

# IS A WELLSITE OPENING A SAFETY ZONE FOR A WILDLAND FIREFIGHTER OR A SURVIVAL ZONE OR NEITHER?

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## ABSTRACT

The Wildland Fire Operations Research Group (WFORG) of FPInnovations – Feric Division in collaboration with the University of Alberta initiated a project in late 2007 at the request of its stakeholders to examine and define the limits of wildland firefighter safety and survival zones. This partnership combines research and practical expertise in wildland fire suppression, fire behavior, heat transfer, and fire-resistant clothing evaluation.

What constitutes a safety zone has been shown to vary widely among individuals, irrespective of experience. Based on analytical work involving theoretical considerations of radiative heating, it has been suggested that the diameter or separation distance of a safety zone should be as a minimum at least four times the maximum expected flame height. In such cases, it is assumed that a wildland firefighter clothed in personal protective clothing is standing upright and receives no burn injuries.

Given the propensity for high-intensity crown fire behavior in the boreal forest and the general scarcity of suitable natural openings in the continuous overstory tree canopy, it has been suggested that wellsite openings could possibly serve as safety zones or alternatively as survival zones (G. Dakin, personal communication). In northern Alberta, these man-made clearings are quite common in some regions. They generally vary from 100 × 100 m to 120 × 120 m in area. The ground cover at active wellsites is typically maintained in a nonflammable state, which make them a potentially ideal safety or survival zone.

Based on fire behavior knowledge obtained from experimental fires, prescribed fires, and wildfire observations, we can say with some degree of certainty that the maximum flame heights in grasslands, shrublands, and hardwood stands (e.g., trembling aspen [*Populus tremuloides*]) varies from about 2 to 10 m. Thus, a separation distance of 40 m is easily met by a wellsite opening in these fuel types based on previously described criteria.

The average flame height of crown fires in conifer forests is generally 2–2.5 times the stand height. Thus, a 100 × 100-m wellsite opening with conifer trees greater than ~10 m in height bordering its edge would not be adequate as a safety zone. However, perhaps such an opening might serve as a survival zone (i.e., a firefighter is lying face down as opposed to standing upright but still does not experience any burn injuries).

The derivation of the “four times the maximum flame height” guideline for safety zone size was based on the geometry of a planar flame front at some distance from the firefighter. The present work extends this approach in that the blockage or shielding effects from the unburned vegetation or fuel between the advancing flames and the receiving surface are modeled in addition to the flame front wrapping around and passing along the wellsite opening, thereby more closely resembling real-world fire behavior.

Simulations were undertaken of the radiant heat energy emitted from the flames of an advancing crown fire to a person clothed in personal protective equipment (PPE) while lying prone in a wellsite opening, assuming a 200-m-wide × 20-m-high flame front directly approaching a 100 × 100-m wellsite opening. Given a nominal rate of fire spread of 40 m/minute and a flame front residence time of 45 seconds, this equates to a 30-m flame depth or thickness. Given this residence time, the critical radiant heat flux to avoid any burn injuries was judged for present purposes to be ~7.5 kW/m<sup>2</sup> based on existing information regarding the effectiveness of PPE from the literature.

The heat transfer simulations consisted of “snapshots” in time of the radiant heat fluxes or “isotherms” at ground level as the flame front approached and then passed along the sides of the wellsite opening. Based on an examination of the temporal and spatial extent of radiant heat fluxes found in these preliminary simulations, it appears that a wellsite opening could very well serve as a survival zone. However, it must be emphasized that these simulations have only considered thermal radiation (i.e., other mechanisms of heat transfer have not been considered such as flame impingement or horizontal reach into the wellsite opening, fire whirls, or any allowance for convection).

We have deduced that the suitability of a wellsite opening as a safety zone or as a survival zone depends on the characteristics of the surrounding fuel/vegetation types (i.e., height and species composition). The idealized simulations performed to date will serve as a guide in the designing of field experiments. Plans are being formulated to verify these types of simulations using experimental fires to be carried out in Alberta and the Northwest Territories in the near future. A more in-depth review of the literature on the effectiveness of PPE and of burn injuries and survival will also be undertaken. Wildfire case studies involving firefighter fatalities and near-miss incidents will also be examined in relation to simulations of the thermal environment associated with safety and survival zones in wildland fires. For further updates on this project, visit the WFORG Web site (<http://fire.feric.ca>).

**keywords:** crown fire, fire behavior, fire behavior simulation modeling, firefighter safety, flame front residence time, flame height, heat transfer, personal protective equipment, thermal radiation.

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