

*Case Study in Settlement Distress
From Railway Vibrations*

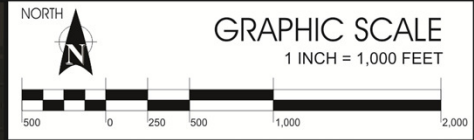
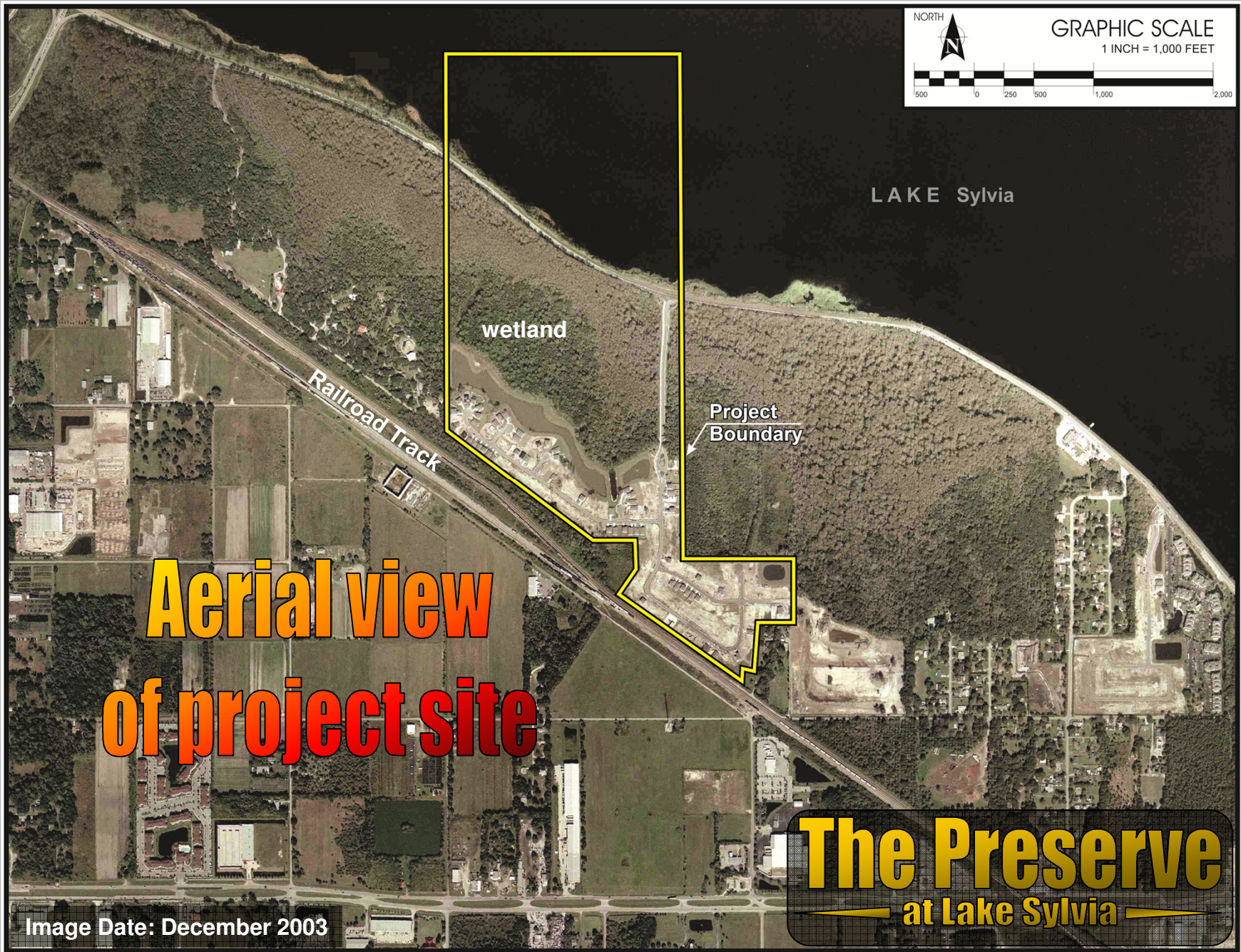
AT

The Preserve

at Lake Sylvania

Ocala, Florida

Click to continue...



LAKE Sylvania

wetland

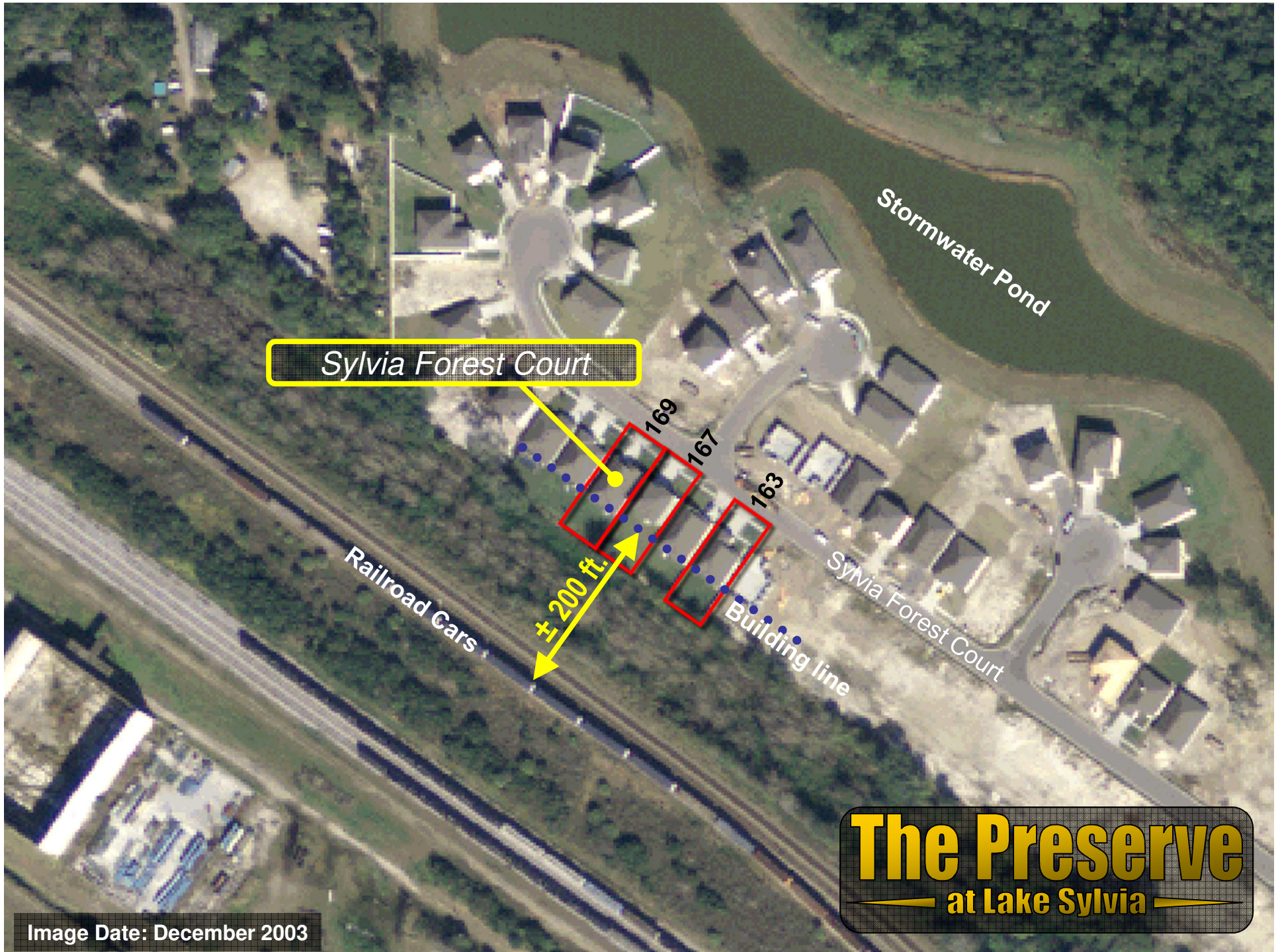
Railroad Track

Project Boundary

**Aerial view
of project site**

**The Preserve
at Lake Sylvania**

Image Date: December 2003



Sylvia Forest Court

Stormwater Pond

Railroad Cars

± 200 ft.

169

167

163

Building line

Sylvia Forest Court

The Preserve
at Lake Sylvia

Image Date: December 2003

Sylvia Forest Court

Ocala, Florida

Chronology of Construction

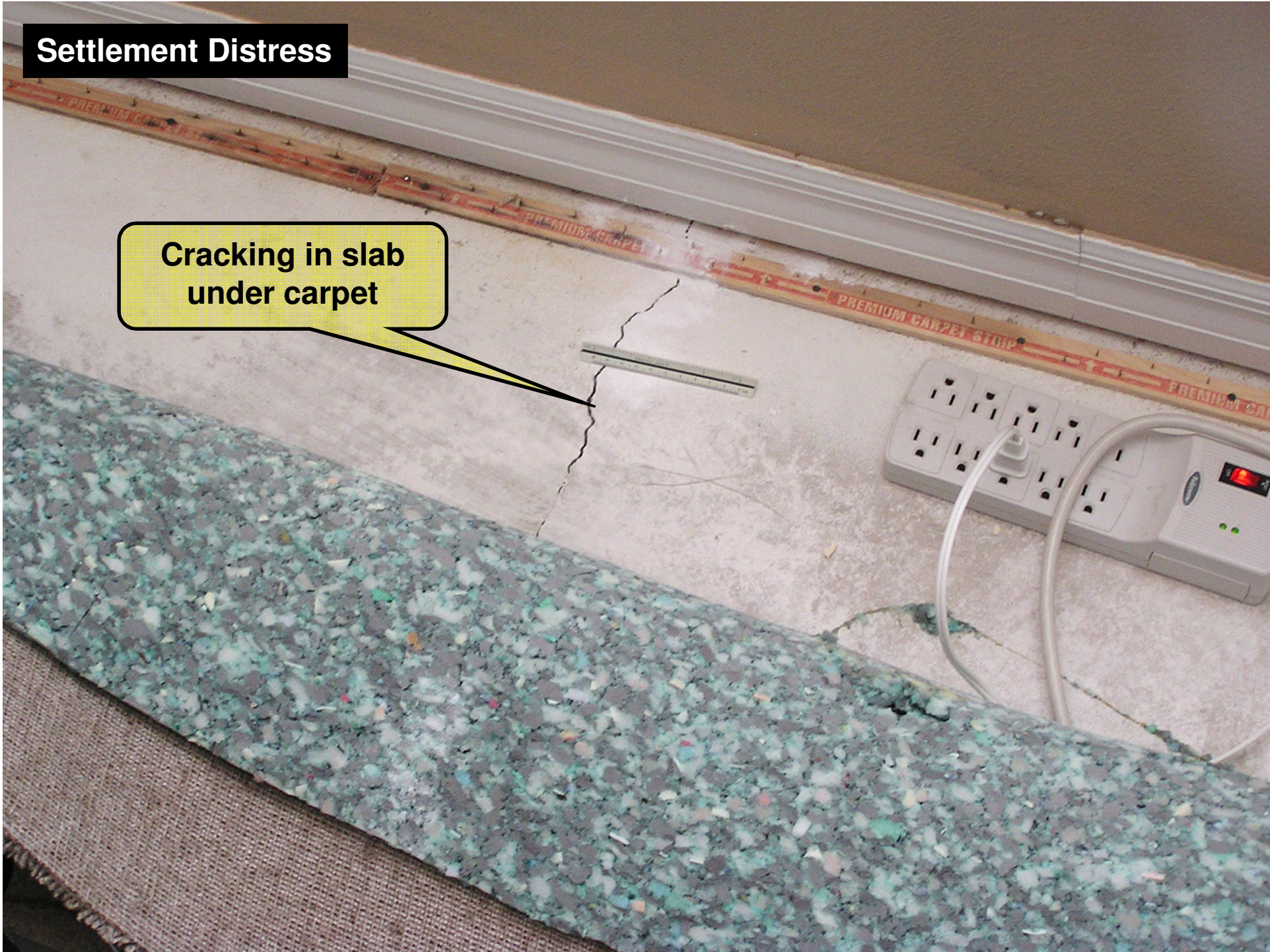
- **Site Preparation: Last Quarter 2002**
- **Construction: June 2003**
- **Closing date: September 2003**

Settlement Distress

- The home owner reported feeling railway vibrations from the first day of occupancy
- Within 30 days hairline cracks started to appear, gradually increasing in size

Settlement Distress

Cracking in slab
under carpet




Settlement Distress

Cracking in slab
under vinyl flooring



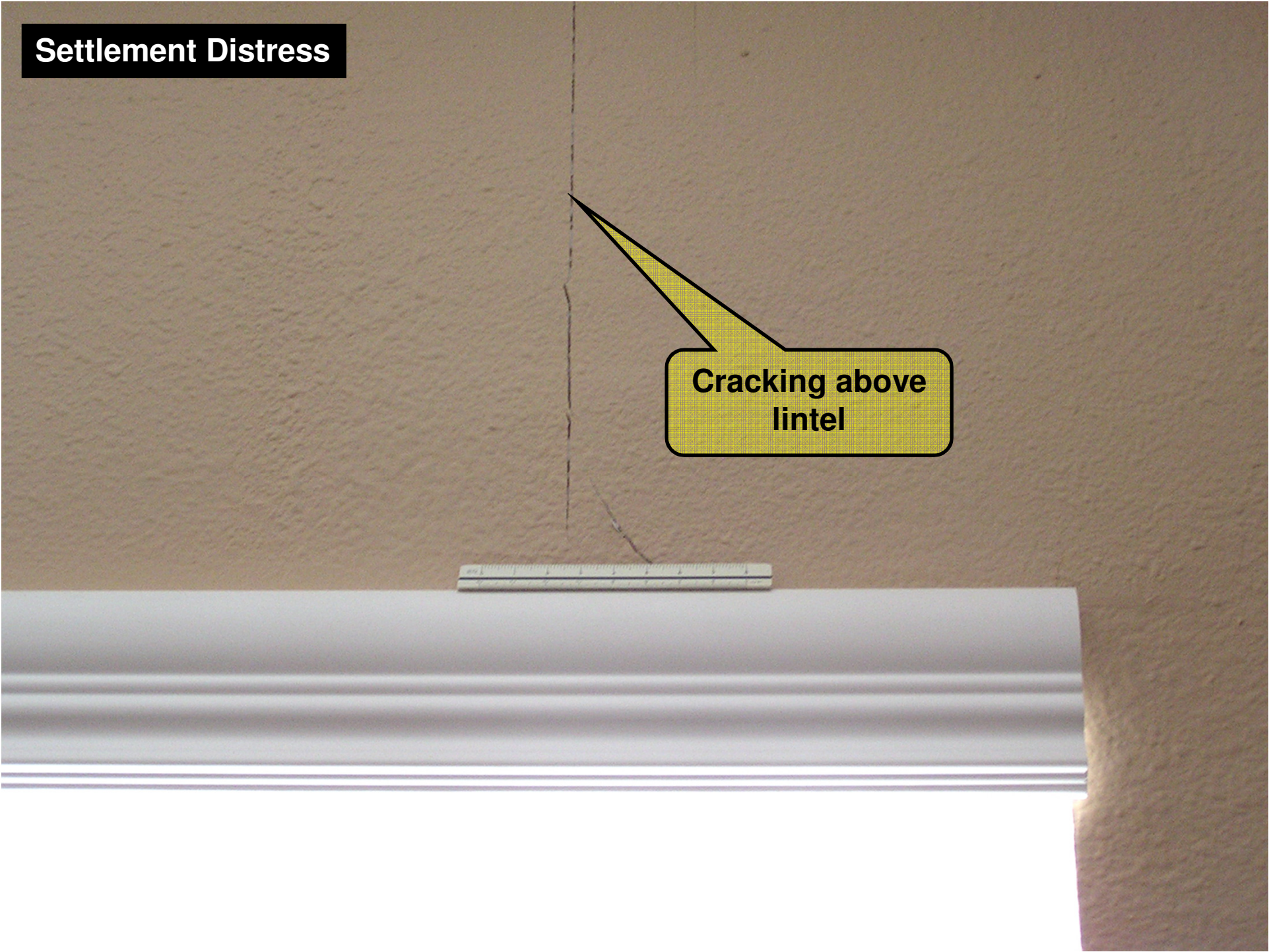
Settlement Distress



Cracking in interior wall beneath window

The image shows a brown interior wall with a vertical crack running down from the bottom of a window. The window has white blinds and a white frame. Below the wall is a white baseboard and a carpeted floor. A yellow callout box with a black border points to the crack.

Settlement Distress



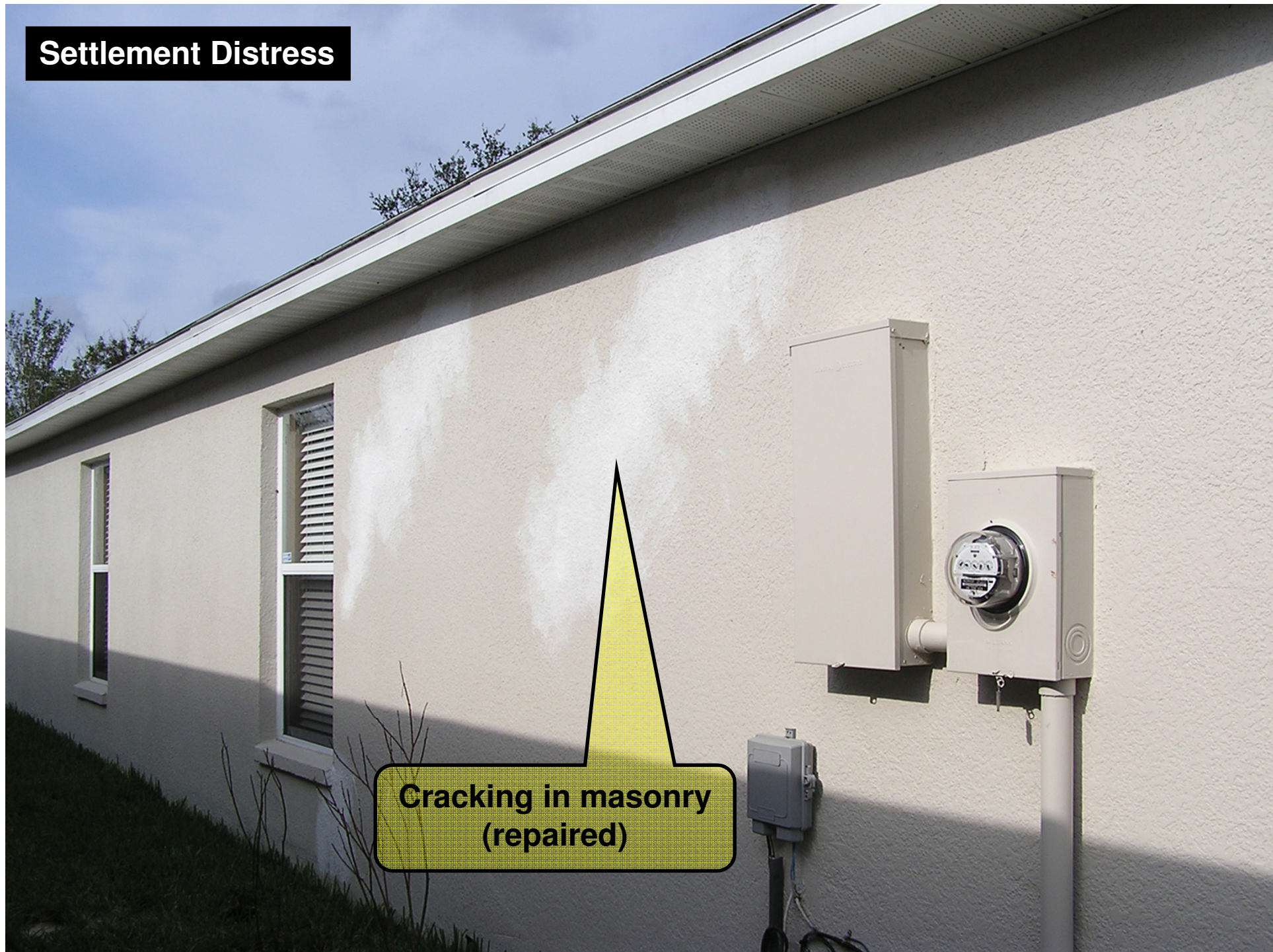
Cracking above
lintel

Settlement Distress

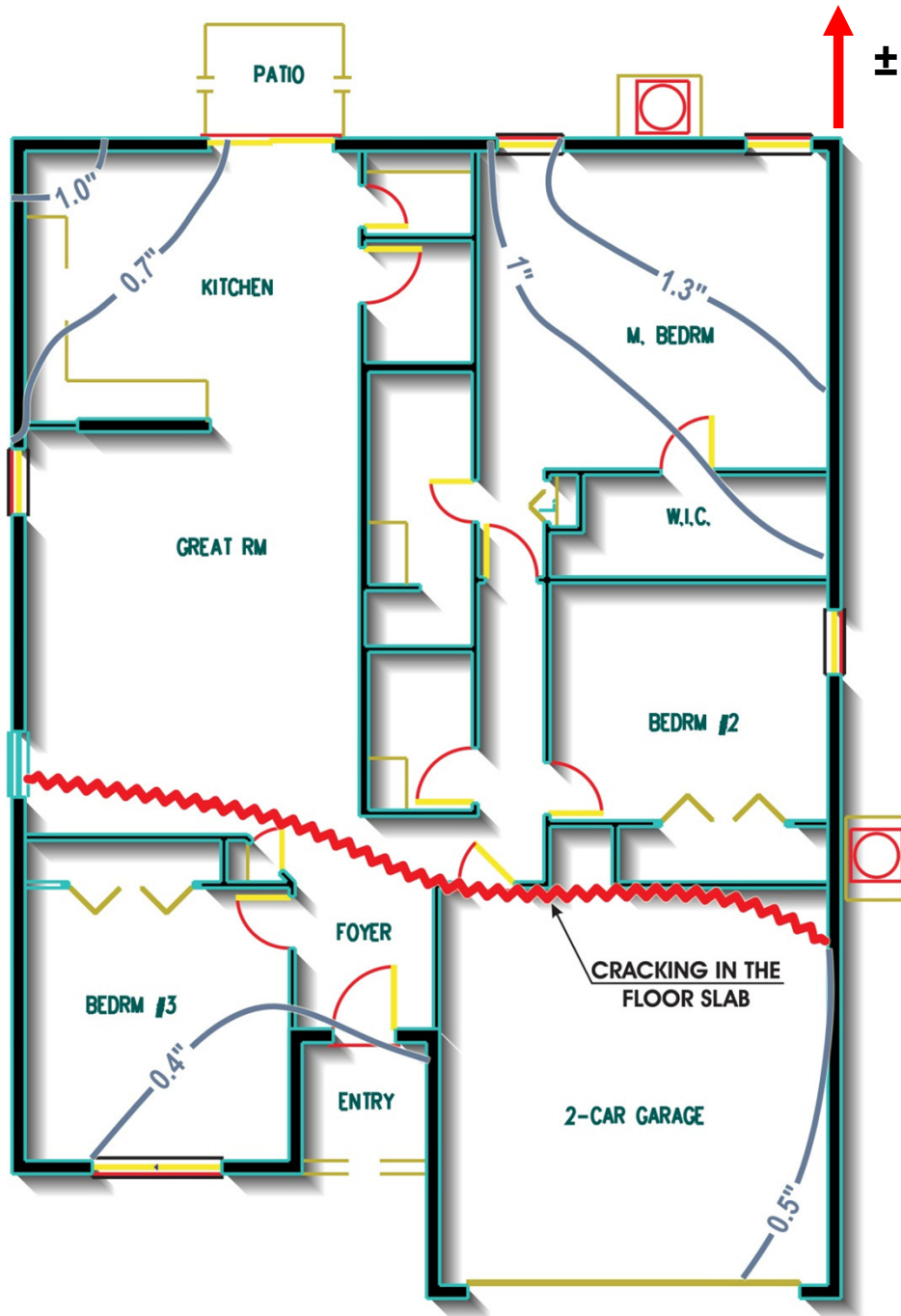
Cracking in ceiling



Settlement Distress

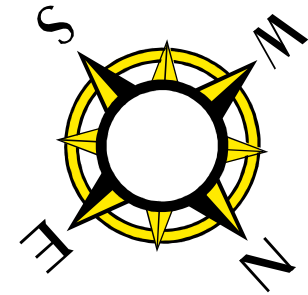


**Cracking in masonry
(repaired)**



± 200 ft. to railroad track

Sylvia Forest Court
Ocala, Florida



Pattern of Settlement Distress

Note: Contours are in Inches

Initial Suspects


- Improperly compacted fill (see subsequent photos)
- Consolidation of the underlying clay
- Buried organic soils
- Vibration from adjacent freight train
- Some loss of soil under the slab due to erosion/ground water seepage
- Sinkhole activity

Unsuitable fill pad preparation such as shown here may have contributed to settlement distress.

Poor site conditions after Plumbing installation

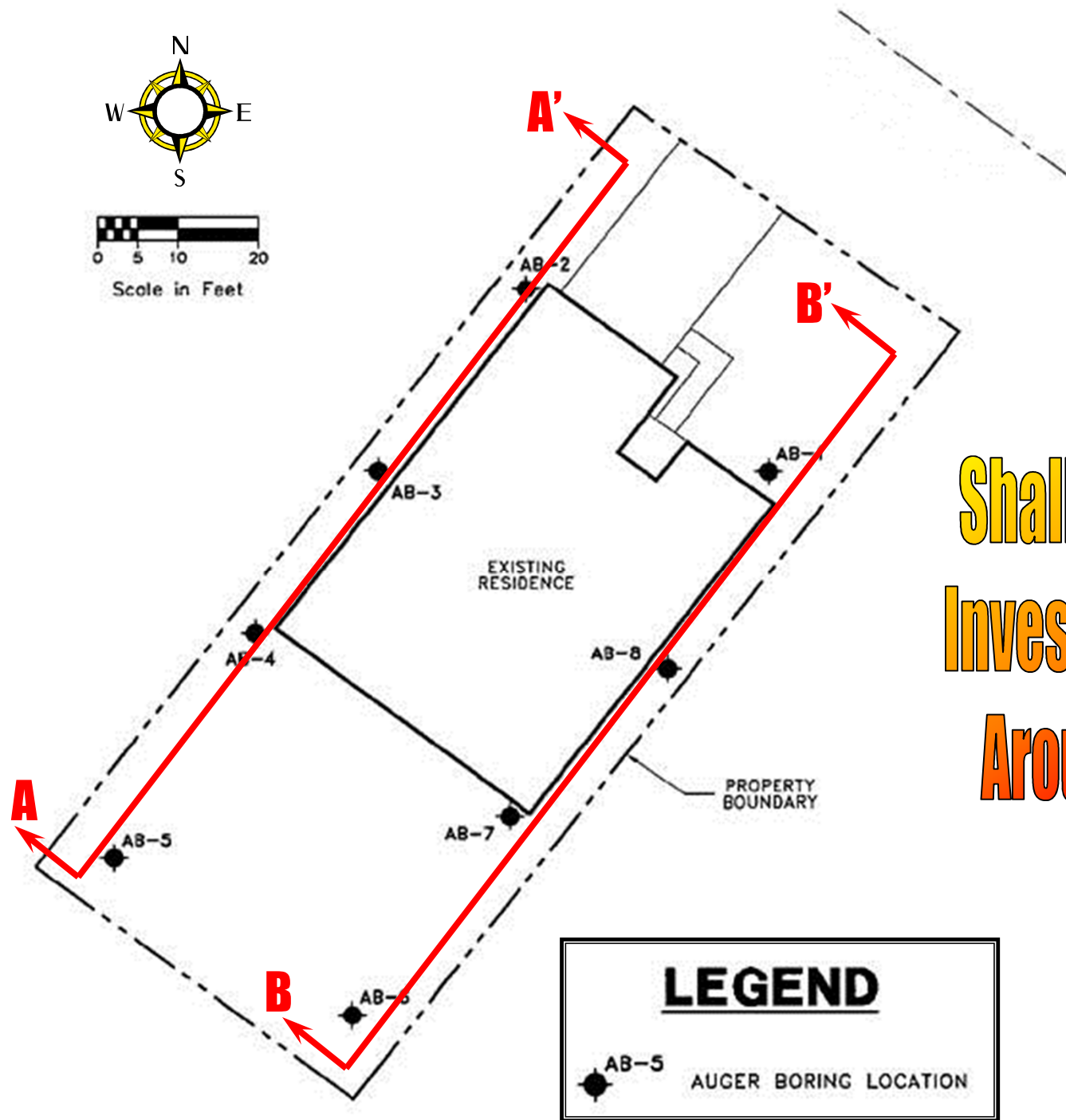
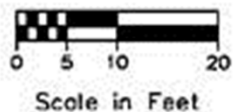
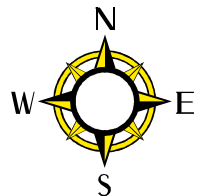
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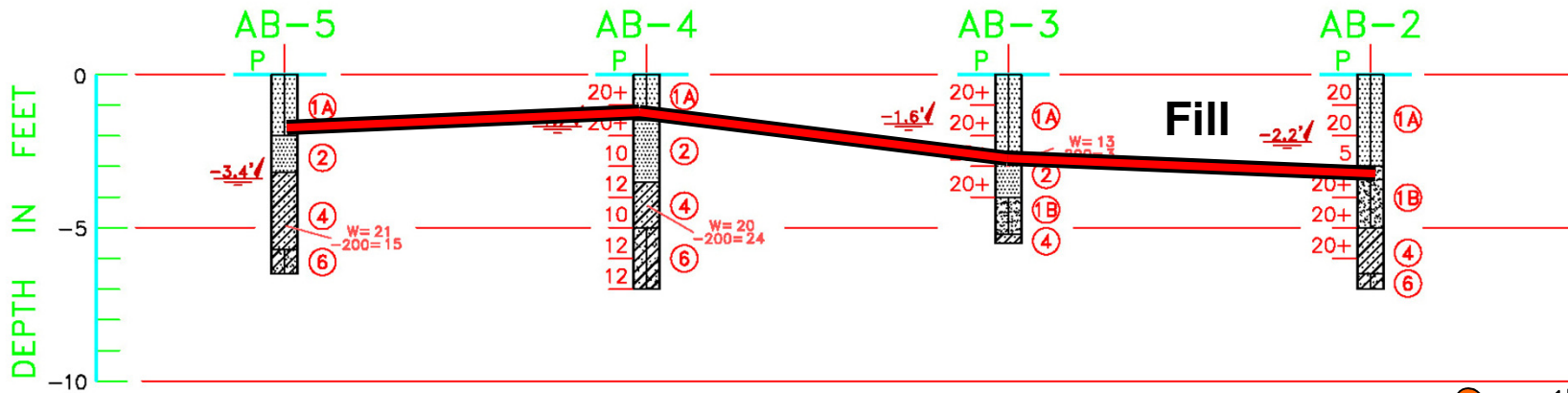


**Soft saturated
unstable subgrade
“apparently ready” for
concrete pour**

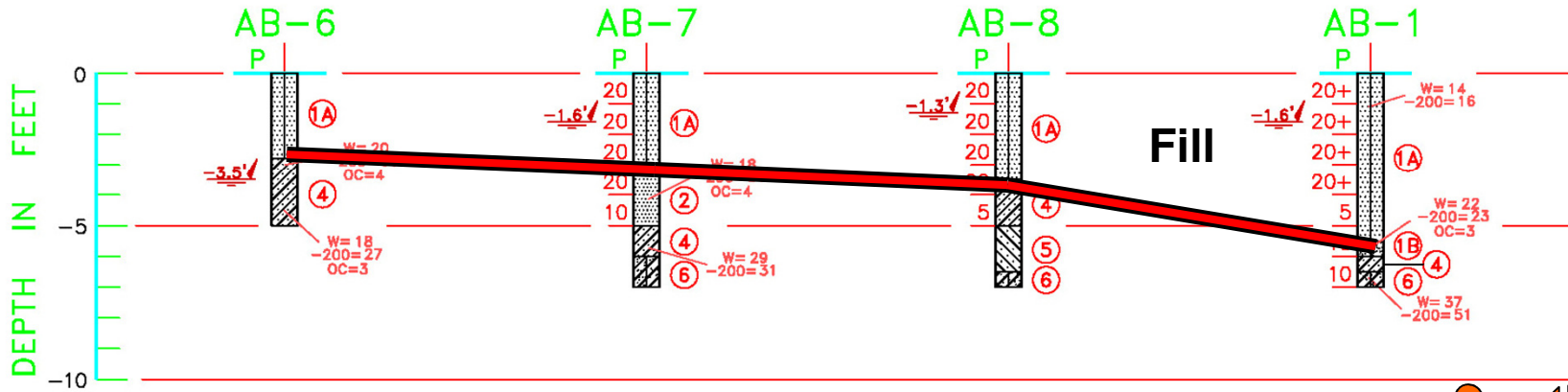
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Shallow Subsurface Investigation Results Around House Pad



Section A-A'



Section B-B'

LEGEND

- ①A MIXED BROWN AND GRAYISH BROWN FINE SAND TO SLIGHTLY SILTY FINE SAND
- ①B GRAY AND LIGHT BROWNISH GRAY SILTY FINE SAND WITH PIECES OF CLAY
- ② LIGHT TAN FINE SAND (SP)
- ③ GRAY AND LIGHT BROWNISH GRAY SILTY FINE SAND (SM)
- ④ GRAYISH BROWN CLAYEY FINE SAND WITH ORANGE MOTTLING AND SMALL ROOTS (SC)
- ⑤ GRAY CLAYEY FINE SAND (SC)
- ⑥ GRAY SANDY CLAY WITH OCCASIONAL ORANGE MOTTLING (CL)

- (SP) UNIFIED SOIL CLASSIFICATION GROUP SYMBOL
- P** PENETROMETER PROBE RESISTANCE VALUE
- 1.2' DEPTH TO GROUNDWATER LEVEL (MEASURED 9/04)
- W** NATURAL MOISTURE CONTENT IN PERCENT
- 200** PERCENT FINES PASSING U.S. NO. 200 SIEVE
- OC** ORGANIC CONTENT IN PERCENT DRY WEIGHT

**Soil Cross
Sections
Around
Building Pad**

Preliminary Evaluation

Ruling out Potential Suspected Causes

- There was no buried muck. Buried organic layers undergo time dependent settlement.
- This area is not within an active sinkhole zone.
- The fill material appears to be of suitable texture and is compacted, except that a 1-ft thick loose zone is observed at the base of the fill.
- There is no evidence of seepage related soil loss below the slab because the eroded soils would have been observed at some downgradient location.

Preliminary Evaluation

Ruling out Potential Suspected Causes (continued)

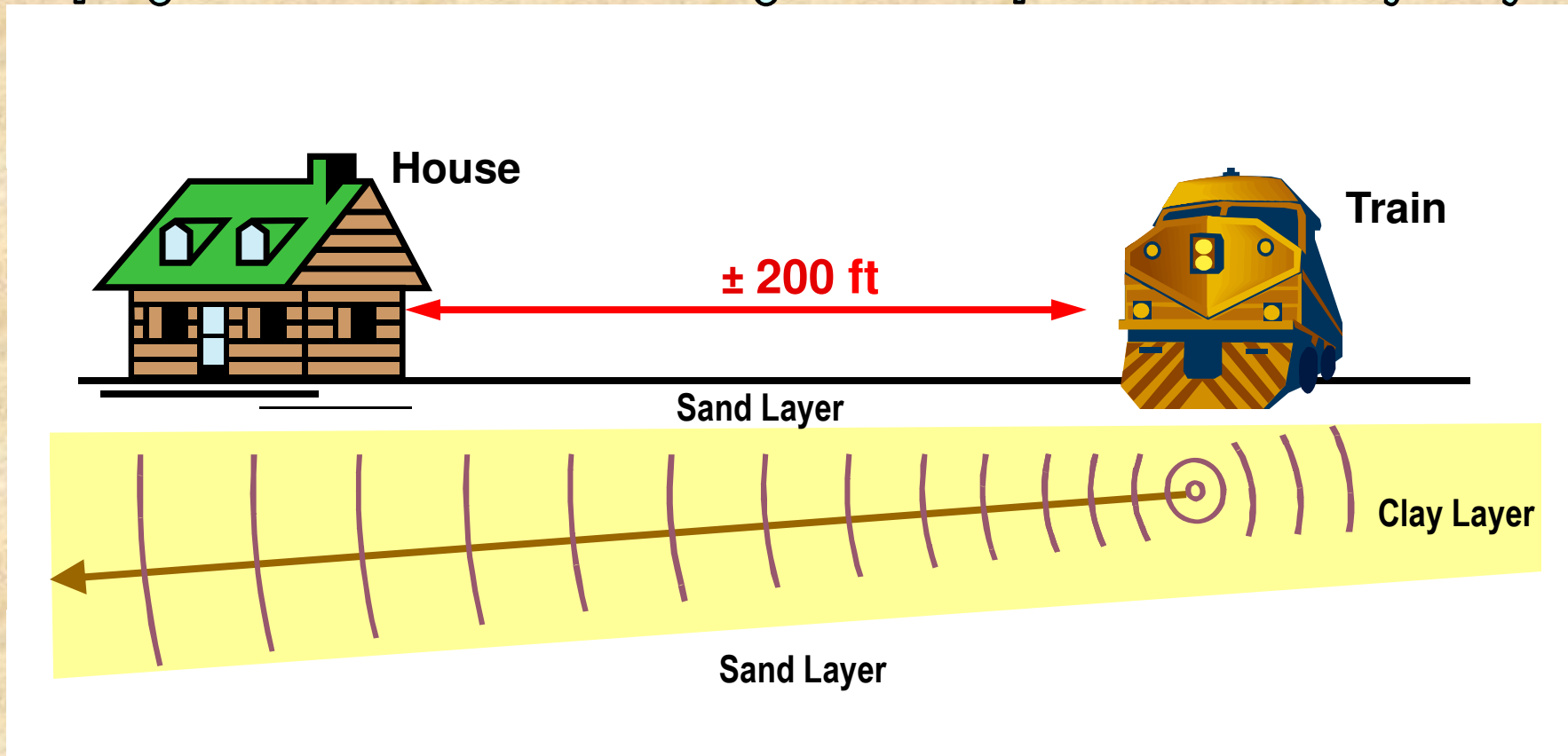
Settlement does not appear to be related to consolidation of clays

- The change in site grade was not significant. About 1 ft of fill was placed above existing grade.
- Plastic clays are too deep (> 5 ft) and generally outside the high stress zones.
- These clays are generally very overconsolidated, and the magnitude of settlement is expected to be small. Overconsolidated clays are clays which have experienced higher stresses in the past.

Final Evaluation

- Vibrations from passing freight trains are being conducted through a layer of “fat” clay near the ground surface. This clay layer occurs at shallow depth beneath the railroad track, and extends beneath the building footprint where distress has occurred.
- The clay layer acts as a “shaking table” which further compacts the loose sandy soils above the clay.

Propagatation of Wave Through Incompressible Clay Layer



This clay layer is incompressible during short term loading, and acts as a conduit for the transmission of vibrations from the freight train. As a result, vibrations are felt at a greater distance than would normally be expected.

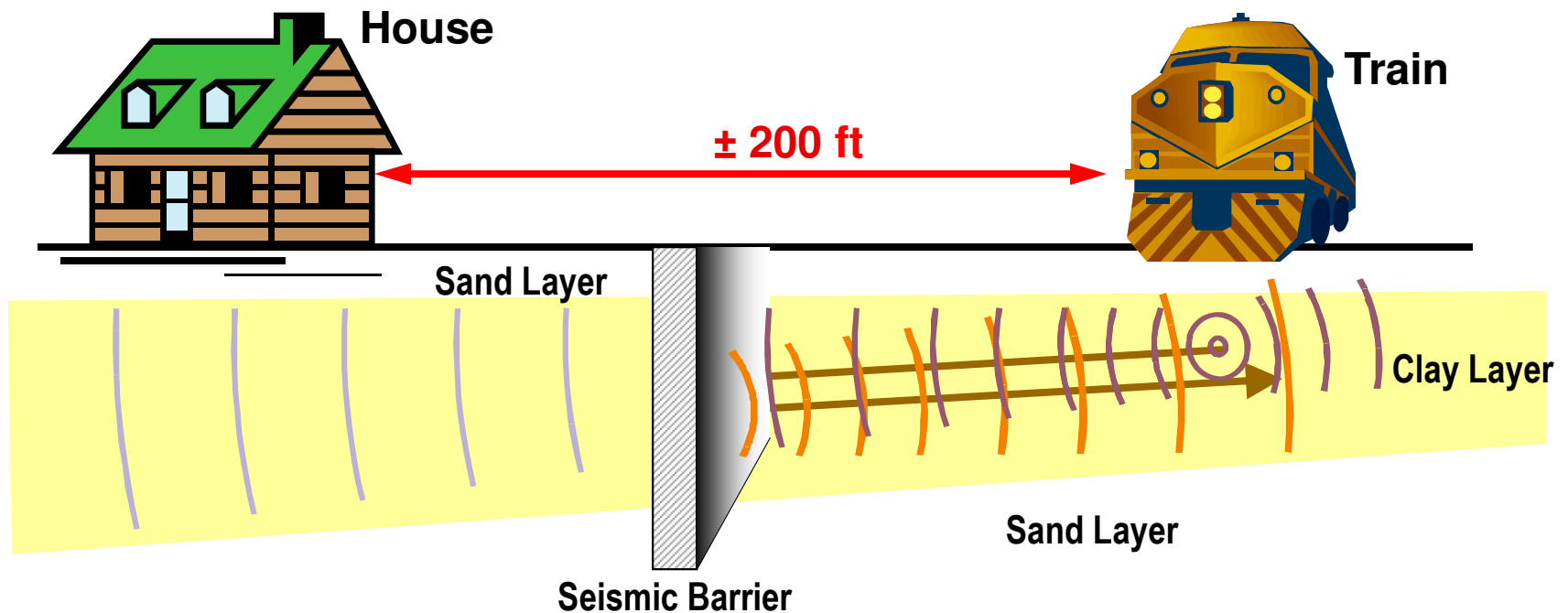
Combination of Adverse Factors

- Site preparation resulted in loose soil zones in natural ground and/or fill material
- No settlement distress was observed during construction. Loose soil zones may not have resulted in significant settlement, except that...
- Vibration from passing trains, conducted through the incompressible clays, resulted in further compaction of loose sandy materials after construction.

Mitigating Building Settlement Distress

Raising foundations to original elevations using one of the following methods:

- **Chemical grouting**
- **Compaction grouting**
- **Pin piles and jacking**



Construction of a seismic barrier to reflect and/or attenuate wave energy, using:

- Sheet piling
- Soil cement curtain
- Chemical grout

Technical Guidelines for Assessing Potential Impact of Railroad Vibrations On Settlement Distress of Residential Structures

Additional borings and engineering analysis should be performed if the following conditions are present.

1. **Offset Distance is less than 250 ft.** Distress was encountered within 200 ft. of railroad track, so a threshold distance less than 250 ft. will require additional investigation.
2. **Fill pads with greater than 18" of sandy soils.** This type of soil can settle by repeated vibration.
3. **Material beneath the fill is continuous solid clay** (or other relatively incompressible materials such as rock, hardpan, etc.) **which can transmit vibration.**
4. **The solid clay is found close to the surface beneath the railroad track (less than 36") such that the vibration can be transmitted to the clay.**

Site Preparation is Critical

Proper site preparation is always important.

In an environment that may be subjected to vibrational stresses, site preparation becomes more critical.

Building distress due to improper site preparation, which may not develop under static loading conditions, is more likely to occur when vibrations are present.