MEMO

TO: Resolution Copper – Vicky Peacey

FROM: WSP – Gustavo Meza-Cuadra, Chris Pantano, Doug Oliver

SUBJECT: **Resolution Copper Groundwater Flow Model – Predicted Flows to Block Cave**

DATE: **September 28, 2018**

INTRODUCTION

This technical memorandum presents predictive results from the Resolution Copper (RC) groundwater flow model developed by WSP in support of the EIS for the Resolution Copper Mine plan and land exchange. Specifically, it presents the modeled groundwater inflows to the Resolution block cave mine, as requested by the USFS Groundwater Modeling Workgroup on a conference call held on September 9th, 2018. A draft memo was submitted to the USFS Groundwater Modeling Workgroup in August 2018 detailing the impact assessment, but no discussion of flows to the mine were included in that memo.

The groundwater flow model was constructed and calibrated to historical conditions to assess future impacts of construction and operation of the Resolution Copper Mine. The conceptualization, construction and calibration of the model was detailed in the report submitted by WSP to Resolution Copper in October 2017 (to be revised and updated in October 2018, consistent with direction from the Groundwater Modeling Workgroup). This includes details of the methodology used to represent the transient nature of block caving into the Life of Mine (LOM) models.

PREDICTIVE MODEL RESULTS

The results detailed below are based on the base case Life of Mine model presented in the memo *DRAFT Resolution Copper Groundwater Flow Model – Predictive Results* dated August, 6th, 2018 (WSP, 2018). As the time-varying nature of the block cave development was incorporated into the LOM model, intra-cell water balance calculations can estimate flows to and from different units within the model. The Resolution Mine workings are simulated as boundary conditions (drains) within the model and were used to represent the removal of groundwater via dewatering. The results below were generated with the Groundwater Vistas post-processing tools.

A conceptual cross-section of the Resolution Mine workings (represented with drain cells beneath the block cave mine) and the fractured zone (modeled with time-varying material property package) is shown in Figure 1. The Apache Leap Tuff (Tal) and Whitetail Conglomerate (Tw)

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hydrogeologic units, as well as the Deep System are also shown. The green shading shows the full extent of the fractured rock from block caving at end of LOM, however the caving occurs in stages throughout the Life of Mine.

For flow budget calculations, the Apache Leap Tuff and Whitetail Conglomerate were combined as one unit, and the deep system including the Kvs, pCy and Pz rocks as a second unit. Tracking flows from these two units allows for transient behavior to be visualized, as shown in the graph in Figure 2. This graph illustrates total flow to the drains beneath the block cave mine (grey line), as well as components of flow from the Apache Leap Tuff/Whitetail Conglomerate and vertical recharge (blue line) and the Deep System (orange line). As the two units (Tal +Tw and Deep System) ultimately exit at the drain boundary conditions below the block cave, the grey line is the sum of the other two. Flows to the HGUs were obtained using the hydrostratigraphic unit (HSU) package.

At LOM year 5 (model year 16), the upward fracturing of rock breaches the top of the Whitetail (ITASCA, 2017) into the Apache Leap Tuff aquifer, which releases water through the high permeability fractures downward. A spike in flow rate of approximately 2800 gpm occurs when the fracturing (increased hydraulic conductivity from block caving) connects the Apache Leap Tuff aquifer with the underlying system. The flow rates remain high for a few years, draining the higher conductivity rock, but then eventually tail off and stabilize at between 800 – 1500 gpm. The flow rates from the Deep System, overall, stay relatively constant (average of 630 gpm) with a few spikes largely related to the release of water in storage from block cave panel expansion. A table summarizing the average flow rates per year is shown in Table 1.

REFERENCES

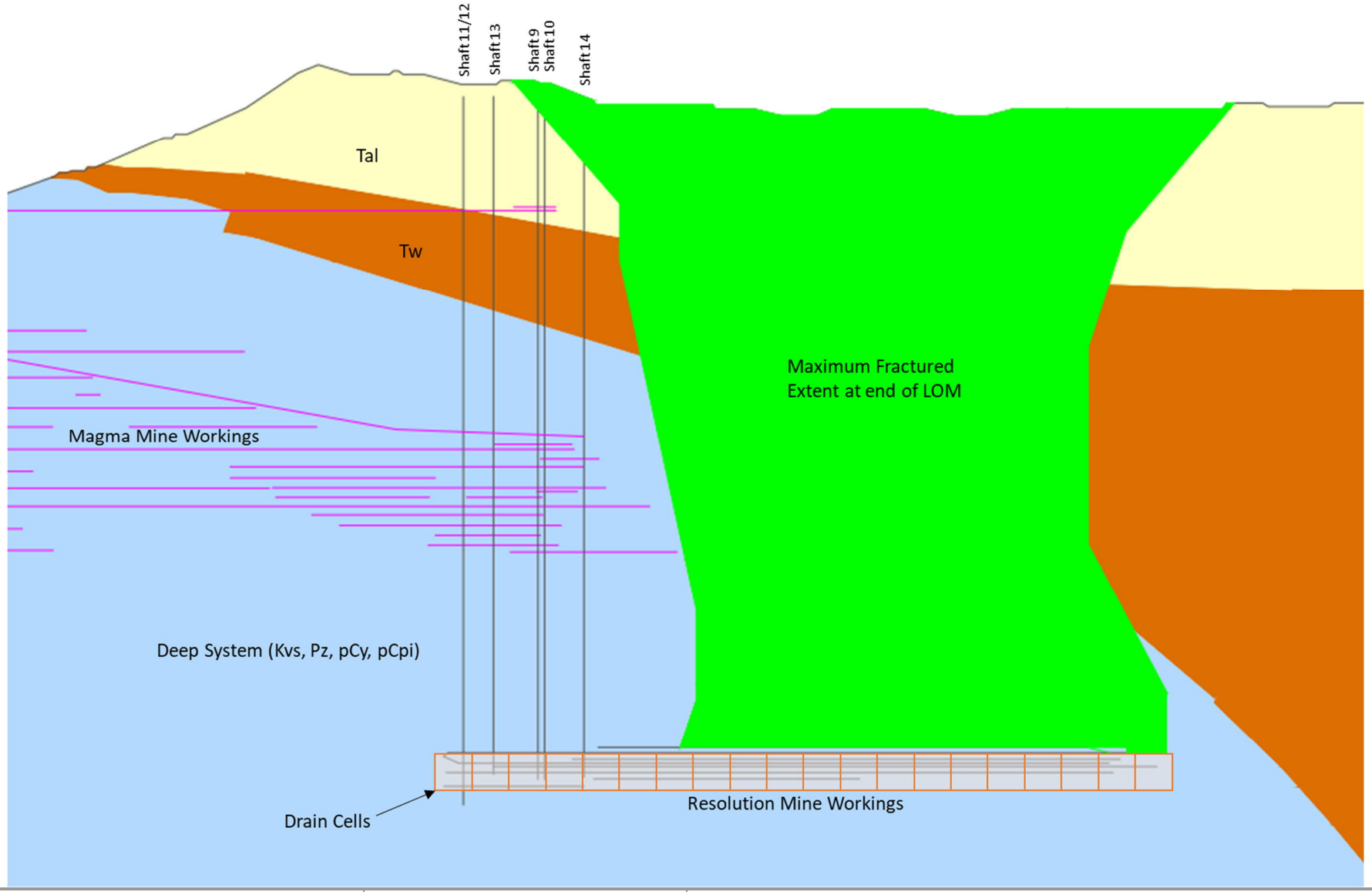
ITASCA Consulting Group, Inc., 2017. *Assessment of Surface Subsidence Associated with Caving Resolution Copper Mine Plan of Operations*. July 17, 2017.

WSP USA, 2017. *Resolution Copper Groundwater Flow Model Report.* October 2017.

WSP USA, 2018. *Resolution Copper Groundwater Flow Model – Predictive Results Technical Memorandum*. August 2018.

Table 1. Average Modeled Flow Rates into the Resolution Block Cave

Year	Tal + Tw [gpm]	Deep System [gpm]	RC Workings / Drain Outflows [gpm]
1.0	4	681	685
2.0	4	384	388
3.0	4	348	352
4.0	4	324	328
5.0	4	511	515
6.0	4	522	526
7.0	4	584	588
8.0	4	648	652
9.0	4	667	671
10.0	4	676	680
10.5	4	681	685
11.0	4	681	685
11.5	4	674	678
12.0	4	677	681
12.5	4	713	717
13.0	4	772	776
13.5	4	852	856
14.0	40	828	869
14.5	121	817	938
15.0	297	831	1127
15.5	592	897	1488
16.0	1578	1197	2776
16.5	1554	1124	2678
17.0	979	888	1867
17.5	926	940	1866
18.0	939	903	1842
18.5	826	874	1700
19.0	813	809	1621
19.5	704	769	1473
20.0	670	725	1395
20.5	622	725	1347
21.0	710	736	1446
21.5	687	754	1441
22.0	608	666	1275
22.5	573	658	1231
23.0	558	656	1214
23.5	572	656	1227
24.0	496	654	1151
24.5	582	697	1278
25.0	724	735	1459
25.5	576	677	1253
26.0	557	661	1218
26.5	541	681	1222
27.0	547	652	1199
27.5	552	633	1184
28.0	591	636	1227
28.5	639	638	1277
29.0	624	614	1238
29.5	616	610	1227
30.0	620	580	1200
30.5	597	589	1186
31.0	589	599	1188
31.5	566	601	1166
32.0	495	573	1068
32.5	475	546	1021
33.0	452	529	981
33.5	434	530	965
34.0	428	544	972
34.5	431	533	964
35.0	427	560	987
35.5	428	591	1019
36.0	439	607	1046
36.5	454	657	1111
37.0	495	762	1257
37.5	590	885	1475
38.0	588	677	1265
38.5	558	621	1180
39.0	549	576	1125
39.5	585	559	1144
40.0	610	567	1177
40.5	649	557	1205
41.0	666	560	1226
41.5	706	576	1282
42.0	719	609	1328
42.5	684	600	1284
43.0	644	580	1224
43.5	625	559	1184
44.0	635	531	1166
44.5	592	514	1106
45.0	543	496	1039
45.5	512	476	988
46.0	481	465	945
46.5	467	454	921
47.0	445	448	893
47.5	426	441	867
48.0	413	436	848
48.5	402	431	833
49.0	394	426	820
49.5	385	422	807
50.0	378	419	797
50.5	373	416	789
51.0	368	414	782
51.5	364	411	776



Deep System

Whitetail Conglomerate

Apache Leap Tuff

Resolution Block Cave

Conceptual cross-section across block cave

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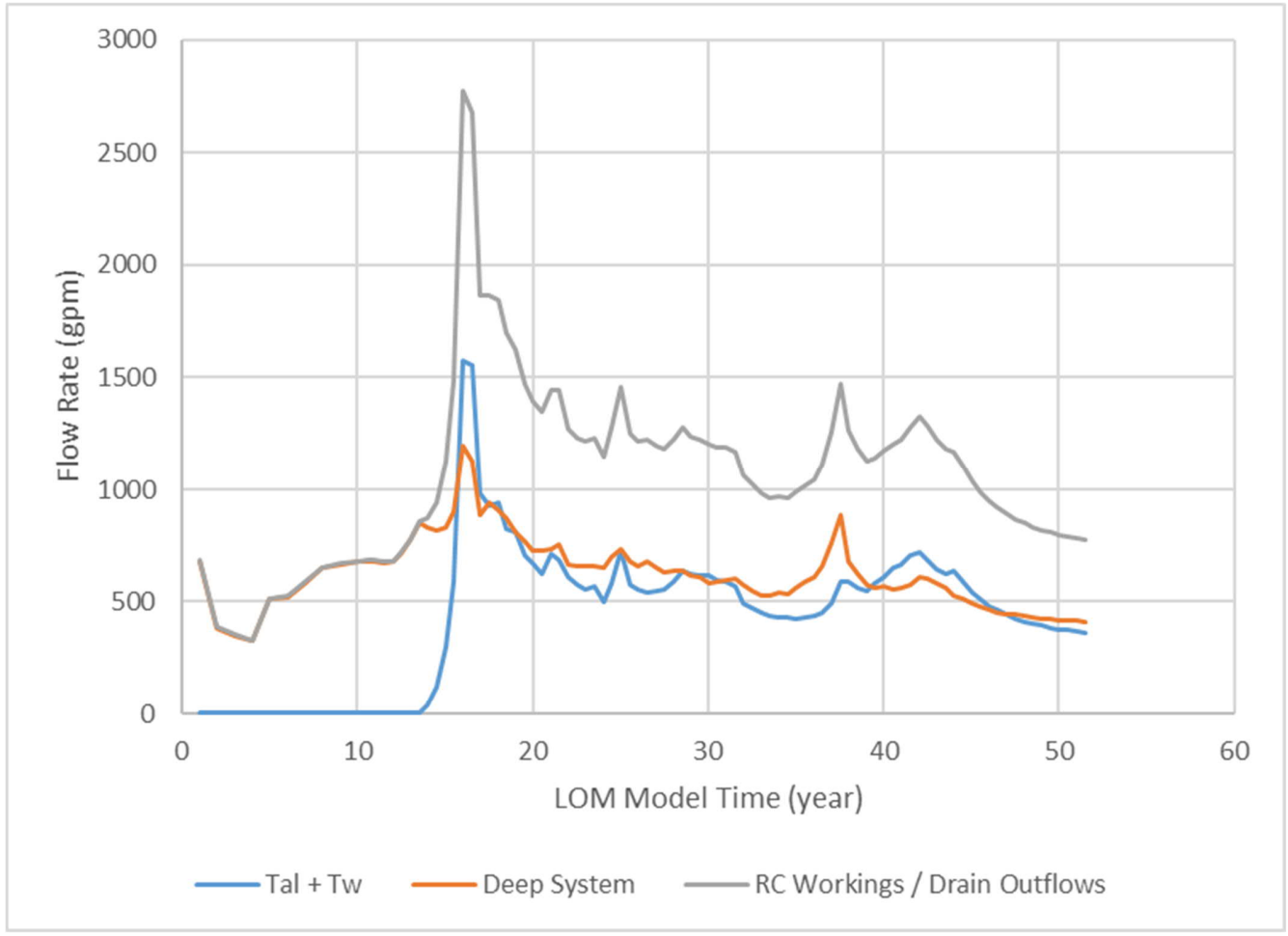
JOB:	31400968.001	DRAWN:	GM	CHECKED: DO
DATE:	September 2018	FIGURE:	1	



Flow discharged from two units into the fractured zone and exiting at the drains beneath the mine

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DATE:	September 2018	FIGURE:	2	

Victoria Boyne

From: ResolutionProjectRecord
Subject: FW: Response to Request - GW Modeling Workgroup Meeting 9/12/2018
Attachments: Memo - RC GW Model Predicted Flow 092818 WSP.PDF

From: Peacey, Victoria (RC) <Victoria.Peacey@riotinto.com>
Sent: Sunday, September 30, 2018 12:04 PM
To: mcrasmussen@fs.fed.us
Cc: Chris Garrett <cgarrett@swca.com>; Donna Morey <dmorey@swca.com>
Subject: Response to Request - GW Modeling Workgroup Meeting 9/12/2018

Hello Mary,

As a follow-up to the 9/12/2018 Groundwater Modeling Workgroup conference call please see the attached technical memorandum from WSP describing flows for mine dewatering.

Thanks,

Vicky Peacey
Senior Manager – Permitting and Approvals

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