Abstract: The surface reconstruction phase map of GaAs$_{1-x}$Bi$_x$ is explored in this study as a function of growth temperature and As:Ga ratio. For comparison, the phase map of GaAs, at low temperatures is also obtained. It is observed that the (1×3), (2×3), (2×4) surface phases are common between GaAs and GaAs$_{1-x}$Bi$_x$ but due to the presence of Bi, a new (2×1) reconstruction appears in the case of GaAs$_{1-x}$Bi$_x$. This new reconstruction is observed for various Bi fluxes, showing the evolution of this phase with substrate temperature and As:Ga flux ratio. In addition, the emissivity of the (2×1) surface was found to be lower than for the other As-rich reconstructed surfaces (e.g. (1×3) and (2×3) surfaces) which suggests that the (2×1) surface phase is metallic. Several GaAs$_{1-x}$Bi$_x$ films were grown with (1×3) and (2×1) reconstructions at different substrate temperatures. Each film is characterized using high-resolution x-ray diffraction (XRD), photoluminescence spectra (PL). Superior crystal quality, higher Bi incorporation and higher intensity PL was observed for GaAs$_{1-x}$Bi$_x$ samples grown on (2×1) surfaces, relative to samples grown on (1×3) surfaces.