6.2 Service Building

6.2.1 Summary of Service Building

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

The Service Building is located inside of the PA and is an extension of the Turbine Building to the east. The northern portion of the Service Building is currently used to store and heat water for plant operations, and the southern portion of the Service Building houses offices on two levels. The building housed a water treatment system prior to the implementation of the Blair Water Line, which now supplies treated water directly from the City of Blair.

From field observations and a review of plans provided by OPPD, the Service Building is a rectangular steel-framed structure. Building dimensions are 224 ft on the east and west sides, which are parallel to the Turbine Building, by 50 ft on the north and south sides. The Maintenance Shop, located north of the Service Building, can be accessed through a man door on the north wall of the Service Building. Several man doors as well as an overhead garage door are located along the building's east side. The Turbine Building can be accessed through a man door on the south wall of the Service Building.

Moment frames span east to west at 28-ft increments along the Service Building's 224-ft length. The northern portion of the building is an open floor plan with a two-story ceiling height. The southern portion, which houses offices, has a steel-framed second floor composed of floor joists and concrete topped metal decking. The roof is comprised of joists and roof deck spanning between steel framing members. The building is supported on steel-pipe piling. Each steel column is supported by individual pile caps of varying geometry and number of piles per the load requirements. Top of pile caps are at 1000.5 ft, which is 7 ft below top-of-slab elevation. Spanning over the Circulating Water Tunnel is a grade beam that provides support to the structural slab, which is at el. 1007.5 ft. The grade beam is supported by a pile cap at each end and two intermediate pile columns bearing on the Circulating Water Tunnel below. The bottom of the grade beam is at 1004.5 ft, which is 3 ft below the top-of-slab elevation. Precast concrete panels clad the building on its east and south sides. The west wall, which is shared with the Turbine Building, is a cast-in-place concrete wall. The north wall, which is shared with the Maintenance Shop, is precast concrete panels.

6.2.2 Inputs/References Supporting the Analysis

Table 6.2-1 lists references provided by OPPD and other documents used to support HDR's analysis.

Table 6.2-1 - References for Service Building

Document Title	OPPD Document Number (if applicable)	Date	Page Number(s)
Service Building Foundations-Plan & Details	11405-S-309 (#16529)	1/22/1975	
Service Building Foundation-Details	11405-S-310 (#16530)	1/23/1975	
Service Building El. 1019'-6" & 1036'-0" Row 1-3	11405-S-346 (#16555)	1/28/1973	
Service Building El. 1019'-6" & 1036'-0" Row 3-6	11405-S-347 (#16556)	1/28/1975	

Table 6.2-1 - References for Service Building			
Document Title	**OPPD Document Number (if applicable)**	**Date**	**Page Number(s)**
Service Building El. 1019'-6" & 1036'-0" Row 6-9	11405-S-348 (#16557)	1/28/1975	
Service Building Roof Framing Plan & Details	11405-S-349 (#16558)	1/28/1975	
Service Building Misc. Details	11405-S-350 (#16559)	1/28/1975	
Service Building Plan El. 1007'-6" Row 1-5	11405-S-421 (#16590)	1/29/1975	
Service Building Plan El. 1007'-6" Row 5-9	11405-S-421 (#16591)	1/9/1975	x
Service Building Grade Beam Details	11405-S-423 (#16592)	1/29/1975	
Service Building Grade Beam Details	11405-S-424 (#16593)	1/29/1975	
Service Building Foundation Details	11405-S-425 (#16594)	1/28/1975	
Service Building Concrete Floor Plan El. 1019-6 & 1036-1 Row 1-3	11405-S-427 (#16595)	Unknown	
Service Building Concrete Floor Plan El. 1019'-6" & 1036'-0" Row 3-6	11405-S-428 (#16596)	Unknown	
Service Building Concrete Floor Plan El. 1019'-6" & 1036'-0" Row 6-9	11405-S-429 (#16597)	Unknown	
Service Building Foundations	-	6/16/1969	FC-15600506
Incident Report Summary	CR 2011-5469	6/10/2011	-

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

Observed performance and pertinent background data are as follows:

- The Service 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. Approximate river elevation during the period of the breach was 1006 ft, which was 1.5 ft below the slab elevation of the Service Building.
- According to OPPD CR 2011-5469, a pipe penetration below the northeast door exiting to the outside was leaking water into a below-ground tank pit. The pit continued to fill with water until it equalized with the exterior waters. The water in the pit has since been pumped out. A small amount of residual sediment was observed in the pit.
- According to OPPD personnel, voids below the Service Building have existed since the mid-1980s. The two manholes allowing access to these voids were placed after the building's construction to allow access to these areas to repair and remove piping.
  - The first manhole, located in the north area of the water treatment/storage area, had a void below the slab that measured approximately 11 ft north to south by 4 ft east to west by 3 ft deep. There was a significant amount of concrete corrosion on one area of the slab and grade beams, which seems to have been caused by a highly corrosive product such as an acid. The area affected was approximately 2 ft square. A hole in the slab approximately 6 in. in diameter had been patched in the area of the corrosion, which seems to indicate that the corrosive material may have eaten through the slab and caused this damage.
  - The second manhole, located in the south area of the water treatment/storage area, had a larger void below the slab that measured approximately 40 ft north to south by 4 ft east to west by 3 ft

deep at the manhole location and deepened to approximately 4 ft as you moved south into the hole. The void starts at the manhole and extends to the south. Overall, the structure exposed in these areas was in good condition. Four pipes were exposed in this area, two of which were located approximately 5 ft to the south of the manhole and were wrapped in a white plastic material, one of which was located approximately 6 ft to the south of the manhole and was covered in an asphaltic coating, and one of which was located approximately 3 ft to the northwest of the manhole and seemed to be an iron pipe. The void extends a significant distance past the pipes to the south and continues under a grade beam to the west for a short distance.

6.2.3 Assessment Methods and Procedures

6.2.3.1 Assessment Procedures Accomplished

Assessments of the Service Building included the following:

- A visual inspection of perimeter rooms on the lowest level.
- A visual inspection of upper level offices.
- A visual inspection of the exterior walls along the south and east sides of the building.
- Results of continued survey by LRA (see Attachment 6A).
- A review of previously documented condition reports, as-built building plans, and geotechnical reports.
- CPT using a portable static hand-pushed cone penetrometer to determine soil strength in the Paved Access Area between the Service Building and the Intake Structure.
- Video inspection of the drain pipes below the basement floor of the Turbine Building, which is west of and adjacent to the Service Building, by EPS (see Attachment 6D).
- GPR along portions of the basement floor of the Turbine Building, which is west of and adjacent to the Service Building, by Geotechnology (see Attachment 6C).
- Hammer drilling in the basement floor of the Turbine Building, which is west of and adjacent to the Service Building, to map the extent of the voids below the floor slab. Bore scopes and fiberglass T-probes were used to both visually and mechanically measure void depths and extents. Both portable static hand-pushed and dynamic cone penetrometers were used to determine soil strength.
- Core and hammer drilling in the vicinity of the settled column in the Maintenance Shop, which is north of and adjacent to the Service Building, to map the extent of the voids below the floor slab. Bore scopes and fiberglass T-probes were used to both visually and mechanically measure void depths and extents. Both portable static hand-pushed and dynamic cone penetrometers were used to determine soil strength.
- Access to and photographs of the voids below the floor slab through two manholes located in the water treatment/storage portion of the Service Building.
- Results of KDI #1 forensic investigation (see Section 4.1)
- Results of KDI #2 forensic investigation (see Section 4.2)
- Results of KDI #3 forensic investigation (see Section 4.3)
- 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).

6.2.3.2 Assessment Procedures Not Completed

No additional assessment procedures were identified for the Service Building.

6.2.4 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. Nineteen PFMs associated with eight different Triggering Mechanisms were determined to be "non-credible" for all Priority 2 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 6.2.4.1. The CPFMs carried forward for detailed assessment are discussed in Section 6.2.4.2.

The following analysis of selected data was conducted for the Service Building:

- Results of geophysical investigation by Geotechnology

  GPR investigations found numerous shallow anomalies in various locations throughout the FCS site. Some of these anomalies were investigated in association with KDI's #1, #2 and #3. Additional anomalies were investigated with probes as part of a ground truthing process. The results of which can be found in Attachment 6C.

  Seismic Refraction and Seismic ReMi tests performed around the outside perimeter of the power block as part of KDI #2 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.

6.2.4.1 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 2b – Loss of lateral support for pile foundation

Reasons for ruling out:

- Surface erosion was not observed near the Service Building at the time of the site observations.
- The area around the Service Building was inside the perimeter of the Aqua Dam and was therefore not subjected to conditions that could facilitate surface erosion. This area is also paved and would not be susceptible to surface erosion.

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:

- Distress to the structure that can be attributed to this Triggering Mechanism and associated CPFMs was not identified at the time of the site observations.
- The top-of-slab elevation is at 1007.5 ft, which is approximately 6 in. above the highest flood elevation. The differential height between the top of slab and the exterior grade surrounding the Service Building is at most 3.5 ft and thus could create minimal hydrostatic lateral loading on the structure.
- The structure was protected from floodwater by an Aqua Dam for the majority of the 2011 flood. The Service Building was subjected to floodwater when 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. The relative flood elevation during this time was at approximately 1006 ft, which is below the top-of-slab elevation and thus produced negligible hydrostatic lateral load on the structure.

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:

- The top-of-slab elevation is at 1007.5 ft, which is approximately 6 in. above the highest flood elevation. The differential height between the top of slab and the exterior grade surrounding the Service Building is at most 3.5 ft and thus could create minimal hydrodynamic lateral loading on the structure.
- The structure was protected from floodwater by an Aqua Dam for the majority of the 2011 flood. The Service Building was subjected to floodwater when 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. The relative flood elevation during this time was at approximately 1006 ft, which is below the top-of-slab elevation and thus produced negligible hydrodynamic lateral load on the structure.

Triggering Mechanism 6 – Buoyancy, Uplift Forces on Structures
CPFM 6a – Fail tension piles
CPFM 6b – Cracked slab, loss of structural support
CPFM 6c – Displaced structure/broken connections

Reason for ruling out:

- The top-of-slab elevation is at 1007.5 ft, which is above the highest flood elevation. Therefore, the Service Building was not subjected to conditions that could facilitate degradation related to buoyancy or uplift forces.

Triggering Mechanism 7 – Soil Collapse (first time wetting)
CPFM 7b – Displaced structure/broken connections
CPFM 7c – General site settlement
CPFM 7d – Pile buckling from down drag

Reasons for ruling out:

- Soil collapse due to first time wetting occurs immediately as soils are wetted. Degradation related to this Triggering Mechanism and associated CPFMs would have been apparent at the time of the site observations. Although voids were observed below the Service Building, these were noted to be hand dug for piping repair and removal by OPPD personnel and were too large to be caused by first time wetting.
- Voids found below the Service Building slab were not large enough to expose piling, and no signs of structural distress related to soil collapse were evident.
- The slab is designed as a structural slab and does not require soil support.

Triggering Mechanism 9 – Swelling of Expansive Soils

CPFM 9b – Displaced structure/broken connections
CPFM 9c – Fail tension piles
CPFM 9d – Additional lateral force on below-grade walls

Reason for ruling out:

- Degradation that could be attributed to swelling of expansive soils was not identified at the time of the site observations.

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

CPFM 11b – Displaced structure/broken connections
CPFM 11c – Additional lateral force on below-grade walls
CPFM 11d – Pile/pile group instability

Reason for ruling out:

- Degradation that could be attributed to static liquefaction or upward seepage was not identified at the time of the site observations.

6.2.4.2 Detailed Assessment of Credible Potential Failure Modes

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

Triggering Mechanism 3 – Subsurface Erosion/Piping

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

The Turbine Building, which is connected to the Service Building on its west, has a documented history of a void below the foundation slab dating back to 1997. This void was confirmed via cored holes in the foundation slabs and camera recordings of broken drain piping that lies under the floor slab. Conversations with OPPD personnel indicate that groundwater has been flowing at varying rates through these broken pipes into the sump from 1993 to the present day. The rate of flow into the sump is directly related to the hydraulic head of the groundwater. As the floodwater increased in elevation across the site, observed flow rates increased. The flow of groundwater into this drain piping system through the breaks in the pipes is KDI #1 discussed in Section 4. This drain pipe system was designed as a closed system; therefore, the pipes are not surrounded by appropriate filter systems to preclude the transportation of soils from the surrounding area under the slab. It is logical to assume that because the groundwater moves below the foundation and into the broken piping, some movement of the soil has occurred. If these voids were to continue under the Service Building in areas that could not have been observed through the manholes, they could become large enough to create a loss of lateral support for the piling.

The Triggering Mechanism and CPFM could then occur as follows: multiple potentially connected seepage paths could exist in the soil backfill at the site, including soil backfill in utility trenches, granular trench bedding, and building floor drains with open/broken joints. The paths could be exposed at some locations to the river floodwater and high groundwater. This network of seepage paths could be connected to the sump pit in the Turbine Building. The breaks in the piping have been documented for an extended period (dating back to at least 1993), thus creating a continuous head differential on the potential seepage path networks. Gradient has been sufficient to begin erosion of surrounding soil. The gradient during the 2011 flood was increased, which could have led to higher flows through the seepage path networks. The unfiltered seepage condition will continue until the breaks in the piping system are repaired, which means the potential for further erosion remains. Erosion could create large voids under the Turbine Building base slab and potentially under adjacent building foundations, including the Service Building. The potential damage includes loss of soil support around piles leading to pile buckling, decreased pile capacity, and foundation failure.

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 Service Building.

Adverse (Degradation/Direct Floodwater Impact More Likely)	Favorable (Degradation/Direct Floodwater Impact Less Likely)
A documented void exists under the foundation slab of the Turbine Building with a known hydraulic connection between groundwater elevation and flows into the building sump.	
The in-situ and fill material around the piling was not compacted to the requirements under the Class I structures (vibroflotation).	There have been no observed signs of structural distress in the floor slab under the current loading conditions.
	Survey data to date does not identify movement of the building.
Data Gaps: • None	

Conclusion

Significance

Potential for Degradation/Direct Floodwater Impact

Indicators for this CPFM have been observed in the Turbine Building, which is adjacent to the Service Building. The voids below the base slab in the Turbine Building are known to exist with heavy flows of water being pumped from the sump. Because the 2011 flood caused increased flow through the broken drain pipes, the potential that it caused further and more rapid degradation due to this CPFM is high. It is possible that these voids extend under the Service Building and current data suggest that a flow path may extend in the direction of the Service Building.

Implication

The occurrence of this CPFM on a large scale could negatively impact the capacity of the piling supporting the building. This could lead to excessive foundation movement and negatively impact the integrity or intended function of the Service Building. Therefore, the implication of the potential degradation for this CPFM is high.

Confidence

The extent of subsurface erosion and its potential impact on the building is not known due to the lack of data gathered on subsurface conditions in the Service Building. Because there is not enough information on the subsurface conditions at this time, and the pumping in the Turbine Building could have caused subsurface erosion, the confidence for this CPFM is low.

Summary

For CPFM 3b, as discussed, the potential for degradation is high due to the potential flow paths leading under the Service Building. This degradation could have caused enough erosion to impact the integrity or intended function of the structure. The combined consideration of the potential for degradation and the implications of that degradation to a structure of this type puts it in the "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/or inspections are necessary to draw a conclusion.

6.2.5 Results

The CPFM evaluated for the Service Building is 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**	CPFM 3b	
Potential for Failure **Not Significant**		

6.2.6 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 Service Building other than CPFM 3b had been ruled out prior to Revision 2, and because CPFM 3b will be ruled out when the physical modifications recommended for KDI #1 in Section 4.1 and 8.3 are implemented, no Triggering Mechanisms and their associated PFMs will remain credible for the Service Building. HDR has concluded that the geotechnical and structural impacts of the 2011 Missouri River flood will be mitigated by the implementation of the physical modifications recommended in this Assessment Report. Therefore, after the implementation of the recommended physical modifications, the potential for failure of this structure due to the flood will not be significant.