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TBV-361 Resolution Analysis: Emplacement Drift Orientation

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July 1999

Prepared for

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TBV-361 Resolution Analysis: Emplacement Drift Orientation

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July 1999

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Remarks: TBV-779 and TBV-682 applies to this TBX resolution analysis

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1. INTRODUCTION

The purpose of this To Be Verified/To Be Determined (TBX) resolution analysis is to release To Be Verified (TBV) - 361 related to the emplacement drift orientation. The system design criterion in *Subsurface Facility System Description Document* (CRWMS M&O 1998a, p.9) specifies that the emplacement drift orientation relative to the dominant joint orientations should be at least 30 degrees. The specific objectives for this analysis include the following:

- Collect and evaluate key block data developed for the repository host horizon rock mass.
- Assess the dominant joint orientations based on available fracture data.
- Document the maximum block size as a function of drift orientation.
- Assess the applicability of the drift orientation/joint orientation offset criterion in the *Subsurface Facility System Description Document* (CRWMS M&O 1998a, p.9).
- Consider the effects of seepage on drift orientation.
- Verify that the viability assessment (VA) drift orientation complies with the drift orientation/joint orientation offset criterion, or provide justifications and make recommendations for modifying the VA emplacement drift layout.

In addition to providing direct support to the System Description Document (SDD), the release of TBV-361 will provide support to the Repository Subsurface Design Department. The results from this activity may also provide data and information needs to support the MGR Requirements Department, the MGR Safety Assurance Department, and the Performance Assessment Organization.

1.1 SCOPE

The impacts of rockfall and seepage to the emplacement drift orientation are assessed in this analysis. The impact of rockfall is analyzed using the available key block analysis results. This report presents an analysis of the maximum key block size as the emplacement drift orientation is varied in 15° increments. The maximum block sizes for the emplacement drifts located in the lithologic units of the repository host horizon are all considered. An assessment of drift orientation to seepage is also included.

1.2 BACKGROUND

The Monitored Geologic Repository requirement allocation process is being conducted through the development of the SDDs. This process identifies and incorporates design criteria based on the applicable higher-level requirements defined in the Monitored Geologic Repository Requirements Document (MGR RD) (DOE 1999, Section 3). The SDDs currently present these system design criteria and will describe how the design satisfies them. As a criterion is developed, available information from existing Type I analyses (e.g., other documents, studies, or evaluations) are identified as a basis for parameter performance or it is identified that no information is available or it is to be determined (TBD). If the available information (e.g., scientific data, design requirements, engineering data, or performance assessment data) is unverified and it is utilized as a basis for a criterion it is designated as TBV within the SDD.

TBX resolution analyses are developed to evaluate the design data and the other design-related information so that the requirements for the release of TBDs and TBVs are satisfied. Availability of data obtained in accordance with quality assurance procedures (qualified data) provides the evidence needed to remove the TBV and TBD flags and release the TBV/TBD information.

It should be clearly understood that TBX resolution analyses are primarily intended to be used for establishing baseline data and information for the design of the repository. It is however likely that the results of these analyses will also be used as a reference or as input to other analyses.

1.3 REPORT ORGANIZATION

The format of this document follows the general guidelines of the Technical Document Preparation Plan (TDPP) for TBX Resolution Analyses (CRWMS M&O 1999a, pp. 6-9). Section 1 describes the purpose of this analysis and how it supports the TBX resolution process. Section 2 indicates the applicability of the Quality Assurance (QA) program. An outline of the analytical methods used in this analysis is presented in Section 3. The source of all data and information is identified and documented in Section 4, and listed in Section 5 together with supplemental references that support this analysis. Section 6 includes a list of software used to support the TBX resolution. The TBX resolution analysis is presented in Section 7, and the conclusions and recommendations based on the results of the analysis are presented in Section 8. A list of acronyms and abbreviations used throughout this report is provided in Appendix A.

2. QUALITY ASSURANCE

This section provides evidence of the determination of Quality Assurance (QA) controls in accordance with NLP-3-18. A QAP-2-0 activity evaluation was performed for the preparation of this report, which showed that this analysis activity is subject to the controls of a QA program (CRWMS M&O 1999c). This activity may impact the design of subsurface facility system. The subsurface facility system has been classified in accordance with QAP-2-3 as QA-2 (CRWMS M&O 1999d, p. IV-1).

All software used in this analysis is identified in Section 6 and is controlled by appropriate software QA procedures. There are no NLP-2-0 Determination of Importance Evaluations (DIEs) applicable to the development of this document. Unverified and undetermined data are identified and tracked in accordance with NLP-3-15. The data needed to support this TBX resolution analysis that were not available in the Project Technical Database were requested in accordance with QAP-3-12. This document was prepared in accordance with QAP-3-5 and the TDPP for TBX Resolution Analyses (CRWMS M&O 1999a, all).

3. METHOD

This TBX resolution analysis was developed using the results produced by analytical methods. The method of probabilistic key block theory was used in the original analysis. Scientific publications, project documents, and data obtained from the technical database were reviewed for use in this analysis.

4. DATA AND INFORMATION

4.1 TBX RESOLUTION PARAMETERS

The fracture data and key block data obtained from the preliminary key block analysis, transmitted in CRWMS M&O 1999b (all), were used to assess the impact of rockfall to drift orientation. TBV-779 is applied to the results of the preliminary key block analysis due to its preliminary nature. TBV-779 will be released when the key block analysis is finalized.

The geotechnical parameters used in the preliminary key block analysis include data and information collected either by field mapping or by laboratory testing. Two sets of joint geometrical data were used in this analysis. The first set, collected from the Exploratory Studies Facility (ESF) Main Loop (i.e., the North Ramp, Main Drift, and South Ramp), is referred to as the ESF data in this report. The second set, collected from the Enhanced Characterization of the Repository Block (ECRB) Cross Drift, is called the ECRB data. Qualified joint mapping data for the Topopah Spring Tuff crystal poor middle nonlithophysal zone (Tptpmn) lithologic units are available from the ESF data. Preliminary joint mapping data for the Tptpmn, Topopah Spring Tuff crystal poor lower lithophysal zone (Tptpll), and Topopah Spring Tuff crystal poor lower nonlithophysal zone (Tptpln) lithologic units are available from the ECRB data.

Mapping data from the ESF being used in the analysis includes both U.S. Geological Survey/U.S. Bureau of Reclamation (USGS/USBR) Full Periphery Geologic Maps (FPGMs) and the Detailed Line Survey (DLS). Fracture strike and dip data contained in the electronic files of the FPGMs were used to determine fracture set orientation, while fracture set spacing and trace length data were obtained from the DLS. All fracture spacing information for the primary joint sets has been converted to true spacing. True spacing is defined as the spacing measured from the scan line which is perpendicular to the fracture plane. Details for the determination of fracture set orientations, the identification of joint sets, and fracture spacing and trace length data are provided in the preliminary key block analysis, transmitted in CRWMS M&O 1999b (pp. 7-8).

Currently, data from the ECRB is limited to preliminary results of the USGS/USBR DLS (TBV-682). The preparation FPGMs of the ECRB Cross Drift are currently in progress, and were not available for this report. The origin of the data for specific joint geometrical parameters is listed in Table 1. TBV-682 is applied to the preliminary DLS from the ECRB cross drift since it is not the qualified data at this time. TBV-682 will be released when the ECRB DLS data is finalized and qualified.

4.2 TBX RESOLUTION CRITERIA

The TBV-361 shall be resolved by the providing qualified block size data and seepage consideration for use in developing procurement, fabrication, and construction documents.

The system design criterion 1.2.1.18 in *Subsurface Facility System Description Document* (CRWMS M&O 1998a, p. 9), as stated below, is directly affected by TBV-361.

The system shall orient emplacement drifts at least 30 degrees (TBV-361) from dominant joint orientations.

[Function 1.1.2, 1.1.7, 1.1.8, 1.1.9]

System functions related to the above system design criterion are:

1.1.2 The system provides location, arrangement, size, and spacing of the subsurface openings.

1.1.7 The system layout provides a stable emplacement area.

1.1.8 The system layout minimizes impact to the natural barrier.

1.1.9 The system minimizes the creation of water preferential pathways to the waste packages.

Table 1. Origin of Data for Joint Geometrical Parameters

Lithologic Unit	Origin of Joint Geometrical Parameters		
	Joint Set Orientation	Joint Spacing	Joint Trace Length
Tptpmn	ESF FPGM	ESF DLS & ECRB DLS	ESF DLS & ECRB DLS
Tptpll	ECRB DLS	ECRB DLS	ECRB DLS
Tptpln	ECRB DLS	ECRB DLS	ECRB DLS

4.3 ASSUMPTIONS

This TBX resolution analysis uses the results of the preliminary key block analysis (CRWMS M&O 1999b, all). The following assumptions are inherited from the preliminary key block analysis.

4.3.1 Joints are represented as circular discs with radii equal to twice the mapped trace length. This is considered conservative since the diameter of the joint disc developed from mean trace length is greater or equal to the emplacement drift diameter.

4.3.2 The positioning parameter required as joint parameter input is assumed to be the offset measured from the center of the trace length to the scan line of the detailed line survey. This is the best available way to represent the positioning parameter since the determination of the true positioning parameter requires the three dimensional information of the joint plane that is not available. This approach is considered conservative because the offset measured from the one dimensional scan line is smaller than the true offset in three dimensional space (The probability of forming key block is higher with smaller offset value).

5. REFERENCES

The following is a complete list of references used in this TBX resolution analysis. Data tracking numbers (DTN), Records Processing Center accession numbers (ACC), and Technical Information Center catalog numbers (TIC) are noted as appropriate for each reference.

5.1 DOCUMENTS CITED

Birkholzer, J.T.; Li, G.; Tsang, C.F.; and Tsang, V. 1998. *Drift Scale Modeling: Studies of Seepage into a Drift.* SP4CKLM4. Berkeley, California: Lawrence Berkeley National Laboratory. ACC: MOL.19980825.0204.

Hoek, E. and Brown, E.T. 1980. *Underground Excavations in Rock.* London, England: The Institute of Mining and Metallurgy. TIC: 217577.

CRWMS M&O 1998a. *Subsurface Facility System Description Document.* BCA000000-01717-1705-00014 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981214.0020.

CRWMS M&O 1998b. *Total System Performance Assessment – Viability Assessment (TSPA-VA) Analyses Technical Basis Document, Chapter 2, "Unsaturated Zone Hydrology Model".* B00000000-01717-4301-00002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981008.0002.

CRWMS M&O 1999a. *Technical Document Preparation Plan for TBX Resolution Analyses.* B00000000-01717-4600-00161 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990325.0217.

CRWMS M&O 1999b. *Preliminary Results from the Key Block Analysis.* QAP-3-12 Design Input Transmittal, SEI-SSR-99088.T. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990219.0505. (TBV-779)

CRWMS M&O 1999c. *TBX Resolution and System Trade-off Evaluations (Revision 01)* [*Work Packages 16012310M3, 16012023M3, 21019076MA*]. QAP-2-0 Activity Evaluation. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990312.0394.

CRWMS M&O 1999d. *Classification of the Preliminary MGDS Repository Design,* B00000000-01717-0200-00134 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981103.0546.

DOE (U.S. Department of Energy) 1998. *Viability Assessment of a Repository at Yucca Mountain, Volume 3: Total System Performance Assessment* DOE/RW-0508V3. North Las Vegas, Nevada: DOE Office of Civilian Radioactive Waste Management. ACC: MOL.19981007.0030.

DOE 1999. *Monitored Geologic Repository Requirements Document.* YMP/CM-0025, Revision 3, DCN 01. North Las Vegas, Nevada: DOE Office of Civilian Radioactive Waste Management. ACC: MOL.19990415.0090.

Goodman, R.E. and Shi, G. 1985. *Block Theory and Its Application to Rock Engineering.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc. TIC: 241514.

Stone, C.A. 1999. *DRKBA Version 3.2 Program Manual.* Las Vegas, Nevada: Stone Mineral Ventures. TIC: 242604.

Tsang, C.F.; Birkholzer, J.; Li, G.; d Tsang, Y. 1997. *Drift Scale Modeling: Progress in Studies of Seepage into a Drift.* SP331CM4. Berkeley, California: Lawrence Berkeley National Laboratory. ACC: MOL.19971204.0420.

Wickham, G.E.; Tiedemann, H.R.; and Skinner, E.H. 1972. *Support Determinations Based on Geologic Predictions.* Rapid Excavation Tunneling Conference, 43-64. New York, New York: AIME. TIC: 226274.

5.2 STANDARDS AND REGULATIONS

10 CFR 60 (Title 10, Code of Federal Regulations, Part 60) 1998. Energy: Disposal of High-Level Radioactive Wastes in Geologic Repositories Subpart E - Technical Criteria, *Federal Register*. Washington, D.C.: U.S. Government Printing Office. TIC: 239475.

5.3 PROCEDURES

NLP-2-0. *Determination of Importance Evaluations.* Revision 5. June 5, 1998.

NLP-3-15. *To Be Verified (TBV) and To Be Determined (TBD) Monitoring System.* Revision 5. November 4, 1998.

NLP-3-18. *Documentation of QA Controls on Drawings, Specifications, Design Analyses, and Technical Documents.* Revision 4. December 13, 1995.

QAP-2-0. *Conduct of Activities.* Revision 5. July 20, 1998.

QAP-2-3. *Classification of Permanent Items.* Revision 10. May 26, 1999.

QAP-3-5. *Development of Technical Documents.* Revision 8. December 15, 1998.

QAP-3-12. *Transmittal of Design Input.* Revision 8. November 24, 1998.

AP-SI-1Q. *Software Management.* Revision 1, ICN 0. May 5, 1999.

6. COMPUTER SOFTWARE

6.1 QUALIFIED COMPUTER SOFTWARE

No qualified software is used in the TBX resolution analysis.

6.2 NON-QUALIFIED SOFTWARE

Microsoft Excel 97 was used in this TBX resolution analysis. It was used to perform support activities and is not the controlled source of information in this TBX resolution analysis, and thus not subject to software management per AP-SI-1Q.

Excel is a commercial spreadsheet program designed to assist in routine calculations. The program provides built-in mathematical functions together with user-defined formulas to automate the calculation process. Output formulas are automatically updated as input data are added or changed. *Excel* also includes a graphical package to assist in data presentation. *Excel* was used to calculate excavation orientation inputs, to assist in the summary of the block size data, to provide graphical presentation of the block size versus drift orientation and its relation with offset criterion.

7. TBX RESOLUTION ANALYSIS

7.1 INTRODUCTION

The conventional wisdom for the optimum orientation for the excavation is at right angles to the strike direction of the line of intersection of the joint sets (Hoek and Brown 1980, p.197; Wickham et al. 1972, p.53). The most unfavorable orientation is the one parallel to the line of intersection of the joint sets. This orientation can result in the formation of large key blocks. The observation is shown graphically in Figure 1. From the rock mechanics perspective, the optimum orientation of an underground excavation in a jointed rock mass are those which give the smallest volume of potentially unstable blocks. In this analysis, the maximum block size data from the preliminary key block analysis results (CRWMS M&O 1999b, p.26) were obtained to establish the criterion for drift orientation.

The dominant joint set orientations are first identified based on the mapped fracture data. The results from the preliminary key block analysis (CRWMS M&O 1999b, p.26) are then utilized to obtain the maximum key block size as a function of drift orientation. The drift orientation/joint orientation offset criterion is examined based on the maximum key block size as a function of drift orientation. Consideration of the effects of seepage on drift orientation is also included based on the assessment in the technical documents on studies of seepage into a drift.

7.2 IDENTIFICATION OF DOMINANT JOINT SET ORIENTATIONS

Joint sets were identified based on clustering of the data from joint normal vectors plotted on stereonets as shown in Figures 2 through 4 (CRWMS M&O 1999b, Figures 3 to 5). The scatter plots, contour plots, strike rosettes, and major planes are all included in these figures. The orientation of joint planes in three-dimensional space are defined by dip direction/dip, or strike/dip. The strike is the azimuth of a horizontal line in the plane of the fracture. The dip direction is perpendicular to strike and pointing down the joint plane. A right hand rule is used such that the strike azimuth is measured 90° clockwise from the dip direction. The dip is the angle of the plane of the fracture from horizontal downward, measured perpendicular to the strike.

The major joint plane is expressed using the strike/dip format in these figures. Using the right hand rule, the strikes are expressed as dip directions in Table 2. Two high-angle joint sets and one low-angle joint set were identified in each of the lithologic unit within the repository host horizon. The low dipping joint sets do not impact the decision of joint orientation, they are therefore not considered in this analysis (Wickham et al. 1972, p.53). Table 3 presents the joint sets considered in this analysis with the number of mapped joints and the corresponding fracture spacing listed. A major joint set with strike trending SE and dipping to the SW is observed in all three lithologic units. Another joint set with strike trending NE and dipping to the NW is found for the two nonlithophysal units.

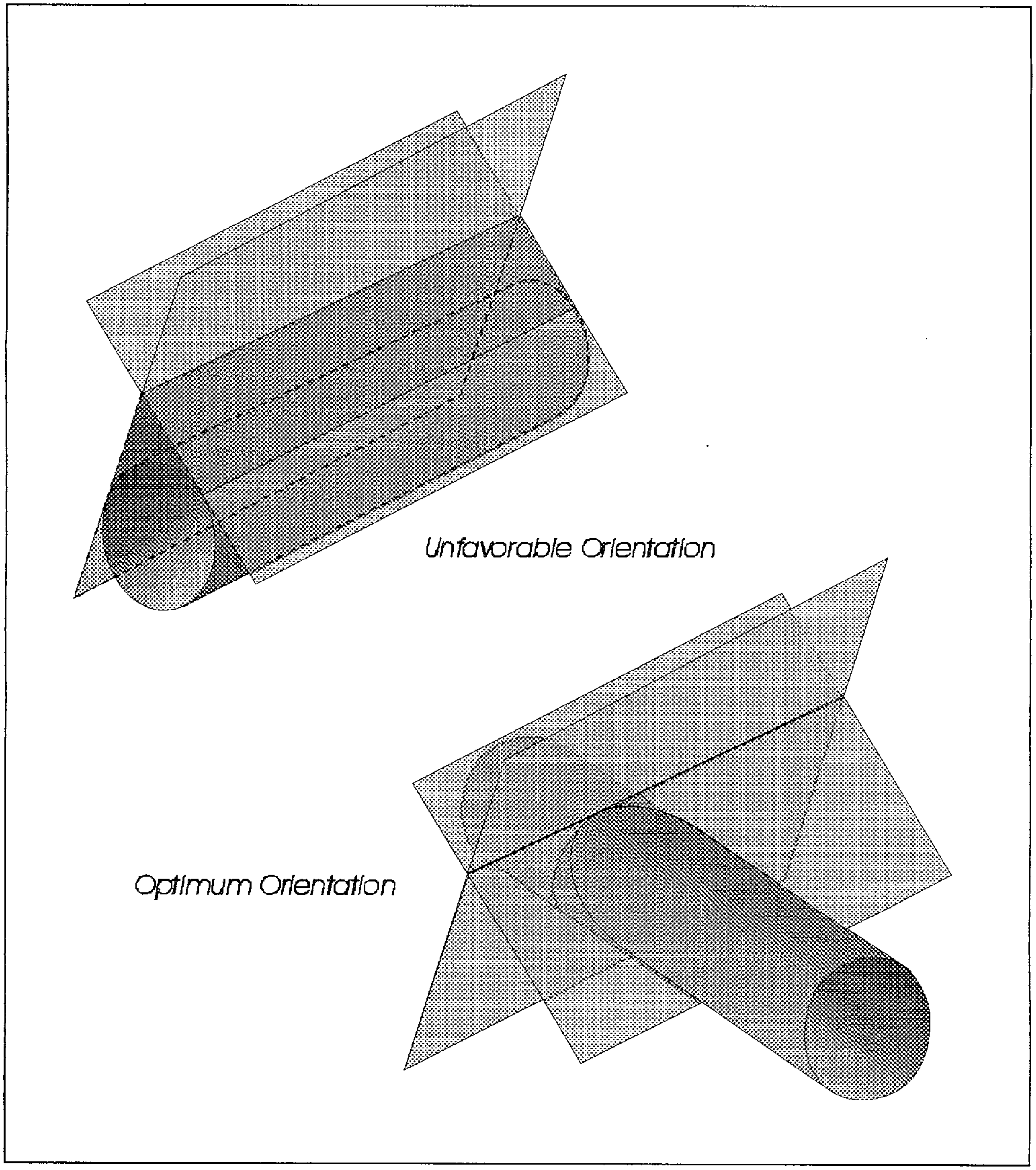

Figure 1. Influence of Excavation Orientation upon the Formation of Unstable Blocks (after Hoek and Brown, 1980, p.196)

Table 2. Joint Set Orientation Data (CRWMS M&O 1999b, p.14, TBV-682)

Lithologic Unit	Joint Set Number	Mean Dip Direction (degrees)	Mean Dip (degrees)
Tptpmn	1	221	84
	2	303	82
	3	57	13
Tptpll	1	260	80
	2	221	80
	3	76	4
Tptpln	1	227	79
	2	301	83
	3	70	17

Table 3. Dominant Joint Sets Data (CRWMS M&O 1999b, p.14, TBV-682)

Lithologic Unit	Joint Set Number	Mean Dip Direction (degrees)	Mean Dip (degrees)	Number of Mapped Fractures	Mean Joint Spacing (m)
Tptpmn	1	221	84	5820	0.50
	2	303	82	1092	1.74
Tptpll	1	260	80	74	3.02
	2	221	80	68	6.99
Tptpln	1	227	79	74	0.96
	2	301	83	31	1.55

Joints not counted in the primary sets are treated as part of the random joint set in the preliminary key block analysis. The distribution of joint spacing, trace length, and concentration factor for the random joint set were obtained from the population of joints not included in the primary sets. The approach enables us to account all the mapped fractures in the preliminary key block analysis.

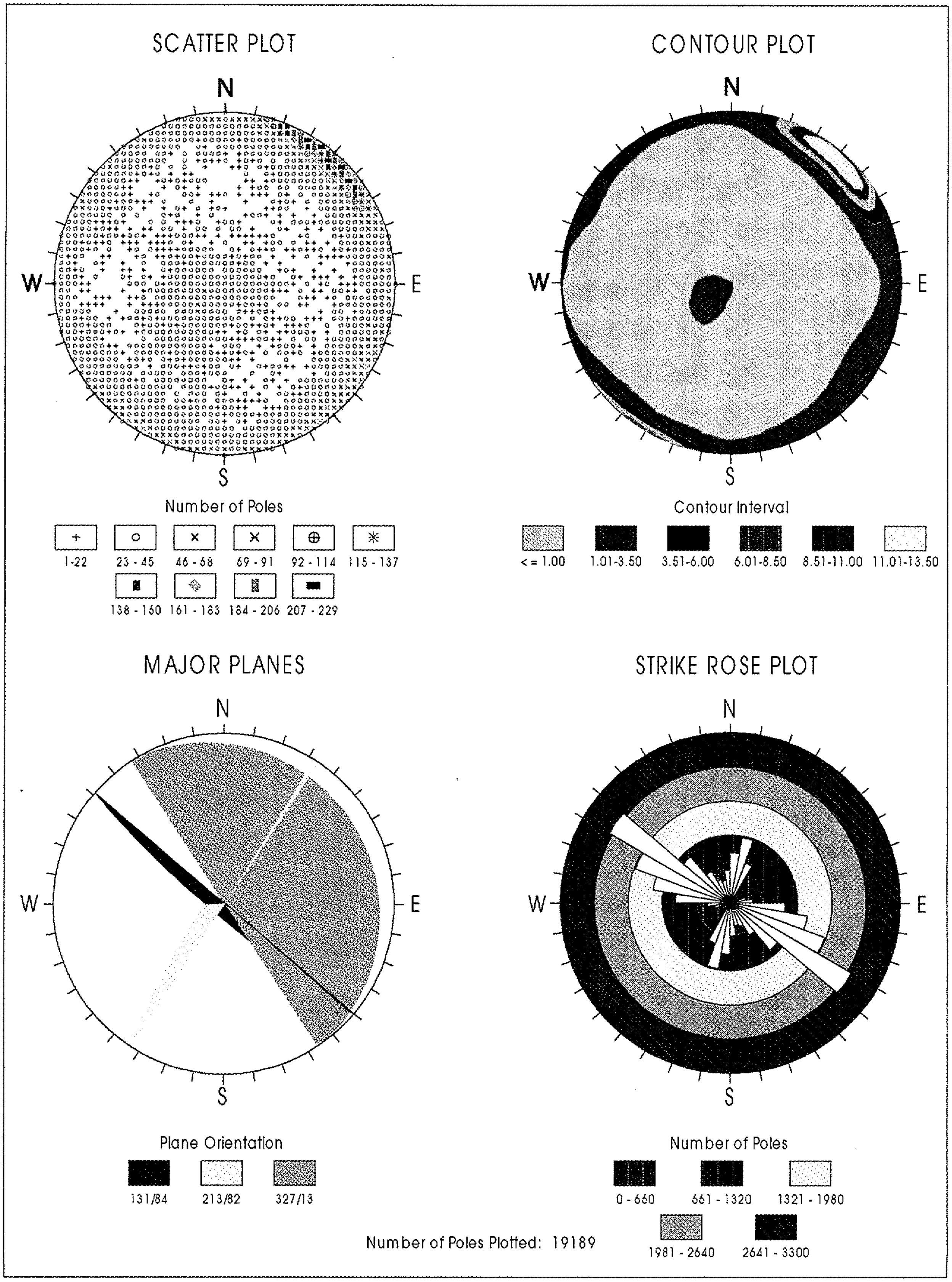

Figure 2. Determination of Primary Joint Sets, Tptpmn

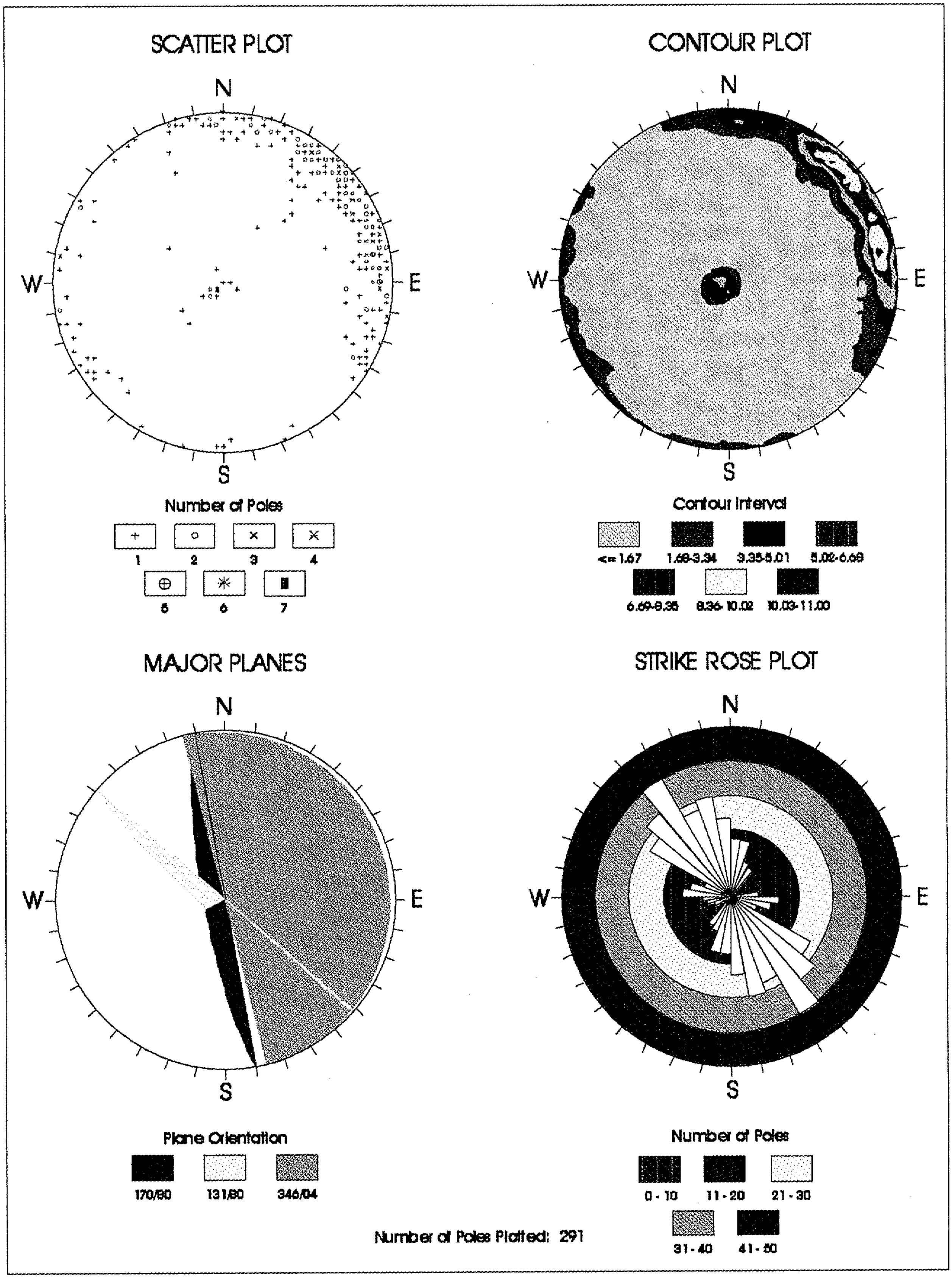

Figure 3. Determination of Primary Joint Sets, Tptpll

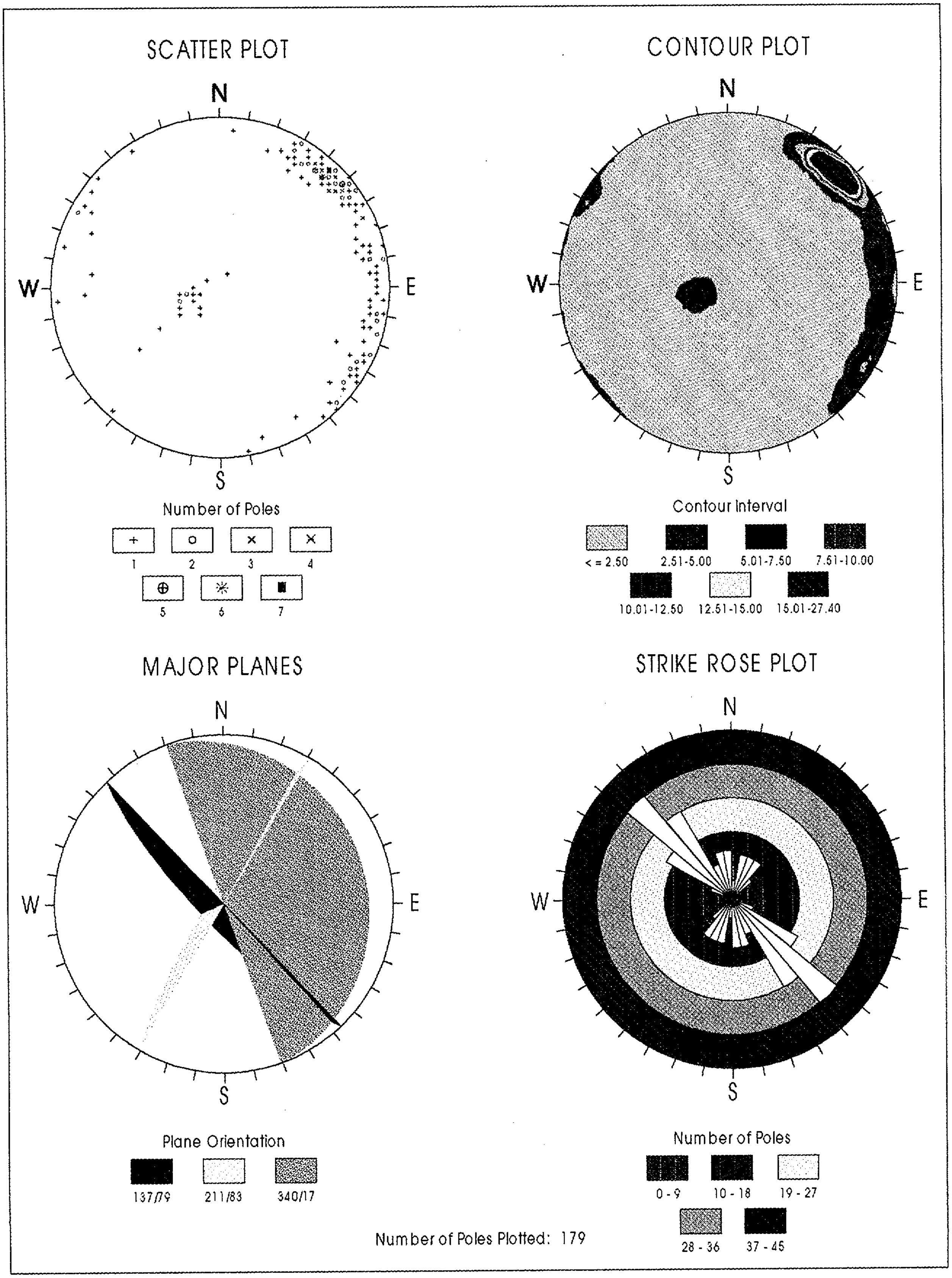

Figure 4. Determination of Primary Joint Sets, Tptpln

7.3 PREDICTED MAXIMUM KEY BLOCK SIZE AS A FUNCTION OF DRIFT ORIENTATION

The preliminary key block analysis (CRWMS M&O 1999b, all) provides an assessment of the possible formation of key blocks within the repository horizon based on the orientations of joints data mapped in the ESF Main Loop and in the ECRB Cross Drift. The probabilistic key block analysis program DRKBA (Stone 1999, all), with theoretical basis from the key block theory (Goodman and Shi 1985, all), was used for the analysis. Details for joint geometrical properties modeling, joint strength modeling, and excavation modeling are provided in CRWMS M&O 1999b (pp.8-23).

The preliminary key block analysis considered various emplacement drift orientations with drift azimuth varying every 15 degrees. The predicted maximum key block sizes for the range of drift orientations evaluated are shown in Figure 5.

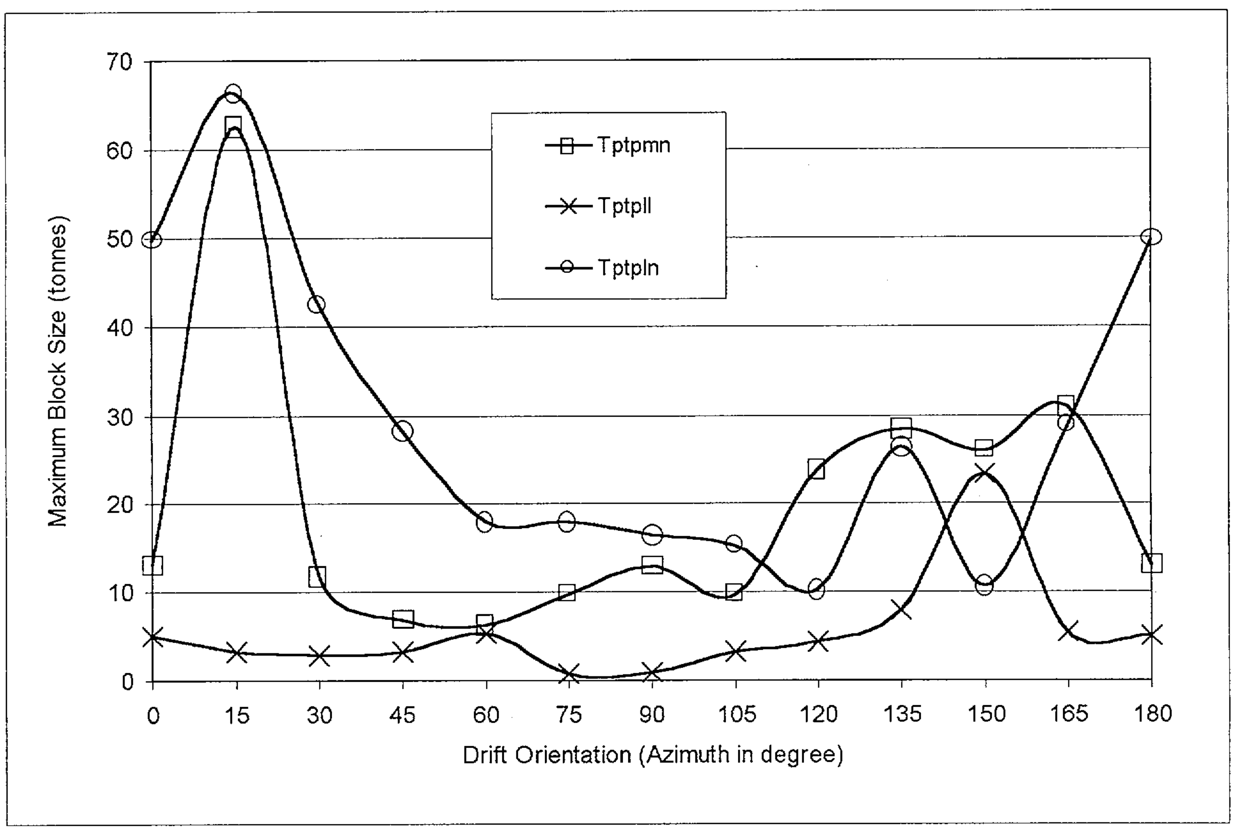

Figure 5. Maximum Block Size vs. Drift Orientation (CRWMS M&O 1999b, p.26, TBV-682 and TBV-779)

7.4 ASSESSMENT OF THE DRIFT ORIENTATION/JOINT ORIENTATION OFFSET CRITERION BASED ON KEY BLOCK RESULTS

The offset criteria of 15°, 30°, and 45° for each of the joint set identified in Table 3 were evaluated based on the predicted key block size results described in Section 7.3. The offset criterion was superimposed on the figures of predicted maximum block sizes to assess its impact to the block size. It was first found that the offset criterion of 45° would exclude most of the orientations for emplacement drifts. This criterion was therefore excluded in the analysis.

Figures 6 and 7 present the predicted maximum block size versus drift orientation for Tptpmn unit with consideration of the offset criterion of 15° and 30° respectively. By comparing these two figures, it was observed that the 30° criterion covers most of the peak values while the 15° criterion fails to include the maximum block of 63 metric tons at drift orientation of 15°.

The predicted maximum block size versus drift orientation for Tptpll unit with consideration of the offset criterion of 15° and 30° are presented in Figures 8 and 9 respectively. The strikes for the two dominant joint sets in Tptpll unit are only less than 40° apart. The range covered by the offset criterion of 30° for the two joint sets is partially overlapped as shown in Figure 8. Similar to the observation in Tptpmn unit, the 30° criterion covers all the peak values while the 15° criterion fails to include the peak key block oriented at 150°.

Figures 10 and 11 present the predicted maximum block size versus drift orientation for Tptpln unit with consideration of the offset criterion of 15° and 30° respectively. The conclusion drawn from comparing these two figures is the same as in other two units. The 30° criterion covers most of the peak values while the 15° criterion fails to include the maximum block of 66 metric tons at drift orientation of 15°.

The evaluation is summarized in Table 4 in the format that the highest value of key block size would be encountered as the function of the offset criterion. The benefit of the 30° criterion is clearly shown based on the comparison of the key block size.

Table 4. Predicted Highest Value of Key Block Size (metric tons) as Function of the Offset Criterion (TBV-682 and TBV-779)

Lithologic Unit	Offset Criterion of 30°	Offset Criterion of 15°
Tptpmn	31	63
Tptpll	5	23
Tptpln	50	66

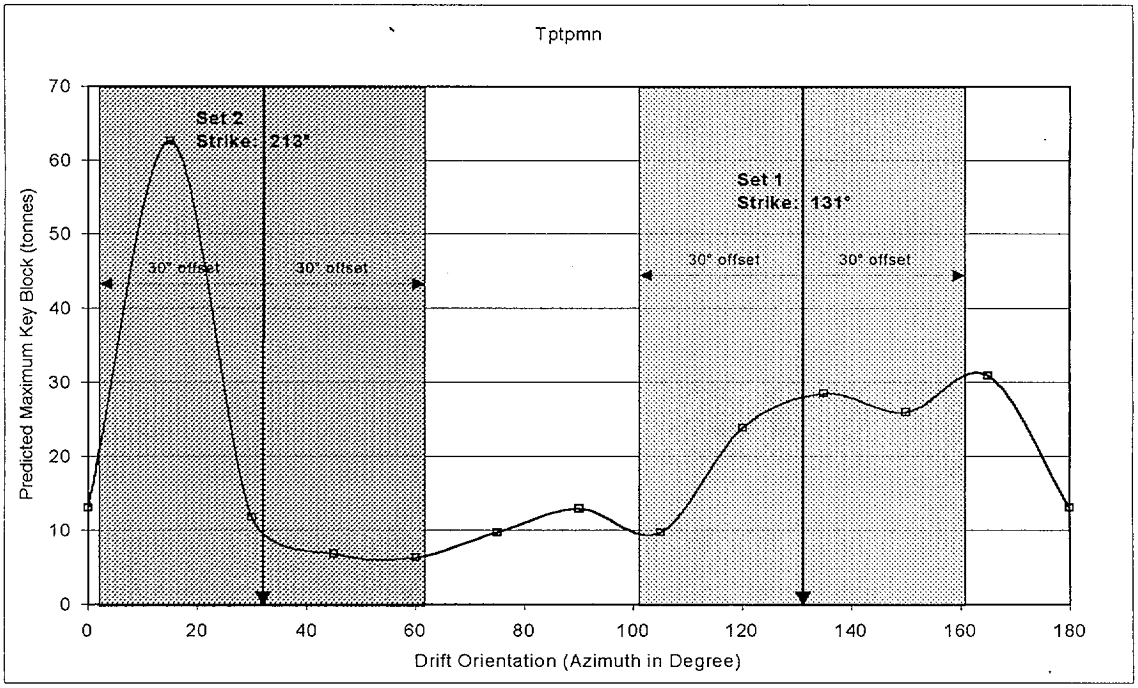

Figure 6. Predicted Maximum Block Size Relative to the Offset Criterion of 30°, Tptpmn (TBV-682 and TBV-779)

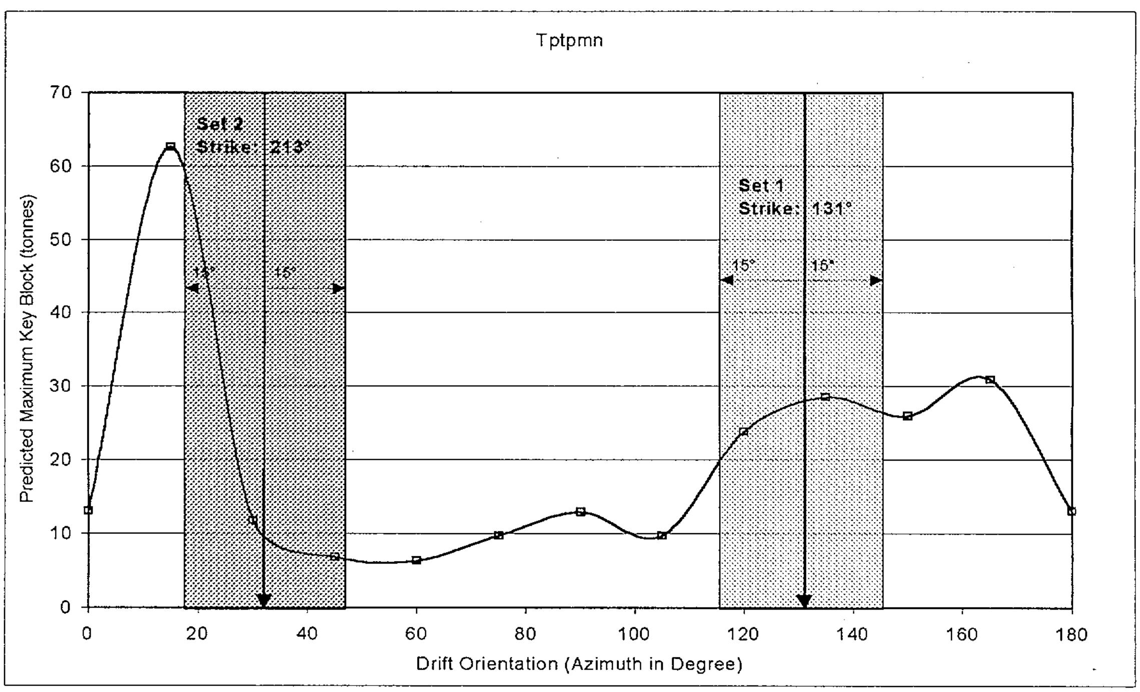

Figure 7. Predicted Maximum Block Size Relative to the Offset Criterion of 15°, Tptpmn (TBV-682 and TBV-779)

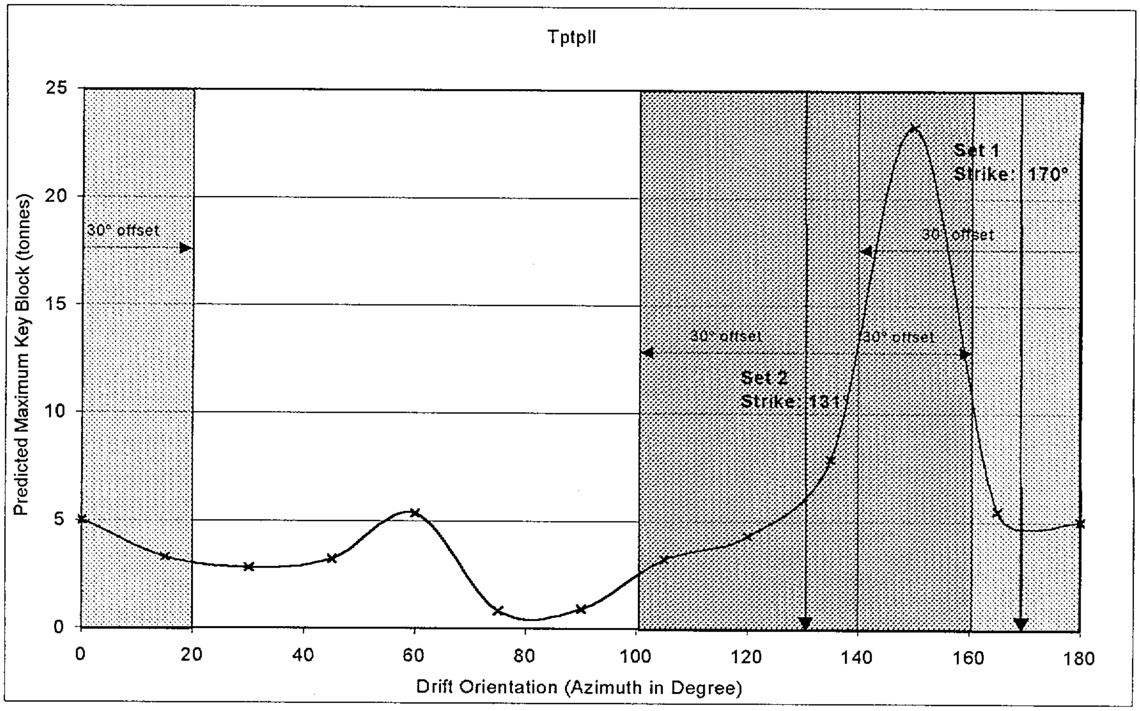

Figure 8. Predicted Maximum Block Size Relative to the Offset Criterion of 30°, Tptpll (TBV-682 and TBV-779)

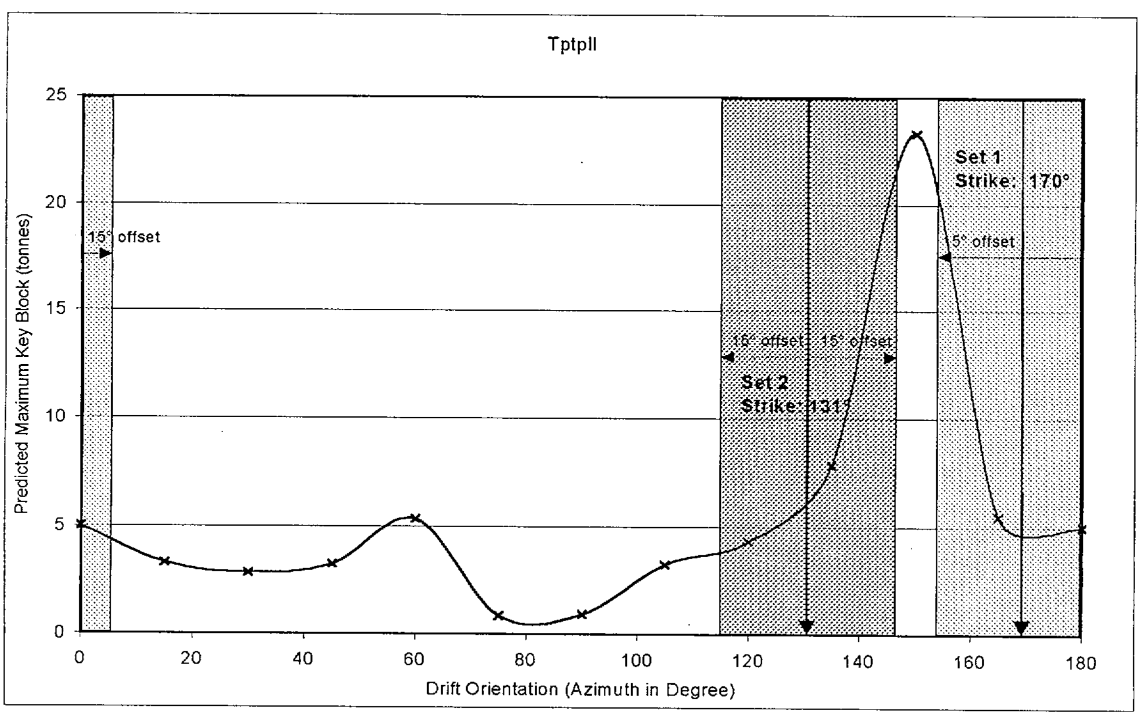

Figure 9. Predicted Maximum Block Size Relative to the Offset Criterion of 15°, Tptpll (TBV-682 and TBV-779)

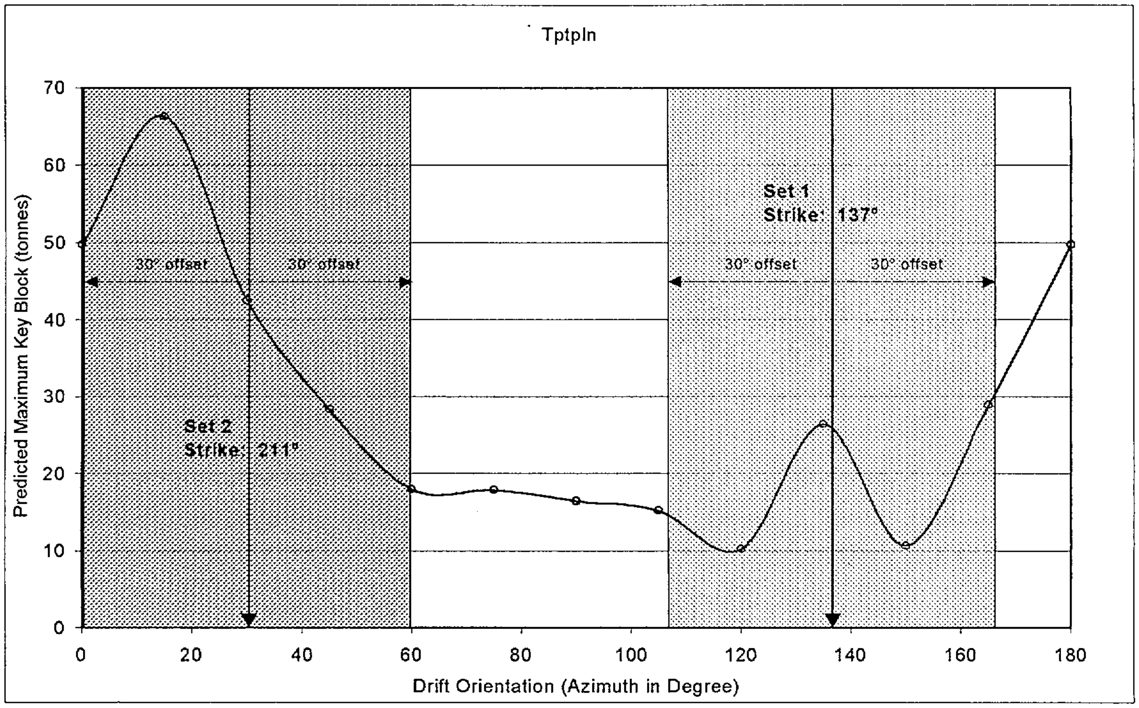

Figure 10. Predicted Maximum Block Size Relative to the Offset Criterion of 30°, Tptpln (TBV-682 and TBV-779)

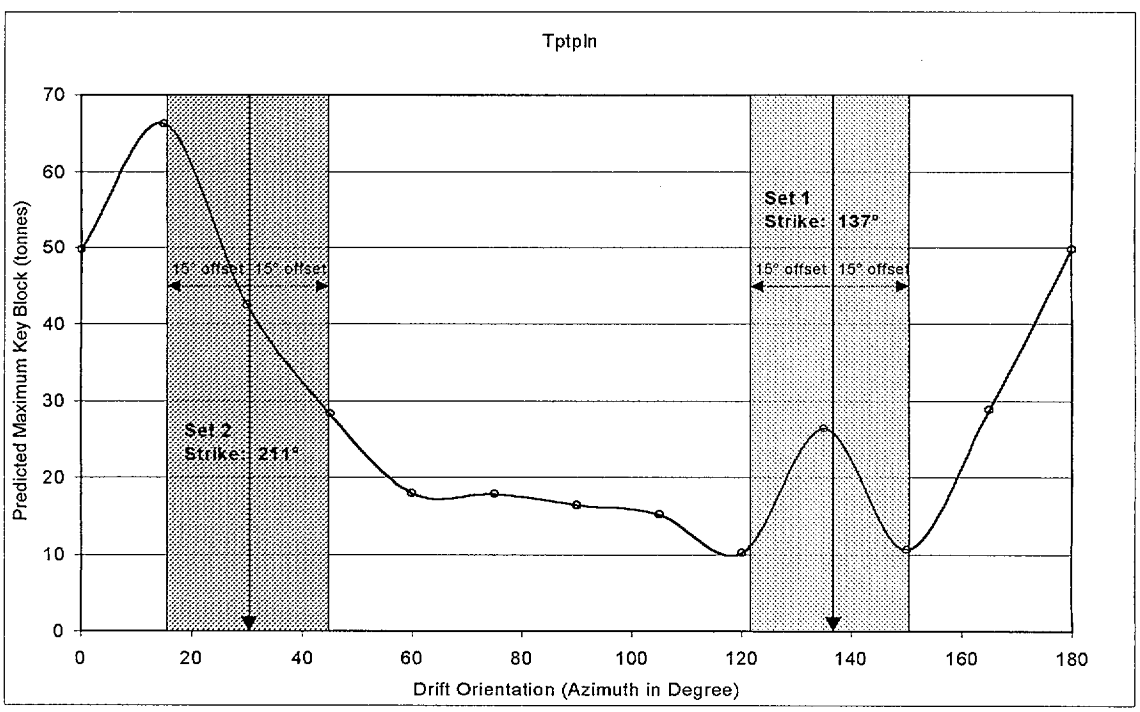

Figure 11. Predicted Maximum Block Size Relative to the Offset Criterion of 15°, Tptpln (TBV-682 and TBV-779)

7.5 THE EFFECT OF DRIFT ORIENTATION ON SEEPAGE

Seepage, as defined in this analysis, is the movement of water into emplacement drift. The unsaturated zone flow component in the Total System Performance Assessment (TSPA) – Viability Assessment (VA) includes the consideration of seepage into drifts (DOE 1998, pp.3-11 and 3-12). As stated in the TSPA-VA, the basic conceptual model for seepage is that openings in unsaturated media act as capillary barriers and divert water around them. This capillary-barrier effect has been tested and verified in the ESF by niche tests (TSPA-VA, CRWMS M&O 1998b, Section 2.4.4.9).

The calculation of seepage into drifts in the TSPA-VA was based on a three-dimensional fracture continuum flow model that includes a stochastic fracture permeability field (CRWMS M&O 1998b, Section 2.4.4.2). The permeability field was generated using the data from the DLS and Drift Scale Test. Although the fracture frequency data mapped from the DLS was used, the fracture orientation data was not considered in the model (CRWMS M&O 1998b, Section 2.4.4.2). The effect of orientation to the seepage is therefore not explicitly described in the TSPA-VA analysis.

Although the TSPA-VA analysis does not address the effect of drift orientation on seepage, the results presented in the supporting documents do support a favorable orientation perpendicular to the strike of the joint sets. The explanation is that since joints provide higher permeability than the matrix, it will be easier for flow to move around the drift (the capillary barrier) with fracture intersecting the drift perpendicularly. For the case of fracture parallel to the drift orientation, the rock matrix will prohibit the flow from going around the drift and therefore produce the pathway for seepage into the opening. The observation is shown graphically in Figure 12. A general discussion of two-dimensional flow towards and around a drift provided in Tsang et al., 1997 (pp. 17-19, 23- 25). Discussions on dependence of seepage on permeability around the drift are provided in Birkholzer et al., 1998 (pp. 9-11, 15-16) and support the observation made above.

Considerations of the effect of seepage and key block to the drift orientation indicate that the favorable drift orientation is the one perpendicular to the strike of the joint sets. Since the current study on seepage does not provide the level of details to support an offset criterion, the offset criterion is therefore primarily determined based on key block results.

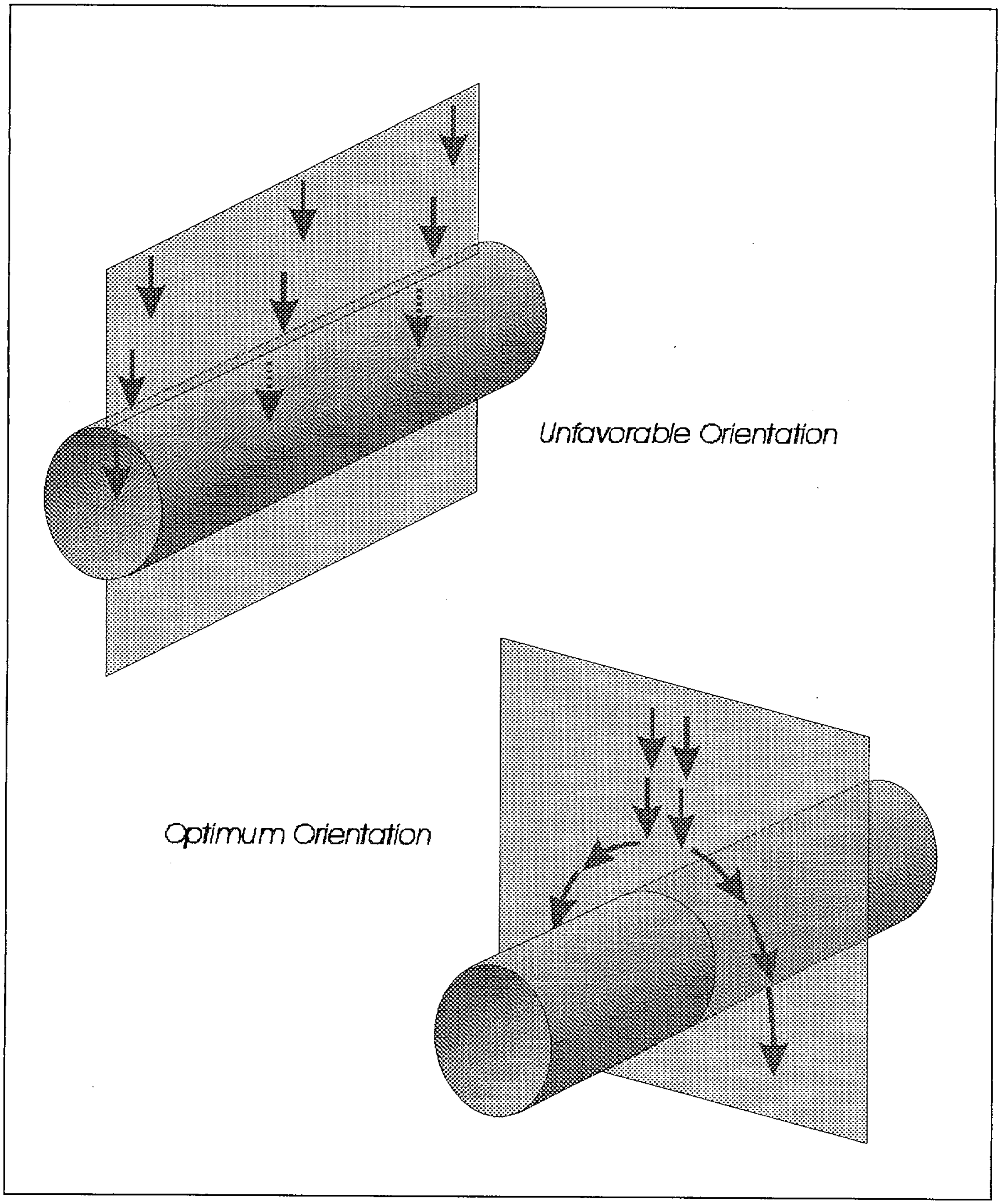

Figure 12. The Effect of Seepage on Drift Orientation

7.6 SENSITIVITY ANALYSIS OF THE OFFSET CRITERION TO THE VARIABILITY OF KEY BLOCK RESULTS

This section addresses the potential variability of the key block analysis results and its impact to the offset criterion. The potential variations are considered because of the usage of preliminary fracture data for the key block analysis as stated in Section 4 (TBV 682 and TBV 779).

The experiences gained in the ESF Main Loop indicated that only minor differences existed for the preliminary data and qualified data for the mapped fracture data. With the consideration of the same mapping personnel and technique, similar conclusion is drawn for the mapped fracture data in the ECRB cross drift. The potential minor difference of the preliminary and qualified data for the mapped fractures is projected to have minor impact to the key block analysis results. This is because that the variation of the fracture input parameters have already been accounted in the probabilistic key block analysis.

The fracture input parameters, such as joint orientations, joint spacings, and joint trace lengths were represented with statistical distributions (Watson distribution for joint orientation, Beta distribution for joint spacings and trace lengths, CRWMS M&O 1999b, pp. 8 and 13) in the key block analysis. The results obtained from the key block analysis therefore represent a probabilistic distribution of the potential key blocks. Accumulative percentages of occurrence for various levels of block sizes were reported in the preliminary key block analysis results (CRWMS M&O 1999b, Figures 6 to 9). The analysis in Section 7.4 uses the predicted maximum key blocks (100 percentile block). To assess the potential impact of the variability of the key block analysis results to the conclusion of the offset criterion, the key blocks with 98 percentile accumulative frequency of occurrence were selected. The 30° offset criterion was superimposed on the figures of predicted 98 percentile blocks as shown in Figures 13 to 15. It is shown that the offset criterion of 30° is adequate considering the potential variation of the key block analysis results.

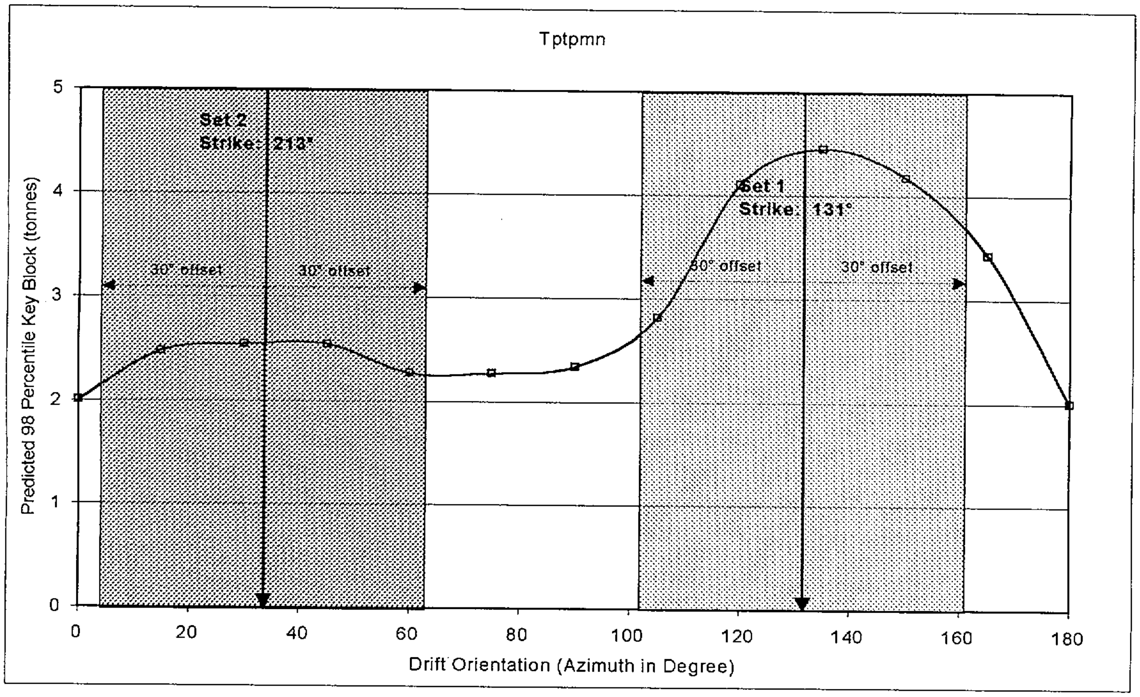

Figure 13. Predicted 98 Percentile Block Size Relative to the Offset Criterion of 30°, Tptpmn (TBV-682 and TBV-779)

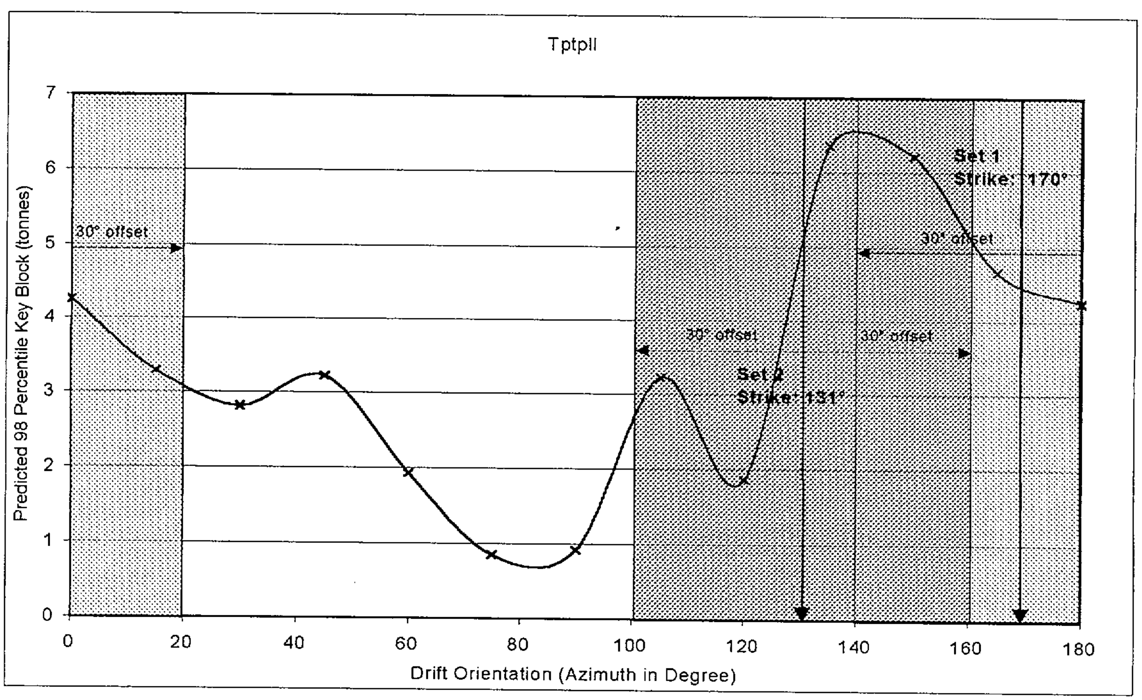

Figure 14. Predicted 98 Percentile Block Size Relative to the Offset Criterion of 30°, Tptpll (TBV-682 and TBV-779)

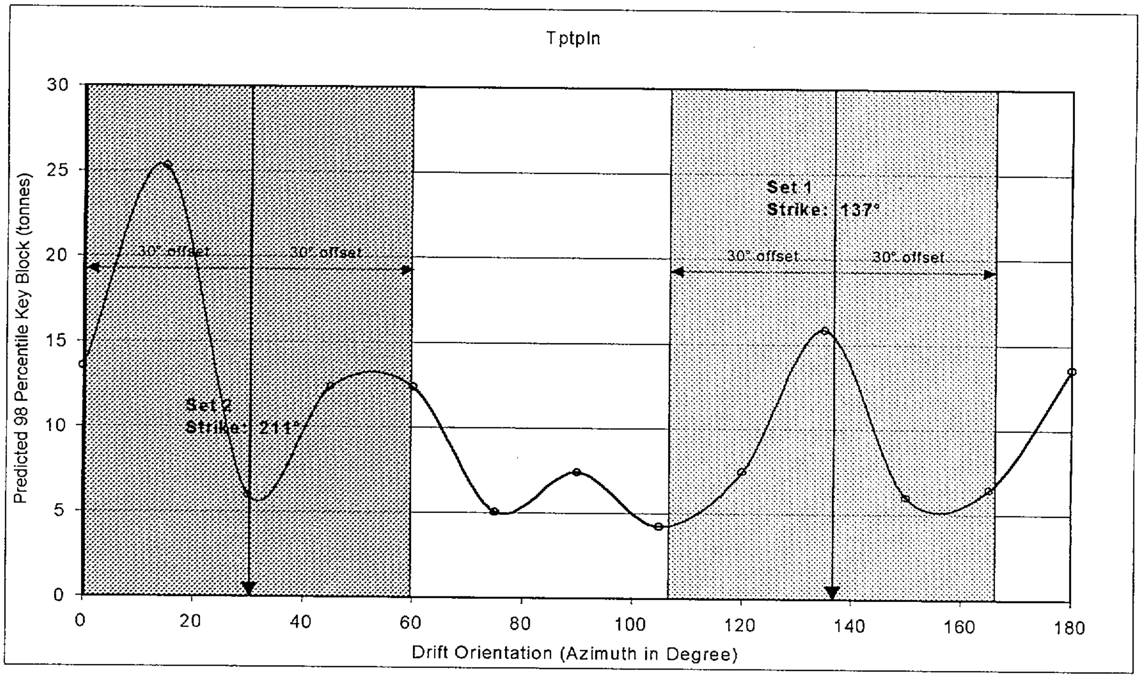

Figure 15. Predicted 98 Percentile Block Size Relative to the Offset Criterion of 30°, Tptpln (TBV-682 and TBV-779)

8. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this TBX resolution analysis is to provide data and information to support the release of the TBV-361 related to the emplacement drift orientation. The results of this evaluation are based on preliminary, unqualified inputs (TBV-682 and TBV-779). Efforts are underway to qualify these inputs. The results of a sensitivity study, provided in Section 7.6, indicate that the conclusion drawn from this analysis is adequate considering the potential variation of the key block analysis results. A TBV indicator is therefore not required on the analysis outputs as documented herein. The analysis is traceable to the aforementioned inputs, and in the event qualification of the input data produces substantial changes to the values used herein, an update to this analysis would be required. The following conclusions and recommendations have resulted from this analysis.

8.1 CONCLUSIONS

- With the consideration of both the formation of key blocks and seepage, the favorable orientation is the one perpendicular to the strike of the dominant joint set. The most unfavorable orientation is the one parallel to the strike of the joint. Notice that this is true from both the seepage and key block perspectives.

- Offset criteria of 15° and 30° between joint strike and drift orientation were both examined based on preliminary key block analysis results. The 15° offset criterion does not cover the maximum key block predicted. The 30° criterion covers the predicted maximum key block as shown in Figures 6, 8, and 10.

- The VA emplacement drift layout of 288° (or 108°) is 23° from the 1st set of Tptpmn unit, 23° from the 2st set of Tptpll unit, and 29° from the 1st set of Tptpln unit. It does not satisfy the 30° offset criterion.

8.2 RECOMMENDATIONS

- The offset criterion of 30° is adequate based on the resolution analysis. It is recommended that TBV-361 be released with no change to this criterion.

- Revise the SDD to reflect the release of TBV-361.

- Emplacement drifts shall be reoriented based on the offset criterion and other operational considerations. A preferred orientation based on the resolution analysis appears to be the mirror image of the VA orientation with azimuth of 252° (or 72°). This is provided for information purposes only.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

ACC	Records Processing Center accession number
AIME	American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc.
AP	Administrative Procedure
CFR	Code of Federal Regulations
CRWMS M&O	Civilian Radioactive Waste Management System Management and Operating Contractor
DCN	Document Change Notice
DIE	Determination of Importance Evaluation
DLS	Detailed Line Survey
DOE	U.S. Department of Energy
DRKBA	Discrete Region Key Block Analysis
DTN	Data Tracking Number
ECRB	Enhanced Characterization of the Repository Block
ESF	Exploratory Studies Facility
FPGM	Full Periphery Geologic Map
M&O	Management and Operating Contractor
MGR RD	Mined Geologic Repository Requirements Document
MOL	M&O Las Vegas (Location of Document)
NLP	Nevada Line Procedure
QA	Quality Assurance
QAP	Quality Assurance Procedure
SDD	System Description Document
TBD	To Be Determined
TBV	To Be Verified
TBX	To Be Verified/To Be Determined
TDPP	Technical Document Preparation Plan
TIC	Technical Information Center
Tptpll	Topopah Spring Tuff crystal poor lower lithophysal zone
Tptpln	Topopah Spring Tuff crystal poor lower nonlithophysal zone
Tptpmn	Topopah Spring Tuff crystal poor middle nonlithophysal zone
TSPA	Total System Performance Assessment
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
VA	Viability Assessment of the Repository