Total Maximum Daily Load for Copper in Pinto Creek, Arizona

U.S. Environmental Protection Agency
Region 9

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Approved by:

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LIST OF ACRONYMS AND ABBREVIATIONS

%	percent
mg/L	milligrams per liter, equivalent to parts per million
µg/L	micrograms per liter, equivalent to parts per billion
kg/day	kilograms per day (1 kg/day = 2.2 pounds/day)
A.A.C	Arizona Administrative Code
A&Ww	Aquatic and Wildlife, warm water
ADEQ	Arizona Department of Environmental Quality
AgI	Agricultural Irrigation
AgL	Agricultural Livestock Watering
CFR	Code of Federal Regulations
CN	Curve Number
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FBC	Full Body Contact
FC	Fish Consumption
HEC	United States Army Corps of Engineers, Hydrologic Engineering Center
LA	Load Allocation
MDL	Method Detection Limit
MWMT	Meteoric Water Mobility Test
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System

NRCS	Natural Resource Conservation Service; formerly Soil Conservation Service
PCDOT&FCD	Pima County Department of Transportation and Flood Control District
SCS	Soil Conservation Service
SX/EW	Solvent Extraction/Electrowinning
TMDL	Total Maximum Daily Load
TS	Target Site
USFS	United States Forest Service
WLA	Wasteload Allocation

1.0 EXECUTIVE SUMMARY

The Pinto Creek watershed contains areas of known natural copper mineralization that have been exploited by past and present mining activities. These activities have created point and non-point pollution sources that potentially contribute copper to the creek and its tributaries. Natural mineralization also contributes copper loadings to the basin. Pinto Creek has been listed by the State of Arizona under Section 303(d) of the Clean Water Act for non-attainment of the water quality standard for dissolved copper. Consequently, the U.S. Environmental Protection Agency (EPA), with the support of the Arizona Department of Environmental Quality (ADEQ), is establishing this Total Daily Maximum Load (TMDL) to address this non-attainment.

This document describes the TMDL, supporting analysis, and information compiled and analyzed to develop the TMDL, including: applicable water quality standards, available water quality data, calculation methods, legal and policy considerations, and implementation mechanisms. The proposed TMDL establishes target sites, loading capacities, background conditions, load allocations (LAs), wasteload allocations (WLAs), and a margin of safety in accordance with federal regulations (40 CFR 130).

1.1 Water Quality Standards

The TMDL is established to define goals for the watershed that are necessary to achieve the applicable water quality criteria for dissolved copper in surface waters of Pinto Creek. The State of Arizona has established numeric water quality criteria to protect the designated uses described above for Pinto Creek. For dissolved copper, the water quality criterion established to protect wildlife and warm water aquatic life (A&Ww) from chronic exposure effects is the most stringent criterion that applies to the waters of Pinto Creek.

The acute and chronic A&Ww criteria for dissolved copper are hardness-based. This is because toxicity to aquatic biota decreases with increasing hardness. Based on available water quality data in the Pinto Creek watershed, EPA used a hardness level of 400 mg/L for calculating the TMDL elements. Based on this hardness level, the TMDL is designed to achieve the applicable water quality standards for dissolved copper. These standards are presented in Table 1-1.

1.2 Target Sites

Nine target sites or locations were chosen in the Pinto Creek watershed to establish loading capacities in the creek and to provide the basis for allocations to copper loading sources, background sources, and margin of safety. These target sites were defined based on the locations of known and proposed facilities, potential sources of copper loading, the locations of currently established monitoring points, and the locations of confluences of major tributaries. The TMDL has been developed to ensure compliance with water quality criteria at each of these target sites. A description of target sites established by the TMDL is provided in Table 1-2.

Table 1-1. Arizona Water Quality Criteria for Copper in Pinto Creek

Designated Use Classification	Hardness-Dependent Criteria for Dissolved Copper (μg/L)
	Criterion at Hardness of 400 mg/L
A&Ww-acute	65.4
A&Ww-chronic	38.7

Table 1-2. Target Sites for Allocation of Loading Capacity

Target Site (TS) Designation	Description of Location
TS-1	Pinto Creek immediately above the confluence with the Gibson Mine tributary
TS-2	Pinto Creek immediately below the confluence with the Gibson Mine tributary
TS-3	Pinto Creek above the Cactus Breccia Formation; Location of BHP monitoring site AMP-2.
TS-4	Pinto Creek below the Cactus Breccia Formation; Location of BHP monitoring site AMP-3.
TS-5	Pinto Creek immediately above the confluence with Haunted Canyon.
TS-6	Powers Gulch immediately above the confluence with Haunted Canyon**;** Location of current Carlota Copper monitoring location PG-4.
TS-7	Haunted Canyon immediately above the confluence with Pinto Creek.
TS-8	Pinto Creek immediately below the confluence with Haunted Canyon.
TS-9	Pinto Creek at the Pinto Valley Weir.

1.3 Stream Discharge Estimation

The term “stream discharge” refers to the volume of water per unit time that is flowing in a stream and it is commonly measured using units of cubic feet per second (cfs). Stream discharge is sometimes referred to as “stream flow”. For the purposes of this document, the term “stream discharge” will be used throughout and it is considered synonymous with the term “stream flow”.

The Pinto Creek watershed is composed of several drainages that are intermittent and/or ephemeral and that generally flow only in direct response to precipitation events. Because of the ephemeral and intermittent properties of the drainages in this watershed, detailed data characterizing rainfall/runoff relationships in the Pinto Creek watershed are not available. For these reasons, a HEC-1 (U.S. Army Corps of Engineers, Hydrologic Engineering Center) rainfall-runoff model was developed for the Pinto Creek watershed to estimate stream discharge at the established target sites in the drainage. This model allows stream discharges to be estimated for different frequencies and magnitudes of precipitation events. Estimated stream discharges were then used to establish loading capacities (i.e., the TMDLs), background loads, LAs, and WLAs, at established target sites. These are referred to as “TMDL Elements”.

1.4 TMDL Elements

TMDL elements were calculated based on analysis of existing and anticipated future loading sources, including facilities associated with the proposed Carlota Copper Project. Table 1-3 lists the total loading capacity, natural background loading, margin of safety, and capacity available for allocation at each target site.

1.5 Loading Capacity (LC), Load Allocations (LAs) and Wasteload Allocations (WLAs)

The Loading Capacity is the greatest amount of pollutant loading that a water can receive without violating water quality standards, and the TMDL must be set at a level equal to or less than the loading capacity. A LA is the portion of the loading capacity that is allocated to non-point sources. A WLA is the portion of the loading capacity that is allocated to point sources. The total loading capacity at each target site is calculated by multiplying the stream discharge (calculated by the HEC-1 model) by the water quality criterion concentration and a conversion factor to convert the value to units of kilograms per day. Loading capacities, background loads, LAs, and WLAs for the TMDL are based on five flow tiers applied at each target site. EPA established these tiers at each target site using the maximum 6-hour average stream discharge that would result from each of four precipitation events being applied to the entire watershed. These flow tiers are:

1. Less than the 2-year, 1-hour storm event;
2. 2-year, 1-hour storm to 10-year, 1-hour storm event;
3. 10-year, 1-hour storm to 10-year, 24-hour storm event;
4. 10-year, 24-hour storm to 100-year, 24-hour storm event;
5. Greater than the 100-year, 24-hour storm event.

The loading capacity for each flow tier is established at the lower discharge value for the tier. An exception is the first flow tier which represents conditions ranging from no stream discharge (zero flow) to the discharge that would result from the 2-year, 1-hour storm event. For this flow tier, mass loading capacities were not used for allocations. Rather, allocations in this flow tier are established so that each source meets applicable acute and chronic water quality criteria. In addition, WLAs for a few BHP stormwater discharge outfalls and for the Carlotta wellfield outfall are established on a concentration basis such that the discharge must meet applicable acute and chronic water quality criteria. The LAs and WLAs for each identified source in the Pinto Creek Watershed are listed in Table 1-4 for each flow tier.

Table 1-3. TMDL Elements for Dissolved Copper by Target Site

Target Site	Storm Event	Stream Discharge [1] (cfs)	Total Loading Capacity [2] (kg/day)	Background [3] (kg/day)	Previously Allocated Capacity [4] (kg/day)	Net Available Capacity (kg/day)	Margin of Safety[5] (kg/day)	Capacity Available for Allocation (kg/day)
TS-1	< 2-Year, 1-Hour	0-73	Note 6			Note 6		Note 6
	2-Year, 1-Hour	74	7.08	5.88	0.00	1.20	0.12	1.08
	10-Year, 1-Hour	202	19.14	16.01	0.00	3.13	0.31	2.82
	10-Year, 24-Hour	1037	98.31	82.45	0.00	15.86	1.59	14.27
	100-Year, 24-hour	1740	164.97	138.35	0.00	26.62	2.66	23.96
TS-2	< 2-Year, 1-Hour	0-78	Note 6			Note 6		Note 6
	2-Year, 1-Hour	79	7.48	6.27	0.42	0.79	0.08	0.71
	10-Year, 1-Hour	217	20.48	17.26	1.11	2.11	0.21	
	10-Year, 24-Hour	1109	105.14	88.70	5.72	10.72	1.07	9.65
	100-Year, 24-hour	1863	176.64	148.14	9.59	18.91	1.89	17.02
TS-3	< 2-Year, 1-Hour	0-234	Note 6			Note 6		Note 6
	2-Year, 1-Hour	235	22.30	18.69	1.20	2.41	0.24	2.17
	10-Year, 1-Hour	610	57.85	48.49	3.32	6.04	0.60	5.44
	10-Year, 24-Hour	2952	279.89	234.72	16.97	28.20	2.82	25.38
	100-Year, 24-hour	4913	465.82	390.65	28.50	46.67	4.67	42.00
TS-4	< 2-Year, 1-Hour	0-238	Note 6			Note 6		Note 6
	2-Year, 1-Hour	239	22.65	19.01	3.61	1.03	0.003	0.027
	10-Year, 1-Hour	624	59.15	49.63	9.33	0.19	0.02	0.17
	10-Year, 24-Hour	3015	285.87	239.72	45.18	0.97	0.10	0.87
	100-Year, 24-hour	5021	476.06	399.23	75.21	1.62	0.16	1.46

Table 1-3. TMDL Elements for Dissolved Copper by Target Site

Target Site	Storm Event	Stream Discharge [1] (cfs)	Total Loading Capacity [2] (kg/day)	Background [3] (kg/day)	Previously Allocated Capacity [4] (kg/day)	Net Available Capacity (kg/day)	Margin of Safety[5] (kg/day)	Capacity Available for Allocation (kg/day)
TS-5	< 2-Year, 1-Hour	0-259	Note 6			Note 6		Note 6
	2-Year, 1-Hour	260	24.67	20.67	3.61	0.39	0.08	0.31
	10-Year, 1-Hour	683	64.77	54.31	9.36	1.10	0.20	0.90
	10-Year, 24-Hour	3346	317.27	266.05	45.27	5.95	1.19	4.76
	100-Year, 24-hour	5581	529.17	443.76	75.37	10.04	2.01	8.03
TS-6	< 2-Year, 1-Hour	0-176	Note 6			Note 6		Note 6
	2-Year, 1-Hour	177	16.77	14.07	0.00	2.70	0.54	2.16
	10-Year, 1-Hour	367	34.81	29.19	0.00	5.62	1.12	4.50
	10-Year, 24-Hour	1337	126.78	106.31	0.00	20.47	4.09	16.38
	100-Year, 24-hour	2106	199.68	167.44	0.00	32.24	6.45	25.79
TS-7	< 2-Year, 1-Hour	0-382	Note 6			Note 6		Note 6
	2-Year, 1-Hour	383	36.30	30.45	0.26	5.59	1.12	4.47
	10-Year, 1-Hour	919	87.13	73.06	0.55	13.52	2.70	10.82
	10-Year, 24-Hour	4086	387.43	324.87	20.48	42.08	8.42	33.66
	100-Year, 24-hour	6721	637.26	534.40	32.24	70.62	14.12	56.50
TS-8	< 2-Year, 1-Hour	0-639	Note 6			Note 6		Note 6
	2-Year, 1-Hour	640	60.68	51.12	4.49	5.07	1.01	4.06
	10-Year, 1-Hour	1600	151.71	127.37	11.70	12.64	2.53	10.11
	10-Year, 24-Hour	7420	703.53	590.92	70.56	42.05	8.41	33.64
	100-Year, 24-hour	12,287	1165.00	978.15	124.71	62.14	12.43	49.71

Table 1-3. TMDL Elements for Dissolved Copper by Target Site

Target Site	Storm Event	Stream Discharge [1] (cfs)	Total Loading Capacity [2] (kg/day)	Background [3] (kg/day)	Previously Allocated Capacity [4] (kg/day)	Net Available Capacity (kg/day)	Margin of Safety[5] (kg/day)	Capacity Available for Allocation (kg/day)
TS-9	< 2-Year, 1-Hour	0-1914	Note 6			Note 6		Note 6
	2-Year, 1-Hour	1915	181.58	152.49	4.97	24.12	4.82	19.30
	10-Year, 1-Hour	4667	442.52	371.25	12.68	58.59	11.72	46.87
	10-Year, 24-Hour	20,786	1970.83	1653.67	74.75	242.41	48.48	193.93
	100-Year, 24-hour	34,144	3237.39	2716.03	130.65	390.71	78.14	312.57

[1] Maximum 6-hour Average stream discharge estimated by the HEC-1 Model for the target site..

[2] Loading Capacity is calculated from the Chronic Water Quality Standard using a hardness value of 400 mg/l CaCO3 and the lowest flow associated with the flow tier.

[3] For Target Sites TS-1 through TS-5, background computed from ½ MDL for analyses at station METF-1 (MDL = 0.02 mg/L) = 0.01 mg/L; for Target Sites TS-6 and TS-7, background computed from ½ MDL for analyses at station PG-4 (MDL = 0.02 mg/L) = 0.01 mg/L; for Target Sites TS-8 background computed by summing background loads from TS-7 and from TS-5; for Target Site TS-9, background computed by summing background loads from TS-8 and combining with the computed background load for the reach between TS-8 and TS-9 using the 0.01 mg/L value.

[4] Based on allocations made to sources at upstream target sites; value represents the running sum of previous allocations made for margin of safety, LAs, and WLAs (See Tables C-2 through C-10).

[5] A 10 percent margin of safety (MOS) is provided in the calculation of the TMDLs and associated allocations for target sites TS-1 through TS-4. A 20% MOS is provided in the calculation of the TMDLs and associated allocations for target sites TS-5 through TS-9. See the Margin of Safety discussion in Section 8.7 for a description of the basis for these margin of safety allowances.

[6] The loading capacity , net available capacity, and capacity available for allocation for the lowest flow tier are articulated on a concentration basis rather than a mass loading basis. The loading capacity and associated capacity available for allocation for this tier are equal to the concentration based water quality standard for chronic and acute exposures to copper. Because these acute and chronic water quality standards are expressed as a function of receiving water hardness, they are expressed here in the same functional form. Specifically, the loading capacity, net available capacity, and capacity available for allocation for the lowest flow tier for each target site equal:

Acute criterion = $e^{(0.9422\,[\ln(\text{hardness})]\,-\,1.464)}$

Chronic criterion = $e^{(0.8545\,[\ln(\text{hardness})]\,-\,1.465)}$

Table 1-4. Dissolved Copper Load Allocations (LAs) and Wasteload Allocations (WLAs) by Flow Tier (kg/day except where noted)

		< 2-Year, 1-Hour Storm Event	2-Year, 1-Hour Storm Event	10-Year, 1-Hour Storm Event	10-Year, 24-Hour Storm Event	100-Year, 24-Hour Storm Event
TS-1	Henderson Ranch Mines LA	Note 1	0.29	0.81	4.13	6.92
TS-2	Gibson Mine LA	Note 1	0.71	1.90	9.65	17.02
TS-3	BHP NPDES 005 WLA	Note 1	0.012	0.012	0.012	0.012
	BHP NPDES Outfalls 001-004 WLAs[2]	0.0	0.0	0.0	0.0	Note 1
	BHP NPDES MSGP[3] Stormwater Outfalls WLAs	Note 1	Note 1	Note 1	Note 1	Note 1
	Collective Undesignated Mine Sources LA	Note 1	2.16	5.43	25.37	41.99
TS-4	Carlotta- Cactus Breccia Formation WLA	0.0	0.0	0.0	0.0	0.0
TS-5	Miller Spring Gulch LA	Note 1	0.003	0.003	0.003	0.003
	Carlota Main Dump Outfall WLA	0.0	0.0	0.0	0.0	1.00
TS-6	Carlota Eder Dump - 2 Outfalls WLAs	0.0	0.0	0.0	1.89	2.97
	Carlota Main Dump - 4 Outfalls WLAs	0.0	0.0	0.0	3.78	5.95
TS-7	Carlotta Wellfield Outfall 008	Note 1	Note 1	Note 1	Note 1	Note 1
TS-8	No Sources Identified	0.0	0.0	0.0	0.0	0.0
TS-9	Gold Gulch Weir	0.008	0.008	0.008	0.008	0.008
	South Ripper Spring	0.0004	0.0004	0.0004	0.0004	0.0004
	North Ripper Spring	0.0007	0.0007	0.0007	0.0007	0.0007

[1] Where noted, the wasteload and load allocations are equal to the concentration based water quality standards for chronic and acute exposures to copper. These concentration-based allocations apply to most sources at the lowest flow tier, and in all flow tiers for two discharge sources: the Carlotta Mine wellfield outfall (designated 008 in the permit) and the BHP facility stormwater outfalls (designated 001,

002, 003, and 004 in the existing permit). Because these acute and chronic water quality standards are expressed as a function of receiving water hardness, they are expressed here in the same functional form. Specifically, waste load allocations equal:

Acute criterion = $e^{(0.9422\ [\ln(\text{hardness})]\ -\ 1.464)}$

Chronic criterion = $e^{(0.8545\ [\ln(\text{hardness})]\ -\ 1.465)}$

[2] BHP outfalls designated 001, 002, 003, and 005 in BHP's individual NPDES permit refer to discharge points downstream from process facilities which are designed not to discharge except in response to flows associated with a 100-Year, 24-Hour storm. The WLAs are expressed in the functional form described in Note 1 because insufficient information was available for this analysis to characterized the expected copper loads associated discharges from these outfalls. The WLAs for these outfalls are reported in the TS-3 target site area because we believe these outfalls discharge to this area; however, the WLAs will still apply if it is determined that the discharge locations actually fall in other target site areas.

[3] BHP has 8 stormwater outfalls which are not associated with mining process areas and which are covered by the Arizona NPDES Multi-sector General Permit for stormwater discharges. Insufficient information was available for this TMDL to accurately determine the locations of these outfalls in relation to the target site areas. The WLAs are expressed in the functional form described in Note 1 because insufficient information was available for this analysis to characterized the expected copper loads associated discharges from these outfalls. The WLAs for these outfalls are reported in the TS-3 target site area because we believe these outfalls discharge to this area; however, the WLAs will still apply if it is determined that the discharge locations actually fall in other target site areas.

2.0 INTRODUCTION

Pinto Creek is a stream with ephemeral, intermittent, and some perennial reaches that generally flows only in direct response to precipitation events. The creek drains an area of about 178.2 square miles in Gila and Pinal Counties, central Arizona (USFS, 1997). From its source in the Pinal Mountains south of the town of Miami, the stream flows approximately 32 miles northward, discharging into Lake Roosevelt, an artificial impoundment constructed along the Salt River. Lake Roosevelt serves as a source of drinking and irrigation water for portions of central Arizona, including the Phoenix metropolitan area.

The Pinto Creek watershed contains areas of known natural copper mineralization that have been exploited by past and present mining activities. These activities have created point and non-point pollution sources that contribute dissolved copper to Pinto Creek. Natural mineralization also contributes copper loadings to the basin. Mining disturbances have included exploration, open pit and underground mining, waste rock disposal, dump leaching, ore milling and processing, and tailings disposal (USFS, 1997). Past mining activities have included the Gibson mine, Black Bess mine, Swede Mine, Henderson mine, Yo Tambien tunnel, and old Carlota mine, as well as numerous other exploratory tunnels and mine workings. At present, only the BHP Pinto Valley Mine is active in the area. BHP ceased ore extraction at Pinto Valley in February 1998 and recently announced that all mining activities will be suspended.

Proposed new activities include the Carlota Copper Project, a proposed copper mine that would be located in the Pinto Creek watershed. A detailed description and evaluation of environmental impacts is provided in the Final EIS for the Carlota Copper Project (USFS, 1997). EPA Region 9 issued a National Pollutant Discharge Elimination System (NPDES) Permit and Fact Sheet for this project in July, 2000 that describes the conditions under which discharges would occur to Pinto Creek and its tributary, Powers Gulch, the expected quality of these discharges, and the anticipated discharge volume.

Pinto Creek was listed by the State of Arizona on its 1998 Clean Water Act Section 303(d) list for non-attainment of the water quality standard for dissolved copper. Total Maximum Daily Loads (TMDLs) must be developed for all waters listed on the Section 303(d) list. Consequently, EPA, with ADEQ's support and assistance, is adopting this proposed TMDL to address this non-attainment. Most of the analysis supporting the TMDL was developed by SAIC, based on technical direction from EPA.

This document identifies required TMDL elements and describes the information compiled and analyzed to develop the TMDL, including the following: applicable water quality standards, available water quality data, calculation methods, legal and policy considerations, and implementation mechanisms. The proposed TMDL establishes loading capacities, background conditions, load allocations (LAs), wasteload allocations (WLAs), and a margin of safety in accordance with federal regulations (40 CFR 130). The TMDL analysis also considers seasonal variations as required by the Clean Water Act.

Data tables and figures discussed within the text are provided separately in Appendix A of this document. A glossary of terms is provided in Section 11.0.

EPA and ADEQ have provided several opportunities for the public to participate in the TMDL process for Pinto Creek, and these activities are ongoing by ADEQ. Two public meetings have been held to discuss the TMDL. EPA and ADEQ advertised the availability of the proposed TMDL for public review in a local newspaper, and provided a 60 day comment period during which the public could submit formal comments. EPA carefully considered the detailed written comments submitted by the public, and has prepared a responsiveness summary describing the comments and EPA's responses to them (including identification of changes in the TMDL made in response to public comment). ADEQ is continuing to collect data in the Pinto Creek watershed and may develop a revised second phase TMDL if warranted in the future.

3.0 SCOPE OF THE TMDL

3.1 Geographic Scope

The TMDL addresses the entire Pinto Creek watershed, from the headwaters in the Pinal Mountains to Roosevelt Lake, which is located on the Salt River. Pinto Creek is currently attaining State water quality standards for copper in the reach downstream of Pinto Valley Weir to Roosevelt Lake; therefore, specific TMDLs and allocations are established only for the reaches upstream of the Pinto Valley Weir.

The watershed is composed of several drainages that are intermittent or ephemeral and generally flow only in direct response to precipitation events. Perennial reaches occur in this watershed where stream alluvium thins above bedrock constrictions. These reaches terminate where surface flow infiltrates into stream alluvium. The channels are mountain streams with relatively steep slopes and coarse bed materials. Major tributaries to Pinto Creek include Powers Gulch, Haunted Canyon, West Fork of Pinto Creek, Horrell Creek, and Willow Spring Creek. Each major tributary has many named and unnamed smaller tributaries. Figure 3-1 (Appendix A) presents a map of major drainages in the Pinto Creek watershed. A detailed description of the watershed and its associated major tributaries is provided in Section 4.0.

3.2 Pollutant Parameters

The TMDL is established for copper in the dissolved form in the surface waters of Pinto Creek. Pinto Creek from its headwaters to Roosevelt Lake is listed as "water quality limited" by the State of Arizona according to provisions of the Clean Water Act Section 303(d). ADEQ cited the stream for non-attainment of the Aquatic and Wildlife warm water (A&Ww) standard for dissolved copper due to mining activities in the watershed (ADEQ, 1998a; 1998b). A portion of Pinto Creek from its headwaters to Spring Creek was first listed in 1992 (ADEQ, 1992) based on elevated copper concentrations and pH values that were related to discharges from the Pinto

Valley and Gibson Mines. The remaining portions of the stream were added to the 303(d) list in 1994 (ADEQ, 1994). Monitoring data cited in the 1994 listing include an investigation of a 1993 tailings spill at the BHP Pinto Valley Mine by Hargis and Associates (1993), three Gibson Mine investigations, and a cooperative EPA/ADEQ investigation conducted as part of the "Copper Mine Initiative." Subsequent listings cite the same data sources (ADEQ, 1998b). Pinto Creek was listed under Section 303(d) by ADEQ because it met the following established criteria (ADEQ, 1998):

> "The water body was assessed as being in "non-support" of designated use(s) based on Arizona's numeric surface water standards and assessment criteria; **and** sufficient monitoring existed to be classified as a "monitored assessment"; **and** the standard was exceeded more than once."

4.0 THE PHYSICAL CHARACTERISTICS OF THE PINTO CREEK WATERSHED

Pinto Creek drains an area of approximately 178.2 square miles from its headwaters in the Pinal Mountains to its point of discharge into Roosevelt Lake (USFS, 1997). The upper reaches of Pinto Creek are ephemeral. However, the stream flows perennially in three reaches: from the confluence with Miller Gulch to a point downstream of the Haunted Canyon confluence; from a point below the Iron Bridge to a point above the West Fork of Pinto Creek confluence; and from the Pinto Valley weir to a point upstream from the Blevens Wash confluence (USFS, 1997; BHP, 1998a). In general, perennial reaches in this watershed occur where stream alluvium thins above bedrock constrictions. These reaches terminate where surface flow infiltrates into stream alluvium.

Eight tributary drainages comprise the Pinto Creek watershed (Figure 3-1). The contributing area of each tributary basin is shown in Table 4-1. The character of Pinto Creek changes significantly along the stream course. In its upper reaches, Pinto Creek and its tributaries have the characteristics of mountain stream channels, with relatively steep gradients and coarse bed material. In these areas, the stream is enclosed by steep, rugged terrain possessing only a thin soil cover. The stream channel, which generally has only a small flood plain, is underlain by a thin alluvial cover. Pinto Creek transitions to flatter gradients, with wider flood plains as it continues toward Roosevelt Lake. The Powers Gulch and Haunted Canyon tributaries, which are similar to the upper reaches of Pinto Creek, also are mountain streams with relatively steep slopes and coarse bed materials. In many reaches, channel morphology is controlled by bedrock exposures.

5.0 MINING HISTORY OF THE PINTO CREEK AREA

Pinto Creek flows across the western margin of the historic Globe-Miami mining district, one of the major porphyry copper districts in the southwestern United States. Mining activities in the district include active open-pit copper operations, several historic open-pit and underground operations, and hundreds of smaller adits, shafts and prospects. Most of these operations are located in the Pinal Creek drainage east of the Pinto Creek watershed. In addition to copper, the district has produced gold, silver, molybdenum, lead and zinc either as primary commodities or as by-products of copper production (Peterson, 1962).

According to Peterson (1962), the first claims were located in the Globe-Miami district in 1874. In general, early exploration and production centered on small vein deposits of gold and silver scattered throughout the region. Significant copper production began in 1882 when mining was initiated on two copper vein deposits east of the Pinto Creek watershed. Exploitation of large, low-grade copper deposits began in 1904 (Peterson, 1962). In general, the low-grade deposits are developed in materials that were altered and mineralized by the Schultze Granite, a composite granodiorite-quartz monzonite porphyry intrusion emplaced approximately 61 million years ago (Titley and Anthony, 1989). Most of the major open-pit mines in the district have exploited primary sulfide ores and secondarily enriched copper oxide and sulfide ores that occur either within the pluton or in the overlying Precambrian metamorphic and sedimentary rocks (Peterson, 1962; Titley and Anthony, 1989). Depending on the nature of the material (sulfide vs. oxide), these operations beneficiate ore either through (1) crushing and milling, flotation concentration, smelting and refining, or (2) acid leaching, and solvent extraction/electrowinning (SX/EW). Solid waste materials produced during extraction, beneficiation, and processing include concentrator tailings, smelter slag, waste rock, and spent leach ore.

The Pinto Creek drainage hosts one active open-pit mine (BHP Pinto Valley Mine) and numerous historic mining operations scattered throughout the upper, ephemeral reaches of the watershed. Mining in the Pinto Creek watershed dates back to at least 1904, when the Arizona National shaft was excavated to explore mineralization along the Kelly Fault. As summarized in Table 5-1, the area hosted numerous mines that extracted copper, zinc, lead, and molybdenum, and perhaps silver and gold as well. For the most part, few records have been found that document these activities and the quantities of minerals they produced. Nevertheless, it is clear that most of these operations were small efforts, perhaps exploratory in nature, that targeted vein deposits. Exceptions included the Cactus and Carlota mine sites which aimed to exploit disseminated copper oxide mineralization along Pinto Creek. According to Peterson (1962), nearly 6,500 feet of lateral workings were driven off of the Hamilton shaft (Cactus deposit) on three levels between 1908 and 1910; these workings have since collapsed. Although this work defined a small, low-grade orebody, it is not clear that production ever ensued. Exploration of the Carlota deposit was considerably less aggressive; however, an unspecified quantity of "shipping ore" was produced from an open cut in 1943-1945 (Peterson, 1962).

The Gibson Mine, originally operated from 1906 to about 1920, is the most recently worked (1965-1992) small deposit in the Pinto Creek drainage (ADEQ, 1991a; 1991b; 1995; AZ Attorney General, 1993). This facility, which has not been operated since 1992, comprises several acres of surface disturbance in the headwaters of the stream, including adits and shafts, waste rock dumps, leach pads, concrete precipitation launders, a mill foundation, and lined pregnant and barren solution ponds. Most of this area remains unvegetated. A report prepared by ADEQ (1991a) describes the dumps and pads as consisting of approximately 150,000 tons of mixed copper-oxide- and copper-sulfide-bearing rock that has an average copper grade of 0.7 percent. During an EPA site visit in March 1999, representatives observed copper sulfate precipitate coating the liner of the dry pregnant leach solution pond. Heavy rainfall in the fall of 1990, winter of 1992-1993, and spring of 1995 apparently caused the PLS pond to either breach or overflow and discharge low pH, copper-laden water to a tributary of Pinto Creek (ADEQ, 1991a; 1991b; 1995). The 1990 breaching and flow event led to the negotiation and acceptance of a Consent Judgment between the State of Arizona and mine operators that provided for the construction of storm water ditches to control surface water run on and the inspection and evaluation of the leach pad liner and solution ponds (AZ Attorney General, 1993). The remedial steps required by the Consent Judgment were not effective in halting the periodic discharge of copper to Pinto Creek (ADEQ, 1995).

Large-scale mining of the Pinto Valley mine site began in 1943 with the onset of production from the Castle Dome open-pit mine, which was operated by the Miami Copper Company. This operation targeted an upper zone of secondary copper enrichment (Titley, 1989). The Castle Dome operation produced more than 500 million pounds of copper and lesser amounts of gold and silver from 41 million tons of ore (Peterson, 1962). Upon closure in 1953, the mine left behind nearly 48 million tons of waste rock and an unspecified quantity of tailings (Cottonwood Impoundment; Peterson, 1962). In 1969, Cities Service Company acquired the properties of Miami Copper and developed the Pinto Valley porphyry deposit. This mine exploited a deeper level of the Castle Dome orebody that consists of primary sulfide minerals (Titley, 1989). The Pinto Valley operation was acquired by the Magma Copper Company in 1986. Magma Copper, which was part of Newmont Mining in 1986, subsequently was reorganized and spun-off to Newmont stockholders in 1987. Broken Hill Proprietary Ltd. (BHP) acquired Magma Copper in 1996 and formed BHP Copper, Inc. shortly thereafter. The BHP Pinto Valley Mine is a major operation that was forced, through depressed copper prices, to curtail its operations in early 1998. Until recently, limited operations continued, including overburden stripping, acid leaching and SX/EW processing, but new sulfide ore was not being mined (BHP, 1998b). Prior to curtailment, approximately 55 million tons of material were excavated annually (150,000 tpd) from the BHP Pinto Valley pit. This material yielded 151 million pounds of copper from concentrate and an additional 40 million pounds of copper from leaching in 1997 (BHP, 1998b). Many of BHP's facilities lie adjacent to Pinto Creek or its tributaries.

Since 1989, a combination of extreme storm events and design exceedances caused releases of copper bearing sediments and liquids to Pinto Creek from Pinto Valley operations. These releases resulted from partial tailings dam failures, pipeline breaks, seepage flows, conveyance blockages, and storm water overflows. Recent significant release events occurred in August 1989, July 1990, January 1991, August to September 1991, January to February 1993, and October 1997 (U.S. EPA, 1991; Magma Copper, 1993; BHP, 1999a). In each of these events, materials were released in quantities sufficient to impact Pinto Creek or its tributaries. Although the 1989 and 1993 discharges were preceded by high precipitation events, other recent releases apparently were unrelated to climatic fluctuations. Studies conducted by BHP following the 1997 tailings failure identified earlier tailings residues that were deposited along Pinto Creek by a spill occurring in the 1940s (BHP, 1999a).

Data presented by Magma Copper (1993) indicate that the 1993 releases from the Pinto Valley mine site transported a substantial quantity of copper, perhaps as much as 100,000 pounds, to Pinto Creek. The amount of copper remaining in the drainage following the cessation of flow is unknown. Studies conducted as part of the 1997 Removal Action described the presence of 129,000 cubic feet of “early tailings residue” along Pinto Creek (BHP, 1999a). These materials, which included tailings deposited in the 1940s and during 1993, may contain as much as 2,000 pounds of copper (based on median total copper concentration [BHP, 1999a]). The 1997 partial tailings failure deposited an estimated 276,000 cubic yards of debris in Pinto Creek. According to BHP, 99.98 percent of this material, which contained a median copper concentration of 699 ppm, was removed from Pinto Creek and the slopes below the point of failure by the end of summer 1998 (BHP, 1999a).

6.0 APPLICABLE WATER QUALITY STANDARDS

6.1 General

Water quality standards are adopted by states and tribes to maintain and restore the nation’s waters for designated “beneficial uses” such as consumption, recreation, agriculture, and aquatic biota. The standards for a particular water body consist of a set of protected uses, the water quality criteria necessary to maintain these uses and an “antidegradation” requirement (see Section 7.4). Water quality criteria can be expressed either as numeric values (e.g., contaminant concentrations) or narrative statements (e.g., “A surface water shall be free from...”). The following sections describe the water quality standards applicable to Pinto Creek.

6.2 Beneficial Use Designations

ADEQ codifies water quality regulations in Title 18, Chapter 11 of the Arizona Administrative Code (*A.A.C.*). Designated uses are described in Section R18-11-104 of the *A.A.C.* and are listed for specific surface waters in Appendix B of Title 18, Chapter 11. Pinto Creek is protected along its entire length for the following designated uses:

- Aquatic and Wildlife, warm water (A&Ww)
- Full Body Contact (FBC)
- Fish Consumption (FC)
- Agricultural Irrigation (AgI)
- Agricultural Livestock Watering (AgL).

6.3 Applicable Water Quality Criteria

The State of Arizona has established numeric water quality criteria to protect the designated uses described above for Pinto Creek. The criteria are listed in Appendix A of *A.A.C.* § R18-11. Under these criteria, Pinto Creek is considered a perennial drainage. For dissolved copper, the water quality criterion established to protect wildlife and warm water aquatic life (A&Ww) from chronic exposure effects is the most stringent criterion that applies to the waters of Pinto Creek. The dissolved fraction of copper is normally much more bioavailable than the particulate fraction and is therefore of greatest concern for the protection of aquatic life. In large amounts copper can cause death or sublethal adverse health effects in aquatic organisms.

The acute and chronic A&Ww criteria for dissolved copper are hardness-based. This is because toxicity to aquatic biota decreases with increasing hardness. Algorithms to compute criterion concentrations are provided in Appendix A, Table 3 (footnote e) of *A.A.C.* § R18-11. These equations are:

$$\text{Acute criterion} = e^{(0.9422\,[\ln(\text{hardness})]\,-\,1.464)}$$
$$\text{Chronic criterion} = e^{(0.8545\,[\ln(\text{hardness})]\,-\,1.465)}$$

where hardness is expressed as milligrams per liter (mg/L) as calcium carbonate ($CaCO_3$) and the criterion for dissolved copper is designated in micrograms per liter (µg/L). The criteria applicable to a specific water body are based on the measured hardness of the water body. The maximum hardness accepted by the State of Arizona under the *A.A.C.* and EPA under the National Toxics Rule for purposes of calculating the specific criteria is 400 mg/L. Hardness levels measured in Pinto creek have often exceeded the 400 mg/L level by a large amount.

Powers Gulch is considered an ephemeral drainage under the State of Arizona criteria. The criteria established for ephemeral drainages are less stringent than for perennial waters. The algorithms to compute criterion concentrations for ephemeral drainages are also provided in Appendix A, Table 3 (footnote e) of *A.A.C.* § R18-11. These equations are:

$$\text{Acute criterion} = e^{(0.9422\,[\ln(\text{hardness})]\,-\,1.1514)}$$
$$\text{Chronic criterion} = e^{(0.8545\,[\ln(\text{hardness})]\,-\,1.1448)}$$

Because this TMDL is developed to achieve water quality goals in Pinto Creek, EPA used the more stringent criteria established for Pinto Creek to establish loading allocations to Powers Gulch.

6.4 Antidegradation

The Arizona antidegradation requirements stated in *A.A.C.* § R18-11-107 are applicable to the Pinto Creek TMDL. Arizona does not permit further degradation of existing water quality in a surface water that does not meet the applicable water quality standard. In cases where the existing surface water quality is better than the applicable standards, Arizona requires that the existing water quality shall be maintained and protected unless permitted by the Director of the ADEQ pursuant to the provisions stated in *A.A.C.* § R18-11-107-C. As described in Section 3.2, Pinto Creek is listed as "water quality limited" according to provisions of the Clean Water Act Section 303(d) for non-attainment of dissolved copper (ADEQ, 1998a). The TMDL analysis shows that upon implementation of the wasteload and load allocations, Pinto Creek will meet water quality standards and will not experience further degradation. Moreover, we understand that the Carlota Copper Mine has agreed carry out remedial actions at the Gibson Mine site to remove significant copper loading sources prior to initiating any discharges from the new Carlota Mine facility. As a result, net copper loadings to the Creek are expected to be reduced, consistent with the State's antidegradation requirements. Arizona Department of Environmental Quality issued a Clean Water Act Section 401 certification for the Carlota project in which it found that the project will not result in exceedances of applicable State water quality standards.

7.0 DATA SOURCES

EPA compiled water quality data from 26 monitoring points throughout the drainage. In addition, meteoric water data and monitored stream discharge data are available at some limited locations in the basin. These data were obtained from numerous sources including BHP Copper, Inc., Carlota Copper Company, ADEQ, and US Forest Service (USFS). Data were gathered from some sample locations beginning in the mid-1970s. For other sites, data collection did not begin until 1995. Few sites have a data record that exceeds 5 years.

EPA divided the Pinto Creek watershed into 14 sub-basins that are associated with a distinct tributary or a specific stream segment of Pinto Creek. These sub-basins were used to group available monitoring data, evaluate and identify potential sources of copper loadings, and develop the TMDL. Table 7-1 provides a description of each sub-basin. Table 7-2 summarizes the compiled water quality data, data sources, and periods of record. Sub-basins and the sample locations described in Table 7-2 are shown on Figure 7-1. Data used to develop the TMDL were collected from 1990 to 1999; the majority of these data were collected between 1993 and mid-1998. These data are noted on Table 7-2.

7.1 Data Limitations

While water quality monitoring data are available for the TMDL analysis, certain data limitations required EPA to make interpretative judgements and assumptions in the data analysis. The limitations or inconsistencies in the available data include:

- Samples were collected on an irregular basis at most locations.
- Stream discharge data associated with water quality samples (e.g., constituent concentrations) are very limited at most locations.
- Generally, concurrent or synoptic samples (e.g., samples collected at approximately the same time from different sites throughout the basin) are not available. One synoptic sampling event for water quality was conducted by EPA at several locations in upper Pinto Creek (Mining & Environmental Consultants, 1993). This event, however, did not have corresponding measurements of stream discharge.
- Knowledge of ephemeral stream discharge and contributions from sub-basins in the other parts of the watershed cannot be correlated with most water quality or site specific stream discharge data.
- The same sampling locations were not used by different agencies and companies.
- The same method detection limits (MDLs) were not used by the different agencies and companies.
- Different MDLs were used for different sampling dates at the same monitoring locations.
- Many of the MDLs that were used to analyze samples were higher than the water quality criteria.
- Some available data sets are comprised of only summary information (e.g. averages, maxima, etc.), rather than results from individual samples.

These issues are not unusual in water quality analysis and regulation because water quality and stream discharge data are often collected by a variety of sources using a variety of methods. Although data limitations exist, the data are sufficient to permit the development of the TMDL. In the following descriptions of the methods used to develop the TMDL, EPA have documented the approach for integrating and interpreting the varied data sources, including simplifying assumptions.

8.0 DERIVATION OF TMDL ELEMENTS

This chapter describes the derivation of the required “TMDL Elements”, which include the establishment of target sites (e.g., points of compliance), water quality standards, loading capacity, natural background loads, gross allocations, LAs, WLAs, and margin of safety. A LA is the portion of the loading capacity that is allocated to non-point sources. A WLA is the portion of the loading capacity that is allocated to point-sources. Further definitions of terms are provided in Section 11. These elements are consistent with the requirements of current TMDL regulations (40 CFR § 130).

In general, the TMDL was developed to provide for compliance with water quality criteria at each target site. Total and available loading capacities at target sites are calculated based on several factors, including: (1) hardness and applicable water-quality criteria, (2) stream discharge, and (3) natural background conditions. First, EPA defined the applicable water quality criteria based on hardness, determined stream discharges through modeling, and calculated total loading capacity in kilograms per day (kg/day) of dissolved copper at each target site. The amount of dissolved copper available for allocation to sources was then determined by subtracting background loads, loads from upstream allocations, and a margin of safety. A detailed description of the methods used to derive each of these elements is provided in the Sections 8.1 through 8.9 below. Results of calculations performed to derive these elements are provided in Table C-1 and summarized in Tables 1-3 and 1-4 above.

8.1 Identification of Target Sites

Nine target sites or locations were chosen in the Pinto Creek watershed to establish loading capacities in the creek and to provide the basis for allocations to sources, background, and margin of safety. These target sites were defined based on the locations of known and proposed facilities, potential sources of copper loading, the locations of currently established monitoring points, and the locations of confluences of major tributaries. A description of target sites is provided in Table 8-1 and target site locations are depicted in Figure 8-1.

The site of the Pinto Valley Weir is the furthest downstream target site. EPA did not establish additional target sites between the Pinto Valley Weir and Roosevelt Lake because an evaluation of water quality data obtained at the Pinto Valley Weir suggests that water quality criteria are currently being met at this location. In addition, no significant sources of dissolved copper are known below this site.

8.2 Hardness and Water Quality Criteria

As discussed in Section 6.3, A&Ww criteria for dissolved copper are hardness-based. EPA evaluated existing water quality data available throughout the Pinto Creek watershed to determine appropriate hardness levels to use in establishing water quality goals for the TMDL. The analysis resulted in several observations. First, hardness values generally decrease with increasing runoff and associated stream discharge at individual locations in the watershed. Second, a correlation was observed that showed decreasing hardness measured in samples collected from the Carlota Crossing site with an increase in precipitation recorded at the Miami gage during January and February, 1993. This correlation also supports the conclusion that hardness decreases with increasing runoff and stream discharge. Third, hardness appears to increase substantially in the more highly mineralized area of the watershed between the Pinto Valley Mine site and the Pinto Valley Weir. The average hardness level of water samples from the entire Pinto Creek watershed is approximately 704 mg/l as $CaCO_3$ and is higher in the reaches between Highway 60 and the Pinto Valley Weir.

In the draft TMDL, EPA proposed and requested comment on two alternative approaches for addressing variability in hardness in the Pinto Creek watershed. The first approach involved the calculation of the TMDL based on a single, extremely conservative hardness level of 101 mg/l. The second approach involved the expression of the TMDL and all associated allocations in the form of the function:

$$TMDL_{(\text{target site x in flow tier y})} = (flow_{(\text{target site x in flow tier y})}) * e^{(0.8545\,[\ln(\text{measured hardness})]\,-\,1.465)}.$$

Some commenters supported the use of a single highly stringent hardness value to calculate the TMDL and associated allocations. They believed this would result in a more protective TMDL. Other commenters believed the proposed hardness value was much too stringent, particularly in the lower portions of the watershed where hardness values appear to be higher. These commenters also noted that the single hardness approach appeared inconsistent with the functional form in which State water quality standards are expressed.

Based on the data review and comments received, EPA used a 400 mg/l hardness level to calculate the final TMDL. The 400 mg/l hardness level is equal to the maximum value allowed by Arizona State water quality standards in applying the copper standard equations. However, use of the 400 mg/l hardness level appears conservative when compared with the average hardness level measured in the watershed (704 mg/l). EPA concluded that applying a 101 mg/l hardness level, as proposed in the draft TMDL, would be excessively and needlessly stringent and that the use of the 400 mg/l hardness level is sufficiently conservative to ensure the protection of Pinto Creek. EPA concluded that expression of the TMDL in a functional form would be too complex from a computational perspective and would be unnecessarily difficult for the public to understand.

EPA believes it would be appropriate to measure and consider the actual hardness values observed when follow-up monitoring data are collected. If follow-up monitoring data indicate that allocations or the TMDLs are not being attained, EPA expects that ADEQ and EPA will consider the relative importance of measured copper discharge amounts and actual water hardness values in assessing whether water quality standards are actually being violated.

8.3 Stream Discharge Estimation

The Pinto Creek watershed is composed of several drainages that are intermittent and/or ephemeral and that, in most areas, flow only in direct response to precipitation events. Because of the ephemeral and intermittent properties of the drainages in this watershed, detailed data characterizing rainfall/runoff relationships in the Pinto Creek watershed are not available. Furthermore, stream discharge data that have been collected in the major drainages and at the Pinto Valley Weir are insufficient to accurately predict the frequency and magnitude of different flow events. For these reasons, a rainfall-runoff model was developed for the Pinto Creek watershed to estimate stream discharge at the established target sites in the drainage. This model allows stream discharges to be calculated for different frequencies and magnitudes of precipitation events. Modeled stream discharges were then used to establish loading capacities, background loads, and determine LAs and WLAs. The model was developed using the U.S. Corps of Engineers (COE) flood hydrograph software package, HEC-1 (COE, 1987).

HEC- 1 is the software package that is most commonly used for watershed and surface hydrological analyses in support of structure design and water balance studies. HEC-1 is often used to calculate the stream or river discharges that would result from specific (or extreme) precipitation or snowmelt events and used to assess water quality and to design and size retention dams, spill ways, diversion channels, etc. It is also commonly used for conducting water balance studies to calculate the contribution to stream discharge from different sub-basins and tributaries in a watershed where little or no data has been taken. The software was originally developed in 1967 by the COE Hydrologic Engineering Center (HEC). The software has been modified and improved throughout the years with the most recent version being released in 1998. HEC-1 is a computer program that generates hydrographs (e.g., a plot of stream discharge versus time) from specific rainfall and/or snowmelt events at specific locations in a watershed. It then performs calculations to route surface runoff and stream discharge from various locations in the watershed through the stream channels to designated points downstream.

The HEC-1 Pinto Creek watershed model was developed using the options available to apply the hydrologic methods developed by the Natural Resource Conservation Service (NRCS), formerly known as the Soil Conservation Service (SCS, 1972). Precipitation intensity patterns are calculated using the SCS Type II frequency distribution. Infiltration, surface storage, initial abstractions of precipitation, and runoff volume are computed using the SCS Curve Number (CN) method. Stream discharge hydrographs are calculated using the SCS unit hydrograph approach. Runoff hydrographs are routed through stream reaches using Muskingum-Cunge procedures (COE, 1987).

The model divides the Pinto Creek Watershed into the 14 sub-basins (i.e., sub-watersheds) described in Table 7-1 and shown in Figure 8-1. Soil and vegetation descriptions and maps of vegetation types available in the Final EIS for the Carlota Copper Project (USGS, 1997), as well as on site observations were used to assign SCS curve numbers (CN) to each vegetation/soil type occurring in each sub-basin. Other sources reviewed during the development of CNs were Van Haveren (1986) and Barfield et al. (1981). CNs were calculated as an area-weighted average of the vegetation/soil types occurring in each sub-basin, using an Antecedent II soil-moisture condition (Barfield et al., 1981). Sub-basin geomorphologic parameters, used as model input to calculate SCS unit hydrographs, were developed from USGS 1:24,000 topographic maps. Stream channel geometry data, used to calculate flow routings, were estimated from on-site observations and photographs taken of the major tributary channels in the watershed, and from data obtained for specific cross sections that were measured during flow events by Carlota Copper Company (unpublished data).

Climatic data for the Pinto Creek watershed are insufficient to describe precipitation depths and rates of rainfall, the durations of precipitation events, and the distribution and timing of rainfall throughout the watershed for specific storm events. Moreover, data that relate the above precipitation variables to stream discharge at various points in the watershed also are unavailable. For these reasons, a formal model calibration based on actual observed precipitation and stream discharge data could not be conducted (this type of calibration typically is used to check the realism of HEC models prior to their use). Rather, the HEC-1 model was calibrated to correspond with the peak discharges presented in the Final EIS for the Carlota Copper Project (USFS, 1997) that were estimated using the Pima County Department of Transportation and Flood Control District (PCDOT&FCD) procedure. The PCDOT&FCD procedure uses empirical relationships developed between measured watershed geomorphologic characteristics, such as drainage area, channel length, channel slope, vegetation type, soils, and land surface types, to estimate peak discharge at a basin outlet for storms of various durations and frequencies of occurrence. The Pinto Creek HEC-1 model was calibrated by slightly modifying the CNs assigned to different vegetation/soil types and by making small adjustments to the values used for initial abstraction (Ia) as defined by (SCS, 1972). Calibration continued until peak discharge measurements for a 10-year, 1-hour storm event was less than ± 5% of the discharge values estimated using the PCDOT&FCD procedure at four different hydrologic concentration points:

- Pinto Creek at the downstream limit of the proposed Carlota Project boundary;
- Powers Gulch above the confluence with Haunted Canyon;
- Haunted Canyon below the confluence with Powers Gulch; and
- Pinto Creek immediately downstream of the Haunted Canyon confluence.

Precipitation depths for several durations and recurrence intervals were developed from the Rainfall Frequency Atlas for Arizona (NOAA, 1973), and are also presented in the Final EIS for the Carlota Copper Project (USFS, 1997). Point precipitation depths were reduced using an areal reduction factor appropriate for the total drainage area to the Pinto Creek Weir (95 mi^2) using methods described by NOAA (1973). The following precipitation frequency and durations were modeled:

- 2-Year, 1-Hour (0.93 inches);
- 10-Year, 1-Hour (1.40 inches);
- 10-Year, 24-Hour (4.20 inches);
- 100-Year, 24-Hour (6.20 inches).

Precipitation events were applied as a single storm event occurring simultaneously in the 95 square mile drainage area. As previously indicated, precipitation events were applied using the SCS Type II, 24-hour storm distribution. The 1-hour distributions were developed using the most intense single hour of the 24-hour Type II distribution.

The modeled scenario developed to study loading capacity, source loading, and conditions for establishing LAs and WLAs assumed all Carlota Copper proposed facilities were in place. For this scenario, the acreage of all major proposed Carlota Copper facilities were considered as non-contributing drainage areas for the purposes of calculating runoff and stream discharge. These facilities included:

- Cactus-Carlota Pit
- Eder North Pit
- Eder South Pit
- Eder Middle Pit
- Main Rock Dump
- Eder Rock Dump
- Cactus Southwest Dump
- Leach Pad

A further description of the proposed Carlota Copper facilities and projections of the quality of discharges from proposed NPDES outfalls are discussed in Section 9.1.

8.4 Total Loading Capacity

The total loading capacity at each target site is calculated by multiplying the stream discharge (calculated by the HEC-1 model) by the water quality criterion concentration and a conversion factor to convert the value to units of kilograms per day. Loading capacities, background loads, LAs, and WLAs for the TMDL are based on five flow tiers applied at each target site. EPA established these tiers at each target site using the maximum 6-hour average stream discharge that were estimated to result from each of four precipitation events being applied to the entire watershed. These flow tiers are:

1. Less than the 2-year, 1-hour storm event;
2. 2-year, 1-hour storm to 10-year, 1-hour storm event;
3. 10-year, 1-hour storm to 10-year, 24-hour storm event;
4. 10-year, 24-hour storm to 100-year, 24-hour storm event;
5. Greater than the 100-year, 24-hour storm event.

EPA emphasizes that the TMDL and associated allocations are based on the modeled flow rates estimated to be associated with these different storm magnitudes at different locations in the watershed, not the actual flows which may be found later to be associated with storms of a particular size or recurrence interval. EPA believes the model provided useful estimates of the magnitude of stream discharges associated with storms of different size, and that these estimates are helpful in relating stormwater management facility design to TMDL requirements. However, these storm-related stream discharge estimates may not be absolutely accurate.

The maximum 6-hour average stream discharge value was used because it balances the timing of peak flows discharging from each sub-basin, but still allows calculation of total loading capacities, LAs, and WLAs to be developed along high flow conditions in each tier. The loading capacity for each flow tier is established at the lower discharge value for the tier. An exception is the first flow tier which represents conditions ranging from no stream discharge (zero flow) to the discharge that would result from the 2-year, 1-hour storm event. For this flow tier, loading capacities were not used for allocations. Rather, allocations in this flow tier are established so that each source meets applicable acute and chronic water quality criteria (See Section 9.2).

8.5 Natural Background Conditions

The TMDL takes into account natural background loadings of dissolved copper in Pinto Creek and its tributaries. Background load at each of the target sites was computed by multiplying the stream discharge estimated by the HEC-1 model at each target site by the appropriate background copper values.

To estimate natural loading conditions, EPA reviewed all available water quality data in the watershed. Although there are differences in the geology, rock units, and extent of exposed mineralization between the upper reaches in Pinto Creek and the eastern tributaries (i.e., Powers Gulch, Haunted Canyon, West Fork Pinto, etc.), the available water quality data suggest that background concentrations of dissolved copper are similar in both areas. For the main stem and tributaries of Pinto Creek from its headwaters to the confluence with Haunted Canyon, EPA selected a background copper value of 0.010 mg/L. This value represents ½ MDL for analyses of 2 samples collected in 1981 at station METF-1, located upstream of the Henderson Ranch mines, near the headwaters. Available information indicates that this site is above any known influences from historic mining operations.

As described in Section 9.1, a single sample analysis suggests that natural background in the vicinity of the Gibson Mine may be higher than the background value described above. However, EPA has elected to rely on the data available for station METF-1 until additional sampling and analysis confirms that natural background is truly higher in the Gibson Mine area.

For Powers Gulch, Haunted Canyon, and the main stem and tributaries of Pinto Creek downstream of the Haunted Canyon confluence, EPA used a background copper concentration of 0.010 mg/L. The value of 0.010 mg/L represents ½ MDL for the lowest non-detected value available for surface water samples from Powers Gulch, Haunted Canyon, and West Fork Pinto Creek. Samples with non-detected values at higher MDL (0.1 to 2.0 mg/L) were eliminated. One detected value of 0.002 mg/L is reported for station HC-2 at the mouth of Haunted Canyon, but EPA felt that use of the 0.010 mg/L value was more conservative. This conservative value also takes into account that several historic mine workings occur in Powers Gulch that potentially could be loading sources. However, the available water quality data are insufficient to segregate these sources or determine if they affect water quality.

8.6 Upstream Allocations

Target sites were established at important locations and stream junctions throughout the watershed (Section 8.1). In this manner, some target sites are downstream from other target sites. Under the flow tiers established, loading capacity increases with increasing stream discharge and stream discharge increases in the downstream direction. Calculations to establish allocations, therefore, begin at the target sites located near the headwaters of the basin and step through each target site in the downstream direction. Before allocating loads at a downstream target site, the loading capacity (kg/day) that had been previously allocated at up stream sites is subtracted from the total loading capacity. For example, the dissolved copper loads allocated at target sites TS-1, TS-2, and TS-3 are subtracted from the loading capacity at target site TS-4 before allocating the remaining capacity to sources specifically associated with TS-4. This method was also applied in major tributaries, such as Powers Gulch.

8.7 Margin of Safety

Clean Water Act Section 303(d) requires to inclusion of a margin of safety (MOS) to account for uncertainties in the TMDL analysis. The required MOS may be provided explicitly by reserving (not allocating) a portion of available pollutant loading capacity and/or implicitly by making environmentally conservative analytical assumptions in the supporting analysis. The Pinto Creek TMDL provides both an explicit and implicit MOS.

EPA has included an explicit margin of safety equal to 10% of the loading capacity available for allocation for target sites TS-1, TS-2, TS-3, and TS-4; and equal to 20% of the loading capacity available for allocation for target sites TS-5, TS-6, TS-7, TS-8, and TS-9. The higher MOS was selected for the downstream target sites because many of the less well-characterized potential source areas identified by commenters are located in these portions of the watershed. After subtraction of the allocation for natural background and upstream allocations from the total loading capacity for each target site, either 10% or 20% of the remaining loading capacity is subtracted for the MOS, depending on the target site location.

EPA has also provided an implicit margin of safety by making numerous conservative assumptions in the supporting analysis. Table 8.2 discusses these sources of uncertainty and the conservative assumptions and approaches used to account for them in the TMDL analysis.

8.8 Seasonal Variations and Critical Conditions

Clean Water Act Section 303(d) requires the consideration of “seasonal variations” in the establishment of TMDLs. In addition, federal regulations at 40 CFR 130.7 state that TMDLs must take into account critical conditions for stream flow, loading, and water quality parameters. The TMDL analysis indicates that most copper loading in the Pinto Creek watershed is associated with precipitation events and associated runoff from the land and mining facilities.

Most precipitation in this generally arid area occurs in the winter and during the summer "monsoon" season. However, rainfall and runoff may occur at any time. Precipitation and runoff events are generally intense and of relatively short duration. Copper loading appears to increase in proportion to increases in rainfall and runoff magnitude. As discussed above, most of Pinto Creek and its tributaries flow in response to runoff events.

No information was found in the development of the TMDL which indicates that the aquatic life beneficial use is more or less sensitive during particular seasons of the year. Arizona water quality standards make no provision for seasonal differences. Therefore, the TMDL is based on the assumption that the aquatic life beneficial use must be protected to the same level at all times.

The TMDL does not attempt to identify a single critical condition for which a single TMDL and associated allocations are calculated. This approach would be inappropriate for Pinto Creek due to the variability and unpredictability of individual precipitation and runoff events and associated water quality impacts in the watershed. Given the dynamic pollutant loading characteristics which are present in the watershed, the TMDL identifies individual TMDLs and associated load and wasteload allocations for all possible flow levels from zero to the highest possible flows, thereby accounting for any possible seasonal variations in flows and pollutant loads.

8.9 Loading Available for Allocation

For each flow tier, the portion of the loading capacity at each target site that is available for allocation is equal to the total loading capacity minus the natural background load, upstream allocated load, and margin of safety. Each of these values, including the loading available for allocation, LAs, and WLAs are shown in the tables presented in Appendix C. Because loading capacities are not established for the first flow tier, allocations at each target site for this tier are based on dissolved copper concentrations that equal the water quality criteria for dissolved copper.

9.0 CURRENT LOADING AND ALLOCATION TO SOURCES

9.1 Identification of Loading Sources

A number of sources that contribute dissolved copper have been identified in the Pinto Creek drainage. In some cases, these sources are discrete and easily identified (e.g., the currently permitted BHP NPDES discharge point). In other cases, the sources are not well defined and, therefore, difficult to quantify. A majority of the potential sources of dissolved copper loading in Pinto Creek are non-discrete. Appendix B provides tables summarizing existing monitoring data and potential sources associated with each target site. Specific sources are discussed in greater detail in the following sections. It should be noted that some of these sources need further definition and characterization. For example, available water quality data indicate that dissolved copper concentration increases between TS-2 and TS-3, which may be attributed to historic mines and mining claims located in this reach of Pinto Creek and its tributaries. However, the contribution of dissolved copper from these specific sources and sites is unknown (e.g., adits, non-point source sediment, naturally occurring areas of mineralization, etc.). Additional characterization of sources is consistent with the phased approach to this TMDL, as discussed in Section 10.0.

EPA evaluated "worst-case" projected loadings of dissolved copper for sources located above each target site. "Worst-case" estimates of potential loading from proposed Carlota facilities were also determined. These analyses are summarized in the following sections and tabular results of these projected loadings are provided in Appendix C for each target site and for the different flow tiers.

BHP Facilities

The BHP Pinto Valley Mine maintains one permitted continuous discharge point (NPDES outfall 005). BHP also has several monitoring points that are unrelated to this permit on tributaries to Pinto Creek (Miller Spring Gulch, Gold Gulch, and North and South Ripper Spring Canyon). These springs and tributaries drain from BHP and other mining operations that formerly operated in the watershed. For this reason, EPA evaluated loading from each of these points using the available water quality monitoring data. Available information indicates that BHP does not contribute copper from any other sources. Background values were used to represent the remaining portions of the contributing basin adjacent to the BHP facilities. Monitoring data from NPDES outfall 005 (Bingham, 1999b) indicates that discharges reported by BHP were independent of storm runoff.

In October, 1997, a partial failure of BHP Tailings Impoundments 1 and 2 spilled into Pinto Creek while a waste rock cover was being placed on the impoundment. Primary and remobilized tailings debris impacted the creek from slightly downstream of Miller Spring Gulch to a point upstream of the Haunted Canyon confluence, a distance of approximately 7,800 feet (contained within sub-basin UPBC). The debris was removed under a CERCLA Time-Critical Removal Action as implemented under a draft Administrative Order on Consent adopted by the U.S. Forest Service in January, 1998 (BHP, 1999a). Debris removal was completed by July 1, 1998. Water quality monitoring of stations AMP-4 (downstream of the Iron Bridge), PV Weir, and temporary stations within the impacted area conducted following debris removal indicates that there is no continuing copper contribution to Pinto Creek as a result of this incident (data presented in BHP, 1999a). For this reason, no projected future loading from this source was considered in deriving the TMDL.

The projected "worst-case" loading of dissolved copper from BHP NPDES 005 was computed using the maximum observed concentration (0.015 mg/L), as reported by BHP for samples from the outfall, and the maximum observed flow (0.33 cubic feet per second [cfs]) reported for the outfall. The projected "worst-case" loading for this source is approximately equal to the chronic water quality criteria at the point of discharge (Table C-4).

The projected loading of dissolved copper from Miller Spring Gulch (Appendix C, Table C-6) was computed using the mean measured concentration (0.0093 mg/L) reported by BHP and the maximum reported flow (0.1114 cfs). These data are provided in Appendix B, Table B-6. The mean copper value was used because only 2 of 18 samples had copper concentrations exceeding the detection limit and only summary statistical values were available (BHP, 1999b). These data suggest that the projected "worst-case" loading for this source is significantly less than the total loading capacity for Pinto Creek at TS-5 (Table C-6).

The projected loading from the Gold Gulch weir, and North and South Ripper Canyons were computed using the mean measured dissolved copper concentration and the maximum flow reported by BHP for each station (Appendix B, Table B-10). Mean copper values were used for the reasons cited above. Similar to Miller Gulch, the projected "worst-case" loading for this source is significantly less than the available loading capacity for Pinto Creek at TS-9 (Table C-10).

BHP also maintains several stormwater discharge outfalls that could potentially discharge copper to Pinto Creek and its tributaries. Four outfall points are defined in BHP's individual NPDES permit, designated as outfalls 001, 002, 003, and 004. These outfalls are located down-gradient of mine process facilities which are designed to contain up to the 100-year, 24-hour storm. Therefore, no discharge is allowed from these outfalls except in response to such extreme events. BHP also maintains 8 stormwater outfalls which are not associated with mine process facilities, and which are covered under the NPDES multi-sector general permit (MSGP) for Arizona. Insufficient information was available to characterize copper loadings associated with discharges from the 001, 002, 003, 004, or MSGP outfalls, but such loadings are expected to be minor.

Henderson Ranch

Available monitoring data indicate that dissolved copper concentration increases from values measured near the headwaters in upper Pinto Creek to TS-1. The projected load from the Henderson Ranch mines and other potential sources in upper Pinto Creek was determined by first computing a total load at target site TS-1 using the maximum measured copper concentration (0.035 mg/L) from water quality sampling and flows predicted by the HEC-1 model. The background load at TS-1 was then subtracted from the total load at TS-1 to determine the projected loading for the Henderson Ranch mines. This computation assumed that all dissolved copper above background levels is attributable to the Henderson Ranch mines. The "worst-case" projected loading for this source suggests that the available loading capacity above background could be exceeded at TS-1, as a result of contributions from this source (Table C-2).

Gibson Mine

Available water quality data in the Gibson Mine tributary above its confluence with Pinto Creek are limited, with only six samples collected by ADEQ between 1990 and 1995 (Mining & Environmental Consultants, 1993; ADEQ, 1995). These data, summarized in Table A-2 (Appendix A), show a wide variation in measured dissolved copper concentrations. Stream discharge in the tributary was measured during only one of the water quality sampling events (March 1995). Measured dissolved copper concentrations ranged between 1.82 and 236 mg/L, with a mean concentration of 63.7 mg/L. All of these values are much larger than the acute water quality criteria of 0.0387 mg/L (calculated using a hardness value of 400 mg/).

One source of dissolved copper from the Gibson Mine is associated with storm runoff from the waste-rock and low-grade ore dumps, the leach pad, and other unreclaimed mine facilities. Another source of dissolved copper is from the overflow of a remnant pregnant solution pond that was associated with leaching operations in the 1980s and 1990s. This pond continues to collect solution that naturally infiltrates through the leach pad and it periodically overflows during high precipitation events. A series of samples collected by ADEQ during a pond overflow event on March 9, 1995 illustrate the impact of the Gibson Mine site on the copper loads delivered to Pinto Creek. The sample data emphasize that more work will be needed to fully understand the fate and transport of copper in this portion of the watershed. The 1995 sample analyses show that the concentration of dissolved copper in the Gibson Mine tributary increased from 0.11 mg/L (load of 0.001 kg/day) above the mine workings to 16.6 mg/L (load of 7.96 kg/day) below the mine workings then decreased to 1.82 mg/L (load of 1.71 kg/day) above the Pinto Creek confluence. Based on measured discharges and analyses of total copper, the PLS pond contributed approximately 18 percent of the total copper load measured immediately downstream of the mine at the time of sampling. The decrease in load from the downstream edge of the mine property to the Pinto Creek confluence indicates that dissolved copper was lost in this stream reach through one or more unidentified processes.

The “worst-case” projected loadings from the Gibson Mine were determined by first computing a total load at the mouth of Gibson Mine tributary (directly above the Pinto Creek confluence), using the maximum measured copper concentration (236 mg/L) and flows predicted by the HEC-1 model for the sub-basin at each flow tier. A background load was then subtracted from the total load to attain a projected load from the Gibson Mine. This load was then applied at TS-2 (Pinto Creek immediately below the Gibson Mine tributary confluence). It should be noted that the document describing the sample with 236 mg/L of dissolved copper (ADEQ, 1991a) does not clearly state whether this sample was collected from flowing water or from a standing pool in which the copper content had increased through evapoconcentration. The loading computation assumed that all dissolved copper above background in the tributary was attributable to the Gibson property. The Gibson Mine loading calculations used the background copper concentration determined for ADEQ monitoring station PC-1, located on Pinto Creek upstream of the Henderson Ranch Mines (0.010 mg/L). This dissolved copper concentration is significantly lower than the concentration measured in a single sample collected by ADEQ in the Gibson Mine tributary above the mine site in March 1995 (0.11 mg/L). While the latter value suggests that the background copper value in the naturally mineralized area of the Gibson Mine could be higher than that used in the loading allocations, EPA elected to use the lower background value until additional sampling and analysis confirms that natural background is truly higher in the Gibson Mine area.

The “worst-case” projected loading from this source is significantly larger than the total and the available loading capacities calculated for TS-2 (Table C-3). It should be noted that the large projected load from this source assumes that large amounts of dissolved copper are being contributed through surface runoff and overflow from the abandoned pregnant leach solution pond, regardless of the magnitude of the precipitation event producing runoff from this area. Further study would be required to more accurately assess the conditions causing the large variation in measured dissolved copper concentrations that have been observed at this site, and the amount of dissolved copper that is contributed from the abandoned PLS pond. These studies could also be designed to address how copper concentration varies with stream discharge and identify the processes that modify the copper load in the stream reach from the northern property boundary to the Pinto Creek confluence.

Unspecified Sources between TS-2 and TS-3

One or more undesignated sources appear to occur between the confluence of Pinto Creek and the Gibson Mine tributary (TS-2) and the upstream boundary of the Cactus Breccia formation (TS-3). TS-3 is also the upstream boundary of the proposed Carlota Cactus pit. This conclusion is based on existing water quality data that show an increase in copper concentration in Pinto Creek between the confluence and the old Highway 60 bridge sampling site (one synoptic sampling event). To evaluate loading for these undesignated sources, total load was computed at target site TS-3 using the 95th percentile dissolved copper concentration at monitoring station AMP-2 (0.072 mg/L). A background load and loads estimated for the Henderson Ranch mines and BHP outfall 005 were then subtracted from the total load to yield an estimated load for the undesignated sources. It is important to note that this calculation assumes that the Gibson property did not contribute copper to Pinto Creek at those times when samples were collected from BHP monitoring point AMP-2. This assumption was made because data obtained at this location were obtained under very low stream discharges where significant contributions to stream discharge from the Gibson Mine tributary were probably not occurring. Furthermore, the observed dissolved copper concentrations are relatively low, suggesting that significant contributions from the Gibson mine were not occurring during those sampling events.

The projected loading from these sources suggest that these sources contribute to exceedances in the water quality criteria for dissolved copper at TS-3. These data are presented in Table C-4.

Cactus Breccia Formation

Existing water quality data indicate that the Cactus Breccia Formation (the location of the proposed Carlota Copper Cactus pit) also provides a natural source of copper to Pinto Creek. This is indicated by generally higher copper concentrations in samples from BHP monitoring site AMP-3 (TS-4), which is downstream, than from BHP monitoring site AMP-2 (TS-3). To evaluate loading for the Cactus Breccia formation, a total load at target site TS-4 was computed using the 95^{th} percentile dissolved copper concentration at monitoring station AMP-3 (0.097 mg/L). A background load and estimated loads for upstream sources were then subtracted from the total load at TS-4. The remainder was assumed to represent the load contributed by the Cactus Breccia formation. As previously noted, this calculation assumes that the Gibson tributary did not contribute to stream discharge and, therefore, dissolved copper in Pinto Creek, at those times when samples were collected from monitoring point AMP-3. The projected loading from this source suggests that the Cactus Breccia Formation provides significant contributions of dissolved copper to Pinto Creek. These data are provided in Table C-5.

Proposed Carlota Facilities

The Carlota Copper Project is a proposed new copper mine that would have open pits, an SX/EW plant, heap leach pad, process solution ponds, waste rock disposal areas, and ancillary facilities. A detailed project description and analysis of environmental impacts is provided in the Final EIS for the Carlota Copper Project (USFS, 1997). Construction of the mine would require the diversion of both Pinto Creek, for a distance of approximately 5,250 feet, and Powers Gulch, a tributary to Pinto Creek, for a distance of approximately 1 mile.

Storm runoff from the proposed Carlota Copper waste rock dumps would be managed in seven storm water retention ponds. The outlets from these ponds represent potential NPDES outfalls where discharges could occur during large precipitation events that exceed the design criteria. Five storm water ponds and outfalls would be located below the Main Dump, while two ponds and outfalls would be located below the Eder Dump. Four of the ponds below the Main Dump and the two ponds below the Eder Dump would discharge to Powers Gulch. Discharges to Powers Gulch through the pond outlet structures would occur only for storm events that exceed the volume of runoff from the 10-year, 24-hour event. The remaining pond on the Main dump would discharge to Pinto Creek. Discharges from this pond would occur only for storm events that exceed the volume of runoff from the 100-year, 24-hour event.

Storm water discharges from the seven proposed detention/retention dams were estimated using information provided by Simons Li & Associates, Inc. (SLA, 1997; 1998). Studies conducted by SLA (1998) for pond design and performance indicate that a storm event exceeding the 10-year, 24-hour event by 10 percent would produce an average discharge of 2.4 cfs for a duration of two hours at each of the six outfall locations on Powers Gulch. These results were used to estimate the volume and rate of discharge from the six potential NPDES outfall locations to Powers Gulch for the 10-year, 24-hour to 100-year, 24-hour flow tier.

SLA (1998) further indicated that a storm event exceeding the 100-year, 24-hour event by 10 percent would produce an average discharge of 23 cfs for a duration of two hours from the detention/retention pond located on Pinto Creek. These results were used to estimate the volume and rate of discharge from this outfall location to Pinto Creek for the greater than 100-year, 24-hour flow tier. This discharge would result from a storm event exceeding the 100-year, 24-hour event by 10 percent. Specific data were not provided by SLA (1998) estimating discharge from the six outfall locations on Powers Gulch for the 100-year, 24-hour design event. Using the SLA data, however, EPA estimated the average discharge from each of the six outfall locations on Powers Gulch to be 23 cfs for approximately 4.1 hours for an event exceeding the 100-year, 24-hour event by 10 percent. This assumes that the design criteria for all outfall structures are similar and that the storage capacity of these ponds would be exceeded by 7.8 acre-feet.

Dissolved copper loads for both the proposed Main and Eder dumps were estimated using the tonnage-weighted maximum Meteoric Water Mobility Test (MWMT) value for copper (Tables 10-1 and 10-2), where the maximum MWMT value represents the highest copper concentration measured for each rock type during MWMT leach testing of waste rock samples (Knight Piesold, 1993). Weighting was based on the percentage of each rock type that would be disposed of in each facility. Thus, the weighted contribution from each rock type was determined by multiplying the MWMT value by the percentage of waste rock tons. The discharge composition is the sum of the contributions from each rock type. As shown in Tables 9-1 and 9-2, the weighted maximum MWMT value is considerably higher than the weighted average MWMT value. The latter value uses the average MWMT value for each rock type as determined from samples of material that would be disposed of in each facility.

Dissolved copper loads estimated for the Carlota facilities were determined by computing the total mass of copper that would be discharged from each facility over the duration of the discharge and assuming that this mass would be released in a day.

Carlota also expects to develop an outfall designated 008 in its NPDES permit which will discharge from a wellfield area to Haunted Canyon and/or Pinto Creek. Because the characteristics, specific location, and timing of discharges from this outfall have not yet been specified, insufficient information was available for this TMDL to specifically estimate copper loads associated with its discharges. Discharges of pumped groundwater through this outfall are not expected to carry large copper loads; however, the TMDL includes a concentration-based WLA to account for this potential source.

9.2 Load Allocations and Wasteload Allocations

As described in Section 8.4, loading capacities, background loadings, margins of safety, LAs and WLAs for the TMDL are based on five flow tiers. WLAs are established for all existing or proposed point sources, such as the BHP NPDES 005 outfall, and proposed outfalls for the Carlota Copper Project. LAs are established for all other non-point and non-discrete sources, such as for the Henderson Ranch mine area. As further source characterization is conducted in the basin, EPA may determine that some non-point pollutant sources are point sources and that allocations for the TMDL would then be redefined as WLAs. The allocations assume that the proposed Carlota Copper Project would be constructed. Allocation tables outlining LAs and WLAs for each source by target site, and for each flow tier are presented in Appendix C. (see Section 9.2.3 below for additional information concerning the assumptions made in calculating the allocations). Tables 1-3 and 1-4 of the Section 1.0 (Executive Summary) provide a summary list the allocations presented in Appendix C for each source.

The flow tiers are established at each target site using the maximum 6-hour average stream discharge that would result from each of the specified precipitation events occurring over the entire watershed. The loading capacity for each flow tier is established at the lower discharge value for the tier. An exception is the first flow tier which represents conditions ranging from no stream discharge (zero flow) to the discharge that would result from the 2-year, 1-hour storm event. Under these low flow conditions, Pinto Creek does not act as a well mixed stream, where stream discharge and pollutant concentrations are passed downstream through the entire drainage. Therefore, LAs and WLAs based on levels of stream discharge have not been calculated for low flow conditions. Instead the TMDL requires each source that discharges under low flow conditions to meet applicable water quality standards at the point of discharge. This does not apply to the proposed Carlota facilities (with the possible exception of outfall 008) because no discharge is anticipated to occur at stream discharges that result from less than the 10-year, 24-hour storm event.

9.2.1 Existing Sources Not Associated with the BHP Pinto Valley Mine

The LAs for each identified non-BHP source are based on the total available capacity at each target site, and for each flow tier, as defined in Section 8.4. For most identified sources that are not associated with the BHP Pinto Valley Mine, the LAs necessary to achieve the water quality goals for the TMDL are significantly less than the projected loading of dissolved copper. This is specifically true for the Gibson Mine. The projected loading of dissolved copper from the Gibson Mine, calculated using the maximum observed concentration of 236 mg/L, show a large contrast to the LA that can be allotted to this source to meet the goals of the TMDL (Table C-3).

The feasibility of achieving the necessary LAs for the Gibson Mine are discussed in detail in Section 10.0. Initial site evaluations and knowledge of other remedial activities in the watershed suggest that large reductions in the loading of dissolved copper from the Gibson Mine are feasible. However, remedial studies and additional feasibility analyses will be required to confirm that reductions in the loading of dissolved copper from this site to levels of natural background can be achieved. To address this issue, the LA established for the Henderson Ranch mine area is smaller than the available loading capacity at TS-1 (See Table C-2). The LA, established for the Henderson Ranch mine assumes that this source can be remediated to achieve water quality discharges less than 0.01 mg/L, which is approximately equal to background conditions. This approach reserved available loading capacity at TS-1 which was then allocated to the Gibson Mine at TS-2. The LA for the Gibson Mine is provided in Table C-3.

9.2.2 Sources Associated with the BHP Pinto Valley Mine

A WLA is established for the BHP NPDES Outfall 005 and LAs are established for potential sources that contribute drainage to Pinto Creek at Miller Spring Gulch, Gold Gulch, and North and South Ripper Spring Canyon. Although these latter tributaries and springs are not designated NPDES discharge outfalls, LAs were established for these potential sources because they drain from BHP and other mining operations that formerly operated in the watershed. Evaluation of loading estimates for NPDES 005 and the other potential sources listed above (see Tables C-4 and C-10) show that these sources are not significant contributors of dissolved copper in Pinto Creek and discharges consistently meet water quality standards.

Initial WLAs and LAs were allotted to each identified BHP source based on the total available capacity at each target site, as defined in Section 8.4. For the purposes of achieving the water quality goals of the TMDL, sources associated with BHP facilities were given priority over other non-discrete or historical sources when allotting LAs and WLAs at a given target site. Allocations were based on the maximum flow reported for that site by BHP (memo from E. Bingham (BHP) to L. Gentile (EPA), 4/19/99) and the chronic water quality criteria. After establishing the LAs and WLAs for the BHP sources, remaining available capacity was then allotted to the other sources associated with a given target site. For example, the WLA was allocated to BHP NPDES 005 before a LA was established for the undesignated mine sources identified above TS-3.

There are several stormwater outfalls covered by the BHP NPDES permit (outfalls 001, 002, 003, and 004) and the Arizona multi-sector general permit. The timing and magnitude of discharges from these locations are not well characterized at this time. However, EPA believes it is important to account for these potential discharge sources in the TMDL. Therefore, the TMDL provides concentration-based WLAs for these stormwater outfalls in the form of the equations which express the State water quality standards for copper:

$$\text{Acute criterion} = e^{(0.9422\,[\ln(\text{hardness})]\,-\,1.464)}$$

$$\text{Chronic criterion} = e^{(0.8545\,[\ln(\text{hardness})]\,-\,1.465)}$$

9.2.3 Proposed Carlota Facilities

LAs and WLAs for all identified sources in the Pinto Creek watershed were calculated based on the assumption that the proposed Carlota Copper Mine is developed. This scenario has two main assumptions: (1) WLAs for all sources were estimated using stream discharge values estimated with the assumption that all proposed facilities were in place (See Section 8.2.1), and (2) the Cactus Breccia Formation would not be a source of dissolved copper to Pinto Creek because of the development of the Carlota Cactus pit and the Pinto Creek diversion channel. WLAs for the proposed Carlota Copper Main and Eder dumps is the maximum load that is available for allocation to discrete sources for each flow tier. For proposed outfalls to Powers Gulch, the available load was established according to the proportion of discharge estimated from the four Main Dump and two Eder Dump outfalls. In addition, the Carlota project provides for discharges from a wellfield area designated 008 in the NPDES permit. The timing and magnitude of discharges from the wellfield areas are not well characterized at this time. Therefore, the TMDL provides concentration-based WLAs for these stormwater outfalls in the form of the equations which express the State water quality standards for copper:

Acute criterion = $e^{(0.9422\,[\ln(\text{hardness})]\,-\,1.464)}$

Chronic criterion = $e^{(0.8545\,[\ln(\text{hardness})]\,-\,1.465)}$

10.0 IMPLEMENTATION ISSUES

An implementation plan is not a required element of a TMDL at this time. Rather, the TMDL is used to establish water quality, management and remediation goals that are necessary to achieve water quality criteria in the water body. As noted in Section 9.2.1, the LAs necessary to achieve the water quality goals for the TMDL are significantly less than the current estimated "worst case" loading of dissolved copper for many of the sources that are associated with historic mining activities in the watershed (see Appendix C; Tables C-2 through C-4). EPA recognizes that abandoned mine projects present significant technical, legal, and monetary challenges to designing and implementing remedial measures.

After initial allocations are established, EPA would typically evaluate the feasibility of each source meeting the assigned loadings. Feasibility is a function of both engineering and cost requirements. Given that copper levels within Pinto Creek are not significantly above water quality standards and there appears to be only one potentially significant source (the Gibson Mine), EPA believes it is technically feasible to meet the proposed LAs. This is also true for other sources that are not yet well-defined (e.g., non-discrete sources between TS-2 and TS-3, etc.). EPA endorses the use of a phased approach to revising allocations and implementing TMDL requirements. This first phase has identified those sources and areas that are contributing to water quality exceedances. For example, there appear to be no significant sources downstream of TS-4. Ongoing monitoring by BHP Copper, Carlota Copper, and the Agencies during this first phase will be used to confirm this finding. At the same time, additional characterization will be performed with the support of Carlota Copper and BHP Copper to further define contributions from specific sources. The second phase will then define and assign LAs to these sources. A part of this process is to further understand related background concentrations in different sections of the watershed.

Achieving water quality standards in Pinto Creek depends largely on the feasibility of meeting the LA assigned to the Gibson Mine property. Based on “worst case” values, Table C-3 suggests that reductions of the copper load from Gibson Mine exceeding 99 percent will be required to achieve the assigned LA. Detailed site investigations have not been conducted; however, a preliminary assessment was completed in conjunction with the 1993 Consent Judgment (E&E, 1993; AZ Attorney General, 1993). Based on present knowledge of the property, EPA assumes needed reductions are feasible at the Gibson Mine for several reasons.

First, the major copper sources at Gibson, including the remnant pregnant leach solution (PLS) pond, waste rock and ore dumps, and abandoned precipitation launders, occupy a limited area, suggesting that the significant sources could be remediated by removal and/or capping. Similar remedial actions have resulted in reductions in copper loadings of more than 99% (see, e.g., discussions of the effectiveness of remedial actions to address tailings spills in the Pinto Creek basin, p. 25).

Second, it is probable that a large proportion of the observed contamination issues from discrete sources such as the PLS pond and launders which could be completely removed. The Carlota Copper Company has agreed to carry out a remedial action at the Gibson Mine to address many of the most significant copper sources at the site.

Third, it is unlikely that the extreme concentration of dissolved copper used in the loading analysis would be maintained for a protracted time. An upset condition that occurred in early 1993 at the Pinto Valley Mine provides an example of increased copper loads from storm overflow of a PLS facility. Pinto Valley’s Gold Gulch Weir overflowed during a series of large precipitation events that occurred in January to February, 1993, releasing a mix of storm water runoff and PLS to Pinto Creek. Initially high concentrations of dissolved copper in the effluent decreased rapidly from 340 mg/L on January 19 to 1.08 mg/L on January 26 to values less than 0.5 mg/L by February 9 (Magma Copper, 1993). EPA believes that overflow of the Gibson Mine PLS pond is likely to produce the same concentration-time effect (although on a much smaller volumetric scale). During a site visit in March 1999, EPA personnel observed copper sulfate crystals coating the dry bottom of Gibson Mine PLS pond liner. This type of coating provides a significant source of readily soluble copper that can be flushed from the pond during overflow. By analogy with the Gold Gulch Weir overflow, EPA believes that the high concentrations of dissolved copper measured in Gibson Gulch could have resulted from the early stages of overflow of the remnant PLS pond at the Gibson Mine (it is unclear from ADEQ’s sampling report if the sample containing 236 mg/L of dissolved copper was collected from flowing or standing water).

EPA believes that removal of the copper sulfate material is likely to have a dramatic impact on copper loads from the Gibson property. As discussed in Section 9.2.1, a feasibility study would identify additional remedial measures to further reduce and control copper loading.

The phased TMDL provides WLAs to Carlota Copper Company and BHP Copper, Inc. sources because their current and proposed discharges contribute minimally to exceedances of water quality standards. They will also participate in studies to further define the contribution of historic sources in the watershed and aid ADEQ in evaluating remedial measures to address these sources. As shown in Appendix C, the WLA to Carlota Copper's proposed discharge point in Pinto Creek is significantly lower than the natural loading from the Cactus Breccia Formation that would be eliminated by project construction. The WLAs to Pinto Creek under the scenario that the "Carlota Copper Project would proceed" is zero up to the 100-year, 24-hour event. This allocation is lower than the scenario that the "Carlota Copper Project would not proceed" because the Cactus Breccia Formation would still provide a naturally occurring non-point source of dissolved copper to Pinto Creek, adding to the degradation of water quality caused by the historic mining sources in the upper part of the watershed. In Powers Gulch, WLAs assigned to proposed Carlota Copper Company discharge points are zero up to the 10-year, 24-hour event. For greater storm events, the loadings from these discharges will have a minimal effect on water quality.

11.0 DEFINITIONS

Curve Number (CN) is a factor used to represent the soil, vegetation, and surface conditions that occur in a watershed; the factor is used to calculate storm water runoff by the SCS method (SCS, 1972).

Gross Allocation is a portion of the loading capacity allocated to an entire category of sources, rather than to a specific source

Loading or Pollutant Loading refers to the mass of a pollutant discharged per unit of time. Loading is calculated by multiplying the stream discharge by the constituent concentration and applying a coefficient to convert the result to the desired units. The loadings for this TMDL are expressed in kilograms per day (kg/day).

Load Allocation is a portion of the loading capacity that is allocated to a non-point source.

Loading Available for Allocation is the loading capacity minus the natural background load, any upstream allocations, and the margin of safety.

Loading Capacity is the maximum amount of a constituent that a water body can receive without exceeding water quality standards.

Margin of Safety addresses uncertainty in a TMDL through conservative assumptions and/or unallocated loading capacity.

Method Detection Limit (MDL) is the minimum concentration of a chemical or compound that can be detected by a specific analytical procedure at a 99 percent confidence level.

Natural Background is the estimated constituent level in the water body in the absence of human activity.

Stream Discharge is the volume of water passing a point in the stream per unit time. Stream discharge is sometimes referred to as stream flow. Stream discharge is expressed in units of cubic feet per second (cfs) in this document.

Target Sites are locations in the river network where the loading capacities for dissolved copper are calculated and allocated. Allocations are calculated for identified sources upstream of a given target site.

Total Maximum Daily Load (TMDL) is a technical plan designed to attain water quality standards. A TMDL consists of a number of "TMDL Elements".

TMDL Elements are the water quality standards, loading capacity, natural background loads, wasteload allocations, load allocations, and margin of safety.

Wasteload Allocation (WLA) is a portion of the loading capacity that is allocated to a point source.

12.0 REFERENCES

(Note: This is a partial list of references and guidance documents considered in developing the TMDL; a full list of documents relied upon to establish the TMDL is maintained in EPA's administrative record for this action.)

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