MEMO

TO: Resolution Copper – Vicky Peacey

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

SUBJECT: Resolution Copper Groundwater Flow Model – Sensitivity Analysis

DATE: November 19, 2018

INTRODUCTION

This technical memorandum presents the results of the sensitivity analysis completed for the Resolution Copper (RC) groundwater flow model developed by WSP in support of the EIS for the Resolution Copper Mine plan and land exchange. A separate memo dated October 31st, 2018, summarized the base case predictive model results, which establish the starting point for the sensitivity analysis. The model tested within the predictive sensitivity framework is based on this base case, varying parameters to test the divergence of the modeled results and interpreted impacts. This memo provides the sensitivity analysis methodology and results with figures and hydrographs to allow for clear visualization of the changes to the predictive results.

The USFS Groundwater Modeling Workgroup has been involved, providing input throughout the process of defining the scope and methodology used within this document.

METHODOLOGY

A groundwater model is a representation of a hydrogeological system that can be used to predict the impacts of a natural or human induced change to that system. Groundwater models are composed of hydrogeological parameters and boundary conditions, which are used to solve the groundwater flow equation. Groundwater models are inherently uncertain because the real-world values of the parameters used in them are estimated and the future of time-dependent parameters, such as recharge, are unknown. This uncertainty is not eliminated through the calibration process and remains present in predictive scenarios. Since model predictions inform real-world decisions, it is best practice to evaluate uncertainty and assess its potential impact on results.

ASTM standard D5611-4 *Standard Guide for Conducting a Sensitivity Analysis for a Groundwater Flow Model Application* (ASTM International, 2016) has been used as the reference to guide sensitivity analysis for the Resolution Copper groundwater model. An important concept described in ASTM standard D5611-4 (Section 3.1.8.1) is that sensitivity should be jointly analyzed in model calibration and model predictions. Testing parameter variations on both parts helps interpret where the greatest sensitivity lies and what parameters can be considered significant for the purposes of the analysis. The model calibration provides a check on the model, to validate the sufficiency of data matching in order to be used for predictive modeling. The ASTM standard considers models with high predictive sensitivity, but that remain calibrated, most relevant to decision making. As such, the ASTM standard provides a reasonable and appropriate internationally recognized framework for the overall analysis.

In alignment with the concepts of the ASTM, the first step in the analysis was to determine which parameters had the largest impact on the model calibration (i.e., most sensitive). This task was achieved using the inverse model code PEST (Watermark Numerical Computing, 2016) which can be used to quantify the effect parameters have on the calibration (evaluated based on the sum of squared residuals). With this tool, a preliminary list of parameters was derived to test for predictive purposes. However, through discussions with the Groundwater Modeling Workgroup, this list was expanded to test a broader range of parameters due to their significance at groundwater dependent ecosystems (GDE) (e.g., springs), which the distribution of calibration targets may have missed[1]. Additionally, parameters not present in the calibration but included in the predictive models were added (e.g., storage parameters for the damaged zone associated with the block cave mine).

The full list of parameters tested in the sensitivity analysis is shown below.

- Hydraulic conductivity (K_x, K_y, K_z) of all zones within the Apache Leap Tuff (Tal)
- Hydraulic conductivity (K_x, K_y, K_z) of the Gila Conglomerate (QTg)
- Hydraulic conductivity (K_x, K_y, K_z) of the Lower Whitetail Conglomerate (Tw)
- Hydraulic conductivity (K_x, K_y, K_z) of the Paleozoic units (Pz) north and south of graben
- Hydraulic conductivity (K_x, K_y, K_z) of the Younger pre-Cambrian unit (pCy) north of graben
- Hydraulic conductivity (K_x, K_y, K_z) of the Pinal Schist (pCpi)
- Hydraulic conductivity (K_x, K_y, K_z) of the Devils Canyon, JI Ranch and graben faults
- Recharge of high elevation zone
- Recharge of low elevation zone
- Specific yield of all zones within the Apache Leap Tuff
- Specific yield of the Paleozoic unit south of graben
- Specific yield of the Younger pre-Cambrian unit south of graben
- Specific yield of block caved material
- Conversion of General Head Boundaries to No-Flow Boundaries.

Parameters with a logarithmic distribution (e.g., hydraulic conductivity) were varied by one order of magnitude in each direction and non-logarithmic parameters (e.g., specific yield and recharge) were varied by +/- 50%. The range of specific yields tested for the block-caved material, were constrained by the ranges of sensitivity values presented in *Assessment of Surface Subsidence Associated with Caving - Resolution Copper Mine Plan of Operations* (ITASCA, 2017). A full list of all 87 predictive model runs (43 parameter increases, 43 parameter decreases and 1 change in

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[1] Sensitivity of parameters within the calibration model are measured relative to the variation in statistics of the head targets. Hence, areas without targets are by definition not sensitive to the calibration.

boundary condition type), including parameter zone, corresponding Hydrogeologic Unit (HGU), and the tested values are included in Table 1.

For each sensitivity scenario, the historical model was run with the corresponding parameter change to ensure model calibration statistics had not degraded above an acceptable point, which for our analysis was defined as >10% Normalized Root Mean Squared Error (NRMS) value for the shallow and deep targets separately. No-Action and Proposed Action models were run with the same parameterizations, and impact was calculated in the same way as the base case predictive results (i.e., Proposed Action minus No-Action drawdown).

RESULTS – IMPACT MAPS

Maps illustrating the results of the sensitivity runs are presented in Figures B-1 through B-44. Each figure shows the model domain with three 10-ft impact contour lines: black representing the base case, red representing the increase in parameter value, and green representing the decrease in parameter value. Additionally, a shaded polygon of the parameter zone that was varied for that run was included, alongside the GDE locations shown as points (also included with names in Figure A) for reference. The results shown are for 200 years after the beginning of the Life of Mine model. All scenarios showed degradation in the corresponding historical (calibration) model statistics, to different extents, but none past the 10% NRMS cut-off criterion.

The sections below present brief interpretation of the figures and the effect that parameter changes had on the predicted impacts.

HYDRAULIC CONDUCTIVITY

Figure B-1 presents the changes to the results caused by varying hydraulic conductivity of the Gila Conglomerate unit west of the Apache Leap escarpment. The variation in the 10-ft contour is small, with a decrease in the impact in the Queen Creek stream channel area for the parameter reduction and a small increase westward for the parameter increase.

Figures B-2 through B-12 present the changes to the results based on varying hydraulic conductivity for each of the 11 Apache Leap Tuff zones. Variations in results are generally consistent with the expected outcome, larger areal extent of impacts are shown for increased hydraulic conductivity values, smaller areal extent of impacts for decreased hydraulic conductivity values. An increase in impacted area towards the north-east is present in most figures, and is especially evident for zones 13, 15, 18 and 22 (Figures B-2, B-4, B-7, and B-11, respectively). Results in Figures B-3 and B-6 appear contradictory, where an increase in the hydraulic conductivity value results in a smaller area of impact relative to the base case, however this is due to the fracturing of the block cave for the Proposed Action model[2].

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[2]The behavior presented in sensitivity scenarios for zones 14 and 17 (Figures B-3 and B-6) is best explained through hydrograph HRES-06 shown in Appendix A. As described in WSP (October, 2017), the block caving in the Proposed Action (PA) models greatly increases the hydraulic conductivity of cells within its footprint, allowing for value up to 100 ft/d. Because Zones 14 and 17 are located within the footprint of the block cave, the increase (and decrease) in hydraulic conductivity from the sensitivity scenario is “over-printed” by the much larger increase in conductivity from the block cave. Hence, the hydraulic head solution of the PA runs for both models in the sensitivity scenario (parameter increase and decrease) are very similar, as shown by the two solid lines (red and green) in the hydrograph. However, the No-Action (NA) models do diverge since they don’t have the “over-printing” effect of the block caving, as shown by the dashed lines. As impact is calculated by subtracting head in the NA model from the PA model, this creates an inverse in the expected impact contours compared to other scenarios.

Two zones from the Whitetail Conglomerate were included in the sensitivity analysis, zones 52 and 56, representing the lower parts of the unit. Figure B-14 indicates no material difference in the impact contours, however Figure B-13 expands the contours slightly in most directions. This behavior is due to Zone 52 being a thicker and more extensive zone, hence having a larger influence on the results.

Results of the parameter variation in the Paleozoic Units (zones 64 and 67) are shown in Figures B-15 and B-16. The footprint of zone 67 extends to the south as indicated by the shaded region, and creates slightly more impact in the south-east direction.

Similarly, the sensitivity runs on the Younger pre-Cambrian Apache Group Unit presented in Figures B-17 and B-18 show similar patterns of increased impacts in the south and north directions, respectively. Zone 69 (Figure B-17) does show greater magnitude of change on the impact contours as the zone is more extensive and parts of the 10-ft impact contour reach the southern boundary.

Sensitivity of the Pinal Schist is shown in Figure B-19. The Pinal Schist is the largest unit by volume in the model and hence variations in its hydraulic property values create impact changes in almost every direction. The largest change is in the north-west direction in the area of McGinnel Spring and McGinnel Mine Spring.

FAULTS

Faults are important parameters for the model, and a significant factor in the drawdown calibration of the graben wells (DHRES-01, DHRES-02, DHRES-08) as detailed in WSP (October, 2017). The faults included in the sensitivity analysis were the graben faults (North Boundary, Rancho Rio, South Boundary, West Boundary, and Conley Springs faults), plus the two north-south faults in the Devils Canyon area (JI Ranch and Devils Canyon faults).

Hydraulic conductivity of the faults was varied for each sensitivity scenario as shown in Table 1. Results for each of these model runs are shown in Figures B-20 through B-26. Sensitivity runs for faults created variations in the impact contours simulated, with varying degrees of significance. The most significant changes are shown in Figures B-20 and B-22, representing the Conley Springs and North Boundary faults, where impacts propagate further east and north-east.

Additionally, the groundwater modeling workgroup requested a run be simulated where the hydraulic conductivity of all graben faults was changed simultaneously. Despite this scenario representing the run with most degradation in the calibration (i.e., increased root mean squared error and reduction in match of hydrograph trends) the results were compiled and are shown in Figure B-27. The contours expand in all directions outward with a large bias in the north-east direction, but they also contract significantly in the lower hydraulic conductivity scenario.

SPECIFIC YIELD

Specific yield was also varied for every zone in the Apache Leap Tuff (Figures B-28 to B-38), however negligible change was shown. This is due to the shallow drawdowns in most of the Apache Leap Tuff, therefore variation in storage did not have much effect on the results.

Specific yield was also varied for the Paleozoic and younger pre-Cambrian Apache group (Figures B-39 and B-40), however negligible variation was shown.

Block cave specific yield was varied in Figure B-41. The ranges were set at +/- 25%, in accordance with the geomechanical model sensitivity ranges tested (ITASCA, 2018). The figure shows the outer impact contours are not very sensitive to this parameter, which is expected because the block cave water level is still well below the groundwater levels in the Apache Leap Tuff at 200 years.

BOUNDARY CONDITIONS

All General Head Boundaries (used in the base case model) were converted into No-Flow boundaries, which resulted in an expansion of impacts in the north and south direction at the boundaries (Figure B-42). This run represents an unrealistic discontinuity in the hydrogeological system, but it was thought important to show that boundary conditions were not altering results in a significant way. The low amount of flow across these boundaries in the base case is a more realistic representation of the hydrogeological system.

The High Elevation recharge run (Figure B-43) had a similar change in impact contours to some of the Apache Leap Tuff hydraulic conductivity variations, extending the impact further to the north-east part of the domain. The Low Elevation, Low Kz (Figure B-44) recharge run shows minimal variation in the impact contours.

SUPERPOSITION

Lastly, Figure B-45 represents a superposition of all scenarios, delineating their maximum 10-ft contour extent into one polygon. This figure was requested by the Groundwater Modeling Workgroup, and could serve to put an upper bound on the extent of potential impacts and guide the extent of monitoring. Overall, the pattern of impacts appears similar to the base case, but the 10-ft impact contour expanded further, encompassing larger areas of the Apache Leap Tuff and additional Devils Canyon GDEs (DC 8.1C, DC 8.2W and DC 8.8C).

RESULTS – GDE HYDROGRAPHS

Additionally, hydrographs for each of the GDEs were compiled by superimposing every single run onto a single graph as shown in Figures C-1 through C-26. The black line represents the base case and the grey lines represent all 87 sensitivity runs superimposed. Generally, the base case lies in the middle of the grey runs, representing a central case as the parameter increases and decreases bracket it in both directions. Hydrographs are useful to visualize the temporal behavior of individual points in the model.

REFERENCES

ASTM International, 2016. ASTM standard D5611-4 *Standard Guide for Conducting a Sensitivity Analysis for a Groundwater Flow Model Application*

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

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

Watermark Numerical Computing, 2016. *PEST: Model-Independent Parameter Estimation User Manual.* Software Documentation, 6th Edition published in 2016, 390 p.

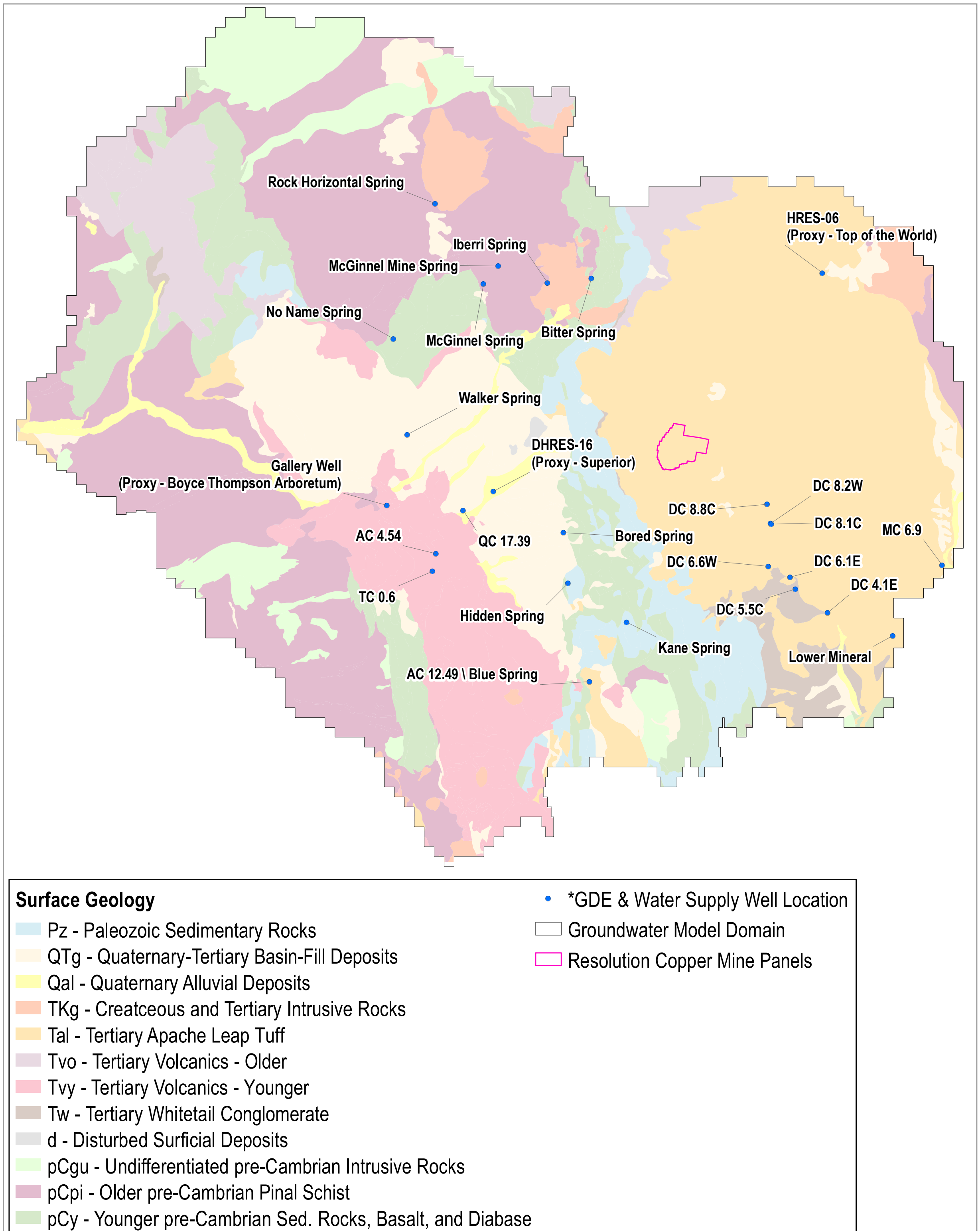
TABLES

Table 1: Sensitivity Parameters Tested

Figure #	HGU	Zone	Parameter	Unit	Base Case Value[1]	Upper Value Tested	Lower Value Tested
B-1	Tal	7	Hydraulic Conductivity	ft/d	2.54E-04	2.5E-03	2.5E-05
B-2	Tal	13	Hydraulic Conductivity	ft/d	6.25E-02	6.3E-01	6.3E-03
B-3	Tal	14	Hydraulic Conductivity	ft/d	2.50E-01	2.5E+00	2.5E-02
B-4	Tal	15	Hydraulic Conductivity	ft/d	1.26E-02	1.3E-01	1.3E-03
B-5	Tal	16	Hydraulic Conductivity	ft/d	3.00E+00	3.0E+01	3.0E-01
B-6	Tal	17	Hydraulic Conductivity	ft/d	6.00E-02	6.0E-01	6.0E-03
B-7	Tal	18	Hydraulic Conductivity	ft/d	5.00E-03	5.0E-02	5.0E-04
B-8	Tal	19	Hydraulic Conductivity	ft/d	1.00E+00	1.0E+01	1.0E-01
B-9	Tal	20	Hydraulic Conductivity	ft/d	4.00E-01	4.0E+00	4.0E-02
B-10	Tal	21	Hydraulic Conductivity	ft/d	1.07E-02	1.1E-01	1.1E-03
B-11	Tal	22	Hydraulic Conductivity	ft/d	1.00E-03	1.0E-02	1.0E-04
B-12	Tal	23	Hydraulic Conductivity	ft/d	4.00E-01	4.0E+00	4.0E-02
B-13	Tw	52	Hydraulic Conductivity	ft/d	1.25E-05	1.3E-04	1.3E-06
B-14	Tw	56[2]	Hydraulic Conductivity	ft/d	3.0E-06 / 5.0E-07	3.0E-05 / 5.0E-06	3.0E-07 / 5.0E-08
B-15	Pz	64	Hydraulic Conductivity	ft/d	1.48E-05	1.5E-04	1.5E-06
B-16	Pz	67	Hydraulic Conductivity	ft/d	1.00E-04	1.0E-03	1.0E-05
B-17	pCy	69	Hydraulic Conductivity	ft/d	1.00E-03	1.0E-02	1.0E-04
B-18	pCy	70	Hydraulic Conductivity	ft/d	1.28E-04	1.3E-03	1.3E-05
B-19	pCpi	80	Hydraulic Conductivity	ft/d	1.00E-04	1.0E-03	1.0E-05
B-20	**Conley Springs Fault[3]**	**175**	Hydraulic Conductivity	ft/d	1.00E-04	**1.0E-03**	**1.0E-05**
B-21	Devils Canyon Fault	203	Hydraulic Conductivity	ft/d	1.00E-01	1.0E+00	1.0E-02
B-22	JI Ranch Fault	218	Hydraulic Conductivity	ft/d	1.00E-03	1.0E-02	1.0E-04
B-23	**North Boundary Fault[3]**	**250**	Hydraulic Conductivity	ft/d	6.25E-04	**6.3E-03**	**6.3E-05**
B-24	**Rancho Rio Fault[3]**	**265**	Hydraulic Conductivity	ft/d	2.50E-04	**2.5E-03**	**2.5E-05**
B-25	**South Boundary Fault[3]**	**284**	Hydraulic Conductivity	ft/d	1.60E-05	**1.6E-04**	**1.6E-06**
B-26	**West Boundary Fault[3]**	**290**	Hydraulic Conductivity	ft/d	1.25E-05	**1.3E-04**	**1.3E-06**
B-27	**All Graben Faults**	**All Graben Faults**	Hydraulic Conductivity	ft/d	-	**+1 OoM**	**-1 OoM**
B-28	Tal	13	Specific Yield	-	5.0E-03	7.5E-03	2.5E-03
B-29	Tal	14	Specific Yield	-	1.0E-03	1.5E-03	1.0E-03
B-30	Tal	15	Specific Yield	-	5.0E-03	7.5E-03	2.5E-03
B-31	Tal	16	Specific Yield	-	5.0E-03	7.5E-03	2.5E-03
B-32	Tal	17	Specific Yield	-	5.0E-03	7.5E-03	2.5E-03
B-33	Tal	18	Specific Yield	-	5.0E-03	7.5E-03	2.5E-03
B-34	Tal	19	Specific Yield	-	5.0E-03	7.5E-03	2.5E-03
B-35	Tal	20	Specific Yield	-	5.0E-03	7.5E-03	2.5E-03
B-36	Tal	21	Specific Yield	-	5.0E-03	7.5E-03	2.5E-03
B-37	Tal	22	Specific Yield	-	5.0E-03	7.5E-03	2.5E-03
B-38	Tal	23	Specific Yield	-	5.0E-03	7.5E-03	2.5E-03
B-39	Pz	67	Specific Yield	-	1.0E-02	1.5E-02	5.0E-03
B-40	pCy	69	Specific Yield	-	8.8E-03	1.3E-02	4.4E-03
B-41	-	Block Cave[4]	Specific Yield	-	-	+25%	-25%
B-42	-	-	Boundary Condition	-	GHB	NO FLOW	
B-43	-	4	Recharge	ft/d	1.3E-04	2.0E-04	6.6E-05
B-44	-	6	Recharge	ft/d	3.8E-06	5.7E-06	1.9E-06

Notes:
OoM = Order of Magnitude
[1]The base case was presented in WSP memo Resolution Copper Groundwater Flow Model - Predictive Results (August 7th, 2018)
[2]Whitetail conglomerate (Zone 56) anisotropic; Kxy differs from Kz
[3]Graben fault; **Value used in All Graben Faults**
[4]The block cave scenario adjusts all block cave cells calculated porosity value by +/-25% at each time step

FIGURES



*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

0 2.5 5 10 Miles

wsp

GDE & Water Supply Well Locations and Surface Geology

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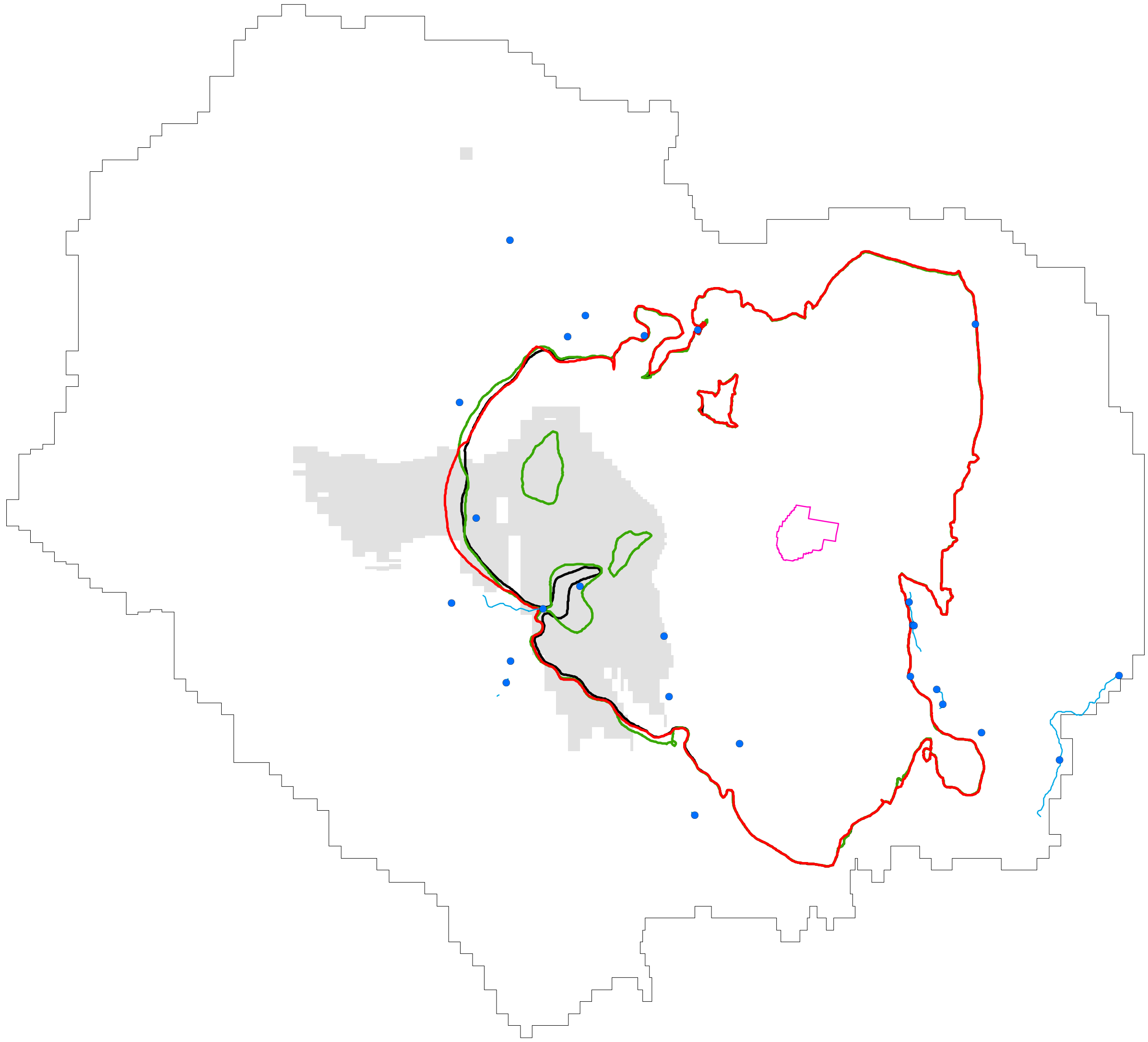

Base Case (10 ft Impact)	*GDE or Water Supply Well Location
QTg (Zone 7) K +1 OoM (10 ft Impact)	Continuously Saturated Reach
QTg (Zone 7) K -1 OoM (10 ft Impact)	Groundwater Model Domain
QTg (Zone 7)	Resolution Copper Mine Panels

Model Results: 181102, Run01/02

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

0 2.5 5 10 Miles

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QTg (Zone 7) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

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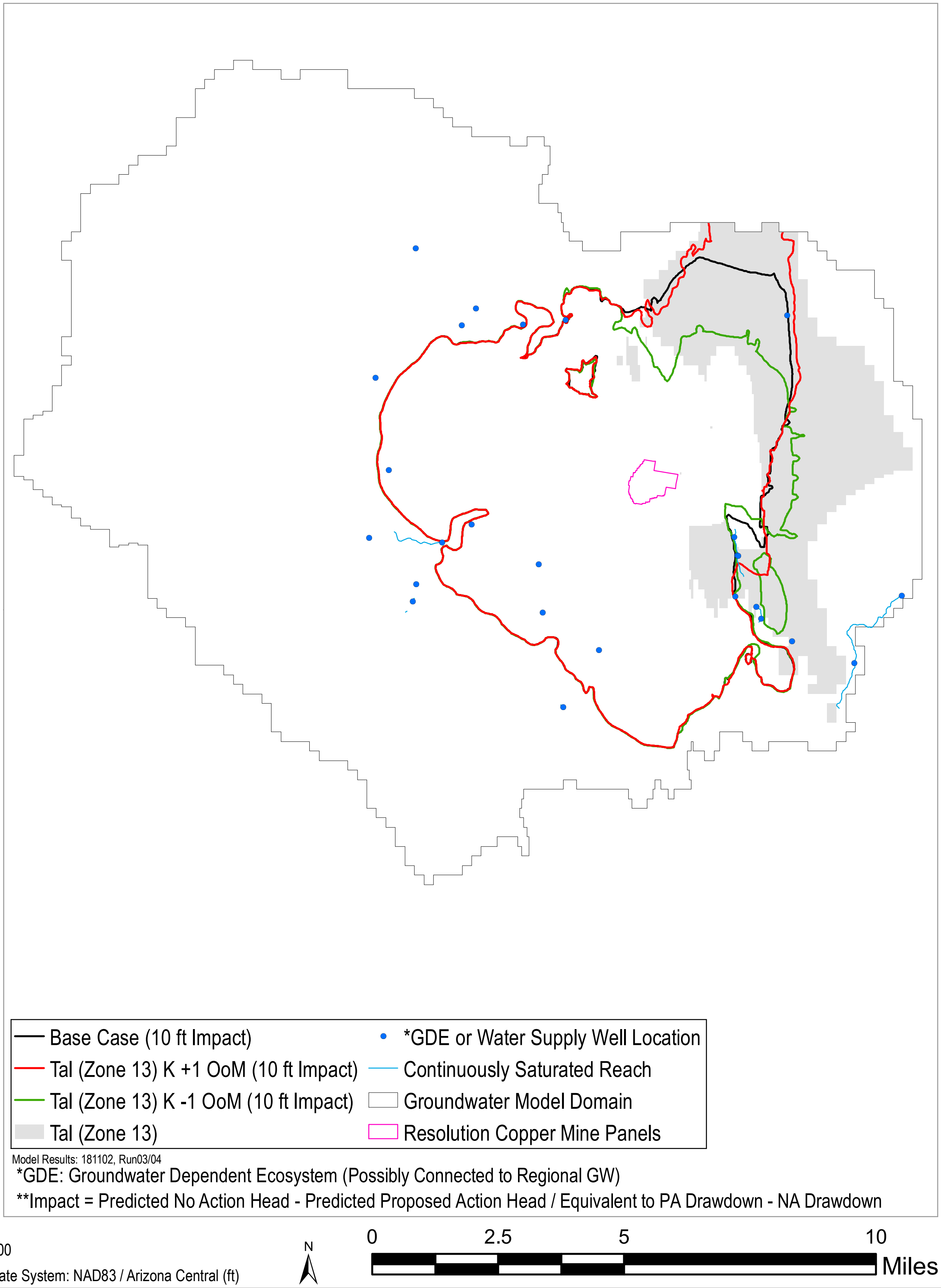

Tal (Zone 13) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

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DRAWN: CDM	CHECKED: DO	DATE:	November 2018

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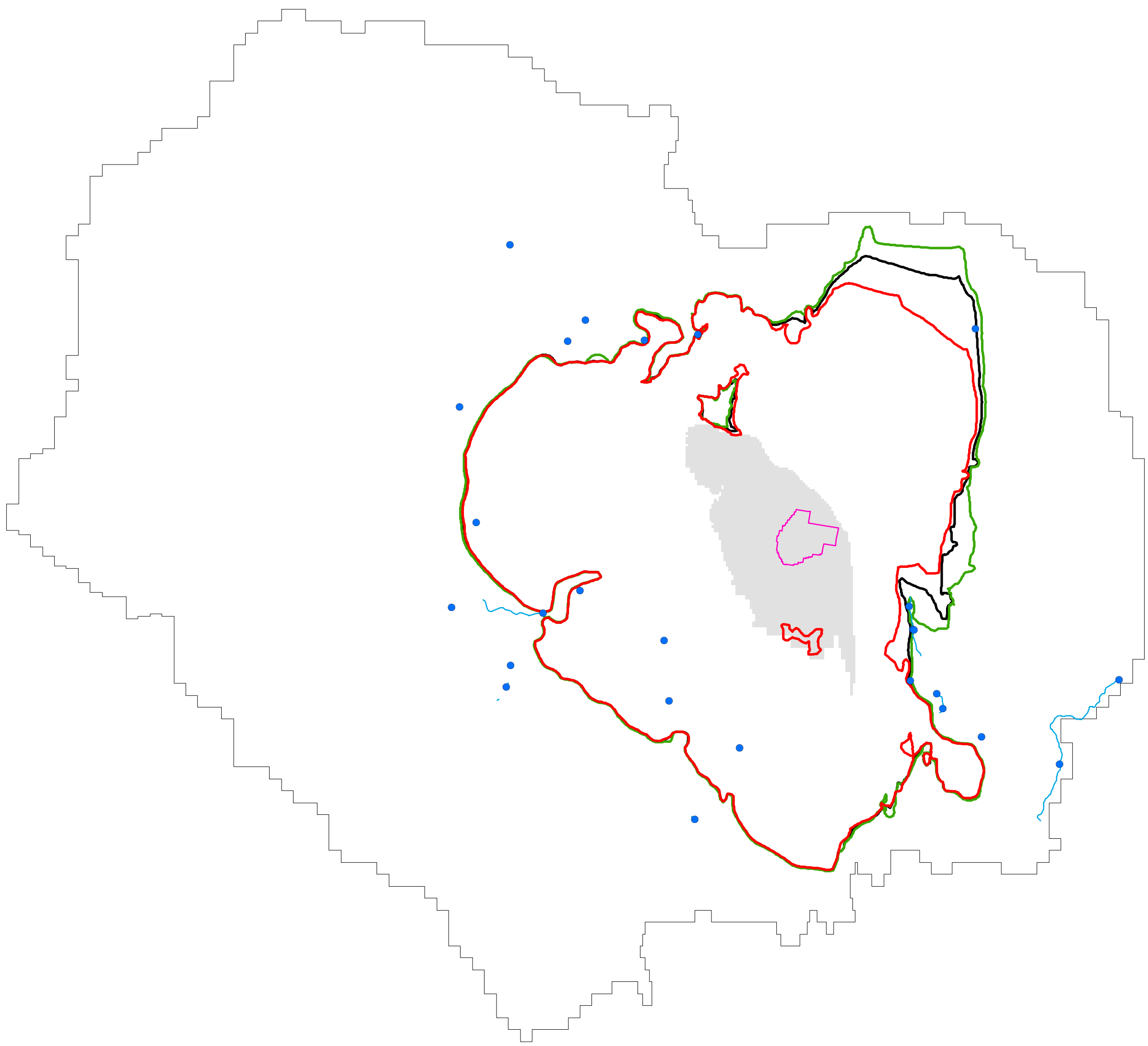

Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Tal (Zone 14) K +1 OoM (10 ft Impact)	Continuously Saturated Reach
Tal (Zone 14) K -1 OoM (10 ft Impact)	Groundwater Model Domain
Tal (Zone 14)	Resolution Copper Mine Panels

Model Results: 181102, Run05/06

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

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Tal (Zone 14) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

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DRAWN: CDM	CHECKED: DO	DATE:	November 2018

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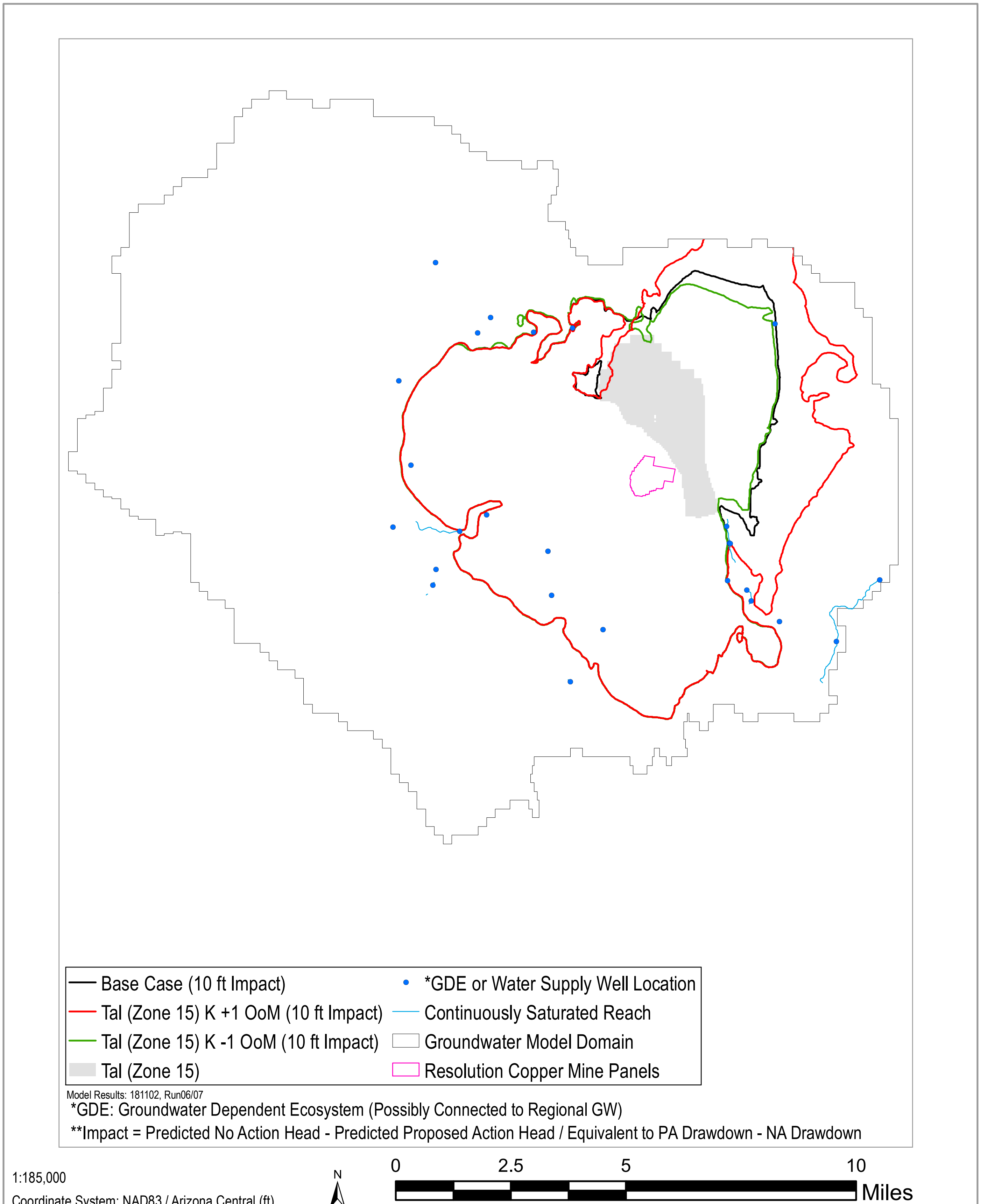

Tal (Zone 15) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

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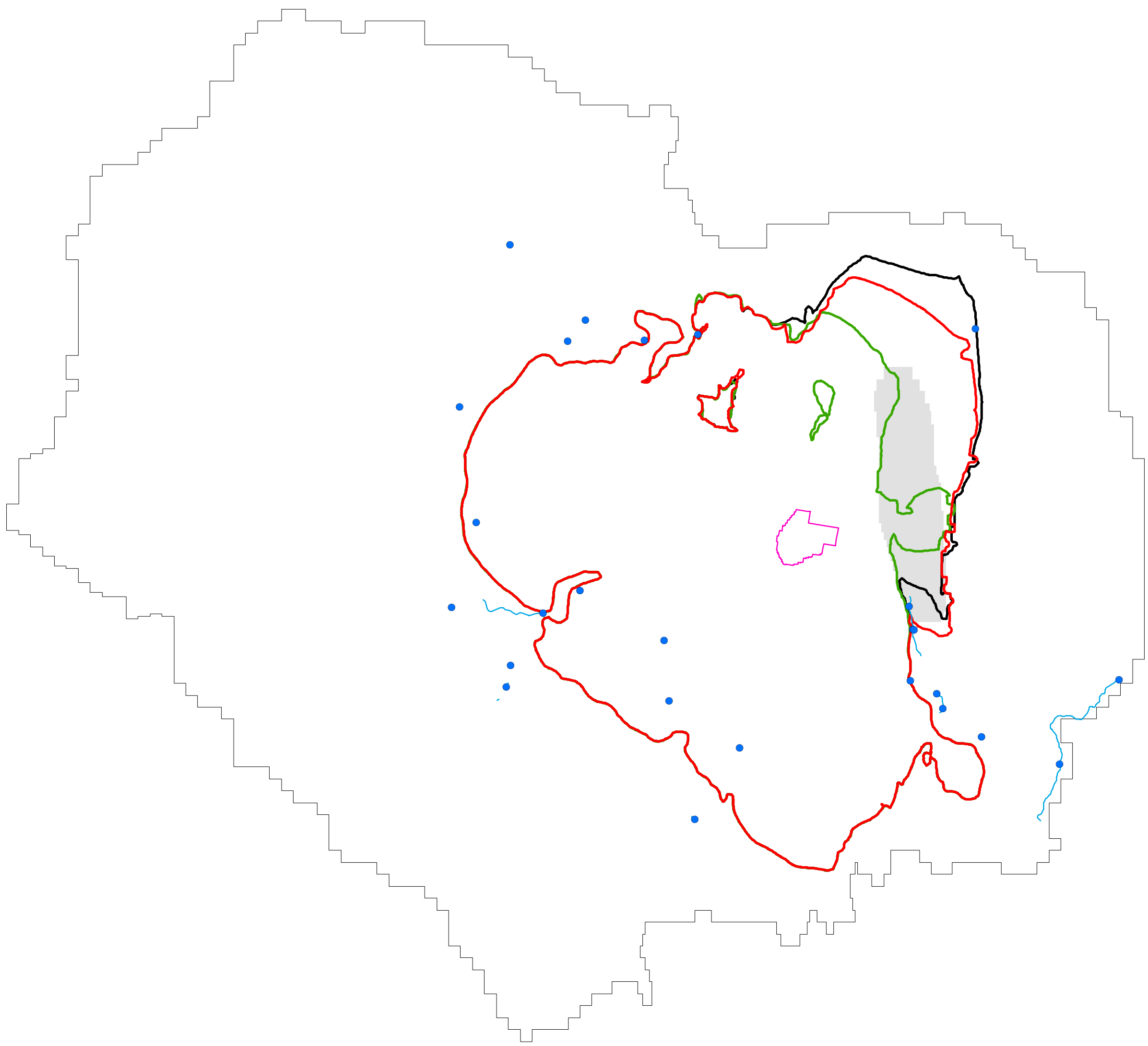
DRAWN: CDM	CHECKED: DO	DATE: November 2018	



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Tal (Zone 16) K +1 OoM (10 ft Impact)	Continuously Saturated Reach
Tal (Zone 16) K -1 OoM (10 ft Impact)	Groundwater Model Domain
Tal (Zone 16)	Resolution Copper Mine Panels

Model Results: 181102, Run09/10

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

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Coordinate System: NAD83 / Arizona Central (ft)

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0 2.5 5 10 Miles

Tal (Zone 16) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

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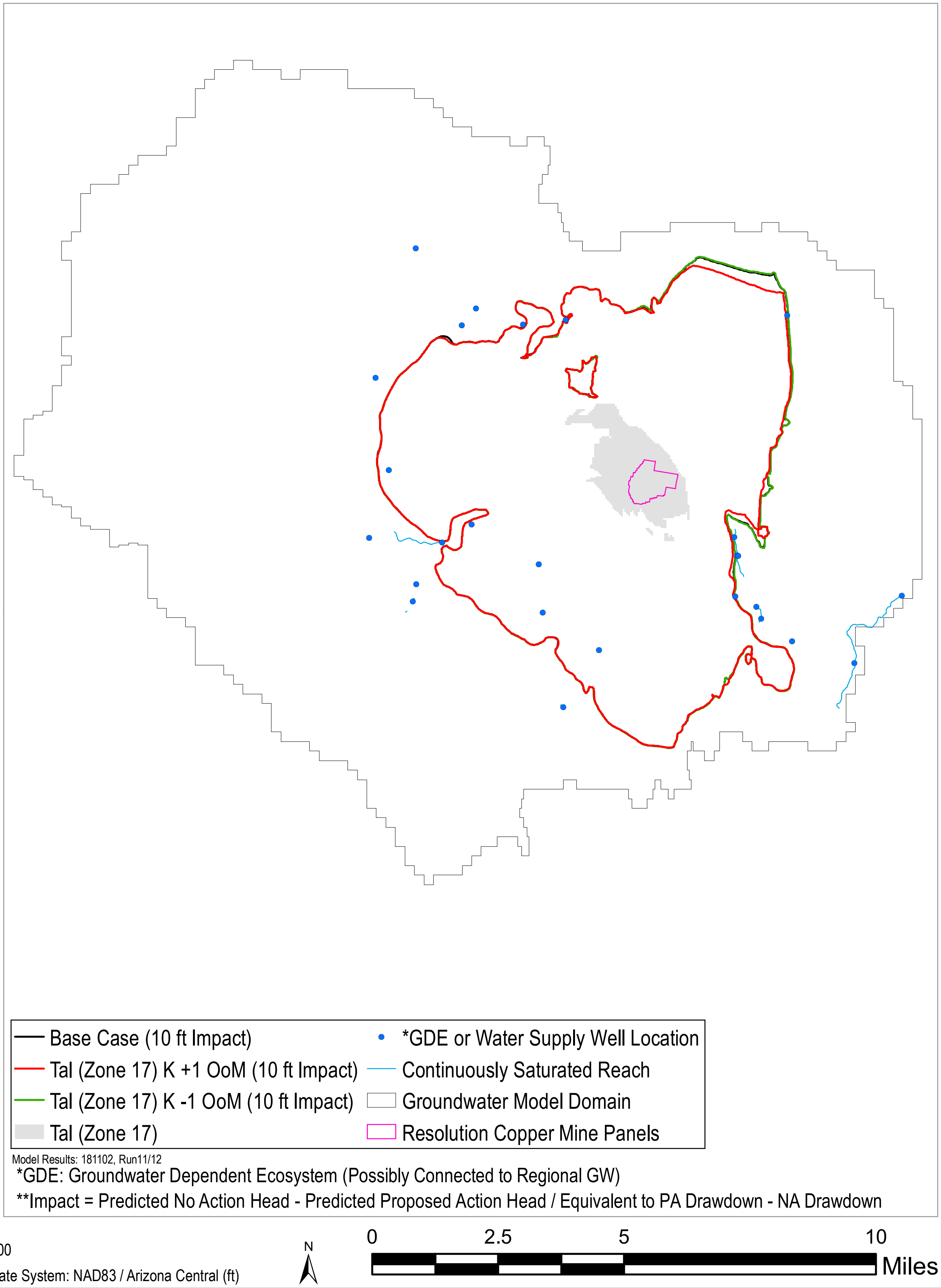

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Tal (Zone 17) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

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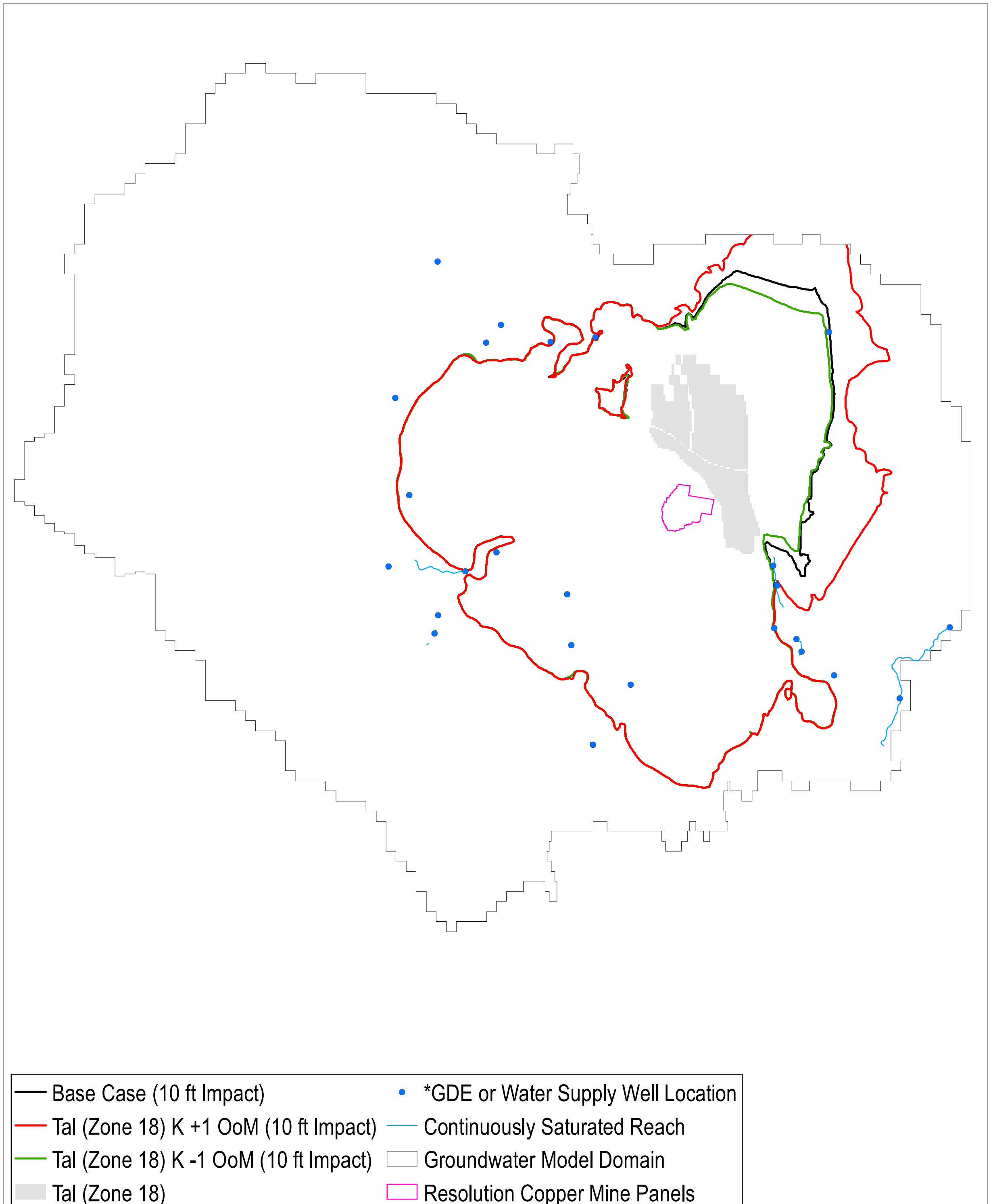

Model Results: 181102, Run13/14

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

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0 2.5 5 10 Miles

Tal (Zone 18) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-7
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

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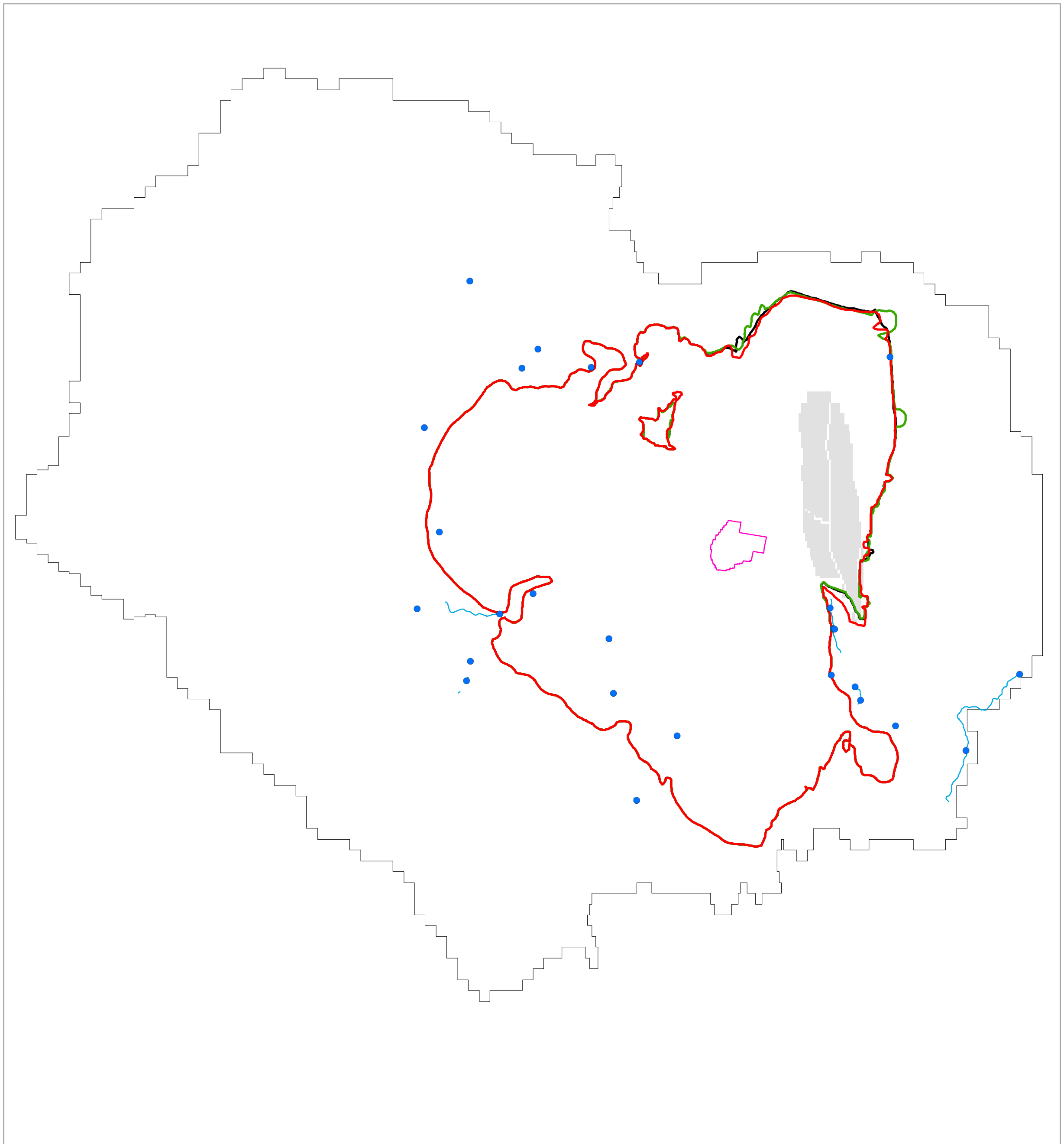


Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Tal (Zone 19) K +1 OoM (10 ft Impact)	Continuously Saturated Reach
Tal (Zone 19) K -1 OoM (10 ft Impact)	Groundwater Model Domain
Tal (Zone 19)	Resolution Copper Mine Panels

Model Results: 181102, Run15/16

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

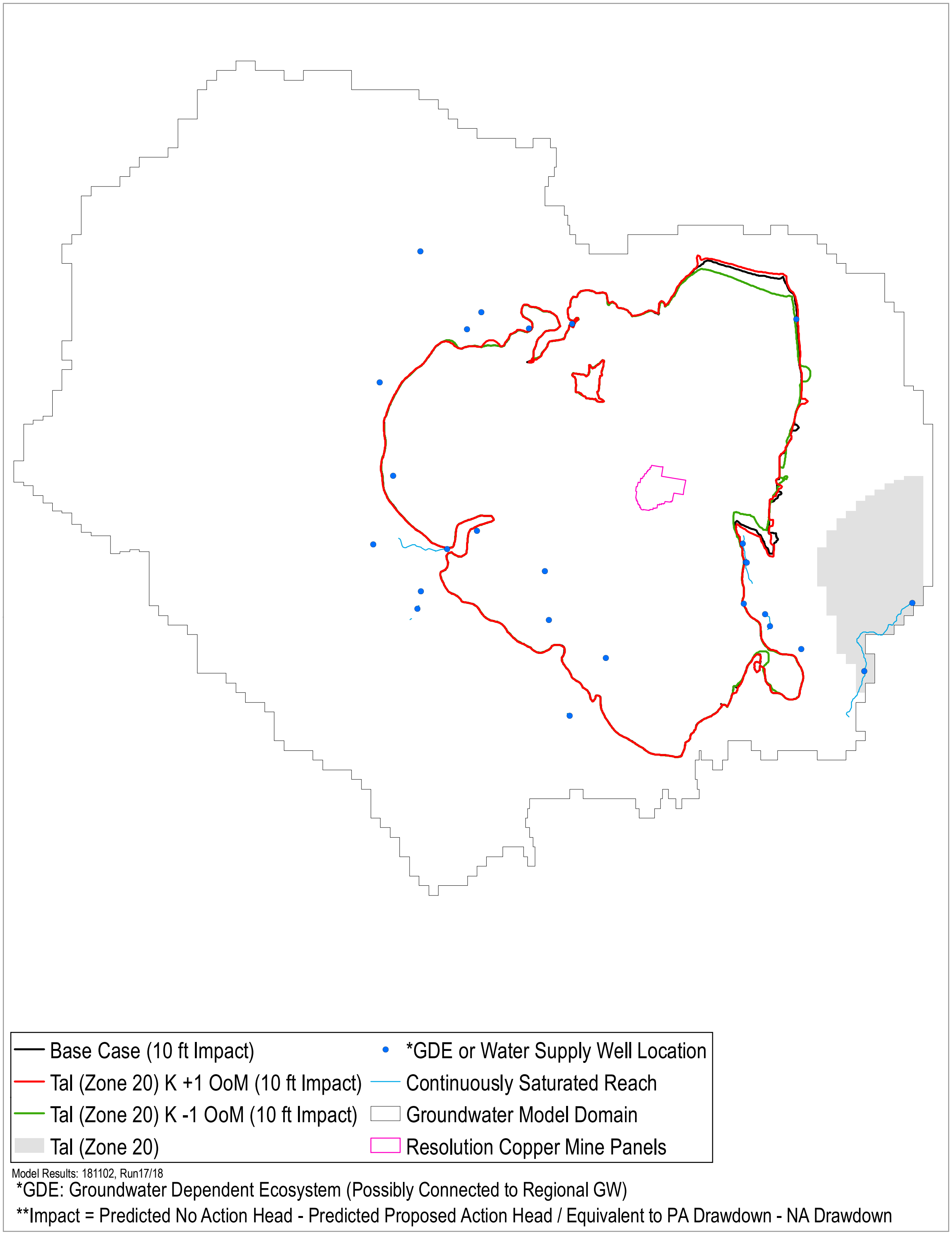
0 2.5 5 10 Miles

wsp

Tal (Zone 19) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-8
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

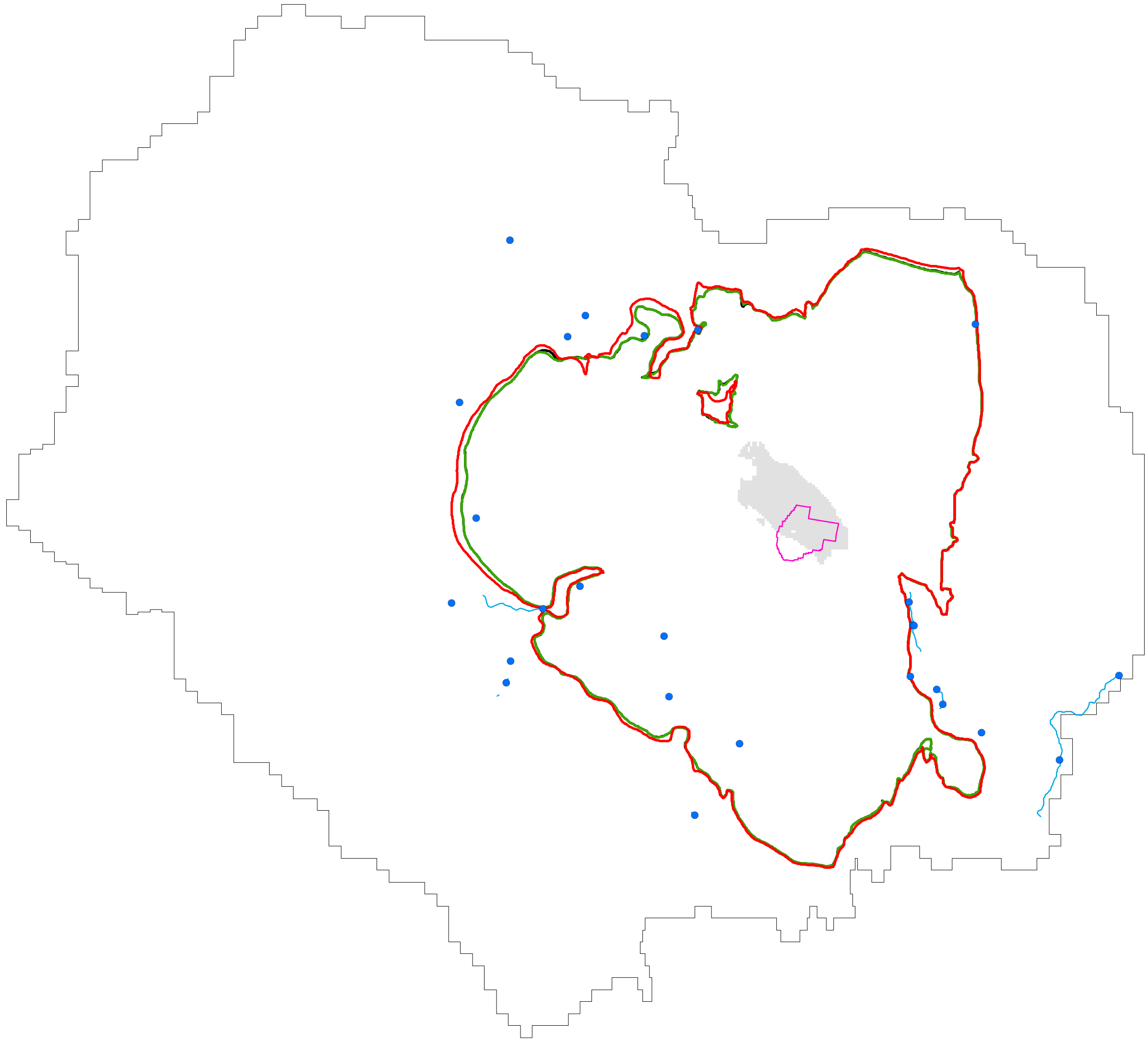
N

0 2.5 5 10 Miles

Tal (Zone 20) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-9
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Tal (Zone 21) K +1 OoM (10 ft Impact)	Continuously Saturated Reach
Tal (Zone 21) K -1 OoM (10 ft Impact)	Groundwater Model Domain
Tal (Zone 21)	Resolution Copper Mine Panels

Model Results: 181102, Run19/20

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

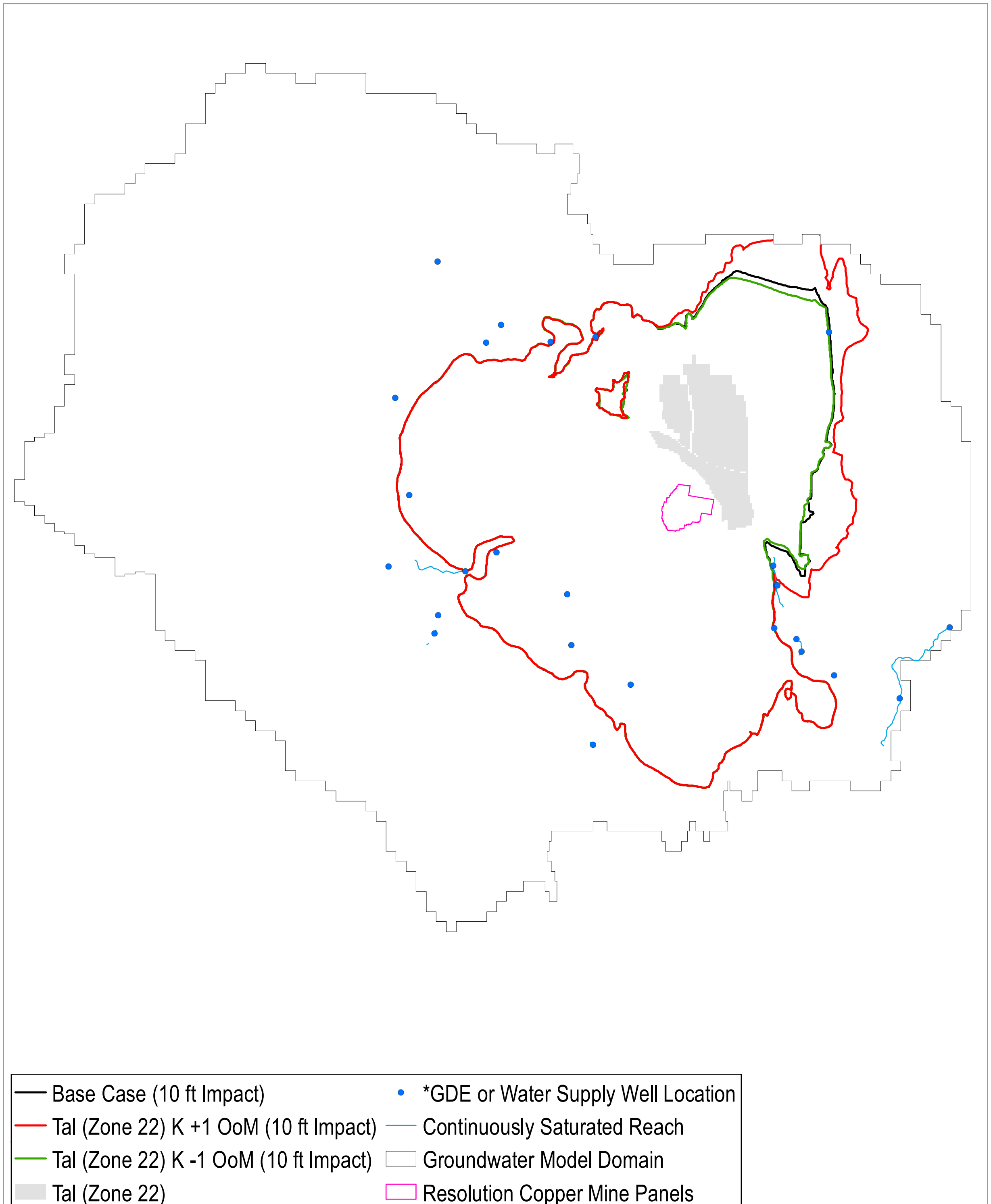
N

0 2.5 5 10 Miles

wsp

Tal (Zone 21) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-10
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Model Results: 181102, Run21/22

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

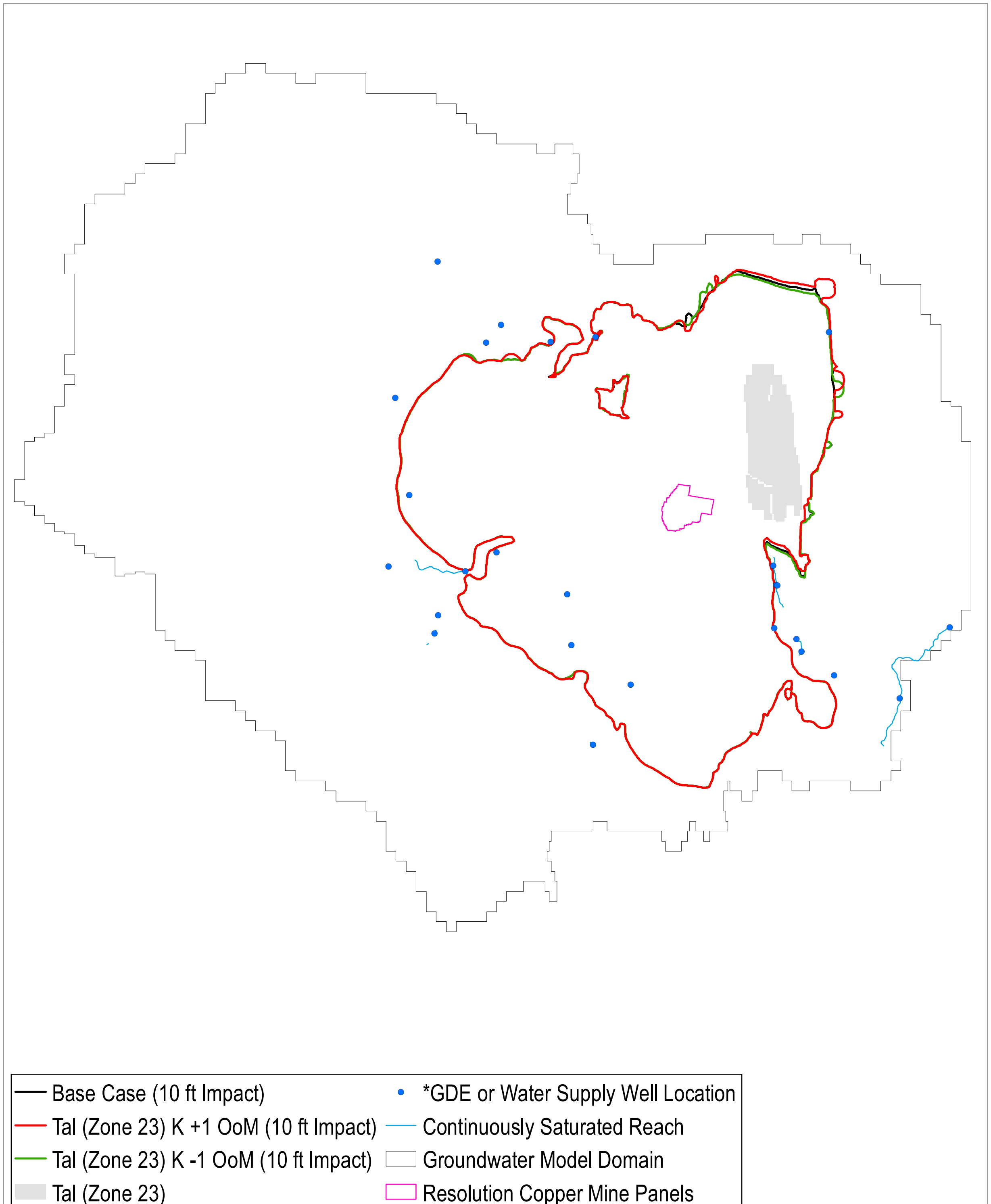
0 2.5 5 10 Miles

WSP

Tal (Zone 22) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-11
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Model Results: 181102, Run23/24

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

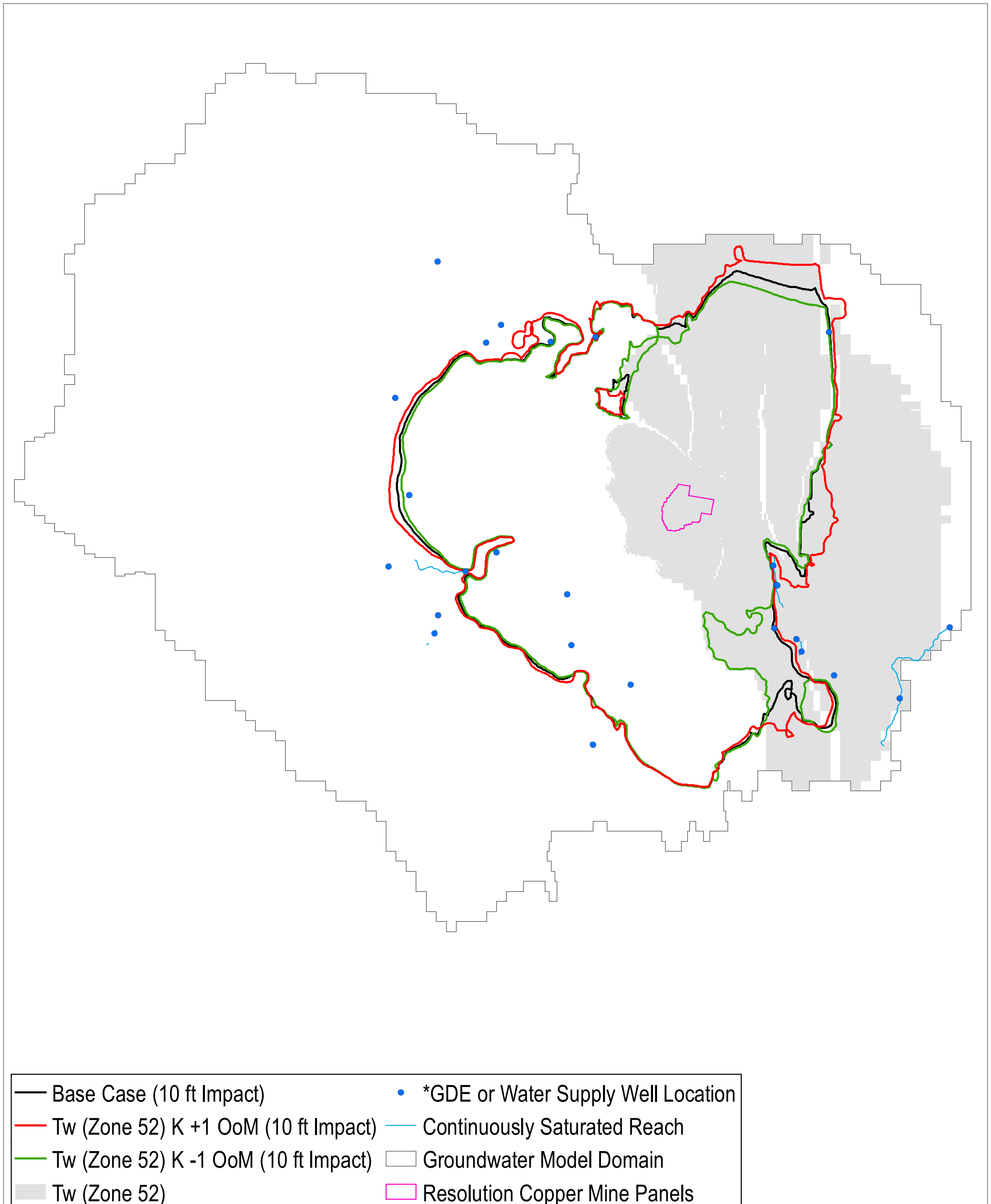
N

0 2.5 5 10 Miles

Tal (Zone 23) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-12
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Model Results: 181102, Run25/26

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

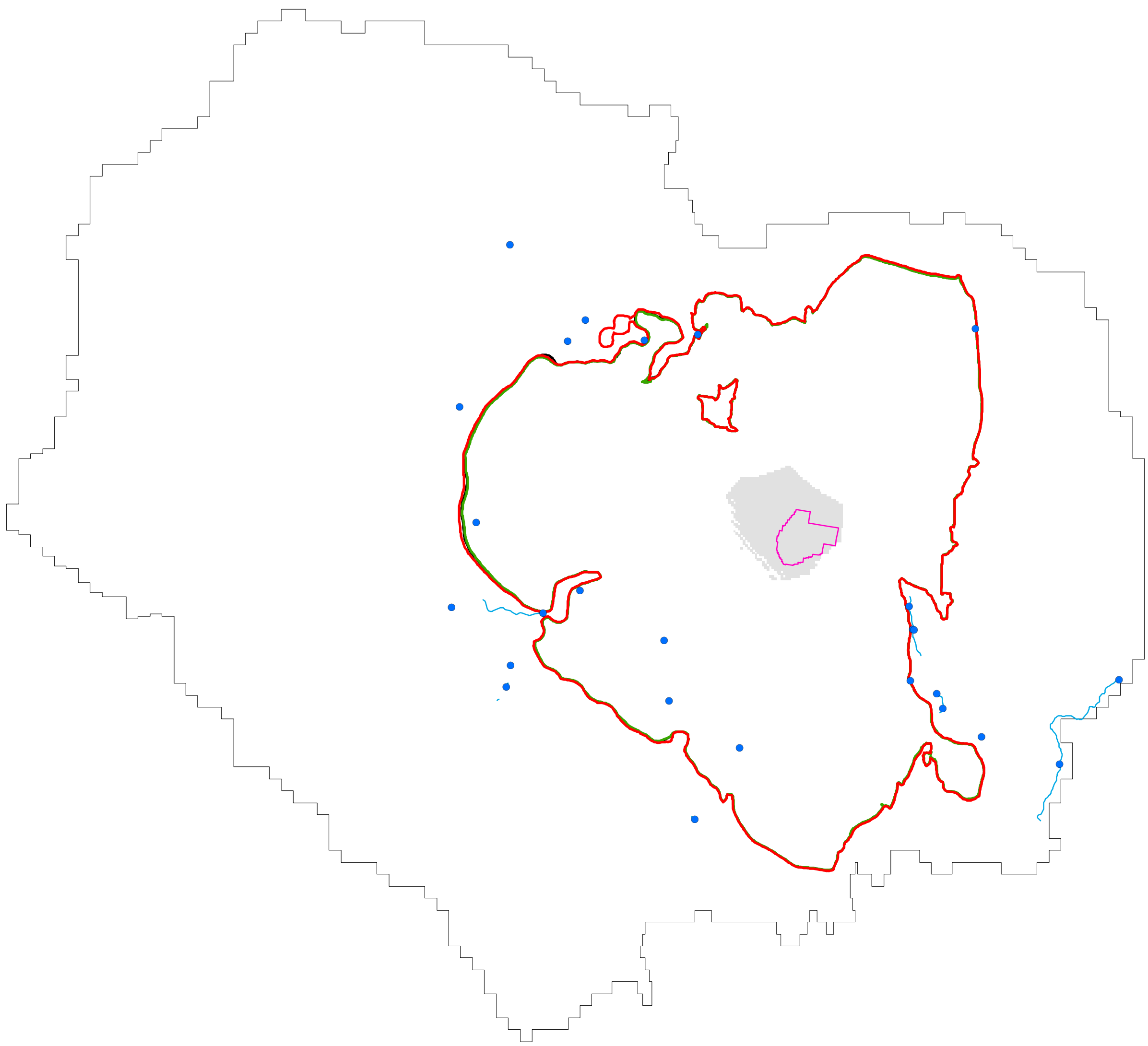
0 2.5 5 10 Miles

wsp

Tw (Zone 52) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #: B-13	
CLIENT: Resolution Copper		PROJECT #: 31400968.001	
DRAWN: CDM	CHECKED: DO	DATE: November 2018	

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Tw (Zone 56) K +1 OoM (10 ft Impact)	Continuously Saturated Reach
Tw (Zone 56) K -1 OoM (10 ft Impact)	Groundwater Model Domain
Tw (Zone 56)	Resolution Copper Mine Panels

Model Results: 181102, Run27/28

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

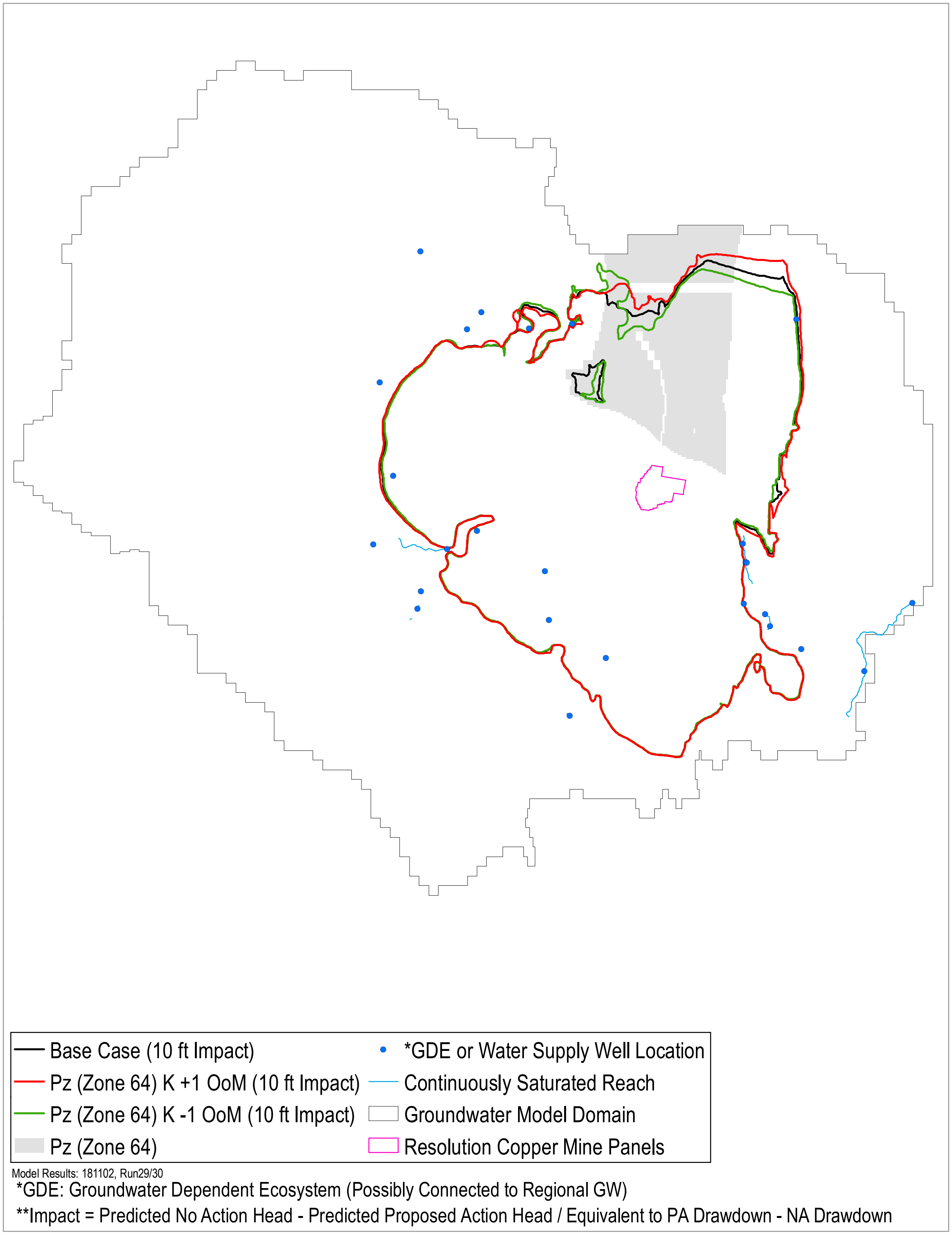
0 2.5 5 10 Miles

wsp

Tw (Zone 56) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-14
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

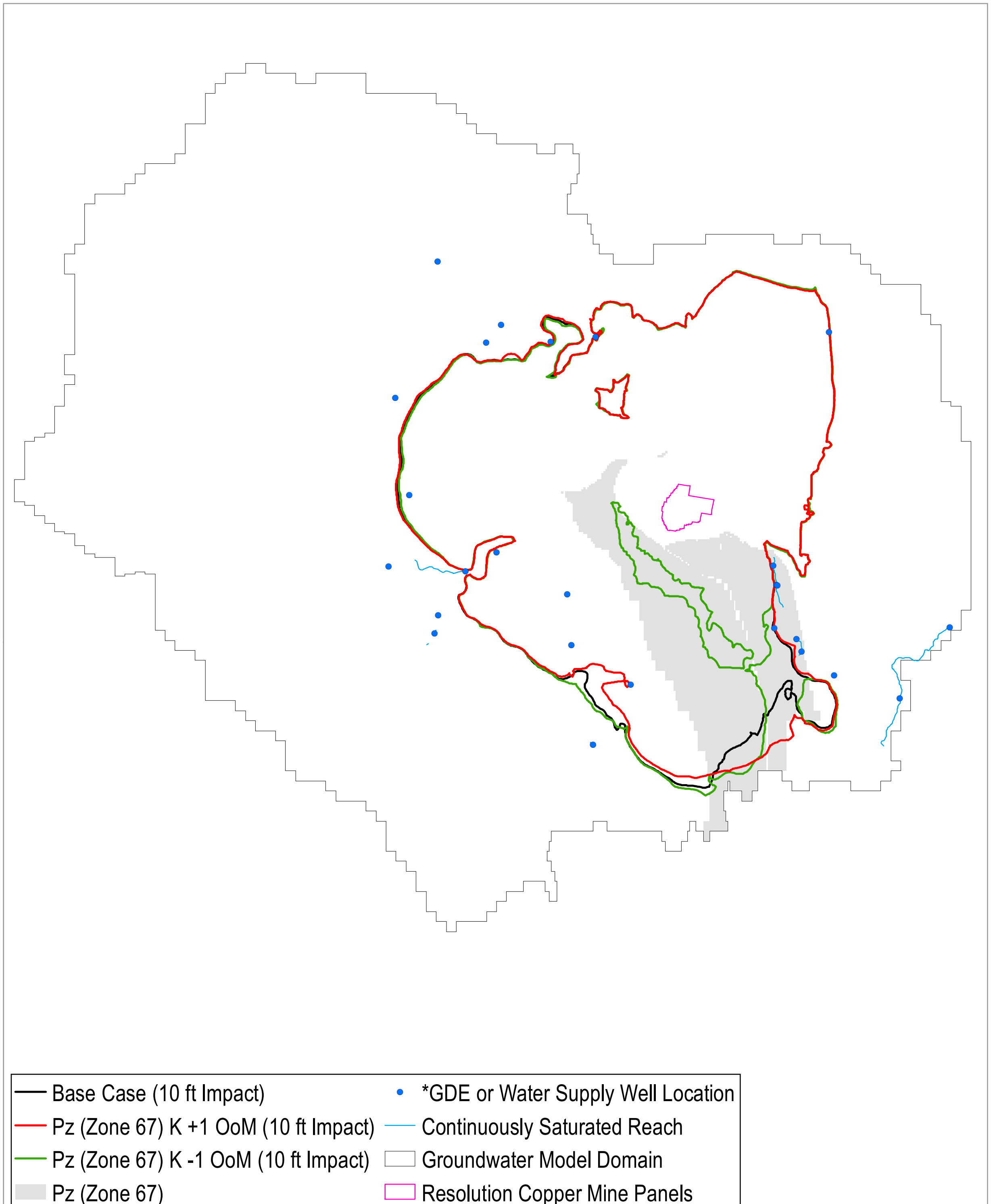
0 2.5 5 10 Miles

wsp

Pz (Zone 64) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-15
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



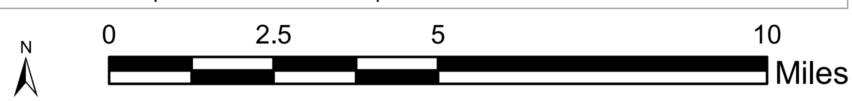
Model Results: 181102, Run31/32

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

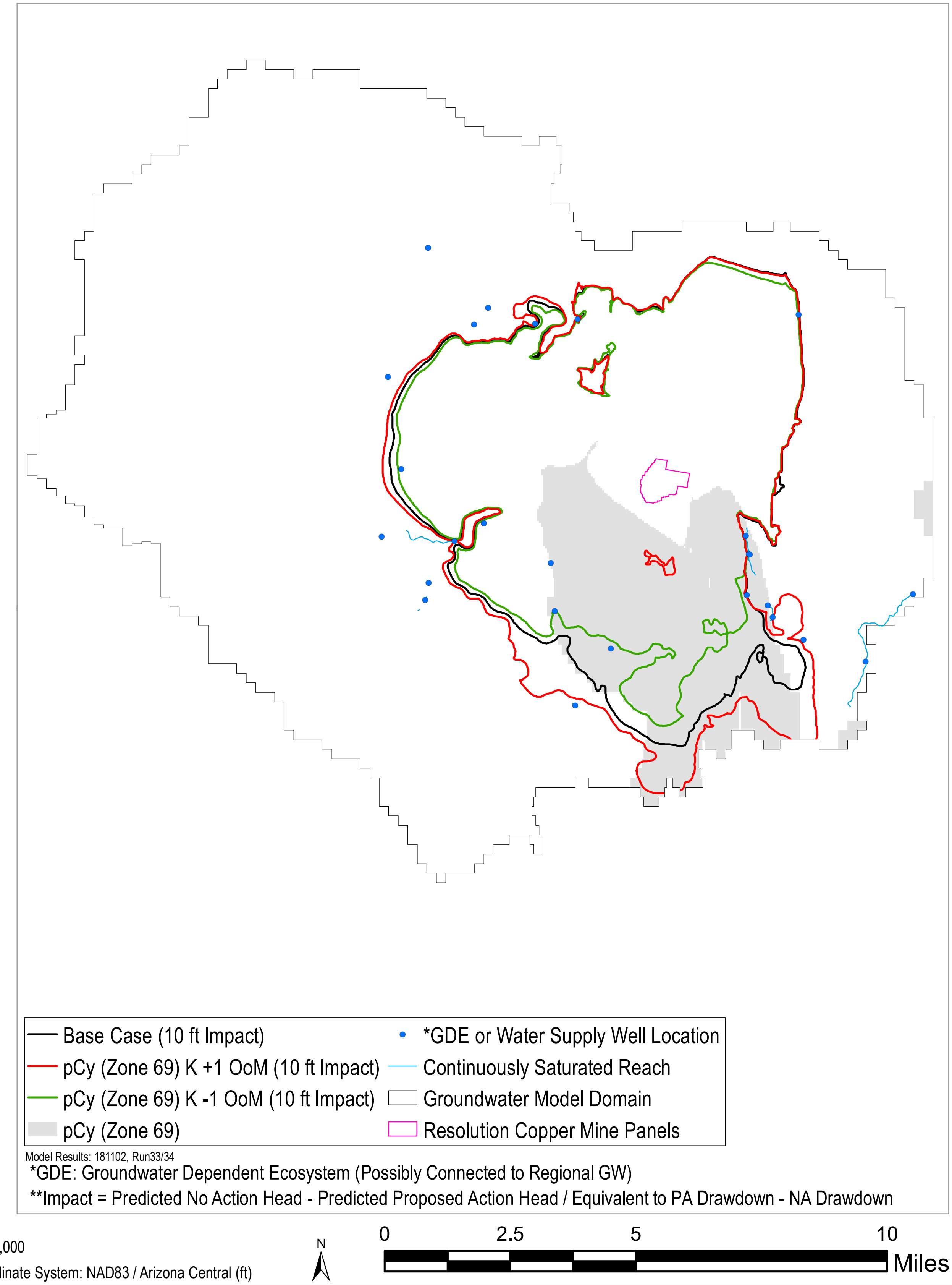


wsp

Pz (Zone 67) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT:	3D Regional Groundwater Model		FIGURE #:	B-16
CLIENT:	Resolution Copper		PROJECT #:	31400968.001
DRAWN:	CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

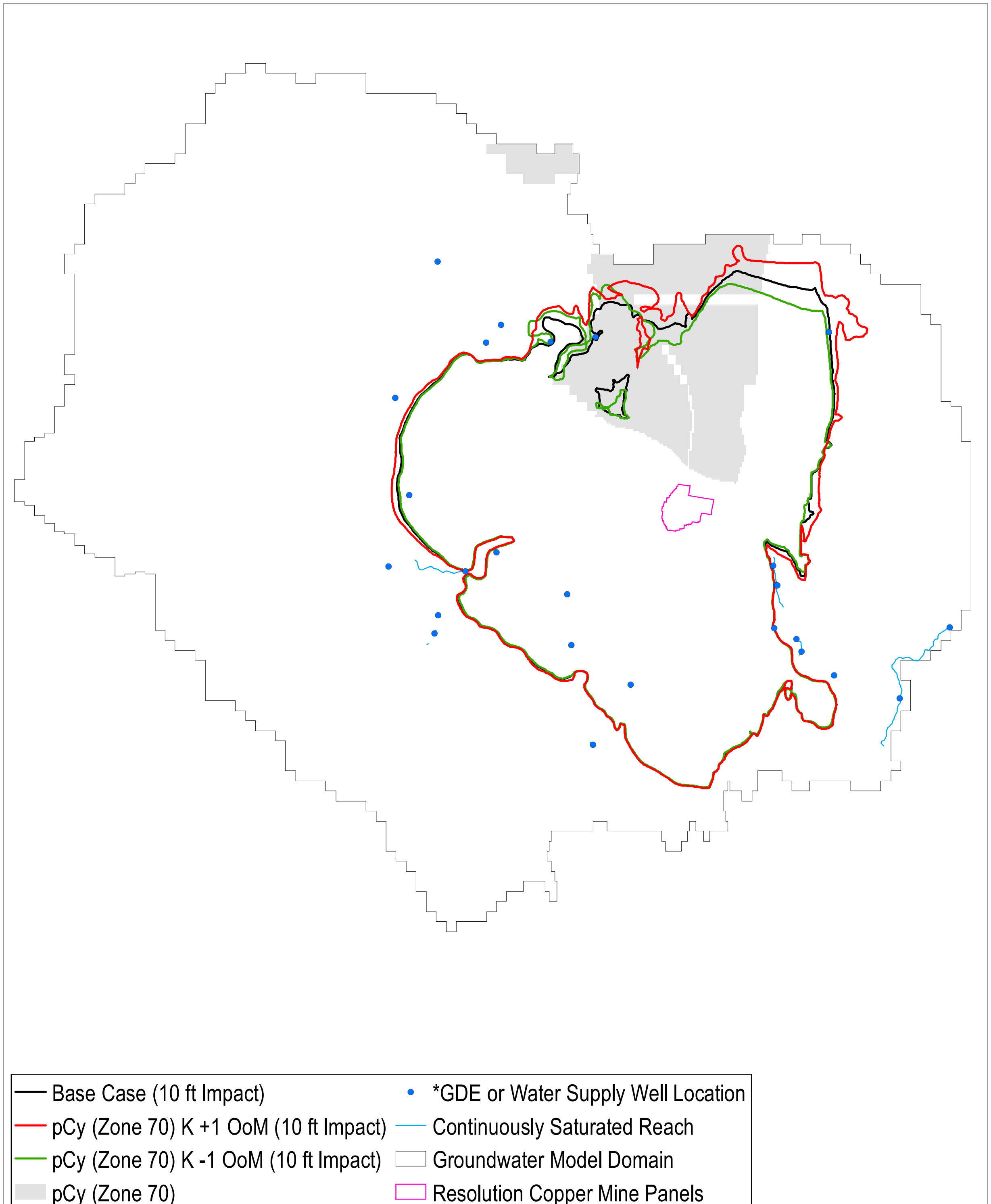
**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

pCy (Zone 69) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-17
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Model Results: 181102, Run35/36

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

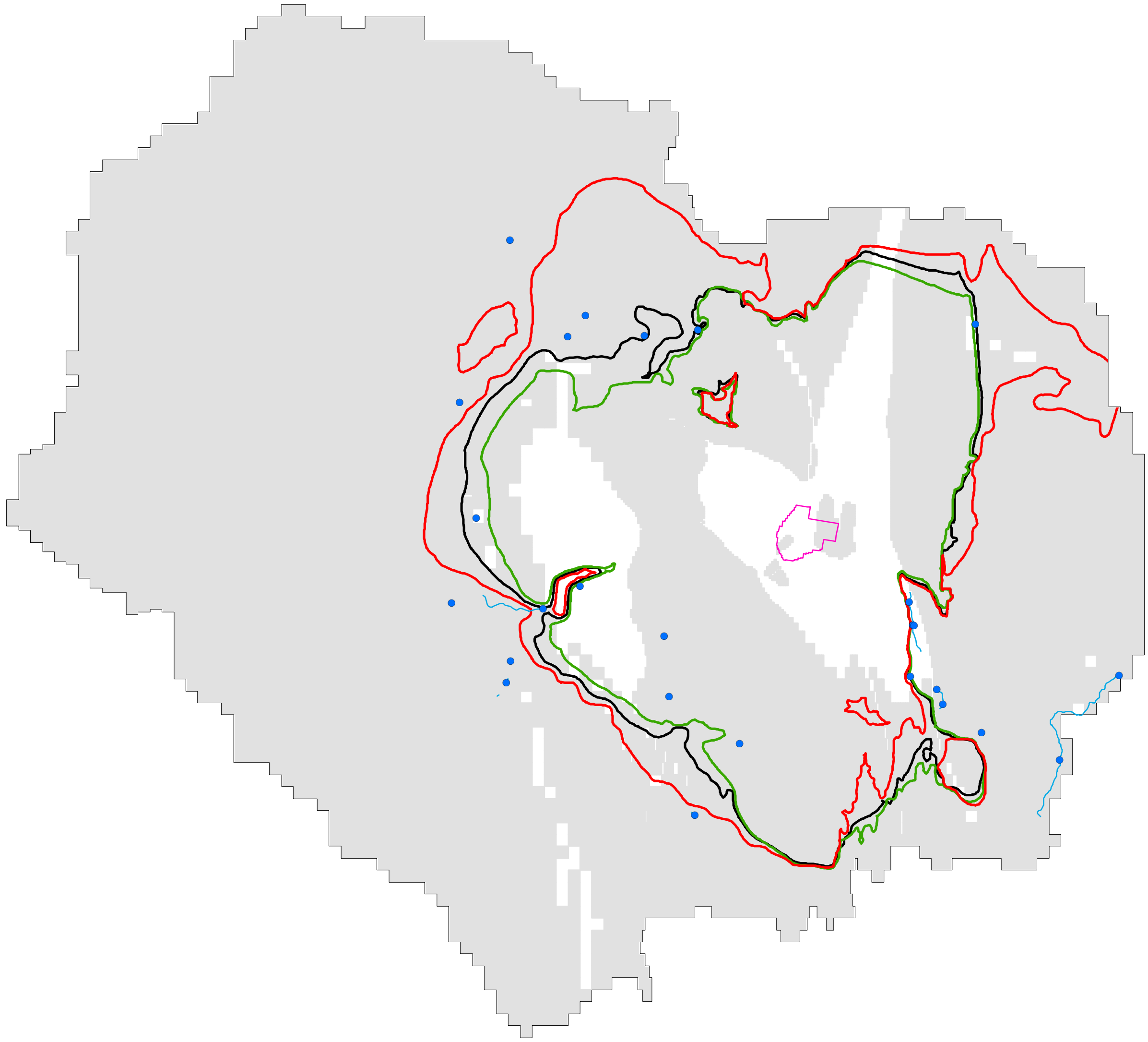
0 2.5 5 10 Miles

wsp

pCy (Zone 70) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-18
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN:	CDM CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



- Base Case (10 ft Impact)
- pCpi (Zone 80) K +1 OoM (10 ft Impact)
- pCpi (Zone 80) K +1 OoM (10 ft Impact)
- pCpi (Zone 80)
- *GDE or Water Supply Well Location
- Continuously Saturated Reach
- Groundwater Model Domain
- Resolution Copper Mine Panels

Model Results: 181102, Run37/38

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

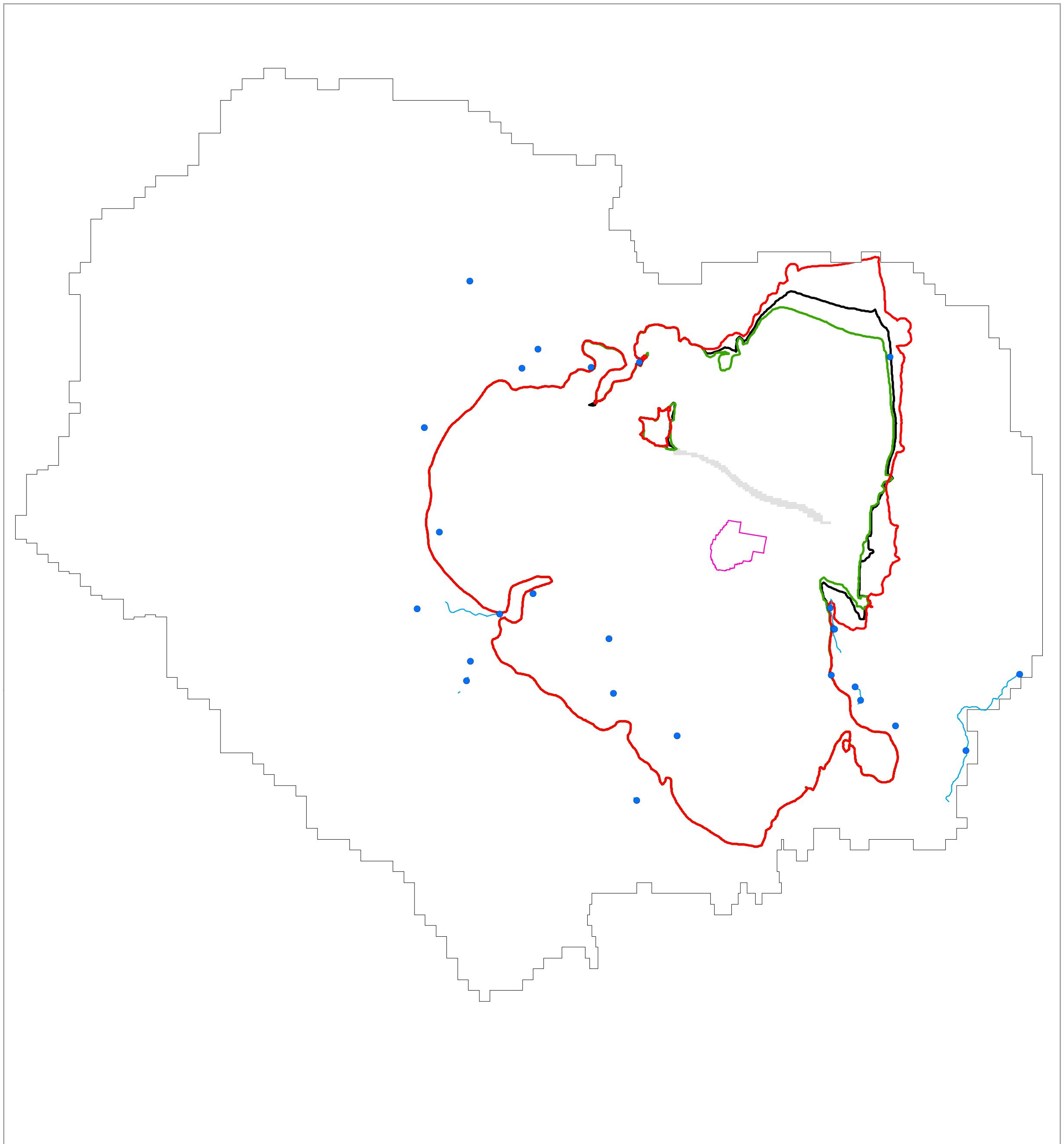
0 2.5 5 10 Miles

wsp

pCpi (Zone 80) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-19
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Conley Springs Fault (Zone 175) K +1 OoM (10 ft Impact)	Continuously Saturated Reach
Conley Springs Fault (Zone 175) K -1 OoM (10 ft Impact)	Groundwater Model Domain
Conley Springs Fault (Zone 175)	Resolution Copper Mine Panels

Model Results: 181102, Run39/40

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

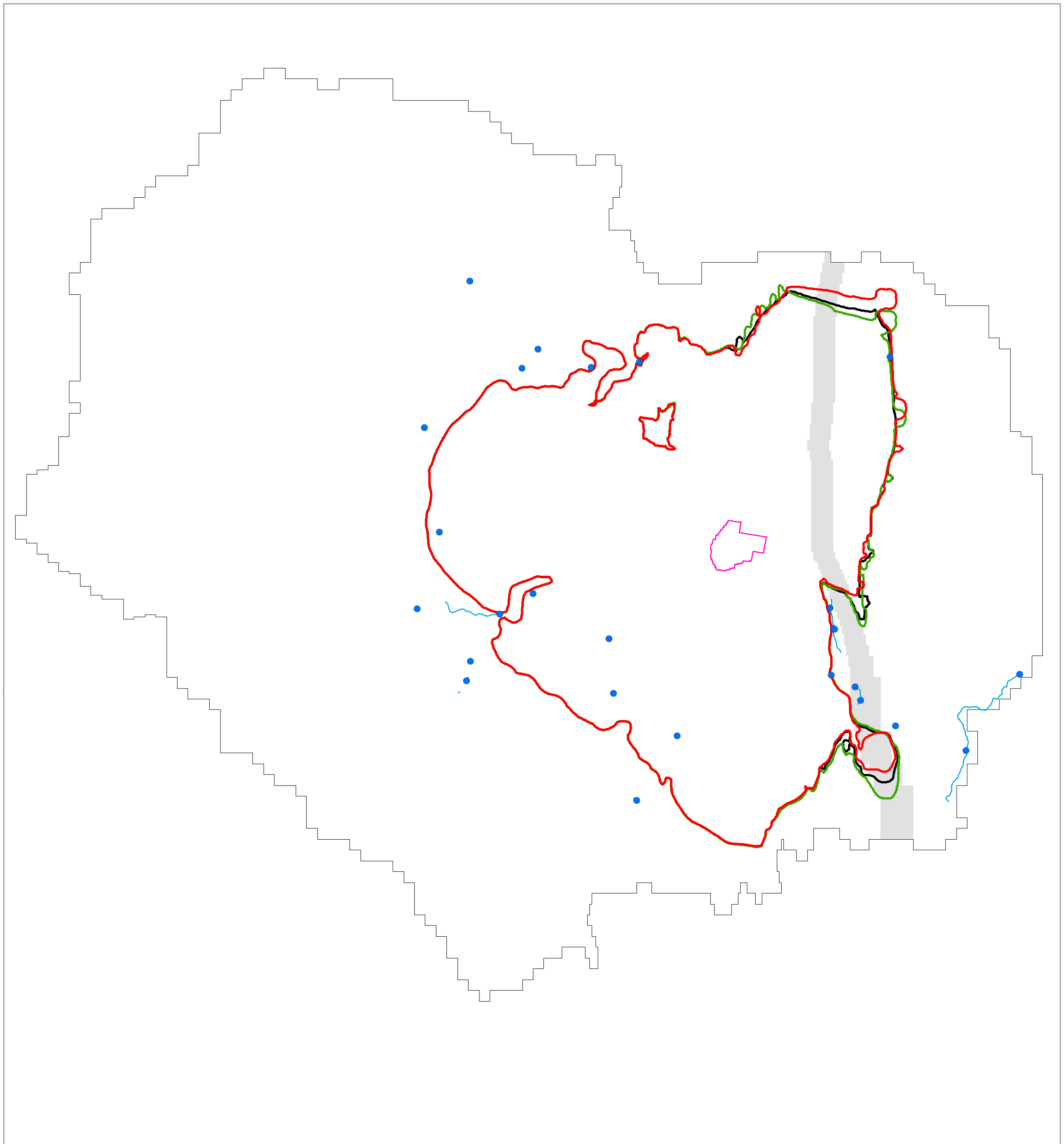
N

0 2.5 5 10 Miles

wsp

Conley Springs Fault (Zone 175) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-20
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Devils Canyon Fault (Zone 203) K +1 OoM (10 ft Impact)	Continuously Saturated Reach
Devils Canyon Fault (Zone 203) K -1 OoM (10 ft Impact)	Groundwater Model Domain
Devils Canyon Fault (Zone 203)	Resolution Copper Mine Panels

Model Results: 181102, Run41/42

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

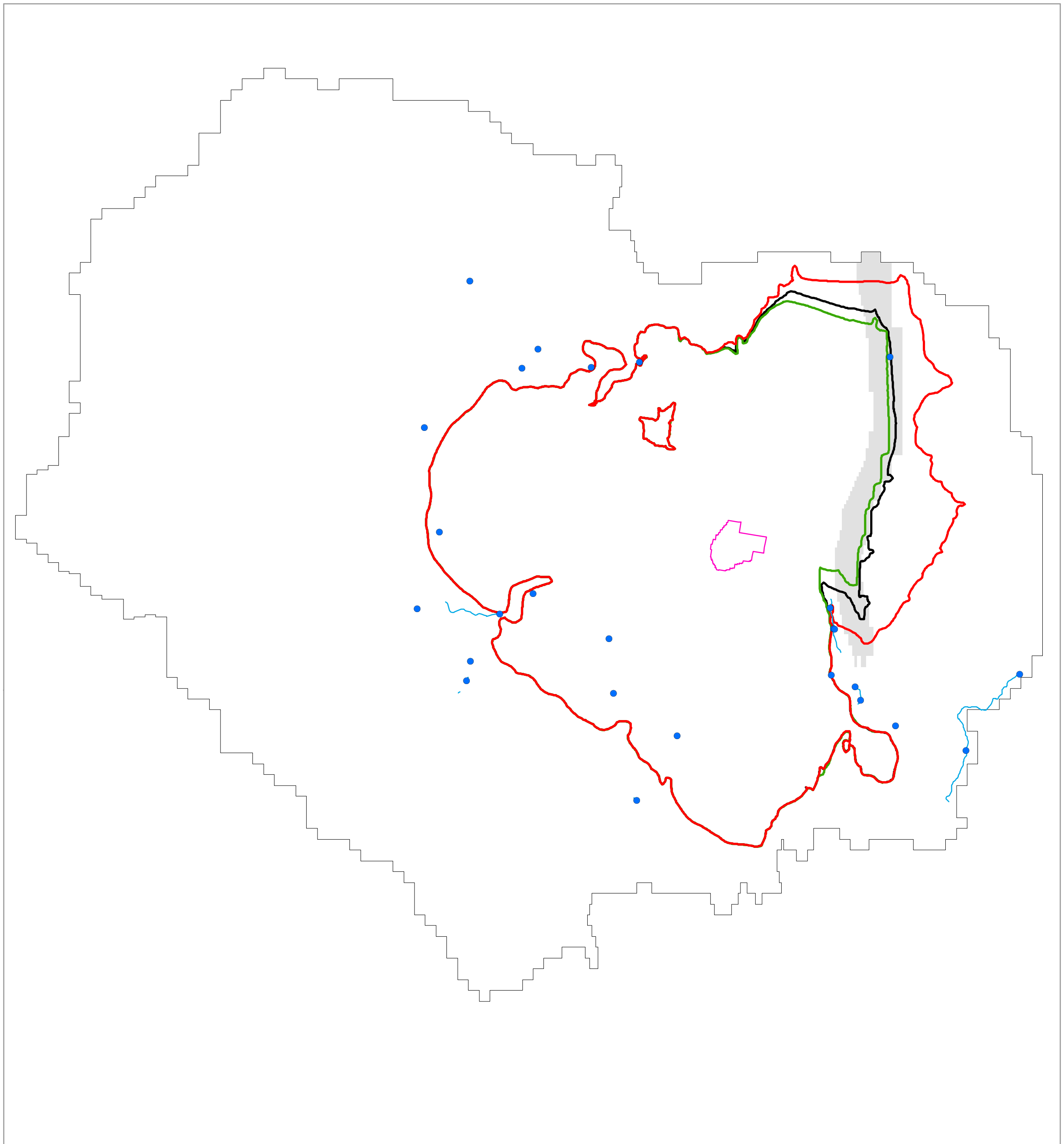
N

0 2.5 5 10 Miles

wsp

Devils Canyon Fault (Zone 203) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-21
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Model Results: 181102, Run43/44

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

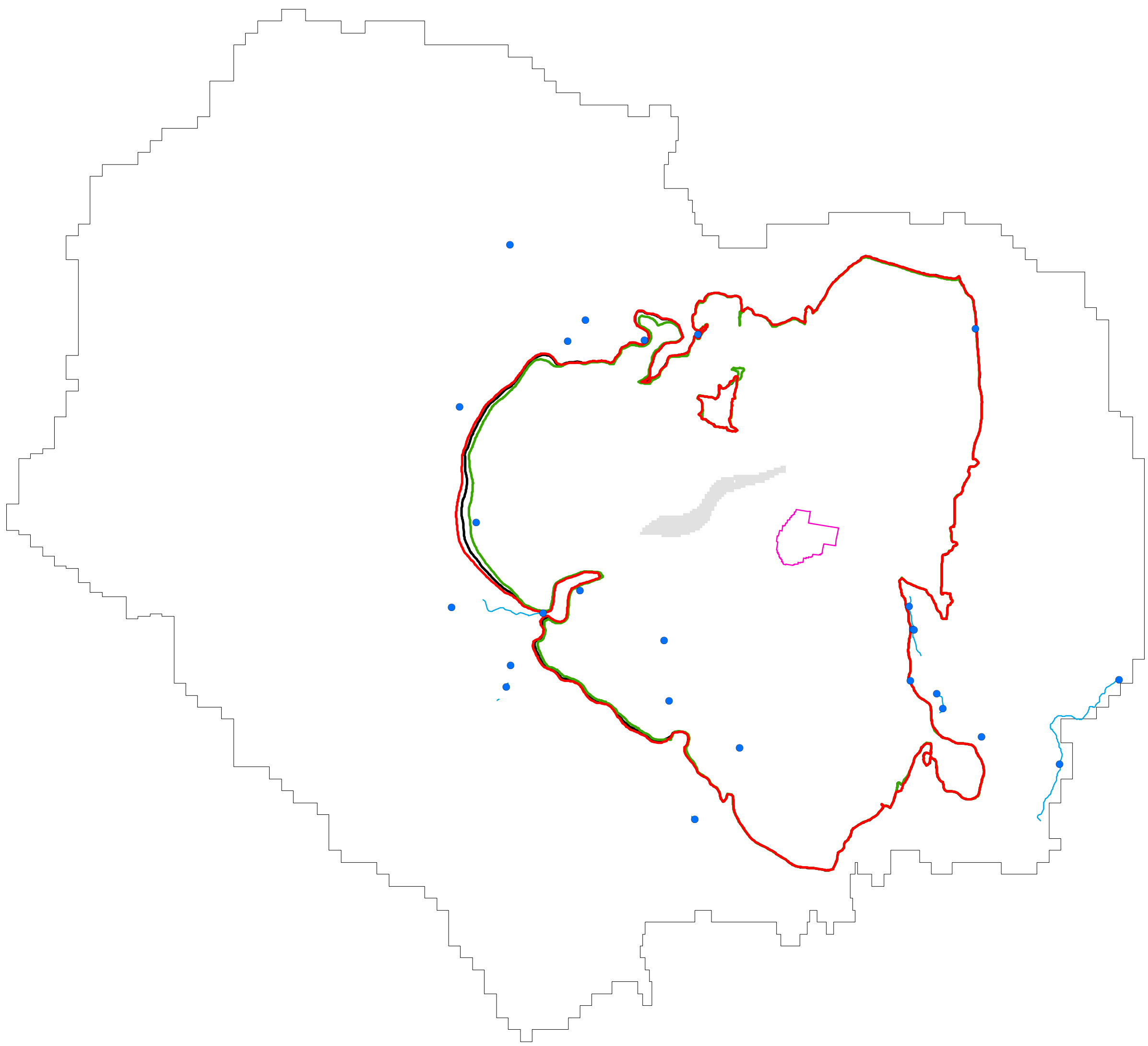
0 2.5 5 10 Miles

wsp

JI Ranch Fault (Zone 218) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-22
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
North Boundary Fault (Zone 250) K +1 OoM (10 ft Impact)	Continuously Saturated Reach
North Boundary Fault (Zone 250) K -1 OoM (10 ft Impact)	Groundwater Model Domain
North Boundary Fault (Zone 250)	Resolution Copper Mine Panels

Model Results: 181102, Run45/46

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

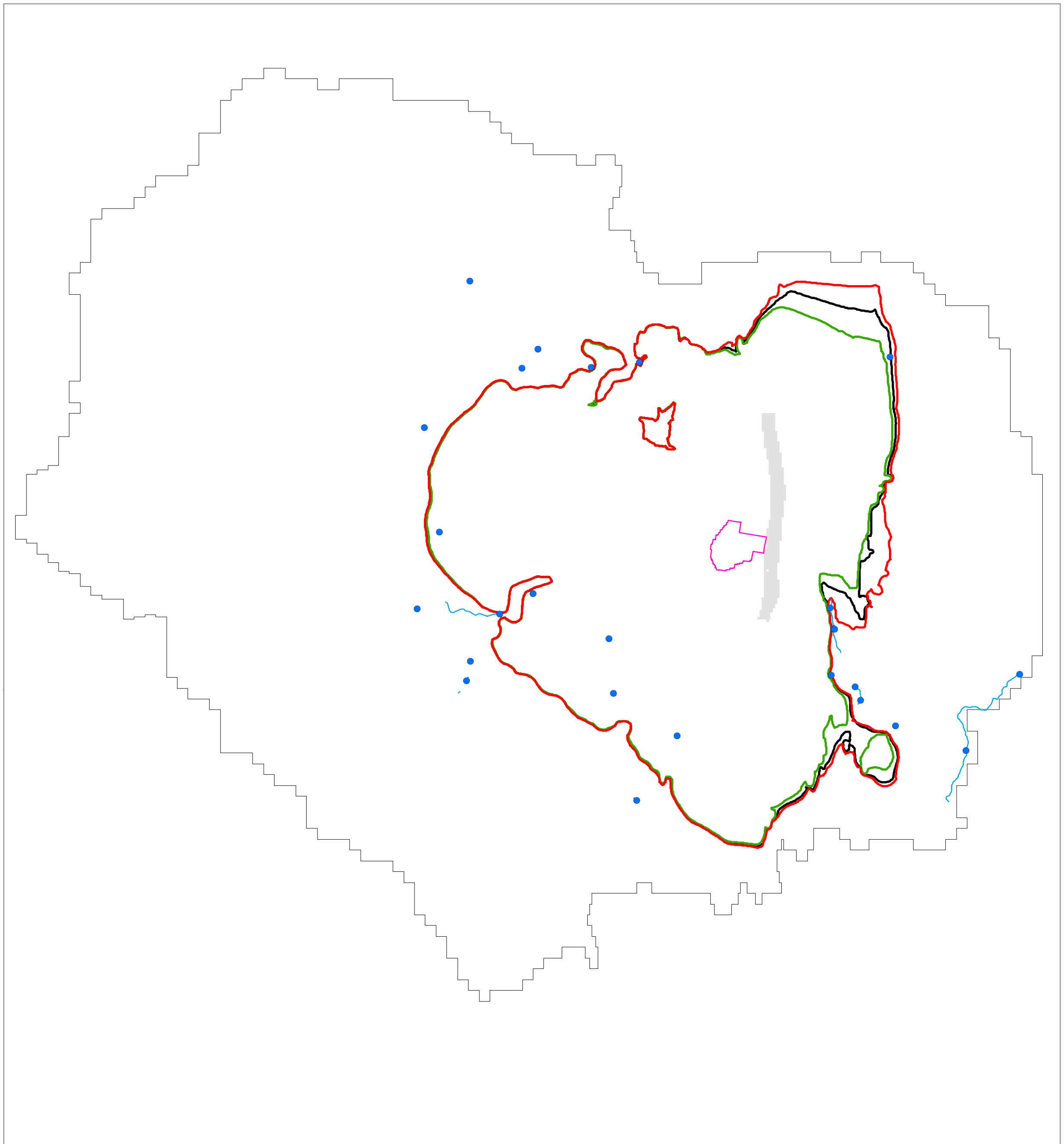
N

0 2.5 5 10 Miles

wsp

North Boundary Fault (Zone 250) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-23
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Rancho Rio Fault (Zone 265) K +1 OoM (10 ft Impact)	Continuously Saturated Reach
Rancho Rio Fault (Zone 265) K -1 OoM (10 ft Impact)	Groundwater Model Domain
Rancho Rio Fault (Zone 265)	Resolution Copper Mine Panels

Model Results: 181102, Run47/48

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

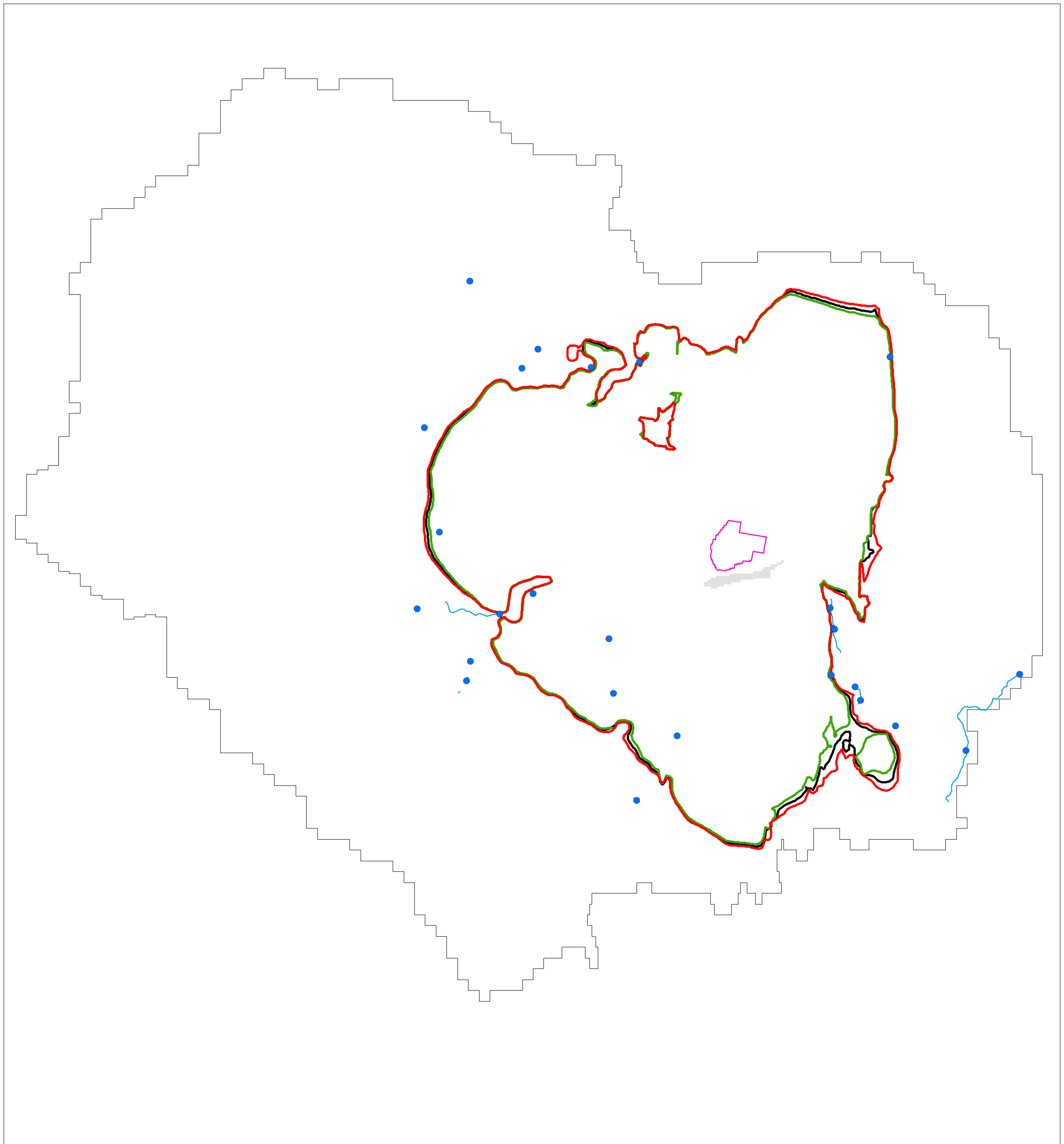
N

0 2.5 5 10 Miles

Rancho Rio Fault (Zone 265) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-24
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
South Boundary Fault (Zone 284) K +1 OoM (10 ft Impact)	Continuously Saturated Reach
South Boundary Fault (Zone 284) K -1 OoM (10 ft Impact)	Groundwater Model Domain
South Boundary Fault (Zone 284)	Resolution Copper Mine Panels

Model Results: 181102, Run49/50

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

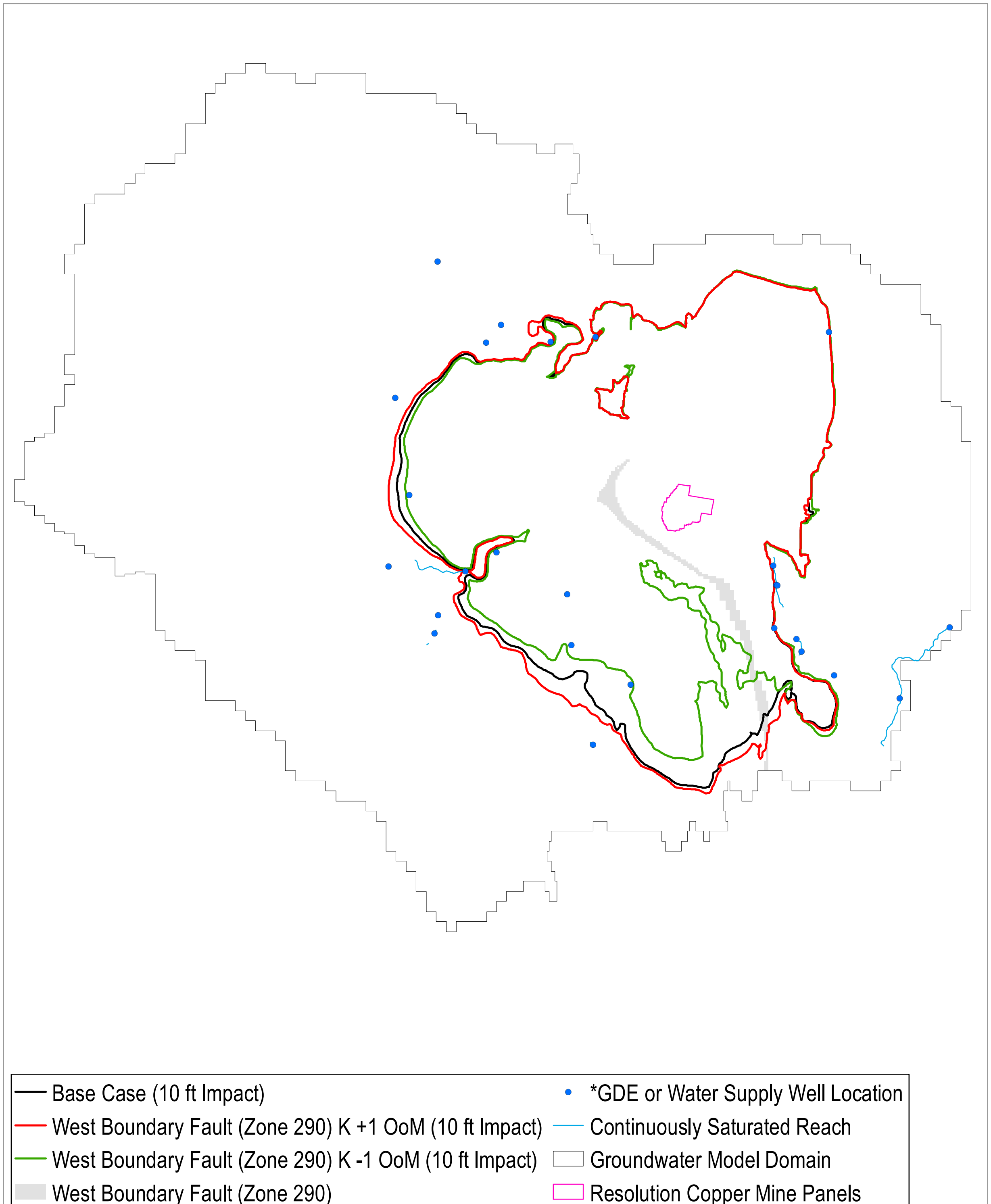
N

0 2.5 5 10 Miles

wsp

South Boundary Fault (Zone 284) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-25
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Model Results: 181102, Run51/52

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

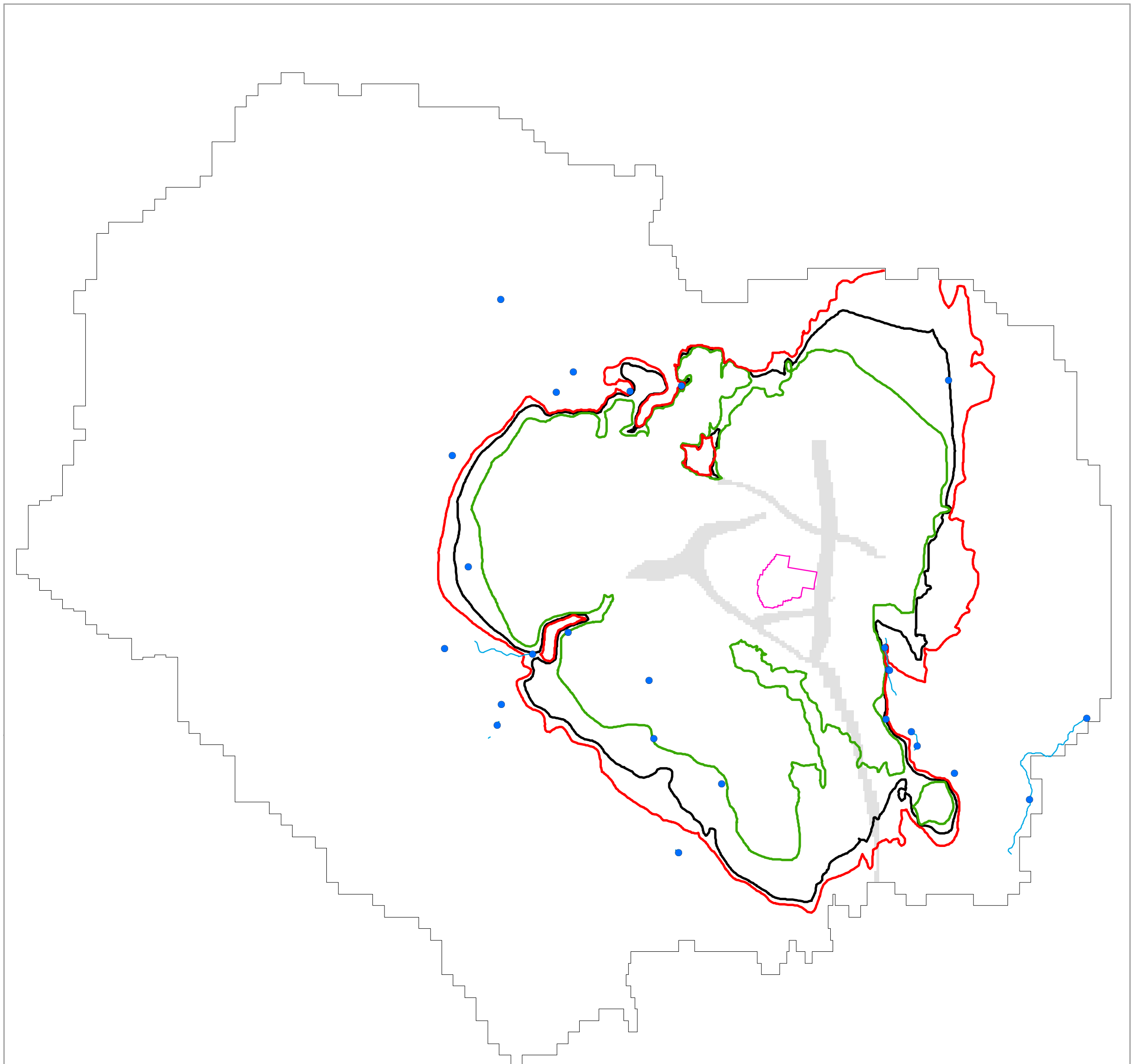
N

0 2.5 5 10 Miles

wsp

West Boundary Fault (Zone 290) Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-26
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



- Base Case (10 ft Impact)
- All Graben Faults K +1 OoM (10 ft Impact)
- All Graben Faults K -1 OoM (10 ft Impact)
- Conley Springs Fault (Zone 175)
- North Boundary Fault (Zone 250)
- Rancho Rio Fault (Zone 265)
- South Boundary Fault (Zone 284)
- West Boundary Fault (Zone 290)
- *GDE or Water Supply Well Location
- Continuously Saturated Reach
- Groundwater Model Domain
- Resolution Copper Mine Panels

Model Results: 181102, Run53/54

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

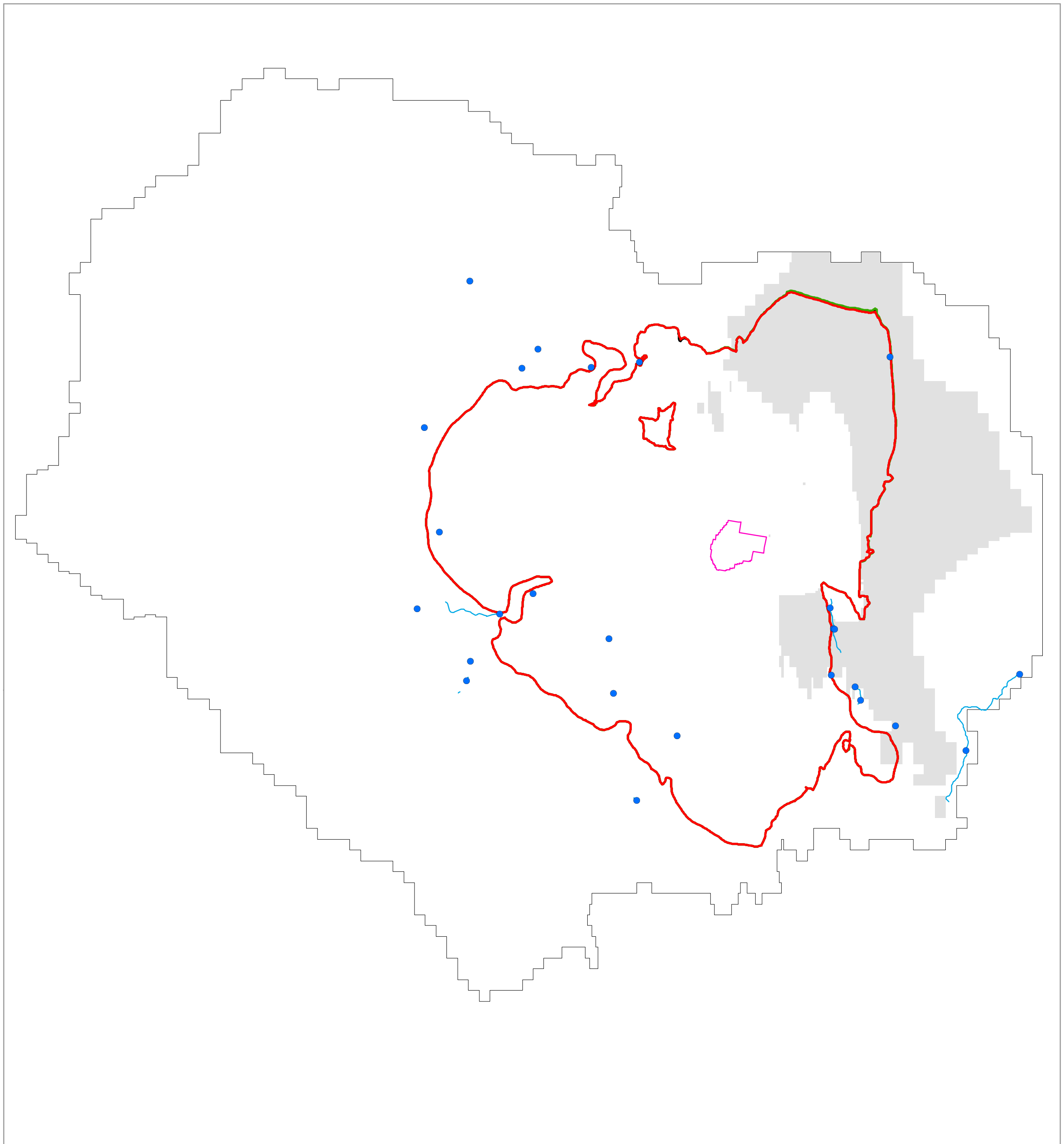
0 2.5 5 10 Miles

wsp

All Graben Faults Hydraulic Conductivity (K) +/- 1 OoM - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-27
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Tal (Zone 13) Sy +50% (10 ft Impact)	Continuously Saturated Reach
Tal (Zone 13) Sy -50% (10 ft Impact)	Groundwater Model Domain
Tal (Zone 13)	Resolution Copper Mine Panels

Model Results: 181102, Run55/56

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

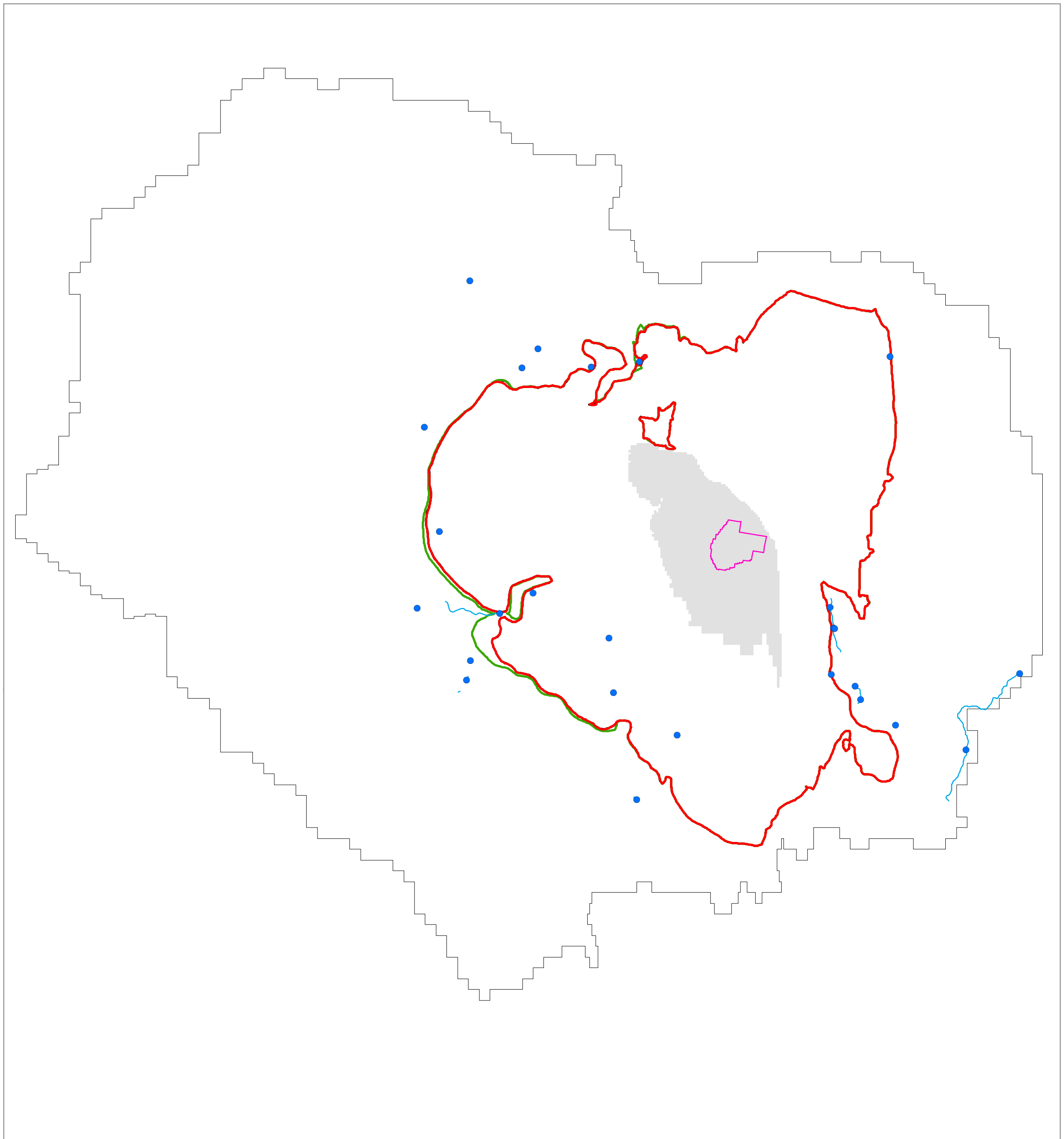
N

0 2.5 5 10 Miles

wsp

Tal (Zone 13) Specific Yield (Sy) +/- 50% - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-28
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Base Case (10 ft Impact)
Tal (Zone 14) Sy +50% (10 ft Impact)
Tal (Zone 14) Sy -50% (10 ft Impact)
Tal (Zone 14)
*GDE or Water Supply Well Location
Continuously Saturated Reach
Groundwater Model Domain
Resolution Copper Mine Panels

Model Results: 181102, Run57/58

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

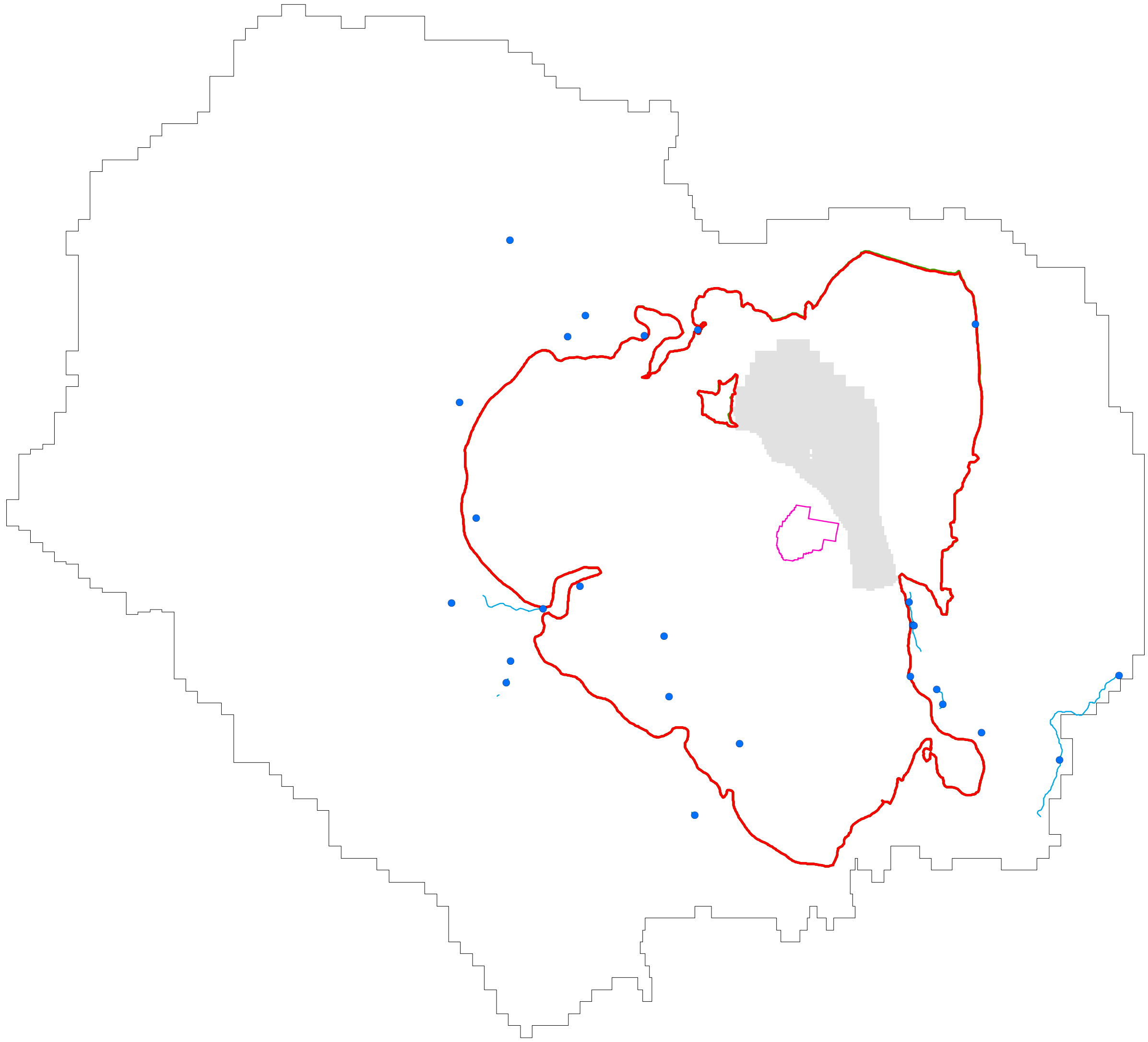
N

0 2.5 5 10 Miles

wsp

Tal (Zone 14) Specific Yield (Sy) +/- 50% - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-29
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Tal (Zone 15) Sy +50% (10 ft Impact)	Continuously Saturated Reach
Tal (Zone 15) Sy -50% (10 ft Impact)	Groundwater Model Domain
Tal (Zone 15)	Resolution Copper Mine Panels

Model Results: 181102, Run59/60

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

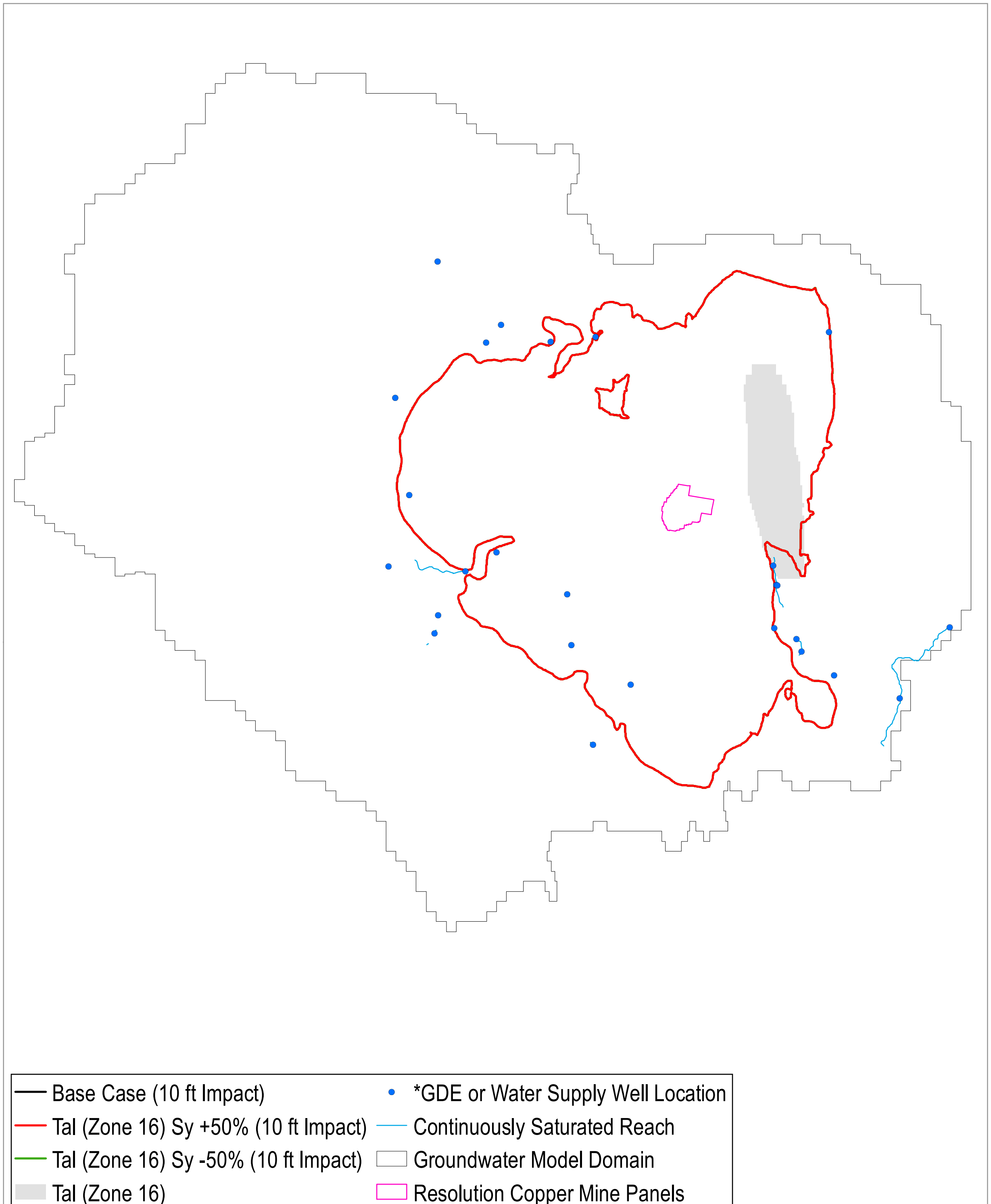
0 2.5 5 10 Miles

wsp

Tal (Zone 15) Specific Yield (Sy) +/- 50% - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-30
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Model Results: 181102, Run61/62

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

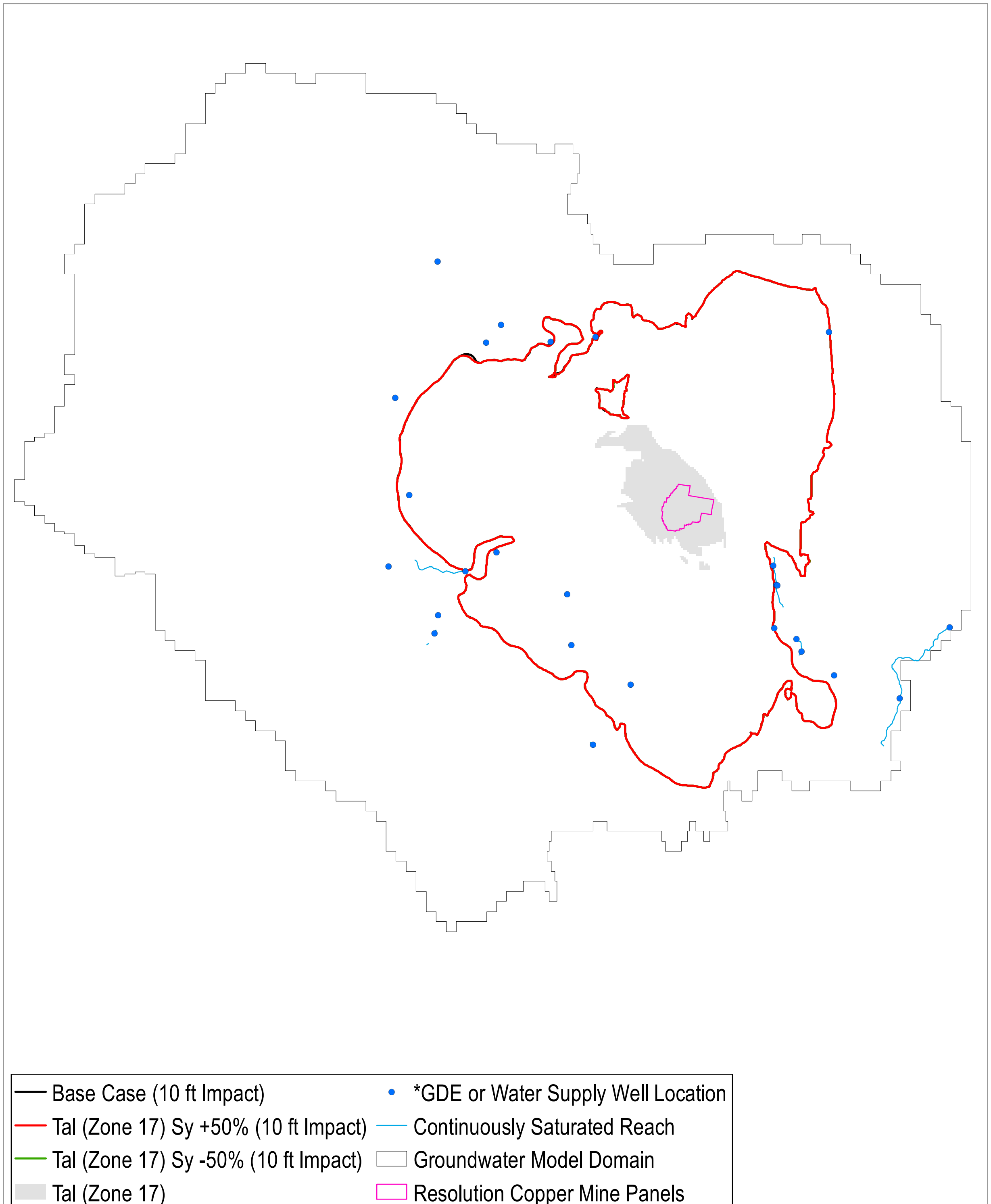
N

0 2.5 5 10 Miles

Tal (Zone 16) Specific Yield (Sy) +/- 50% - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-31
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN:	CDM CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Model Results: 181102, Run63/64

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

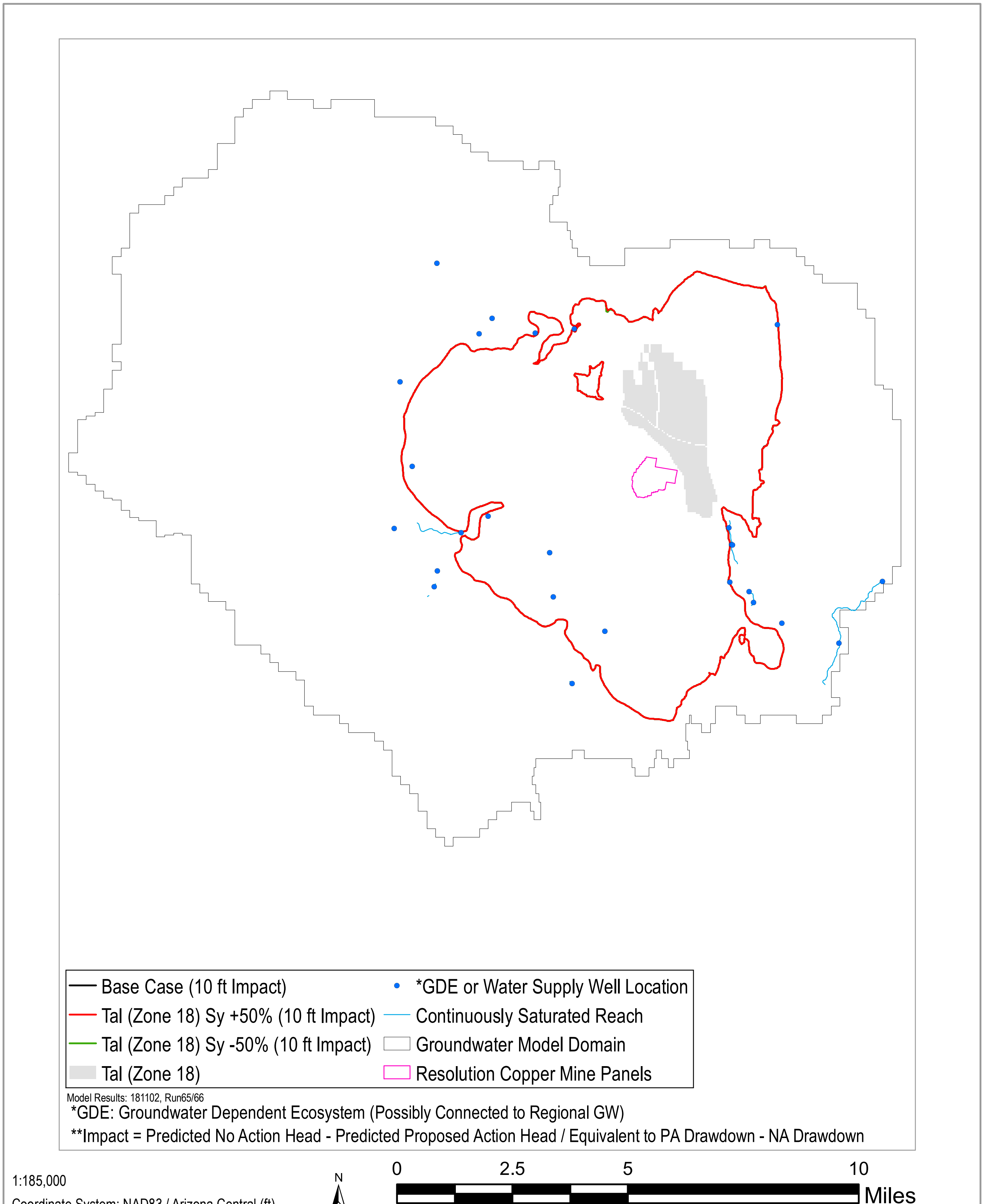
0 2.5 5 10 Miles

wsp

Tal (Zone 17) Specific Yield (Sy) +/- 50% - Year 200

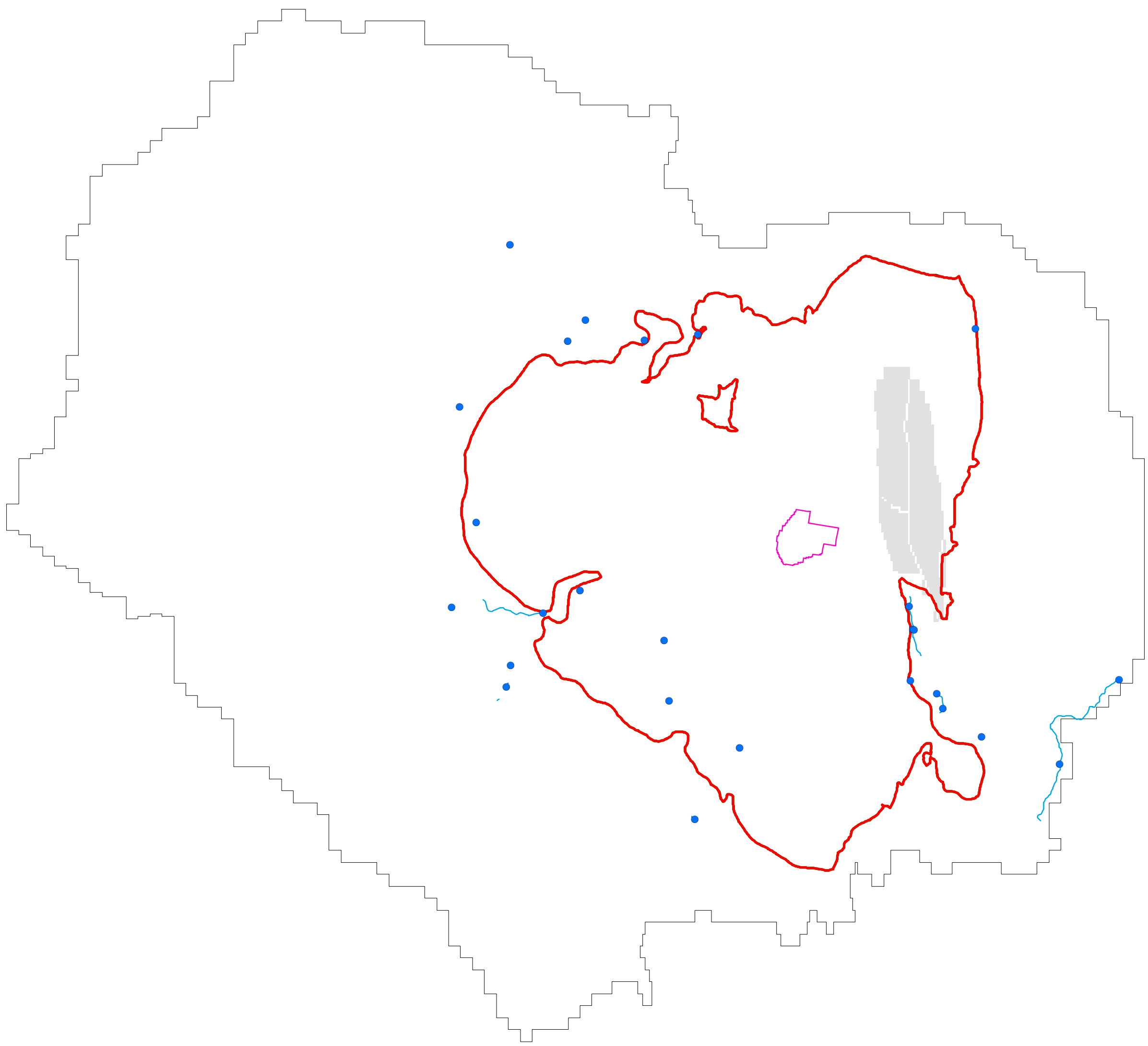
PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-32
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Tal (Zone 18) Specific Yield (Sy) +/- 50% - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #: B-33	
CLIENT: Resolution Copper		PROJECT #: 31400968.001	
DRAWN: CDM	CHECKED: DO	DATE: November 2018	



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Tal (Zone 19) Sy +50% (10 ft Impact)	Continuously Saturated Reach
Tal (Zone 19) Sy -50% (10 ft Impact)	Groundwater Model Domain
Tal (Zone 19)	Resolution Copper Mine Panels

Model Results: 181102, Run67/68

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

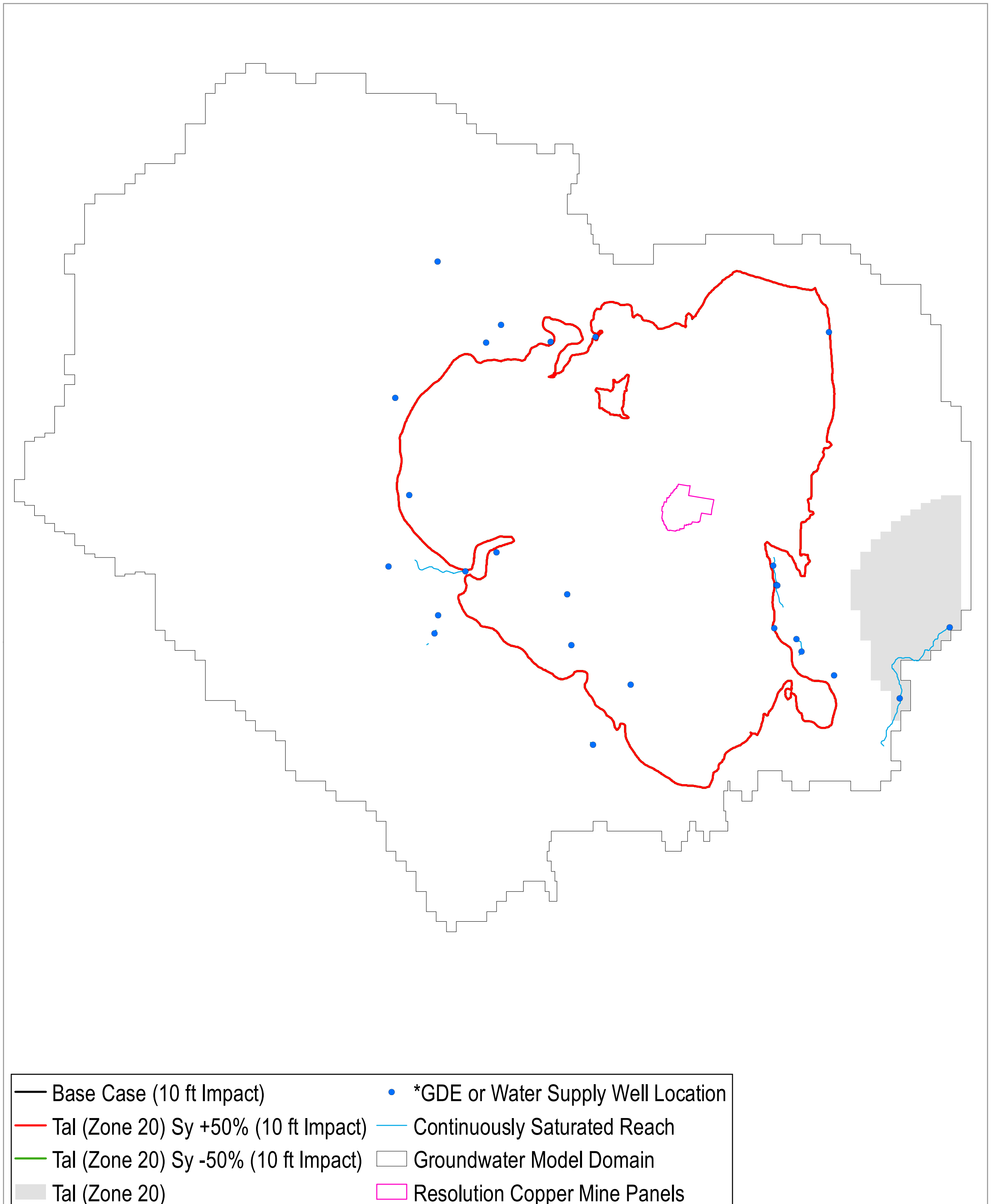
Coordinate System: NAD83 / Arizona Central (ft)

0 2.5 5 10 Miles

Tal (Zone 19) Specific Yield (Sy) +/- 50% - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-34
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN:	CDM CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Model Results: 181102, Run69/70

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

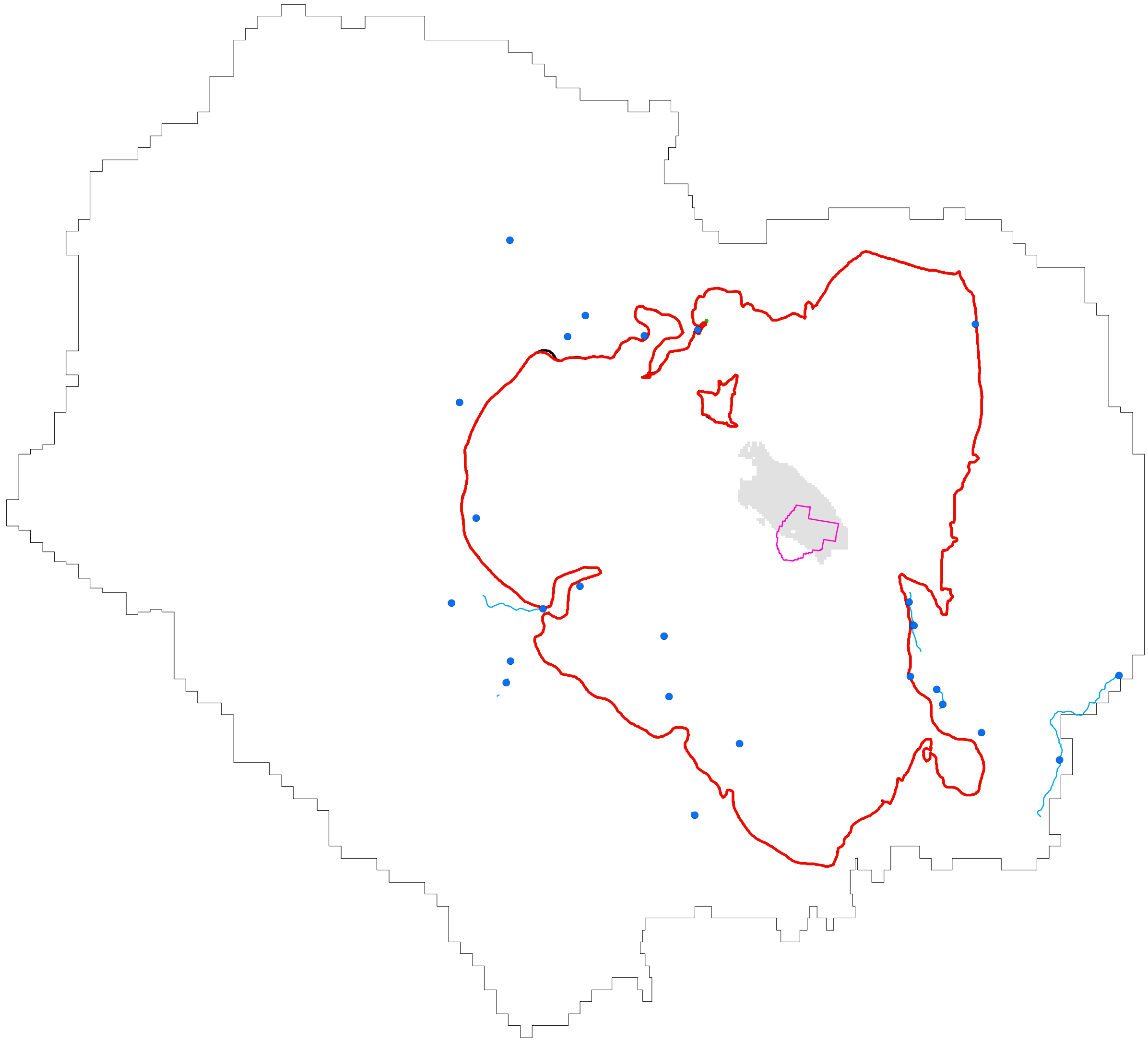
Coordinate System: NAD83 / Arizona Central (ft)

N

0 2.5 5 10 Miles

Tal (Zone 20) Specific Yield (Sy) +/- 50% - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-35
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Tal (Zone 21) Sy +50% (10 ft Impact)	Continuously Saturated Reach
Tal (Zone 21) Sy -50% (10 ft Impact)	Groundwater Model Domain
Tal (Zone 21)	Resolution Copper Mine Panels

Model Results: 181102, Run71/72

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

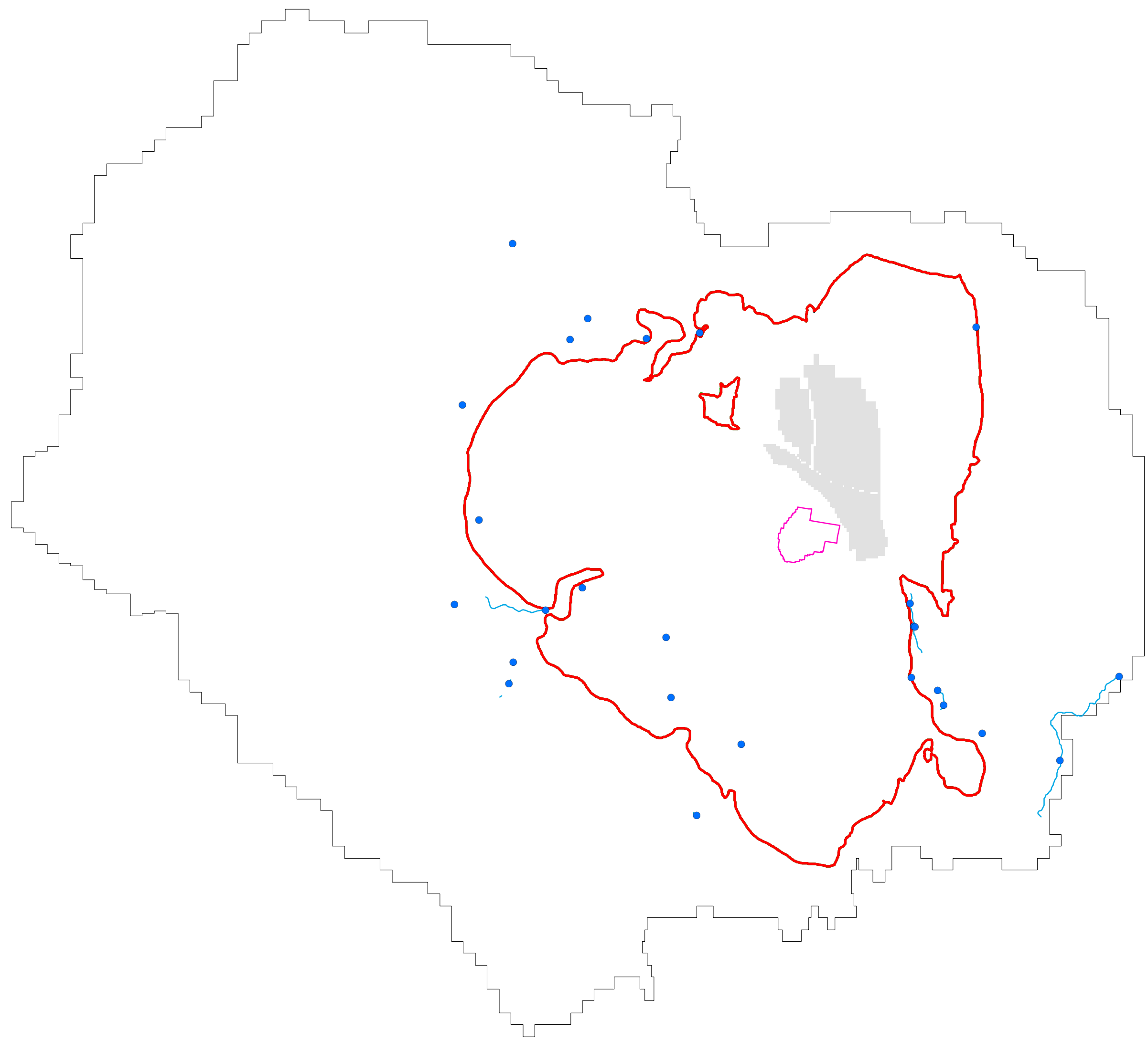
N

0 2.5 5 10 Miles

Tal (Zone 21) Specific Yield (Sy) +/- 50% - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-36
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Tal (Zone 22) Sy +50% (10 ft Impact)	Continuously Saturated Reach
Tal (Zone 22) Sy -50% (10 ft Impact)	Groundwater Model Domain
Tal (Zone 22)	Resolution Copper Mine Panels

Model Results: 181102, Run73/74

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

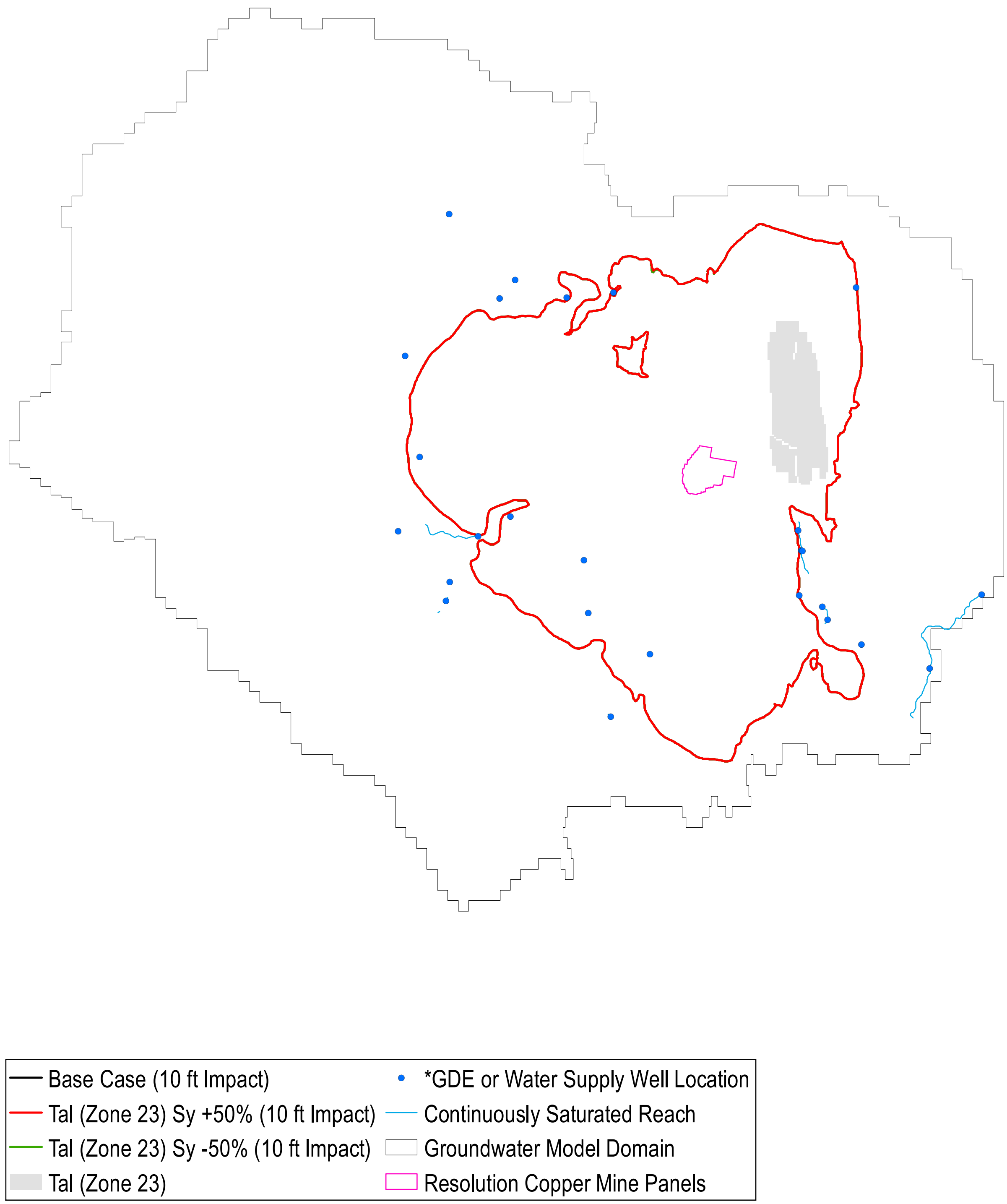
N

0 2.5 5 10 Miles

wsp

Tal (Zone 22) Specific Yield (Sy) +/- 50% - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-37
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Model Results: 181102, Run75/76

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

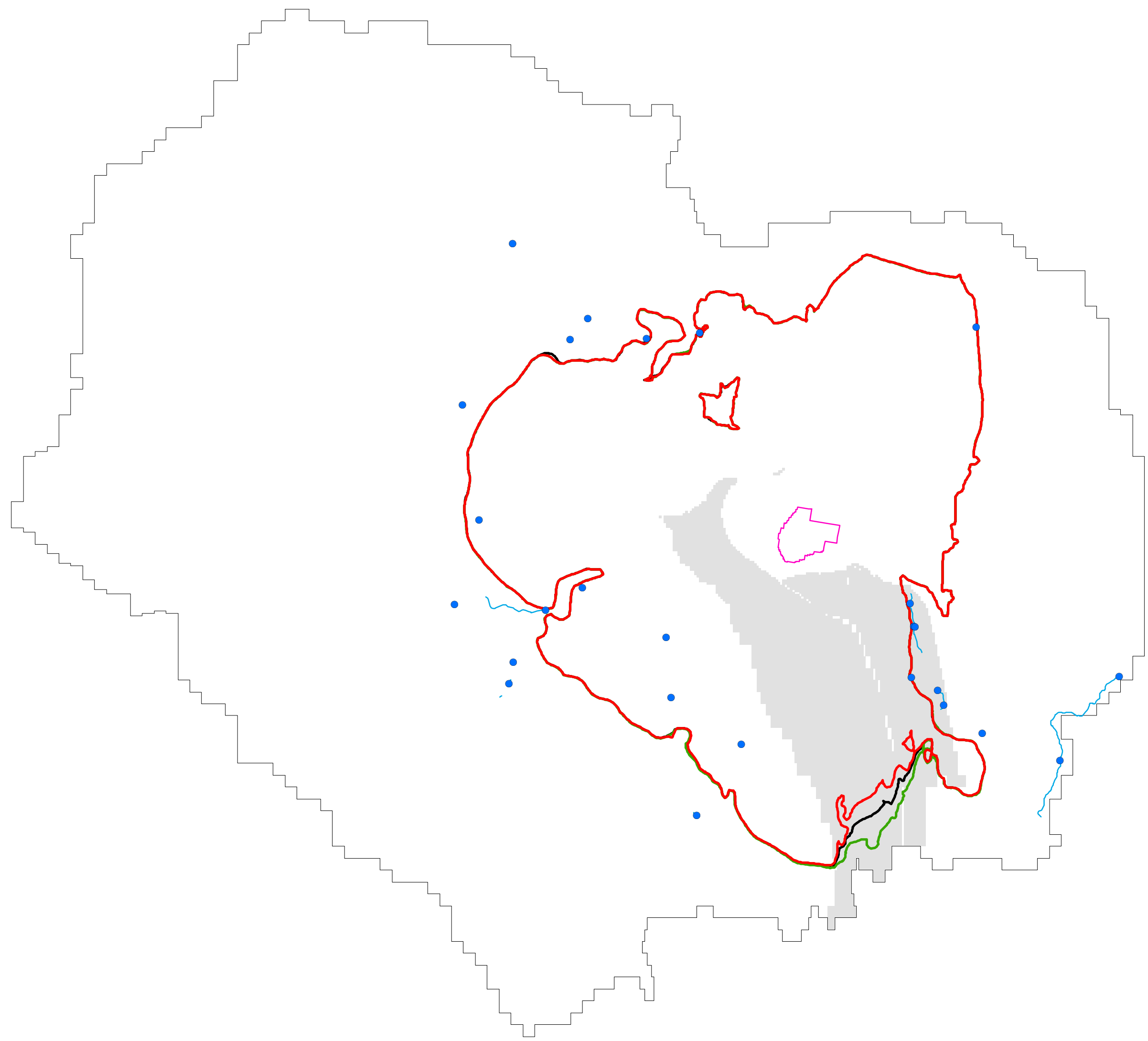
N

0 2.5 5 10 Miles

wsp

Tal (Zone 23) Specific Yield (Sy) +/- 50% - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-38
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Pz (Zone 67) Sy +50% (10 ft Impact)	Continuously Saturated Reach
Pz (Zone 67) Sy -50% (10 ft Impact)	Groundwater Model Domain
Pz (Zone 67)	Resolution Copper Mine Panels

Model Results: 181102, Run77/78

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

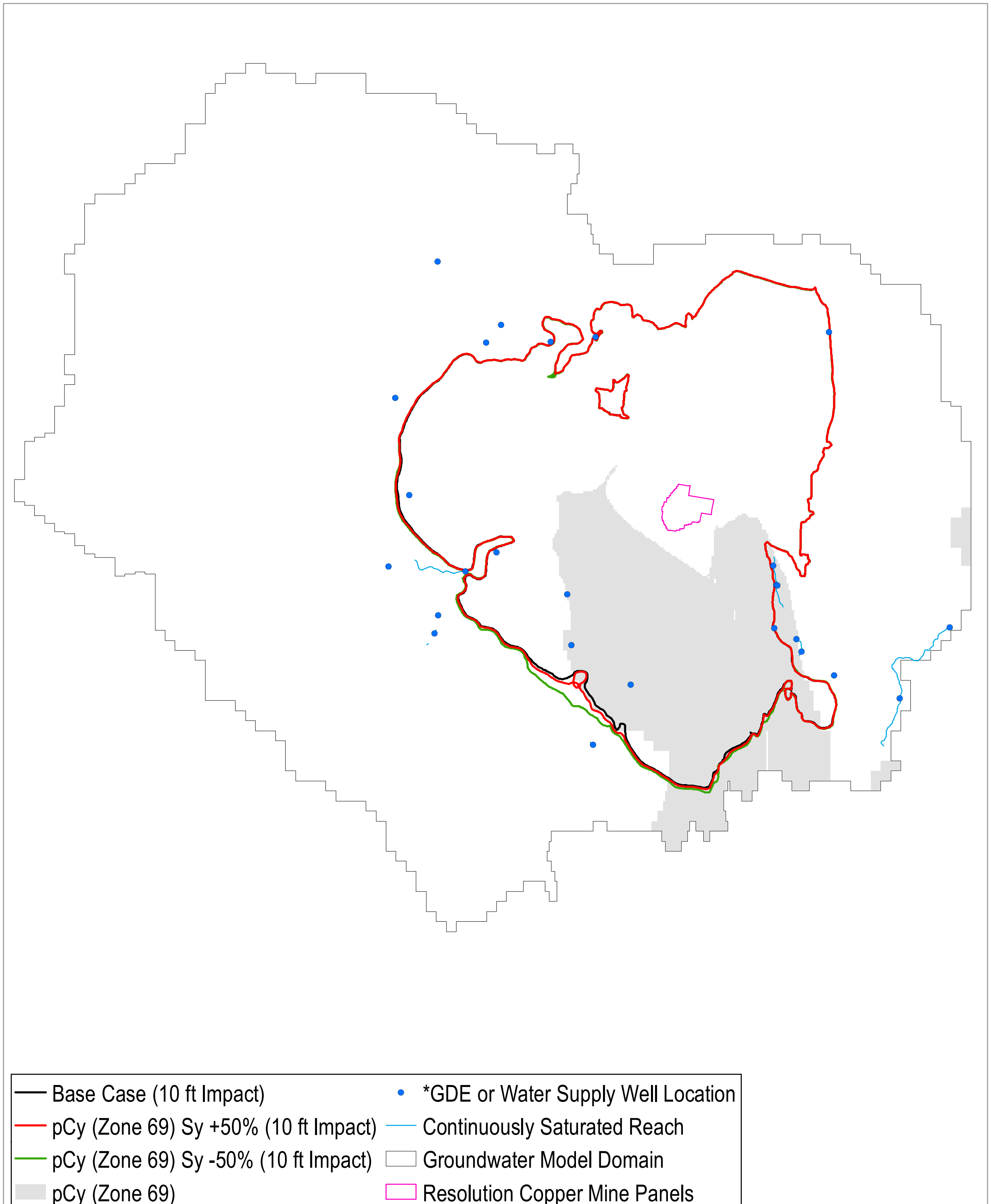
N

0 2.5 5 10 Miles

Pz (Zone 67) Specific Yield (Sy) +/- 50% - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-39
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

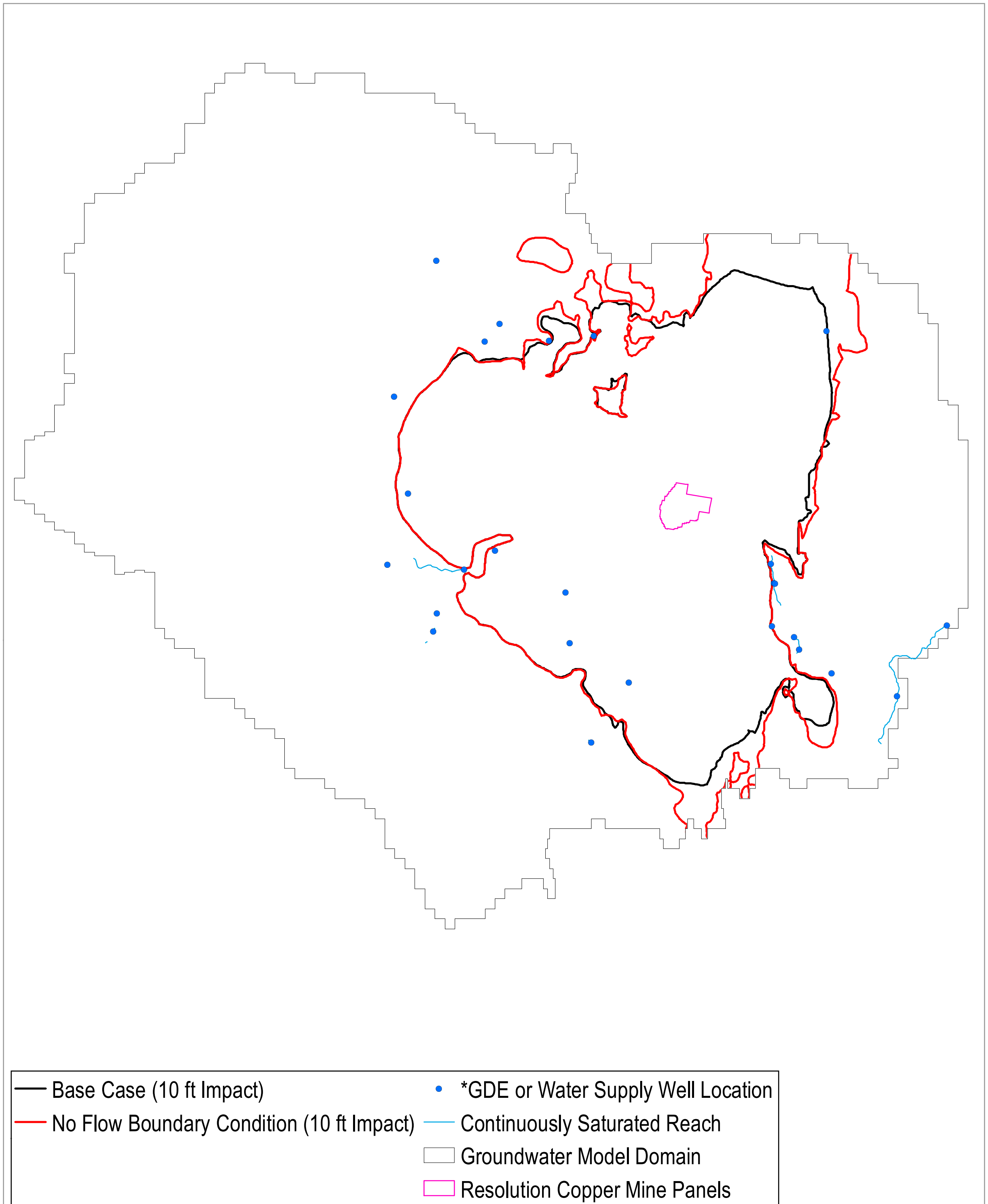
N

0 2.5 5 10 Miles

wsp

pCy (Zone 69) Specific Yield (Sy) +/- 50% - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-40
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN:	CDM CHECKED: DO	DATE:	November 2018



*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

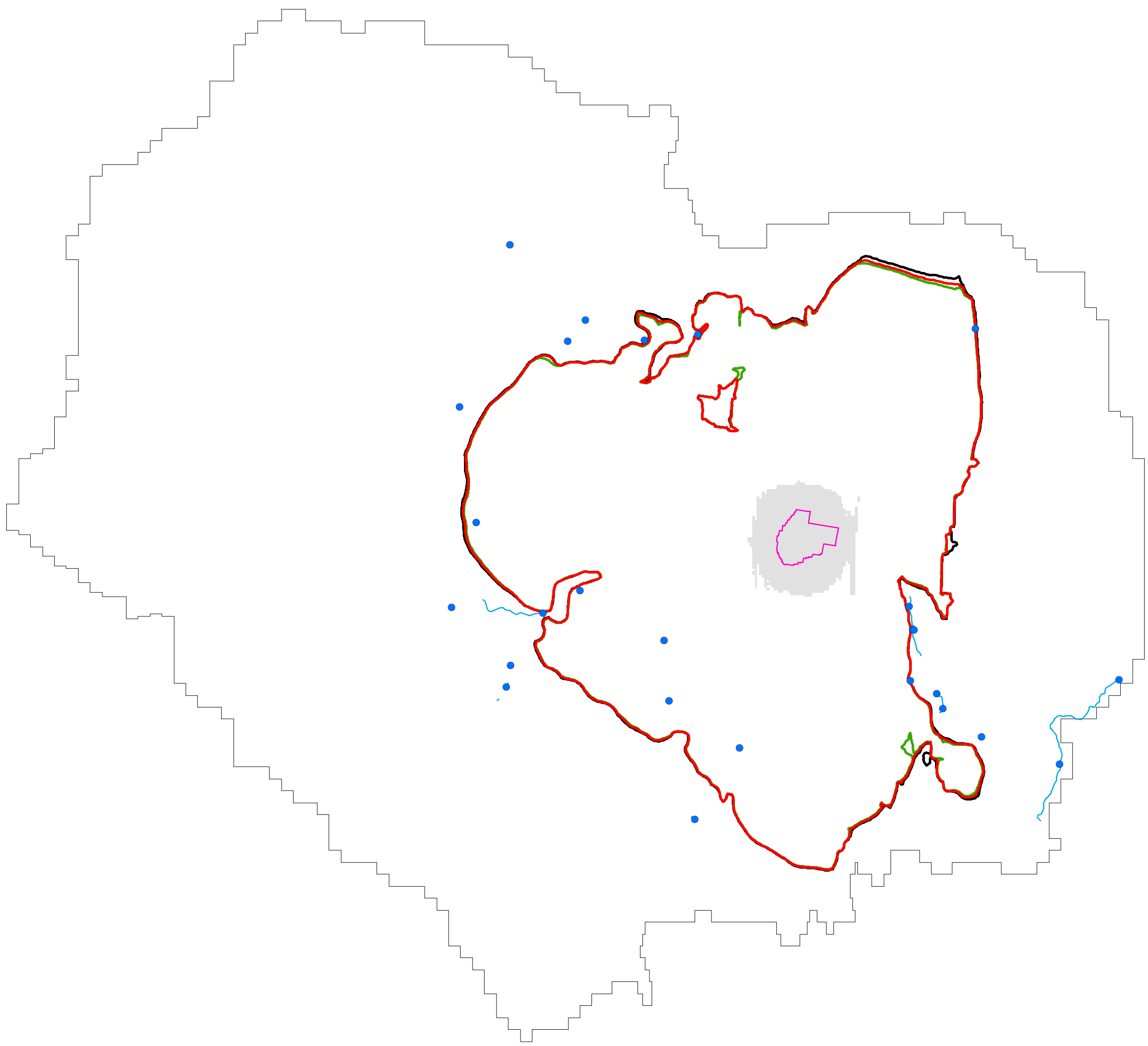
0 2.5 5 10 Miles

wsp

No Flow Boundary Condition - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-41
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Cave Porosity Sy +25% (10 ft Impact)	Continuously Saturated Reach
Cave Porosity Sy -25% (10 ft Impact)	Groundwater Model Domain
Cave	Resolution Copper Mine Panels

Model Results: 181102, Run82/83

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

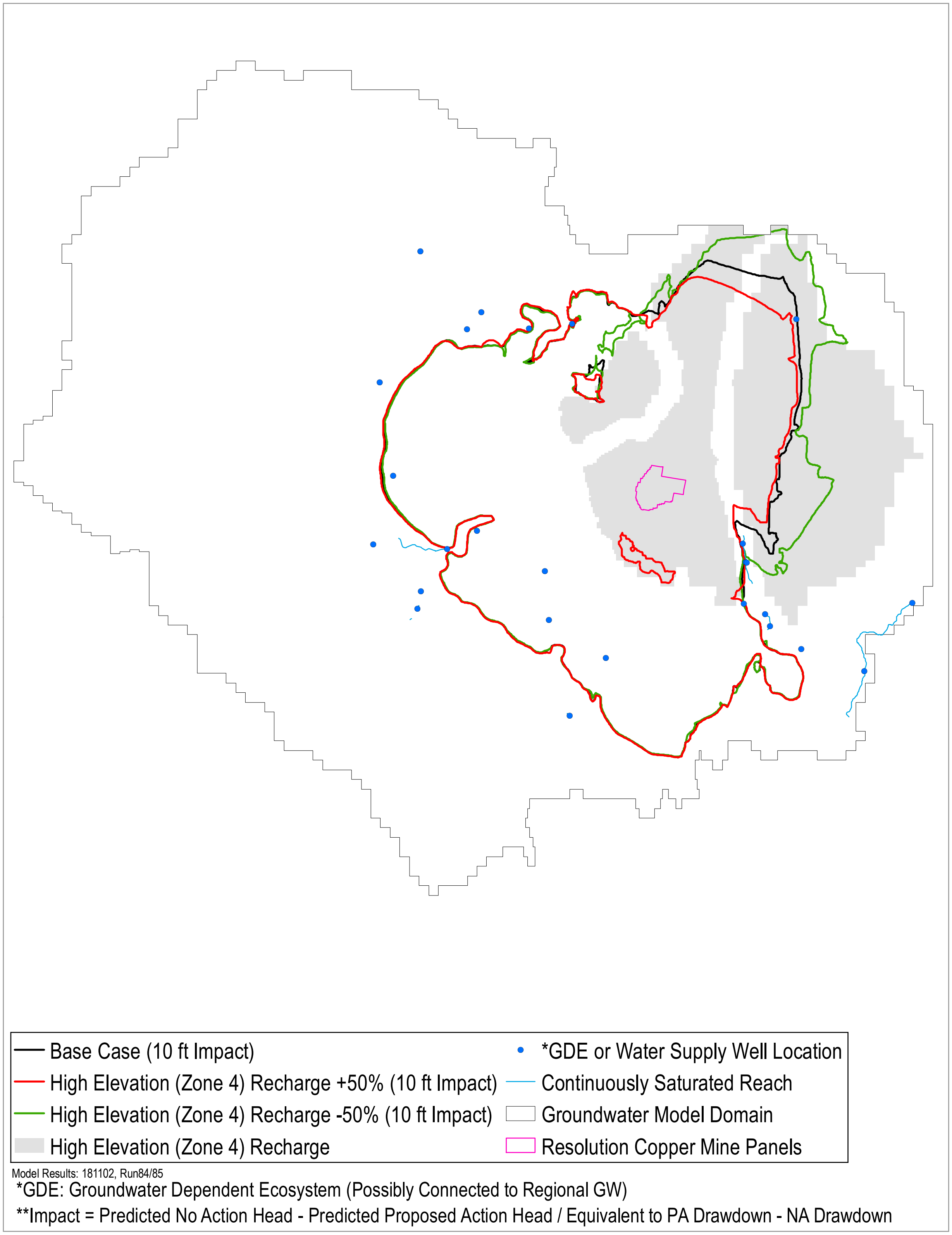
N

0 2.5 5 10 Miles

wsp

Cave Porosity/Specific Yield (Sy) +/- 25% - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-42
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



1:185,000

Coordinate System: NAD83 / Arizona Central (ft)

N

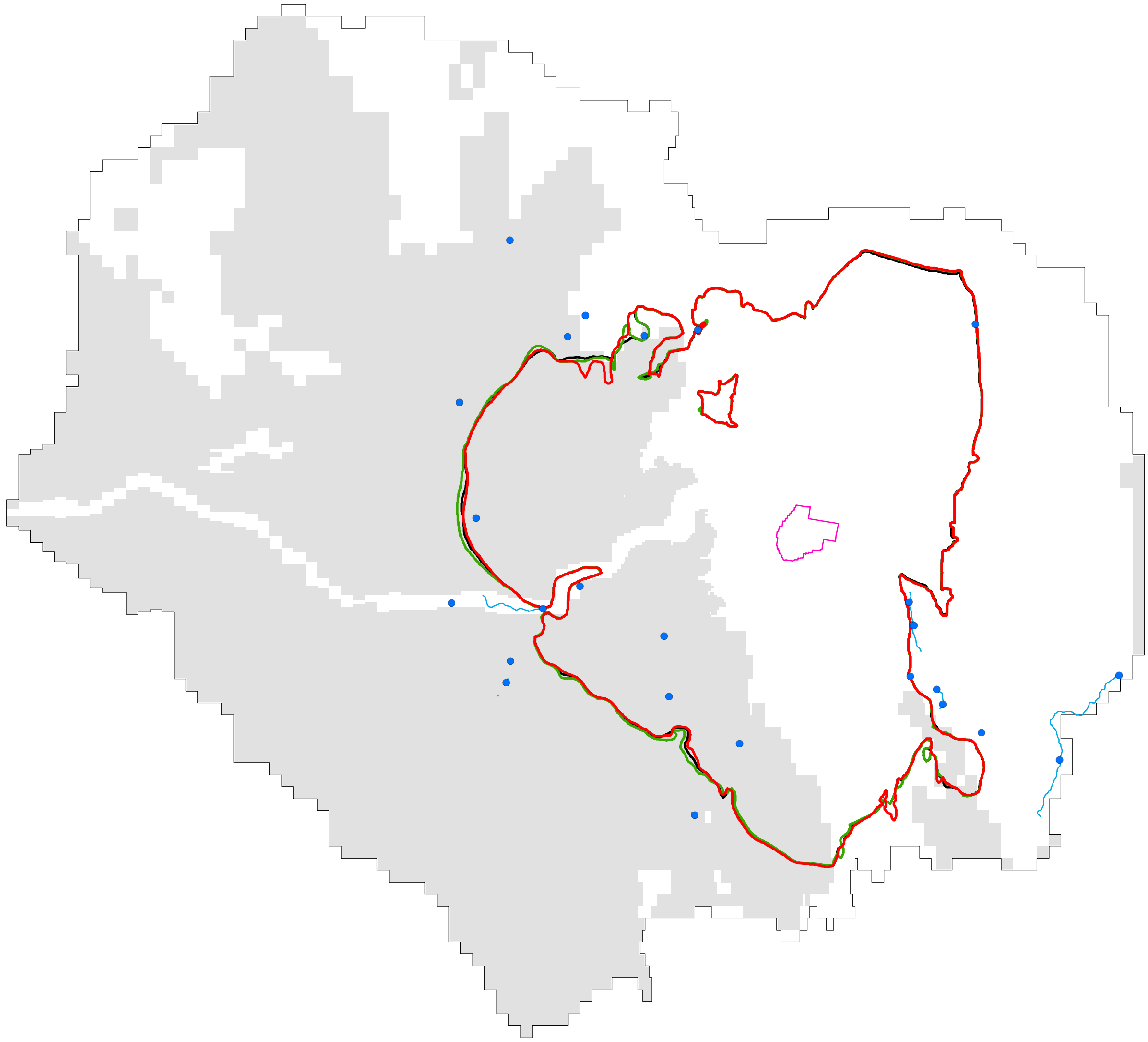
0 2.5 5 10 Miles

wsp

High Elevation (Zone 4) Recharge +/- 50% - Year 200

PROJECT: 3D Regional Groundwater Model		FIGURE #:	B-43
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Low Elevation, Low Kz (Zone 6) Recharge +50% (10 ft Impact)	Continuously Saturated Reach
Low Elevation, Low Kz (Zone 6) Recharge -50% (10 ft Impact)	Groundwater Model Domain
Low Elev, Low Kz (Zone 6) Recharge	Resolution Copper Mine Panels

Model Results: 181102, Run86/87

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,000

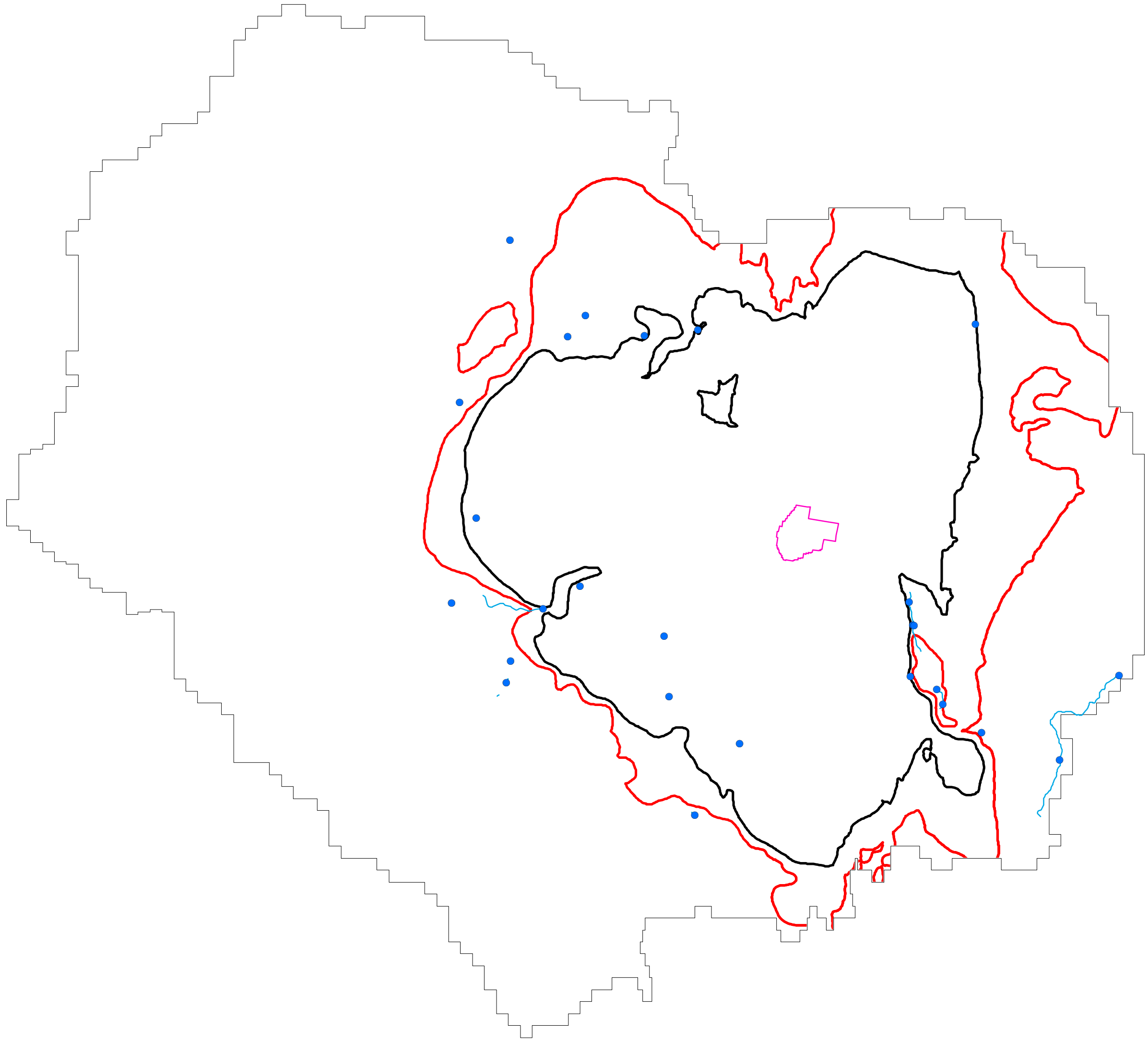
Coordinate System: NAD83 / Arizona Central (ft)

N

0 2.5 5 10 Miles

Low Elevation, Low Kz (Zone 6) Recharge +/- 50% - Year 200

PROJECT:	3D Regional Groundwater Model	FIGURE #:	B-44
CLIENT:	Resolution Copper	PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018



Base Case (10 ft Impact)	*GDE or Water Supply Well Location
Maximum Sensitivity Extent (10 ft Impact)	Continuously Saturated Reach
	Groundwater Model Domain
	Resolution Copper Mine Panels

Model Results: 181102, All Sensitivity

*GDE: Groundwater Dependent Ecosystem (Possibly Connected to Regional GW)

**Impact = Predicted No Action Head - Predicted Proposed Action Head / Equivalent to PA Drawdown - NA Drawdown

1:185,256

Coordinate System: NAD83 / Arizona Central (ft)

N

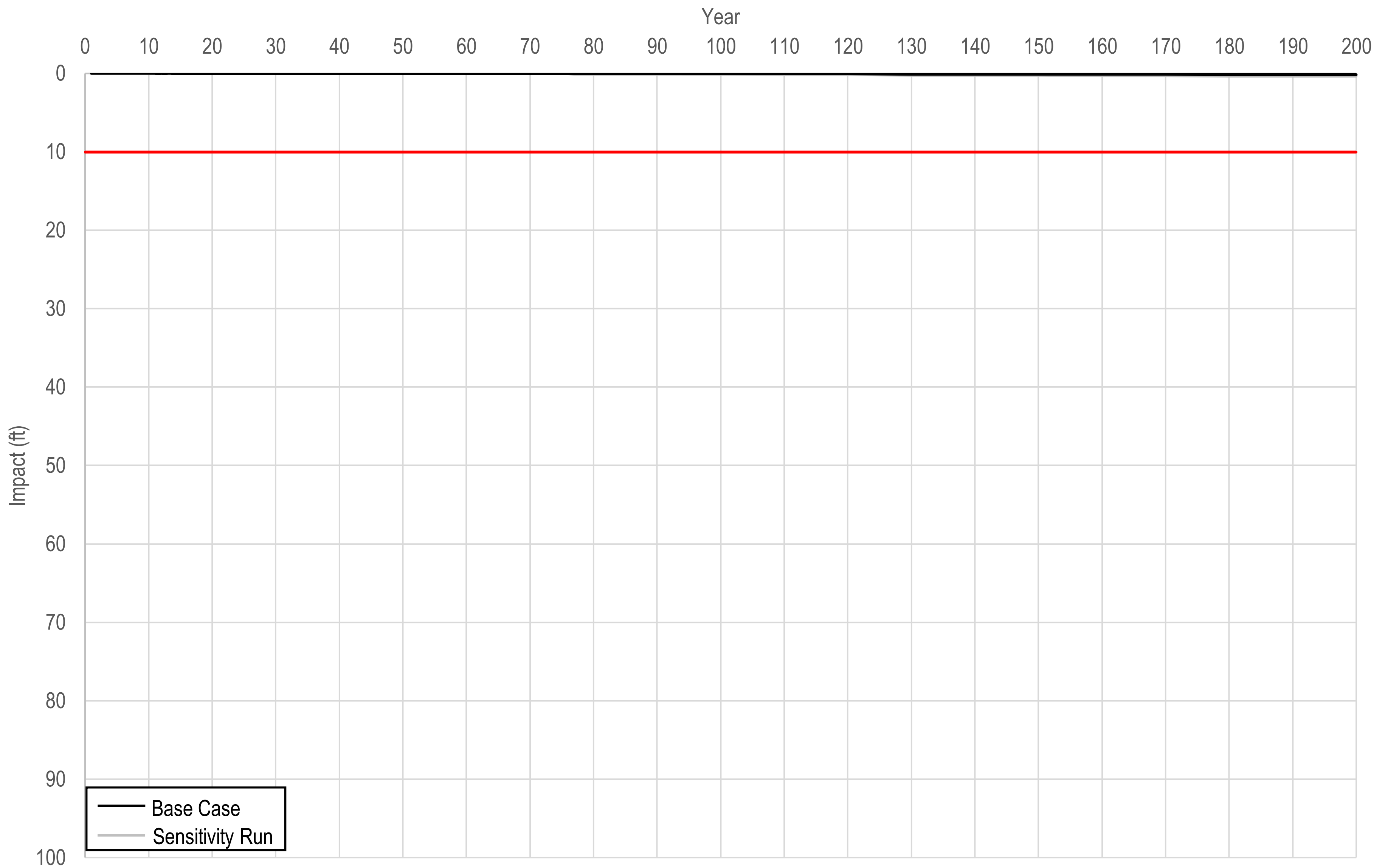
0 2.5 5 10 Miles

wsp

Regional GW Model Sensitivity Analysis
Base Case & Superposition of Maximum Sensitivity Extent

PROJECT: 3D Regional Groundwater Model		FIGURE #:	A-45
CLIENT: Resolution Copper		PROJECT #:	31400968.001
DRAWN: CDM	CHECKED: DO	DATE:	November 2018

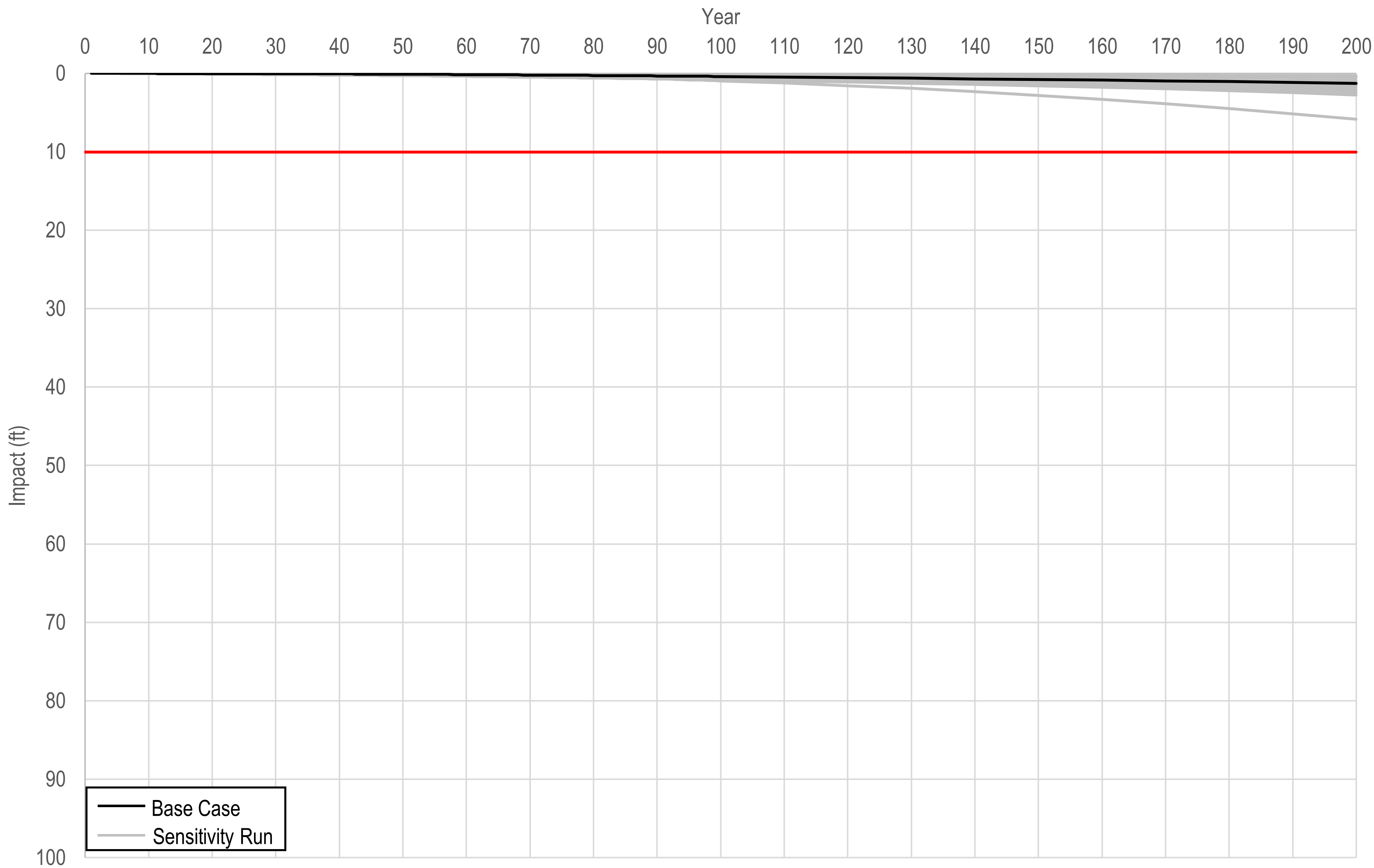
Document Path: C:\Users\USCM02932\Documents\ArcGIS\Packages\Sensitivity_Impacts_110818_2F774B8C-A582-4E1B-B5ED-72C672377D04\v105\Sensitivity_Impacts.mxd



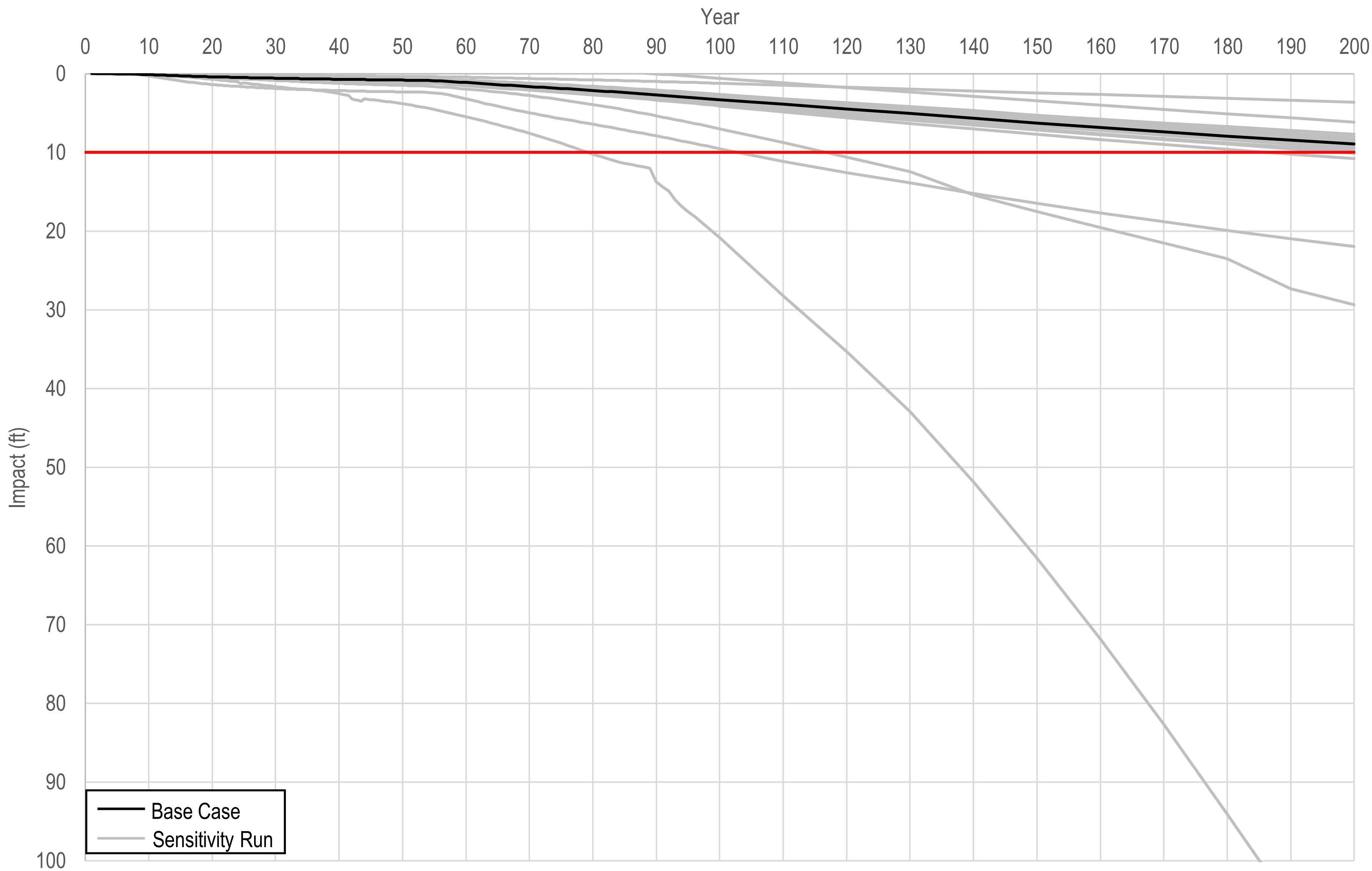
GDE Impact Hydrograph – Sensitivity Analysis – Arnett Creek (AC) 4.54

CLIENT: Resolution Copper	PROJECT: 3D Regional Groundwater Model		
JOB: 31400968.001	DRAWN: GM	CHECKED: DO	
DATE: November 2018	FIGURE: C-1		

D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx

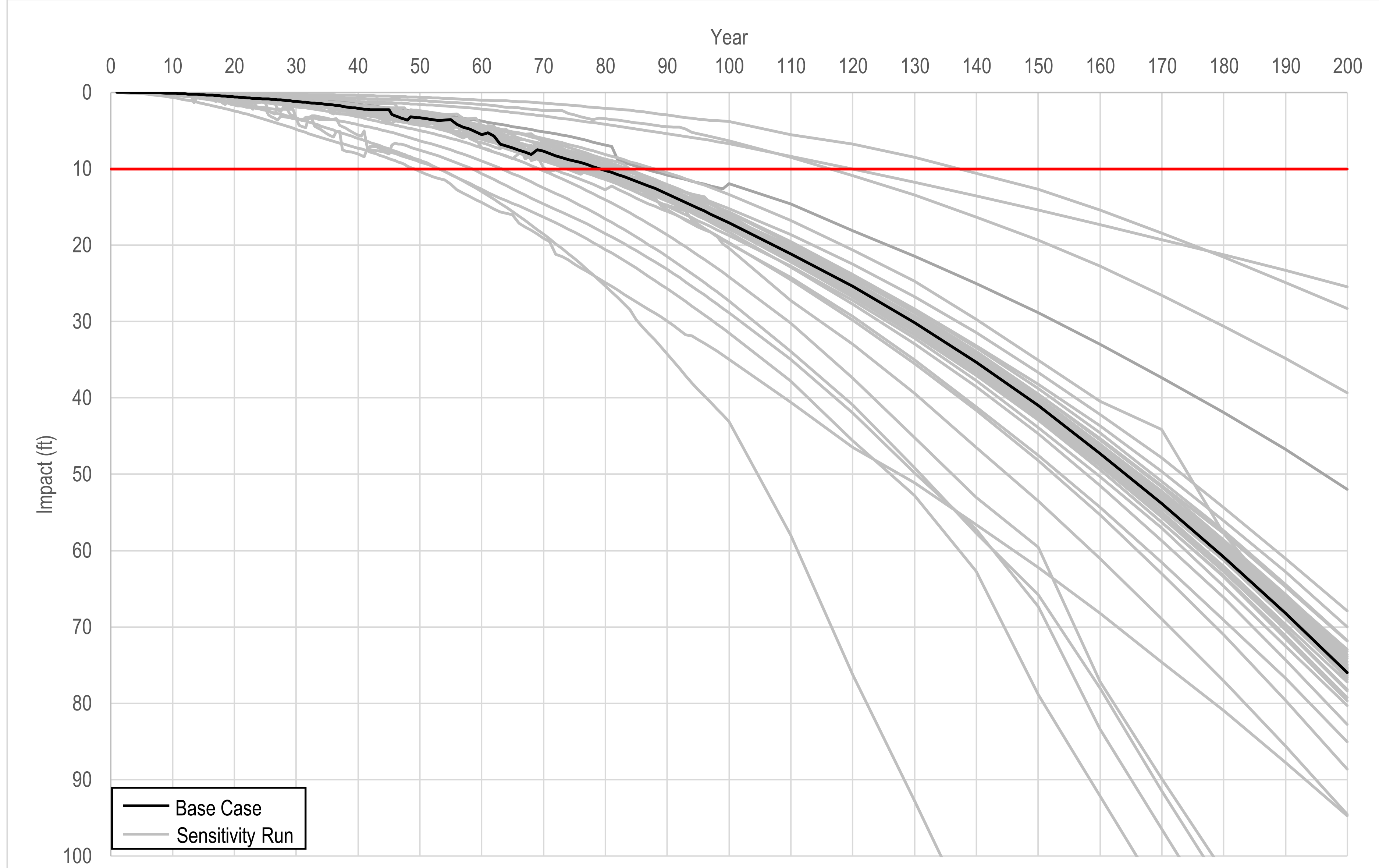


GDE Impact Hydrograph – Sensitivity Analysis – Arnett Creek (AC) 12.49 / Blue Spring		
CLIENT: Resolution Copper	PROJECT: 3D Regional Groundwater Model	
JOB: 31400968.001	DRAWN: GM	CHECKED: DO
DATE: November 2018	FIGURE: C-2	



GDE Impact Hydrograph – Sensitivity Analysis – Bitter Spring

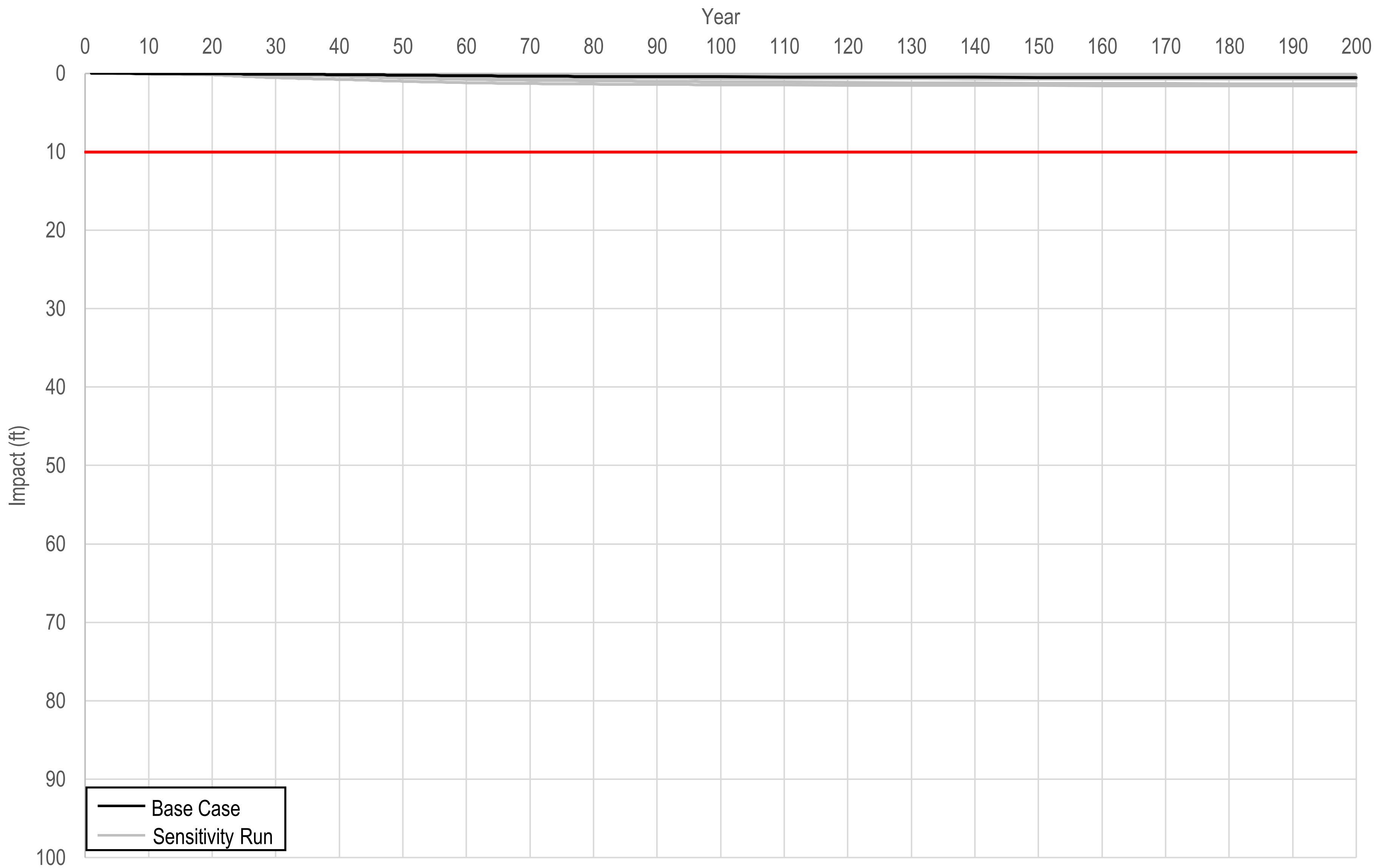
CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-3		



GDE Impact Hydrograph – Sensitivity Analysis – Bored Spring

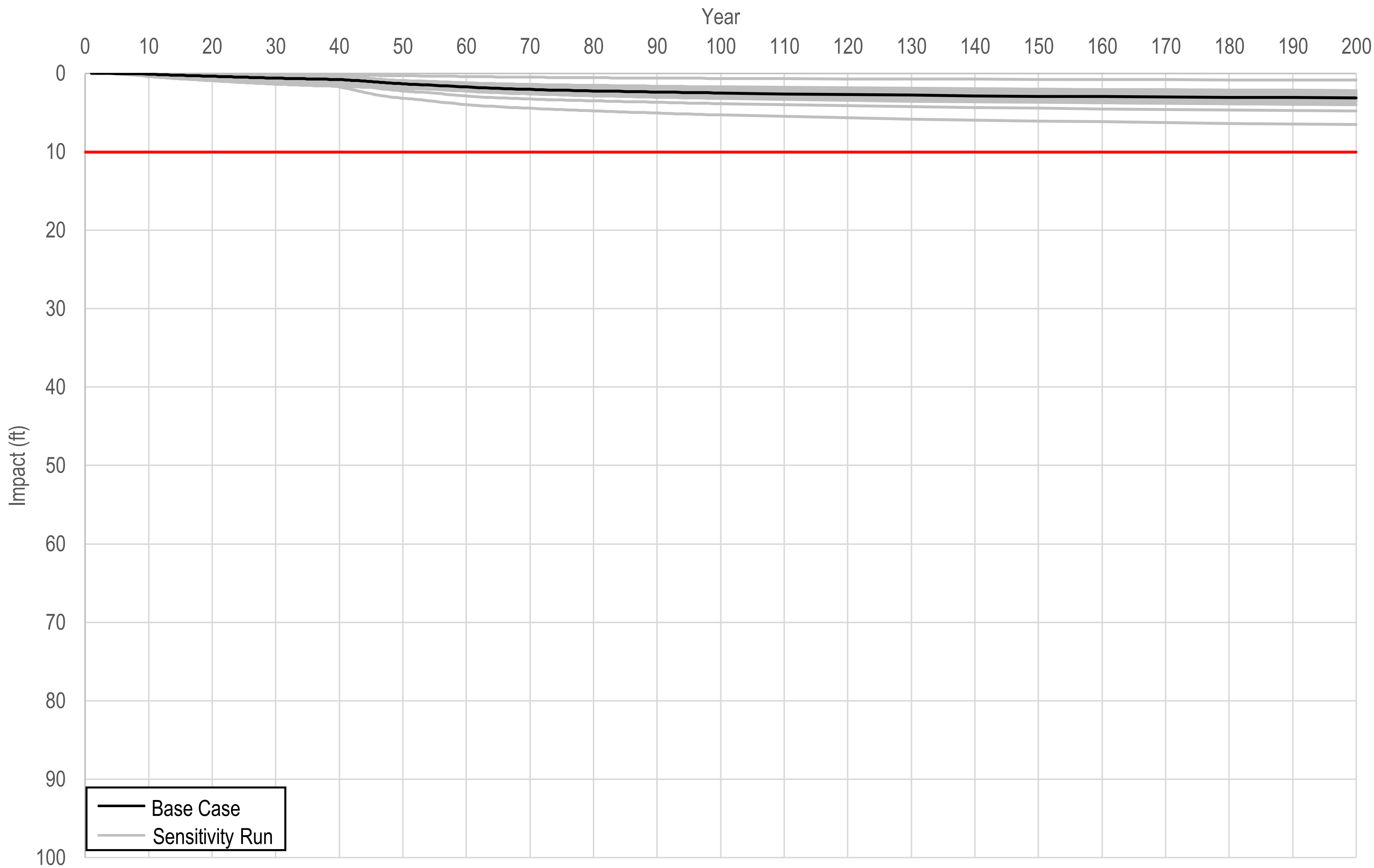
CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-4		

D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx



GDE Impact Hydrograph – Sensitivity Analysis – Devils Canyon (DC) 4.1E

CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-5		



GDE Impact Hydrograph – Sensitivity Analysis – Devils Canyon (DC) 5.5C			
CLIENT: Resolution Copper		PROJECT: 3D Regional Groundwater Model	
JOB: 31400968.001		DRAWN: GM	CHECKED: DO
DATE: November 2018		FIGURE: C-6	

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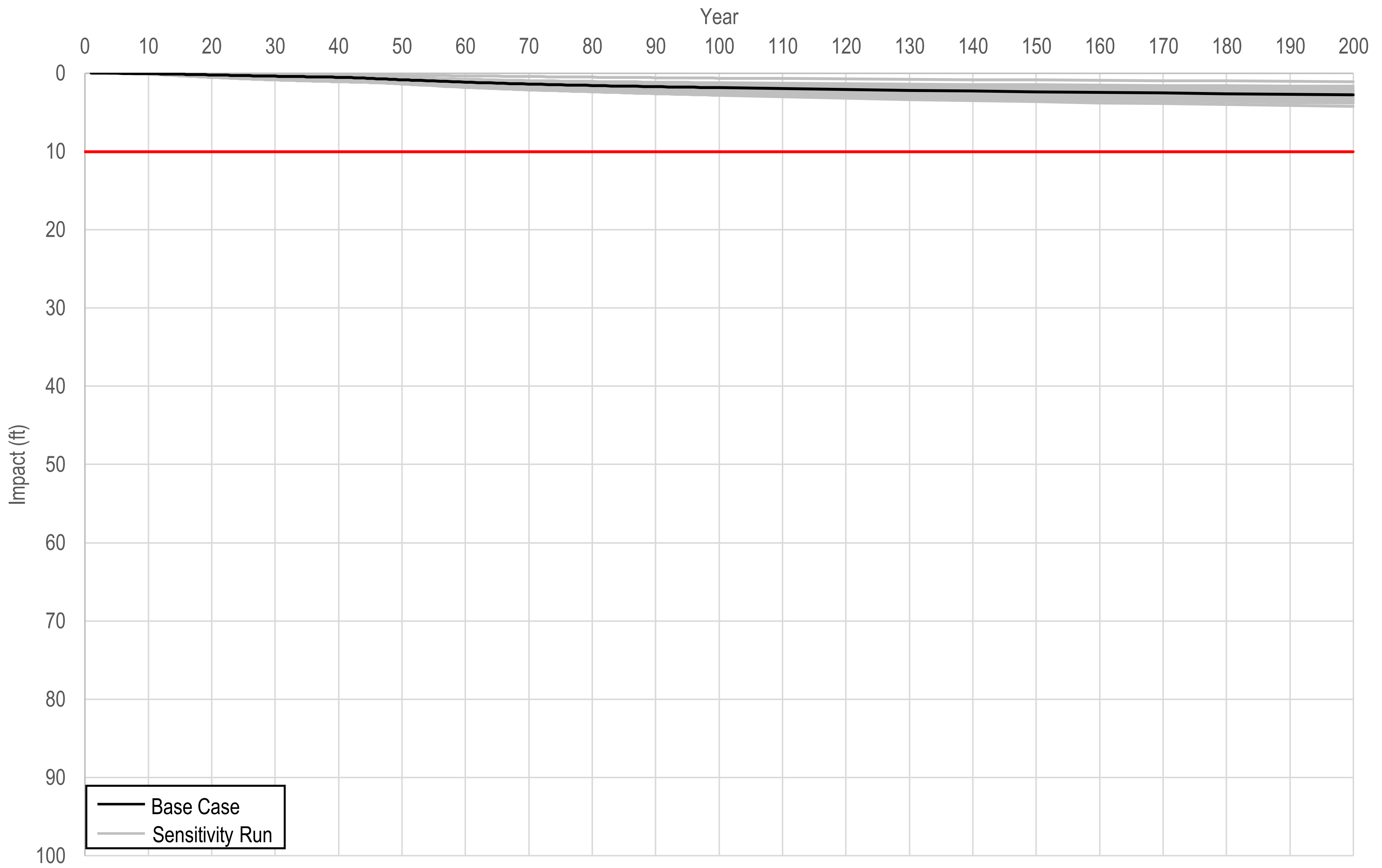
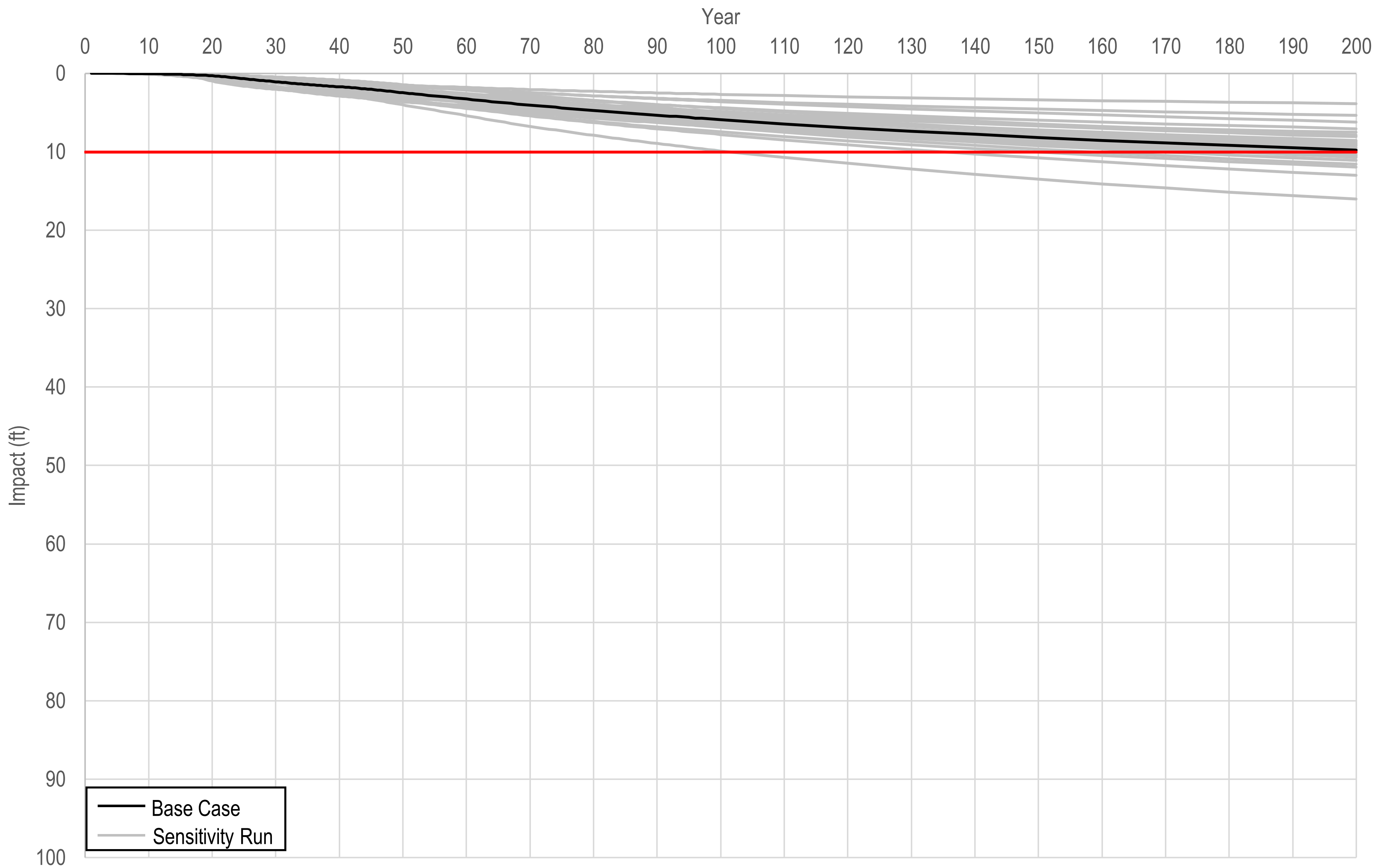


GDE Impact Hydrograph – Sensitivity Analysis – Devils Canyon (DC) 6.1E

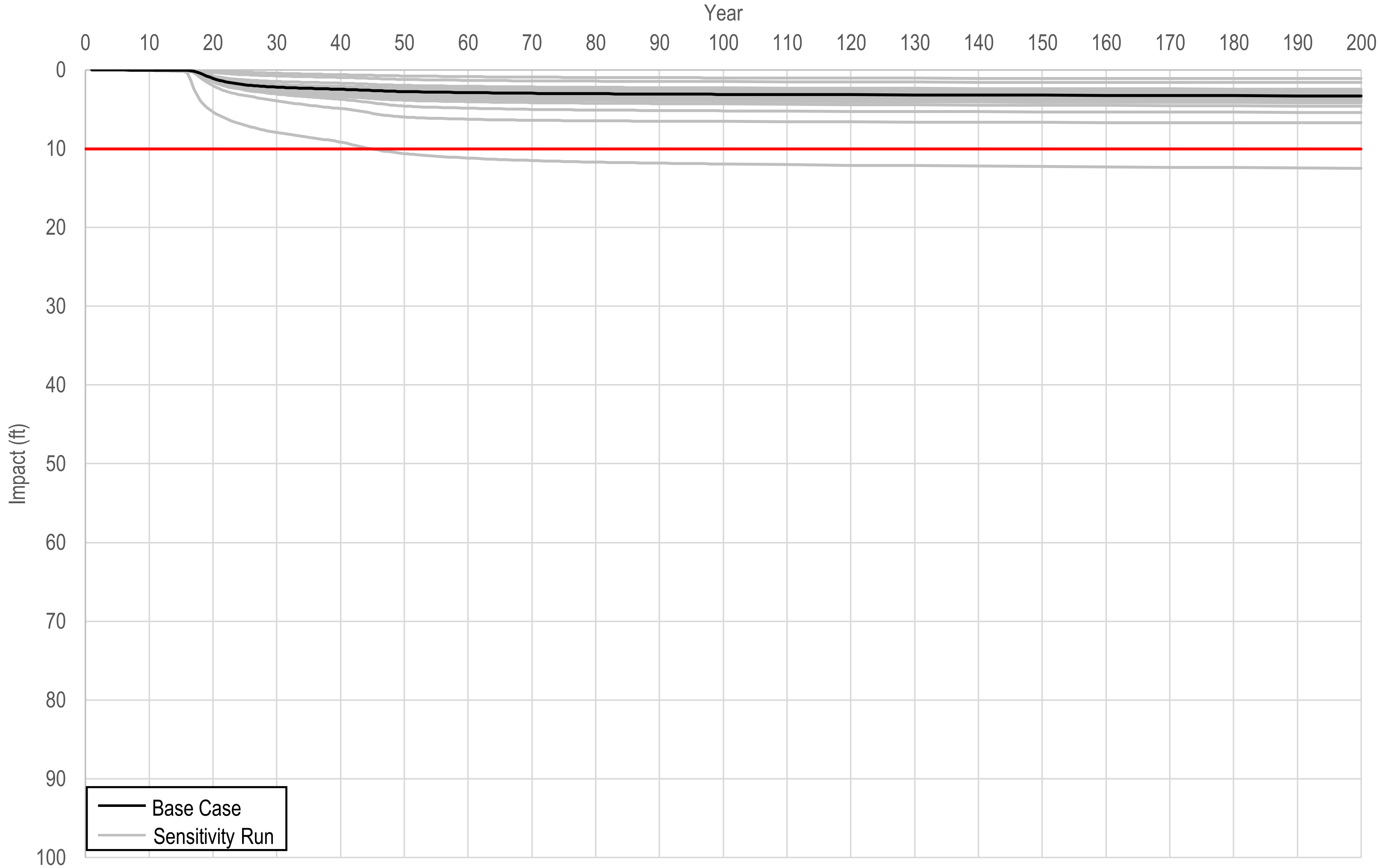
CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-7		



GDE Impact Hydrograph – Sensitivity Analysis – Devils Canyon (DC) 6.6W

CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-8		

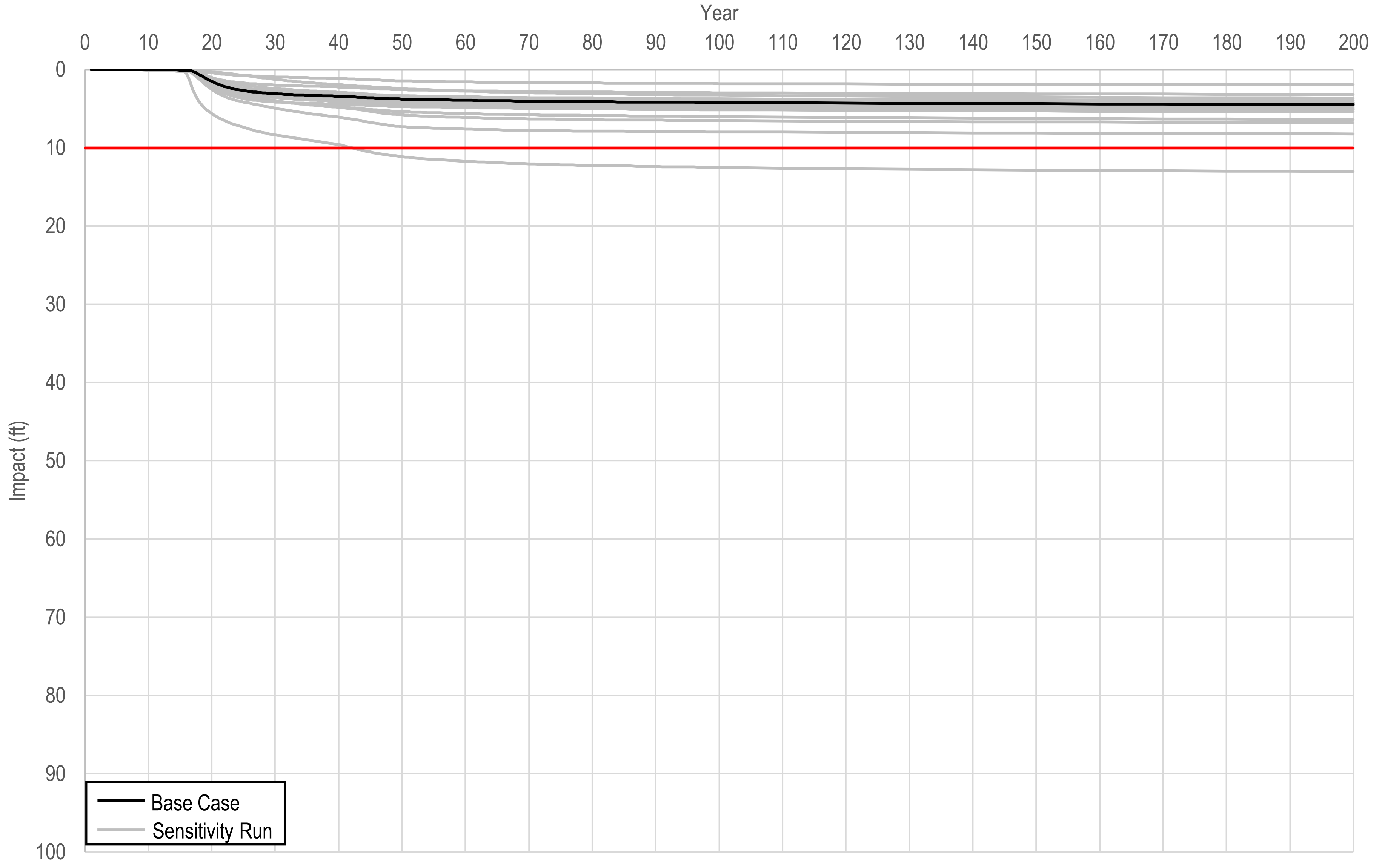
D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx



GDE Impact Hydrograph – Sensitivity Analysis – Devils Canyon (DC) 8.1C

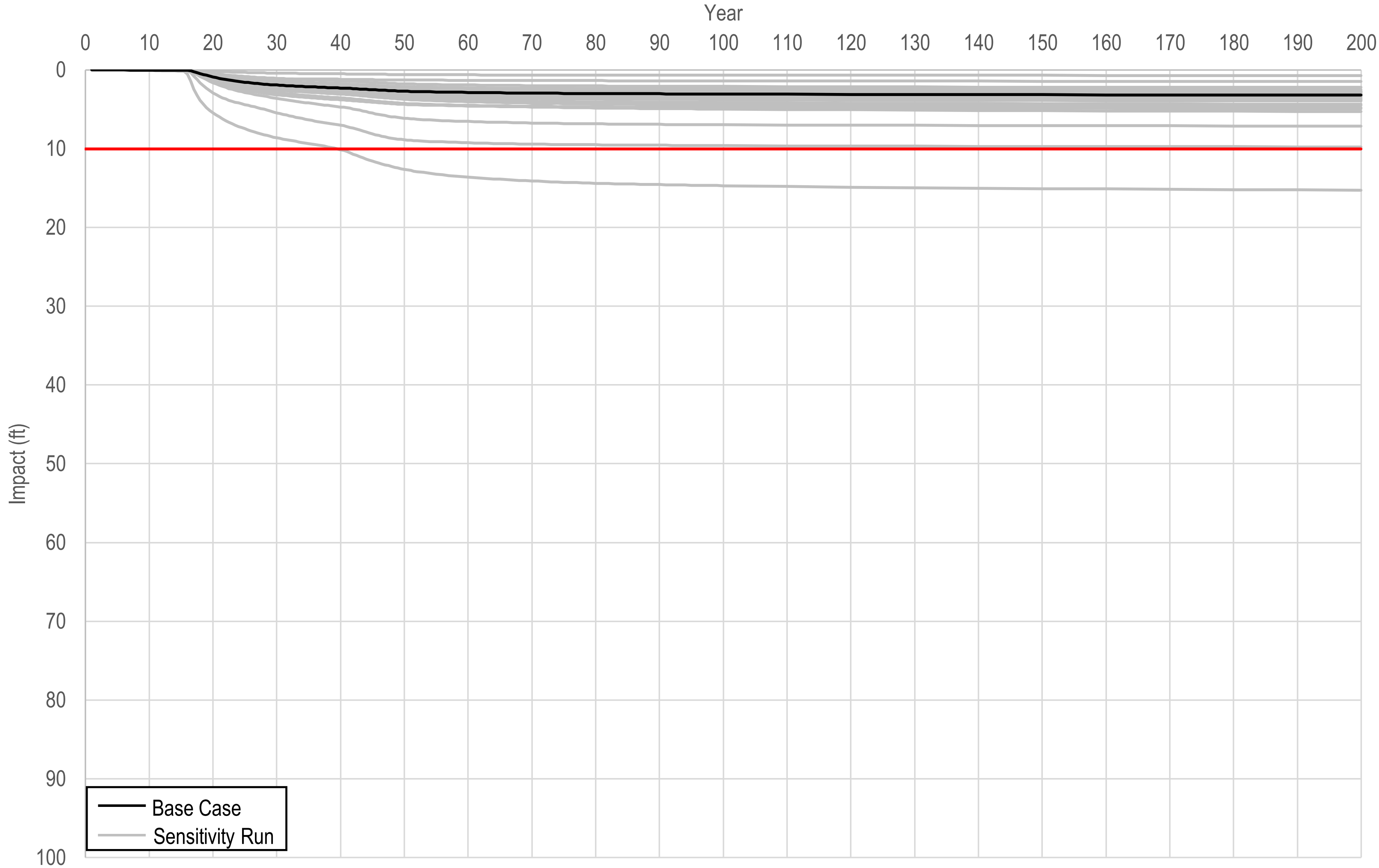
CLIENT: Resolution Copper		PROJECT: 3D Regional Groundwater Model	
JOB: 31400968.001		DRAWN: GM	CHECKED: DO
DATE: November 2018		FIGURE: C-9	

D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx



GDE Impact Hydrograph – Sensitivity Analysis – Devils Canyon (DC) 8.2W

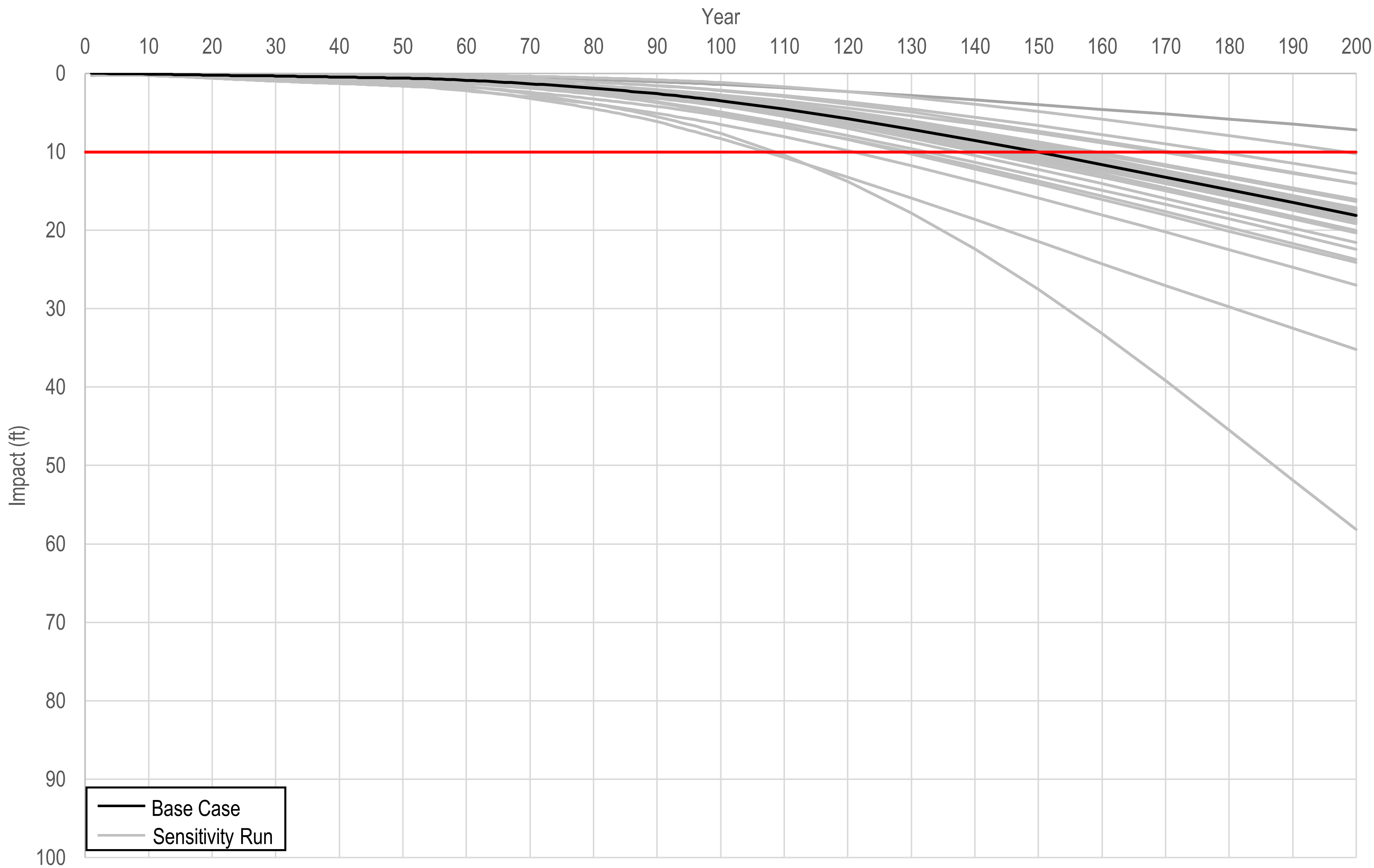
CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-10		



GDE Impact Hydrograph – Sensitivity Analysis – Devils Canyon (DC) 8.8C

CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-11		

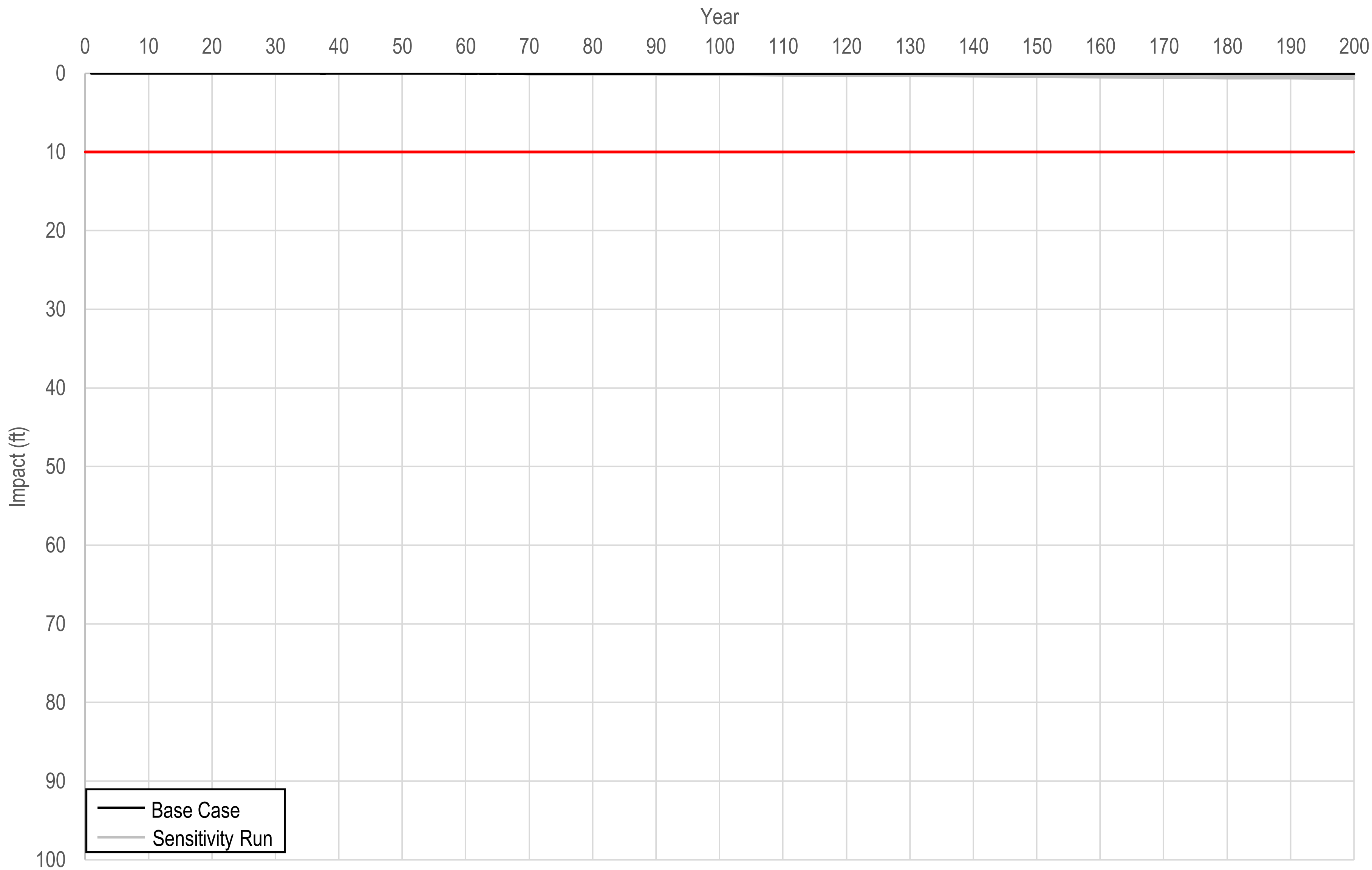
D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx



GDE Impact Hydrograph – Sensitivity Analysis – DHRES-16_743

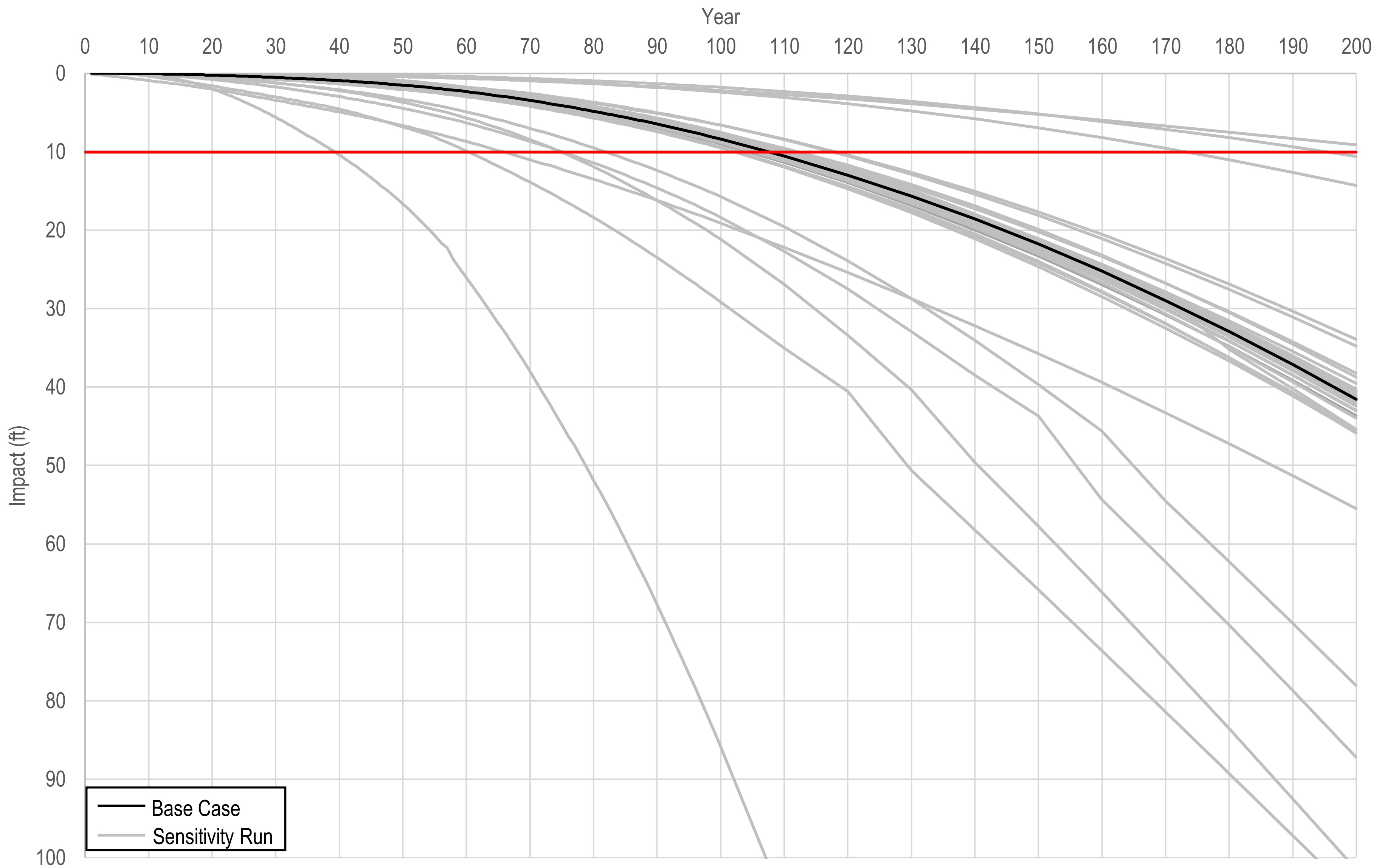
CLIENT: Resolution Copper		PROJECT: 3D Regional Groundwater Model	
JOB: 31400968.001		DRAWN: GM	CHECKED: DO
DATE: November 2018		FIGURE: C-12	

D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx



GDE Impact Hydrograph – Sensitivity Analysis – Gallery Well

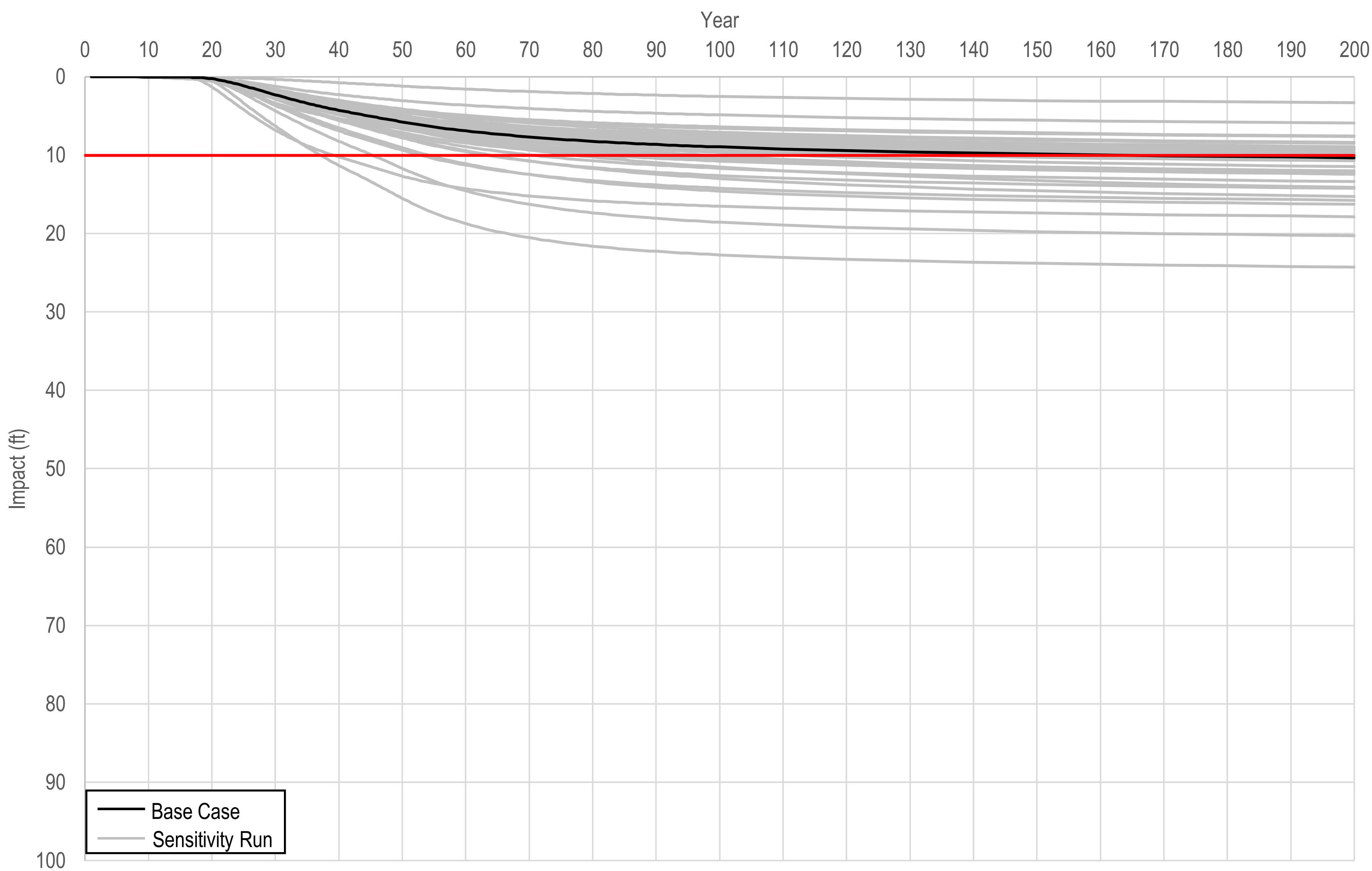
CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model
JOB:	31400968.001	DRAWN: GM	CHECKED: DO
DATE:	November 2018	FIGURE:	C-13



GDE Impact Hydrograph – Sensitivity Analysis – Hidden Spring

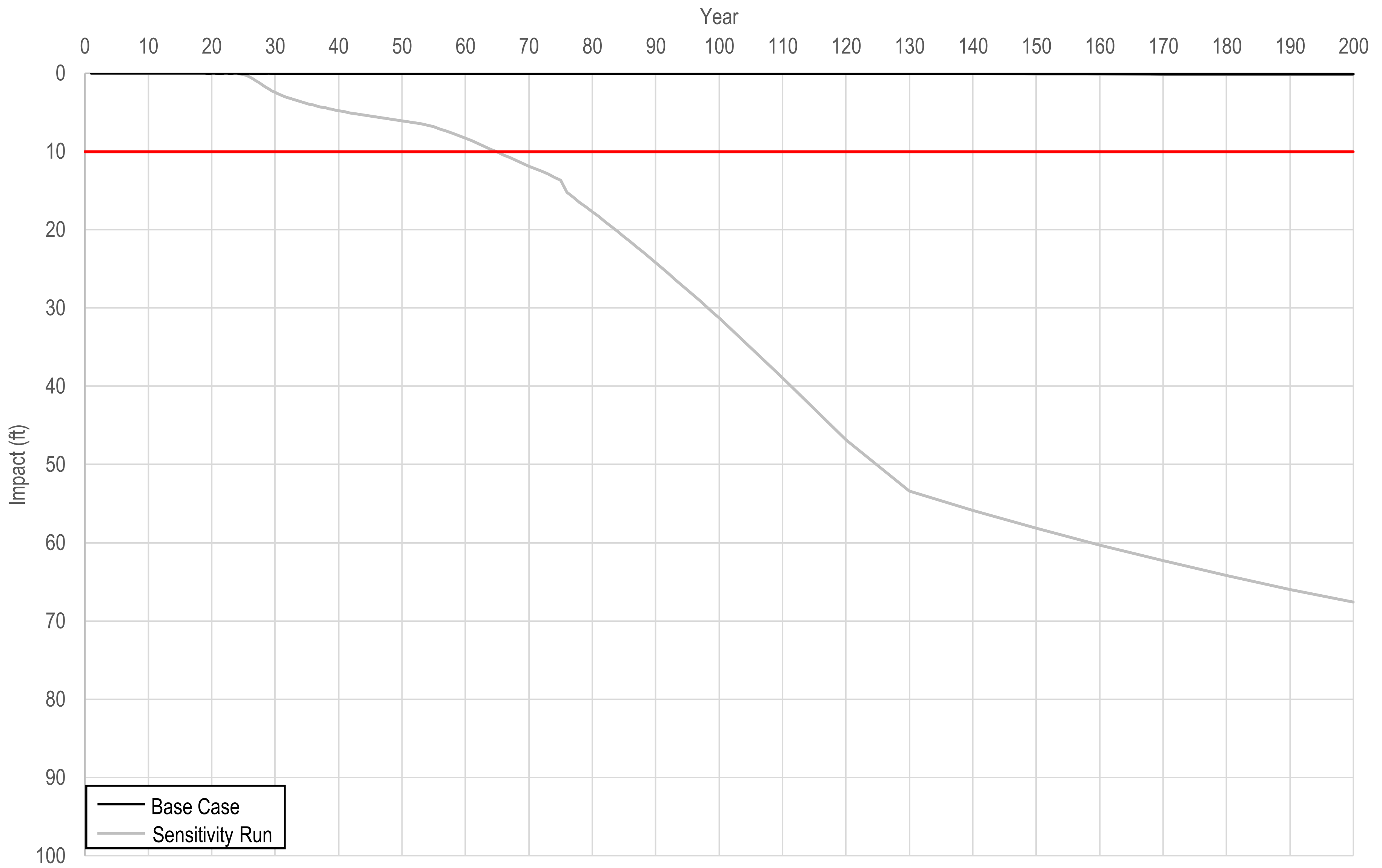
CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-14		

D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx

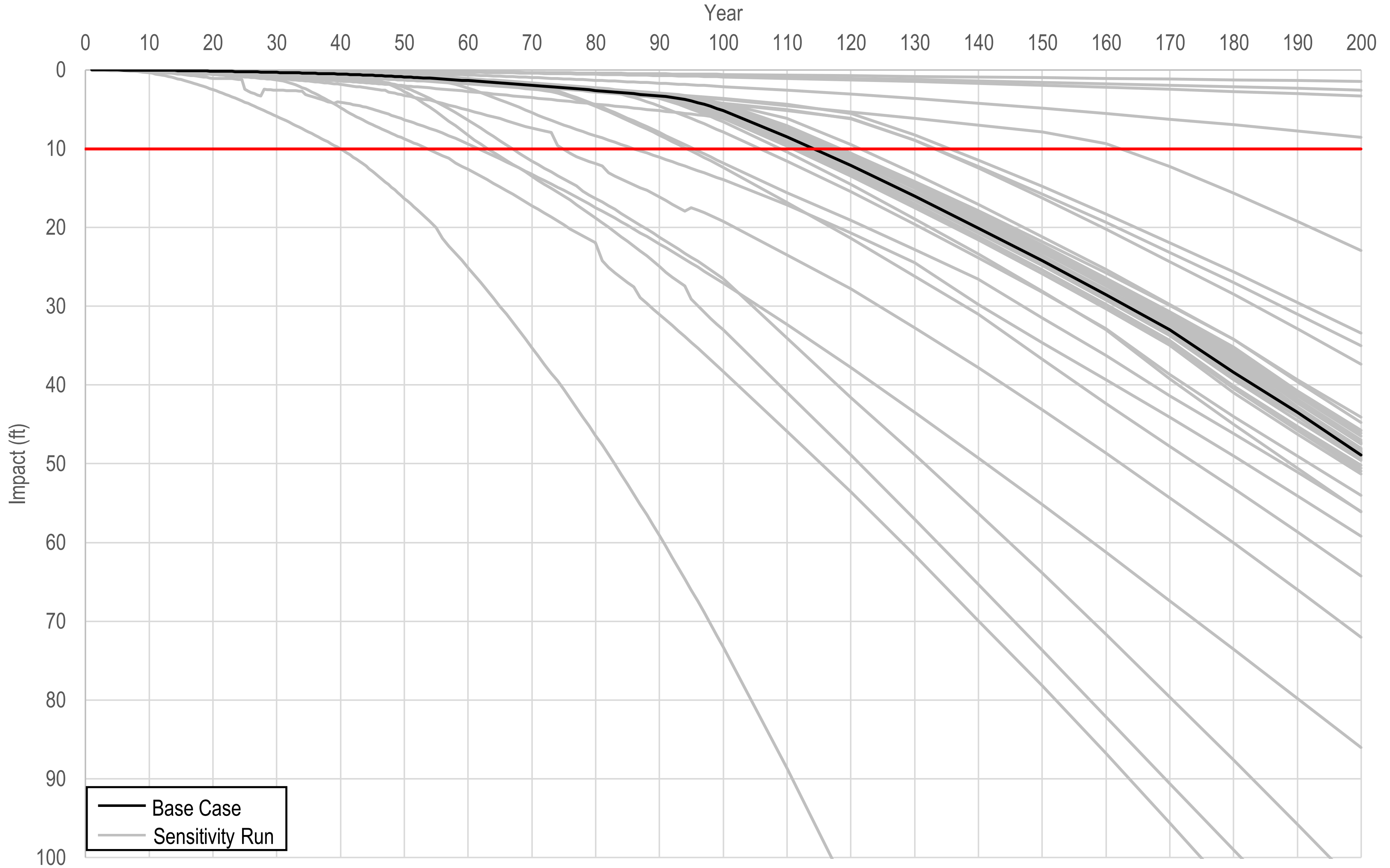


GDE Impact Hydrograph – Sensitivity Analysis – HRES-06			
CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model
JOB:	31400968.001	DRAWN: GM	CHECKED: DO
DATE:	November 2018	FIGURE:	C-15

D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx



GDE Impact Hydrograph – Sensitivity Analysis – Iberri Spring			
CLIENT: Resolution Copper		PROJECT: 3D Regional Groundwater Model	
JOB: 31400968.001		DRAWN: GM	CHECKED: DO
DATE: November 2018		FIGURE: C-16	

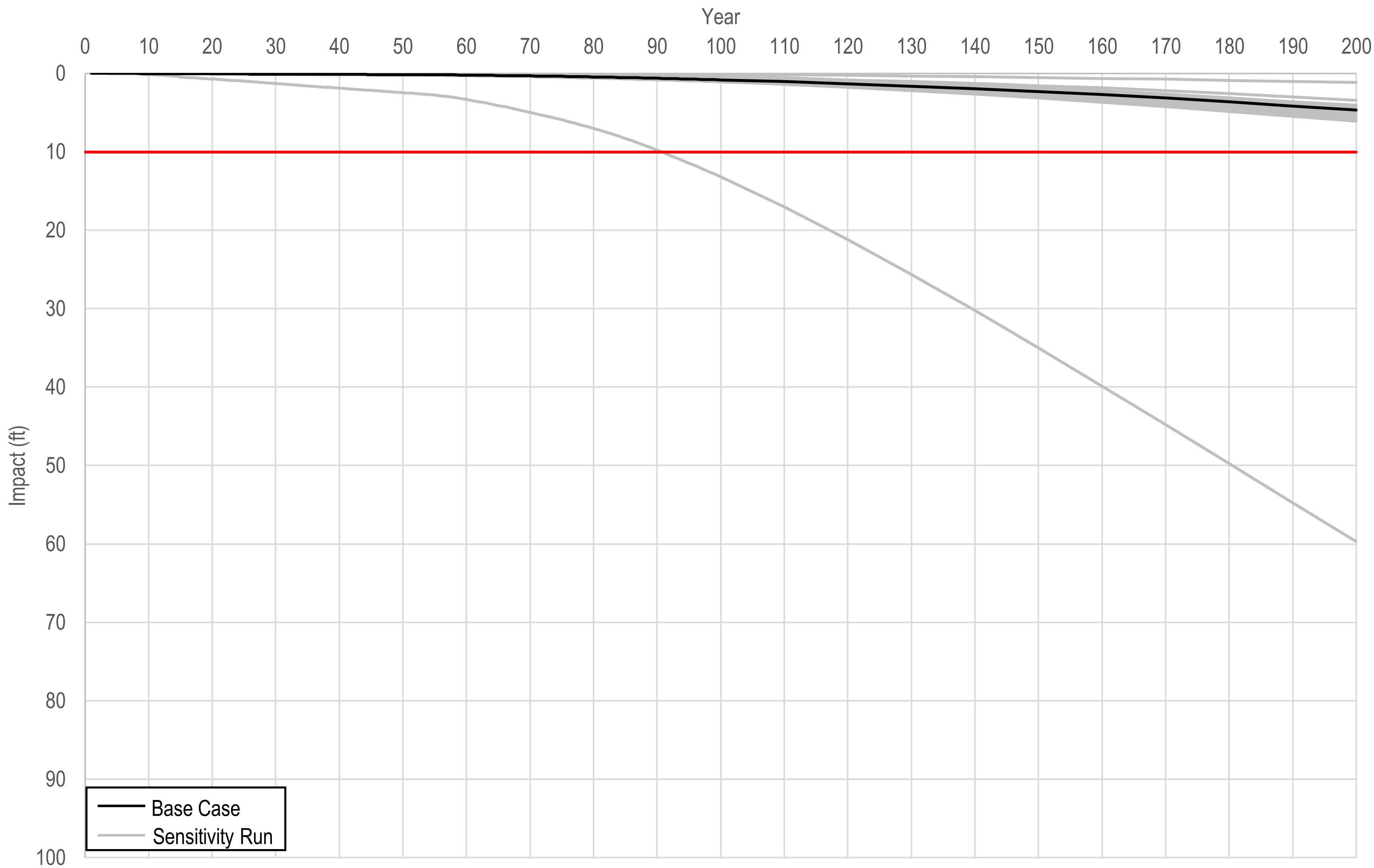


wsp

GDE Impact Hydrograph – Sensitivity Analysis – Kane Spring

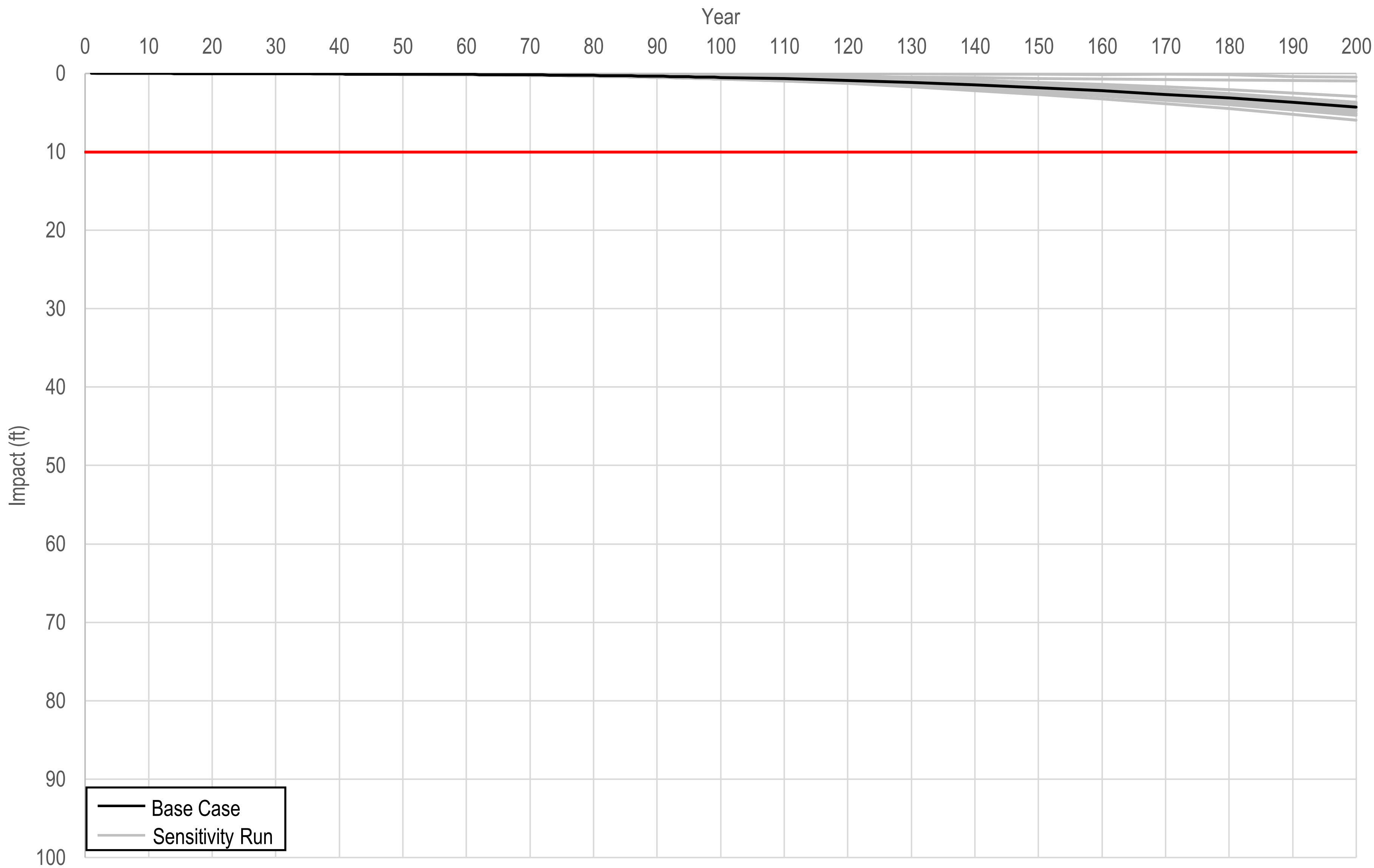
CLIENT: Resolution Copper	PROJECT: 3D Regional Groundwater Model		
JOB: 31400968.001	DRAWN: GM	CHECKED: DO	
DATE: November 2018	FIGURE: C-17		

D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx



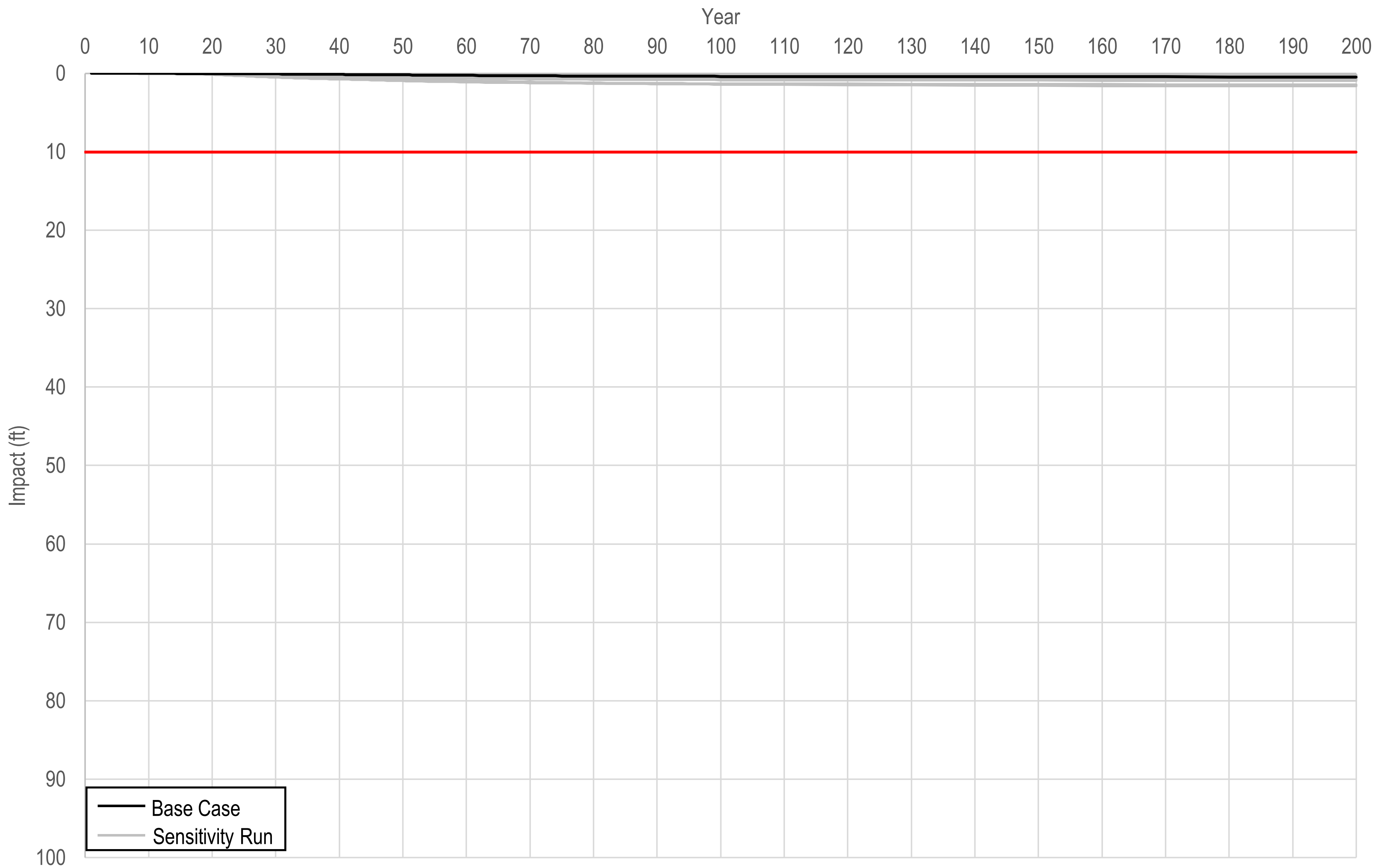
GDE Impact Hydrograph – Sensitivity Analysis – McGinnel Mine Spring	
CLIENT: Resolution Copper	PROJECT: 3D Regional Groundwater Model
JOB: 31400968.001	DRAWN: GM CHECKED: DO
DATE: November 2018	FIGURE: C-18

D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx



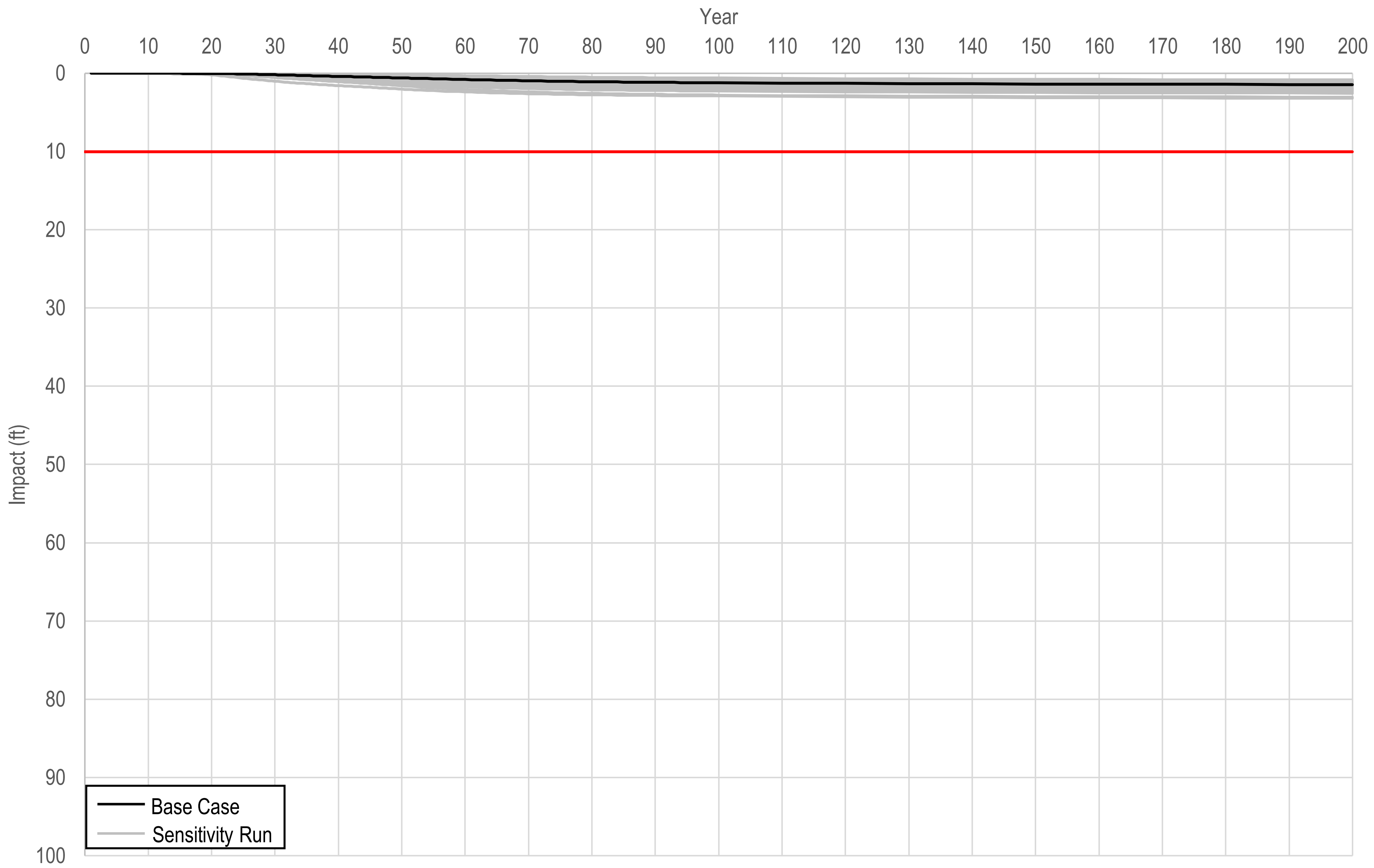
GDE Impact Hydrograph – Sensitivity Analysis – McGinnel Spring			
CLIENT: Resolution Copper		PROJECT: 3D Regional Groundwater Model	
JOB: 31400968.001		DRAWN: GM	CHECKED: DO
DATE: November 2018		FIGURE: C-19	

D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx

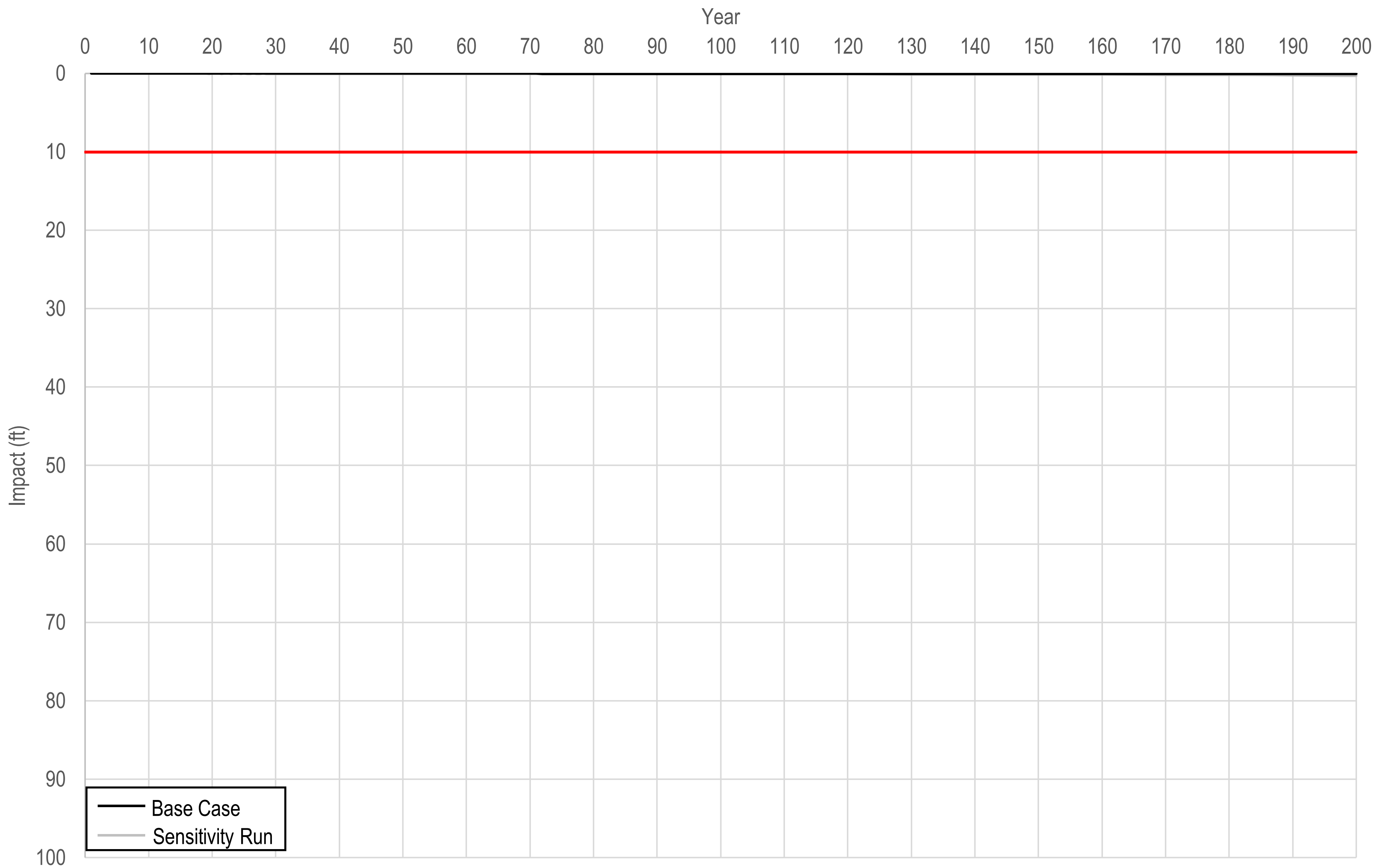


GDE Impact Hydrograph – Sensitivity Analysis – Lower Mineral Spring

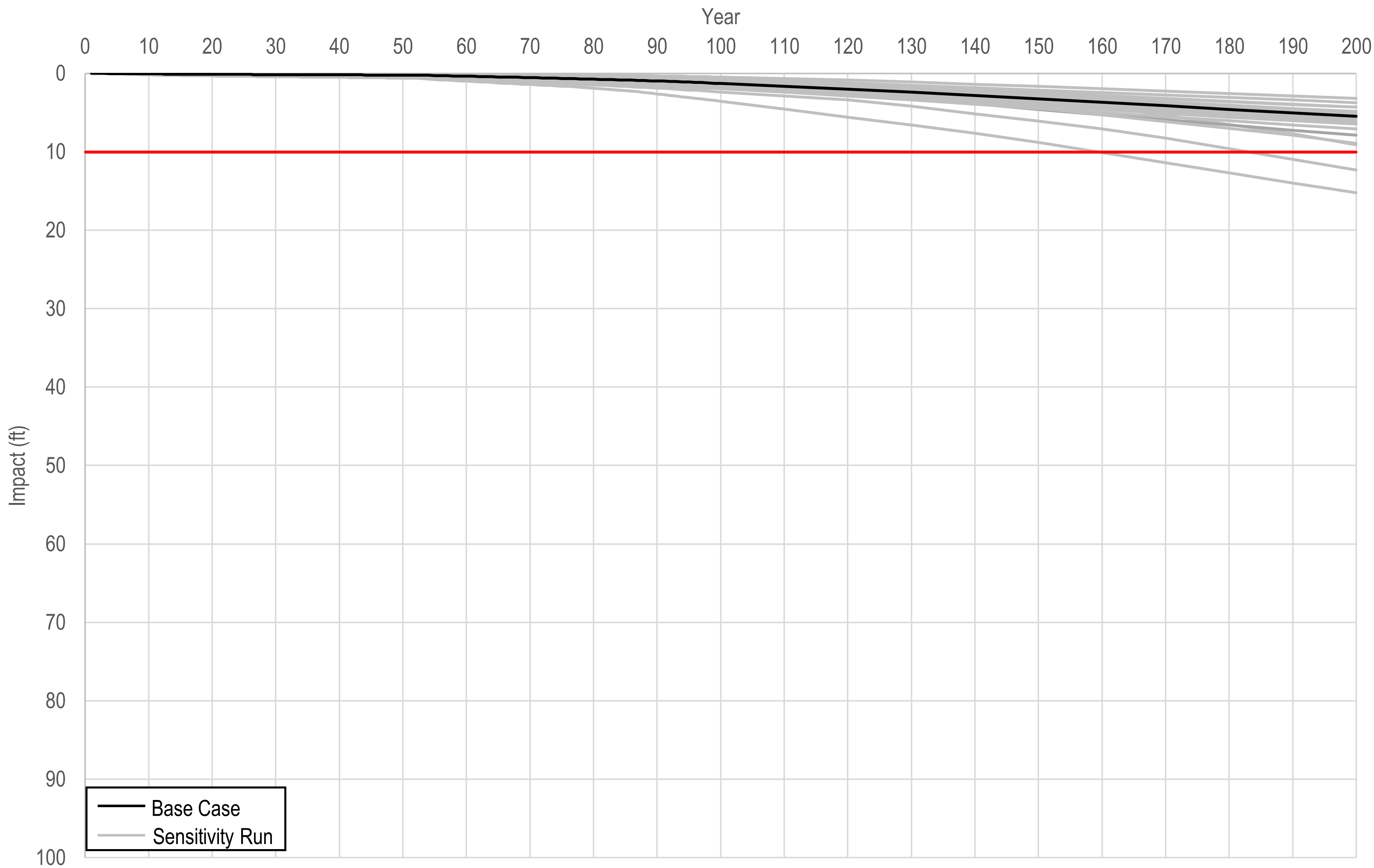
CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-20		



GDE Impact Hydrograph – Sensitivity Analysis – Mineral Creek (MC) 6.9	
CLIENT: Resolution Copper	PROJECT: 3D Regional Groundwater Model
JOB: 31400968.001	DRAWN: GM CHECKED: DO
DATE: November 2018	FIGURE: C-21

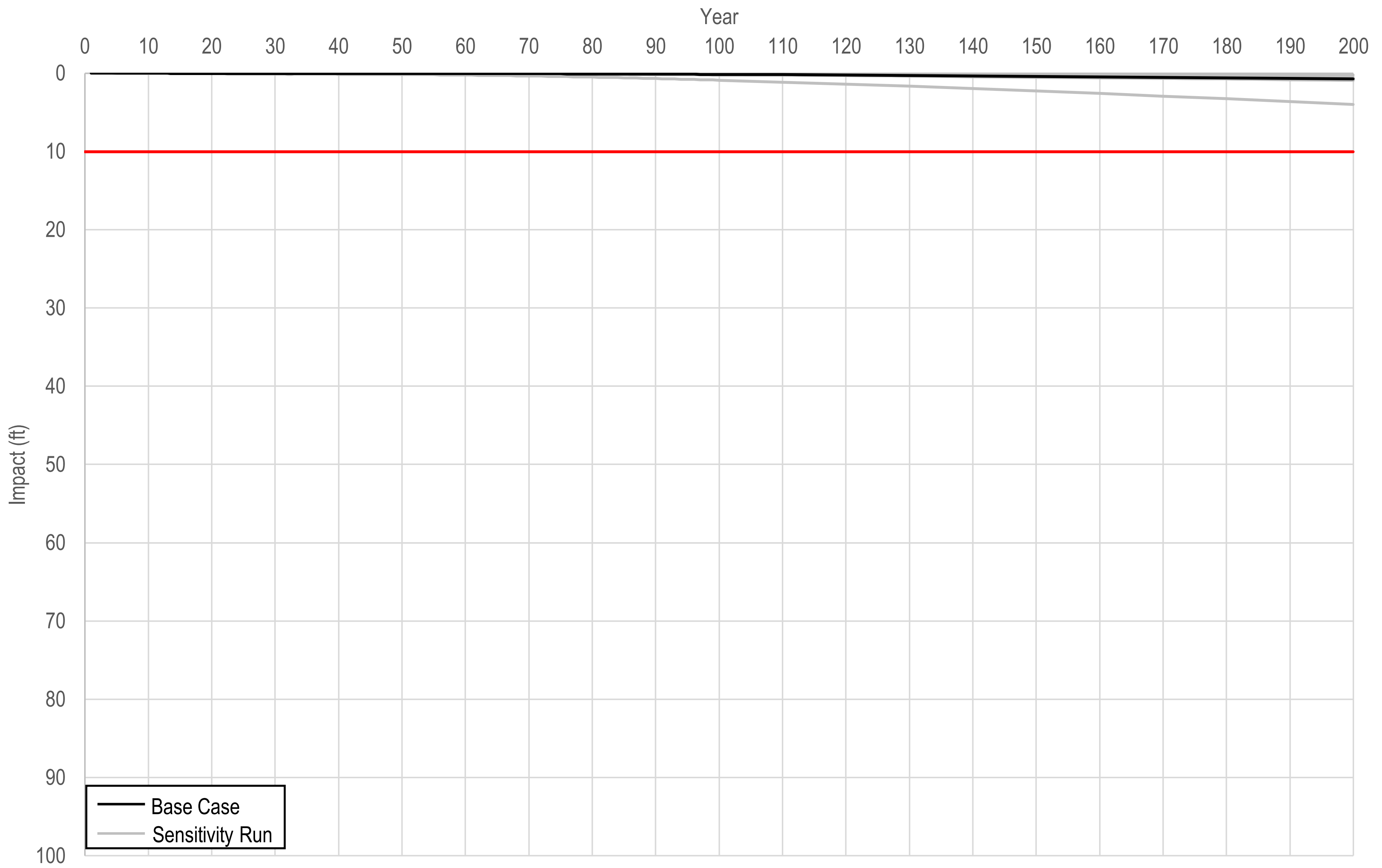


GDE Impact Hydrograph – Sensitivity Analysis – No Name Spring			
CLIENT: Resolution Copper		PROJECT: 3D Regional Groundwater Model	
JOB: 31400968.001		DRAWN: GM	CHECKED: DO
DATE: November 2018		FIGURE: C-22	

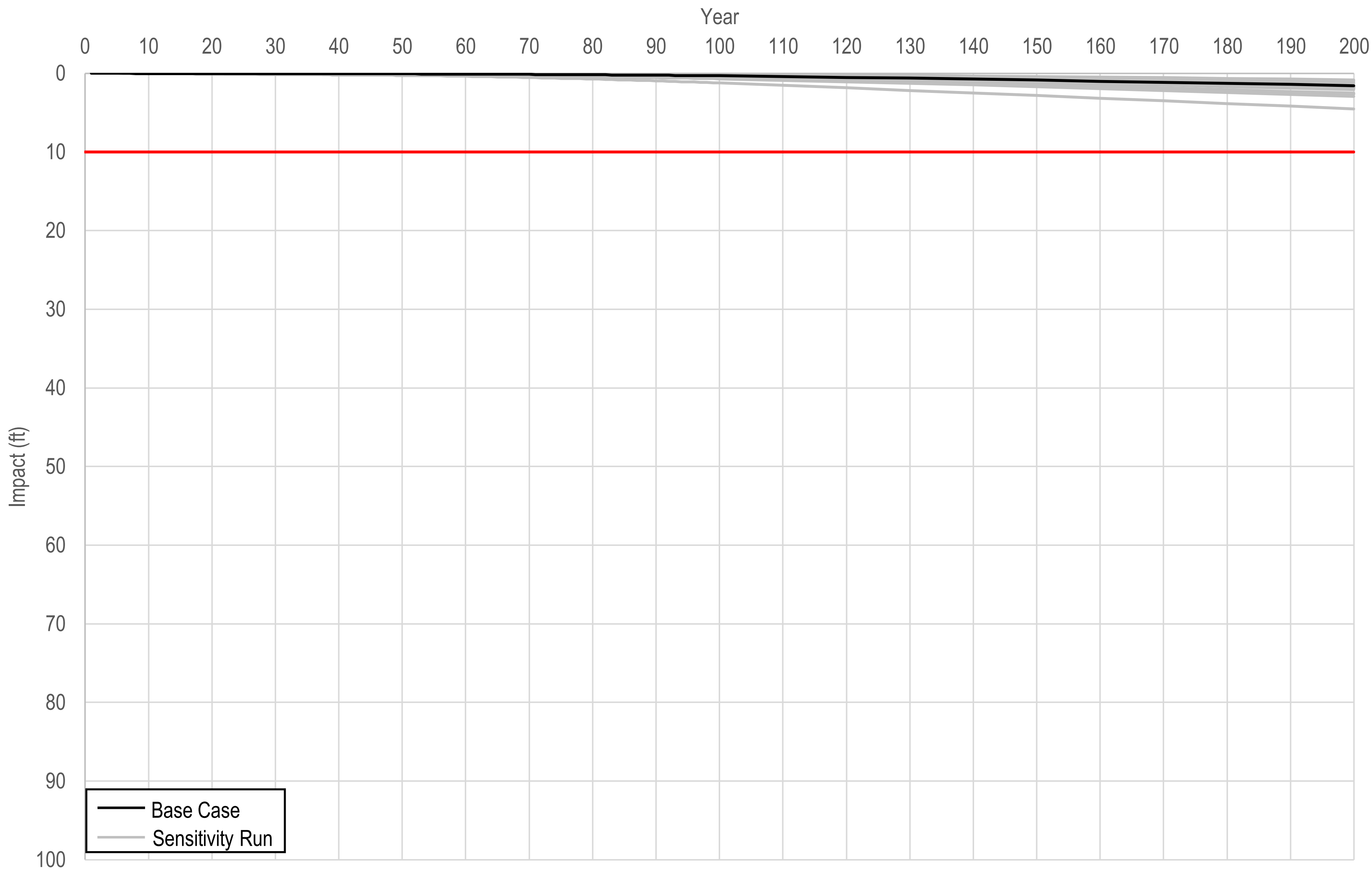


GDE Impact Hydrograph – Sensitivity Analysis – Queen Creek (QC) 17.39

CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-23		

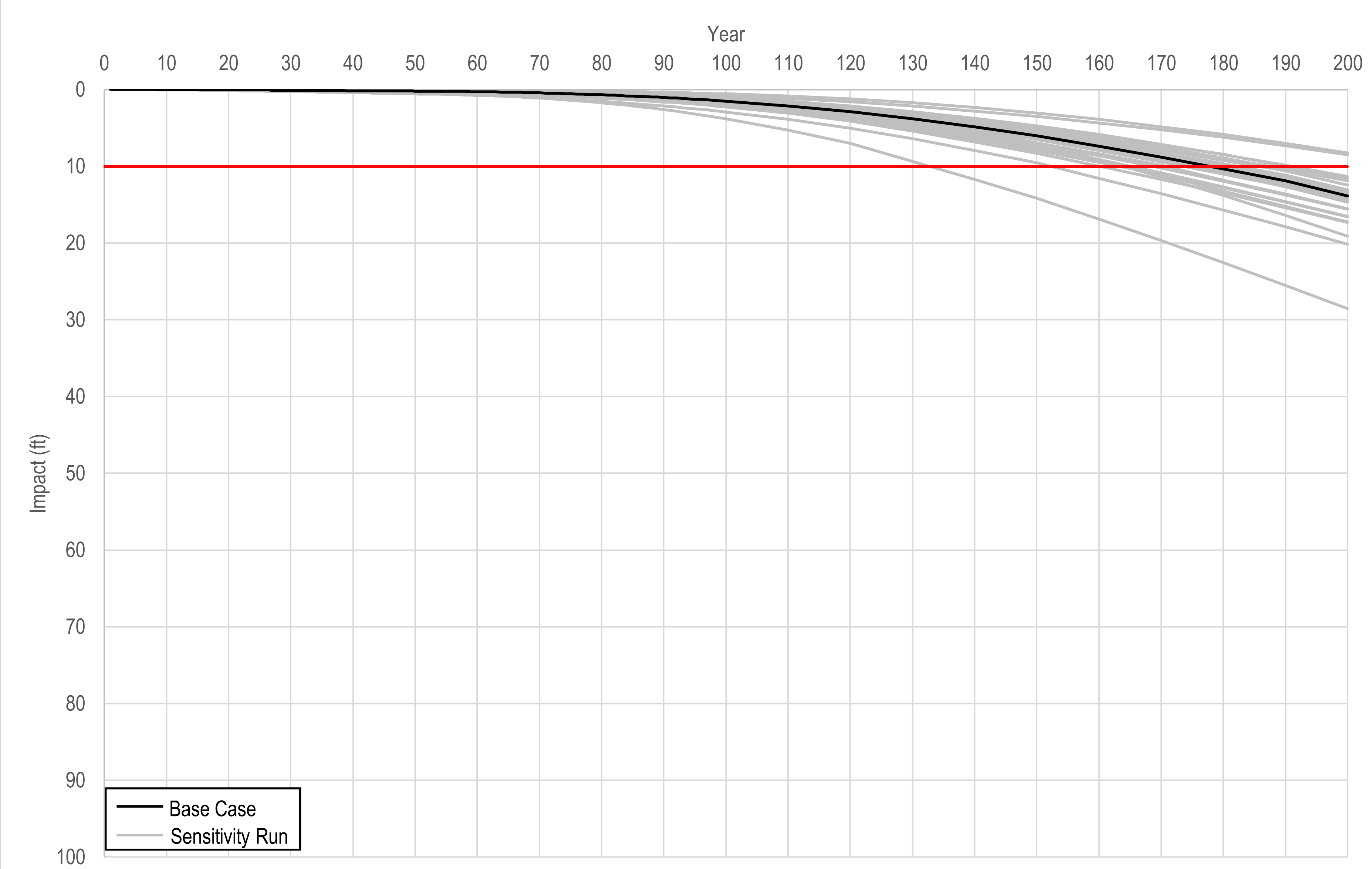


GDE Impact Hydrograph – Sensitivity Analysis – Rock Horizontal Spring		
CLIENT: Resolution Copper	PROJECT: 3D Regional Groundwater Model	
JOB: 31400968.001	DRAWN: GM	CHECKED: DO
DATE: November 2018	FIGURE: C-24	



GDE Impact Hydrograph – Sensitivity Analysis – Telegraph Canyon (TC) 0.6

CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-25		

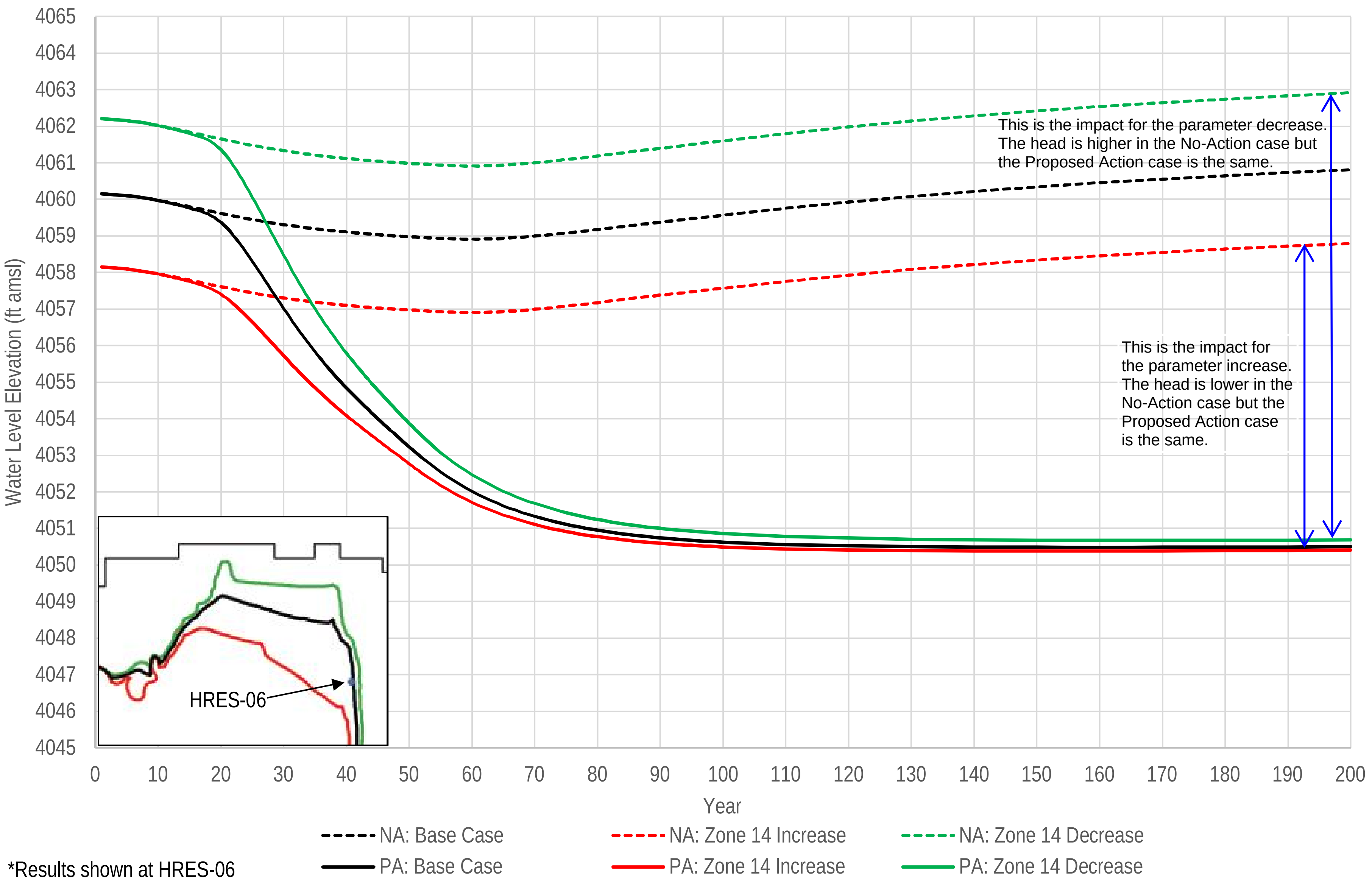


GDE Impact Hydrograph – Sensitivity Analysis – Walker Spring

CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model		
JOB:	31400968.001	DRAWN:	GM	CHECKED:	DO
DATE:	November 2018	FIGURE:	C-26		

D:\Resolution_models\Results Processing\GDE\GDE_LinkedChart.docx

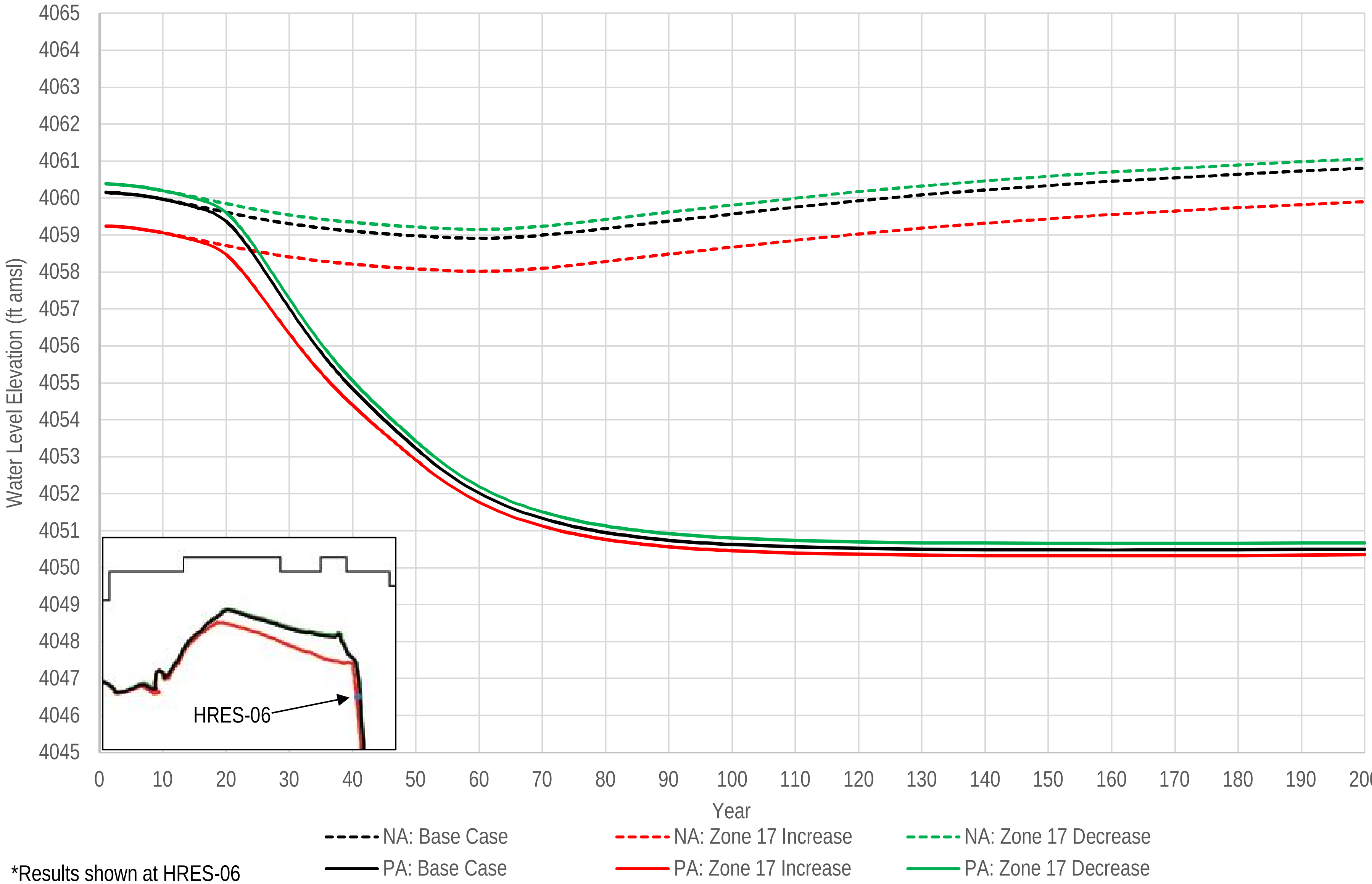
APPENDIX A



*Results shown at HRES-06

Zone 14 (Tal) – Sensitivity Analysis Hydrograph Comparison

CLIENT:	Resolution Copper	PROJECT:	3D Regional Groundwater Model
JOB:	31400968.001	DRAWN: CP	CHECKED: DO
DATE:	November 2018	FIGURE:	Appendix A



Zone 17 (Tal) – Sensitivity Analysis Hydrograph Comparison

CLIENT: Resolution Copper
PROJECT: 3D Regional Groundwater Model
JOB: 31400968.001
DRAWN: CP
CHECKED: DO
DATE: November 2018
FIGURE: Appendix A

Victoria Boyne

From: ResolutionProjectRecord
Subject: FW: Response to GW-90
Attachments: Memo - RC GW Model Sensitivity Analysis Results_111918 WSP.PDF

From: Peacey, Victoria (RC) <Victoria.Peacey@riotinto.com>
Sent: Tuesday, November 20, 2018 2:39 PM
To: Chris Garrett <cgarrett@swca.com>; mcrasmussen@fs.fed.us; Oliver, Douglas <douglas.oliver@wsp.com>; gustavo.meza-cuadra@wsp.com
Cc: Donna Morey <dmorey@swca.com>; Morissette, Mary (RC) <Mary.Morissette@riotinto.com>; RCPermitting <RCPermitting@riotinto.com>; Ghidotti, Greg (G&I) <Gregory.Ghidotti@riotinto.com>
Subject: RE: Response to GW-90

Hi Chris,

Thanks for the review. In response to your first point (There's one missing GDE: Queen Creek at Whitlow Ranch Dam) - it was not listed as a GDE in the final September 10th process memo, so WSP did not generate impact or drawdown hydrographs for this location. There won't be any impact at this location. It is located at a far distance to the west of the mine and separated by depth and geologic units/structure. Further, a hydrograph for this location won't show any drawdown or impact as it is a specified head cell.

Your comment on the internal inconsistency with Bitter Spring is a good catch. WSP has re-checked all impact hydrographs against those in the predictive results memo and Bitter Spring was the only one with an issue. Although Bitter Spring is the only hydrograph that was changed, WSP has re-issued the Sensitivity memo and entire excel file pack rather than providing replacement sheets, as that will be cleaner.

Attached is the revised Sensitivity Analysis Memo (November 9) with corrected impact hydrograph for Bitter Springs (Figure C-3).

I will send the revised Sensitivity Analysis Hydrograph Excel zip file in a separate e-mail due to file size constraints.

Thanks,
Vicky