Dry Basements and Crawl Spaces

K·STATE Research and Extension

Spring rains in eastern Kansas and sometimes in western Kansas cause some homes to have problems with water entry into the basement or crawl space. People wonder, "Does this have to be?" The answer: The entry of water into a basement can be controlled; it requires understanding and following principles. This publication addresses the principles and procedures to have a dry basement. Correcting above-ground and below-ground problems should prevent structural damage to your home as well as dry up those wet areas and damp spots in the basement or crawl space. A dry basement or crawl space improves indoor air quality, makes a healthier home environment, and helps maintain home value.

Diligence is needed to achieve and maintain a dry basement. The principles are:

- Keep surface water from entering
- Keep high groundwater out
- Control water vapor entry through the soil contact walls and floor
- Manage humidity on floor level(s) that have direct soil contact
- Maintain the control practices that are essential

As with all principles, there are likely to be cases where it is difficult to get some component or part to work as described. However, it is important to fully follow all principles to prevent wet or damp conditions. It is the homeowner's responsibility to take action to ensure a dry basement.

Keep the water out

Water enters from three general sources: run-in from near the building, often through a window, door, or a hole or crack in the foundation; high water table (permanent or seasonal); and of course, flooding (Figure 1). When selecting a home or a building site, it is important to know about the water table in the area. High water tables may be either permanent or intermittent (seasonal) wet conditions. The intermittent or seasonal water most often contributes to wet basements. Site selection away from a high water table for a new structure and subsurface drainage for both new and existing buildings are two ways to cope with high water tables.

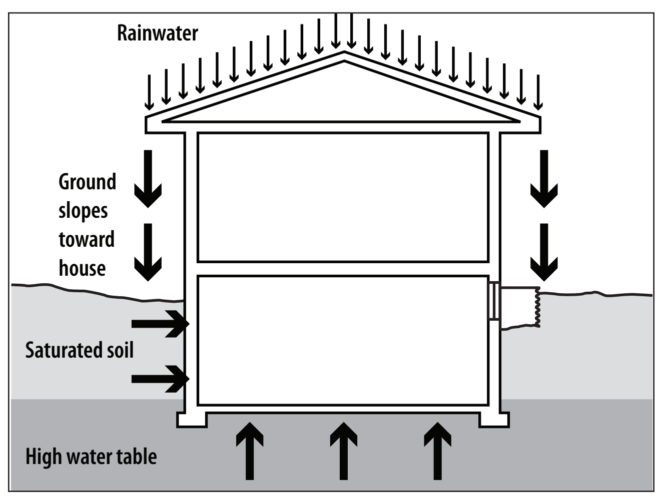

Figure 1. Run-in and high water table water sources

Maintaining a dry basement or crawl space begins with keeping the water away from the structure. Carefully plan and follow construction practices that collect both surface and subsurface water from the building exterior and convey that water away so it does not enter the structure. Site selection for a new home must consider proximity to potential water sources. When purchasing an existing home, location relative to potential water sources should be carefully considered especially if the home is relatively new and has not been exposed to an extended wet period. A buyer should also be aware of the upstream watershed and adjacent lots for increased impervious surfaces or changes in drainage, especially when the house is near a flood plain, close to a stream, or in a low area. Look for new housing development, roads, industrial or office complex, and all other areas with impervious surfaces. Impervious surfaces increase the runoff, shorten the time for water to arrive downstream, and cause higher flood levels.

Stay out of the floodplain

Be aware of and avoid building in floodplains, along streams, near lakes, or in low areas (Figure 2). Horizontal separation from surface water is not as important as vertical separation (elevation) above a possible high flood level. A 100-year floodplain will not assure protection from flooding over a 100-year structure life because a bigger flood, such as 500- or 1000-year event could occur. A difficulty when assessing site vulnerability is possible future development that increases the impervious area. When upstream development occurs in a watershed, the result is higher flood flows downstream during runoff events. Thus, a house not originally subject to flooding may later be flooded because of upstream development. The community planning department should be able to identify expected flood levels under build-out conditions (full upstream development in the watershed).

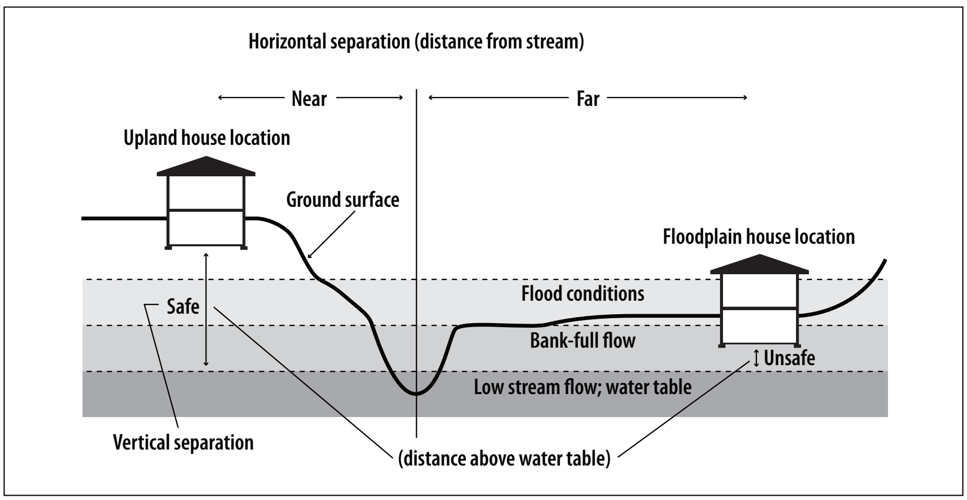

Figure 2. Location with respect to floods and groundwater

Plan for high water table

When evaluating a home site, examine soil and rock profile layers for evidence of drainage restrictions. Restrictive layers are especially important in rocky areas because these layers will impede drainage. Layers that restrict downward movement through the soil profile cause water to collect above the layer during wet weather. Surface water may appear as seeps or seasonal springs. When this condition occurs near a basement wall with inadequate drainage control, the result may be water in the basement. However, when surface drainage is correctly designed, installed, and maintained, water is easily diverted without a problem (Figure 3). The construction of a basement wall through layers of soil or rock can act as a barrier to water movement above a restrictive layer causing a water buildup next to the wall. It is wise to always install a footing water collection and drainage system (building codes typically require this) to protect the basement even on sites considered to be well drained. The cost is quite minimal during construction (few hundred dollars) but disruptive and very costly (several thousand dollars) to install for an existing structure.

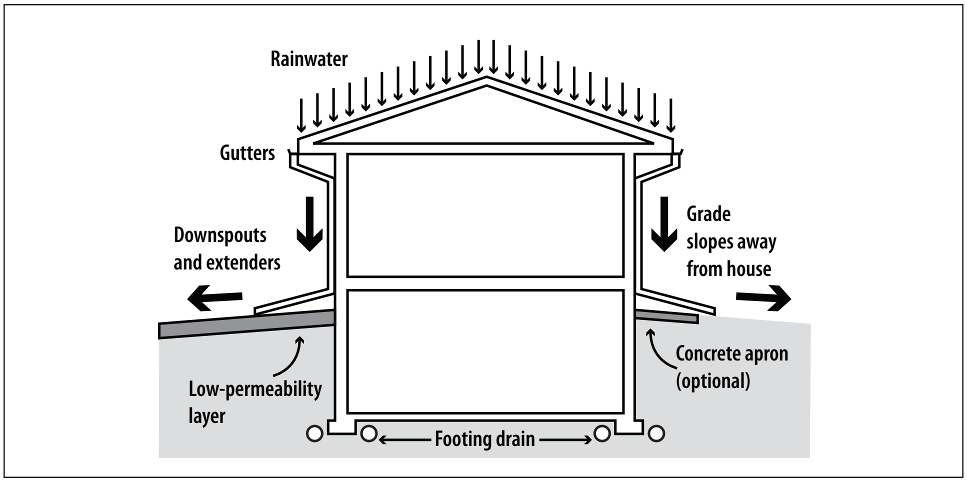

Figure 3. Good practices to remove water from the homesite

In high rainfall areas, it is standard practice to install perforated drainage pipes both inside and outside of the foundation wall footings. These drains collect water from around the foundation and must connect to an adequate outlet to drain that water away from the footings. On sloping sites with enough elevation difference, the drain can gravity flow on a slight grade to the ground surface. Because gravity drains do not require power or mechanical equipment, they are much more reliable than pumping; therefore use gravity when possible. For sites that do not have enough elevation difference, a pump is necessary to remove water. Consider how the water will be removed when the electricity is out.

A properly installed drainage system besides the foundation footing below the basement floor will prevent saturated soil conditions next to the walls and helps ensure a dry basement. One study of wet basement problems found that the cause for more than 90 percent of the cases was due to improperly installed footing drainage systems. Properly installed footing drainage is a must-do building component to keep the basement or crawl space dry.

A properly installed foundation drainage system includes perforated drainpipes placed alongside the footing, with the top of the drainpipe at least 2 inches below the top of the footing. Preferably install drains at both the inside and outside of the footing. If installing drainpipe only on one side of the footing, 2-inch-diameter weep holes through the footing are required every 6 feet. For new homes, install at least 5 inches of coarse granular material such as gravel or crushed rock under the basement floor. The drainpipe system must either drain by gravity to the surface or be pumped. The drainage system cannot protect the basement from water if it does not have a reliable outlet.

Photo 1. Excavation of the basement wall shows no retarder and causes much disruption of landscape for repair.

Installing footing drains on an existing home is likely to be quite expensive. This can be done by excavating to the footing level on the outside (Photo 1). *Note:* excavations deeper than 5 feet usually require shoring to protect workers. An alternative on the inside is to remove a section of concrete floor next to the outside wall. After the soil is excavated beside the footing, install a perforated drain line, gravel envelope around the drain, a geotechnical soil barrier, and grade to gravity outlet or sump pit and pump to surface.

Sewage water backup

Another cause of water run-in to a basement is sewage backup from central collection systems, a plugged drain, or an onsite (septic) system. Central sewage collection systems occasionally are overloaded during high rainfall/runoff conditions and can backup into the lowest outlets. This is most common where the same sewer system carries both stormwater and sewage but may also occur because of infiltration into the sewer system. A malfunction or failure of a lift station can also cause a sewage backup. If a home is subject to frequent backups, a backflow valve can be installed on the sewer line to help prevent a sewage backup. A backflow valve requires maintenance and is subject to failure, so it is not foolproof.

Where homes are served by an onsite system, high rainfall conditions that result in soil saturation can cause a malfunction. Backup into the structure or surfacing in the absorption field occurs when the soil cannot handle the excess rainfall plus the normal sewage flows. When either condition occurs, immediately reduce water use as much as possible until the field dries out.

Cleaning after a sewage backup is critical to protect the health of those living in the home. The Kansas Department of Health and Environment publication *Basement Flooding* addresses actions to prevent sewage backup and steps for cleanup. It is posted on line at *www.kdheks.gov/download/Basement_Flooding.pdf.*

Avoiding water run-in

Just as the roof is sloped to shed water, the soil surface around your home should be sloped, so water drains away from the foundation (Figure 3). Drain water away from the foundation using gutters, downspouts, and surface elevation control. This avoids conditions where water accumulates within 15 feet of the foundation and helps ensure that water cannot flow into the basement. A surface slope away from the foundation for 15 feet using about one inch per foot is ideal. A sloping pipe or other channel is ideal to carry water away from the downspout. In cases where backfill materials near the footing are permeable such as sand, it is a good idea to use a 6- to 12-inch thick layer of low permeability soil on the surface or a sloping plastic membrane buried 6 to 12 inches deep adjacent to the house to limit downward movement in this backfill. The membrane must be continuous and slope away from the foundation as specified above.

The backfilled soil next to the foundation frequently settles over time, lowering the elevation, and perhaps reversing the slope. When this occurs, water will run toward the foundation rather than away from it. As settling occurs, add fill to maintain the slope away from the foundation of at least 6 inches in 10 feet.

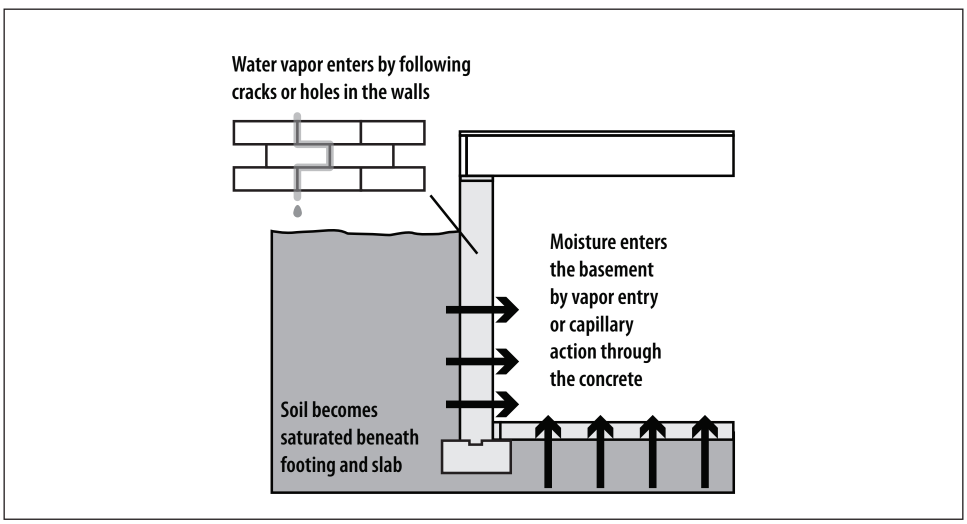

Figure 4. Water vapor entry via cracks and concrete transmission

Include periodic checks of the slope when doing routine landscape maintenance. A simple carpenter's level, a 10-foot straight board, and tape measure are all that are needed to make sure the grade away from the foundation is adequate. Be sure to maintain the slope when doing new foundation plantings or replacing plants.

Caution: In areas of high shrink-swell soil, do not fill and tightly compact cracks next to the basement wall when the soil is dry. Soil often expands when it s rewetted causing pressure against the basement wall that could crack it and even cause it to collapse.

Basement window wells require special attention because water that collects there can easily enter the basement. Surface water must readily drain away and gutters must prevent roof runoff from flowing into the window well. With heavy driving rain, wind can deposit a lot of water onto the siding where it runs down into the window well.

A plastic cover for the well is a good way to prevent entry of water from above while allowing natural light to enter the window. When raised above the well, it can still allow ventilation. A drain in the bottom of the window well to the surface or the foundation drainpipe may be a good addition. However, it must remain unclogged.

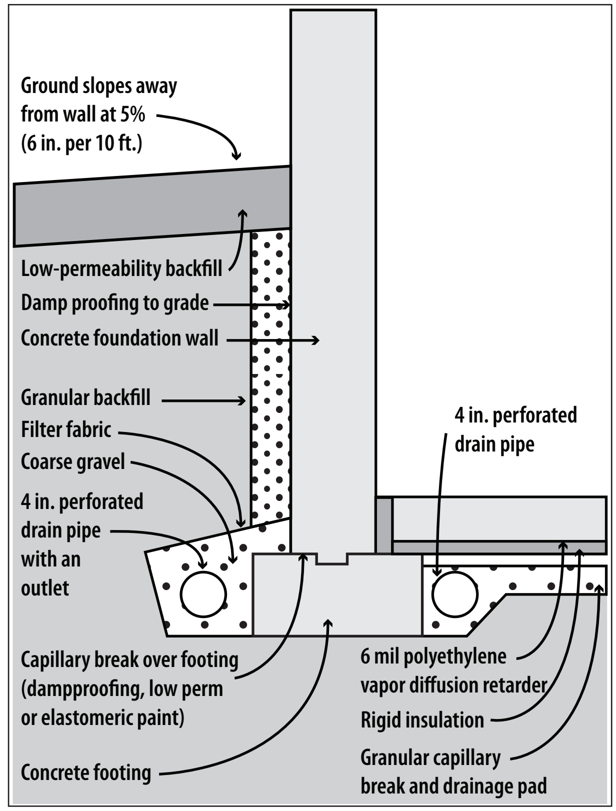

Figure 5. Details showing good construction of drains, vapor retarder, insulation, and granular backfill for basement wall and floor

Controlling water vapor entry

Although it may seem unlikely, research has documented as much as 15 gallons per day of water vapor entering a basement space via vapor transmission through unsealed walls, floors, cracks, and openings and by evaporation from wet surfaces (Figure 4). Control of water vapor entry is best done by a vapor retardant or barrier on the exterior of earth contact walls and beneath earth contact floors. On soil contact walls, asphalt or tar coating is typically applied to the foundation surface as a vapor retarder. This should be done with at least two coats. The greater the care in applying this retarder, the better the protection from water vapor entry. For concrete floors, a polyethylene membrane at least 10 mil thick is often placed over the rock layer before pouring the floor.

In crawl spaces, a carefully placed and protected 10 mil thick plastic membrane is usually adequate to control moisture evaporation from the soil surface. It is important to prepare the soil surface to help protect the membrane from damage and also to protect it with a layer of sand after it is placed. This is especially important in unvented crawl spaces. For more information and details about vapor retarders and house foundations, see *The House Handbook*.

In areas of known moisture problems, the vapor retarder on the outside of the walls should be upgraded to a plastic vapor-retarding membrane. In cases where free water is expected adjacent to the outside wall, a free draining fill material (medium or coarse sand) or drainage mat should be placed just outside of the vapor membrane (Figure 5).

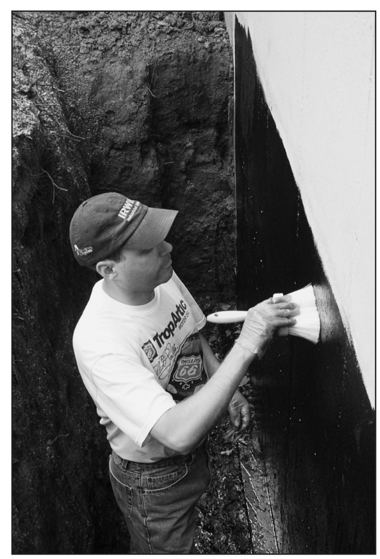

Photo 2. Application of third coat of retarder to wall helps assure a continuous barrier for water vapor and moisture control.

For an existing home, controlling water vapor entry into a basement may not be easy. Sealers can be applied to the interior of walls to reduce water vapor transmission. Often the most reliable option is to excavate the outside wall, carefully clean the surface, and apply a vapor retarder coating as is done for new construction (Photo 2). Be sure that the wall is thoroughly dry before applying the retarder coating. If not already present, footing drains should be added.

For the soil contact floor of a new structure, the plastic vapor retarder membrane should be placed on top of the granular fill or insulation before pouring the concrete. In existing homes it should be possible to seal the concrete floor with a surface-applied, penetrating, vapor-retarding liquid.

Controlling humidity

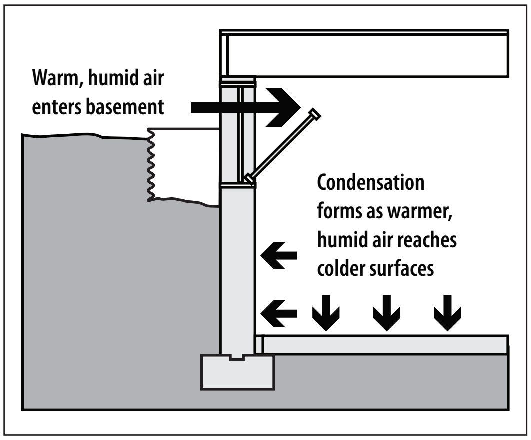

Figure 6. Condensation and high humidity on earth contact walls and floors.

Even when a home is protected from water run-in and water vapor transmission through walls and floors, it can still be affected by moisture from humid air. Humidity is water vapor in the air. Water evaporated into the home's interior contributes to humidity. Many water uses and appliances contribute to in-house humidity including laundry, automatic dishwasher, cooking, hot tub, and bathroom (shower, wet towels, wet clothing, and tub). Humidity is noticed most on the level with soil contact (the basement) because the temperature there is lower, thus making the relative humidity higher even when the moisture in the air is the same throughout the entire house. Reduce excessive indoor moisture by exhausting warm moist air from laundry, cooking, and bath areas and by providing adequate moisture control for the whole house.

Because the soil contact floor level is cooler, humidity may cause condensation on the walls or floor, resulting in damp surfaces and/or high relative humidity (Figure 6). This most often occurs seasonally in the spring when the walls and floor are cold and the outdoor air is warm and moist. When windows are opened for ventilation, warm moist air comes in contact with cool surfaces and causes sweating, much like a glass of ice water in the summer.

Mold and mildew on surfaces and in fabrics are caused or increased by high humidity. Molds can create a serious health problem for some people and are a concern for everyone. A mildew odor can also seriously reduce the value of a house. The easiest control is to limit the time windows are opened when the outside air is warm or hot with high humidity. Carefully watch the outside dew point temperature and avoid opening windows when the dew point is above 55 degrees. Wait until the walls and floor warm up. Later in the summer when the walls and floor are warm, moist air usually does not cause sweating.

Even with good measures to control water and water vapor entry, high humidity is still possible in humid climates and seasons. A good method to control humidity – especially on levels with earth contact – is to use a dehumidifier (unless the space is conditioned by refrigeration). A dehumidifer reduces the dew point temperature of air. This is especially helpful in basements.

Maintenance of Water and Vapor Controls

All components that control water entry, water vapor entry, and humidity require operation and maintenance to ensure good performance. Gutters, downspouts and extensions, ground surface slope control, and window wells must be maintained to avoid water run-in. The footing drain outlets or sump pump must be kept operational to ensure that drain water is carried away to the surface. A regular check of components that keep water and water vapor out is essential on a monthly or even weekly basis during the wet season. A water level monitor for a drain sump is a relatively inexpensive device that will alert the occupant if water levels rise too high or if floor drains back up.

Name/Description	Advantages	Limitations	Risks/Questions	Relative Cost
1. Footing drain: outside and below bottom of footing. Can be used in combination with option 4.	**Best option;** most complete lowering of water table. Avoids water contact with footing; prevents wick up.	Retrofit installation is costly; destructive to landscaping.	In unstable soil, footing may shift. Slight chance of soil getting into drain – may be able to clean. **Must have an effective outlet.**	New construction – few $100. Retrofit – several $1,000.
2. Footing drain: outside and beside footing. Can be used in combination with option 4.	**Good option;** adequate lowering of water table.	Water in contact with footing; can wick up. Retrofit installation is costly and disrupts landscaping.	Slight chance of soil getting into drain – should be able to clean . **Must have an effective outlet.**	New construction – few $100. Retrofit – several $1,000.
3. Footing drain: outside and above footing.	Cheapest to install; involves only materials and placement. No extra excavation.	Would not keep footing or basement floor dry. Generally unsuitable for finished basement.	Basement floor is wet; water wicks through. Mold and mildew probable. A poor option.	New construction – $100–200. Retrofit – several $1,000.
4. Footing drain: inside and beside footing. Can be used in combination with options 1 or 2.	**Good option;** adequate lowering of water table below floor. Drain doubles to facilitate radon removal.	Water is in contact with footing; can wick up. Retrofit involves removing a 2 ft or greater width of basement floor.	Slight chance of soil getting into drain – should be able to clean. Does not control water from wall cracks. **Must be connected to a sump with a pump.**	New construction – few $100. Retrofit – few $1,000; much more with finished basements.
5. Drain tube (or channel) placed on top of inside of footing.	Easy installation for many retrofits.	Water must wet floor to enter tubing. Retrofit requires removing several inch width of concrete floor.	Not a good option to keep floor dry. Water level will be in concrete; floor will be wet. **Must be connected to a sump with a pump.**	Retrofit – many $100 to $1,000s; much more expensive for finished basements.
6. Baseboard style channel placed on inside of outside basement wall. Conveys water to drain.	Easy and quick to install; just glue down. Little preparation required.	Drain collects water after it enters. Walls and floor may be wet. High humidity and mold are probable.	Adequate capacity to carry all water. Seems unsuitable for finished basement. Cost may seem high for results obtained. Not a good option.	Retrofit – several $100 to $1,000s.

References and information sources:

Assessing, Repairing, and Rebuilding Basements: Building Basements in Wet Locations, PM-1561, March 1994, Tom Greiner and Stewart Melvin, Extension Agricultural Engineers and Laura Sternweis, Extension Communications, Iowa State University – Extension, Ames.

Avoiding Basement Flooding in About Your House — General Series, Canada Mortgage and Housing Corporation, Web site *www.cmhc-schl.gc.ca/en/co/maho/gemare/gemare_002.cfm*

Moisture in Basements: Causes and Solutions, FO-07051, Revised 2006, John Carmody and Brent Anderson; Revised by Richard Stone, University of Minnesota, Cooperative Extension Service.

The House Handbook, MWPS-16, Midwest Plan Service, 122 Davidson Hall, Iowa State University, Ames, IA 50011 *www.mwps.org*

Wet Basement and Crawl Space Problems, Causes, and Remedies —Tips for Homeowners, and Home Buyers, September 1997 by Dr. Bruce A. Tschantz, P.E., Professor, Civil Engineering, University of Tennessee, Knoxville.

Wet Basements, D-12, A.R. Jarrett, Professor, Agricultural Engineering, Pennsylvania State University, College of Agricultural Sciences, Cooperative Extension

Figures 1–4 and 6 adapted from Carmody, Anderson, and Stone, FO-07051, University of Minnesota.
Figure 5 adapted from *The House Handbook,* MWPS-16, Midwest Plan Service.

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