

5.4 Rad Waste Building

5.4.1 Summary of Rad Waste Building

Baseline information for the Rad Waste Building is provided in Section 2.0, Site History, Description, and Baseline Condition.

The Rad Waste Building is a single-story, rectangular-shaped building with plan dimensions of about 73 by 175 ft. The building was added onto the south side of the Auxiliary Building. The roof is supported by a steel moment frame that transfers the load to a structural mat foundation. Exterior walls consist of precast panels, and interior walls consist of masonry block. The top of the mat foundation ranges from about el. 1002 to 1007 ft and is thickest along the exposed perimeter where it extends to 4 ft below exterior grades (up to 7 ft thick). The basement floor elevation of the Auxiliary Building where the Rad Waste Building abuts is 987 ft. Excavations for the Auxiliary Building would have extended to about el. 983.5 ft. Site grades prior to the original development ranged from about el. 1002 to 1004 ft. This would suggest placement of about 20 ft of backfill along the Auxiliary Building wall and minimal placement of additional fill to establish design grades. Excavations as deep as about 4 ft would have been necessary where the top of the mat foundation is established at 1002 ft.

5.4.2 Inputs/References Supporting the Analysis

Table 5.4-1 lists references provided by OPPD and other documents used to support HDR's analysis.

Document Title	OPPD Document Number (if applicable)	Date	Page Number(s)
Foundation Plan North Area	7753-03-A-12 (#46694)	10/03/1988	
Foundation Plan South Area	7753-03-A-13 (#46694)	10/03/1988	
(Site Topo)		Unknown	
Bathymetric Survey		Unknown	
Survey Point Elevations		Unknown	
Naval Facilities Engineering Command, Design Manual 7.01, Soil Mechanics		9/1986	All

Detailed site observations—field reports, field notes, and inspection checklists—for the Rad Waste Building are provided in Attachment 8.

Observed performance and pertinent background data are as follows:

- Vibrofloation was not documented to have been performed below the structure.
- The electrical ductbank located inside the Rad Waste Building was present prior to construction.
- The sump in the truck bay did not have groundwater infiltration at the time of the field assessment.
- The Rad Waste Building was protected from floodwater by an Aqua Dam for the majority of the 2011 flood; however, the Aqua Dam failed for a short period of time because it was damaged, which allowed floodwater to enter the area inside the perimeter of the Aqua Dam. This incident

resulted in the flooding of the truck bay. Floodwater flowed into the sump until the temporary flood barrier was installed.

- Water that is pumped from the sumps is documented and stored.
- Hairline and stair-step cracking was observed in the masonry walls at various locations. It is unclear whether these cracks were present prior to the 2011 flood.
- The structure is designated as a Class I (seismic) structure in accordance with OPPD.
- No incident report summaries or inspection records are available for this structure.
- No design basis summary document is available for this structure.
- General observations of the interior of the structure were limited by the accessibility in certain rooms.

5.4.3 Assessment Methods and Procedures

5.4.3.1 Assessment Procedures Accomplished

Assessments of the Rad Waste Building included the following:

- Visual inspection of the accessible areas of the interior of the structure
- Visual inspection of the accessible exterior of the structure
- An assessment of collected survey data to date for indications of trends in the movement of the structure
- Review of previously documented condition reports, as-built plans, site topography, and geotechnical reports to identify possible conditions that could be affected by the 2011 flood

Additional investigations were performed. These included the following non-invasive geophysical and invasive geotechnical investigations:

- Seismic surveys (seismic refraction and seismic ReMi) in the PA. (Test reports were not available at the time of Revision 0.)
- Geotechnical test borings in the PA. Note that OPPD required vacuum excavation for the first 10 ft of proposed test holes to avoid utility conflicts. Therefore, test reports will not show soil conditions in the upper 10 ft of test boring logs. (Test reports were not available at the time of Revision 0.)

5.4.3.2 Assessment Procedures Not Completed

No additional assessment procedures have been identified for this structure.

5.4.4 Analysis

Identified PFMs were initially reviewed as discussed in Section 3.0. The review considered the preliminary information available from OPPD data files and from initial walk-down observations. Eleven PFMs associated with five different Triggering Mechanisms were determined to be “non-credible” for all Priority 1 Structures, as discussed in Section 3.6. The remaining PFMs were carried forward as “credible.” After the design review for each structure, the structure observations, and the results of available geotechnical, geophysical, and survey data were analyzed, a number of CPFMs were ruled out as discussed in Section 5.4.4.1. The CPFMs carried forward for detailed assessment are discussed in Section 5.4.4.2.

5.4.4.1 Potential Failure Modes Ruled Out Prior to the Completion of the Detailed Assessment

The ruled-out CPFMs reside in the Not Significant/High Confidence category and for clarity will not be shown in the Potential for Failure/Confidence matrix.

Triggering Mechanism 2 – Surface Erosion

CPFM 2a – Undermining shallow foundation/slab/surfaces

Reasons for ruling out:

- The Rad Waste Building was protected from floodwater by an Aqua Dam for the majority of the 2011 flood; however, the Aqua Dam failed for a short period of time because it was damaged, which allowed floodwater to enter the area inside the perimeter of the Aqua Dam.
- Surface erosion was not identified near the structure during the field assessments.

Triggering Mechanism 3 – Subsurface Erosion/Piping

CPFM 3a – Undermining and settlement of shallow foundation/slab/surfaces (due to pumping)

Reason for ruling out:

- The structure is a sufficient distance from the known pumping locations to be outside the zone of influence of the CPM.

Triggering Mechanism 3 – Subsurface Erosion/Piping

CPFM 3d – Undermining and settlement of shallow foundation/slab (due to river drawdown)

Reason for ruling out:

- The structure is a sufficient distance from the river to be outside the zone of influence of the CPM.

Triggering Mechanism 4 – Hydrostatic Lateral Loading (water loading on structures)

CPFM 4a – Overturning
CPFM 4b – Sliding
CPFM 4c – Wall failure in flexure
CPFM 4d – Wall failure in shear
CPFM 4e – Excess deflection

Reasons for ruling out:

- The Rad Waste Building is designed to withstand an external water load due to flooding of the Missouri River to el. 1007 ft. The peak flood elevation in 2011 was approximately 1006.9 ft.
- Visual observation did not identify distress to the structure that can be attributed to this CPM.

Triggering Mechanism 5 – Hydrodynamic Loading

- CPFM 5a – Overturning
- CPFM 5b – Sliding
- CPFM 5c – Wall failure in flexure
- CPFM 5d – Wall failure in shear
- CPFM 5e – Damage by debris
- CPFM 5f – Excess deflection

Reasons for ruling out:

- Sufficient high floodwater velocities were not identified near the structure.
- The Rad Waste Building was protected from floodwater by an Aqua Dam for the majority of the 2011 flood; however, the Aqua Dam failed for a short period of time because it was damaged, which allowed floodwater to enter the area inside the perimeter of the Aqua Dam.
- Visual observation did not identify distress to the structure that can be attributed to this CPFM.

Triggering Mechanism 6 – Buoyancy, Uplift Forces on Structures

- CPFM 6b – Cracked slab, loss of structural support
- CPFM 6c – Displaced structure/broken connections

Reason for ruling out:

- The Rad Waste Building is designed to withstand an external water load due to flooding of the Missouri River to el. 1007 ft. The peak flood elevation in 2011 was approximately 1006.9 ft.

Triggering Mechanism 7 – Soil Collapse (first time wetting)

- CPFM 7c – General site settlement

Reasons for ruling out:

- Site settlement was not observed near the Rad Waste Building during the field assessments.
- The peak flood elevation prior to 2011 was documented in 1993 at 1003.3 ft, which would indicate the soils below and surrounding the building have been saturated.

Triggering Mechanism 10 – Machine/Vibration-Induced Liquefaction

- CPFM 10a – Cracked slab, differential settlement of shallow foundation, loss of structural support
- CPFM 10b – Displaced structure/broken connections
- CPFM 10c – Additional lateral force on below-grade walls

Reason for ruling out:

- Machine/vibration-induced liquefaction was not observed to have occurred at the site.

Triggering Mechanism 11 – Loss of Soil Strength due to Static Liquefaction or Upward Seepage

- CPFM 11a – Cracked slab, differential settlement of shallow foundation, loss of structural support
- CPFM 11b – Displaced structure/broken connections
- CPFM 11c – Additional lateral force on below-grade walls

Reason for ruling out:

- Machine/vibration-induced liquefaction was not observed to have occurred at the site.

Triggering Mechanism 12 – Rapid Drawdown

- CPFM 12a – River bank slope failure and undermining surrounding structures
- CPFM 12b – Lateral spreading

Reason for ruling out:

- The Rad Waste Building is a sufficient distance from the river to be outside the zone of influence of the CPM.

Triggering Mechanism 14 – Frost Effects

- CPFM 14a – Heaving, crushing, or displacement

Reason for ruling out:

- The Rad Waste Building's foundation system is below frost level, and the interior of the building is a heated structure. The building will not be subjected to freeze/thaw cycles. Flooding did not change the frost and foundation conditions.

5.4.4.2 Detailed Assessment of Credible Potential Failure Modes

The following CPMs are the only CPMs carried forward for detailed assessment for the Rad Waste Building as a result of the 2011 flood. This detailed assessment is provided below.

Triggering Mechanism 7 – Soil Collapse (first time wetting)

- CPFM 7a – Cracked slab, differential settlement of shallow foundation, loss of structural support
- CPFM 7b – Displaced structure/broken connections

Portions of the Rad Waste Building are supported on a differential thickness of backfill and new fill placed along the Auxiliary Building exterior wall. The thickness of a portion of this fill could be up to about 20 ft thick.

This Triggering Mechanism and CPM could then occur as follows: the rise of the groundwater elevation associated with the flooding, in addition to the flooding that occurred when the Aqua Dam failed, could have resulted in the first time wetting of a portion of this backfill. When sandy soils are wetted, the water acts like a lubricant, allowing the sand particles to rearrange. When clayey soils are wetted, the water reacts with the clay, causing it to slake. When cemented soils are wetted, the water dissolves the cement, allowing the particles to rearrange.

Since backfilling of the Auxiliary Building wall, the peak flood elevation prior to 2011 was 1003.3 ft, which occurred in 1993. Rise in groundwater elevations during previous floods could have previously wetted portions of the backfill.

The following table describes observed distress indicators and other data that would increase or decrease the potential for degradation associated with this CPFM for the Rad Waste Building.

Adverse (Degradation/Direct Floodwater Impact More Likely)	Favorable (Degradation/Direct Floodwater Impact Less Likely)
Hairline and stair-step cracking of the masonry walls was observed.	Previous floods could have already wetted a majority of the fill.
	The site soils are not cemented.
	Survey data to date does not identify measurable movement.
Data Gaps: <ul style="list-style-type: none"> Subsurface conditions and how they may facilitate the CPFMs are not well understood. Additional data will be acquired from GPR, seismic survey, and geotechnical test borings. 	

Conclusion

Significance

Potential for Degradation/Direct Floodwater Impact

The presence of thick fills below the Rad Waste Building may increase the potential that degradation due to these CPFMs has occurred prior to or due to the 2011 flood. Because the 2011 flood was approximately 3 ft higher than previous floods and occurred for a longer duration, the potential that the 2011 flood caused further degradation due to these CPFMs is high.

Implication

The Rad Waste Building is supported on a mat foundation that can tolerate moderate settlement. Additionally, the thickness of fill that potentially was wetted from the 2011 flood is relatively small. The occurrence of this CPFM is not expected to negatively impact the performance of the mat foundation. Therefore, the implication of the potential degradation for this CPFM is low.

Confidence

The available data are not sufficient to rule out these CPFMs or lead to a conclusion that the Rad Waste Building foundations might have been impacted because of the CPFMs. Therefore, the confidence in the above assessment is low, which means more data are necessary to draw a conclusion.

Summary

For CPFMs 7a and 7b, as discussed above, the potential for degradation is high. However, this degradation is expected to be relatively small due to previous wetting. Therefore, the combined consideration of the potential for degradation and the implications of that degradation to a structure of this type puts it in the "not significant" category. The data currently collected are

not sufficient to rule out this CPFM. Therefore, the confidence in the above assessment is "low," which means more data or continued monitoring and inspections might be necessary to draw a final conclusion.

5.4.5 Results and Conclusions

The CPFMs evaluated for the Rad Waste Building are presented in the following matrix, which shows the rating for the estimated significance and the level of confidence in the evaluation.

	Low Confidence (Insufficient Data)	High Confidence (Sufficient Data)
Potential for Failure Significant		
Potential for Failure Not Significant	CPFM 7a CPFM 7b	

5.4.6 Recommended Actions

Continued monitoring is recommended to include a continuation of elevation surveys of the previously identified targets on this structure and surrounding site. The purpose is to monitor for signs of structure distress and movement or changes in soil conditions around the structure. The results of this monitoring will be used to increase the confidence in the assessment results. Elevation surveys should be performed weekly for 4 weeks and biweekly until December 31, 2011. At the time of Revision 0, groundwater levels had not yet stabilized to nominal normal levels. Therefore, it is possible that new distress indicators could still develop. If new distress indicators are observed before December 31, 2011, appropriate HDR personnel should be notified immediately to determine whether an immediate inspection or assessment should be conducted. Observation of new distress indicators might result in a modification of the recommendations for this structure.

5.4.7 Updates Since Revision 0

Revision 0 of this Assessment Report was submitted to OPPD on October 14, 2011. Revision 0 presented the results of preliminary assessments for each Priority 1 Structure. These assessments were

incomplete in Revision 0 because the forensic investigation and/or monitoring for most of the Priority 1 Structures was not completed by the submittal date. This revision of this Assessment Report includes the results of additional forensic investigation and monitoring to date for this structure as described below.

5.4.7.1 Additional Data Available

The following additional data were available for the Rad Waste Building for Revisions 1 and 2 of this Assessment Report:

- Foundation drawings that show the Rad Waste mat foundation supported by step-tapered driven pile. These drawings are 7753-03-A-10 and 7753-03-A-17.
- Results of geophysical investigation by Geotechnology (see Attachment 6C).
- Results of geotechnical investigation by Thiele Geotech (see Attachment 6A).
- Data obtained from inclinometers by Thiele Geotech (see Attachment 6A).
- Results of continued survey by LRA (see Attachment 6E).

5.4.7.2 Potential Failure Modes Ruled Out Prior to the Completion of the Detailed Assessment

The CPFMs ruled out in Section 5.4.4.1 were based on the understanding that the Rad Waste Building was supported by a grade-supported mat foundation. New information available for Revision 1 shows the mat foundation to be pile supported. The paragraphs below provide the ruled-out CPFMs based on the additional information available for Revisions 1 and 2 of this Assessment Report and reevaluation of each CPFM.

As previously stated, the ruled-out CPFMs reside in the Not Significant/High Confidence category and for clarity will not be shown in the Potential for Failure/Confidence matrix.

Triggering Mechanism 2 – Surface Erosion

CPFM 2b – Loss of lateral support for pile foundation

Reasons for ruling out:

- The Rad Waste Building was protected from floodwater by an Aqua Dam for the majority of the 2011 flood; however, the Aqua Dam failed for a short period of time because it was damaged, which allowed floodwater to enter the area inside the perimeter of the Aqua Dam.
- Surface erosion was not identified near the structure during the field assessments.

Triggering Mechanism 3 – Subsurface Erosion/Piping

CPFM 3b – Loss of lateral support for pile foundation (due to pumping)

Reason for ruling out:

- The structure is a sufficient distance from the known pumping locations to be outside the zone of influence of the PFM.

Triggering Mechanism 3 – Subsurface Erosion/Piping

CPFM 3e – Loss of lateral support for pile foundation (due to river drawdown)

Reason for ruling out:

- The structure is a sufficient distance from the river to be outside the zone of influence of the PFM.

Triggering Mechanism 6 – Buoyancy, Uplift Forces on Structures

CPFM 6a – Fail tension piles

Reason for ruling out:

- Distress was not observed at the structure that can be attributed to the PFM.

Triggering Mechanism 10 – Machine/Vibration-Induced Liquefaction

CPFM 10d – Pile/pile group instability

Reason for ruling out:

- Machine/vibration-induced liquefaction was not observed to have occurred at the site.

Triggering Mechanism 11 – Loss of Soil Strength due to Static Liquefaction or Upward Seepage

CPFM 11d – Pile/pile group instability

Reason for ruling out:

- Machine/vibration-induced liquefaction was not observed to have occurred at the site.

5.4.7.3 Additional Analysis

The following analysis of additional data was conducted for the Rad Waste Building:

- Results of geophysical investigation report by Geotechnology

Seismic Refraction and Seismic ReMi tests performed around the outside perimeter of the power block identified deep anomalies that could be gravel, soft clay, loose sand, or possibly voids.

- Results of geotechnical investigation by Thiele Geotech

Six test borings were drilled, with continuous sampling of the soil encountered, to ground truth the Geotechnology seismic investigation results as part of the KDI #2 forensic investigation. Test bore holes were located to penetrate the deep anomalies identified in the seismic investigation. The test boring data did not show any piping voids or very soft/very loose conditions that might be indicative of subsurface erosion/piping or related material loss or movement.

All of the SPT and CPT test results conducted for this Assessment Report were compared to similar data from numerous other geotechnical investigations that have been conducted

on the FCS site in previous years. This comparison did not identify substantial changes to the soil strength and stiffness over that time period. SPT and CPT test results were not performed in the top 10 ft to protect existing utilities.

Data from inclinometers to date, compared to the original baseline measurements, have not exceeded the accuracy range of the inclinometers. Therefore, deformation at the monitored locations since the installation of the instrumentation has not occurred.

- Results of continued survey by LRA

Survey data to date compared to the original baseline surveys have not exceeded the accuracy range of the surveying equipment. Therefore, deformation at the monitored locations, since the survey baseline was shot, has not occurred.

The CPFMs that could not be ruled out in Revision 0 are analyzed below based on the additional data available for Revisions 1 and 2 of this Assessment Report.

Triggering Mechanism 7 – Soil Collapse (first time wetting)

CPFM 7b – Displaced structure/broken connections

Portions of the Rad Waste Building are supported on a differential thickness of backfill and new fill placed along the Auxiliary Building exterior wall. The thickness of a portion of this fill could be up to about 20 ft thick. The rise of the groundwater elevation associated with the flooding, in addition to the flooding that occurred when the Aqua Dam failed, could have resulted in the first time wetting of a portion of this backfill. When sandy soils are wetted, the water acts like a lubricant, allowing the sand particles to rearrange. When clayey soils are wetted, the water reacts with the clay causing it to slake. When cemented soils are wetted, the water dissolves the cement allowing the particles to rearrange.

Since backfilling of the Auxiliary Building wall, the peak flood elevation prior to 2011 was 1003.3 ft, which occurred in 1993. Rise in groundwater elevations during previous floods could have previously wetted portions of the backfill.

Significance

Potential for Degradation/Direct Floodwater Impact

The presence of thick fills below the Rad Waste Building could increase the potential that degradation due to these CPFMs has occurred prior to or due to the 2011 flood. Because the 2011 flood was approximately 3 ft higher than previous floods and occurred for a longer duration, the potential that the 2011 flood caused further degradation due to the CPM is high.

Implication

The structures supported on the grade would settle while structures supported by piles would not. This could result in a “pinch-point at the interface of the non-pile supported and pile supported structures. Depending on the flexibility of the interface connection and the magnitude of settlement, the occurrence of the CPM could impact the performance of the structure negatively. The amount of settlement due to collapse of the upper 3 ft of fill is negligible. Therefore, the implication of the potential degradation for the CPM is low.

Confidence

The available data lead to a conclusion that the Rad Waste Building was not impacted by the CPFM. Therefore, the confidence in the above assessment is high.

Summary

For CPFM 7b as discussed above, the potential for degradation is high. However, this degradation is expected to be relatively small due to previous wetting. Therefore, the combined consideration of the potential for degradation and the implications of that degradation to a structure of this type put it in the "not significant" category. The data currently collected are sufficient to rule out these CPFMs. Therefore, the confidence in the above assessment is "high."

Triggering Mechanism 7 – Soil Collapse (first time wetting)

CPFM 7d – Piles buckling from down drag

Portions of the Rad Waste Building are supported on a differential thickness of backfill and new fill placed along the Auxiliary Building exterior wall. The thickness of a portion of this fill could be up to about 20 ft thick. The rise of the groundwater elevation associated with the flooding, in addition to the flooding that occurred when the Aqua Dam failed, could have resulted in the first time wetting of a portion of this backfill. When sandy soils are wetted, the water acts like a lubricant, allowing the sand particles to rearrange. When clayey soils are wetted, the water reacts with the clay causing it to slake. When cemented soils are wetted, the water dissolves the cement allowing the particles to rearrange.

Since backfilling of the Auxiliary Building wall, the peak flood elevation prior to 2011 was 1003.3 ft, which occurred in 1993. Rise in groundwater elevations during previous floods could have previously wetted portions of the backfill.

Significance*Potential for Degradation/Direct Floodwater Impact*

The presence of thick fills below the Rad Waste Building could increase the potential that degradation due to the CPFM has occurred prior to or due to the 2011 flood. Because the 2011 flood was approximately 3 ft higher than previous floods and occurred for a longer duration, the potential that the 2011 flood caused further degradation due to the CPFM is high.

Implication

The amount of down drag force that would be applied to the piles due to collapse of the upper 3 ft of fill is negligible. The occurrence of the CPFM is not expected to impact the performance of the mat foundation negatively. Therefore, the implication of the potential degradation for the CPFM is low.

Confidence

The available data lead to a conclusion that the Rad Waste Building foundation was not impacted by the CPFM. Therefore, the confidence in the above assessment is high.

Summary

For CPFM 7d, as discussed above, the potential for degradation is high. However, this degradation is expected to be relatively small due to previous wetting. Therefore, the combined consideration of the potential for degradation and the implications of that degradation to a structure of this type put it in the “not significant” category. The data currently collected are sufficient to rule out the CPFM. Therefore, the confidence in the above assessment is “high.”

5.4.7.4 Revised Results

The CPFM evaluated for the Rad Waste Building is presented in the following matrix, which shows the rating for the estimated significance and the level of confidence in the evaluation. CPFMs 7b and 7d for the Rad Waste Building are not associated with KDIs. The results of the additional forensic investigation show that these CPFMs are ruled out. Therefore, these CPFMs are placed in the quadrant of the matrix representing “No Further Action Recommended Related to the 2011 Flood.”

	Low Confidence (Insufficient Data)	High Confidence (Sufficient Data)
Potential for Failure Significant		
Potential for Failure Not Significant		CPFM 7b CPFM 7d

5.4.7.5 Conclusions

In the assessment of the FCS Structures, the first step was to develop a list of all Triggering Mechanisms and PFMs that could have occurred due to the prolonged inundation of the FCS site during the 2011 Missouri River flood and could have negatively impacted these structures. The next step was to use data from various investigations, including systematic observation of the structures over time, either to eliminate the Triggering Mechanisms and PFMs from the list or to recommend further investigation and/or physical modifications to remove them from the list for any particular structure. Because all CPFMs for the Rad Waste Building other than CPFMs 7b and 7d had been ruled out prior to Revision 1, and because CPFMs 7b and 7d have been ruled out as a result of the Revision 1 findings, no Triggering Mechanisms and their associated PFMs remain credible for the Rad Waste Building. Therefore, HDR has concluded that the 2011 Missouri River flood did not impact the geotechnical and structural integrity of the Rad Waste Building because the potential for failure of this structure due to the flood is not significant.