Fall 9-12-2024

Response to Agency Comments on the Butte Priority Soils Operable Unit (BPSOU) Draft Blacktail Creek Groundwater Hydraulic Control System Pre-Design Investigation Evaluation Report Prepared for Atlantic Richfield Company By Stantec Consulting Services, Inc. Dated September 12, 2024 Date of Comments: February 1, 2024

Stantec Consulting Services, Inc.

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1 Introduction

We have reviewed the EPA comment letter dated February 1, 2024, regarding the draft Blacktail Creek (BTC) Groundwater Hydraulic Control System (GHCS) Pre-Design Investigation Evaluation Report (PDI ER).

For clarity and to avoid duplication in response, we have compiled the individual comments from the letter, categorized them, and organized responses by category below. As part of this process, multi-part comments were separated into individual comments. For example, comment 68 relating to various aspects of the water budget for the groundwater model was split into three separate comments which are addressed separately under the sections titled "Increase reporting: Flow Budget and Recharge" (Section 7.4), "Increase reporting: Flux" (Section 7.2), and "Hydrogeologic Framework: Wetland Drains" (Section 3.5). Table 1 is a summary of the comments and the assigned categories. The table has been provided in a digital format so that the comments can be sorted and filtered. The following sections provide a summary and response for each category of comment. The comment numbers provided in parentheses correspond to the detailed comment numbers assigned in Table 1 and to the more generalized numbers provided in original comment letter. An index is provided at the end of this letter.

2 Complete Additional Testing.

The following comments suggest completion of additional field testing or installation of additional wells to support selection and design of the BTC GHCS.

2.1 Testing to evaluate Interaction Between Subdrain and Proposed BTC GHCS (42, 40c4)

Comments: "Further predesign evaluation should be done using either an accurately calibrated model or additional field tests, whichever will provide the best and most reliable data.

Additional evaluation of the potential BTC GHCS elements is needed before they are selected and designed. The PDI ER and appendices focus largely on using the groundwater model for this evaluation. There may be limitations to producing a model that is sufficiently calibrated and accurate that it can be the sole determinant used for remedy selection and design.

The data provided by the BTC pumping test shows the utility of field-testing potential capture systems. The pumping test provides real-world data demonstrating how capture well BTC-PW- 01 near the Visitor Center causes small scale declines in water levels near the subdrain which could have significant effects on the existing remedy. There is value in conducting additional pumping tests to provide pilot tests for proposed groundwater controls. General Comments discusses that a subdrain tracer test should be performed during additional pumping tests to evaluate if the capture wells induce leakage from the subdrain and the flow path such leakage takes.

All potential BTC groundwater hydraulic controls will require a pipeline to BTL for treatment and that pipeline could be constructed to accommodate long-term pumping tests. It may be appropriate to better calibrate the groundwater model and use it to help bookend the flow rates from the BTC capture system so that the pipeline can be constructed and used for further pump testing. Then additional pump tests could be conducted to vary the flow rates and optimize them to provide the BTC hydraulic control required by the CD while reducing negative impacts to the subdrain and other existing groundwater remedy elements." (42)

"There were comments provided to MTAC on 9/22/22 recommending that modeled head calibration achieve 0.5-foot accuracy and be unbiased near the lower subdrain. That recommendation is based on the magnitude of the groundwater divide that separates the subdrain groundwater capture from the creek. This groundwater divide is approximately 0.5-1 foot higher than upgradient groundwater levels. This level of calibration accuracy may be needed to accurately portray the existing subdrain capture and any impacts to the subdrain from the new BTC GHCS. If the model cannot be sufficiently calibrated to achieve this level of detail it may be appropriate to perform additional pumping and tracer tests." (40c4)

Response: The comments above emphasize a multiple lines of evidence approach that includes field testing along with numerical modeling to support the design of the BTC GHCS. Atlantic Richfield (AR) agrees with this approach and has conducted the pumping test at BTC-PW-01 specifically to collect reliable field data to validate modeling and support design elements. The numerical model can then be used to extrapolate and evaluate the design to the larger full scale BTC GHC.

These comments express concern that pumping at BTC-PW-01 and the proposed BTC GHCS could induce leakage from the BPSOU Subdrain and impact capture of the BPSOU Subdrain. The reduction of flow within the BPSOU Subdrain that was observed during the BTC pumping tests (approximately 12.5 gallons per minute during the 72-hour test) was consistent with a reduction of gain to the BPSOU Subdrain. The reduction in flow is not interpreted to represent leakage from the BPSOU Subdrain. Observed and simulated gradients indicate that pumping at BTC-PW-01 and proposed pumping from the BTC GHCS has not and would not induce leakage from the BPSOU Subdrain. Overlap of the influence of the BPSOU Subdrain and the proposed BTC GHCS is consistent with best practices for capture system optimization to prevent loss of capture from between the individual systems. Additionally, the flexibility of the proposed remedy and optimization of the remedy will further address potential for leakage from the BPSOU Subdrain.

The comments suggest completing field tests including additional pumping tests and BPSOU Subdrain tracer tests. The existing monitoring network contains sufficient monitoring wells to support model calibration. Specially, between north of BTC, south of uSBC and West of Kaw Avenue there are 34 wells that were included as head targets in the Model. This includes 16 well locations, 13 of which have wells screened at multiple depths.

These comments emphasize the importance of including flexibility in the design of the BTC GHCS and the inclusion of performance monitoring and optimization in operation of the remedy. Vertical extraction wells have been selected as the preferred alternative specifically because of their flexibility. In response to performance monitoring data, the pumping rates at individual wells can be adjusted and if necessary, additional wells could be added to the system. Although the current preferred alternative identifies the installation of two extraction wells, the 60% design will consider utilizing a single header pipe with higher hydraulic capacity (instead of multiple dedicated conveyance lines) to accommodate potential expansion. This would accommodate changes/variability in well details, as warranted.

2.2 Testing to Evaluate Groundwater Quality from Long-Term Operation of BTC GHCS (6)

Comments: "Assessment of groundwater quality for groundwater captured during construction dewatering and by long-term operation of the BTC GHCS should be based on additional data that are collected during construction and not from the short-term BTC pumping test.

A DQO for the BTC pumping test is, "Estimate the groundwater quality that may be captured during construction dewatering and by the BTC groundwater control, which may require treatment at Butte Treatment Lagoons (BTL)." Section 5.1 of the PDI ER responds to this DQO by stating metal concentrations in the discharge from the pumping test did not exceed in-stream chronic surface water performance standards. A 72-hour pumping test and a 24-hour pumping test are not sufficiently long-term to understand how chemistry may change during long-term pumping (i.e., during construction and operation of the GHCS). Water treatment plans for both construction and long-term operation of the GHCS should be developed based on additional data or estimates of long-term capture water quality." (6)

Response: Due to the complex hydrogeology, temporal variability, and importance of geochemical processes on the fate and transport of inorganic contaminants of concern (COCs), it is difficult to determine the concentrations of groundwater that the proposed BTC GHCS will extract over the period of operation. This uncertainty emphasizes the importance of the flexibility included in the proposed remedy.

Existing historical groundwater sampling data from monitoring wells in the confluence area and upgradient of the proposed BTC GHCS provide significant information regarding the potential dissolved COC concentrations in groundwater that may be extracted from the proposed pumping wells. Those data were summarized in the PDI ER, including in:

- Figures 6A through 6F (dissolved COC concentrations compared to groundwater remediation goals);
- Figures 7A through 7H (total recoverable COC concentrations compared to surface water performance standards); and,
- Appendix D to the PDI ER (Comparison of Historical COC Results to Groundwater Remediation Goals).

The relevant sections of the PDI ER text (Section 3.3 and Section 5.1) will be updated to expand the discussion of the groundwater chemistry evaluation as they relate to anticipated chemistry of the extracted groundwater.

2.3 Install Additional Monitoring Wells (16b, 40c5, 40c7, 40c8)

Comments: "The gentler and more widespread drawdown shown in Figures B-9A and B-9B, extending from BTC-PW-01 towards Upper Silver Bow Creek and the BPSOU subdrain in a north-northwest direction, could also be because of the lack of piezometers in that area. Piezometers along that direction could help to constrain contour interpretation. The same is true moving to the south of BTC-PW-01. The shallower gradient could also be due to shorter distance and greater flow impact at BTC compared to the subdrain." (16B)

"The magnitude and extent of the groundwater capture zone created by the subdrain could be much better understood if additional nested shallow wells or piezometers were installed adjacent to the lower subdrain." (40c5)

"Installation of additional wells would also help with drawing potentiometric contours which are currently being drawn using subdrain water levels that are not representative of the adjacent aquifer. Those wells would also be valuable if additional pumping tests are conducted to evaluate effects of BTC groundwater controls on the subdrain." (40c7)

"In the absence of additional monitoring wells adjacent to the subdrain, a very high level of accuracy is needed in the model calibration to the existing wells to assess the impacts to subdrain capture." (40c8)

Response: The comments suggest that additional wells located northwest of BTC-PW-01 as well as nested shallow wells adjacent to the lower BPSOU Subdrain could help constrain the observed groundwater elevation contours and the capture zones of the systems. The current monitoring system is sufficient for remedy selection. Specially, between north of BTC, south of uSBC and West of Kaw Avenue there are 34 wells that were included as head targets in the Model. This includes 16 well locations, 13 of which have wells screened at multiple depths. Installation of additional wells is not necessary to support remedy selection and design.

We recognize the limitations of using water levels measured within the MH-MSD locations. Specifically, that the BPSOU Subdrain levels measured at the MH-MSD locations represent levels within the BPSOU Subdrain and are expected to be lower than the adjacent groundwater levels due to well loss. We have removed the MH-MSD elevations from the head targets in the model. Because the MH-MSD levels directly represent water levels in the BPSOU Subdrain, however, we have updated the model to instead use these elevations to set transient stages for the drain boundary conditions representing the BPSOU Subdrain. The BPSOU Subdrain water levels will also continue to be used to inform manual contours included in the pumping test evaluation but with understanding of the limitations of using these monitoring points to represent groundwater elevations (they represent minimum elevations expected for groundwater adjacent to the drain at those locations).

For discussion regarding concern of potential leakage from the BPSOU Subdrain, see Section 2.1.

3 Hydrogeologic Framework

The following comments relate to the hydrogeologic framework for the model. Specifically, they express concern regarding the applicability of selected properties, boundary conditions, and temporal discretization used in the model based on the hydrogeologic understanding of the Site.

3.1 Hydraulic Conductivity (k) Ranges (52, 79, 40b7)

Comments: "Though it's hard to tell exactly, it appears that the undifferentiated K is lower than the average K in the detailed study area. If so, is there a geological reason why this should be? Please explain." (52)

"The K of 150 ft/day assigned to peat is surprising. Is the calibration sensitive to this, or is it insensitive such that the PEST calculation of peat K drifted to a limiting value? Looking online, it appears that the upper range of peat K is considered to be less than 1 ft/day." (79)

"...revisiting the horizontal to vertical K anisotropy approach used in the calibration process is recommended. Current calibrated K anisotropy values for many of the lithologies are quite high, without discussion of any basis." (40b7)

Response: The first comment regards comparison of the hydraulic conductivity used for the undifferentiated alluvium zone versus the average hydraulic conductivity of the study area. The BTC PDI ER Groundwater Model Technical Memorandum (Appendix C) will be updated to facilitate comparison and will provide some discussion on this topic.

The second comment notes that the horizontal hydraulic conductivity used for the peat lithology zone (150 ft/d) is high compared to the range reported online. During calibration using PEST, the peat K zone did reach the limiting value for the calibration. That value was set to ten times the initial value. The revised groundwater model has grouped the peat lithology zones with other fine grained lithology types and those model cells have lower hydraulic conductivity in the revised model.

The third comment suggests that the horizontal to vertical hydraulic conductivity anisotropy was high and the report lacked discussion of the basis for this. The relatively high horizontal to vertical anisotropy used in the model was found to be important for calibration of the draft model. The relatively high anisotropy is consistent with the hydrogeologic framework. The anisotropy is representative of thin layers of interbedded alluvium that are difficult to explicitly represent at the scale of the groundwater model discretization but nonetheless impact groundwater flow.

3.2 Hydraulic Conductivity (k) Zones (39f)

Comments: "With respect to varying K within model lithology zones, it is noted that while boring logs in the pumping test area tend to support the concept of upper sand having a somewhat higher K than lower sand, boring logs in other areas farther east do not necessarily support this. This could be one initial basis for varying K within the lithology zones (or redefining the zones)." (39f)

Response: This comment regards the split between the shallow and deep sand hydraulic conductivity zones that was discussed in Section 7.2 of Appendix C. It noted that although field data may support this split in some areas of the Site, it may not be consistent with the hydrogeologic framework for the entire model domain. The revised model utilizes a different approach to incorporating the lithology model and calibrating the hydraulic conductivity values. That revised approach is documented in the revised PDI ER and discussed in more detail in Section 4.0 and Section 5.0 of this response to comments.

3.3 SFR Conductance Ranges (81)

Comments: "The reported streambed vertical hydraulic conductivity of 28 ft/day for model reach 7 is surprisingly high, an order of magnitude greater than the value assigned to other reaches. Is this necessary for head or streamflow calibration? What physical condition in the field does this represent?" (81)

Response: The streambed hydraulic conductivity value was a calibration parameter. The higher value for reach 7 was used to calibrate to flux targets for the stream reach between SS-01 and SS-04 and the head targets near BTC along that reach.

Stream flow data from gauging station SS-01.35 (USGS 12323233) are available starting in April 2020. As part of model updates, we have used data from this station to calculate groundwater flux targets for the stress periods where data are available. This change provides more resolution to the BTC flux calibration along this reach. Additionally, the model calibration approach has been revised to use general pilot points to allow the conductance of the simulated creeks to vary within reaches (instead of just between reaches).

3.4 Storage (40b4a, 40b4b)

Comments: "Please note that storage parameters assigned in the model are appropriately typical of an unconfined aquifer, contrary to the analyses presented in the pumping test report." (40b4a)

"We find it strange that the BTC pumping test analysis gives storativity values typical of confined conditions when the lithology and shallow piezometer response suggests it is unconfined or semiconfined." (40b4b)

Response: The first comment refers to the storage parameters listed in Table C-6.3 which include Specific Yield (Sy) and Specific Storage (SS). Sy is applied to cells that are not fully saturated (cells in which the water table is present). For cells that are fully saturated, SS is multiplied by the cell thickness to obtain the storage coefficient. So, the Sy values listed in Table C-6.3 were only used by the Model for cells that are representative of the water table.

The second comment regards the storage parameters reported in the PDI ER Pumping Test Interpretation Technical Memorandum (Appendix B). This comment highlights the heterogeneity of the aquifer and the variations of the response to the aquifer test. The methods used in the aquifer test analysis focused on the aquifer response in similar depth intervals to the pumping well. The drawdown observed at those wells was consistent with confined to semi-confined conditions with varying amounts of leakage. The storage values reported for those wells were intended to be representative of that interval and not of the shallower unconfined piezometers. Attempts to use those analytical methods to identify storage parameters from the water table when pumping at depth would go well beyond the assumptions and limitations of those methods.

3.5 Wetland Drains (68c)

Comments: "For the wetlands within MT DEQ's BTC riparian actions project area (i.e., the area on the opposite side of Blacktail Creek from the Butte visitor center), we are aware of no such surface water connection to BTC. If this wetland is hydraulically connected to BTC only through the water bearing zone, then using drain (or any) BCs in this area would not be appropriate and may impact calibration and model predictions for alternatives developed in the PDI ER." (68c)

Response: The drain condition representing the wetland within the riparian action area has been removed from the updated model to reflect the Site conditions more accurately. This wetland doesn't need a separate boundary condition to represent it in the model since the surface water is not draining to the creek. Although the wetland will not be represented with a boundary condition, it is still simulated as saturated soils which is consistent with the presence of the wetland surface water that is in hydraulic connection with groundwater.

3.6 Steady State Initial Condition (41c)

Comments: "A steady state condition does not exist within the BPSOU alluvial aquifer and the creeks. Seasonality in streamflow, precipitation, and weather all cause the hydrology to be highly transient. It may be appropriate to use a steady state simulation to develop initial heads, if there is sufficient spin-up period within the transient model before the time period being evaluated." (41c)

Response: During calibration we have observed that the simulated groundwater flow system responds quickly to transient stresses. This can be seen for example in the calibration hydrographs and calibration flux graphs (PDI ER Attachment C-5). If a longer spin-up period was necessary, we would expect to see a difference in the quality of the calibration between the steady state stress period (the first data point on these graphs), the early transient data, and the later transient data. What the graphs show is similar magnitude of residuals and response to transient stresses between the early transient and later transient data. Additionally, because the transient simulation period includes four years of monthly stress periods the importance of the early stress periods in the overall transient calibration is minimal.

We have used the steady state simulation as the start for the transient calibration and as the basis for particle tracking. Because the steady state condition represents average conditions and the particle tracks represent flow paths over a long period of time, the steady state condition is appropriately applied for these uses.

We continue to use transient simulations where appropriate, including in calibration and evaluation of the evaluated BTC GHCS alternatives control of discharge to BTC. Figure C-8.11 shows the transient simulated flux to BTC and additions to this figure are discussed in Section 6.3 of this response to comments.

4 Calibration Improvements

The following comments relate to the calibration of the model. Specifically, they suggest improving calibration and emphasize calibration to the area of focus for BTC GHCS remedy selection and design.

The groundwater model has been updated to improve calibration. The updated calibration approach is summarized in Section 5.0 of this response to comments and will be documented in the revised PDI ER.

4.1 Improve calibration to area of focus (40, 7c)

"The groundwater model needs significant further calibration before it can be reliably used for remedy evaluation. The head and flux calibration presented in the Groundwater Model Technical Memorandum shows a calibration process that is underway but not finished" (40)

"...More fundamentally, it is possible that the model representation of the flow distribution to BTC is it an artifact of incomplete model calibration near the lower part of the BTC. That is, it is possible that the simulated distribution of groundwater inflow to BTC will change somewhat with improved model calibration (both head and flow). Further model calibration is necessary and important..." (7c)

Response: These comments suggest focusing on calibration to the BTC GHCS area and suggest that more calibration is needed before the model can be reliably used for remedy evaluation. AR maintains that the model was sufficiently calibrated in the BTC GHCS area to meet the model objectives and support the remedy selection and 30% design for the BTC GHCS. Models are approximations that describe physical systems using numerical methods; they are not exact descriptions of physical systems. By representing a simplified version of a complex hydrogeological system, reasonable alternatives can be predicted, tested, and compared against one another. As documented, the current draft of the model captures the major elements of the flow system sufficiently to support comparative analysis of remedy alternatives. However, models are generally evergreen and may be continuously updated to add new information or test new numerical approximations. During recent revisions, the model has been updated to improve calibration and those updates have focused on the BTC GHCS area to help refine and/or confirm remedial design decisions.

4.1.1 Qualitative Calibration Goals (43)

Comments: "...The Groundwater Model Technical Memorandum should evaluate the following qualitative calibration goals. Is the subdrain capture and the groundwater depression and divide created by the subdrain accurately simulated? Are the hydraulic gradients between groundwater and surface water representative of those measured? Does the model accurately represent the drawdown response observed during the BTC pumping test in the shallow groundwater, in the deeper groundwater?" (43)

Response: The comment is acknowledged. The updated PDI ER will include additional discussion of these specific qualitative calibration goals and results.

4.2 BTC-PW-01 Pumping Test (46, 39a, 39b, 40a2)

Comments: "Improving the pumping test simulations should increase the reliability and accuracy of the model to assess remedial alternatives and dewatering simulations in the BTC GHCS area. Better understanding of hydraulic controls and constraints in this area could help inform remedial design decisions." (46)

"This review focusses largely on modeling of the BTC-PW-01 pumping test and the BTC groundwater gain in the BTC GHCS area because these features are directly relevant to the model applications presented." (39a)

"Overall, the model appears to be sufficiently comprehensive and at an appropriate level of detail for its intended purpose. Improved model calibration to the pumping test and further examination of the simulated BTC gain from groundwater should increase the reliability and accuracy of model simulations in the BTC GHCS area." (39b)

"The calibration of the BTC pumping test shown in Attachment C-5 to the Groundwater Model Technical Memorandum also shows significant deficiencies in this same area. This is significant because this demonstrates that the model does not represent groundwater hydraulics in the area of the proposed BTC GHCS." (40a2)

Response: These comments suggest improving the model calibration to targets from the BTC-PW-01 pumping test to support BTC GHCS design. Related comments with more detail (44a, 44c, 45, and 90) are included in the following subsections. We agree that calibration to the BTC-PW-01 pumping test is important for the model objectives because of the direct relationship to design of the BTC GHCS. AR maintains, however, that the model was sufficiently calibrated to the pumping test to meet the model objectives and support the 30% design for the BTC GHCS. Since the submittal of the draft PDI ER, the model has been updated and the calibration improved and those updates have included improvements to the BTC pumping test calibration to help inform remedial design decisions.

4.2.1 Use Calibration to Pumping Test as Evaluation of the Test (44a)

Comments: "Because the groundwater model explicitly represents the geometry of the subdrain, BTC and nearby wetlands with respect to the test pumping well, calibration of the model to the pumping test data can provide an appropriate and comprehensive hydraulic analysis of the test." (44a)

Response: While we agree that the calibration of the groundwater model to the pumping test data is important, combining the model calibration with other lines of evidence included in the pumping test evaluation (Appendix B) provides a more robust evaluation of the test and is consistent with standard evaluation methods. Additionally, this comment conflicts with other comments which request the use of additional pumping test evaluation methods (Section 8.2 of this response to comments).

4.2.2 Improve calibration to model simulated drawdown (90, 44c)

Comments: "Section 7.4.3 presents statistics for model calibration of the BTC pumping test including residual mean and standard deviation. On average the BTC pumping test may be calibrated, but this masks the poor calibration shown in the graphs in Attachment C-5. Those calibration graphs should be used to further calibrate the model by adjusting vertical and horizontal K. The focus should be on calibrating head best near to the features of interest such as BTC and the subdrain." (90)

"...the model simulated drawdown, with few exceptions, underestimates the measured drawdown. Also, at some locations the model simulated a difference between shallow and deep well response that is significantly greater than observed." (44c)

Response: The pumping test hydrographs demonstrate the significant heterogeneity of the aquifer. The model was well calibrated to the pumping test and the hydrographs demonstrate that calibration. Although the observed drawdown at a few wells was not well represented by the model, overall, the observed drawdown was well represented

At some paired well locations, the simulated induced vertical gradients were greater than observed. This is consistent with the scale of the model objectives and the heterogeneity of the aquifer. Locally, fine-grained materials may mute the short-term pumping response at some wells. These fine-grained materials may be present at smaller scales than can reasonably be represented in the model. Additionally, the simulated wells and lithology must be assigned to layers and the resolution of these are limited by the simulated layer thickness. With longer term pumping (as is planned for the BTC GHCS), the drawdown at these locations would be expected to increase.

The calibration to the pumping test supported conservative design of the BTC GHCS because the model erred on the side of underestimating drawdown due to operation of the pumping well compared to observed drawdown. Additionally, the comment does not acknowledge the importance of other calibration targets (head and flux) which must be balanced with the pumping test drawdown targets.

It is unclear if the comment is suggesting manually changing the aquifer properties by creation of new zones or changing the values for the existing lithology zones. Changing the properties of the zones was part of the calibration method. The updated calibrated model which will be documented in the revised PDI ER does take the approach of using the lithology model to create separate zones and allowing PEST to modify the aquifer properties of those individual zones. To further improve calibration, the updated model pilot points were used within the BTC Pumping Test area of influence. Additional detail is provided in Section 5.0 of this response to comments and will be provided in the revised PDI ER.

4.2.3 Complete sensitivity analysis focused on the pumping test (45)

Comments: "Because the pumping test is so relevant to the BTC GHCS, it is recommended that additional test simulations incorporating adjustments to model parameters be made specifically to improve the calibration to the pumping test." (45)

Response: The comment suggests completing additional sensitivity analysis focused only calibration to the BTC Aquifer Test. Calibration to the BTC Aquifer Test data has been improved in the updated model. The updated calibration is presented in the revised PDI ER. Additional sensitivity analysis focused on the pumping test would be of limited use given the improved calibration.

4.3 Groundwater/surface water gradients (59, 95)

Comments: "From the standpoint of model application, reasonably accurate representation of groundwater surface water interaction in the BTC reach that passes through the BTC GHCS study area is the most important aspect of the streamflow modeling. Model results presented for the reach from SS-01 to SS-04 (or SS-05) would include this area." (59)

"Figure C-8.1A: The modeled contours do not show groundwater flow towards BTC that are depicted in the contours drawn from measurements prior to the pumping test in Figure B-8A1 of the BTC Pump Test Interpretation Technical Memorandum. This suggests the model may not be accurately simulating groundwater gains in this section of BTC. This also suggests the model does not simulate stream gain from the north side of BTC where buried local contaminant sources exist that are described in EPA's Groundwater and Surface Water Interaction Butte Priority Soils Operable Unit Final Report (December 2018)." (95)

Response: We agree that evaluating groundwater / surface water interaction in this reach from Kaw Ave to George Street is important because controlling the discharge of groundwater to surface water in that reach is the goal of the BTC GHCS. The addition of the details requested in EPA comment number 56 (Section 7.1.1 of this response to comments) will improve reporting of simulated flux in this key reach of BTC.

The contours from Figure C-8.1A are for steady state average conditions while Figure B-8A1 shows the conditions prior to the start of the 72-hour pumping test. Part of the difference is attributable to the use of a steady state boundary condition as the initial condition for the simulated aquifer test. We acknowledg that the head residuals adjacent to BTC prior to the start of the pumping test are positive (indicating the simulated heads are lower than the observed heads) which underrepresents the gradient from the groundwater to the surface water in this area. Head targets and contours of the simulated groundwater elevation from the updated groundwater model more closely match the contours drawn from measurements prior to the pumping test. The updated model will be documented in the revised PDI ER.

4.4 Head targets (40c1, 87a)

4.4.1 Reduce spatial bias in calibration to head targets (40a)

Comments: "The bias in water level (head) residuals is especially problematic because the bias is most pronounced near the subdrain and location of the BTC pumping well near visitor center. This is the area that is the focus of the predictive modeling that is used to evaluate the GHCS alternatives and predict effects on the existing remedy. The modeled water levels are biased high in the Upper Silver Bow Creek corridor and are biased low near the lower subdrain and BTC pumping well. This low bias means the model is not correctly simulating groundwater contact and hydraulics near the lower subdrain and the model is likely not capable of accurately predicting the effects of new hydraulic controls on subdrain performance." (40a)

"Groundwater Model Technical Memorandum Section 7.4.1 discusses the head calibration statistics. The head calibration statistics described may be adequate to predict regional groundwater flow. However, the focus of this model calibration should be on creating a model capable of accurately simulating comparatively small changes in groundwater elevation and flow that affect BTC stream gain and the existing subdrain. This will require more accurate calibration near features of concern such as BTC, the subdrain, the groundwater depression/divide created by the subdrain, and the various known contaminant sources and plumes (Parrot, Diggings East, Northside, etc.). The bias apparent in the head calibration should be eliminated." (40c1)

"Section 7.4.1 states, “shallow water levels in the BTC and SBC confluence area, however, tend to be low compared to simulated values (positive residuals).” If simulated values near the confluence are high and the simulated flux is approximately correct, this suggests the simulated K and conductance are set to compensate for the inaccuracy and are likely not representative of the actual hydraulics." (87a)

Response: These comments note that *s*patial bias in calibration to head targets is pronounced in the area of interest. The spatial bias in calibration to head targets was acknowledged and discussed in Appendix C Section 7.4.1 of the PDI ER. Model updates have significantly reduced spatial bias of head residuals while also maintaining model parsimony and improving calibration to other important targets (flux and drawdown). The updated model will be documented in the revised PDI ER.

4.4.2 Achieving residuals less than 0.5 feet in areas of interest (40c2)

Comments: "There were comments provided to MTAC on 9/22/22 recommending that modeled head calibration achieve 0.5-foot accuracy and be unbiased near the lower subdrain. That recommendation is based on the magnitude of the groundwater divide that separates the subdrain groundwater capture from the creek. This groundwater divide is approximately 0.5-1 foot higher than upgradient groundwater levels. This level of calibration accuracy may be needed to accurately portray the existing subdrain capture and any impacts to the subdrain from the new BTC GHCS." (40c2)

Response: The comment recommends that head target residuals near the lowest reach of the BPSOU Subdrain be less than 0.5 feet due to the magnitude of the groundwater divide between the BPSOU Subdrain and the creek. The 0.5-foot criteria for head residuals in the areas of concern was a goal for calibration improvements of the model although this was balanced with maintaining model parsimony and calibration to other target types. In the updated model, steady state head residuals within the TI Zone and south of uSBC and north of BTC are 0.5-feet or less with a few exceptions (including BPS11-19B in layer 11 and BPS11-10C in L18). The revised PDI ER will include to compare the simulated flow divide to the interpreted flow divide based on observed data.

4.4.3 Include additional head target locations (40a3, 80, 84)

Comments: "There are multiple monitoring well data from the BTC pumping test that are not used in model calibration. Figure 3 of the PDI ER shows BTC pumping test monitoring locations. The PMP wells, BTC-PZ series piezometers, and BWE-3 are not included in the model calibration. Reasons for omitting these data should be discussed in Section 7.1." (84)

"Figure C-7.1 of the Groundwater Model Technical Memorandum illustrates that most water level gaging locations available in the model domain were not used in model calibration. Consistent with this, Section 7.1 states ""To meet the BTC GHCS model objectives, the targets were further filtered to focus on the areas near and upgradient of the BTC and SBC confluence."" Some of the purple-symbolized wells on Figure C-7.1 may have been eliminated due to datum uncertainties, but it is assumed, based on the text statements and the spatial locations on the map, that most were eliminated based on location.

While the focus on the areas near and upgradient of the BTC and SBC confluence is understandable/ desirable, important information is lost by eliminating water level data outside these areas. Could this data have been included, but with smaller weights than the data in focus areas? Alternatively, these targets may not need to be weighted less if K is allowed to vary spatially per lithology. Calibration statistics can be generated for all targets, and for desired subsets of targets in key areas." (40a3)

"It would be helpful to present model calibration results at a limited number of well locations in the undifferentiated portion of the model. The statistics for these wells can be accounted for separately from the refined model area." (80)

Response: Some head target locations were inadvertently excluded from the model during the calibration process. These targets have been added back to the model, and the updated model will be documented in the revised PDI ER. Review of updated simulated versus observed head target graphs for the previous calibrated model indicate that the additional targets follow similar trends as the previously included targets and provide improved resolution of calibration targets in the area of interest.

The comments also suggest including some targets from outside of the area of focus in the reporting of calibration statistics. Because the model is included in the PDI ER for the BTC GHCS, the focus for calibration remains on the area of interest and the areas upgradient of the area of interest. This is consistent with other EPA comments in Section 4.1 through 4.4 which urge focusing on the area of interest. Targets excluded from the current reporting of the model were downgradient of the area of interest. The updated PDI ER will continue to focus on the area of interest. Future model updates to support Groundwater Remedy Optimization (GWRO) will expand the calibration downgradient to the rest of the model domain. The revised calibration approach (Section 5.0 of this response to comments) will facilitate future calibration to other areas of the model without significantly impacting the calibration focused on the BTC GHCS PDI ER.

4.4.4 Exclude head targets within the BPSOU Subdrain (40c6)

Comments: "We note below in Specific Comment #1 under Pumping Test Memo that the current depiction of the subdrain capture zone is based on measured water levels within the subdrain pipe, which does not accurately represent conditions within the adjacent aquifer." (40c6)

Response: This comment also relates to comment 40c7 which was addressed above in Section 2.3. We agree that the measured water levels in the BPSOU Subdrain may not accurately represent groundwater elevations adjacent to the BPSOU Subdrain. Due to well loss, the water levels in the BPSOU Subdrain will be lower than the groundwater elevations adjacent to the BPSOU Subdrain. We have removed the MH-MSD elevations from the head targets in the model. Because the MH-MSD levels directly represent water levels in the BPSOU Subdrain, however, we have updated the model to use these elevations to set transient stages for the drain boundary conditions representing the BPSOU Subdrain. The updated model will be documented in the revised PDI ER.

4.4.5 Add vertical gradient targets (40b8)

Comments: "Also, it is suggested that head difference targets for paired wells and piezometers be incorporated, which may prove useful especially for pumping test calibration." (40b8)

Response: Head difference targets will be discussed in the updated PDI ER.

4.4.6 Flooded Cells (14)

Comments: "Page 15, Section 4.3.2.1, 2nd bullet on page 15: The text states, “There are some areas of simulated flooding along BTC upstream of Sand Creek. This is also a reach where BTC is simulated to be gaining.” Simulated flooding should be explained. If this means the groundwater elevation is higher than the ground surface and no evidence of this exists in the field, the model should be calibrated in this area. Please explain and address as necessary." (14)

Response: The simulated cells that were fully saturated in layer 1 (“flooded”) were located east of Oregon Ave. along the riparian corridor for BTC. These are areas where the cells in layer 1 are fully saturated which is consistent with the shallow groundwater and wetlands located along the creek through this stretch. Appendix C figures will be updated to show the areas of fully saturated layer 1 cells.

4.5 SFR flux targets (39c)

Comments: "Overall, the model appears to be sufficiently comprehensive and at an appropriate level of detail for its intended purpose. Improved model calibration to the pumping test and further examination of the simulated BTC gain from groundwater should increase the reliability and accuracy of model simulations in the BTC GHCS area." (39c)

Response: This comment suggests further examining simulated groundwater gain as part of model calibration and in simulation of BTC GHCS remedial alternatives. The following subsections discuss SFR flux calibration and simulation in more detail. Note that SFR boundary conditions have been replaced with river boundary conditions in the revised model. This change was completed to facilitate additional use of PEST for model calibration and the use of general pilot points to vary the simulated river conductance.

4.5.1 Flux Targets downgradient of area of interest (40a4)

Comments: "There are stream flux targets in areas where water level data were eliminated. Calibration to flux targets with simulated water levels that do not match available water level data may have resulted because those areas were not included as targets." (40a4)

Response: The comment notes that although head targets outside of areas of interest were removed from the model, stream flux targets in those areas were retained. We agree and plan to revise PDI ER Table C-7.1 and Section 7.4.3 to focus on the results from the SFR segments in the area near and upgradient of the confluence. Additionally, stream flow data from gauging station SS-01.35 (USGS 12323233) is available starting in April 2020. As part of model updates, we have used data from this station to calculate groundwater flux targets for the stress periods where data are available (see Section 3.3 of this response to comments).

4.5.2 Steady state vs Transient Discharge (41b)

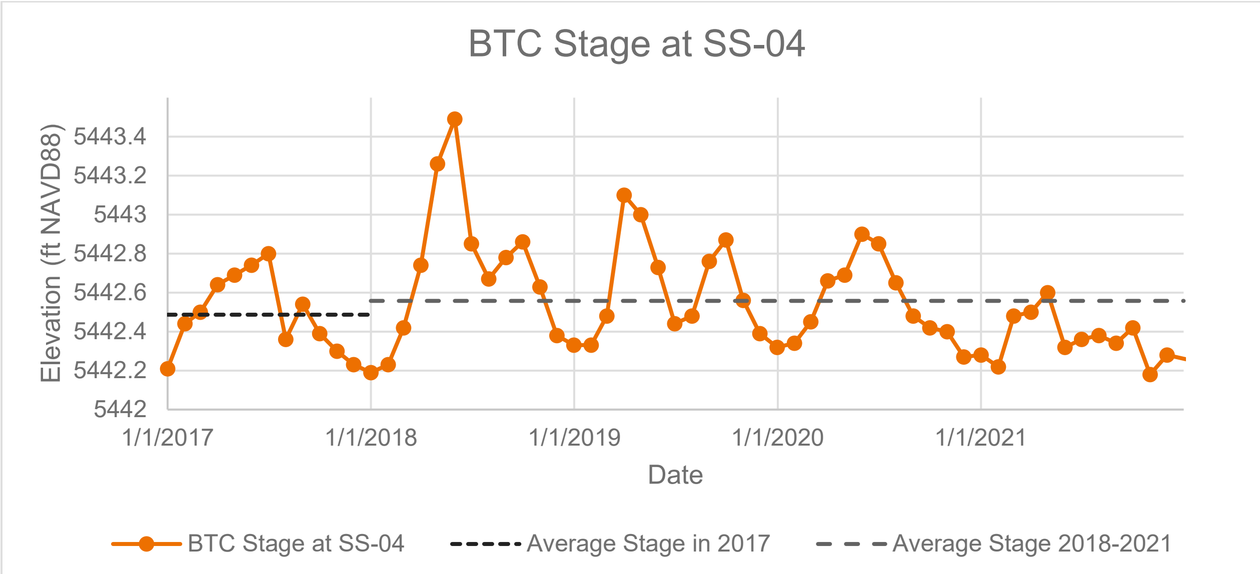
Comments: "For this transient simulation, it is stated in Section 8.2.6 of the Groundwater Model Technical Memorandum that “the simulated flux values [from below and from the northeastern side of BTC to the SFR boundaries] for Alternative 6 ranged from 0.0017 cfs to 0.0043 cfs”.

In the preceding paragraph, it is stated that for the steady-state simulation, the same flux values total 0.004 cfs.

Are these flux values for the same reach of BTC and for the same model cells? If so, is there a reason that the steady-state (average condition) value is near the max value from the transient simulation? Similarly, an abrupt reduction in flow over the first-time step is noted in the Alternative 6-time history plot in Figure C-8.11. The precipitation and recharge patterns shown in Figure C-3-5 don’t indicate that 2017 steady-state flows should be much higher than the 2018-2021 average." (41b)

Response: 2017 was selected as the steady state stress period because 2017 precipitation was close to the long-term average, so it was unexpected that the steady state value is 25% higher than the transient average. A review of the model results indicated that the average BTC stage in 2017 was lower than the average stage from 2018-2021. The graph below shows the BTC stage at SS-04 over time. Although the precipitation in 2017 was near average, the stream stages were lower than average. The difference in stream stage led to higher gradients towards BTC and thus to higher simulated discharge of groundwater to BTC. Based upon this review (and several other considerations), we have modified the initial steady-state stress period in the model to represent average conditions from 2017 through 2021.

Reference: **Response to Agency Comments on the Butte Priority Soils Operable Unit (BPSOU) Draft Blacktail Creek Groundwater Hydraulic Control System Pre-Design Investigation Evaluation Report**



4.5.3 Muted Variability of Simulated BTC Gain (60, 61)

Comments: "Attachment C-5, "Calibration Flux Bar Charts: SFR Gain", compares model simulated and gage measured inflow (or outflow) fluxes. The results show that model simulated groundwater inflow fluxes are very constant over time, while the gage measured fluxes are quite variable." (60)

"It is surprising that the simulated BTC gain fluxes vary so little (no more than 10% for SS-01 to SS-04), considering the pronounced seasonality and year-to-year variability of the recharge. Does the modeling team have any insight about this? Could this be related to the very high streambed conductance assigned to reach 7? Examining the model water budget as well as direct groundwater-surface water elevation comparisons would be helpful." (61)

Response: The comments point out that the simulated variation of gain to BTC is less than the observed variation. The simulated variation of gain to BTC is expected to be less than the observed variation for several reasons which are discussed below.

- **Measurement Error.** The BTC flux targets (stream gain) are based on the difference between stream discharge rates measured at an upgradient stream gauge and a downgradient stream gauge. Therefore, measurement error of the stream flow is compounded when calculating the flux targets for the model. Additionally, the magnitude of the differences between the stream gauging stations tends to be a small percentage of the total flow rate. For example, the average magnitude of stream gain/loss between SS-04 and SS-05 was only 9% of the total flow in the stream at SS-05. For stream gauge pairs that have significant tributaries or outfalls between them (for example SS-01.35 to SS-05), the measured gain may be a higher percentage of the total flow but the percentage of that gain attributable to groundwater flux remains a small percentage of the total. For more discussion regarding flux target error, see Section 4.5.4, below.

- **Overland flow.** Overland flow and stormwater discharge to the creeks contribute to the observed variation from baseflow that occurs after precipitation and snow melting events, however, these sources of stream flow were not accounted for in the model.

- **Time Discretization.** The transient model has been discretized into monthly stress periods. The temporal discretization has a muting effect on simulated transient variation.

For two reasons, the model calibration is insensitive to the muted variability of the simulated gain to BTC.

- **Specified Stage.** Stream flow stages were set in the model (using the simple Streamflow-Routing [SFR] method). With the simple SFR method, the stream stage is user specified and surface water flow is used to limit the amount of water available for losing stream reaches to discharge to groundwater (Langevin et al., 2017). Because the stage is specified in the SFR boundaries, the flux of groundwater to surface water is not sensitive to the simulated stream flow. So lower simulated fluxes in the streams do not lead to correspondingly increased fluxes of groundwater to surface water. The stage is also specified in the river boundary conditions used instead of SFR boundary conditions in the revised model.

- **Focus on Baseflow.** Because the model calibration focused on baseflow conditions (months with minimal precipitation or snow melt) and most of the observed variability of gain to BTC occurs during wet periods, the difference in simulated vs. observed stream flow during wet season has reduced impact on the quality of the calibration. The revised model has increased this focus on baseflow conditions. Stream flux calibration targets in the updated model have been revised to exclude data from non-baseflow conditions. Specifically, the first two months after the average temperature was above freezing and months with high outlier total precipitation were excluded from the stream flux calibration targets. Additional information about the updated flux targets will be included in the revised PDI ER.

4.5.4 Flux Measurement Error (62a, 99)

Comments: "Some of the variability of the gage measured fluxes is likely due to measurement imprecision, as noted in the report" (62a)

"Attachment C-5 Calibration Flux Bar Charts: SFR Gain: The flux calibration charts (simulate vs observed gain/loss) should include error bars to indicate uncertainty in the observed measurement. Calibration should strive to get the model calibrated so that the simulated flux falls within the error bars. If the error bars show the uncertainty in the stream exchange or subdrain gain/loss measurements is high relative to the measured flux, it is acceptable to calibrate the model within the error bars, but focus should instead be put on calibrating head near these features." (99)

Response: We agree that some of the variability of the gauge-measured fluxes is due to error in the gauged data and that adding error bars when graphing the flux targets would be helpful. The surface water data summary reports provide a summary of the residuals between the field-measured surface water flow and the rating curve-based values for BPSOU specific stream gauges. The rating curve is adjusted when three or more consecutive residuals are more than 5% of the flow (AR, 2023). Because the BTC flux targets (stream gain) are based on the difference between stream flow measured at an upgradient stream gauge and a downgradient stream gauge, the measurement error of the stream flow is compounded when calculating the flux targets for the model. For reference the PDI ER graphs of flux calibration targets have been modified to include error bars at 10% of the downstream flow rate. More sophisticated statistical evaluation of the multiple error sources and propagation of those errors is beyond the scope of the model and is not necessary to provide indications of the expected range of potential values for the flux targets.

The EPA Groundwater and Surface Water Interaction Report (2018) completed an evaluation of surface water gauging data to identify statistically significant increases in discharge between stations without tributary input (indicative of groundwater gain to surface water). Even when using only baseflow data, the method only identified statistically significant gains between SS-01 and SS-04. This result was attributed to accuracy and precision limitations for the method.

4.5.5 Direct runoff (62b, 65b, 67)

Comments: "The gage measured fluxes, however, also likely include some direct runoff and drainage system inflows in addition to gains from groundwater and are therefore not directly analogous to the model simulated gain from groundwater." (62b)

"Direct runoff inflows to the tributaries, as noted above, are also not accounted for." (65b)

"In summary, neglecting direct runoff and tributary inflows from outside of the model domain could cause the calibrated model to overestimate BTC groundwater gain in the BTC GCHS area of interest. This should be further investigated." (67)

Response: We agree that the gauge-measured fluxes include some contributions from other sources (for example direct runoff) which is why the calibration to stream flux targets has focused on baseflow conditions and why the updated model has increased the focus on baseflow conditions (Section 4.5.3). The contribution from these other sources is also part of why the simulated variation in the stream flow is less than the observed variation (Section 4.5.3). Under simulation of the surface water flow in the streams, however, does not impact the simulated flux of groundwater to the streams. This is due to the use of the simple SFR routing method. The simple routing option calculates flow across the streambed based on specified stream stage. Required input for each stream boundary condition cell includes stage of stream, streambed elevation, and the conductance term (see draft PDI ER Section C-6.4.5). The SFR package accounts for the flow in the stream but that flow does not impact the exchange with groundwater unless the simulated surface flow drops to zero.

Contribution of tributary inflows from outside of the model domain were included in the model by adding specified flux to the SFR boundaries where appropriate. This is discussed in more detail in Section 4.5.7 below.

The “Calibration Flux Graphs: SFR Flow” included in Attachment C-5 show that the magnitude and variation of the simulated flow compared to the observed flow at the SFR gauging stations match quite closely. At the highest flow rates (during non-baseflow conditions), the simulated flow rates do slightly under simulate the observed rate which is consistent with the omittance of direct runoff in the model. However, the relatively small differences further highlight the low sensitivity of the model to the lack of accounting for direct runoff and the updated model excludes stream flux calibration targets from non-baseflow conditions (Section 4.5.3).

4.5.6 Baseflow separation (63)

Comments: "Applying common statistical base flow separation techniques might reduce the discrepancy between gage data and simulated results. While there is uncertainty associated with statistical base flow separation, neglecting baseflow separation risks creating a somewhat inflated calibration target, and thus the calibrated groundwater model might tend to overestimate actual stream gain from groundwater." (63)

Response: As we discussed during the MTAC meetings, we decided to avoid baseflow separation because of the uncertainty in applying the methods to a snow melt dominated flow regime. We will update the PDI ER to provide more discussion regarding this decision and will update the presentation of flux calibration to be consistent with this decision. After excluding non-baseflow months (Section 4.5.3), we expect that baseflow separation would result in negligible changes to the groundwater gain to surface water flux targets.

4.5.7 Tributary Flow (64, 67, 65a, 65b)

Comments: "Another factor that could affect the model simulation of groundwater gain in the SS-01 to SS-04 reach is the effect of tributary streams, Sand Creek and Grove Gulch, that discharge to BTC within that reach. The model computes groundwater flows to the tributaries and these flows are added to the BTC within the SS-01 to SS-04 reach. However, upstream inflows to the tributaries at the model boundary are apparently neglected." (64)

"In summary, neglecting direct runoff and tributary inflows from outside of the model domain could cause the calibrated model to overestimate BTC groundwater gain in the BTC GCHS area of interest. This should be further investigated." (67)

"It appears from the report figures (and Google Earth) that the tributary watersheds extend beyond the model domain. These external watershed areas might be steep, low-recharge areas that could create flashy inflows. These flows are likely small compared to BTC flows but might be significant with respect to with SS-01 to SS-04 groundwater gain." (65a)

"Direct runoff inflows to the tributaries, as noted above, are also not accounted for." (65b)

Response: The stream flow in BTC and Basin Creek where they enter the model domain were accounted for in the model by adding specified flow to the upgradient SFR cells for these reaches. Grove Gulch does not extend to the edge of the model domain (see SFR segment 10 in PDI ER Figure C-6.3) so specified flow was not added to that segment. Sand Creek does extend to the edge of the model domain (see SFR segment 6 in PDI ER Figure C-6.3), however, the upper reach of Sand Creek does not have baseflow so specified flow was not added to that segment.

Because flux calibration is focused on baseflow conditions (months with minimal precipitation or snow melt), the impact of flashy surface water flows from tributaries on the SFR gain calibration targets is minimized.

Because the simple SFR routing method was used, the stage of the streams is directly input to the model and the flux in the streams is only used to limit the available surface water available to discharge to groundwater, thus the model is not sensitive to the magnitude of the surface flow. Additionally, the calibration targets are based on the groundwater gain to surface water between gauging stations and not the magnitude of the flows.

4.6 BPSOU Subdrain flux (40e1, 40a1, 89)

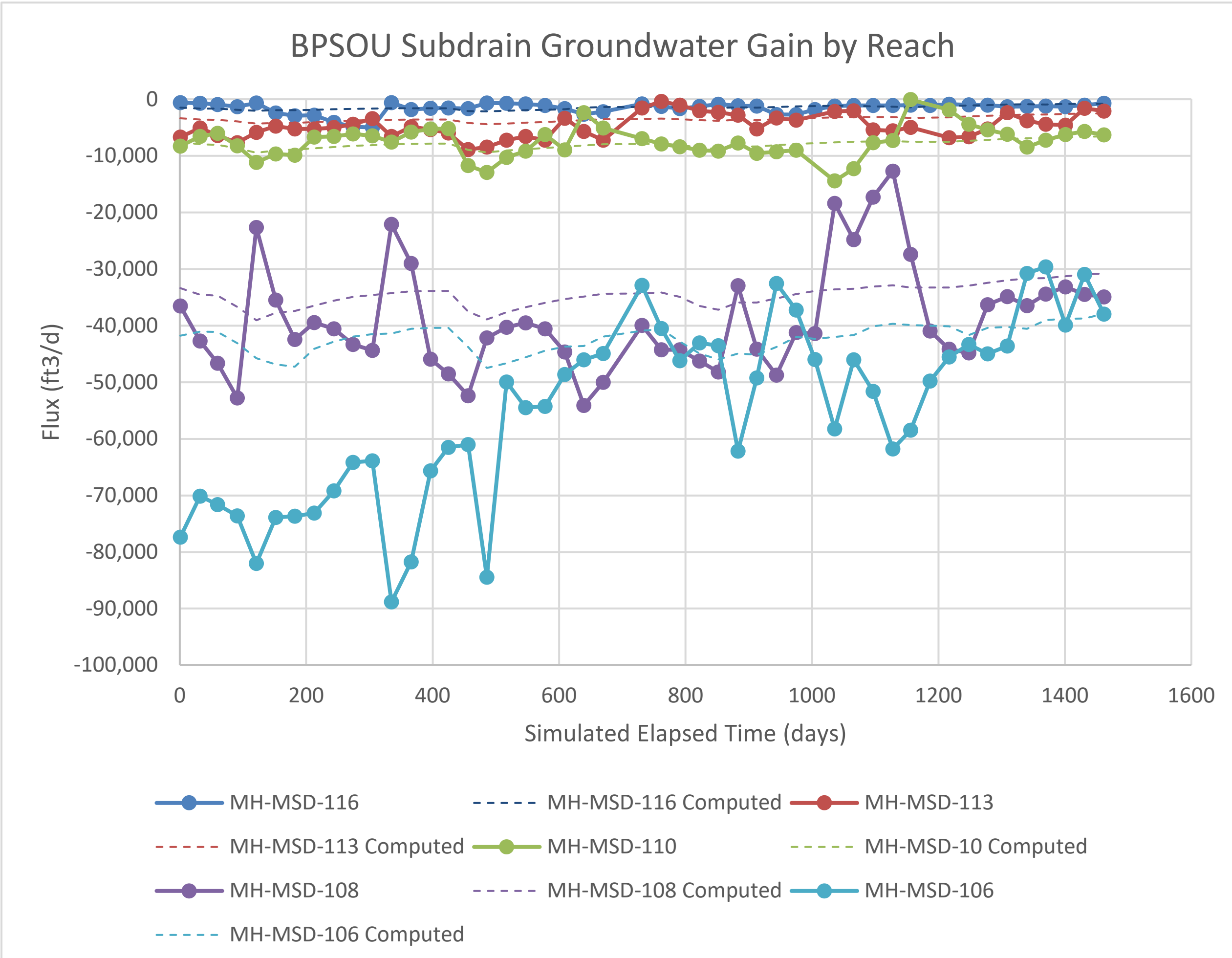
Comments: "At the 8/23/23 Model Technical Advisory Committee (MTAC) scrum it was discussed that the subdrain flux calibration is a compromise so that the flux into different segments of the subdrain are not grossly over or under simulated. On this subject, section 7.4.1 of the Groundwater Model Technical Memorandum states, “during calibration, most Model iterations tended to under simulate the flux gained in the lowest reach of the BPSOU Subdrain and the calibrated Model attempted to balance simulated flux and simulated head in that area.”" (40e1)

"Flux calibration is also deficient in the lowest reaches of the subdrain. The bias in the calibration shows the model may not be capable of accurately predicting the stream-groundwater hydraulics near the visitor center, an area which is known to contain buried waste contaminant sources (see EPA's Groundwater and Surface Water Interaction Butte Priority Soils Operable Unit Final Report, December 2018). " (40a1)

"Section 7.4.2 states, "simulated flux to the drain on average tends to be low compared to the observed values." It may not be necessary to perfectly capture the observed variability in subdrain inflows, which are affected by transient scaling of the subdrain which is difficult to characterize. However, the bias in simulated flux should be addressed with better calibration such that the simulated flux is not biased high or low and no subdrain segment is biased differently than others. The current calibration for segment "flxtrg_mh_msd110" and flxtrg_mh_msd116 appears to be unbiased whereas flxtrg_mh_msd106, flxtrg_mh_msd108, and flxtrg_mh_msd113 the modeled flux is biased low." (89)

Response: These comments discuss the calibration to the lowest reaches of the BPSOU Subdrain, specifically that the simulated flux to the BPSOU Subdrain is low compared to observed flux in the lowest reach. We disagree that flux calibration is deficient in the lower reaches of the BPSOU Subdrain. To support this point and to respond to comment 101 (Section 7.2.9), we have prepared a graph which better communicates the BPSOU Subdrain flux calibration results (see below). The graph plots simulated and observed BPSOU Subdrain gain (flux) versus simulated elapsed time. Each BPSOU Subdrain segment is graphed as a separate series.

The graph shows that for the target representing the lowest reach of the BPSOU Subdrain (MH-MSD-106) the observed gain was significantly higher prior to May 2019 (elapsed time of approximately 500 days) than after. Prior to May 2019, the average monthly flux to the lowest reach of the BPSOU Subdrain was approximately 73,000 cubic feet per day (ft^3/d). From May 2019 through the end of 2021, the average monthly flux was approximately 45,000 ft^3/d (a reduction of 38%). That change is not reflected in other data (groundwater elevation, precipitation, flux to other segments) and we are unaware of what might have caused the change. We are unable to simulate that change without changes in other model transient properties or an understanding of what might have caused it. During calibration it was decided to calibrate to the more recent (lower) flux to that segment and the graph demonstrates that the model is well calibrated to that more recent data for the lowest segment. The graph also demonstrates that the model is also well calibrated to the other segments of the BPSOU Subdrain. The PDI ER will be updated to discuss the step change in the observed data for the lowest reach of the BPSOU Subdrain and the calibration to the more recent targets.



4.7 Model Validation (58)

Comments: "Is it worth considering model simulation of the 2010 MSD pumping test for model verification? The MSD test is somewhat removed from the BTC GHCS area (roughly a half mile) and such a simulation might be beyond the scope of the current modeling project. On the other hand, the aquifer conditions are similar and both tests show the effects of surface water interaction. (The MSD shallow well response was notably different for downgradient wells, where the subdrain is active, and upstream wells, where it is not.)" (58)

Response: Given the distance of the test from the area of focus for the Model, we have not included it for model verification or calibration. We will consider using the data from the 2010 MSD pumping test for calibration or verification during future use of the model to support GWRO.

5 Suggested Calibration Methods

The groundwater model has been updated to address comments and improve calibration. The details of the updated calibration results will be documented in the revised PDI ER. The two most significant changes to the calibration approach are summarized here:

- **Changed SFR boundaries to river boundaries.** SFR boundaries have several limitations when calibrating with PEST using Groundwater Vistas. With SFR boundaries, each cell within a reach has the same conductance. Additionally, SFR flux targets must be for a single "reach" (while the flux targets calculated between gauging stations include flow from multiple "reaches"). As was discussed in Section 4.5.3, because the simple SFR routing method was used, the stage of the streams is directly input to the model and the flux in the streams is only used to limit the available surface water available to discharge to groundwater. This meant that the SFR boundary conditions could be changed to river boundary conditions without changing the simulated groundwater flow. By using river boundary conditions, we were able to use general pilot points to adjust the conductance of the simulated creeks and were able to directly include the flux targets in the PEST model runs.

- **Used pilot points to adjust hydraulic conductivity.** In the updated model, the lithology model was generalized into five groups: fill, fine grained alluvium, coarse grained alluvium, undifferentiated alluvium, and weathered bedrock. In the area of interest (i.e., close to and upgradient of the upper Silver Bow Creek [uSBC] and BTC confluence), single pilot points for horizontal and vertical hydraulic conductivity were added to these zones so that PEST could adjust these properties. Larger contiguous areas of a single lithology group were broken up into separate areas. For zones with single pilot points, PEST adjusts the value for the zone and each cell within that zone is assigned that value. Multiple pilot points were added to some key zones. For zones with multiple pilot points, PEST interpolates the properties so that each cell within the zone does not have to have the same value.

The following comments relate to the model calibration approach. Specifically, they suggest specific parameters and properties to adjust and suggest increasing the use of PEST in the calibration process. This response to comments discusses some of the changes to the calibration approach, which will be documented in more detail in the revised PDI ER.

5.1 General Suggestions (39e)

Comments: "Also, based on examination of the model structure and the distribution of simulated head residuals, it should be possible to make substantial improvements to both the pumping test and long-term transient calibrations by making the more basic mode structure and parameter adjustments. Basic model parameter and geometry adjustments to be addressed might include:

• adjusting the geometry of the surficial low-K zone underlying the BTC,

• minor adjustment to the geometry of a few other low-K "lenses" to improve simulated pumping test response at particular wells,

• adjusting BTC and subdrain hydraulic property assignments, particularly the distribution of conductance assigned to the subdrain,

• adjusting the overall K assigned to the current upper and lower sand zones,

• minor adjustment to model storage parameters,

• adjusting K assigned to the undifferentiated model zone, and

• possibly, minor adjustment to the recharge model to slightly increase or decrease overall recharge." (39e)

Response: This comment provides a list of model parameters to adjust during calibration. Specifically, the comments provide suggestions for calibration methods with a focus on adjusting K zone geometry, K values, boundary condition properties, storage parameters, and recharge. These parameters have been adjusted during revised model calibration and will continue to be adjusted or considered for adjustment during ongoing calibration updates.

5.2 Hydraulic Conductivity (K; 50, 53, 54, 77, 40e2, 40e3, 39d, 40b1, 40b2, 40b6, 40d9)

Comments: These comments provided suggestions for calibration methods related to the assignment of hydraulic conductivity properties in the groundwater model. The full comments are available in the original letter and the comment tracking table which has been provided along with this letter. These comments can be grouped into the following three categories:

- Add more hydraulic conductivity zones and/or adjust the boundaries of existing zones.
    - May require more K zones. (40b2)
    - "The fact that the model hydraulic conductivity (K) zones were not adjusted during calibration appears to have led to poor calibration and accuracy…." (40b1)
    - Calibrate by adjusting K in the surrounding aquifer or by changing K zone boundaries and then adjust the subdrain conductance to improve subdrain flux calibration. (40e2)

- Keep the zones the same but allow hydraulic conductivity to vary within those zones.
    - Allow K to vary spatially within a range for each lithology. (39d)
    - "With respect to K adjustments, starting with allowing K to vary spatially per lithology within realistic ranges is recommended, rather than introducing new K zones each with spatially constant K (which could turn into a long trial-and-error process)." (40b6)
    - Scaled RSD >10% may be improved with allowing K to vary spatially. (40d9)
    - Piecewise-constant K zones are not appropriate for simulating local conditions. (40e3)

- Adjust hydraulic conductivity values and/or zones to improve calibration to the pumping test data.
    - "Horizontal hydraulic conductivity (Kh) – Simulated drawdown will be increased by reduction of the Kh assigned to the shallow sand or both shallow and deep sand." (50)
    - Possibly, adjustment to the thickness, extent or Kv applied to clay/silt in specific areas would improve results." (53)
    - "Vertical hydraulic conductivity (Kv) – Increasing Kv assigned to the sand layers, silt/clay layers or both will tend to reduce the difference in simulated drawdown between shallow and deep wells. It is possible, however, that simulated drawdown will be decreased at some locations due to better hydraulic connection with water table damping. It is also possible that simulated drawdown will be increased at some locations." (54)
    - "Per the discussion above, improving model calibration of the pumping test data will likely require some change to K assignments." (77)

Response: The first group of comments suggests adding more hydraulic conductivity zones or adjusting the boundaries of existing zones. As was discussed in Section 5.0, the calibration approach for the updated model retained the zonation from the lithology model, split some of the lithology zones in key areas and used pilot points and PEST to adjust the values of those zones.

The second group of comments suggests keeping the zones the same but allowing hydraulic conductivity to vary within those zones. This would be accomplished using pilot points with PEST. As was discussed in Section 5.0, the calibration approach for the updated model included using multiple pilot points with PEST in some zones which allows the hydraulic conductivity to vary within those zones. To maintain model parsimony, we limited this change to several zones with a concentration of head and drawdown targets.

The third group of comments focuses on changes to horizontal and vertical hydraulic conductivity to improve calibration to the pumping test data. For discussion regarding improving calibration to the pumping test data, see Section 4.2. Horizontal and vertical hydraulic conductivity values were adjusted using PEST during calibration for the updated model.

5.3 Recharge (51)

Comments: "If simulated steady-state (or long-term transient) head levels and/or stream flows are adversely affected by a Kh adjustment, it might be possible to compensate by making adjustment to the undifferentiated alluvium K or recharge." (51)

Response: The hydraulic conductivity of the undifferentiated alluvium was adjusted during updates to the calibration of the model. Additionally, with the use of pilot points, the undifferentiated alluvium was allowed to vary between layers.

Adjustments to the recharge model (PDI ER Attachment C-3) were considered during model updates, however, with the revised calibration approach summarized in Section 5.0 adjustments to the simulated recharge were not necessary.

5.4 Storage (48, 40b3)

Comments: "Specific yield reduction – This would apply specifically to the pumping test simulation. A slightly lower Sy (say, 0.15) than the value applied to the long-term transients might be appropriate for simulating pumping test drawdown due to possible incomplete drainage over the relatively short duration of the test. (This is a simple model revision that does not affect steady state model applications but is unlikely to be sufficient.)" (48)

"Additional calibration should focus on adjustments to the K zone boundaries, the K values, and potentially storativity (S) values". (40b3)

Response: We have evaluated a range of Sy values for simulation of the pumping test and found that the results were not very sensitive to Sy. For the updated model, PEST was used to vary Sy, in the area of influence from the BTC Pumping Test.

5.5 SFR and Conductance (49, 40b5)

Comments: "Reduction of BTC streambed conductance – This could apply to the nearby reach of the BTC and possibly also the nearby wetlands adjacent to the BTC and/or the subdrain. However, a relatively low value has already been assigned in this area." (49)

"Stream conductance will likely require recalibration in tandem with recalibration of the groundwater parameters." (40b5)

Summary: We agree that updates to streambed conductance would be required as part of the updates to the model calibration. As was discussed in Section 5.0, the approach to calibration was adjusted to allow PEST to adjust conductance of the simulated creeks and to allow that conductance to vary within reaches (and not just between reaches).

5.6 PEST (47, 85, 40e4, 40d10)

Comments: "The Groundwater Model Technical Memorandum states that the subdrain and stream conductance values and the storage parameter values were manually adjusted during model calibration. It would likely be more efficient and effective to incorporate these into the PEST calibration, providing realistic ranges to PEST for each parameter. PEST is a model independent parameter estimation and uncertainty analysis software package. Note: PEST should be used with care. It is a useful tool, but many models suffer from an overreliance on PEST." (40e4)

"Consideration may need to be given to relative weights of flux vs. head compared to head difference targets to get a good balance during further calibration efforts." (40d10)

"Section 7.1 states, "a well with 10 observations in a month would have 1/10th the weight of a well with one value for that month." Why would a well with more observations have less weight? We recommend averaging the observations during the particular time step, and if appropriate assigning more weight because there is a greater assurance the measurement is correct because there are multiple measurements." (85)

"To the extent that multiple parameter sets may provide satisfactory model calibration (non-unique solution), a range of predictive results may be developed for remedy and dewatering simulations. Sensitivity simulations for remedy and dewatering simulations should be run, varying key sensitive parameter values. PEST provides feedback on the most sensitive parameters, which can then be varied for remedy and dewatering simulations. Alternatively, PEST utilities (such as null-space Monte Carlo) can be used to develop a suite of equally well-calibrated models that can be used for these sensitivity simulations." (47)

Response: The first comment suggests incorporating conductance values into PEST calibration along with other parameters but cautions to avoid overreliance on PEST. To allow PEST to adjust conductance values of the simulated creeks and to allow PEST to include the creek flux targets, the SFR boundaries were changed to river boundaries in the updated model (Section 5.0) which will be documented in the revised PDI ER. To limit overreliance on PEST, most of the hydraulic conductivity zones included only one pilot point and the PEST parameters were constrained within CSM ranges.

The second comment points to the importance of relative weights between flux and head targets when using PEST to calibrate the model. By changing the SFR boundaries to river boundaries, the PEST runs included the creek flux targets more effectively. A global relative weight was assigned to the flux targets to balance the head and flux targets in the PEST runs.

The third comment questions the method used to assign weights to transient head targets. To clarify the example provided, we assigned 1/10th the weight to **each** observation for a well with 10 observations in a month. The resultant total weight assigned to that well would be 1, which is the same as a well with 1 observation in that month. The approach results in similar weighting to the averaging method that the comment suggests but retains the higher resolution transient data which is useful in identifying outliers and reviewing the transient calibration hydrographs (PDI ER Attachment C-5).

The fourth comment suggests using PEST tools to facilitate sensitivity analysis for remedy simulations, varying parameters that the model is sensitive to and evaluating the impact the changes have on the performance of the remedy. Sensitivity analysis was completed to evaluate the impact that uncertainty in model parameters has on calibration and on key elements of remedy design and optimization. The approach and results of the sensitivity analysis are presented in Section 9.0 of Appendix C and Attachment C-6.

6 Evaluation of Alternatives

6.1 Evaluate Interaction Between the BPSOU Subdrain and Proposed BTC GHCS (16c, 4d, 5a)

Comments: "Further evaluation of the hydraulic impacts on the subdrain due to pumping at BTC-PW-01 is needed." (16c)

"...At a minimum, the potential impact of inducing flow from the subdrain into the aquifer seems like a significant gap in the evaluation..." (4d)

"Additional evaluation of groundwater hydraulic controls and effects on the existing remedial elements such as the subdrain are needed prior to remedy selection and design. As discussed further in the comments below, the evaluation provided in the PDI ER and appendices is inadequate to select the BTC hydraulic controls..." (5a)

Response: These comments express concern that pumping at BTC-PW-01 and the proposed BTC GHCS could induce leakage from the BPSOU Subdrain and impact capture of the BPSOU Subdrain. Additional discussion on this topic is provided in Section 2.1 and was presented in the MTAC meeting on May 1, 2024.

The revised PDI ER includes additional details regarding the simulated impact of the proposed remedy on capture of the BPSOU Subdrain. Some specific additional reporting on this topic is covered in Sections 7.2.7 through 7.2.9.

Additionally, the model will be updated to change the simulated BPSOU Subdrain from a drain boundary condition to a river boundary condition. Drain boundary conditions are one directional head-dependent boundary conditions where water can be removed from the model but not added to the model. River boundary conditions are two directional head-dependent boundaries where water can be removed from or added by the boundary, depending on the head differential. We have evaluated the change and found that it made no difference in the model simulations. This change would, however, allow for simulated leakage from the BPSOU Subdrain if the gradients were reversed in a future simulation.

Overlap of the influence of the BPSOU Subdrain and the proposed BTC GHCS is consistent with best practices for capture system optimization to prevent loss of capture from between the individual systems. Additionally, the interaction between the BPSOU Subdrain the proposed BTC GHCS is inherently a three-dimensional problem (the capture zone of the BPSOU Subdrain is larger at the water table than at depth while the capture zone of BTC-PW-01 is larger at the depth of the pumping well than at the water table). The flexibility of the proposed remedy along with performance monitoring and optimization will further address potential for leakage from the BPSOU Subdrain.

6.2 Evaluate additional alternatives for BTC GHCS (82, 3e, 4c, 4e, 4f)

Comments: "Additional alternatives for the BTC GHCS should be evaluated." (82)

"Additional hydraulic controls may be possible and should be investigated. Every option does not need to be included in a full modeling "Alternative," but the Groundwater Model Technical Memorandum should give some discussion of what was evaluated, the result, and why options were not included in the alternatives." (3e)

"...Furthermore, the range of alternatives considered is limited (see comment No. 3)..." (4c)

"...The Alternative 6 extraction rate of 130 gallons per minute (gpm) reduced the predicted discharge for the GHCS reach of BTC from the northeast and below...This is a 5.6 gpm predicted decrease in discharge to BTC for the 130 gpm pumping rate. For the same well configuration which yields better predicted results than the other limited configurations evaluated, the report does not evaluate or present the discharge reduction at other extraction rates, such as 50, 100, 200, and 400 gpm, which would be useful for evaluating ability to meet the RAOs under differing scenarios...” (4e)

"...Other pumping configurations not included in Alternatives 1 through 6 might achieve a similar or greater reduction in flow to BTC at lower overall pumping rates. While more efficient hydraulically, such configurations, likely including a greater number of wells, might be less practical and cost effective. This should be evaluated...." (4f)

Response: These comments suggest simulating additional alternatives. A sufficient number of alternatives have been evaluated. A discussion of the remedial alternatives considered will be provided in the 30% design. A point-well extraction system has been selected as the preferred remedial alternative. Such a system provides the necessary flexibility to meet the requirements of the FRESOW. This alternative will be further evaluated between preliminary and intermediate design submittals. Consistent with the comments, additional simulations of the point-well extraction system will be documented for the intermediate design submittal.

Some of the reasoning for additional evaluation of alternatives centered around concern that pumping for the BTC GHCS could induce flow out of the lowest reach of the BPSOU Subdrain into the aquifer. Those comments are specifically addressed in Section 6.1.

We agree that additional simulation and evaluation for BTC GHCS design details will be part of the selection and design process, however, we maintain that the level of detail simulated was sufficient for the PDI ER and 30% design. The revised PDI ER has been updated to include two additional simulations of different combinations of well locations and depths. Alternative extraction well configurations aligned along the walking trail will be evaluated for the 60% design (see discussion regarding including a 30% design prior to the 60% design in Section 9.2). For example, varying the simulated pumping rate and the screened intervals would be part of further optimization of the selected remedy.

6.2.1 Vary Simulated Well Details (3a, 7b)

Comments: "The PDI ER, Groundwater Model Technical Memorandum, and groundwater modeling effort should evaluate a greater range of possible capture and hydraulic alternatives. The modeling only evaluates four locations for new capture wells and does not evaluate a range of well screening depths at each of those locations. The only other change to the capture system that is evaluated is isolation of segment 1 of the existing subdrain, which simulates changing this lowest segment from perforated to solid pipe but adds no additional or replacement capture for segment 1.

Section 4.1 of the PDI ER gives the Principal Study Questions for the model from the modeling data quality objectives (DQOs): ""Design details will vary by remedy but generally include key elements such as location(s), installation depth(s), size, and groundwater extraction rates, as applicable."" Meeting this DQO requires a more robust evaluation of locations, depths, and rates of capture wells and other hydraulic controls."'" (3a)

"...The lateral extent of the “upper part” may correspond to the section of BTC running along simulated wells BTC-PW-02 and BTC-PW-03. Was extraction at both BTC-PW-02 and BTC-PW-03 considered and simulated to further reduce discharge to BTC? Shallow extraction at BTC-PW-02 was simulated in Alternative 5, but deeper extraction (e.g., layers 6 and 7) might be best in a scenario with both BTC-PW-02 and BTC-PW-03. Shifting the extraction to the upper part of the GHCS reach might have negative consequences for the lower part, but this can be readily simulated with the model. Distributed pumping across BTC-PW-01, BTC-PW-02, and BTC-PW-03 may also further reduce groundwater discharge to the upper part of the GHCS reach without negatively impacting simulation results for the lower part; this suggestion is consistent with the 3rd bullet in comment No. 3. As most of the simulated groundwater flow to the GHCS reach of the BTC occurs within the first 500 feet downstream of Grove Gulch, a focus on the remedial pumping in this area should be evaluated..." (7b)

Response: The first comment suggests varying the simulated wells details, including extraction rates and screened intervals. We agree that additional simulation and evaluation for BTC GHCS design details will be part of the remaining design process, however, we maintain that the level of detail simulated was sufficient for the PDI ER. The revised PDI ER has been updated to include two additional simulations of different combinations of well locations and depths. Additional extraction well configurations will be evaluated for the 60% design.

The second comment suggests simulating combined pumping from BTC-PW-01, BTC-PW-02, and BTC-PW-03 with a focus on discharge of groundwater to surface water within the first 500 feet downgradient of Grove Gulch. The revised PDI ER has been updated to include two additional simulations of different combinations of well locations and depths . The figures showing the simulated gain to BTC for the BTC GHCS alternatives will be revised to show only the extent where the remedial goals specify control of discharge. Additional discussion regarding the target capture zone and the lateral extent of discharge control is provided in Section 7.5.

6.2.2 Isolate Segment 1 of BPSOU Subdrain (3b)

Comments: "...we recommend the following potential hydraulic controls be evaluated and modeled: Isolation of segment 1 of the subdrain (to prevent the more highly contaminated groundwater captured higher in the subdrain from leaking out of the subdrain) combined with replacement and optimization of segment 1 capture to prevent the reduction in the capture zone predicted by segment 1 isolation alone..." (3b)

Response: Simulation of the requested scenario is not necessary because groundwater flow in the requested simulation would not be different from the scenarios which include Segment 1 of the BPSOU Subdrain. Additionally, multiple lines of evidence indicate that pumping from the BTC GHCS will not induce water to leak form the BPSOU Subdrain to the groundwater. Performance monitoring and optimization of the BTC GHCS will include monitoring for and optimization to avoid inducing leakage from the BPSOU Subdrain. These concerns were also discussed in the May 1st, 2024 MTAC meeting and in other sections of this response to comments (Section 2.1 and Section 6.1).

6.2.3 Hydraulic barrier between BPSOU Subdrain and BTC GHCS (3c)

Comments: "...we recommend the following potential hydraulic controls be evaluated and modeled: ... A hydraulic barrier between the BPSOU subdrain and the proposed BTC capture system to see if this would eliminate any negative impacts due to interference between the capture systems (see General Comments)…" (3c)

Response: We disagree regarding the potential utility of a barrier between the BPSOU Subdrain and BTC GHCS. Overlap of the influence of the BPSOU Subdrain and the proposed BTC GHCS is consistent with best practices for capture system optimization to prevent loss of capture from between the individual systems. The flexibility of the proposed remedy along with performance monitoring and optimization will further address potential for leakage from the BPSOU Subdrain. Additional discussion on this topic is provided in Section 2.1 and was presented in the MTAC meeting on May 1, 2024. The revised PDI ER will include additional details regarding the simulated impact of the proposed remedy on capture of the BPSOU Subdrain.

6.2.4 BTC Subdrain or Horizontal Well (3d)

Comments: "...we recommend the following potential hydraulic controls be evaluated and modeled: ... More dispersed capture along BTC that may avoid negatively impacting subdrain capture. Various locations and depths should be considered. A BTC subdrain or horizontal well should be considered if this could be installed in coordination with the State's BTC waste remediation efforts." (3d)

Response: We agree that more dispersed capture along BTC is worth evaluating. The revised PDI ER has been updated to include two additional simulations of different combinations of well locations and depths. This included a simulation with a total of 3 wells located along a line parallel to BTC.

We disagree regarding the utility of a horizontal well or drain because of the lack of flexibility for optimization compared to vertical wells.

6.3 Transient simulation of baseline and alternatives (41a, 41d, 41e, 41f)

Comments: "A Principal Study Question from the DQOs is: “How do varying surface flow conditions affect BTC GHCS operation?” Evaluating this with the model requires transient modeling that incorporates realistic variability in groundwater levels and surface water stage. The Groundwater Model Technical Memorandum indicates that only Alternative 6 was modeled using a transient simulation, stating this was done to “evaluate how varying surface flow conditions affect BTC GHCS operation.” The remaining alternatives appear to have been modeled using steady state models, which the Groundwater Model Technical Memorandum suggests shows “average conditions.”" (41a)

"The simulated alternatives and baseline model that is used for comparison should all be transient models. The discussion and figures in Section 8.1 describing the current baseline should describe transient conditions and specifically identify if certain hydrologic conditions or seasonal times exist where contaminated groundwater is most likely to reach BTC. A typical baseflow condition could also be described." (41d)

"The Groundwater Model Technical Memorandum should evaluate performance of the alternatives on an annual timespan, during the hydrologic conditions most likely to transport contaminants to BTC if one exists, and during typical baseflow conditions at a minimum." (41e)

"The Groundwater Model Technical Memorandum should assess and compare how transient stream and groundwater elevations affect GHCS performance between the alternatives. The capture zone analysis (e.g., shown in Figures C-8.1A and B) should be evaluated for those transient hydrologic conditions that bookend the seasonal variations." (41f)

Response: The comments suggest simulating all the alternatives using transient simulations. Additionally, the comments suggest reporting performance of the alternatives on an annual timespan, based on typical baseflow conditions, and during the conditions most likely to transport contaminant to BTC. The preferred alternative was simulated using a transient simulation (PDI ER Appendix C Section 8.2.6 and Figure C-8.11). The PDI ER has been updated to include a graph of the simulated flux to BTC for each of the primary alternatives evaluated.

7 Increase Reporting

The following comments relate to the details reported in the model memorandum. Specifically, they suggest increasing the level of detail included in the report.

7.1 Calibrated Heads

The following comments request additional detail regarding calibrated heads.

7.1.1 Groundwater/Surface water gradient change during pumping (56)

Comments: "Comparing groundwater and surface water elevations - A table comparing surface water and groundwater levels pre-test and end-of-test would provide a simple illustration of the impact of pumping on groundwater-surface water interaction. Time history plots in the Pumping Test Interpretation memo show measured BTC/wetland surface water elevations compared with groundwater elevations at nearby monitoring wells. The head difference measured between the surface water gages and nearby wells just before the test and at the end of the 72-hr pumping period could be tabulated and compared with the model simulated results." (56)

Response: We agree. A table which summarizes the groundwater surface water elevations shown in PDI ER Attachment B-1 has been prepared to help summarize how the observed gradients changed during the pumping tests. Also, a version of that table which includes simulated water levels has been added to the revised PDI ER Appendix C to support review of the model calibration.

7.1.2 Show head on cross sections (57)

Comments: "Cross sections – Visualization of drawdown (or head) contours with model stratigraphy and monitoring wells would be helpful." (57)

Response: This comment is from the "Assessing pumping test simulation results" section of the comment letter. Figures B-6 and B-7 from the draft PDI ER showed stratigraphy, well screen intervals, and static groundwater elevations for two cross sections. The figures have been revised to also show the observed drawdown amount from the 72-hour pumping test. An additional cross section has also been added to Appendix B which is drawn at a scale that shows water levels in more detail.

7.1.3 Observed and simulated contours (86)

Comments: "Section 7.4.1: please show simulated and observed contours on the same map, with focus on the area of interest near BTC and the subdrain." (86)

Response: A figure has been added o the PDI ER to address the comment. The figure is focused on the area of interest and shows simulated groundwater elevations and head residuals from Layer 1 of the model for the steady state stress period. For reference, this figure also shows estimates of the southern extent of the capture zone for the BPSOU Subdrain from multiple sources.

7.1.4 Map mean of the absolute head residuals (92b2)

Comments: "Add a companion figure to Figure C-7.3A that uses the mean of the absolute residuals per well, rather than the mean residual per well. Figure C-7.3A communicates overall bias in the transient head residuals, while the companion figure would better communicate overall deviation in the transient head residuals. This may help to illustrate the relatively poorer calibration to the pumping test data. Residual RMS or residual standard deviation, similar statistics that are commonly used, would be acceptable if preferred by the modeling team." (92b2)

Response: The head targets included in Figures C-7.3A and C-7.3B included wells used in the pumping test but excluded the groundwater elevation data collected during the pumping phase of the BTC pumping test. Instead, drawdown targets were used to represent the pumping test in the quantitative calibration statistics (Table C-7.1). This separation prevented calibrating to the lower average head of the wells where simulated drawdown was less than observed. The exclusion of pumping test targets addresses the reasoning provided for the additional figure. We will add more discussion regarding this to the text.

7.2 Flux

The following comments request additional detail regarding simulated flux in the calibrated model.

7.2.1 Focus on area of interest (40d1)

Comments: "The scaled flux calibration statistics described in Section 7.4.2 of the Groundwater Model Technical Memorandum mask the lack of calibration around features of interest because they are scaled to the large amount of water flowing daily to all of these features combined. The combined residual mean does not show whether flux to specific parts of BTC or the subdrain are poorly calibrated because the mean averages out those inaccuracies. Flux calibration should be based on the specific flux targets and should consider measurement error in stream flow or subdrain flow." (40d1)

Response: The overall flux calibration statistics were provided for completeness but were not the only basis for calibration or for communicating the calibration results. The graphs provided in Attachment C-5 provided more detail and the revised PDI ER includes calibration graphs for each of the flux target locations.

The revised PDI ER includes transient and steady state flux targets residual statistics for each type of flux target as well as statistics for each flux target location.

Variation in the observed flux values is expected to be greater than variation in the simulated flux values for the reasons discussed in Section 4.5.3, including measurement error, temporal discretization of the Model, overland flow and stormwater discharge (for surface water boundaries), and cyclical fouling / rehab of the BPSOU Subdrain. For those reasons, the calibration criteria for the flux targets are focused on residual statistics for steady state flux targets and on the scaled residual mean statistic for the transient targets.

Measurement error in flux targets was discussed above in Section 4.5.4 and is discussed in the revised PDI ER. Flux calibration graphs included in the revised PDI ER include 10% error bars for reference.

7.2.2 Flux measurement error (40d2, 40d3, 40d4)

Comments: "The bar charts in the “Calibration Flux Bar Charts: SFR Gain” section of Attachment C-5 provide a useful flux target format for BTC, but the lack of error bars on the stream flow target do not allow assessment of residual values (modeled vs observed field measured values)." (40d2)

"Similar bar charts should be produced for the subdrain flow." (40d3)

"Where calibration falls outside of the measured target +/- measurement error, this should be explained in the Groundwater Model Technical Memorandum." (40d4)

Response: These comments suggest considering measurement error in stream flow and BPSOU Subdrain flow. Specifically, they suggest adding error bars to the SFR Gain bar charts and discussing where flux calibration is outside of the flux targets +/- measurement error.

The revised PDI ER incudes a figure of flux (simulated and observed) vs. elapsed time for each of the BPSOU Subdrain segments. These graphs include error bars for reference.

The objectives of the model do not require all transient simulated targets to be within the range of measurement error. For example, as was discussed in Section 4.5.4 and 7.1.1 above, the variation in the Model is expected to be somewhat muted compared to the transient variation.

7.2.3 Simulated vs. Observed flux (40d5, 40d6)

Comments: "A scatterplot of simulated vs. observed flux would be helpful." (40d5)

"… With about 300 flux targets, error bars could likely be included. If this suggested approach results in an overly busy plot, separate scatterplots for surface water flow and subdrain could be generated." (40d6)

Response: These comments suggest including a scatterplot of simulated vs. observed flux along with error bars for the observed data and that separate graphs could be provided for Creek flux and BPSOU Subdrain flux. We agree and plan to include separate simulated vs. observed graphs for Creek and BPSOU Subdrain flux. Further, we expect to separate the data for each segment into different graphs. Error bars have been added to the graphs of flux calibration vs time instead of to the simulated vs. observed flux graphs as discussed in Section 4.5.4 above.

7.2.4 Map flux residuals (40d7)

Comments: "Maps of average flux residual and average absolute flux residual should also be generated to better understand and communicate matches and mis-mismatches. The flux residual plots should include comparison of simulated groundwater inflow to BTC stream segments compared with estimated inflow from streamflow data." (40d7)

Response: The flux targets in the revised memorandum will be limited to eight locations (five BPSOU Subdrain segments and two surface water segments). These locations of are shown on figures in the PDI ER. Flux statistics for these targets have also been summarized in a new table in the PDI ER which provides separate statistical summaries for each flux target.

7.2.5 Split BTC SFR reach to coincide with Bromide tracer test reach (66, 88)

Comments: "Bromide tracer test -The 2014 bromide tracer test is noted to be one of the most reliable estimates of average groundwater discharge to the BTC. The tracer test estimates BTC groundwater gain between Oregon Avenue and SS-04. This reach is in the BTC GCHS study area. For assessment of both model calibration and model application simulations it would be helpful to subdivide the BTC reach at Oregon Avenue so that simulated inflows can be compared directly with the tracer test result.” (66)

"Section 7.4.2 states, “Qualitatively, the Model simulation indicates that groundwater discharge to BTC between SS-01 and SS-04 (before December 2019) and between SS-01 and SS-05 (after December 2019) is typically on the order of 400,000 ft3/d (4.6 cfs). This result is consistent with estimates based on the bromide tracer study which indicated a groundwater gain of 1.4 cfs over a shorter reach from Oregon Avenue to SS-04 (Tucci, 2014; EPA, 2018; Section 4.3.3).” Why isn’t the simulated stream gain given in this comparison specific to the bromide tracer test reach?" (88)

Response: To facilitate comparison to flux targets during calibration, this SFR segment was split at the gauging locations. The calibration results section of the memorandum has been updated to compare the simulated flux results to the results of the bromide tracer test. The simulated flux data for that discussion was specific to the reach reported for the Bromide tracer test.

7.2.6 Account for flow from drains (83, 68b)

Comments: "Section 6.4.3 indicates that simulated Parrot Tailings dewatering uses drain boundaries. It is not clear where the flow from the drain is reported and compared to measured dewatering. Please provide this in the flux calibration section." (83)

"According to Figure C-6.3 of the Groundwater Model Technical Memorandum, drain boundary conditions were used to simulate a number of wetland areas along Blacktail Creek. This may result in water out of the model that presumably should go into BTC for those wetland areas that have a direct surface water (or culvert) connection to Blacktail Creek. Stream flow routing boundary conditions may be more appropriate, or at least the drain flux needs to be accounted for in the simulated BTC flows." (68b)

Response: The flux from the simulated Parrot Tailings dewatering was not a primary calibration target. The revised PDI ER, however, has been updated to compare the simulated flux rate from the dewatering to the reported average rate.

The water extracted from the drain boundary conditions for wetlands was accounted for in the BTC flux targets and in simulation of the BTC GHCS remedies during processing of the data. In the revised model, these wetland drain boundary conditions have been converted to river boundary conditions and included in the reach of BTC that they discharge to so that the flux targets used in the PEST runs include groundwater gain to these simulated wetlands.

7.2.7 Boundary flow accretion curves for other reaches (102)

Comments: "Additional graphs should be provided showing modeled stream exchange in Upper Silver Bow Creek and the confluence area similar to that shown for BTC in Figure C-8.2. If no flux calibration data exists for these reaches, calibration should be qualitatively assessed." (102)

Response: Flux to uSBC above the confluence with BTC is included in the SS-05 flux target in the revised Model.

7.2.8 Compare change in BPSOU Subdrain flow (observed to simulated; 55)

Comments: "Subdrain flow - The Pumping Test Interpretation memo indicated that flow at the BPSOU pump station, adjusted for test pumping discharge, decreased 12.5 gpm and 9.6 gpm for the 72-hr and 24-hr pumping tests, respectively. If this is considered to be representative of the change in subdrain total flow then it would be informative to compare simulated change in subdrain flow to the estimated values." (55)

Response: The simulated reduction of the flow for the 72-hr pumping test was 9 gpm using the version of the model reported in the draft PDI ER. The simulated reduction of the flow in the revised Model is 15.9 gpm. Given the significant noise in the observed data, these values are considered a close match to the observed response to pumping. The model memorandum has be updated to compare the observed and simulated change in Subdrain gain during the pumping test.

7.2.9 Show BPSOU Subdrain flux by segment (101)

Comments: "Attachment C-5 please include graphs of gain/loss in the specific subdrain segments such as done for the BTC stations under the subsection “Calibration Flux Bar Charts: SFR Gain.” (101)

Response: We agree that providing graphs which summarize the BPSOU Subdrain flux calibration results would be helpful. We have added figures of flux (simulated and observed) vs. elapsed time for each of the BPSOU Subdrain segments. These figures include error bars for reference (Section 7.2.2). This graph format would be better suited to the data than bar charts. The revised PDI ER also includes separate simulated vs. observed graphs for surface water and BPSOU Subdrain flux targets (Section 7.2.3).

7.2.10 State Performance Metrics for Flux Calibration (40d8)

Comments: "Note that the scaled residual standard deviation (10.6%) exceeds a typical performance metric of 10%. It is important to note that the performance metric for this statistic is not specifically stated in the Groundwater Model Technical Memorandum." (40d8)

Response: The discussion and supporting graphics communicating the flux calibration results will be expanded (see previous sections). We will discuss the 10% “rule-of-thumb” performance metric for scaled residual standard deviation in the calibration criteria section of the model memorandum.

Additionally, variation in the observed flux values is expected to be greater than variation in the simulated flux values for the reasons discuss in Section 7.1.2 including measurement error, temporal discretization, overland flow and stormwater discharge (for surface water boundaries) and cyclical fouling / rehab for the BPSOU Subdrain. For those reasons, the calibration criteria for the flux targets are focused on residual statistics for steady state flux targets and on the scaled residual mean statistic for the transient targets.

7.3 Lithology Model and K Zones

The following comments request additional detail regarding the lithology model.

7.3.1 Additional cross sections (76)

Comments: "It would be helpful to show additional cross sections that might clarify the extent of these clay and silt layers and why they were created in the model. Projecting boring logs a short distance onto the cross sections might also help." (76)

Response: Additional detail regarding the basis for the lithology zones is provided in Attachment C-2 (Lithologic Model). An EVS viewer file with numerous cross sections cut through the model can be provided upon request.

7.3.2 Discuss Interpolation (75)

Comments: "Cross section plots such as Figure C-2-6 that show model material assignments and boring logs are useful. However, Figure C-2-6 shows significant layers of clay and silt with no corresponding boring logs to support the stratigraphic delineation." (75)

Response: The basis for the lithologic zones was discussed in detail in Attachment C-2 and in multiple MTAC meetings (the slides and recordings of which are available on the shared folder). The lithologic distribution of the alluvial material was modeled in EVS using indicator kriging to interpolate material types from ground surface down to the top of the weathered bedrock surface using the compiled lithologic dataset.

7.3.3 Map of Average K (78)

Comments: "Would it be easy to make a map of average K assigned to the alluvium in the refined model area? It would be good to know how the average alluvium K in the refined area compares with the undifferentiated alluvium K assigned elsewhere." (78)

Response: The PDI ER has been revised to include comparison of pilot points from the differentiated and the undifferentiated alluvial zones. Additionally, the PDI ER has been revised to include a figure which presents the calibrated average horizontal hydraulic conductivity of the alluvial aquifer.

7.3.4 Map of Simulated Transmissivity (44b)

Comments: "... Though it is difficult to tell exactly, it appears that the aquifer T value in the model is a little lower than the corresponding T value indicated by the distance-drawdown analysis. This is reasonable…." (44b)

Response: The PDI ER has been revised to include a figure which presents the calibrated transmissivity of the alluvial aquifer. The PDI ER has been revised to discuss the calibrated transmissivity values and the ranges provided in the pumping test evaluation (Appendix B).

7.4 Flow Budget and Recharge

The following comments request additional detail regarding the flow budget for the model.

7.4.1 Present flow budget (68a, 69, 70, 71)

Comments: "Model simulated groundwater budget flows should be presented. This is important for understanding area groundwater hydrology, model sensitivity and assessing remedial approaches. The budget can be presented as figures and/or tables. The data should include:

- Areal recharge
- Upgradient CHD boundary inflows
- Downgradient boundary outflows (if any)
- Subdrain inflows and outflows
- BTC inflows and outflows - Subdivide as appropriate, e.g., BTC GHCS area
- River boundaries – BTL cells, pond, etc.
- Wetlands, dewatering and other drain boundary condition outflows
- Pumping outflows"(68a)

"Water budgets should be provided for 2017 and preferred alternative steady state simulations." (69)

"For the transient simulations, time history graphs would be ideal, but selected summer and winter snapshots might be sufficiently informative." (70)

"A zone budget focused on the study area, possibly defined by model refinement area or BTC GHCS, would be very informative." (71)

Response: We agree that inclusion of additional detail regarding the water budgets is warranted and will update Appendix C accordingly.

7.4.2 Compare simulated CHD flow to expected (72)

Comments: "An explicit check should be presented comparing model simulated upgradient inflow for the CHD boundary with expected flow from the upgradient watershed. The recharge model should be useful for estimating upgradient watershed recharge. Stream flow across the boundary should be accounted for in the assessment." (72)

Response: The calibration results section has been updated to discuss the inflow to the model from the constant head boundary at the upgradient edge of the active model domain.

Stream flow across the upgradient boundary was accounted for in the draft model appendix to the PDI ER.

7.4.3 Compare simulated no-flow to expected (73)

Comments: "A no-flow boundary condition is assigned at the limit of the alluvial aquifer. The report should confirm that it is reasonable to neglect inflow to the alluvium/weathered rock aquifer from the upgradient watershed area. The recharge model should be useful for this (and also model water budget data)." (73)

Response: Section 6.4.1 has been updated to discuss limited expected inflow to the model from the no flow boundary at the upgradient edge of the active model domain.

7.4.4 Discuss areas of higher recharge (74)

"The recharge model appears to show areas of relatively high recharge (greater than 10 ipy) near the model west boundary. Does this represent a “mountain front recharge” phenomenon? These areas are mostly, but not entirely, within the model domain. Please add some discussion of this." (74)

Response: Figure C-4.8 and the figures in Attachment C-3 do not show areas recharge greater than 10 inches per year along the western boundary of the Model.

7.5 Remedial Action Objectives (4a, 4b)

Comments: "Performance metrics for the BTC GHCS are not defined as a flow rate. The overall groundwater goal is to prevent discharge of contaminated groundwater that causes exceedances of surface water performance standards. The degree of groundwater contamination is variable across the site, so it is not possible to directly connect the groundwater goal of preventing discharge of contaminated water with the model simulated reduction in discharge which does not consider the degree of groundwater contamination..." (4a)

"...Among the alternatives evaluated, Alternative 6 resulted in the least groundwater discharge to BTC from the northeast and below under steady-state conditions, and the smallest extraction rate of the six alternatives considered. Although Alternative 6 is predicted to perform the best of the alternatives evaluated, there is no discussion or evaluation of its adequacy or its ability to meet RAOs..." (4b)

Response: These comments request additional discussion regarding the ability for the simulated remedies to meet the remedial action objectives (RAOs). Specifically, they point to the objective to control discharge of contaminated water to BTC and note that the model evaluated the total flow of all groundwater to BTC along the area of interest.

As was discussed in the MTAC meetings and stated in the model Quality Assurance Project Plan (QAPP), reactive contaminant transport modeling was not included in the modeling scope of work. Reactive contaminant transport modeling was specifically excluded due to the controlling factor that chemical reactions have on the transport of inorganic COCs. Instead of reactive contaminant transport modeling, conservative particle tracking and mass balance data from the groundwater simulations were used to evaluate the performance of the simulated remedial alternatives.

We understand that the intent of the FRESOW was for the BTC GHCS to have the ability to control discharge to BTC, as needed, along a reach extending from approximately 500 feet downstream of Kaw Ave to George St. (PDI ER Figure 2). To be conservative, our evaluation focused on the full extent of that reach.

The PDI ER included review of groundwater sampling data and compared the data to groundwater and surface water criteria. Exceedances of groundwater standards were limited to wells located within the capture zone of the BPSOU Subdrain (Section 3.3.2 and Figures 6A through 6F). Exceedances of surface water standards were limited to cadmium in BTC-PZ04D, and aluminum, cadmium, and zinc in BTC-PZ05D (Section 3.3.3 and Figures 7A through 7H). Additionally, qualitative review of COCs over time (PDI ER Appendix D) indicates that, in general, concentrations of COCs have been decreasing or stable.

8 Revisions and Clarifications for the Memorandum

The following comments were related to figures included in the main text of the PDI ER and Appendix C (Groundwater Model Technical Memorandum). These comments suggest revisions and/or request clarification.

8.1 PDI ER

8.1.1 Figure 9, Figure 10, and Table 10 (7a)

Comments: "According to Figures 9 and 10, Table 10, and the text discussion, groundwater discharge from the northeast and below occurs to the upper part of the GHCS reach of BTC. The lateral extent of the “upper part” is unclear and should be clarified in the figures..." (7a)

Response: Figure 9 (and associated Figure C-8.3) has been revised so that the x-axis is in units of feet instead of segment numbers.

8.1.2 Section 2.1 (8)

Comments: "Page 4, Section 2.1, 1st paragraph, last sentence: Calcium was also analyzed by XRF and should be added to the analyte list." (8)

Response: The text has been updated accordingly.

8.1.3 Section 3.2 (10)

Comments: “Page 8, Section 3.2, 1st bullet on Page 8, last sentence: The geometric mean values for storativity are stated with units of ft2/day. Storativity is a dimensionless parameter and should, therefore, have no units. Please remove the units from the storativity values stated in the text.” (10)

Response: The text will be updated accordingly.

8.1.4 Section 3.3.2 (11)

Comments: "Pages 9 and 10, Section 3.3.2: It is not clear what the trend analysis described in Section 3.3.2 and Appendix D is used for. Also, trend analysis is not specified in the DQOs in the BTC GHCS Remedial Design Work Plan (RDWP). It is indicated in the report that groundwater standards are not a relevant benchmark because those standards are waived in the TI zone. Also, a trend analysis, if needed, should make use of a statistical test." (11)

Response: The groundwater chemistry data were provided to support evaluation of future extracted groundwater concentrations and capture zone analysis. Specifically, the data were used to support identifying locations with elevated COCs where groundwater discharge to BTC should be focused on (see Section 7.5 of this response). The trends shown were provided to support qualitative visual evaluation of the data and further statistical analysis is not necessary to meet the objectives of the PDI ER.

8.1.5 Section 4.3.1 (12, 13)

Comments: "Page 13, Section 4.3.1, bullets: The description of modeled alternatives in Section 4.3.1 of the PDI ER seems to differ from the descriptions in the Groundwater Model Technical Memorandum (Appendix C). Alternative 2 in the PDI ER includes "Deep pumping well and shallow pumping wells / interceptor drain along BTC" but the Groundwater Model Technical Memorandum only includes the deeper well BTC-PW-01. Alternative 3 in the PDI ER includes "Shallow pumping wells / interceptor drain along east side of Kaw Ave" but the Groundwater Model Technical Memorandum has the deeper well DE-PW-01 which is simulated in layers 6 and 7. Please address." (12)

"Page 13, Section 4.3.1, 5th bullet: The text for Alternative 6 states that simulated extraction at BTC-PW-03 is deep but on page 18 (Section 4.3.2.7, 2nd paragraph) the text states that BTC-PW-03 was simulated in Layers 1, 2, 3 of the model. This should be resolved. The PDI ER indicates pumping from layers 1, 2, 3 while the Groundwater Model Technical Memorandum indicates layers 4 to 7. Based on the contours, tracks and labels shown in Groundwater Model Technical Memorandum and Figure C-8.10B, BTC-PW-03 pumps from layers 4 to 7 in the model." (13)

Response: The description of alternatives included in the Groundwater Model Technical Memorandum (Appendix C) are accurate. The PDI ER text has been updated to be consistent with the model text.

8.1.6 Section 5.1 (15)

Comments: "Page 19 Section 5.1, 1st bullet, 2nd paragraph, last sentence: This is the same comment as above for Page 8, Section 3.2. The geometric mean values for storativity are stated with units of ft2/day. Storativity is a dimensionless parameter and should, therefore, have no units. Please remove the units from the storativity values stated in the text." (15)

Response: The text has been updated accordingly.

8.1.7 Section 5.1 (16a)

Comments: "Page 20, Section 5.1, last paragraph on page 20: "Shallower hydraulic gradients are observed between BTC- PW-01 and the BPSOU Subdrain, indicating the potential for well interference (reduction of water available to BTC-PW-01 and the BPSOU Subdrain)." This shallower gradient is evident in the maximum observed drawdown contours for both the 72-hour and 24-hour pumping tests (Figures B-9A and B-9B). The fact that the drawdown field is less here should not be affected by well interference unless there was an increase in subdrain capture to create additional drawdown from the subdrain. Otherwise, the drawdown from the BTC pumping test should be superimposed on the existing drawdown pattern from the subdrain. The flow into the subdrain was measured to decrease during the pumping tests which should lead to a decrease in drawdown from the subdrain. This shallower gradient may be a zone of higher hydraulic conductivity and preferential flow which should be incorporated into the model. This comment also applies to Section 2.2.2.1 of the Pumping Test Memo. Please address. The gentler and more widespread drawdown shown in Figures B-9A and B-9B, extending from BTC-PW-01 towards Upper Silver Bow Creek and the BPSOU subdrain in a north-northwest direction, could also be because of the lack of piezometers in that area. Piezometers along that direction could help to constrain contour interpretation.

The same is true moving to the south of BTC-PW-01. The shallower gradient could also be due to shorter distance and greater flow impact at BTC compared to the subdrain. That is, there is likely a little more flow to the pumping well from the south than from the north. Further evaluation of the hydraulic impacts on the subdrain due to pumping at BTC-PW-01 is needed." (16a)

Response: We have revised the text in Section 5.1 of the PDI ER and Section 2.2.2.1 of the Pumping Test Memo to clarify the discussion regarding gradients, interaction with the BPSOU Subdrain, and the shallow groundwater divide during pumping. For additional discussion regarding interaction between the BPSOU Subdrain and BTC-PW-01, see Sections 2.1, and 6.1 of this response to comments and the May 1, slides and recording from the May 1, 2024 MTAC meeting.

8.2 Appendix A

8.2.1 Section 1 (18)

Comments: "Page 1, Section 1.0, 2nd paragraph: The EPA National Functional Guidelines for Organic Superfund Methods Data Review (2020) should be listed in this section and any other applicable sections." (18)

Response: The text in Section 1.0 has been revised to include a reference to *EPA National Functional Guidelines for Organic Superfund Methods Superfund Data Review* as suggested in the Agency comment.

8.2.2 Section 2.3 (19)

Comments: "Page 9, Section 2.3, bullets: Inductively Coupled Plasma Serial Dilution review is part of a Stage2A review. The data validation report indicated that information was not provided in the data package. Going forward the appropriate type of data package should be procured by the laboratory so all required data validation elements can be reviewed." (19)

Response: Comment noted. Serial dilution was not included in verification and validation methods described in Section 8.2.3 or Table 4 of the *Final Blacktail Creek Pumping Test Quality Assurance Project Plan (QAPP)* because it is not currently provided in the laboratory's standard data packages. AR has been working with the laboratory to develop a data package that includes Inductively Coupled Plasma serial dilution to address the Agency comment in future efforts.

8.2.3 Section 3.5 (17)

Comments: "Page 13, Section 3.5, 1st paragraph, 4th sentence: This sentence indicates that 16 samples were collected when previous sentences in the paragraph state that 4 samples were collected. Please revise the sentence to state that 4 samples were collected." (17)

Response: The number of organic samples was incorrect as described in the Agency comment. The text in this location has been revised to correctly state that four organic samples resulted in 164 data points generated.

8.2.4 Section 4.1.1 (20)

Comments: "Page 10, Section 4.1.1, 2nd paragraph: Going forward it would be good to identify site specific samples for XRF duplicate and replicate analyses." (20)

Response: Comment noted.

8.2.5 Section 4.1.2 (21)

Comments: "Page 11, Section 4.1.2, Laboratory Precision, Table: Please confirm the DV reason code for sample BTC-PZ01S-20220816. It appears that it should be RB, FD and not FB, FD. In accordance with the text and table in Section 4.2.2, there were 5 natural samples qualified for rinsate blank detection, including BTC-PZ01S-20220817." (21)

Response: The data validation reason code for sample BTC-PZ01S-20220816 was incorrect in the location described in the Agency comment. The data validation reason code for sample BTC-PZ01S-20220816 was updated to RB, FD in the table.

8.2.6 Section 4.6.2 (22)

Comments: "Page 16, Section 4.6.2, Laboratory Sensitivity, 4th paragraph: In this paragraph, it is stated that the MDL for TSS results (5 mg/L) was greater than the required RL in the QAPP (2 mg/L). EPA recommends a maximum TSS concentration of 0.5 mg/L for treated drinking water. For surface water concentrations in Blacktail Creek for example, many of the results were non-detect at 5 mg/L(the elevated MDL value). It is recommended that going forward, the procured laboratory meet the QAPP RL of 2 mg/L in order to evaluate results that may be above the 2 mg/L RL or, the data quality objective for what standard the TSS results should be compared to should be re-evaluated." (22)

Response: Comment noted.

8.2.7 Attachment 1 (23)

Comments: "Title: This Attachment is named Attachment 1 and it is attached to the BTC Pumping Test Data Validation Report which is Attachment 1 of the BTC Pumping Test Data Summary Report. It is confusing to have Attachment 1 attached to Attachment 1. Please rename the attachments to the BTC Pumping Test Data Validation Report." (23)

Response: The Data Validation Report attachments were retitled A, B, and C to avoid confusion as described in the Agency comment.

8.3 Appendix B

8.3.1 Section 2.3 (25)

Comments: "Two methods of quantitative hydraulic analysis are presented: distance-drawdown (Cooper-Jacob)and time-drawdown (Hantush and Jacob, Neuman and Witherspoon). Very different results were reported.

• Distance-drawdown: T = 1765–2039 ft^2/day, K = 135–156 ft/day

• Time Drawdown: T = 7404-8444 ft^2/day, K = 570-650 ft/day

It is surprising that there was little or no discussion of this discrepancy in the report. In fact, it is likely that neither analysis accurately reflects the impact of BTC and subdrain groundwater-surface water interaction on the groundwater response. More discussion should be provided. There are simplifications and assumptions in the methods used that may not be consistent in this setting. It may be worthwhile to briefly discuss the simulation of the pumping test in the model (the model accounts, for example, for boundary conditions that may impact pumping test data) and what insights this may give into K." (25)

Response: Section 2.3.4 (Well Test Interpretation) has been added to the document. This section provides a short comparison of the two methods. Given the heterogeneity of the alluvial aquifer and the simplifying assumptions used in each estimation method, the transmissivity and hydraulic conductivity results are actually quite similar (less than half an order of magnitude difference). For these reasons and because transmissivity and hydraulic conductivity range over many orders of magnitude the differences between the estimates were not unexpected. The text in Section 2.3.4 will be revised to compare the values.

8.3.2 Section 2.3 (26)

Comments: "Suppressed drawdown due to surface water interaction with groundwater increases the apparent T/K values indicated by the traditional analyses presented. Because the distance drawdown analysis focusses on changes in drawdown from point to point, it is less affected by overall suppressed drawdown. Hence, the calculated T/K values are much lower using this method. However, calculated T/K are still likely over-estimates because the actual point to point flow rate is likely less than the flow rate calculated in the analysis assuming purely radial flow to the pumping well. Please address." (26)

Response: See response in Section 8.3.1 (25) above. Additional discussion is provided in Section 2.3.4. Commenters use of “Suppressed” is assumed to be conditions that reduce or mitigate the extent of drawdown.

8.3.3 Section 2.3.3 (27)

Comments: "Section 1.5.2.1 describes a multi-layer aquifer with discontinuous confining layers. Some of the paired well response curves match each other nearly perfectly suggesting strong interconnection between shallow and deeper water-bearing zones as would occur in a single layer aquifer without delayed yield. Other well pairs show a difference in magnitude of response suggesting a leaky confined or multi-layer aquifer. This imparts a challenge in describing the response model. A derivative analysis is typically used in concert with descriptive hydrogeology to identify the model; however, the derivative analysis was nearly nonexistent with only a single plot (Figure B-14) that didn’t match the data very well. Additional analysis should be conducted. The derivative curves from the Neuman-Witherspoon solution don’t make sense with the possible diagnostic plots of Renard et al. (2009). It seems that it might actually match the “no flow boundary” or even the “heterogenous behavior” “caused by a layered aquifer” of Studner et al. 1997. Please include more derivative analysis plots in the Pumping Test Technical Memorandum.

References

Renard, P., D. Glenz, and M. Mejias 2009, Understanding Diagnostic Plots for Well-Test Interpretation. Hydrogeology Journal v.17, n.3, pp.589-600.

Studner, M, G. Zangle, and F. Komlosi 1997, A Modern Concept Simplifying the Interpretation of Pumping Tests. Transactions on Ecology and the Environment, c.14, pp.431-440. (27)

Response:

Section 2.3.3.4 (Derivative Analysis) has been added to the document. Each AQTESOLV output plot provided in Appendix B-5 includes a derivative diagnostic plot (plotted in red). The pumping data and not the recovery data was analyzed for the interpretation of the derivative analysis. Not including the recovery data yielded different estimates of T and K than previously estimated. The single derivative plot (Figure B-14) is no longer included because multiple derivative diagnostic plots are provided in Appendix B-5.

Studner et al. (1997) describes a derivative plot pattern that drops and rises to be typical of heterogenous aquifer behavior, potentially caused by a layered aquifer system, or distinctive areal changes in permeability. Each of the derivative plots in **Attachment B-5** shows a pattern that drops and rises, which helps support the interpretation that the aquifer is heterogenous and is layered.

8.3.4 Section 2.2.2.1 (28)

Comments: "The BTC pumping test reversed upward groundwater gradients in the lower subdrain area. The consequences of altering groundwater capture near the subdrain and transporting contaminated groundwater from near the subdrain toward BTC needs to be evaluated. Pumping Test Technical Memorandum Table B-3 and Figure B-11A and B-11B show water level data from nested wells during the tests. The vertical gradients at BPS07-21/BPS07-21B and BPS07-22R/BPS07- 22B changed from upwards to downwards during the tests. These nested wells are representative of the vertical hydraulic gradient near the bottom of the subdrain. The existing hydraulic gradients are positive indicating flow is upwards towards the subdrain. Reversing this gradient will reverse flow and may cause loss of water from the subdrain or transport of highly contaminated groundwater to locations with inadequate controls. This is a concern in part because the highly contaminated Parrot impacted groundwater that is captured within the upper subdrain should not be lost to the alluvial aquifer in the lower segments where it is more likely to impact surface water. We did not see where this is evaluated in the PDI ER or appendices. It is also not clear if the reduction in subdrain flow reported in the Pumping Test Memo is a reduction in capture or a loss of subdrain flow. This is an important distinction that needs to be evaluated, potentially by performing a tracer test simultaneously with another pumping test. If a tracer test is performed during a pumping test, additional piezometer coverage should be considered southwest of MH-MSD106 and west of BPS07-21x to better identify potential flow path impacts.

Pumping Test Technical Memorandum Figures B-8A2 and B-8B2 show the potentiometric surface during the 72 and 24-hour pumping tests respectively. Both potentiometric surfaces show that pumping of BTC-PW-01 may also capture contaminated groundwater from near the lower subdrain and draw that groundwater towards BTC. This is acknowledged in Section 2.2.2.1 of the Pumping Test Technical Memorandum which states, “Groundwater within the BPSOU Subdrain is within the capture zone of the pumping well as shown on Figure B-8A2 and Figure B-8B2.” This may also affect transport of contaminated groundwater near well BPS07-21 where the water quality data shows groundwater to be highly contaminated with arsenic and zinc. The PDI ER should base selection of new BTC GHCS elements on a better understanding of how the new controls will affect the existing capture systems and known contaminant plumes. Additional hydraulic controls to those evaluated in the PDI ER and Groundwater Model Technical Memorandum may be necessary to meet the CD requirements for additional capture, while protecting the existing groundwater remedy. The General Comments include several recommendations for additional controls that could be evaluated. (28)

Response: For additional discussion regarding interaction between the BPSOU Subdrain and BTC-PW-01, see Sections 2.1 and 6.1 of this response, and the slides and recording of the May 1, 2024 MTAC meeting.

This comment highlights that the interaction between the BPSOU Subdrain and the proposed BTC GHCS is inherently a three-dimensional problem. As the comment notes, upward vertical gradients in the area of influence of BTC-PW-01 were reduced or reversed (becoming downward vertical gradients). This was the expected result because BTC-PW-01 is screened at depth (42.5 feet to 52.5 feet below ground surface). Upward vertical gradients are a primary contributing factor for why groundwater discharges to BTC along this reach and reversal of those gradients is necessary to control discharge to the creek. Observed and simulated gradients, however, indicate that pumping at BTC-PW-01 and proposed pumping from the BTC GHCS has not and would not induce leakage from the BPSOU Subdrain. For more discussion, see Section 2.1 and the May 1, 2024 MTAC meeting. We will expand and update the discussion in Appendix B accordingly.

Overlap of the influence of the BPSOU Subdrain and the proposed BTC GHCS is consistent with best practices for capture system optimization to prevent loss of capture from between the individual systems. The capture zones overlap in three-dimensions. When pumping, BTC-PW-01 captures water from deeper layers of the aquifer. Although, the capture zone of the lower reach of the BPSOU Subdrain is somewhat reduced when BTC-PW-01 is pumping, the BPSOU Subdrain continues to capture shallow groundwater and the combined capture zone is increased. The reduction of gain to the BPSOU Subdrain during the pumping tests was consistent with the reduction of the BPSOU capture zone and is not indicative of leaking of BPSOU Subdrain water to the groundwater.

Section 2.2.2.2 has been revised to include the discussion provided above. In addition, Figure B-7, hydrogeological cross section C-C’ is cut through the BPSOU Subdrain. Figure B-7 shows the groundwater head elevations for groundwater monitoring locations (BPS07-21B and BPS07-22B) screened within the Pumped Water Bearing Zone. The head elevation within these groundwater monitoring locations remained greater than head elevations within the BPSOU Subdrain during the BTC Pump Test. Hydrographs for groundwater monitoring locations BPS07-21 and BPS07-22R are shown in **Attachment B-1** (**Graph 9**) and **Attachment B-1** (**Graph 13),** respectively**.** These groundwater monitoring locations are screened across the shallow aquifer and did not respond as readily (change in magnitude) as groundwater monitoring locations screened within the Pumped Water Bearing Zone and also had head elevations greater than the BPSOU Subdrain.

The necessity of additional testing was discussed in Section 2.1. The flexibility of the proposed remedy along with performance monitoring and optimization will further address potential for leakage from the BPSOU Subdrain. The necessity for evaluation of additional hydraulic controls was discussed in Section 6.1.

8.3.5 Section 2.2.2.1 (29)

Comments: "Section 2.2.2.1 states, "Shallower hydraulic gradients are observed between BTC-PW-01 and the BPSOU Subdrain vault indicating that the BPSOU Subdrain is contributing to the drawdown caused by the BTC Pumping Test." PDI ER Specific Comment No. 16 above discusses that the shallower gradient is unlikely to be caused by drawdown from the subdrain. While there is drawdown associated with the BPSOU Subdrain prior to the pumping test, the drawdown shown on Figures B-9A and B-9B is relative to the BPSOU Subdrain active base condition. Therefore, the BPSOU subdrain does not contribute to the pumping drawdown displayed on these figures. However, the pumping test drawdown may have been attenuated by the subdrain (relative to if the subdrain were not there). In short, the two are in hydraulic connection during the pumping test and additional discussion of the potential impacts and hydraulic communication between the systems is warranted in the report. As stated in PDI ER Specific Comment #16, further evaluation of the hydraulic impacts on the subdrain due to pumping at BTC-PW-01 is needed." (29)

Response:

The discussion referenced in Section 2.2.2.1 (Groundwater) has been moved to Section 2.2.2.2 (BPSOU Subdrain). Section 2.2.2.2 integrates the response provided to Section 8.3.4 (28) above. Section 2.2.2.2 provides additional clarification concerning the contribution of the BPSOU Subdrain.

The groundwater around the BPSOU Subdrain is maintained at a lower elevation due to the groundwater extraction. When water levels are drawn down by pumping at BTC-PW-01, the gradient between the two sources of groundwater extraction can be expected to be lower than in other directions from the pumping well because of the pre-existing drawdown from the BPSOU Subdrain.

8.3.6 Section 2.3.4 (30)

Comments: "Page 3.29, Section 2.3.4, 2nd complete paragraph on page 3.29: Please provide an explanation for the discrepancy between the range of transmissivity values determined from distance drawdown analysis (1,765 ft2/day to 2,039 ft2/day) and from type curve, time-drawdown analyses (4,575ft2/day to 14,110 ft2/day)." (30)

Response: See response to comment 25 in Section 8.3.1 above.

8.3.7 Section 2.3.4 (31)

Comments: "Page 3.29, Section 2.3.4, 3rd complete paragraph on page 3.29: The storativity value for the Hantush-Jacob analysis on piezometer BTC-PZ07 is incorrect. According to the Aqtesolv Type Curve Solution Plot for the Hantush-Jacob (1955)/Hantush (1964) analysis in Attachment B-4, the storativity value is 6.65E-08. The value shown in Table-B4 (9.19E-05) is the r/B solution parameter. Replacing the storativity with the correct value (6.65E-08) changes the geometric mean storativity and the minimum storativity value for the Hantush-Jacob (1955)/Hantush (1964) analyses. Please revise the text and table B-4, accordingly." (31)

Response: The text and table referenced by the Commenter have been revised. See response to comment 27 in Section 8.3.3 above. Estimated K & S values have changed due to the exclusion of the recovery data analysis. Table B-5 summarizes the estimated K & S values provided in Attachment B-5

8.3.8 Table B-4 (32)

Comments: "Table B-4: As noted in the previous comment, the storativity value shown for the Hantush-Jacob analysis on piezometer BTC-PZ07 is incorrect. According to the Aqtesolv Type Curve Solution Plot for the Hantush-Jacob (1955)/Hantush (1964) analysis in Attachment B-4, the storativity value is 6.65E-08. The value shown in Table-B4 (9.19E-05) is the r/B solution parameter. Replacing the storativity with the correct value (6.65E-08) changes the geometric mean storativity and the minimum storativity value for the Hantush-Jacob (1955)/Hantush (1964) analyses in TableB-4. Please revise Table B-4 accordingly as well as references to geometric mean storativity and the range (minimum) storativity throughout the report (e.g., page 3.29, 3rd complete paragraph)." (32)

Response: See response to comment 31 in Section 8.3.7 above.

8.3.9 Figure B-6 (33, 9)

Comments: "Figure B-6: Please add the BPSOU subdrain construction profile to cross section A-A'." (33)

"Page 7, Section 3.1, 2nd paragraph, 1st sentence: Confining layers should be identified on cross-sections (Figures B-6 and B-7 of Appendix B)." (9)

Response: The profile of the BPSOU Subdrain has been added to newly constructed cross section C-C';(Figure B-7)Due to the scale of cross section A-A', additional detail would be illegible. We added the additional cross section (Figure B-7 [Hydrogeological Cross Section]) to the pumping test memo which is at a smaller scale and it provides more detail of the BPSOU Subdrain construction. Cross section C-C' was presented in the May 1, 2024 MTAC meeting.

Confining layers or fine grained layers (clay, peat, and silt) are identified in cross section A-A' (Figures B-6A) and cross section B-B' (Figure B-6B) using fill with shades of green. Confining layers are discussed in Section 1.5.2.

8.3.10 Figure B-8B1 and Figure B-8A2 (34)

Comments: "Figures B-8B1 and B-8A2: These figures depict the "Shallow Groundwater Divide" but the contours are drawn using wells from intermediate depth. The shallow groundwater divide should be estimated using wells completed in the shallowest portion of the alluvial aquifer. The divide should be called out as "Pumped Water-Bearing Zone Groundwater Divide" or "Groundwater Divide in Water-Bearing Zone Intersected by BTC-PW-01". The text states that "[G]roundwater elevations are not contoured for each paired piezometer on Figure B-8A1 and Figure B-8B1. The piezometer in the pair monitoring within or proximal to the Pumped Water Bearing Zone was selected for contouring." In some cases, the well symbology on Figures B-8B1 and B-8A2indicates that both of two paired piezometers were used for contouring (e.g., BTC-PZ05S/D andPZ03S/D), but the corresponding drawdown maps indicate that only the deeper (D) piezometer was used. Additionally, the text elsewhere indicates that the PZ0 series piezometers don't intersect the pumped interval. Wherever possible, the same set of wells should be consistently used for contouring potentiometric surface and drawdown. Also, indicate the wells on the figures, and screen location relative to the pumped interval. Please address. (34)

Response: The figures will be reevaluated to address this comment. Due to complex 3D flow, aquifer heterogeneity, and difficulties knowing which well is to be selected, an additional figure may help communicate water level differences between well screens above and within the pumped interval. Previously, professional judgement and identification of the well screen relative to the pumping well were used for well selection. Additionally, use of "Shallow Groundwater Divide" will be removed from the figure. Please reference the response provided in Section 8.3.4 above.

8.3.11 Figures B-8A1 through B-8B2 (35)

Comments: "Figures B-8A1 through B-8B2: The potentiometric surface contours use water levels measured in the BPSOU Subdrain manholes to contour the groundwater surface. The BPSOU Subdrain water levels are representative of pipe flow, not the alluvial groundwater and should not be used to contour the potentiometric surface. Contouring of BPSOU Subdrain water levels gives an unrealistic depiction of the magnitude and extent of the groundwater depression associated with the subdrain capture zone. The contours were developed using kriging which does not account for the hydraulic conductivity contrast that exists between the subdrain pipe, bedding material, and surrounding aquifer. Please address." (35)

Response: This comment also relates to comment 40c7 which was addressed in Section 2.3 and comment 40c6 which was addressed in Section 4.4.4. We agree that the measured water levels in the BPSOU Subdrain do not directly represent groundwater elevations adjacent to the BPSOU Subdrain. Due to well loss, the water levels in the BPSOU Subdrain will be lower than the groundwater elevations adjacent to the BPSOU Subdrain. We have removed the MH-MSD elevations from the head targets in the model. Because the MH-MSD levels directly represent water levels in the BPSOU Subdrain, we have updated the model to use these elevations to set transient stages for the drain boundary conditions representing the BPSOU Subdrain. These BPSOU Subdrain water levels are no longer used as calibration targets for the groundwater model. They will continue to be used to inform manual contouring included in the pumping test evaluation, however, with understanding of the limitations of using these monitoring points to represent groundwater elevations (they represent minimum elevations expected for groundwater adjacent to the drain at those locations).

Figures B-8A1 through B-8B2 have been adjusted to show less groundwater interpretation in the vicinity of the BPSOU Subdrain.

8.3.12 Figure B-11A and Figure B-11B (36)

Comments: "Figures B-11A and B-11B: The BTC-PZ02s/BTC-PZ02D well pair is mis-labeled as BPSPZ02S/BTC-PZ01D on both figures. Please revise." (36)

Response: Figures B-11A and B-11B have been updated

8.3.13 Attachment B-4 (37)

Comments: "Attachment B-4: The output of the Aqtesolv software includes transmissivity and storativity values for a pumped aquifer (T1, S1) and an unpumped aquifer (T2 and S2). The printouts in Attachment B-4 for the Neuman-Witherspoon solution all show unrealistically low T2 values. Section 1.5.2.1 indicates a crude pumping test generated a transmissivity value for the shallow groundwater at 600 ft2/day. Another shallow aquifer test was reported in the Phase II RI report, Appendix B-7, at PW-2 next to the BPSOU subdrain. This had observation wells and a geometric mean transmissivity for the shallow aquifer (10 to 15 feet deep) of 333 ft2/day. This general range of transmissivity should be used in the Aqtesolv Neuman-Witherspoon solution. This will not radically alter the T1 values but will at least eliminate some unrealistic T2 values. Please attempt the analysis with more reasonable T2 and S2 values." (37)

Response: Section 2.3.3.2 (Numerical Solution Inputs) was added to the document to discuss the input for the unpumped aquifer (T2 and S2). Based on these previously reported transmissivity values for the shallow groundwater zone, the minimum and maximum transmissivity value in the unpumped aquifer (T2) was limited to 50 and 950 ft^2/day, respectively. Limiting the minimum and maximum T2 values did not radically alter the T1 values. The estimation of the T2 and S2 values are provided in **Attachment B-5**.

8.3.14 Attachment B-5 (38)

Comments: "Attachment B-5: The Cover Page for Attachment B-5 lists Hantush (1960) as the source for the solution assumptions provided. This should be Hantush-Jacob (1955)/Hantush (1964) to be consistent with the solution model used for the analyses and the assumptions listed in Attachment B-5." (38)

Response: The text has been updated to address this comment.

8.4 Appendix C

8.4.1 Section 7.4.1 (87b)

Comments: "Section 7.4.1 states, “shallow water levels in the BTC and SBC confluence area, however, tend to be low compared to simulated values (positive residuals).” …According to Figures C-7.3A and B, the residuals in this area are positive, which indicates that observed water levels are higher than simulated water levels. While this passage states that this indicates that observed water level are lower than simulated water levels." (87b)

Response: The text in the draft PDI ER was incorrect. Head residuals and discussion regarding calibration results has been revised in the updated PDI ER.

8.4.2 Section 8.1 (91)

Comments: "Section 8.1: please describe if the flux values and figures are from a steady state or transient model." (91)

Response: As noted in Section 8.1 of the Groundwater Model memo, the contour maps are from steady state simulations. The particle tracks on these maps are from the same steady state simulations. The flux summary graphs (Figure 8.3 and 8.4) are also from steady state simulations.

8.4.3 Figure C-7.1 (92a)

Comments: "On Figure C-7.1, symbolize eliminated gauging locations by rationale for eliminating. Use distinct symbol (e.g., triangle) for the eliminated locations vs. retained locations." (92a)

Response: The model has been updated to include some head targets that were inadvertently excluded during model development (see Section 4.4.3 above). Figure C-7.1 has been updated to include the classified symbology as requested.

8.4.4 Figure C-7.3A (92b1)

Comments: "On Figure C-7.3A, include well IDs and make the symbols distinct for the -1 to 0 ft range and the 0 to 1 ft range." (92b1)

Response: Including well ID labels on Figure C-7.3A would be impractical due to the scale of the figure, and with the additional head targets included in the revised model. We plan to add a figure, however, that will be focused on the area of interest, and will include head target labels (see Section 7.1.3). Additionally, Attachment C-5-2 is a table of the head target residuals and includes target coordinates. A shapefile of the table can be provided upon request.

In the revised PDI ER, the symbology for these figures has been updated to make the -1 to 0 foot symbology distinct from the 0 to 1 foot symbology. The symbology has also been updated to separate absolute residuals from 0 to 0.5 from absolute residuals from 0.5 to 1.

8.4.5 Figure C-7.3A and C-7.3B (92c, 92d)

Comments: "On Figure C-7.3A, clarify the title. It appears based on the legend that the contours are for layer 1 and the residuals are for layers 1 through 4. However, the figure title is not consistent with this… (92c)

On Figure C-7.3B, similar comments as above for Figure C-7.3A." (92d)

Response: The layer listed in the figure titles was intended to refer to the contours. The figure titles have been updated to clarify.

8.4.6 Figure C-7.3A (93)

Comments: "Figure C - 7.3A indicates the head residuals shown are “Steady State & 4-year Transient Simulations.” Are the residuals steady state or transient or some combination?" (93)

Response: The residuals shown were the average of the steady state and the 4-year transient simulations. With the revised model, the steady state simulation now represents the average of 2017 through 2022. Accordingly, these figures have been updated to show the steady state targets.

8.4.7 Figure C-7.4 (94)

Comments: "Figure C-7.4: please label the contours." (94)

Response: The contours were labeled on the figure, but the label font size has been increased.

8.4.8 Figure C-8.1A, C-8.1B and C-8.2 (96)

Comments: "It is not clear if Figure C-8.1A, C-8.1B, and C-8.2 are from steady state or transient simulation." (96)

Response: These figures represent the steady state simulation.

8.4.9 Attachment C-5 Calibration BTC Pumping Test Combined Calibration Drawdown Hydrographs (97, 98)

Comments: “Attachment C-5 Calibration BTC Pumping Test Combined Calibration Drawdown Hydrographs: What are wells 1-4 shown in all the BTC Pumping Test Combined Calibration Hydrographs? We could not find a description in the modeling report or pumping test report." (97)

“Attachment C-5 Figure 9: What is the third well in this graph? Only two wells are identified in the text of the figure label.” (98)

Response: Wells 1 through 4 in the legend correspond (in order) to the wells listed in the figure title. For example, the first figure is titled "BTC-PW-01 and BTC-PZ07" and so BTC-PW-01 is Well 1 (shown in green) and BTC-PZ07 is Well 2 (shown in orange). In that example there are no Wells 3 and 4. In these figures, the wells were listed in order of increasing screen depth. This facilitates rapid visual comparison of vertical gradients. The generalized names in the legend allow for the use of scripting to efficiently produce and update these graphs during the iterative calibration process. A note has been added to these figures to clarify.

In Attachment C-5 Figure 9, the three wells shown are BPS07-21, BPS07-21B, and BPS07-21C.

8.4.10 Attachment C-5 Calibration - Calibration Flux Graphs: SFR Gain (100)

Comments: "Attachment C-5 Calibration - Calibration Flux Graphs: SFR Gain: What are green triangles in the graphs? What is the x axis?" (100)

Response: The green triangles represented the "Residual % of Observed Flow" and were plotted on the secondary y axis. The symbol was cut off in the legend. These figures were not retained in the revised report as they have been replaced with other methods of visualizing the calibration to flux targets.

9 CD Requirements

The following comments were related to requirements of the consent decree (CD).

9.1 PDI Work Plan (2)

Comments: "In accordance with the BPSOU Consent Decree Appendix D Section 3.3, the development and submittal of the Pre-Design Investigation (PDI) Work Plan is to be the initial step of the PDI and is to precede the investigation and the PDI ER. To date, the EPA has not received the PDI Work Plan. Please notify EPA and Montana Department of Environmental Quality (DEQ) as to the schedule for submittal of the PDI Work Plan." (2)

Response: During the agency comment review meeting for the BTC GHCS Pumping Test QAPP on May 5, 2022, it was agreed to keep the QAPP separate from the PDI WP. The QAPP would inform development of subsequent documents. The draft RDWP was submitted in July 2022 and resubmitted as the draft-final in December 2022. The RDWP draft-final indicated that the PDI WP will address remaining data gaps as warranted depending on the result of the BTC pumping test, groundwater model study, and potential design considerations for the selected groundwater hydraulic control system. At this time AR has not identified data gaps associated with the design and recommendations associated with this PDI ER; however, considering the requirements of the BPSOU Consent Decree Appendix D Section 3.3, we are planning to incorporate the BTC GHCS Pumping Test QAPP into a PDI WP and have provided with the Draft-Final submittal.

9.2 30% Design (5b)

Comments: "..AR’s contractor Stantec indicated at the November Remedial Design/Remedial Action (RD/RA) progress meeting that they would like to move straight to 60% design of BTC hydraulic controls because the proposed capture wells in the PDI ER are not complicated. This course of action is not recommended. The remedial design steps, as described in Appendix D to the BPSOU Consent Decree, should be followed in entirety." (5b)

Response: AR will follow the Design Steps listed in Appendix D to the BPSOU Consent Decree. Submittal of a Basis of Design/30% Design Package will be the first step.

10 References

AR, 2023. Final 2022 Site-Wide Surface Water Data Summary Report Normal Flow, Wet Weather, and Diagnostic Surface Water, Sediment, BMI, and Habitat Monitoring January 2022 – December 2022.

EPA, 2008. A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems. EPA/600/R-08/003

EPA, 2018. Groundwater and Surface Water Interaction. Butte Priority Soils Operable Unit. Silver Bow Creek/Butte Area NPL Site. Butte, Montana. Administrative Record 1903042 – R8 SDMS. Prepared by CDM Smith. December.

Langevin, C.D., Hughes, J.D., Banta, E.R., Niswonger, R.G., Panday, Sorab, and Provost, A.M., 2017, Documentation for the MODFLOW 6 Groundwater Flow Model: U.S. Geological Survey Techniques and Methods, book 6, chap. A55,197 p., https://doi.org/10.3133/tm6A55.

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Attachment: Table 1: Summary and Categorization of Comments

Table 1
Response to Comments on the BPSOU Draft BTC GHCS PDI ER

Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
Appendix C	General Comments	42	"Further predesign evaluation should be done using either an accurately calibrated model or additional field tests, whichever will provide the best and most reliable data. Additional evaluation of the potential BTC GHCS elements is needed before they are selected and designed. The PDI ER and appendices focus largely on using the groundwater model for this evaluation. There may be limitations to producing a model that is sufficiently calibrated and accurate that it can be the sole determinant used for remedy selection and design. The data provided by the BTC pumping test shows the utility of field testing potential capture systems. The pumping test provides real-world data demonstrating how capture well BTC-PW- 01 near the Visitor Center causes small scale declines in water levels near the subdrain which could have significant effects on the existing remedy. There is value in conducting additional pumping tests to provide pilot tests for proposed groundwater controls. General Comments discusses that a subdrain tracer test should be performed during additional pumping tests to evaluate if the capture wells induce leakage from the subdrain and the flow path such leakage takes. All potential BTC groundwater hydraulic controls will require a pipeline to BTL for treatment and that pipeline could be constructed to accommodate long-term pumping tests. It may be appropriate to better calibrate the groundwater model and use it to help bookend the flow rates from the BTC capture system so that the pipeline can be constructed and used for further pump testing. Then additional pump tests could be conducted to vary the flow rates and optimize them to provide the BTC hydraulic control required by the CD while reducing negative impacts to the subdrain and other existing groundwater remedy elements."	2.1	42	Complete Additional Testing : Testing to evaluate Interaction Between Subdrain and Proposed BTC GHCS
Appendix C	Groundwater pump test model calibration (head calibration)	40.19	"There were comments provided to MTAC on 9/22/22 recommending that modeled head calibration achieve 0.5-foot accuracy and be unbiased near the lower subdrain. That recommendation is based on the magnitude of the groundwater divide that separates the subdrain groundwater capture from the creek. This groundwater divide is approximately 0.5-1 foot higher than upgradient groundwater levels. This level of calibration accuracy may be needed to accurately portray the existing subdrain capture and any impacts to the subdrain from the new BTC GHCS. If the model cannot be sufficiently calibrated to achieve this level of detail it may be appropriate to perform additional pumping and tracer tests."	2.1	40c4	Complete Additional Testing : Testing to evaluate Interaction Between Subdrain and Proposed BTC GHCS
General Comments		6	"Assessment of groundwater quality for groundwater captured during construction dewatering and by long-term operation of the BTC GHCS should be based on additional data that are collected during construction and not from the short-term BTC pumping test. A DQO for the BTC pumping test is, "Estimate the groundwater quality that may be captured during construction dewatering and by the BTC groundwater control, which may require treatment at Butte Treatment Lagoons (BTL)." Section 5.1 of the PDI ER responds to this DQO by stating metal concentrations in the discharge from the pumping test did not exceed in-stream chronic surface water performance standards. A 72-hour pumping test and a 24-hour pumping test are not sufficiently long-term to understand how chemistry may change during long-term pumping (i.e., during construction and operation of the GHCS). Water treatment plans for both construction and long-term operation of the GHCS should be developed based on additional data or estimates of long-term capture water quality."	2.2	6	Complete Additional Testing : Testing to Evaluate Groundwater Quality from Long-Term Operation of BTC GHCS
PDI ER	Specific Comments	16.2	"The gentler and more widespread drawdown shown in Figures B-9A and B-9B, extending from BTC-PW-01 towards Upper Silver Bow Creek and the BPSOU subdrain in a north-northwest direction, could also be because of the lack of piezometers in that area. Piezometers along that direction could help to constrain contour interpretation. The same is true moving to the south of BTC-PW-01. The shallower gradient could also be due to shorter distance and greater flow impact at BTC compared to the subdrain."	2.3	16b	Complete Additional Testing : Install Additional Wells
Appendix C	Groundwater pump test model calibration (head calibration)	40.2	"The magnitude and extent of the groundwater capture zone created by the subdrain could be much better understood if additional nested shallow wells or piezometers were installed adjacent to the lower subdrain."	2.3	40c5	Complete Additional Testing : Install Additional Wells
Appendix C	Groundwater pump test model calibration (head calibration)	40.22	"Installation of additional wells would also help with drawing potentiometric contours which are currently being drawn using subdrain water levels that are not representative of the adjacent aquifer. Those wells would also be valuable if additional pumping tests are conducted to evaluate effects of BTC groundwater controls on the subdrain."	2.3	40c7	Complete Additional Testing : Install Additional Wells
Appendix C	Groundwater pump test model calibration (head calibration)	40.23	"In the absence of additional monitoring wells adjacent to the subdrain, a very high level of accuracy is needed in the model calibration to the existing wells to assess the impacts to subdrain capture."	2.3	40c8	Complete Additional Testing : Install Additional Wells
Appendix C	Suggested parameter adjustments to be tested	52	"Though it’s hard to tell exactly, it appears that the undifferentiated K is lower than the average K in the detailed study area. If so, is there a geological reason why this should be? Please explain."	3.1	52	Hydrogeologic Framework: K Ranges
Appendix C	Hydraulic property distribution: Hydraulic conductivity (K) values	79	"The K of 150 ft/day assigned to peat is surprising. Is the calibration sensitive to this, or is it insensitive such that the PEST calculation of peat K drifted to a limiting value? Looking online, it appears that the upper range of peat K is considered to be less than 1 ft/day."	3.1	79	Hydrogeologic Framework: K Ranges
Appendix C	General Comments	40.14	"...revisiting the horizontal to vertical K anisotropy approach used in the calibration process is recommended. Current calibrated K anisotropy values for many of the lithologies are quite high, without discussion of any basis."	3.1	40b7	Hydrogeologic Framework: K Ranges
Appendix C	Groundwater pump test model calibration	39.6	"With respect to varying K within model lithology zones, it is noted that while boring logs in the pumping test area tend to support the concept of upper sand having a somewhat higher K than lower sand, boring logs in other areas farther east do not necessarily support this. This could be one initial basis for varying K within the lithology zones (or redefining the zones)."	3.2	39f	Hydrogeologic Framework: K Zones

Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
Appendix C	Hydrualic property distribution: Streambed hydraulic conductivity	81	"The reported streambed vertical hydraulic conductivity of 28 ft/day for model reach 7 is surprisingly high, an order of magnitude greater than the value assigned to other reaches. Is this necessary for head or streamflow calibration? What physical condition in the field does this represent?"	3.3	81	Hydrogeologic Framework: SFR Conductance Ranges
Appendix C	General Comments	40.1	"Please note that storage parameters assigned in the model are appropriately typical of an unconfined aquifer, contrary to the analyses presented in the pumping test report."	3.4	40b4a	Hydrogeologic Framework: Storage
Appendix C	General Comments	40.11	"We find it strange that the BTC pumping test analysis gives storativity values typical of confined conditions when the lithology and shallow piezometer response suggests it is unconfined or semiconfined."	3.4	40b4b	Hydrogeologic Framework: Storage
Appendix C	Water Budget	68.3	"For the wetlands within MT DEQ's BTC riparian actions project area (i.e., the area on the opposite side of Blacktail Creek from the Butte visitor center), we are aware of no such surface water connection to BTC. If this wetland is hydraulically connected to BTC only through the water bearing zone, then using drain (or any) BCs in this area would not be appropriate and may impact calibration and model predictions for alternatives developed in the PDI ER."	3.5	68c	Hydrogeologic Framework: Wetland Drains
Appendix C	General Comments	41.3	"A steady state condition does not exist within the BPSOU alluvial aquifer and the creeks. Seasonality in streamflow, precipitation, and weather all cause the hydrology to be highly transient. It may be appropriate to use a steady state simulation to develop initial heads, if there is sufficient spin-up period within the transient model before the time period being evaluated."	3.6	41c	Hydrogeologic Framework: Steady State Initial Condition
Appendix C	General Comments	40.01	"The groundwater model needs significant further calibration before it can be reliably used for remedy evaluation. The head and flux calibration presented in the Groundwater Model Technical Memorandum shows a calibration process that is underway but not finished"	4.1	40	Calibration Improvements: Improve calibration to area of focus
Appendix C	Groundwater pump test model calibration	39.1	"This review focusses largely on modeling of the BTC-PW-01 pumping test and the BTC groundwater gain in the BTC GHCS area because these features are directly relevant to the model applications presented."	4.2	39a	Calibration Improvements: BTC-PW-01 Pumping Test
General Comments		7.3	"...More fundamentally, it is possible that the model representation of the flow distribution to BTC is it an artifact of incomplete model calibration near the lower part of the BTC. That is, it is possible that the simulated distribution of groundwater inflow to BTC will change somewhat with improved model calibration (both head and flow). Further model calibration is necessary and important..."	4.1	7c	Calibration Improvements: Improve calibration to area of focus
Appendix C	General Comments	43	"...The Groundwater Model Technical Memorandum should evaluate the following qualitative calibration goals. Is the subdrain capture and the groundwater depression and divide created by the subdrain accurately simulated? Are the hydraulic gradients between groundwater and surface water representative of those measured? Does the model accurately represent the drawdown response observed during the BTC pumping test in the shallow groundwater, in the deeper groundwater?..."	4.1.1	43	Calibration Improvements: Qualitative Calibration Goals
Appendix C	Pumping test calibration refinement	46	"Improving the pumping test simulations should increase the reliability and accuracy of the model to assess remedial alternatives and dewatering simulations in the BTC GHCS area. Better understanding of hydraulic controls and constraints in this area could help inform remedial design decisions."	4.2	46	Calibration Improvements: BTC-PW-01 Pumping Test
Appendix C	Groundwater pump test model calibration	39.2	"Overall, the model appears to be sufficiently comprehensive and at an appropriate level of detail for its intended purpose. Improved model calibration to the pumping test and further examination of the simulated BTC gain from groundwater should increase the reliability and accuracy of model simulations in the BTC GHCS area."	4.2	39b	Calibration Improvements: BTC-PW-01 Pumping Test
Appendix C	General Comments	40.04	"The calibration of the BTC pumping test shown in Attachment C-5 to the Groundwater Model Technical Memorandum also shows significant deficiencies in this same area. This is significant because this demonstrates that the model does not represent groundwater hydraulics in the area of the proposed BTC GHCS."	4.2	40a2	Calibration Improvements: BTC-PW-01 Pumping Test
Appendix C	General Comments	44.1	"Because the groundwater model explicitly represents the geometry of the subdrain, BTC and nearby wetlands with respect to the test pumping well, calibration of the model to the pumping test data can provide an appropriate and comprehensive hydraulic analysis of the test."	4.2.1	44a	Calibration Improvements: BTC-PW-01 Pumping Test - Use Calibration to Pumping Test as Evaluation of the Test
Appendix C	Additional Comments	90	"Section 7.4.3 presents statistics for model calibration of the BTC pumping test including residual mean and standard deviation. On average the BTC pumping test may be calibrated, but this masks the poor calibration shown in the graphs in Attachment C-5. Those calibration graphs should be used to further calibrate the model by adjusting vertical and horizontal K. The focus should be on calibrating head best near to the features of interest such as BTC and the subdrain."	4.2.2	90	Calibration Improvements: BTC-PW-01 Pumping Test - Improve calibration to model simulated drawdown
Appendix C	General Comments	44.3	"...the model simulated drawdown, with few exceptions, underestimates the measured drawdown. Also, at some locations the model simulated a difference between shallow and deep well response that is significantly greater than observed."	4.2.2	44c	Calibration Improvements: BTC-PW-01 Pumping Test - Improve calibration to model simulated drawdown
Appendix C	Pumping test calibration refinement	45	"Because the pumping test is so relevant to the BTC GHCS, it is recommended that additional test simulations incorporating adjustments to model parameters be made specifically to improve the calibration to the pumping test."	4.2.3	45	Calibration Improvements: BTC-PW-01 Pumping Test - Complete sensitivity analysis focused on the pumping test

Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
Appendix C	BTC Streamflow	59	"From the standpoint of model application, reasonably accurate representation of groundwater surface water interaction in the BTC reach that passes through the BTC-GHCS study area is the most important aspect of the streamflow modeling. Model results presented for the reach from SS-01 to SS-04 (or SS-05) would include this area."	4.3	59	Calibration Improvements: Groundwater / surface water gradients
Appendix C	Additional Comments	95	"Figure C-8.1A: The modeled contours do not show groundwater flow towards BTC that are depicted in the contours drawn from measurements prior to the pumping test in Figure B-8A1 of the BTC Pump Test Interpretation Technical Memorandum. This suggests the model may not be accurately simulating groundwater gains in this section of BTC. This also suggests the model does not simulate stream gain from the north side of BTC where buried local contaminant sources exist that are described in EPA's Groundwater and Surface Water Interaction Butte Priority Soils Operable Unit Final Report (December 2018)."	4.3	95	Calibration Improvements: Groundwater / surface water gradients
Appendix C	Groundwater pump test model calibration (head calibration)	40.16	"Groundwater Model Technical Memorandum Section 7.4.1 discusses the head calibration statistics. The head calibration statistics described may be adequate to predict regional groundwater flow. However, the focus of this model calibration should be on creating a model capable of accurately simulating comparatively small changes in groundwater elevation and flow that affect BTC stream gain and the existing subdrain. This will require more accurate calibration near features of concern such as BTC, the subdrain, the groundwater depression/divide created by the subdrain, and the various known contaminant sources and plumes (Parrot, Diggings East, Northside, etc.). The bias apparent in the head calibration should be eliminated."	4.4	40c1	Calibration Improvements: Head targets
Appendix C	Additional Comments	87.1	"Section 7.4.1 states, “shallow water levels in the BTC and SBC confluence area, however, tend to be low compared to simulated values (positive residuals).” If simulated values near the confluence are high and the simulated flux is approximately correct, this suggests the simulated K and conductance are set to compensate for the inaccuracy and are likely not representative of the actual hydraulics."	4.4	87a	Calibration Improvements: Head targets
Appendix C	General Comments	40.02	"The bias in water level (head) residuals is especially problematic because the bias is most pronounced near the subdrain and location of the BTC pumping well near visitor center. This is the area that is the focus of the predictive modeling that is used to evaluate the GHCS alternatives and predict effects on the existing remedy. The modeled water levels are biased high in the Upper Silver Bow Creek corridor and are biased low near the lower subdrain and BTC pumping well. This low bias means the model is not correctly simulating groundwater contact and hydraulics near the lower subdrain and the model is likely not capable of accurately predicting the effects of new hydraulic controls on subdrain performance."	4.4.1	40a	Calibration Improvements: Head targets - Reduce spatial bias in calibration to head targets
Appendix C	Groundwater pump test model calibration (head calibration)	40.18	"There were comments provided to MTAC on 9/22/22 recommending that modeled head calibration achieve 0.5-foot accuracy and be unbiased near the lower subdrain. That recommendation is based on the magnitude of the groundwater divide that separates the subdrain groundwater capture from the creek. This groundwater divide is approximately 0.5-1 foot higher than upgradient groundwater levels. This level of calibration accuracy may be needed to accurately portray the existing subdrain capture and any impacts to the subdrain from the new BTC GHCS."	4.4.2	40c2	Calibration Improvements: Head targets - Achieving residuals less than 0.5 feet in areas of interest
Appendix C	Hydraulic property distribution: Regional model calibration	80	"It would be helpful to present model calibration results at a limited number of well locations in the undifferentiated portion of the model. The statistics for these wells can be accounted for separately from the refined model area."	4.4.3	80	Calibration Improvements: Head targets - Include additional head target locations
Appendix C	Additional Comments	84	"There are multiple monitoring well data from the BTC pumping test that are not used in model calibration. Figure 3 of the PDI ER shows BTC pumping test monitoring locations. The PMP wells, BTC-PZ series piezometers, and BWE-3 are not included in the model calibration. Reasons for omitting these data should be discussed in Section 7.1."	4.4.3	84	Calibration Improvements: Head targets - Include additional head target locations
Appendix C	General Comments	40.05	"Figure C-7.1 of the Groundwater Model Technical Memorandum illustrates that most water level gaging locations available in the model domain were not used in model calibration. Consistent with this, Section 7.1 states "To meet the BTC GHCS model objectives, the targets were further filtered to focus on the areas near and upgradient of the BTC and SBC confluence." Some of the purple-symbolized wells on Figure C-7.1 may have been eliminated due to datum uncertainties, but it is assumed, based on the text statements and the spatial locations on the map, that most were eliminated based on location. While the focus on the areas near and upgradient of the BTC and SBC confluence is understandable/desirable, important information is lost by eliminating water level data outside these areas. Could this data have been included, but with smaller weights than the data in focus areas? Alternatively, these targets may not need to be weighted less if K is allowed to vary spatially per lithology. Calibration statistics can be generated for all targets, and for desired subsets of targets in key areas. "	4.4.3	40a3	Calibration Improvements: Head targets - Include additional head target locations
Appendix C	Groundwater pump test model calibration (head calibration)	40.21	"We note below in Specific Comment #1 under Pumping Test Memo that the current depiction of the subdrain capture zone is based on measured water levels within the subdrain pipe, which does not accurately represent conditions within the adjacent aquifer."	4.4.4	40c6	Calibration Improvements: Head targets - Exclude head targets within the BPSPOU Subdrain
Appendix C	General Comments	40.15	"Also, it is suggested that head difference targets for paired wells and piezometers be incorporated, which may prove useful especially for pumping test calibration."	4.4.5	40b8	Calibration Improvements: Head targets - Add vertical gradient targets
PDI ER	Specific Comments	14	"Page 15, Section 4.3.2.1, 2nd bullet on page 15: The text states, “There are some areas of simulated flooding along BTC upstream of Sand Creek. This is also a reach where BTC is simulated to be gaining.” Simulated flooding should be explained. If this means the groundwater elevation is higher than the ground surface and no evidence of this exists in the field, the model should be calibrated in this area. Please explain and address as necessary."	4.4.6	14	Calibration Improvements: Head targets - Flooded Cells

Table 1
Response to Comments on the BPSOU Draft BTC GHCS PDI ER

Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
Appendix C	Groundwater pump test model calibration	39.3	"Overall, the model appears to be sufficiently comprehensive and at an appropriate level of detail for its intended purpose. Improved model calibration to the pumping test and further examination of the simulated BTC gain from groundwater should increase the reliability and accuracy of model simulations in the BTC GHCS area."	4.5	39c	Calibration Improvements: SFR flux targets
Appendix C	General Comments	40.06	"There are stream flux targets in areas where water level data were eliminated. Calibration to flux targets with simulated water levels that do not match available water level data may have resulted because those areas were not included as targets."	4.5.1	40a4	Calibration Improvements: SFR flux targets - Flux Targets downgradient of area of interest
Appendix C	General Comments	41.2	"For this transient simulation, it is stated in Section 8.2.6 of the Groundwater Model Technical Memorandum that “the simulated flux values [from below and from the northeastern side of BTC to the SFR boundaries] for Alternative 6 ranged from 0.0017 cfs to 0.0043 cfs”. In the preceding paragraph, it is stated that for the steady-state simulation, the same flux values total 0.004 cfs. Are these flux values for the same reach of BTC and for the same model cells? If so, is there a reason that the steady-state (average condition) value is near the max value from the transient simulation? Similarly, an abrupt reduction in flow over the first time step is noted in the Alternative 6 time history plot in Figure C-8.11. The precipitation and recharge patterns shown in Figure C-3-5 don’t indicate that 2017 steady-state flows should be much higher than the 2018-2021 average."	4.5.2	41b	Calibration Improvements: SFR flux targets - Steady state vs Transient Discharge
Appendix C	BTC Streamflow	60	"Attachment C-5, “Calibration Flux Bar Charts: SFR Gain”, compares model simulated and gage measured inflow (or outflow) fluxes. The results show that model simulated groundwater inflow fluxes are very constant over time, while the gage measured fluxes are quite variable."	4.5.3	60	Calibration Improvements: SFR flux targets - Muted Variability of Simulated BTC Gain
Appendix C	BTC Streamflow	61	"It is surprising that the simulated BTC gain fluxes vary so little (no more than 10% for SS-01 to SS-04), considering the pronounced seasonality and year-to-year variability of the recharge. Does the modeling team have any insight about this? Could this be related to the very high streambed conductance assigned to reach 7? Examining the model water budget as well as direct groundwater-surface water elevation comparisons would be helpful."	4.5.3	61	Calibration Improvements: SFR flux targets - Muted Variability of Simulated BTC Gain
Appendix C	BTC Streamflow	62.1	"Some of the variability of the gage measured fluxes is likely due to measurement imprecision, as noted in the report"	4.5.4	62a	Calibration Improvements: SFR flux targets - Flux Measurement Error
Appendix C	BTC Streamflow	62.2	"The gage measured fluxes, however, also likely include some direct runoff and drainage system inflows in addition to gains from groundwater and are therefore not directly analogous to the model simulated gain from groundwater."	4.5.5	62b	Calibration Improvements: SFR flux targets - Direct runoff
Appendix C	BTC Streamflow	65.2	"Direct runoff inflows to the tributaries, as noted above, are also not accounted for."	4.5.5	65b	Calibration Improvements: SFR flux targets - Direct runoff
Appendix C	BTC Streamflow	63	"Applying common statistical base flow separation techniques might reduce the discrepancy between gage data and simulated results. While there is uncertainty associated with statistical base flow separation, neglecting baseflow separation risks creating a somewhat inflated calibration target, and thus the calibrated groundwater model might tend to overestimate actual stream gain from groundwater."	4.5.6	63	Calibration Improvements: SFR flux targets - Baseflow separation
Appendix C	BTC Streamflow	64	"Another factor that could affect the model simulation of groundwater gain in the SS-01 to SS-04reach is the effect of tributary streams, Sand Creek and Grove Gulch, that discharge to BTC within that reach. The model computes groundwater flows to the tributaries and these flows are added to the BTC within the SS-01 to SS-04 reach. However, upstream inflows to the tributaries at the model boundary are apparently neglected."	4.5.7	64	Calibration Improvements: SFR flux targets - Tributary Flow
Appendix C	BTC Streamflow	67	"In summary, neglecting direct runoff and tributary inflows from outside of the model domain could cause the calibrated model to overestimate BTC groundwater gain in the BTC GCHS area of interest. This should be further investigated."	4.5.7	67	Calibration Improvements: SFR flux targets - Tributary Flow
Appendix C	BTC Streamflow	65.1	"It appears from the report figures (and Google Earth) that the tributary watersheds extend beyond the model domain. These external watershed areas might be steep, low-recharge areas that could create flashy inflows. These flows are likely small compared to BTC flows but might be significant with respect to with SS-01 to SS-04 groundwater gain."	4.5.7	65a	Calibration Improvements: SFR flux targets - Tributary Flow
Appendix C	Additional Comments	89	"Section 7.4.2 states, “simulated flux to the drain on average tends to be low compared to the observed values.” It may not be necessary to perfectly capture the observed variability in subdrain inflows, which are affected by transient scaling of the subdrain which is difficult to characterize. However, the bias in simulated flux should be addressed with better calibration such that the simulated flux is not biased high or low and no subdrain segment is biased differently than others. The current calibration for segment “flxtrg_mh_msd110” and flxtrg_mh_msd116 appears to be unbiased whereas flxtrg_mh_msd106, flxtrg_mh_msd108, and flxtrg_mh_msd113 the modeled flux is biased low."	4.6	89	Calibration Improvements: BPSOU Subdrain flux
Appendix C	Groundwater pump test model calibration (flux calibration)	40.34	"At the 8/23/23 Model Technical Advisory Committee (MTAC) scrum it was discussed that the subdrain flux calibration is a compromise so that the flux into different segments of the subdrain are not grossly over or under simulated. On this subject, section 7.4.1 of the Groundwater Model Technical Memorandum states, “during calibration, most Model iterations tended to under simulate the flux gained in the lowest reach of the BPSOU Subdrain and the calibrated Model attempted to balance simulated flux and simulated head in that area.”"	4.6	40e1	Calibration Improvements: BPSOU Subdrain flux
Appendix C	General Comments	40.03	"Flux calibration is also deficient in the lowest reaches of the subdrain. The bias in the calibration shows the model may not be capable of accurately predicting the stream-groundwater hydraulics near the visitor center, an area which is known to contain buried waste contaminant sources (see EPA's Groundwater and Surface Water Interaction Butte Priority Soils Operable Unit Final Report, December 2018). "	4.6	40a1	Calibration Improvements: BPSOU Subdrain flux

Table 1
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Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
Appendix C	Upper Metro Storm Drain (MSD) area 2010 pumping test	58	"Is it worth considering model simulation of the 2010 MSD pumping test for model verification? The MSD test is somewhat removed from the BTC GHCS area (roughly a half mile) and such a simulation might be beyond the scope of the current modeling project. On the other hand, the aquifer conditions are similar and both tests show the effects of surface water interaction. (The MSD shallow well response was notably different for downgradient wells, where the subdrain is active, and upstream wells, where it is not.)"	4.7	58	Calibration Improvements: Model Validation
Appendix C	Groundwater pump test model calibration	39.5	"Also, based on examination of the model structure and the distribution of simulated head residuals, it should be possible to make substantial improvements to both the pumping test and long-term transient calibrations by making the more basic mode structure and parameter adjustments. Basic model parameter and geometry adjustments to be addressed might include: • adjusting the geometry of the surficial low-K zone underlying the BTC, • minor adjustment to the geometry of a few other low-K "lenses" to improve simulated pumping test response at particular wells, • adjusting BTC and subdrain hydraulic property assignments, particularly the distribution of conductance assigned to the subdrain, • adjusting the overall K assigned to the current upper and lower sand zones, • minor adjustment to model storage parameters, • adjusting K assigned to the undifferentiated model zone, and • possibly, minor adjustment to the recharge model to slightly increase or decrease overall recharge."	5.1	39e	Suggested Calibration Methods: General Suggestions
Appendix C	Suggested parameter adjustments to be tested	50	"Horizontal hydraulic conductivity (Kh) – Simulated drawdown will be increased by reduction of the Kh assigned to the shallow sand or both shallow and deep sand."	5.2	50	Suggested Calibration Methods: Hydraulic Conductivity (k)
Appendix C	Suggested parameter adjustments to be tested	53	"Possibly, adjustment to the thickness, extent or Kv applied to clay/silt in specific areas would improve results."	5.2	53	Suggested Calibration Methods: Hydraulic Conductivity (k)
Appendix C	Suggested parameter adjustments to be tested	54	"Vertical hydraulic conductivity (Kv) – Increasing Kv assigned to the sand layers, silt/clay layers or both will tend to reduce the difference in simulated drawdown between shallow and deep wells. It is possible, however, that simulated drawdown will be decreased at some locations due to better hydraulic connection with water table damping. It is also possible that simulated drawdown will be increased at some locations."	5.2	54	Suggested Calibration Methods: Hydraulic Conductivity (k)
Appendix C	Hydraulic property distribution: Hydraulic conductivity (K) values	77	"Per the discussion above, improving model calibration of the pumping test data will likely require some change to K assignments."	5.2	77	Suggested Calibration Methods: Hydraulic Conductivity (k)
Appendix C	Groundwater pump test model calibration (flux calibration)	40.35	"Subdrain flux should be calibrated in part by adjusting the K in the surrounding aquifer and or by changing the boundaries of the K zones within reason given the lithologic model to match local groundwater head. Then the subdrain conductance value should be adjusted until inflows are adequately calibrated."	5.2	40e2	Suggested Calibration Methods: Hydraulic Conductivity (k)
Appendix C	Groundwater pump test model calibration (flux calibration)	40.36	"Piecewise-constant K zones are probably a primary limiting factor in the ability to match fluxes for stream flow and subdrain targets and trying to match heads. Considerable density exists with the flux and head targets that cannot be matched well with a very coarse K parameterization approach. This coarse K parameterization is not warranted or suggested by the borehole data. Such an approach could be an appropriate level of detail for assessing regional flow but is not appropriate for simulating local conditions."	5.2	40e3	Suggested Calibration Methods: Hydraulic Conductivity (k)
Appendix C	Groundwater pump test model calibration	39.4	"...the model calibration and representativeness of the system, especially in key remedy areas, would be improved by allowing K to vary spatially within a range for each lithology."	5.2	39d	Suggested Calibration Methods: Hydraulic Conductivity (k)
Appendix C	General Comments	40.07	"The fact that the model hydraulic conductivity (K) zones were not adjusted during calibration appears to have led to poor calibration and accuracy...."	5.2	40b1	Suggested Calibration Methods: Hydraulic Conductivity (k)
Appendix C	General Comments	40.08	May require more K zones	5.2	40b2	Suggested Calibration Methods: Hydraulic Conductivity (k)
Appendix C	General Comments	40.09	"Additional calibration should focus on adjustments to the K zone boundaries, the K values, and potentially storativity (S) values"	5.4	40b3	Suggested Calibration Methods: Storage
Appendix C	General Comments	40.13	"With respect to K adjustments, starting with allowing K to vary spatially per lithology within realistic ranges is recommended, rather than introducing new K zones each with spatially constant K (which could turn into a long trial-and-error process)."	5.2	40b6	Suggested Calibration Methods: Hydraulic Conductivity (k)
Appendix C	Groundwater pump test model calibration (flux calibration)	40.32	"...the scaled residual standard deviation (10.6%)...This can likely be improved by allowing K to vary spatially within lithology zones."	5.2	40d9	Suggested Calibration Methods: Hydraulic Conductivity (k)
Appendix C	Suggested parameter adjustments to be tested	51	"If simulated steady-state (or long-term transient) head levels and/or stream flows are adversely affected by a Kh adjustment, it might be possible to compensate by making adjustment to the undifferentiated alluvium K or recharge."	5.3	51	Suggested Calibration Methods: Recharge
Appendix C	Suggested parameter adjustments to be tested	48	"Specific yield reduction – This would apply specifically to the pumping test simulation. A slightly lower Sy (say, 0.15) than the value applied to the long-term transients might be appropriate for simulating pumping test drawdown due to possible incomplete drainage over the relatively short duration of the test. (This is a simple model revision that does not affect steady state model applications but is unlikely to be sufficient.)"	5.4	48	Suggested Calibration Methods: Storage

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Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
Appendix C	Suggested parameter adjustments to be tested	49	"Reduction of BTC streambed conductance – This could apply to the nearby reach of the BTC and possibly also the nearby wetlands adjacent to the BTC and/or the subdrain. However, a relatively low value has already been assigned in this area."	5.5	49	Suggested Calibration Methods: SFR and Conductance
Appendix C	General Comments	40.12	"Stream conductance will likely require recalibration in tandem with recalibration of the groundwater parameters."	5.5	40b5	Suggested Calibration Methods: SFR and Conductance
Appendix C	Pumping test calibration refinement	47	"To the extent that multiple parameter sets may provide satisfactory model calibration (non-unique solution), a range of predictive results may be developed for remedy and dewatering simulations. Sensitivity simulations for remedy and dewatering simulations should be run, varying key sensitive parameter values. PEST provides feedback on the most sensitive parameters, which can then be varied for remedy and dewatering simulations. Alternatively, PEST utilities (such as null-space Monte Carlo) can be used to develop a suite of equally well-calibrated models that can be used for these sensitivity simulations."	5.6	47	Suggested Calibration Methods: PEST
Appendix C	Additional Comments	85	"Section 7.1 states, "a well with 10 observations in a month would have 1/10th the weight of a well with one value for that month." Why would a well with more observations have less weight? We recommend averaging the observations during the particular time step, and if appropriate assigning more weight because there is a greater assurance the measurement is correct because there are multiple measurements."	5.6	85	Suggested Calibration Methods: PEST
Appendix C	Groundwater pump test model calibration (flux calibration)	40.37	"The Groundwater Model Technical Memorandum states that the subdrain and stream conductance values and the storage parameter values were manually adjusted during model calibration. It would likely be more efficient and effective to incorporate these into the PEST calibration, providing realistic ranges to PEST for each parameter. PEST is a model independent parameter estimation and uncertainty analysis software package. Note: PEST should be used with care. It is a useful tool, but many models suffer from an overreliance on PEST."	5.6	40e4	Suggested Calibration Methods: PEST
Appendix C	Groundwater pump test model calibration (flux calibration)	40.33	"Consideration may need to be given to relative weights of flux vs. head compared to head difference targets to get a good balance during further calibration efforts."	5.6	40d10	Suggested Calibration Methods: PEST
PDI ER	Specific Comments	16.3	"Further evaluation of the hydraulic impacts on the subdrain due to pumping at BTC-PW-01 is needed."	6.1	16c	Evaluation of Alternatives: Evaluate Interaction Between BPSOU Subdrain and Proposed BTC GHCS
General Comments		4.4	"...At a minimum, the potential impact of inducing flow from the subdrain into the aquifer seems like a significant gap in the evaluation..."	6.1	4d	Evaluation of Alternatives: Evaluate Interaction Between BPSOU Subdrain and Proposed BTC GHCS
General Comments		5.1	"Additional evaluation of groundwater hydraulic controls and effects on the existing remedial elements such as the subdrain are needed prior to remedy selection and design. As discussed further in the comments below, the evaluation provided in the PDI ER and appendices is inadequate to select the BTC hydraulic controls..."	6.1	5a	Evaluation of Alternatives: Evaluate Interaction Between BPSOU Subdrain and Proposed BTC GHCS
Appendix C	Hydraulic property distribution: Streambed hydraulic conductivity	82	"Additional alternatives for the BTC GHCS should be evaluated."	6.2	82	Evaluation of Alternatives: Evaluate additional alternatives for BTC GHCS
		3.5	"Additional hydraulic controls may be possible and should be investigated. Every option does not need to be included in a full modeling "Alternative," but the Groundwater Model Technical Memorandum should give some discussion of what was evaluated, the result, and why options were not included in the alternatives."	6.2	3e	Evaluation of Alternatives: Evaluate additional alternatives for BTC GHCS
General Comments		4.3	"...Furthermore, the range of alternatives considered is limited (see comment No. 3)..."	6.2	4c	Evaluation of Alternatives: Evaluate additional alternatives for BTC GHCS
General Comments		4.5	"...The Alternative 6 extraction rate of 130 gallons per minute (gpm) reduced the predicted discharge for the GHCS reach of BTC from the northeast and below...This is a 5.6 gpm predicted decrease in discharge to BTC for the 130 gpm pumping rate. For the same well configuration which yields better predicted results than the other limited configurations evaluated, the report does not evaluate or present the discharge reduction at other extraction rates, such as 50, 100, 200, and 400 gpm, which would be useful for evaluating ability to meet the RAOs under differing scenarios..."	6.2	4e	Evaluation of Alternatives: Evaluate additional alternatives for BTC GHCS
General Comments		4.6	"...Other pumping configurations not included in Alternatives 1 through 6 might achieve a similar or greater reduction in flow to BTC at lower overall pumping rates. While more efficient hydraulically, such configurations, likely including a greater number of wells, might be less practical and cost effective. This should be evaluated...."	6.2	4f	Evaluation of Alternatives: Evaluate additional alternatives for BTC GHCS

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General Comments		3.1	"The PDI ER, Groundwater Model Technical Memorandum, and groundwater modeling effort should evaluate a greater range of possible capture and hydraulic alternatives. The modeling only evaluates four locations for new capture wells and does not evaluate a range of well screening depths at each of those locations. The only other change to the capture system that is evaluated is isolation of segment 1 of the existing subdrain, which simulates changing this lowest segment from perforated to solid pipe but adds no additional or replacement capture for segment 1. Section 4.1 of the PDI ER gives the Principal Study Questions for the model from the modeling data quality objectives (DQOs): "Design details will vary by remedy but generally include key elements such as location(s), installation depth(s), size, and groundwater extraction rates, as applicable." Meeting this DQO requires a more robust evaluation of locations, depths, and rates of capture wells and other hydraulic controls."	6.2.1	3a	Evaluation of Alternatives: Evaluate additional alternatives for BTC GHCS - Vary Simulated Well Details
General Comments		7.2	"...The lateral extent of the "upper part" may correspond to the section of BTC running along simulated wells BTC-PW-02 and BTC-PW-03. Was extraction at both BTC-PW-02 and BTC-PW-03 considered and simulated to further reduce discharge to BTC? Shallow extraction at BTC-PW-02 was simulated in Alternative 5, but deeper extraction (e.g., layers 6 and 7) might be best in a scenario with both BTC-PW-02 and BTC-PW-03. Shifting the extraction to the upper part of the GHCS reach might have negative consequences for the lower part, but this can be readily simulated with the model. Distributed pumping across BTC-PW-01, BTC-PW-02 and BTC-PW-03 may also further reduce groundwater discharge to the upper part of the GHCS reach without negatively impacting simulation results for the lower part; this suggestion is consistent with the 3rd bullet in comment No. 3. As most of the simulated groundwater flow to the GHCS reach of the BTC occurs within the first 500 feet downstream of Grove Gulch, a focus on the remedial pumping in this area should be evaluated..."	6.2.1	7b	Evaluation of Alternatives: Evaluate additional alternatives for BTC GHCS - Vary Simulated Well Details
General Comments		3.2	"...we recommend the following potential hydraulic controls be evaluated and modeled: Isolation of segment 1 of the subdrain (to prevent the more highly contaminated groundwater captured higher in the subdrain from leaking out of the subdrain) combined with replacement and optimization of segment 1 capture to prevent the reduction in the capture zone predicted by segment 1 isolation alone..."	6.2.2	3b	Evaluation of Alternatives: Evaluate additional alternatives for BTC GHCS - Isolate Segment 1 of BPSOU Subdrain
General Comments		3.3	"...we recommend the following potential hydraulic controls be evaluated and modeled: ... A hydraulic barrier between the BPSOU subdrain and the proposed BTC capture system to see if this would eliminate any negative impacts due to interference between the capture systems (see General Comments)..."	6.2.3	3c	Evaluation of Alternatives: Evaluate additional alternatives for BTC GHCS - Hydraulic barrier between BPSOU Subdrain and BTC GHCS
General Comments		3.4	"...we recommend the following potential hydraulic controls be evaluated and modeled: ... More dispersed capture along BTC that may avoid negatively impacting subdrain capture. Various locations and depths should be considered. A BTC subdrain or horizontal well should be considered if this could be installed in coordination with the State's BTC waste remediation efforts."	6.2.4	3d	Evaluation of Alternatives: Evaluate additional alternatives for BTC GHCS - BTC Subdrain or Horizontal Well
Appendix C	General Comments	41.1	"A Principal Study Question from the DQOs is: "How do varying surface flow conditions affect BTC GHCS operation?" Evaluating this with the model requires transient modeling that incorporates realistic variability in groundwater levels and surface water stage. The Groundwater Model Technical Memorandum indicates that only Alternative 6 was modeled using a transient simulation, stating this was done to "evaluate how varying surface flow conditions affect BTC GHCS operation." The remaining alternatives appear to have been modeled using steady state models, which the Groundwater Model Technical Memorandum suggests shows "average conditions.""	6.3	41a	Evaluation of Alternatives: Transient simulation of baseline and alternatives
Appendix C	General Comments	41.4	"The simulated alternatives and baseline model that is used for comparison should all be transient models. The discussion and figures in Section 8.1 describing the current baseline should describe transient conditions and specifically identify if certain hydrologic conditions or seasonal times exist where contaminated groundwater is most likely to reach BTC. A typical baseflow condition could also be described."	6.3	41d	Evaluation of Alternatives: Transient simulation of baseline and alternatives
Appendix C	General Comments	41.5	"The Groundwater Model Technical Memorandum should evaluate performance of the alternatives on an annual timespan, during the hydrologic conditions most likely to transport contaminants to BTC if one exists, and during typical baseflow conditions at a minimum."	6.3	41e	Evaluation of Alternatives: Transient simulation of baseline and alternatives
Appendix C	General Comments	41.6	"The Groundwater Model Technical Memorandum should assess and compare how transient stream and groundwater elevations affect GHCS performance between the alternatives. The capture zone analysis (e.g., shown in Figures C-8.1A and B) should be evaluated for those transient hydrologic conditions that bookend the seasonal variations."	6.3	41f	Evaluation of Alternatives: Transient simulation of baseline and alternatives
Appendix C	Assessing pumping test simulation results	56	"Comparing groundwater and surface water elevations - A table comparing surface water and groundwater levels pre-test and end-of-test would provide a simple illustration of the impact of pumping on groundwater-surface water interaction. Time history plots in the Pumping Test Interpretation memo show measured BTC/wetland surface water elevations compared with groundwater elevations at nearby monitoring wells. The head difference measured between the surface water gages and nearby wells just before the test and at the end of the 72-hr pumping period could be tabulated and compared with the model simulated results."	7.1.1	56	Increase reporting: Calibrated Heads - Groundwater/Surface water gradient change during pumping
Appendix C	Assessing pumping test simulation results	57	"Cross sections – Visualization of drawdown (or head) contours with model stratigraphy and monitoring wells would be helpful."	7.1.2	57	Increase reporting: Calibrated Heads - Show head on cross sections

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Appendix C	Additional Comments	86	"Section 7.4.1: please show simulated and observed contours on the same map, with focus on the area of interest near BTC and the subdrain."	7.1.3	86	Increase reporting: Calibrated Heads - Observed and simulated contours
Appendix C	Additional Comments	92.2	"Add a companion figure to Figure C-7.3A that uses the mean of the absolute residuals per well, rather than the mean residual per well. Figure C-7.3A communicates overall bias in the transient head residuals, while the companion figure would better communicate overall deviation in the transient head residuals. This may help to illustrate the relatively poorer calibration to the pumping test data. Residual RMS or residual standard deviation, similar statistics that are commonly used, would be acceptable if preferred by the modeling team."	7.1.4	92b2	Increase reporting: Calibrated Heads - Map mean of the absolute head residuals
Appendix C	Groundwater pump test model calibration (flux calibration)	40.24	"The scaled flux calibration statistics described in Section 7.4.2 of the Groundwater Model Technical Memorandum mask the lack of calibration around features of interest because they are scaled to the large amount of water flowing daily to all of these features combined. The combined residual mean does not show whether flux to specific parts of BTC or the subdrain are poorly calibrated because the mean averages out those inaccuracies. Flux calibration should be based on the specific flux targets and should consider measurement error in stream flow or subdrain flow."	7.2.1	40d1	Increase reporting: Flux - Focus on area of interest
Appendix C	Groundwater pump test model calibration (flux calibration)	40.25	"The bar charts in the "Calibration Flux Bar Charts: SFR Gain" section of Attachment C-5 provide a useful flux target format for BTC, but the lack of error bars on the stream flow target do not allow assessment of residual values (modeled vs observed field measured values)."	7.2.2	40d2	Increase reporting: Flux - Flux measurement error
Appendix C	Groundwater pump test model calibration (flux calibration)	40.26	"Similar bar charts should be produced for the subdrain flow."	7.2.2	40d3	Increase reporting: Flux - Flux measurement error
Appendix C	Groundwater pump test model calibration (flux calibration)	40.27	"Where calibration falls outside of the measured target +/- measurement error, this should be explained in the Groundwater Model Technical Memorandum."	7.2.2	40d4	Increase reporting: Flux - Flux measurement error
Appendix C	Groundwater pump test model calibration (flux calibration)	40.28	"A scatterplot of simulated vs. observed flux would be helpful."	7.2.3	40d5	Increase reporting: Flux - Simulated vs. Observed flux
Appendix C	Groundwater pump test model calibration (flux calibration)	40.29	"A scatterplot of simulated vs. observed flux would be helpful. With about 300 flux targets, error bars could likely be included. If this suggested approach results in an overly busy plot, separate scatterplots for surface water flow and subdrain could be generated."	7.2.3	40d6	Increase reporting: Flux - Simulated vs. Observed flux
Appendix C	Groundwater pump test model calibration (flux calibration)	40.3	"Maps of average flux residual and average absolute flux residual should also be generated to better understand and communicate matches and mis-mismatches. The flux residual plots should include comparison of simulated groundwater inflow to BTC stream segments compared with estimated inflow from streamflow data."	7.2.4	40d7	Increase reporting: Flux - Map flux residuals
Appendix C	BTC Streamflow	66	"Bromide tracer test -The 2014 bromide tracer test is noted to be one of the most reliable estimates of average groundwater discharge to the BTC. The tracer test estimates BTC groundwater gain between Oregon Avenue and SS-04. This reach is in the BTC GCHS study area. For assessment of both model calibration and model application simulations it would be helpful to subdivide the BTC reach at Oregon Avenue so that simulated inflows can be compared directly with the tracer test result.	7.2.5	66	Increase reporting: Flux - Split BTC SFR reach to coincide with Bromide tracer test reach
Appendix C	Additional Comments	88	"Section 7.4.2 states, "Qualitatively, the Model simulation indicates that groundwater discharge to BTC between SS-01 and SS-04 (before December 2019) and between SS-01 and SS-05 (after December 2019) is typically on the order of 400,000 ft3/d (4.6 cfs). This result is consistent with estimates based on the bromide tracer study which indicated a groundwater gain of 1.4 cfs over a shorter reach from Oregon Avenue to SS-04 (Tucci, 2014; EPA, 2018; Section 4.3.3)." Why isn't the simulated stream gain given in this comparison specific to the bromide tracer test reach?"	7.2.5	88	Increase reporting: Flux - Split BTC SFR reach to coincide with Bromide tracer test reach
Appendix C	Additional Comments	83	"Section 6.4.3 indicates that simulated Parrot Tailings dewatering uses drain boundaries. It is not clear where the flow from the drain is reported and compared to measured dewatering. Please provide this in the flux calibration section."	7.2.6	83	Increase reporting: Flux - Account for flow from drains
Appendix C	Water Budget	68.2	"According to Figure C-6.3 of the Groundwater Model Technical Memorandum, drain boundary conditions were used to simulate a number of wetland areas along Blacktail Creek. This may result in water out of the model that presumably should go into BTC for those wetland areas that have a direct surface water (or culvert) connection to Blacktail Creek. Stream flow routing boundary conditions may be more appropriate, or at least the drain flux needs to be accounted for in the simulated BTC flows."	7.2.6	68b	Increase reporting: Flux - Account for flow from drains
Appendix C	Additional Comments	102	"Additional graphs should be provided showing modeled stream exchange in Upper Silver Bow Creek and the confluence area similar to that shown for BTC in Figure C-8.2. If no flux calibration data exists for these reaches, calibration should be qualitatively assessed."	7.2.7	102	Increase reporting: Flux - Boundary flow accretion curves for other reaches
Appendix C	Assessing pumping test simulation results	55	"Subdrain flow - The Pumping Test Interpretation memo indicated that flow at the BPSOU pump station, adjusted for test pumping discharge, decreased 12.5 gpm and 9.6 gpm for the 72-hr and 24-hr pumping tests, respectively. If this is considered to be representative of the change in subdrain total flow then it would be informative to compare simulated change in subdrain flow to the estimated values."	7.2.8	55	Increase reporting: Flux - Compare change in subdrain flow (observed to simulated)
Appendix C	Additional Comments	101	"Attachment C-5 please include graphs of gain/loss in the specific subdrain segments such as done for the BTC stations under the subsection "Calibration Flux Bar Charts: SFR Gain."	7.2.9	101	Increase reporting: Flux - Show BPSOU Subdrain flux by segment

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Appendix C	Groundwater pump test model calibration (flux calibration)	40.31	"Note that the scaled residual standard deviation (10.6%) exceeds a typical performance metric of 10%. It is important to note that the performance metric for this statistic is not specifically stated in the Groundwater Model Technical Memorandum."	7.2.10	40d8	Increase reporting: Flux - State Performance Metrics for Flux Calibration
Appendix C	Hydraulic property distribution: Stratigraphy	76	"It would be helpful to show additional cross sections that might clarify the extent of these clay and silt layers and why they were created in the model. Projecting boring logs a short distance onto the cross sections might also help."	7.3.1	76	Increase reporting: Lithology Model and K Zones - Additional cross sections
Appendix C	Hydraulic property distribution: Stratigraphy	75	"Cross section plots such as Figure C-2-6 that show model material assignments and boring logs are useful. However, Figure C-2-6 shows significant layers of clay and silt with no corresponding boring logs to support the stratigraphic delineation."	7.3.2	75	Increase reporting: Lithology Model and K Zones - Discuss Interpolation
Appendix C	Hydraulic property distribution: Hydraulic conductivity (K) values	78	"Would it be easy to make a map of average K assigned to the alluvium in the refined model area? It would be good to know how the average alluvium K in the refined area compares with the undifferentiated alluvium K assigned elsewhere."	7.3.3	78	Increase reporting: Lithology Model and K Zones - Map of Average K
Appendix C	General Comments	44.2	"... Though it is difficult to tell exactly, it appears that the aquifer T value in the model is a little lower than the corresponding T value indicated by the distance-drawdown analysis. This is reasonable...."	7.3.4	44b	Increase reporting: Lithology Model and K Zones - Map of Simulated Transmissivity
Appendix C	Water Budget	69	"Water budgets should be provided for 2017 and preferred alternative steady state simulations."	7.4.1	69	Increase reporting: Flow Budget and Recharge - Present flow budget
Appendix C	Water Budget	70	"For the transient simulations, time history graphs would be ideal, but selected summer and winter snapshots might be sufficiently informative."	7.4.1	70	Increase reporting: Flow Budget and Recharge - Present flow budget
Appendix C	Water Budget	71	"A zone budget focused on the study area, possibly defined by model refinement area or BTC GHCS, would be very informative."	7.4.1	71	Increase reporting: Flow Budget and Recharge - Present flow budget
Appendix C	Water Budget	68.1	"Model simulated groundwater budget flows should be presented. This is important for understanding area groundwater hydrology, model sensitivity and assessing remedial approaches. The budget can be presented as figures and/or tables. The data should include: •Areal recharge •Upgradient CHD boundary inflows •Downgradient boundary outflows (if any) •Subdrain inflows and outflows •BTC inflows and outflows - Subdivide as appropriate, e.g., BTC GHCS area •River boundaries – BTL cells, pond, etc. •Wetlands, dewatering and other drain boundary condition outflows •Pumping outflows "	7.4.1	68a	Increase reporting: Flow Budget and Recharge - Present flow budget
Appendix C	Water Budget	72	"An explicit check should be presented comparing model simulated upgradient inflow for the CHD boundary with expected flow from the upgradient watershed. The recharge model should be useful for estimating upgradient watershed recharge. Stream flow across the boundary should be accounted for in the assessment."	7.4.2	72	Increase reporting: Flow Budget and Recharge - Compare simulated CHD flow to expected
Appendix C	Water Budget	73	"A no-flow boundary condition is assigned at the limit of the alluvial aquifer. The report should confirm that it is reasonable to neglect inflow to the alluvium/weathered rock aquifer from the upgradient watershed area. The recharge model should be useful for this (and also model water budget data)."	7.4.3	73	Increase reporting: Flow Budget and Recharge - Compare simulated no-flow to expected
Appendix C	Water Budget	75	"The recharge model appears to show areas of relatively high recharge (greater than 10 ipy) near the model west boundary. Does this represent a "mountain front recharge" phenomenon? These areas are mostly, but not entirely, within the model domain. Please add some discussion of this."	7.4.4	74	Increase reporting: Flow Budget and Recharge - Discuss areas of higher recharge
General Comments		4.1	"Performance metrics for the BTC GHCS are not defined as a flow rate. The overall groundwater goal is to prevent discharge of contaminated groundwater that causes exceedances of surface water performance standards. The degree of groundwater contamination is variable across the site, so it is not possible to directly connect the groundwater goal of preventing discharge of contaminated water with the model simulated reduction in discharge which does not consider the degree of groundwater contamination..."	7.5	4a	Increase reporting: Remedial Action Objectives
General Comments		4.2	"...Among the alternatives evaluated, Alternative 6 resulted in the least groundwater discharge to BTC from the northeast and below under steady-state conditions, and the smallest extraction rate of the six alternatives considered. Although Alternative 6 is predicted to perform the best of the alternatives evaluated, there is no discussion or evaluation of its adequacy or its ability to meet RAOs..."	7.5	4b	Increase reporting: Remedial Action Objectives
General Comments		7.1	"According to Figures 9 and 10, Table 10, and the text discussion, groundwater discharge from the northeast and below occurs to the upper part of the GHCS reach of BTC. The lateral extent of the "upper part" is unclear and should be clarified in the figures..."	8.1.1	7a	Revisions and Clarifications for the Memorandum: PDI ER - Figure 9, Figure 10 and Table 10

Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
PDI ER	Specific Comments	8	"Page 4, Section 2.1, 1st paragraph, last sentence: Calcium was also analyzed by XRF and should be added to the analyte list."	8.1.2	8	Revisions and Clarifications for the Memorandum: PDI ER - Section 2.1
PDI ER	Specific Comments	10	"Page 8, Section 3.2, 1st bullet on Page 8, last sentence: The geometric mean values for storativity are stated with units of ft2/day. Storativity is a dimensionless parameter and should, therefore, have no units. Please remove the units from the storativity values stated in the text."	8.1.3	10	Revisions and Clarifications for the Memorandum: PDI ER - Section 3.2
PDI ER	Specific Comments	11	"Pages 9 and 10, Section 3.3.2: It is not clear what the trend analysis described in Section 3.3.2 and Appendix D is used for. Also, trend analysis is not specified in the DQOs in the BTC GHCS Remedial Design Work Plan (RDWP). It is indicated in the report that groundwater standards are not a relevant benchmark because those standards are waived in the TI zone. Also, a trend analysis, if needed, should make use of a statistical test."	8.1.4	11	Revisions and Clarifications for the Memorandum: PDI ER - Section 3.3.2
PDI ER	Specific Comments	12	"Page 13, Section 4.3.1, bullets: The description of modeled alternatives in Section 4.3.1 of the PDIER seems to differ from the descriptions in the Groundwater Model Technical Memorandum(Appendix C). Alternative 2 in the PDI ER includes “Deep pumping well and shallow pumping wells / interceptor drain along BTC” but the Groundwater Model Technical Memorandum only includes the deeper well BTC-PW-01. Alternative 3 in the PDI ER includes “Shallow pumping wells / interceptor drain along east side of Kaw Ave” but the Groundwater Model Technical Memorandum has the deeper well DE-PW-01 which is simulated in layers 6 and 7. Please address."	8.1.5	12	Revisions and Clarifications for the Memorandum: PDI ER - Section 4.3.1 (12, 13)
PDI ER	Specific Comments	13	"Page 13, Section 4.3.1, 5th bullet: The text for Alternative 6 states that simulated extraction at BTC-PW-03 is deep but on page 18 (Section 4.3.2.7, 2nd paragraph) the text states that BTC-PW-03 was simulated in Layers 1, 2, 3 of the model. This should be resolved. The PDI ER indicates pumping from layers 1, 2, 3 while the Groundwater Model Technical Memorandum indicates layers 4 to 7. Based on the contours, tracks and labels shown in Groundwater Model Technical Memorandum and Figure C-8.10B, BTC-PW-03 pumps from layers 4 to 7 in the model."	8.1.5	13	Revisions and Clarifications for the Memorandum: PDI ER - Section 4.3.1 (12, 13)
PDI ER	Specific Comments	15	"Page 19 Section 5.1, 1st bullet, 2nd paragraph, last sentence: This is the same comment as above for Page 8, Section 3.2. The geometric mean values for storativity are stated with units of ft2/day. Storativity is a dimensionless parameter and should, therefore, have no units. Please remove the units from the storativity values stated in the text."	8.1.6	15	Revisions and Clarifications for the Memorandum: PDI ER - Section 5.1 (15)
PDI ER	Specific Comments	16.1	"Page 20, Section 5.1, last paragraph on page 20: “Shallower hydraulic gradients are observed between BTC- PW-01 and the BPSOU Subdrain, indicating the potential for well interference (reduction of water available to BTC-PW-01 and the BPSOU Subdrain).” This shallower gradient is evident in the maximum observed drawdown contours for both the 72-hour and 24-hour pumping tests (Figures B-9A and B-9B). The fact that the drawdown field is less here should not be affected by well interference unless there was an increase in subdrain capture to create additional drawdown from the subdrain. Otherwise, the drawdown from the BTC pumping test should be superimposed on the existing drawdown pattern from the subdrain. The flow into the subdrain was measured to decrease during the pumping tests which should lead to a decrease in drawdown from the subdrain. This shallower gradient may be a zone of higher hydraulic conductivity and preferential flow which should be incorporated into the model. This comment also applies to Section 2.2.2.1 of the Pumping Test Memo. Please address. The gentler and more widespread drawdown shown in Figures B-9A and B-9B, extending from BTC-PW-01 towards Upper Silver Bow Creek and the BPSOU subdrain in a north-northwest direction, could also be because of the lack of piezometers in that area. Piezometers along that direction could help to constrain contour interpretation. The same is true moving to the south of BTC-PW-01. The shallower gradient could also be due to shorter distance and greater flow impact at BTC compared to the subdrain. That is, there is likely a little more flow to the pumping well from the south than from the north. Further evaluation of the hydraulic impacts on the subdrain due to pumping at BTC-PW-01 is needed."	8.1.7	16a	Revisions and Clarifications for the Memorandum: PDI ER - Section 5.1 (16a)

Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
Appendix A	Attachment 1 – BTC Pumping Test Data Validation Report	18	"Page 1, Section 1.0, 2nd paragraph: The EPA National Functional Guidelines for Organic Superfund Methods Data Review (2020) should be listed in this section and any other applicable sections."	8.2.1	18	Revisions and Clarifications for the Memorandum: Appendix A - Section 1
Appendix A	Attachment 1 – BTC Pumping Test Data Validation Report	19	"Page 9, Section 2.3, bullets: Inductively Coupled Plasma Serial Dilution review is part of a Stage2A review. The data validation report indicated that information was not provided in the data package. Going forward the appropriate type of data package should be procured by the laboratory so all required data validation elements can be reviewed."	8.2.2	19	Revisions and Clarifications for the Memorandum: Appendix A - Section 2.3
Appendix A	Specific Comments	17	"Page 13, Section 3.5, 1st paragraph, 4th sentence: This sentence indicates that 16 samples were collected when previous sentences in the paragraph state that 4 samples were collected. Please revise the sentence to state that 4 samples were collected."	8.2.3	17	Revisions and Clarifications for the Memorandum: Appendix A - Section 3.5
Appendix A	Attachment 1 – BTC Pumping Test Data Validation Report	20	"Page 10, Section 4.1.1, 2nd paragraph: Going forward it would be good to identify site specific samples for XRF duplicate and replicate analyses."	8.2.4	20	Revisions and Clarifications for the Memorandum: Appendix A - Section 4.1.1
Appendix A	Attachment 1 – BTC Pumping Test Data Validation Report	21	"Page 11, Section 4.1.2, Laboratory Precision, Table: Please confirm the DV reason code for sample BTC-PZ01S-20220816. It appears that it should be RB, FD and not FB, FD. In accordance with the text and table in Section 4.2.2, there were 5 natural samples qualified for rinsate blank detection, including BTC-PZ01S-20220817."	8.2.5	21	Revisions and Clarifications for the Memorandum: Appendix A - Section 4.1.2
Appendix A	Attachment 1 – BTC Pumping Test Data Validation Report	22	"Page 16, Section 4.6.2, Laboratory Sensitivity, 4th paragraph: In this paragraph, it is stated that the MDL for TSS results (5 mg/L) was greater than the required RL in the QAPP (2 mg/L). EPA recommends a maximum TSS concentration of 0.5 mg/L for treated drinking water. For surface water concentrations in Blacktail Creek for example, many of the results were nondetect at 5 mg/L(the elevated MDL value). It is recommended that going forward, the procured laboratory meet the QAPP RL of 2 mg/L in order to evaluate results that may be above the 2 mg/L RL or, the data quality objective for what standard the TSS results should be compared to should be re-evaluated."	8.2.6	22	Revisions and Clarifications for the Memorandum: Appendix A - Section 4.6.2
Appendix A	Attachment 1 – Data Validation Checklists	23	"Title: This Attachment is named Attachment 1 and it is attached to the BTC Pumping Test Data Validation Report which is Attachment 1 of the BTC Pumping Test Data Summary Report. It is confusing to have Attachment 1 attached to Attachment 1. Please rename the attachments to the BTC Pumping Test Data Validation Report."	8.2.7	23	Revisions and Clarifications for the Memorandum: Appendix A - Attachment 1
Appendix B	Quantitative analysis	25	"Two methods of quantitative hydraulic analysis are presented: distance-drawdown (Cooper-Jacob)and time-drawdown (Hantush and Jacob, Neuman and Witherspoon). Very different results were reported. • Distance-drawdown: T = 1765–2039 ft^2/day, K = 135–156 ft/day • Time Drawdown: T = 7404-8444 ft^2/day, K = 570-650 ft/day It is surprising that there was little or no discussion of this discrepancy in the report. In fact, it is likely that neither analysis accurately reflects the impact of BTC and subdrain groundwater-surface water interaction on the groundwater response. More discussion should be provided. There are simplifications and assumptions in the methods used that may not be consistent in this setting. It may be worth while to briefly discuss the simulation of the pumping test in the model (the model accounts, for example, for boundary conditions that may impact pumping test data) and what insights this may give into K."	8.3.1	25	Revisions and Clarifications for the Memorandum: Appendix B - Section 2.3 (25)

Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
Appendix B	Quantitative analysis	26	"Suppressed drawdown due to surface water interaction with groundwater increases the apparent T/K values indicated by the traditional analyses presented. Because the distance drawdown analysis focusses on changes in drawdown from point to point, it is less affected by overall suppressed drawdown. Hence, the calculated T/K values are much lower using this method. However, calculated T/K are still likely over-estimates because the actual point to point flow rate is likely less than the flow rate calculated in the analysis assuming purely radial flow to the pumping well. Please address."	8.3.2	26	Revisions and Clarifications for the Memorandum: Appendix B - Section 2.3 (26)
Appendix B	Quantitative analysis	27	"Section 1.5.2.1 describes a multi-layer aquifer with discontinuous confining layers. Some of the paired well response curves match each other nearly perfectly suggesting strong interconnection between shallow and deeper water-bearing zones as would occur in a single layer aquifer without delayed yield. Other well pairs show a difference in magnitude of response suggesting a leaky confined or multi-layer aquifer. This imparts a challenge in describing the response model. A derivative analysis is typically used in concert with descriptive hydrogeology to identify the model; however, the derivative analysis was nearly nonexistent with only a single plot (Figure B-14) that didn't match the data very well. Additional analysis should be conducted. The derivative curves from the Neuman-Witherspoon solution don't make sense with the possible diagnostic plots of Renard et al. (2009). It seems that it might actually match the "no flow boundary" or even the "heterogenous behavior" "caused by a layered aquifer" of Studner et al. 1997. Please include more derivative analysis plots in the Pumping Test Technical Memorandum. References Renard, P., D. Glenz, and M. Mejias 2009, Understanding Diagnostic Plots for Well-Test Interpretation. Hydrogeology Journal v.17, n.3, pp.589-600. Studner, M, G. Zangle, and F. Komlosi 1997, A Modern Concept Simplifying the Interpretation of Pumping Tests. Transactions on Ecology and the Environment, c.14, pp.431-440.	8.3.3	27	Revisions and Clarifications for the Memorandum: Appendix B - Section 2.3.3
Appendix B	Quantitative analysis	28	"The BTC pumping test reversed upward groundwater gradients in the lower subdrain area. The consequences of altering groundwater capture near the subdrain and transporting contaminated groundwater from near the subdrain toward BTC needs to be evaluated. Pumping Test Technical Memorandum Table B-3 and Figure B-11A and B-11B show water level data from nested wells during the tests. The vertical gradients at BPS07-21/BPS07-21B and BPS07-22R/BPS07-22B changed from upwards to downwards during the tests. These nested wells are representative of the vertical hydraulic gradient near the bottom of the subdrain. The existing hydraulic gradients are positive indicating flow is upwards towards the subdrain. Reversing this gradient will reverse flow and may cause loss of water from the subdrain or transport of highly contaminated groundwater to locations with inadequate controls. This is a concern in part because the highly contaminated Parrot impacted groundwater that is captured within the upper subdrain should not be lost to the alluvial aquifer in the lower segments where it is more likely to impact surface water. We did not see where this is evaluated in the PDI ER or appendices. It is also not clear if the reduction in subdrain flow reported in the Pumping Test Memo is a reduction in capture or a loss of subdrain flow. This is an important distinction that needs to be evaluated, potentially by performing a tracer test simultaneously with another pumping test. If a tracer test is performed during a pumping test, additional piezometer coverage should be considered southwest of MH-MSD106 and west of BPS07-21x to better identify potential flow path impacts. Pumping Test Technical Memorandum Figures B-8A2 and B-8B2 show the potentiometric surface during the 72 and 24-hour pumping tests respectively. Both potentiometric surfaces show that pumping of BTC-PW-01 may also capture contaminated groundwater from near the lower subdrain and draw that groundwater towards BTC. This is acknowledged in Section 2.2.2.1 of the Pumping Test Technical Memorandum which states, "Groundwater within the BPSOU Subdrain is within the capture zone of the pumping well as shown on Figure B-8A2 and Figure B-8B2." This may also affect transport of contaminated groundwater near well BPS07-21 where the water quality data shows groundwater to be highly contaminated with arsenic and zinc. The PDI ER should base selection of new BTC GHCS elements on a better understanding of how the new controls will affect the existing capture systems and known contaminant plumes. Additional hydraulic controls to those evaluated in the PDI ER and Groundwater Model Technical Memorandum may be necessary to meet the CD requirements for additional capture, while protecting the existing groundwater remedy. The General Comments include several recommendations for additional controls that could be evaluated.	8.3.4	28	Revisions and Clarifications for the Memorandum: Appendix B - Section 2.2.2.1 (28)
Appendix B	Specific Comments	29	"Section 2.2.2.1 states, "Shallower hydraulic gradients are observed between BTC-PW-01 and the BPSOU Subdrain vault indicating that the BPSOU Subdrain is contributing to the drawdown caused by the BTC Pumping Test." PDI ER Specific Comment No. 16 above discusses that the shallower gradient is unlikely to be caused by drawdown from the subdrain. While there is drawdown associated with the BPSOU Subdrain prior to the pumping test, the drawdown shown on Figures B-9A and B-9B is relative to the BPSOU Subdrain active base condition. Therefore, the BPSOU subdrain does not contribute to the pumping drawdown displayed on these figures. However, the pumping test drawdown may have been attenuated by the subdrain (relative to if the subdrain were not there). In short, the two are in hydraulic connection during the pumping test and additional discussion of the potential impacts and hydraulic communication between the systems is warranted in the report. As stated in PDI ER Specific Comment #16, further evaluation of the hydraulic impacts on the subdrain due to pumping at BTC-PW-01 is needed."	8.3.5	29	Revisions and Clarifications for the Memorandum: Appendix B - Section 2.2.2.1 (29)

Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
Appendix B	Specific Comments	30	"Page 3.29, Section 2.3.4, 2nd complete paragraph on page 3.29: Please provide an explanation for the discrepancy between the range of transmissivity values determined from distance drawdown analysis (1,765 ft2/day to 2,039 ft2/day) and from type curve, time-drawdown analyses (4,575ft2/day to 14,110 ft2/day)."	8.3.6	30	Revisions and Clarifications for the Memorandum: Appendix B - Section 2.3.4 (30)
Appendix B	Specific Comments	31	"Page 3.29, Section 2.3.4, 3rd complete paragraph on page 3.29: The storativity value for theHantush-Jacob analysis on piezometer BTC-PZ07 is incorrect. According to the Aqtesolv TypeCurve Solution Plot for the Hantush-Jacob (1955)/Hantush (1964) analysis in Attachment B-4, thestorativity value is 6.65E-08. The value shown in Table-B4 (9.19E-05) is the r/B solutionparameter. Replacing the storativity with the correct value (6.65E-08) changes the geometric meanstorativty and the minimum storativity value for the Hantush-Jacob (1955)/Hantush (1964)analyses. Please revise the text and table B-4, accordingly."	8.3.7	31	Revisions and Clarifications for the Memorandum: Appendix B - Section 2.3.4 (31)
Appendix B	Specific Comments	32	"Table B-4: As noted in the previous comment, the storativity value shown for the Hantush-Jacobanalysis on piezometer BTC-PZ07 is incorrect. According to the Aqtesolv Type Curve SolutionPlot for the Hantush-Jacob (1955)/Hantush (1964) analysis in Attachment B-4, the storativityvalue is 6.65E-08. The value shown in Table-B4 (9.19E-05) is the r/B solution parameter.Replacing the storativity with the correct value (6.65E-08) changes the geometric mean storativtyand the minimum storativity value for the Hantush-Jacob (1955)/Hantush (1964) analyses in TableB-4. Please revise Table B-4 accordingly as well as references to geometric mean storativity andthe range (minimum) storativity throughout the report (e.g., page 3.29, 3rd complete paragraph)."	8.3.8	32	Revisions and Clarifications for the Memorandum: Appendix B - Table B-4
PDI ER	Specific Comments	9	"Page 7, Section 3.1, 2nd paragraph, 1st sentence: Confining layers should be identified on crosssections(Figures B-6 and B-7 of Appendix B)."	8.3.9	9	Revisions and Clarifications for the Memorandum: Appendix B - Figure B-6
Appendix B	Specific Comments	33	"Figure B-6: Please add the BPSOU subdrain construction profile to cross section A-A'."	8.3.9	33	Revisions and Clarifications for the Memorandum: Appendix B - Figure B-6
Appendix B	Specific Comments	34	"Figures B-8B1 and B-8A2: These figures depict the "Shallow Groundwater Divide" but thecontours are drawn using wells from intermediate depth. The shallow groundwater divide shouldbe estimated using wells completed in the shallowest portion of the alluvial aquifer. The divideshould be called out as "Pumped Water-Bearing Zone Groundwater Divide" or "GroundwaterDivide in Water-Bearing Zone Intersected by BTC-PW-01". The text states that "[G]roundwaterelevations are not contoured for each paired piezometer on Figure B-8A1 and Figure B-8B1. Thepiezometer in the pair monitoring within or proximal to the Pumped Water Bearing Zone wasselected for contouring." In some cases, the well symbology on Figures B-8B1 and B-8A2indicates that both of two paired piezometers were used for contouring (e.g., BTC-PZ05S/D andPZ03S/D), but the corresponding drawdown maps indicate that only the deeper (D) piezometerwas used. Additionally, the text elsewhere indicates that the PZ0 series piezometers don't intersectthe pumped interval.Wherever possible, the same set of wells should be consistently used for contouring potentiometricsurface and drawdown. Also, indicate the wells on the figures, and screen location relative to thepumped interval. Please address.	8.3.10	34	Revisions and Clarifications for the Memorandum: Appendix B - Figure B-8B1 and Figure B-8A2
Appendix B	Specific Comments	35	"Figures B-8A1 through B-8B2: The potentiometric surface contours use water levels measured inthe subdrain manholes to contour the groundwater surface. The subdrain water levels arerepresentative of pipe flow, not the alluvial groundwater and should not be used to contour thepotentiometric surface. Contouring of subdrain water levels gives an unrealistic depiction of themagnitude and extent of the groundwater depression associated with the subdrain capture zone.The contours were developed using kriging which does not account for the hydraulic conductivitycontrast that exists between the subdrain pipe, bedding material, and surrounding aquifer. Please address."	8.3.11	35	Revisions and Clarifications for the Memorandum: Appendix B - Figures B-8A1 through B-8B2
Appendix B	Specific Comments	36	"Figures B-11A and B-11B: The BTC-PZ02s/BTC-PZ02D well pair is mis-labeled as BPSPZ02S/BTC-PZ01D on both figures. Please revise."	8.3.12	36	Revisions and Clarifications for the Memorandum: Appendix B - Figure B-11A and Figure B-11B
Appendix B	Specific Comments	37	"Attachment B-4: The output of the Aqtesolv software includes transmissivity and storativityvalues for a pumped aquifer (T1, S1) and an unpumped aquifer (T2 and S2). The printouts inAttachment B-4 for the Neuman-Witherspoon solution all show unrealistically low T2 values.Section 1.5.2.1 indicates a crude pumping test generated a transmissivity value for the shallowgroundwater at 600 ft2/day. Another shallow aquifer test was reported in the Phase II RI report,Appendix B-7, at PW-2 next to the BPSOU subdrain. This had observation wells and a geometricmean transmissivity for the shallow aquifer (10 to 15 feet deep) of 333 ft2/day. This general rangeof transmissivity should be used in the Aqtesolv Neuman-Witherspoon solution. This will notradically alter the T1 values but will at least eliminate some unrealistic T2 values. Please attemptthe analysis with more reasonable T2 and S2 values."	8.3.13	37	Revisions and Clarifications for the Memorandum: Appendix B - Attachment B-4
Appendix B	Specific Comments	38	"Attachment B-5: The Cover Page for Attachment B-5 lists Hantush (1960) as the source for thesolution assumptions provided. This should be Hantush-Jacob (1955)/Hantush (1964) to beconsistent with the solution model used for the analyses and the assumptions listed in AttachmentB-5."	8.3.14	38	Revisions and Clarifications for the Memorandum: Appendix B - Attachment B-5
Appendix C	Additional Comments	87.2	"Section 7.4.1 states, "shallow water levels in the BTC and SBC confluence area, however, tend to be low compared to simulated values (positive residuals)...According to Figures C-7.3A and B, the residuals in this area are positive, which indicates that observed water levels are higher than simulated water levels. While this passage states that this indicates that observed water level are lower than simulated water levels."	8.4.1	87b	Revisions and Clarifications for the Memorandum: Appendix C - Section 7.4.1

Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
Appendix C	Additional Comments	91	"Section 8.1: please describe if the flux values and figures are from a steady state or transient model."	8.4.2	91	Revisions and Clarifications for the Memorandum: Appendix C - Section 8.1
Appendix C	Additional Comments	92.1	"On Figure C-7.1, symbolize eliminated gauging locations by rationale for eliminating. Use distinct symbol (e.g., triangle) for the eliminated locations vs. retained locations."	8.4.3	92a	Revisions and Clarifications for the Memorandum: Appendix C - Figure C-7.1
Appendix C	Additional Comments	92.3	"On Figure C-7.3A, include well IDs and make the symbols distinct for the -1 to 0 ft range and the 0 to 1 ft range.	8.4.4	92b1	Revisions and Clarifications for the Memorandum: Appendix C - Figure C-7.3A (92b1)
Appendix C	Additional Comments	92.4	"On Figure C-7.3A, clarify the title. It appears based on the legend that the contours are for layer 1 and the residuals are for layers 1 through 4. However, the figure title is not consistent with this."	8.4.5	92c	Revisions and Clarifications for the Memorandum: Appendix C - Figure C-7.3A and C-7.3B
Appendix C	Additional Comments	92.5	"On Figure C-7.3B, similar comments as above for Figure C-7.3A."	8.4.5	92d	Revisions and Clarifications for the Memorandum: Appendix C - Figure C-7.3A and C-7.3B
Appendix C	Additional Comments	93	"Figure C - 7.3A indicates the head residuals shown are “Steady State & 4-year Transient Simulations.” Are the residuals steady state or transient or some combination?"	8.4.6	93	Revisions and Clarifications for the Memorandum: Appendix C - Figure C-7.3A (93)
Appendix C	Additional Comments	94	"Figure C-7.4: please label the contours."	8.4.7	94	Revisions and Clarifications for the Memorandum: Appendix C - Figure C-7.4
Appendix C	Additional Comments	96	"It is not clear if Figure C-8.1A, C-8.1B, and C-8.2 are from steady state or transient simulation."	8.4.8	96	Revisions and Clarifications for the Memorandum: Appendix C - Figure C-8.1A, C-8.1B and C-8.2
Appendix C	Additional Comments	97	"Attachment C-5 Calibration BTC Pumping Test Combined Calibration Drawdown Hydrographs: What are wells 1-4 shown in all the BTC Pumping Test Combined Calibration Hydrographs? We could not find a description in the modeling report or pumping test report."	8.4.9	97	Revisions and Clarifications for the Memorandum: Appendix C - Attachment C-5 Calibration BTC Pumping Test Combined Calibration Drawdown Hydrographs
Appendix C	Additional Comments	98	"Attachment C-5 Figure 9: What is the third well in this graph? Only two wells are identified in the text of the figure label."	8.4.9	98	Revisions and Clarifications for the Memorandum: Appendix C - Attachment C-5 Calibration BTC Pumping Test Combined Calibration Drawdown Hydrographs
Appendix C	Additional Comments	99	"Attachment C-5 Calibration Flux Bar Charts: SFR Gain: The flux calibration charts (simulate vs observed gain/loss) should include error bars to indicate uncertainty in the observed measurement. Calibration should strive to get the model calibrated so that the simulated flux falls within the error bars. If the error bars show the uncertainty in the stream exchange or subdrain gain/loss measurements is high relative to the measured flux, it is acceptable to calibrate the model within the error bars, but focus should instead be put on calibrating head near these features."	4.5.4	99	Calibration Improvements: SFR flux targets - Flux Measurement Error
Appendix C	Additional Comments	100	"Attachment C-5 Calibration - Calibration Flux Graphs: SFR Gain: What are green triangles in the graphs? What is the x axis?"	8.4.10	100	Revisions and Clarifications for the Memorandum: Appendix C - Attachment C-5 Calibration - Calibration Flux Graphs: SFR Gain
General Comments		2	"In accordance with the BPSOU Consent Decree Appendix D Section 3.3, the development and submittal of the Pre-Design Investigation (PDI) Work Plan is to be the initial step of the PDI and is to precede the investigation and the PDI ER. To date, the EPA has not received the PDI Work Plan. Please notify EPA and Montana Department of Environmental Quality (DEQ) as to the schedule for submittal of the PDI Work Plan."	9.1	2	CD Requirements: PDI Work Plan
General Comments		5.2	"..AR’s contractor Stantec indicated at the November Remedial Design/Remedial Action (RD/RA) progress meeting that they would like to move straight to 60% design of BTC hydraulic controls because the proposed capture wells in the PDI ER are not complicated. This course of action is not recommended. The remedial design steps, as described in Appendix D to the BPSOU Consent Decree, should be followed in entirety."	9.2	5b	CD Requirements: 30% Design

Table 1
Response to Comments on the BPSOU Draft BTC GHCS PDI ER

Comment Letter Section	Comment Letter Sub-Section	Original Order	Comment Text (Original)	Response Letter Section	Detailed comment number	Response Letter Section Title
General Comments		1	"...Comments provided below are intended to encourage further analyses and continued calibration of the groundwater model. The groundwater model will be an important tool to support the design of the GHCS and the evaluation of remedial alternatives."	NA	1	NA
Appendix B	General Comments	24	"The BTC-PW-01 pumping test performed near the BTC in 2022 was, in effect, a short-term pilot of a significant component of the proposed BTC GHCS program."	NA	24	NA