PMP Mapping Issues - Alberta

Introduction

In 2005, Alberta Infrastructure and Transportation decided to pursue a study to develop mapping of the probable maximum precipitation (PMP) for the province. The intention was that such mapping would complement the "Extreme Flood Guidelines" document published in November 2004, which deals with Probable Maximum Flood (PMF) modelling. It was thought that such mapping would provide consistency and avoid duplication of effort in future PMF studies required for the provincial government's high and very high consequence of failure dams.

The intention was that the PMP mapping processes would be somewhat similar to those used in preparation of Hydrometeorological Report No. 55A, prepared by the US government for the area of the US just east of the continental divide. The study was to incorporate all relevant meteorological data for Alberta and surrounding areas. The Parameter-elevation Regressions on Independent Slopes Model (PRISM) was also to be used for gridding the climate data, as it was believed to be well suited to mountainous terrain.

The project was assigned to hydrometeorology consultants who were familiar with Canadian rainfall data, PMP mapping procedures, and the use of the PRISM model. A review panel consisting of experts in hydrometeorology, hydrology, and water resource engineering was formed to assist in the process. A draft document was prepared in July 2005, which included an overview of the process, some illustrative figures, a map of proposed PMP values, and depth-area and timing distribution curves for both local storms and large general storms.

The draft report generated significant discussion between the mapping consultants and the review panel. Discussion focused on concerns over the underlying data, the mapping process, and the applicability of the resulting map. After several rounds of discussion, a consensus on a final approach to the mapping was not reached, and it appeared that an end product that would meet the requirements of Alberta Infrastructure and Transportation might not be achievable.

This note briefly documents some of the issues that were raised during the PMP mapping study.

Data Issues

As the process used to derive the PMP mapping is very data driven, issues arose concerning the accuracy and applicability of the underlying data. The June 1970 storm in Central Alberta was identified during the study as being one of the controlling storms. However, it was later noted that the largest point in the data-set for that storm (located near Eckville) appeared to be inconsistent with the rest of the data based on magnitude and timing. Research into the actual recording sheets revealed that there was an error in

this data point, as the monthly total was incorrectly entered as a daily value. It was not clear if this error would be enough to eliminate use of this storm as one of the controlling storms.

A 1974 spring storm was also identified as being a controlling storm in the development of the spring PMP mapping. However, it was not clear how much of the precipitation fell as snow and how much as rain. It was suspected that this might impact the hydrologic response, calling into question the applicability of this storm for PMP mapping.

The maximization process makes use of upper air data, which is believed to be most representative of the availability of moisture to the storm. However, this data is only available at two locations (one in Edmonton, and one in Glasgow, Montana). It was suggested that a better geographic distribution could be achieved by using dewpoint data, which is available at more than 20 locations. Although the upper air data is a direct measurement, it was suggested that its significance is only justified for spring events.

It was also noted that the existing rainfall gauging network can miss the eye of the storm. Analysis of informal data for the July 2000 storm near Vanguard, Saskatchewan suggests that a significant area was covered by more than 300mm of rain, even though the largest value recorded by an official rainfall gauge was approximately 150mm. It was suggested that analysis of each large storm utilize additional data, such as results of bucket surveys or other gauge networks such as those of Alberta Environment and the Foothills Climate Array. However, most of the known supplemental data is relatively recent.

Process Issues

The PMP mapping process appears to be a very complex data manipulation exercise, with several steps involved. Significant discussion was generated by some of the maps developed at various stages. However, it was never clear what the impact of changes to these various steps might be on the final PMP map.

At one of the early stages, a map of the 1:100 year 24 hour precipitation was produced. The PMP is based on maximization and translation of historic storms, and not frequency analysis of gauge data. However, this 1:100 year map appears to be used in the analysis to separate orographic and convergence components of rainfall. Concerns were raised over the sensitivity of the results to existing data-sets that showed great variance in results over short distances, with no physical explanation of the differences. Significant discussion was generated on whether these local variations were real or just statistical noise. Potential solutions were proposed such as cell smoothing at various stages in the process, or some form of regional analysis.

Maps of monthly rainfall data were also prepared, and were intended to be used in geographic distribution of the calculated PMP values. It was suggested that this focus on gauge data statistics might not be consistent with observations of actual storms and their distribution, as storms of the magnitude that typically cause severe flooding appear to

have occurred in most areas of the province. Therefore, the applicability of monthly data statistics as an indication of the geographic distribution of storms was questioned.

Maps of 1:100 year precipitable water and 1:100 year convergence component of precipitation were also generated. A lack of correlation between these two maps was noted. This led to the suggestion that perhaps the orographic separation was not complete and that the PMP values at higher elevations might be inflated.

Applicability of Map

The draft version of the 24 hour PMP map showed values ranging from 350 to 450mm over most of the province, generally increasing from the NW to the SE. These values appear to be relatively consistent with the results of most recent project specific PMP studies. Also, this map did not show as high a degree of local variance as the 1:100 year map on the non-mountainous portion of the province. However, significant local variation was still present in the mountainous areas, with some values exceeding 700mm.

The mountainous portion of the map caused the most concern to review panel members involved in application of PMP values to PMF generation and dam design. The total area covered appears to be relatively small compared to the overall area of the province. However, these areas are in the region of highest runoff potential and water supply, magnifying the potential impact on dam infrastructure.

Discussion on the high level of local variance focused on some gauge sites that were inconsistent with nearby gauges. One such gauge was located in Crowsnest Pass. Rain shadow effect was one suggestion for the anomaly. However, it was not clear if this was due to a consistent physical effect for the area, or due to a gauging issue or statistical sampling issue (e.g. gauge hasn't been in operation during a large storm yet).

The magnitude of the highest PMP values was also the subject of some discussion. These values represent a very large extrapolation from any observed rainfall values. The largest factor in this extrapolation appears to be the orographic adjustment factor. It was suggested that perhaps there should be a cap on the application of the orographic adjustment with elevation. Reference was made to papers by Jarrett who observed that there was a lack of evidence for extreme floods at high elevations in Colorado. Examination of the available precipitation for Alberta suggests that rainfall values appear to fall off somewhere in the 1500 – 2000m elevation range. Runoff data shows a similar trend. However, there are few data for higher elevations.

Conclusion

Current PMP mapping procedures appear to be very sensitive to available data, leading to some results that appear inconsistent with large storm observations. These procedures are also quite complex, making it difficult to relate the results to the underlying factors. The great variation in topography in Alberta also results in complications due to orographic enhancement and magnifies the sensitivity to available data. These issues

resulted in considerable debate and lack of consensus on a presentation of PMP mapping for Alberta that would be considered universally acceptable for dam and associated infrastructure design throughout the province.

However, some useful observations were made during the PMP mapping study. Limitations and need for scrutiny of the available data were discovered. It appears that there is a decreasing trend in PMP with increasing latitude, due to a decrease in precipitable water. Orographic lifting suggests that there should be an increase in precipitation with elevation, but there may be a cap. Based on current techniques and data, the magnitude of the orographic impact is difficult to evaluate. It also appears that the point PMP for much of the province is in the 400mm range, which is approximately double the magnitude of precipitation near the eye of typical large storms in Alberta.

Future PMF studies that follow current guidelines will still require site specific PMP evaluation. However, some of the insights gained during the PMP mapping study will be of use in evaluation of any such PMP. Evaluation of recent PMF estimates suggest that the results are more sensitive to changes in hydrologic modelling than to PMP estimates. Also, it appears that few high or very high consequence of failure dams will be built or rehabilitated in the foreseeable future. Therefore, development of a comprehensive PMP map for Alberta is not presently critical to the design of the province's major water management infrastructure.