GCC Rio Grande Inc.
Response to Regulatory Agency Comments:
Quarry 1 As-Built Report

June 11, 2024

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I, Ryan Wade, state that the information presented in this report entitled "GCC Rio Grande Inc. Response to Comments on Quarry 1 As-Built Report" was prepared by me or a person(s) under my supervision and is correct to the best of my knowledge and information. Furthermore, I have personally inspected the as-built Quarry 1 reclamation site.

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PROFESSIONAL ENGINEER

Ryan Wade 6-11-24

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INTRODUCTION

EMNRD provided two comments, via email on April 8, 2024, on the Quarry 1 As-Built submittal package (dated December 19, 2023). This report and the attached drawings respond to EMNRD's comments. The comments pertain to topographic clarity on the as-built maps and to the channel design. The EMNRD comments are shown in italics, followed by the response.

COMMENTS AND RESPONSES

Comment 1

The topographic lines on the as-built drawings are faint and we would like to see a color change if possible to make them visible.

Response 1

The attached as-built drawings have been updated with topography line colors that are more visible.

Comment 2

What rain event was the permanent stormwater channels constructed for? Please provide information on why this was chosen. We require at a minimum it can withstand a 24 hour – 100 year rain event. If this is the case, please provide detail on how that was accomplished with the constructed permanent stormwater channels that were constructed and why the width and length will hold that event.

Response 2:

Permanent stormwater channels were designed and constructed to withstand stormwater runoff from the 24-hour, 100-year storm event. SEDCAD software was used to design the Quarry 1 channels, as well as many other hydraulic structures, and has been used for the past 20 years at the GCC Tijeras Mine. However, SEDCAD software is no longer receiving updates and its future viability is uncertain. Hydrologic analyses are now conducted with HEC-HMS, which is developed and maintained by the US Army Corps of Engineers.

Runoff from the specified design storm event was originally determined with SEDCAD, but has now been remodeled using HEC-HMS. To confirm that the as-built channels can withstand the 100-year, 24-hour storm the following work was performed sequentially:

1) Peak discharges were modeled with HEC-HMS (version 4.11);
2) Required channel riprap sizes were calculated based on peak discharge modeling; and
3) Riprap size was measured at the riprap stockpile, confirming that the installed riprap size is at least as large as the calculated riprap size.

HYDROLOGIC MODELING

There are twenty-one reclaimed channels in Quarry 1. Most of these channels have watershed areas on the order of 1 acre. The largest, downstream channel drains a 17.2 acre watershed. Since the aspect, gradient, elevations, soils, etc. are largely the same for all channels, they can reasonably be expected to generate consistent hydrologic responses to stormwater runoff from the 100-year, 24-hour storm, with variability in peak discharges primarily dependent upon watershed size.

Instead of modeling each of the twenty-one channels individually, this analysis was streamlined by modeling six representative watersheds ranging from 1 acre to 17.2 acres. The SCS Curve Number method was used to determine rainfall excess (stormwater runoff), and a curve number of 77 was used, consistent with previous hydraulic structure design for the Tijeras quarry.

The Clark Unit hydrograph was used as the transform method, and Time of Concentration (Tc) and the R-value were calculated from physical watershed parameters measured from the as-built Quarry 1 topography including watershed area, longest flowpath length and slope, and centroidal flowpath length (Table 1).

Table 1. Summary of Clark Unit Hydrograph Parameters

Subbasin	Area (ac)	Area (sq mi)	Longest Flowpath Length (mi)	Longest Flowpath Slope (ft/mi)	Centroidal Flowpath Length (mi)	Tc (hrs)	R (hrs)
Sub-1 ac	1.0	0.0016	0.07	0.26	1,362.24	0.07	0.02
Sub-3 ac	3.0	0.0047	0.12	0.17	897.60	0.11	0.03
Sub-5 ac	5.0	0.0078	0.20	0.20	1,056.00	0.14	0.05
Sub-10 ac	10.0	0.0156	0.25	0.13	675.84	0.17	0.05
Sub-15 ac	15.0	0.0234	0.32	0.08	427.68	0.23	0.07
Sub-17.2 ac	17.2	0.0269	0.39	0.10	533.28	0.25	0.08

The 100-year, 24-hour rainfall total (3.55 inches) was determined from NOAA Atlas 14 (Bonnin, et al, 2011), and increased by 7 percent to account for future increases in precipitation due to climate change.

This rainfall percentage increase is consistent with the Colorado Office of the State Engineer (State Engineer) for design of jurisdictional dams (DNR, 2020). The State Engineer cites a joint Colorado-New Mexico report on climate change for regional extreme precipitation as guidance for their 7 percent rainfall increase required for dam safety designs (Mahoney, et al, 2018).

Peak discharges for the selected watershed sixes were plotted demonstrating that peak discharge for the 100-year, 24-hour storm event increases almost linearly for this range of watershed areas (Figure 1).

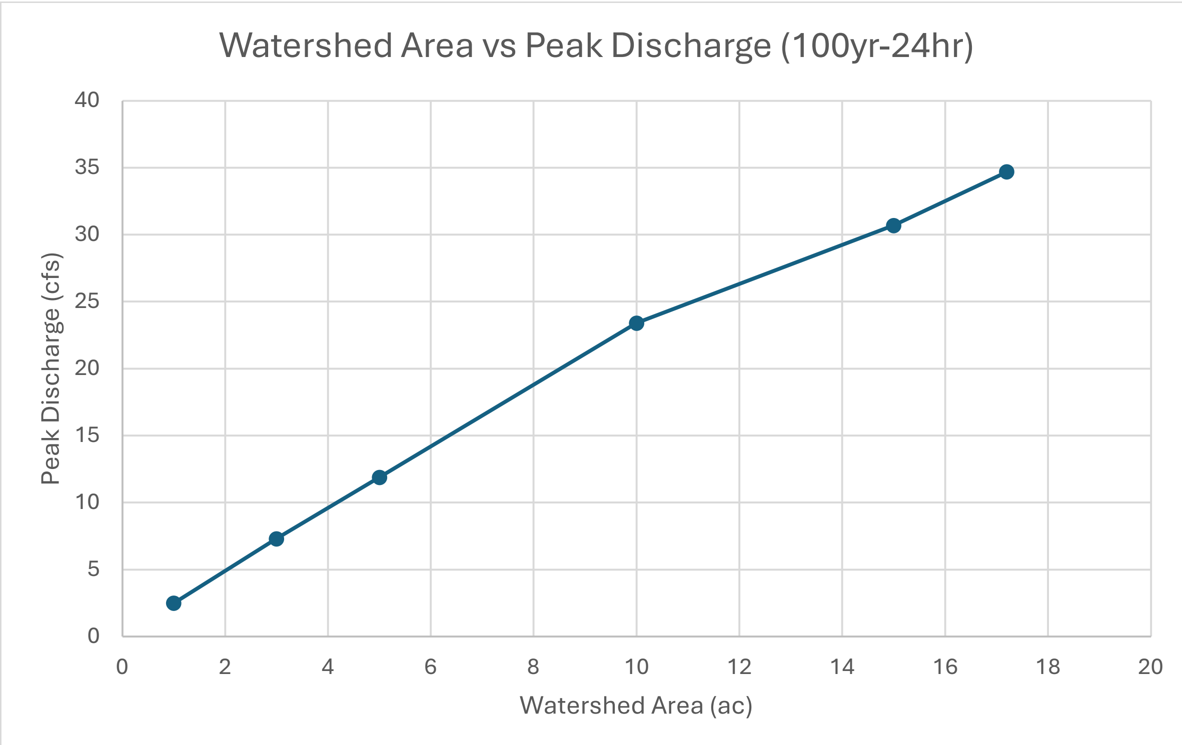

Figure 1. Watershed Area vs Peak Discharge for the 100-Year, 24-Hour Storm

RIPRAP SIZING ANALYSIS

D50 riprap size was calculated using both the Isbash method (1935) and the more recent method from Abt & Johnson (1991). The D50 riprap size calculated by the Abt and Johnson method was larger (more conservative) and was therefore used for channel lining design. The Abt and Johnson (1991) riprap equation is based on flume testing at Colorado State University, specifically for steep chute channels which is representative of the reclaimed channels at Quarry 1. The Abt and Johnson riprap size equation is shown below.

$\mathbf{D50 = 5.23 * S^{0.43} * q_d^{0.56}}$

Where:

D50 = median stone size (in)

S = bed slope (ft/ft)

q_d = unit discharge (ft^2/s)

Bed slopes were measured directly from as-built topography, and unit discharge is equal to the peak discharge (from the 100-year, 24-hour storm) divided by channel width.

Riprap size was tabulated for longitudinal bed slopes ranging from very steep chutes down to relatively low gradients. Figure 2 shows the minimum riprap D50 for a given bed slope and watershed area.

Figure 2

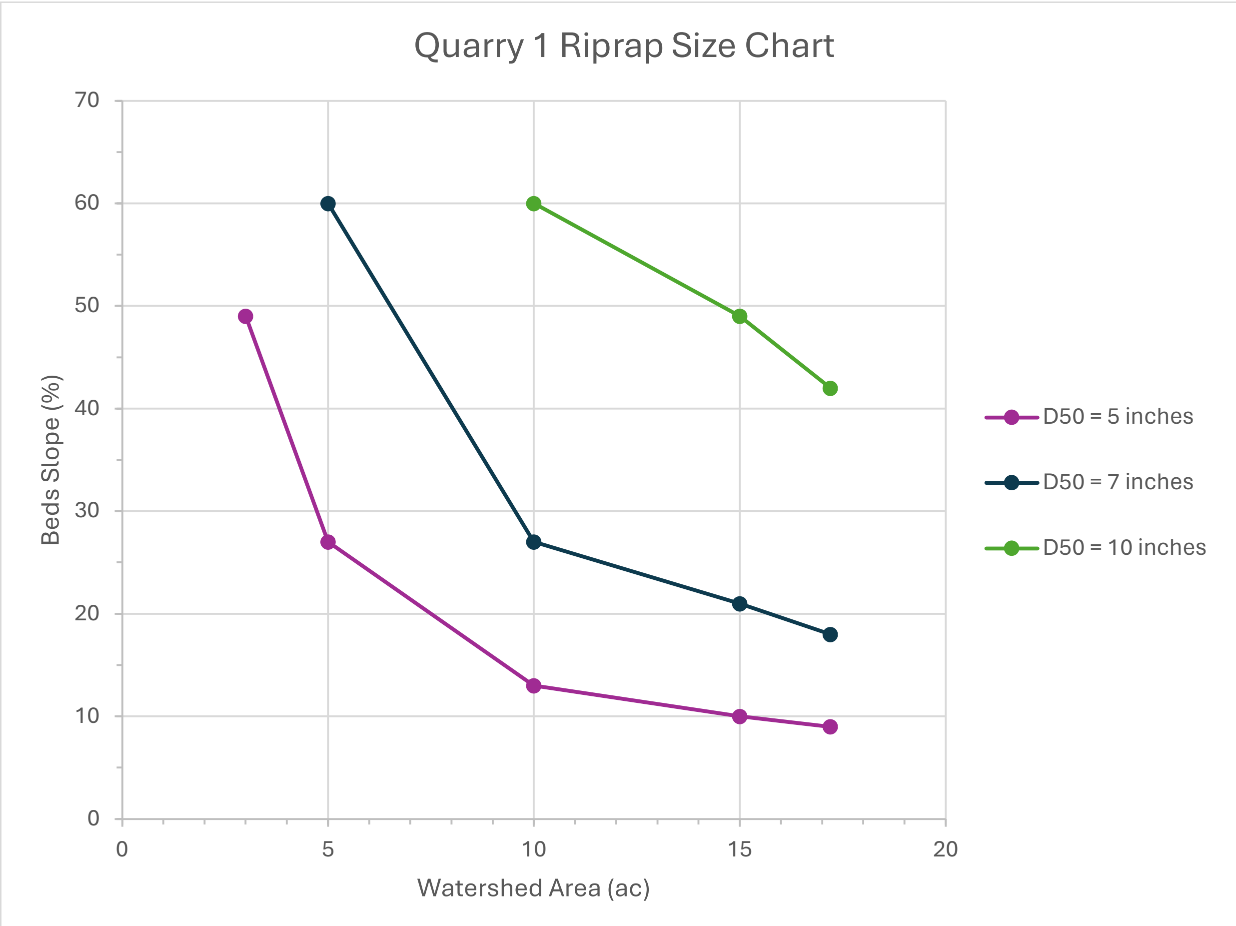

Figure 2. Watershed Area/Bed Slope Curve for 3 Sizes of Riprap at Quarry 1 (GCC Tijeras Mine)

The minimum watershed area depicted in Figure 2 is 3 acres, for the following reason. The calculated riprap D50 size for 1-acre watersheds ranges from 1.4 inches to 2.4 inches for bed slopes ranging from 10 percent to 33 percent, respectively. Riprap of these sizes is impractical to produce at GCC Tijeras, therefore, channels in watersheds up to 3-acres, were designed with 5-inch D50 riprap.

INSTALLED RIPRAP

GCC Tijeras can produce three grades of riprap, two of which were installed at Quarry 1: 1) Small riprap with a 5-in D50, and 2) Medium riprap with a 10-in D50. These riprap gradations were measured from riprap stockpiles using WipFrag 4 image analysis software (Appendix A).

The reclaimed channels in Quarry 1 were reviewed at various locations for bed slope and watershed area to verify that the specified riprap can withstand projected hydraulic forces. The small riprap was placed in all channel reaches except at two locations. Medium riprap was placed in Channels D1 and D16 at the short steep reach leading into Sediment Pond 1. These two locations have sufficiently large watershed areas (6.0 acres and 17.2 acres, respectively), and were sufficiently steep that larger riprap was warranted.

SUMMARY

This document includes responses to the EMNRD comments that were emailed to GCC Tijeras on April 8, 2024. Comment 1 was resolved with the attached maps that are updated with colored topographic lines that are easier to see. Comment 2 was resolved by demonstrating that the channels were designed to safely pass stormwater runoff the 100-year, 24-hour storm.

The as-built channel hydrology was reanalyzed using a newer unit hydrograph method and with increased rainfall amounts to account for future climate change. The minimum riprap size was calculated using two riprap methods. The method requiring the larger minimum riprap size was used for design. Lastly, the installed riprap was measured to confirm that it is at least as large as the minimum required riprap size.

REFERENCES

Abt R. Steven, Johnson L. Terry. *Riprap Design for Overtopping Flow*. Journal of Hydraulic Engineering. August, 1991.

Bonnin M. Geoffrey, Martin Deborah, Lin Bingzhang, Parzybok Tye, Yekta Michael, Riley David. *NOAA Atlas 14 Precipitation-Frequency Atlas of the Unites States, Volume 1 Version 5.0: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah)*. Revised 2011. National Oceanic and Atmospheric Administration.

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Guidelines for the Use of Regional Extreme Precipitation Study (REPS) Rainfall Estimation Tools, Colorado Dam Safety Branch, January 21, 2020.

Isbash, S.V. 1935. *Construction of Dams by Dumping Stones in Flowing Water*. Translated by A. Dorijikow, US Army Engineer District, Eastport, ME.

APPENDIX A – SUPPORTING DOCUMENTATION

1. HEC-HMS Summary Results
2. TYP1 – Typical riprap gradation and photograph
3. MD1 – Medium riprap gradation and photograph

Summary Results for Subbasin "Subbasin-1"

Project: Quarry 1 Simulation Run: 1ac_CN77-100yr24hr
Subbasin: Subbasin-1

Start of Run:	01Jan2000, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2000, 00:00	Meteorologic Model:	100yr_24hr_II
Compute Time:	11Jun2024, 10:51:03	Control Specifications:	Control 1

Volume Units: ○ IN ◉ ACRE-FT

Computed Results

Peak Discharge:	2.5 (CFS)	Date/Time of Peak Discharge:	01Jan2000, 12:00
Precipitation Volume:	0.3 (ACRE-FT)	Direct Runoff Volume:	0.1 (ACRE-FT)
Loss Volume:	0.2 (ACRE-FT)	Baseflow Volume:	0.0 (ACRE-FT)
Excess Volume:	0.1 (ACRE-FT)	Discharge Volume:	0.1 (ACRE-FT)

Summary Results for Subbasin "Subbasin-3ac"

Project: Quarry 1 Simulation Run: 3ac_CN77-100yr24hr
Subbasin: Subbasin-3ac

Start of Run:	01Jan2000, 00:00	Basin Model:	Basin 3ac
End of Run:	02Jan2000, 00:00	Meteorologic Model:	100yr_24hr_II
Compute Time:	11Jun2024, 10:52:20	Control Specifications:	Control 1

Volume Units: ○ IN ◉ ACRE-FT

Computed Results

Peak Discharge:	7.3 (CFS)	Date/Time of Peak Discharge:	01Jan2000, 12:00
Precipitation Volume:	0.9 (ACRE-FT)	Direct Runoff Volume:	0.4 (ACRE-FT)
Loss Volume:	0.5 (ACRE-FT)	Baseflow Volume:	0.0 (ACRE-FT)
Excess Volume:	0.4 (ACRE-FT)	Discharge Volume:	0.4 (ACRE-FT)

Summary Results for Subbasin "Subbasin-5ac"

Project: Quarry 1 Simulation Run: 5ac_CN77-100yr24hr
Subbasin: Subbasin-5ac

Start of Run:	01Jan2000, 00:00	Basin Model:	Basin 5ac
End of Run:	02Jan2000, 00:00	Meteorologic Model:	100yr_24hr_II
Compute Time:	11Jun2024, 10:53:08	Control Specifications:	Control 1

Volume Units: ○ IN ◉ ACRE-FT

Computed Results

Peak Discharge:	11.9 (CFS)	Date/Time of Peak Discharge:	01Jan2000, 12:00
Precipitation Volume:	1.6 (ACRE-FT)	Direct Runoff Volume:	0.7 (ACRE-FT)
Loss Volume:	0.9 (ACRE-FT)	Baseflow Volume:	0.0 (ACRE-FT)
Excess Volume:	0.7 (ACRE-FT)	Discharge Volume:	0.7 (ACRE-FT)

Summary Results for Subbasin "Subbasin-10ac"

Project: Quarry 1 Simulation Run: 10ac_CN77-100yr24hr
Subbasin: Subbasin-10ac

Start of Run:	01Jan2000, 00:00	Basin Model:	Basin 10ac
End of Run:	02Jan2000, 00:00	Meteorologic Model:	100yr_24hr_II
Compute Time:	11Jun2024, 10:54:18	Control Specifications:	Control 1

Volume Units: ○ IN ◉ ACRE-FT

Computed Results

Peak Discharge:	23.4 (CFS)	Date/Time of Peak Discharge:	01Jan2000, 12:00
Precipitation Volume:	3.2 (ACRE-FT)	Direct Runoff Volume:	1.4 (ACRE-FT)
Loss Volume:	1.8 (ACRE-FT)	Baseflow Volume:	0.0 (ACRE-FT)
Excess Volume:	1.4 (ACRE-FT)	Discharge Volume:	1.4 (ACRE-FT)

Summary Results for Subbasin "Subbasin-15ac"

Project: Quarry 1 Simulation Run: 15ac_CN77-100yr24hr
Subbasin: Subbasin-15ac

Start of Run:	01Jan2000, 00:00	Basin Model:	Basin 15ac
End of Run:	02Jan2000, 00:00	Meteorologic Model:	100yr_24hr_II
Compute Time:	11Jun2024, 10:55:32	Control Specifications:	Control 1

Volume Units: ○ IN ◉ ACRE-FT

Computed Results

Peak Discharge:	30.7 (CFS)	Date/Time of Peak Discharge:	01Jan2000, 12:05
Precipitation Volume:	4.7 (ACRE-FT)	Direct Runoff Volume:	2.1 (ACRE-FT)
Loss Volume:	2.7 (ACRE-FT)	Baseflow Volume:	0.0 (ACRE-FT)
Excess Volume:	2.1 (ACRE-FT)	Discharge Volume:	2.1 (ACRE-FT)

Summary Results for Subbasin "Subbasin-17.2ac"

Project: Quarry 1 Simulation Run: 17.2ac_CN77-100yr24hr
Subbasin: Subbasin-17.2ac

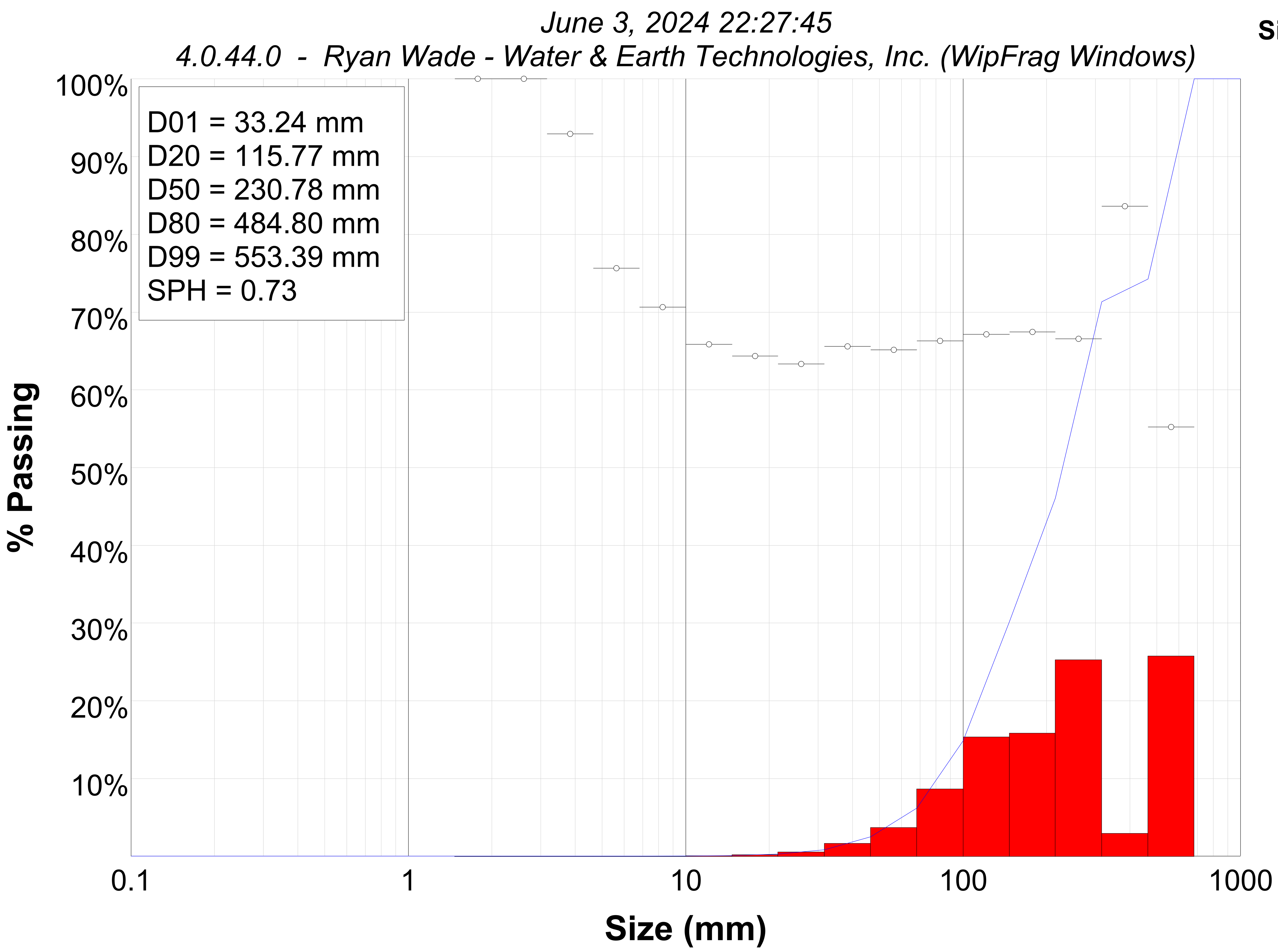
Start of Run:	01Jan2000, 00:00	Basin Model:	Basin 17.2ac
End of Run:	02Jan2000, 00:00	Meteorologic Model:	100yr_24hr_II
Compute Time:	11Jun2024, 10:56:17	Control Specifications:	Control 1

Volume Units: ○ IN ◉ ACRE-FT

Computed Results

Peak Discharge:	34.7 (CFS)	Date/Time of Peak Discharge:	01Jan2000, 12:05
Precipitation Volume:	5.4 (ACRE-FT)	Direct Runoff Volume:	2.4 (ACRE-FT)
Loss Volume:	3.1 (ACRE-FT)	Baseflow Volume:	0.0 (ACRE-FT)
Excess Volume:	2.4 (ACRE-FT)	Discharge Volume:	2.4 (ACRE-FT)

TYP1



Size (mm)	% Passing
1000.00	100.00%
681.00	100.00%
464.00	74.24%
316.00	71.31%
215.00	46.05%
147.00	30.21%
100.00	14.84%
68.10	6.18%
46.40	2.49%
31.60	0.82%
21.50	0.26%
14.70	0.07%
10.00	0.01%
6.81	0.00%
4.64	0.00%
3.16	0.00%
2.15	0.00%
1.47	0.00%
1.00	0.00%
0.68	0.00%
0.46	0.00%
0.32	0.00%
0.22	0.00%
0.15	0.00%
0.10	0.00%

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Latitude
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Altitude
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Legend
Fines
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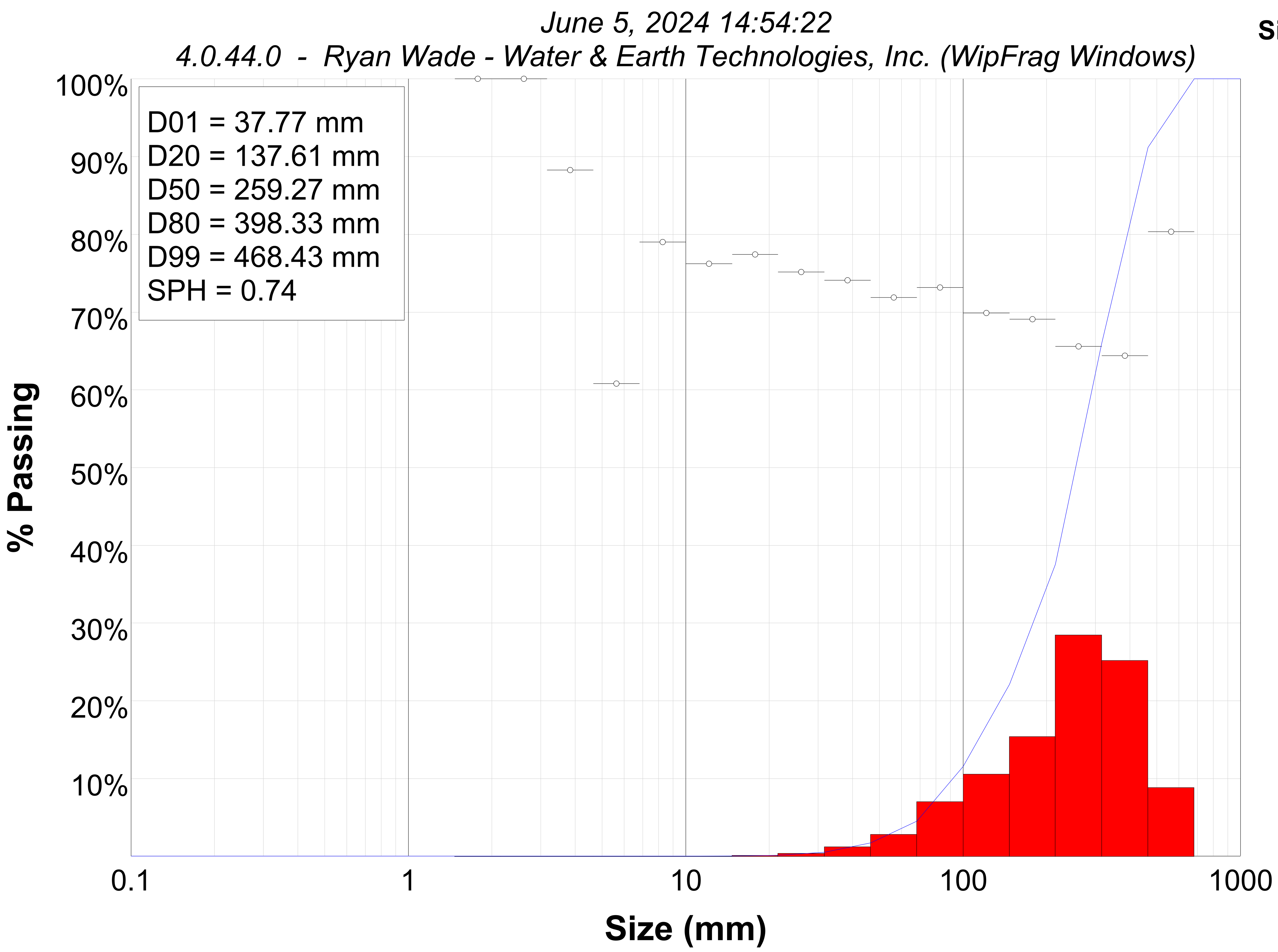
Engineers Note: The 20 largest particles (size 215 mm and larger) were removed from the gradation calculation and the D50 was recalculated. These 20 particles are considered oversize material, occur very infrequently, and are not expected to significantly change the behavior of overall riprap mass with resisting hydraulic forces.

The recalculated D50 is 126.3 mm, or 5.0 inches.

MD1



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100.00	11.54%
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46.40	1.70%
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Legend

Fines

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