The role of groundwater as a component of mountain water systems is poorly understood due to a lack of data for these remote and inaccessible high relief regions. Yet, two of the main processes that act to replenish water resources for populated valleys, baseflow (BF) generation and mountain block recharge (MBR), are a direct result of mountain groundwater flow. The research conducted for this thesis involved numerical modelling of 2-D and 3-D domains representing simple generic systems, as well as real topographic scenarios, to investigate the influence of topography on deep groundwater (DG) flow patterns, and the sensitivity of these patterns to uncertainty in recharge (R) and bedrock hydraulic conductivity (K). Regional-scale topographically-driven DG flow patterns that develop in mountain bedrock are reflective of prominent topographic features comprising the mountain block which, for linear-ridge mountain ranges, consist of watershed-bounding ridges, deeply incised primary stream valleys, and triangular facet areas at the mountain front. DG contributing areas for BF at primary stream valleys are generally close to watershed boundaries, and contributing areas for MBR are generally coincident with triangular facet areas. At the regional (~ 10 – 100 km) and sub-catchment (~ 500 m to 2 km) scales, the fundamental characteristics of topographically-driven DG flow patterns are dominant despite smaller-scale variations in topography, and uncertainty in recharge and sub-catchment K heterogeneity. At the local scale, topographically-driven DG flow patterns vary due to uniqueness and complexity of topography, recharge spatial and/or temporal variability, and K heterogeneities, indicating the importance of understanding these factors for a detailed understanding of DG flow systems. DG flow patterns and boundaries are influenced by the topography of a given catchment as well as surrounding topography and regional topographic setting, and therefore, analysis of DG flow systems and boundaries must consider areas outside the target catchment. The results of this study support the development of topography-based predictive tools for conceptualizing DG flow patterns and BF/MBR contributing areas. Numerical modelling using topographic data, which are often the only available data for mountainous areas, provides a convenient approach for preliminary characterization of topographically-driven DG flow patterns in mountains on a site-specific basis.