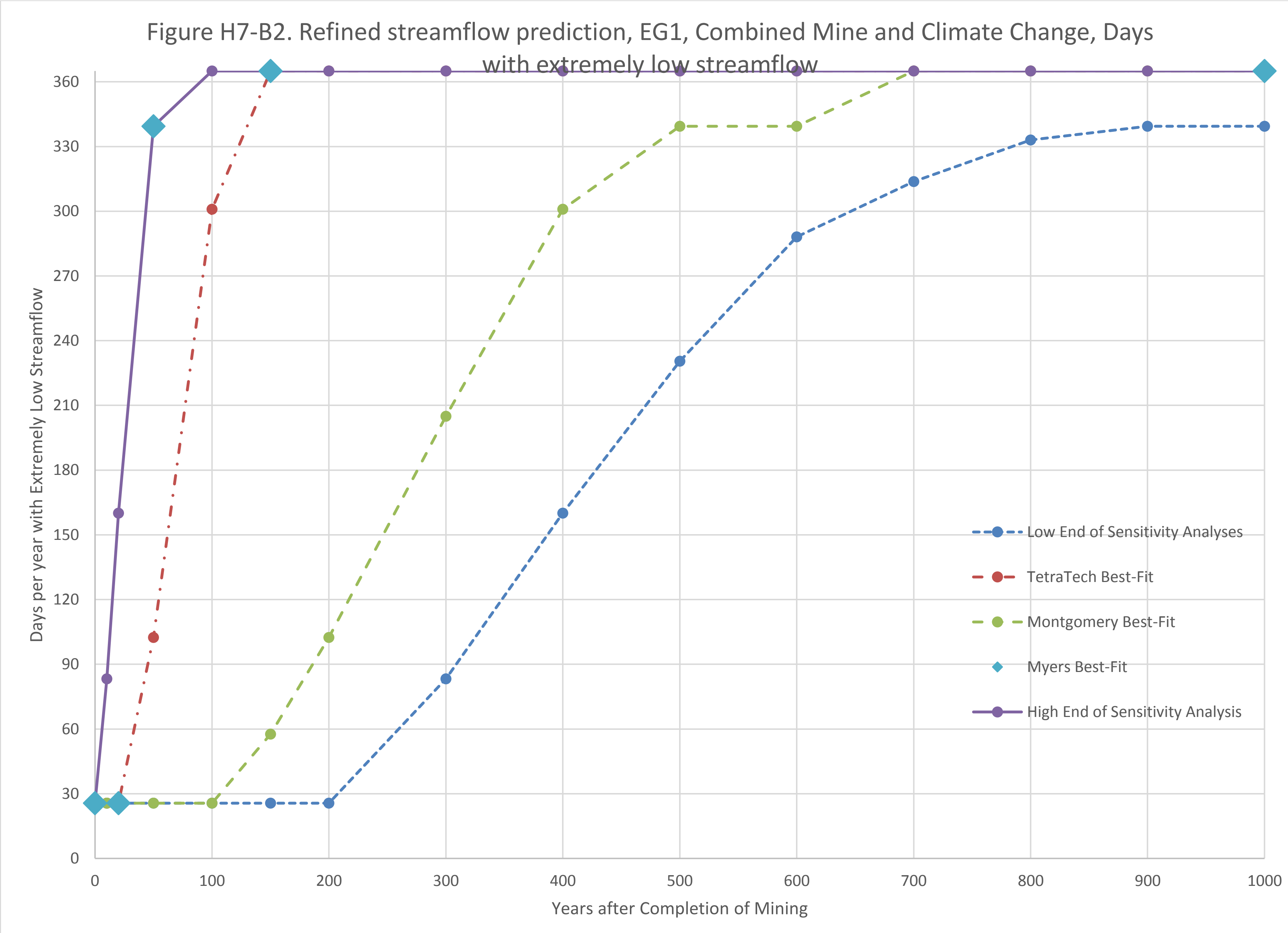


Figure H7-B2. Refined streamflow prediction, EG1, Combined Mine and Climate Change, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
0
30
60
90
120
150
180
210
240
270
300
330
360
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

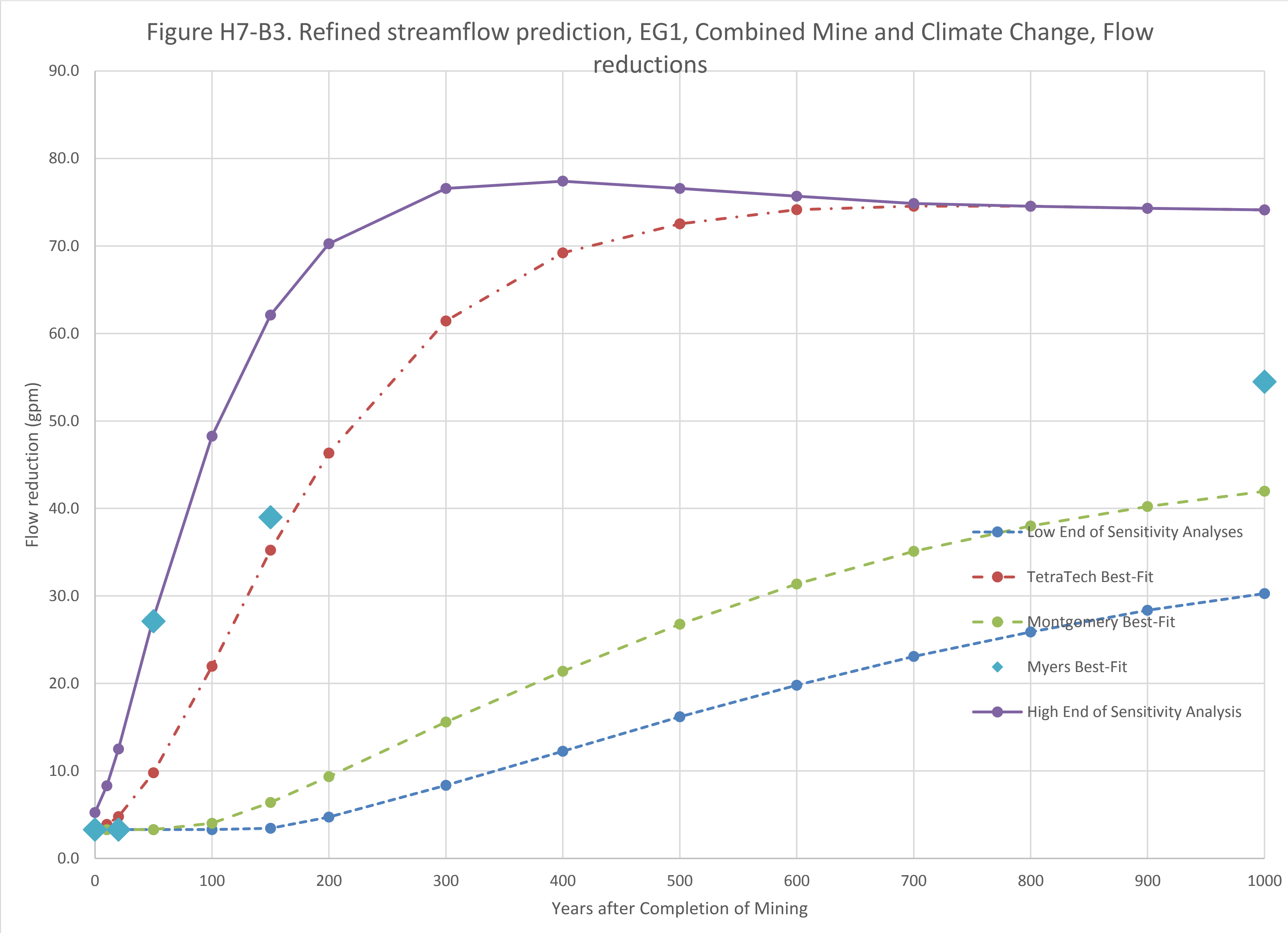


Figure H7-B3. Refined streamflow prediction, EG1, Combined Mine and Climate Change, Flow reductions
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Flow reduction (gpm)
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

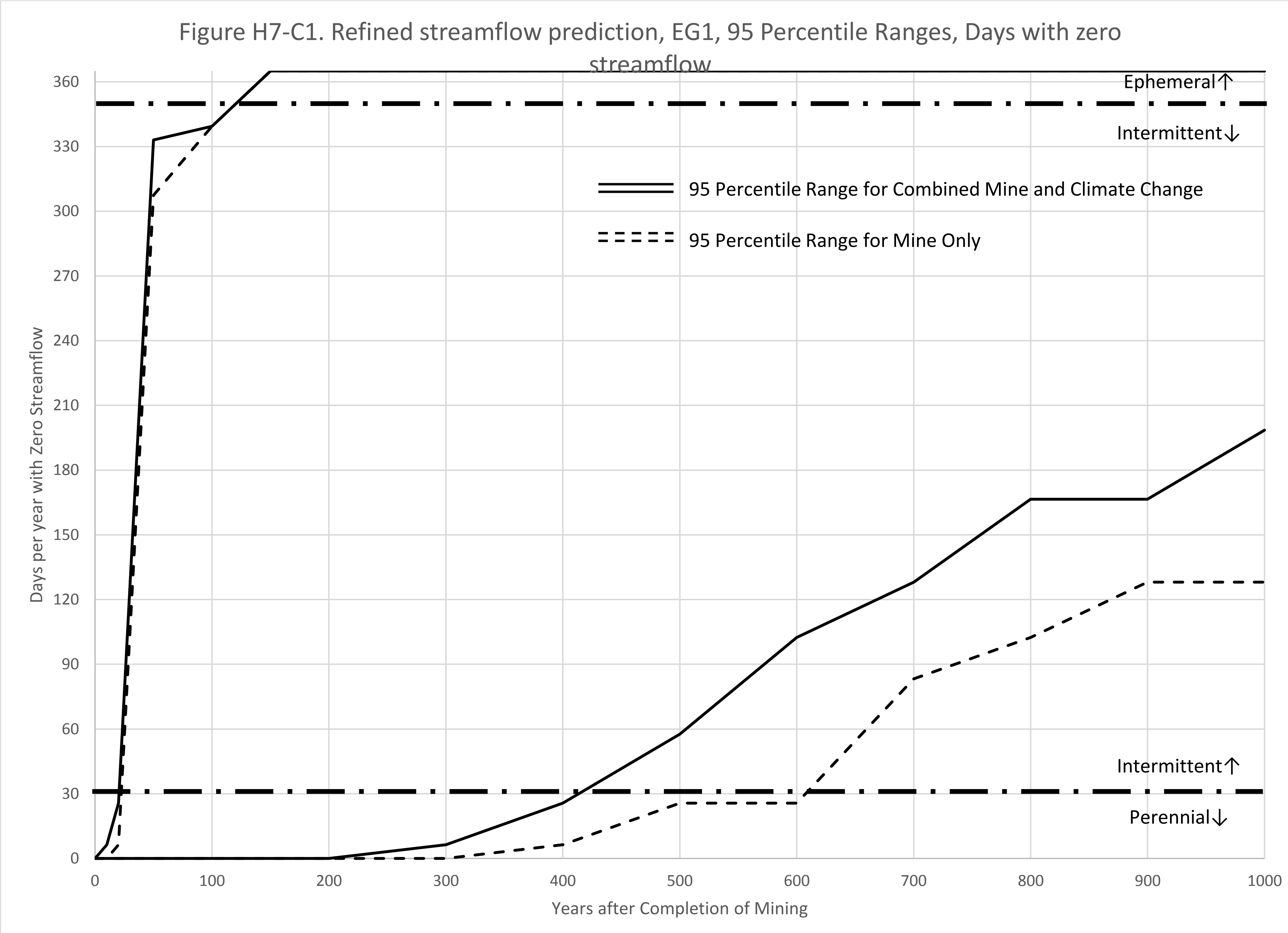


Figure H7-C1. Refined streamflow prediction, EG1, 95 Percentile Ranges, Days with zero streamflow
Ephemeral↑
Intermittent↓
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

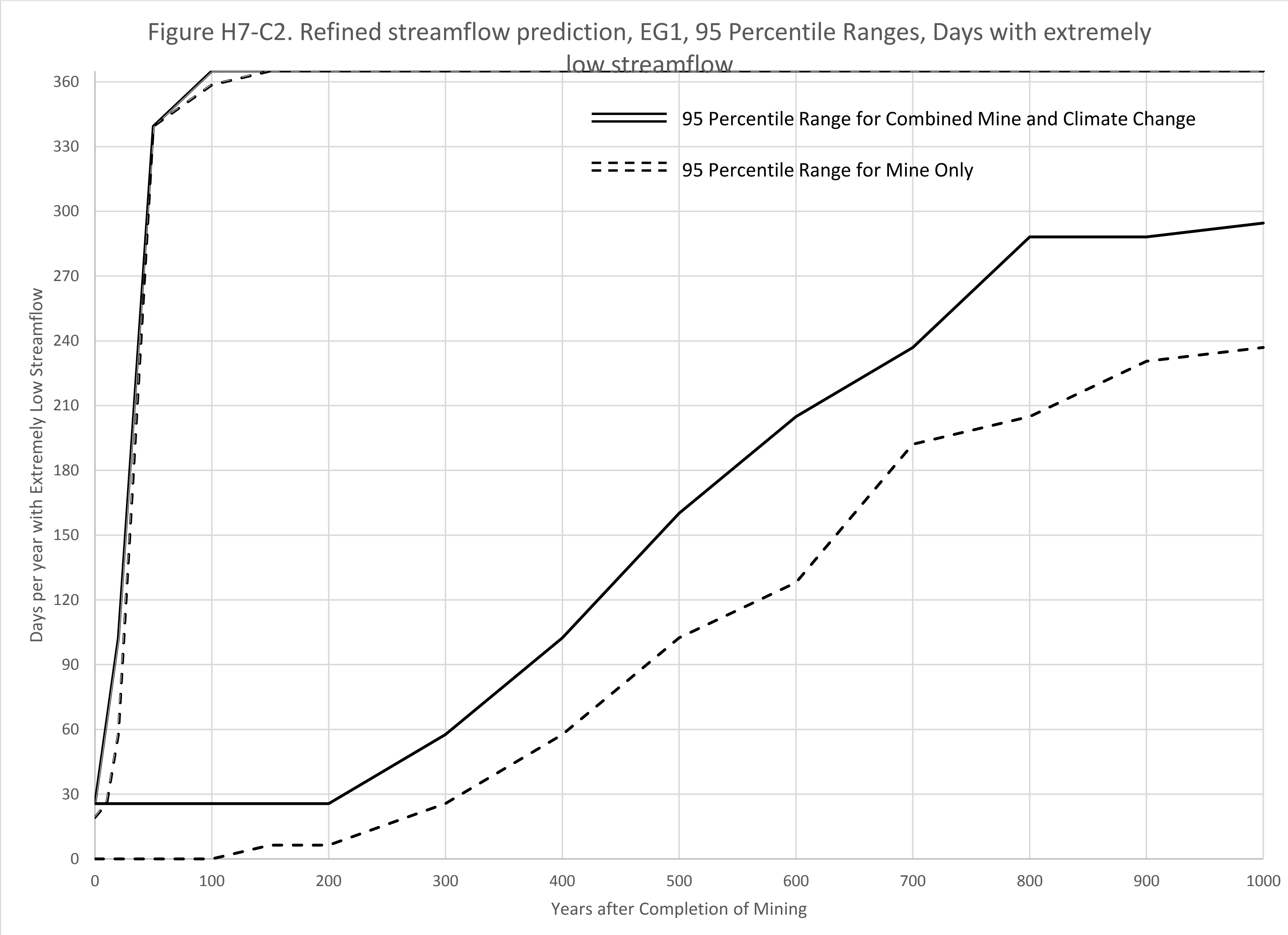


Figure H7-C2. Refined streamflow prediction, EG1, 95 Percentile Ranges, Days with extremely low streamflow
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Days per year with Extremely Low Streamflow
Years after Completion of Mining
0
30
60
90
120
150
180
210
240
270
300
330
360
0
100
200
300
400
500
600
700
800
900
1000

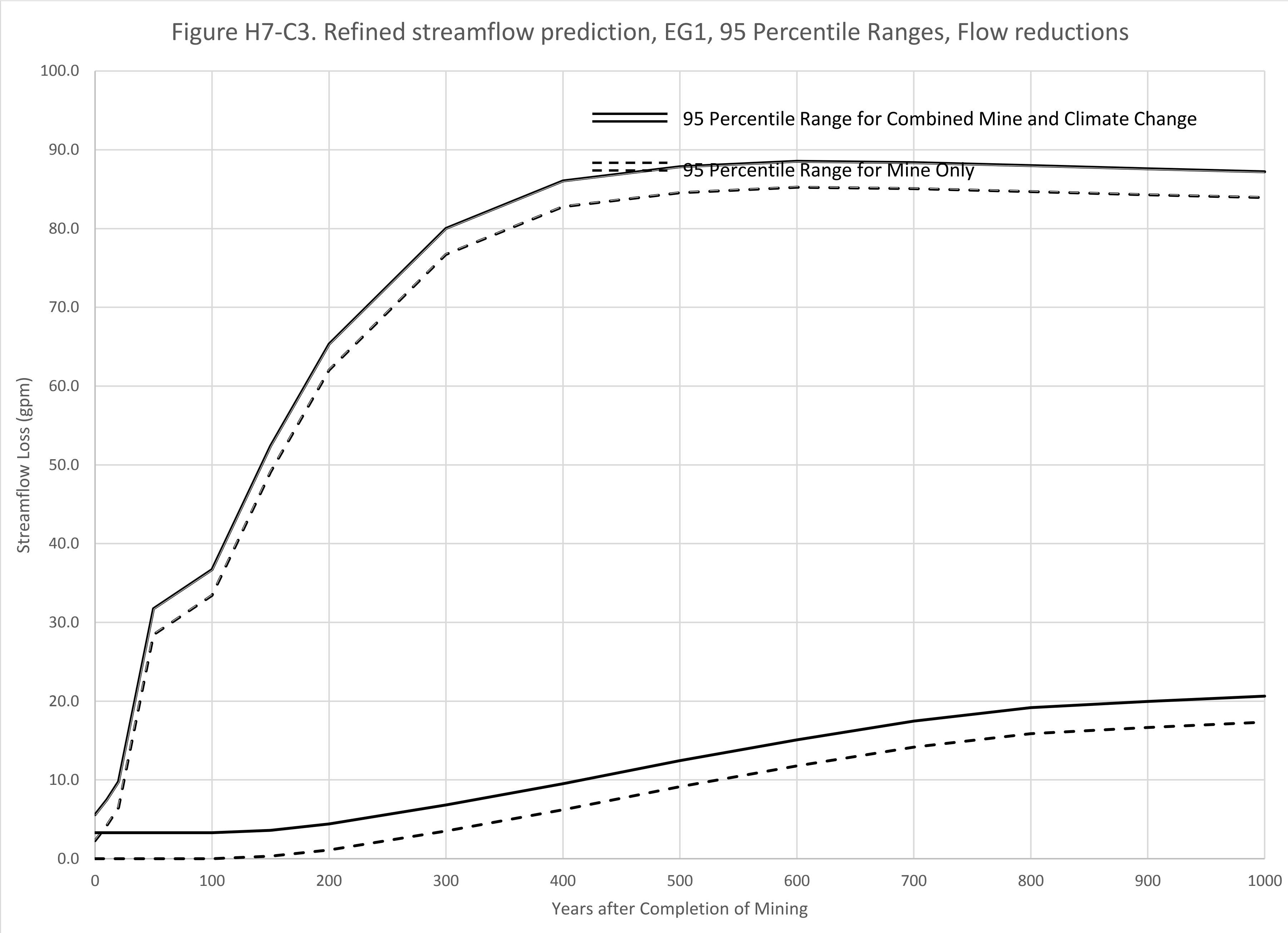


Figure H7-C3. Refined streamflow prediction, EG1, 95 Percentile Ranges, Flow reductions
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Streamflow Loss (gpm)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

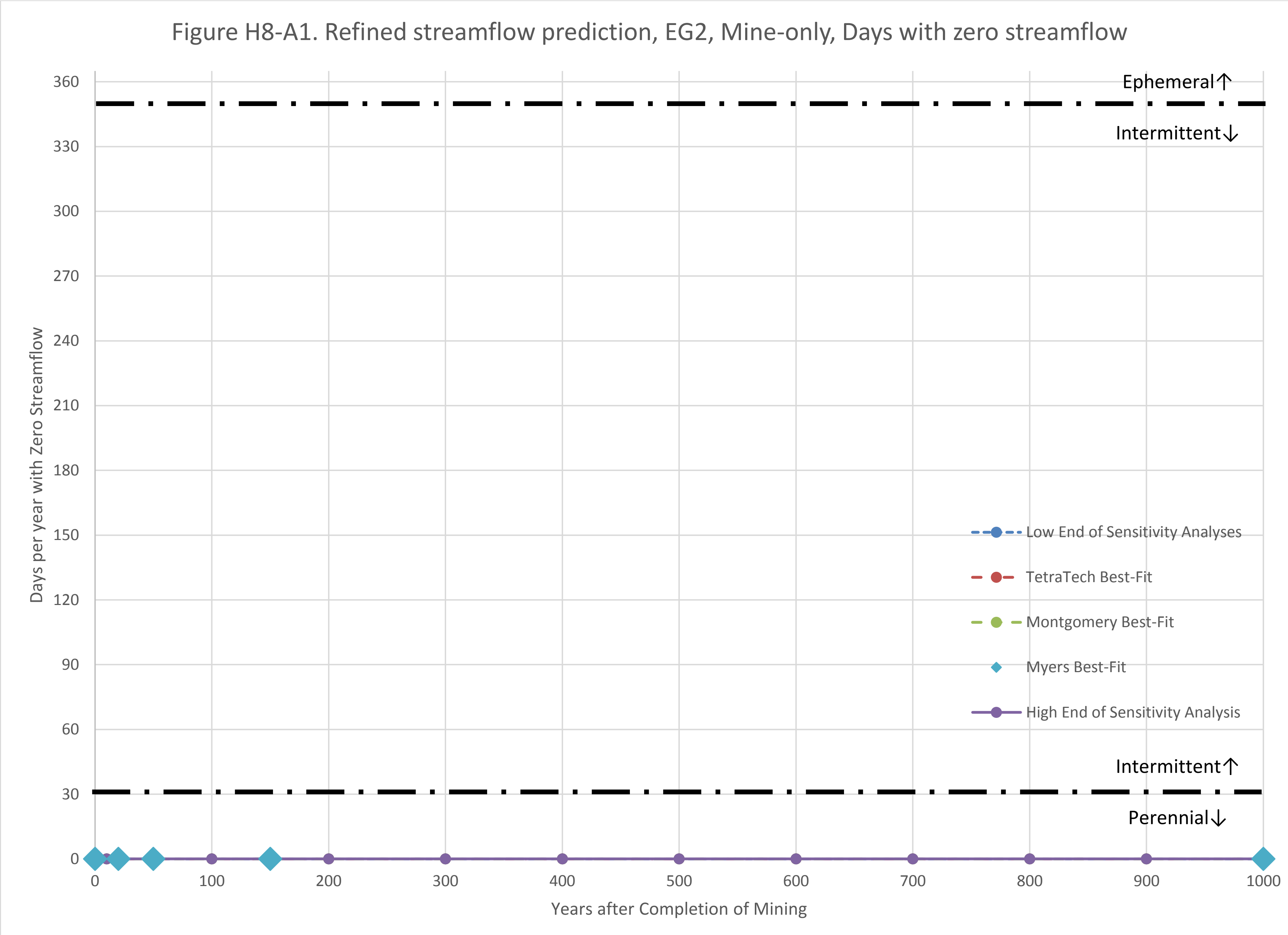


Figure H8-A1. Refined streamflow prediction, EG2, Mine-only, Days with zero streamflow
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

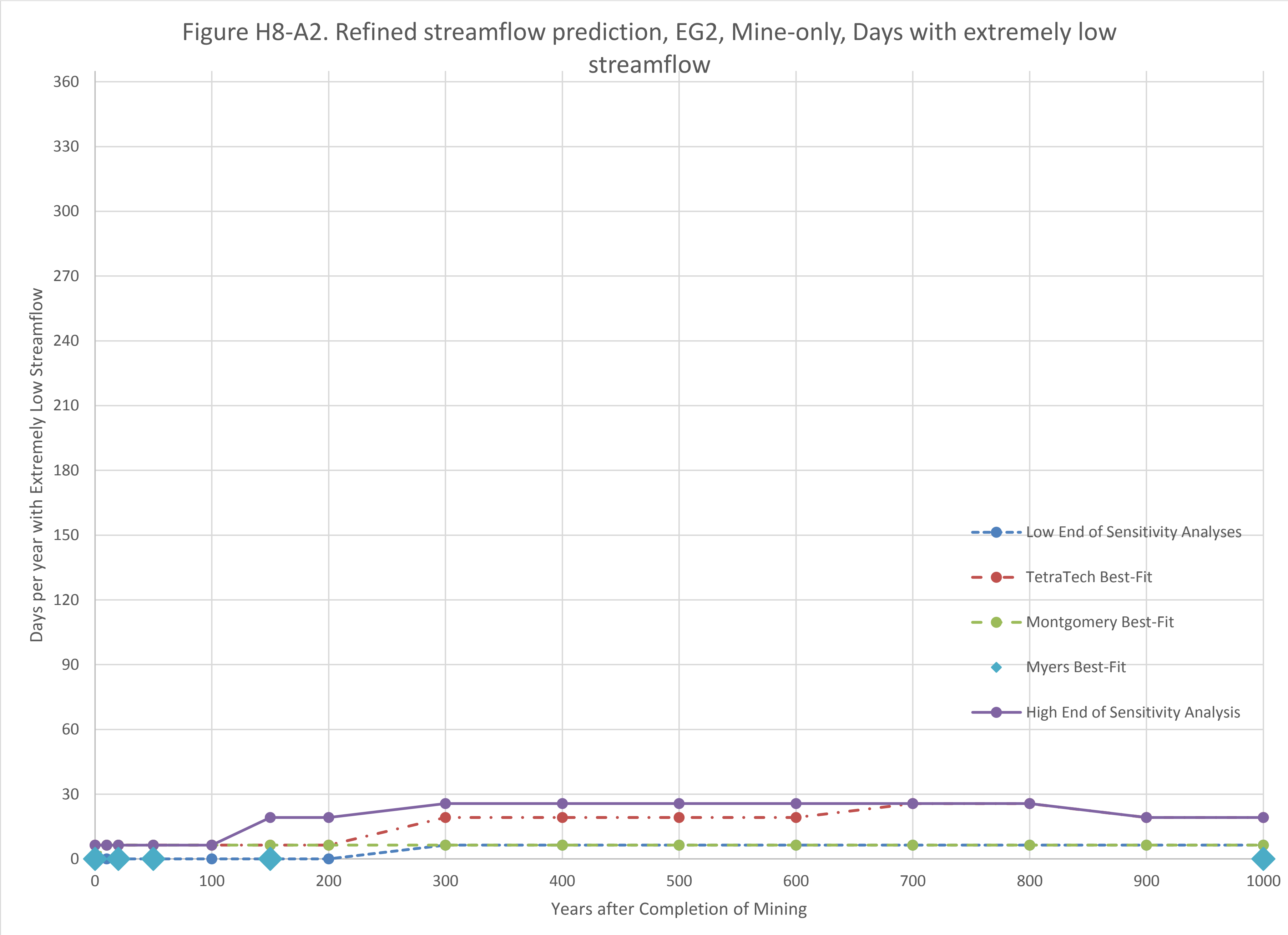


Figure H8-A2. Refined streamflow prediction, EG2, Mine-only, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

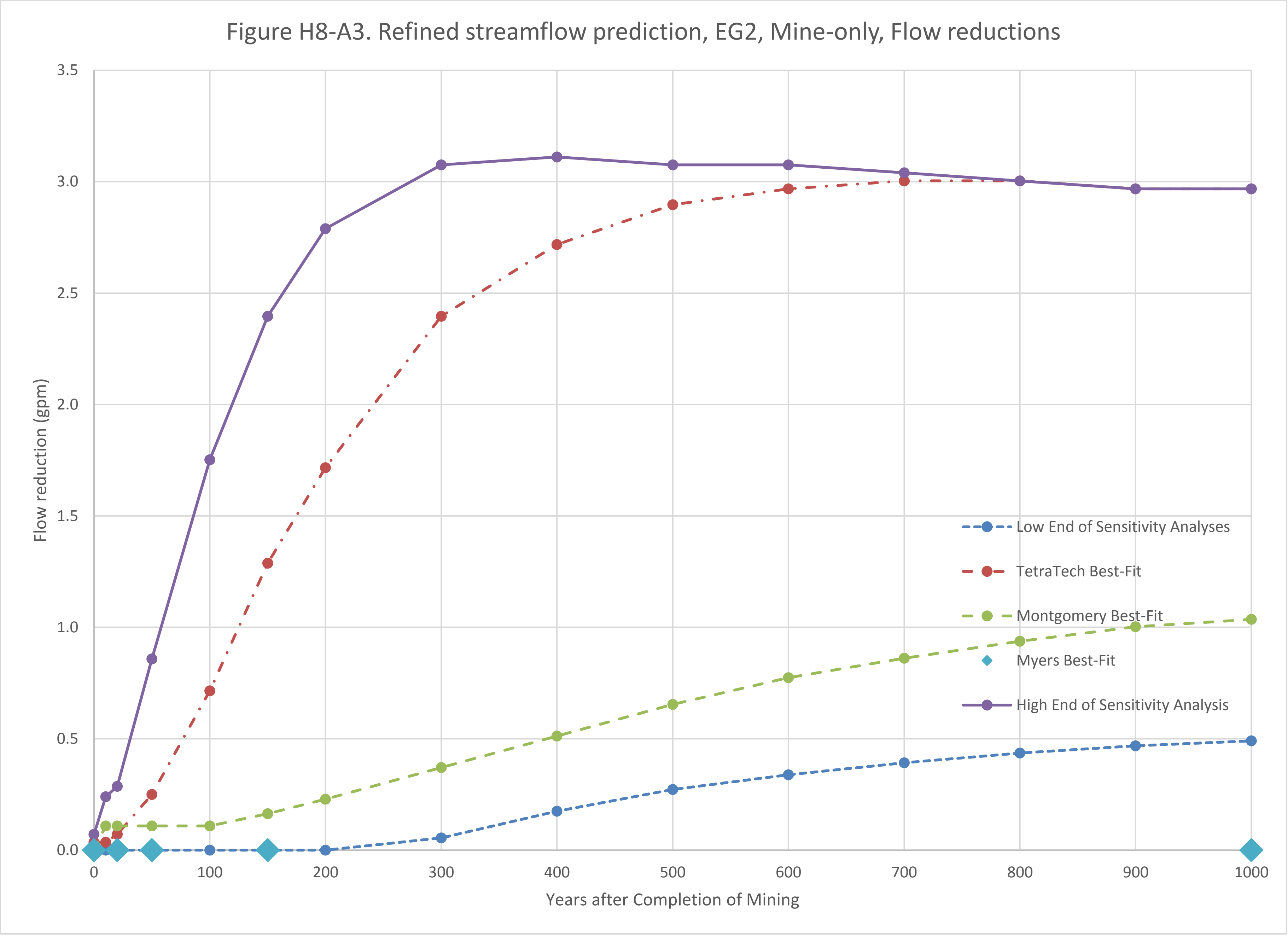


Figure H8-A3. Refined streamflow prediction, EG2, Mine-only, Flow reductions
Flow reduction (gpm)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

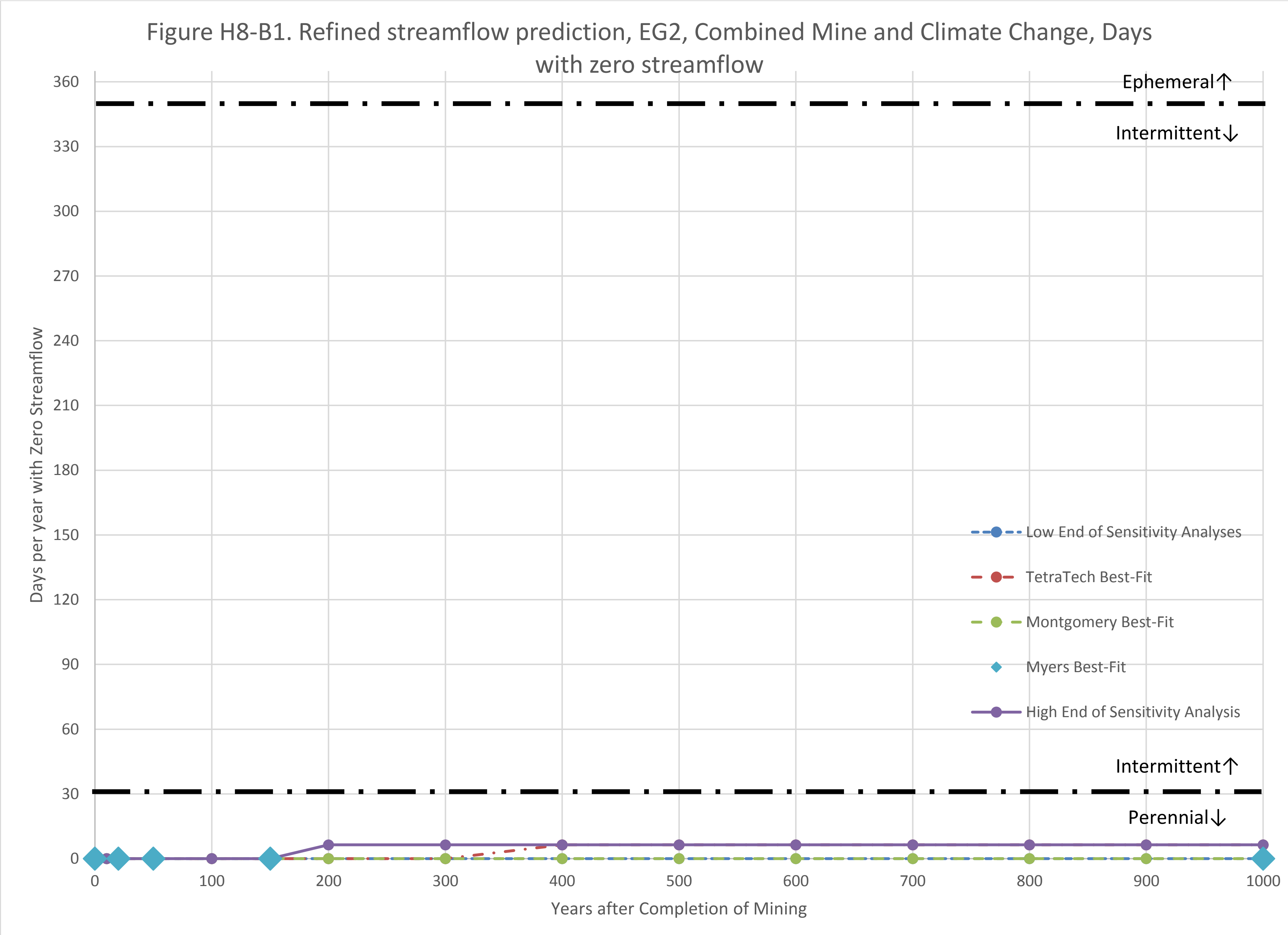


Figure H8-B1. Refined streamflow prediction, EG2, Combined Mine and Climate Change, Days with zero streamflow
Ephemeral↑
Intermittent↓
Intermittent↑
Perennial↓
Days per year with Zero Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

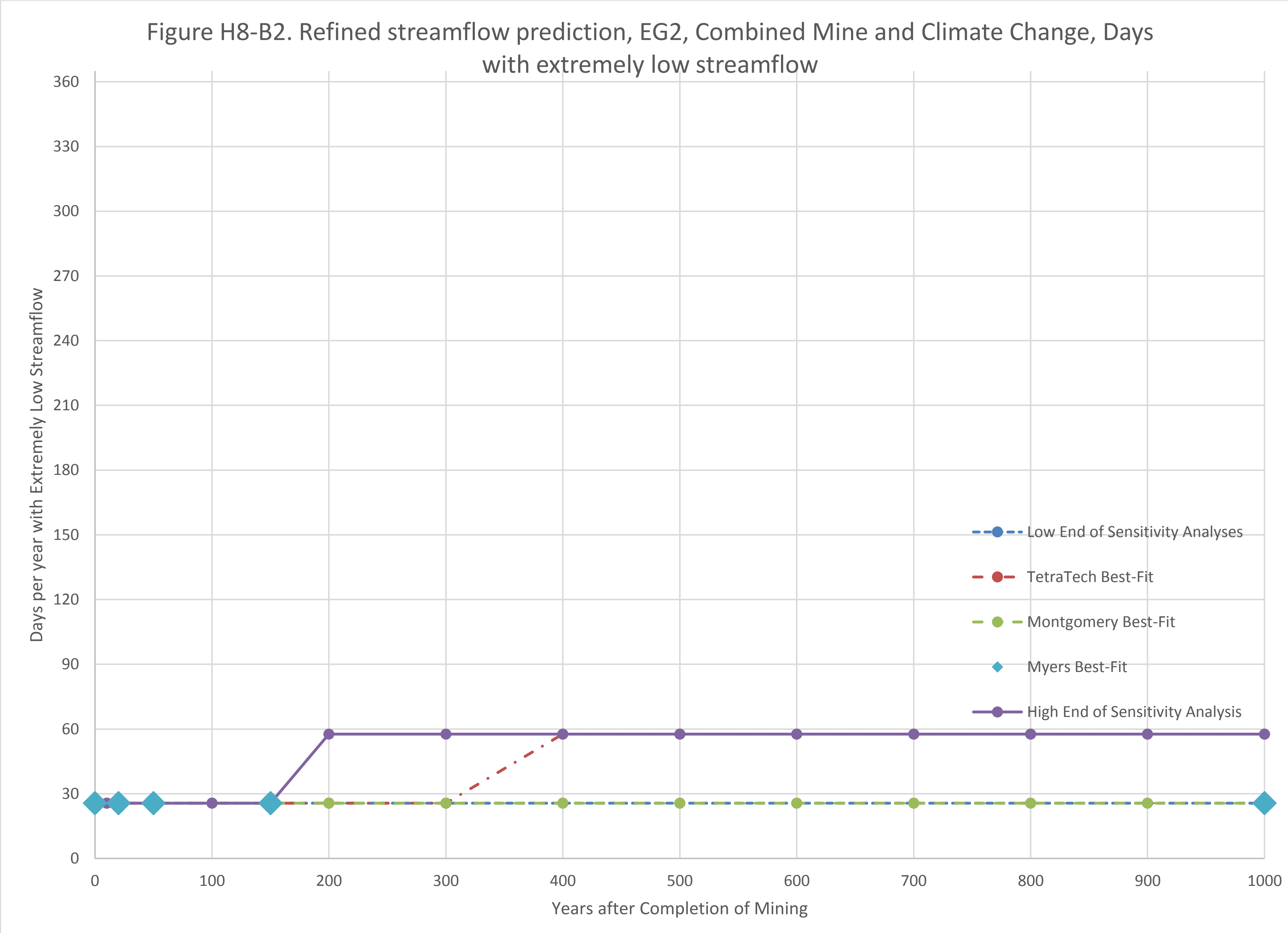


Figure H8-B2. Refined streamflow prediction, EG2, Combined Mine and Climate Change, Days with extremely low streamflow
Days per year with Extremely Low Streamflow
360
330
300
270
240
210
180
150
120
90
60
30
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
Low End of Sensitivity Analyses
TetraTech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analysis

Figure H8-B3. Refined streamflow prediction, EG2, Combined Mine and Climate Change, Flow reductions

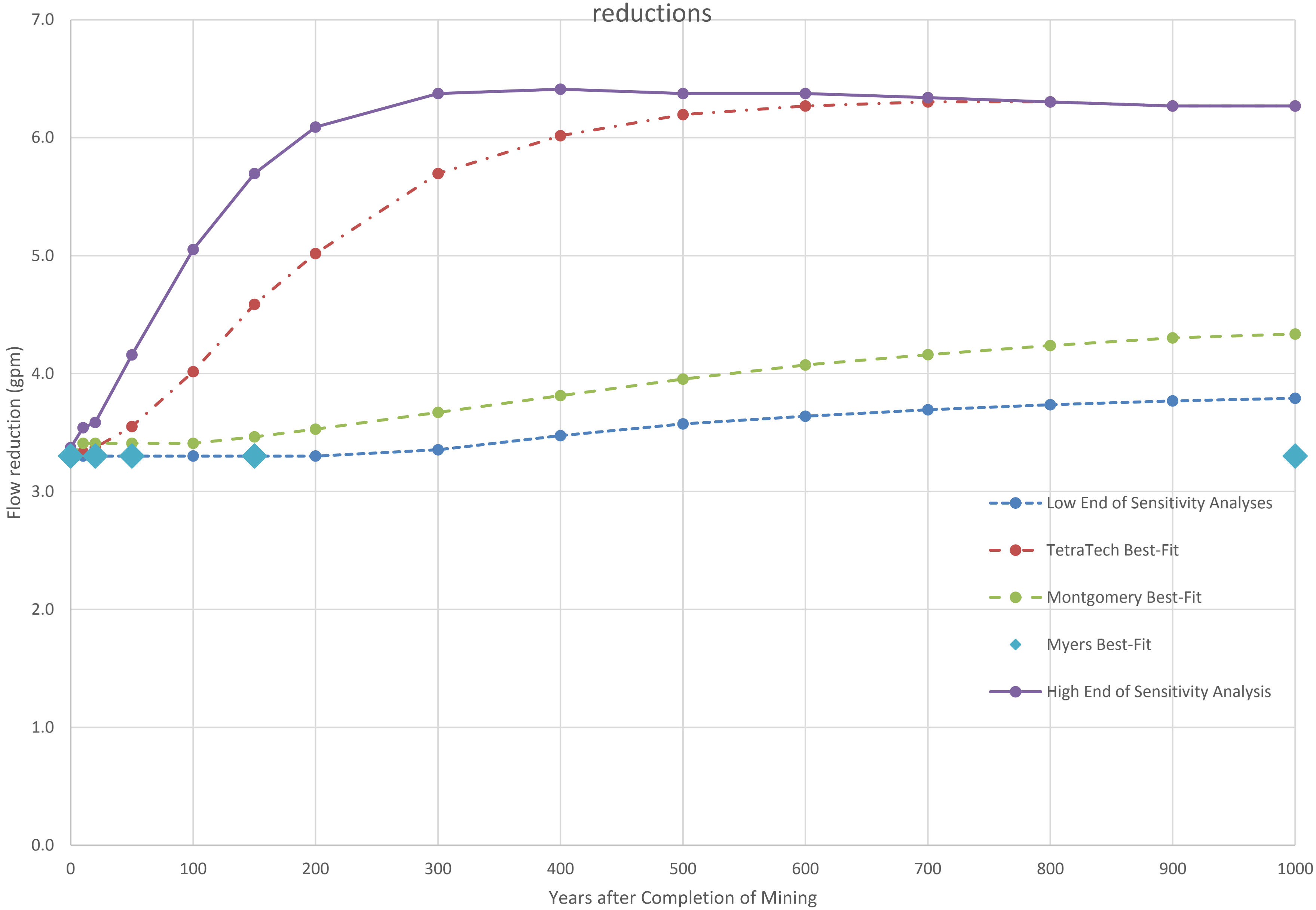


Figure H8-C1. Refined streamflow prediction, EG2, 95 Percentile Ranges, Days with zero streamflow

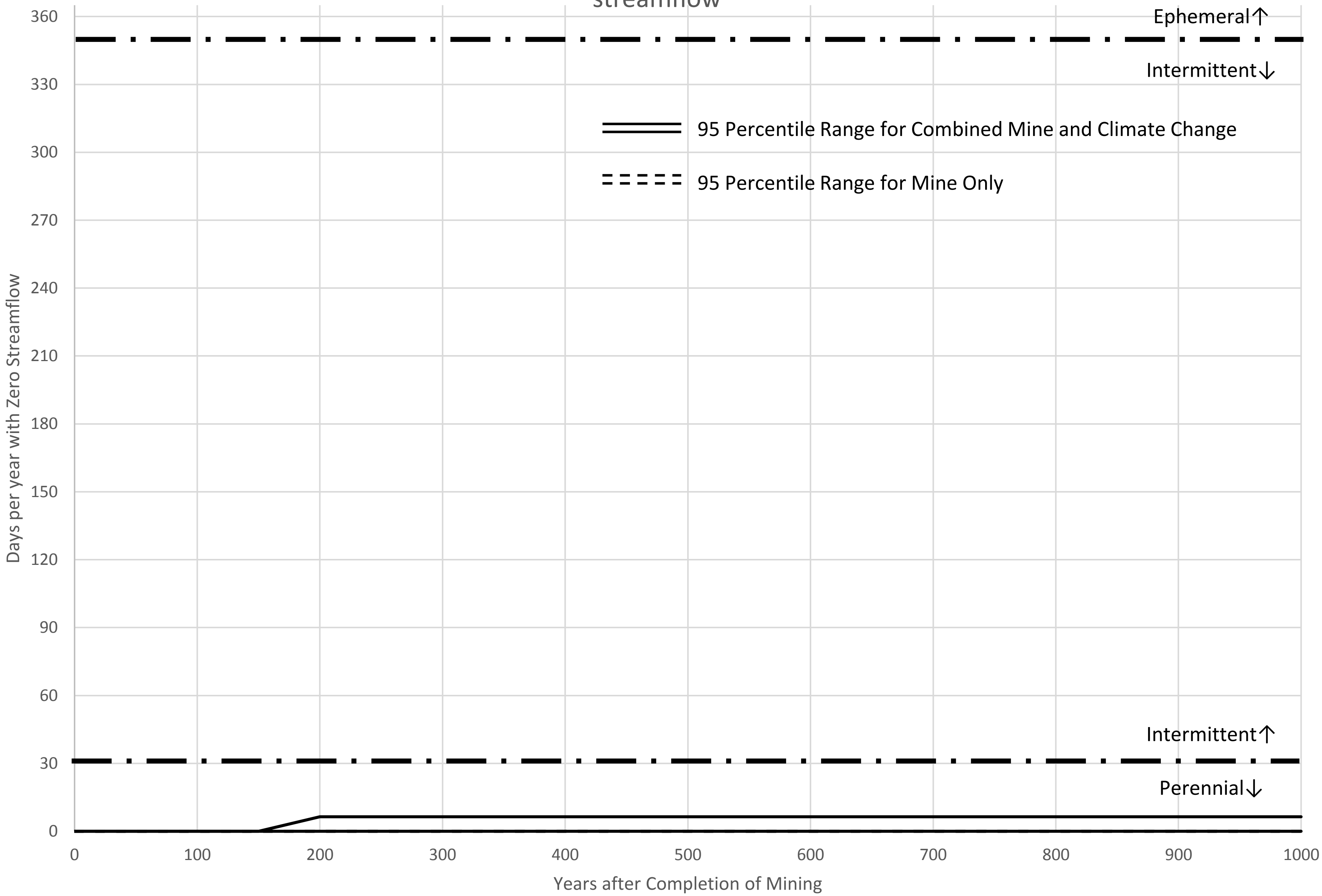
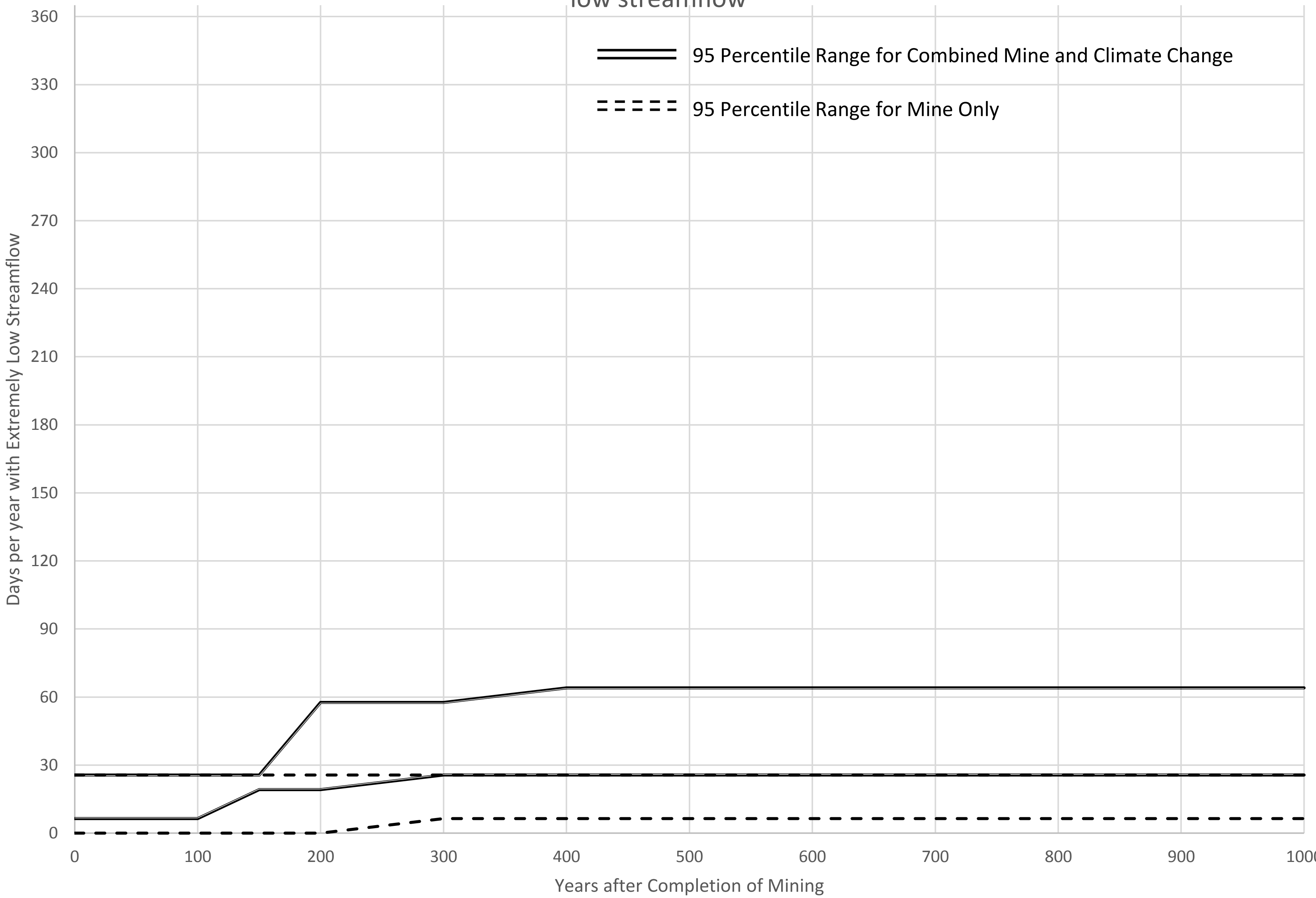


Figure H8-C2. Refined streamflow prediction, EG2, 95 Percentile Ranges, Days with extremely low streamflow



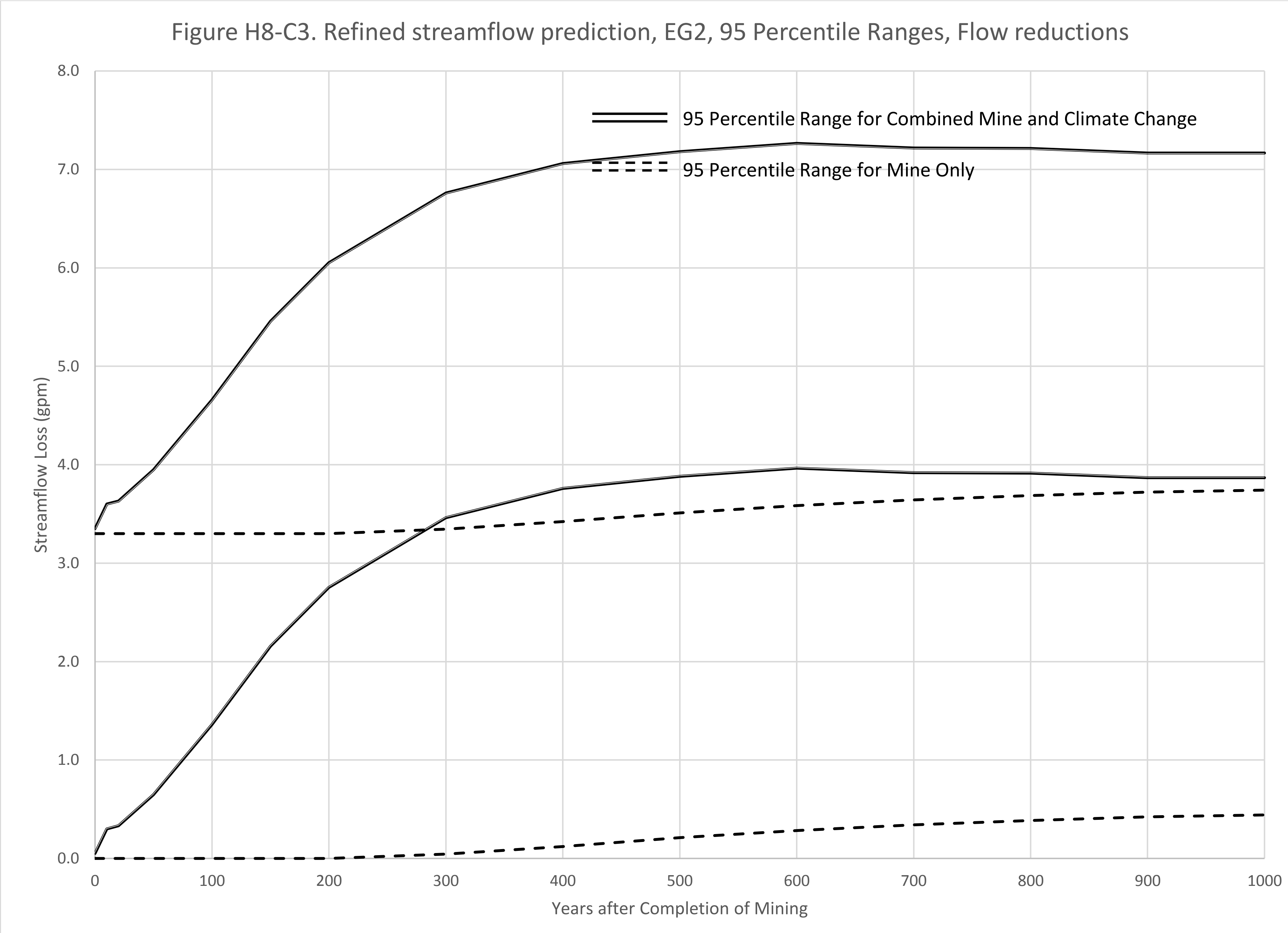


Figure H8-C3. Refined streamflow prediction, EG2, 95 Percentile Ranges, Flow reductions
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Streamflow Loss (gpm)
Years after Completion of Mining
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
100
200
300
400
500
600
700
800
900
1000

I. Standing Pool Analysis for Incremental Drawdowns

List of Figures and Tables

Figures

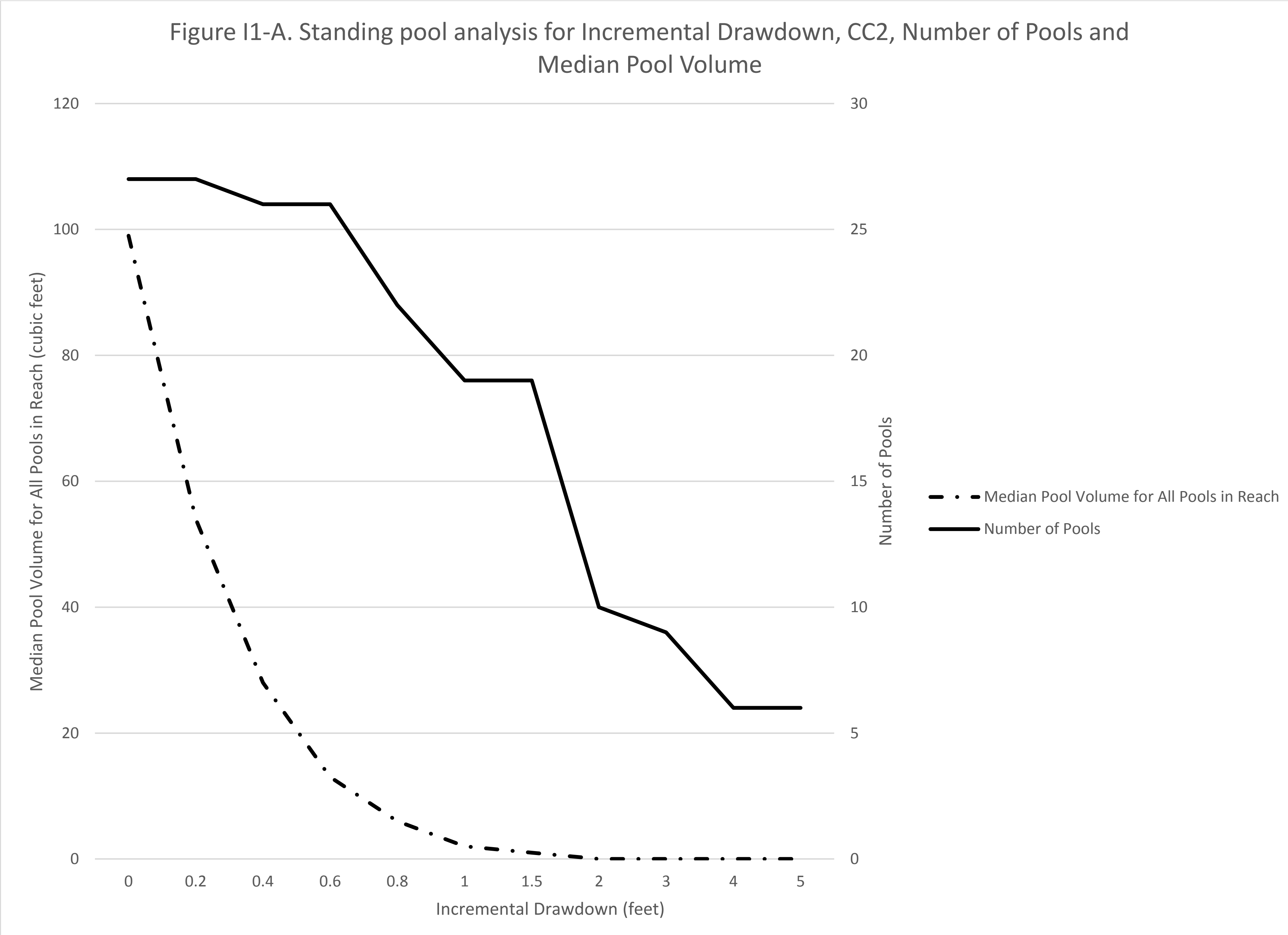


Figure I1-A. Standing pool analysis for Incremental Drawdown, CC2, Number of Pools and Median Pool Volume
120
100
80
60
40
20
0
30
25
20
15
10
5
0
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Median Pool Volume for All Pools in Reach (cubic feet)
Number of Pools
Incremental Drawdown (feet)
Median Pool Volume for All Pools in Reach
Number of Pools

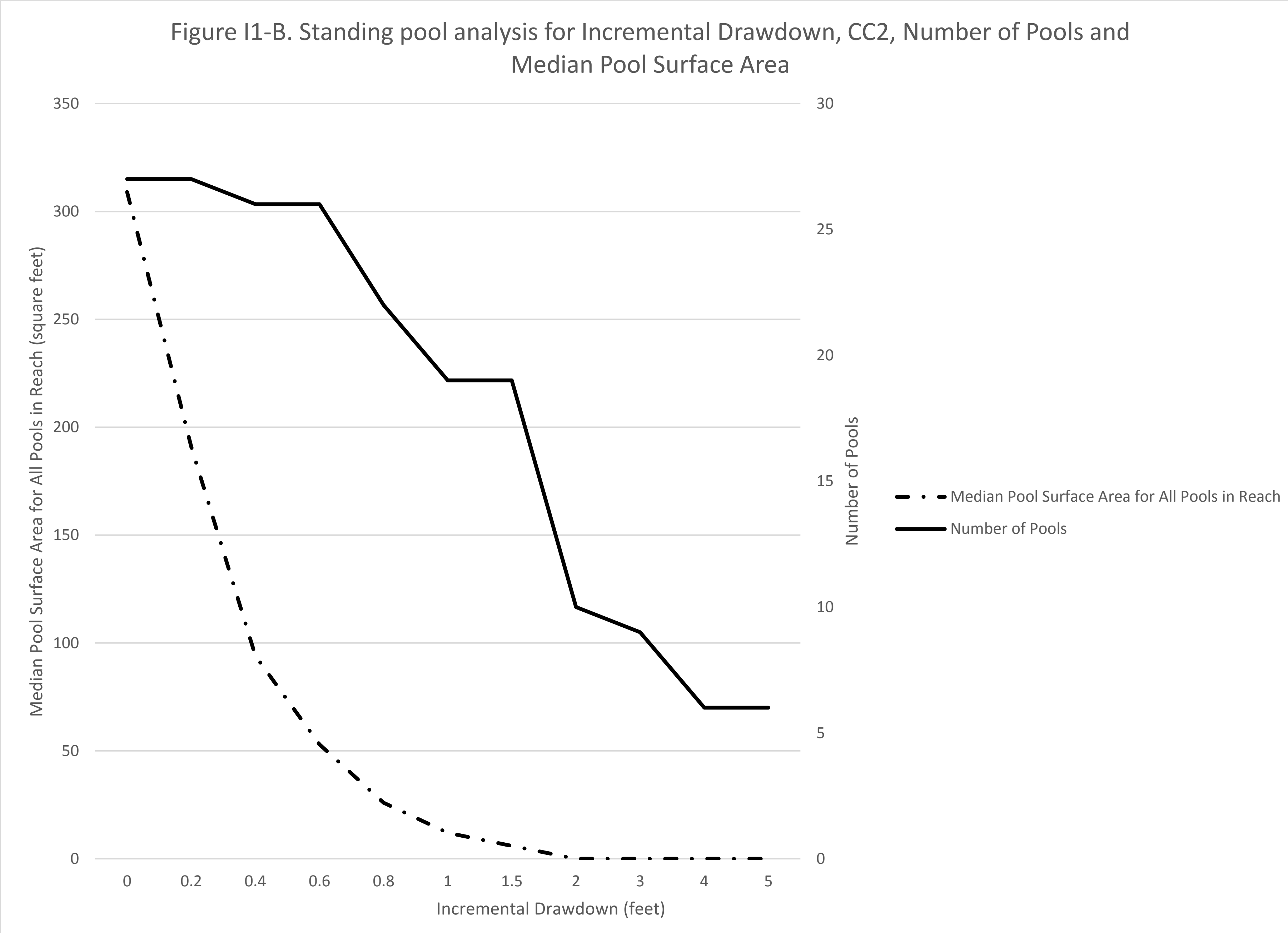


Figure I1-B. Standing pool analysis for Incremental Drawdown, CC2, Number of Pools and Median Pool Surface Area
Median Pool Surface Area for All Pools in Reach (square feet)
Number of Pools
Incremental Drawdown (feet)
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Median Pool Surface Area for All Pools in Reach
Number of Pools

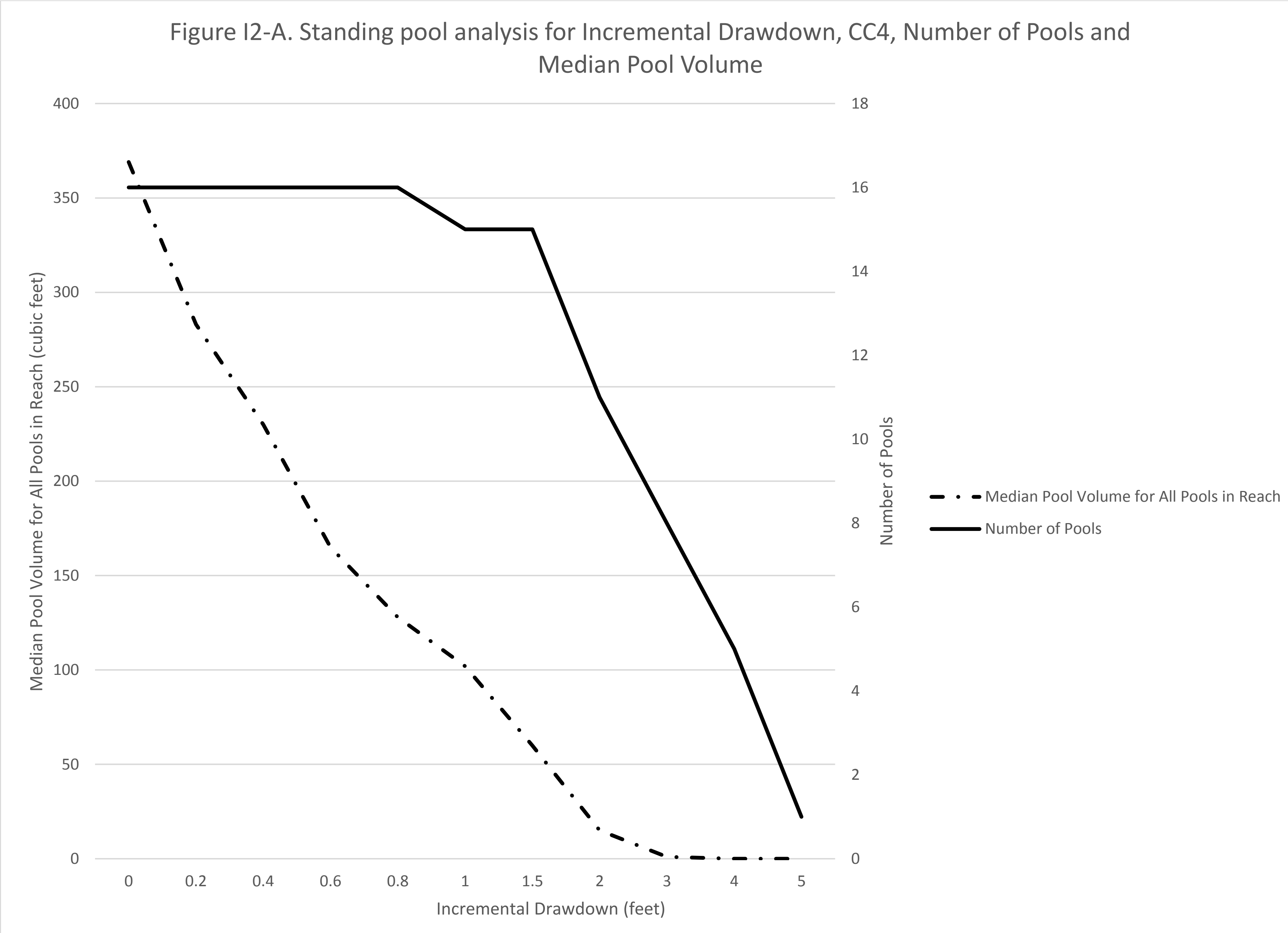


Figure I2-A. Standing pool analysis for Incremental Drawdown, CC4, Number of Pools and Median Pool Volume
Median Pool Volume for All Pools in Reach (cubic feet)
400
350
300
250
200
150
100
50
0
Number of Pools
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Incremental Drawdown (feet)
Median Pool Volume for All Pools in Reach
Number of Pools

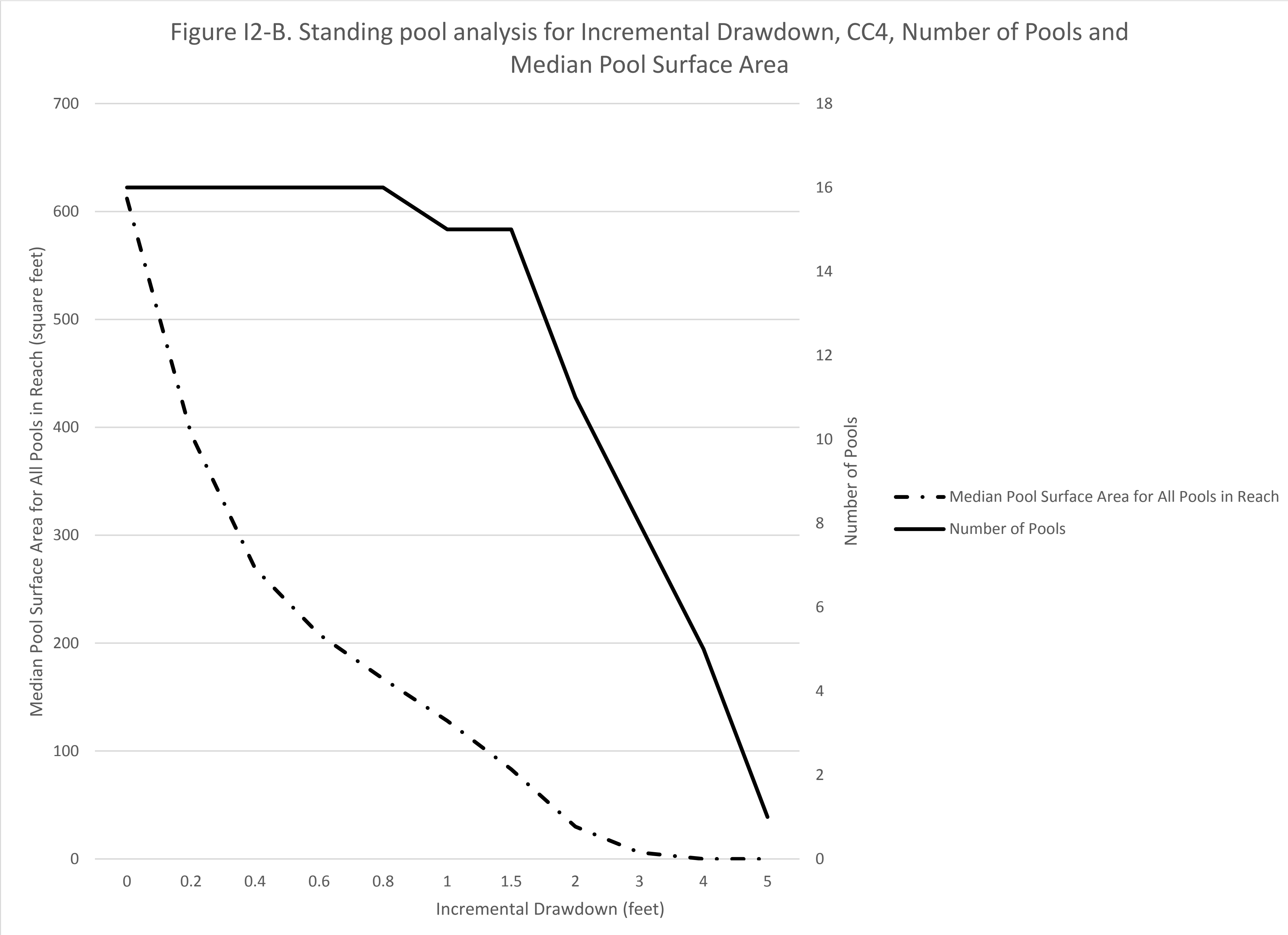


Figure I2-B. Standing pool analysis for Incremental Drawdown, CC4, Number of Pools and Median Pool Surface Area
700
600
500
400
300
200
100
0
Median Pool Surface Area for All Pools in Reach (square feet)
18
16
14
12
10
8
6
4
2
0
Number of Pools
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Incremental Drawdown (feet)
Median Pool Surface Area for All Pools in Reach
Number of Pools

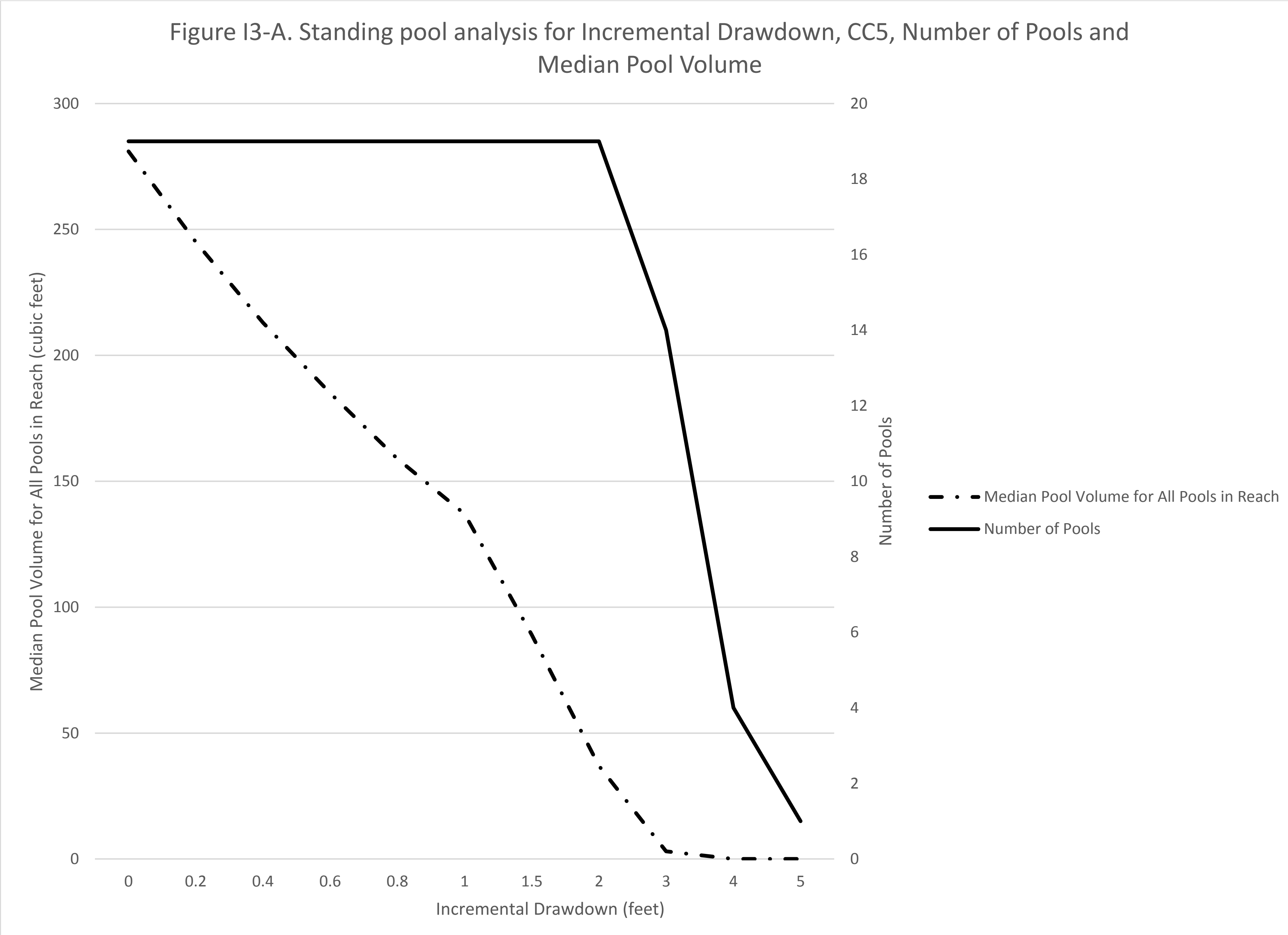


Figure I3-A. Standing pool analysis for Incremental Drawdown, CC5, Number of Pools and Median Pool Volume
300
250
200
150
100
50
0
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Median Pool Volume for All Pools in Reach (cubic feet)
Number of Pools
Incremental Drawdown (feet)
Median Pool Volume for All Pools in Reach
Number of Pools

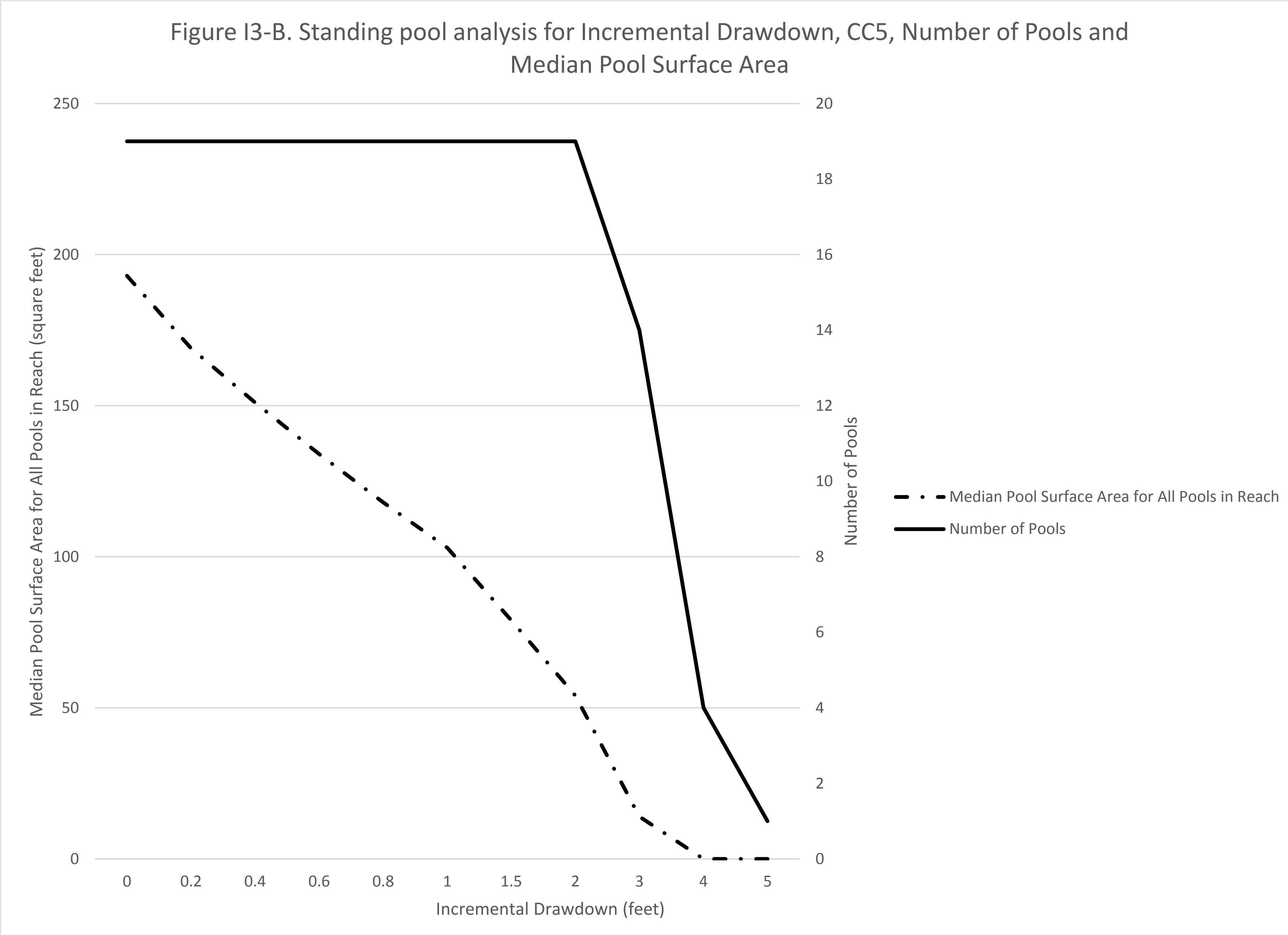


Figure I3-B. Standing pool analysis for Incremental Drawdown, CC5, Number of Pools and Median Pool Surface Area
250
200
150
100
50
0
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Incremental Drawdown (feet)
Median Pool Surface Area for All Pools in Reach (square feet)
Number of Pools
Median Pool Surface Area for All Pools in Reach
Number of Pools

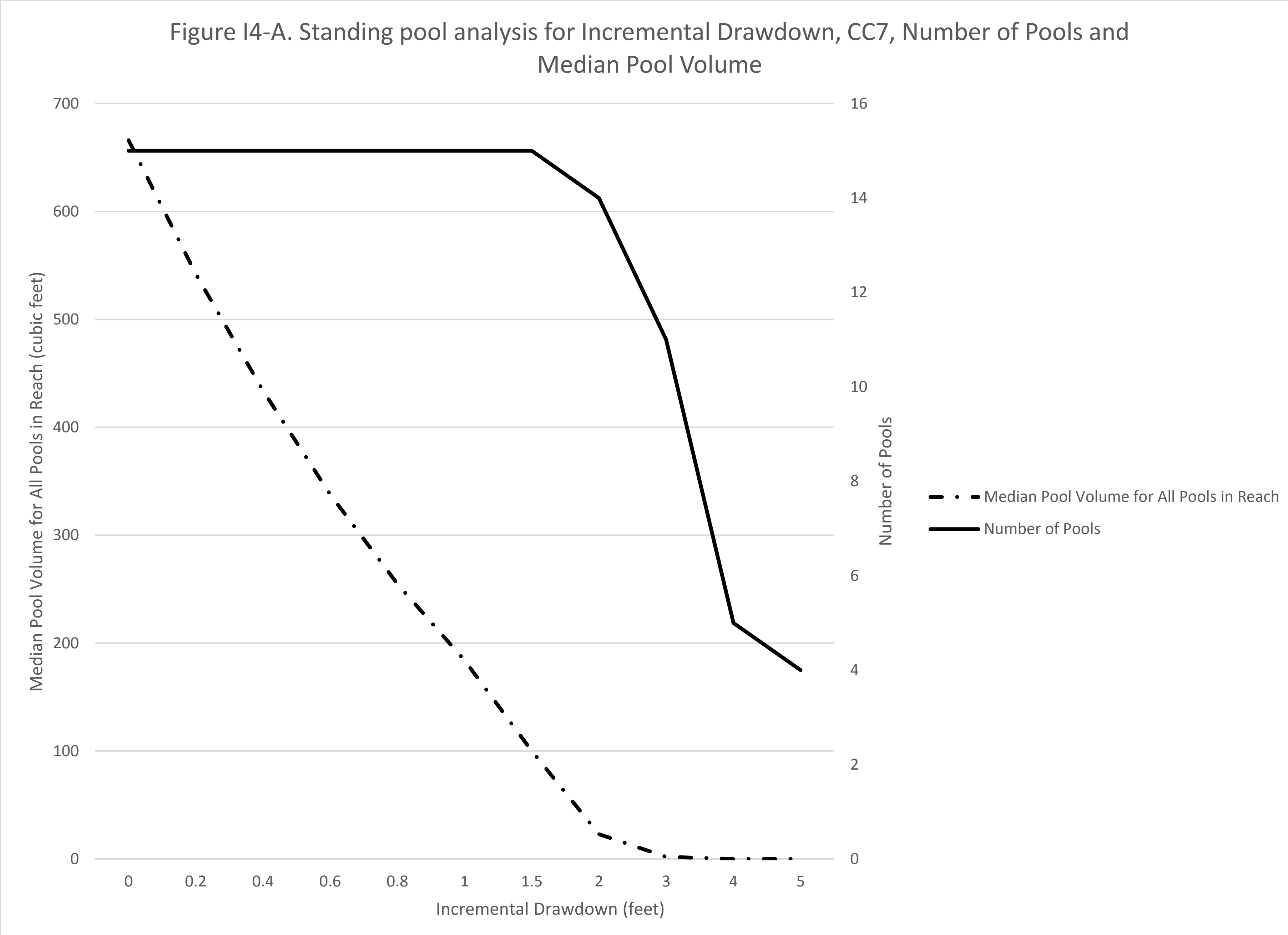


Figure I4-A. Standing pool analysis for Incremental Drawdown, CC7, Number of Pools and Median Pool Volume
Median Pool Volume for All Pools in Reach (cubic feet)
700
600
500
400
300
200
100
0
Number of Pools
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Incremental Drawdown (feet)
Median Pool Volume for All Pools in Reach
Number of Pools

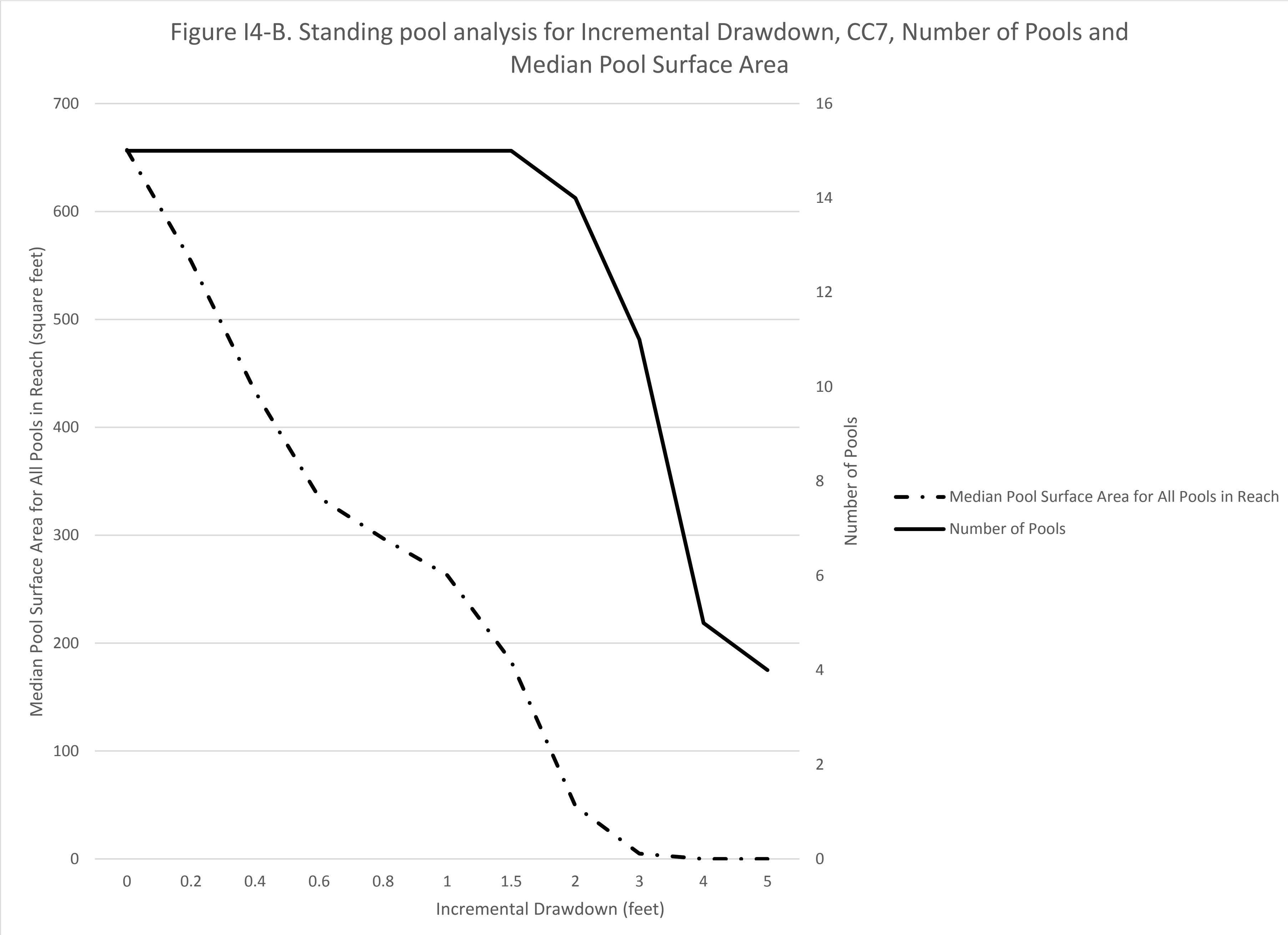


Figure I4-B. Standing pool analysis for Incremental Drawdown, CC7, Number of Pools and Median Pool Surface Area
Median Pool Surface Area for All Pools in Reach (square feet)
700
600
500
400
300
200
100
0
16
14
12
10
8
6
4
2
0
Number of Pools
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Incremental Drawdown (feet)
Median Pool Surface Area for All Pools in Reach
Number of Pools

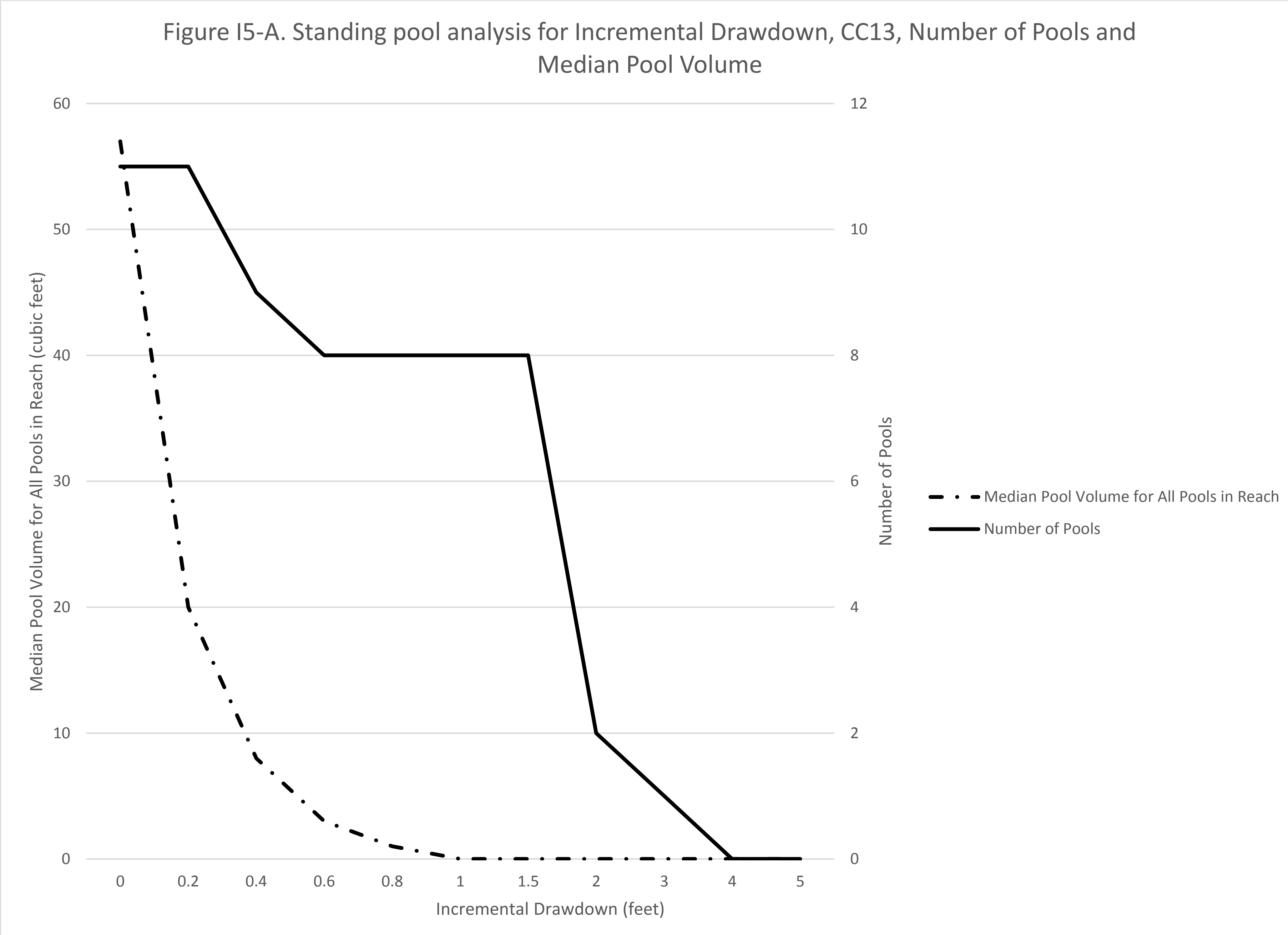


Figure I5-A. Standing pool analysis for Incremental Drawdown, CC13, Number of Pools and Median Pool Volume
60
50
40
30
20
10
0
12
10
8
6
4
2
0
Median Pool Volume for All Pools in Reach (cubic feet)
Number of Pools
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Incremental Drawdown (feet)
Median Pool Volume for All Pools in Reach
Number of Pools

Figure I5-B. Standing pool analysis for Incremental Drawdown, CC13, Number of Pools and Median Pool Surface Area

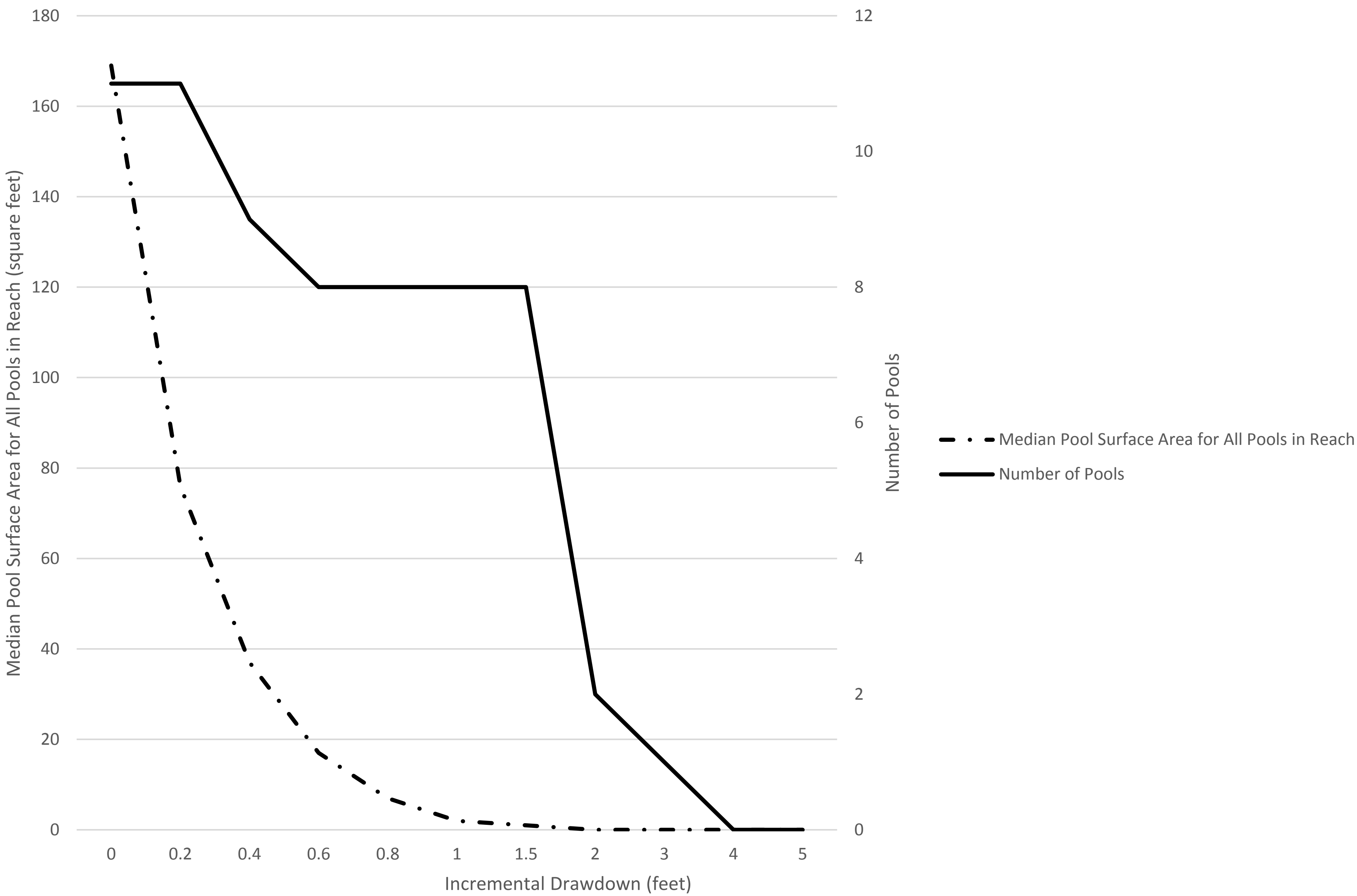
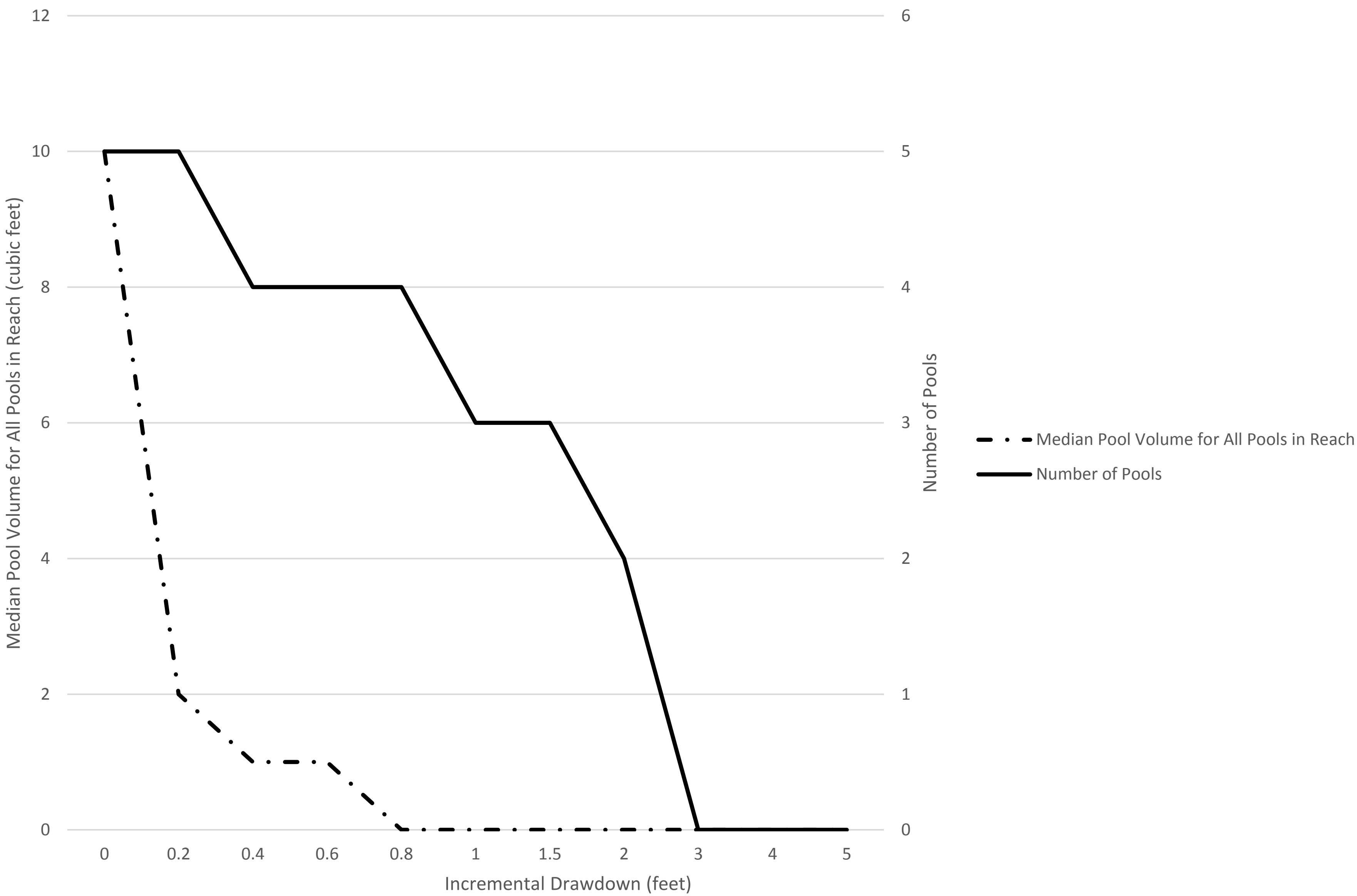


Figure I6-A. Standing pool analysis for Incremental Drawdown, CC15, Number of Pools and Median Pool Volume



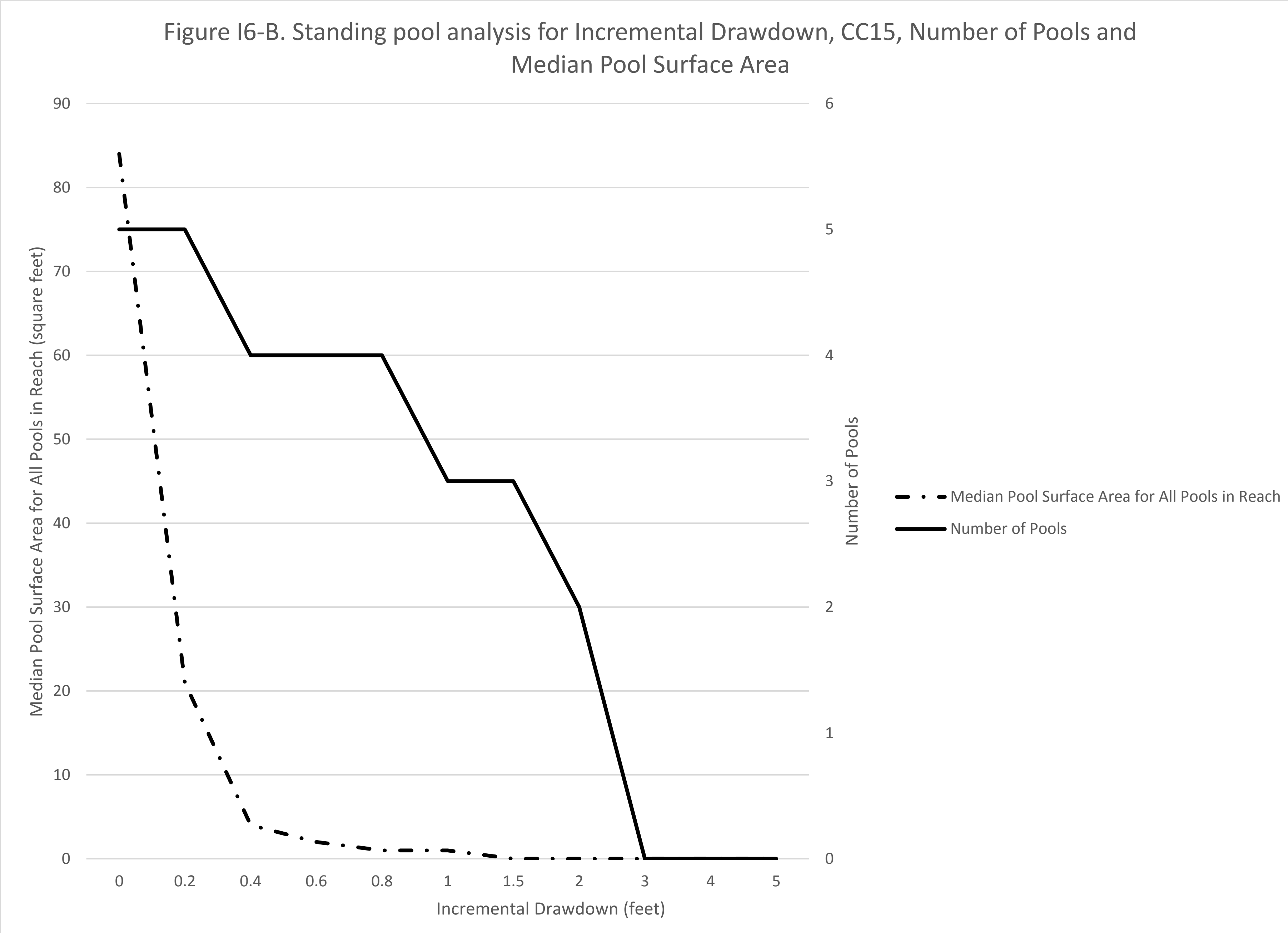


Figure I6-B. Standing pool analysis for Incremental Drawdown, CC15, Number of Pools and Median Pool Surface Area
Median Pool Surface Area for All Pools in Reach (square feet)
Number of Pools
Incremental Drawdown (feet)
0
10
20
30
40
50
60
70
80
90
0
1
2
3
4
5
6
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Median Pool Surface Area for All Pools in Reach
Number of Pools

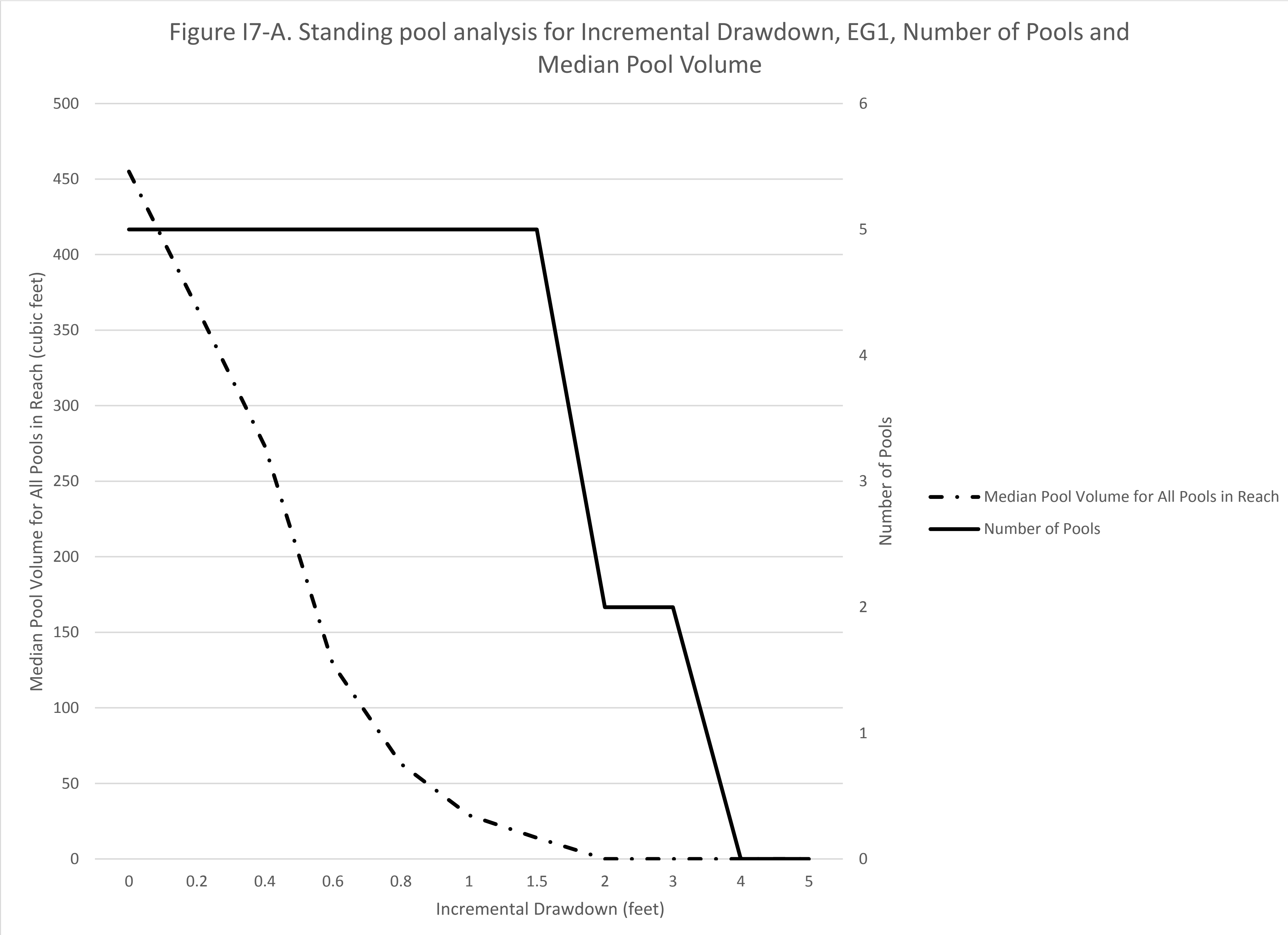


Figure I7-A. Standing pool analysis for Incremental Drawdown, EG1, Number of Pools and Median Pool Volume
Median Pool Volume for All Pools in Reach (cubic feet)
500
450
400
350
300
250
200
150
100
50
0
Number of Pools
6
5
4
3
2
1
0
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Incremental Drawdown (feet)
Median Pool Volume for All Pools in Reach
Number of Pools

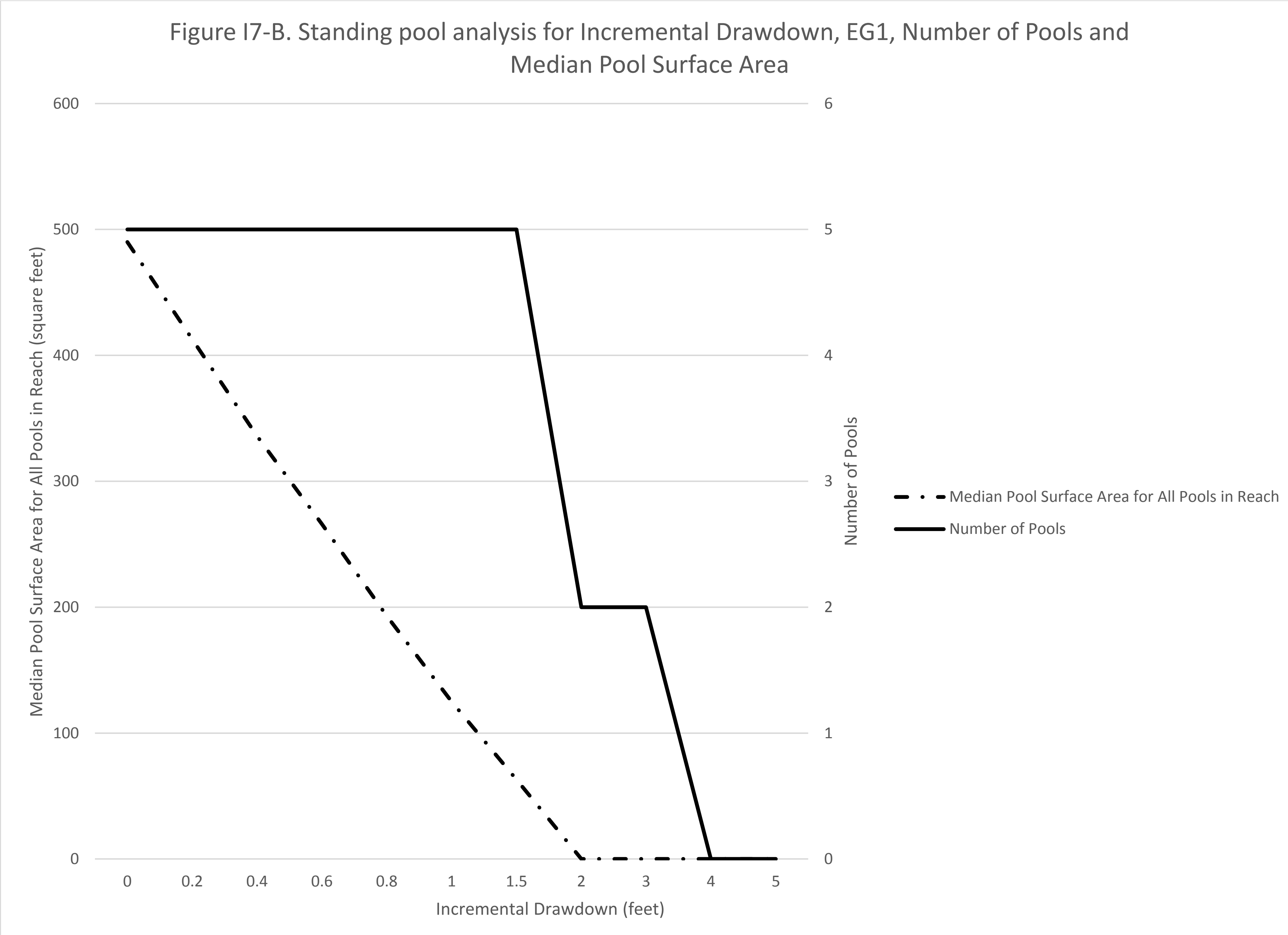


Figure I7-B. Standing pool analysis for Incremental Drawdown, EG1, Number of Pools and Median Pool Surface Area
600
500
400
300
200
100
0
6
5
4
3
2
1
0
Median Pool Surface Area for All Pools in Reach (square feet)
Number of Pools
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Incremental Drawdown (feet)
Median Pool Surface Area for All Pools in Reach
Number of Pools

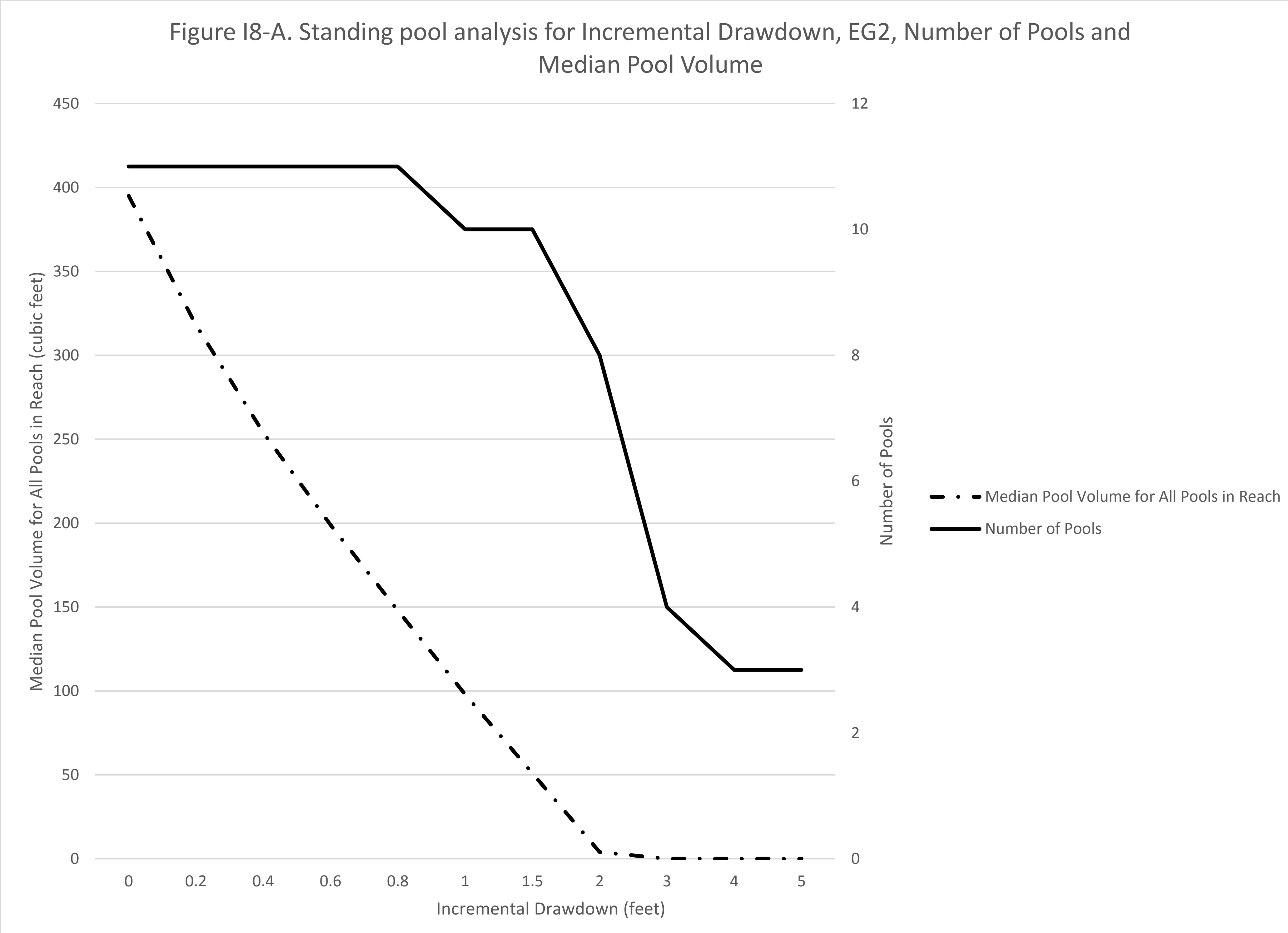


Figure I8-A. Standing pool analysis for Incremental Drawdown, EG2, Number of Pools and Median Pool Volume
450
400
350
300
250
200
150
100
50
0
Median Pool Volume for All Pools in Reach (cubic feet)
12
10
8
6
4
2
0
Number of Pools
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Incremental Drawdown (feet)
Median Pool Volume for All Pools in Reach
Number of Pools

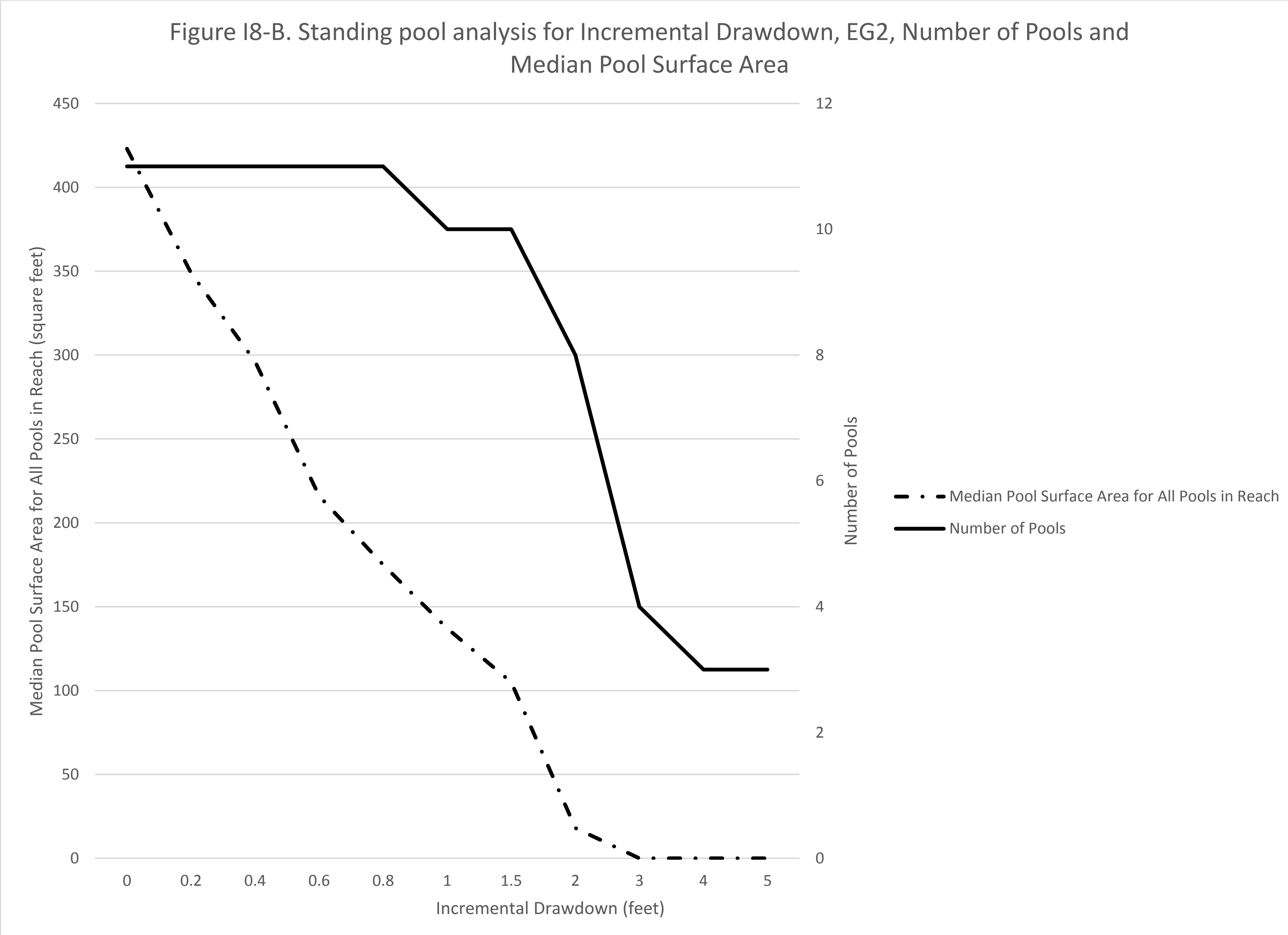


Figure I8-B. Standing pool analysis for Incremental Drawdown, EG2, Number of Pools and Median Pool Surface Area
Median Pool Surface Area for All Pools in Reach (square feet)
450
400
350
300
250
200
150
100
50
0
12
10
8
6
4
2
0
Number of Pools
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Incremental Drawdown (feet)
Median Pool Surface Area for All Pools in Reach
Number of Pools

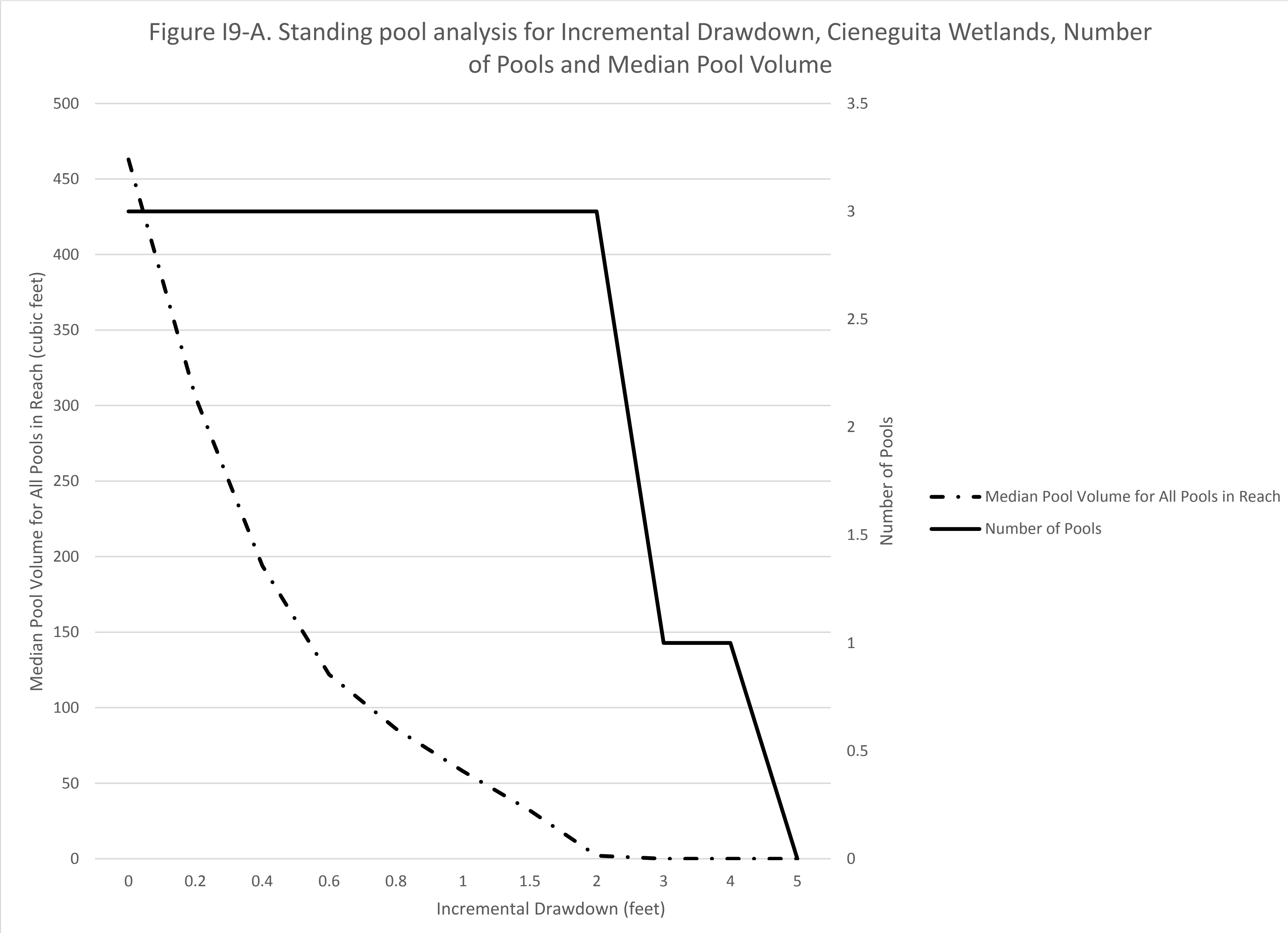


Figure I9-A. Standing pool analysis for Incremental Drawdown, Cieneguita Wetlands, Number of Pools and Median Pool Volume
Median Pool Volume for All Pools in Reach (cubic feet)
Number of Pools
Incremental Drawdown (feet)
0
50
100
150
200
250
300
350
400
450
500
0.5
1
1.5
2
2.5
3
3.5
0.2
0.4
0.6
0.8
3
4
5
Median Pool Volume for All Pools in Reach
Number of Pools

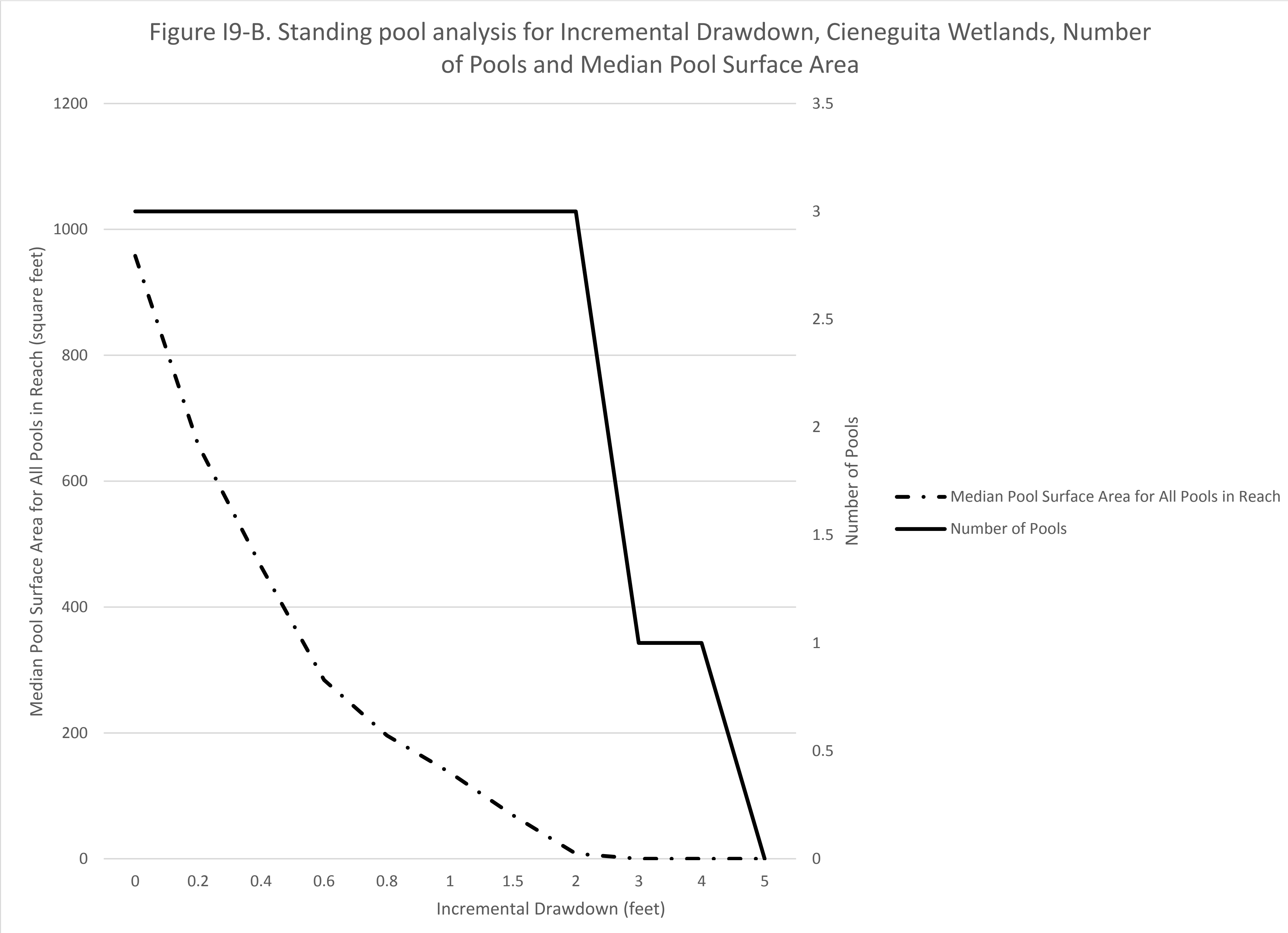


Figure I9-B. Standing pool analysis for Incremental Drawdown, Cieneguita Wetlands, Number of Pools and Median Pool Surface Area
Median Pool Surface Area for All Pools in Reach (square feet)
0
200
400
600
800
1000
1200
Number of Pools
0
0.5
1
1.5
2
2.5
3
3.5
0
0.2
0.4
0.6
0.8
1
1.5
2
3
4
5
Incremental Drawdown (feet)
Median Pool Surface Area for All Pools in Reach
Number of Pools

J. Standing Pool Analysis for Modeling Scenarios

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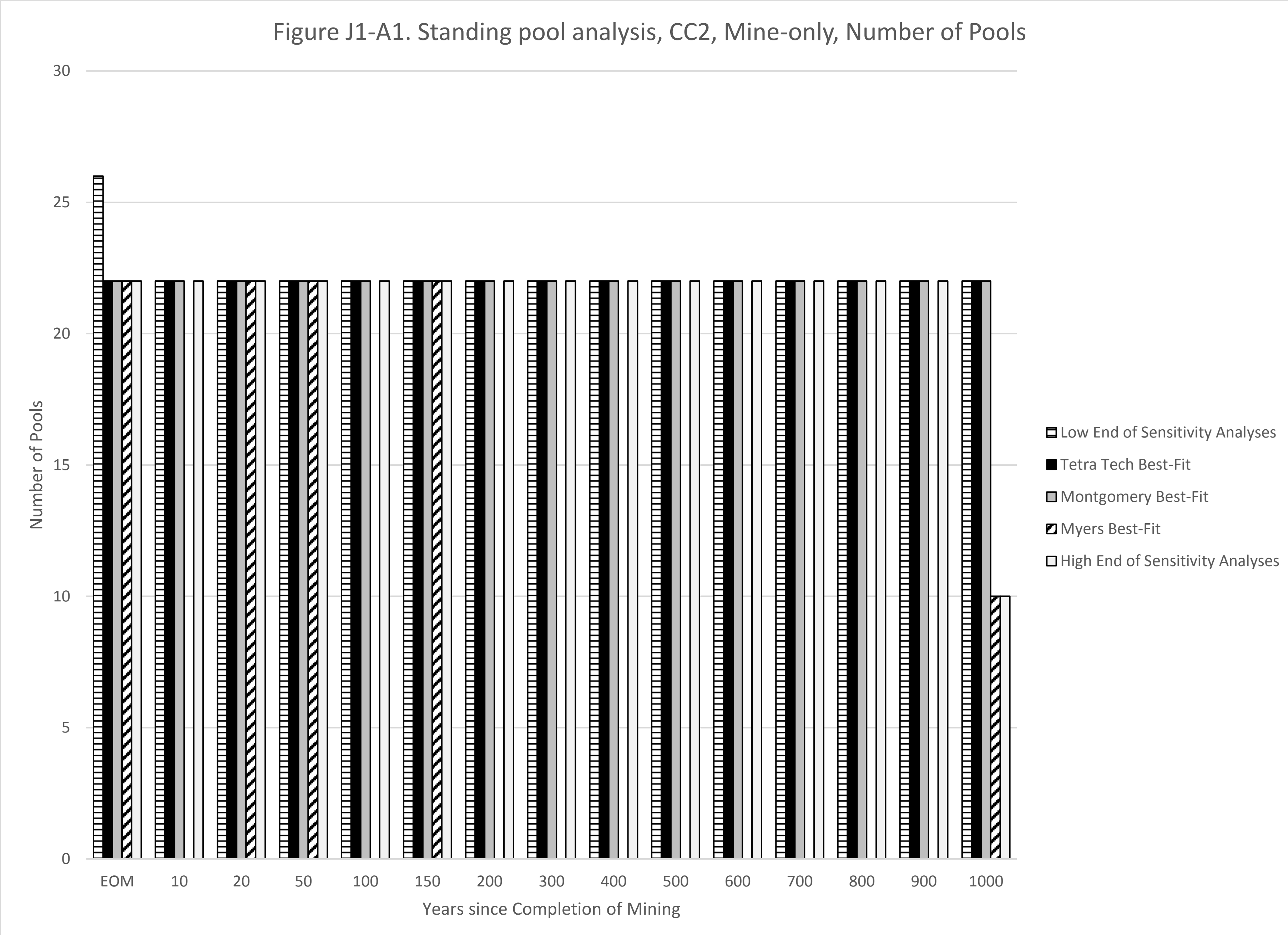
Figure J1-A1. Standing pool analysis, CC2, Mine-only, Number of Pools
30
25
20
15
10
5
0
Number of Pools
EOM
10
20
50
100
150
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analyses

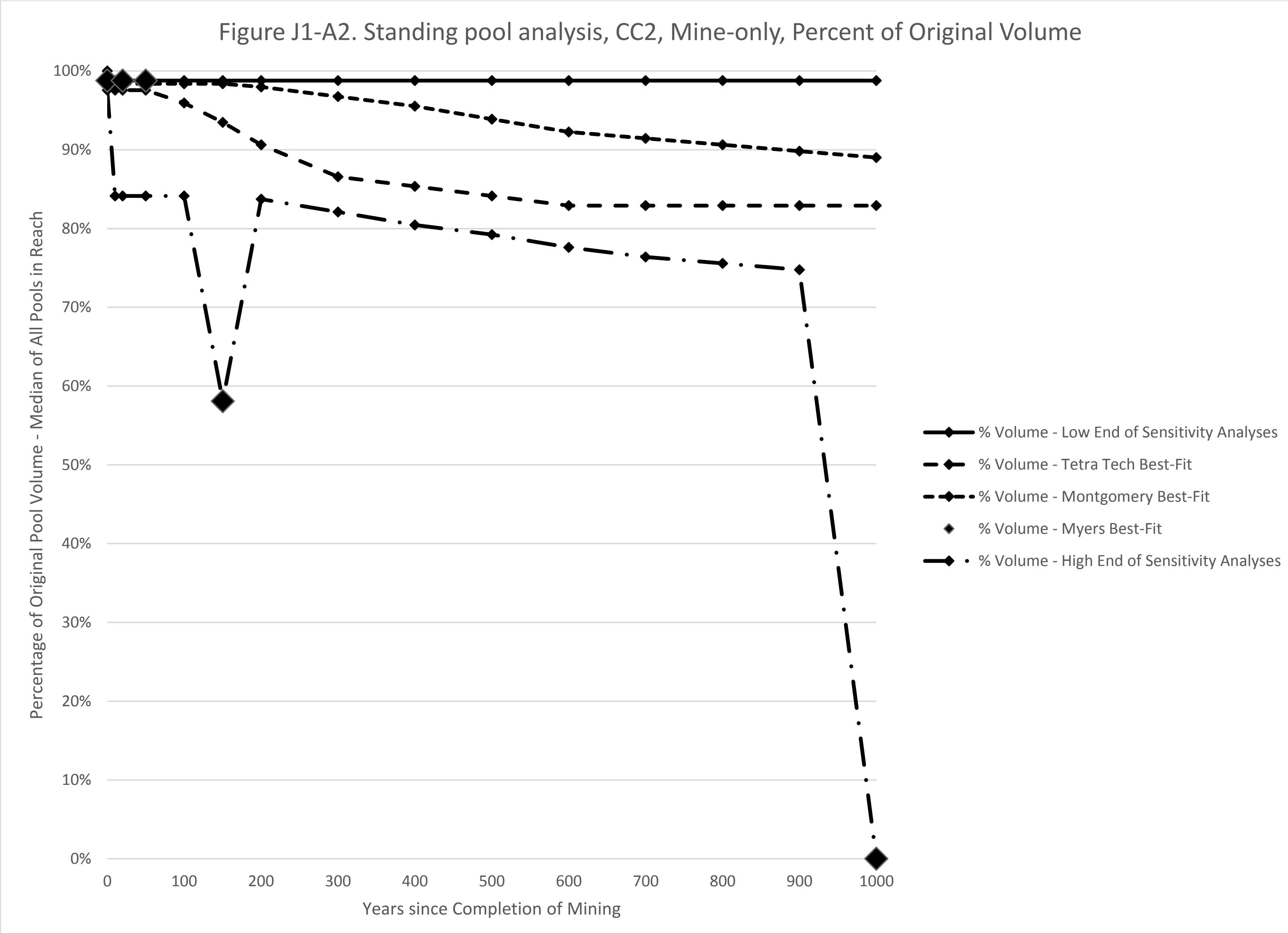

Figure J1-A2. Standing pool analysis, CC2, Mine-only, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Percentage of Original Pool Volume - Median of All Pools in Reach
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

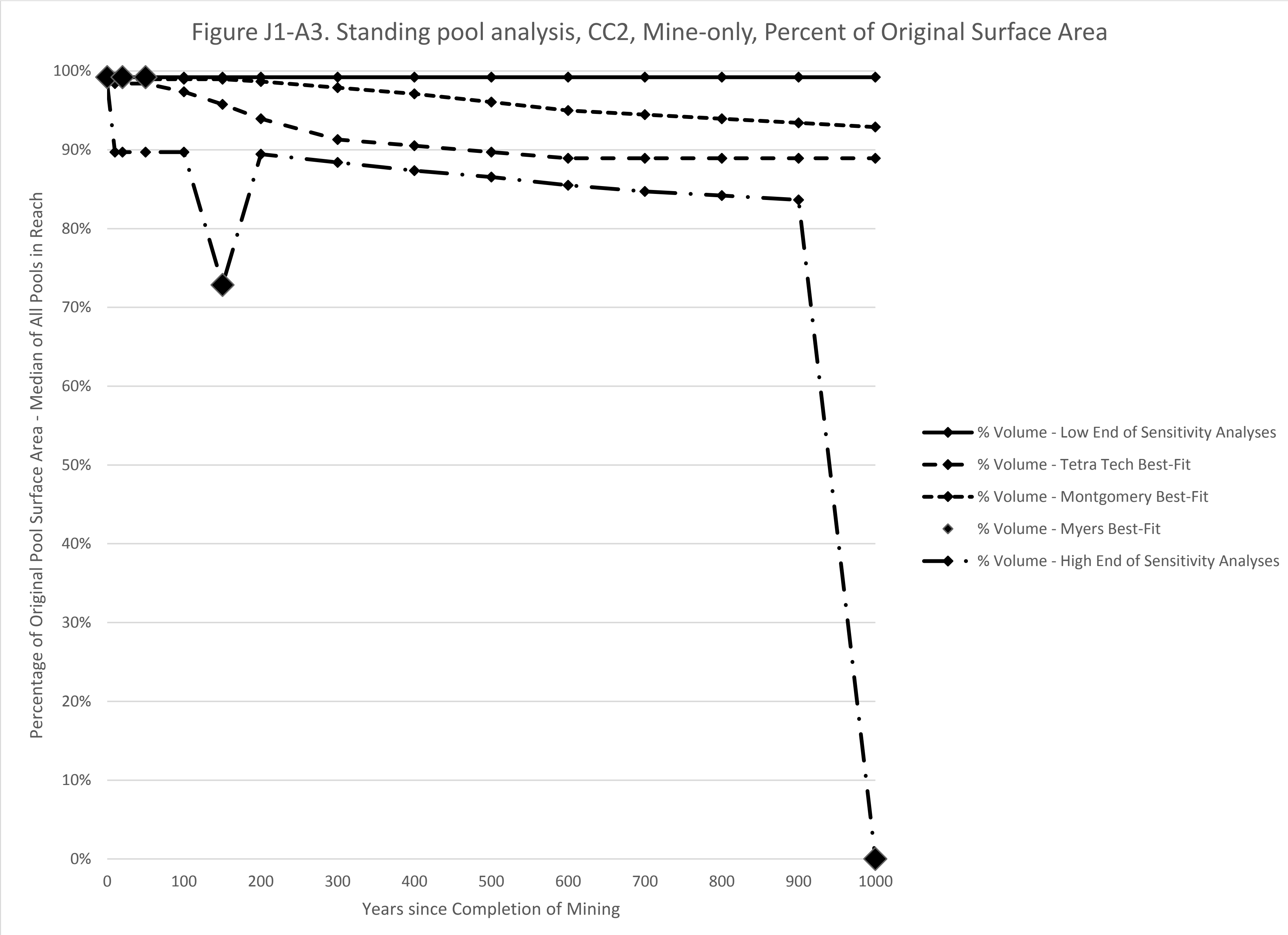
Figure J1-A3. Standing pool analysis, CC2, Mine-only, Percent of Original Surface Area
Percentage of Original Pool Surface Area - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

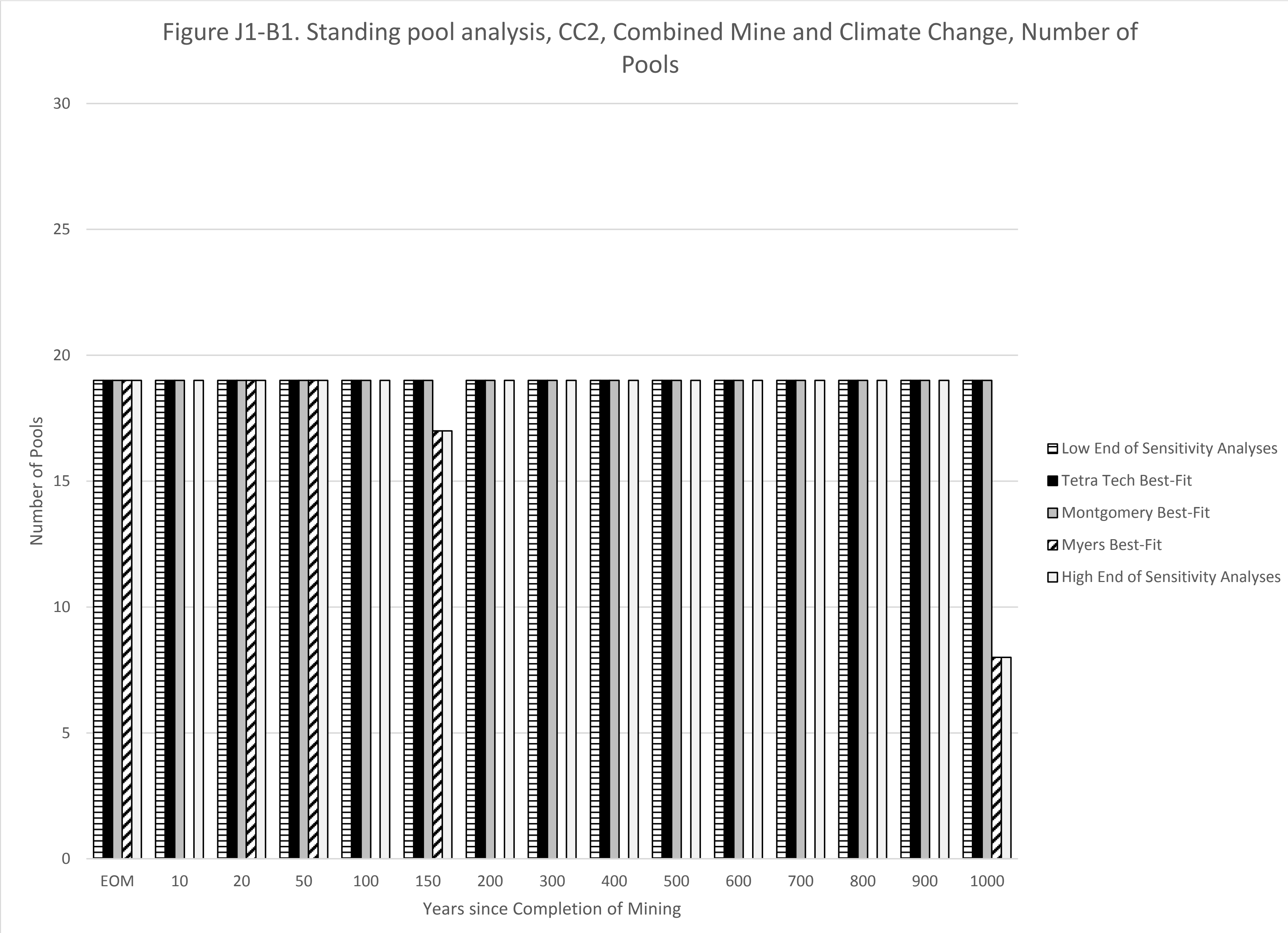
Figure J1-B1. Standing pool analysis, CC2, Combined Mine and Climate Change, Number of Pools
Number of Pools
30
25
20
15
10
5
0
EOM
10
20
50
100
150
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analyses

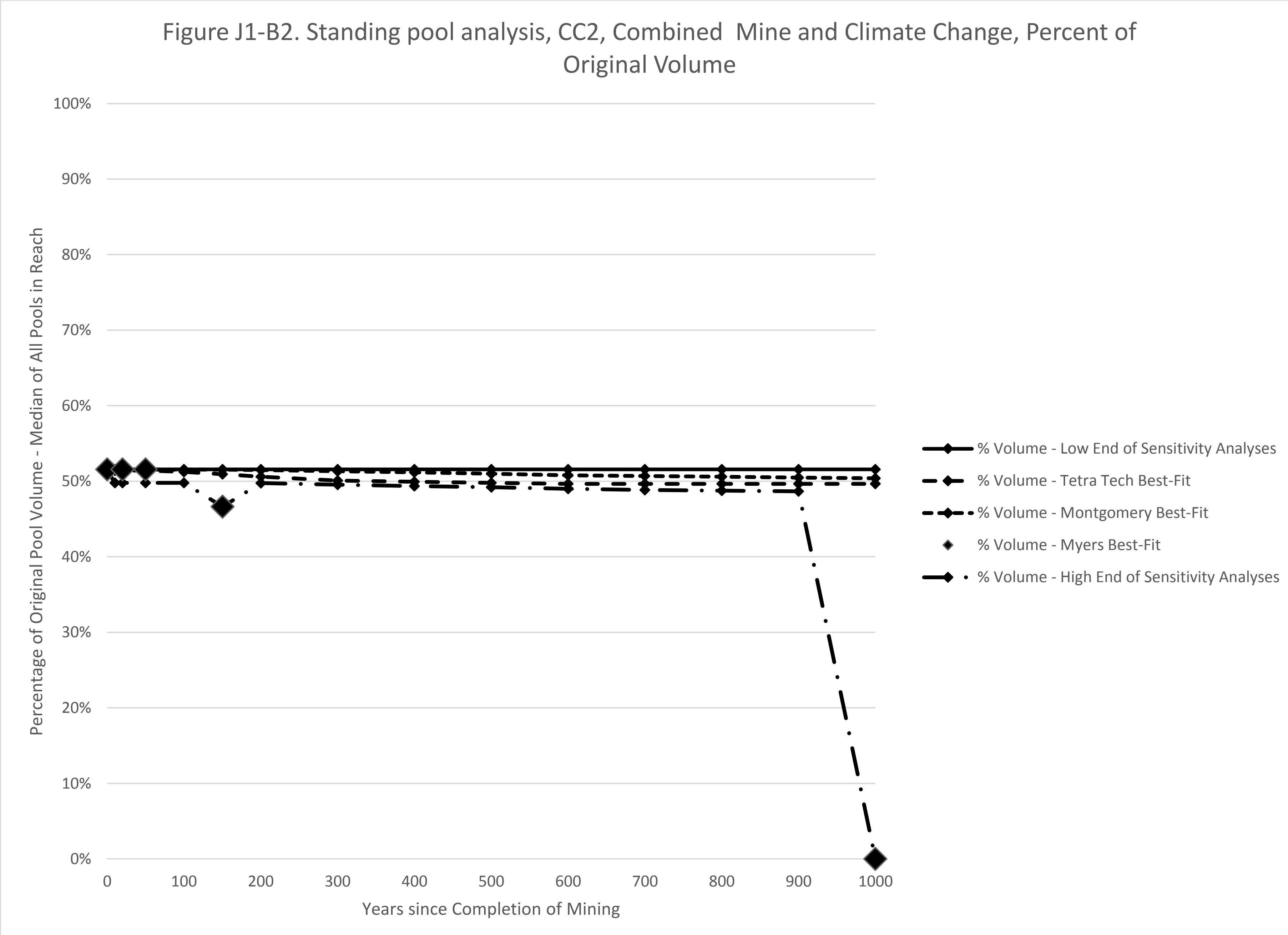

Figure J1-B2. Standing pool analysis, CC2, Combined Mine and Climate Change, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of All Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

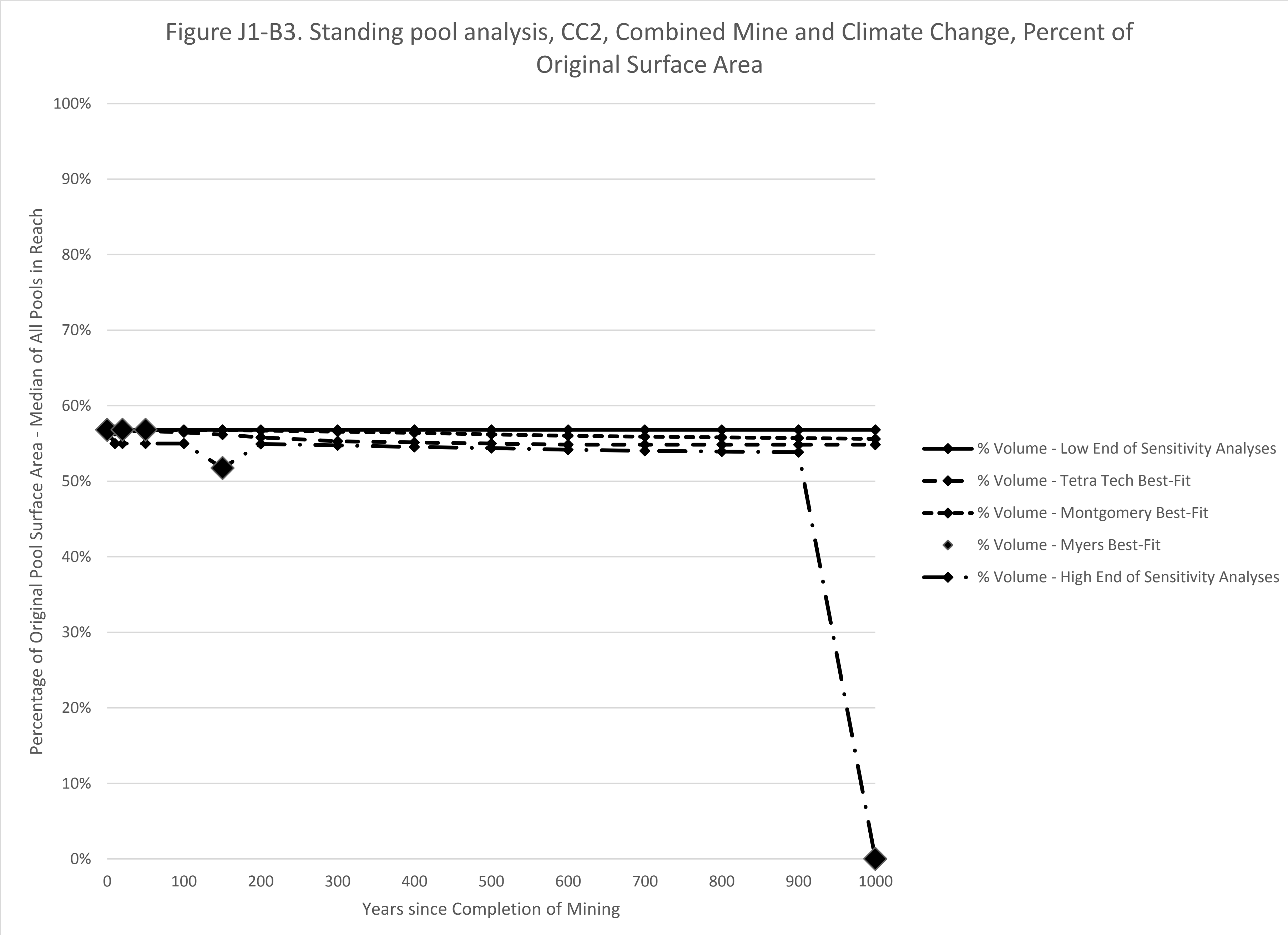
Figure J1-B3. Standing pool analysis, CC2, Combined Mine and Climate Change, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of All Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

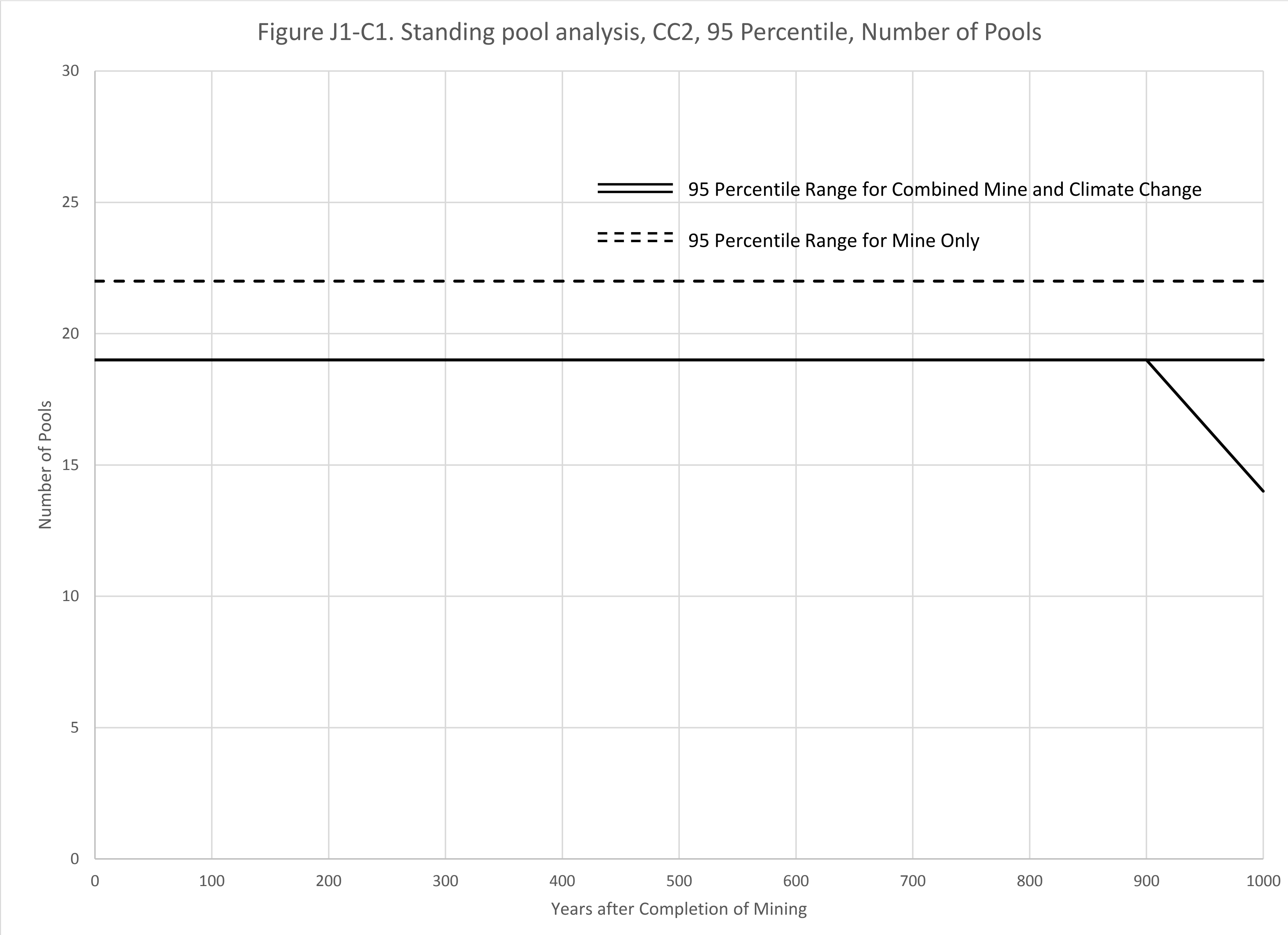
Figure J1-C1. Standing pool analysis, CC2, 95 Percentile, Number of Pools
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Number of Pools
Years after Completion of Mining
0
5
10
15
20
25
30
0
100
200
300
400
500
600
700
800
900
1000

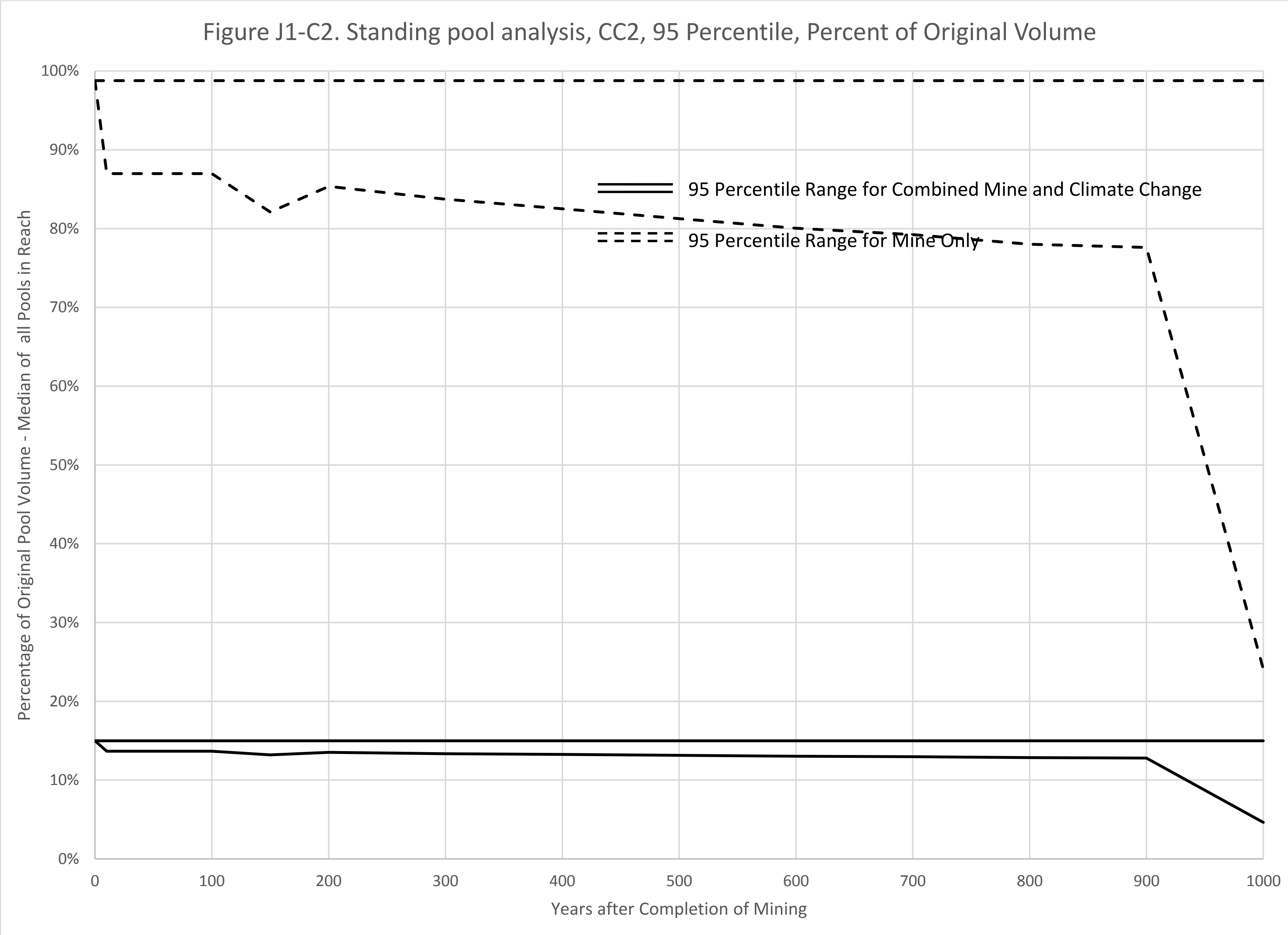
Figure J1-C2. Standing pool analysis, CC2, 95 Percentile, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of all Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only

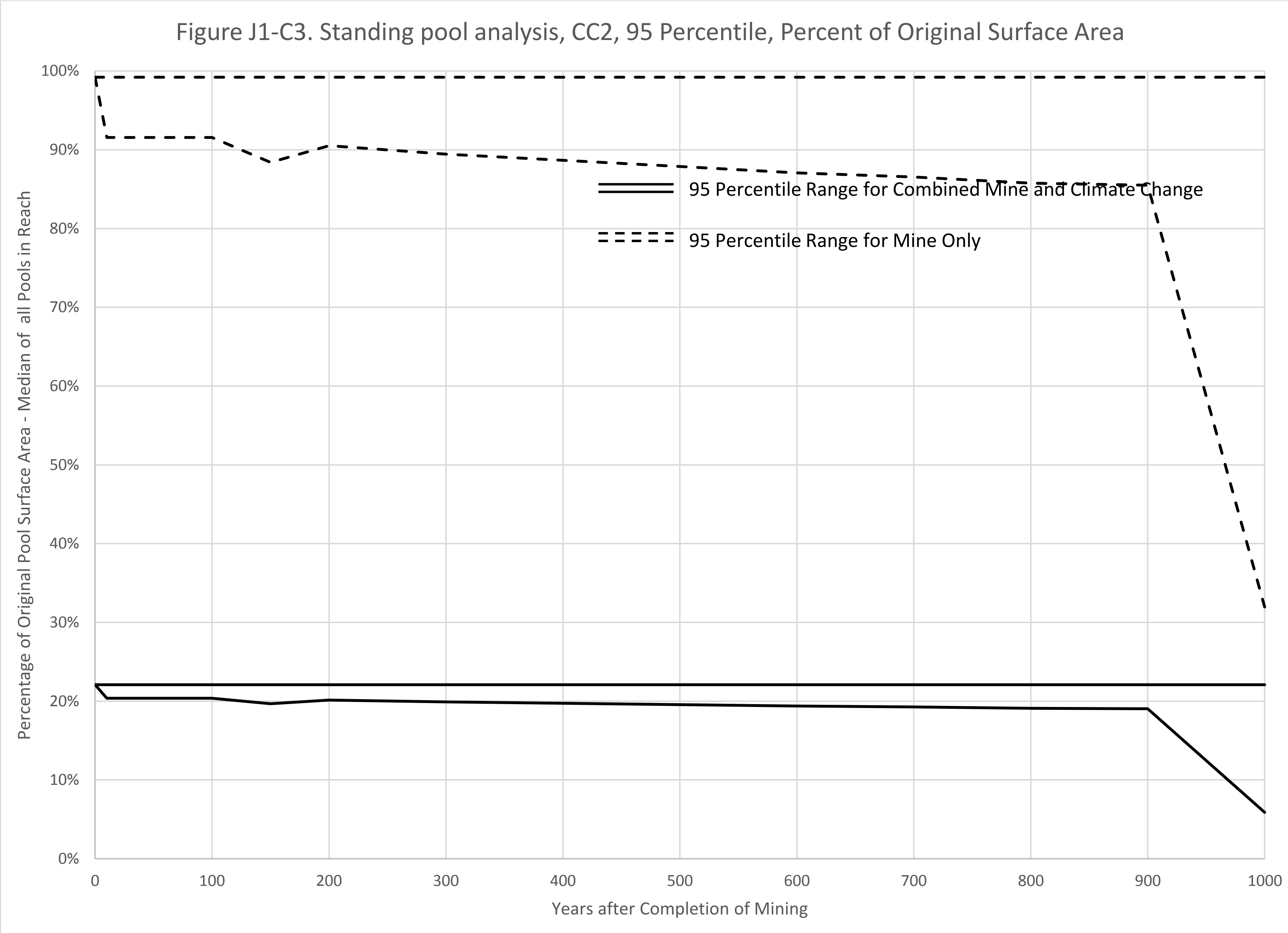

Figure J1-C3. Standing pool analysis, CC2, 95 Percentile, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of all Pools in Reach
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
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100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

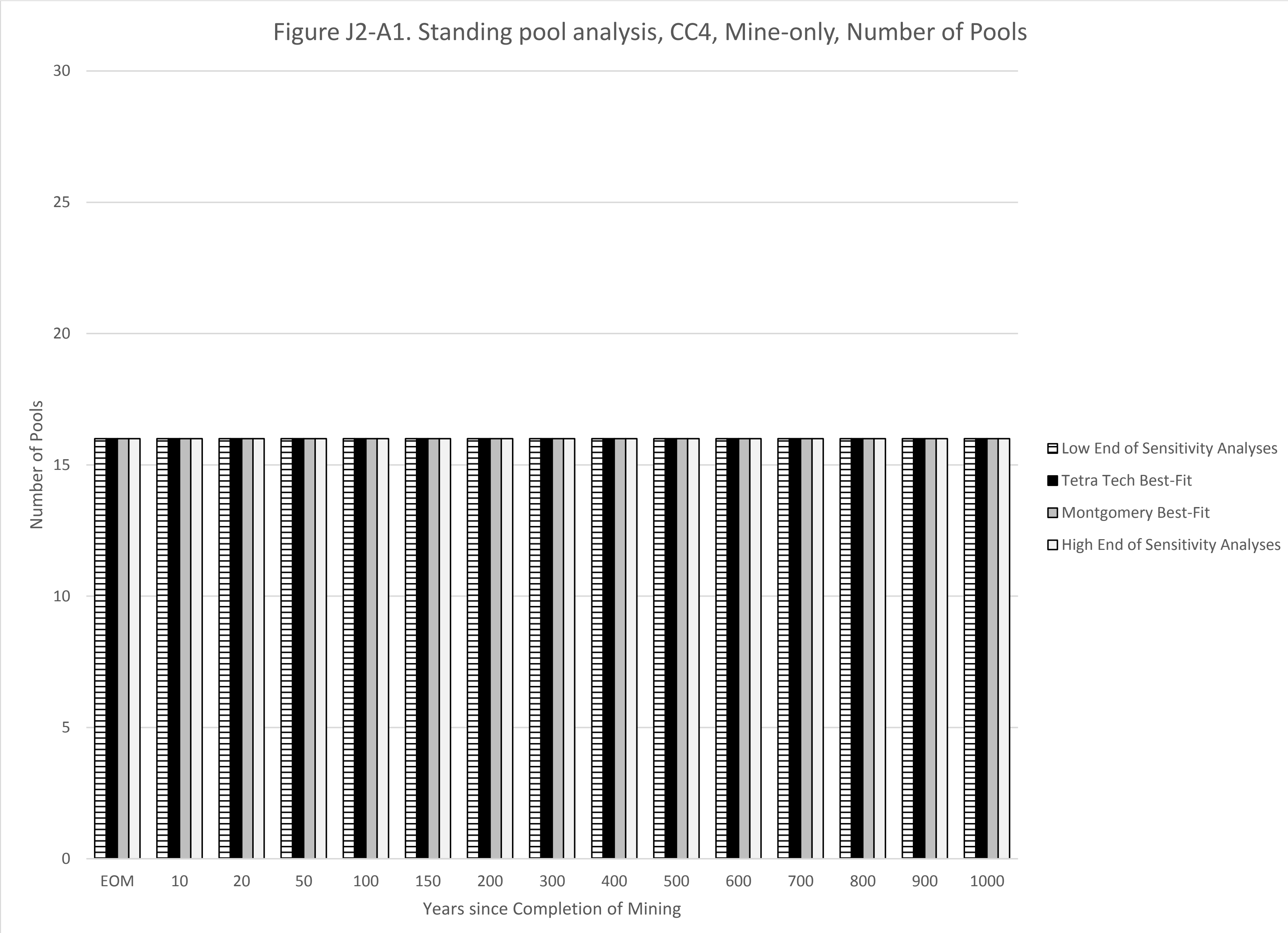

Figure J2-A1. Standing pool analysis, CC4, Mine-only, Number of Pools
Number of Pools
30
25
20
15
10
5
0
EOM
10
20
50
100
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200
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Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
High End of Sensitivity Analyses

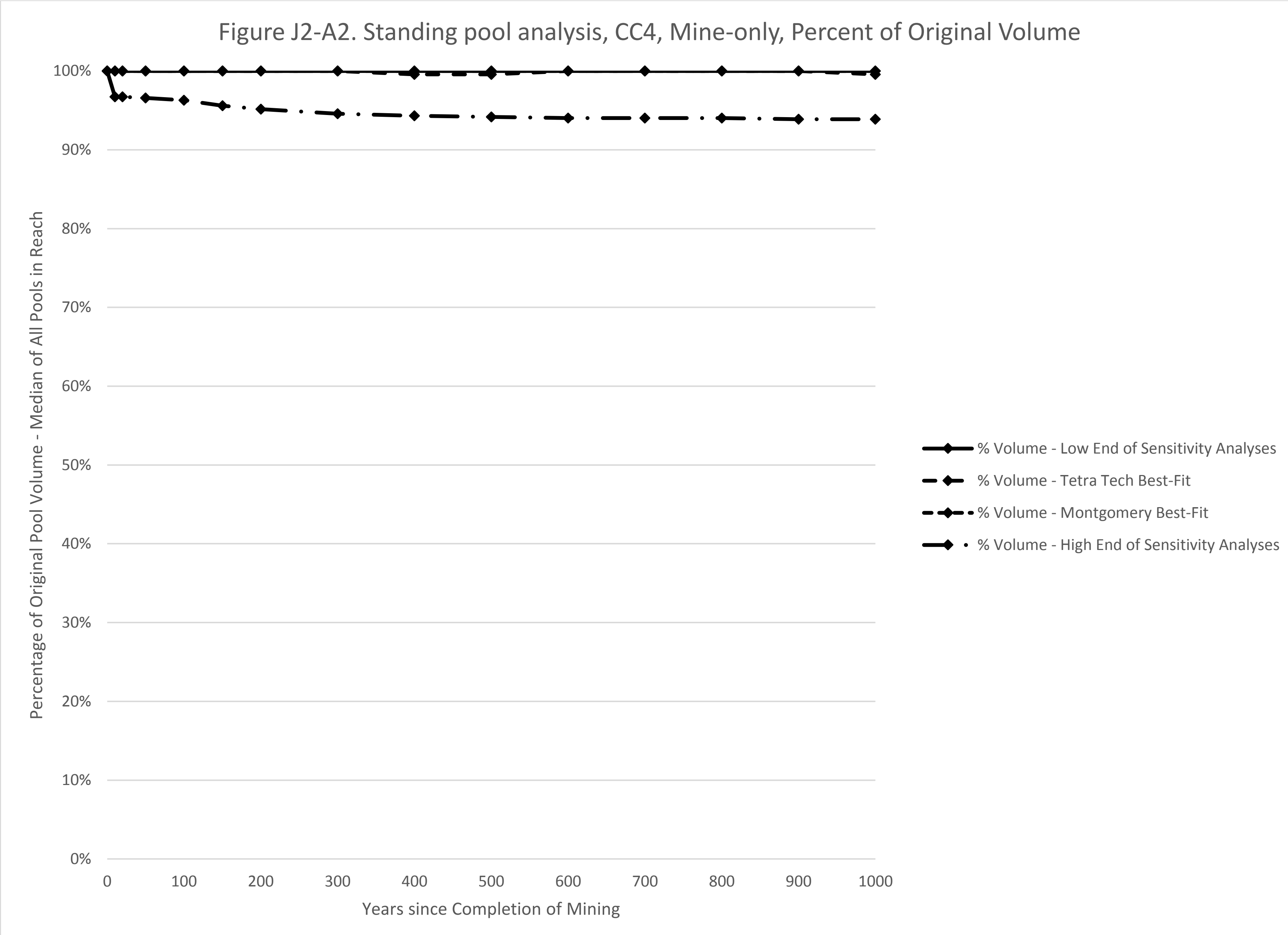
Figure J2-A2. Standing pool analysis, CC4, Mine-only, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of All Pools in Reach
0
100
200
300
400
500
600
700
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900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

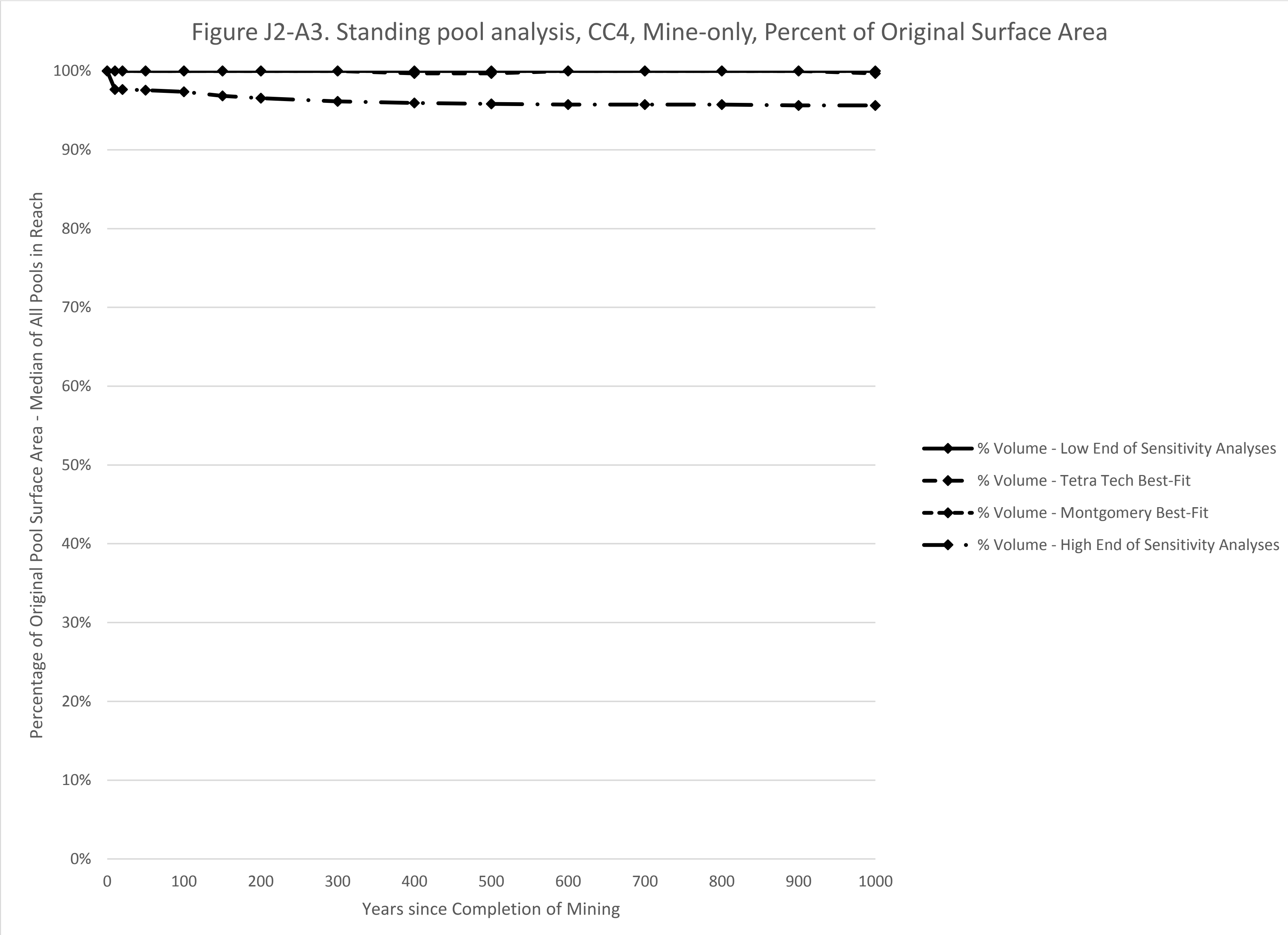
Figure J2-A3. Standing pool analysis, CC4, Mine-only, Percent of Original Surface Area
100%
90%
80%
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30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of All Pools in Reach
0
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600
700
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900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

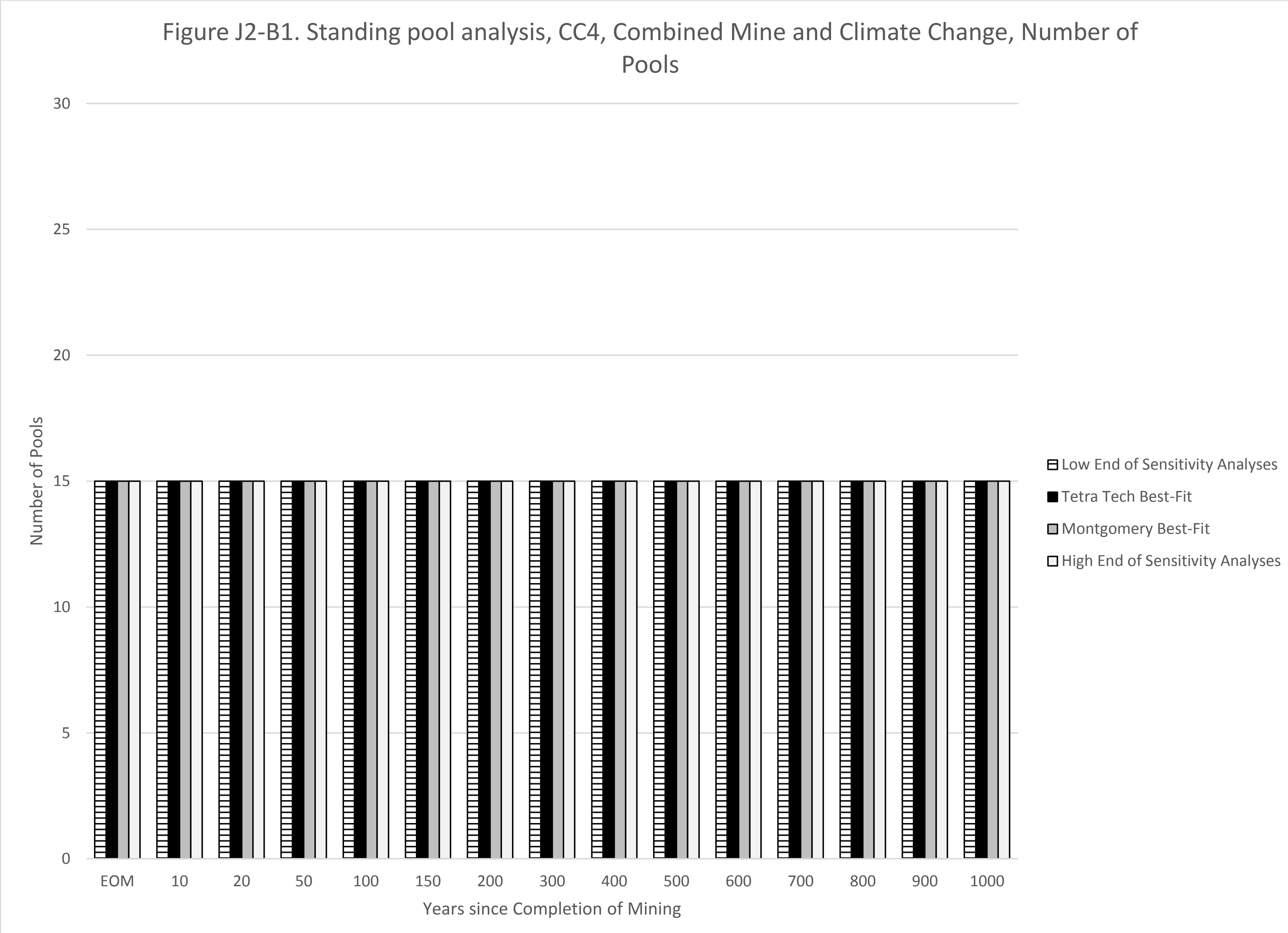
Figure J2-B1. Standing pool analysis, CC4, Combined Mine and Climate Change, Number of Pools
30
25
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Number of Pools
EOM
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Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
High End of Sensitivity Analyses

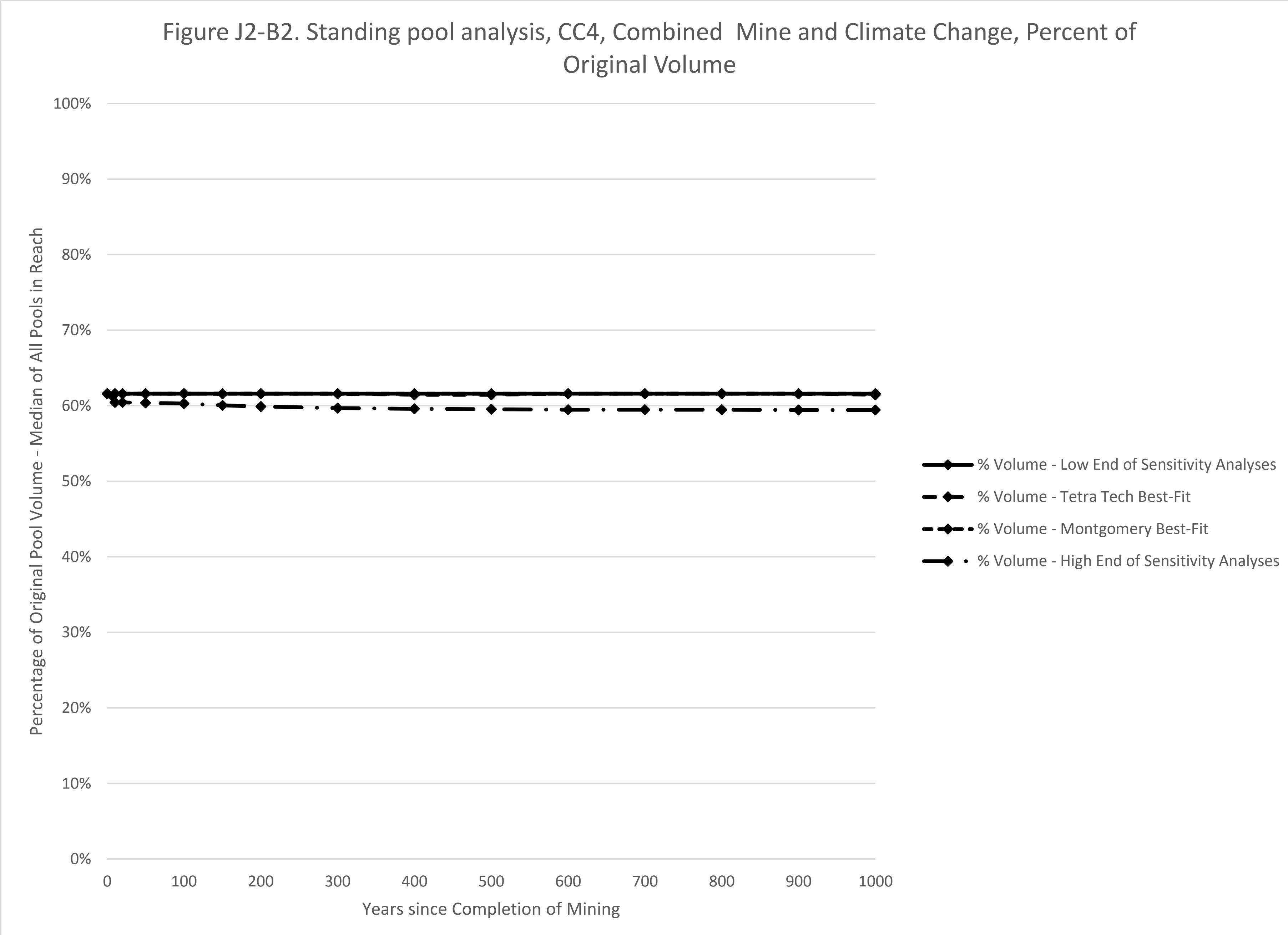

Figure J2-B2. Standing pool analysis, CC4, Combined Mine and Climate Change, Percent of Original Volume
100%
90%
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Years since Completion of Mining
Percentage of Original Pool Volume - Median of All Pools in Reach
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

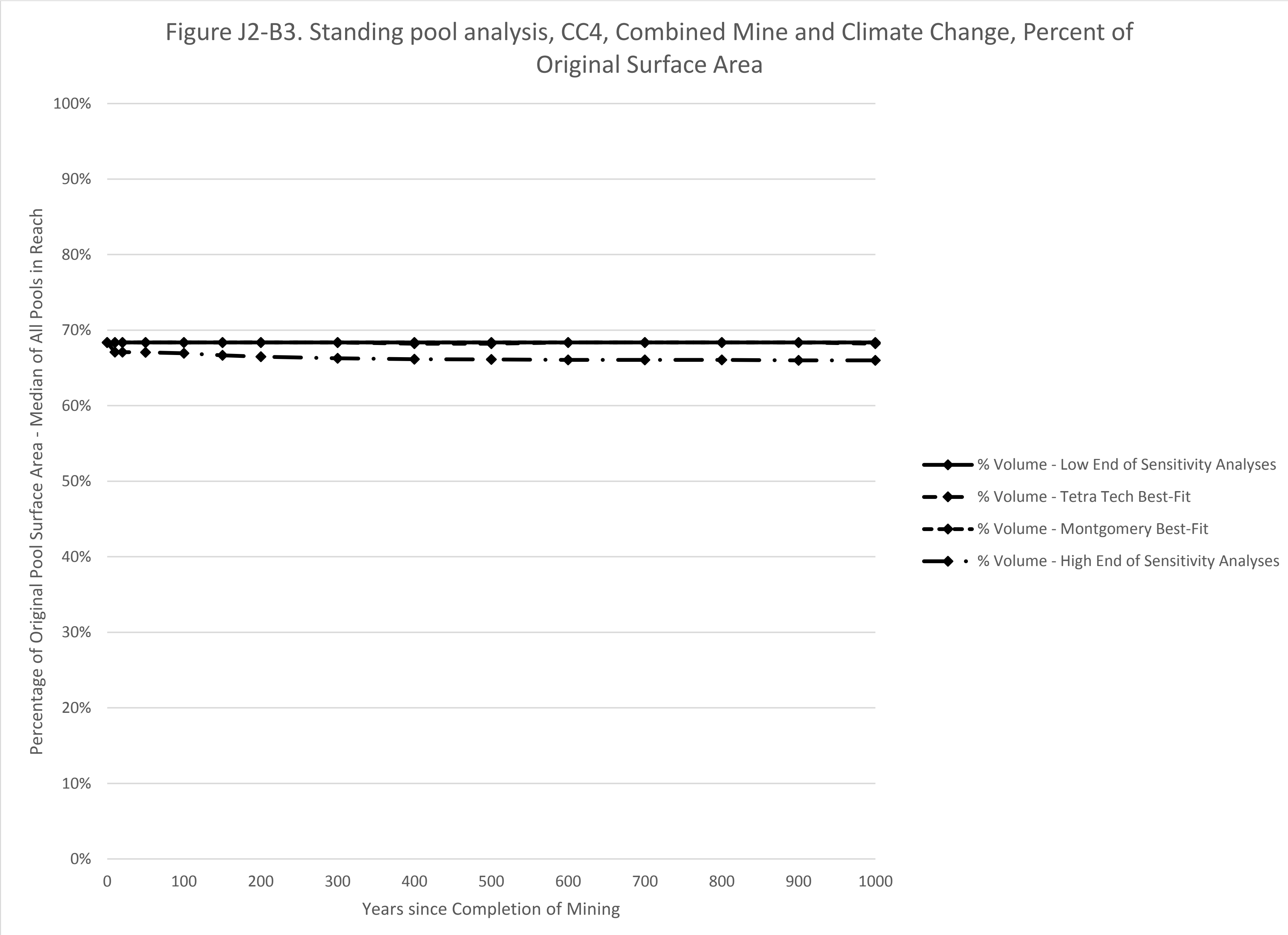

Figure J2-B3. Standing pool analysis, CC4, Combined Mine and Climate Change, Percent of Original Surface Area
100%
90%
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20%
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0%
Percentage of Original Pool Surface Area - Median of All Pools in Reach
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Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

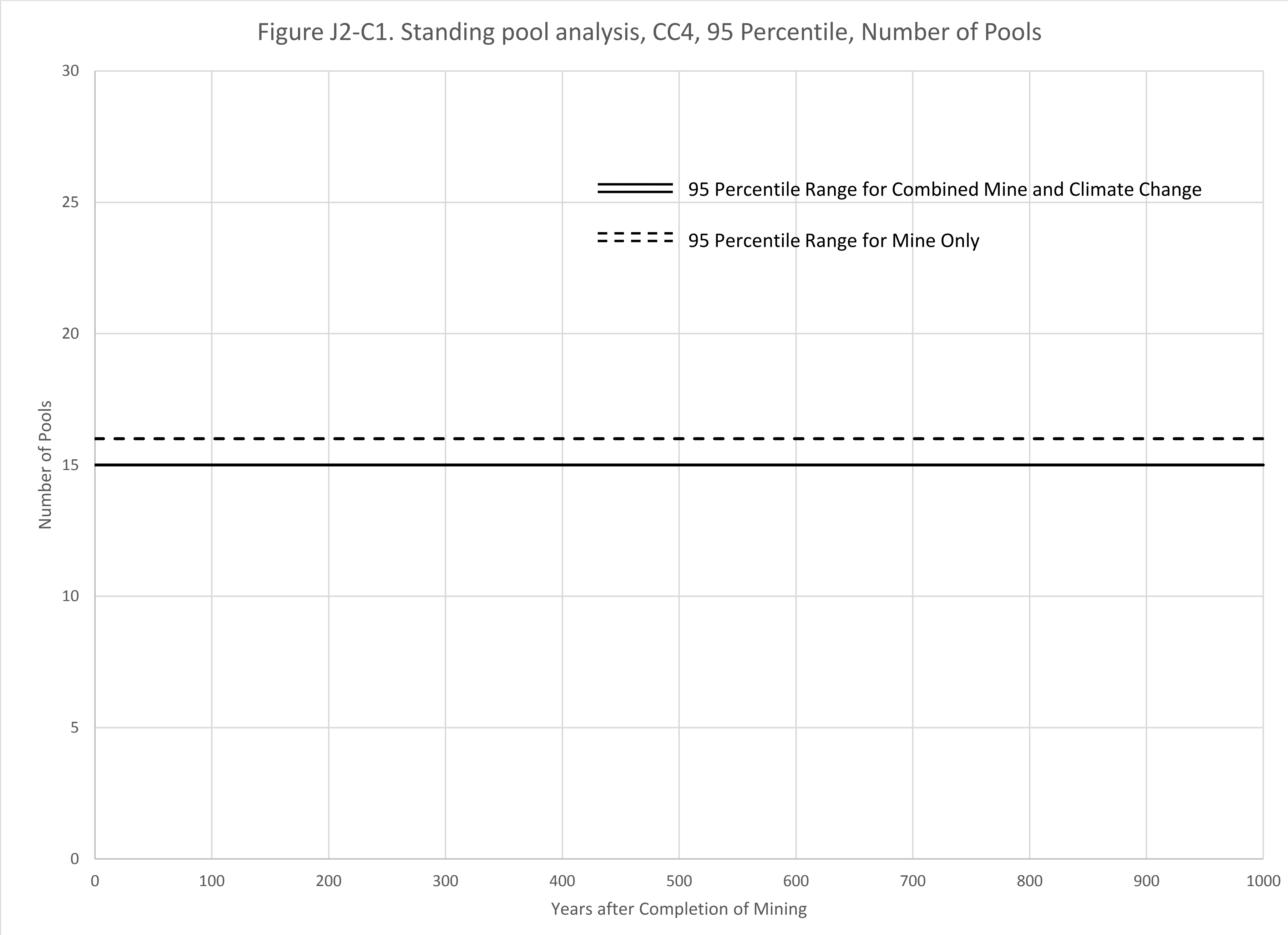
Figure J2-C1. Standing pool analysis, CC4, 95 Percentile, Number of Pools
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Number of Pools
30
25
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200
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400
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600
700
800
900
1000
Years after Completion of Mining

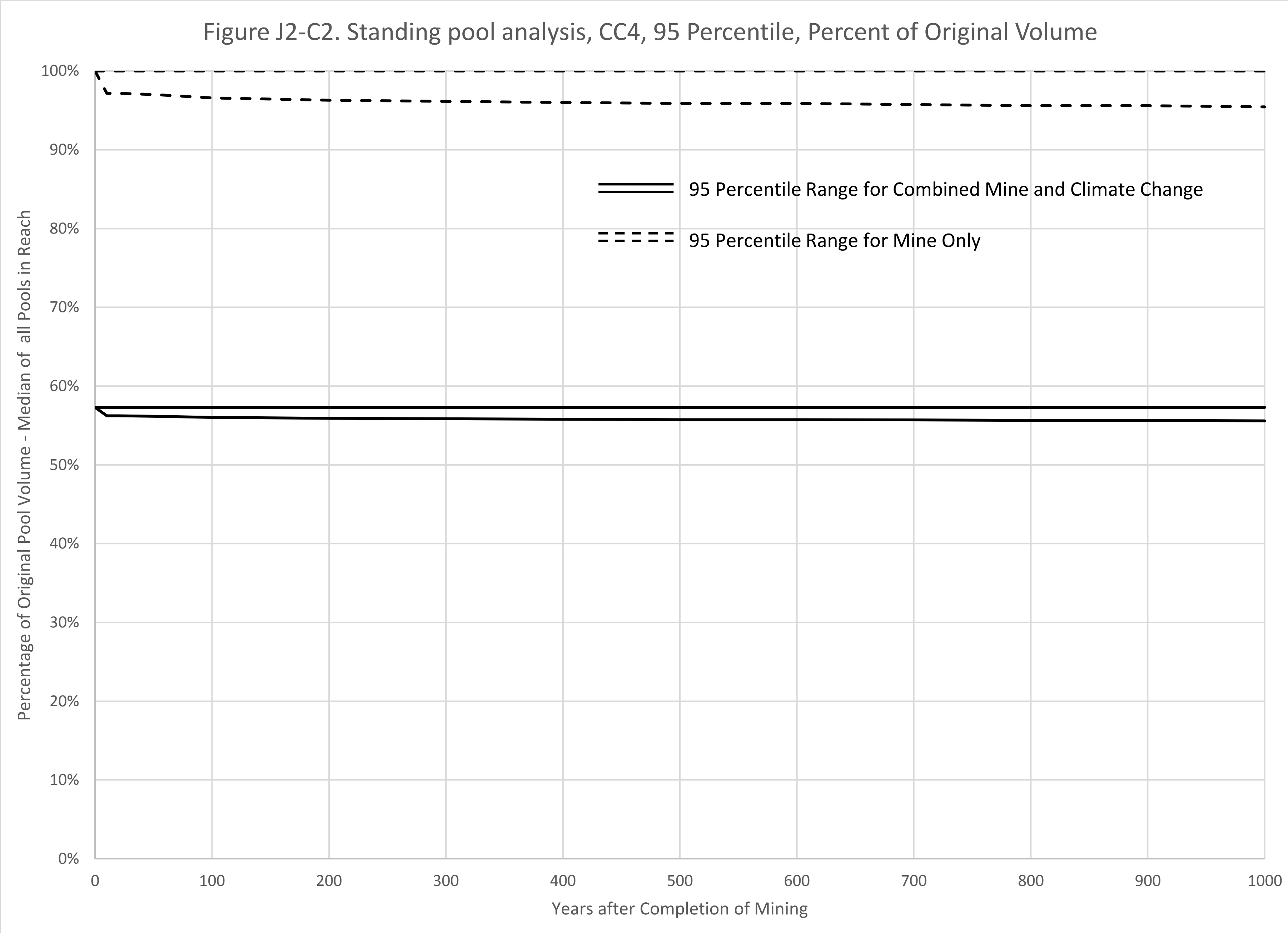
Figure J2-C2. Standing pool analysis, CC4, 95 Percentile, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of all Pools in Reach
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
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200
300
400
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900
1000
Years after Completion of Mining

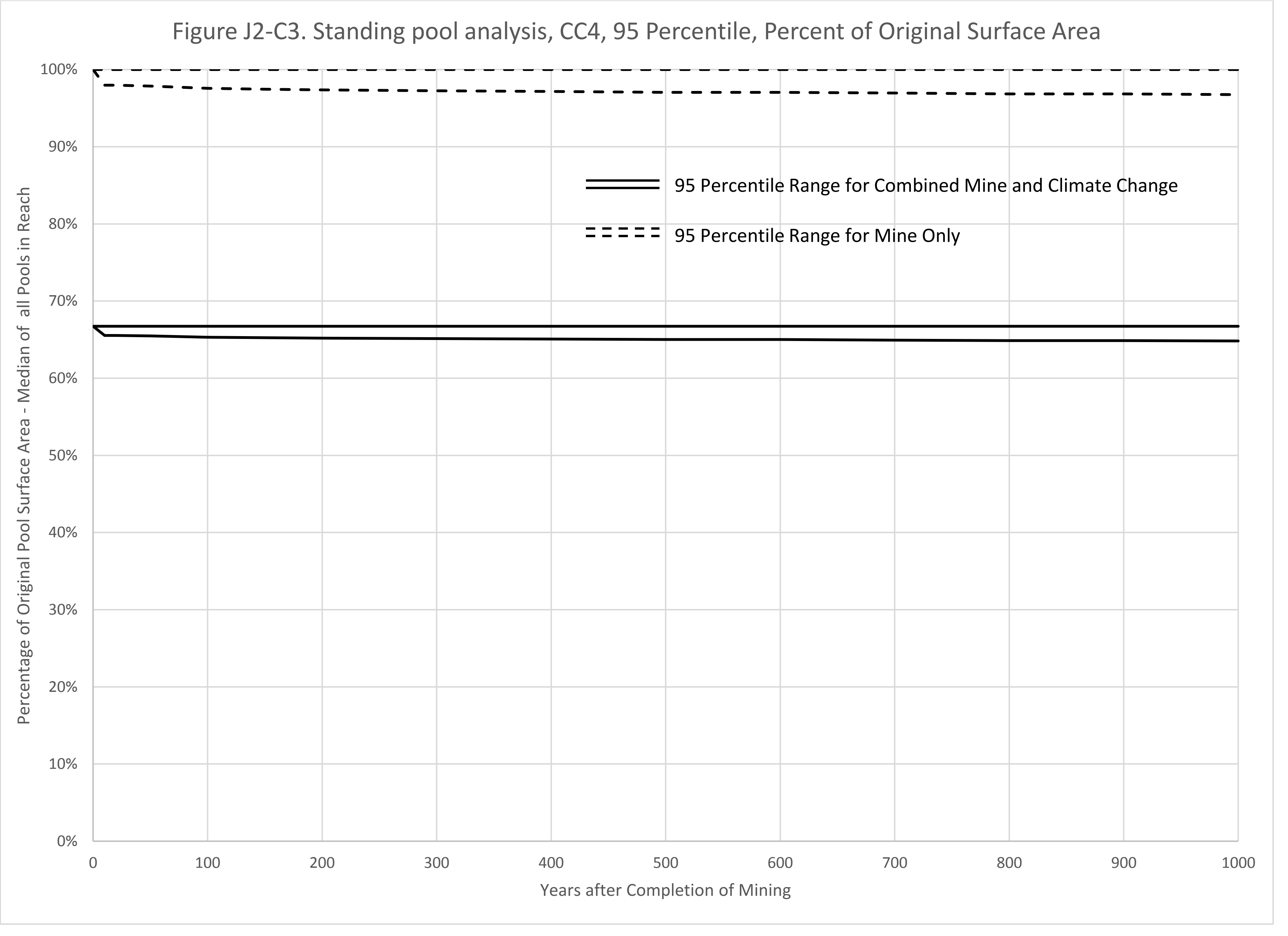
Figure J2-C3. Standing pool analysis, CC4, 95 Percentile, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of all Pools in Reach
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100
200
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400
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900
1000
Years after Completion of Mining
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only

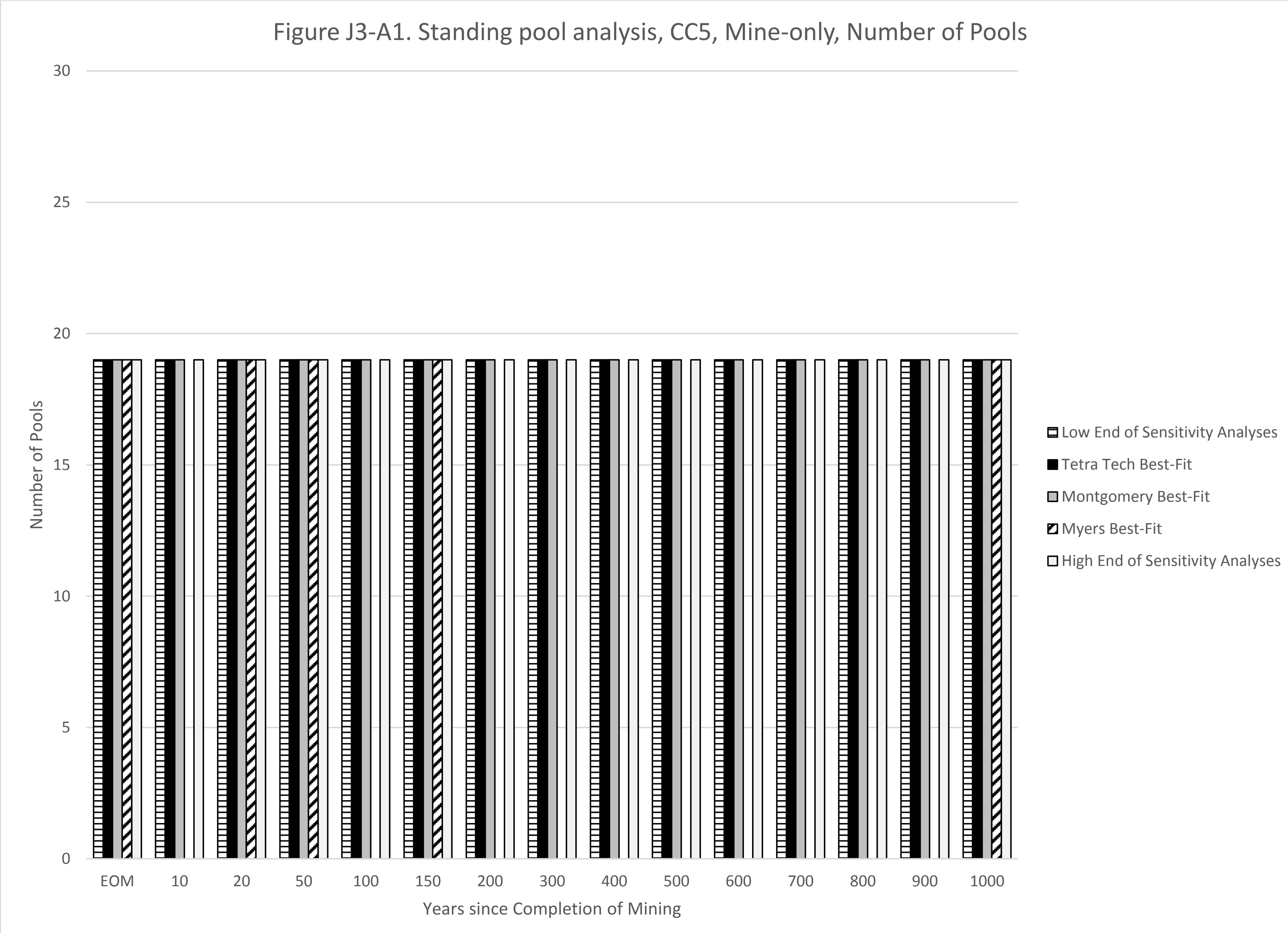
Figure J3-A1. Standing pool analysis, CC5, Mine-only, Number of Pools
30
25
20
15
10
5
0
Number of Pools
EOM
10
20
50
100
150
200
300
400
500
600
700
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900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analyses

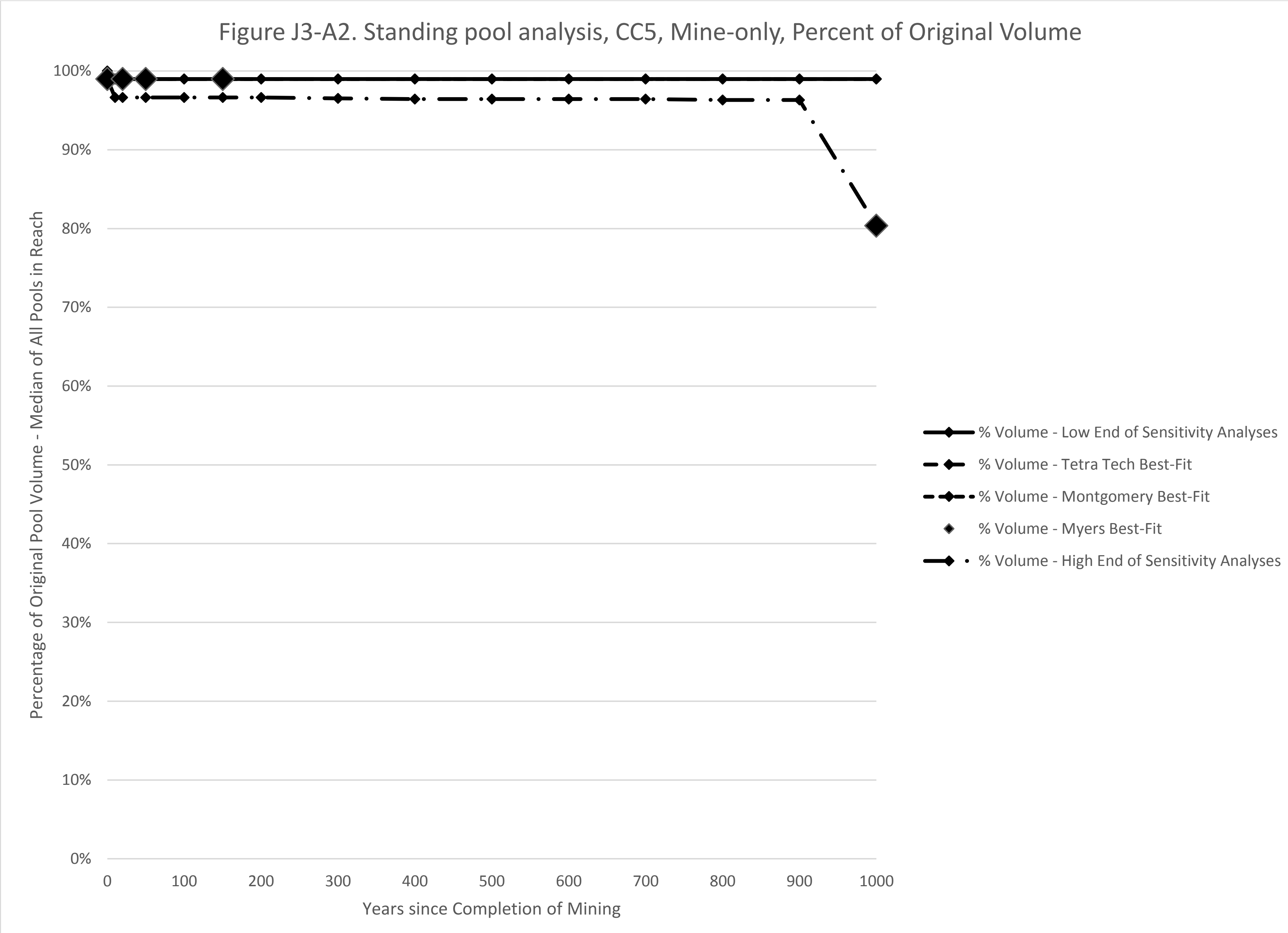
Figure J3-A2. Standing pool analysis, CC5, Mine-only, Percent of Original Volume
Percentage of Original Pool Volume - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

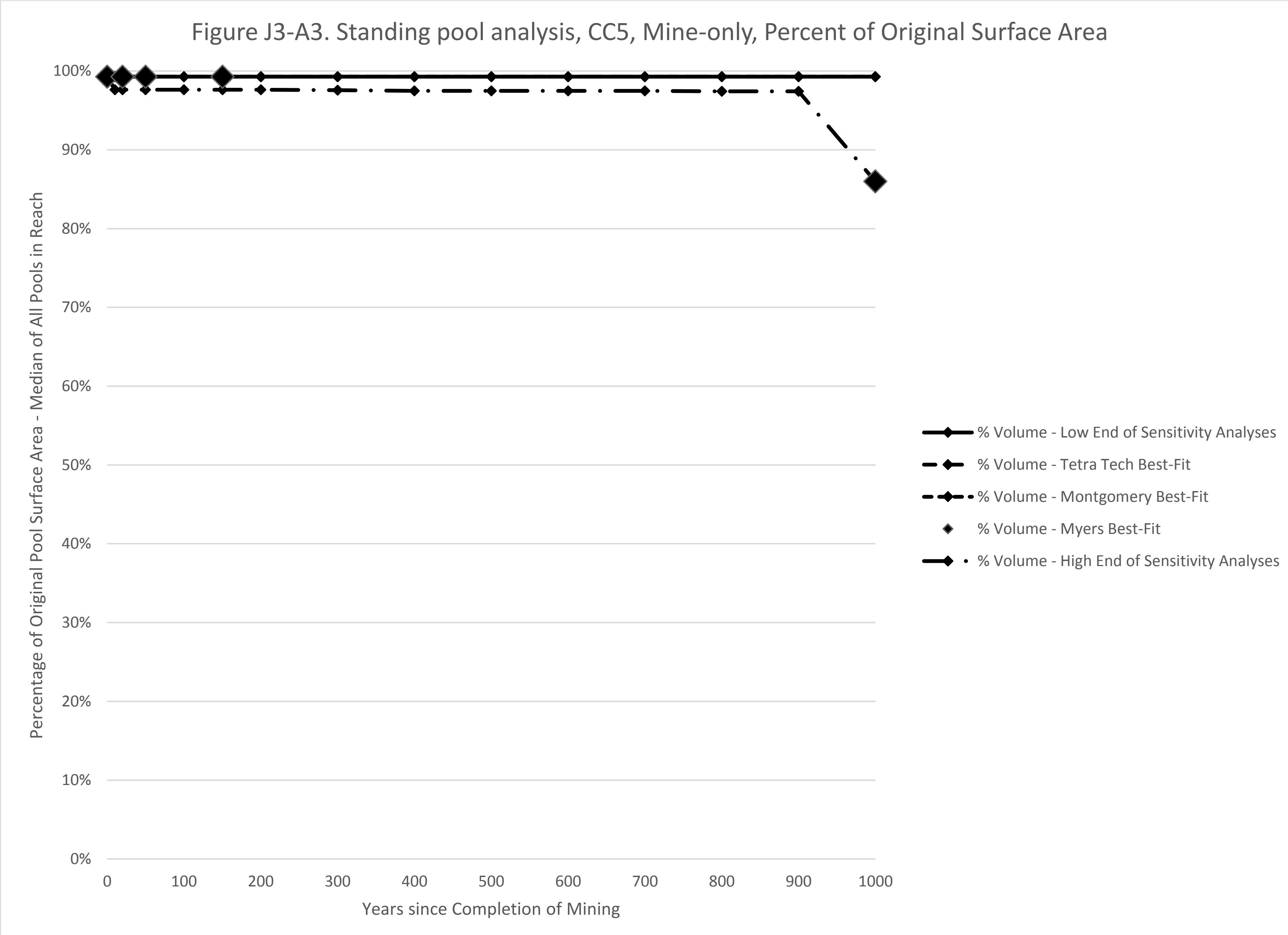
Figure J3-A3. Standing pool analysis, CC5, Mine-only, Percent of Original Surface Area
Percentage of Original Pool Surface Area - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

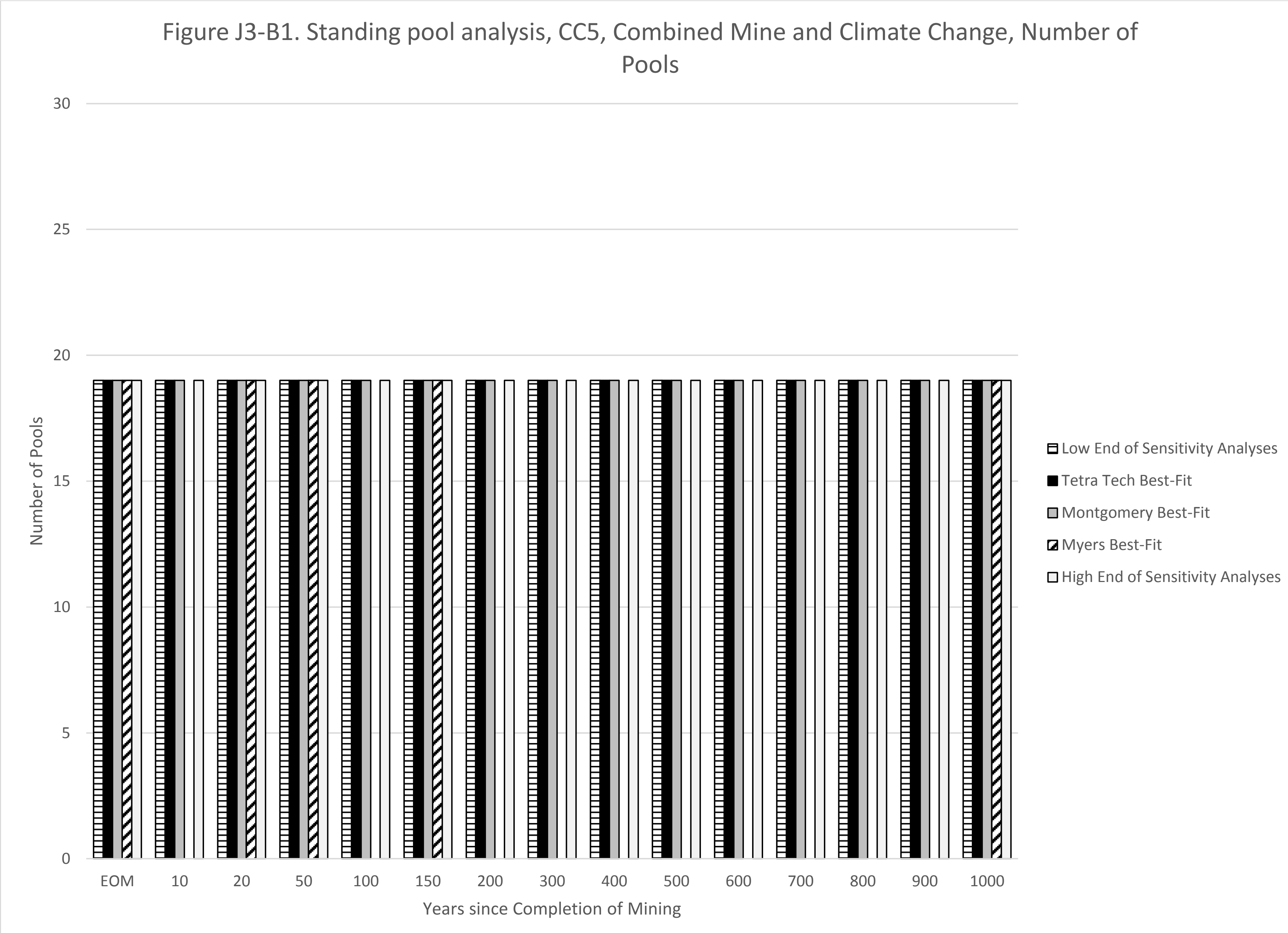
Figure J3-B1. Standing pool analysis, CC5, Combined Mine and Climate Change, Number of Pools
30
25
20
15
10
5
0
Number of Pools
EOM
10
20
50
100
150
200
300
400
500
600
700
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900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analyses

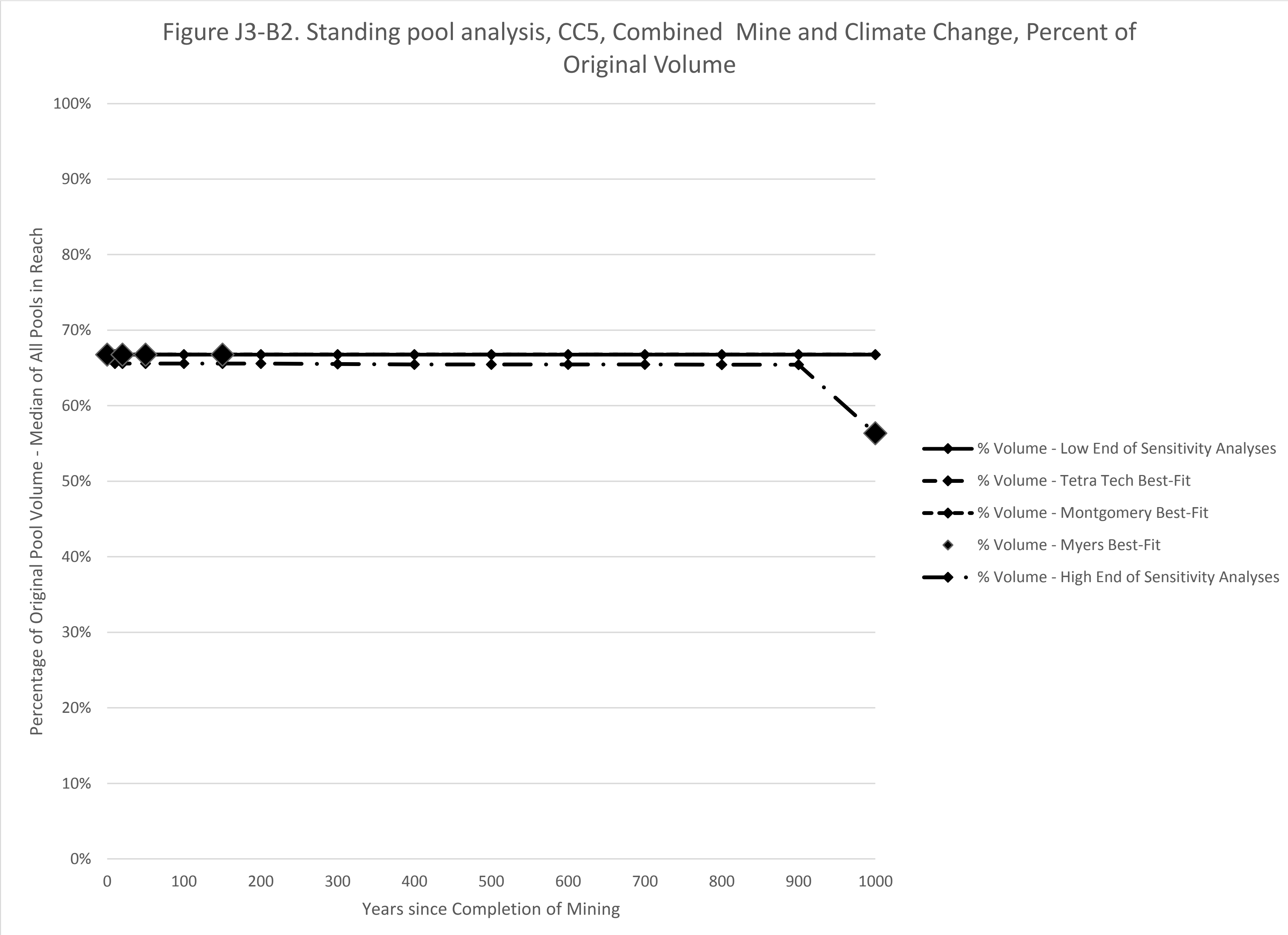
Figure J3-B2. Standing pool analysis, CC5, Combined Mine and Climate Change, Percent of Original Volume
Percentage of Original Pool Volume - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

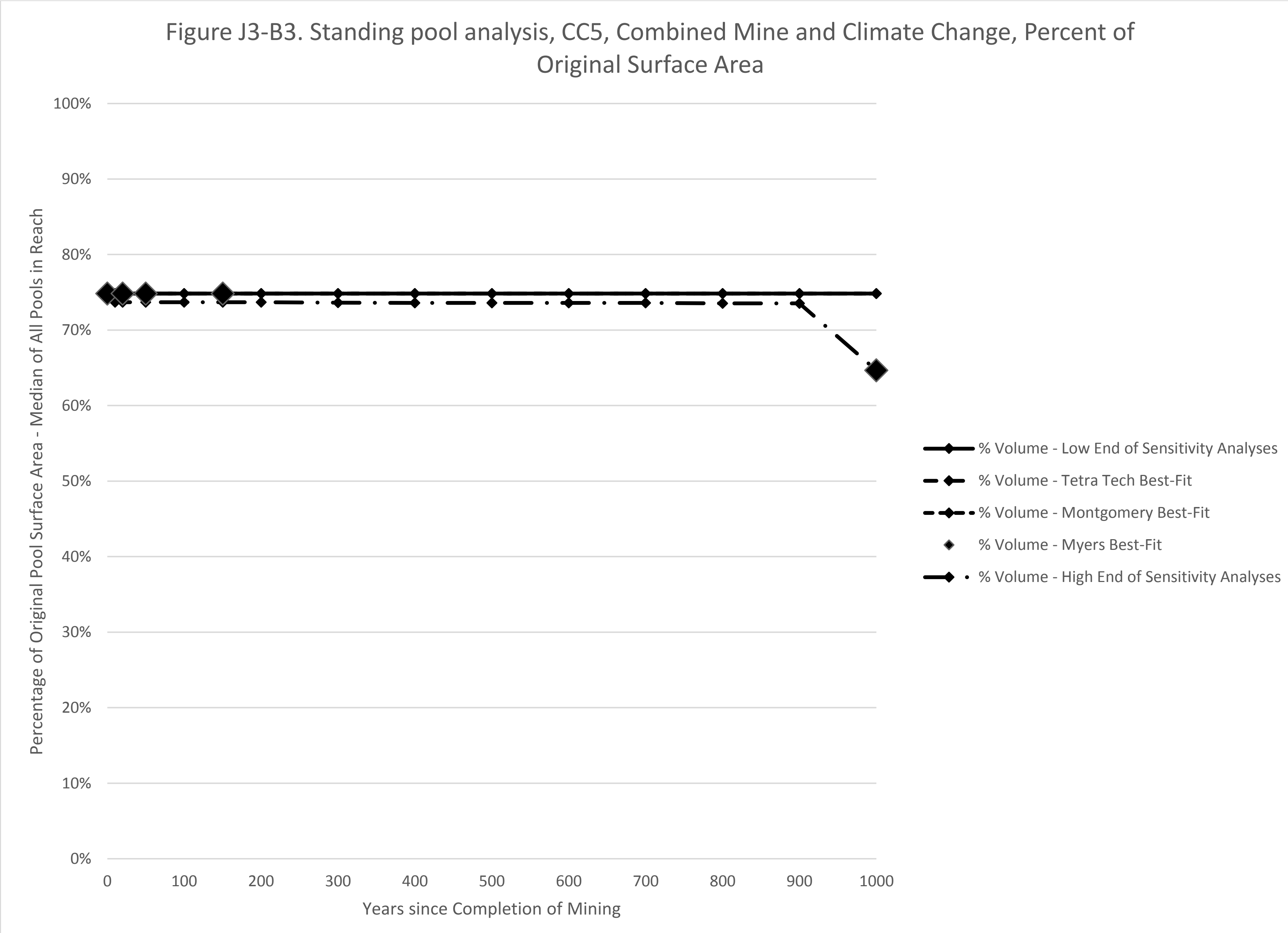

Figure J3-B3. Standing pool analysis, CC5, Combined Mine and Climate Change, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of All Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

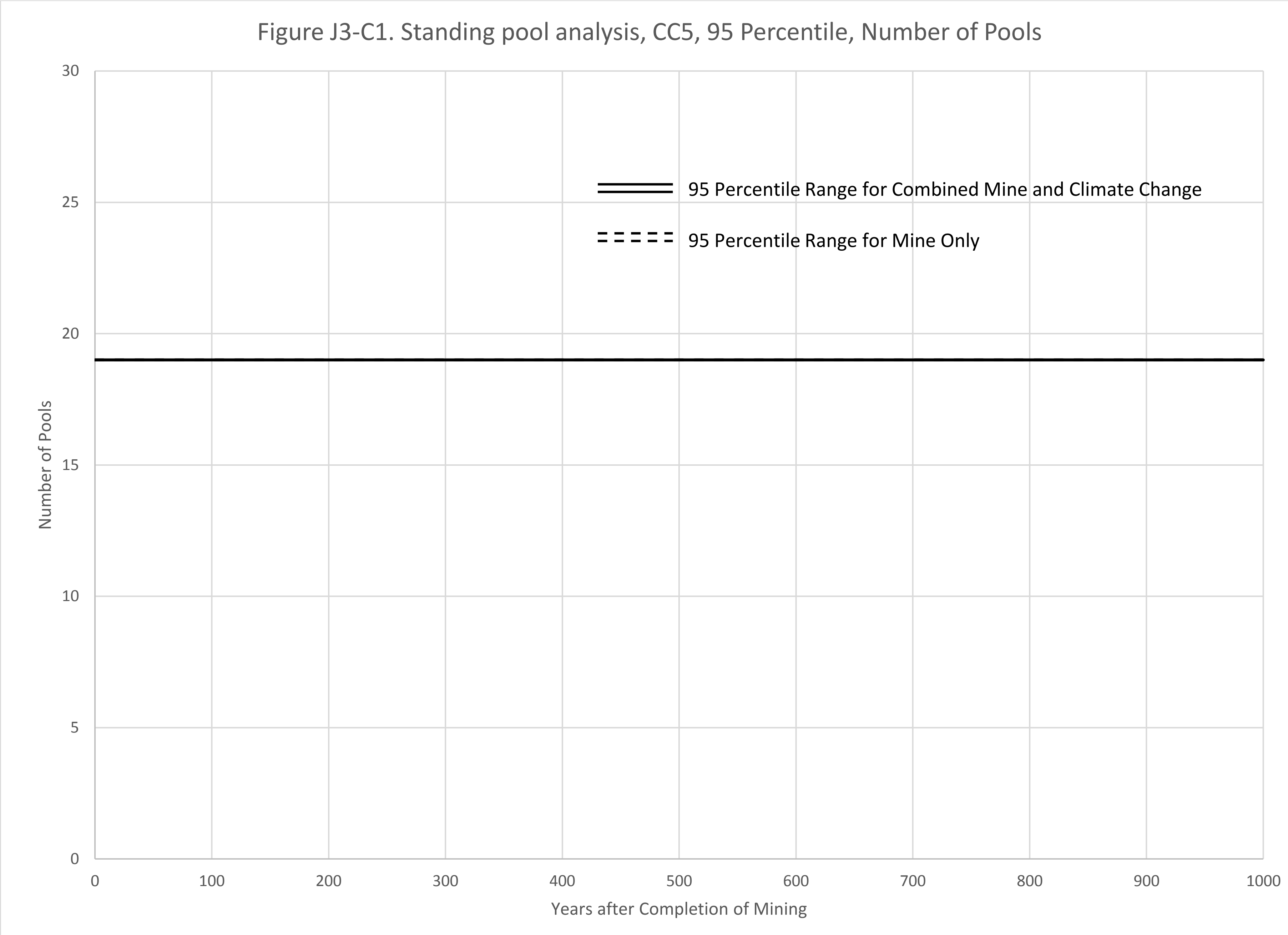
Figure J3-C1. Standing pool analysis, CC5, 95 Percentile, Number of Pools
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Number of Pools
0
5
10
15
20
25
30
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

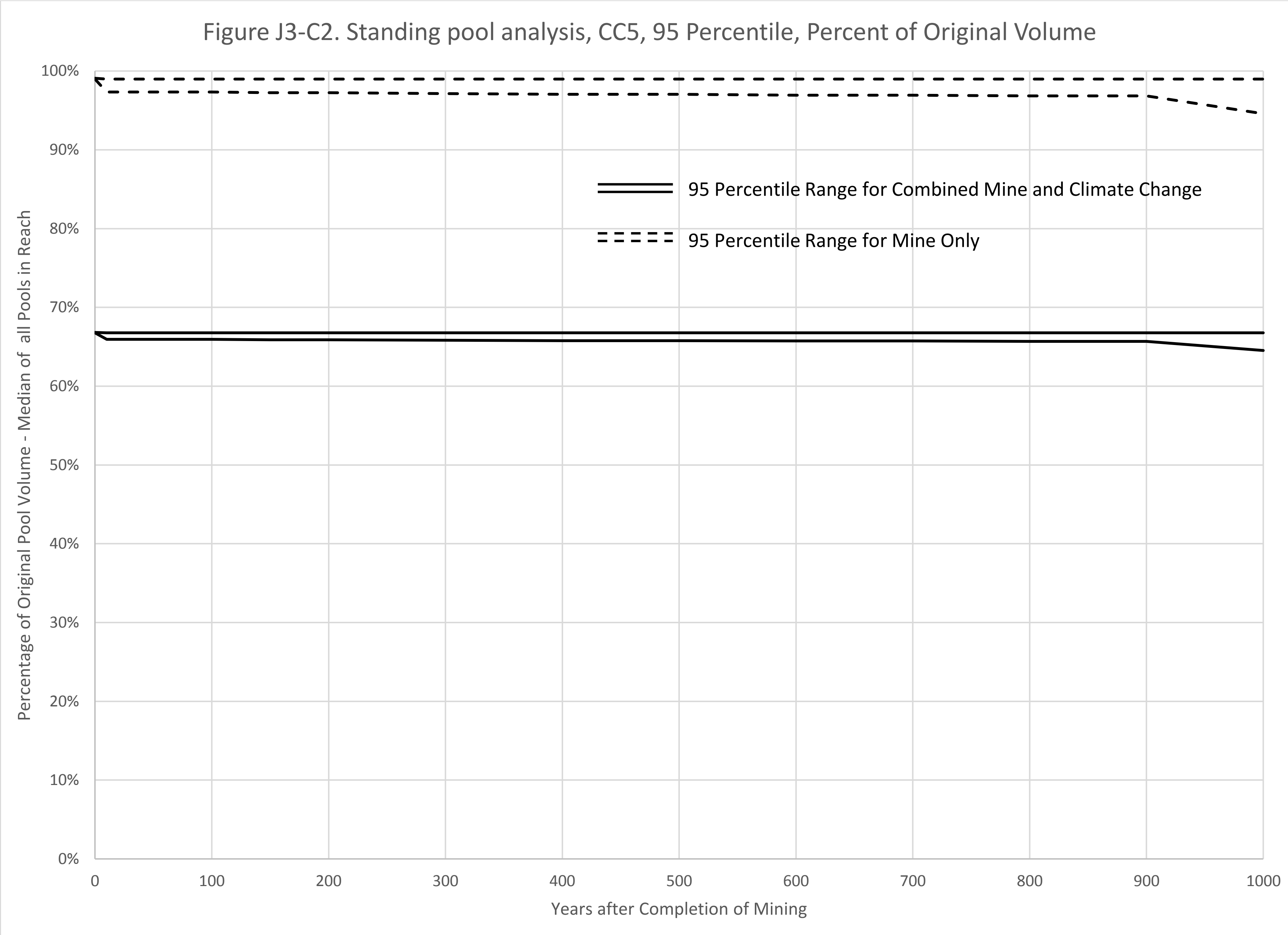
Figure J3-C2. Standing pool analysis, CC5, 95 Percentile, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of all Pools in Reach
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

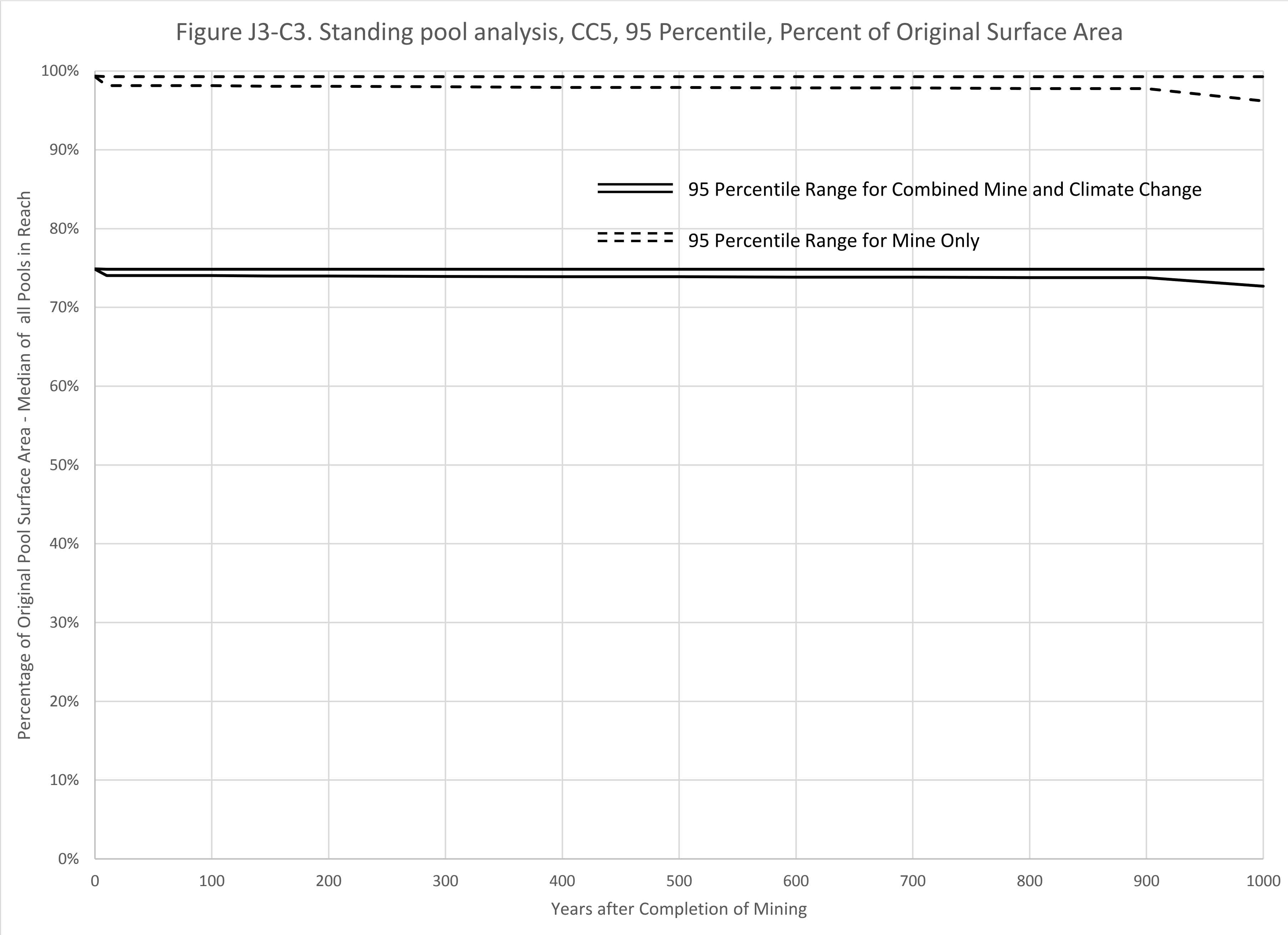
Figure J3-C3. Standing pool analysis, CC5, 95 Percentile, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of all Pools in Reach
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
0
100
200
300
400
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600
700
800
900
1000
Years after Completion of Mining

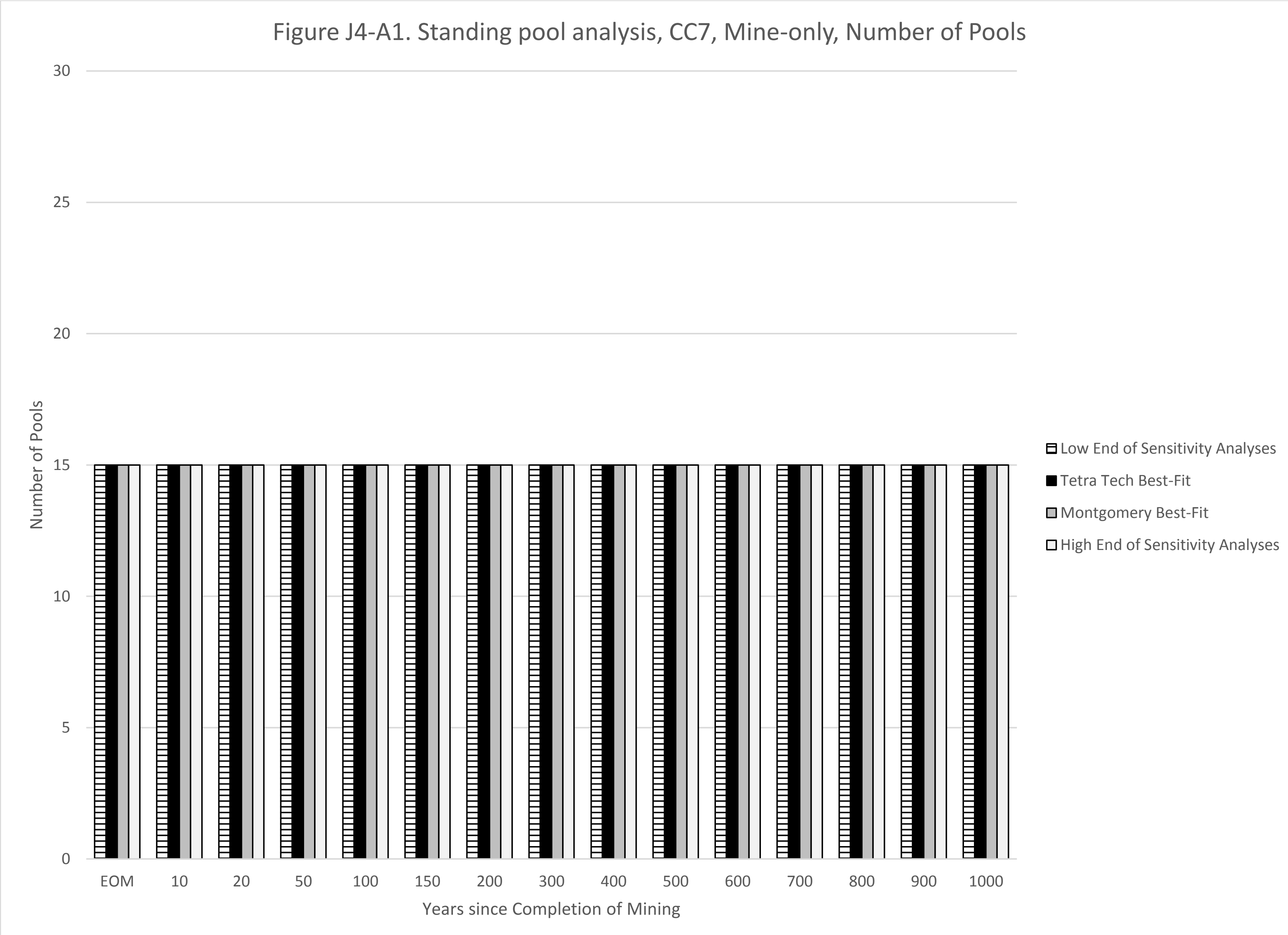
Figure J4-A1. Standing pool analysis, CC7, Mine-only, Number of Pools
30
25
20
15
10
5
0
Number of Pools
EOM
10
20
50
100
150
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
High End of Sensitivity Analyses

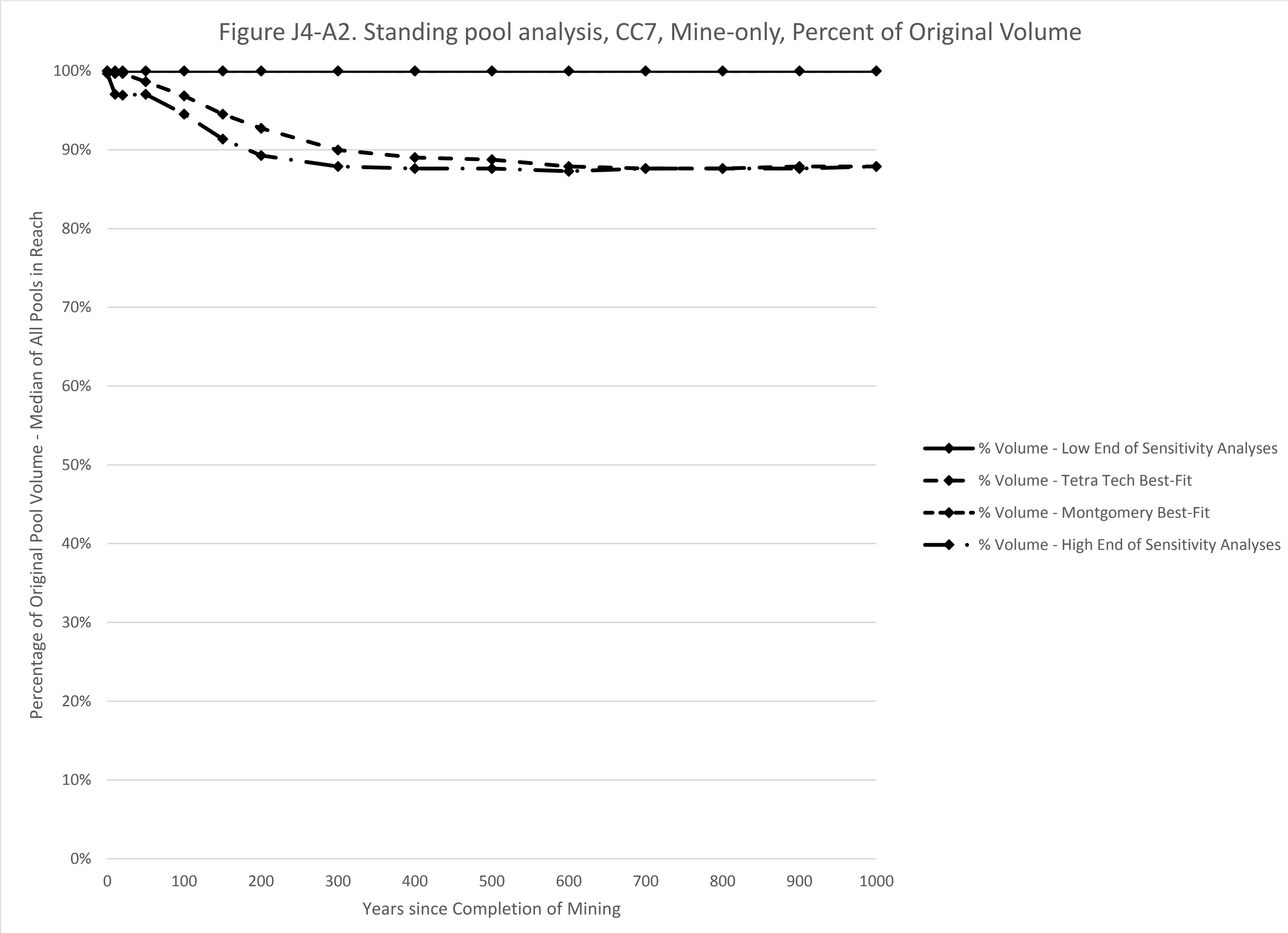
Figure J4-A2. Standing pool analysis, CC7, Mine-only, Percent of Original Volume
Percentage of Original Pool Volume - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
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900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

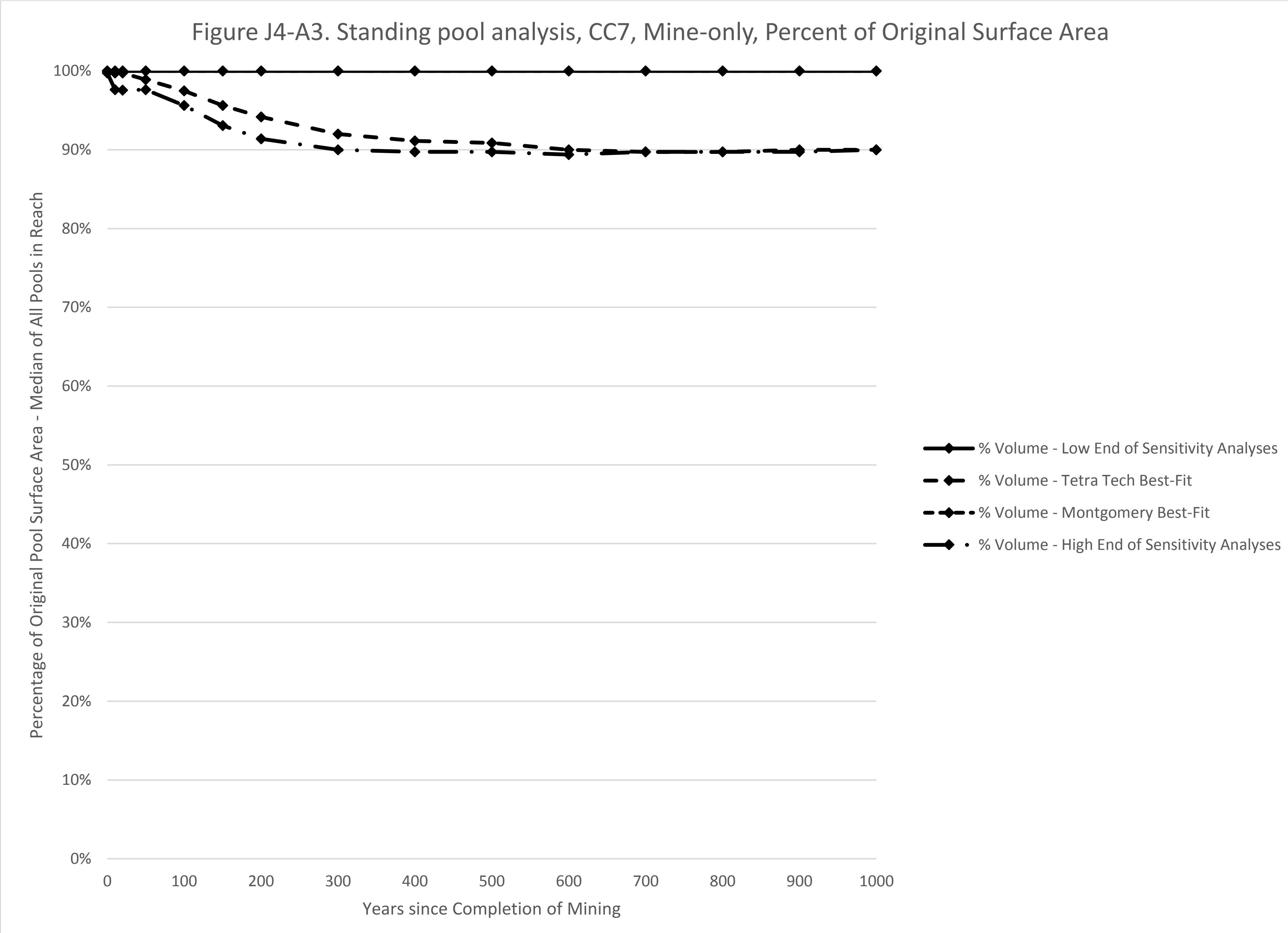

Figure J4-A3. Standing pool analysis, CC7, Mine-only, Percent of Original Surface Area
Percentage of Original Pool Surface Area - Median of All Pools in Reach
100%
90%
80%
70%
60%
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40%
30%
20%
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100
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300
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700
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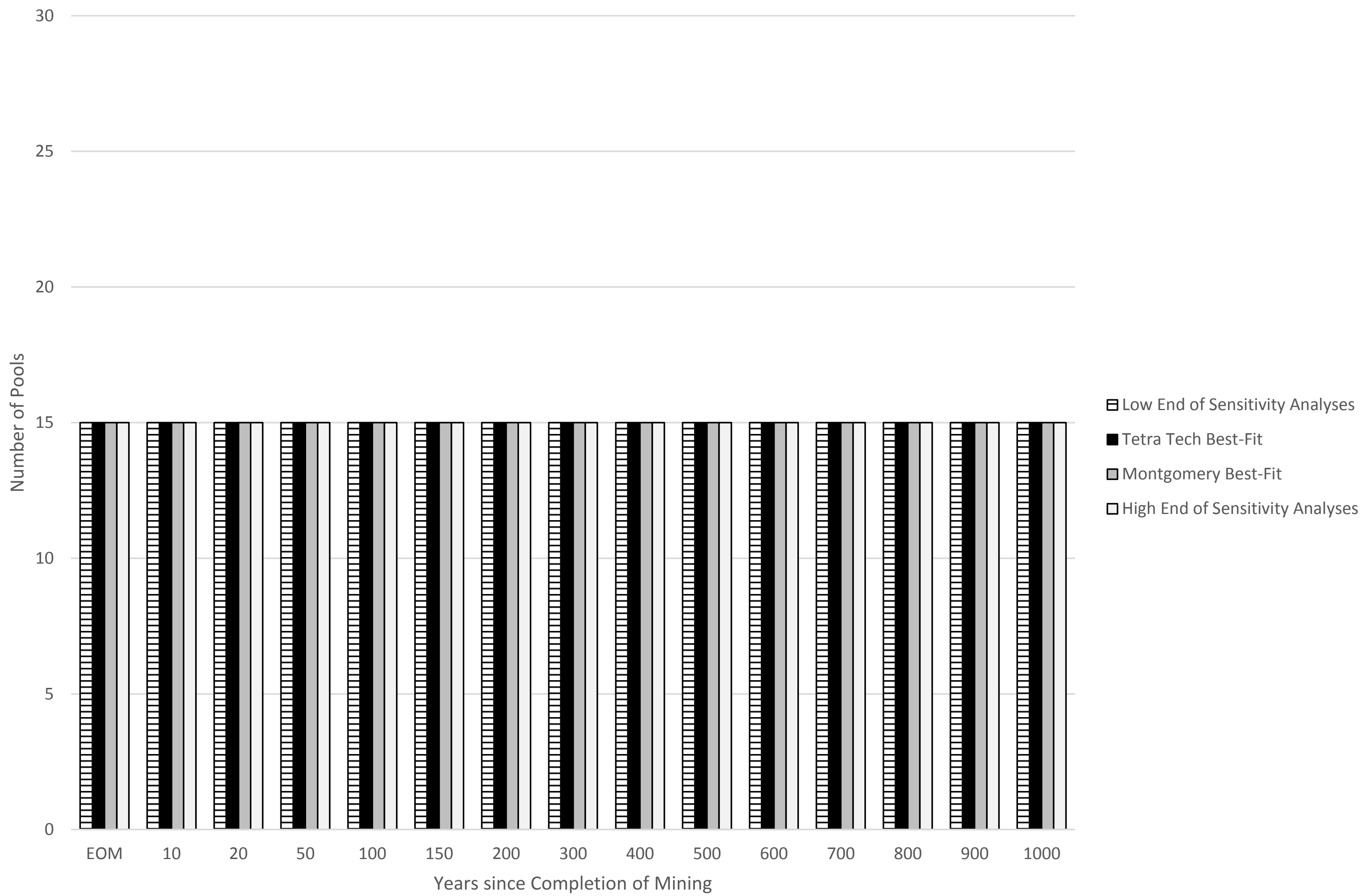
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

Figure J4-B1. Standing pool analysis, CC7, Combined Mine and Climate Change, Number of Pools



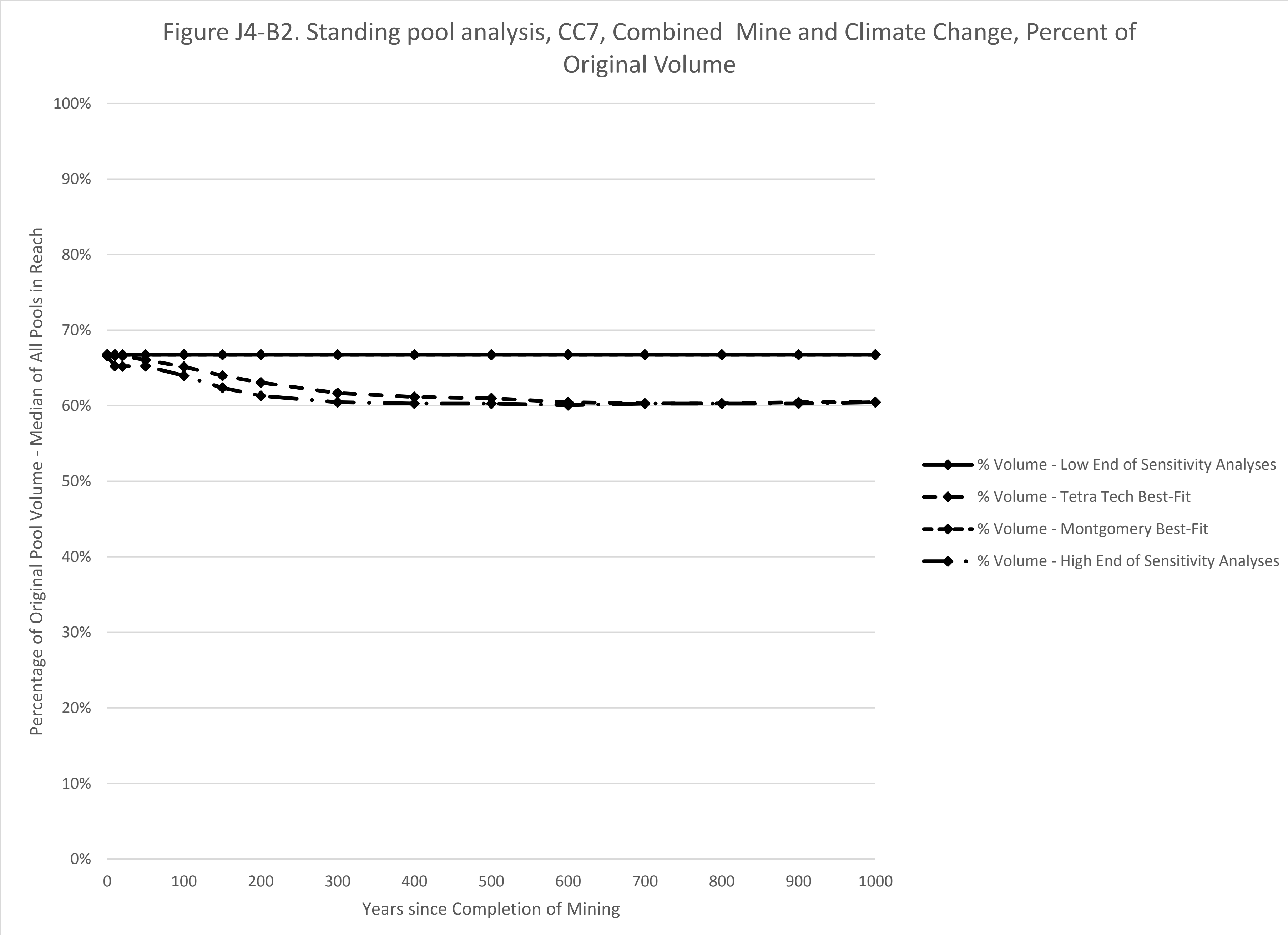


Figure J4-B2. Standing pool analysis, CC7, Combined Mine and Climate Change, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of All Pools in Reach
0
100
200
300
400
500
600
700
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900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

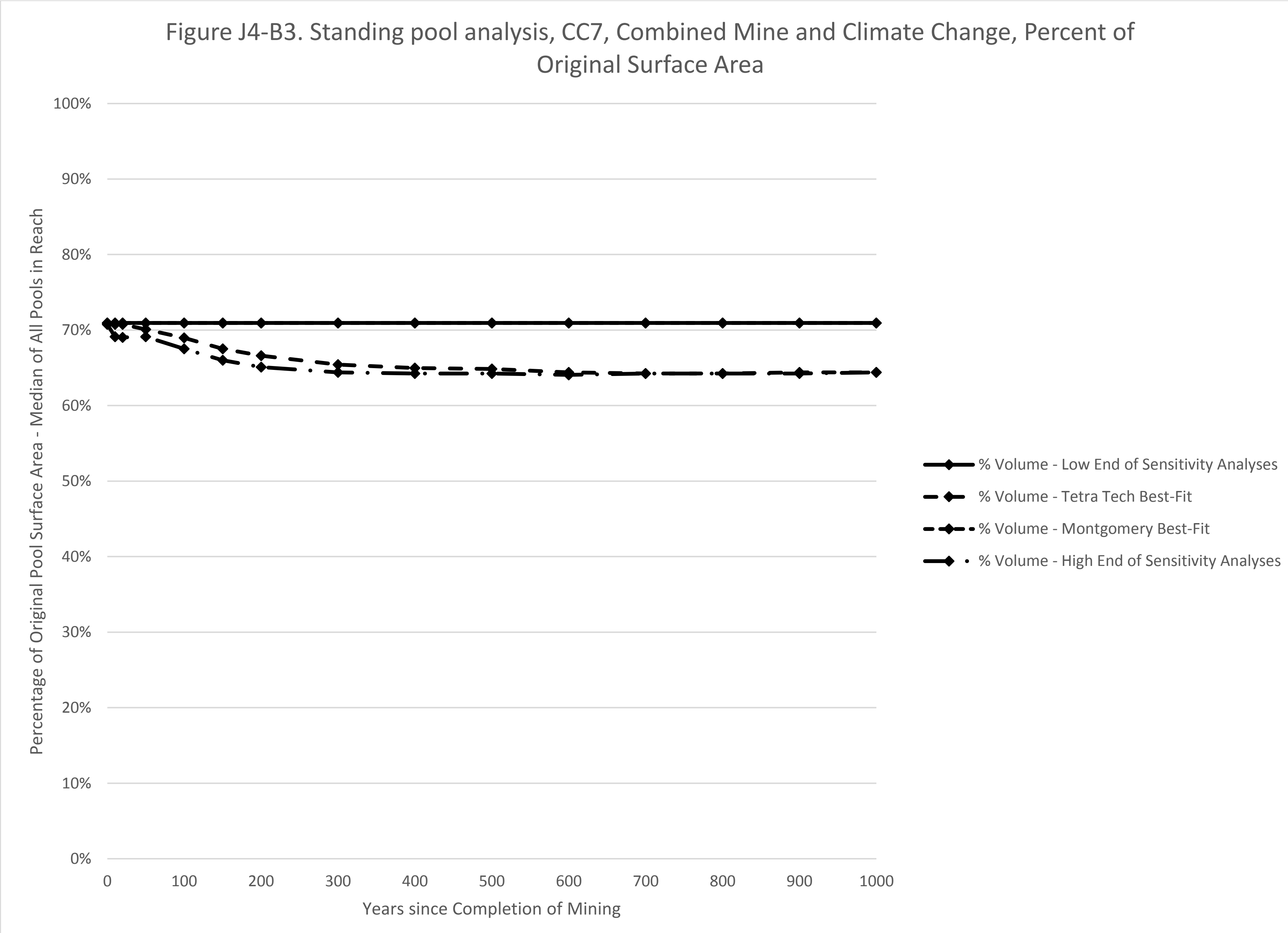
Figure J4-B3. Standing pool analysis, CC7, Combined Mine and Climate Change, Percent of Original Surface Area
Percentage of Original Pool Surface Area - Median of All Pools in Reach
100%
90%
80%
70%
60%
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30%
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Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

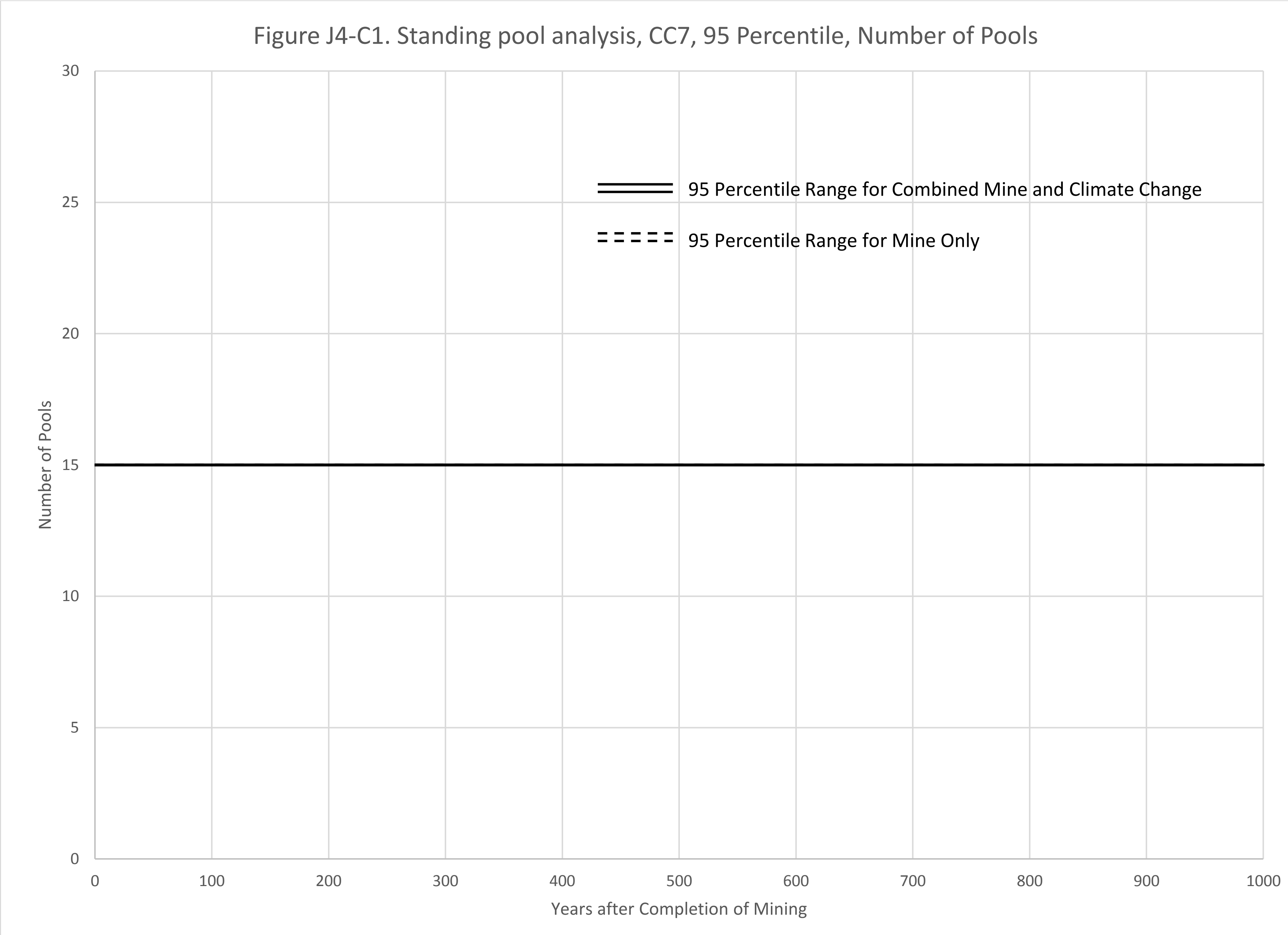
Figure J4-C1. Standing pool analysis, CC7, 95 Percentile, Number of Pools
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Number of Pools
Years after Completion of Mining
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5
10
15
20
25
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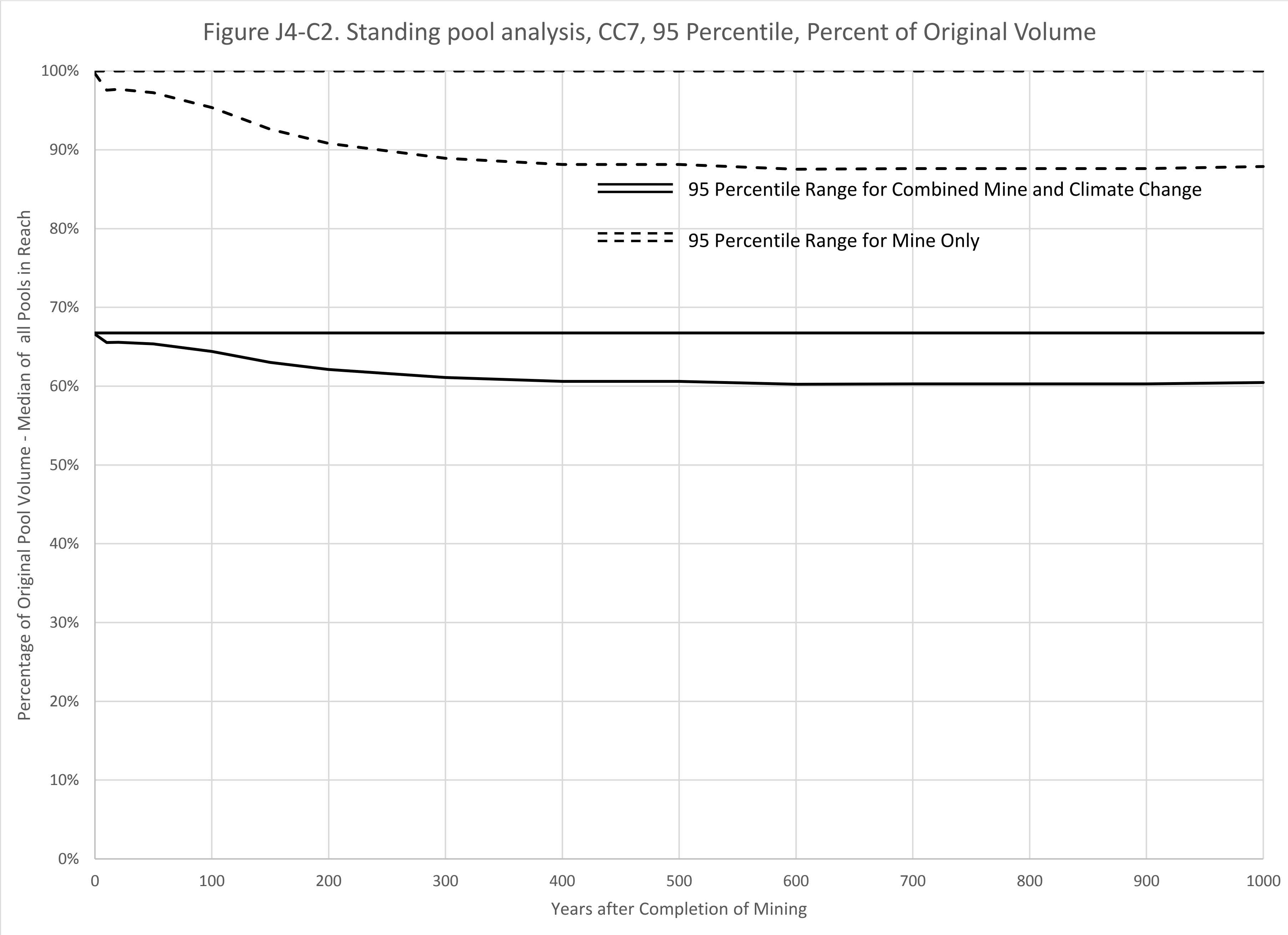
Figure J4-C2. Standing pool analysis, CC7, 95 Percentile, Percent of Original Volume
100%
90%
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70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of all Pools in Reach
0
100
200
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900
1000
Years after Completion of Mining
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only

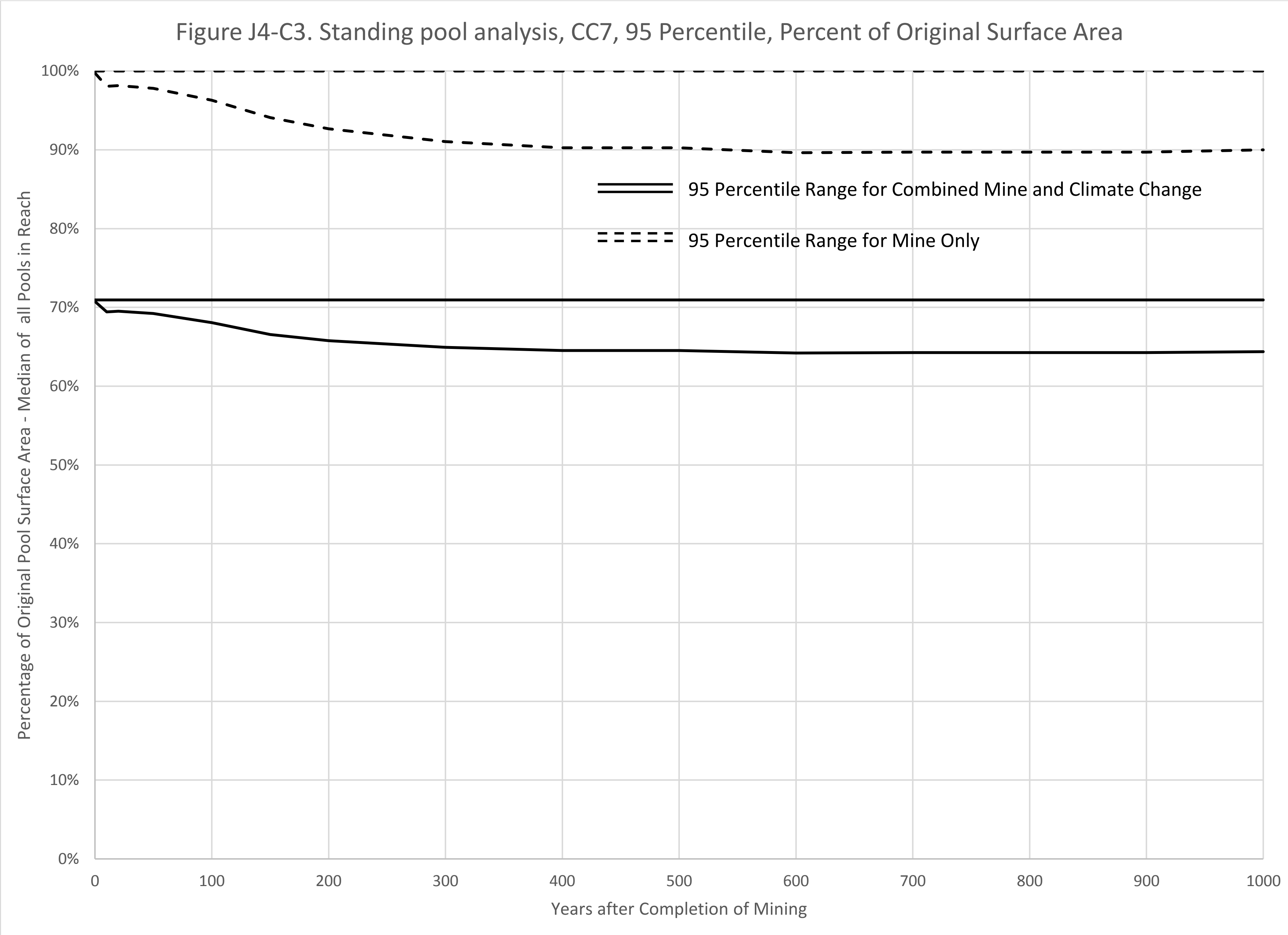


Figure J4-C3. Standing pool analysis, CC7, 95 Percentile, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of all Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only

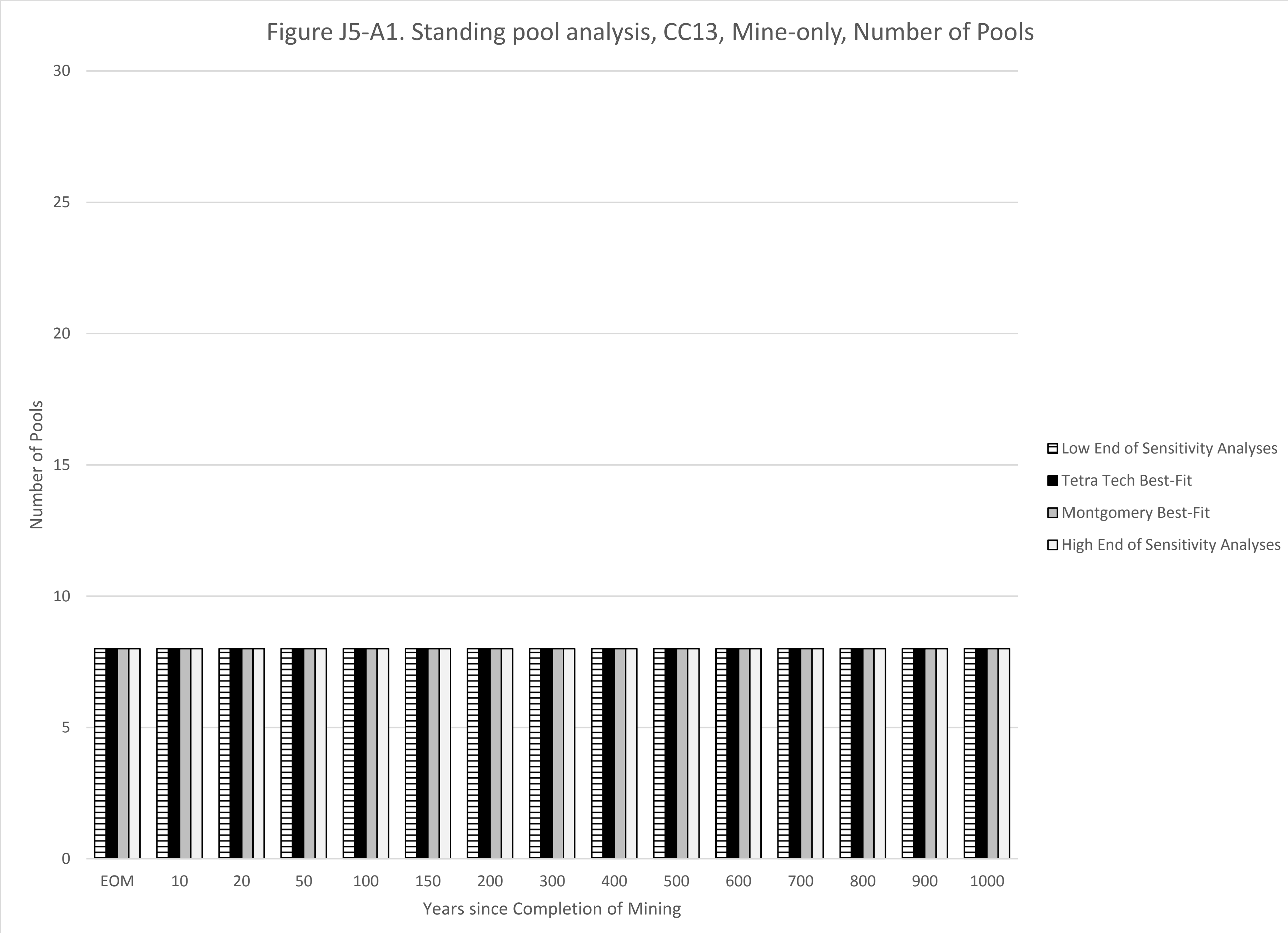


Figure J5-A1. Standing pool analysis, CC13, Mine-only, Number of Pools
30
25
20
15
10
5
0
Number of Pools
EOM
10
20
50
100
150
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
High End of Sensitivity Analyses

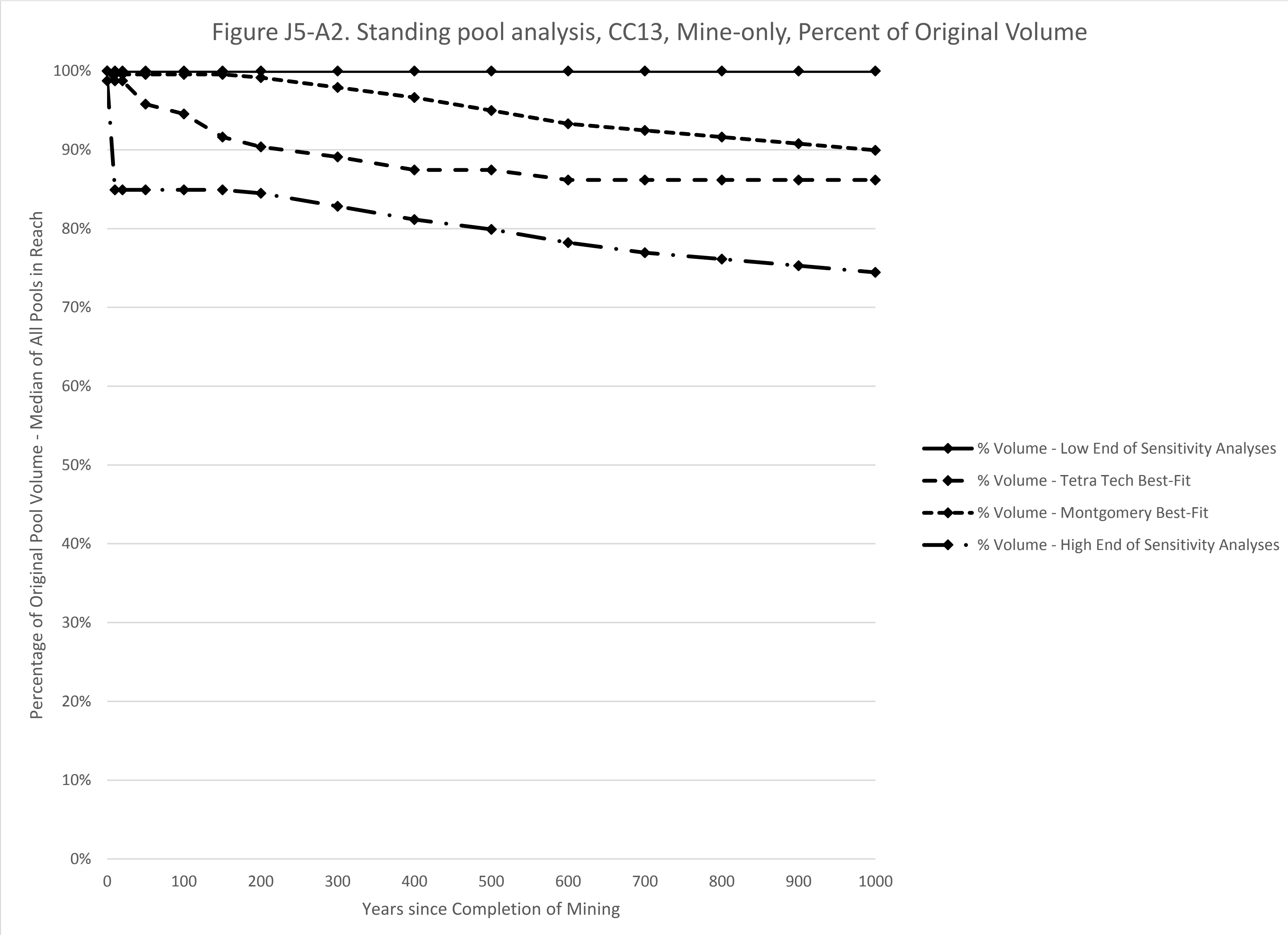


Figure J5-A2. Standing pool analysis, CC13, Mine-only, Percent of Original Volume
Percentage of Original Pool Volume - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

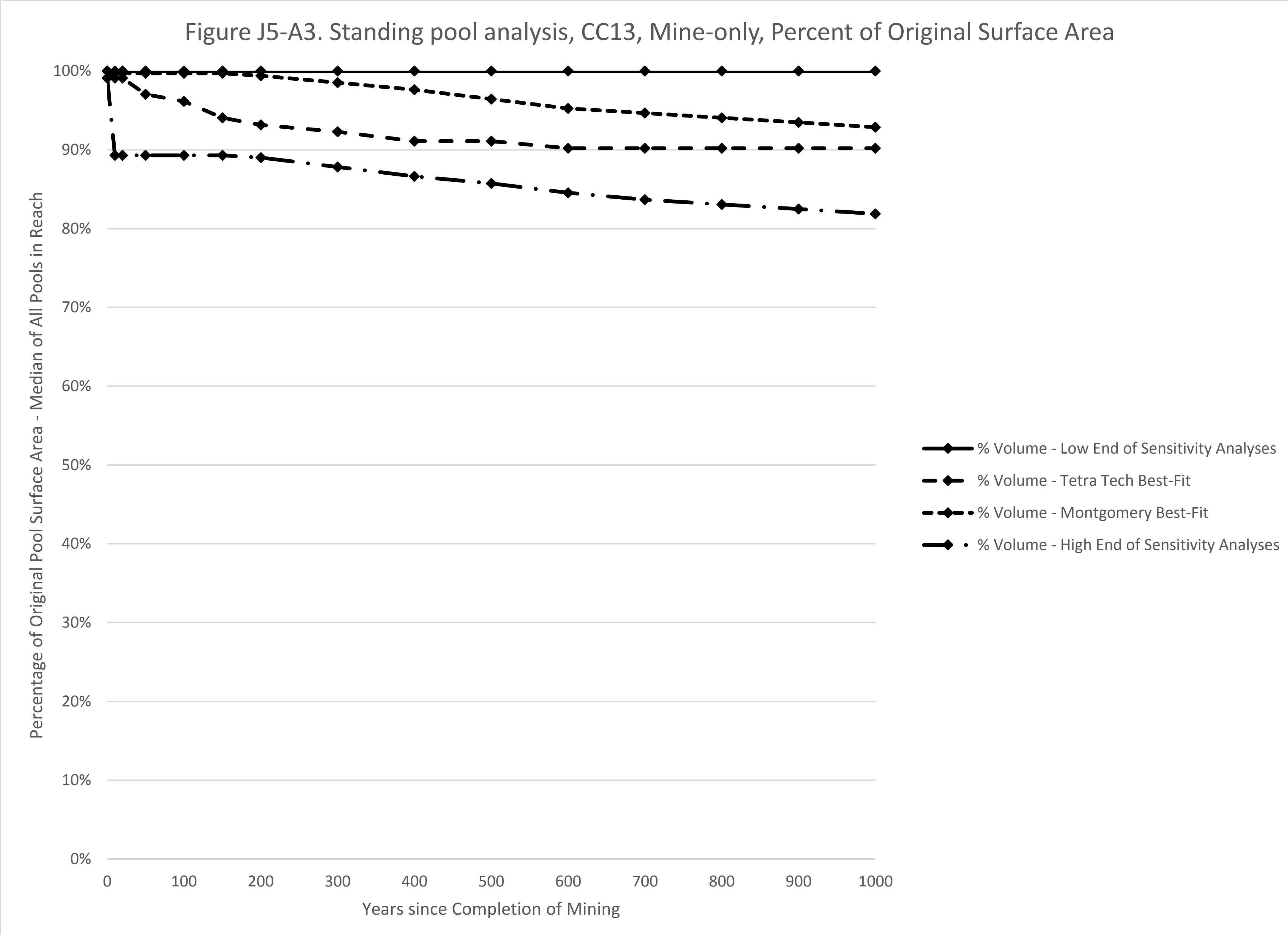


Figure J5-A3. Standing pool analysis, CC13, Mine-only, Percent of Original Surface Area
Percentage of Original Pool Surface Area - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

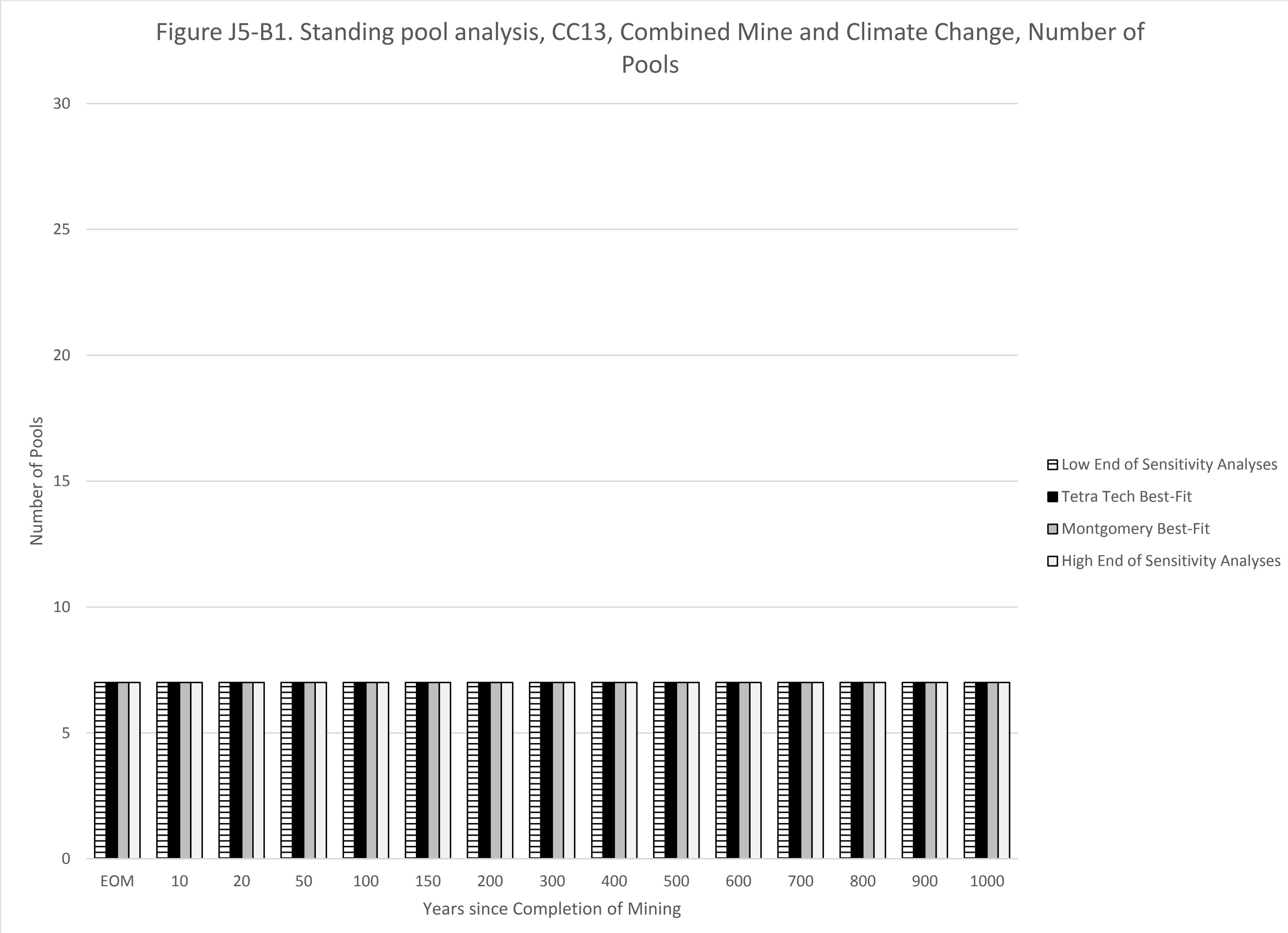
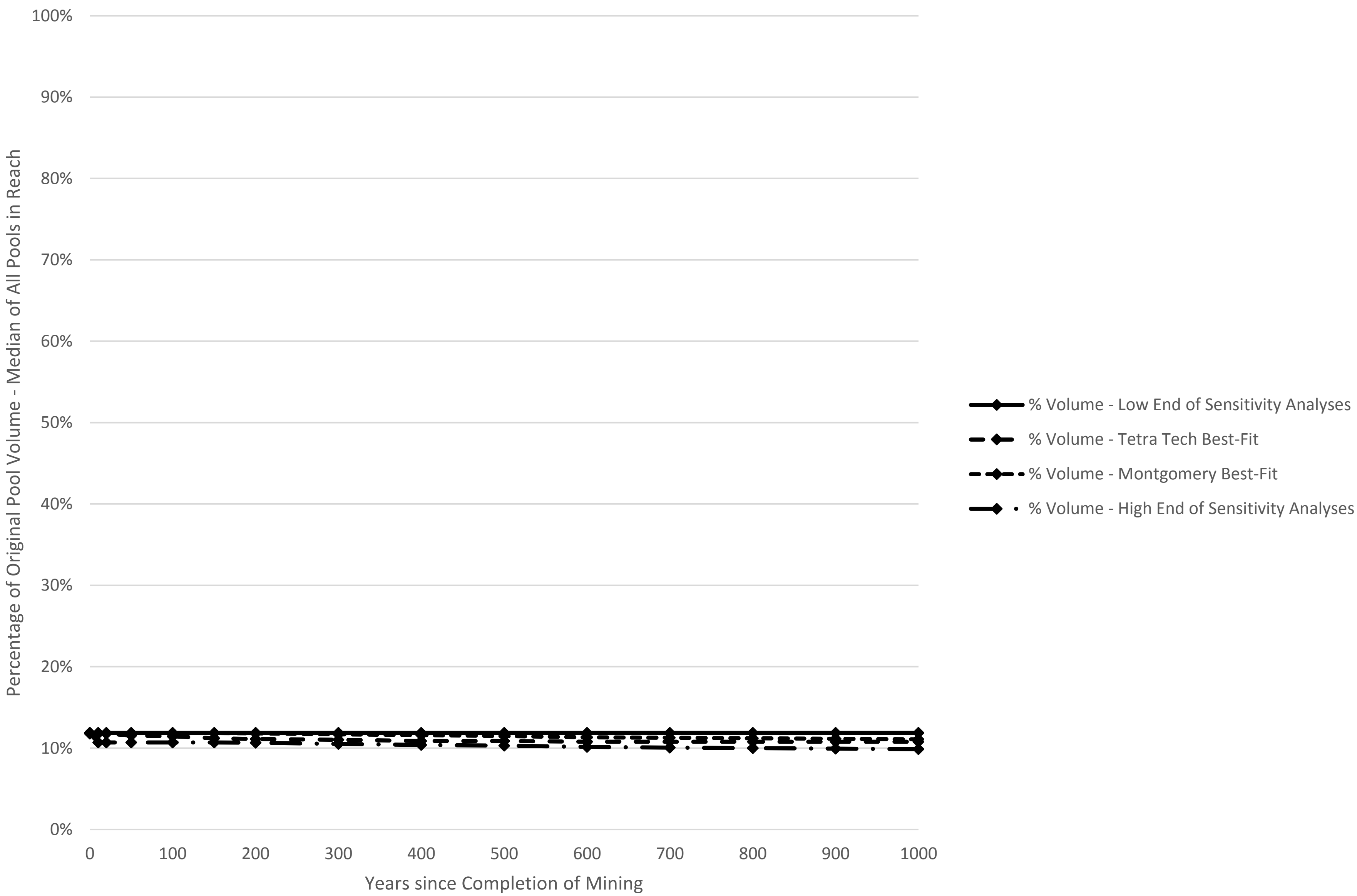


Figure J5-B1. Standing pool analysis, CC13, Combined Mine and Climate Change, Number of Pools
30
25
20
15
10
5
0
Number of Pools
EOM
10
20
50
100
150
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
High End of Sensitivity Analyses

Figure J5-B2. Standing pool analysis, CC13, Combined Mine and Climate Change, Percent of Original Volume



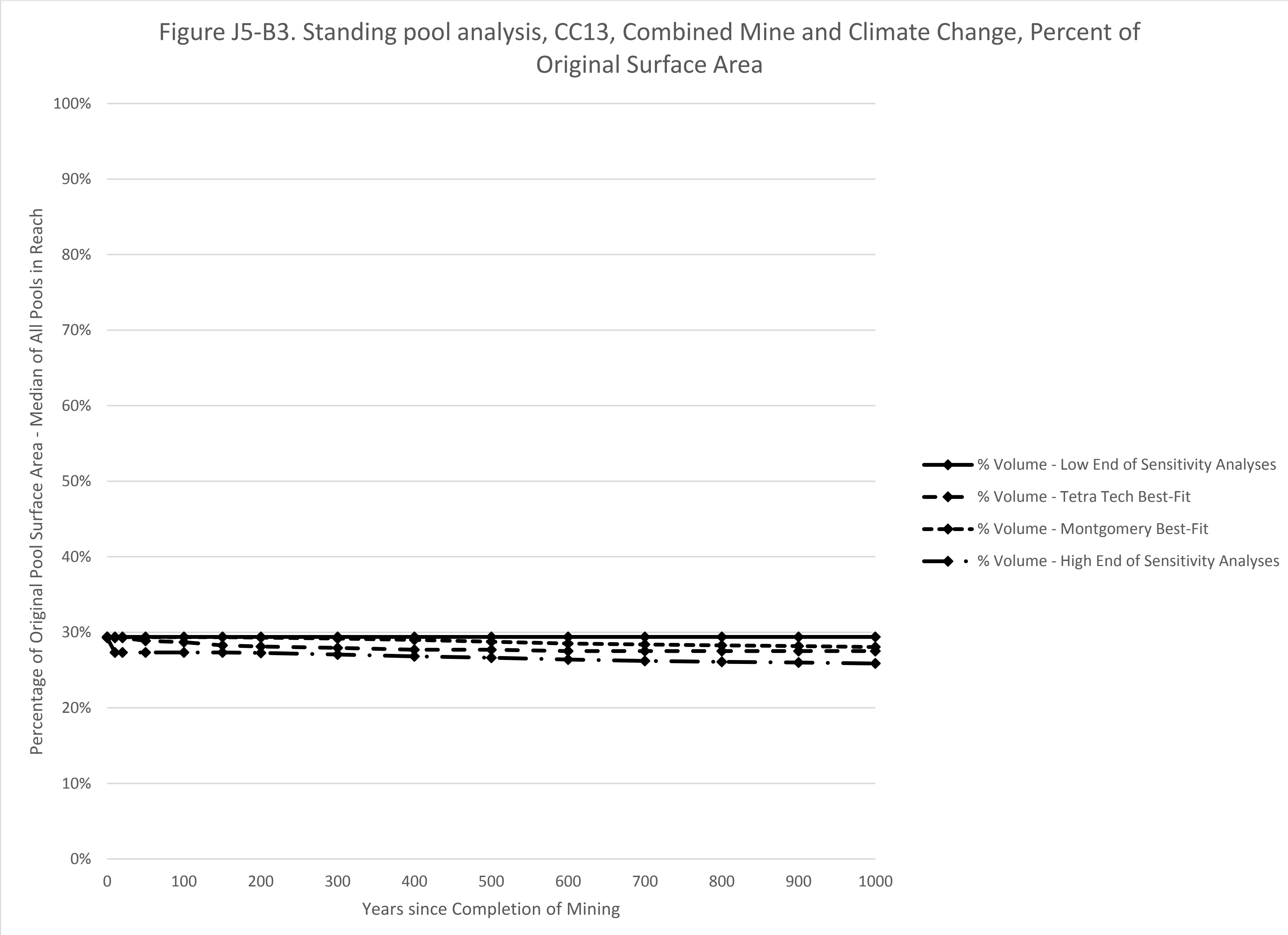


Figure J5-B3. Standing pool analysis, CC13, Combined Mine and Climate Change, Percent of Original Surface Area
Percentage of Original Pool Surface Area - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

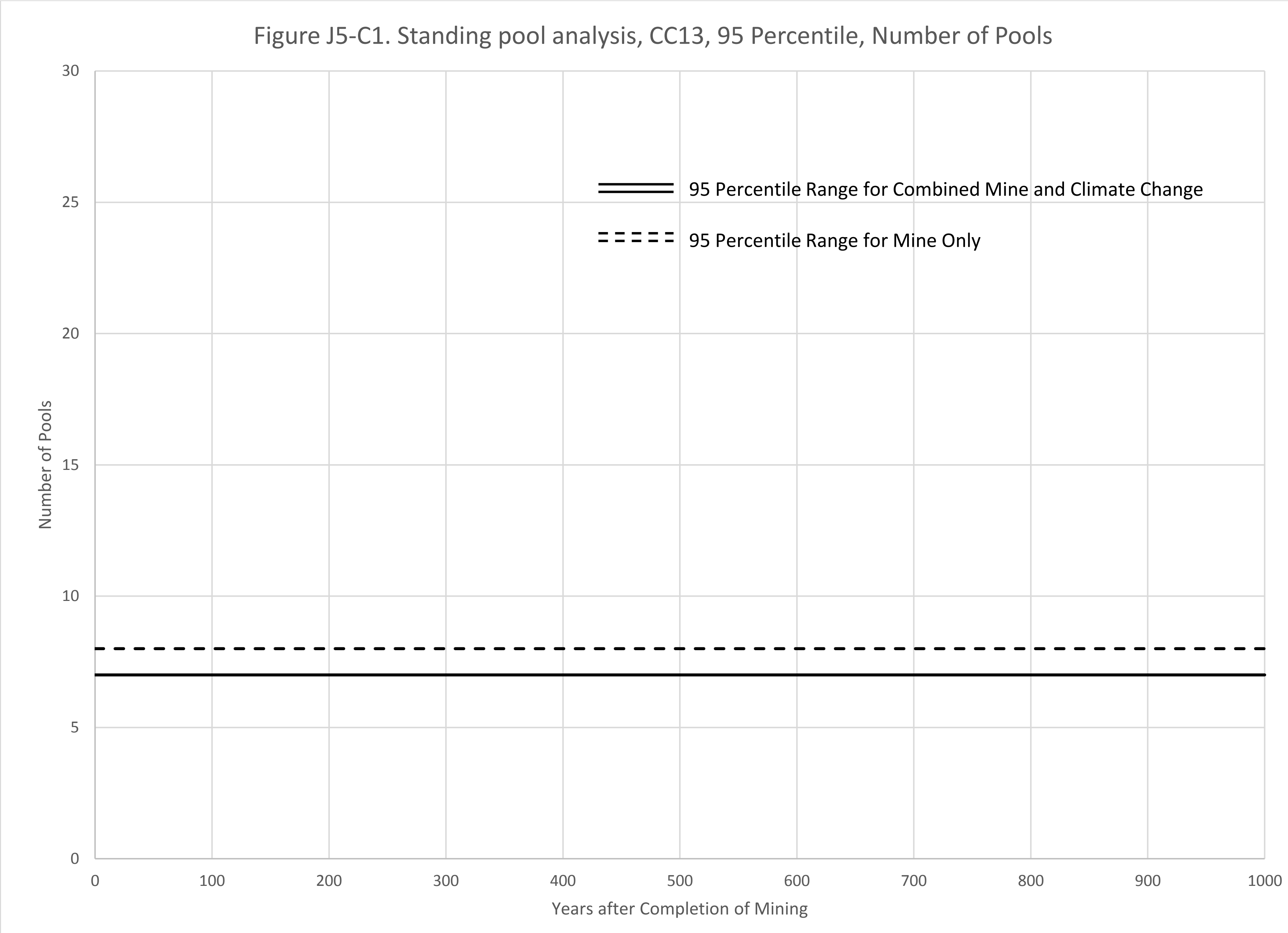


Figure J5-C1. Standing pool analysis, CC13, 95 Percentile, Number of Pools
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Number of Pools
30
25
20
15
10
5
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

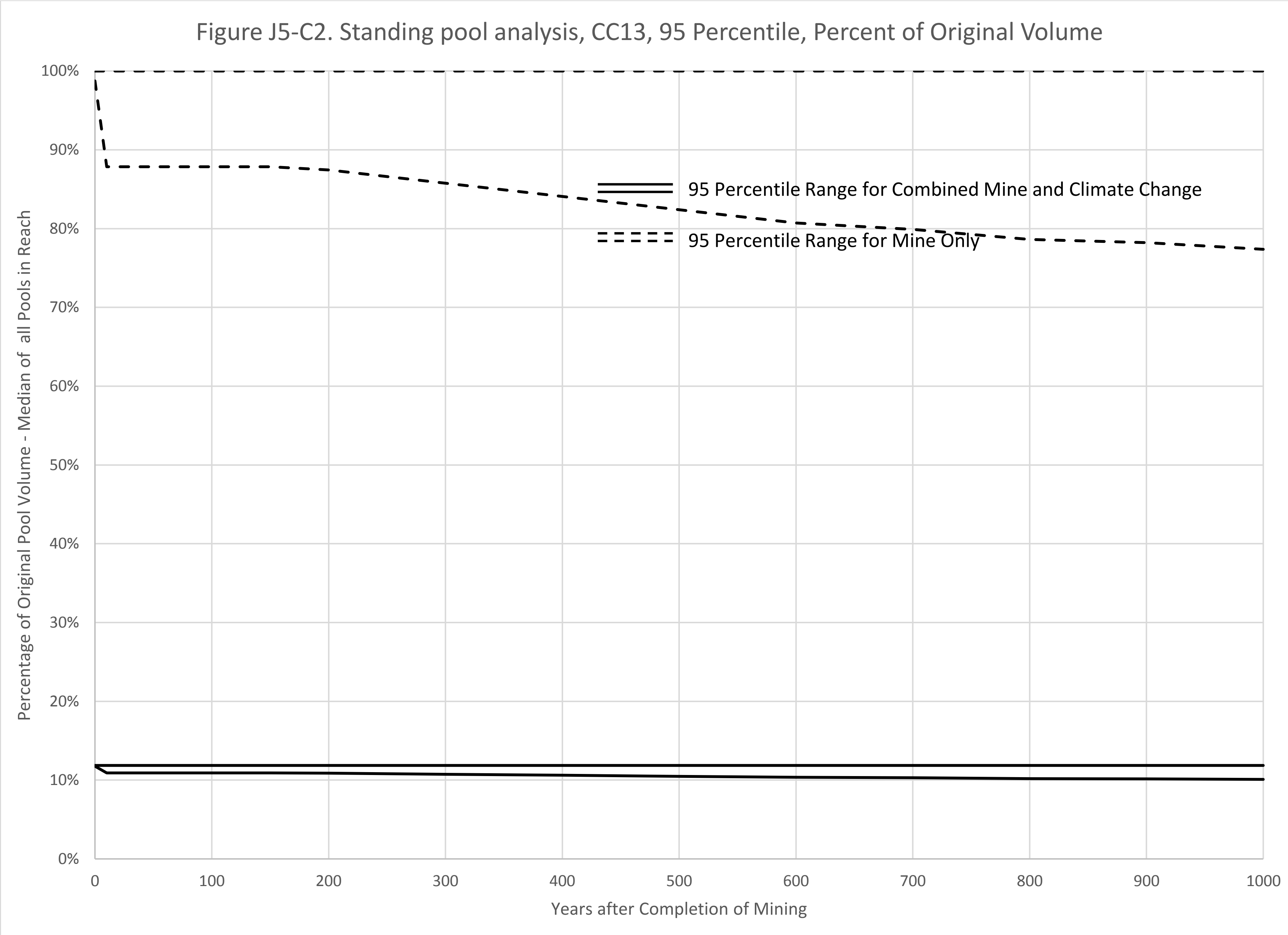


Figure J5-C2. Standing pool analysis, CC13, 95 Percentile, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of all Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only

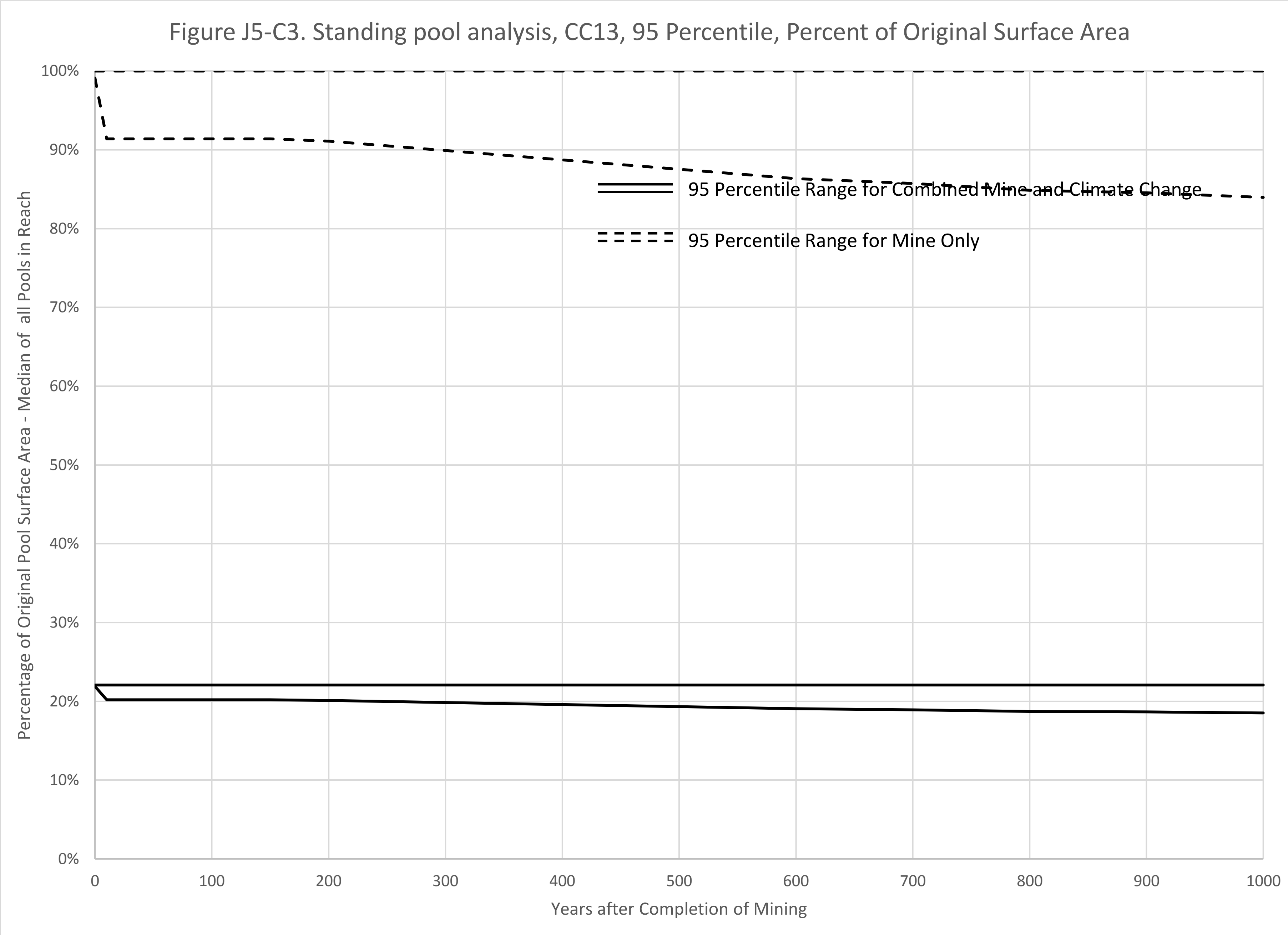


Figure J5-C3. Standing pool analysis, CC13, 95 Percentile, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of all Pools in Reach
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

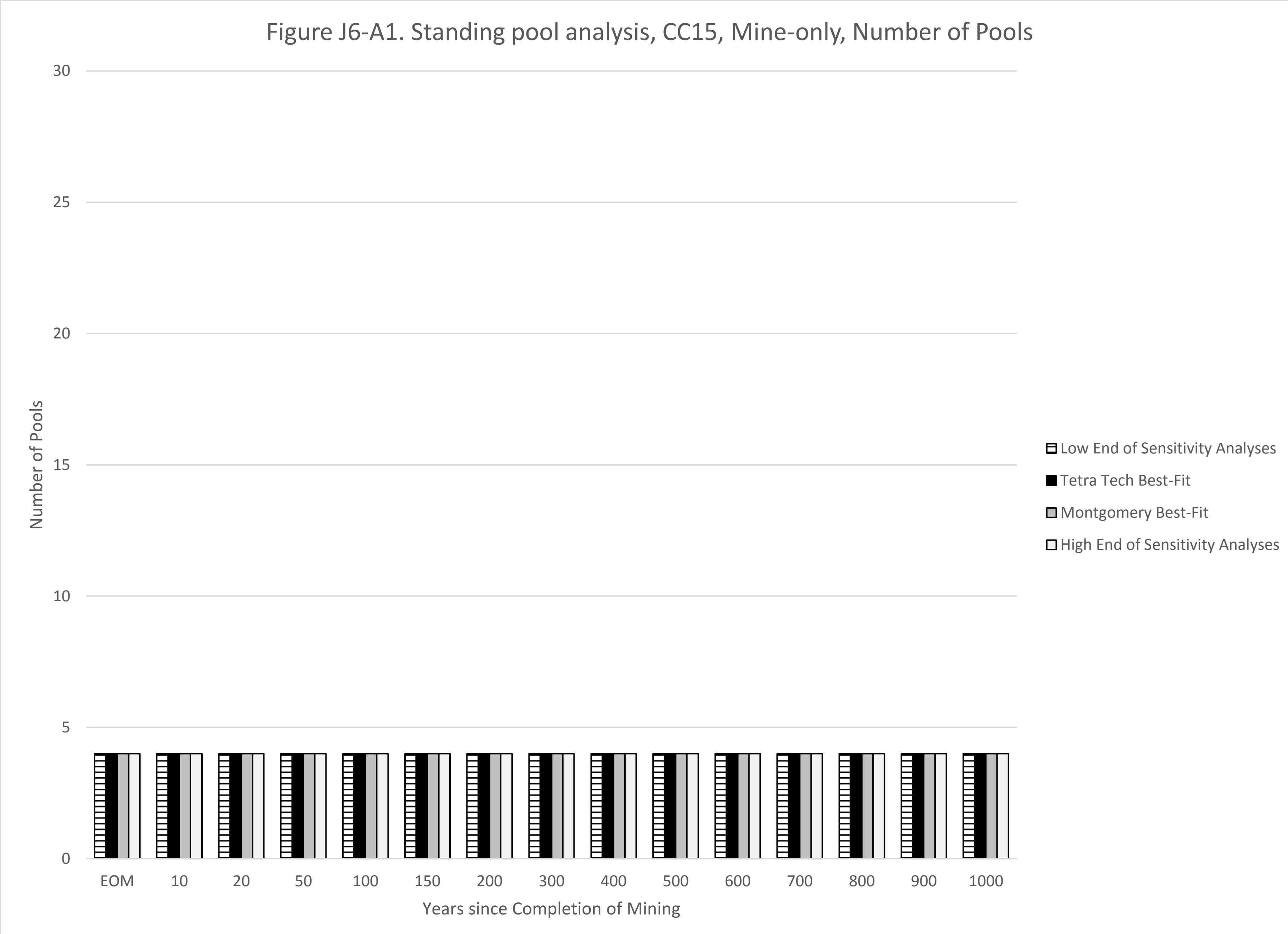


Figure J6-A1. Standing pool analysis, CC15, Mine-only, Number of Pools
30
25
20
15
10
5
0
Number of Pools
EOM
10
20
50
100
150
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
High End of Sensitivity Analyses

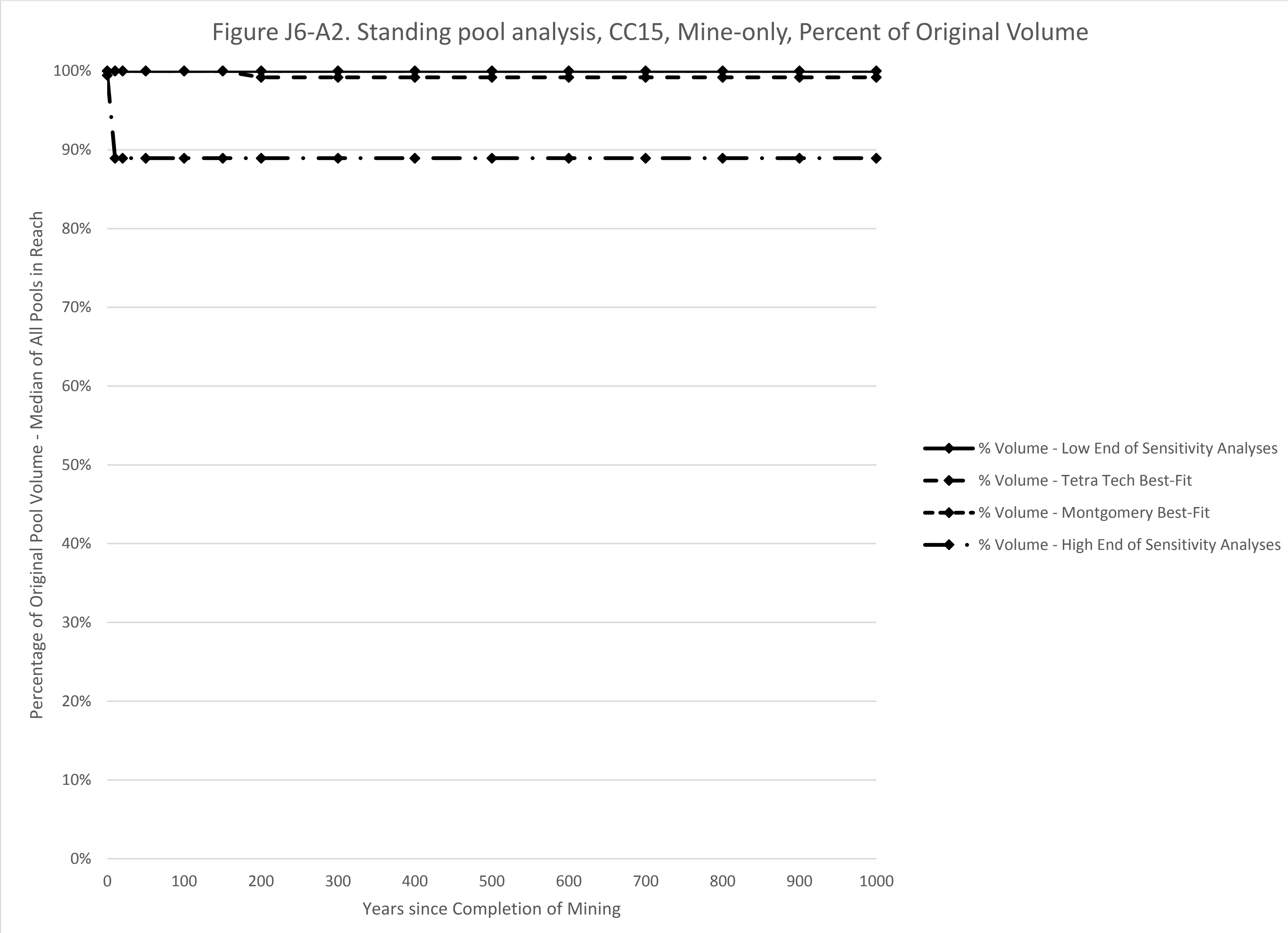


Figure J6-A2. Standing pool analysis, CC15, Mine-only, Percent of Original Volume
Percentage of Original Pool Volume - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

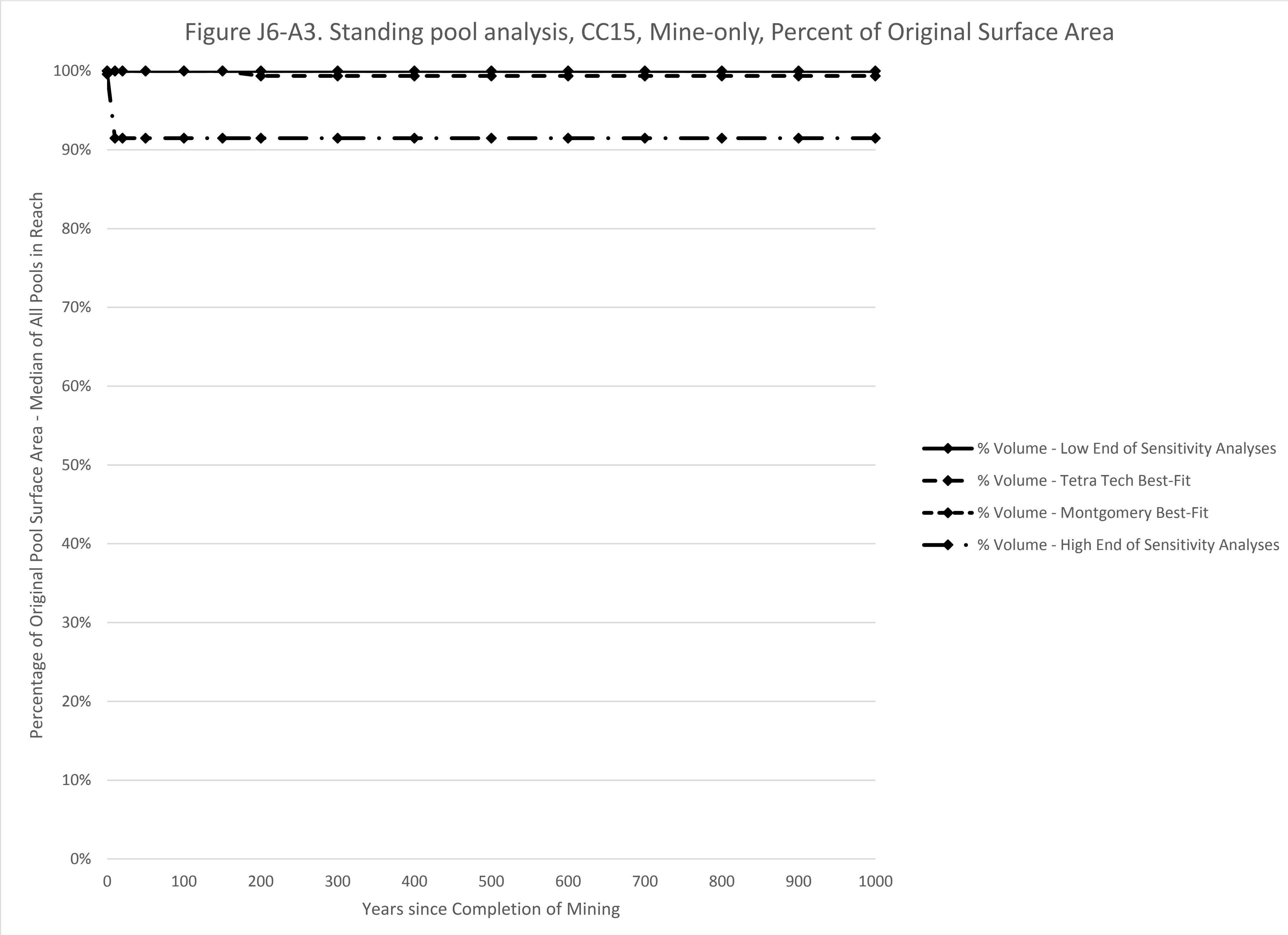


Figure J6-A3. Standing pool analysis, CC15, Mine-only, Percent of Original Surface Area
Percentage of Original Pool Surface Area - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
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Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

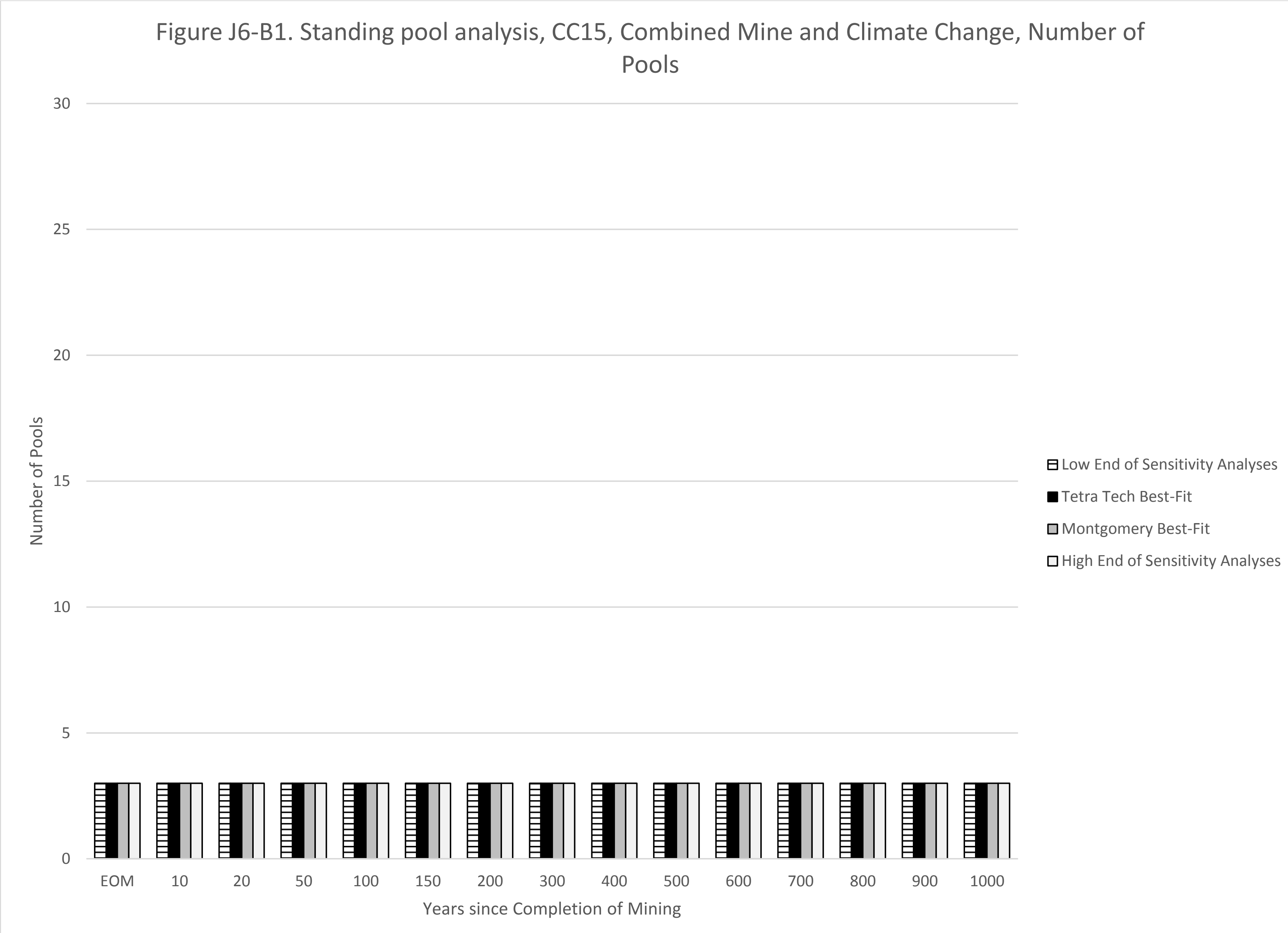
Figure J6-B1. Standing pool analysis, CC15, Combined Mine and Climate Change, Number of Pools
Number of Pools
30
25
20
15
10
5
0
EOM
10
20
50
100
150
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
High End of Sensitivity Analyses

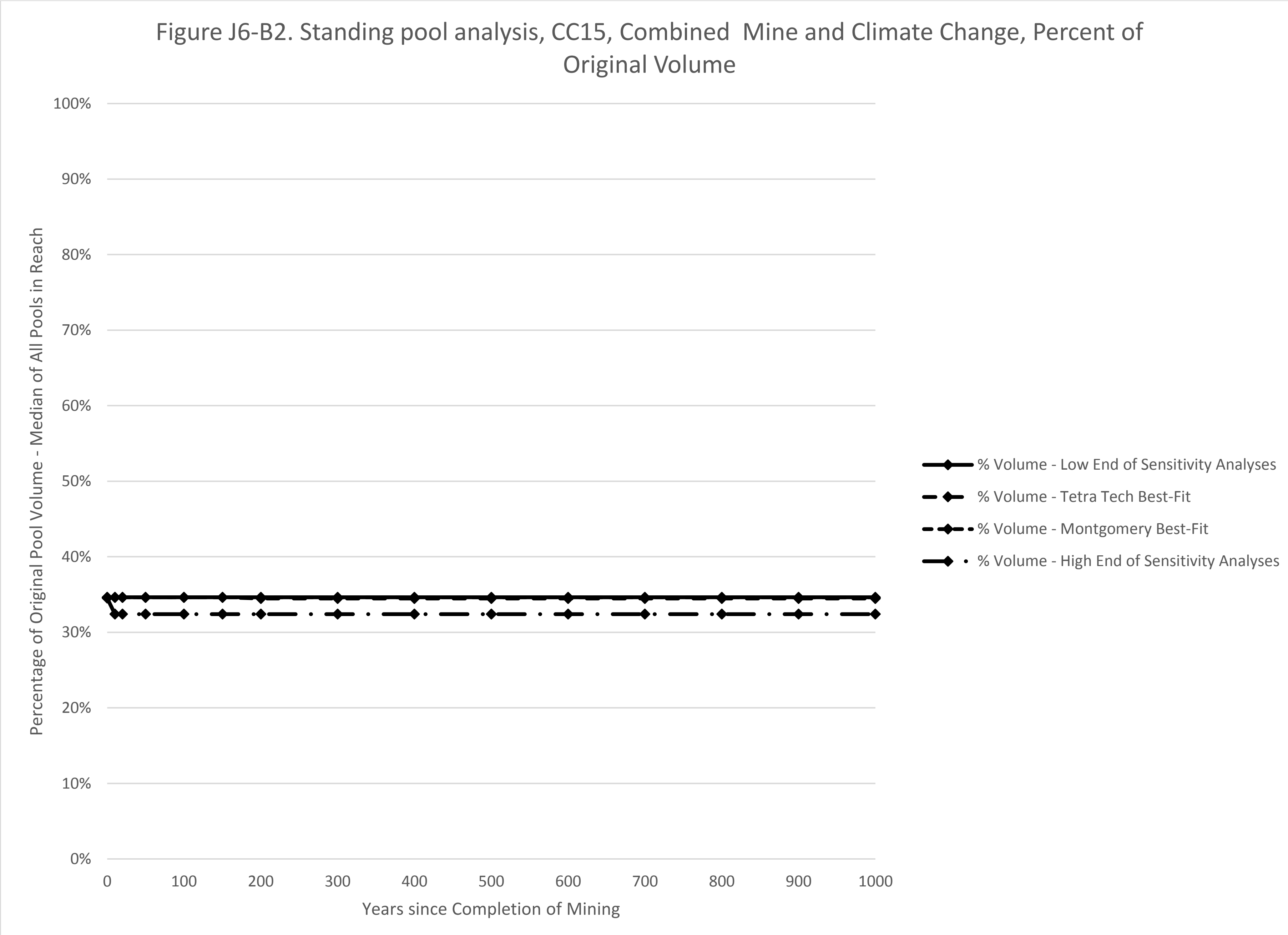
Figure J6-B2. Standing pool analysis, CC15, Combined Mine and Climate Change, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of All Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

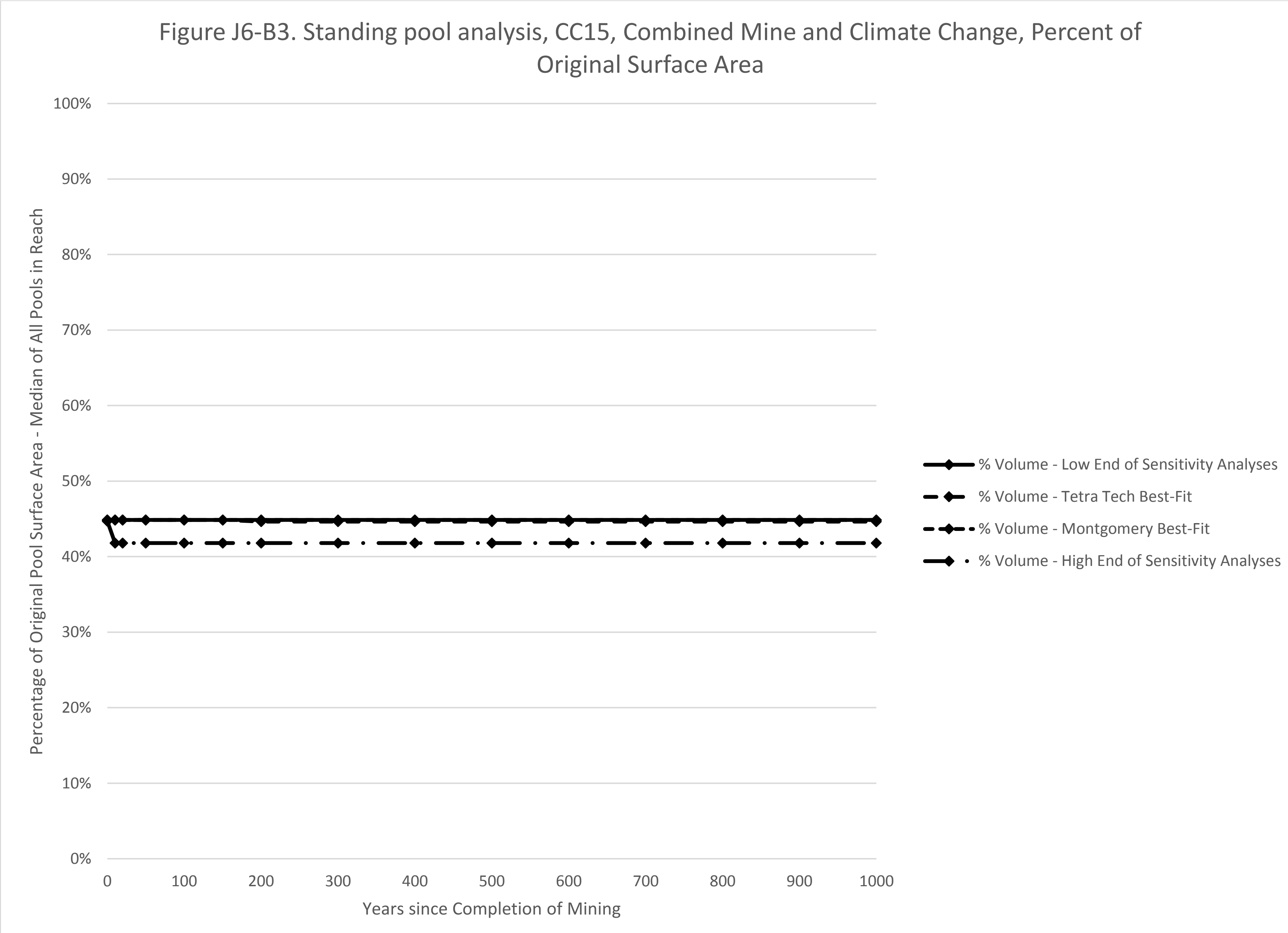

Figure J6-B3. Standing pool analysis, CC15, Combined Mine and Climate Change, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of All Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

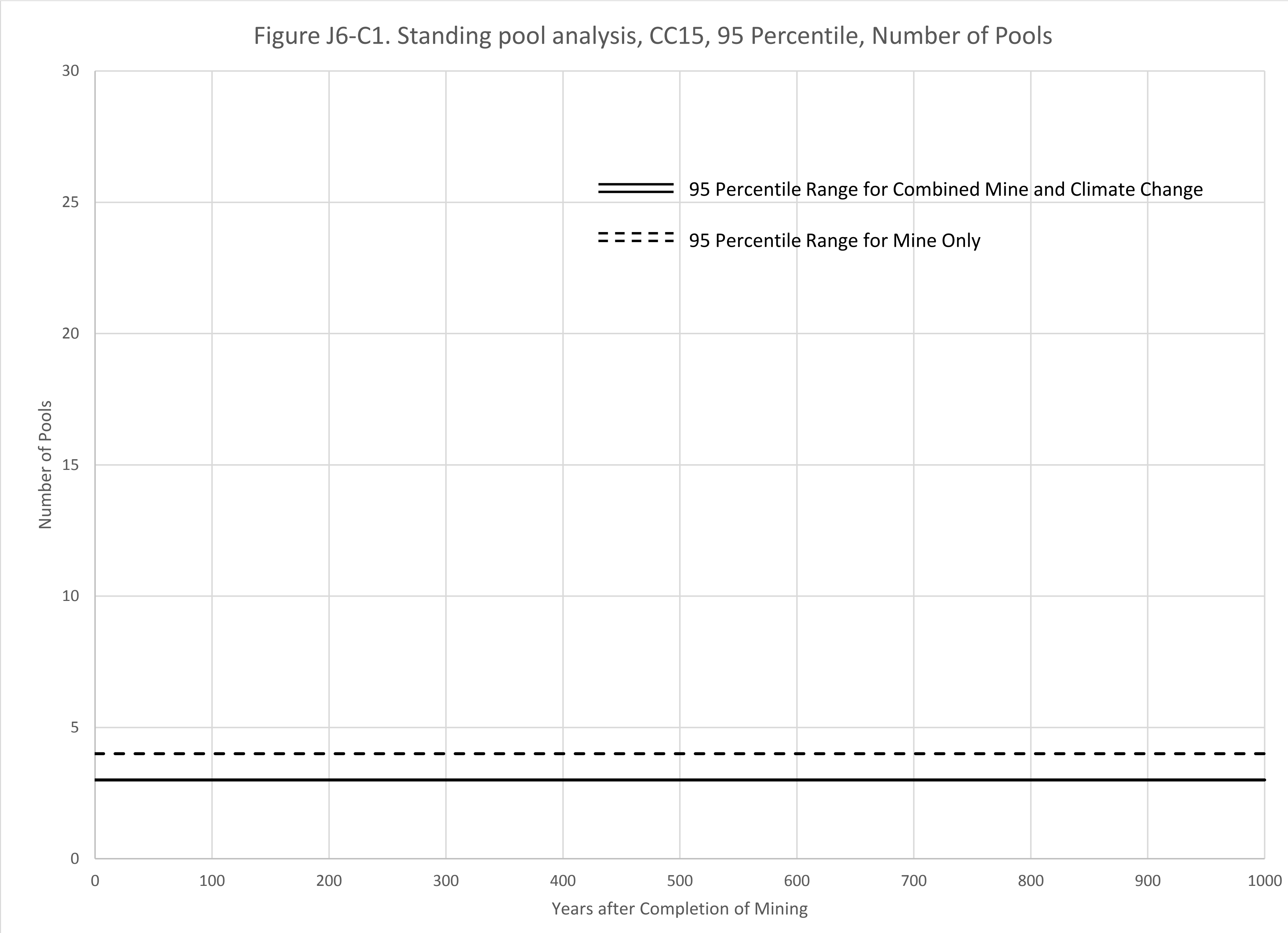
Figure J6-C1. Standing pool analysis, CC15, 95 Percentile, Number of Pools
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Number of Pools
Years after Completion of Mining
0
5
10
15
20
25
30
0
100
200
300
400
500
600
700
800
900
1000

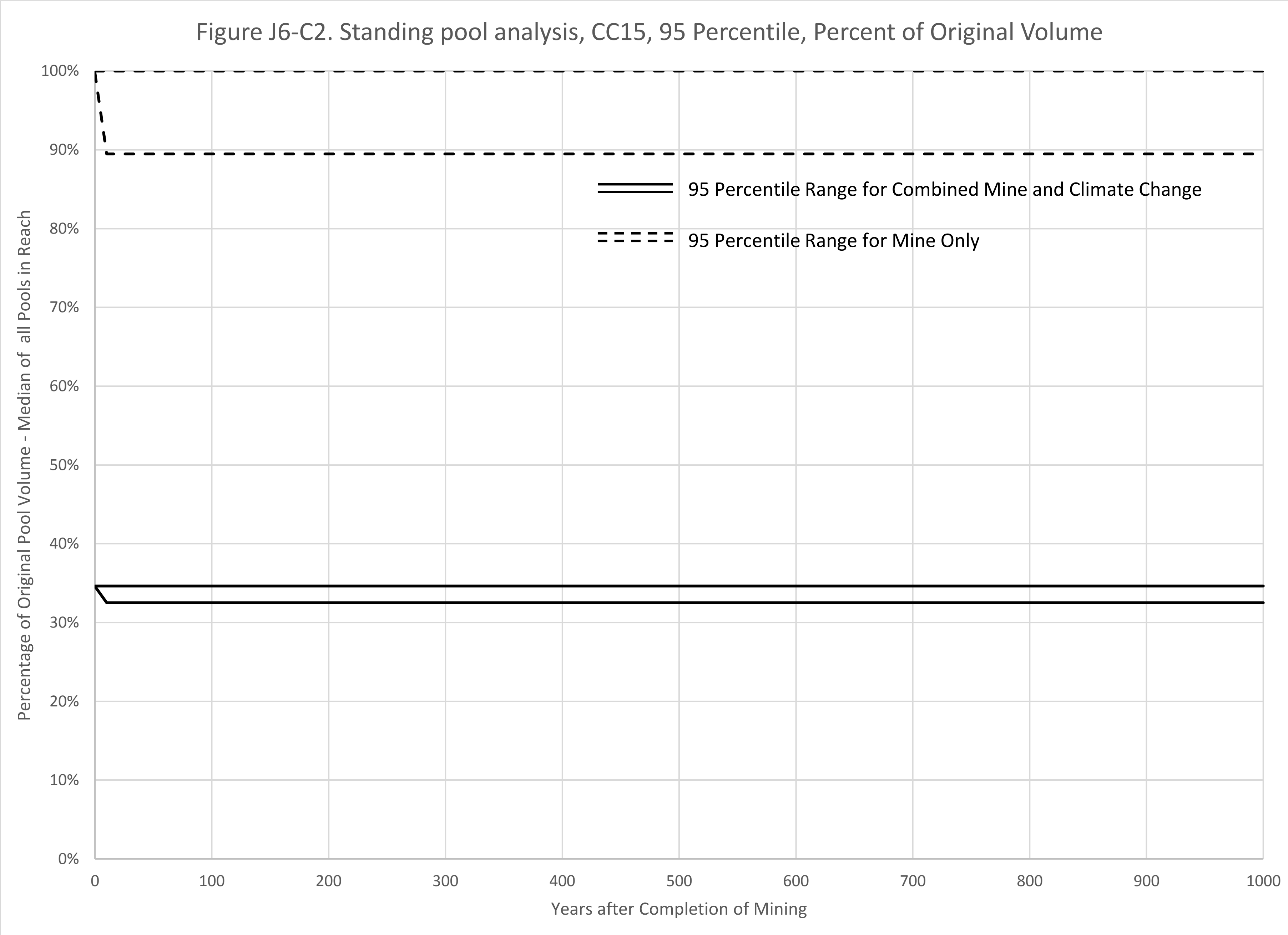

Figure J6-C2. Standing pool analysis, CC15, 95 Percentile, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of all Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only

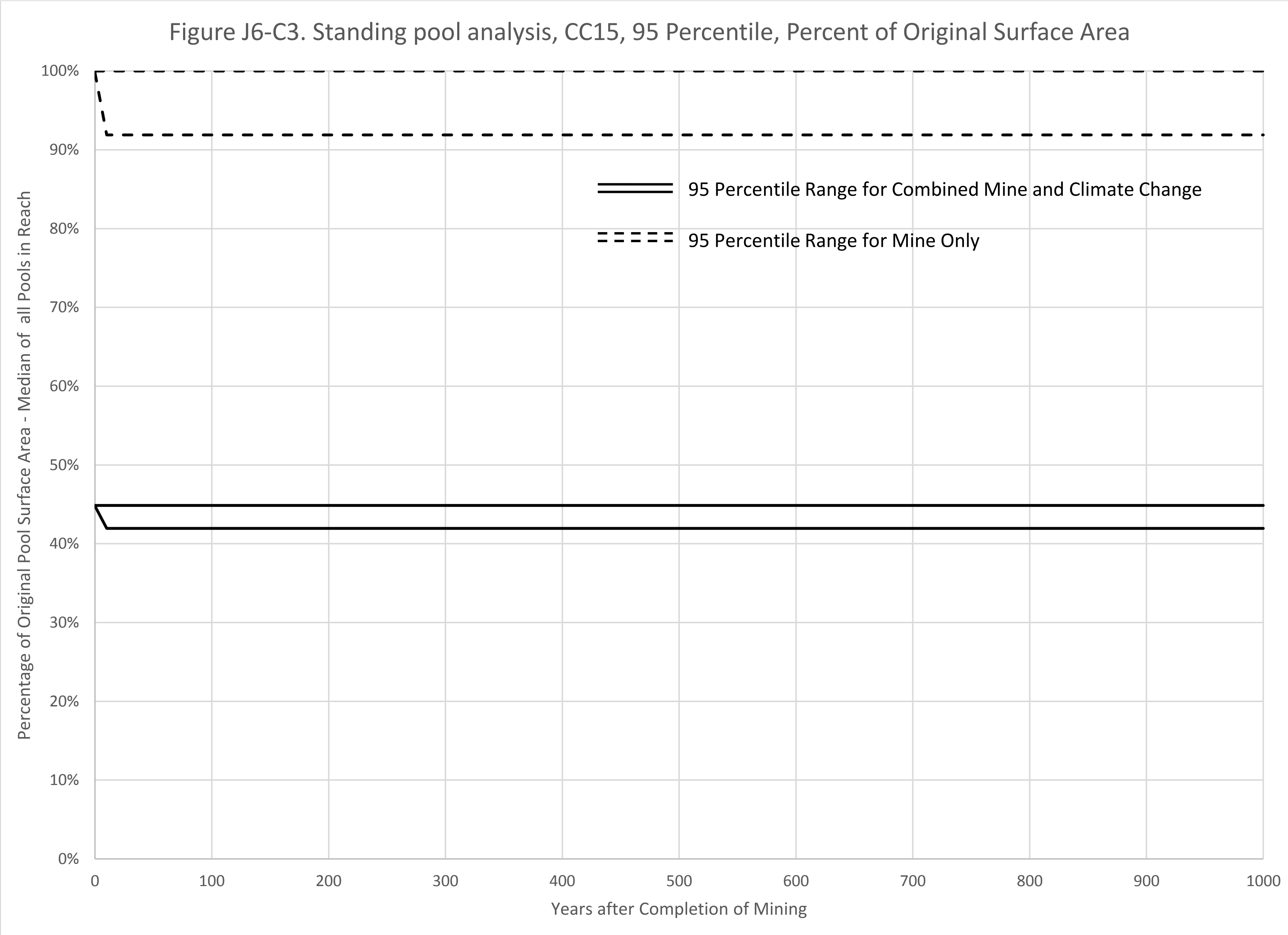
Figure J6-C3. Standing pool analysis, CC15, 95 Percentile, Percent of Original Surface Area
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Percentage of Original Pool Surface Area - Median of all Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
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600
700
800
900
1000
Years after Completion of Mining

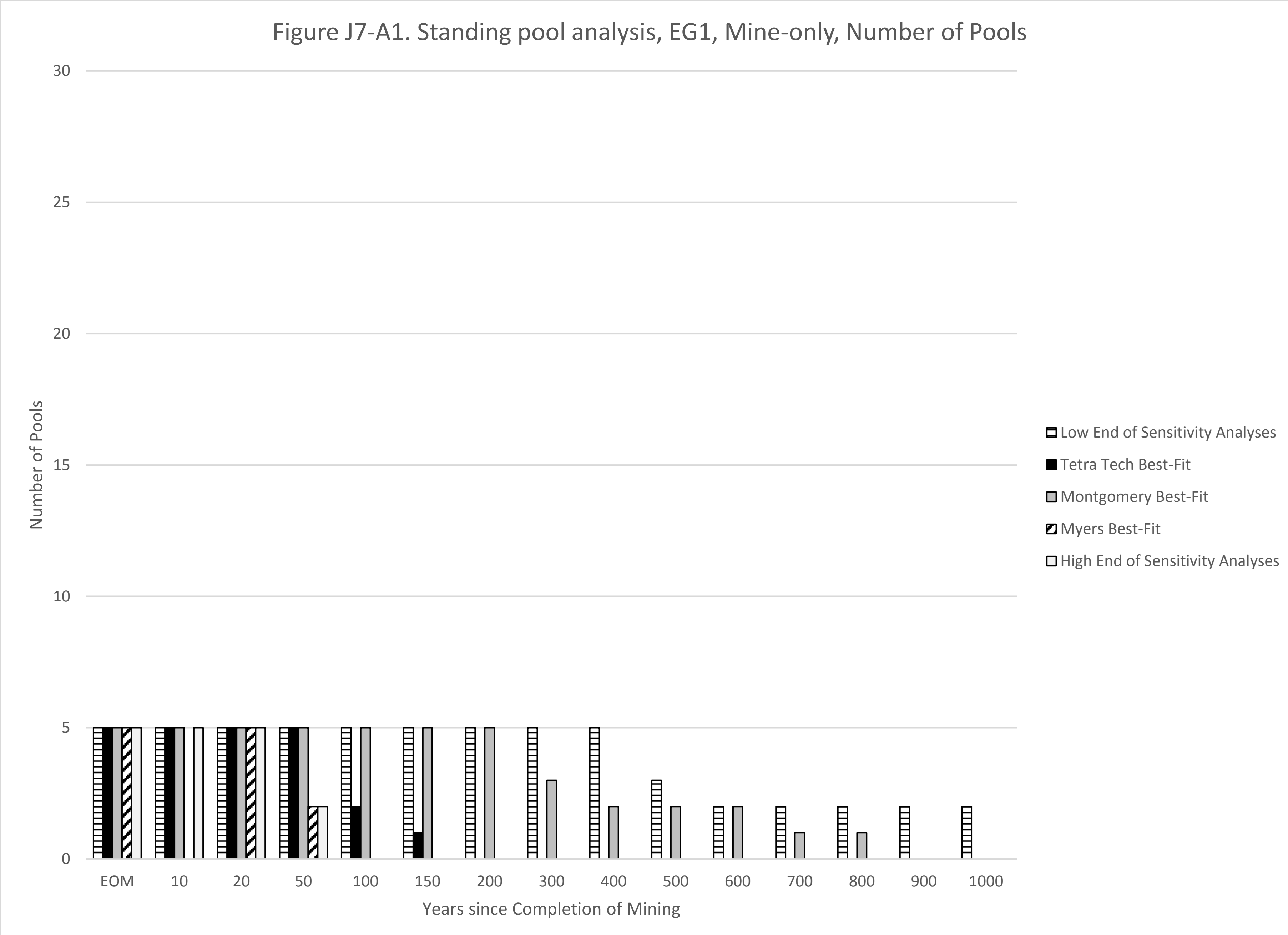


Figure J7-A1. Standing pool analysis, EG1, Mine-only, Number of Pools
30
25
20
15
10
5
0
Number of Pools
EOM
10
20
50
100
150
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analyses

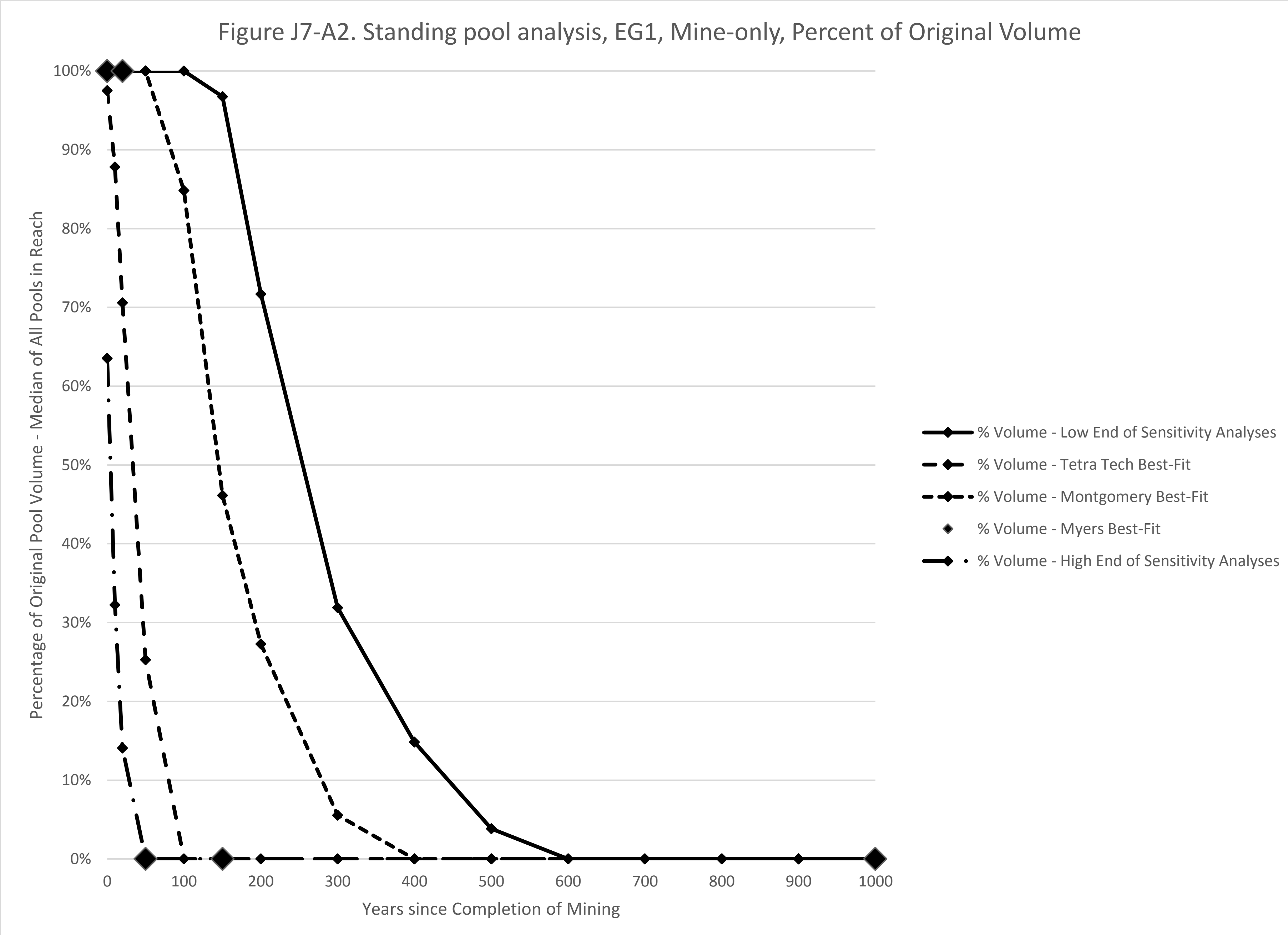


Figure J7-A2. Standing pool analysis, EG1, Mine-only, Percent of Original Volume
Percentage of Original Pool Volume - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

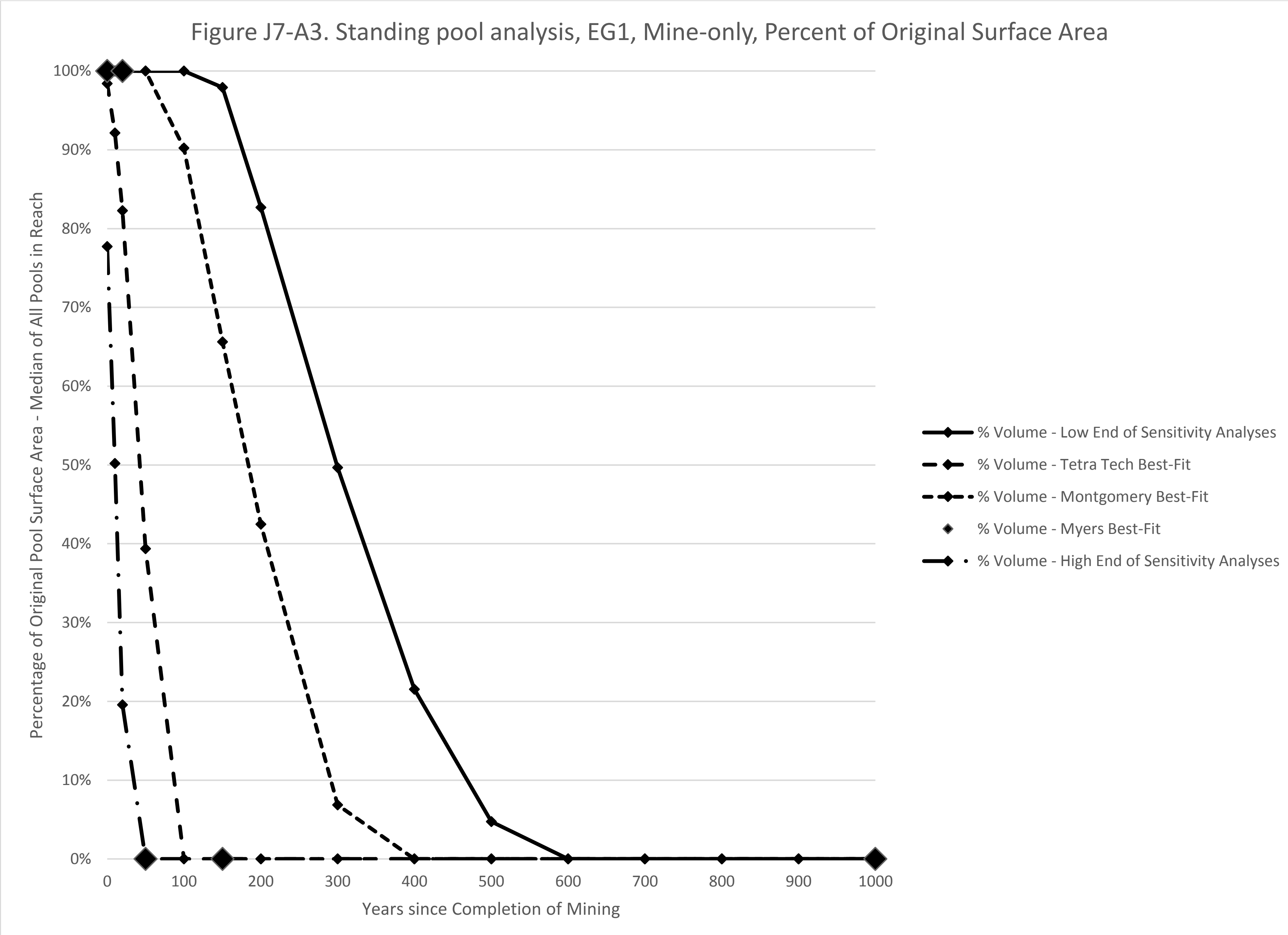


Figure J7-A3. Standing pool analysis, EG1, Mine-only, Percent of Original Surface Area
Percentage of Original Pool Surface Area - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

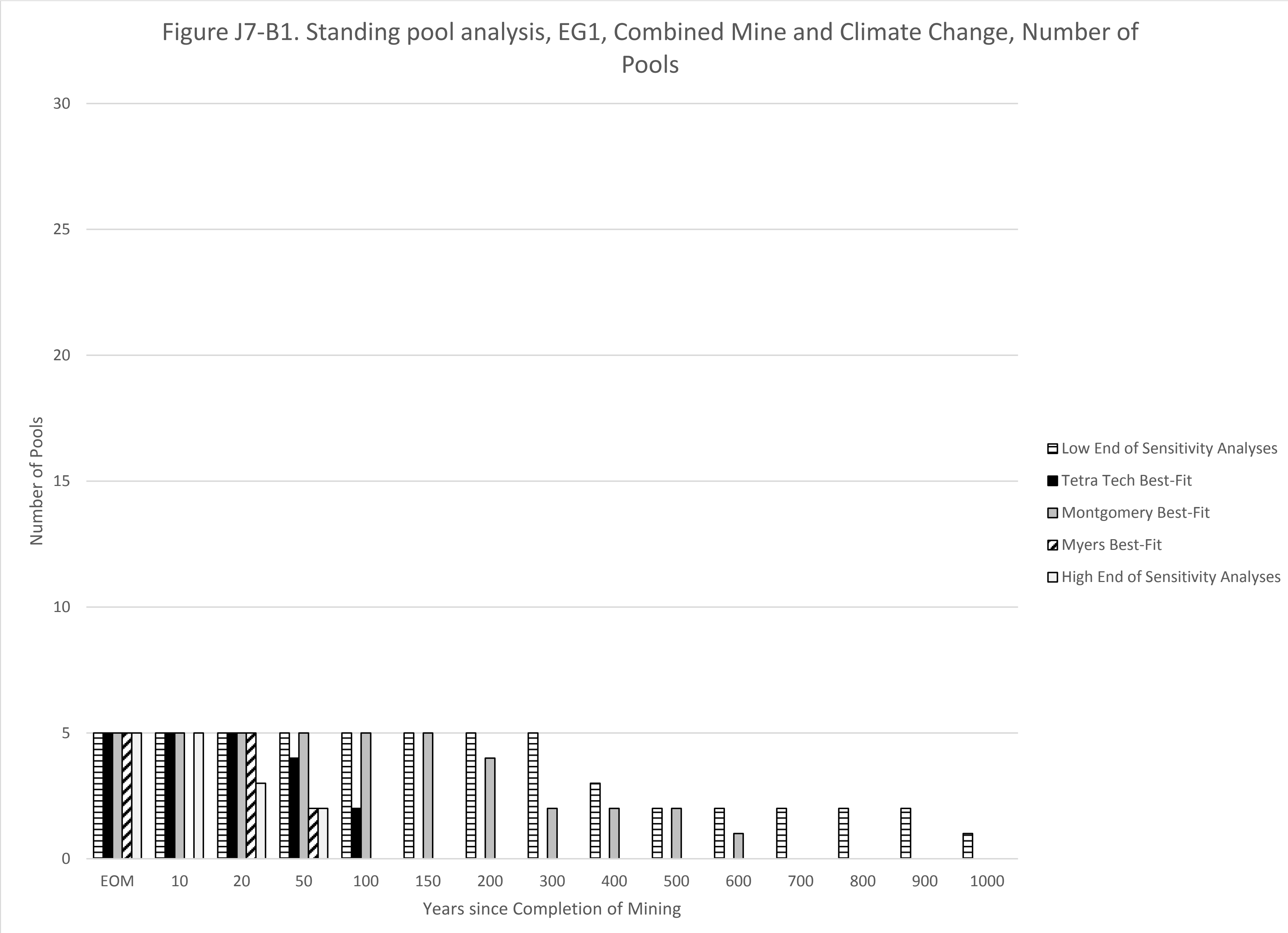


Figure J7-B1. Standing pool analysis, EG1, Combined Mine and Climate Change, Number of Pools
Number of Pools
30
25
20
15
10
5
0
EOM
10
20
50
100
150
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
Myers Best-Fit
High End of Sensitivity Analyses

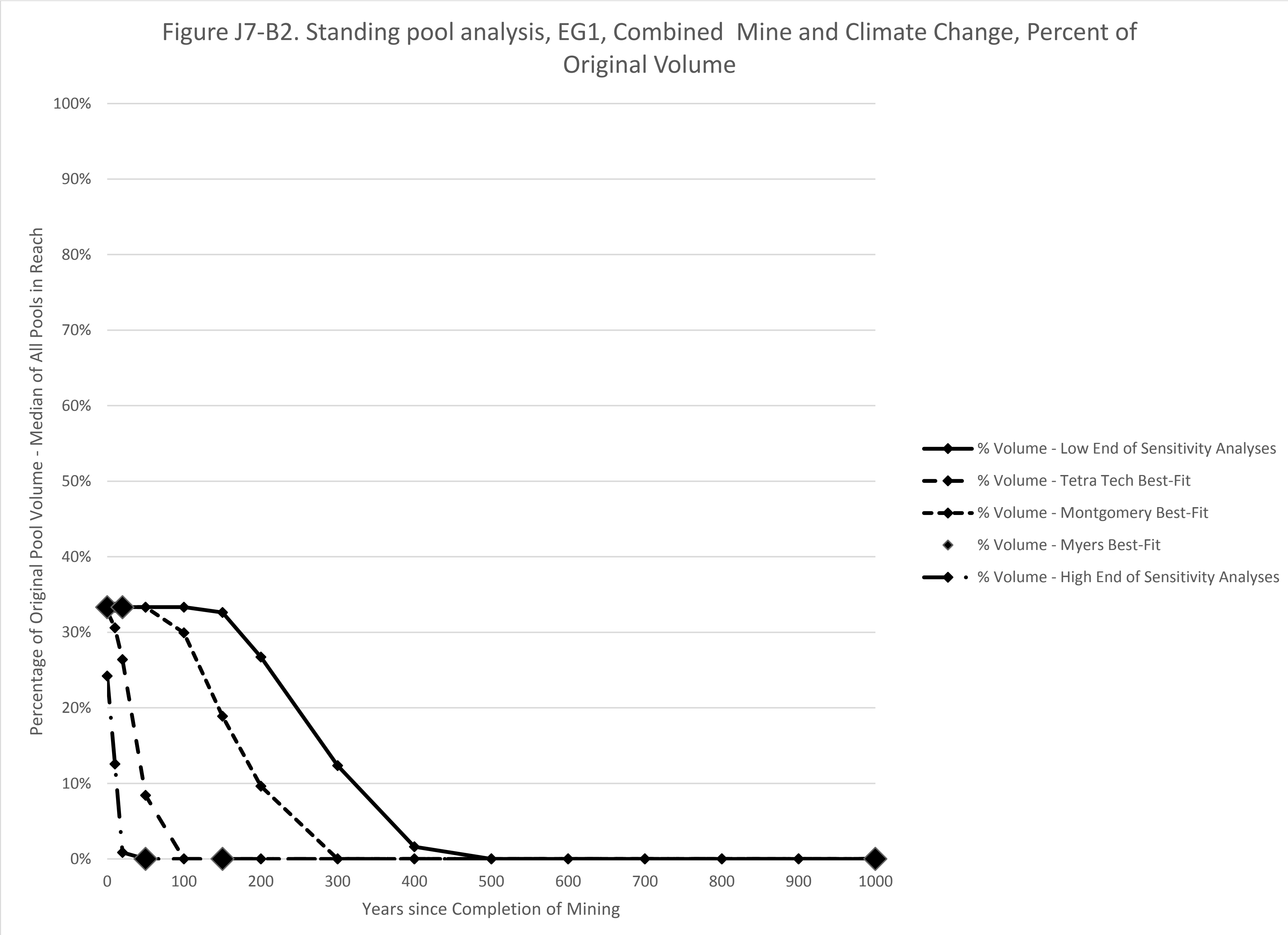


Figure J7-B2. Standing pool analysis, EG1, Combined Mine and Climate Change, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of All Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

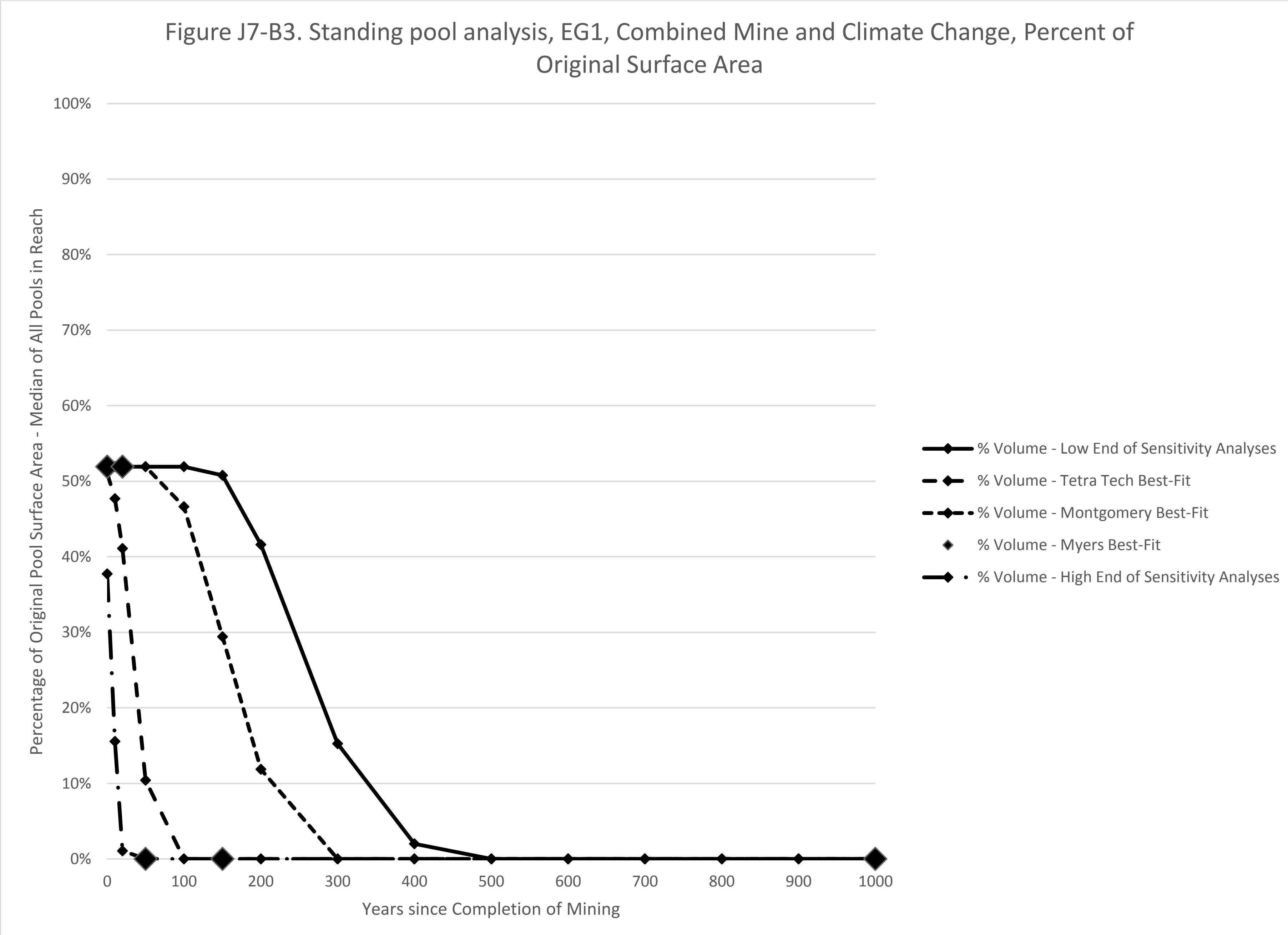


Figure J7-B3. Standing pool analysis, EG1, Combined Mine and Climate Change, Percent of Original Surface Area
Percentage of Original Pool Surface Area - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - Myers Best-Fit
% Volume - High End of Sensitivity Analyses

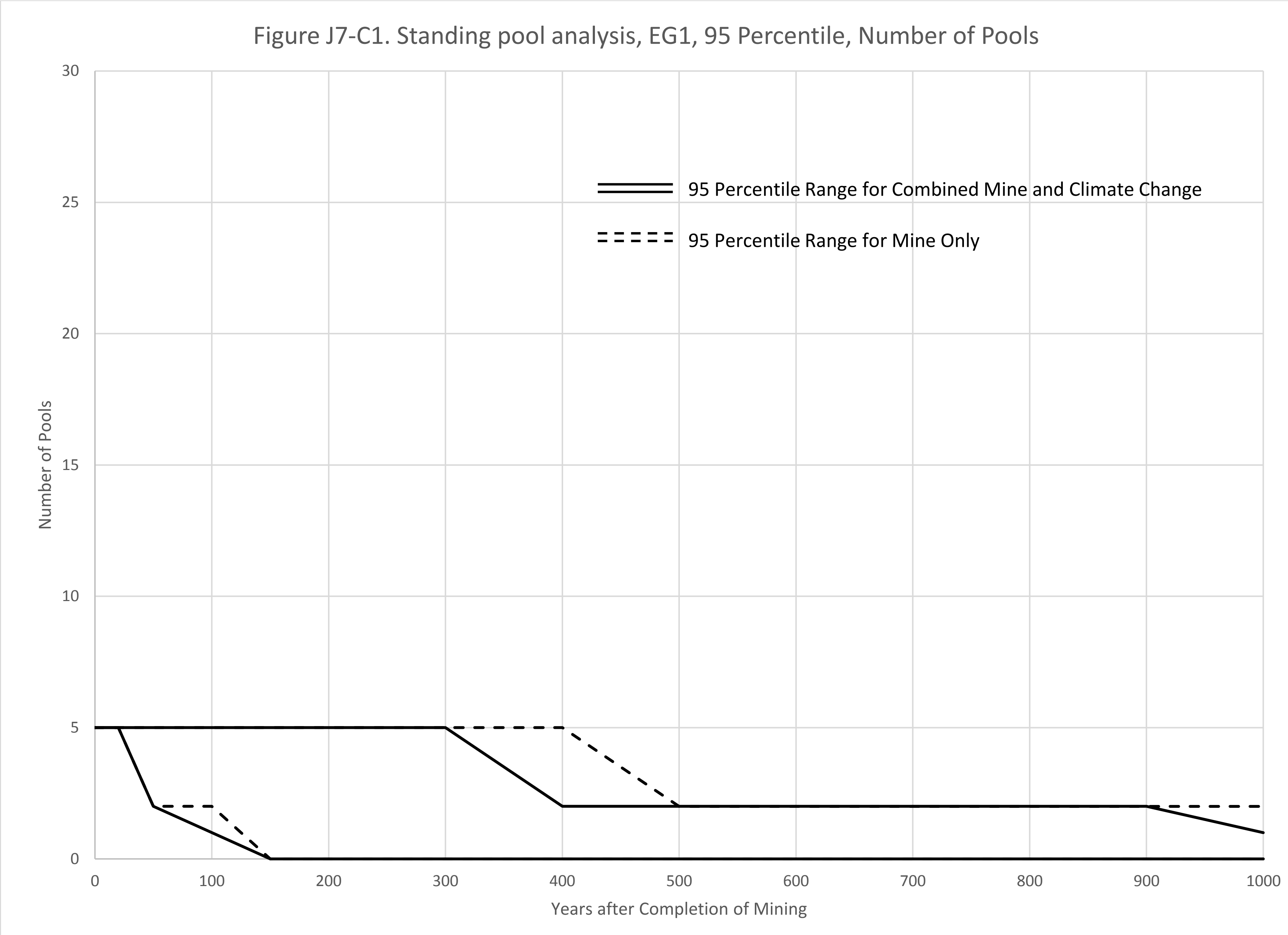


Figure J7-C1. Standing pool analysis, EG1, 95 Percentile, Number of Pools
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Number of Pools
0
5
10
15
20
25
30
Years after Completion of Mining
0
100
200
300
400
500
600
700
800
900
1000

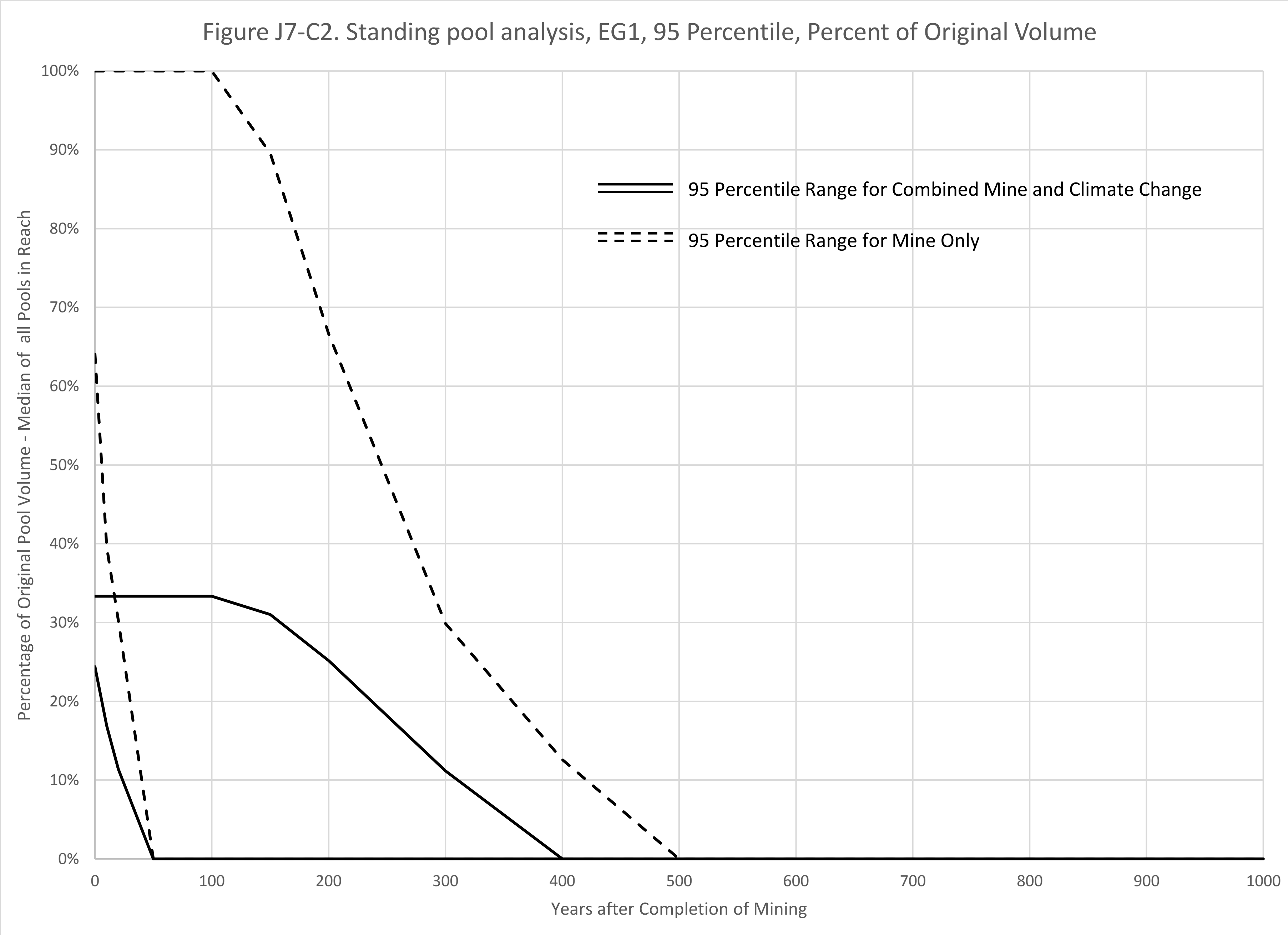
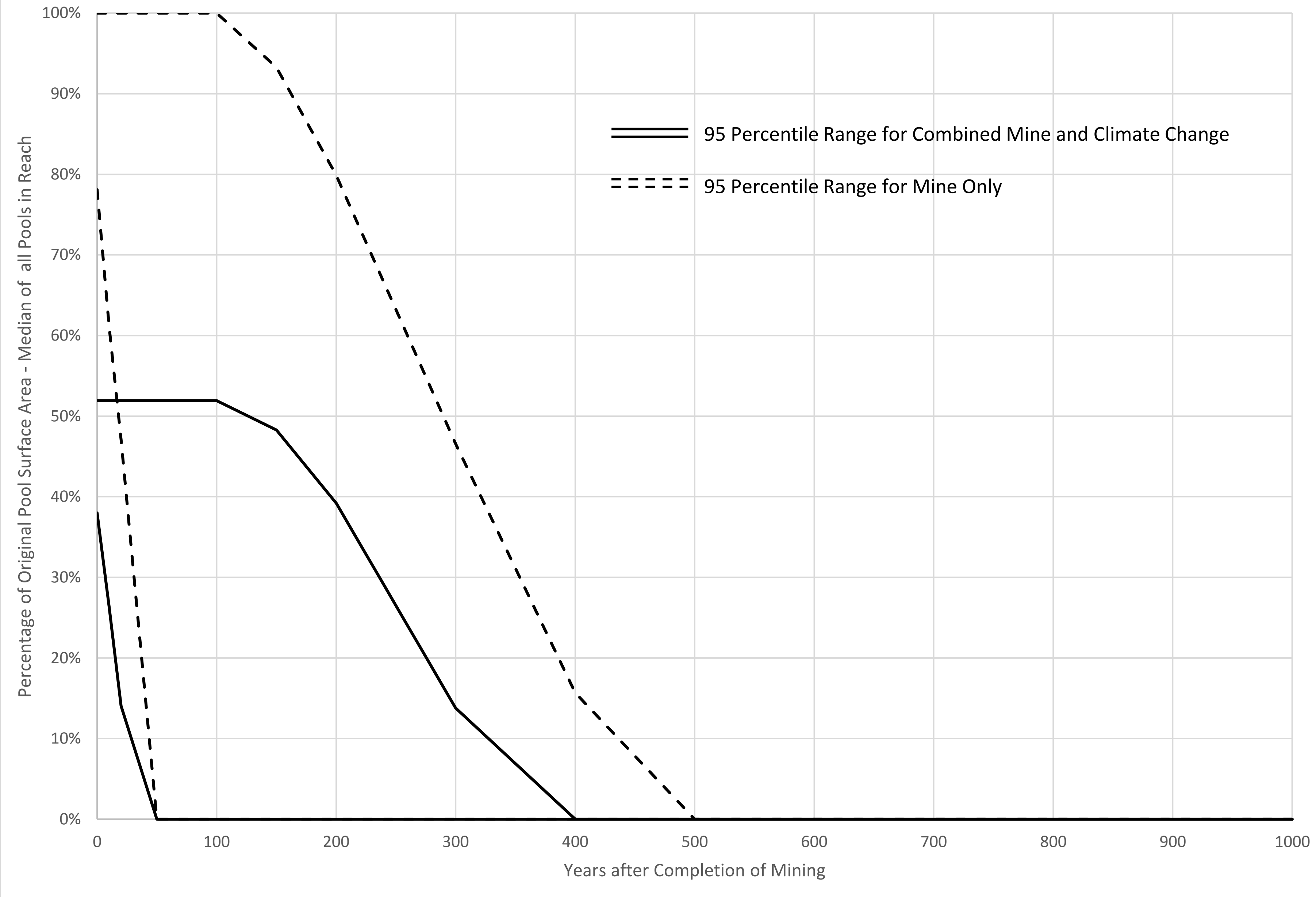


Figure J7-C2. Standing pool analysis, EG1, 95 Percentile, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Percentage of Original Pool Volume - Median of all Pools in Reach
Years after Completion of Mining
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only

Figure J7-C3. Standing pool analysis, EG1, 95 Percentile, Percent of Original Surface Area



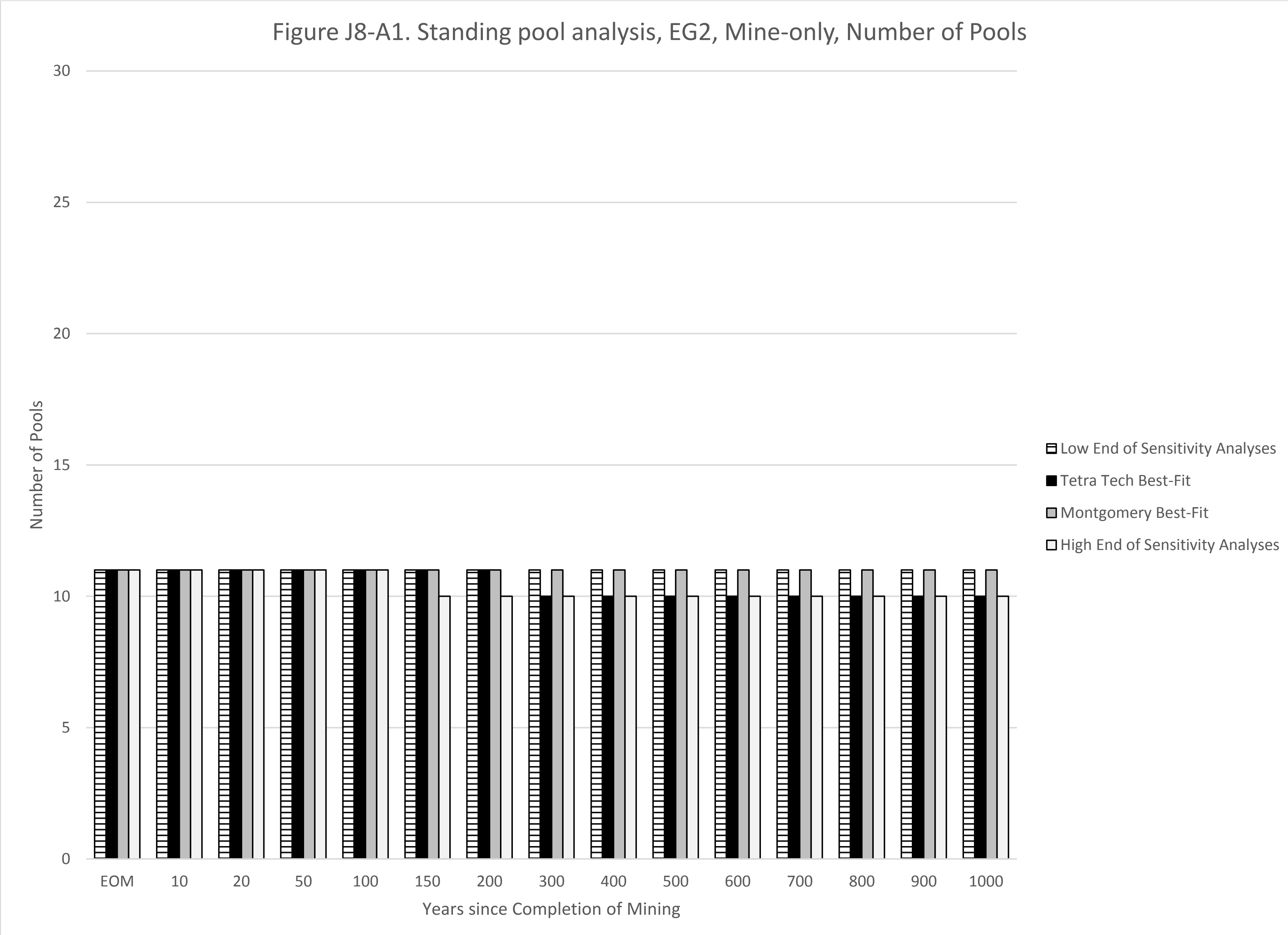
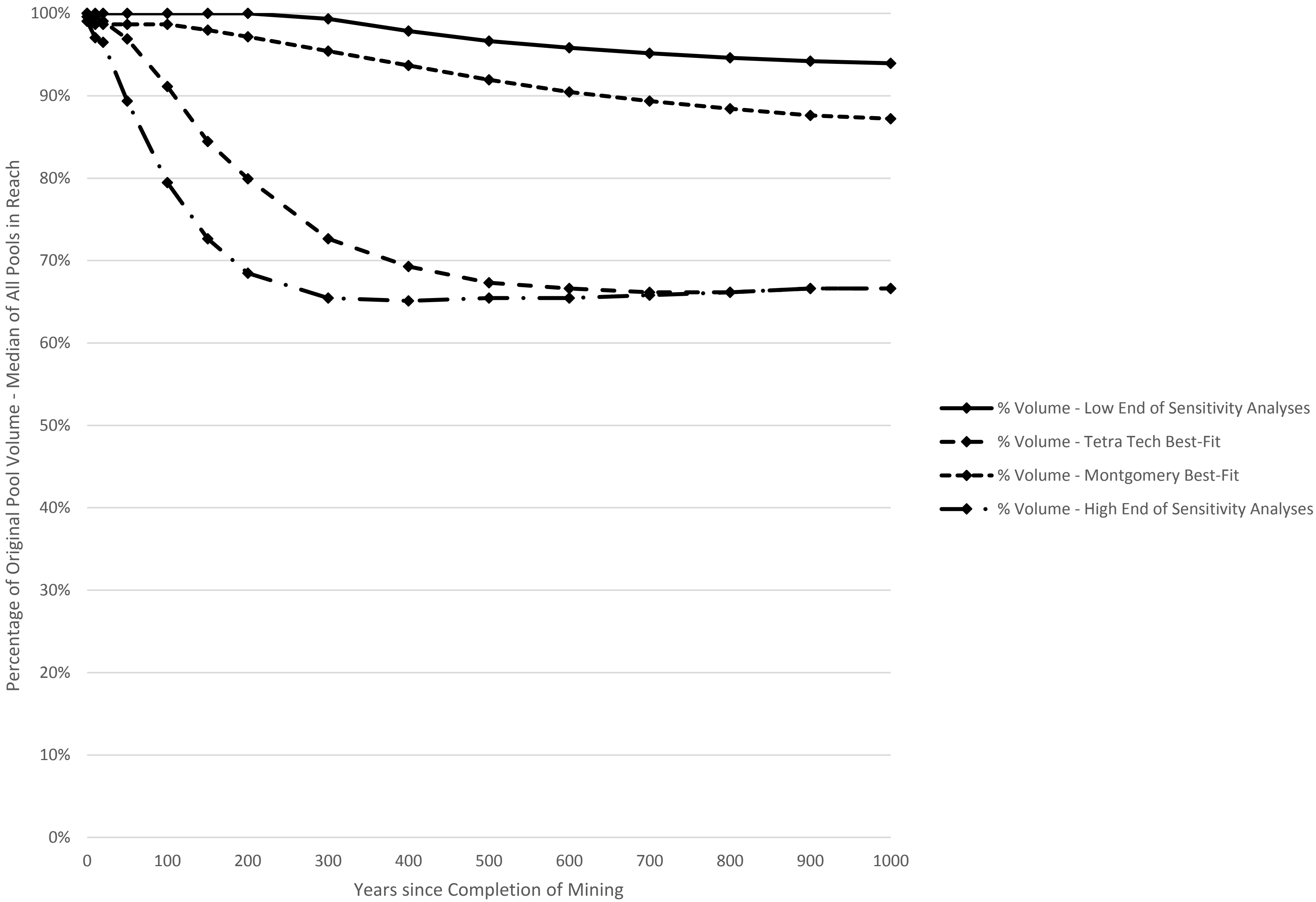


Figure J8-A1. Standing pool analysis, EG2, Mine-only, Number of Pools
30
25
20
15
10
5
0
Number of Pools
EOM
10
20
50
100
150
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
High End of Sensitivity Analyses

Figure J8-A2. Standing pool analysis, EG2, Mine-only, Percent of Original Volume



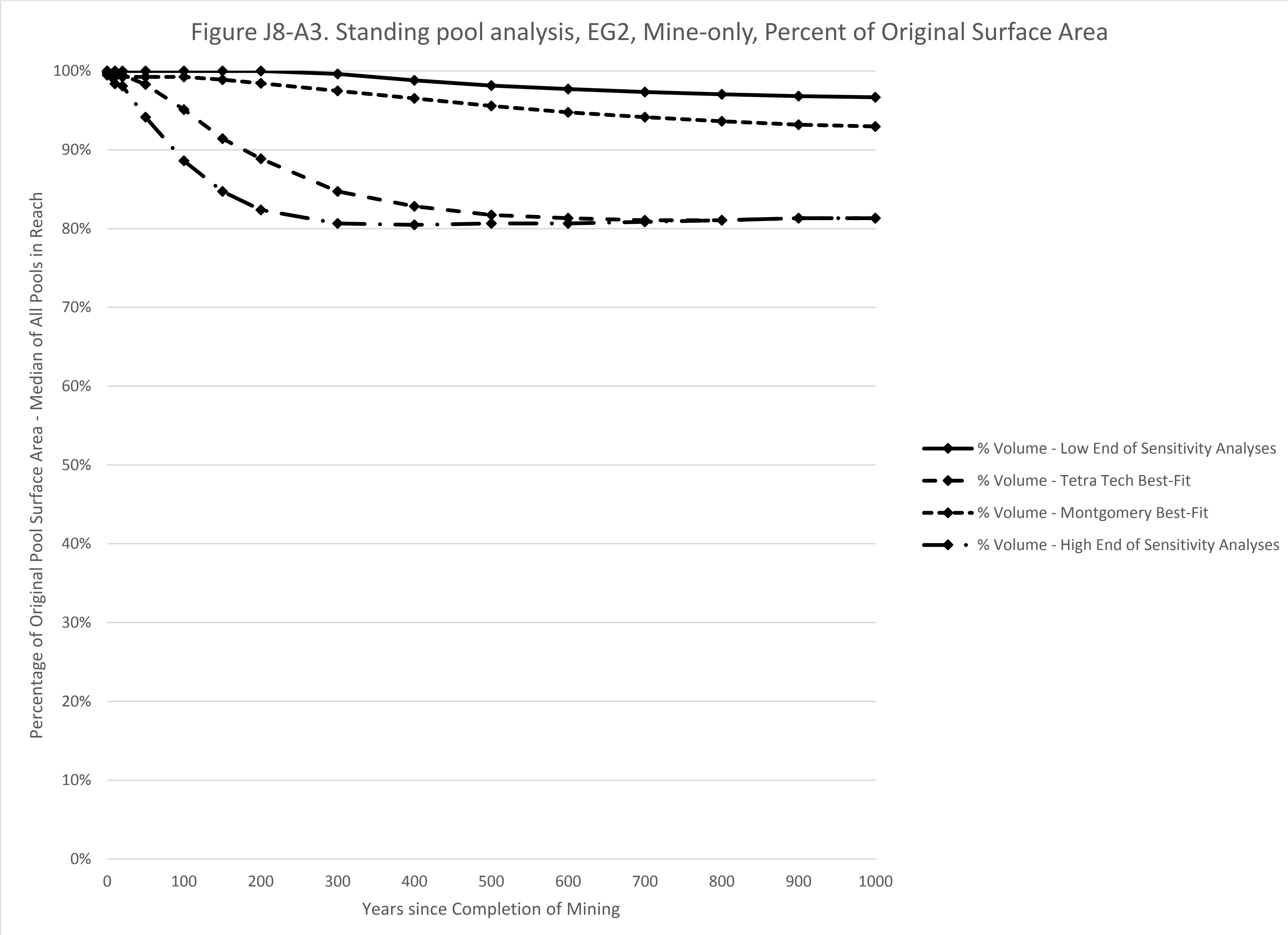


Figure J8-A3. Standing pool analysis, EG2, Mine-only, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of All Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

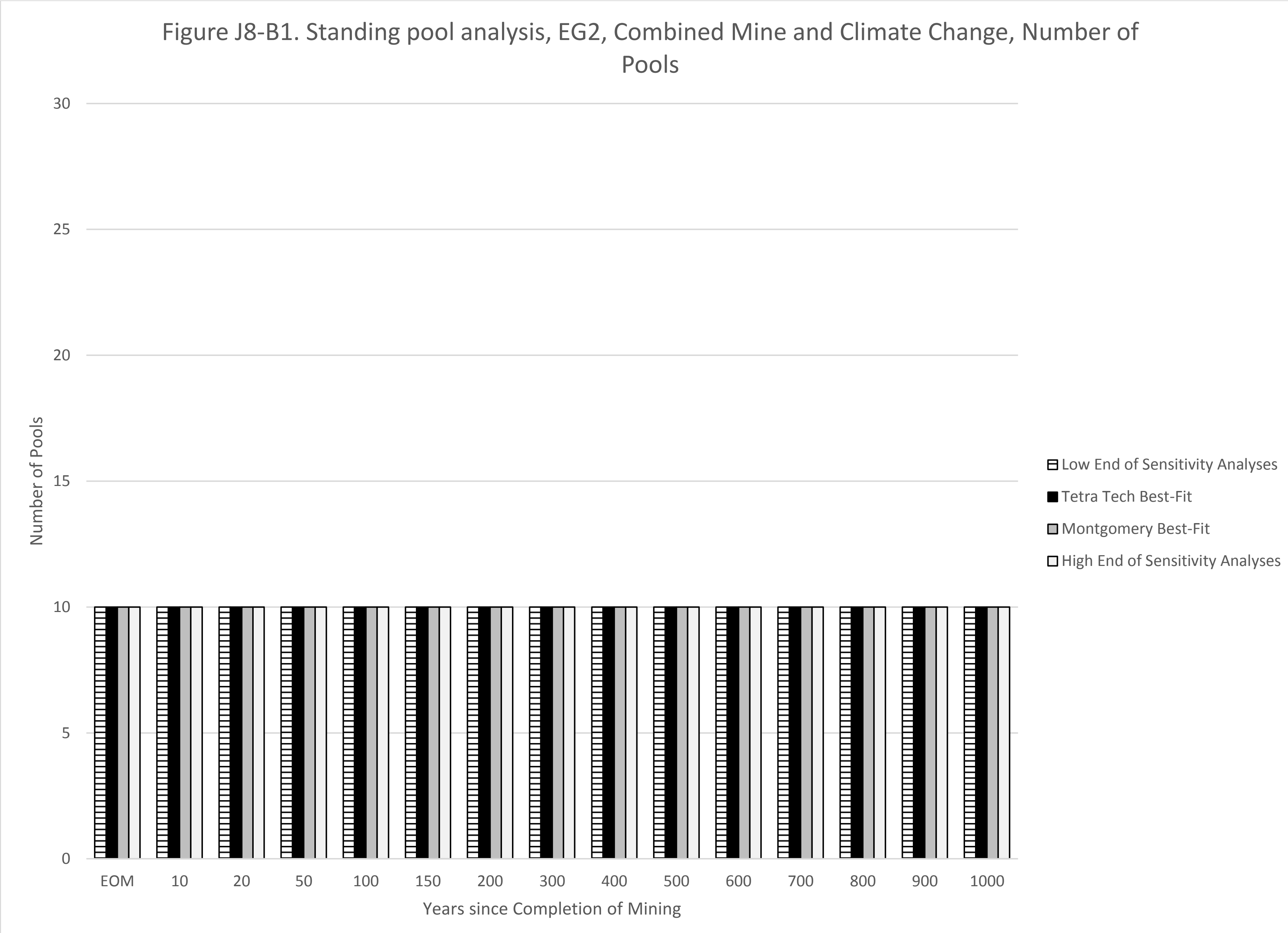


Figure J8-B1. Standing pool analysis, EG2, Combined Mine and Climate Change, Number of Pools
30
25
20
15
10
5
0
Number of Pools
EOM
10
20
50
100
150
200
300
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500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
High End of Sensitivity Analyses

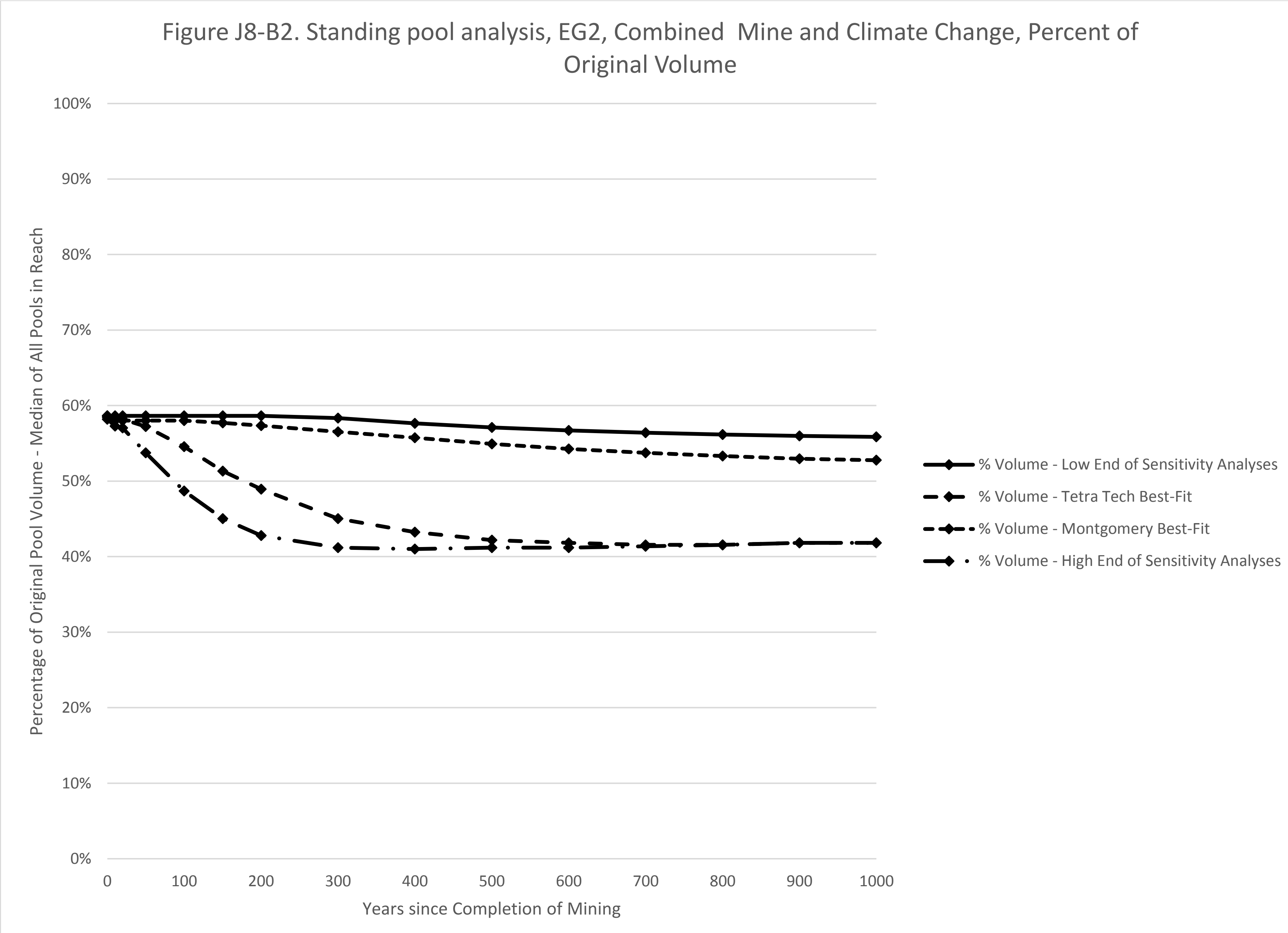

Figure J8-B2. Standing pool analysis, EG2, Combined Mine and Climate Change, Percent of Original Volume
Percentage of Original Pool Volume - Median of All Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
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1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

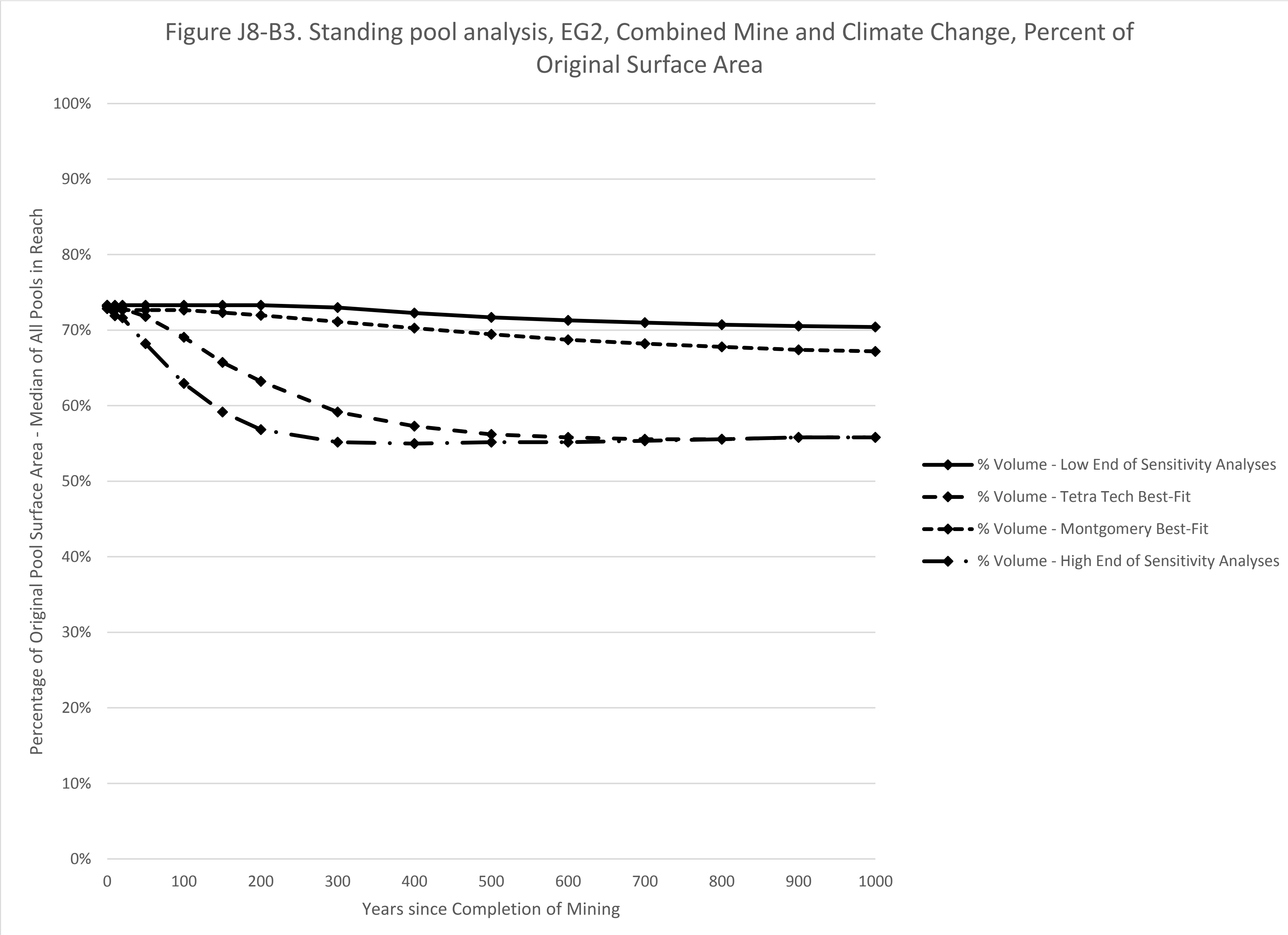


Figure J8-B3. Standing pool analysis, EG2, Combined Mine and Climate Change, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of All Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

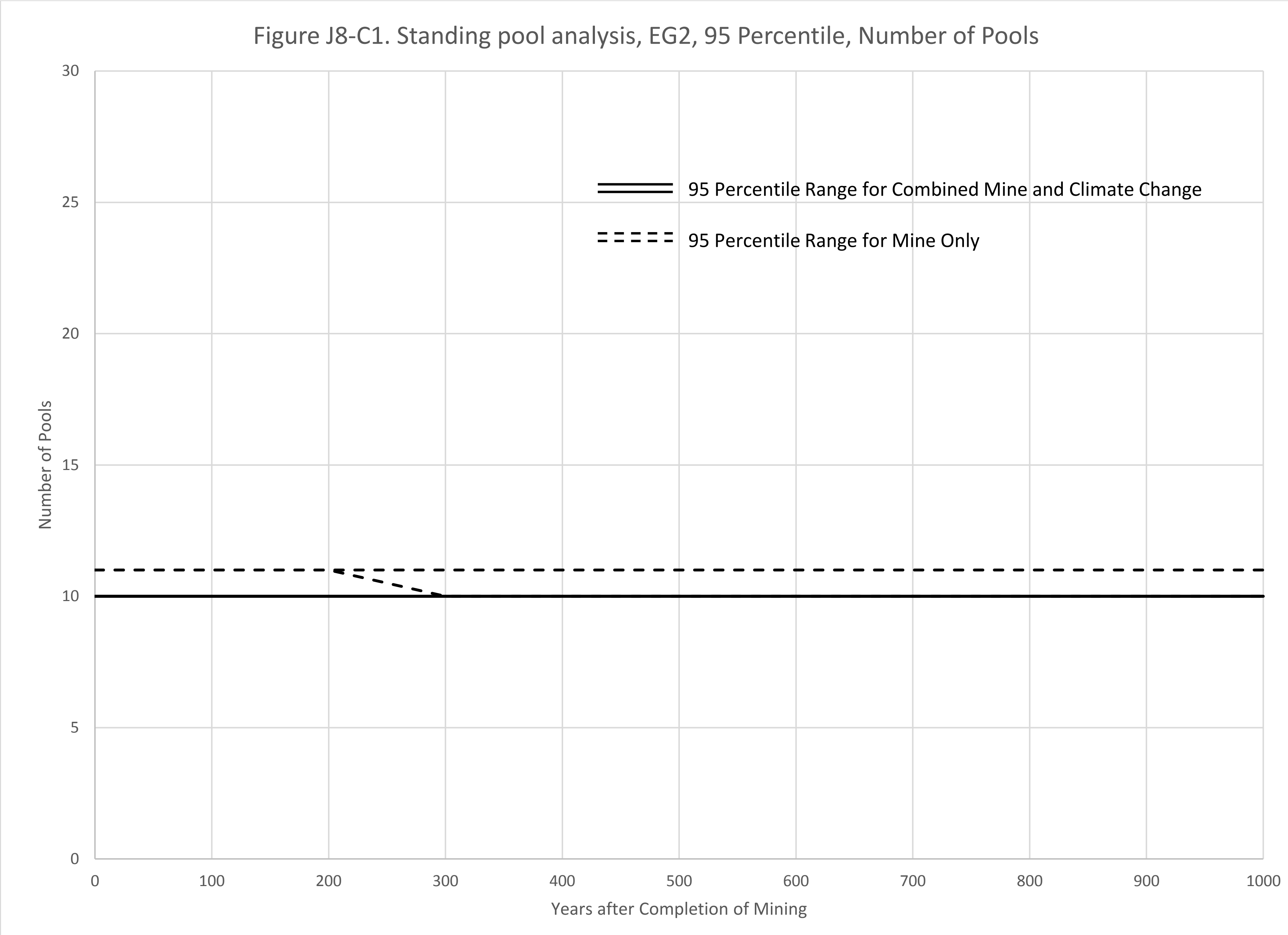


Figure J8-C1. Standing pool analysis, EG2, 95 Percentile, Number of Pools
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Number of Pools
30
25
20
15
10
5
0
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

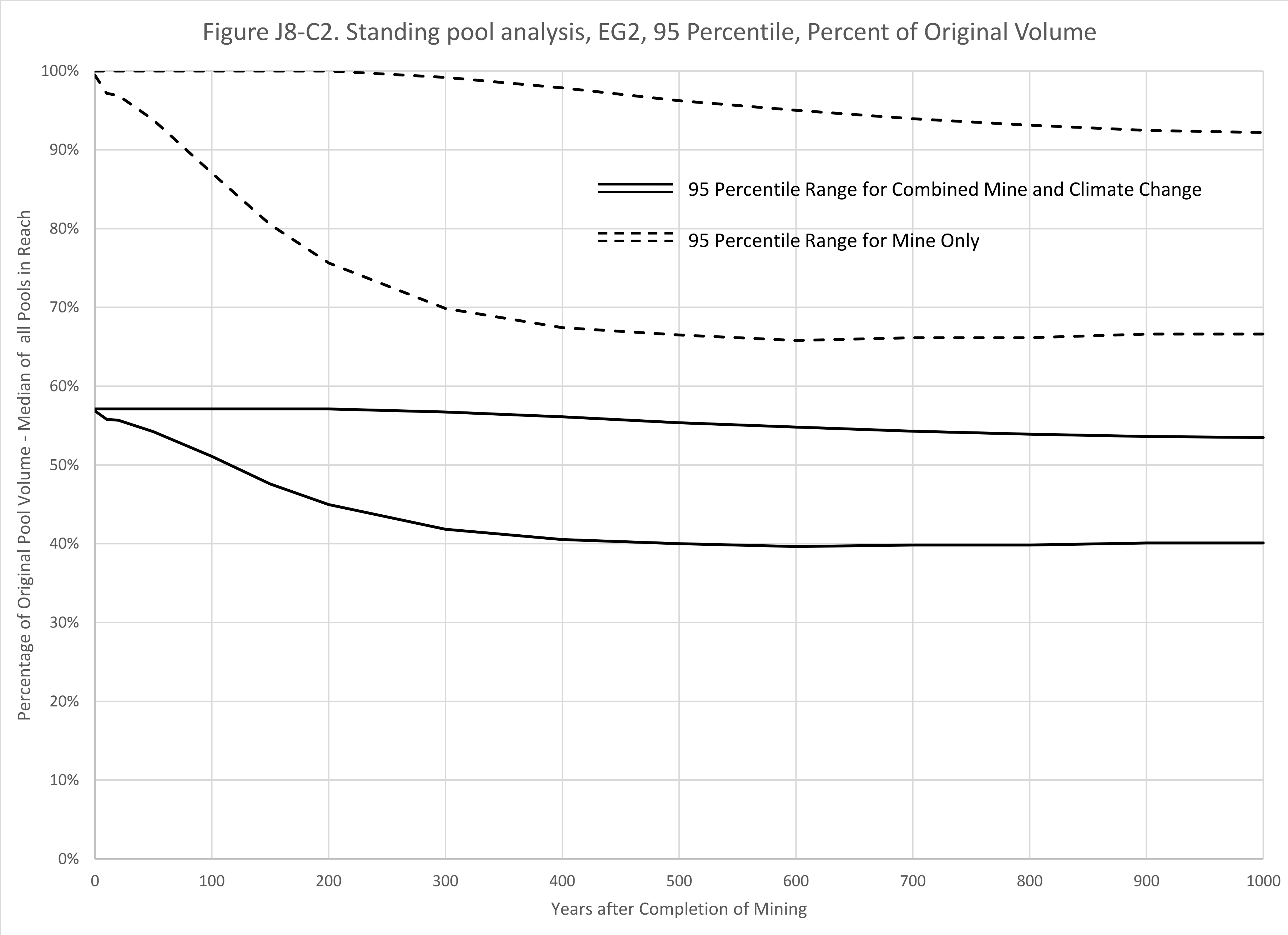


Figure J8-C2. Standing pool analysis, EG2, 95 Percentile, Percent of Original Volume
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Percentage of Original Pool Volume - Median of all Pools in Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

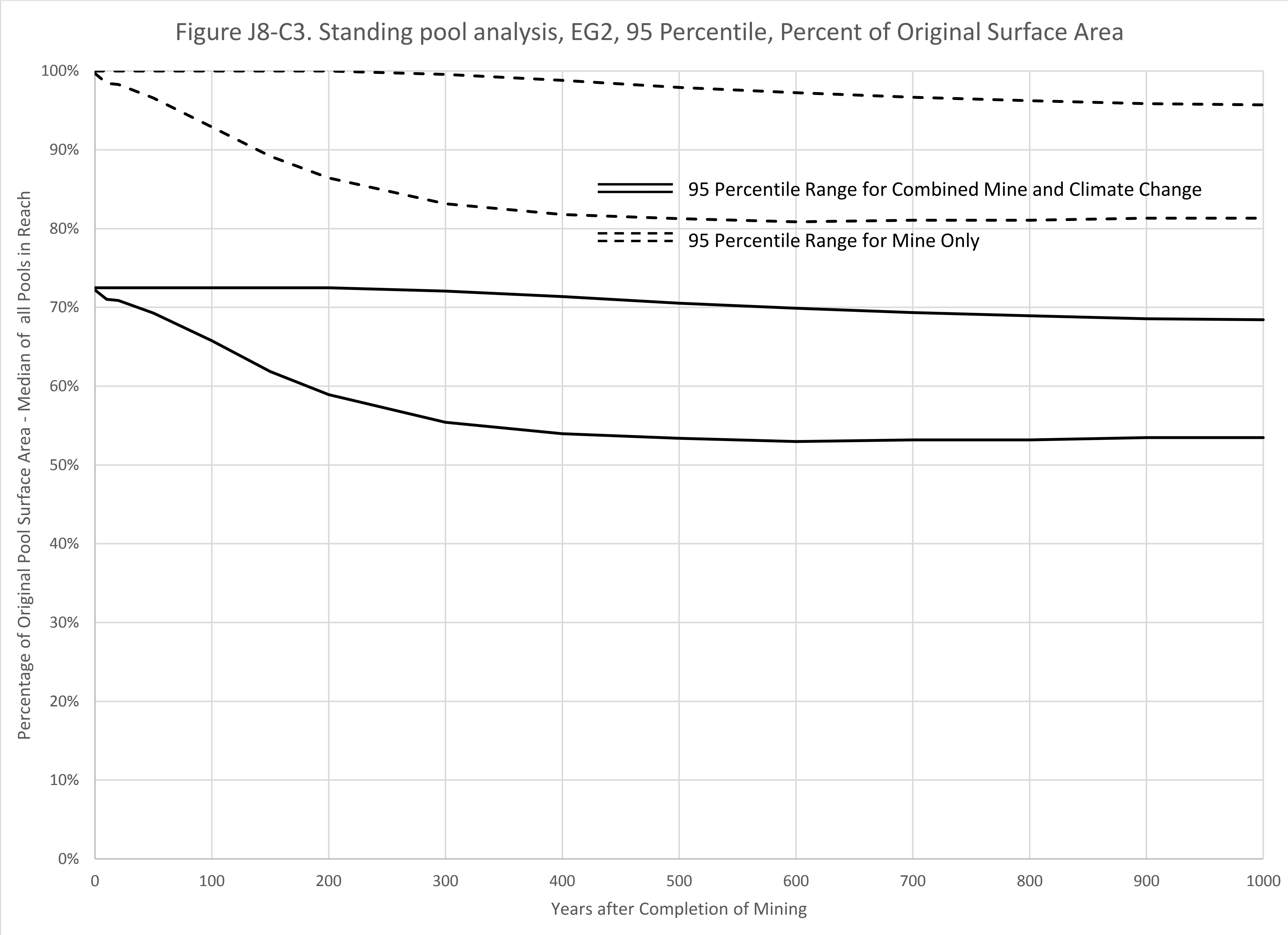


Figure J8-C3. Standing pool analysis, EG2, 95 Percentile, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of all Pools in Reach
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

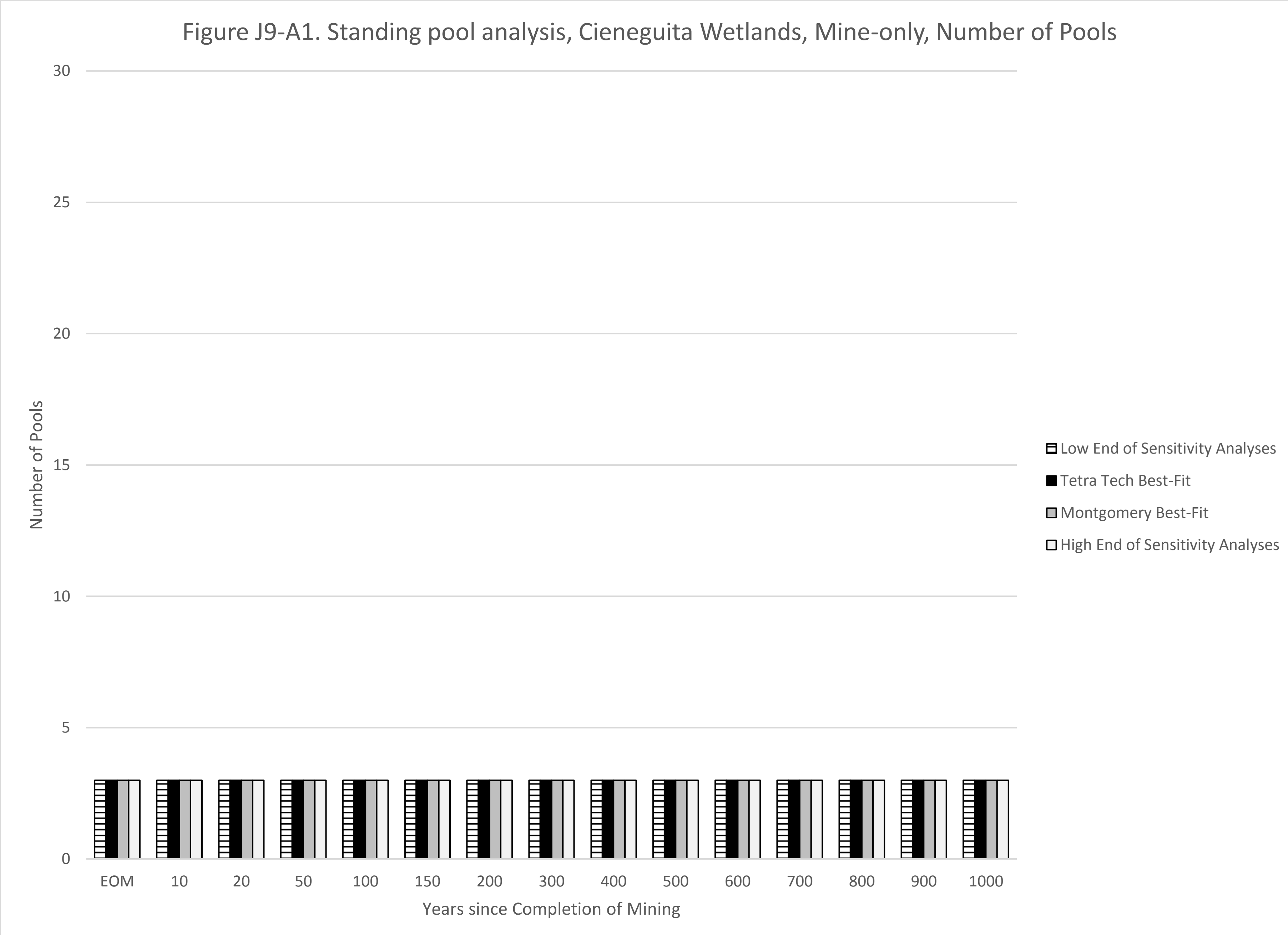


Figure J9-A1. Standing pool analysis, Cieneguita Wetlands, Mine-only, Number of Pools
30
25
20
15
10
5
0
Number of Pools
EOM
10
20
50
100
150
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
Low End of Sensitivity Analyses
Tetra Tech Best-Fit
Montgomery Best-Fit
High End of Sensitivity Analyses

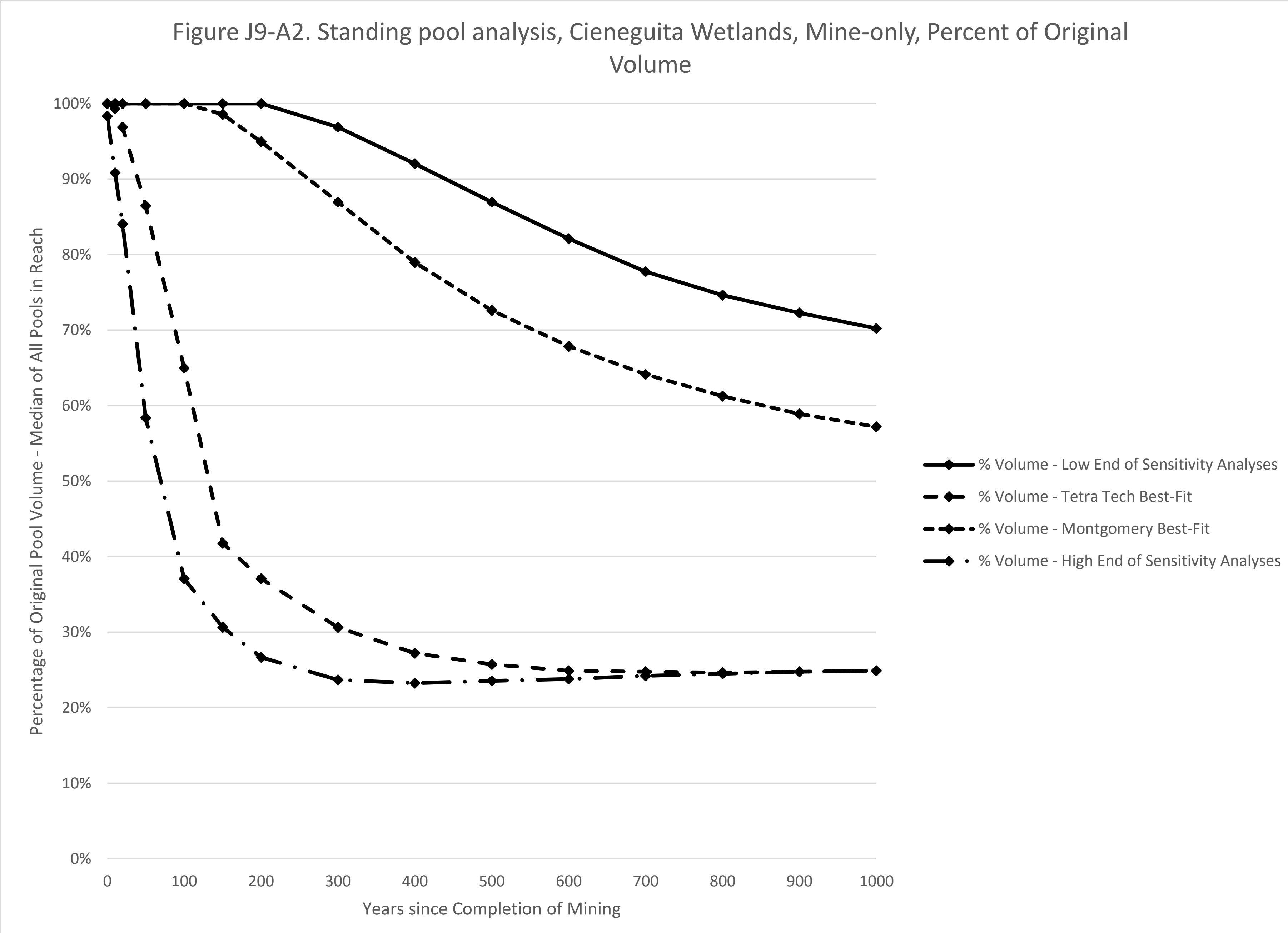


Figure J9-A2. Standing pool analysis, Cieneguita Wetlands, Mine-only, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of All Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

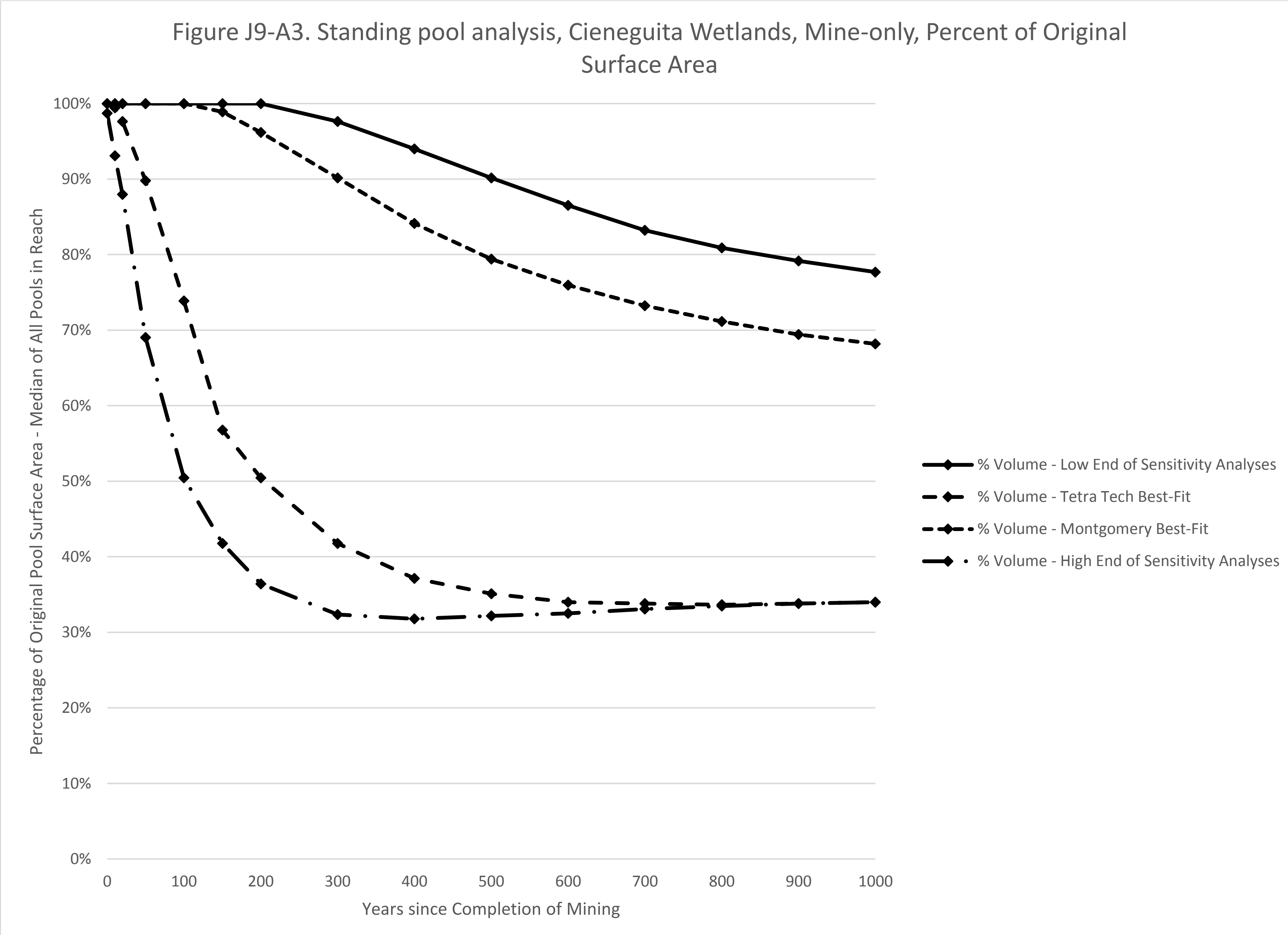


Figure J9-A3. Standing pool analysis, Cieneguita Wetlands, Mine-only, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of All Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

Figure J9-B1. Standing pool analysis, Cieneguita Wetlands, Combined Mine and Climate Change, Number of Pools

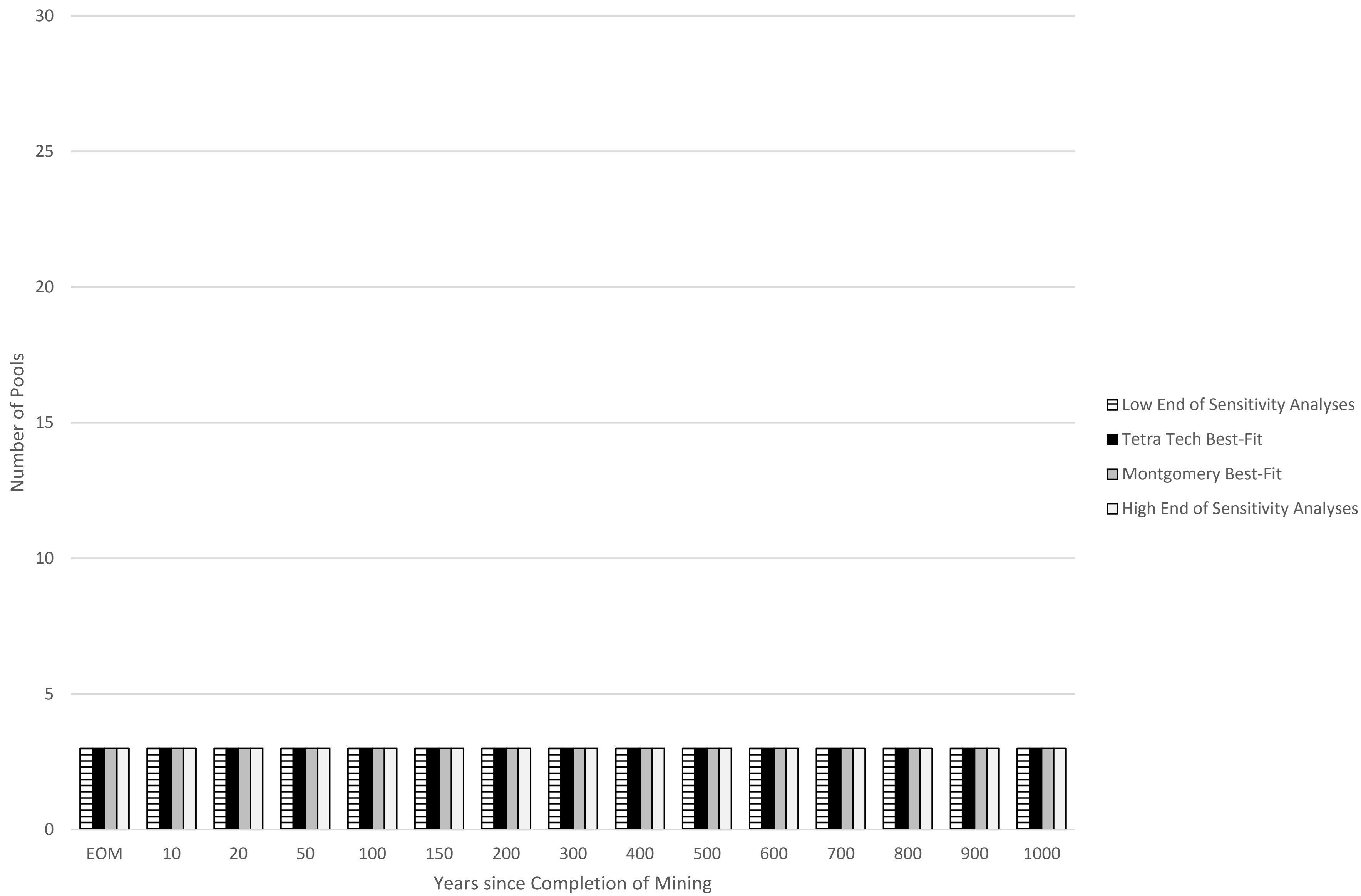
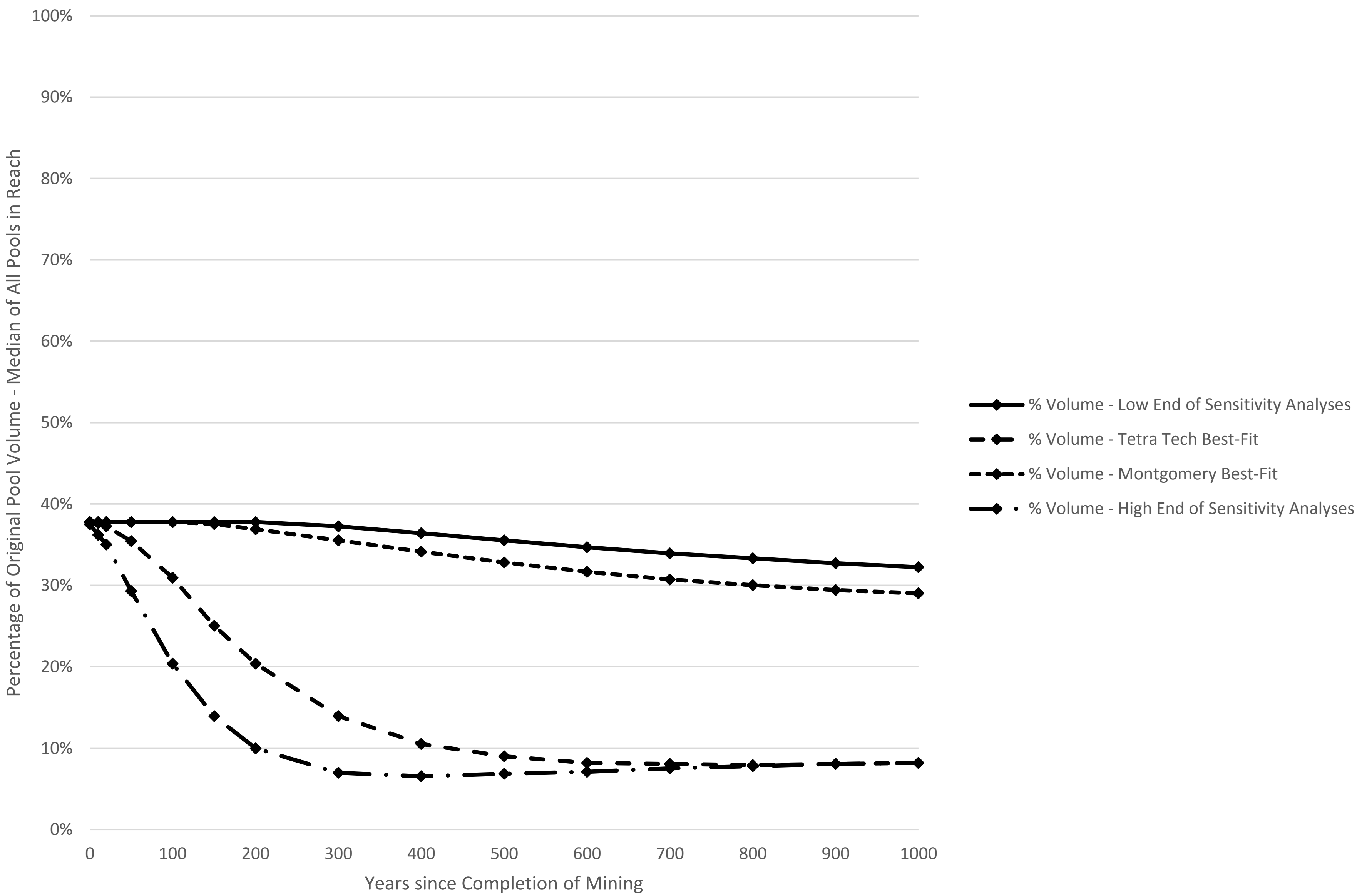


Figure J9-B2. Standing pool analysis, Cieneguita Wetlands, Combined Mine and Climate Change, Percent of Original Volume



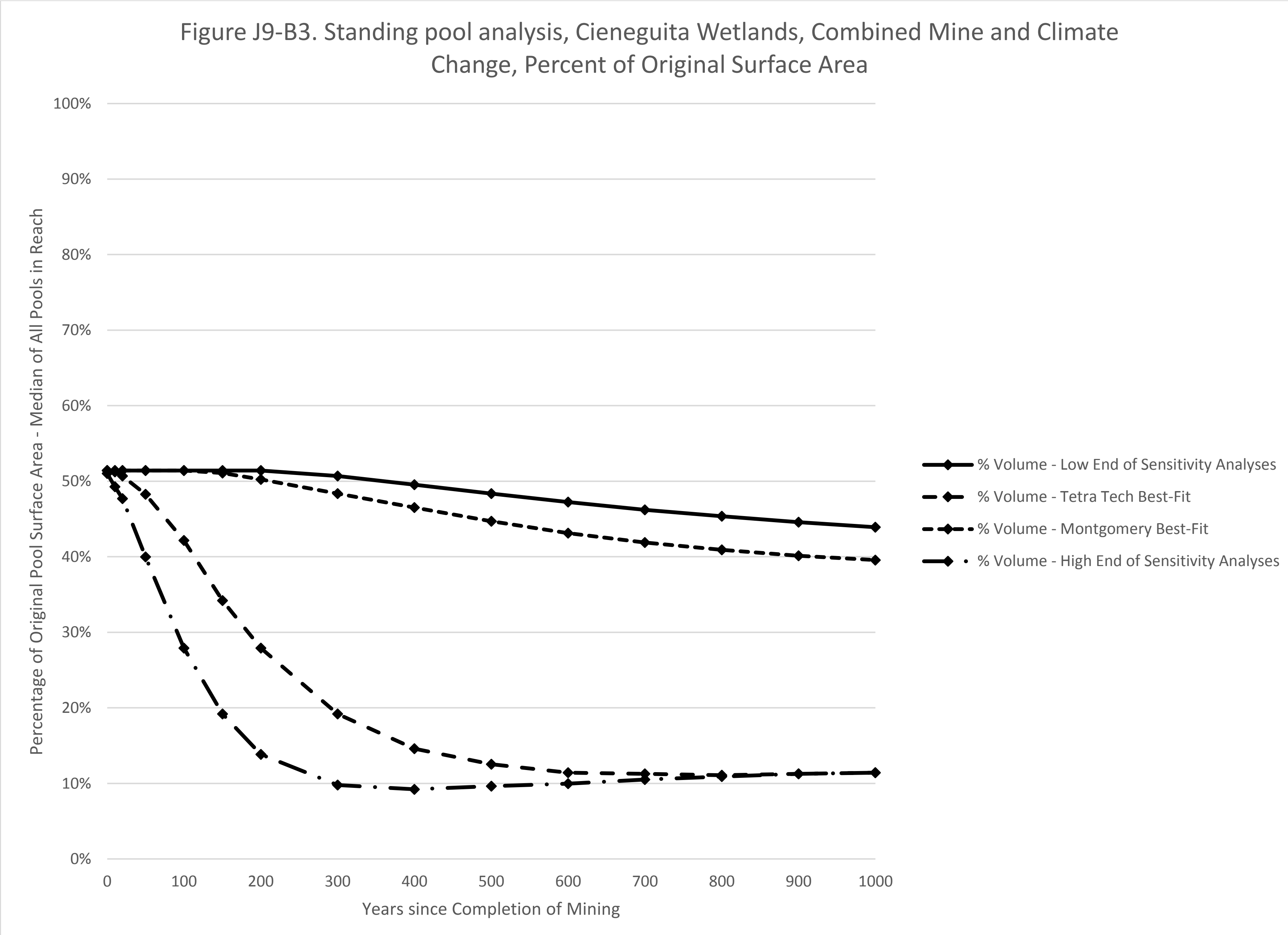
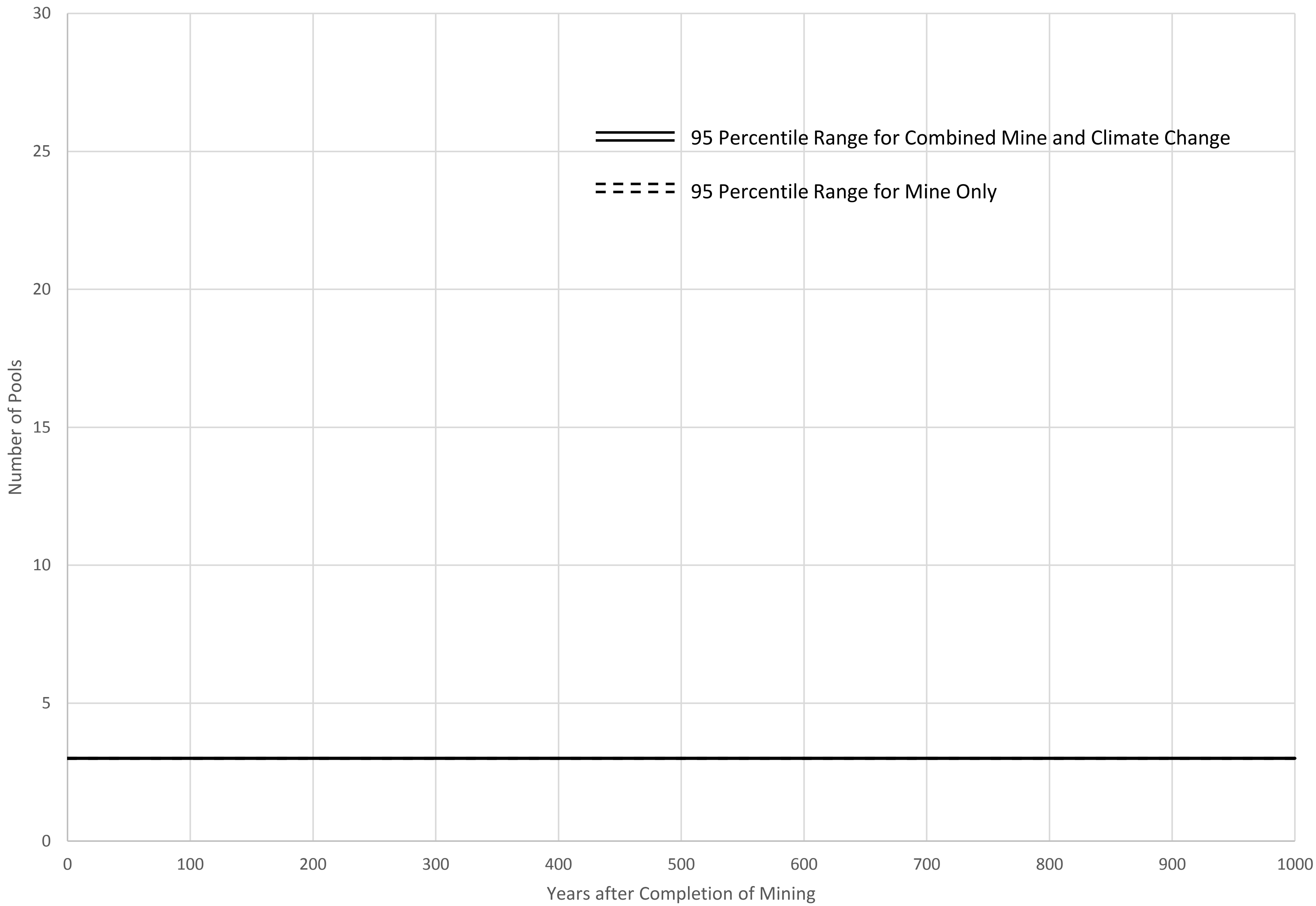


Figure J9-B3. Standing pool analysis, Cieneguita Wetlands, Combined Mine and Climate Change, Percent of Original Surface Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Surface Area - Median of All Pools in Reach
0
100
200
300
400
500
600
700
800
900
1000
Years since Completion of Mining
% Volume - Low End of Sensitivity Analyses
% Volume - Tetra Tech Best-Fit
% Volume - Montgomery Best-Fit
% Volume - High End of Sensitivity Analyses

Figure J9-C1. Standing pool analysis, Cieneguita Wetlands, 95 Percentile, Number of Pools



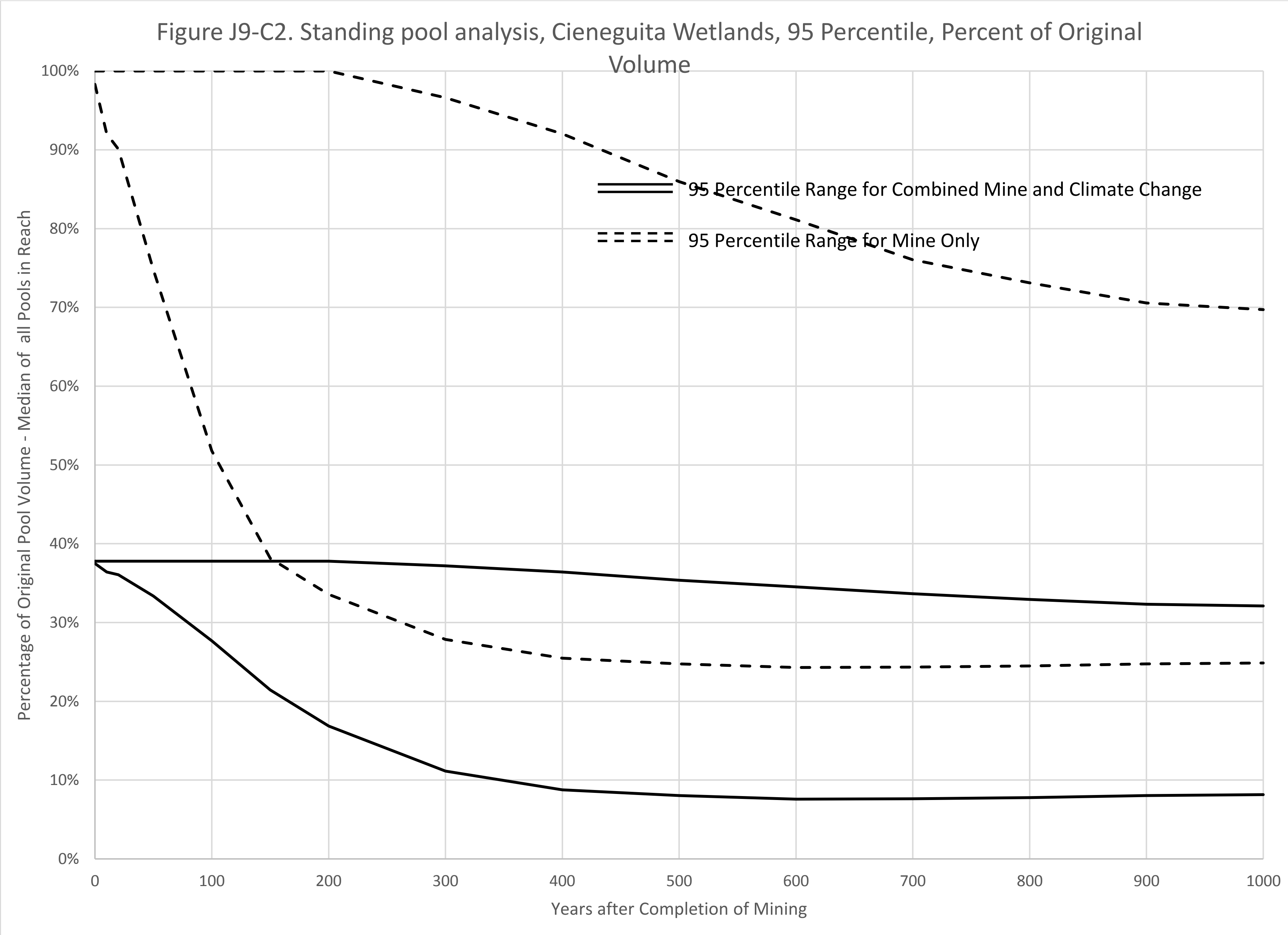


Figure J9-C2. Standing pool analysis, Cieneguita Wetlands, 95 Percentile, Percent of Original Volume
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Original Pool Volume - Median of all Pools in Reach
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
0
100
200
300
400
500
600
700
800
900
1000
Years after Completion of Mining

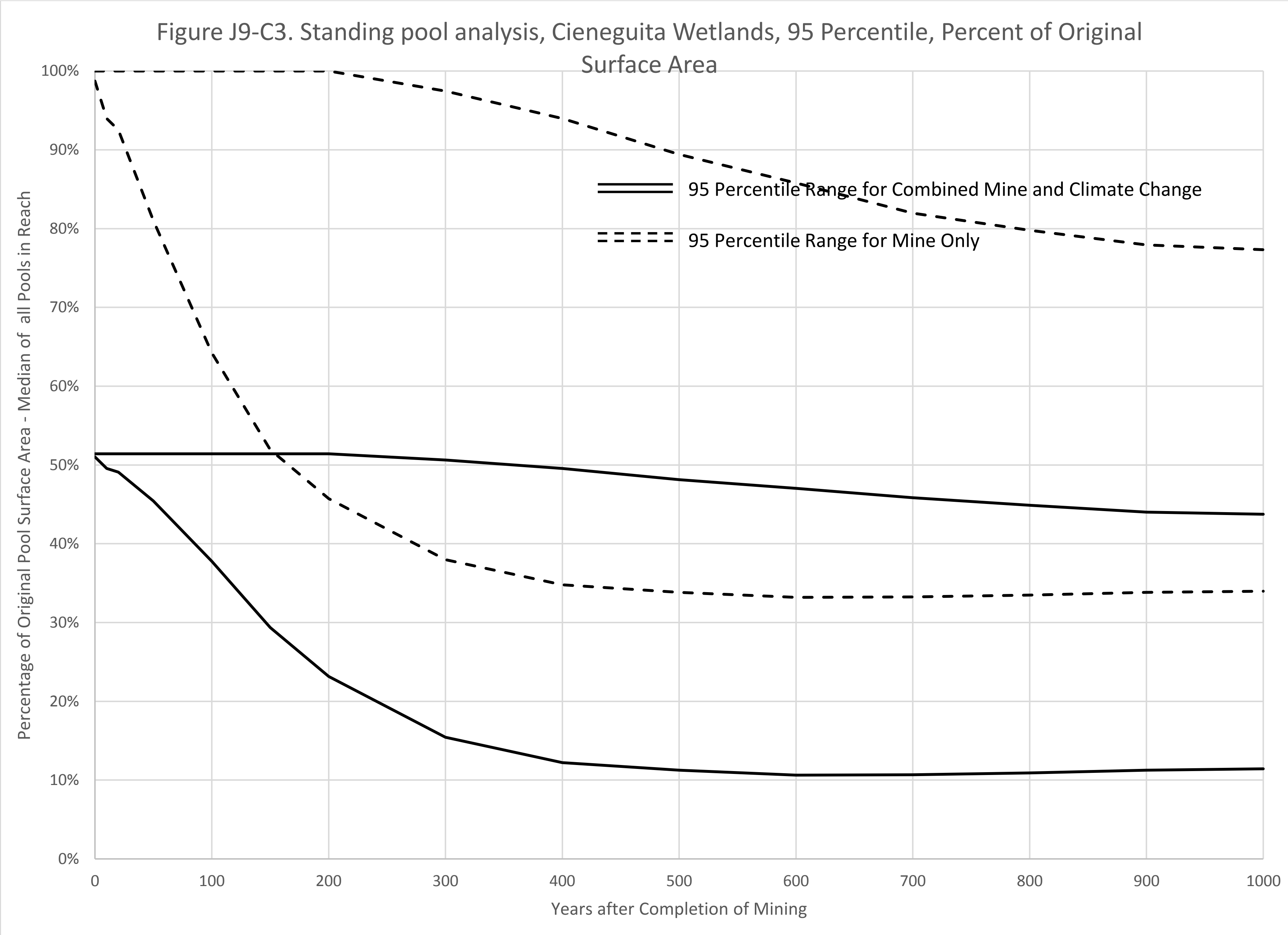


Figure J9-C3. Standing pool analysis, Cieneguita Wetlands, 95 Percentile, Percent of Original Surface Area
95 Percentile Range for Combined Mine and Climate Change
95 Percentile Range for Mine Only
Percentage of Original Pool Surface Area - Median of all Pools in Reach
Years after Completion of Mining
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0
100
200
300
400
500
600
700
800
900
1000

K. Literature Review of Vegetation Response to Drawdown

List of Figures and Tables

Tables

TABLE K1. LITERATURE REVIEW FOR CHANGES IN RIPARIAN VEGETATION BASED ON RELATIVE CHANGE IN GROUNDWATER DEPTH

Study	Vegetation Type	Parameter	Change in Water Table (feet)											Uncertainty of Correlation	Notes
			0	0.2	0.4	0.6	0.8	1	1.5	2	3	4	5		
Shafroth 2000	Cottonwood, Willow - Saplings	Stem Density (2-year % change)	33	32	31	30	29	28	26	24	19	15	10	r^2 = 0.65 p = 0.05 df = 4	1
Shafroth 2000	Cottonwood, Willow - Saplings	Basal Area (2-year % change)	363	353	343	334	324	314	290	266	218	170	121	r^2 = 0.99 p = <0.01 df = 4	2
Shafroth 2000	Tamarisk – Saplings	Stem Density (2-year % change)	194	192	190	188	186	184	179	173	163	153	143	r^2 = 0.04 p = 0.74 df = 3 CORRELATION NOT STATISTICALLY SIGNIFICANT	3
Shafroth 2000	Tamarisk - Saplings	Basal Area (2-year % change)	123	125	128	131	134	137	144	151	165	179	193	r^2 = 0.12 p = 0.56 df = 3 CORRELATION NOT STATISTICALLY SIGNIFICANT	4
Stella 2010	Cottonwood - Seedlings	Survivorship (50-day)	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	r^2 = 0.74 p = 0.07 df = 1	5
Scott 1999	Cottonwood - Mature	Survivorship (3-year)	98-100%	94% (for drawdown <0.5 meters), Not statistically different								12% (for drawdown >1 meter)		T = 1.9, P = 0.086, df = 9.8 T = 5.6, P = 0.0049, df = 4	6
Scott 1999	Cottonwood - Mature	% Change in live crown volume (3-year)	-20% to +20%	No statistical difference (for drawdown <0.5 meters)								-20% to -55% (for drawdown >1 meter)		T = 0.53, P = 0.60, df = 11.4 T = 6.37, P = 0.0025, df = 4.4	6
Scott 1999	Cottonwood - Mature	Stem increment (3 year, cm^2/tree)	50 to 220	No statistical difference (for drawdown <0.5 meters)								20 to 75 (for drawdown >1 meter)		T = 0.85, P = 0.405, df = 27 T = 3.9, P = 0.002, df = 12.5	6
Scott 1999	Cottonwood - Mature	% of pre-change branch increment (3-year)	54% to 88%	40% to 60% for drawdown <0.5 meters)								52% to 62% (for drawdown >1 meter), Not statistically different		T = 5.05, P = <0.0001, df = 25 T = 1.2, P = 0.24, df = 20	6
Scott 1999	Cottonwood - Mature	Leaf area (cm^2)	33.5 ± 1.9	31.3 ± 1.2, Not statistically different								30.0 ± 0.8, Not statistically different		P = 0.38	7
Scott 1999	Cottonwood - Mature	Average specific leaf mass (mg/cm^2)	10.6 ± 0.2	10.7 ± 0.4, Not statistically different								11.4 ± 0.4, Not statistically different		P = 0.28	7
Shafroth 1998	Cottonwood – Seedlings	Presence/Absence	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	p = 0.0143 See Note 9	8
Shafroth 1998	Willow – Seedlings	Presence/Absence	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	p = 0.0143 See Note 9	10

Table K1 – Page 1

Study	Vegetation Type	Parameter	Change in Water Table (feet)											Uncertainty of Correlation	Notes
			0	0.2	0.4	0.6	0.8	1	1.5	2	3	4	5		
Shafroth 1998	Tamarisk – Seedlings	Presence/Absence	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	p = 0.0143 See Note 9	11
Shafroth 1998	Seep Willow - Seedlings	Presence/Absence	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	p = 0.0143 See Note 9	12
Horton 2001b	Willow	Survivorship (42-day)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	Without respect to species: F = 12.890, p = 0.0008, df = 3	13
Horton 2001b	Tamarisk	Survivorship (42-day)	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	Without respect to species: F = 12.890, p = 0.0008, df = 3	13
Horton 2001b	Willow	Plant Height (mm)	19	19	19	19	19	19	19	19	19	19	19	Without respect to species: F = 15.292, p <0.0001, df = 3	13
Horton 2001b	Tamarisk	Plant Height (mm)	31	31	31	31	31	31	31	31	31	31	31	Without respect to species: F = 15.292, p <0.0001, df = 3	13
Elmore 2003	Meadow community	% Change in cover	-2%	-2.6%	-3.2%	-3.7%	-4.3%	-4.9%	-6.3%	-7.8%	-10.6%	-13.5%	-16.4%	p <0.05	14
Elmore 2003	Shrub community	% Change in cover	0%	-0.2%	-0.4%	-0.6%	-0.8%	-1.1%	-1.6%	-2.1%	-3.2%	-4.2%	-5.3%	p <0.05	15
Nilsson 2002			This paper looks at basic principles but does not provide empirical data.												
RMRS-GTR-282			This Forest service guidance document summarizes previous research and provides general response mechanisms.												
Busch 1995			This study includes most of the information needed to match plant physiological responses to groundwater depth, but the groundwater component is not clear enough to establish the relationship.												
Lite 2004			Informal publication. Not enough detail to utilize data, but very likely similar to Leenhouts 2005 and Lite 2005												
Stromberg 1997	Cottonwood, willow, tamarisk seedlings		This study was primarily related to soil moisture content and is not directly related to groundwater.												
Rains 2004	Community types		This study was a modeling exercise and did not produce empirical relationships. In addition, the community types used are not directly applicable.												
Cooper 1999	Cottonwood - seedlings		This study related seedling establishment to a variety of environmental factors (shade, competition) but not hydrologic factors.												
Capon 2003	Community Types		This study relates community responses to wetting and drying from flood flows, but not groundwater hydrology.												

Table K1 – Page 2

Common definitions of statistical parameters

r^2 = Coefficient of determination. For a linear regression, r^2 represents the percent of the variation that can be explained by the regression equation. Larger values are considered a better correlation.

r = correlation coefficient. For a linear regression, represents the relative strength and type of relationship between two variables.

T = For a comparison of two groups, the difference in the means of the two groups. Not very useful by itself.

P or p = Answers this question: "If the null hypothesis is true (i.e., there is no correlation between these two parameters or groups), what is the likelihood that we would still get this difference or result?" Lower values are considered to be better, and typically a cutoff is given for statistical significance (0.10 or 0.05 or 0.01).

Notes

1. Shafroth 2000. Statistics given in document. Slope = 14.9% reduction in stem density per meter decline in water table.
2. Shafroth 2000. Statistics given in document. Slope = 159.2% reduction in basal area per meter decline in water table.
3. Shafroth 2000. Statistics given in document. Slope = 33.9% reduction in stem density per meter decline in water table
4. Shafroth 2000. Statistics given in document. Slope = 46.8% increase in basal area per meter decline in water table
5. Stella 2010. Statistics calculated based on linear regression from values presented in document (Table 1); more sophisticated statistical model is presented in document but not utilized. Research was conducted based on rate of groundwater drawdown (cm/day). Drawdown magnitude converted to rate assuming 20 year time period; note that even at a 1 year time period, 5 feet of drawdown is still <0.5 cm/day. Slope = 8.4% reduction in survivorship for increase of 1 cm/day drawdown rate.
6. Scott 1999. Statistics shown as reported in document. Range of change estimated from graphs in document (Figure 3). Uncertainty statistics shown first for transect with <0.5 m drawdown, and second for transect with >1.0 m drawdown.
7. Scott 1999. Statistics and range shown as reported n document.
8. Shafroth 1998. Statistics given in document (Table 3). Shown are mean and standard deviation. Cottonwood Seedling Presence, Rate of water table decline = 0.1 ± 0.01 feet/day. Cottonwood Seedling Absence, Rate of water table decline = 0.4 ± 0.02 feet/day. At 20 year duration, rate of drawdown is not measurable.
9. Shafroth 1998. Cohort from 1993 showed no statistically significant correlation between of decline and presence/absence. Cohort from 1995 showed statistical significance between presence/absence and rate of decline at p = 0.0143.
10. Shafroth 1998. Statistics given in document (Table 3). Shown are mean and standard deviation. Willow Seedling Presence, Rate of water table decline = 0.09 ± 0.002 feet/day. Willow Seedling Absence, Rate of water table decline = 0.3 ± 0.026 feet/day. At 20 year duration, rate of drawdown is not measurable.
11. Shafroth 1998. Statistics given in document (Table 3). Shown are mean and standard deviation. Tamarisk Seedling Presence, Rate of water table decline = 0.11 ± 0.026 feet/day. Tamarisk Seedling Absence, Rate of water table decline = 0.31 ± 0.026 feet/day. At 20 year duration, rate of drawdown is not measurable.
12. Shafroth 1998. Statistics given in document (Table 3). Shown are mean and standard deviation. Seepwillow Seedling Presence, Rate of water table decline = 0.14 ± 0.026 feet/day. Seepwillow Seedling Absence, Rate of water table decline = 0.29 ± 0.03 feet/day. At 20 year duration, rate of drawdown is not measurable.
13. Horton 2001b. Ranges interpolated from Figure 2, statistics from Table 1. Research was conducted based on rate of groundwater drawdown (cm/day). Drawdown magnitude converted to rate assuming 20 year time period; note that even at a 1 year time period, 5 feet of drawdown is still <0.5 cm/day. Study also looked at dry weight, root length, root to shoot ratio, and leaf area.
14. Elmore 2003. Slope = 9.5% reduction in cover per meter of groundwater drawdown. Figure 6.
15. Elmore 2003. Slope = 3.5% reduction in cover per meter of groundwater drawdown. Figure 6.

TABLE K2. LITERATURE REVIEW FOR CHANGES IN RIPARIAN VEGETATION BASED ON ABSOLUTE DEPTH TO GROUNDWATER

Study	Vegetation Type	Parameter	Depth to Water (feet)																Uncertainty of Correlation	Notes
			0	0.2	0.4	0.6	0.8	1	1.5	2	3	4	5	6	7	8	9	10		
Shafroth 1998	Cottonwood – Seedlings	Presence/Absence					Presence 0.76 ± 0.26						Absence 4.9 ±0.36						p = 0.0143. See note 9.	1
Shafroth 1998	Willow – Seedlings	Presence/Absence				Presence 0.69 ± 0.17						Absence 4.1 ± 0.52							p = 0.0143. See note 9.	1
Shafroth 1998	Tamarisk – Seedlings	Presence/Absence					Presence 0.86 ± 0.23						Absence 4.49 ± 0.56						p = 0.0143. See note 9.	1
Stromberg 1996	Cottonwood – juvenile	Presence/Absence									Presence 2.97 ± 1.65 (0.66 – 6.6)								Most statistics presented in document are for DCA analysis	2
Stromberg 1996	Cottonwood – mature	Presence/Absence											Presence 4.95 ± 3.63 (0.33 – 16.83)						Most statistics presented in document are for DCA analysis	2
Stromberg 1996	Willow – juvenile	Presence/Absence					Presence 1.98 ± 1.98 (0.33 – 6.6)												Most statistics presented in document are for DCA analysis	2
Stromberg 1996	Willow – mature	Presence/Absence											Presence 4.62 ± 2.97 (0.33 – 10.56)						Most statistics presented in document are for DCA analysis	2
Stromberg 1996	Tamarisk – juvenile	Presence/Absence										Presence 4.29 ± 1.98 (0.66 – 8.25)							Most statistics presented in document are for DCA analysis	2
Stromberg 1996	Tamarisk – mature	Presence/Absence											Presence 4.62 ± 1.98 (1.32 – 8.25)						Most statistics presented in document are for DCA analysis	2
Stromberg 1996	Seepwillow	Presence/Absence										Presence 3.96 ± 2.97 (0 – 9.24)							Most statistics presented in document are for DCA analysis	2
Horton 2001a	Cottonwood	% Recent canopy dieback	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1.5%	$r^2 = 0.450$ $p < 0.001$ See Note 10.	3
Horton 2001a	Willow	% Recent canopy dieback	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.4%	0.6%	1.1%	2%	3.6%	6.4%	11%	18%	27.7%	39.1%	$r^2 = 0.544$ $p < 0.001$ See Note 11.	4
Horton 2001a	Tamarisk	% Recent canopy dieback	0%	0%	0%	0%	0%	0%	0%	0%	0.1%	0.3%	0.7%	1.7%	4.2%	9.2%	17.1%	25.6%	$r^2 = 0.463$ $p < 0.001$ See Note 12.	5
Lite 2005	Cottonwood	Basal area (m^2/ha)							GW Depth <8.25 feet = 10.46								8.25 – 11.55 feet = 13.89 11.55 – 13.2 feet = 4.34 > 13.2 feet = 0		None provided.	6
Lite 2005	Willow	Basal area (m^2/ha)							GW Depth <8.25 feet = 2.31								8.25 – 11.55 feet = 1.48 11.55 – 13.2 feet = 0.40 > 13.2 feet = 0.75		None provided.	6

Table K2 – Page 1

Study	Vegetation Type	Parameter	Depth to Water (feet)																Uncertainty of Correlation	Notes
			0	0.2	0.4	0.6	0.8	1	1.5	2	3	4	5	6	7	8	9	10		
Lite 2005	Tamarisk	Basal area (m^2/ha)							GW Depth <8.25 feet = 3.75								8.25 – 11.55 feet = 6.07 11.55 – 13.2 feet = 8.78 > 13.2 feet = 22.75		None provided.	6
Leenhouts 2005	Cottonwood	Stem Density (stems/hectare)	281	277	273	269	265	262	252	242	223	203	184	165	145	126	106	87	r = -0.78, p = 0.01 See note 13.	7
Leenhouts 2005	Willow	Stem Density (stems/hectare)	164	162	160	158	156	154	149	143	133	123	112	102	92	82	71	61	r = -0.65, p = 0.03 See note 14.	7
Leenhouts 2005	Cottonwood-Willow	Size class diversity									Unable to calculate predictive statistics								r = -0.61, p = 0.05	7
Leenhouts 2005	Cottonwood	Presence/Absence													Presence 6.9 ± 3.3					8
Leenhouts 2005	Willow	Presence/Absence												Presence 6.6 ± 4.0						8
Leenhouts 2005	Tamarisk	Presence/Absence																Presence 9.9 ± 3.3		8
Leenhouts 2005	Willow-Young (<20 cm)	Presence/Absence												Presence 5.9 ± 3.6						15
Leenhouts 2005	Willow-Mature (20-60 cm)	Presence/Absence													Presence 7.6 ± 4.3					15
Leenhouts 2005	Willow-Mature (60-90 cm)	Presence/Absence															Presence 12.2 ± 3.3			15
Leenhouts 2005	Willow-Old (>90 cm)	Presence/Absence																Presence 13.9 ±2.6		15
Leenhouts 2005	Cottonwood-Young (<20 cm)	Presence/Absence													Presence 6.6 ± 2.0					15
Leenhouts 2005	Cottonwood-Mature (20-60 cm)	Presence/Absence													Presence 6.9 ± 3.0					15
Leenhouts 2005	Cottonwood-Mature (60-90 cm)	Presence/Absence													Presence 7.3 ± 2.6					15
Leenhouts 2005	Cottonwood-Old (>90 cm)	Presence/Absence															Presence 10.6 ± 3.3			15
Leenhouts 2005	Tamarisk-Young (<6 cm)	Presence/Absence															Presence 9.6 ± 2.3			15

Table K2 – Page 2

Study	Vegetation Type	Parameter	Depth to Water (feet)																Uncertainty of Correlation	Notes
			0	0.2	0.4	0.6	0.8	1	1.5	2	3	4	5	6	7	8	9	10		
Leenhouts 2005	Tamarisk-Mature (6-20 cm)	Presence/Absence															Presence 9.9 ± 2.3			15
Leenhouts 2005	Tamarisk-Mature (20-36 cm)	Presence/Absence																Presence 13.2		15
Leenhouts 2005	Tamarisk-Old (>36 cm)	Presence/Absence																Presence 12.9 ± 0.3		15

Common definitions of statistical parameters

r^2 = Coefficient of determination. For a linear regression, r^2 represents the percent of the variation that can be explained by the regression equation. Larger values are considered a better correlation.

r = correlation coefficient. For a linear regression, represents the relative strength and type of relationship between two variables.

T = For a comparison of two groups, the difference in the means of the two groups. Not very useful by itself.

P or p = Answers this question: "If the null hypothesis is true (i.e., there is no correlation between these two parameters or groups), what is the likelihood that we would still get this difference or result?" Lower values are considered to be better, and typically a cutoff is given for statistical significance (0.10 or 0.05 or 0.01).

Notes

1. Shafroth 1998. Statistics given in document (Table 3). Shown are mean and standard deviation
2. Stromberg 1996. This study has details on many more woody and herbaceous species than are shown here. Statistics shown are mean, standard deviation, and range.
3. Horton 2001a. $y = 41.89/(1+\exp^{(-(x-3.16)/0.04)})$. Dieback threshold roughly 9.9 feet. Study also includes statistical relationships for physiological factors: predawn water potential, stomatal conductance, net photosynthetic rate, and leaf carbon isotope discrimination. Also included annual branch increment and radial growth, but no predictive statistics given.
4. Horton 2001a. $y = 76.69/(1+\exp^{(-(x-3.01)/0.50)})$. Dieback threshold roughly 8.25 feet. Study also includes statistical relationships for physiological factors: predawn water potential, stomatal conductance, net photosynthetic rate, and leaf carbon isotope discrimination. Also included annual branch increment and radial growth, but no predictive statistics given.
5. Horton 2001a. $y = 37.29/(1+\exp^{(-(x-2.78)/0.32)})$. Dieback threshold roughly 6.6 – 9.9 feet. Study also includes statistical relationships for physiological factors: predawn water potential, stomatal conductance, net photosynthetic rate, and leaf carbon isotope discrimination. Also included annual branch increment and radial growth, but no predictive statistics given.
6. Lite 2005. Most predictive statistics in this report are based on "importance". Threshold for cottonwood/willow dominance over tamarisk = 8.58 feet. Numbers shown are range of groundwater depths vs. mean basal area
7. Leenhouts 2005. Report is extensive but largely only provides correlation statistics, not predictive or regression statistics. From available data, predictive statistics were calculated for stem density. Was not able to calculate statistics for size class diversity. Note that there are also correlations of basal area and stem density with streamflow permanence.
8. Leenhouts 2005. Mean and one standard deviation shown. From Figure 29A.
9. Shafroth 1998. Cohort from 1993 showed no statistically significant correlation between water table depth and presence/absence. Cohort from 1995 showed statistical significance between presence/absence and groundwater depth at $p = 0.0143$.
10. Horton 2001a. Statistics shown for 1997 cohort. Cohort for 1998 not statistically significant at $p < 0.05$
11. Horton 2001a. Statistics shown for 1997 cohort. Cohort for 1998 not statistically significant at $p < 0.05$
12. Horton 2001a. Statistics shown for both 1997 and 1998 cohorts.13
13. Leenhouts 2005. Calculated predictive regression: $y=-64x+281$
14. Leenhouts 2005. Calculated predictive regression: $y=-34x+164$
15. Leenhouts 2005. Mean and one standard deviation shown. From Figure 29B.

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TABLE K3. LITERATURE REVIEW FOR CHANGES IN RIPARIAN VEGETATION BASED ON STREAMFLOW PERMANENCE

Study	Vegetation Type	Parameter	Streamflow Permanence (Percent of Time)										Uncertainty of Correlation	Notes
			0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100		
Lite 2005	Cottonwood	Basal area (m2/ha)				25-49% 1.55			50-75% 6.73		76-99% 13.60	100% 14.32	p = 0.002	1
Lite 2005	Willow	Basal area (m2/ha)				25-49% 0.43			50-75% 0.28		76-99% 2.78	100% 2.36	p = 0.04	1
Lite 2005	Tamarisk	Basal area (m2/ha)				25-49% 9.76			50-75% 8.84		76-99% 2.87	100% 3.11	p = 0.06	1
Leenhouts 2005	Willow	Stem Density (per hectare)	Raw data provided in appendix, but could not replicate regression statistics.										p = 0.02 r = 0.65	2
Leenhouts 2005	Tamarisk	Stem Density (per hectare)	Raw data provided in appendix, but could not replicate regression statistics.										p = 0.01 r = -0.73	2
Leenhouts 2005	Cottonwood	Basal area (m2/ha)	Correlation only reported. No raw data provided to replicate regression statistics.										p = 0.08 r = 0.53	2
Leenhouts 2005	Willow	Basal area (m2/ha)	Correlation only reported. No raw data provided to replicate regression statistics.										p = 0.08 r = 0.53	2
Leenhouts 2005	Tamarisk	Basal area (m2/ha)	Correlation only reported. No raw data provided to replicate regression statistics.										p = 0.01 r = -0.77	2
Leenhouts 2005	All	Max Vegetation Height	Intermittent-Dry 13 ± 0.5						Intermittent-Wet 21 ± 4			Perennial 23 ± 3		3
Leenhouts 2005	Cottonwood-Willow	Number of Stem Size Classes	Intermittent-Dry 4 ± 1						Intermittent-Wet 6 ± 1.6			Perennial 6.5 ± 1.7		4

<u>Common definitions of statistical parameters</u>

r^2 = Coefficient of determination. For a linear regression, r^2 represents the percent of the variation that can be explained by the regression equation. Larger values are considered a better correlation.

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<u>Notes</u>

1. Lite 2005. Uncertainty statistics are given for regression analysis, but predictive regression equations were not provided. Some predictive graphs provided for tamarisk "importance" parameter.
2. Leenhouts 2005. Document primarily provides correlation statistics, but not predictive regression equations. Document also includes detailed analysis of herbaceous cover correlation with streamflow permanence.
3. Leenhouts 2005. Estimated from Figure 21. Perennial = Flow 100% of year; Intermittent-Wet = Flow 60-99% of year; Intermittent-Dry = Flow <60% of year.
4. Leenhouts 2005. Estimated from Figure 30. Perennial = Flow 100% of year; Intermittent-Wet = Flow 60-99% of year; Intermittent-Dry = Flow <60% of year.