Roadway Concrete Sidewalk & Curb Brine Impact Study 2020 Edmonton, AB

PRESENTED TO
City of Edmonton

DECEMBER 3, 2020
ISSUED FOR USE
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EXECUTIVE SUMMARY

Introduction

Tetra Tech Canada Inc. (Tetra Tech) was retained by the City of Edmonton (CoE) to conduct an investigation into the effects of sodium chloride (salt) and calcium chloride (brine) on concrete infrastructure (i.e. concrete curbs, medians, bus pads and crossings) adjacent to main arterial roadways and freeways.

The Design and Control of Concrete Mixtures, eighth Canadian edition states: "*The most destructive weathering factor is freezing and thawing while the concrete is wet, particularly in the presence of de-icing materials"*. Tetra Tech undertook this research to determine if concrete deterioration was accelerated due to the use of salt and brine.

Roadway Survey

Tetra Tech was tasked to determine if there were differences in concrete field performance after construction in 2018 compared to the same areas as surveyed in the summer of 2020 that could be related to the use of salt with sand and/or brine.

In order to document the field performance of concrete curbs, medians, bus pads and crossings photographic images of five (5) selected sites were obtained in fall of 2018, after street cleaning in spring of 2019 and the summer of 2020.

Concrete infrastructure was surveyed along the following de-icing routes, where only salt was placed on the adjacent roadway:

- 122 Street between Whitemud Drive and Fox Drive northbound; and
- Groat Road (87 Ave to Groat Bridge), northbound and southbound.

Concrete infrastructure was also surveyed along the following anti-icing routes where a combination of brine and salt was placed on the adjacent roadway:

- 178 Street between 87 Avenue and 95 Avenue;
- 111 Avenue between 124 Street and 132 Street (Groat Road); and
- 50 Street, 82 Avenue to 101 Avenue and 106 Avenue to 109 Avenue,

Condition of Infrastructure in 2019

After a single winter season, there were few if any signs of actual or potential damage caused by freeze/thaw distress exacerbated by anti-icing and de-icing solutions on the concrete infrastructure.

Some mortar flaking of the surface was observed in isolated areas, but this is attributed to poor protection and/or delayed curing during construction.

The primary issue observed on the concrete infrastructure was damage by the snow removal equipment, especially on 111 Avenue. The areas of significant equipment damage are now somewhat more susceptible to freeze-thaw attack exacerbated by anti-icing and de-icing chemicals and deterioration in general.

Current Condition of Infrastructure - 2020

Based on the survey of five roadways where concrete was placed in 2018, there is still little to no indication of actual or potential damage caused by freeze/thaw distress potentially exacerbated by anti-icing and de-icing solutions.

The primary issue of damage caused by snow removal equipment did not seem to increase in overall severity; however, new damage was noted at some additional locations. This includes a portion of curbs with markings from snowplowing equipment. The infrastructure damage has left some curbs somewhat more susceptible to freeze-thaw attack and deterioration in general.

Future Observations

Further investigation into the areas where mortar flaking or similar distresses observed could be completed in the future. This would include an additional photographic survey in 2021.

Concrete core sampling to determine roadway and sidewalk salt/brine concentrations (chloride ion profile) could also be completed. This would aid in determining year over year increase in chloride ion concentrations

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LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the City of Edmonton and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than the City of Edmonton, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by the City of Edmonton (CoE) to provide an updated assessment of the impacts of sodium chloride (salt) and calcium chloride (brine) when placed adjacent to Portland cement concrete (concrete) infrastructure (i.e. concrete curbs, medians, bus pads and crossings) adjacent to main arterial roadways and freeways.

A previous report was submitted in the summer of 2019 which compared the fall 2018 condition of recently constructed concrete to the conditions in spring of 2019 after a winter season of exposure to de-icing salts and freezing conditions. This updated report details a summer of 2020 survey to assess the impact and/or distress to the concrete infrastructure after an additional season of winter exposure.

2.0 CITY OF EDMONTON WINTER ROADWAY MAINTENANCE PRACTICES

The 2018 City of Edmonton winter maintenance practices include the use of:

1. Sodium Chloride (NaCl) De-icer (typically with sand as a traction aid).
2. Calcium Chloride ($CaCl_2$) Anti-icer on arterial roads and bus routes.
3. NaCl De-icer after $CaCl_2$ Anti-icer*.

*Depending on the intensity and duration of the snowfall event and/or changes in pavement temperature, de-icers may be applied to roadways after pre-treatment with an anti-icer.

Anti-icers are applied before a snow fall event to facilitate snow clearing. De-icers are used to help melt and remove ice and snow from roadways and sidewalks. The effectiveness of salt as a de-icer decreases as the pavement temperature goes down to temperatures below about -10°C. CoE incrementally reduces the amount of salt in the sand mixture as application temperatures drop from -5°C to -25°C. At lower dosages (3%) the salt is primarily used to prevent the road sand from freezing into unmanageable lumps.

In the winter of 2019, the roadway maintenance program was changed to only include salt without the use of brine; however, brine was still used as an anti-icing agent on sidewalks, bike lanes and paths. Brine continues to be used as a pre-wetting agent in pre-blended sand and salt to aid with adhesion to snow and ice accumulation on the road surface.

3.0 CONCRETE INVESTIGATION

3.1 Areas of Study

Tetra Tech was tasked to determine if there were differences in concrete field performance that could be related to the use of salt with sand and/or brine.

In order to document the field performance of sidewalks, medians, and curbs, photographic images of five (5) selected sites were obtained in fall of 2018, after street cleaning in spring of 2019 and during the summer of 2020. These surveys provided an effective method of documenting field performance and allowed an objective assessment of the effects of the use of salt and/or brine. The photographic surveys completed for this study included concrete surfaces obtained in the fall of 2018, the spring of 2019 and the summer of 2020. About 11,000 photographic images were obtained in each year.

Concrete infrastructure was surveyed along the following de-icing routes where only salt was used on the adjacent roadway:

- 122 Street between Whitemud Drive and Fox Drive northbound; and
- Groat Road (87 Avenue to Groat Bridge), northbound and southbound.

Concrete infrastructure was also surveyed along the following anti-icing routes where a combination of brine and salt was used on the adjacent roadway in 2018 only:

- 178 Street between 87 Avenue and 95 Avenue;
- 111 Avenue between 124 Street and 132 Street (Groat Road); and
- 50 Street, 82 Avenue to 101 Avenue and 106 Avenue to 109 Avenue.

4.0 CONCRETE PHOTOGRAPHIC SURVEY

The sidewalks, curbs and adjacent portions of driveways were surveyed by the Pavement Surface Profiling (PSP-7000) vehicle in 2018 and 2019. The PSP-7000, designed specifically to provide integrated data collection services for network level roadway condition data collection, is a state-of-the-art and highly integrated data collection platform. It combines roughness (IRI), rut, automated and semi-automated pavement distress, digital videolog, and 3D LiDAR with gap free sub-metre inertially-aided real-time differential GPS spatial referencing and high precision linear referencing systems into a single full-sized cargo van chassis. The PSP-7000's real-time inertially-aided differential GPS system provides virtually error free GPS positions, even in areas with poor or no satellite coverage.

The PSP-7000 vehicle collects all roadway information at speeds from 15 kph to 110 kph and is well suited to municipal roadway networks. Tetra Tech combines the data collection systems with integrated linear and spatial referencing to minimize referencing errors for all collected data.

The vehicle also includes a high-resolution right-of-way (ROW) digital videolog system and two separate imaging systems. All imaging systems provide permanent and fully referenced records of the roadway corridor at the time of survey. The forward-looking driver's eye view is supplemented by a high-resolution panoramic camera system used to collect continuous 360° digital videologs. The driver's eye view will be adjusted to reduce the forward-looking view in order to provide better resolution of the pavement surface texture.

The reduced lane widths on Groat Road during the 2019 to 2020 construction precluded the use of the PSP-7000 vehicle. The 2019 Groat Road images were captured with a GoPro Hero7 Black wide screen mounted on a passenger vehicle. All the 2020 images from the 5 roadways investigated were collected utilizing the upgraded GoPro Hero8 model which was similarly mounted to a passenger vehicle. This change in equipment/method was used to obtain improved image quality from a vantage point closer to the concrete infrastructure. Once the images were collected, they were similarly labeled to the previous years. The decision to change equipment type and method of obtaining images was at Tetra Tech's discretion.

This photographic survey provided a visual log of the concrete surfaces prior and after the winter season. This included a total of over 11,000 images obtained each year at the five locations. The images were obtained in late fall of 2018, spring of 2019 and summer of 2020. Electronic copies of the photos along with corresponding locations have been provided under separate cover.

Once all images were visually reviewed by our concrete specialists, a site trip by a Tetra Tech concrete specialist was completed to confirm the extent of potential damage observed. Three sites including 122 Street, 111 Avenue, and 50 Street from the photo survey were selected for field review by our concrete specialist.

5.0 CONDITIONS OF INFRASTRUCTURE IN 2019

After a single winter season, there was little to no sign of actual or potential damage caused by freeze/thaw distress exacerbated by anti-icing and de-icing solutions on the concrete infrastructure. This exposure would include salt and/or brine solutions that may have come into contact with the concrete. Typical concrete damage caused by salt or brine would include scaling and spalling of the surface paste (about 1 mm to 2 mm in thickness) exposing the coarse aggregate below. Few indications of this was observed on the infrastructure logged.

Some mortar flaking of the surface was observed in isolated areas. Mortar flaking occurs when a near surface coarse aggregate particle blocks bleedwater migrating to the concrete surface. The overlying mortar layer then prematurely dries out. This weaker mortar layer eventually flakes off, exposing the underlying coarse aggregate particle. This is primarily a construction defect that is observed after one to two years of winter exposure. An example of mortar flaking is shown in Photo 1.

The primary issue observed on the concrete infrastructure was damage by the snow removal equipment especially on 111 Avenue and 50 Street. The areas of significant damage at 111 Avenue and 50 Street due to snow removal are now somewhat more susceptible to freeze-thaw attack exacerbated by anti-icing and de-icing chemicals and deterioration in general.

6.0 2020 CONCRETE OBSERVATIONS

6.1 Previous Anti-Icing (Brine) Routes

6.1.1 111 Avenue, 124 Street to 132 Street

No significant change in condition of concrete infrastructure at this location was observed from spring 2019 to the summer of 2020. It was previously reported in 2019 that the concrete sidewalks and curbs on the south side of 111 Avenue generally appeared in good condition; however, some mortar flaking was observed at some locations on the north side of the roadway. The mortar flaking from the curb to about 1 m back observed on about 20 panels did not appear to have experienced further deterioration (Photo 2). The defects may have been exposure related as this concrete would have been subjected to more freeze thaw cycles than the south side of the road. It is also possible that the snow clearing may have been different along the curb.

Tetra Tech previously reported severe concrete damage observed on the curbs and sidewalks caused by snow clearing equipment. It appears that snowplows would place the edge of the blade to the edge/face of curb. It also appears that skid steers loaders (or equivalent equipment) may have been used to clear snow from the sidewalks. As this is completed, some of the concrete surface may have been removed. Once the concrete surface mortar is removed, the exposed interior is more prone to be saturated when frozen, potentially leading to a decrease in service life. The amount of concrete surface removal caused by snow clearing damage did not appear to increase in size from 2019 to 2020 (Photo 3) at this location. Between 2019 and 2020, no increase in the amount of concrete damage caused by snow clearing activities was noted.

A slight change in the surface colour of the concrete was observed (Photo 4). This is attributed to continuing ultraviolet breakdown of the white concrete curing compound and/or scraping of the surface by snow clearing.

A couple sidewalk panels developed cracks (Photo 5). These cracks are likely due to contraction joints not being tooled deeply enough to be effective.

One panel contained severe scaling (Photo 6). This panel was marked with spray paint and has likely been identified for removal.

6.1.2 178 Street

Some replacement panels were constructed in 2018 rather than full reconstruction of the sidewalks and curbs; however, it appeared that significant lengths of sidewalk were being rehabilitated in 2020.

Some maintenance caused discoloration on pararamps which may not be aesthetically pleasing (Photo 7).

A couple sidewalk panels developed cracks (Photo 8). Some of the cracks occurred in recently placed concrete and are identified as construction related.

Severe scaling was observed on Southbound 178 Street, but this is isolated to a few panels (Photo 9). This defect appears to be construction related as opposed to the impact of deicing salts

Some other areas contained minor mortar flaking, but these are considered to be construction defects (Photo 10).

6.1.3 50 Street, 82 Avenue to 101 Avenue and 106 Avenue and 109 Avenue

It should be noted that the concrete infrastructure was at various ages constructed from 2014 to 2018.

The curbs and bus pad bench aprons appeared to be in good condition from the fall of 2018 to the summer of 2020, with the exception of a few curb panels damaged by snow clearing maintenance operations. It is expected that these areas will deteriorate further due to freeze thaw cycles. The severity of damage did not seem to increase in size from 2019 to 2020 (Photo 11).

Some of the median at 101 Avenue contained a moderate amount of mortar flaking. This is be attributed to a construction defect. The severity of mortar flaking did not seem to increase from 2019 to 2020 (Photo 12). Some of the photos contain dark specs on the median but these were confirmed to be dark aggregate on the concrete surface that can be swept off of the surface.

No obvious signs of damage caused by de-icing and anti-icing were observed.

6.2 NaCl (Salt) Routes

6.2.1 122 Street between Whitemud and Fox Drive Northbound

The concrete observed from the fall of 2018 to the summer of 2020 was generally in good condition. Rust streaks were originally observed on long stretches of the curb face indicating the snowplows/graders scraped the curb during snow removal. Areas of damaged concrete was observed due to snow removal. No significant increase in damage was noted from 2019 to 2020 (Photo 13). These areas were usually located at rounded curb transitions.

The sidewalks and medians were also in good condition with the exception of a few panels that contained minor to moderate mortar flaking. This defect was not widespread and therefore appears to be a construction defect rather than a result of exposure to salt. The photos appear to have an increase in mortar flaking, but it was confirmed during our site visit that the darker spots are pieces of dark coarse aggregate.

6.2.2 Groat Road (87 Avenue to Groat Bridge), Northbound and Southbound

The curbs appeared to be in good condition from the fall of 2018 to the summer of 2020.

Some rust marks were observed due to the snowplows/graders scrapping the curb during snow removal. Some black tire marks were observed on the curb faces. Some damage was noticed on a rounded curb likely caused during snow removal.

No signs of indication of freeze/thaw damage caused by de-icing and anti-icing chemicals were observed.

7.0 DISCUSSION

Based on the survey of five roadways with recently placed concrete, there is little to no indication of actual or potential damage caused by freeze/thaw distress as well as no indications that this damage was exacerbated by the use of anti-icing or de-icing solutions. This exposure would include salt and/or brine solutions that may have come into contact with the concrete.

Damage to concrete caused by anti-icing and de-icing solutions would include surface spalling or loss of surface mortar exposing coarse aggregate. Continued scaling would erode the mortar around the coarse aggregate, eventually resulting in raveling and/or concrete disintegration. Some mortar flaking, and minor scaling (similar to freeze/thaw distress caused by anti-icing and de-icing solutions) was observed on the north side of 111 Avenue, the median at 50 Street and 101 Avenue and the sidewalk at 122 Street but this may be attributed to factors such as construction defects or exposure (curing) to more frequent freeze/thaw cycles.

The primary issue observed on the concrete infrastructure was damage from the snow removal equipment on 111 Avenue and 50 Street. The areas of significant damage due to snow removal are now somewhat more susceptible to freeze/thaw attack and deterioration in general. Some snow removal scraping was observed at other locations; however, the observed damage is not expected to reduce the service life.

A large portion of the curbs observed in the survey locations exhibited markings from snowplow equipment. Over time this process may remove the surface mortar exposing the interior aggregate. Once this is completed, the exposed concrete will also be somewhat more susceptible to freeze/thaw damage.

There was no significant difference in defects observed from 2019 to 2020.

8.0 FUTURE OBSERVATIONS

Further investigation into the areas where mortar flaking or similar distresses observed could be completed in the future. This would include an additional photographic survey in 2021.

Concrete core samples could also be obtained for chemical analysis to determine if road salt/brine applications have significantly increased the chloride ion concentrations at various depths in the concrete. This data would aid in determining the life cycle predictions for reinforced roadway concrete.

9.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Tetra Tech Canada Inc.

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The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

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PHOTOGRAPHS

Photo 1 122 Street near Fox Drive, September 2020: Mortar flaking on sidewalk surface caused by drying of surface above coarse aggregate.

Photo 2 111 Avenue: July 2019 photo on left, September 2020 photo on right. No noticeable change in mortar flaking volume.

Photo 3 111 Avenue: July 2019 photo on left, September 2020 photo on right. No noticeable difference in damage to volume of concrete removal by snow clearing equipment.

Photo 4 111 Avenue, August 2020: Difference in concrete surface colour due to removal of curing compound.

Photo 5 111 Avenue, August 2020: Concrete cracking on sidewalk panel.

Photo 6 111 Avenue, September 2020: One panel with severe scaling, likely to be removed.

Photo 7 178 Street, August 2020: Discolouration and scraping of pararamp caused by snow removal.

Photo 8 178 Street, August 2020: Recently placed concrete with cracks related to construction.

Photo 9 178 Street: May 2019 photo on left, August 2020 photo on right. Severe scaling on panel likely construction related. Likely to be removed.

Photo 10 178 Street, August 2020: Minor mortar flaking on concrete apron on right side of photo.

Photo 11 50 Street and 106A Avenue: July 2019 photo on the left, September 2020 photo on the right. No visible increase in snowplow damage at rounded curb transition.

Photo 12 50 Street and 101 Avenue: July 2019 photo on the left, September 2020 photo on the right. No visible increase in volume of mortar flaking.

Photo 13 122 Street: May 2019 photo on left, September 2020 photo on right. No visible increase in curb damage caused by snow removal.

Photo 1: 122 Street near Fox Drive, September 2020: Mortar flaking on sidewalk surface caused by drying of surface above coarse aggregate.

Photo 2: 111 Avenue: July 2019 photo on left, September 2020 photo on right. No noticeable change in mortar flaking volume.

Photo 3: 111 Avenue: July 2019 photo on left, September 2020 photo on right. No noticeable difference in damage to volume of concrete removal by snow clearing equipment.

Photo 4: 111 Avenue, August 2020: Difference in concrete surface colour due to removal of curing compound.

Photo 5: 111 Avenue, August 2020: Concrete cracking on sidewalk panel.

Photo 6: 111 Avenue, September 2020: One panel with severe scaling, likely to be removed.

Photo 7: 178 Street, August 2020: Discolouration and scraping of pararamp caused by snow removal.

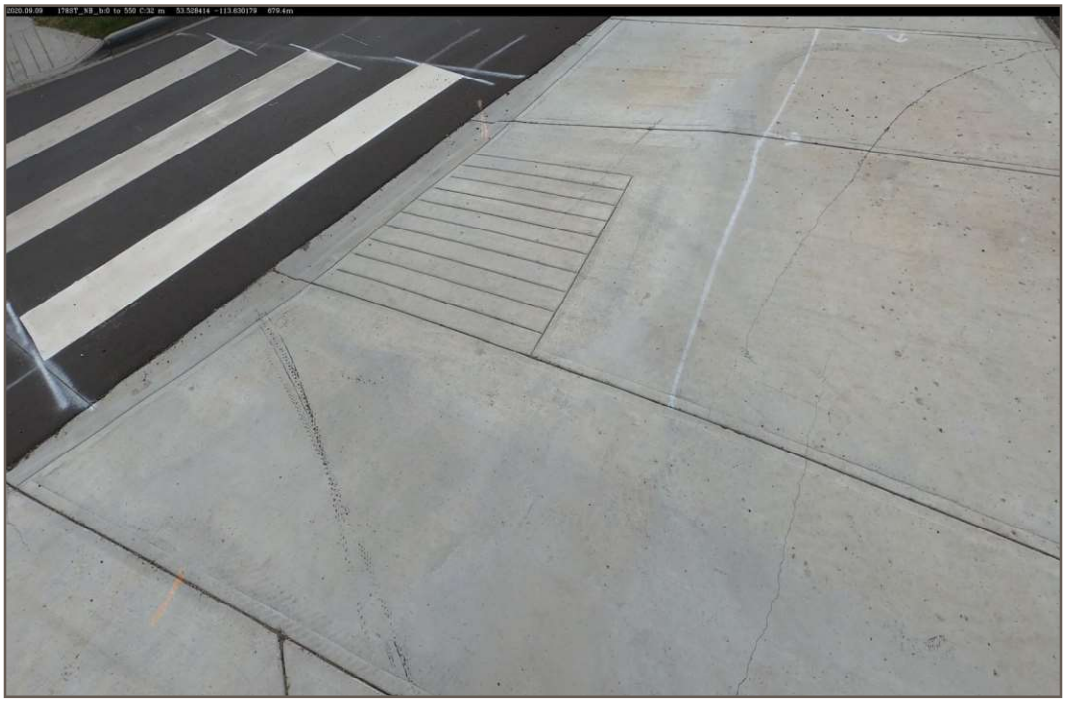

Photo 8: 178 Street, August 2020: Recently placed concrete with cracks related to construction.

Photo 9: 178 Street: May 2019 photo on left, August 2020 photo on right. Severe scaling on panel likely construction related. Likely to be removed.

Photo 10: 178 Street, August 2020: Minor mortar flaking on concrete apron on right side of photo.

Photo 11: 50 Street and 106A Avenue: July 2019 photo on the left, September 2020 photo on the right. No visible increase in snowplow damage at rounded curb transition.

Photo 12: 50 Street and 101 Avenue: July 2019 photo on the left, September 2020 photo on the right. No visible increase in volume of mortar flaking.

Photo 13: 122 Street: May 2019 photo on left, September 2020 photo on right. No visible increase in curb damage caused by snow removal.

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

CONSTRUCTION MATERIALS ENGINEERING AND TESTING

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

Any unauthorized use of the Professional Document is at the sole risk of the user. TETRA TECH accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where TETRA TECH has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Professional Document and any other form or type of data or documents generated by TETRA TECH during the performance of the work are TETRA TECH's professional work product and shall remain the copyright property of TETRA TECH.

The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the Document, if required, may be obtained upon request.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by persons other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary investigation and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental, regulatory, or sediment and erosion issues associated with construction on the subject site.

1.8 VARIATION OF MATERIAL CHARACTERISTICS AND CONDITIONS

Observations and standardized sampling, inspection and testing procedures employed by TETRA TECH will indicate conditions of materials and construction activities only at the precise location and time where and when Services were performed. The Client recognizes that conditions of materials and construction activities at other locations may vary from those measured or observed, and that conditions at one location and time do not necessarily indicate the conditions of apparently identical material(s) at other locations and/or times.

Services of TETRA TECH, even if performed on a continuous basis, should not be interpreted to mean that TETRA TECH is observing, verifying, testing or inspecting all materials on the Project. TETRA TECH is responsible only for those data, interpretations, and recommendations regarding the actual materials and construction activities observed, sampled, inspected or tested, and is not responsible for other parties' interpretations or use of the information developed. TETRA TECH may make certain inferences based upon the information derived from these procedures to formulate professional opinions regarding conditions in other areas.

1.9 SAMPLING, OBSERVATION & TEST LOCATIONS

Unless specifically stated otherwise, the Scope of Services does not include surveying the Site or precisely identifying sampling, observation or test locations, depths or elevations. Sampling, observation and test locations, depths and elevations will be based on field estimates and information furnished by the Client and its representatives. Unless stated otherwise in the report, such locations, depths and elevations provided are approximate.

1.10 CONTRACTOR'S PERFORMANCE

TETRA TECH is not responsible for Contractor's means, methods, techniques or sequences during the performance of its Work. TETRA TECH will not supervise or direct Contractor's Work, nor be liable for any failure of Contractor to complete its Work in accordance with the Project's plans, specifications and applicable codes, laws and regulations. The Client understands and agrees that Contractor, not TETRA TECH, has sole responsibility for the safety of persons and property at the Project Site.

1.11 NOTIFICATION AND LEVEL OF SERVICE

Unless the Client requests or the building code requires full-time services, the Client understands that services provided by TETRA TECH are on an "On-Call" basis. The Client shall assume responsibility for adequate notification and scheduling of TETRA TECH services. TETRA TECH will make every reasonable effort to meet the Client's schedule, but will not guarantee service availability without direct confirmation from with the Client or their agent.

1.12 CERTIFICATIONS

The Client will not require TETRA TECH to execute any certification regarding Services performed or the Work tested or observed unless: 1) TETRA TECH believes that it has performed sufficient Services to provide a sufficient basis to issue the certification; 2) TETRA TECH believes that the Services performed and Work tested or observed meet the criteria of the certification; and 3) TETRA TECH has reviewed and approved in writing the exact form of such certification prior to execution of the Service Agreement. Any certification by TETRA TECH is limited to the expression of a professional opinion based upon the Services performed by TETRA TECH, and does not constitute a warranty or guarantee, either express or implied.

1.13 WEATHER AND PROTECTION OF MATERIALS

Performance of the Services by TETRA TECH and/or its designated subcontractor may be delayed or excused when such performance is commercially impossible or impracticable as a result of weather events, strikes, shortages or other causes beyond their reasonable control which may also impact cost estimates.

Excavation and construction operations expose materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations, and stockpiles, must be protected from the elements, particularly moisture, desiccation, frost action and construction activities.

1.14 CALCULATIONS AND DESIGN

Where TETRA TECH has undertaken design calculations and has prepared project specific designs in accordance with terms of reference that were previously set out in consultation with, and agreement of, TETRA TECH's client. These designs have been prepared to a standard that is consistent with industry practice. Notwithstanding, if any error or omission is detected by TETRA TECH's Client or any party that is authorized to use the Design Report, the error or omission should be immediately drawn to the attention of TETRA TECH.

1.15 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

1.16 SAMPLES

The Client will provide samples for testing (at the Client's expense). TETRA TECH will retain unused portions of samples only until such time as internal review is accomplished for intended purpose. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded. The duration of sample retention must be discussed in advance.

1.17 GEOTECHNICAL CONDITIONS

A Geotechnical Report is commonly the basis upon which the specific project design or testing has been completed. It is incumbent upon TETRA TECH's Client, and any other authorized party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the geotechnical information that was reasonably acquired to facilitate completion of the design.

If a Geotechnical Report was prepared for the project by TETRA TECH or others, it will be referenced in the Construction Materials or Materials Design Report. The Geotechnical Report contains General Conditions that should be read in conjunction with these General Conditions for this Report.