WYOMING STATE PENITENTIARY
Independent Peer Review Study

2900 South Higley Boulevard
Rawlins, Wyoming 82301

In-Progress Draft Report
June 30, 2017
WJE No. 2017.3123

Prepared for:
Members, Joint Appropriations Committee
State of Wyoming Legislature
200 West 24th Street, Rm 213
Cheyenne, Wyoming 82002

Prepared by:
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WJE ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

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EXECUTIVE SUMMARY

The Wyoming State Penitentiary (WSP) comprises multiple buildings, was constructed from 1998 to 2009, and has been subsequently affected by slab and foundation movements. The South Facility exhibits distress from uplift due to heave of the underlying clays and shallow claystone bedrock beneath this structure, while the CPF and K Unit/Support buildings have been affected by settlement of the deeper fill and settlement prone native soil materials beneath the eastern area of the site.

The penitentiary has been the subject of considerable investigation, testing, analysis, and monitoring by various engineering firms over the past decade. As part of our assignment, we have spent three days at the site and we have attempted to review all of the relevant work product generated by others that has been provided to us. Our specific charge has been to conduct an independent peer review and comment upon the Option 1 Remedial Plan proposed by Martin/Martin (M/M) in their Structural Engineering Reconnaissance Study and Conceptual Cost Estimate issued on September 14, 2016.

Based upon our review, we have reached the following conclusions:

- The extent and severity of the distress varies considerably throughout the WSP. There are certainly localized areas that are severely distressed, but there are many areas within the South Facility, the CPF, and the K Unit/Support Building that exhibit no significant distress.
- Where movements have occurred and collateral damage has developed, there appears to be a fairly strong correlation in most areas with poor water management (grading and drainage) issues associated with the original construction. Some of these issues have been corrected but there are numerous additional improperly graded and drained areas within and around the site that are still contributing to the wetting of the underlying soils.
- Contrary to one of M/M's conclusions, we believe that the South Facility has been affected by deep-seated heave affecting both the slabs and the drilled pier foundations.
- Concerns with the mud slabs installed beneath the grade beams in the South Facility are overstated. Similarly, concerns with the structural integrity of the original drilled piers are unwarranted.
- Unfortunately, elevation survey measurements, made by Coffey Engineering & Surveying (Coffey) from August 2013 through March 2015, were in large part a poorly executed and imprecise monitoring effort. That said, comparison of the August 2013 Coffey elevation measurements with those taken by WJE as part of our study suggest that significant portions of the South Facility have remained stable, or largely so, since 2013.
- M/M's geotechnical consultant provided predictions of potential additional movement that were understandably conservative and based upon worst-case scenarios. We believe that the magnitudes of likely additional movement are a fraction of those predicted potential movements, especially if the water management issues are promptly and fully addressed.
- The existing distress, distortion and other problems at the penitentiary can be repaired and effectively managed at costs far below the cost to rebuild the penitentiary or the cost to perform the

"universal" repairs recommended by M/M in Option 1; i.e., repairs to areas and building components not significantly affected by movements.

- While we do not endorse the Option 1 approach outlined by M/M, it is our opinion that their calculated cost of $87 million for Option 1 is substantially overestimated.

WJE is recommending, in lieu of M/M's Option 1, the following alternative remedial action plan:

1. Fully correct all of the surface grading and drainage deficiencies, including the enclosed courtyards, immediately.
2. Remove and replace only those doors and windows and other operational elements within the South Facility damaged by excessive movement or that are not fully operable.
3. Conduct masonry repairs at the limited locations where the distress is significant. Remove the temporary column in the corridor outside of the electrical room in Area F after installation of more appropriate, less conspicuous, and permanent repair.
4. In most areas the masonry damage (cracking) is minor and largely occurs in non-load bearing walls where it can be repaired by repointing or, in some cases, by the use of appropriate sealants. Existing joint sealants and backing rods should be removed and replaced in control joins affected by past movements at both interior and exterior wall surfaces. (Realize that properly selected and installed sealant materials cannot be expected to have the same service life as masonry components and will need to be inspected on a routine basis and repaired as needed.)
5. Perform localized slab-on-ground repairs or replacement in the South Facility at limited selected areas.
6. Perform targeted compaction grouting beneath portions of K Unit and Support Building.
7. Perform reliable and precise elevation surveys and complete condition assessments at six month intervals to define the nature and extent of any ongoing movements. These surveys should be repeated in the areas that have been surveyed in the past, and it may be prudent to include additional inmate housing dayrooms. Continue to monitor groundwater levels as well at quarterly intervals. The data from each of these surveys and assessments should be reviewed by a qualified engineer.
8. Except where deteriorated control joint sealants on exterior wall surfaces may affect the performance of the building envelope, all minor, non-structural, and cosmetic repairs, including much of the minor damage to non-load bearing masonry walls discussed above in Item 4, may be postponed until the recommended surveying and monitoring indicates no appreciable ongoing movements.
9. Establish realistic budgets for future maintenance and localized repairs.
10. The estimated cost of performing WJE's alternative Option 1 repairs is currently and conservatively estimated to be in the range of $8 to $18 million. We will provide a more precise estimate in our final report on July 13, 2017.

BACKGROUND

The Wyoming State Penitentiary, located in Rawlins, Wyoming, includes a North Facility and a South Facility. The North Facility opened in about 1980; however, due to safety concerns, the North Facility was abandoned following construction of the South Facility Housing Unit (SFHU) in 2001. The buildings currently associated with the complete South Facility, identified in Figure 1, now include the following:

- SFHU, hereinafter referred to as simply the South Facility; with the exception of Area A, this building was completed in September 2000, and Area A was completed in March 2001,
- Central Production Facility (CPF), reportedly completed and/or occupied in 2006,

- K Unit and the Support Building, reportedly completed and/or occupied in 2009,
- Industries Building, WJE does not have information regarding the completion and/or occupied date of this building.

It is our understanding that Groathouse Construction, Inc. (Groathouse) served as the General Contractor for both the South Facility and the CPF, and Sletten Construction Co. (Sletten) was the General Contractor for the K Unit/Support Building.

Portions of some of these buildings have been adversely affected by soil movements over the years since they were constructed, and some of the movements have caused both structural and non-structural damage in some areas. In December 2014 Martin/Martin (M/M) was retained by the State of Wyoming to conduct a comprehensive investigation to determine the cause of the damage and to make recommendations for repair and/or replacement of the affected structures. M/M's report, titled *Wyoming State Penitentiary - Rawlins, Wyoming - Structural Engineering Reconnaissance Study and Conceptual Cost Estimate*, dated September 14, 2016, was generally focused on the South Facility, i.e. Areas A through H, the CPF, and the K Unit/Support Building, and included the following four options for the repair and/or replacement of the facility.

- Option 1: Repair the South Facility, the CPF Building, and the K Unit Building
- Option 2: Repair the South Facility except for Housing Pods (Areas) A, B, and C; Repair the CPF and K Unit Buildings; Rebuilding Housing Pods (Areas) A, B, and C at another on-site or off-site location
- Option 3: Repair the CPF and K Unit Buildings; Rebuild the South Facility at another on-site or off-site location
- Option 4: Rebuild the entire Wyoming State Penitentiary at an off-site location.

WJE was subsequently retained by the State of Wyoming to conduct an independent peer review of the M/M study and cost estimate for Option 1 only. This report details the documents reviewed, our site visits, our analytical studies, and outlines our findings, opinions, and recommendations.

SCOPE

In accordance with the Request for Professional Services (0774) issued by the Wyoming Legislative Service Office (LSO), acting on behalf of the Wyoming State Legislature's Management council, WJE provided a Statement of Qualifications (Appendix A) to conduct an independent peer review of the *Structural Engineering Reconnaissance Study and Conceptual Cost Estimate* report prepared by M/M. A scope of services was outlined in document 0774 and included the following tasks, which were subsequently completed by WJE.

- An in-depth examination of the observations, investigations, testing programs, conclusions, recommendations, design considerations, and estimated costs to repair the South Facility, CPF, and K Unit Buildings as described in "Option 1" of the M/M report. This study was to include a review of all pertinent and available documentation, including existing geotechnical reports, associated with the M/M report. A review of documents pertaining to the design, construction and performance of the affected buildings. In general these documents included geotechnical studies and reports, the original architectural, structural, civil, and mechanical drawings, certain documents and other correspondence between the Owner/Engineer/Contractor during construction, and other documents produced over the years following completion of construction. A list of the most pertinent documents reviewed by WJE is included in Appendix B.

- Site visits as necessary and in conjunction with the LSO, or other designated agencies, firms or individuals, to investigate the structural condition of the South Facility, CPF and K Unit buildings. Representatives of WJE's investigative team visited the site on June 15, 22, and 23, 2017. These representatives included the following individuals with WJE: Mr. Andrew Jenkins, PE, Mr. Jerry Maly, PE, Mr. John Reins, PE, Mr. Peter Stauffer, PE, and Ms. Jennifer Volz, PE. Mr. Don Harrington with Sage Consulting Group, who has provided cost estimating services on this project, also visited the site on June 23, 2017.
- Develop a peer review opinion of "Option 1" related to the South Facility, CPF, and K Unit buildings as described in the *Structural Engineering Reconnaissance Study and Conceptual Cost Estimate*.
- Provide revised or alternate recommendations, design considerations, and cost estimates to repair the South Facility, CPF, and K Unit buildings, as determined necessary.
- Assist the LSO staff as requested.
- Prepare the results of the project and independent peer review study in a report or reports, and present the final report to the Legislative Committee(s) in Rawlins, Wyoming. A preliminary draft report was issued on June 30, 2017, and the final report was issued on July 13, 2017. We currently anticipate presenting the final report to the legislative committee(s) on July 18, 2017.

REVIEW OF PERTINENT DOCUMENTS

Terracon Reports

Geotechnical Engineering Report, Project No. 24965021, dated October 20, 1997

Neither a specific Terracon project number nor date was identified on the structural plans for the South Facility and the CPF. However, based on the basic soil design criteria provided, it appears that the recommendations in this Terracon report were utilized in the design and construction of the foundation systems and slab-on-ground floors for the South Facility and possibly for the CPF. Work completed for this study included drilling, sampling and laboratory testing of 23 borings for the administration and maintenance buildings, roadways, and for the South Facility. Borings 6 through 15 were drilled in the area currently occupied by the South Facility. The following citations were taken from this report:

- "**Field and Laboratory Test Results**...the on-site sand displays characteristic consolidation behavior upon wetting and loading. The slightly moist, less dense sands display moderate to high collapse potential when wetted and upon loading. The on-site clay and siltstone/claystone bedrock display moderate to high swell potential when wetted."
- "**Groundwater Conditions**...Groundwater was encountered at a depth of three and one-half (3½) feet below the surface in Boring 1... All remaining Borings were dry during the field investigation... These observations represent only current groundwater conditions, and may not be indicative of other times, or at other locations. Groundwater levels can be expected to fluctuate with varying seasonal and weather conditions."
- "**Conclusions and Recommendations**. Present site configuration and grades indicate that cuts and fills will be required to achieve final construction elevation in all the proposed buildings. Final grades will result in expansive bedrock and potential collapsible sands near foundation and slab elevation..., the potentially expansive bedrock and materials which collapse upon elevation in moisture content will require particular attention in the design and construction...Slab-on-grade construction is considered acceptable for use when subgrade soils consist of the on-site sands provided that design and construction recommendations are followed..."

- "**Foundation Systems - All Buildings**...a grade beam and drilled pier foundation system is recommended for support of the proposed structures. Straight shaft piers, drilled a minimum of six (6) feet into firm or harder bedrock, with a minimum shaft length of twenty-four (24) feet are recommended...Uplift forces on piers should be resisted by a combination of dead-load and skin friction...A minimum 6-inch void space should be provided beneath grade beams between piers...To provide increased resistance to potential uplift forces, the sides of each pier should be mechanically roughened in the bedrock bearing strata below a depth of seven (7) feet. This should be accomplished by a roughening tooth placed on the auger..."
- "**Floor Slab Design and Construction**. Due to the moderate expansive potential of the bedrock, differential movement of floor slab-on-grade may occur should the bedrock increase in moisture content. Use of floor systems supported structurally independent of the subgrade is a positive means of eliminating the potentially detrimental effects of floor movement. If the owner selects slab-on-grade construction and is willing to assume the risk of future slab movement and related structural damage, the following recommendations are applicable to all planned slab-on-grade construction." One of the seven recommendations for slab-on-grade construction stated the following:

  > "A four (4) foot zone of non-expansive soil should be placed under slab-on-grade construction. A minimum [2] inch void space should be constructed above or below non-bearing partition walls placed on the floor slabs when constructed within six (6) feet of the expansive bedrock stratum. Special framing details should be provided at door jambs and frames within partition walls to avoid potential distortion. Partition wall should be isolated from suspended ceilings."

- "**Drainage - Surface Drainage**...2. In areas where sidewalks or paving do not immediately adjoin the structures, we recommend that protective slopes be provided with a minimum grade of approximately ten (10) percent for at least 10 feet from perimeter walls...3. Gutters should be provided on all roofs, and downspouts, roof drains or scuppers should discharge into splash blocks or extensions at least ten (10) feet beyond the edges of excavations not protected by exterior slabs or paving..."

Geotechnical Engineering Report, Project No. 24045017, dated June 2, 2004

This Terracon project number and date are specifically referenced in the General Notes on Structural Drawing Sheet S1.0 for the K Unit and Support Building, it appears that this report was utilized by the structural engineer for the design of these structurers. However, a copy of this report was reportedly not available for our review.

Post Construction Geotechnical Engineering Report, dated January 11, 2013

This report documents 2 borings drilled in October 2012, one located in the northwest corner of the gymnasium and one at the west corner of the courtyard northwest of the gymnasium. The following citations were taken from this report:

- "**6.0 Conclusions.** The gain in moisture in the weathered bedrock is significant, and likely due from [sic] external sources such as precipitation, poor drainage, or broken utility lines. It is Terracon's opinion the piers and grade beams under the north and south gymnasium walls have heaved due to increased moisture introduction into the subsoils and swelling claystone. The north and south walls are in close proximity or directly adjacent to exterior grading, which is flat and exhibits poor or negative drainage. The subsoils at these locations are exposed to a higher potential to increased moisture content in the subsoils due to external conditions. The middle of the east and west walls, being farther away from the moisture source, are displaying relatively less movement, In similar fashion as described for the gymnasium walls, the corridor walls and slabs adjacent to the open

triangular area are also experiencing moisture intrusion due to flat grading, and poor drainage in this area.

"It is likely the heave in these portions of the building will continue at a slower rate. If the drainage is improved and the surrounding exterior areas hardscaped, it would be anticipated that additional heave of the foundation and slabs would diminish with time as the effects of eliminating the water intrusion source or sources is corrected. To date, it appears the movement has not rendered the walls or roof unstable."

- "**7.0 Remediation Recommendations.** Based on the information and data gathered for this study and the conclusions concerning the causes of foundation movement, we believe there are limited cost-effective options for addressing the movement issues of the foundation and slabs. Considering that most of the movement so far is nuisance-related and visually unsettling, no remedial action to stabilize the foundation or slabs is recommended. Repairing cracks and re-adjusting door frames may be necessary until the movement has substantially ceased. This should be confirmed by the structural engineer.

  "A baseline survey of pertinent foundation elements and slab elements in the corridor and gymnasium areas should be performed by a qualified surveyor. Subsequent surveys should be performed quarterly to determine what elements are moving and the rate of movement.

  "The exterior drainage in the open yard area, and the exterior drainage that perimeters the gymnasium should be re-graded to accommodate ta positive slope away from the perimeter walls and foundations. These areas should be re-constructed to receive a minimum 6-inch thick Portland cement concrete pavement (PCCP). This PCCP should be sloped a minimum of 3% away from the building. The concrete should be sealed adjacent to building walls. Additionally, control joints that are constructed in the PCCP to accommodate shrinkage should be sealed. An on-going crack-sealing maintenance program should be implemented to reduce runoff moisture from infiltrating the subgrade. The existing storm drains may need to be adjusted to accommodate a different pavement elevation.

  "Some of the slab-on-grade distress suggests a tripping hazard may develop if further movement occurs. After establishing relevant history of survey data and presuming the slab movement has slowed to an acceptable level, select slab-on-grade areas should be removed and replaced. A 2-foot subgrade over excavation should be performed..."

  "If movement continues to the point that Lower Co. P.C. deems the walls and roof unstable, or the space un-useable, then underpinning the foundation would likely be required. This would entail installing additional piers or piles in the gymnasium area significantly deeper than the present lengths, to ensure enough friction resistance to counteract the uplift on the piers due to the swelling claystone."

Groundwater Monitoring Study, dated December 6, 2013

This investigation included completion of 3 borings located east, west and south of the area encompassing the South Facility, and the CPF and K Unit/Support buildings. The following citations were taken from this report:

- "**2.1 Project Description.** The area under consideration for this groundwater study included the south facility of the Wyoming State Penitentiary...Terracon opines that the building movements are being caused by swelling soils due to an increase in pre-construction soil moisture contents. The increase in moisture content is a result of poor surface water drainage around the perimeter of the building. The purpose of this investigation is to evaluate other possible sources of moisture

migration that might be impacting the swelling soils. The borings were converted to piezometers after drilling for future groundwater monitoring events."

- "**3.4 Groundwater.** Groundwater was not encountered immediately after drilling, nor when checked after the piezometer installation. Future quarterly monitoring events will be performed by Wyoming Department of Corrections south facility maintenance personnel. This information will be reported to the remedial design team upon completion."
- "**4.0 Opinions and Conclusions; 4.1 Impact of Off-Site Utilities on Groundwater Migration**. Based on information from the subsurface exploration, initial groundwater measurements, and laboratory testing results, it is our initial opinion and conclusion the nearby subsurface utilities are not contributing to an increase in moisture content of the swelling soils under and adjacent to the buildings and slabs at the south facility. Additional groundwater measurements should be performed by DOC personnel on a quarterly basis to monitor future groundwater impact to the south facility infrastructure."

Site Visit Observations, DRAFT, dated March 17, 2015

A copy of this report is provided in Appendix C. The following citations were taken from this report:

- "In the south facility, there has been relative movement occurring in the floors and masonry walls, Indications of movement were observed during the 2012 site visit, and included cracks in masonry walls, displacements at construction (expansion) joints, and binding and/or racked doors. The movement is most pronounced at the north side of the gymnasium, but there has also been significant movement in Area A and along the Northwest Hall, as well as indications of movement elsewhere in the facility."
- "**Baseline and On-Going Survey Data.** A baseline survey of elevations in the South Facility was performed in August 2013. The survey has been repeated about quarterly through October 2014. Coffey surveyors were on site performing another of these surveys during our March 9 site visit...Our review of the survey data through October 2014 indicates that the surveyed elevation results have been somewhat erratic. However, the trends in the data suggest that relative vertical movements of up to1/2" may have occurred over the survey period, with the greatest relative movements being in the Gymnasium area."
- "**Recent Construction at South Facility**. In our January 11, 2013 Report, Terracon recommended that the exterior areas surrounding the corridors and gymnasium be re-graded with positive slopes and that they be hard-scaped with concrete...We were pleased to observe that the outdoor patio and the area immediately adjacent to the east side of the Gymnasium were hard-scaped in 2014. We understand that outdoor areas adjacent to Area A are scheduled to be hard-scaped this year. This hard-scaping program should appreciably reduce moisture infiltration into the subsurface near the portions of the facility that have had the greatest distress....We understand that underfloor utilities have been inspected for leakage and were found to be in good condition. Terracon constructed piezometers in a follow-up geotechnical investigation titled Groundwater Monitoring Study dated December 6, 2013. More piezometers have since been installed by others, and Terracon understands that standing water has been observed in some of the piezometers...We will be pleased to review the water level data as it becomes available."
- **Site Visit Observations**. This section of the report addressed some of the most notable distress that was present at that time, and included the following:

- Area F: northeast corner of the gymnasium and elsewhere in this room; mechanical (electrical) room (F116) west of the gymnasium and installation of a shoring column in the hallway adjacent to this room.
- Area A: Noticeable cracking in the window jamb at the northwest corner of the office (A164) immediately east of the Area A entrance hall; significant displacement in the small closet off the southwest corner of the Area A multi-purpose room (A180).
- Other Locations: Typical displacements in the CMU expansion (control) joints in the northwest hall and in the long east-west hall that passes by the north endo of the gymnasium; horizontal cracks in the hallway walls; vertical cracks in the west and north walls at the housing area at the east end of the east-west hall.
- CPF: In general, the distress is of a somewhat different nature and not as great as in the South Facility. The distress in this facility consists of cracking of concrete floor slabs, distress in joints in CMU walls, and some diagonal cracking across CMU blocks. The most significant distress is in an upper level mechanical room where a horizontal crack of about one-half inch width carries completely through a CMU block that is laid adjacent to a cast-in-place concrete wall...Some of the interior halls are tiled. There are cracks in the floor tiles on either side of some door openings. At an exterior door at the end of a hallway of the east end of the building, it appears that the floor on the right side of the interior of the door has settled somewhat compared to the floor at the left side of the door. A crack stair-steps through the floor tile joints and the door jamb appears to be racked at this location.

- "**Comments on Site Visit Observations - South Facility**. In general the relative displacement and distress that we observed during this site visit were of a similar nature to what we observed in our site visit during 2012, but the distress has increased due to continuing relative movements. At several locations the displacements have become more dramatic due to spalling of CMU blocks, and the opening of large and very visible cracks. As a result of the additional and on-going movement, a shoring column has been placed in the east-west hall just outside the mechanical room that is immediately west of the gymnasium...It is probable that the newly constructed and planned hard-scaping will minimize surface water infiltration so that over time the amount and rate of relative movement will decrease. With respect to how long the on-going movements will continue, we note that the claystone materials on which the facility is supported is very tight. That is, water moves through these materials very slowly. This is indicated by the fact that movements that [sic] are still continuing fourteen years after facility construction. As it has taken many years for the continuing distress to occur, it could be a number of years before the facility finally stabilizes...Based on our experience with remedial construction in similar facilities impacted by heave of swell potential subsurface materials, it is often cost effective to address specific portions of the structure where the data and observations indicate such repairs are needed. At this time, it is our opinion that if elements need to be underpinned, the underpinning should be planned for the affected locations only rather than for the facility as a whole...During a telephone conversation between our Mr. Attwooll and Mr. Bob Kiser of the State of Wyoming Department of Administration and Information at the conclusion of our March 9, 2015 site visit, Mr. Kiser asked if it were possible that the subsurface water could be coming from native areas uphill of the site and from other natural drainages...Mr. Attwooll expressed his opinion that it was more likely that the subsurface moisture is infiltrating within the area of the greater overall facility footprint. The construction of the overall facility creates many loosened and gravel covered surfaces which allow more of the typical nine inches of annual precipitation that occurs at the site to infiltrate than occurs on nearby native surfaces. The greater transpiration and evaporation from the native surfaces

minimizes deep penetration of water into the subsurface compared to the modified surfaces within the overall facility."

- "**Comments on Site Visit Observations - CPF Facility**. Based on our site visit observations, the causes of the distress observed at the CPF Facility are different than at the South Facility. Rather than being the result of heave of the swell potential subsurface materials, the distress appears to be primarily the result of settlement in the fill materials that underlie the facility...Based on our site observations, the main floor level at the north end of the facility...it appears that the floor slabs have locally settled about one-half inch and possibly up to about one inch relative to the footing [sic] supported walls and structural elements. The differential floor slab settlements are indicated by the cracks in the flooring tile at doorways...The floor slab cracks are a response to the differential settlement between the floors and walls and across the floor themselves. The wall separations at the elevated guard area are likely the result of floor slab settlement under the elevated guard area...There also appears to be some localized differential settlement under the footing [sic] supported structural elements. This displacements observed across CMU wall joints and the cracking through some of the CMU blocks appear to be the result of the response of the relatively rigid structure to the differential settlement. This is also indicated by the racking of some door frames, and the distress in the upper level mechanical room."

Original Drawings and Specifications

South Facility

This building is primarily a one story structure; however, in the prisoner housing areas mezzanines were constructed directly above the main level cells to accommodate a greater inmate population. This building features steel framed roofs and structural concrete mezzanine floors supported primarily by interior and exterior concrete masonry unit (CMU) bearing walls with isolated columns in some locations. The load bearing walls and columns are supported on concrete grade beams and drilled pier foundations. The main level floors are concrete slabs-on-ground that, in general, were isolated from the concrete grade beams and drilled pier foundations to allow differential vertical movements of the floor slabs with respect to the load bearing walls and foundations. However, non-load bearing CMU partition walls, supported directly on the slab-on-ground floors, were also provided in many areas throughout the building used primarily for offices, classrooms, restrooms, and the like; i.e. non-inmate housing areas. As such, these partitions, like the slabs that support them, were intended to be able to move up or down relative to the load bearing walls and foundations.

In general, it appeared that the foundations and ground-supported components were designed in general accordance with the Terracon recommendations; however, we identified a number of locations where the plans did not appear to comply with these recommendations, including the following: 1) Specifications for providing mechanically roughened piers were not included in the drawings and specifications reviewed by WJE. We have not reviewed any project addenda issued during construction by the designers and any requests for information (RFIs) that may have been issued by the contractor during construction, regarding this issue, nor do the Terracon drilled pier observation reports reviewed by WJE mention any such mechanical roughening. 2) The plans and details reviewed by WJE did not appear to have specified 2 in. separations between the top of all non-bearing masonry partitions and the above floor or roof in areas where the slab-on-ground floor was constructed within six ft of the expansive bedrock stratum, as recommended by Terracon. Similarly, the construction documents did not appear to have specified special framing details at door jamb and frames located in masonry partition walls supported by slab-on-ground floors so as to avoid or minimize potential distortion. 3) Supplemental Instructions/Information prepared by Plan One/Architects regarding RFI EH-01, indicated that 'skim slabs' having a thickness of 1½ in. could be

installed over the specified void forms, and below the grade beams between piers to facilitate installation of the grade beam forms, provided that these were later broken off fairly flush with the faces of the grade beams. However, as discussed by M/M, it appears that not only were these skim slabs (referred to as mud slabs by M/M) not removed, but they were found to be about 3 in. thick and to extend 3½ in. or more beyond the faces of the grade beams on one or both sides. 4) The Civil plans generally specified 2 percent slopes away from the building for exterior concrete/asphalt flatwork. With respect to exterior grades, these plans specified that all finished subgrades were to slope away from the building; however, specific grades were generally not indicated. Recall that Terracon recommended exterior slopes of 10 percent within 10 ft of the building.

CPF

With the exception of two relatively small mechanical mezzanines near the center of the building, the CPF is primarily a one story structure. This building features steel framed roofs and steel framed mezzanine floors, the latter with concrete slabs over metal deck, supported primarily by interior steel columns and exterior CMU bearing walls. The load bearing walls and columns are supported on concrete grade beams and drilled pier foundations. The main level floors are concrete slabs-on-ground that, in general, were isolated from the concrete grade beams and drilled pier foundations to allow differential vertical movements of the floor slabs with respect to the load bearing walls and foundations. The exterior face of the perimeter CMU walls feature an exterior insulated finish system (EIFS).

As with the South Facility, in general the civil plans fell short of specifying exterior grades/slopes away from the building that were in accordance with those recommended in the reports prepared by Terracon.

K Unit and Support Building

The K Housing Unit is a two story building that features a steel framed roof structure, and two levels of stacked six-sided precast concrete cell modules. Each cell module includes two housing units. At the main level, the precast cells are supported by concrete grade beams and drilled pier foundations along the front and back of the cells, and were installed over 6 in. void forms. The mezzanine level cells are supported directly on top of the main level cells, and include concrete slabs that cantilever 5 ft to create the mezzanine walkways. The cell modules at the exterior walls of the building were fabricated with insulation panels between inner and outer wythes of concrete. The main level floors outside of the cells are concrete slabs-on-ground, isolated from the cell walls and the exterior walls; however, these slabs-on-ground were continuous over the interior corridor grade beams.

The Support Building is a pre-engineered metal structure with steel frames that span the width of the building, with support provided by concrete grade beams and drilled pier foundations along the long sides. The floor is a concrete slab-on-ground, isolated from the perimeter grade beams. At the interior of the building, there are numerous non-bearing partition walls, featuring either CMU or metal studs with gypsum board, supported directly on the floor slab.

As with the South Facility, in general the civil plans for these buildings fell short of specifying exterior grades/slopes away from the building that were in accordance with those recommended in the reports prepared by Terracon.

Monitoring, Surveying, and Inspection Records and Data

Crack Monitoring Gauges and Photographic Records

Four crack monitoring gauges, identified as Nos. 1, 2, 3, and 4, were installed in Area F of the South Facility by M/M in August 2015. Three of these gauges were installed over existing cracks in Electrical Room F117, with No. 1 located about midway along the east wall, No. 2 was located at the northwest corner, and

No. 3 was located at the northeast corner. Copies of photographs taken by others at the time of the initial installation of these cracks are provided in Figures 2A, 3A, and 4A, respectively. Finally, Gauge No. 4 was located over a crack in the east wall of the Gymnasium F125, adjacent to the northeast corner. A copy of a photograph of this gauge taken by others at the time of its installation is provided in Figure 5A.

WJE took photographs of these same four gauges during our site visits on June 15 and 22, 2017. Our photographs of gauge Nos. 1 through 4 are provided in Figures 2B through 5B, respectively, so that differences in the position of the gauges, indicating movements of these cracks over this twenty-two month period can be identified.

Lower Elevation Surveys

Lower conducted relative elevation surveys of the Gymnasium, Room F125, walls of the South Facility in December 2011 and in July 2012. In their letter dated December 23, 2011, Lower indicated that it appeared that the grade beams supporting the west and east gymnasium walls, as well as the gymnasium floor along its west and east edges, had displaced downward as much as 1½ in. and 1 in., respectively, at the center. Similarly, Lower stated that the Gymnasium floor slab had also settled. Finally, Lower also stated that, based on reports from staff members who have been at the facility since the building was completed, these movements have been progressing slowly since that time.

Lower's letter dated August 9, 2012 reported that additional settlement had occurred in the west gymnasium wall since December 2011, such that the total vertical displacement was 1⅜ in. at that time; however, Lower also reported that additional movements had not occurred in the east, north, and south walls of the gymnasium over this period of time. In addition, measurements by Lower indicated that certain walls along the corridor south of Area C had moved vertically upward as much as about 1½ to 1¾ in., and that a window in Room C164 had fractured. Copies of this Lower documentation is included in Appendix D.

Coffey Elevation Surveys

Based on recommendations made by Terracon in their report dated January 2013, Coffey conducted a baseline elevation survey of certain foundation elements and slabs-on-ground in the South Facility in August 2013. These elevation surveys included: 1) the perimeter walls and floor slab in Gymnasium F125, 2) the full length of the walls in the primary corridor that extends from the west exterior walls at Areas A and B to the sally port in Area D, 3) the full length of the walls in the primary north-south corridor that extends from the sally port in Area D to the corridor immediately adjacent to the Control Room in Area G, 4) the walls in the east-west corridor that runs along the north side of the gymnasium, and 5) the floors in the office, storage, multi-purpose rooms in Area A. The survey points were measured with a combination of a Trimble VX Series Robotic total station and a conventional surveyor's level, with the total station used predominately in hallways and the gymnasium. According to the legend on Sheet 2 of 2, dated December 30, 2013, wall elevations were "calculated to top of 2nd block above floor from measured point." A fire hydrant located on the south side of the A-Unit was used as the benchmark for the six surveys. Coffey then conducted five follow up surveys of these same areas at intervals of approximately three to five months, conducting their final survey in March 2015. A plan view of their survey points is included in Appendix E.

In their Draft report dated March 17, 2015, Terracon stated the following with respect to the Coffey elevation survey data: *"...Our review of the survey data through October 2014 indicates that the surveyed elevation results have been somewhat erratic. However, the trends in the data suggest that relative vertical movements of up to 1/2" may have occurred over the survey period, with the greatest relative movements being in the Gymnasium area."* On page 5 of the same report, Terracon stated the following: *"We understand that the surveyor, Coffey Engineers, is aware of the erratic elevation data in the previous surveys. We understand that they were making special efforts to assure that the elevations on the current*

survey will be internally consistent. If, after these efforts, it the elevation data [sic] continue to be erratic, it may be because the benchmarks are not stable but are also subject to relative movement. If that is the case, we recommend that stable benchmarks be established at locations not immediately adjacent to the Facility. Stable benchmarks are typically established by drilling a boring to about forty foot depth, placing a continuous reinforcing bar within the boring, and backfilling with concrete grout. We can provide details for stable benchmarks if needed and requested."

In email correspondence from John Lund to Bob Kiser, dated March 2, 2015, Mr. John Lund with M/M stated the following regarding the protocol for the Coffey elevation surveys: *"1) It appears that Coffey did not close the loops on all their surveys. This is an important aspect of providing control to the surveys. I recommend that all surveys from now on have the loops closed to ensure this level of control. 2) Coffey is using a total station for the survey. This is probably okay given the restrictions of the penitentiary environment, but I would prefer an optical level be used with measurements taken to the nearest 1/1000th of a foot...Alternatively, a total station can continue to be used, but take readings to the nearest thousandth of a foot, if possible. 3) I am still concerned about the reliability of the benchmarks. I suggest we install at least three deep benchmarks (maybe four) at approximately equal distances around the facility (90 degrees or 120 degrees apart). I would use 4½" micropiles...Doug Jobe should review and approve the final micropile installation specifications."*

Storm and Sanitary Sewer Inspections

Based on discussions with Mr. Terry Keys, Facilities Manager for the Wyoming Department of Corrections (WDOC), it is our understanding that all of the underground storm and sanitary sewer lines at the South Facility were inspected via video camera by personnel with the WDOC in 2014. (WJE was provided with copies of annotated plans indicating the specific pipes that were inspected.) Mr. Keys reported that no leaks or other serviceability issues with any of these sewer lines were found during their investigations.

Pressurized water lines were not tested at any of the buildings. However, Mr. Keys reported that City of Rawlins domestic water records for the WSP were retrieved and reviewed, and no anomalies in water use were identified.

Summary of Reported Damage History, and Past and On-Going Repairs

Problems with doors and windows, many door adjustments and window replacements

NE corner of gymnasium - in progress

Wall cracking in general and numerous cracks and separations in CMU walls and partitions, especially at control joints and where non-bearing walls supported directly on the slab-on-ground floors intersect with other non-bearing walls or bearing walls control joints in structurally supported walls

Caulking corners and other cracks in non-bearing CMU partition walls

Temporary shoring column outside of electrical room F116, leaning north wall, problem at south wall, dislodged fireproofing

Courtyard conversions from exposed earth to concrete SOG with storm drains

CMU face shell collapse at wall in room A164, Area A

Slab heave in corridor intersection

M/M Structural Engineering Reconnaissance Study and Conceptual Cost Estimate

M/M Findings

Under M/M's direction, numerous observation pits were excavated adjacent to the foundation grades beams at various locations around the facility. Based on their observations at these pits, mud slabs were noted at the grade beams associated with the South Facility and the CPF, but were not observed at the K Unit/Support Building. As discussed previously, these mud slabs were constructed on top of the void forms, between drilled piers, were about 3 in. thick, and extended about 3½ in. or more beyond the faces of the grade beams on one or both sides. Because the void forms beneath the mud slabs were only as wide as the grade beams themselves, M/M expressed concerned that expansive soils beneath the outer edges of the mud slabs could exert upward pressures on the grade beams, potentially lifting both the grade beams themselves and the drilled piers.

With respect to the void forms, M/M stated only that the void form in one excavation location at the K Unit building was found to be collapsed over about half of the particular grade beam's span; they also indicated that they observed locations where concrete overpour or seepage from the forms of the concrete grade beam was noted. With respect to the collapsed void, they indicated that the void form collapse was the result of original construction activities, in which wet concrete caused the void to fail, and then completely filled the void. Because M/M's report did not include observations of the general condition of the void forms discovered throughout the WSP facility, WJE contacted Mr. John Lund, PE who informed us of the following typical conditions. Six (6) in. tall void form was observed at all excavations. Nowhere in any of their excavations at the South Facility did they identify any locations where the height of the void was compromised, reduced, or filled in any significant way to something less than 6 in. by swelling soils. Similarly, Mr. Lund indicated that at the CPF and K Unit/Support Building, the originally installed 6 in. tall voids were still 6 in. tall.

M/M stated that nowhere did they observe structurally significant cracking of the concrete grade beams or separations of the drilled piers from the grade beams and walls. As such, they indicated that most of the damage observed in the buildings was the result of slab-on-ground movement rather than foundation movement alone. They went on to state that foundation movement undoubtedly caused some of the damage at the facility, and will continue to do so, but does not appear to be the most significant cause of the damage.

Olson Testing

M/M retained the services of Olson Engineering (Olson) in June 2015 to assess the length and integrity of fifteen (15) drilled pier shafts supporting various buildings throughout the WSP using Sonic Echo/Impulse Response (SE/IR) testing techniques. This testing was documented in a report addressed to M/M dated June 22, 2015, and was subsequently included in the M/M report. The piers that were selected for testing were located at pits that were excavated by M/M to examine other aspects of the foundation construction, discussed above. As reported by M/M, Olson found that 13 of the 15 piers tested appeared to have lengths equal to or greater than the anticipated minimum length of 21 ft from top to bottom, or from top to a potential crack or other irregularity along the length of the shaft. Testing on the other two piers indicated apparent lengths of 13.6 ft for the pier identified as at Location 6 at Courtyard B/C, and 19.5 ft for the pier located at Location 12 at the CPF Boiler House. M/M stated that the pier at Location 6, having an apparent length of only 13.6 ft, was of particular concern. M/M also stated that these lengths less than 21 ft may be a result of improper installation, i.e. the piers were simply installed too short, or a result of a break or crack in the piers at the lengths indicated by the testing.

In June 2017, Olson conducted additional SE/IR testing on three drilled piers that were exposed in the vicinity of the northeast corner of the gymnasium as part of other structural repair work being performed in this area. This testing is documented in a report prepared by Olson and issued to M/M on June 20, 2017.

One of the three piers was located directly at the northeast corner of the gymnasium, and was one of the fifteen piers previously tested in 2015. During the 2015 testing, Olson reported an apparent length of 28.8 ft for this corner pier, at Location 4; however, Olson's report for the recent testing indicated an apparent length of only 25.3 ft for this same pier.

CTL/Thompson Studies

CTL/Thompson, Inc. (CTL) drilled two borings on July 22, 2014. One of the borings is located west of the South Facility and the other is in the courtyard southeast of the gymnasium. These borings were included in the documents provided for our review, but do not appear to have been issued in a geotechnical report.

Recently, CTL/Thompson (CTL) completed a geotechnical investigation at the South Facility, and the CPF and K Unit/Support buildings, as documented in their report titled *Geotechnical Consultation, Building Movement, Wyoming State Penitentiary*, Project No. DN47,925-149, dated December 18, 2015 (a copy of which was included in the M/M report). This investigation included drilling, sampling and laboratory testing of 9 borings, five at and around the South Facility, and four at and around the CPF and K Unit/Support buildings. Laboratory testing of samples included soil suction measurements.

JMB Cost Estimate

M/M retained the services of JMB Consulting Group (JMB) to prepare a cost estimate for M/M Options 1 through 4, a copy of which was included in the M/M report. JMB's total cost estimate for the M/M proposed repairs for Option 1 is $87,232,454.

WJE FIELD INVESTIGATION

South Facility

Interior Observations

Area A

WJE entered Dayroom/Cell Pods A1 and A2, and walked the floors at both levels; however we did not enter any individual cells. We also entered and observed a large majority of the relatively small, individual offices, storage rooms, multi-purpose rooms, etc. throughout Area A.

In general the slab-on-ground floors were in good condition. There was some floor cracking and evidence of modest heave in the Dayroom/Cell Pods. This was most apparent were there was evidence that the slab surface had been ground down slightly at doors (Figure 6), along cracks parallel to the front walls of the cells and located at about the edge of the mezzanine floor above (Figure 7), and at the interior floor slab adjacent to the courtyard (Figure 8).

The masonry in the Dayroom/Cell Pods was generally in good condition, with some modest cracks at wall intersections. Numerous cracks were observed in the office areas where non-bearing masonry walls intersect with other bearing or non-bearing masonry walls or columns. The most significant masonry damage was observed in Room A164 where the face shells of four stacked masonry units, adjacent to a window jamb, were dislodged in the bearing wall along the corridor at the intersection with a non-bearing wall (Figures 9A and 9B). A portion of the floor slab was removed in this area, and a soil boring had been taken, with the bore hole subsequently converted to a piezometer. The most significant masonry separation was observed in Room A180, a triangular storage room that exhibited a ± 1 in. wide gap at what appeared to be a control joint at the intersection of a non-bearing and bearing masonry walls (Figures 10A and 10B). Distress was also observed in the floor slab and masonry at the entrance to Corridor A181, immediately adjacent to Room A164. Failure of masonry wall control joint sealant was noted in some locations.

Some doors were racked, and others exhibited modest offsets at the latching plates. Some windows were shattered.

Locations of masonry distress in Area A are identified in Appendix F, Exhibit F-1.

Area B

WJE entered Dayroom/Cell Pods B1 and B2, and walked the floors at both levels; however, we entered only a single individual cell. We also entered and observed a majority of the relatively small, individual offices, storage rooms, multi-purpose rooms, etc. throughout Area B.

In general the slabs-on-ground floors were in good condition, with limited cracking. There was some evidence of modest floor heave in the Dayroom/Cell Pods. This was most apparent along cracks parallel to the front walls of the cells and located at about the edge of the mezzanine floor above, and at the interior floor slab adjacent to courtyard associated with Pod B2 (Figure 11).

The masonry in the Dayroom/Cell Pods was generally in good condition, with some modest cracks at wall intersections. Numerous cracks were observed in the office areas where non-bearing masonry walls intersect with other bearing or non-bearing masonry walls or columns. The most significant masonry crack was observed in a bearing wall in Room B171 where a non-bearing partition intersects this wall (Figures 12A and 12B). Failure of the masonry wall control joint sealant was noted in some locations, especially in the southwest corner of the courtyard associated with Pod B1 (Figure 13).

In the Pod B rotunda adjacent to Control Room B159, a weld was broken and a steel plate modestly buckled (Figure 14). Some doors were racked, and others exhibited modest offsets at the latching plates. Some windows were shattered (Figure 15).

Locations of masonry distress in Area B are identified in Appendix F, Exhibit F-2.

Area C

WJE entered Dayroom/Cell Pods C1 and C2, and walked the floors at both levels; however we did not enter any individual cells. We also entered and observed a large majority of the relatively small, individual offices, storage rooms, multi-purpose rooms, etc. throughout Area C.

In general the slab-on-ground floors were in good condition. However, there was some floor cracking and evidence of modest heave in the Dayroom/Cell Pods. This was most apparent were there was evidence that the slab surface had been ground down slightly at cell doors, along cracks parallel to the front walls of the cells and located at about the edge of the mezzanine floor above.

The masonry in the Dayroom/Cell Pods was generally in good condition, with some modest cracks at wall intersections. Numerous cracks were observed in the office areas where non-bearing masonry walls intersect with other bearing or non-bearing masonry walls or columns. Some of the most significant masonry damage was observed above Door C167A, along Corridor D151 where the door was racked and the masonry at the adjacent control joint was displaced and cracked (Figure 16); inside Vestibule C167 (adjacent to Door C167A) where a crack was observed in a non-bearing partition at its intersection with the bearing wall along Corridor D151 (Figures 17A and 17B); and in Room C161 where a crack was observed in a non-bearing partition at its intersection with the bearing wall adjacent to the courtyard associated with Pod C1 (Figure 18). Failure of masonry wall control joint sealant was noted in some locations.

Some doors were racked, and others exhibited modest offsets at the latching plates. Some windows were shattered.

Locations of masonry distress in Area C are identified in Appendix F, Exhibit F-3.

Area D

WJE entered and observed the vast majority of the relatively small, individual offices, storage rooms, multi-purpose rooms, etc. throughout Area D. There are no inmate housing areas in Area D.

In general the slab-on-ground floors appeared to be in good condition; however, it is apparent that the floor slabs in this area have exhibited some heave. This is because a majority of the masonry walls are non-bearing partitions supported directly on the slab-on-ground floor, and, as such, there is a significant amount of cracking and other distress where non-bearing partitions intersect with either other non-bearing partitions or with bearing walls. Typical examples of the distress are shown in Figure 19 and Figure 20. Cracking was noted in the floor tile over the concrete slab in Waiting Area D108 (Figure 21).

Some doors were racked, and others exhibited modest offsets at the latching plates. Door frame D151 in Corridor D151 exhibits slight buckling where the jamb meets the header at the center of the frame (Figures 22A and 22B).

Locations of masonry distress in Area D are identified in Appendix F, Exhibit F-4.

Area E

WJE entered Dayroom/Cell Pods E1, E2 and E3, and walked the floors at both levels; however we entered only a single individual cell. We also entered and observed a large majority of the relatively small, individual offices, storage rooms, multi-purpose rooms, etc. throughout Area E.

In general the slab-on-ground floors were in good condition. There was some floor cracking and evidence of modest heave in the Dayroom/Cell Pods.

The masonry in the Dayroom/Cell Pods was generally in good condition, with some modest cracks at wall intersections. Numerous cracks were observed in the office areas where non-bearing masonry walls intersect with other bearing or non-bearing masonry walls or columns. Failure of masonry wall control joint sealant was noted in some locations.

Some doors were racked, and others exhibited modest offsets at the latching plates.

Locations of masonry distress in Area E are identified in Appendix F, Exhibit F-5.

Area F

WJE entered and observed the vast majority of the rooms throughout Area D that includes the gymnasium, various mechanical and receiving rooms, and smaller rooms associated with the kitchen, gymnasium offices, and the electrical room. There are no inmate housing areas in Area F.

In general the slab-on-ground floors appeared to be in good condition; however, it is apparent that the floor slabs, as well as some of the bearing walls in the gymnasium and electrical room in this area have exhibited some heave. As previously discussed, three crack gauges were installed in the electrical room and one in the gymnasium by M/M in August 2015. Photographs were also taken by WJE of these same gauges during our recent site visits. Comparisons of these gauges are shown in Figures 2A and 2B through 5A and 5B. Other cracks in the gymnasium and in the corridor immediately outside the Electrical Room F116 were also photographed previously by others and by WJE during our recent site visits. Comparisons of some of these gymnasium cracks are provided in Figures 23A and 23B through 28A and 28B, and a comparison of masonry distress adjacent to a temporary shoring column outside of Electrical Room F116 is provided in Figures 29A and 29B.

Locations of masonry distress in Area F are identified in Appendix F, Exhibit F-6.

Area G-H

WJE entered Dayroom/Cell Pods G1 and G2, and walked the floors at both levels; however we did not enter any individual cells. We also entered about a dozen of the relatively small, individual offices, storage rooms, multi-purpose rooms, etc. throughout Area G. However, we did not enter either of the two Dayroom/Cell Pods, which essentially make up the entirety of Area H.

The slab-on-ground floors and masonry walls were in good condition in the Area G Dayroom/Cell Pods. However, like Areas A, B, C, and D, there were a fair number of cracks in the office areas where non-bearing masonry walls intersect with other bearing or non-bearing masonry walls or columns.

Locations of masonry distress in Area G-H are identified in Appendix F, Exhibit F-7.

Exterior Observations and Surveys

On June 23, 2017, WJE also performed a limited relative elevation survey of the F Courtyard slab-on-ground to determine if the slab had adequate slope to the two interior drains. The Hixon 32X Auto Level and telescoping rod were again used.

We understand that the Area A courtyard (identified on the plans as an Outdoor Recreation Area) was resurfaced between October 2014 and March 2015; therefore, we did not measure elevations in this area.

Surface grading around this building was typically very poor; i.e., grades immediately adjacent to the building were flat and did not provide positive drainage away from the exterior grade beams.

The entrance to the South Facility features split face CMU, while the remainder of the perimeter CMU walls are clad with EIFS. In general, the EIFS was in good condition. However, water staining was noted below first floor windows, around lighting fixtures, and at overflow scuppers (Figure 30). In addition, minor cracking was observed at window corners (Figure 31) and reentrant corners. A series of three vertical cracks was also observed on the northwest elevation of Area B (Figure 32). Joint sealants were present around windows and in vertical control joints. Much of the sealant appeared to be reaching the end of its service life or had been poorly installed. As a result, the joint sealants have failed in either adhesion or cohesion (Figures 33 and 34).

It was also observed that concrete slabs-on-ground had been constructed at egress doors. In many locations, these slabs have either been damaged or removed and replaced with gravel. It is our understanding that these slabs had moved upward relative to the door threshold, which did not allow the doors to open outward. Therefore, portions of the slabs were chipped away to allow the doors to operate properly (Figures 35 and 36).

Interior Elevation Surveys

On June 22 and 23, 2017, WJE performed a relative elevation survey of the interior of the South Facility using a Hixon 32X Auto Level. The purposes of the survey were: 1) to determine the reliability of Coffey's measurements; 2) determine if movement has occurred since March 2015; and 3) to estimate the nature, magnitude, and extent of any ongoing movement.

Unlike Coffey's surveys, WJE's survey was not tied to a benchmark. However, WJE was able to locate and perform measurements at Control Points 20 and 21, which had been etched into the concrete slabs with an "X." Additionally, where possible, measurements were taken at survey points previously established by Coffey. In hallways, the locations of Coffey's survey points were typically marked on the walls with a black permanent marker and were readily apparent. The locations of Coffey's points in the Gymnasium, Hobby Room (i.e. Cardio Room), the Kitchen Hallway, and within Unit A were not typically marked; therefore, in these areas, WJE used landmarks (e.g. doorways, windows, and turns in the walls) to estimate the

locations of the survey points. This was most difficult in the Gymnasium due to its large size and lack of consistently spaced landmarks within the field of the floor. Floor slab elevations were measured to the thousandths of a foot with a telescoping aluminum rod. Wall elevations were measured to the nearest sixteenth of an inch using a folding ruler.

It was unclear to WJE where Coffey measured the elevations at walls. Therefore, WJE recorded measurements on the floor and on the walls at the top of the sixth CMU above the slab. Typically, these measurements were taken at every other Coffey survey point location.

Finally, due to construction barricades in the hallways adjacent to the northeast corner of the gymnasium, WJE was unable to directly tie the survey points in the northern portion of the east hall and the eastern portion of the hall north of the gymnasium to the remainder of the survey.

CPF AND K Unit/Support Building

Interior Observations

Laundry

In general, the floor slab was in very good condition. The most pronounced distress was minor settlement and vertical offsets across a slab crack near the door in the southwest corner of this large room. No significant distress was noted in any of the perimeter bearing walls.

Office/Vestibule/Break Room

There was minor slab distress in the handicap ramp leading up to the office and miscellaneous cracking distress in certain CMU partition walls. A small portion of the slab in the vestibule had been removed and replaced, ostensibly to repair a sewer line break.

Covered Loading Docks

There were indications of minor foundation movement that has produced some diagonal cracking distress in the CMU block walls between the overhead doors and cracks in the ceiling adjacent to these walls. The personnel door exiting the building was racked.

Kitchen

Given the usage and heavy traffic within this space, the slab was in good condition. We noted signs of some slab settlement and cracking as well as ceiling cracks and minor distress in certain half-height CMU divider walls in the food prep area. It was apparent that considerable volumes of water are introduced onto the floor slab on a regular basis as a result of food preparation efforts, dishwashing, and daily "hose down" clean-ups. This underscored the importance of maintaining good underslab drain systems that do not leak and to maintain reasonable levels of water tightness in the control joints provided in the slab.

Ramp from CPF to K Unit

Minor slab settlement and cracks in the CMU walls were noted along this ramp.

Main Hallway to and through K Unit

There were persistent signs of slab settlement and lateral gaps developing between the hallway slab and the CMU walls along each side of the hallway. The vinyl composition tile along the edges of the slab had been replaced, apparently as a consequence of these differential movements.

K-1 Cell Block

Minor slab settlement and crowned floors were noted in this area. The door to the computer/exercise room was beginning to rub against the floor slab. Minor distress had developed in the showers and common rooms on the mezzanine level.

K-2 Cell Block
There was widespread evidence of moderate slab movement and cracking throughout this space. The uneven profile of the slab has resulted in certain cell doors rubbing against the floor. In addition, there were issues with differential movements affecting the precast cell units; e.g. racking doors, separations at joints, cracking distress.

Gymnasium
The slab in this open area was in very good condition with no significant offsets between the slab and the perimeter foundations.

Industries Building (Shop)
The slab in this open space was in good condition but with some indications of significant differential settlement relative to the perimeter foundations.

Hallway between Gym and Shop
At the far eastern end of the hallway, localized settlement had produced slab distress and distortion of the frame around the personnel door exiting the building.

Mechanical Rooms above Hallway
CMU cracks documented by previous investigators appeared to be unchanged. See Figure 37. These cracks are a pronounced but structurally insignificant consequence of differential movements that were not properly accommodated due to the lack of slip/soft joints in the original design and construction.

Exterior Observations

Sitework
There were a number of locations where the concrete flatwork surrounding CPF and K Unit/Support Building had settled and cracked, producing vertical offsets and potential trip hazards. Surface grading around these buildings was typically very poor; i.e., grades immediately adjacent to the buildings often sloped toward the foundation. Downspouts typically discharged directly next to the building and, where splashblocks were provided, they were not positioned to effectively direct water well away from the buildings.

Exterior Walls
For reasons that were not apparent, a number of the vertical control joints in the exterior EIFS panels did not extend for the full height of the wall. However, these discontinuities have not produced any significant consequences and the sealant joints in the EIFS walls were typically in fair condition. Vertical joints between precast panels on the east face of K-2 exhibited signs of movement and/or both cohesive and adhesive failures in the sealant. Some cracks ranging from minor to moderate had developed in certain CMU walls at and around the Support Building.

Interior Elevation Surveys

On June 23, 2017, WJE performed a relative elevation survey of portions of the interior of the CPF and K Unit/Support buildings, using a Hixon 32X Auto Level. The purpose of this survey was to determine the out-of-levelness of the slabs for comparison with the areas of known distress and to determine the elevation differential between exposed grade beams and slabs-on-ground.

We understand that the interior slabs-on-ground have recently been surveyed by another firm; however, the locations of the survey points and their respective elevations have not been provided to WJE. Nonetheless, WJE was able to locate approximately sixteen control points established by the prior surveyor who etched "Xs" into the concrete slabs at certain locations. Most of these control points were also outlined in blue tape (Figure 38). WJE recorded over 100 slab elevations in the laundry room, hall between the laundry and

kitchen, hall in the K Unit, Area K-2, the gymnasium, and the print shop. In addition to measuring the elevations of the slabs-on-ground, where possible WJE also measured the relative elevations at the known control points and, within the gymnasium and print shop, elevations were recorded on the tops of exposed grade beams adjacent to slab measurements to determine the vertical offsets, if any.

Floor slab elevations were measured to the thousandths of a foot with a telescoping aluminum rod. In a few locations, wall elevations were measured to the nearest sixteenth of an inch using a folding ruler at the top of the sixth CMU block above the floor slab.

WJE FINDINGS AND DISCUSSION

M/M and Olson Findings

Given that M/M did not observe any significant cracking of the grade beams or separation of the drilled piers from the grade beams, and given the conditions reported to us by M/M, where the original 6 in. voids have remained intact, without being compromised, filled, or exhausted in any meaningful way by swelling soils, we believe that the heave affecting the South Facility is deep-seated; i.e. the swelling is occurring at sufficient depths that the slabs-on-ground and the piers are being lifted together and somewhat uniformly. As such, while we agree with M/M that the mud slabs should certainly have been removed during construction, there is no compelling need for them to be removed at this time.

We have reviewed only a small portion of the drilled pier installation observation reports prepared by Terracon during construction. However, in all cases.....

Geotechnical Information

Subsurface information collected as part of the geotechnical investigations identified above is summarized on Table G-1 in Appendix G. Soil and bedrock materials at the South Facility and CPF and K Unit/Support buildings exhibit both swell and compression when wetted at overburden stresses in the laboratory. The laboratory test results summarized in Table 1 also indicate that moisture contents have increased since construction. The average pre-construction moisture content profile in the South Facility area (Terracon, October 20, 1997) is plotted along with post-construction moisture contents from recent borings completed at the South Facility on Exhibit G-1 in Appendix G, and for the CPF and K Unit/Support buildings on Exhibit G-2. These plots clearly show that the moisture contents of subsurface soil and bedrock materials have increased since construction. Plots of percent saturation versus depth provided on Exhibits G-3 and G-4 indicate increased saturation consistent with the increased moisture contents. This wetting has caused some ground heave and settlement, with resulting areas of distress observed at the buildings as described in this report.

Consolidation/swell tests completed for the recent CTL investigation indicate the following volume change characteristics when existing subsurface materials are wetted: fill materials exhibited very low swell to very low compression; native sand and clay soils exhibited low swell to low to moderate compression; claystone bedrock exhibited moderate to very high swell potential; and the sandstone bedrock was non-expansive. Based on these results, there is the potential for additional heave to occur at the South Facility and the potential for additional settlement to occur at CPF and K Unit/Support buildings if additional subsurface wetting occurs.

We performed independent heave/settlement computations using the CTL consolidation/swell test results, as presented on Tables G-2 and G-3 in Appendix G. These calculations assume additional wetting will occur to a depth of 20 feet. The results are summarized as follows:

- The western subsurface profile, typified by relatively shallow claystone bedrock at about 13 feet depth and shallower to the west and north (CTL borings TH-6, TH-7 and TH-5), exhibits future

heave potential of 1.6 inches at TH-6 located at the northeast corner of the gymnasium, 3.4 inches at TH-7 located in the western portion of the South Facility, and 8.5 inches at TH-5 located outside and to the north of the South Facility. These calculated heave potentials vary from CTL's estimates to a modest degree.

- The eastern subsurface profile, typified by top of bedrock depths greater than approximately 15 feet, becoming deeper to the east (CTL borings TH-1, TH-2, TH-3, TH-4, TH-8 and TH-9), exhibits minor settlement potential ranging from essentially no settlement to 0.9 inches of settlement. These calculated settlement potentials vary from CTL's estimates by a considerable degree; i.e., WJE's estimates of potential settlement are substantially less.
- It should be noted that these are conservative estimates of potential movements. The likely movements that will occur are significantly less.

Groundwater was encountered at 3 ½ feet depth in Boring 1 at the Administration Building, but not in any of the remaining 22 borings drilled for the original geotechnical investigation (Terracon, October 20, 1997), when checked one day after drilling. Logs for borings completed in 2012 and 2013 (Terracon, January 11, 2013 and Terracon, December 6, 2013), and 2014 (CTL, July 22, 2014) indicate that groundwater was not encountered in any of these borings when checked one day after drilling. Subsequently, groundwater has been measured in piezometers installed in two of these borings. Groundwater was encountered in two of the five borings completed at the South Facility, and in two of the four borings at the CPF and K Unit/Support buildings, at the time of drilling the recent CTL borings (CTL, December 18, 2015).

Periodic water level measurements have been obtained at six piezometers at the South Facility beginning in 2014 at some locations. However, it should be noted that two of the original six piezometers, i.e. #4 and #6, have been abandoned and are no longer available. Recent measurements were taken at three of the remaining four piezometers, i.e. #1, #3, and #7 that were accessible during WJE's June 22 and 23, 2017 site visit. The available readings indicate relatively stable water levels in "Bore Hole #1 Monitoring Well" located outside and to the southeast of the South Facility, and in "Bore Hole #5 Monitoring Well" located in the courtyard southeast of the gymnasium. (Note: Bore Hole #5 was not accessible during our June 22 and 23, 2017 site visit.) However, water levels measured in "Bore Hole #3 Monitoring Well" located outside and immediately west of Area B, and in "Bore Hole #7 Monitoring Well" located in the hallway between Area B and Area A, showed significant increases when measured during the June 2017 site visit, i.e. 7.3 feet and 5 feet, respectively. Monitoring of groundwater levels in all four of the remaining piezometers should continue. Response testing of the "Bore Hole #3 Monitoring Well" and "Bore Hole #7 Monitoring Well" may be warranted to confirm that these piezometers are performing as intended. See Appendix H for the piezometer locations and water level data.

Interior Elevation Surveys at South Facility

WJE performed a location-by-location comparison of the elevation measurements performed by Lower, Coffey, and WJE. Our comparison considered that the benchmark assumed by Coffey may not have been reliable. In doing so, we reduced each data set down by a uniform elevation offset (e.g. 6746.69 ft) and converted the elevations from feet to inches for easier comparison. The elevation offset for each data set varied slightly and was chosen to achieve the best fit between data sets closest together in time (i.e. December 2013 to August 2013, etc.). This alteration converted the benchmarked surveys to "relative" surveys, or surveys that are considered relative to each other and not a location with a known stable elevation.

Our analysis confirmed Terracon's and Martin/Martin's opinions that portions of the Coffey data were unreliable. Specifically, portions of the October 2014 and March 2015 data did not align with either previous Coffey results or WJE's later results. This was most prevalent in the Area A - Northwest Hall, the

Pod A Hall, the Multi-Purpose Room, Closet A170, and Control Room Area A, as defined by Coffey. Given the close proximity of these areas, it appears that there may have been a turning point error during these surveys.

When the suspect data was removed from consideration, good correlation between Coffey and WJE's surveys was observed. In many locations, the comparisons fell within reasonable survey tolerance, which we estimate to be +/- 1/4 in. to +/- 1/2 in. considering the difficulties of this particular survey and the equipment used. In these locations, ongoing movement is unlikely, but cannot be ruled out based on the survey data alone. In other locations, such as the Hobby Room, Gymnasium, East Hall, and the North Hall along the Gymnasium, the data indicates that subtle movements may have occurred since August 2013. Exhibits I-1 and I-2 in Appendix I provide a graphic comparison of the relative elevation results from Coffey's August 2013 and WJE's June 2017 surveys.

Interior Elevation Surveys at CPF and K Unit/Support Building

Our preliminary analysis indicates that the slab-on-ground within the laundry room and hallway to the kitchen were measured to be approximately 1 7/8 in. out-of-level. Given the large area, this amount of out-of-levelness is arguably within construction tolerances; however, there are indications of past slab movement. Given the lack of historical survey data for this building, it is not possible to determine when the movement occurred and if it is ongoing.

The K Unit, inclusive of the Housing and Support buildings, was measured to be approximately 5 1/2 in. out-of-level. The lowest elevations were measured in the print shop at the northeast corner of the building. In addition, the tops of exposed grade beams were measured to be up to 1¼ in. above the adjacent slab-on-ground. Within the gymnasium, the top of grade beams were located within 1/4 in. of adjacent slab measurements.

Exhibits I-3 and I-4 in Appendix I graphically illustrate our preliminary elevation survey results for the CPF and K Unit/Support buildings, respectively. It should be noted that these are relative surveys and, as such, the high point in each building was normalized to a value of 0 in.

WJE OPINIONS AND CONCLUSIONS REGARDING M/M REPORT

South Facility

It is apparent that many portions of the WSP have been adversely affected by soil movements, and the extent and severity of the distress varies greatly throughout the facility. We agree with M/M that swelling of expansive soils has been the primary cause of building movements at the South Facility. However, we do not agree with M/M's conclusion that the vertical movements at the South Facility are predominately the result of slab-on-ground movements, with vertical movements of the drilled piers playing a smaller part.....

CPF and K Unit/Support Building

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Cost Estimate

M/M prepared and presented four options for addressing the damage to the WSP, including a full repair, two options for partial repair and partial replacement, and full replacement of the WSP facility. At M/M's request, JMB estimated the cost for each of those options. JMB's total cost estimate for the M/M proposed repairs for Option 1 is $87,232,454.

At WJE's request, Sage Consulting Group (Sage) prepared a cost estimate for the Option 1 scope of work recommended by M/M. Sage's total cost estimate for the M/M proposed repairs for Option 1 is $59,867,884 for the very same scope of work included in JMB's estimate. However, it is important to note that JMB's estimate includes costs for work to repair various components of the building that are not the result of building movements. These include the roofing, roof drain work, replacement of AHUs, and replacement of the PLC Platform. When these items are excluded from Sage's estimate for Option 1, the total estimated cost is $51,257,587. See Appendix J for a description of Sage's approach, costs, etc., as well as their breakdown documentation and spreadsheet.

WJE OPTION 1 ALTERNATIVE REPAIR RECOMMENDATIONS

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