SNOWFALL QPF VERIFICATION
IN THE LAKE TAHOE AREA

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Introduction

The importance of accurate snowfall forecasts in the Lake Tahoe area and over the northern Sierra mountain passes is related to the number of people that are affected by the snow that falls. The area's economy is very dependent on the tourism and ski industries. The area has 10,000 hotel rooms, capacity for 30,000 skiers a day, and a permanent population center of 40,000, not including Reno/Sparks. Average daily traffic counts alone on I-80, the main route between Sacramento, California and Reno, Nevada, are 24,000 cars.

This study arose to address the question, "Do we have any skill in forecasting snowfall amounts in the Lake Tahoe area?", and when the public asks, "How much is it going to snow?", are we giving them a valid answer. They will base many important decisions on that answer.

This is not a storm verification study, but a study of Quantitative Snowfall Forecasts (QPF) only, and is intended to be the start of a continuous effort to monitor the skill of our forecasts. The study includes 35 snow events during the last two winter seasons, 1990-91 and 1991-92.

Method

Examination of 213 Special Weather Statements (SPS), of which 41 had no QPF, while mentioning some sort of approaching weather system, was done. The 41 SPSs with no QPF were not included in this study. Each QPF was placed into one of three specific lead time categories, (i.e., < 24 hours, 24-48 hours, $\geq$ 48 hours) determined by the difference between the QPF valid time and the SPS issuance time. The choice of QPF category, (i.e., < 6 inches, 6-12 inches, 12-24 inches and > 24 inches) was based on forecast snowfall amount mentioned in the SPS.

A forecast was considered a "hit" if the actual snowfall amount fell into the same category as the QPF. In most cases, the average of the reporting station's snowfall total during the QPF valid time determined the actual snowfall amount. In situations when an SPS had different forecasts above and below 7000 feet, two QPFs were used and only the appropriate reporting stations were used for verification. The percent of correct forecasts were calculated by taking the number of hits and dividing it by the number of snowfall events in that QPF category. A record was kept of whether a forecast was over or under the actual snowfall total.

The locations used to verify snowfall are in Fig. 1; 4 stations at lake level, Tahoe City, Incline Village, Glenbrook, and Stateline, (Truckee was slightly below lake level, but was used as a lake level site), three stations above 7000 feet, Daggett Pass, Sierra Ski Ranch, and Echo Summit. These sites were chosen because they reported regularly at approximately the same time of day so a continuous record was available, keeping overlap snowfall to a minimum. Other data were available, and used if any of the three sites had missing data, or we felt was not representative of the general snowfall of the storm. Snowfall from the other high elevations sites in Fig. 1, (Donner Summit, Sugar Bowl ski area and Squaw Valley ski area) were used.

Results

Verification of snowfall amounts showed that the percent of correct forecasts decreased with increased snowfall and longer lead times, [i.e the heavier the snowfall and/or the earlier the forecast was made, the less likely the forecast was in the right category.]

In Figs. 2a-d, at all lead times, the number of "hits" decreased as the snowfall increased. It should be noted that there were fewer events where snowfall was more than 12 inches. Figures 3a-d confirms that the more snow forecasted, the less likely the snowfall amount fell within the forecasted range. With lead times of 48 hours or more, there were too few events to draw any conclusions about the precise numbers. However, extending the trend of the 24-48 hour forecast lead time to > 48 hours suggests even less skill.

Figures 4a and 4b indicate that longer lead time QPFs showed less skill, although the percent correct remained near 50 percent. Figure 4c indicates there was a tendency to over forecast snowfall amounts when the forecast did not verify. Figures 5a-d confirm this for each category of QPF. When there was not a "hit" the amount that fell, "Actual Results", was more often less than the amount forecast.

Conclusion

This study shows that the WSFO Reno forecasters have demonstrated skill in forecasting snowfall QPFs for the Lake Tahoe area, but that this skill decreases as lead time increases and actual snowfall amounts increase. In general, for forecast lead time beyond 24 hours, the forecasters have a tendency to overforecast snow amounts.

The authors plan to collect data and continue the evaluation of snow QPFs over the next few seasons with a goal of answering the following questions:

1) How does the forecaster skill level vary with smaller QPF intervals, (i.e., $\leq$ 3 inches, 3-6 inches) at longer lead times?

2) Would larger QPF intervals, (i.e., 12-24 inches, $\geq$ 24 inches) provide the user with useful information for forecasts beyond 24 hours?
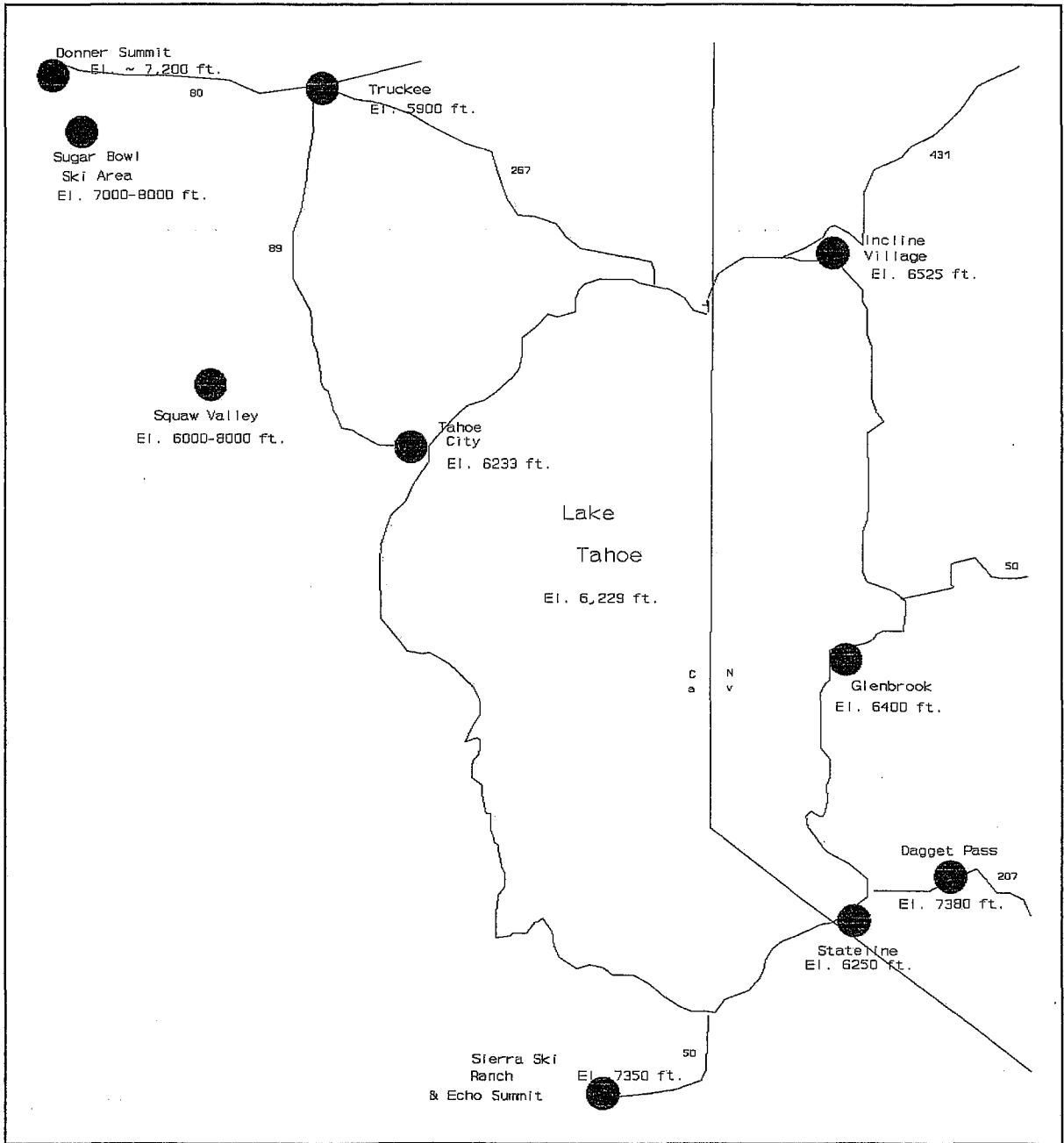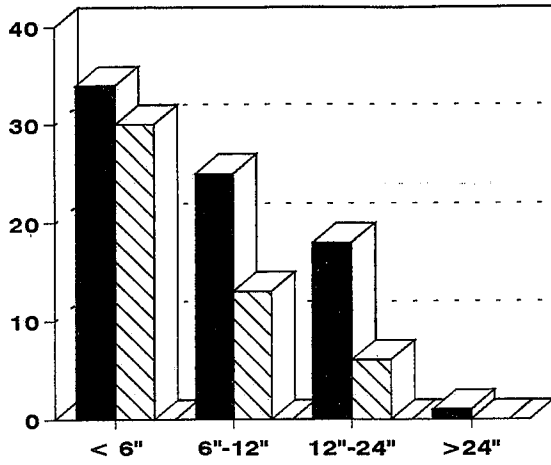
Donner Summit
El. ~ 7,200 ft.

80

Truckee
El. 5900 ft.

Sugar Bowl
Ski Area
El. 7000-8000 ft.

267

431

Incline
Village
El. 6525 ft.

89

Squaw Valley
El. 6000-8000 ft.

Tahoe
City
El. 6233 ft.

Lake

Tahoe

El. 6,229 ft.

50

C
a

N
v

Glenbrook
El. 6400 ft.

Dagget Pass

207

El. 7380 ft.

State line
El. 6250 ft.

50

Sierra Ski
Ranch
& Echo Summit

El. 7350 ft.

Fig. 1, Observation Points

QPF <= 24 Hours
Lead Time
1990-91 & 1991-92

	< 6"	6"-12"	12"-24"	>24"
Forecasts	34	25	18	1
Hits	30	13	6	0

■ Forecasts ◻ Hits

Fig. 2a

QPF 24 to 48 Hours
Lead Time
1990-91 & 1991-92
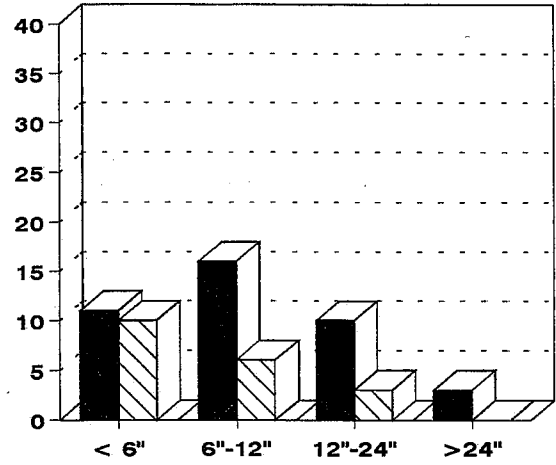
	< 6"	6"-12"	12"-24"	>24"
Forecasts	11	16	10	3
Hits	10	6	3	0

■ Forecasts ◻ Hits

Fig. 2b

QPF > 48 Hours
Lead Time
1990-91 & 1991-92
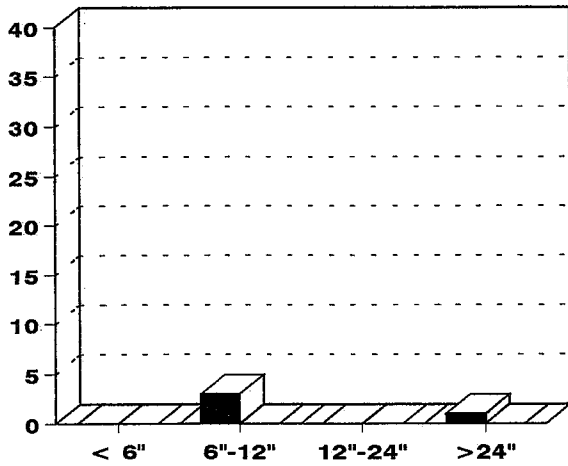
	< 6"	6"-12"	12"-24"	>24"
Forecasts	0	3	0	1
Hits	0	0	0	0

■ Forecasts ◻ Hits

Fig. 2c

All QPF's
1990-1991 & 1991-1992
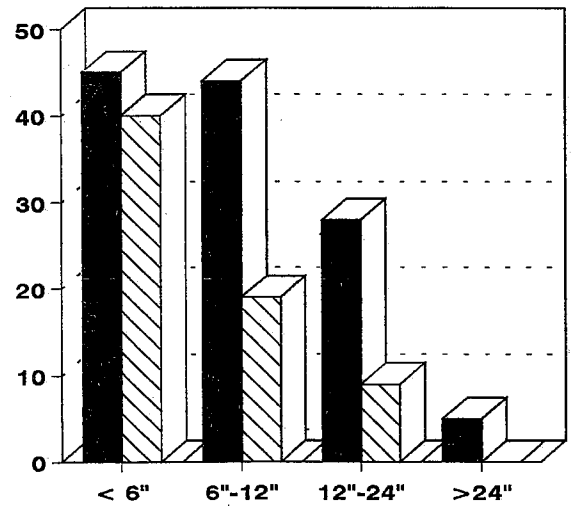
	< 6"	6"-12"	12"-24"	>24"
Forecasts	45	44	28	5
Hits	40	19	9	0

■ Forecasts ◻ Hits

Fig. 2d

**% Correct QPF with Lead Time
<= 24 Hours
1990-91 & 1991-92**

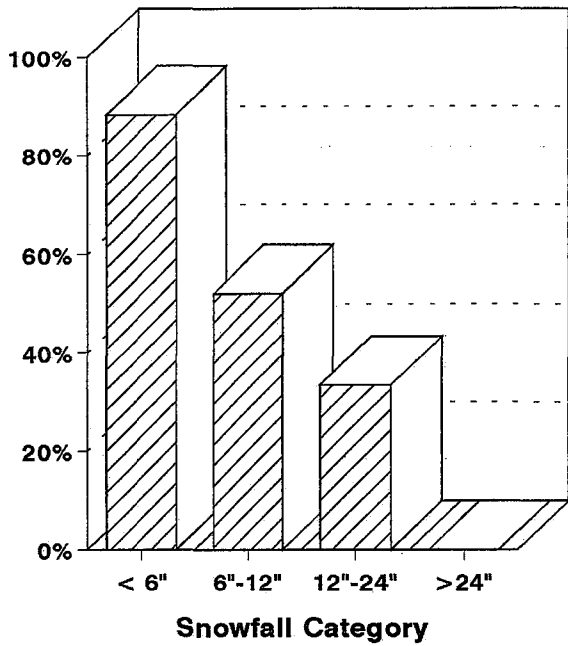Snowfall Category

Fig. 3a

**% Correct QPF with Lead Time
24 - 48 hours
1990-91 & 1991-92**

Snowfall Category
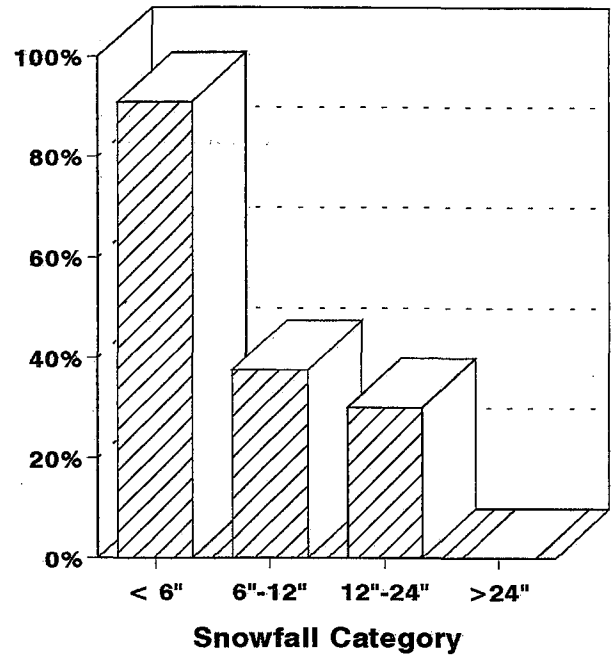
Fig. 3b

**% Correct QPF with Lead Time
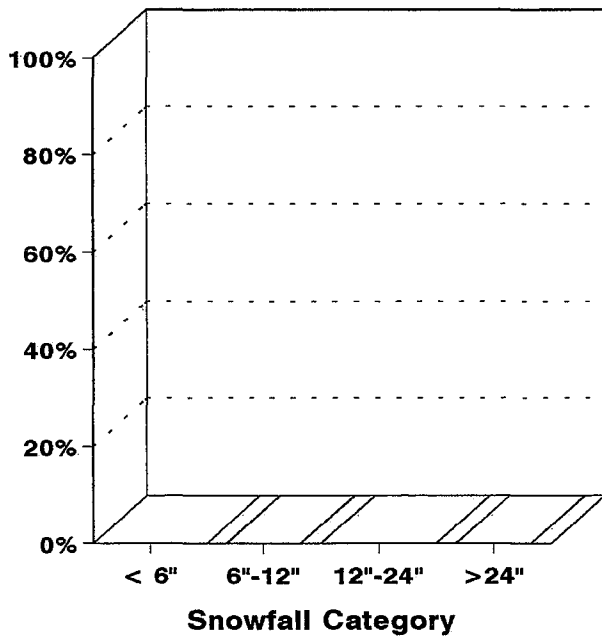>= 48 Hours
1990-91 & 1991-92**

Snowfall Category

Fig. 3c

**% Correct All QPF's
1990-91 & 1991-92**

Snowfall Categroy

Fig. 3d

Snowfall QPF Verification with Time 1990-91 & 1991-92

	<= 24 Hours	24 - 48 Hours	>= 48 Hours
Forecast	78	40	4
Hits	49	19	0

Lead Time

■ Forecast ◫ Hits
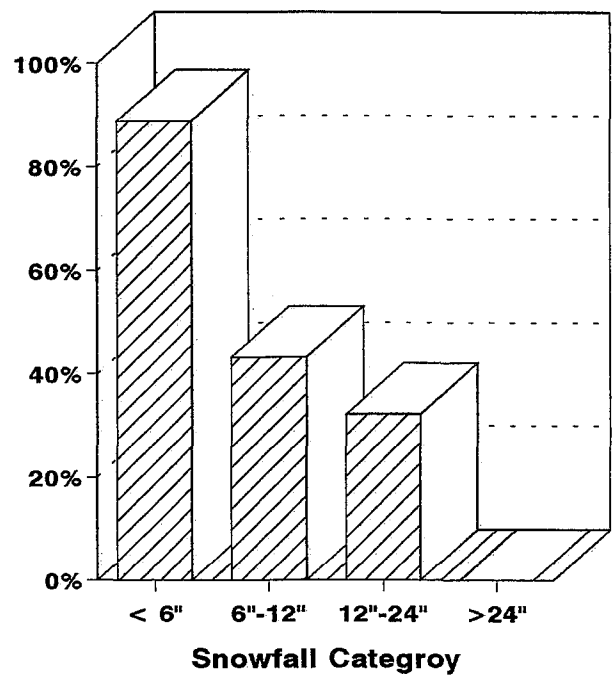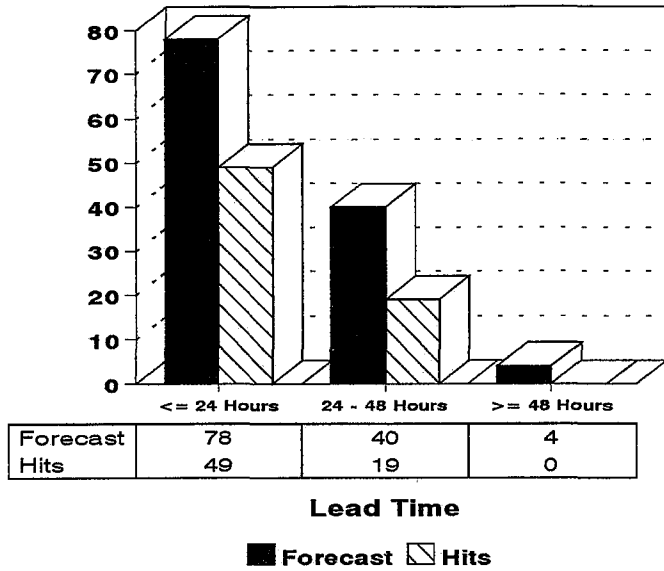
Fig. 4a

% Correct Snowfall QPF Verification with Time 1990-91 & 1991-92

Lead Time
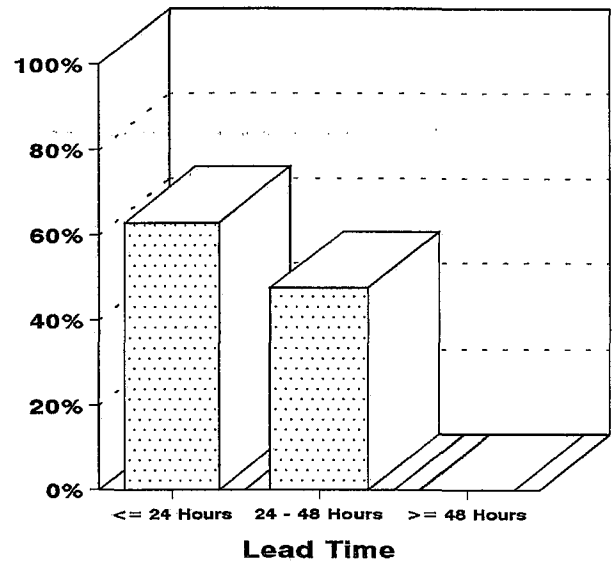
Fig. 4b

Over/Under Forecasts 1990-91 & 1991-92

	< 24 Hrs	24-48 Hrs	> 48 Hrs
Over	24	17	4
Hits	49	19	0
Under	5	4	0

■ Over ◫ Hits ⊡ Under
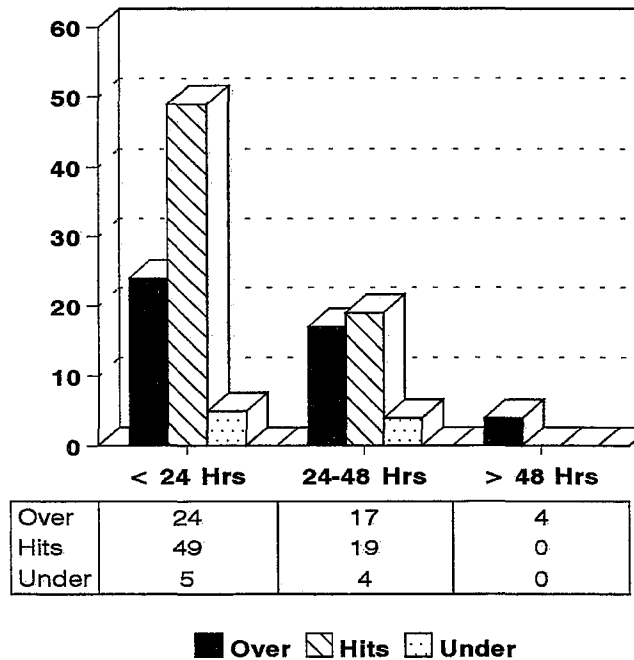
Fig. 4c

QPF < 6 Inches
1990-91 & 1991-92

Actual Result	None	Hits	6-12"	12-24"	>24"
	3	40	2	0	0

■ Actual Result
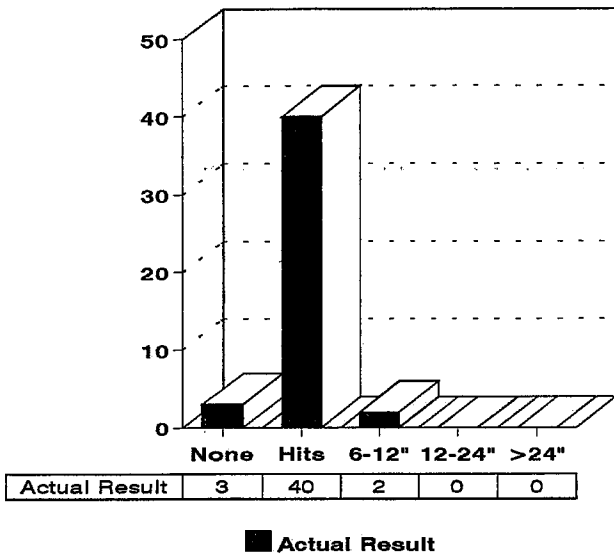
Fig. 5a

QPF 6-12 Inches
1990-91 & 1991-92

Actual Result	None	<6"	Hits	12-24"	>24"
	3	19	19	3	0

■ Actual Result
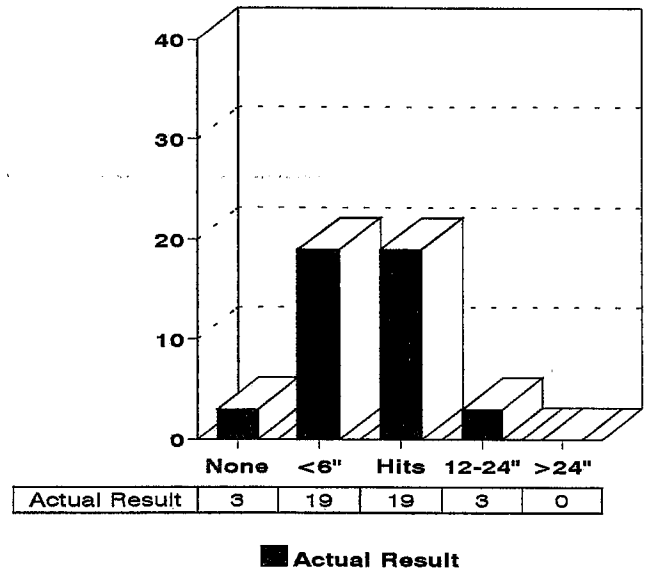
Fig. 5b

QPF 12-24 Inches
1990-91 & 1991-92

Actual Result	None	<6"	6-12"	Hits	>24"
	0	7	8	9	4

■ Actual Result
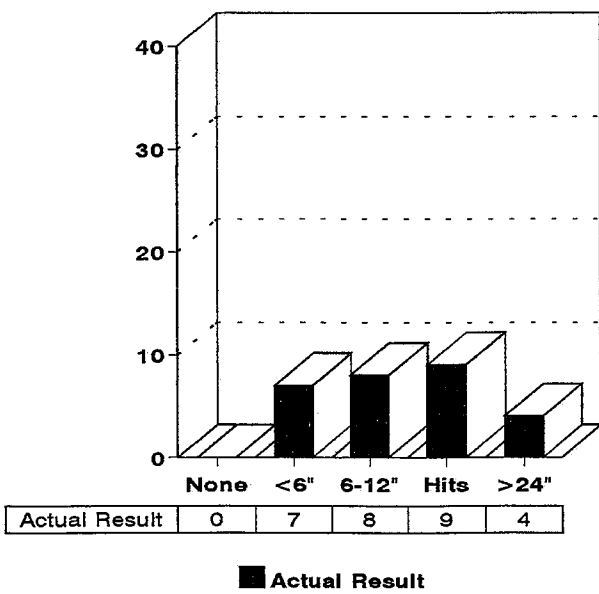
Fig. 5c

QPF > 24 Inches
1990-91 & 1991-92

Actual Result	None	<6"	6-12"	12-24"	Hits
	0	3	0	2	0

■ Actual Result

Fig. 5d