

Table 9.1. Typhoons and Population and Economic Growth on Guam<sup>1</sup>

Year	Typhoon	Winds: Sustained/ Gust (mph)	Red Cross Support Costs (\$million) <sup>2</sup>	Population	Housing Units	Visitor Arrivals	Gross Island Product (\$million)
1970				84,996	16,680		
1976	Pamela	140/170	\$11.0				
1977	Kim	75/90					
1980	Betty	75/90		105,997	28,249		
1984	Bill	65/75					
1988	Roy	95/115	\$0.4			576,178	\$1729.44
1989	Andy	80/100				658,883	\$1897.48
1990	Koryn	70/85		133,152	35,233	769,876	\$2312.47
1990	Russ	115/145	\$2.8				
1991	Yuri	115/145	\$1.0	136,226		728,722	\$2667.37
1992	Omar	120/150	\$6.0	139,371		836,074	\$2902.13
1992	Gay	100/125					
1992	Hunt	75/90					
1992	Elsie	70/85					
1992	Brian	75/90					
1993				142,589			\$2916.73
1994	Wilda	75/90		145,881		1,076,437	\$3035.21
1995				149,249		1,350,476	\$2999.26
1996	Dale	70/85		152,695		1,352,361	\$2992.50
1997	Paka	150/185	\$4.9 <sup>3</sup>	156,261	45,085 (est.)	1,069,348	

Sources: 1. Appendix 4, C. Guard. Hurricane (Typhoon) Program Needs Assessment for the Territory of Guam. Water and Energy Research Institute, University of Guam. 2. Annex I-1. C. Guard. Hurricane (Typhoon) Program Needs Assessment for the Territory of Guam. Water and Energy Research Institute, University of Guam. 3. American Red Cross Disaster Operation Control DR 519.

Guam's population has grown from an estimated 84,996 in 1970 to an estimated 156,261 in 1997. Population growth was fairly steady during that period, increasing 25.6 percent in the 1970s and about 24.7 percent in the 1980s. The number of housing units, however, increased 69.4 percent between 1970 and 1980 and only about 24.7 percent between 1980 and 1990.<sup>4</sup> While the general population continued to grow in the 1990s, the military population on Guam declined from 22,178 in 1992 to 13,792 in 1996.<sup>5</sup>

Guam's economy began to grow rapidly in the early 1980s largely as a result of Japanese investment in the tourism industry. By 1987, the Gross Island Product per capita was about \$13,500, higher than most other island jurisdictions in the Pacific. By 1996, this had grown to almost \$19,600. Much of this economic growth was fueled by growth and investment in the visitor industry. Visitor arrivals on Guam grew from 483,954 in 1987

<sup>4</sup> Guam Department of Commerce. Annual Economic Review: 1996-1997, p. A1.

<sup>5</sup> Guam Department of Commerce. Annual Economic Review: 1996-1997, p. A35.

to 1,362,600 in 1996.<sup>6</sup> Over the same period, the assessed value of buildings on Guam, increased from about \$1.395 billion to \$4.384 billion.<sup>7</sup>

The growth in Guam's population and building stock has put more people and structures potentially at risk from typhoons. However, very little comparable data on people affected and houses destroyed are available to make a comparison (see Past Trends in Social and Economic Impact, below).

## **9.2. SOCIAL AND ECONOMIC IMPACT OF TYPHOON PAKA**

Typhoon Paka struck Guam on December 16, 1997 with sustained winds of 150 m.p.h. and gusts to 185 mph. Torrential rains, high winds, high surf and storm waves pounded Guam from 1:00 p.m. on December 16 through 1 a.m. on December 17, with typhoon-strength winds blowing for a total of 15 hours during that period.<sup>8</sup>

Paka, like other typhoons on Guam, caused a great deal of short-term social and economic disruption. Electric power service was shut down throughout the island, trees were downed, roads were strewn with debris, houses and commercial buildings were damaged, the port and the airport were shut down, schools were closed, tourism and other business activities ceased to function, television service was disrupted, government workers and the military were dispatched to assist people and open roads, and life was generally disrupted. However, the long-term social and economic impact was relatively small considering the intensity of Paka's winds.

From a social perspective, Paka's arrival, less than ten days before Christmas, completely disrupted holiday preparations for the entire island. Undoubtedly, many businesses that depend on Christmas sales for a large part of their income were hurt by the storm. The fact that Christmas school holidays fell during much of the cleanup and recovery probably minimized the impact of the storm on education. Some families were off-island visiting relatives, and there were undoubtedly overseas guests on Guam for the holidays. The government and business community organized a mass and luncheon on Christmas day for the homeless. This is just one of many examples of how Paka brought communities on Guam together.<sup>9</sup> The speed with which public and private services were restored is a tremendous testimony to the hard work and cooperation among the people of Guam.

### **9.2.1. Shelter and Housing**

Virtually everyone on Guam suffered some kind of property damage. For some, damage amounted to trees blown down in the yard or water damage from rain blown in through

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<sup>6</sup> Guam Department of Commerce. Annual Economic Review: 1996-1997, p. A59.

<sup>7</sup> Guam Department of Commerce. Annual Economic Review: 1996-1997, p. A50

<sup>8</sup> Hazard Mitigation Survey Report: Typhoon Paka (DR-1193-GU). Government of Guam and Federal Emergency Management Agency, March 1998, p. 3.

<sup>9</sup> See *Estorlan Paka: Guam's Spirit of Recovery*. Governor Carl Gutierrez, Lieutenant Governor Madeleine Bordallo, February 1998.

walls or around doors and windows by Paka's intense winds. For others, Paka heavily damaged or totally destroyed their homes and commercial buildings.

There are no firm figures available on property losses resulting from Paka. The results of an initial assessment conducted by the American Red Cross are shown in Table 9.2. The latest published figures available for the number of housing units on Guam is for 1996, when there were a total of 34,448 occupied residences.<sup>10</sup> Paka destroyed or damaged the equivalent of about 16.8 percent of the 1996 occupied residences on Guam. About 3.5 percent were destroyed and almost 5 percent suffered major damage.

**Table 9.2. American Red Cross Final Damage Assessment Figures for Typhoon Paka**

Structures	Destroyed	Major Damage	Minor Damage	Total Damaged or Destroyed
Single Family Homes	1,199	1,582	2,376	5,148
Mobile Homes	38	40	46	124
Apartments	44	94	364	502
Total Structures	1,281	1,716	2,797	5,794

Source: FEMA Situation Report #10, FEMA-1193-DR-GU January 2-3, 1998

Insurance claims and losses for residential and commercial structures on Guam are shown in Table 9.3. According the Department of Revenue and Taxation, Real Property Division, there were 27,561 residential and commercial buildings on Guam, 6,887 less than the number of structures cited above and 4,105 less than the 31,666 structures identified through a major survey by the Guam Bureau of Planning (see Chapter 6, Section 6.7. Part of the discrepancy likely arises from the large number apartments and multiplexes on Guam, which were considered separately in the survey. The survey also counted unoccupied and abandoned buildings. However, other Bureau of Planning information (web site) indicates that there are 34,448 households. Using the Department of Revenue and Tax figure for the number of structures, total claims were made for 16 percent of commercial and residential structures. Claims were filed for 39 percent of concrete buildings with shutters, 55 percent of concrete buildings without shutters, and 6 percent of non-concrete buildings. Losses totaled 22 percent for concrete buildings with shutters, 38 percent for concrete buildings without shutters, and 40 percent for non-concrete buildings.

The number of insurance claims is undoubtedly smaller than the number of buildings suffering damage. Following Typhoon Omar in 1992, insurance companies licensed to sell policies on Guam stopped insuring non-concrete structures except for renewal of existing policies. Moreover, the Insurance Commissioner's office reported that many concrete structures equipped with shutters suffered losses that were less than the

<sup>10</sup> General Information. Government Guam Web Site, General Information. Source: Bureau of Planning, 1996. There were 1,527 vacant housing units at the time the 1996 statistics were compiled. Department of Revenue and Taxation reported a total of 27,561 commercial and residential structures on Guam, almost 20% fewer than the Bureau of Planning 1996 figure.

deductibles and were unable to qualify for claims.<sup>11</sup> Some homeowners did not qualify for federal assistance and did not have property insurance when Paka struck. Some homeowners have also reportedly chosen to absorb the cost of repairs rather than seek reimbursement from their insurance companies. Many owners of concrete structures have elected to "self-insure" their property.

Table 9.3. shows the losses from residential and commercial claims for concrete structures with and without shutters and for non-concrete structures. The claims for concrete structures with shutters are higher than expected, especially for residential properties. This suggests that a great deal of "shutters" were not of commercial quality. There was likely a large segment of the population using 4' X 8' plywood sheets as "shutters". While plywood sheets, would probably survive Typhoon Category 2 winds and weak-medium Typhoon Category 3 winds, they would not likely survive winds in excess of strong Typhoon Category 3. Many of the houses with shutters were probably in the stronger wind zone and incurred more damage. Those with engineered shutters likely had smaller claims. Thus, the \$6,095 per claim for houses with shutters was probably even higher for those that used plywood.

Even the losses for commercial structures seem high for "shuttered" concrete structures, but many smaller businesses may have used plywood sheets as shutters. Larger businesses may have lost inventory to water damage, driving up the cost per claim. Table 9.3 does indicate that losses for "shuttered" concrete structures were about 42 percent of the total concrete structures. However, when information on the cost-per-claim is examined, it shows that structures with shutters suffered \$28,350 less damage per claim than structures without shutters, and that concrete structures with shutters suffered about one-half the costs for non-concrete structures. The cost-per-claim information also shows that for both residential and commercial structures, the claim was significantly higher for non-concrete structures than for concrete structures. **This points out both the importance of concrete structures and of engineered typhoon shutters.**

Table 9.3. Typhoon Paka Insurance Claims and Losses

Type of Building	Residential Claims		Commercial Claims		Total Claims	
	Claims	Losses Loss/Claim	Claims	Losses Loss/Claim	Claims	Losses Loss/Claim
Concrete w/ Shutters	1,593	\$9,708,331 \$6,095	122	\$10,729,873 \$87,950	1,715	\$20,438,204 \$11,918
Concrete w/out Shutters	2,213	\$9,063,971 \$4,096	219	\$25,472,740 \$116,300	2,432	\$34,536,711 \$14,200
Non-Concrete	78	\$1,761,231 \$22,579	198	\$34,203,237 \$172,744	276	\$35,964,468 \$130,306
Total	3,884	\$20,533,533 \$5,287	539	\$70,405,850 \$130,623	4,423	\$90,939,383 \$20,561

Source: Insurance Commissioner's Report on Typhoon Paka. Department of Revenue and Taxation, July 28, 1998.

<sup>11</sup> Insurance Commissioner's Report on Typhoon Paka. Department of Revenue and Taxation, July 28, 1998.

Unfortunately, non-concrete structures were not distinguished as wooden, concrete with a wooden/tin roof, or sheet metal, and there is no indication of the age of the structure. As seen in Chapter 6, these are important factors in anticipating the level of wind damage expected.

Another perspective on the impact of Paka on housing and the level of social disruption is provided by the number of people who moved to emergency shelters. On December 24, 1997, FEMA reported that a total of 2,030 people were being housed in shelters, largely schools. On December 24, FEMA and the Government of Guam agreed that tents were to be provided to allow people to return to their own property. Plans were also developed to open a shelter in unoccupied barracks on Andersen (Andersen South) Air Force Base on December 26. The Liheng-Ta Shelter at Andersen South was opened on January 2nd or 3rd with a total of 1,100 people being moved to those quarters.<sup>12</sup> A total of 139 people (30 families) were still in the Liheng-Ta Shelter as of February 23, 1998.<sup>13</sup> That shelter was closed on February 27, 1998. Interviews with Government of Guam, FEMA, and American Red Cross staff indicated that considerably fewer people moved into shelters following Typhoon Paka than after Typhoon Omar. Following Typhoon Omar, a large "tent city" was erected, but it was hot, uncomfortable, lacked privacy, and was unpopular. A total of 4,454 more Paka victims than Omar victims received disaster housing grants. Some officials also attributed the fewer number of people in shelters following Paka to the fact that people seemed more inclined to move in with relatives or stay in tents with their damaged houses than in the past.

FEMA Temporary Housing grants are another measure of the impact of Paka on housing. About 42.7 percent of the estimated 34,448 households on Guam submitted applications for temporary housing grants (See Table 9.3).<sup>14</sup> Of the total number that applied, about 55 percent were deemed eligible. This figure is equivalent to about 23.7 percent of the estimated number of households on Guam.

A final measure of housing impact is the number of households who applied for residential loans from the Small Business Administration. About 16 percent of the estimated number of households on Guam applied for SBA residential loans. Only 44% of the residential loan applications were approved which constitute about 7.4 percent of the total number of households. Part of the variance between the temporary housing grant totals and the number of SBA loans may be a function of the fact many people rent rather than own homes. It should be noted, however, that the most vulnerable groups on Guam did not own houses or have formal rent agreements and, some, may have been living as squatters. At least some of these victims qualified for neither temporary housing grants or SBA loans.

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<sup>12</sup> FEMA Situation Report No.9.

<sup>13</sup> FEMA Situation Report No. 23.

<sup>14</sup> General Information. Government Guam Web Site, General Information. Source. Bureau of Planning, 1996

### 9.2.2. Employment

The impact of Paka on peoples' livelihood is also difficult to measure. Guam does not provide regular unemployment benefits to individuals who lose their jobs. The Department of Labor conducts employment surveys on Guam, and, as of September 1997, a total of 4,550 were unemployed.<sup>15</sup> **The Department of Labor's Annual Census of Establishments: March 1998 Guam (GOVGUAM 1998c) showed no significant loss of employment due to Typhoon Paka. For that matter, the Department of Labor statistics indicated no direct loss of employment due to any previous typhoons.** In fact, net unemployment between September 1997 and March 1998 declined by 1.5 percent, a result of disaster recovery employment.

Initial interviews with Government of Guam officials and private business people indicated that few jobs were lost as a result of the storm. As discussed below, only two hotels were shut down for any length of time, and employees working in hotels and other businesses were the major source of cleanup labor following the storm. The same was true for Government of Guam, Federal domestic agencies, and the military.

However, figures available on the number of people who received emergency unemployment benefits from the US Department of Labor are equivalent to a fairly high percentage of the workforce. This may mean a larger number of people have been laid off than people were aware, or some of those who received benefits were already unemployed, or both. Over 15,000 people, representing about 30% of the total workforce, received emergency unemployment benefits totaling more than \$2.8 million.<sup>16</sup> The eligible applicant unemployment figures do not include farmers and others that were self-employed who could not prove they had been employed to qualify for benefits. Such people appear to be among groups most vulnerable to the social and economic impact of typhoons on Guam (see below).

### 9.2.3. Other Economic Impacts on Individuals and Families

Federal disaster assistance expenditures also provide some insight into other social and economic impacts of Paka. The individual family grant program provides funding that can be used for a wide-range of economic losses, including housing. However, like other federal disaster assistance programs, eligibility requirements are quite strict and applicants must prove economic losses to qualify.

Heads of household applying for the individual family grant program appear to constitute about 29 percent of the total households on Guam.<sup>17</sup> About 66 percent of the total applications were approved, (about 19 percent of total households), and a little over \$11.7

<sup>15</sup> News. The Unemployment Situation of Guam: September 1997. Bureau of Labor Statistics, Guam Department of Commerce.

<sup>16</sup> See Table 3 for unemployment benefits figures. The total number of civilian employees on Guam was 49,540 in September 1997 according to *Current Employment Report*, December 1997. Guam Department of Labor.

<sup>17</sup> The 34,448 households on Guam in 1996 is used throughout to calculate the percentage of households participating in federal disaster relief programs..



million in assistance had been approved by May 1998 with an average grant totaling \$1,768. An additional \$8.4 million was also provided in food-stamp assistance. Presumably, this was over and above the food-stamp assistance normally provided on Guam, which totaled \$26.8 million in 1996. An estimated \$8.3 million was also provided by voluntary agencies to individuals and families, many of whom did not qualify for federal disaster assistance (See Table 9.5). Recipients of voluntary agency assistance appear to be among the most vulnerable people on Guam to the social and economic impacts of typhoons.

**Table 9.4. Federal Disaster Assistance as of March 30, 1998, April 1998, and May 7, 1998<sup>18</sup>**

<b>FEMA Grant Program<sup>1</sup></b>	<b>Apps Received<sup>2</sup></b>	<b>Eligible<sup>2</sup></b>	<b>Ineligible<sup>2</sup></b>	<b>With drawn<sup>1</sup></b>	<b>Pending<sup>1</sup></b>	<b>Number Disbursed<sup>2</sup></b>	<b>Amount Approved<sup>3</sup></b>
Disaster Housing	14,731	8,186	6,234	407	6	8,039	\$15,079,072
Individual Family Grant Program	10,054	6,645	3,202	60		4,720	\$11,750,619
<b>Department of Labor</b>						<b>Eligible Applicants</b>	<b>Amount Approved</b>
Disaster Unemployment						15,476 <sup>2</sup>	\$2,890,030 <sup>4</sup>
<b>USDA</b>							
Food Stamp Program							\$8,412,143 <sup>2</sup> (estimated)
<b>SBA Loans:</b>	<b>Apps Received</b>	<b>Approved<sup>4</sup></b>	<b>Declined<sup>4</sup></b>	<b>With drawn<sup>1</sup></b>	<b>Pending</b>		<b>Amount Approved<sup>4</sup></b>
Home	5,579 <sup>1</sup>	2,580	1,860	333	130		\$83,470,100
Business	1,374 <sup>1</sup>	580	562	180	112		\$40,691,000
EIDL	1,386 <sup>1</sup>	399	594	329	100		\$6,232,700
<b>TOTAL</b>	<b>8,360<sup>2</sup></b>	<b>3,559</b>	<b>3,016</b>	<b>842</b>	<b>842</b>		<b>\$137,443,900</b>

Source: 1. FEMA Situation Report No. 27, March 30, 1998, p. 8. 2. Final Report: Guam Long-term Recovery Task Force, April 1998. 3. Paka DR-1193, FEMA. 4. Personal Communication: S. Poe, Small Business Administration Loan Office, Guam, May 7, 1998.

Note: EIDL=Economic Injury Disaster Loan. Totals for Small Business Administration Loans exceed breakdown because total figures were updated and no breakdown was available

**Table 9.5. Voluntary Agency Assistance**

<b>Voluntary Agency</b>	<b>Type of Assistance</b>	<b>Disbursed 3/26/98</b>	<b>Projected</b>
American Red Cross	Food, Housing Medical Aid	\$7,033,300	\$7,812,116
Catholic Social Services	Food, Water, Clothing	\$60,000	
Church World Services	Disaster Response Co-operative	\$10,000	\$40,000
Salvation Army	Food, Shelter, Clothing	\$420,000	\$450,000
<b>Total</b>		<b>\$7,523,300</b>	<b>\$8,302,116</b>

Source: Final Report: Guam Long-term Recovery Task Force, April 1998, p. 32.

<sup>18</sup> See tables notes for dates of the figures provided. It should be noted that the total figures for SBA are larger than the breakdown listed because the latter figures are more recent.

#### **9.2.4. Impacts on Businesses and the Tourism Industry**

Businesses, small and large, suffered both property losses and lost revenues as a result of Paka. Discussions with business owners conducted in May revealed that most commercial properties sustained some damage, and revenues for December were below normal as a result of the storm.

Federal disaster assistance and insurance losses are the only quantitative measures of Paka's impact on businesses available. The number of Small Business Administration business loan applications is equivalent to about 53 percent of the estimated total private business establishments on Guam.<sup>19</sup> A little over one third of the applications were approved for an estimated 23 percent of businesses for a total of about \$40.7 million in loans. According to SBA officials on Guam, fewer business loan applications were received than expected. Perhaps this is a function of the number of businesses that carry private insurance or that "self-insure".

The number of business insurance claims was slightly less than the number of SBA loans and is equivalent to about 21 percent of total businesses on Guam. Insurance losses covered, however, were about 1.7 times the amount borrowed from the SBA as commercial loans.

No data are available on business property losses other than those reflected in SBA loans and insurance losses. The Department of Revenue and Taxation has indicated that loss claims on income tax returns should be another indication of businesses losses, but these will not be compiled until after the end of the tax year. Data are also unavailable on increases in construction industry activity as a result of damage caused by Typhoon Paka that would, presumably, offset some of the economic losses resulting from the storm.

#### **9.2.5. Impacts on the Tourism Industry**

Guam's visitor industry clearly recognized the potential impact of the storm on tourism. The Hotel and Restaurant Association, the Guam Visitors Bureau, and the major hotels took immediate steps to get the industry up and running following the storm. Only two hotels sustained major damage, and the airport was closed for only three days. In an interview, the Executive Director of the Hotel and Restaurant Association estimated that tourist arrivals were down about 20 percent in December as a result of the storm.

Tourist arrivals on Guam for the first three months of 1998 totaled 312,787, a 13.8 percent decline from the same period in 1997.<sup>20</sup> Tourism officials pointed out that there are many factors that influence both tourist arrivals and tourism revenues. Paka probably

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<sup>19</sup> The most recent statistics available on the number of businesses on Guam is the *Annual Census of Establishments, March 1996, Guam*, which reports a total of 2,564 private business establishments on Guam.

<sup>20</sup> Preliminary March 1998 Visitor Arrivals: CY1997/98-FY1997-98. Guam Visitor Bureau, April 6, 1998.



had less of an impact on both than the August 1997 Korean Air crash on Guam and economic problems in Asia, Guam's largest tourism market. Guam's tourism industry is further described in Chapter 2, Section 2.4. **It appears that for typhoons up to about 150 mph (strong Typhoon Category 4) (slightly stronger than Paka's effective intensity considering that Paka passed slightly north of Guam and was stronger on the west side of the Island than the east side), the impact to tourism can be held to a short term impact. At higher intensities, destruction to critical infrastructure and considerably more hotel damage would seriously impact tourism.**

#### **9.2.6. Impact of Paka on Government Buildings, Infrastructure, and Services**

Government of Guam estimated that public sector damage from Paka totaled over \$134.2 million as of February 21, 1998.<sup>21</sup> Fifteen agencies reported over 77 percent of the Government asset losses (see Table 9.5). Guam Power Authority was hardest hit with 31 percent of the losses (\$32 million). The Department of Education (\$17 million) and the Guam Waterworks Authority (\$10 million) ranked second and third, respectively.

FEMA projects that the Government of Guam will receive a total of \$71.4 million in grants to cover the cost of infrastructure and public facility repair and replacement, and over \$20.4 million in Hazard Mitigation Grant Program assistance, some of which can be used for repairs. An additional \$26.4 million in disaster assistance is projected by the US Department of Transportation for highway, airport and aids-to-navigation repairs and replacement.<sup>22</sup> Federal government assistance from FEMA and DOT are projected to total over \$118 million. This represents the equivalent of more than 88 percent of total federal grants to Guam in 1996.<sup>23</sup>

Government of Guam will be required to provide 10 percent in local matching funds or \$7.1 million as a condition of receiving FEMA public assistance funding. In addition, autonomous agencies including the Department of Education, Guam Memorial Hospital, public utilities, ports authority, the University of Guam and Guam Community College expended over \$33.5 million between December 17, 1997 and February 21, 1998 on Paka recovery efforts. Government of Guam line agencies also spent a total of over \$11.8 million in recovery costs during the same period. Government of Guam spending on Paka recovery represents approximately 7 percent of total government expenditures for fiscal year 1996.

Some of the Government of Guam costs will be reimbursed by federal agencies. However, they do not include the cost of government services that could not be provided because of the damage and destruction caused by the storm. They also do not include the

<sup>21</sup> *Estorian Paka: Guam's Spirit of Recovery*. Governor Carl Gutierrez, Lieutenant Governor Madeleine Bordallo, February 1998.

<sup>22</sup> *Final Report: Guam Long-term Recover Task Force*. Federal Emergency Management Agency, April 1998.

<sup>23</sup> Guam Department of Commerce. *Annual Economic Review: 1996-1997*, pp. A41-A42

impact of unreimbursable funds diverted by Government of Guam from infrastructure development and government services to recovery efforts.

### 9.2.7. Psychological Impacts on Individuals

According to one senior Government of Guam official, Paka brought a greater realization of the impact of disasters on people's psychological and emotional well being than previous disasters on Guam. The Department of Mental Health and Substance Abuse initiated a two-phased effort to provide counseling and mental health services to disaster victims. Between December 29, 1997 and February 6, 1998, Department personnel and Paka Outreach workers, who were supported with federal grant funds totaling \$175,000, provided counseling services to 1,124 people. An additional \$700,000 was granted from the Substance Abuse and Mental Health Services Administration to continue counseling services for nine months. Problems addressed by both Department and Paka Outreach staff included depression (114), anxiety (81), disaster and displacement fears (114), and the need for information. Many of those served were in shelters where tensions at time ran high.<sup>24</sup>

Table 9.5. Preliminary Damage Assessment for Public Sector

Department/Agency	Amount
Airport	\$4,000,000
Economic Development Authority/BRAC	\$2,000,000
Education	\$17,000,000
Governor's Office	\$1,000,000
Housing and Urban Renewal Authority	\$8,000,000
Memorial Hospital	\$1,000,000
Parks & Recreation	\$2,350,000
Police	\$3,400,000
Port Authority	\$6,450,000
Power Authority	\$32,000,000
Public Works	\$3,137,905
Telephone Authority	\$5,000,000
Tiyan Reuse Authority (Old Naval Air Station)	\$1,100,000
University of Guam	\$7,500,000
Waterworks Authority	\$10,000,000
<b>Sub-total</b>	<b>\$103,937,000</b>
Other Executive Branch Agencies	8,146,960
Non-Executive Branch Agencies	\$22,163,000
<b>Total</b>	<b>\$134,246,963</b>

Source: *Estorlan Paka: Guam's Spirit of Recovery*. Governor Carl Gutierrez, Lieutenant Governor Madeleine Bordallo, February 1998, p. 59.

American Red Cross mental health workers reportedly served over 9,800 disaster victims. Many of those served were seeking information about disaster assistance. Some were disaster workers who, unlike the general public, had the benefit of mental health counseling services in previous disasters. The majority, however, were disaster victims

<sup>24</sup> FEMA Regular Services Grant for Crisis Counseling. FEMA 1193 DR GU, 12/29/97-2/6/98.

who were not entitled to federal disaster assistance. These included people who could not prove they had lost houses or jobs and are among the most vulnerable segments of Guam's population. They also included elderly people who had no adult children or other relatives who could help them cope with the complexities of the federal disaster assistance application procedures.

### **9.3. MOST VULNERABLE SEGMENT OF GUAM'S POPULATION**

Guam's stringent building codes and other hazard mitigation efforts by government agencies and statutory bodies and the private sector clearly minimized the social and economic disruption that could have been caused by recent typhoons. Examples of such emotional and economic disruption were observed in Puerto Rico and the Dominican Republic as a result of Hurricane Gorges and in Honduras and Nicaragua as a result of Hurricane Mitch (PDN 1998). Federal disaster assistance and relief and recovery services provided by the Government of Guam also mitigated the most serious social and economic impacts of Typhoon Paka for the vast majority of Guam's population. The most wide-spread impact on Guam's population were power outages and moderate to minor damage to property. Only about 8.5 percent of the households on Guam sustained heavy damage or destruction of their homes. Only about 1.3 percent of the population required emergency shelters.

There were, however, people who did not qualify for federal disaster assistance and those who simply could not cope with the complexities of applying for such programs. These are among those who suffered most from Paka. While no estimate has been made of the number of people who fall in this category, statistics provided by FEMA and the American Red Cross give some indication. As shown in Table 9.3, a total of 6,234 of those who applied for disaster housing assistance were found to be ineligible and a total of 3,202 of those that applied were also ineligible for the Individual Family Grant Program.

American Red Cross statistics show that they provided housing assistance to about 3,000 people. Some were squatters or people living on government-leased land where they were not permitted to build a permanent structure. Discussions with FEMA, Government of Guam, and American Red Cross officials revealed that many of those ineligible for federal disaster assistance were people who could not demonstrate that they owned or rented a residence.

Discussions also indicated that people ineligible for emergency unemployment relief were people who could not prove they had a job. Some of these victims were farmers (many also living on government-leased land), who could not prove they made their income from farming. Many of these disaster victims received housing and economic assistance from the American Red Cross and the Salvation Army.

According to American Red Cross officials, the number of Chamorros living on government-leased land, who are not permitted to build "permanent structures", has declined in recent years. Under government agricultural leasing programs, those holding

leases could not build “permanent structures” on their leased land. With the advent of Chamorro Land Trust leases, this prohibition has been lifted and many of those who previously held agricultural leases now hold Chamorro Land Trust leases. As a result, fewer people are ineligible for Disaster Housing Program and Small Business Administration home loans.

According to Red Cross and FEMA officials, some of those ineligible for federal disaster assistance following Typhoon Paka were citizens of the US Freely Associated States (FAS). However, many FAS citizens did receive federal disaster assistance. FAS citizens also took advantage of shelters and supplemental food programs, and were assisted in applying for local and Federal assistance.

## **9.4. TRENDS IN SOCIAL AND ECONOMIC VULNERABILITY**

### **9.4.1. Past Trends in Social and Economic Vulnerability**

As indicated in the first section of this Chapter, this analysis should compare the social and economic impact of typhoons on Guam over time to allow officials to assess whether Guam's social and economic vulnerability is increasing or decreasing. However, comparable data are simply not available. Moreover, making comparisons of disaster damage from different storms is very difficult. Each typhoon is different in terms of the physical size of the storm, wind speed and direction, the speed of the storm as it passes over or near Guam, the height of storm waves and inundation, and the location of the eye or strongest winds of the storm with respect population and terrain. Guam has also changed. The population has grown, the economy has developed, the number of houses and commercial structures has increased, and mitigation measures have been instituted to reduce the impact of typhoons on Guam.

The only data readily available to compare the social and economic impact of typhoons on Guam are the American Red Cross assistance costs shown in Table 9.1 and federal disaster assistance statistics from Typhoon Omar and Typhoon Paka shown in Table 9.6. Total Red Cross assistance from Typhoon Omar in 1992 was \$6 million or 1.2 times the amount of assistance provided following Paka. This was exceeded only by assistance costs of Typhoon Pamela in 1976, which was \$11 million.

Federal assistance from the Disaster Housing Program, the Individual and Family Grant Program, and Disaster Unemployment Assistance Program following Paka was 1.6 times the amount provided after Omar (see Table 9.6). There are several explanations for the differences in the amount of assistance provided. First, the winds from Paka were stronger when the storm hit Guam than the winds from Omar. Second, FEMA used a completely different approach to providing assistance following Paka than the agency used following Omar. Disaster Assistance Centers (DAC) were set up for Omar and prospective applicants for federal assistance had to go to a DAC to apply. Following Paka, prospective applicants called a toll free telephone number and gave location and damage information to an operator, and teams were dispatched to victims' homes based

on the severity of their needs. Reportedly, this caused some initial confusion because it was not clear that this was a toll-free number. Moreover, most people on Guam do not have street addresses, and trying to explain the location of a house on Guam to an operator who did not know the neighborhood of a caller often proved difficult. Eventually, three assistance centers were set up and people could register either by phone or in person. Several Government of Guam officials said they felt victims found the telephone registration approach impersonal, and some waited until they could speak to someone face to face. Others thought the Paka operation went much more smoothly and that those most in need were assisted first.

**Table 9.6. Federal Disaster Assistance from Typhoons Omar and Paka**

Program	Omar DR-0957		Paka DR-1193	
	Eligible Applicants	Amounts Approved	Eligible Applicants	Amounts Approved
Disaster Housing	3,732	\$9,097,328	8,186	\$15,097,072
Indiv. & Family Grant Prog.	4,040	\$8,053,449	6,645	\$11,750,619
Disaster Unemployment	7,895	\$1,294,129	15,476	\$2,890,030
<b>Total Funding Approved</b>		<b>\$18,444,906</b>		<b>\$29,737,721</b>

Source: Federal Emergency Management Agency, Guam.

The third explanation for the differences in levels of assistance provided by Federal programs and the American Red Cross may be that many more people used shelters following Omar. A tent city was set up to house a reported 7,000 victims. This may have increased Red Cross costs and the sheer numbers may have caused delays in applications for Federal assistance.

#### **9.4.2. Future Social and Economic Vulnerability**

Guam has clearly succeeded in mitigating much of the social and economic impact of typhoons. Stringent building codes, the installation of concrete power poles, burying phone lines, housing emergency generators at wells and waste water lift stations, and other mitigation measures have probably made buildings and infrastructure on Guam less vulnerable to wind storm damage than any other jurisdiction under the US flag. Although Guam had not been hit by a major typhoon for the four years prior to Paka's arrival, the Government of Guam, FEMA, private voluntary organizations, business owners and managers, and most residents know how to respond to a typhoon. As one Government of Guam official said, "practice makes perfect."

As in the past, the people on Guam will further reduce the risk of typhoon damage as they make repairs and rebuild. A *Hazard Mitigation Survey Team Report* (GOVGUAM 1998a) has been completed and the vast majority of the recommendations included in that report came from public officials and representatives of the private sector on Guam. If implemented, the nineteen recommendations contained in that report will significantly reduce the social and economic impact of future typhoons. A total of \$20.6 million of FEMA funding has been allocated for hazard mitigation on Guam, and matching funds will be provided by Government of Guam. These funds will provide initial support for

implementation of the recommendations in the *Hazard Mitigation Survey Team Report*. Undoubtedly public agencies, private businesses and residents will also use property insurance settlements and loan funds to implement the recommendations in the *Survey Team Report* and take other steps to make buildings and infrastructure less vulnerable to typhoons in the future.

Even if most of the *Survey Team Report's* recommendations are implemented, some segments of Guam's population will probably remain more vulnerable to the social and economic impact of typhoons on Guam than others. The elderly and severely disabled will find it difficult to cope with the physical and psychological strain of typhoons. Recent immigrants and older people without younger relatives will find the Federal disaster assistance application process complex and stressful. Although some people living on leased land will not be permitted to build permanent structures, the number of people in this situation is declining.

The only segment of Guam's population that will clearly become significantly more socially and economically vulnerable to typhoons on Guam are Freely Associated State citizens from the Republic of the Marshall Islands, Federated States of Micronesia, and the Republic of Palau. According to FEMA officials, they have been advised that in the future FAS citizens will not be eligible for "public benefits" including grants from the Disaster (temporary) Housing Program, the Individual and Family Grant Program, the Disaster Unemployment Assistance Program, and the Emergency Food Stamp Program. It appears from proposed rules issued on June 4, 1998 in the Federal Register (Volume 63, Number 107) that the Personal Responsibility and Work Opportunity Reconciliation Act of 1996 made FAS citizens ineligible for these programs in the fifty states. The Illegal Immigration Reform and Immigrant Responsibility Act of 1996 made Freely Associated States citizens ineligible for individual disaster assistance in the Freely Associated States and in the US territories, including Guam.

According to the Office of Insular Affairs of the US Department of the Interior, there were an estimated 5,164 Freely Associated State citizens on Guam in 1997.<sup>25</sup> Government of Guam estimates that there are more than 10,000 FAS residents on Guam.<sup>26</sup> If the level of US funding to the Federated States of Micronesia is maintained when the financial terms of the Compact of Free Association are re-negotiated, it is likely the number of FAS citizens on Guam will continue to increase gradually. If US funding levels decline and the economic situation deteriorates further in FSM, as many expect, there will be many more FAS citizens on Guam in the future.

The terms of the Compact and regulations currently being promulgated require FAS citizens to leave Guam if they cannot support themselves without public assistance. However, if FAS citizens continue to come to Guam for employment and education, at least as many will be on Guam when the next typhoon strikes as were there when Paka struck. Some FAS citizens will lose their jobs and some will lose their homes. Without

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<sup>25</sup> The Impact of the Compacts of Free Association on the United States Territories and Commonwealths and on the State of Hawaii. Office of Insular Affairs, US Department of the Interior, January 1998, p. 11.

<sup>26</sup> "Immigration Rules Could Change." *Pacific Sunday News* June 7, 1998.



public benefits provided by FEMA, the immediate burden for food and shelter will likely fall on the private voluntary agencies and Government of Guam.

Under the new regulations, FAS citizen on Guam may be entitled to use shelters and participate in mass feeding programs. However, the Immigration and Naturalization Service may be saddled with responsibility for sending home those who cannot support themselves. Another chapter in the dispute between the US Government and the Government of Guam over compensation for the impact of the Compact of Free Association may also be opened when both governments are in the midst of a major disaster response effort. Recently, compact impact aid to Guam was increased from \$4.9 million per year to about \$10 million per year.

Another implication of the new regulations for Guam is that Freely Associated States citizens will now be ineligible for public benefits at home. If a typhoon strikes the Federated States of Micronesia, it is likely that some FAS citizens will migrate to Guam. This will further compound the problem there.

## 9.5. RECOMMENDATIONS

The public and private sectors on Guam know what can and should be done to reduce the risk of future typhoon damage to buildings and infrastructure. To many, the steps that need to be taken to reduce the social and economic impact of future typhoons is also clear. At the risk of stating the obvious, the following recommendations based on the analysis provided in this Chapter are offered for consideration.

- 1 Recommendations contained in the *Hazard Mitigation Survey Team Report* (GOVGUAM 1998a) should be implemented as soon as possible. Hazard Mitigation Grant Program funds should be used to implement those recommendations and public agencies and statutory bodies should allocate additional funds to support implementation of the recommendations.
2. If FEMA plans to use a toll-free number to register disaster victims on Guam in the future:
  - a) public information materials about the registration procedures should be prepared and disseminated to the residents on Guam;
  - b) victim registration operators should be provided with maps with locally known landmarks and street names to make locating victims' homes easier;
  - c) Disaster Assistance Centers should be offered as an alternative to the telephone registration system.
- 3 Government of Guam should assess options for allowing individuals on government owned leased land to build permanent structures or provide affordable alternative house sites for permanent structures for farmers prohibited from building on their farm leases.
4. The Government of Guam's Department of Mental Health and Substance Abuse, FEMA and the American Red Cross should evaluate emergency counseling



services provided following Typhoon Paka and develop a plan for such services in the future.

5. The Department of the Interior, the Department of State, and the US Congress should take immediate steps to insure that Freely Associated State citizens are or will continue to be entitled to the Disaster (temporary) Housing Program, the Individual and Family Grant Program, the Disaster Unemployment Assistance Program, and the Emergency Food Stamp Program.

## 10. SUMMARY OF TYPHOON VULNERABILITY FOR GUAM

### 10.1. SUMMARY OF RISK TO DESTRUCTIVE WINDS AS TROPICAL CYCLONE RETURN PERIODS

The return periods or recurrence intervals for typhoons of various intensities were determined in Chapter 4. These are summarized in Table 10.1.

Table 10.1. Return periods for typhoon-induced sustained winds of varying intensities, significance of selected intensities, range of return periods for Guam from various computation techniques, average return periods for Guam from various computation techniques, and return periods for Tiyan only.

Wind Speed (mph) and Significance	Range of Return Period for Guam (Years)	Average Return Period for Guam (Years)	Average Return Period for Tiyan (Years)
40 (tropical storm)	1.4-1.5	1.4	2.0
60 (destructive winds)	2.2-2.8	2.5	3.5
75 (minimal typhoon)	4.0-4.9	4.4	6.6
100	9-13	11	15
115 (100 knots)	13-18	15	22
120 (Ty Omar 1992)	17-25	20	26
135 (Ty Pamela 1976)	30-50	38	50
150 (super typhoon; Ty Paka 1997)	45-65	50	65
155 (Ty Karen 1962)	60-100	75	100
160 (100-year storm)	75-125	100	125
175 (Ty Yuri 1991(direct hit))*	140-225	175	225
190 (Ty June 1975(direct hit))*	350-600	425	500
195 (Ty Tip 1979 (direct hit))*	500-900	600	750

\*These typhoons did not hit Guam directly; these intensities reflect the maximum winds associated with these typhoons at peak intensity.

While we know that the probability of getting hit by a medium or strong Category 5 typhoon is much less than getting hit by a lower Category typhoon, we do not know the last time we were hit by a medium or strong Category 5 typhoon. Thus, we do not know where we stand with respect to the expected recurrence interval (return period). There is also a level of uncertainty in determining the return period. **Factoring in the uncertainty and considering the entire Island, we find that the recurrence interval for the 155-mph wind construction standard for Guam is from 60-100 years, with an average of 75-80 years. A more realistic estimate for the entire Island (not just Tiyan) of the 100-year wind on which the construction standard was based is 160-165 mph.** This wind should be considered during the next update of Guam's wind requirements. Even if the return period were perfectly known, it does not mean that the event could not occur twice in a relatively short period of time, then not again for a period much longer than the computed recurrence interval. Thus, even if a strong Category 5 typhoon hit Guam only 150 years ago, one could still hit Guam next year, then perhaps not again for another several hundred years.

**Table 10.2. Selected average return periods for waves affecting Guam. Height of waves (feet) affecting east-side cliffs (includes trade wind-induced waves), east-side reefs and bays, west-side cliffs (includes monsoon-induced waves), and west-side reefs and bays.**

Average Return Period (Years)	Wave Heights (feet) on East-Side Cliffs	Wave Heights (feet) on East-Side Bays/Reefs	Wave Heights (feet) on West-Side Cliffs	Wave Heights (feet) on West-Side Bays/Reefs
1.0	10	1/<1	-	-
1.5	10	2/<1	10	2/<1
2.0	12	3/1	15	3/1
4.0	15	4/2	20	4/2
7.0	17	5/3	25	6/3
10	20	7/4	30	7/4
20	25	10/6	33	10/6
25	27	11/7	35	10/6
30	30	12/8	37	11/7
40	35	14/9	39	12/8
50	37	15/9	40	13/8
60	38	17/11	42	14/9
80	40	19/13	44	17/11
100	42	21/14	45	18/12
150	45	22/15	46	19/13
200	47	23/16	47	21/14
300	50	25/16	50	22/15
400	52	28/17	50	24/16
500	54	30/18	50	25/16
600	55	>30/18	50	27/17

### 10.3. ESTIMATED COSTS OF AND RECOVERY FROM VARIOUS TYPHOON EVENTS

#### 10.3.1. Expected cost of damage from tropical cyclone events of various recurrence interval and wind intensity

From the historical data, one can estimate the costs of tropical cyclone events of various intensities. Using return period information, one can estimate the recurrence of various costs due to tropical cyclones. For example, virtually every year the Island will incur

**Table 10.3. Relationship between wind speed and cost of damage for selected recurrence intervals.**

Return Period (Years)	Sustained Wind (mph)	Estimated Cost (\$)
1	45	500,000
2.5	60	5,000,000
5	80	10,000,000
10	100	50,000,000
20	120	500,000,000
50	150	1,000,000,000
100	160	2,000,000,000
200	180	3,000,000,000
500	190	4,000,000,000
800	200	5,000,000,000

An additional consideration is that the recurrence intervals are based on only a short time series of record. Thus, the extreme events can only be estimated based on the recurrence of less severe events. For this reason, the recurrence interval is not exactly known, and is just an estimate. (See Sections 4.4.4. and 4.7. for additional discussions on return periods.)

Another way to look at the probability is to determine how much more often a 150 mph typhoon moves within a certain distance of Guam, let's say 200 miles, than does a 180 mph storm. In 45 years, 15 typhoons of 150 mph have moved within 200 miles of Guam, while only five typhoons of 180 mph have moved within 200 miles. Therefore, we are three times as likely to be threatened by a 150 mph typhoon than by a 180 mph typhoon. Thus, if the return period for a 150 mph typhoon is 75 years, then the return rate for a typhoon of 180 mph can be expected to occur on the order of every 225 years. This agrees fairly well with the results in Table 10.1.

In 1991, Super Typhoon Yuri, packing sustained winds of 173 mph, passed 80 n mi south of Merizo. In 1992, Super Typhoon Gay, on a beeline for Guam, had 190 mph sustained winds two days east of the Island. Only an unusual meteorological interaction with Typhoon Hunt caused it to rapidly weaken, knocking winds down to 100 mph as it crossed the center of Guam. Two days after passing Guam, Gay reintensified to nearly 135 mph. In 1997, Super Typhoon Keith passed a mere 50 n mi north of the Island, between Rota and Tinian. Guam has had a lot of near misses of very intense typhoons, and in most cases, there is no real meteorological reason why a storm did not go 80 n mi farther north or 70 n mi farther south. Similarly, there is no meteorological reason why Karen, Pamela, Omar or Paka didn't pass 50-100 n mi farther to the north or south of Guam, instead of passing over the Island.

## **10.2. SUMMARY OF RISK TO INUNDATION AS HIGH WAVE RETURN PERIODS**

At return periods less than 20 and 25 years (Table 10.2), the wind waves produced by monsoon surges dominate the majority of west-side large wave events over reefs and open bays. At return periods of around 20-25 years, the waves of typhoons (around intensity 125 mph) become more dominant than the swells produced by the monsoon flow in forcing water over west-side reefs and into west-side open bays. The swell from monsoon surges, however, remains dominant in producing high waves at cliffs until typhoon winds get above super typhoon intensity (around a 50-year event). East-side waves over reefs and in open bays are generally higher than west-side waves for the same return period. This reflects the asymmetry of the moving typhoon, exposing the east side to strong-sector winds and the west side to weak-sector winds.

damages in the \$500,000 range due to a weak tropical storm. These costs may be primarily for cleanup of debris, coastal cleanup, replacement of landscaping, and loss of agriculture for the weakest tropical cyclones. Table 10.3 illustrates how fast the costs escalate with intensity, especially when the intensity exceeds 100 mph. They escalate even more rapidly once the intensity exceeds 150 mph -- super typhoon intensity.

From Table 10.3., every 2.5 years, the port, the airport, the schools, and the Government of Guam will have to be shut down for the setting of Typhoon Condition of Readiness 1 (COR 1). However, due to the inaccuracies in the typhoon forecasts, these actions actually occur more frequently, more on the order of once per year. Since it costs about \$1 million each to close down the port, the airport, the schools, and the Government of Guam, these costs should be factored into the damage costs of events that trigger setting COR 1.

From Table 10.3, we can conclude that Guam can likely handle tropical cyclones less than 100 mph (less than strong Typhoon Category 2) with minimal outside help. This is less than a 10-year event, and presents an argument for the need to set aside money to cover annual tropical cyclone-related expenses, i.e., a rainy day fund. There is an expense incurred for living in the "typhoon belt", and this is not unlike having to budget money for snow removal in colder metropolitan areas.

#### **10.3.2. Expected time for recovery after tropical cyclone events of various recurrence interval and wind intensity**

Using information about the level of damage produced by typhoons of a given intensity and historical recovery information, an estimate of the time required for recovery can be made. While there are many factors that affect the speed of recovery, a general estimate of the recovery time required to return to some semblance of "normal" can be made. These estimates are given in Table 10.4. As seen with costs in Table 10.3, the time required for recovery begins to escalate considerably once winds exceed 100 mph and it escalates very rapidly as intensities reach 150 mph. These estimates are based on a direct hit on the Island by the eye or center of the tropical cyclone in question. The periods also assume the normal amount of Federal assistance.

The long recovery times for the extreme typhoon events assume such a level of damage to the infrastructure, hotels, and personal property that the tourism is lost and must be totally recaptured. A considerable migration of residents is expected after such a typhoon.

### **10.4. VULNERABILITY ASSESSMENT CONCLUSIONS**

Several conclusions can be gleaned from this Vulnerability Assessment. These are listed below. Wind speeds refer to sustained winds; wind gusts will be 20-25% higher.

**Table 10.4. Relationship between tropical cyclone wind speed and estimated length of recovery for selected recurrence intervals. .**

Return Period (Years)	Sustained Wind (mph)	Estimated Recovery Time
1	45	hours
2.5	60	1-2 days
5	80	1 week
10	100	1 month
20	120	3-6 months
50	150	1 year
100	160	2 years
200	180	5 years
500	190	10 years
800	200	20 years

### **(1) General Information**

(a) Winds, waves/storm surge/inundation, and flooding are the primary hazards for Guam from typhoons. The costs incurred from wind damage are more than 10 times the costs from waves/storm surge/inundation. The costs of flooding are undetermined since in typhoons, flooding is frequently attributed to wind damage or wave/storm surge/inundation damage.

(b) Guam's risk of getting hit by a typhoon is greatest for a weak typhoon and least for the most intense typhoons. While the return period for intense typhoons is large, we don't know how many years have elapsed since the last very strong typhoon struck Guam. Based on today's valuation of the dollar, and the value of Island businesses, personal property, structures, infrastructure, etc., Guam can expect a \$100 million typhoon about every 15-16 years and a \$1 billion typhoon about every 50-60 years.

(c) Guam is vulnerable to extended disruptions in basic services and the need for outside assistance (Presidential disaster declaration) when a typhoon with winds exceeding 100 mph moves across the Island (eye passage). Damage and costs escalate rapidly once winds exceed 100 mph (strong Typhoon Category 2 winds).

(d) Guam is vulnerable to considerable damage from waves/storm surge/inundation when a typhoon with winds exceeding 125 mph moves across or near the Island. Damage from waves/storm surge/inundation escalates rapidly once winds reach 125 mph (strong Typhoon Category 3 winds). However, wind damage escalates much more rapidly, than the damage from waves/storm surge/inundation, and the former is generally more than 10 times the latter.



## **(2) Residential and Commercial Structures**

(a) Most wooden, wood- and tin-roofed, and sheet metal structures will be extensively damaged or destroyed when they are exposed to winds exceeding 160 mph (weak Typhoon Category 5 winds).

(b) Most steel reinforced concrete structures with well-designed and well-attached typhoon shutters will endure most any typhoon, but when winds reach 160-165 mph (weak Typhoon Category 5 winds), then shutters will begin to fail, either from wind-pressures or from large debris.

(c) Most steel reinforced concrete structures with attached concrete roofs will endure typhoon wind loads, however, some structural damage from large blowing debris could occur when winds exceed 160-165 mph (weak Typhoon Category 5 winds).

(d) High rise structures in Tumon, because of their numbers and density, will experience higher winds at higher levels and considerably high winds between towers. Glazing and sliding door failures will occur with winds exceeding 150 mph (strong Typhoon Category 4 wind). While winds at higher levels will be stronger than at the surface, there will be smaller and less debris than at lower levels. Higher levels will have considerable window/siding door loss and water damage, but lower levels will be vulnerable to damaged walls from large debris.

## **(3) Commercial Port**

There will be considerable damage to key components of the Commercial Port when winds exceed 160 mph (weak Typhoon Category 5 winds). Vulnerable components include damage to both rail-mounted and rubber-tire gantry cranes, fuel storage tanks, fuel piers, warehouses, communication and navigation towers, the container yard, and the access road. The potential damage to the Kaiser cement silo is unknown.

## **(4) Guam International Airport**

There will be considerable damage to key components of the Guam International Airport when winds exceed 160 mph (weak Typhoon Category 5 winds). The terminal and tower will likely experience massive failures of windows and doors, leading to extensive interior wind and water damage. Most passenger loading bridges (jet ways) will be crushed or torn from the terminal. Extensive damage will also occur to communication and navigation antennas, airfield lighting, and repair facilities. Hangers will lose doors and windows, and there will likely be serious damage to hangered general aviation aircraft. Aircraft traffic control radars at Mt. Santa Rosa and the CERAP facility at Andersen Air Force Base will also be damaged.



## **(5) Power Generation and Distribution**

(a) When winds exceed 150 mph (strong Typhoon Category 4 winds), non-concrete portions of the power generation system will begin to fail. This assumes that containment buildings are all converted to concrete. Condensing units, exposed stainless steel pipes, and other exposed equipment will begin to fail.

(b) The practice of replacing wooden power poles with hollow-spun concrete power poles will mitigate much damage to the power grid. However, when winds exceed 160 mph (weak Typhoon Category 5 winds), failure of the hollow-spun concrete poles will increase rapidly, and costs to repair the power distribution grid will escalate rapidly. Lattice steel towers will also begin to fail. At 175 mph (medium Typhoon Category 5 winds), solid concrete poles and steel poles will begin to fail, greatly damaging the primary distribution system.

(c) When winds exceed 80 mph (medium Typhoon Category 1 winds), secondary lines and some transformers will begin to fail. When winds exceed 125 mph (strong Typhoon Category 3 winds), some primary distribution lines will fail. Primary line failure escalates rapidly when winds exceed 150 mph (strong Typhoon Category 4 winds).

(d) When winds exceed 160 mph (weak Typhoon Category 5 winds), substations and transformers for underground power distribution will begin to incur damage at a rapid rate. In addition, emergency generators on water pumps will have to run for long periods, and failure of the generators will occur, stopping the flow of water to the power plants.

## **(6) Water and waste water**

(a) The practice of putting emergency generators on critical water pumps and sewage lift stations has been important in mitigating the disruptive effects of typhoons. However, they are not designed to run for long periods of time. The damage incurred by the power distribution systems from winds exceeding 150 mph (strong Typhoon Category 4 winds) will have significant impact.

(b) Waste water treatment plants will incur damage when winds exceeding 150 mph (strong Typhoon Category 4 winds), and the Hagåtña plant is especially vulnerable from wave damage. Typhoon-induced elevation of ocean water will make storm drains near sea level (Hagåtña and Tumon) back up, exacerbating flooding in the low lying area.

(c) With winds of 160 mph (weak Typhoon Category 5 winds), above-ground steel reservoirs could be damaged if they are empty. Partially full reservoirs will be susceptible to damage when winds reach 170 mph (medium Typhoon Category 5 winds) and even full reservoirs may be damaged or destroyed when winds reach 180 mph (strong Typhoon Category 5 winds).