SECTION 4 – SUMMARY AND CONCLUSION

4.1 Summary

This section summarizes the major findings related to extent and scope and causative factors.

4.1.1 Extent and Scope

- Foundation failure is a relatively common problem for residential structures built in expansive soils throughout the world, United States and Amherst, New York.
- Fine-grained lacustrine soils cover much of Amherst, Erie County and western New York.
- Fine-grained lacustrine soils in Amherst have medium to high potential expansion (ASTM D4829).
- Soil boring data indicates central and northern Amherst is underlain by a soft stratum.
- Since 1987, a total of 1,095 homeowners either (a) received a foundation repair permit (501) or (b) made a foundation-related inquiry (594). However, many homeowners are reluctant to contact public officials because of the potential impact to their property value.
- The current damage rate for houses on lacustrine soils is about 3 percent (assumes 31,000 total foundations), but some affected neighborhoods report damage rates that are an order of magnitude greater.
- The average house receiving a foundation repair permit is 41 years old, but the onset of problems can occur from a few to nearly 50 years after construction, with an estimated hiatus of about 20 years.
- The average total repair cost as indicated from repair permits is about $7,900, but the range is about $500 to $71,000.
- Utility company data did not provide a secondary indication of affected areas.
- A small but significant number of foundation repairs have not performed as expected.
- We judge the number of repair permits will increase and may approach 2,000, but the timeframe is uncertain because of several unpredictable factors.

4.1.2 Causative Factors

- Foundation damage generally results from lateral pressure and/or differential settlement.

- Four sources are suspected to be contributing to lateral pressures on basement walls in Amherst. These four sources include: (1) pressure from soil weight, (2) pressure from soil swell, (3) hydrostatic pressure, and (4) pressure from frost.
- Historical foundation designs do not appear to account for potential lateral pressures and settlements. Finite-element analyses suggest that historical basement wall design did not adequately consider potential lateral pressures.
- About 93% of inspected houses had basement walls that lacked adequate lateral support at the top.
- Nearly 58% of blueprints did not match the structure built, but only in a few cases were the modifications considered potential causative factors.
- Inadequate concrete strength was not a significant causative factor.
- Stiff, fine-grained lacustrine foundation soils are expansive and may contribute to differential movements of the overlying house as laterally variable changes in foundation soil moisture content occur.
- Lateral variation in foundation soil moisture content was confirmed at several houses in Amherst.
- Post-construction moisture content changes in stiff clayey lacustrine foundation soils are generally controlled by four factors including, 1) concentration and mineralogy of clay in the soil, 2) water availability, 3) confining pressure, and 4) initial moisture content.
- Typical conditions in Amherst promote laterally variable changes in foundation soil moisture content.
- Differential straining of underlying soft lacustrine soils can cause significant differential movements of the overlying house foundation. Three common events may contribute to significant differential straining of the soft stratum including; (1) removal of soil from basement excavations during construction, (2) raising lot elevation with significant amounts of new fill around the perimeter of the house, and (3) long-term lowering of the groundwater level.

4.2 Conclusion

The vast majority of houses in Amherst are apparently performing as expected. Nonetheless, an anomalous number of homeowners (1095) have reported slight to severe foundation-related damage. The majority of houses are located north of Main Street and within lacustrine soils. Lateral pressures and/or settlement are the principal causes of foundation damage. No single causative factor accounts for the variety of damages we observed. Expansive soils, compressible substrata, post-construction hydrologic modification, marginally effective foundation design, poor construction, and inadequate observation/documentation are all potential contributing factors at most sites.

Risks associated with building on expansive soils (and bedrock) have been well known for decades in such western states as Colorado, Texas and California; however,

experience with expansive soil in the Northeast is relatively uncommon. Unlike western states, soils in Amherst are generally moister, contain non-smectitic clays (illite and chlorite), and the houses have full basements. In both environments, laterally variable changes to the soil moisture content across the foundation footprint are a primary concern.

We agree with Meehan and Karp (1994) that the design of shallow residential or other lightly-framed foundations on expansive soils is an art which often presents more difficulties than design of foundations for heavy loads. Traditional design criteria, such as bearing capacity, are not relevant. These simple facts may be recognized by only a few in the building business. The importance of proper implementation of design and engineering inspections and other verification during construction cannot be overemphasized (Meehan and Karp, 1994). We concur that improvements in preventative design practices are less a matter of better advanced theory than of information dissemination, development of coherent quality standards, and coordination among practicing professionals and the construction industry.

The Residential Code of New York State (NYSDOS, 2003) does not provide in-depth guidance regarding design, construction, assessment, and repair of foundations in these soils conditions. We conclude the town of Amherst must develop some additional guidelines for design/construction and assessment/repairs.