ARF-021907

Department of Energy
Savannah River Operations Office
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JAN 22 2019

Ms. Susan B. Fulmer, P.G., Manager
Federal Remediation Section
Division of Site Assessment, Remediation and Revitalization
Bureau of Land and Waste Management
South Carolina Department of Health and Environmental Control
2600 Bull Street
Columbia, South Carolina 29201

Mr. Jon Richards
Acting Savannah River Site Remedial Project Manager
Superfund Division
U. S. Environmental Protection Agency, Region 4
61 Forsyth Street, SW
Atlanta, Georgia 30303

Dear Ms. Fulmer and Mr. Richards:

SUBJECT: Treatability Study Work Plan for Groundwater Injection and Discharge Canal Treatment at the D-Area Groundwater (OU) (U) (SRNS-TR-2018-00128, Revision 1 Redline, January 2019) and Savannah River Site's Responses to the Regulatory Comments on the Revision 0 Document, SEMS Number: 63

In accordance with the terms of the Federal Facility Agreement, the U. S. Department of Energy (DOE) is submitting the subject information for your review. The South Carolina Department of Health and Environmental Control (SCDHEC) and U. S. Environmental Protection Agency (EPA) provided comments on the Revision 0 document on September 19, 2018 and October 23, 2018, respectively. Please review the Revision 1 Redline document and provide your comments or approval within thirty (30) days of receipt. The effort and time that the EPA and the SCDHEC have given on the subject operable unit are greatly appreciated.

Questions from you or your staff may be directed to me at (803) 952-8365, or the DOE Federal Project Director, Karen Adams, at (803) 952-7871.

Sincerely,

Brian T. Hennessey
SRS Remedial Project Manager
Infrastructure and Area Completion Division

IACD-19-122

Enclosures:

1. Treatability Study Work Plan for Groundwater Injection and Discharge Canal Treatment at the D-Area Groundwater (OU) (U) (SRNS-TR-2018-00128, Revision 1 Redline, January 2019) SEMS Number: 63
2. SRS Responses to South Carolina Department of Health & Environmental Control Comments on the Treatability Study Work Plan for Groundwater Injection and Discharge Canal Treatment at the D-Area Groundwater (OU) (U) (SRNS-TR-2018-00128, Revision 0, July 2018) SEMS Number: 63
3. SRS Responses to United States Environmental Protection Agency Comments on the Treatability Study Work Plan for Groundwater Injection and Discharge Canal Treatment at the D-Area Groundwater (OU) (U) (SRNS-TR-2018-00128, Revision 0, July 2018) SEMS Number: 63

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SRS Responses to United States Environmental Protection Agency (US EPA) Comments on the Treatability Study Work Plan for the Groundwater Injection and Discharge Canal Treatment at the D-Area Groundwater OU (U)
SEMS Number: 63
SRNS-TR-2018-00128; Revision 0; July 2018
Comments Received October 23, 2018

EPA COMMENTS:

1. Section 3.0 (Test Objectives), Page 3 of 24, states, "Flush the acidity (increase the pH) out of the upper water table aquifer of the UTRA in the vicinity of and downgradient of the 484-17D Coal Storage Area and 489-D CPRB to improve the aquifer conditions and reduce or eliminate the dissolved metal groundwater plumes." It is noted the treatability study states an estimated 10 pore space volumes are sufficient to flush the aquifer with an estimated duration of 3 years to meet treatability study objectives. As such, the flushing of 10 pore space volumes would result in some dilution of the upper water table of the Upper Three Runs Aquifer (UTRA) via injection wells. Currently, it is unclear how the reduction in dissolved metals contamination in groundwater will be quantified with respect to dilution or sorption and/or redox attenuation mechanisms. Any natural attenuation remedy for dissolved metals in groundwater will rely primarily on sorption and/or redox attenuation mechanisms to reduce contaminant concentrations. Please revise the Treatability Study Work Plan for Groundwater Injection and Discharge Canal Treatment at the D-Area Groundwater to address this issue.

   Response: Clarification

   This treatability study is not the final remedial action on the low-pH/metals plume for DAG OU but is an attempt to improve groundwater pH conditions while studying a proposed treatment system that will provide information to help refine and evaluate future remedial alternatives.

   The intent of this treatability study is to physically flush out the existing low-pH groundwater in the upper water table aquifer in the vicinity of and downgradient of the Coal Storage Area, for the purpose of investigating the viability and observing the effects of this as a potential remedial action. Subsequent pH adjustment of surface water will occur at the CaCO3 reactive structures. DAG OU groundwater and surface water monitoring along with the monitoring associated with this treatability study will include field parameters of redox, dissolved oxygen, pH, specific conductance, and total alkalinity. Metal concentrations will also be analyzed at many of the wells and surface water stations. No changes to the Treatability Study Work Plan are proposed.

   Contact: Ashley Shull (803) 952-7090 (ashley.shull@srs.gov)

2. Section 4.0 (Experimental Design and Procedures), Page 4 of 24 states, "It is estimated that 10 pore space volumes are sufficient to flush the aquifer with an estimated duration of three years to meet treatability study objectives." However, the Work Plan does not discuss or explain if the estimated 10 pore volumes and 3 year duration to meet treatability study objectives considers the additional buffering of the vadose zone by the non-time critical removal action proposed for the D-Area Coal Storage Area (DCSA) (484-17D). Currently, a

removal site evaluation report/engineering evaluation/cost analysis (RSER/EE/CA) is in preparation for the DCSA and will propose removal alternatives including partial excavation of coal fragments (5 acres) and addition of soil neutralization amendments (15 acres). Please revise the Work Plan to address this issue to ensure the feasibility of the action is sufficient to achieve the treatability study objectives.

Response: Agree/Clarification

The groundwater injection treatability study is intended to flush out the existing low-pH groundwater in the upper water table aquifer. Although the water table is expected to rise approximately 5 feet into the vadose zone, the groundwater injection is not intended to be a major treatment for the vadose zone and will not remove all of the acidity from the vadose zone. The RSER/EE/CA action to add neutralization amendments to the vadose zone soils is intended to reduce the acidic vadose zone source that has contributed to groundwater contamination. Acidity is expected to be released from the lower vadose zone soils into the groundwater, but the lower vadose zone is not expected to be neutralized or have much change in pH as a result of the groundwater injection treatability study. The lower vadose zone will eventually see the buffering effects of the upper vadose zone amendments through infiltration. The combined (or synergistic) effects of the two actions have not been estimated or considered but will be apparent from the measurements using the parameters described in the TS Work Plan, the EE/CA, and the regular DAG OU monitoring. The treatability study will be updated to include this information.

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3. The work plan outlines that flushing 10 pore space volumes will be necessary over three years to achieve the desired result of a more neutral pH.
    a. Please provide additional information and clarification within the work plan that explains how the pore space volume and time frame were determined
    b. Please explain how the titration analysis and the Graph of D-Area Discharge Canal Acidic Surface Water with Calcium Carbonate Additions (both noted as Figure 5 on page 19 of 24) informed this treatability study design.

Response: Agree

a. Volume is calculated by multiplying the surface area of the 484-17D Coal Storage Area and the 489-D CPRB by the proposed rise in water elevation (5 ft) by porosity (30%) and converting to gallons. A total of approximately 19 million gallons is estimated to be needed to raise the water table 5 feet. Screening calculations using aqueous chemical equilibrium modeling software indicates that approximately 10 pore volumes may be adequate to raise the pH of the aquifer by 1.5 pH units by

dilution alone. However, the groundwater injection and rising water table elevation is expected to increase groundwater flow downgradient and increase groundwater discharge into the D-Area Discharge Canal. Expected flow rates from each of the two production wells is 60 gallons per minute (gpm). A combined flow rate of 120 gpm would be able to provide the 10 pore volumes of water after approximately 3 years of groundwater injection.

b. Titration tests were performed using water collected from the D-Area Discharge Canal to determine consumption rates of high-purity calcium carbonate. This information was used to calculate the amount of material necessary to sufficiently raise the pH of the acidic surface water to more neutral levels. Results indicated that the surface water pH can successfully be raised to background levels and that larger quantities of calcium carbonate do not overly raise the surface water pH to excessively basic. The velocity of the water passing through the reactive structure can be estimated using Darcy's Law which is valid for laminar flow through sediments. The flow calculations using estimates from other studies on hydraulics in gravels were used to determine contact time needed for the surface water to flow through the reactive structures to effectively raise the pH levels. These factors are then translated into the amount of material needed for the reactive structure. Installation of two reactive structures is planned to account for uncertainties in the actual flow and contact behavior and the potential for metal cladding of the carbonate surface with time. Sampling surface water upgradient, between, and downgradient of the two reactive structures will indicate how the water is reacting.

This information will be included in the Rev. 1 Treatability Study and Figure 5 will be properly referenced in the document.

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4. Section 4.0 Experimental Design and Procedures, second paragraph of section 4.0, Page 4 of 24: "Monitoring of stream conditions upgradient and downgradient of the CaCO3 reactive structures will determine if more CaCO3 material is needed or is feasible." What monitoring parameters will be used to assess upgradient and downgradient stream conditions to determine when and how much CaCO3 material may be necessary?

Response: Agree

The $CaCO_3$ material in the D-Area Discharge Canal will be used to buffer the pH of surface water. Surface water pH will be measured upgradient, between, and downgradient of the two reactive structures to determine the efficiency of the material and design. If the pH of the surface water downgradient of the two reactive structures at surface water station DSWM-9 is not raised up to or above a pH of 5.0, then remixing and/or replacement of calcium carbonate material will be made.

The sentence in Section 4.0, *Experimental Design and Procedures* will be revised as follows: "Monitoring of stream ~~conditions~~ pH will be conducted upgradient, between, and downgradient of the two CaCO3 reactive structures ~~will~~to determine ~~if more the~~ efficiency of both the CaCO3 material (including the potential for metal cladding to occur) and design ~~is needed or is feasable~~. If the pH of the surface water downgradient of the two reactive structures at surface water station DSWM-9 is not raised to or above a pH of 5.0, then remixing and/or replacement of calcium carbonate material will be made."

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5. 4.0, Experimental Design and Procedures, Page 4 of 24, states, "Slug tests in one or both of the existing monitoring wells to be used as part of the injection field (see section 5.0 Equipment and Materials) will also occur before the field start date to measure the aquifer characteristics during injection."

a. Please revise the Work Plan to provide the details for the type of slug test that will be performed and the slug test data collection activities.
b. The report states that slug tests will be performed in 1or both of the existing MWs. Please specifically state if slug tests will be performed in 1 or 2 Monitor wells and the MW designations that will be used for the proposed slug tests.

Response: Agree
A falling-head slug test (also known as a Slug-in test) will be performed on three existing monitoring wells. This includes the two proposed monitoring wells (DCB 2A and DCB 43A) to be used as part of the injection field and also at DCB 8. This information will be added to Section 4.0, *Experimental Design and Procedures.*

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6. Section 5.0 Equipment and Materials, page 5 of 24, second paragraph: states that injection wells will be screened within high permeability (sandy) zones within the upper water table of the UTRA which is ~10 ft bls for injection purposes and well screen placement will be determined in the field based on encountered lithology.

a. Please provide additional clarification as to the differing well screen intervals (5-20 feet) within the sandy zone of the UTRA.
b. Please discuss the depth, lateral extent and lithologic composition of the aquifer that is anticipated to be affected by flushing from both injection fields and if any negative impacts may be encountered, such as dissolution, etc.

Response: Agree/Clarification

a. Screen lengths will depend on the lithology at each of the injection well locations. As the cores are retrieved and cataloged, the permeable zone in the upper aquifer zone will be fitted with an appropriate length screen to maximize the injection flow. It is not practical to install screens within clay zones for injection wells.

b. In the vicinity of the 484-17D Coal Storage Area and the 489-D CPRB, the UTRA aquifer is present down to approximately 40 to 60 ft below ground surface. The UTRA consists of interbedded and laterally discontinuous sand, silt, and clay beds. West of the D-Area Ash Basins and Landfill, which is 2,000 ft or more from the injection field, the UTRA is incised by a 45 ft thick sequence of Quaternary Savannah River deposits consisting of fluvial clay, silt, and sand.

Groundwater injection and flushing is anticipated to cause a localized groundwater mound in the general vicinity of the 484-17D Coal Storage Area and the 489-D CPRB and is expected to increase groundwater discharge to the D-Area Discharge Canal downgradient of the injection field. Negative impacts that could occur as a result of injecting groundwater with a more neutral pH include precipitation of metals or minerals near the point of injection that may cause well fouling and decreased injection rates. This treatability study will include measurement of injection rates and, if necessary, conducting camera surveys inside the injection wells to confirm if fouling has occurred.

This information will be included in the Rev. 1 Treatability Study.

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7. Section 5.0 Equipment and Materials, Page 5 of 24, first paragraph: "Adjustments to the configuration of the injection field may be made based on the actual field conditions to optimize performance once the action is underway."
    a. Please provide clarification as to what field conditions would indicate that adjustments will be needed to the injection field configuration to optimize performance after treatment study startup date.
    b. Please provide additional information with respect to injection field design, specifically schematics of pipe locations, associated valve locations and anticipated flow rates. For instance, an injection field system schematic would be helpful (no as builts drawings – just simple schematic of anticipated layout with the understanding that infield changes may be required, as needed during construction).
    c. Please revise the work plan to include text stating any adjustments to the injection field will be reviewed and approved by the Core Team prior too implementation.

Response: Agree/Clarification

a. **As field conditions warrant, adjustments such as varying injection flows, pulsating flows or connecting wells from one injection field to the other injection field are theoretical ways to optimize injection. Other traditional methods such as re-development of the wells could also be employed. This information will be included in the Rev. 1 Treatability Study.**
b. **A detailed design is still in development for the injection field layout. A general piping and injection well layout is currently provided in Figure 7 and identifies the current monitoring wells to be used as injection wells (DCB 43A and DCB 2A). Based on pressure measurements at the production well meters and calculations based on ground elevations, piping friction, etc., it is estimated that each production well could supply enough flow to supply the injection wells. Flow tests at the production wells, which is currently planned for the February to April 2019 timeframe, will confirm if these flows are achievable and a final design will be completed. No additional figures are proposed to be supplied in the treatability study at this time. No changes are proposed for the Treatability Study.**
c. **Minor operational adjustments (e.g., increasing or decreasing flow into injection wells, adjusting flow out of the production wells, adjusting well configuration, shutdown of a well for redevelopment, etc) do not need prior Core Team approval. Major adjustments (e.g., removal or addition of injection locations) or non-temporary shutdown of the injection action will be communicated with the Core Team and a discussion on the path forward will be conducted as necessary. No changes are proposed for the Treatability Study.**

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8. Section 6.0, Sampling and Analysis, Page 6 of 24, states, "Adjustments to the monitoring may be based on field conditions or monitoring results." Revise the Work Plan to include text stating any adjustments to the monitoring will be reviewed and approved by the Core Team prior to implementation.

Response: Clarification

Any monitoring of wells or parameters will be discussed with the Core Team prior to discontinuing. Any data collected in addition to the proposed monitoring plan will be provided in subsequent data reports.

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9. Section 10.0, Residuals Management, Page 7 of 24, states, "There is a possibility that metal cladding could occur on the CaCO3 reactive structures marble chips due to the reactive pH adjustment of surface water and dissolution of metals." However, the Work Plan does not include a sampling frequency for metals on the CaCO3 reactive structures marble chips.

Based on the length of the treatability study (3 years), please revise the Work Plan to address this issue.

a. If metal cladding is encountered, what is the plan to address this issue?
b. How will marble chips be disposed of subsequent to treatability study, if metal cladding is a problem?
c. How many pounds of marble chips will be used in each reactive structure?
d. How will the marble chips be installed and held in place within each reactive structure?

Response: Agree/Clarification

Metal cladding may be observed through visual iron staining or other discoloration. However, direct surface water monitoring is a better indicator to determine if metal cladding is an issue that requires adjustments or replacement of the reactive material. Sampling of surface water conditions upgradient, between, and downgradient of the $CaCO_3$ reactive structures is proposed to monitor the efficacy of the structures and to adequately adjust the pH of the surface water. Sampling of the reactive structures is not planned.

a. If metal cladding is encountered and the surface water sampling results show that the pH is not being adequately adjusted, the $CaCO_3$ chips can be remixed to increase flow to unaffected particles or the $CaCO_3$ material can be replaced with new material. This information will be included in the Rev. 1 Treatability Study.
b. Disposal of metal-cladded material will occur at an offsite landfill if deemed necessary. No changes to the Treatability Study are proposed.
c. The preliminary design for each reactive structure, based on assumptions and calculations described in the response to comment #3b above, includes approximately 80 cubic yards (~ 5 dump truckloads) of high-purity $CaCO_3$ aggregate. This total includes an additional 3 feet above current stream levels to account for increased flow and potential flooding events. This information will be included in the Rev. 1 Treatability Study.
d. As mentioned in Section 5.0, *Equipment and Materials*, and as shown in the lower portion of Figure 6, riprap will be installed downgradient of each reactive structure to prevent erosion of the $CaCO_3$ aggregate material. Preliminary design includes a rip rap structure with a 20 ft long base and 2 ft long top installed ahead of the placement of $CaCO_3$ aggregate. No changes to the Treatability Study are proposed.

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10. Table 2 Proposed Metals Included in Sample Analyses, Page 10 of 24: at the bottom of Table 2, an asterisk (*) denotes "if chromium exceeds 100 µg/L, chromium-6+ (hexavalent

chromium) will be analyzed during the next sampling event. Please provide the rationale for using the exceedance threshold level of 100 µg/L before sampling for hexavalent chromium.

Response: Clarification

Metal analyses as part of the treatability study mimic the metal analyses for D-Area Groundwater, including chromium and hexavalent chromium (chromium6+) analyses. Per the published EPA "Chromium in Drinking Water" fact sheet (https://www.epa.gov/dwstandardsregulations/chromium-drinking-water), the MCL for total chromium is 100 µg/L. This value "... assumes that a measurement of total chromium is 100 percent chromium-6+, the more toxic form." Because hexavalent chromium requires a separate and different analysis method from total chromium, an additional sample bottle must also be collected. Due to extremely short hold times, there would not be enough time to perform the total chromium analysis and determine if hexavalent chromium would also need to be analyzed at the same time. Therefore, chromium-6+ samples are collected at that well or surface water station during the next sampling event. Additionally, concentrations of chromium-6 in D-Area groundwater have never exceeded 100 µg/L. No changes to the Treatability Study are proposed.

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11. Please include monitor well location points and surface water station sampling points that are located on either side of the injection field. EPA suggests additional sampling points are needed in lateral direction which would include sampling points within groundwater flow direction and upgradient since water will be injected under pressure and will also travel in an upgradient direction. Additional lateral points are needed to assess the lateral movement during and subsequent to aquifer flushing.

Response: Clarification

Multiple wells were selected side gradient of the injection field (i.e., DCB 44A, DCB 45A, DCB 41A, and DCB 26AR to the northeast). No other wells are located within 1000 ft of the injection field in the northeast direction other than DCB 8 and DCB 33B, both of which will be monitored. The tributary to the D-Area Discharge Canal is located to the southeast and the two surface water stations, DSWM-5 and DSWM-6, will also be monitored. Additionally, all surface water locations in the D-Area Discharge Canal (DSWM-4 and DSWM-7) and five new surface water stations (DSWM-4A, DSWM-4B, DSWM-4C, DSWM-8, and DSWM-9) will be monitored. There are no surface water stations located to the northeast within 1,000 ft of the injection field. No new monitoring wells or surface water stations are proposed to be installed and sampled at this time. As the study proceeds, additional sampling locations may be needed and will be installed as

necessary. No changes to the treatability study monitoring network are proposed. The DAG OU annual and semi-annual sampling will continue as normal.

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12. Please provide a generalized timeline of site activities described in this Treatability Study up to the start date of January 31, 2020.

Response: Agree
A general timeline for the field activities will be provided in Section 12 in the Revision 1 document as follows:

- **Dec 2018 – Sampling of production wells during the 4Q18 D-Area Groundwater sampling event.**
- **April 2019 – Conduct artesian flow tests on the production wells and conduct the falling-head slug test on existing wells DCB 43A, DCB 2A, and DCB 8.**
- **Fall 2019 – Complete detailed design based on falling-head slug test data**
- **Calendar Year 2020 Field Start - Install injection wells and associated piping and construct the $CAC0_3$ reactive structures.**

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13. Please include Total Depth and Screen Interval for MWs in Table 1. Proposed D-Area Treatability Study Monitoring Network and Sampling Schedule

Response: Agree

Columns will be added to Table 1 to include Total Depth (ft bgs) and the Screened Interval (ft msl).

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14. Please provide a figure and associated table that demonstrate the locations and water station designations where stream flow measurements will be collected

Response: Clarification

As described in Section 6.0, *Sampling and Analysis*, all surface water stations will include stream flow measurements. The nine surface water stations are listed in Table 1 and shown on Figure 7. No change to document required.

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15. Please make the following corrections to the report:

a. Figure 6: please denote direction of waterflow
b. Figure 7: please include a North Arrow
c. Section 6.0 Sampling and Analysis, page 6 of 24: Please detail and include the specific analyses in the report text instead of "other routine field analyses" indicated in the last sentence of the first full paragraph.

Response: Agree/Clarification

a. A groundwater flow direction arrow will be added to Figure 6.
b. A north arrow is already present on Figure 7 in the lower left of the map.
c. The specific field measurements will be listed in Section 6.0, *Sampling and Analysis* as currently listed in Table 3.

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SRS Responses to South Carolina Department of Health and Environmental Control (SCDHEC) Comments on the Treatability Study Work Plan for the Groundwater Injection and Discharge Canal Treatment at the D-Area Groundwater OU (U)
SEMS Number: 63
SRNS-TR-2018-00128; Revision 0; July 2018
Comments Received September 19, 2018

SCDHEC Specific Comments:

1. Section 1.0, Introduction, page 1. The first sentence of the third paragraph of this section states, "Maintenance actions conducted in 2012 and 2013 removed the majority of coal present at the 484-17D Coal Storage Area..." What percentage of the coal in the storage area is remaining? Please clarify 1) if the remaining coal will inhibit the success of the treatability study and 2) how long this remaining coal will be expected to continue to contribute to the low pH conditions in the soil and groundwater. This question focuses specifically on the southern grassed section of the Coal Storage Area where a layer of coal, 4 to 8 inches thick, was detected in the 0-1 foot samples under the top soil, as noted in the 6/22/18 email from DOE (Brian Hennessey to DHEC and EPA).

Response: Clarification

Approximately 160,000 tons of coal were burned at the 488-D Powerhouse per year. The remaining layer of coal fragments in the southern 5-acres section is a very small percentage (less than 1%) of the total amount of coal stored in the Coal Yard each year. This layer was located near or at the surface before the topsoil cover was applied. The pH of the coal layer is similar to that of the vadose zone soils and therefore poses no greater contribution to groundwater contamination or acidity than the acidified vadose zone soils. The weathered/oxidized coal layer will effectively be "neutralized" along with the vadose zone soils. No changes to the treatability study are proposed.

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2. Section 2.0, Project Description, page 3. The last paragraph of this section on page 3 refers to Figure 4 for carbonate consumption rates and titration test results. Figure 5 should be referenced instead.

Response: Agree

The reference will be corrected to Figure 5.

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