If it is not possible for gas to migrate from targeted formations, why does industry show so much evidence to the contrary in these, their very own documents?
The gas industry asserts that the target formation is thousands of feet from water supply aquifers and that the aquifers therefore cannot be contaminated by migration of natural gas, radioactivity, VOCs and other chemicals.

However, SOUTHWESTERN ENERGY’S own powerpoint deck shows three ways that just such a scenario can occur:

**CEMENT CHANNELING**
The cement forms incomplete bond to the casing, sometimes caused by exposure while curing to pressurized gas.

**LEAK THROUGH CASING**
The casing itself starts to corrode over time due to exposure to moisture and chemicals.

**INSUFFICIENT CEMENT COVERAGE**
The annulus around a casing string is not cemented to the surface, allowing pressurized fluids access upwards to a freshwater aquifer.
SCP can result from direct communication with gas in shallow formations as well as the target formations, usually caused by poor primary cementing.

In this article from Oilfield Review, it is stated that sustained casing pressure is an indication of communication to the annulus from a sustainable pressure source because of inadequate zonal isolation, caused by gas migration due to faulty cement or casings.

This chart shows the number of wells in the Gulf of Mexico with SCP - or the failure rate - by age. As you can see, 6% fail immediately, and within 15 years, over 50% have failed.

Migration is a common problem in Canada. Most of the SCP/migration is due to gas.

It is acknowledged that the search for energy in ever more remote locations — "extreme energy" — will push technology and operators to the limit: the consequences of "poor zonal isolation" are more failures.
There are 4 commonly understood causes of SCP, although identifying the precise cause is often difficult, likely for the same reason that remediating is difficult.

A — Tubing migration leaks. If they lead to a failure of production casing, the outcome can be catastrophic, jeopardizing personnel safety, production facilities and the environment.

B — Poor mud displacement leads to poor zonal isolation and gas migration.

C — Cement loses volume as it sets, leading to unbalanced hydrostatic pressure.
D — Even after a flawless cement job, the cement can still be damaged by the routine operation of the well. Also, the mechanical properties of casing and cement vary over time; differential expansion and contraction due to temperature, pressure or vibration can cause the bond between casing and cement to fail.

Controlling Gas Migration

As the borehole reaches deeper into the earth, previously isolated layers of formation are exposed to one another, with the borehole as the conductive path. Isolating these layers, or establishing annular isolation, is key to minimizing the migration of formation fluids between zones or to the surface where SCP would develop. Careful planning is required in the drilling process to ensure that these layers are properly isolated.

Cuttings response to drilling fluids. Cuttings samples were taken from a well in the southern Gulf of Mexico drilled with oil-base mud, showing that cuttings had not been exposed to water-base mud prior to sampling. Altering cuttings from the cuttings surface, Schlumberger laboratory techniques sized the cuttings in the presence of cuttings from the same well to determine if cuttings were affected. The cuttings samples were then taken from surface and compared to cuttings from the well. The cuttings samples were then taken from the mud log. The cuttings samples were then taken from the mud log.
These three drawings illustrate a concern over migration from non-target shallow gas zones through vertical fractures into non-gas-bearing sand formations as a result of poorly bonded cement.

From Mud to Cement—Building Gas Wells

This and previous 2 pages from 'From Mud to Cement—Building Gas Wells'.
Evaluation of the Potential for Gas and CO₂ Leakage Along Wellbores


Summary
Implementation of carbon dioxide (CO₂) storage in geological media requires a proper assessment of the risk of CO₂ leakage from storage sites. Leakage pathways may exist through and along wellbores, which may precipitate or be near to the storage site. One method of assessing the potential for CO₂ leakage through wells is by using databases that usually reside with regulatory agencies. These agencies collect data concerning wellbores, construction, oil, and gas production, and the number of well failures. The analysis is based on data for more than 315,000 wells drilled up to the end of 2004 in the province of Alberta.

Background
Potential Wellbore-Leakage Pathways. Figs. 1a and 1b illustrate typical wellbores, construction, and abandonment profiles for Alberta. These diagrams were used to identify potential failures.

These charts show a correlation of increased well failures over time, by year of well spud, and cumulatively.

This chart shows a correlation of migration in wells with SCVF with oil price changes, suggesting a trend to less vigilance at times of increased financial pressure.
The occurrence of SCVF is higher in deviated wells than vertical wells, indicating that well bore deviation is a factor affecting overall well leakage.
This study explores the issue of migration long after a well has ceased production and has been plugged:

"Explanatory mechanisms include channelling, poor cake removal, shrinkage, and high cement permeability. The reason is probably cement shrinkage that leads to circumferential fractures that are propagated upward by the slow accumulation of gas under pressure behind the casing.

Assuming this hypothesis is robust, it must lead to better practice and better cement formulations.

Introduction, Environmental Issues

This discussion is necessarily superficial, given the complexity of the issue and attendant practical factors such as workability, density, setting retardation, and cake removal. Entrainment of formation gas, shale sloughing, pumping rate, mix consistency, and so on. A conceptual model will be developed in this article to explain slow gas migration behind casing, but we deliberately leave aside for now the complex operational issues associated with cement placement and behavior.

In 1997, there were ~35,000 inactive wells in Alberta alone, tens of thousands of abandoned and orphan wells, plus tens of thousands of active wells. Wells are costly for environmental security and zonal isolation. In the Canadian heavy oil belt, it is common to use a single production casing string to surface (Figure 1); for deeper wells, additional casing strings may be necessary, and surface casing to isolate shallow unconsolidated sediments is required. As we will see, surface casings have little effect on gas migration, though they undoubtedly give more confidence against blowouts and protect shallow sediments from sand infiltration and pressurization.

To form hydraulic seals for conservation and to isolate deep strata from the surface to protect the atmosphere and reduce groundwater sources, casings are cemented using water-cement slurries. These are pumped down the casing, displacing drilling fluids from the casing-rock annulus, leaving a sheath of cement to set and harden (Figure 1). Casing and rock are prepared by careful conditioning using centriflizers, mudcake removers, and so on. During placement, casing is rotated and moved to increase the sealing effectiveness of the cement grout. Recent techniques to enhance casing-rock cementing may include stimulating the casing, partial cementation and annular filling using an ultrasonic tube, or other means.

Additives may be incorporated to alter properties, but Portland Clink G (API rating) oil well cement forms the base of almost all oil well cement. Generally, slurries are placed at densities up to 2.5 M (5.0 Mdp) and pressures (5 to 10 Mpsi) at the well. The consequences of cement shrinkage are non-trivial. In North America, there are literally tens of thousands of abandoned, inactive, or active well gas wells, including gas storage wells, that currently leak gas to surface. Much of this enters the atmosphere directly, contributing significantly to greenhouse effects. Some of the gas centers shallow aquifers, where issues of sulfurous compounds can render the water unsuitable, or where the methane itself can generate unpleasant effects such as gas leaking of household wells, or gas entering household systems to cause unexplained deaths or other problems.

Methods from leaking wells is widely known in aquifers in Peace River and Lloydminster areas (Alberta), where there are accumulations of the gas in kitchen top water being ignited. It is the case that we need to fear the well as a risk to the local environment, and the concentration of the gases in the shallow aquifers will increase with time.

This implies that current standards for oilwell cementing and P&A are either not well founded, or the criteria are based on a flawed view of the mechanism. This is not a condemnation of industry—components such to comply with standards. Additionally, we believe that the AECB Interim Directive 59.05 is flawed with respect to gas leakage around casings. To rectify this, the mechanisms must be identified correctly. Practice can then be built based on the physical mechanisms, giving a better chance of success (though we do not believe
“Strength is not the major issue in oil well cementing under any circumstances... cement cannot resist the shear that is the most common reason for oil well distortion and rupture during operation...”

"The presence of surface casing provides no assurance against gas leakage."
In this slide presentation, loss of well integrity is recognized as a ubiquitous and common problem.

20% of catastrophic well failures are due to loss of well bore integrity.
Orphaned wells — wells that have been abandoned by their owners/operators and are no longer productive — are a migration pathway to aquifers and the surface.

Often, the original operator of a well is long gone, and there are insufficient funds to remediate these sources of contamination.

It is estimated that there are 35,000 abandoned wells in New York State. The locations of many are unknown.