Subglacial drainage networks are a leading constraint on glacier basal sliding and ice dynamics. At low discharge, subglacial water flows through high-pressure, sheet-like systems that lubricate the glacier bed; however, at high discharge, subglacial water melts the overlying ice into localized channels that easily drain the bed, thereby increasing basal friction. Recent observations have suggested channelized subglacial flow exists beneath Thwaites Glacier, yet it remains unclear if stable channelization is feasible in West Antarctica, where surface melting is nonexistent and water at the bed is limited. Here, we use the MPAS-Albany Land Ice model (MALI) to run a suite of over 100 subglacial hydrology simulations of Thwaites Glacier across a wide range of physical parameter choices to assess the likelihood of channelization. We then narrow our range of realistic simulations by comparing modeled water thickness fields to previously observed radar specularity content, an indicator of spatially extensive, water-saturated conditions at the bed. In all of our realistic simulations, modeled stable channels reliably form within at least 100 km of the grounding line, and commonly reach discharge rates of 40–70 $m^3 s^{-1}$ at the ice-ocean boundary. Our results suggest the size of the Thwaites Glacier drainage basin is large enough to capture sufficient meltwater for stable channelization, which likely has a substantial impact on Thwaites Glacier dynamics.