



Chino Mines Company
PO Box 10
Bayard, NM 88023

February 15, 2024

Mr. Brad Reid
New Mexico Environment Department
Groundwater Quality Bureau
Mining Environmental Compliance Section
P.O. Box 5469
Santa Fe, NM 87502

Ms. Carmen Rose and Mr. Kevin Myers
Energy, Minerals & Natural Resources Dept
Mining and Minerals Division
Mining Act Reclamation Program
1220 South St. Francis Drive
Santa Fe, NM 87505

Dear Ms. Rose, Mr. Reid and Mr. Myers:

**Re: Updated Task 3 Precipitation Analysis for Closure
Freeport-McMoRan Chino and Tyrone Mines**

Freeport-McMoRan New Mexico Operations (Chino and Tyrone) submitted a report entitled Closure Surface Water Conveyances Precipitation Analysis Task 3 to the New Mexico Environment Department (NMED) and the Energy, Minerals and Natural Resources Department, Mining and Minerals Division (MMD) on June 20, 2023 in accordance with the approved Precipitation Workplan Analysis for Closure (Workplan). The agencies provided comments on October 2, 2023. Chino and Tyrone provided responses to some of those comments on November 16, 2023 followed by a conference call to discuss remaining comments for clarity on January 16, 2024. Several updates to the report were made as a result of that discussion and enclosed is the final, updated report entitled Updated Closure Surface Water Conveyances Precipitation Analysis Task 3.

Chino and Tyrone are also preparing a separate letter to fulfill the workplan requirement regarding analysis of the performance of existing structures during recent significant precipitation events as discussed in the January 16 meeting. We propose to present that information at the workshop described in Task 4 of the approved Workplan which is to be scheduled.

If you have any questions, please contact me at 575-912-5927 or Mr. Tom Shelley at 575-912-5773.

Sincerely,

Sherry Burt-Kested, Manager
Environmental Services

TLS:sc
Enclosure
20240215-001
20240215-101



REPORT

**Updated Closure Surface Water Conveyances
Precipitation Analysis Task 3**
Chino and Tyrone Mines

Submitted to:

Tom Shelley

Environmental Manager, Tyrone Mine
Freeport-McMoRan Tyrone Inc.
PO Box 571
Tyrone, New Mexico 88065

Submitted by:

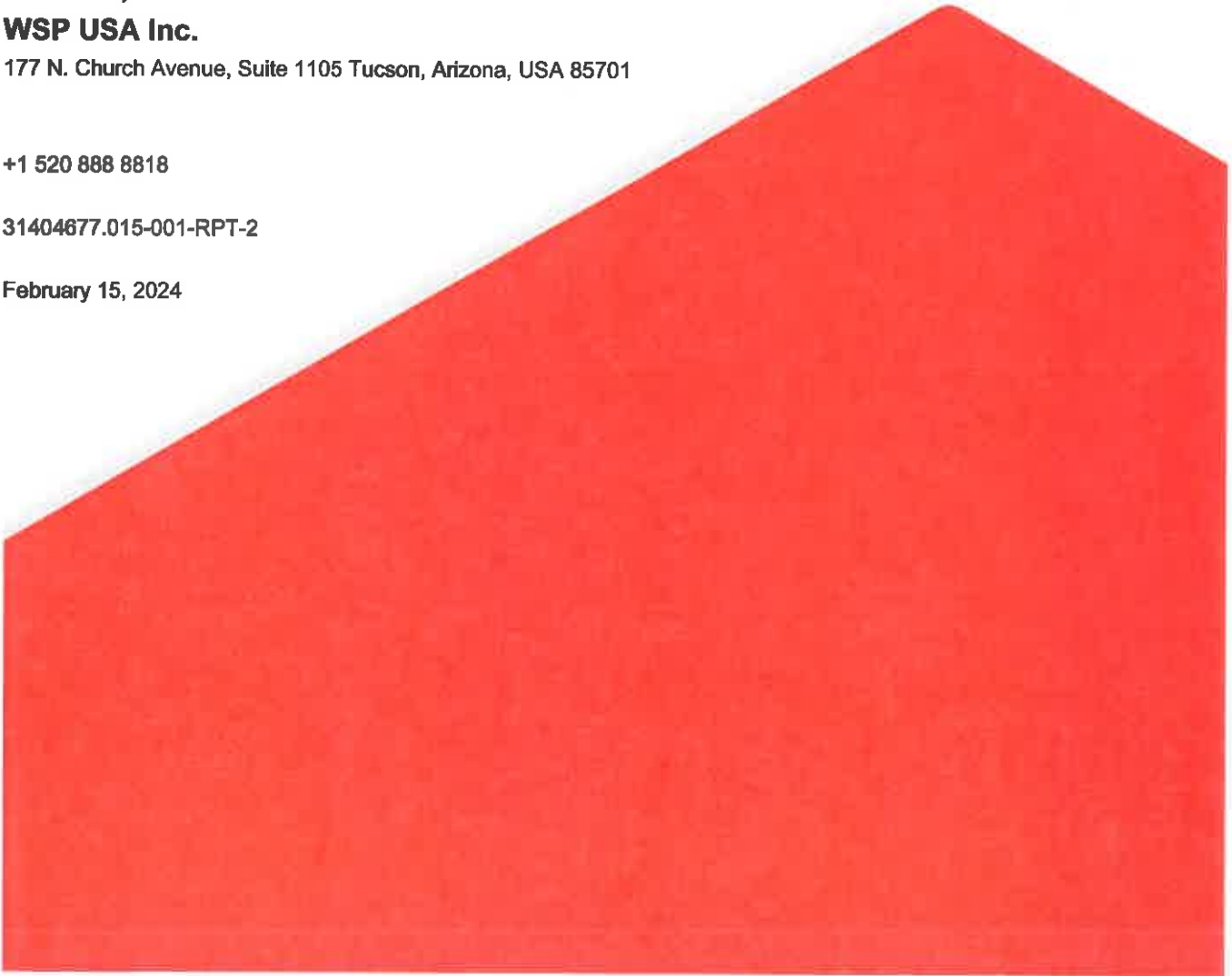
WSP USA Inc.

177 N. Church Avenue, Suite 1105 Tucson, Arizona, USA 85701

+1 520 888 8818

31404877.015-001-RPT-2

February 15, 2024



Distribution List

Tom Shelley

Sherry Burt-Kested

Table of Contents

- 1.0 INTRODUCTION 1**
- 2.0 SCOPE OF ASSESSMENT 1**
- 3.0 METHODOLOGY 6**
 - 3.1 Precipitation Depths 6
 - 3.2 Rational Formula Method 6
 - 3.2.1 Application of the Rational Formula Method 7
 - 3.2.2 Evaluate Conceptual Downchute Channel Capacity 7
 - 3.2.3 Estimated Typical Closure Closeout Plan Bench Channel T_c 7
 - 3.2.4 Estimated Typical Closure Closeout Plan Top Area T_c 8
 - 3.2.5 Top Area Rainfall Intensity 9
 - 3.2.6 Runoff Coefficient 9
 - 3.2.7 Intensity–Duration–Frequency Curves 10
- 4.0 ASSESSMENT OF WORST-CASE STORMWATER CONVEYANCE STRUCTURES 11**
 - 4.1 Analysis of Chino Worst-Case Structures 11
 - 4.1.1 Rational Method Assessment of Chino Closure Closeout Plan Conveyance Structures 12
 - 4.1.2 Rational Formula Method Assessment of Chino Worst-Case Existing Reclaimed Conveyance Structures 13
 - 4.2 Assessment of Tyrone and Little Rock Worst-Case Structures 15
 - 4.2.1 Rational Method Assessment of Tyrone and Little Rock Closure Closeout Plan Conveyance Structures 16
 - 4.2.2 Rational Method Assessment of Tyrone and Little Rock Worst-Case Existing Reclaimed Conveyance Structures 18
 - 4.3 Analysis Results 20
 - 4.3.1 Chino Closure Closeout Plan Conveyance Structures 20
 - 4.3.2 Chino Existing Conveyance Structures 21
 - 4.3.3 Tyrone and Little Rock Closure Closeout Plan Conveyance Structures 21
 - 4.3.4 Tyrone and Little Rock Existing Conveyance Structures 22

5.0 HEC-HMS SECOND-PASS ANALYSIS 23

 5.1 Facilities and Parameters 24

 5.2 Basin Models 24

 5.3 Rational Formula Method and HEC-HMS Results Comparison..... 27

6.0 CONCLUSIONS 30

7.0 CLOSING..... 30

8.0 REFERENCES 34

TABLES

Table 1: Chino, Tyrone, and Little Rock Closure Closeout Plan Facilities and Structures Analyzed..... 3

Table 2: Chino and Tyrone Existing Reclaimed Facilities and Structures Analyzed 4

Table 3: Intensity–Duration–Frequency Curve Table 10

Table 4: Chino Intensity–Duration–Frequency Curve Table..... 12

Table 5: Chino Subbasin Geometries and Rational Method Peak Flow Estimates for Closure Closeout Plan Facilities 12

Table 6: Summary of Peak Flow Estimates through Worst-Case Structures at Existing Chino Reclaimed Facilities (Rational Formula Method)..... 13

Table 7: Tyrone and Little Rock Intensity–Duration–Frequency Curve Table 16

Table 8: Tyrone and Little Rock Subbasin Geometries and Rational Method Peak Flow Estimates for Closure Closeout Plan Facilities 17

Table 9: Summary of Peak Flow Estimates through Worst-Case Structures at Existing Tyrone and Little Rock Reclaimed Facilities (Rational Formula Method) 19

Table 10: Summary of Freeboard Estimates for Present and Climate Change Conditions at Chino Closure Closeout Plan Facilities (Rational Formula Method) 20

Table 11: Summary of Rational Formula Method Analysis Results for Chino Existing Structures..... 21

Table 12: Summary of Freeboard Estimates for Present and Climate Change Conditions at Tyrone and Little Rock Closure Closeout Plan Facilities (Rational Formula Method)..... 22

Table 13: Summary of Rational Formula Method Analysis Results for Tyrone and Little Rock Existing Structures 23

Table 14: Comparison Between HEC-HMS and Rational Formula Method Flow Estimates 28

Table 15: Peak Flow Estimates for All Estimation Methods 29

Table 16: Summary of Conveyance Structure Analysis Results for Chino Existing Structures 31

Table 17: Summary of Conveyance Structure Analysis Results for Tyrone and Little Rock Existing Structures 31

FIGURES

Figure 1: Flow Velocities for Overland and Shallow Concentrated Flows 8

Figure 2: Rational "C" Coefficient Desert (Cactus, Grass, and Brush) as a Function of Rainfall Depth,
Hydrologic Soil Group, and Percent of Vegetation Cover 10

Figure 3: Chino 100-Year, 24-Hour Intensity–Duration–Frequency Curve..... 11

Figure 4: Chino 100-Year, 24-Hour Intensity–Duration–Frequency Curve with 14% Climate Change Modifier 11

Figure 5: Tyrone and Little Rock 100-Year, 24-Hour Intensity–Duration–Frequency Curve 15

Figure 6: Tyrone and Little Rock 100-Year, 24-Hour Intensity–Duration–Frequency Curve with 14% Climate
Change Modifier 16

Figure 7: Chino Tailing Ponds C, 4W, 4E, and 6W Facilities 25

Figure 9: Tyrone 1 and 1A Tailing Impoundment Facilities 26

Figure 10: Tyrone 2 Tailing Impoundment Downchute Subbasin..... 26

Figure 11: Tyrone 7A Waste Downchute Subbasin 27

Figure 12: Burrow Mountain Tailing Impoundment Subbasin 27

APPENDICES

APPENDIX A

Site Maps – Figures 1 through 16

APPENDIX B

Summary Calculation Sheets and Results Tables

1.0 INTRODUCTION

Freeport McMoRan Incorporated (FMI) New Mexico Operations engaged WSP USA Inc. (WSP) to carry out Task 3 of the approved Precipitation Analysis Workplan for closure surface water conveyances at the Chino, Tyrone, and Little Rock mine sites. The intent of the study is to assess the adequacy of stormwater conveyance under projected climate change conditions (evaluated in Task 2) for both planned closure structures documented in the most current Closure Closeout Plans (CCPs) for the Chino, Tyrone, and Little Rock mines and conveyance structures constructed at existing reclaimed facilities at these three mine sites.

The original Task 3 report was prepared on June 16, 2023, and submitted to the New Mexico Environment Department (NMED) and the Energy, Minerals and Natural Resources Department, Mining and Minerals Division (EMNRD MMD) on June 20, 2024. The agencies provided comments on both the Task 2 report prepared by Applied Weather Associates, LLC (AWA 2022) and the Task 3 report on October 2, 2023, and FMI provided responses to the comments on November 16, 2023. This updated Task 3 report has been prepared to address several of the agency's comments, while other remaining agency comments will be addressed during the Task 4 Working Session to be held later in 2024.

This updated report was prepared to summarize the methodology, hydrology and hydraulic calculations, and results of the conveyance assessments. The assessments covered the following facilities and structure types:

- sites:
 - Chino Mine
 - Tyrone Mine
 - Little Rock Mine
- facilities
 - CCP facilities
 - existing reclaimed facilities
- conveyance types:
 - top channels
 - bench channels (includes bench channels and access ramp channels)
 - downchutes (includes downdrains, spillways, and ridge/valley channels)

2.0 SCOPE OF ASSESSMENT

This Updated Closure Surface Water Conveyances Precipitation Analysis was conducted based on specific regulatory agency permit conditions, subsequent meetings with FMI representatives and other project stakeholders, and agency comments received on the original Task 3 report. Key documents reviewed in developing the scope of work associated with the updated assessment included the following:

- *Chino Discharge Permit 1340. Condition C110.C and Tyrone Permit GR010RE Rev 09-1 -Precipitation Workplan Analysis for Closure workplan submitted by Freeport-McMoRan Chino Mines Company on behalf of both Chino and Tyrone Mines (Freeport-McMoRan), dated May 21, 2021.*
- The New Mexico Environment Department's (NMED's) and Energy, Minerals and Natural Resources Department (EMNRD), Mining and Minerals Division's (MMD's) joint agency *Conditional Approval of the*

Precipitation Analysis Work Plan, DP-1340, DP-1341, and Tyrone Permit GR010RE Rev 09-1; Freeport-McMoRan Chino and Tyrone Mines, dated September 3, 2021.

- *Climate Change Projections for the Chino/Tyrone, New Mexico Mine. Report prepared by Applied Weather Associates, LLC (AWA). October 2022.*
- *Chino Mine Closure/Closeout Plan Update – Freeport-McMoRan Chino Mines Company. Report prepared by Golder Associates Inc. (Golder). February 14, 2018.*
- *9 Waste Rock Stockpile Closure/Closeout Plan – Freeport-McMoRan Chino Mines Company. Report prepared by Golder. March 30, 2017.*
- *2013 Tyrone Mine Closure/Closeout Plan Update – Freeport-McMoRan Tyrone Inc. Report prepared by Golder. Revised July 30, 2019.*
- *Little Rock Copper Leach Stockpile and P-Plant Closure Designs Final As-Built prepared by Telesto Solutions Inc. (Telesto). September 27, 2011.*
- *Appendix A Updated Closure/Closeout Plan for the Little Rock Mine – March 2022 Issued for Financial Assurance Reclamation Cost Estimate prepared by Telesto. March 24, 2022.*
- *Joint Agency Response for: 1) Task 2: Climate Change Projection for the Chino/Tyrone, New Mexico Mine; 2) Task 3: Closure Surface Water Conveyances Precipitation Analysis submitted by the NMED and the EMNRD MMD on October 2, 2023.*

The Precipitation Analysis Workplan (Freeport-McMoRan 2021) was submitted to the NMED and the EMNRD MMD on May 21, 2021, in fulfillment of Condition C110.C of DP-1340 and Condition 9.W.2 of Tyrone Permit GR010RE Rev 09-1, which require submittal of a workplan to evaluate, in part, present climatological site condition data and forward projections to determine the adequacy of the design of stormwater structures proposed at closure. The joint agency (NMED and EMNRD MMD) September 3, 2021 Conditional Approval (2021) of the Precipitation Analysis Workplan also specified that existing stormwater structures be included in the analysis along with those proposed at closure.

Chino and Tyrone submitted the Task 2 Climate Change Projections report (AWA 2022) in January 2023.

The scope of the original Task 3 precipitation analysis was split between conceptual CCP surface water conveyance structures and existing surface water conveyance structures constructed on reclaimed facilities across both the Chino and Tyrone mine sites. In response to the October 2, 2023 joint agency comments on the original Task 3 report, WSP has also included both conceptual CCP and existing surface water conveyance structures on reclaimed facilities at the Little Rock Mine in this updated Task 3 precipitation analysis.

The conceptual CCP facilities were analyzed to determine the capacities of the worst-case example of each conveyance structure type across the entirety of each mine site. The main conceptual CCP structures evaluated were the top surface channels, downchutes, and bench channels. For CCP facilities, the longest top channel, longest bench channel with the largest catchment, and downchute with the largest catchment were determined for each mine site, and the flowrate was estimated for each using a conservative Rational Formula Method (NMDOT 2018) approach. The Rational Formula Method was used as a screening tool to determine if additional analysis was warranted. The individual CCP facilities at Chino, Tyrone, and Little Rock and the associated conceptual surface water conveyance structures analyzed as part of this assessment are summarized in Table 1.

Table 1: Chino, Tyrone, and Little Rock Closure Closeout Plan Facilities and Structures Analyzed

Facility	Benches	Downchutes	Top Channels
Chino			
Northwest Stockpile	--	--	--
North Stockpile ^(a)	--	--	--
Lee Hill Stockpile ^(a)	--	--	--
Northeast Stockpile ^(a)	--	--	--
West Stockpile	Yes	Yes	Yes
South Stockpile	Yes	Yes ^(b)	--
STS2 Stockpile	Yes	--	--
Proposed 3A Stockpile ^(a)	Yes	--	--
Upper South Stockpile ^(a)	Yes	--	--
Planned Santa Rita Stockpile ^(a)	--	--	--
Lampbright Leach Stockpile (main, south, southwest)	Yes	Yes	--
9 Waste Rock Stockpile	Yes	Yes	Yes ^(b)
Axiflo Lake	Yes	Yes	--
Southern end of Tailing Pond 6 East and 6 West	Yes	Yes	--
Tailing Pond 7	Yes ^(b)	Yes	--
Tyrone			
1A Leach/1B Leach	Yes	Yes	Yes
2 Leach (Area 1)	Yes	Yes	Yes
2 Leach (Area 2)	Yes	Yes	Yes
2A Leach/2B Leach	Yes	Yes	No
2B Waste	Yes	Yes	Yes
3A Leach/3B Waste	Yes	Yes	Yes
5A Waste	Yes ^(b)	Yes	Yes ^(b)
6A Leach ^(a)	--	--	--
6B Leach	Yes	Yes	--
6C Leach	Yes	Yes	Yes
6D Leach	Yes	Yes	--
8A Waste/8C Waste ^(a)	--	--	--
9A Waste	Yes	Yes	Yes
9AX Waste	Yes	--	--
CSG Waste	Yes	--	--
Gettysburg Waste ^(a)	--	--	--
San Salvador Pit/San Salvador Waste Backfill	Yes	Yes ^(b)	Yes
South Rim Pit/2 Leach/7C Waste	Yes	Yes	Yes
Valencia In-Pit Leach ^(a)	--	--	--

Facility	Benches	Downchutes	Top Channels
Little Rock			
NRW Waste	Yes	Yes	--
East In-Pit Waste	Yes	Yes	--
West In-Pit Waste	Yes ^(b)	Yes ^(b)	--

a. Facility located entirely within the current defined Open Pit Surface Water Drainage Area (Chino) or Open Pit Surface Drainage Area (Tyrone).

b. Facility with worst-case structure.

"Yes" = structure type is present in the current CCP conceptual designs; "--" = structure type is not present in the CCP

For existing reclaimed facilities, the same conservative Rational Formula Method was initially used to estimate the flowrates through each structure. Unlike the CCP analysis, which looked at worst-case conveyance structure types across each mine site, individual existing reclaimed facilities were analyzed to identify the worst-case conveyance structure types at each facility at each of the three mine sites. The existing reclaimed facilities at Chino, Tyrone, and Little Rock and the associated surface water conveyance structures analyzed as part of this assessment are summarized in Table 2.

Table 2: Chino and Tyrone Existing Reclaimed Facilities and Structures Analyzed

Facility	Top Channels	Benches	Downchutes	Other
Chino				
Lake One and Slag Pile	R, MR	R, MR	R, MR	Culvert (HEC-HMS)
Tailing Pond 1	R, MR	R, MR	R, MR	--
Tailing Pond 2	R, MR	R, MR	R, MR	--
Pond 2 Repository	R, MR	--	R, MR	--
Tailing Pond B	R, MR	R, MR	R, MR	Access Ramp (R)
Area North of Pond B	R, MR	R, MR	R, MR	Access Ramp (R)
Tailing Pond C	R, MR	R, MR	R, MR, HEC-HMS	Access Ramp (R)
Tailing Pond 4E	R, MR, HEC-HMS	R, MR	R, MR	--
Pond 4E Repository	R, MR	R, MR	R, MR	--
Tailing Pond 4W	R, MR	R, MR	R, MR, HEC-HMS	--
Tailing Pond 6E	R, MR	R, MR	R, MR	Access Ramp (R)
Tailing Pond 6W	R, MR	R, MR	R, MR, HEC-HMS	Access Ramp (R)
Groundhog No. 5 Stockpile	R, MR	--	--	--

Facility	Top Channels	Benches	Downchutes	Other
Tyrone				
3 Tailing Impoundment	R, MR	R, MR	R, MR	--
3X Tailing Impoundment	R, MR	R, MR	R, MR	--
2 Tailing Impoundment	R, MR	R, MR	R, MR, HEC-HMS	--
1X Tailing Impoundment	R, MR	R, MR	R, MR	--
1 Tailing Impoundment	R, MR	R, MR, HEC-HMS	R, MR	--
1A Tailing Impoundment	R, MR	R, MR, HEC-HMS	R, MR, HEC-HMS	--
Channel Between 1X/1 Tailing Impoundments	--	--	R, MR, HEC-HMS	--
1 Tailing North Ponds Area	R, MR	--	--	--
1 Tailing Southern Area	R, MR	--	--	--
1 Leach Stockpile	R, MR	--	R, MR	--
USNR	R, MR	--	--	--
1C Waste	--	--	R, MR	--
7A Waste	R, MR	R, MR	R, MR, HEC-HMS	Pipe (HEC-HMS)
7A Far West	--	--	R, MR	--
Burro Mountain Tailing Impoundment	R, MR, HEC-HMS	--	--	--
Little Rock				
Copper Leach	--	R, MR	--	--

-- = structure type is not present in the CCP
 R = Structures analyzed with Rational Method
 MR = Structures analyzed with Modified Rational Method
 HEC-HMS = Structures analyzed with HEC-HMS

The conservative Rational Formula Method was used to evaluate whether conveyance channels had sufficient capacity/freeboard to carry the design storm with the additional projected rainfall estimated from Task 2 for the individual conveyance structures at each facility.

As described in Section 5.0, select conveyance structures were further assessed using the Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) (USACE 1998) to evaluate the robustness of the Rational Formula Method analyses. To better understand the large reduction in flow estimates observed with the structures analyzed with HEC-HMS, the facilities were analyzed a third time with a modified Rational Formula Method approach with top surface and sideslope time of concentrations (Tc's) adjusted to be specific to these facilities as described in Section 5.3. The individual analyses conducted for each of the existing facilities are detailed in Table 2. Further details of the scope of the Task 3 precipitation analysis for closure surface water conveyances at the Chino, Tyrone, and Little Rock mine sites are provided in Section 3.0, and the results of the assessment are provided in Section 4.0.

3.0 METHODOLOGY

The precipitation analysis WSP used was similar to analyses completed by Golder in 2018 (Golder 2018) to support a determination that the Chino CCP surface water facilities at the Chino Mine would meet the standards of the Supplemental Rules for Copper Mines. National Oceanic and Atmospheric Administration (NOAA) Atlas 14 precipitation estimates for the 100-year, 24-hour storm event were increased by 14% per the recommended representative concentration pathway (RCP) 4.5 monsoon precipitation described within the Task 2 report (AWA 2022) to provide a representation of hypothetical effects of climate change to the surface water conveyance assessments. The conservative increase of 14% as recommended in the AWA Task 2 study was used on the 100-year, 24-hour storm event as listed for each mine site in NOAA 14 Atlas. This led to 100-year, 24-hour storm depths of 4.48 inches for Chino and 4.29 inches for Tyrone and Little Rock that were applied in the precipitation analysis. Additional scenarios were not considered for reasons discussed in the 2023 FMI Response to Agency Comments (FMI 2023).

An initial high-level, conservative analysis of each CCP facility was conducted using the Rational Formula Method with the 14% increase to the NOAA Atlas 14 100-year storm event described previously. Following this initial screening analysis, a more detailed HEC-HMS analysis was performed on select conveyance structures to evaluate the robustness of the Rational Formula Method analyses, and a modified Rational Formula Method was applied to the structures to better understand the reduced flow estimates observed with the HEC-HMS analyses. The results of the additional HEC-HMS analyses are presented in Section 5.0, and results of the modified Rational Formula Method analyses are presented in Section 5.3.

3.1 Precipitation Depths

Facilities included in the first pass Rational Formula Method analyses are listed within Table 1 and Table 2 within Section 2.0. The stormwater conveyance structures at these facilities were originally sized using the representative NOAA Atlas 14 100-year storm event for each site. Based on the results of the AWA Task 2 climate change study (AWA 2022), total runoff from these facilities were estimated using a 14% modifier to the NOAA Atlas 14 100-year, 24-hour design storm for representation of potential climate change conditions. The AWA Task 2 study results indicated that there was no projected change in the probable maximum precipitation (PMP) estimates for the RCP 4.5 (present climate through 2100) and, as a result, any conveyance structures designed based on PMP estimates were excluded from these analyses.

The focus of this analysis is to observe the change in a structures capacity due to increased precipitation resulting from climate change. Structures designed to the PMP or $\frac{1}{2}$ PMP were not analyzed, as no change to the 1-Day or 3-Day PMP is anticipated per the AWA Task 2 study climate change projections.

3.2 Rational Formula Method

The purpose of the Rational Formula Method evaluation is to develop a high-level conservative (screening) estimate of maximum flow rates for both planned CCP conveyance structures and conveyance structures constructed on existing reclaimed facilities at Chino, Tyrone, and Little Rock. The Rational Formula Method is a widely accepted procedure for estimating peak rates of runoff from small watersheds for prefeasibility through feasibility level of analyses. The concept behind the Rational Formula Method is that if a rainfall of intensity (i) begins instantaneously and continues indefinitely, the rate of runoff will increase until the time of concentration (T_c), when all of the watershed is contributing flow at the outlet. Due to this underlying basic premise, peak flows estimated using the Rational Formula Method result in a conservative estimate of the peak runoff from the watershed.

The product of rainfall intensity (i) and watershed area (A) is the inflow for the system, and the ratio of this rate to the rate of peak discharge (Q) (which occurs at time T_c) is termed the runoff coefficient (C).

The standard form of the equation is:

$$Q = C \times i \times A \quad \text{Equation 1}$$

Where:

Q = the peak rate of runoff, in cubic feet per second (cfs)

C = a dimensionless runoff coefficient

i = the rainfall intensity, in inches/hour (in/hr)

A = the watershed area, in acres (ac)

This equation is in mixed units; therefore, a conversion factor to convert from acre-feet per hour (ac ft/hr) to cubic feet per second (cfs) of 1.008 is used. The Rational Formula Method has several assumptions implicit to the method, including the following:

- Peak flow occurs when all of the watershed is contributing runoff.
- The rainfall intensity is uniform over a duration of time equal to or greater than T_c .
- The frequency of the peak flow is equal to the frequency of the rainfall intensity.

3.2.1 Application of the Rational Formula Method

The following steps describe how to apply the Rational Formula Method for flow analysis:

- Measure each watershed area in acres.
- Obtain the applicable intensity–duration–frequency (IDF) table for the site.
- Compute the T_c for the watershed.
- Determine design i from the IDF table using the design event frequency and the watershed T_c .
- When T_c is computed as less than 10 minutes, a minimum rainfall duration of 10 minutes should be used.
- When T_c is computed as greater than 60 minutes, the Rational Formula Method should not be used.
- Estimate the runoff coefficient for the watershed.
- Calculate runoff $Q = 1.008 \times C \times i \times A$

3.2.2 Evaluate Conceptual Downchute Channel Capacity

To calculate the downchute channel capacity, use the following:

$$\text{Downchute channel flow} = \text{sum of bench channel flow} + \text{top area flow} \quad \text{Equation 2}$$

3.2.3 Estimated Typical Closure Closeout Plan Bench Channel T_c

The following are used to estimate the typical CCP bench channel T_c :

- CCP interbench slope length = 190 feet.
- CCP interbench slope gradient = 33%.

- Assumed nearly bare and untilled (overland flow; conservative assumption representative of conditions prior to vegetation establishment). Alluvial fans in western mountain regions (shallow concentrated flow).
- From Figure 1, the estimated velocity is approximately 5.6 feet/second (ft/s).
- CCP $T_c = 190 \text{ feet} / 5.6 \text{ ft/s} = 33.9 \text{ seconds}$.

Computed T_c is less than 10 minutes; therefore, the minimum allowable T_c is 10.0 minutes. Existing reclaimed facilities on average had an interbench slope length of roughly 126 feet. This led to an even shorter T_c . Due to this, the 10-minute T_c was used across both CCP and existing reclaimed facilities for all bench channels. While this did not affect the T_c , it did lead to a decrease in unit area for existing reclaimed structures and therefore runoff of each bench.

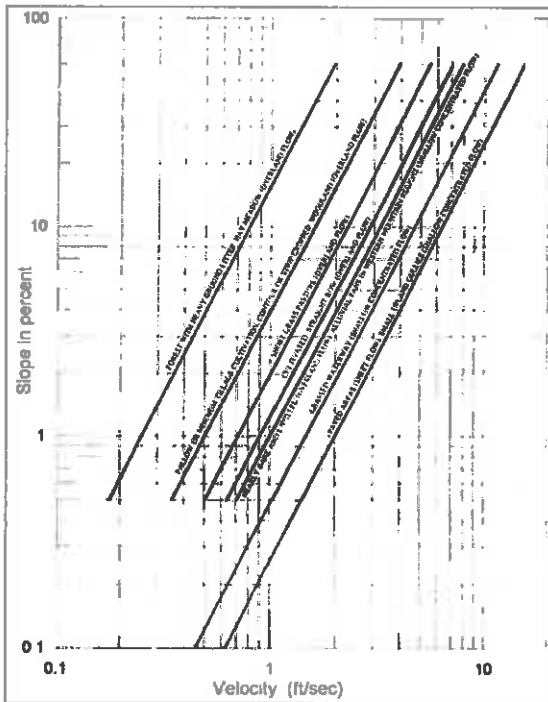


Figure 1: Flow Velocities for Overland and Shallow Concentrated Flows

Source: NMDOT 2018.

3.2.4 Estimated Typical Closure Closeout Plan Top Area T_c

The following calculation was used to estimate the typical CCP top area T_c :

- Assume top-surface slope length = 1,000 feet.
- Slope = 1%.
- Assume nearly bare and untilled (overland flow; conservative assumption representative of conditions prior to vegetation establishment). Alluvial fans in western mountain regions (shallow concentrated flow).
- From Figure 1, the estimated velocity is approximately 1.0 ft/s.
- $T_c = 1,000 \text{ feet} / 1.0 \text{ ft/s} = 1,000 \text{ seconds} = 16.7 \text{ min}$.

The 16.7-minute estimate that was used in previous hydraulic estimates at Chino was found to hold roughly true for a handful of facilities with calculated T_c 's ranging between 10 to 20 minutes per top area.

3.2.5 Top Area Rainfall Intensity

- The following calculation was used to estimate the top area rainfall intensity: $T_c = 16.7$ minutes.
- Rainfall intensity was interpolated from site-specific IDF curves.
- Rational "C" coefficient desert = 0.59 based on data extrapolated from IDF curves.

3.2.6 Runoff Coefficient

Determination of runoff coefficients:

- Hydrologic soil groups (HSGs) are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.
- The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:
 - Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
 - Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
 - Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
 - Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high-water table, soils that have a clay pan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.
- If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Per the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey, Map Unit 46 = pits–dumps association, extremely steep, HSG = B.

Based upon previous characterization of the cover materials at Chino, HSG A and B are considered representative, with 30 to 40% vegetation cover in the reclaimed condition, based on field studies.

Summary:

- HSG = A and B
- 40% cover
- rational "C" coefficient desert = 0.60 based on data extracted from IDF curves

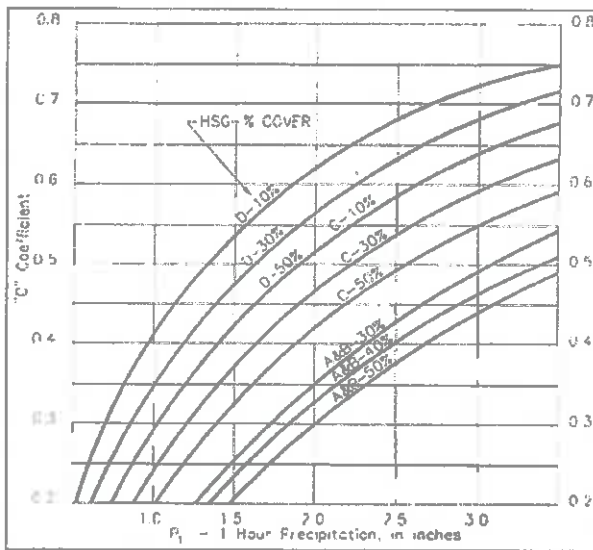


Figure 2: Rational "C" Coefficient Desert (Cactus, Grass, and Brush) as a Function of Rainfall Depth, Hydrologic Soil Group, and Percent of Vegetation Cover

Source: NMDOT 2018.

3.2.7 Intensity–Duration–Frequency Curves

An IDF table was collected from NOAA Atlas 14 for Chino (32.7922N, -108.0378W) and Tyrone/Little Rock (32.645N, -108.3748W). Per the Task 2 AWA climate change study (AWA 2022), a 14% multiplier was added to the NOAA Atlas 14 100-year design storm depths. This was then converted to an IDF table (Table 3). Both the present 100-year precipitation data and the 100-year adjusted climate change data were plotted, and the intensity for the typical top area Tc's was derived using the trendlines presented in Figure 3 and Figure 4 in Section 4.1.

Table 3: Intensity–Duration–Frequency Curve Table

Return Period	Chino 100-Year (in/hr)	Tyrone/Little Rock 100-Year (in/hr)	Chino 100-Year + 14% (in/hr)	Tyrone/Little Rock 100-Year + 14% (in/hr)
5 min	8.53	8.27	9.73	9.43
10 min	6.48	6.30	7.39	7.18
15 min	5.36	5.20	6.11	5.93
30 min	3.62	3.50	4.13	3.99
1 hr	2.24	2.17	2.55	2.47
2 hr	1.32	1.28	1.50	1.46
3 hr	0.91	0.89	1.04	1.01
6 hr	0.51	0.50	0.58	0.57
12 hr	0.29	0.28	0.33	0.32
24 hr	0.16	0.16	0.19	0.18

Following the methodology used in prior channel flowrate estimates at Chino, the HSB A and B 40% cover graph was plotted and projected to have a maximum possible runoff coefficient of 0.6. This value was used for the total composite runoff coefficient for the 100-year, 24-hour storm events at the Chino, Tyrone, and Little Rock sites.

4.0 ASSESSMENT OF WORST-CASE STORMWATER CONVEYANCE STRUCTURES

4.1 Analysis of Chino Worst-Case Structures

Analysis of the Chino worst-case structures began with the creation of the IDF curves for both the present and climate change conditions. The trendline formula for these conditions was used to estimate the intensity of the storm at the T_c of both the top surfaces and side slopes.

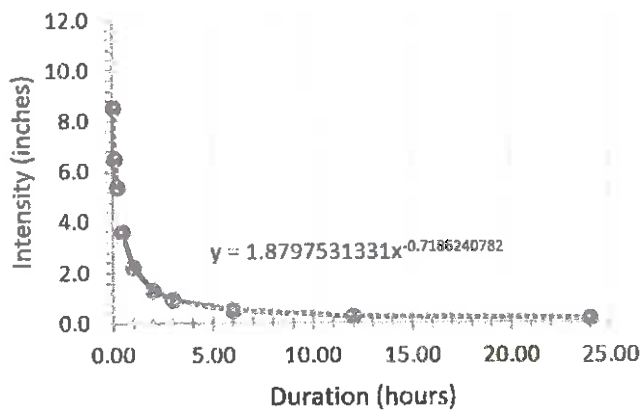


Figure 3: Chino 100-Year, 24-Hour Intensity–Duration–Frequency Curve

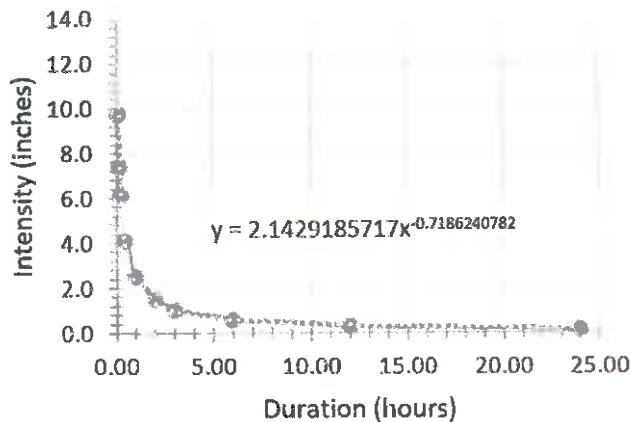


Figure 4: Chino 100-Year, 24-Hour Intensity–Duration–Frequency Curve with 14% Climate Change Modifier

The typical bench and typical top area peak runoff were then calculated as cfs/ft of bench channel and cfs/ac of top area, respectively. Additional times of concentration were calculated for select facilities that exceeded the average typical top surface area by a wide margin. The peak runoff per acre for the typical and facility-specific times of concentration are presented in Table 4.

Table 4: Chino Intensity–Duration–Frequency Curve Table

Catchment ID	Time of Concentration (min)	Climate Change Conditions Unit Runoff	Present Conditions Unit Runoff
Typical bench	10	4.43 cfs/ft	3.89 cfs/ft
Typical top area	16.7	3.17 cfs/ac	2.78 cfs/ac
Pond 7 top area	160	0.63 cfs/ac	0.55 cfs/ac
Pond 6 East & 6 West	89.3	0.95 cfs/ac	0.83 cfs/ac

The estimated peak flows from analyzed catchment areas were then calculated by multiplying the actual facility lengths or areas by the above unit runoff rates. These flows were summed as needed based on the total catchment contributing to a given structure creating very conservative peak flowrates that assume the peak flows from each contributing area arrive at the structure simultaneously. The summary of these values is presented in Table 5 in Section 4.1.1.

4.1.1 Rational Method Assessment of Chino Closure Closeout Plan Conveyance Structures

The facilities were split into subbasins, and total bench channel lengths, as well as top areas, were used to calculate conservative flowrate estimates through the downchutes.

Table 5: Chino Subbasin Geometries and Rational Method Peak Flow Estimates for Closure Closeout Plan Facilities

Facility	Subbasin ID	Length of Bench Channels (ft)	Top Areas (ac)	Total Peak Flow in Downchute – Present Conditions (cfs)	Total Peak Flow in Downchute – Climate Change (cfs)
South Stockpile	South SP-1	50,885	55	1082	1,234
	South SP-2	39,788	29	809	923
West Stockpile	West SP-1	21,523	27	469	534
	West SP-2	9,543	20	231	264
	West SP-3	23,850	92	693	790
	West SP-4	29,257	10	564	643
Lampbright Leach Stockpile	Main Lampbright-1	31,900	25	654	746
	West Lampbright-2	25,138	10	486	555
	South Lampbright-1	25,536	27	543	620
	South Lampbright-2	46,227	15	887	1,011
9 Waste Rock Stockpile	9WRF-A	5,408	97	369	421
	9-WRF-B	6,222	0	114	130

Facility	Subbasin ID	Length of Bench Channels (ft)	Top Areas (ac)	Total Peak Flow in Downchute – Present Conditions (cfs)	Total Peak Flow in Downchute – Climate Change (cfs)
Tailing Pond 6W	P6W-A	4,203	217	258	294
Tailing Pond 6E	P6E-A	3,938	243	275	313
Tailing Pond 7	P7-T	3,149	1,309	776	884
	P7-A	2,537	0	46	53
	P7-B	9,998	0	183	208
	P7-C	13,196	0	241	275
	P7-D	8,829	0	161	184
Axiflo Lake	Axiflo Lake	2,100	95	304	347

4.1.2 Rational Formula Method Assessment of Chino Worst-Case Existing Reclaimed Conveyance Structures

As detailed in Section 3.2, the Rational Formula Method assessment of the existing reclaimed conveyance structures only included the analysis of climate change flow estimates. Each facility’s worst-case conveyance structures were determined via the Rational Formula Method conservative peak flow estimates. The peak flow estimates from the Rational Formula Method analysis of the existing reclaimed facilities at Chino are summarized in Table 6.

Table 6: Summary of Peak Flow Estimates through Worst-Case Structures at Existing Chino Reclaimed Facilities (Rational Formula Method)

Facility	Feature	Worst Case Feature	Contributing Subbasin IDs	Flow (cfs)
Tailing Pond 1	Top channels	Main top channel	P1-T	26
	Bench channels	East face, top southern bench	P1-A	13
	Downchutes	East face downchute	P1-A+P1-T	279
Tailing Pond 2	Top channels	Main Pond 2 top channel	P2-T	267
	Downchutes	East face downchute	P2-T + P2A	310
	Bench channels	East face lower bench	P2A	19
Pond 2 Repository	Top channels	Southern channel through repository (T-2,3)	P2W-TB	166
	Downchutes	Downchute into T-2,3	P2W-SDC	43

Facility	Feature	Worst Case Feature	Contributing Subbasin IDs	Flow (cfs)
Tailing Pond 4 East	Top channels	Main top channel	P4E-T	377
	Downchutes	From top channel to NP6E	P4E-B + P4E-T	468
	Bench channels	East face bench	P4E-B	18
North of Tailing Pond 6 East	Top channels	From Pond 4 to downchute	P4E-B + P4E-T + NP6E-T	513
	Bench channels	East face bench	NP6E-A	24
	Downchutes	East face downchute	P4E-B + P4E-T + NP6E-T + NP6E-A	537
Tailing Pond 6 East	Top channels	Main top channel	P6E-TA	461
	Bench channels	East face lower bench	P6E-A	27
	Downchutes	Southern downchute	P6E-A + P6E-TA	522
	Access ramp channels ^(a)	Southern access ramp	P6E-AR2	21
Tailing Pond 6 West	Top channels	Main top channel	P6W-T + PC-P6W-A	444
	Bench channels	West face, second highest bench	P6W-B	35
	Downchutes	Northern downchute, west face	P6W + PC-P6W-A + P6W-B	525
	Access ramp channels ^(a)	Southern access ramp, west face	AR-2	29
Tailing Pond 4 West	Downchutes	West face downchute	P4W-A + P4W-T + PC-TB + P4W-B	644
	Bench channels	West face bench between PC and P4W	P4W-B	26
	Top channels	Main top channel	P4W-T + PC-TB + P4W-B	593
Tailing Pond C	Top channels	Main top channel	PC-T	424
	Bench channels	South/west face, second highest bench	PC-A	29
	Downchutes	South face downchute	PC-A + PC-T	601
	Access ramp channels ^(a)	Southern access ramp	PC-AR	33
Tailing Pond B	Top channels	Southern main channel	PB-TB	171
	Bench channels	Northern lowest bench, west face	PB-B	15
	Downchutes	Southern downchute, west face	PB-TB + PB-B	246
	Access ramp channels ^(a)	West face, north of northern downchute	PB-AR	16

Facility	Feature	Worst Case Feature	Contributing Subbasin IDs	Flow (cfs)
North of Tailing Pond B	Top channels	Main top channel	NPB-T	38
	Bench channels	West face, lower bench	NPB-A	16
	Downchutes	West face downchute	NPB-A	42
Groundhog	Diversion channel	West diversion channel	GH-A	23
Lake One and Slag Pile	Bench channels	East face lowest bench on slag pile	L1-B	19
	Top channels	Southeast main junction at culvert	L1-TC	694
	Downchutes	slag pile east face	L1-B + L1-TB	52

a. For the purpose of modelling, access ramps are assumed to behave similarly to benches.

4.2 Assessment of Tyrone and Little Rock Worst-Case Structures

Analysis of the Tyrone and Little Rock worst-case structures began with the creation of the IDF curves for both the present and climate change conditions. The trendline formula for these conditions was used to estimate the intensity of the storm at the Tc of both the top surfaces and side slopes.

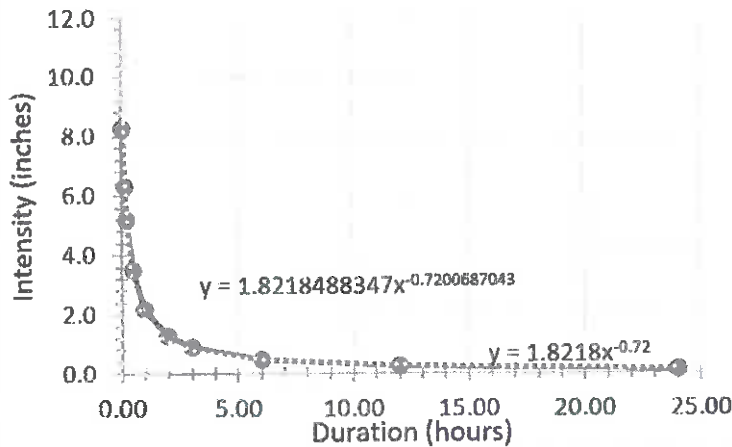


Figure 5: Tyrone and Little Rock 100-Year, 24-Hour Intensity–Duration–Frequency Curve

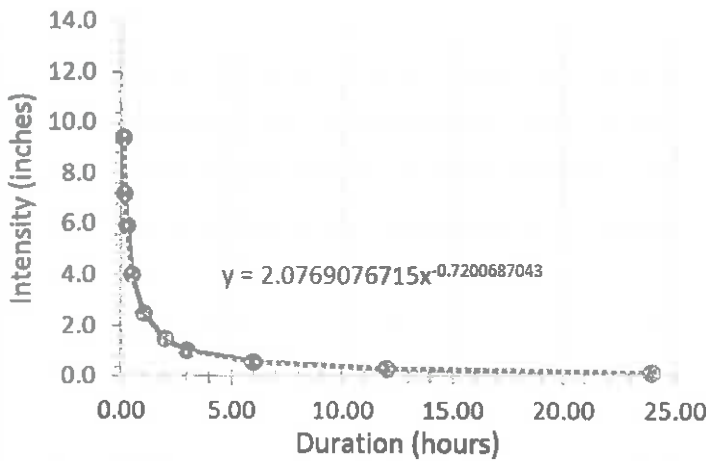


Figure 6: Tyrone and Little Rock 100-Year, 24-Hour Intensity–Duration–Frequency Curve with 14% Climate Change Modifier

Due to similar hydrologic soil composition between Chino, Tyrone, and Little Rock, runoff coefficients from prior Chino work (Golder 2018) were used as an initial calculation of Tc at various facilities found the representative methodology to still be a valid approximation of Tc at facilities with similar top surface and sideslope construction.

The typical bench top and top area peak runoff was then calculated as cfs/ft of bench channel per calculations detailed in Section 2.0. The estimated peak runoff per acre for Tyrone and Little Rock is presented in Table 7.

Table 7: Tyrone and Little Rock Intensity–Duration–Frequency Curve Table

Catchment ID	Time of Concentration (minutes)	Present Conditions Unit Runoff	Climate Change Conditions Unit Runoff
Typical bench	10	3.78 cfs/ft	4.31 cfs/ft
Top area	16.7	2.70 cfs/ac	3.08 cfs/ac

The estimated peak unit runoff per foot of bench channel was used, as well as the runoff per acre to estimate the peak flow rates from top areas and bench channels. These estimated values were summed for each facility creating a very conservative peak flowrate that assumes the flow from top areas and bench channels are simultaneously transported through each facility’s downchute. The summary of these values is presented in Table 8 in Section 4.2.1.

4.2.1 Rational Method Assessment of Tyrone and Little Rock Closure Closeout Plan Conveyance Structures

The Tyrone and Little Rock CCP facilities were split into subbasins, and total bench channel lengths, as well as top areas, were determined to calculate a conservative flow through the downchutes. The peak flow estimates from the Rational Formula Method analysis of the CCP facilities at Tyrone and Little Rock are summarized in Table 8.

Table 8: Tyrone and Little Rock Subbasin Geometries and Rational Method Peak Flow Estimates for Closure Closeout Plan Facilities

Facility	Subbasin ID	Length of Bench Channels (ft)	Top Areas (ac)	Total Peak Flow in Downchute – Present Conditions (cfs)	Total Peak Flow in Downchute – Climate Change (cfs)
Tyrone					
1A Leach/1B Leach	1A/1B-A	4,431	0	79	90
	1A/1B-B	24,095	0	428	488
	1A/1B-C	16,726	17	342	390
6A Leach	Savannah	0	9	23	27
6C Leach	6C-A	615	0	11	12
	6C-B	5,242	10	120	137
6B Leach/6D Leach	6B-A	2,509	7	64	73
2 Leach (Area 2)	6B-B	11,030	0	196	224
South Rim Pit/7B Waste/7C Waste	SRP-A	13,049	92	481	548
San Salvador Pit/San Salvador Waste Backfill	SSP-A	17,327	104	589	671
	SSP-T4	2,655	23	110	126
2 Leach (Area 1)	4C-A	10,995	0	195	223
	4C-B	9,614	3	179	204
	4C-C	3,296	17	104	119
9A Waste	9A-A	24,589	13	471	537
3A Leach/3B Waste	3A/B-A	10,666	0	190	216
	3A/B-B	9,866	0	175	200
	3A/B-C	20,034	0	356	406
	3A/B-D	15,503	39	380	434
5A Waste	5A-A	19,575	8	370	421
	5A-B	19,485	0	346	395
	5A-C	5,498	63	268	305

Facility	Subbasin ID	Length of Bench Channels (ft)	Top Areas (ac)	Total Peak Flow in Downchute – Present Conditions (cfs)	Total Peak Flow in Downchute – Climate Change (cfs)
2A Leach/2B Leach	2A/2B-A	14,165	6	268	305
	2A/2B-B	8,427	0	150	171
	2A/2B-C	10,571	0	188	214
	2A/2B-D	15,503	0	276	314
2B Waste	2B-A	3,872	11	99	113
	2B-B	9,831	0	175	199
Little Rock					
NRW Waste	NRW-A	8,290	14	185	211
	NRW-B	6,362	9	137	156
	NRW-C	482	0	9	10
	NRW-D	385	0	7	8
East In-Pit Waste	EIP-A	2,300	0	41	47
West In-Pit Waste	WIP-A	10,548	1	191	218

4.2.2 Rational Method Assessment of Tyrone and Little Rock Worst-Case Existing Reclaimed Conveyance Structures

As previously described, the Rational Formula Method assessment of the existing reclaimed conveyance structures only included the analysis of climate change flow estimates. Each facility’s worst-case features were determined via the rational method’s conservative peak flow estimate. The peak flow estimates from the Rational Formula Method analysis of the existing reclaimed facilities at Tyrone and Little Rock are summarized in Table 9.

Table 9: Summary of Peak Flow Estimates through Worst-Case Structures at Existing Tyrone and Little Rock Reclaimed Facilities (Rational Formula Method)

Facility	Feature	Worst Case Feature	Contributing Subbasin IDs	Flow (cfs)
1X Tailing Impoundment	Top channels	Main top collector channel	1X-T + 1A-A + 1-T	2,450
	Bench channels	North face, west of downchute, 2nd highest bench	1X-A	21
	Downchutes	North face downchute	1X-A	132
1 Tailing Impoundment	Top channels	Main top collector channel	1-T + 1A-A	1007
	Bench channels	Bottom channel, east face	1-A	35
	Downchutes	East face downchute	1-C + 1A-B	212
1 Tailing North Ponds Area	Top channels	West outlet	N-A + 1X-A	306
1 Tailing Southern Area	Top channels	Easternmost channel	S-A	227
1A Tailing Impoundment	Top channels	Main top collector channel	1A-T	1,037
	Downchutes	Top channel downchute	1A-T	1,037
	Bench channels	Lowest bench east of downchute	1A-A	30
1C Waste	Downchutes	Representative downchute (longest)	Longest Downchute (LDC)	2.3
7A Far West	Downchutes	Downchute with top surface flow	LDC + Top Flow	15
Burro Mountain Tailing Impoundment	Channels	Main runoff V ditch	BM-D	121
7A Waste	Top channels	Eastern top channel	7A-T2	77
	Bench channels	West top bench channel (carries flow from 6C-B and 6C-T)	7A-B	72
	Downchute	Southwest face, downchute off-site	7A-B	67
1 Leach Stockpile	Downchutes	Representative downchute (longest)	LDC	6.0
	Downchutes with top flow	Representative downchute w/ top flow	LDC + N1-T	61
3X Tailing Impoundment	Downchutes	West face southern downchute	3X-B	137
	Bench channels	North face bottom bench	3X-A	33
	Top channels	North main top channel	3X-TA	385

Facility	Feature	Worst Case Feature	Contributing Subbasin IDs	Flow (cfs)
2 Tailing Impoundment	Downchutes	Northwest face downchute	2-A	321
	Top channels	Main collector channel	2-T	832
	Bench channels	Northwest face, bottom bench	2-A	48
3 Tailing Impoundment	Top channels	Third top channel from the south to east channel	3-T	236
	Downchutes	East face downchute, second from south	3-B	185
	Bench channels	East face second from bottom bench	3-C	22
	Downchutes	Longest ridge/valley structure	3-DC	9
Little Rock				
Copper Leach Stockpile	Bench Channels	Middle bench channel (S-2)	CL-2	13

4.3 Analysis Results

4.3.1 Chino Closure Closeout Plan Conveyance Structures

The worst-case CCP structures for Chino were analyzed and found to pass the positive freeboard criteria for climate change conditions, and all the structures passed the freeboard criteria of 6 inches (0.5 feet) for present conditions. Table 10 provides a summary of the results of the Rational Formula Method assessment of the Chino CCP conveyance structures.

Table 10: Summary of Freeboard Estimates for Present and Climate Change Conditions at Chino Closure Closeout Plan Facilities (Rational Formula Method)

Structure	Facility	Length (ft) / Area (ac)	Estimated Flow – Present Conditions (cfs)	Estimated Freeboard – Present Conditions (ft)	Estimated Flow – Climate Change Conditions (cfs)	Estimated Freeboard – Climate Change Conditions (ft)
Longest bench	Tailing Pond 7	2,886 ft	53	0.5 (rirap)	60	0.4 (rirap)
Downchute with the largest catchment	South Stockpile	293.8 ac	1,082	0.7 (ACB)	1,234	0.6 (ACB)
Longest top channel	9 Waste Rock Stockpile	2,496 ft	308	0.8 (desert pav.)	316	0.8 (desert pav.)

ACB = articulated concrete block; desert pav. – desert pavement

As a further evaluation of the robustness of the Rational Formula Method, the longest bench channel and longest top surface channel CCP structures for Chino were further evaluated with HEC-HMS. The results of these analyses are presented in Section 5.0.

4.3.2 Chino Existing Conveyance Structures

Table 11 provides a summary of the results of the Rational Formula Method assessment of the conveyance structures at the existing reclaimed facilities at Chino. The capacity of existing structures was evaluated, and the structures with adequate capacity to convey the modified flow are indicated with a check mark, while other facilities are labeled with the word "capacity" if they did not pass the Rational Formula Method screening analysis.

Table 11: Summary of Rational Formula Method Analysis Results for Chino Existing Structures

Facility	Top Channels	Benches	Downchutes	Access Ramp/Haul Road Channels
Lake One and Slag Pile	✓	✓	✓	--
Tailing Pond 1	Capacity	✓	✓	--
Tailing Pond 2	Capacity	✓	✓	--
Pond 2 Repository	Capacity	--	✓	--
Tailing Pond B	✓	✓	✓	✓
Area North of Pond B	✓	✓	✓	✓
Tailing Pond C	Capacity	✓	✓	✓
Tailing Pond 4E	Capacity	✓	✓	--
Pond 4E Repository	Capacity	✓	✓	--
Tailing Pond 4W	✓	✓	✓	
Tailing Pond 6E	✓	✓	✓	✓
Tailing Pond 6W	✓	✓	✓	✓
Groundhog No. 5 Stockpile	Capacity	--	--	--

Note: "Capacity" indicates the structure requires further/more accurate evaluation for capacity.

✓ = indicates that the structure has sufficient capacity; -- = indicates that a structure type is not present

As a further evaluation of the robustness of the Rational Formula Method, various channels were selected for further detailed evaluation with HEC-HMS. These included the downchute at Tailing Pond 6 West, the downchute at Tailing Pond 4 West, the downchute at Tailing Pond C, and the top surface channels at Tailing Pond 4 East. The results of these analyses are presented in Section 5.0.

4.3.3 Tyrone and Little Rock Closure Closeout Plan Conveyance Structures

The worst-case CCP structures for Tyrone and Little Rock were analyzed and found to pass the freeboard criteria of 6 inches (0.5 feet) for present conditions and positive freeboard for climate change conditions. Table 12 provides a summary of the results of the Rational Formula Method assessment of the Tyrone and Little Rock CCP conveyance structures.

Table 12: Summary of Freeboard Estimates for Present and Climate Change Conditions at Tyrone and Little Rock Closure Closeout Plan Facilities (Rational Formula Method)

Structure	Facility	Length(ft) / Area (ac)	Estimated Flow – Present Conditions (cfs)	Estimated Freeboard – Present Conditions (ft)	Estimated Flow – Climate Change Conditions (cfs)	Estimated Freeboard – Climate Change Conditions (ft)
Tyrone						
Longest bench channel	5A Waste (5A-A)	2,707 ft	49	0.5 (riprap)	56	0.4 (riprap)
Downchute with the largest catchment	San Salvador Pit/San Salvador Waste Backfill	185.2 ac	589	1.1 (ACB)	671	1.0 (ACB)
Longest top channel	5A Waste (5A-A)	62.7	58	0.9 (desert pavement)	66	0.8 (desert pavement)
Little Rock						
Longest bench channel	West In-Pit Waste (WP-A)	1,824 ft	33	1.3 (riprap)	37	0.7 (riprap)
Downchute with the largest catchment	West In-Pit Waste (WP-A)	44.9 ac	191	2.5 (ACB)	218	2.5 (ACB)

ACB = articulated concrete block; -- = indicates that a structure type is not present

As a further evaluation of the robustness of the Rational Formula Method, the longest bench channel CCP structure for Tyrone was further evaluated with HEC-HMS. The results of these analyses are presented in Section 5.0.

4.3.4 Tyrone and Little Rock Existing Conveyance Structures

The capacity of existing Tyrone and Little Rock structures was evaluated using the Rational Formula Method analysis. Table 13 provides a summary of the results of the Rational Formula Method assessment of the conveyance structures at the existing reclaimed facilities at Tyrone and Little Rock.

Table 13: Summary of Rational Formula Method Analysis Results for Tyrone and Little Rock Existing Structures

Facility	Top Channels	Downchutes	Benches
Tyrone			
3 Tailing Impoundment	✓	✓	✓
3X Tailing Impoundment	✓	✓	✓
2 Tailing Impoundment	✓	✓	✓
1X Tailing Impoundment	✓	✓	✓
1/1X Tailing Impoundment	--	Capacity	--
1 Tailing Impoundment	✓	✓	✓
1A Tailing Impoundment	✓	✓	✓
1 Tailing North Ponds Area	✓	--	--
1 Tailing Southern Area	Capacity	--	--
1 Leach Stockpile	✓	✓	--
USNR	✓	--	--
1C Waste	--	✓	--
7A Waste	✓	✓	✓
7A Far West	--	✓	--
Burro Mountain Tailing Impoundment	Capacity	--	--
Little Rock			
Copper Leach Stockpile	--	--	✓

Note: "Capacity" indicates the structure requires further/more accurate evaluation for capacity.

✓ = indicates that the structure has sufficient capacity; -- = indicates that a structure type is not present

As previously described, as a further evaluation of the robustness of the Rational Formula Method, various channels were selected for further detailed evaluation with HEC-HMS. For Tyrone, these included the downchute at 7A Waste (24-inch high-density polyethylene [HDPE] culverts), both the downchute and bench channel at the 1A Tailing Impoundment, the bench channel at the 1 Tailing Impoundment, the downchute between the 1 and 1X Tailing Impoundments, the downchute at the 2 Tailing Impoundment, and the top surface channels at the Burro Mountain Tailing Impoundment. The results of these analyses are presented in Section 5.0.

5.0 HEC-HMS SECOND-PASS ANALYSIS

As previously described in Section 3.0, HEC-HMS modeling was performed on select channels to evaluate the robustness of the Rational Formula Method analyses.

5.1 Facilities and Parameters

The facilities and conveyance structures modeled within HEC-HMS are listed below:

- Chino:
 - existing Tailing Pond C Spillway 3
 - existing Tailing Pond 4 West Spillway 10
 - existing Tailing Pond 6 West Spillway 5
 - existing Tailing Pond 4 East Main Top Surface Channel
 - longest CCP design bench channel
 - longest CCP design top channel
- Tyrone:
 - existing 1/1X Tailing Impoundment T-1 Downchute
 - existing 1 Tailing Impoundment Bench Channel 1-WE-6
 - existing 1A Tailing Impoundment 1A Downchute
 - 1A Tailing Impoundment Bench Channel 1A-NW3
 - 2 Tailing Impoundment Northwest Downchute
 - Burro Mountain Tailing Impoundment V-Ditch 4
 - 7A Waste 7A-B Downchute discharging to HDPE culverts
 - longest CCP design bench channel

The T_c for each subbasin contributing to each structure was calculated individually according to NRCS TR-55 methodology (NRCS 1986). In HEC-HMS, loss and transform methods were set to use the NRCS curve number of 80, consistent with previous HEC-HMS efforts at Chino and Tyrone. The same total precipitation depths used in the Rational Formula Method (see Section 3.1) were applied in the HEC-HMS analyses. These depths were used to create hyetographs according to AWA's East General 24-hour 10th percentile accumulated rainfall distribution. This distribution was found to generate the highest peak flows from among the four distributions provided by AWA.

The 100-year 24-hour storm event was modelled, consistent with the CCP design criteria of a 100-year, 24-hour storm event, and previous analysis performed at CCP facilities at Chino.

5.2 Basin Models

Basin models were created using GIS referenced shapefiles from As-Built AutoCAD drawing files of the facilities using the New Mexico NAD87 West coordinate system. Individual bench channels were analyzed separately as “_Bench Eval” subbasins, where necessary. The individual basin models developed for this analysis are presented in Figure 7 through Figure 12.



Figure 7: Chino Tailing Ponds C, 4W, 4E, and 6W Facilities

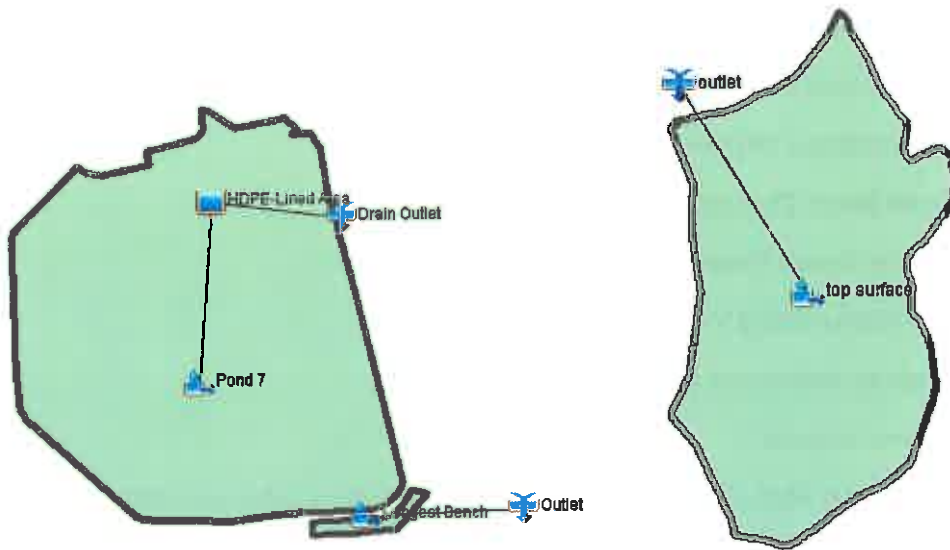


Figure 8: Tailings Pond 7 (left) and 9 Waste Rock (right).

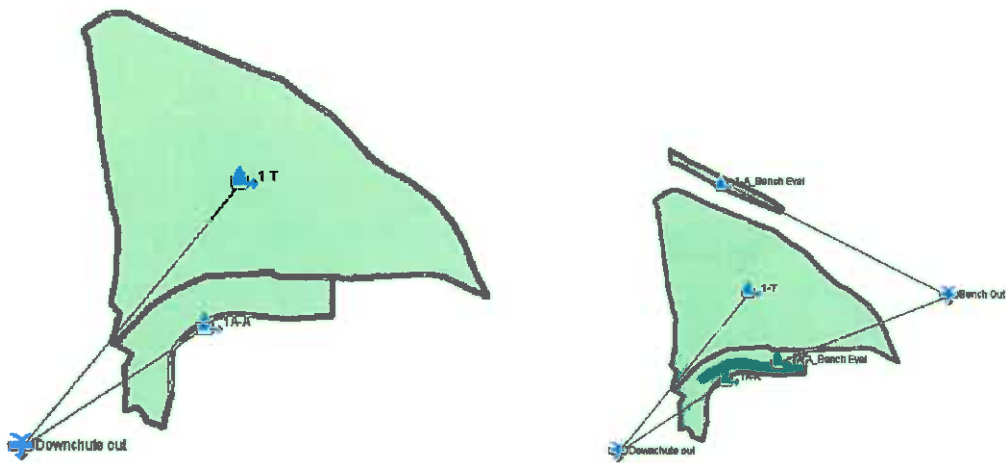


Figure 9: Tyrone 1 and 1A Tailing Impoundment Facilities

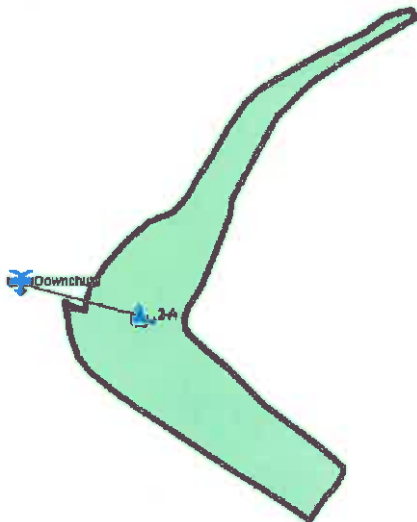


Figure 10: Tyrone 2 Tailing Impoundment Downchute Subbasin

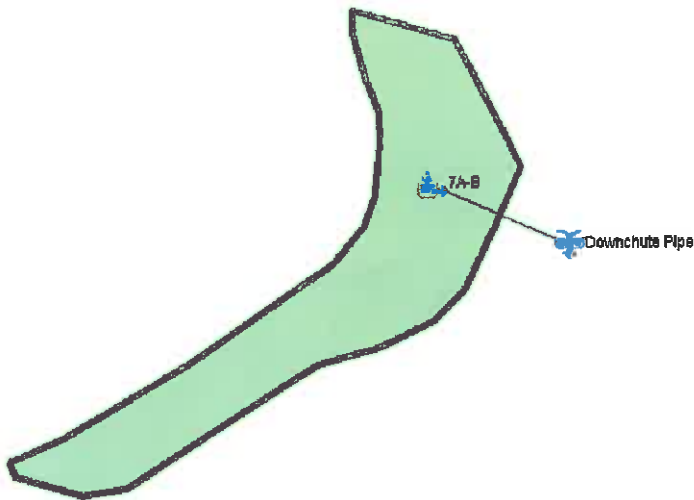


Figure 11: Tyrone 7A Waste Downchute Subbasin

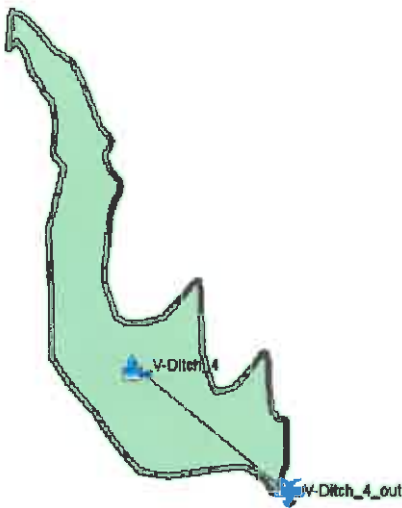


Figure 12: Burrow Mountain Tailing Impoundment Subbasin

5.3 Rational Formula Method and HEC-HMS Results Comparison

Flow estimates from the HEC-HMS model proved to be significantly lower than the conservative outputs from the Rational Formula Method. This is to be expected, as the 10-minute (typical bench) and 16.7-minute (typical top area) T_c 's used across the facilities proved to be significantly shorter (more conservative) than the actual T_c 's estimated in HEC-HMS, which, when measured for each basin for the SCS Unit Hydrograph transform method, were estimated to be up to 57 minutes long.

In addition to this, the conservative Rational Formula Method assumption that all bench channels contained an equal drainage area per foot of channel led to an inflation of side slope areas. This drainage area was calculated based on representative maximum distances between benches. The HEC-HMS model, by way of using the correct sideslope areas as an input, did not include this highly conservative assumption. Another conservative method used by the Rational Formula Method was to simply add peak flowrates from all subbasins to determine

subsequent downstream peak flow rates. For example, this estimation would simply add the total peak flowrate from a top surface to the peak flowrate from the side slopes to determine the flow through a downchute. HEC-HMS does not make this assumption; the model properly staggers these peak flows, greatly decreasing the total flowrates for individual conveyance structures.

The significantly lower flow estimates from the HEC-HMS are expected, as the first pass Rational Formula Method was intentionally meant to provide conservative flow estimates, which would be followed by more precise HEC-HMS modeling as needed. Table 14 provides a comparison of the estimated flows between the Rational Formula Method and the HEC-HMS. As shown, the HEC-HMS flow estimates are reduced by as much as 97.6%.

Table 14: Comparison Between HEC-HMS and Rational Formula Method Flow Estimates

Site	Facility	Structure	HEC-HMS (cfs)	Rational Formula Method (cfs)	% Reduction
Tyrone	1/1X Tailing Impoundment	Downchute	139	1007	-86.2%
	1 Tailing Impoundment	Bench	6	35	-82.0%
	1A Tailing Impoundment	Downchute	25	1037	-97.6%
		Bench	3	30	-90.0%
	2 Tailing Impoundment	Downchute	36	321	-88.7%
	7A Waste	Downchute	8	66	-87.3%
	Burro Mountain Tailing Impoundment	V ditch	13	93	-89.3%
5A Waste	Longest CCP bench channel	6	55	-89.1%	
Chino	Tailing Pond C	Downchute	83	600	-86.3%
	Tailing Pond 4W	Downchute	99	525	-81.2%
	Tailing Pond 6W	Downchute	82	644	-87.3%
	Tailing Pond 4 East	Top channel	58	513	-88.7%
	Tailing Pond 7	Longest CCP bench channel	60	9	-85.0%
	9 WRS	Longest CCP top channel	316	50	-84.2%

To better understand this large reduction in flow estimates, these facilities were analyzed a third time with a modified Rational Formula Method approach. This time the average top surface and sideslope T_c 's were adjusted to be specific to these facilities. The T_c increased from 16.7 to 37.9 minutes for top surfaces, and from 10 to 13.3 minutes for sideslopes. The T_c 's for bench channels were calculated and averaged to a single 29.8-minute T_c . In addition to these new T_c 's, the runoff coefficients were recalculated according to intensities extracted from the

climate change IDF curves. The new bench runoff coefficients for Chino and Tyrone/Little Rock were slightly decreased, from 0.6 for top surfaces to 0.56 and 0.57, respectively. Top surface runoff coefficients saw the biggest change, decreasing from 0.59 to 0.47 and 0.46 for Chino and Tyrone/Little Rock, respectively. A comparison of the estimated flow rates associated with the original Rational Formula Method, modified Rational Formula Method, and HEC-HMS for the structures that were analyzed by all three methods is provided in Table 15.

Table 15: Peak Flow Estimates for All Estimation Methods

Facility	Structure	Original Rational Formula Method (cfs)	Modified Rational Formula Method (cfs)	Reduction from Original Rational Formula Method (%)	HEC-HMS (cfs)	Reduction from Modified Rational Formula Method (%)
Tailing Pond 6 West	Spillway 5	525	279 ^(a)	-46.9%	82 ^(a)	-70.6%
Tailing Pond 4 West	Spillway 10	644	314 ^(a)	-51.2%	99 ^(a)	-68.5%
Tailing Pond 4 East	Top channel T-4E,2	513	225	-56.1%	58 ^(a)	-74.2%
Tailing Pond C	Spillway 3	600	337 ^(a)	-43.8%	83 ^(a)	-75.4%
Tailing Pond 7	Longest CCP bench channel	60	29	-44.9%	9	-69.0%
9 WRS	Longest CCP top channel	316	196	-38.0%	50	-74.5%
1 Tailings Impoundment	Bench 1-WE-6	35	28 ^(a)	-20.0%	3 ^(a)	-89.3%
1A Tailing Impoundment	1A Downchute	1,037	443	-57.3%	25 ^(a)	-94.4%
	Bench 1A-NW3	30	24 ^(a)	-20.0%	6 ^(a)	-75.0%
1X/1 Tailing Impoundments	Downchute	1,007	488 ^(a)	-51.5%	139 ^(a)	-71.5%
7A Waste	Downchute to downdrain pipe	66	54	-18.2%	8 ^(a)	-85.2%
Burro Mountain Tailing Impoundment	V ditch 4	121	93	-23.1%	13 ^(a)	-86.0%
5A Waste	Longest CCP bench channel	55	26	-52.7%	6	-76.9%

a. Estimated flowrate is conveyed with adequate freeboard capacity.

6.0 CONCLUSIONS

The depth of the 100-year, 24-hour storm event obtained from the MetPortal REPS precipitation tool was found to be 17% less than NOAA Atlas 14 design storm depths for Tyrone and Little Rock and 20% less than the design depth for Chino. For the sake of proving the robustness of the planned and as-built conveyance structures, the NOAA Atlas 14 precipitation values were used as the basis for this analysis, as they were the most conservative. A conservative increase of 14% (as recommended in the AWA Task 2 study) was used on the 100-year, 24-hour storm event as listed for each mine site in NOAA 14 Atlas to evaluate climate change conditions.

The results of the Task 3 precipitation analysis for the Chino, Tyrone, and Little Rock conveyance structures (presented in Section 4.3 and Section 5.3) show the success of the facilities in conveying stormwater adequately under both current conditions and climate change conditions for facilities facing closure, as well as those that have already been reclaimed. The first sweep Rational Formula Method analyses, although overtly conservative with many assumptions, showed that all CCP facilities have adequate capacity to convey stormwater under both current conditions and climate change conditions, and the majority of the existing conveyance structures at reclaimed facilities would provide adequate capacity under both current conditions and climate change conditions.

Critical structures (downchutes and bench channels) that did not provide adequate capacity on the original Rational Formula Method screening analyses were reanalyzed using more accurate Tc's. This led to a decrease in estimated flowrates ranging from 18.2% to 57.3% for the original failed structures (Table 15). Results of the modified Rational Formula Method analyses indicated that all structures analyzed provide adequate capacity with the exception of the main top surface channel at Tailing Pond 4 East, which exceeded its channel capacity by an estimated 0.1 foot.

Results of the further analysis with more accurate HEC-HMS modeling indicates that all facilities provide adequate capacity with estimated flowrate reductions ranging from 68.5% to 94.4% of the modified Rational Formula Method estimates (Table 15).

Based on these results, the design of the structures considered in this study appear to be robust in relation to the predicted impacts of climate change on local precipitation.

7.0 CLOSING

The intent of this study was to assess the adequacy of stormwater conveyance under projected climate change conditions for both planned closure structures documented in the most current CCPs for the Chino, Tyrone, and Little Rock mines and conveyance structures constructed at existing reclaimed facilities at each of the three sites. Results of the conveyance structure assessment indicate that all proposed CCP structures and all critical structures constructed on reclaimed lands at Chino, Tyrone, and Little Rock are designed (CCP) and built (existing reclaimed) to provide adequate capacity under projected climate change conditions. With increased specificity and accurate hydraulic modeling, critical facility structures are shown to provide adequate capacity (Table 16 and Table 17).

Table 16: Summary of Conveyance Structure Analysis Results for Chino Existing Structures

Chino Facility	Top Channels	Benches	Downchutes
Lake One and Slag Pile	✓	✓	✓
Tailing Pond 1	□	✓	✓
Tailing Pond 2	□	✓	✓
Pond 2 Repository	□	--	✓
Tailing Pond B	✓	✓	✓
Area North of Pond B	✓	✓	✓
Tailing Pond C	□	✓	□
Tailing Pond 4E	△	✓	✓
Pond 4E Repository	□	✓	✓
Tailing Pond 4W	□	✓	□
Tailing Pond 6E	✓	✓	✓
Tailing Pond 6W	✓	✓	□
Groundhog No. 5 Stockpile	□	--	--

✓ = indicates that the structure provides capacity based on original Rational Formula Method analyses.

□ = indicates that the structure provides capacity based on modified Rational Formula Method analyses.

△ = indicates that the structure provides capacity based on HEC-HMS modeling.

-- = indicates that a structure type is not present

Note: Capacity/stability indicates a failure of the listed criteria and associated (estimated exceedance of criteria) based on original Rational Formula Method analyses.

Table 17: Summary of Conveyance Structure Analysis Results for Tyrone and Little Rock Existing Structures

Tyrone Facility	Top Channels	Benches	Downchutes
3 Tailing Impoundment	✓	✓	✓
3X Tailing Impoundment	✓	✓	✓
2 Tailing Impoundment	✓	✓	✓
1X Tailing Impoundment	✓	✓	✓
1/1X Tailing Impoundments	--	--	□
1 Tailing Impoundment	✓	✓	✓
1A Tailing Impoundment	✓	✓	✓
1 Tailing North Ponds Area	✓	--	--
1 Tailing Southern Area	□	--	--

Tyrone Facility	Top Channels	Benches	Downchutes
1 Leach Stockpile	✓	--	✓
USNR	✓	--	--
1C Waste	--	--	✓
7A Waste	✓	✓	△
7A Far West	--	--	✓
Burro Mountain Tailing Impoundment	△	--	--
Little Rock Copper Leach Stockpile	--	✓	--

✓ = Indicates that the structure provides capacity based on original Rational Formula Method analyses.

□ = indicates that the structure provides capacity based on modified Rational Formula Method analyses.

△ = indicates that the structure provides capacity based on HEC-HMS modeling.

-- = indicates that a structure type is not present

The conservative Rational Formula Method is shown to produce estimated flowrates over five times those estimated with the more detailed HEC-HMS (actual range 5.3 to 41.5 times the HEC-HMS estimates shown in Table 14). The fact that NOAA Atlas 14 precipitation depths (i.e., larger than those from the REPS tool) were used for this analysis adds confidence to the conclusions and demonstrates the robustness of the current and planned conveyance structures. Climate change models were used by AWA in the Task 2 analyses to estimate potential relative increases and decreases in precipitation and that can be applied to different design basis depths (i.e., NOAA versus the REPS tool). The Task 3 study looked at both NOAA Atlas 14 and the REPS tool and added the most reasonable projection of increase in precipitation to the higher value, which is currently the NOAA Atlas 14 value. However, changing precipitation in recent years will likely result in revised numbers in the updated NOAA Atlas 15 that is scheduled to be released in the next few years, and future evaluations may be needed if subsequent changes in the recent precipitation data merit another evaluation. Future design efforts will use the best available and most appropriate information in making informed decisions regarding extreme rainfall and flooding risks.

Signature Page

WSP USA Inc.

Christian Olson
Associate Water Resources Engineer

Todd Stein
Senior Lead Consultant

CO/BO/rm

[https://wsponline.sharepoint.com/sites/global-fminmopsclimatchang/project files/6 deliverable/001-rpt-closure_sw_conv_precip_analysis_t3/rev2/31404677.015-001-rpt-2-closure_sw_conv_precip_analysis_t3_15feb24.docx](https://wsponline.sharepoint.com/sites/global-fminmopsclimatchang/project%20files/6%20deliverable/001-rpt-closure_sw_conv_precip_analysis_t3/rev2/31404677.015-001-rpt-2-closure_sw_conv_precip_analysis_t3_15feb24.docx)

8.0 REFERENCES

- AWA (Applied Weather Associates, LLC). 2022. Climate Change Projections for the Chino/Tyrone, New Mexico Mine. October.
- Freeport-McMoRan (Freeport-McMoRan Chino Mines Company). 2021. Chino Discharge Permit 1340. Condition C110.C and Tyrone Permit GR010RE Rev 09-1 -Precipitation Workplan Analysis for Closure. Workplan submitted by Freeport-McMoRan Chino Mines Company on behalf of both Chino and Tyrone Mines (Freeport-McMoRan) to Brad Reid (NMED and David Ohori (EMNRD MMD). May 21.
- Golder (Golder Associates Inc.). 2018. Chino CCP Conceptual Hydraulic Analysis Technical Memorandum submitted by Terry Fairbanks and Brent Bronson to Rita Lloyd-Mills (Chino Mines Co.) August 20.
- NMED (New Mexico Environment Department) and EMNRD MMD (Energy, Minerals and Natural Resources Department, Mining and Minerals Division). 2021. Conditional Approval of the Precipitation Analysis Work Plan, DP-1340, DP-1341, and Tyrone Permit GR010RE Rev 09-1; Freeport-McMoRan Chino and Tyrone Mines. September 3.
- NMDOT (New Mexico State Highway and Transportation Department of Transportation). 2018. Drainage Design Manual. <https://realfilef260a66b364d453e91ff9b3fedd494dc.s3.amazonaws.com/ae005670-a671-480e-9c33-0e37cf2f6b82?AWSAccessKeyId=AKIAJBKPT2UF7EZ6B7YA&Expires=1686952067&Signature=3Hhzp7T%2F2vqZ41oQwGvAgyMcwcQ%3D&response-content-disposition=inline%3B%20filename%3D%20Drainage+Design+Manual.pdf>
- USACE (United States Army Corps of Engineers). 1998. Hydrologic Engineering Center- Hydrologic Modeling System. Hydrologic Engineering Center, Davis, CA.
- NRCS (Natural Resources Conservation Service). 1986. Urban Hydrology for Small Watersheds, 2nd edition (Technical Release Number 55). Washington D.C. United States Department of Agriculture. [Accessed June 16, 2023.] <https://www.nrc.gov/docs/ML1421/ML14219A437.pdf>

APPENDIX A

Site Maps – Figures 1 through 16

APPENDIX B

**Summary Calculation Sheets and
Results Tables**



wsp.com