Energy-Efficient, Flood-Damage-Resistive Residential Envelope Systems Testing

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Project Objective:

Investigate impact of flood water on performance of traditional and flood-damage-resistant residential envelope systems.

Flooded homes along the Flint River in Albany, Georgia. Photo by Andrea Booher/FEMA

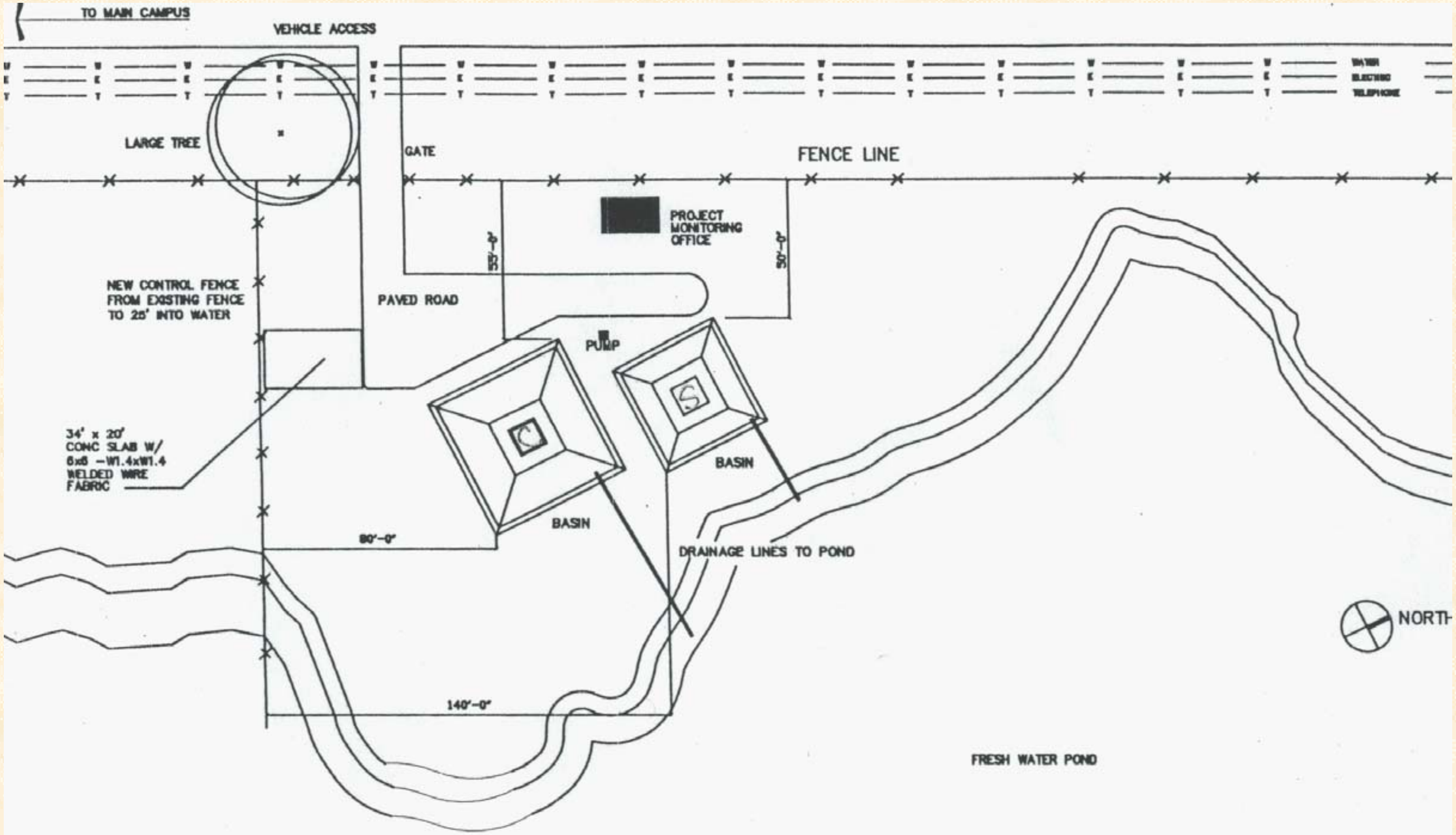
Project Background

- ORNL and Tuskegee University accomplishing this multi-task project.
- Sponsors: HUD, FEMA and DOE.
- Three tasks:
  1) Planning, design, and testing protocol (2000);
  2) Testing, evaluation, and info dissemination (begun 2001);
  3) Analysis and modeling (begins 2003).
- Various tools are being developed to assist those involved in construction or reconstruction of housing.

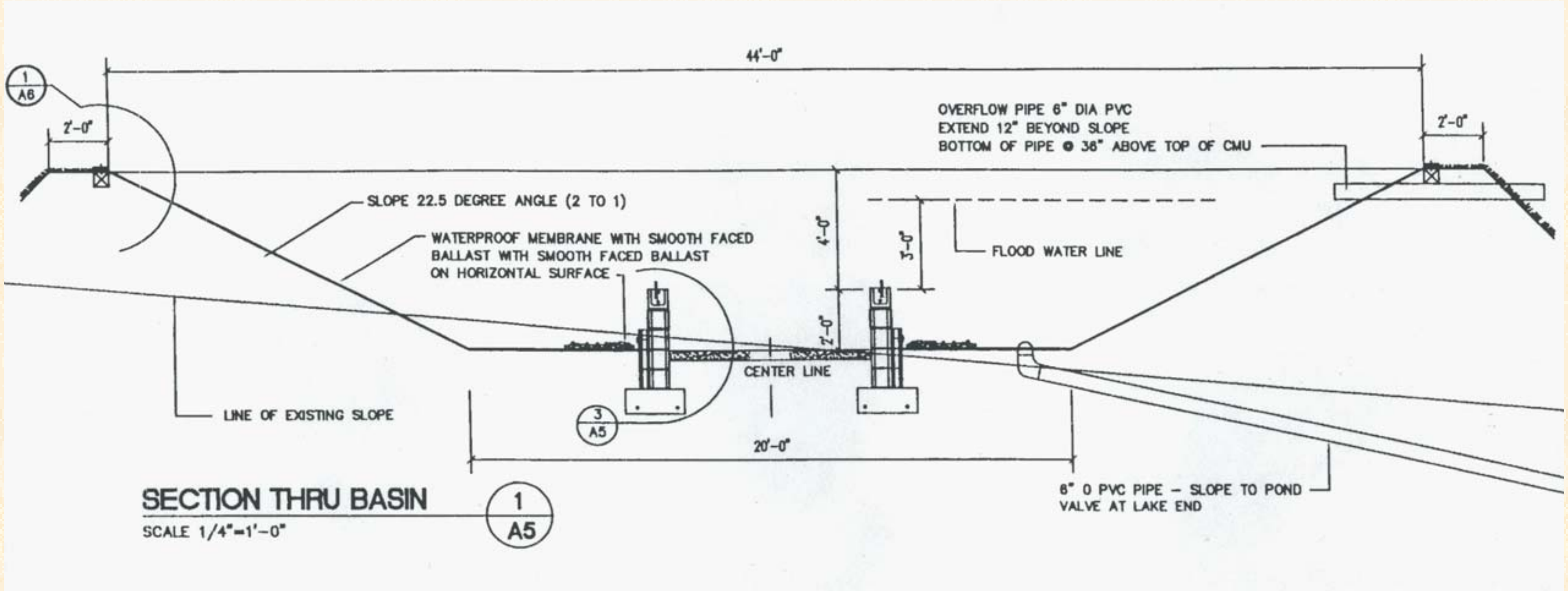
Project Methodology:

- Testing in the field at full size, complete system level, using controlled flooding with untreated lake water.
- Uncontrolled drying conditions (subject to local weather conditions).
- Focus on wetting and drying as cause of damage.
- Address material property changes and restorability to original appearance and intended purpose.

Experimental Facility at Tuskegee University

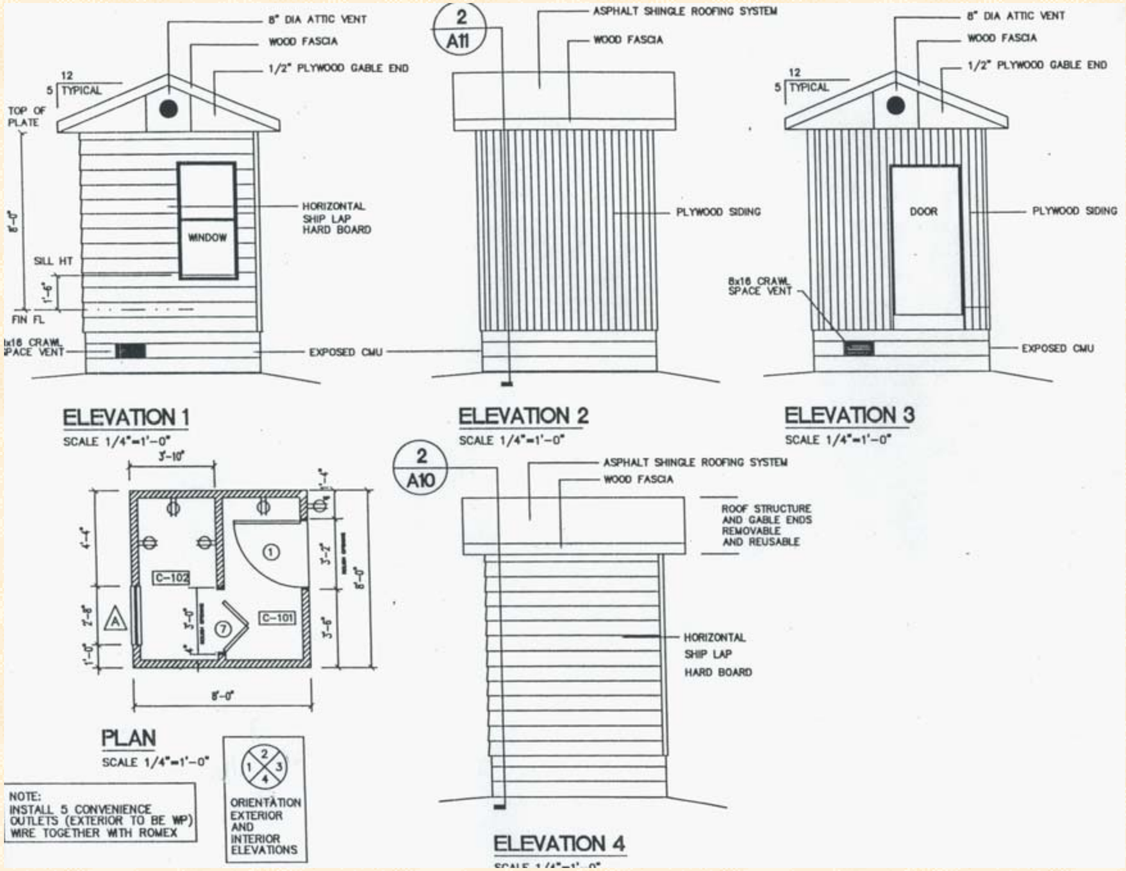


Test Basins

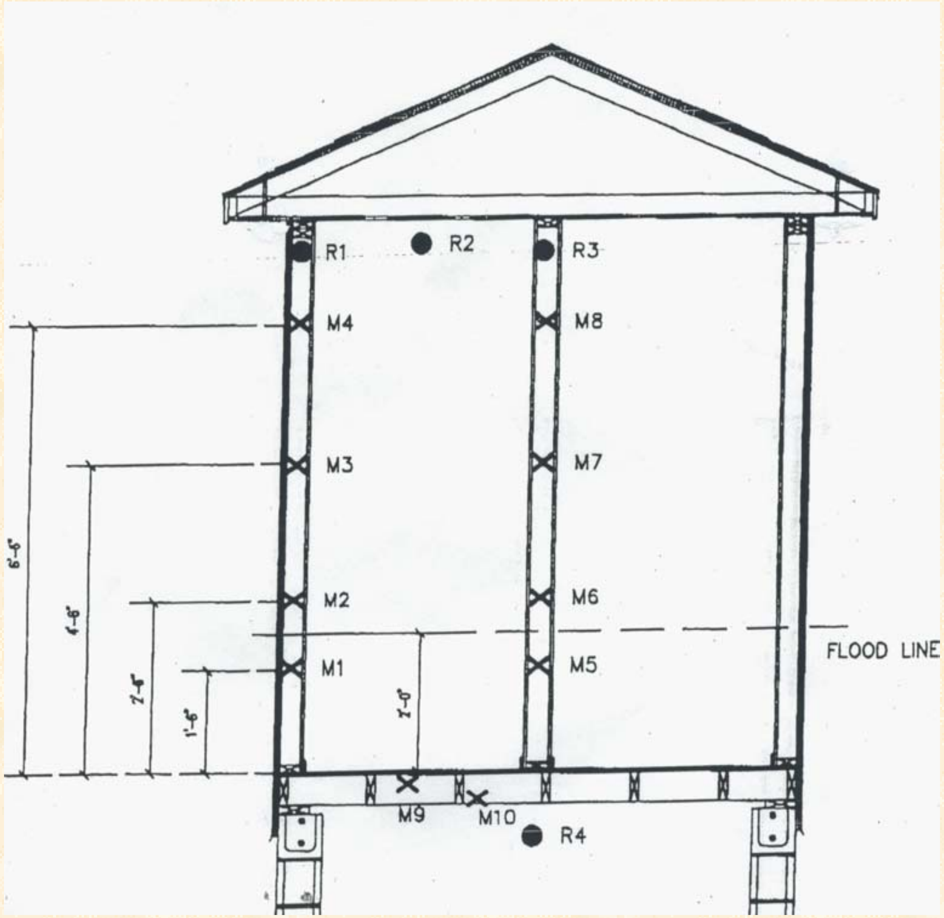


44'-0"
2'-0"
2'-0"
OVERFLOW PIPE 6" DIA PVC
EXTEND 12" BEYOND SLOPE
BOTTOM OF PIPE @ 36" ABOVE TOP OF CMU
SLOPE 22.5 DEGREE ANGLE (2 TO 1)
WATERPROOF MEMBRANE WITH SMOOTH FACED
BALLAST WITH SMOOTH FACED BALLAST
ON HORIZONTAL SURFACE
4'-0"
3'-0"
FLOOD WATER LINE
2'-0"
CENTER LINE
LINE OF EXISTING SLOPE
20'-0"
6" O PVC PIPE – SLOPE TO POND
VALVE AT LAKE END
SECTION THRU BASIN
SCALE 1/4"=1'-0"

Test Module – Traditional Construction



Test Module – Sensor Locations



Slab on Grade Test Module

Before and After Flooding

Crawl Space Test Module

Before and After Flooding

Data Monitoring Module

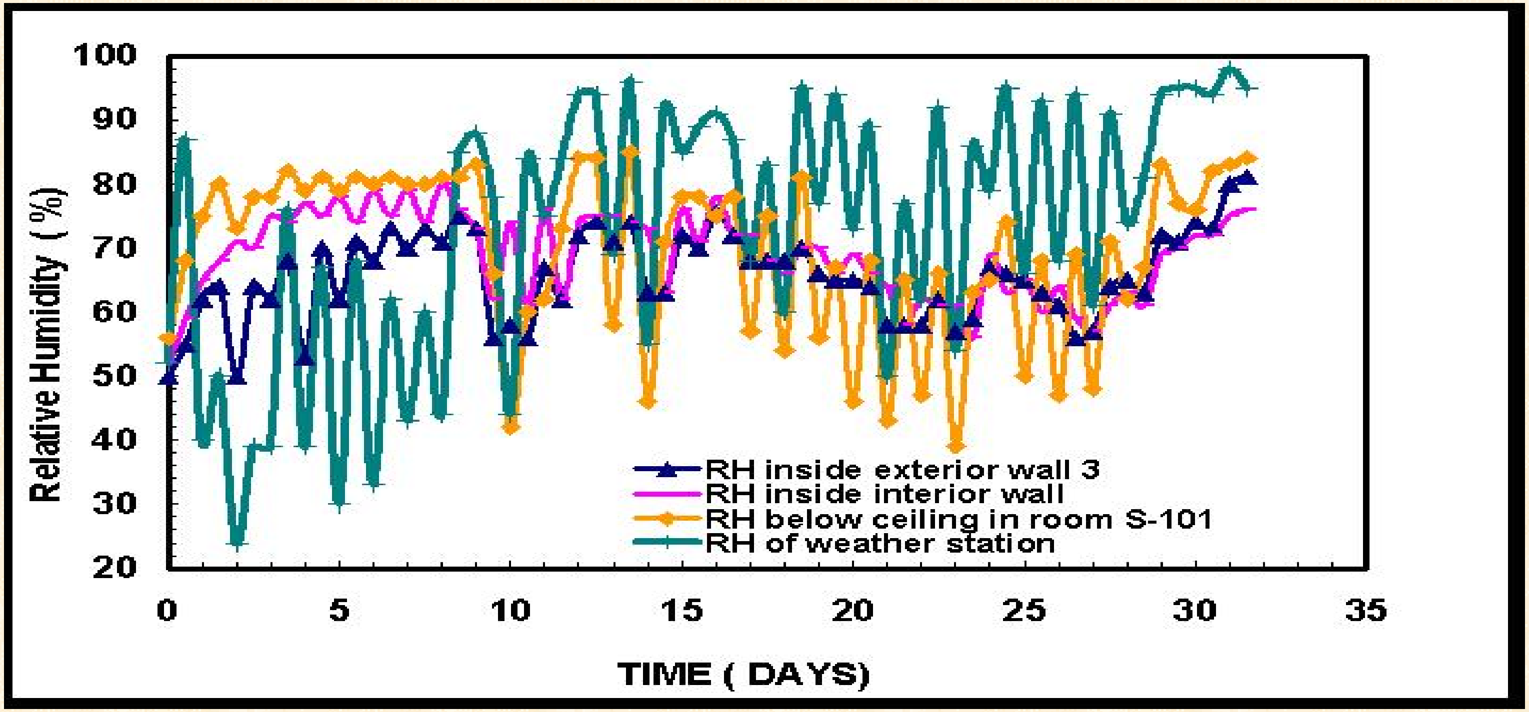
Control Room for Flood Research Project

Testing is Being Guided by:

- Protocol for field Testing Flood-Damage-Resistive Residential Envelope Systems, October 29, 2000.
- Protocol for Drying Out Test Facilities After Flood Water has been Drained from Basins, November, 2001.
- Detailed Evaluation Format and Data Sheets.

Data from Conventional Residential Envelope Systems (Module S1)

Relative humidity versus time at three different locations in module S1 and local weather station.



Photos from Conventional Envelope Systems (Module S1)

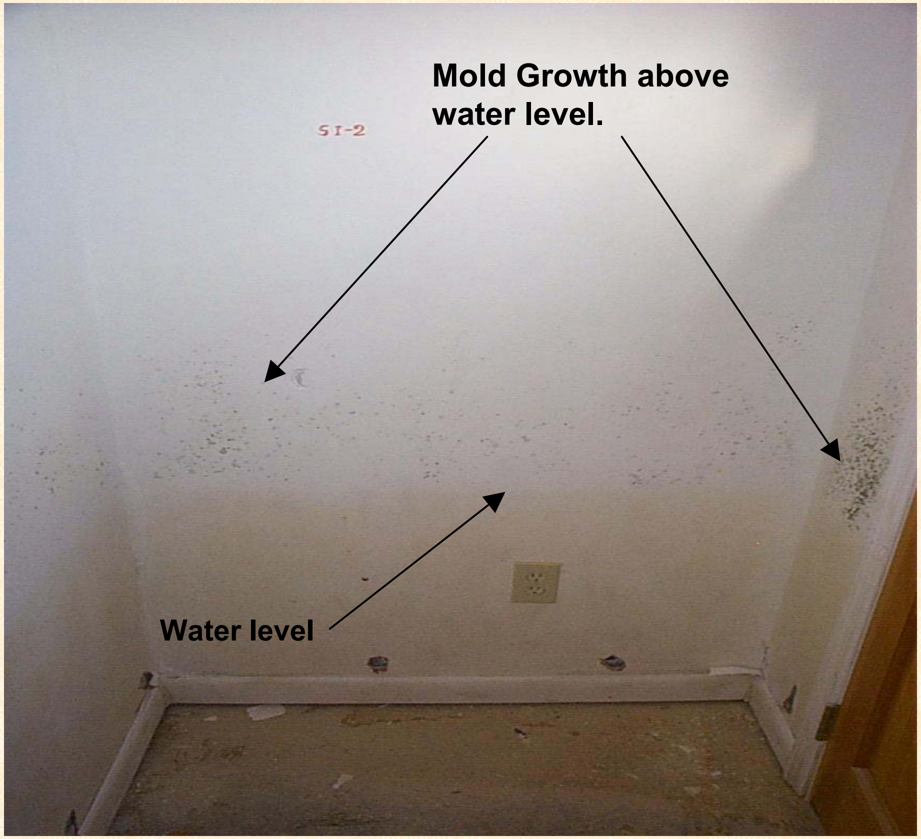
Wall 2 from Room S-102

Pre-flood

Post-flood (12 Days)

Photo from Conventional Residential Envelope Systems (Module S1)

Wall 2 from Room S-101



Post-flood (12 days)

Photos from Conventional Residential Envelope Systems (Module S1)

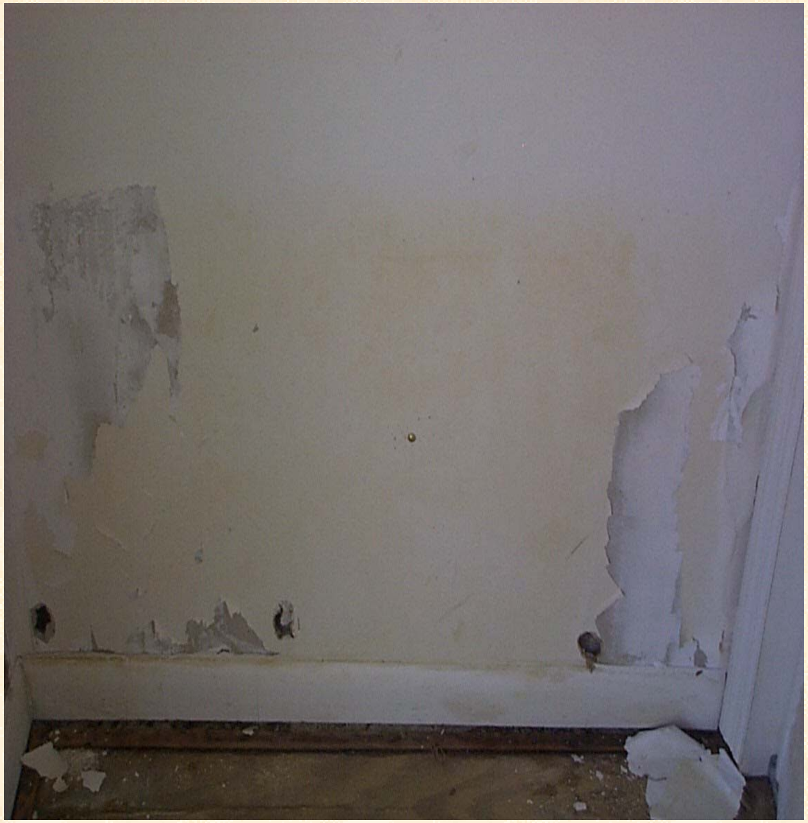
Exterior Wall 2

Post-flood (5 days before washing)

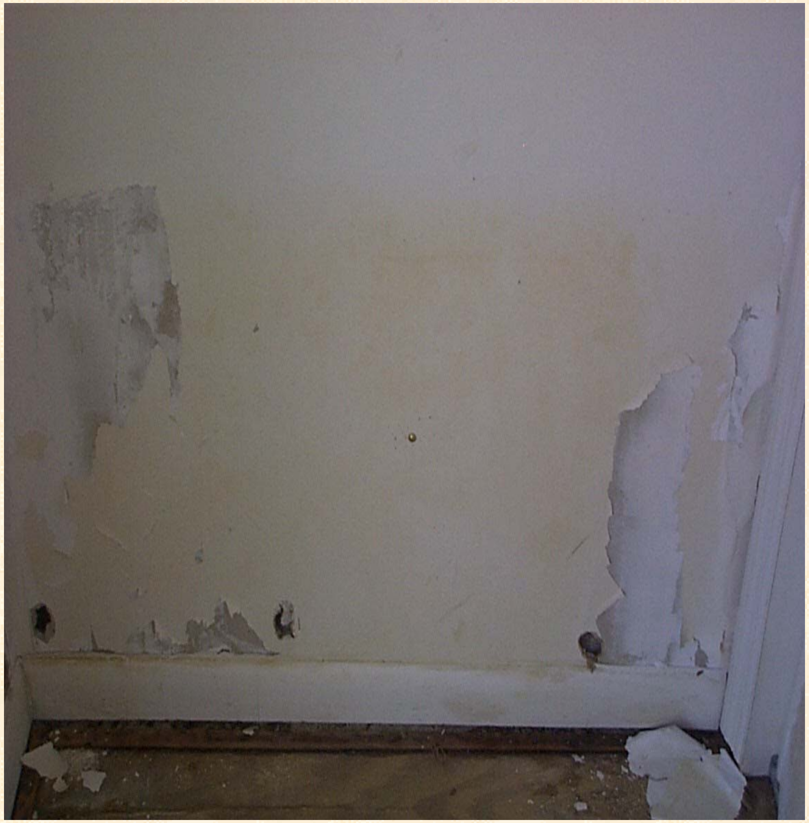
Post-flood (12 days)

Photos from Conventional Residential Envelope Systems (Module C1)

Wall 4 from Room C-101



Post-flood (12 days)



Post-flood (26 days)

Photos from Conventional Residential Envelope Systems (Module C1)

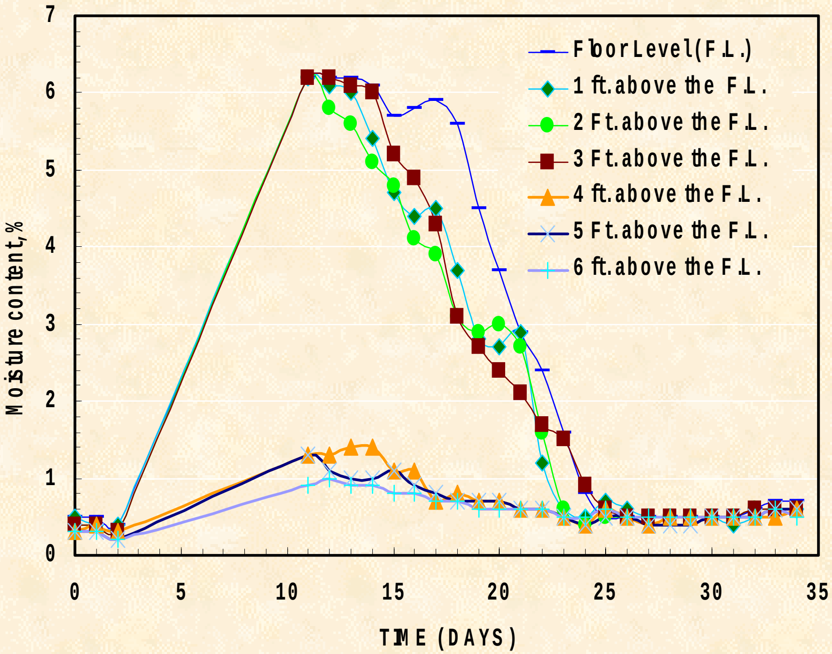
Exterior Wall 3

Post-flood (5 days – before washing)

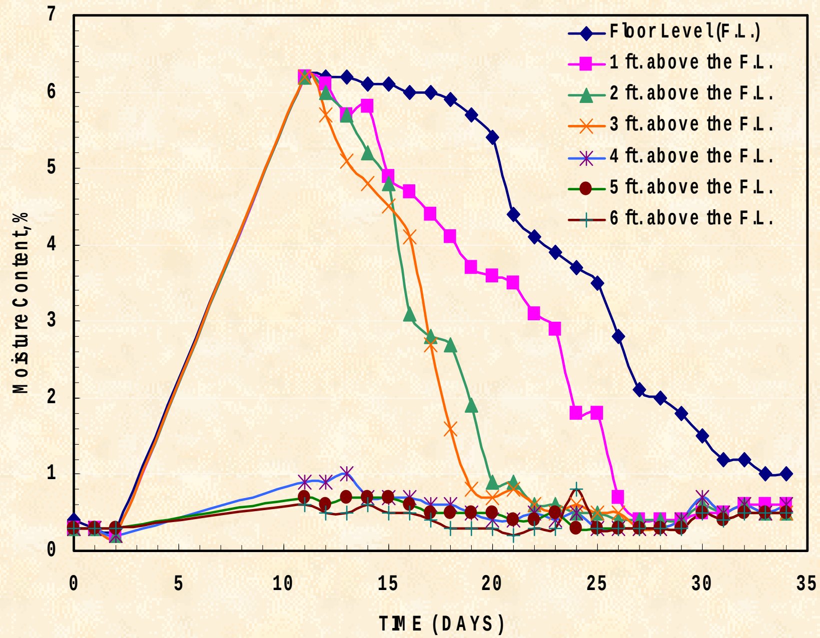
Post-flood (12 days)

Data from Conventional Residential Envelope System (Module S1)

Moisture content of gypsum wallboard before and after flood



Interior wall (open cavity)



South exterior wall (fiberglass insulation)

Data from Conventional Residential Envelope Systems (Modules C1 & S1)

Post drying period flexural strength of gypsum board based on four point bending tests

Module C1 (Crawl Space)

Exterior Wall (Fiberglass insulation)		Interior Wall (Open Cavity)	
Above water level	Below water level	Above water level	Below water level
3.67MPa	1.88MPa	3.75MPa	3.17MPa

Module S1 (Slab on grade)

Exterior Wall (Fiberglass insulation)		Interior Wall (Open Cavity)	
Above water level	Below water level	Above water level	Below water level
3.2MPa	1.64MPa	3.68MPa	3.56MPa

MPa = Mega Pascals

Observations from Conventional Residential Envelope Systems Testing

- Punching holes to let wall cavities drain is unnecessary
- Flat latex wall paint appears to encourage more mold growth than semi-gloss latex enamel
- Standard gypsum drywall may be salvageable if wall cavity dries quickly
- Fiberglass insulation slows drying of the lower portion of gypsum wallboard

Observations from Conventional Residential Envelope Systems Testing con't

- **Solar gain on exterior walls increases drying rate of these walls**
- **Hardboard lap siding (new) and T-111 plywood appear to be restorable**
- **Elevated moisture content (>25%) found in plywood sheathing could be long-term problem if not addressed**

Plans for Future Testing Include:

- Test Modules 2-C and 2-S will be first “flood damage resistive” construction.
  - Typical wood frame construction
  - Spray polyurethane insulation in walls
  - Water durable gypsum wall board
  - Foam plastic sheathing and water durable gypsum sheathing
  - Vinyl siding and fiber cement siding
  - Fiberglass doors and metal doors
  - Vinyl window frames
  - Attention to details
- Test modules 3-C and 3-S will extend and refine the above tests – specifics not yet determined.

Flood Damage Resistant Residential Envelope Systems (Module C2)

Spray Polyurethane Foam (SPUF) Insulation being installed

Energy Performance: SPUF, R-19; Fiberglass, R-11

Potential Future Testing Includes:

- Additional test modules to explore additional materials, systems and testing procedures.
- Testing of most promising systems in contaminated waters (specifics not yet determined).
  - Salt water
  - Fuel oil
  - Sewage
- Industry sponsored testing to evaluate the performance of specific materials and systems.

Expected Outcomes:

- Increased understanding of damage resulting from the wetting/drying cycle.
- Identification of flood damage resistive materials and systems.
- Input to a FEMA pre-standard on wet flood proofing construction.
- Increased interest by government and industry to develop and apply flood damage resistant construction practices.