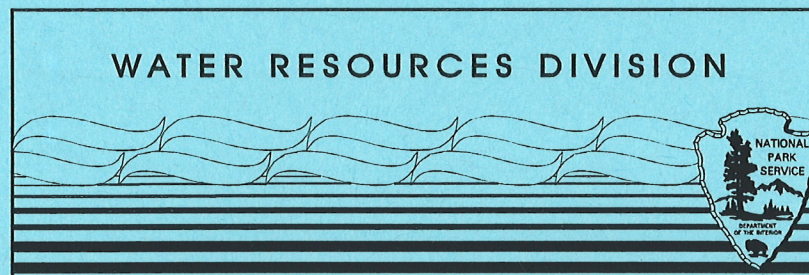


**PRELIMINARY HYDROLOGIC AND GEOMORPHIC
ANALYSIS:**

_____ **SCORPION CREEK FLOOD
DECEMBER 5, 1997
SANTA CRUZ ISLAND
CHANNEL ISLANDS NATIONAL PARK
CALIFORNIA**

William L. Jackson

Technical Report NPS/NRWRD/NRTR-98/172



**National Park Service - Department of the Interior
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February 1998

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ABSTRACT

A large flood occurred on Scorpion Creek, Santa Cruz Island, Channel Islands National Park, on December 5, 1997. The flood was caused by an estimated 11 inches of rain that fell on the watershed over a 24-hour period. This report provides an initial assessment of the flood's magnitude. It also describes associated sedimentation process and discusses the implications for flood recovery and long-term use of the Scorpion Creek floodplain for park facilities. A very crude estimate is that peak flows on Scorpion Creek approached 1000 cfs, and very roughly approximated a 100-year return period discharge. The flood was accompanied by massive amounts of sediment delivery to the channel, resulting in channel aggradation and realignment. In many places the pre-flood channel was completely filled in and obliterated by sediment deposits. Geomorphically all park facilities along Scorpion Creek are, in effect, in the active channel. Continued occupation and use of the site will require a permanent commitment to periodic excavation to maintain an active channel away from park facilities. However, any excavated channel is subject to aggradation and filling, and no excavated channel can sustain and function in events as large as the December 5, 1997, flood. Therefore, facilities along Scorpion Creek will always have some level of vulnerability to impact during large floods.

INTRODUCTION

This report provides an initial assessment of the magnitude of the large flood that occurred December 5, 1997, on Scorpion Creek in Channel Islands National Park, California. It also describes associated sedimentation processes and discusses implications for flood recovery and long-term occupation of the Scorpion Creek floodplain. The assessment is based upon a site visit conducted on December 17, 1997. It was prepared hastily for the Scorpion Creek Flood Incident Team as part of its assessment of flood recovery needs at Channel Islands National Park.

Scorpion Creek drains a small portion of the north side of the eastern-most tip of Santa Cruz Island, Channel Islands National Park, California (Figure 1). In its lower reaches the stream appears to be ephemeral and likely flows only in response to rainfall. There was no flow in the stream at the time this site visit was conducted. The watershed area is approximately 2.4 sq. mi., with a total relief of 1350 ft., and a total length of slightly less than 3 miles. The watershed is steep and highly dissected. Vegetation cover is poor, due in large part to a long history of intensive grazing by domestic animals. Watershed conditions are such that rainfall runs off the watershed surface rapidly, mass hillslope failures are common, and tributary channels are extremely erosive. It is likely that debris flows occur on steep tributaries during periods of intense rainfall, contributing enormous amounts of sediment to the stream.

Scorpion Creek is alluvial (depositional) for about 1 1/2 miles upstream from its mouth. Upstream from that point the stream is extremely steep and deeply incised; the watershed at higher elevations is steep, rugged and largely void of vegetation cover. The lower alluvial reaches of the valley have a long history of human occupation. Structures dating back to the 1800's remain in remarkably well-preserved condition on the left side of the valley approximately 700-1200 feet upstream from the mouth of the river.

It is critical to understand that all developments on lower Scorpion Creek, including historic structures and the campground, exist WITHIN the active river channel. This is not a situation where developments exist on a classic "floodplain." Rather, this is a situation in which extremely active sedimentation processes interact with streamflow to cause frequent realignments of the channel throughout the entire width of the lower valley. Active intervention, largely through periodic channel excavation, has been required historically to control these active channel processes and to permit sustained occupation of the valley.

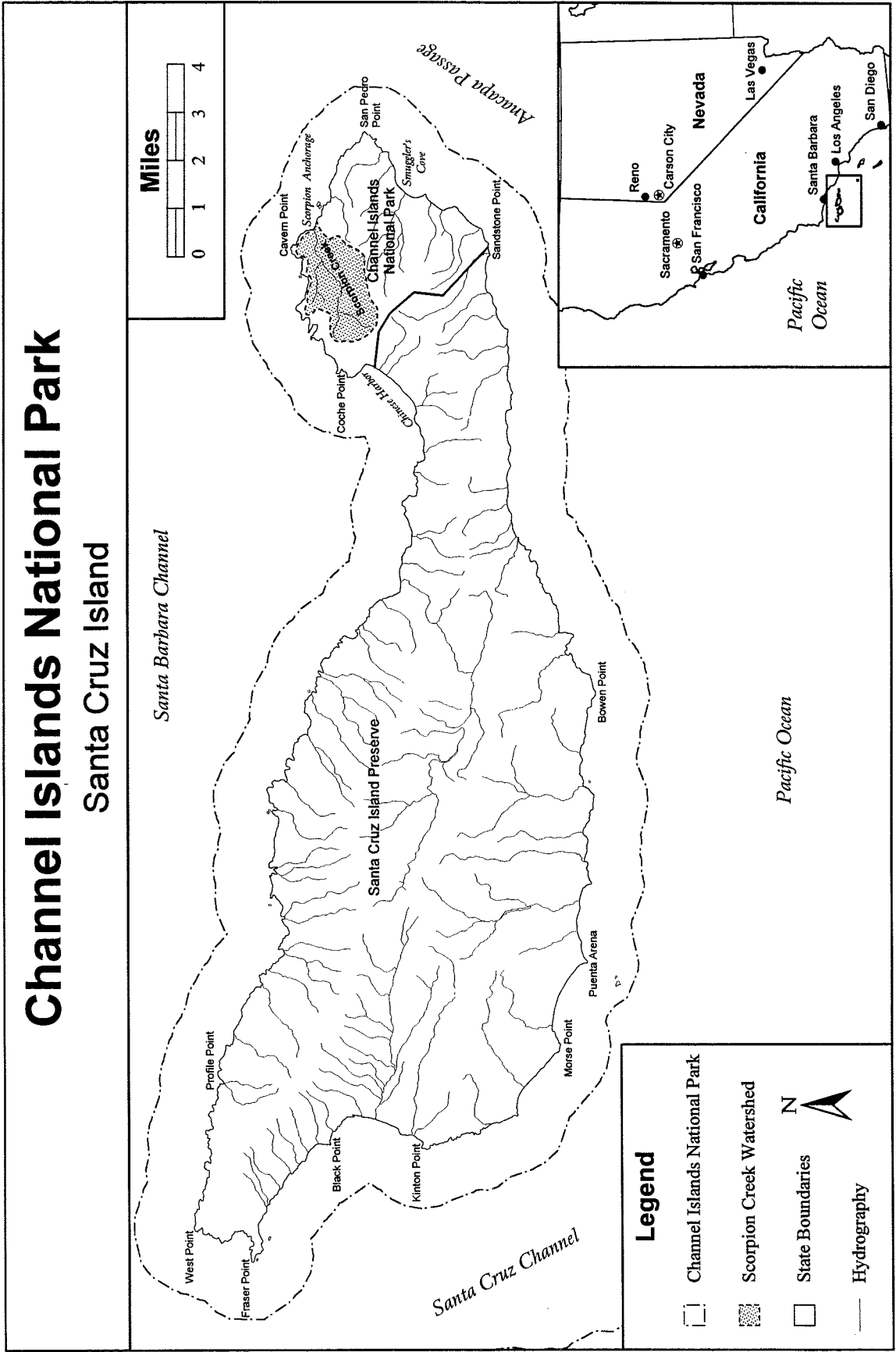


Figure 1: Scorpion Creek Location Map

HYDROLOGY

Between December 5-6, 1997, approximately 11 inches of rain fell in the Smuggler's Creek watershed, immediately to the southeast of the Scorpion Creek watershed, in a 24-hour period. It is assumed for this analysis that precipitation recorded at Smuggler's Creek is representative of the rainfall amount over the Scorpion Creek watershed. Rainfall intensities were constant over the 24-hour duration of the storm. The Rainfall Frequency Atlas of the United States (U.S. Weather Bureau, 1961) data shows the 24-hour, 100-year return period rainfall event in this area to be roughly 6.0 inches. Factoring in elevation influences, it is possible that a 100-year rainfall event in the Scorpion Creek watershed could be as much as 8-10 inches. (Further statistical analysis of local/regional rainfall records is needed for this event to more precisely determine its return period.) In any case, there is reason to conclude that the rainfall event on the Scorpion Creek watershed was large when compared to the generalized historic record for the region; this likely was a precipitation event with a 100-year (1.0%) or less probability of occurrence in any one year. It occurred on a fairly "dry" watershed.

There were few good locations where an indirect estimate of the peak discharge in Scorpion Creek could be made. This is because most reaches of the stream were heavily impacted by sedimentation processes during the storm (resulting in uncertain channel dimensions at the time of peak flows), and because floodplain high-water lines were influenced by tributary and hillslope flows. However, there was one location upstream from the uppermost eucalyptus grove where the channel (though somewhat incised) remained largely intact and where the high water was largely contained by the channel. The channel at this point was approximately 25 feet wide and 4 feet deep.

Assuming a channel gradient (Brunson, 1982) of 1.5% and a velocity (estimated from the Manning equation, $n: .045$) of 8 feet-per-second, an estimate for peak discharge is roughly 800 cubic feet per second (cfs). Correcting, proportionally, for watershed area, this corresponds to a discharge of approximately 1000 cfs at the mouth of Scorpion Creek.

This discharge estimate corresponds approximately with estimates of the 100-year return period discharge as calculated by the SCS Curve Number Method (U.S. Soil Conservation Service, 1972), and from regional flood-frequency equations developed by the USGS for California (U.S. Geological Service, 1977). The SCS model estimates a 100-year runoff event, assuming a 24-hour 100-year rainfall of 8 in. and a curve number of 80, to be between roughly 500 cfs (assuming uniform rainfall distribution) to 1700 cfs (assuming SCS-Type 2 rainfall distribution). Regional equations for California from the USGS, assuming annual precipitation in the basin to be 20 in, result in a 100-year runoff of 1100 cfs.

Therefore, a very preliminary conclusion, subject to further refinement, is that this event was somewhat larger than a 100-year, 24-hour rainfall event, and approximated a 100-year return-period runoff event.

SEDIMENTATION AND GEOMORPHOLOGY

One of the most significant aspects of this flood was the enormous amount of sediment production and delivery within the watershed (Figure 2). Mass hillslope failures and debris flows occurred within the lower mile of the watershed, and huge volumes of coarse sediment (sand, gravel, cobble, and boulder-sized materials) were delivered to the main channel of Scorpion Creek. To understand this flood and its implications for floodplain management requires that the event be considered as much a "sedimentation event" as a hydrologic event.

Massive sediment deposition occurred throughout the lower mile of the Scorpion Creek Channel. In at least four major reaches coarse sediment deposition completely filled and obliterated the channel that existed prior to the flood (Bo Stone, pers. comm., 1998) (Figure 3). Major zones of sediment deposition seemed to correspond to reaches upstream from flow constrictions or sharp bends, and in association with tributary debris flows. It is probable that some sediment deposition in the lower 800 feet of channel was also influenced by reduced channel gradients, high storm tides and ponding behind the cobble beach berm that forms annually as the result of coastal processes. This berm effectively closes off the mouth of Scorpion Creek until it is breached by storm flows. Historic structures are located at about 8 ft. above mean sea level. Storm tides are known to be as much as 6 1/2 feet above mean sea level in this location. Downstream from each major zone of deposition, the channel remained largely well-defined and resembled its pre-storm character (Bo Stone, pers. comm., 1998). These reaches functioned more as sediment transport zones than as sediment deposition zones.

Where large-scale sediment deposition occurred, it interacted with streamflow to redirect flows to different locations on the floodplain and, in some cases, resulted in the establishment of new active channels. This process of flow redirection and channel realignment contributed greatly to the modifications in floodplain character associated with this event.

Tributary sedimentation processes also greatly influenced the general character of the Scorpion Creek floodplain. Tributaries are very steep, and large amounts of sediment were delivered to the active channel and floodplain of Scorpion Creek. A number of management issues are related to tributary processes in addition to main channel processes (see discussion below).



Figure 2. Post-flood photograph of the upper portion of the alluvial reach of Scorpion Creek, showing evidence of hillslope erosion and sediment delivery to the channel. Note the extent to which some channel reaches have lost definition because they have filled with sediment.



Figure 3. Post-flood photograph of lower Scorpion Creek showing the extent to which the pre-flood channel was filled with sediment. The person is standing on a constructed berm that used to represent the left bank of the channel. Flows were to the left in this photo. Note the delivery of sediment from a tributary debris flow on the right side of the channel.

SITE-SPECIFIC FLOOD ASSESSMENT

As part of this preliminary assessment, we hiked the lower mile of Scorpion Creek from the point where steep upland tributaries come together to form the stream's alluvial reach to downstream approximately one mile to its mouth. Several site-specific observations are provided that may influence decisions regarding future management of the floodplain. All sites discussed are shown on Figure 4.

Upper Alluvial Valley

Massive volumes of sediment were delivered from the upper watershed and deposited in the uppermost 1000 feet of the alluvial reach of Scorpion Creek (Reach 1, Figure 4). The channel throughout much of this reach was completely filled and obliterated. Some fencing was buried by sediment, but otherwise impacts to human infrastructure were minimal. The significance of this reach is that it now contains an enormous volume of sediment, that eventually will be routed downstream.

Upstream From the "Upper" Eucalyptus Grove

Reach 2 (Figure 4) encompasses the reach of stream from Reach 1 to just upstream of the upper eucalyptus grove. This reach of stream is strongly influenced by a large tributary and associated alluvial fan that comes in from the right side. The tributary and associated fan force the main channel of Scorpion Creek along the left edge of the valley and contain it there. While some erosion and deposition occurred in this reach, it generally functioned as a "throughput" zone and the channel was maintained largely intact. This was the reach where a rough indirect estimate of peak flood discharge was made.

Upper Eucalyptus Grove

Main channel and tributary fluvial processes were very active in the vicinity of the upper eucalyptus grove and impacted the NPS campground at this site (Reach 3, Figure 4). This site is a low alluvial fan created by a fairly large tributary that enters the middle of the grove from river left. A large zone of main channel sediment deposition occurred in the lower portion of this reach, essentially filling the pre-flood channel. Sediment deposition may have been induced by a slight backwater effect associated with a constriction of the valley and a sharp bend in the channel. A large, deep-seated mass hillslope failure occurred on the right valley across from this site, but it does not appear that there was significant sediment delivery to Scorpion Creek. Sediment deposition in the main channel forced main channel flow across the upper eucalyptus grove, and forced the beginning of a new "cutoff" channel downstream on river right. The channel remains fairly poorly defined in the lower portions of this reach, which may make the campground more prone to flooding from future floods of smaller magnitude than this event. This site also experienced significant flooding and sediment deposition from the tributary. Continued occupation of this site by a campground may

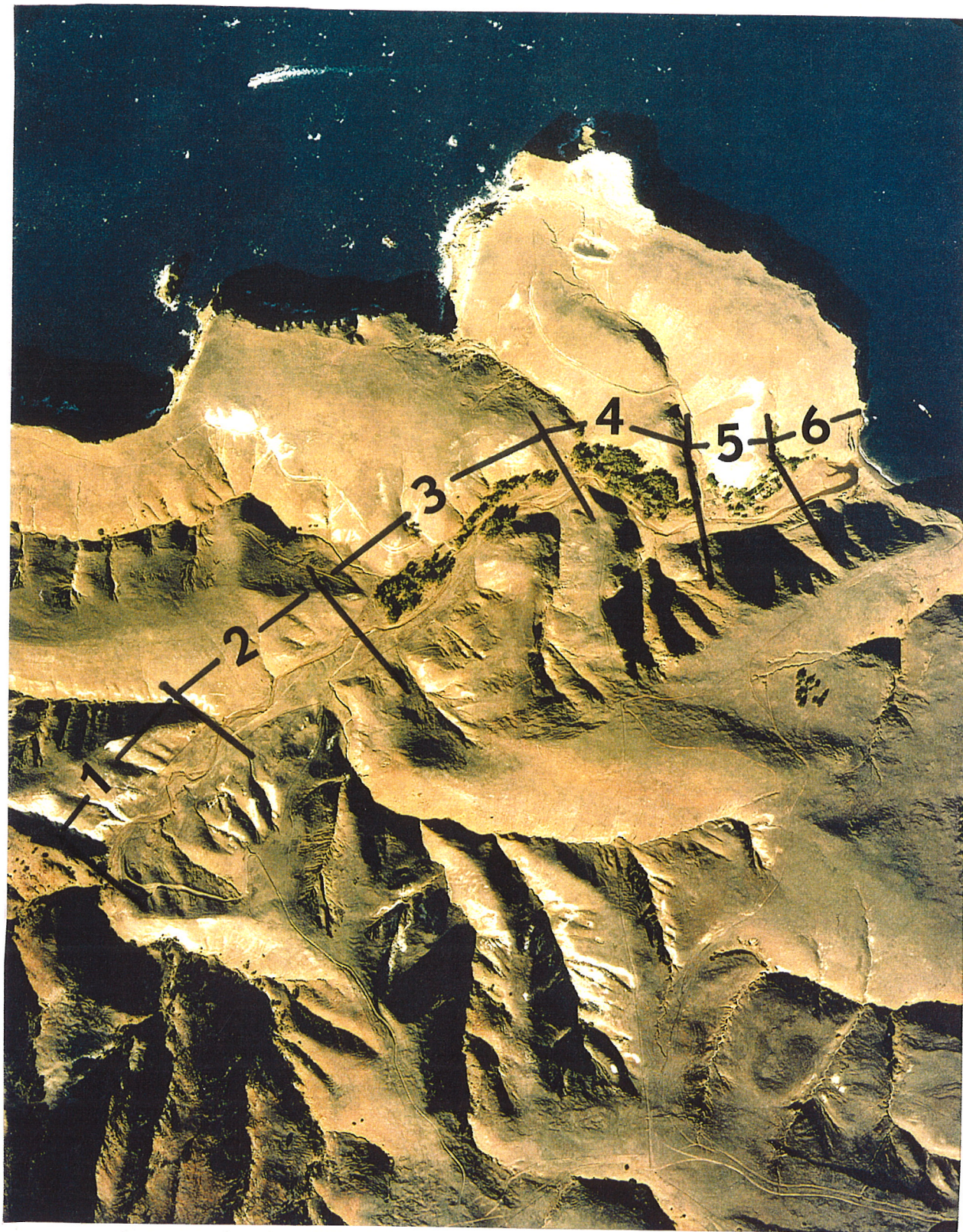


Figure 4. November 1997 aerial photograph of Scorpion Creek, depicting the six reaches of the lower river discussed in the text.

require reexcavating the channel through the sediment deposit in the lower portion of the reach or, at a minimum, excavation of a channel for the tributary, so as to make the site less prone to flooding from tributary runoff. Downstream from the upper eucalyptus grove the channel goes around a large point bar on the left. An impressive amount of boulder-sized material was deposited on the point bar, but the channel remains fairly well defined in this area.

Lower Eucalyptus Grove

Reach 4 (Figure 4) encompasses the lower eucalyptus grove, and includes the lower campground. This area was profoundly impacted by massive sediment deposition. Contributing to sediment deposition in this area was a large input of coarse material from a debris flow on river right. The channel throughout this reach was filled and is now very poorly defined. Channel filling caused flows to spill over and wash through the eucalyptus grove and campground. With the main channel now so poorly defined in this area the lower grove and campground are now extremely vulnerable to additional flooding from significantly smaller floods than the December 5, 1997, flood.

Historic Structures and Horse Corral

Reach 5 (Figure 4) extends from the lower eucalyptus grove downstream to a point roughly across from the adobe building (Figure 5). This reach continues as an area of massive sediment deposition. The channel has been completely filled and obliterated in this reach. Contributing to deposition in this area were (1) the large sediment input from the tributary debris flow immediately upstream, (2) the constriction caused where the river was channelized between the bulldozer garage and the windmill, (3) reduced channel gradients, and (4) likely backwater effects from water impounded behind the ocean berm and/or high storm tides.

Floodwaters were 3-4 feet deep on several park structures (e.g., the "adobe" house). It is likely that maximum flood depths were influenced, in part, by water backing up from the river mouth because of high tides and/or impounding behind the beach berm. The highest velocity and highest energy flows in the vicinity of the historic structures probably occurred at depths less than the maximum depths indicated by mud lines on the structures, when flows were not influenced by backwater effects.

Channel deposition was so complete upstream from the bulldozer that flows readily broke out of the pre-flood channel and ran through the complex of historic buildings. A new channel did not form upon recession of the flood, and currently no well-defined channel exists. The developed site is now extremely vulnerable to future flooding from events much smaller than the one that occurred on December 5, 1997. The filling of the channel on the right side of the valley means that flows have easy access to the breakout channel that now flows through the present location of the buildings. Emergency/short-term measures are warranted at this site to protect structures from future flooding this winter (see recommendations below).

Complicating the situation in this reach is the tributary that comes in from the left side at the location of the horse corral. This tributary has been bermed to keep flows from washing through



Figure 5. Post-flood aerial photograph of lower Scorpion Creek in the vicinity of the historic ranch structures.

the corral. However, sediment deposition behind the berm has created a condition where the channel is now perched well above the elevation of the corrals. The situation is such that the corral is now extremely vulnerable to flows breaking out of the berm. If this were to occur, tributary flows would also be directed down the left side of the floodplain and into the area of the buildings. Dredging (rather than berming) of this tributary may be required to keep flows directed away from the developed site.

River Mouth

Reach 6 (Figure 4) encompasses the lower 700-800 feet of channel downstream from the adobe building to the mouth. The channel here was excavated and diked along the right side of the valley. The channel did not fill significantly during this flood and remains in a functional condition. The channel in this reach is vulnerable to filling during small events, especially prior to breaching of the ocean berm. However, it is not known to what extent ponding behind the ocean berm might have occurred during the December 5, 1997, flood. Historically, continued excavation was required to maintain a defined channel through this reach.

MANAGEMENT IMPLICATIONS

Short Term

Massive sediment deposition and filling of the channel in the vicinity of the lower grove and the historic buildings make this reach extremely vulnerable to additional flooding from events much smaller than the December 5, 1997, flood. Given that it is still early in the winter rainy season, it may be prudent to give consideration to some emergency actions to help reduce the vulnerability of the historic buildings to future flooding until decisions can be made about long-term occupation of the site.

Re-excavating a channel from a point roughly 300 feet downstream from the windmill to a point somewhat upstream of the confluence of the horse corral tributary would help route modest flood flows around the area where the buildings are located, and would make it less likely that flows would access the breakout channel.

Another option might be to develop sandbag berms around the immediate structures of concern. In this case, some ability to pump water out of the buildings might be needed.

It is important to realize that berms are not long-term options for dealing with flooding and channel realignment issues in this reach. Berms over the long-term would result in the channel aggrading to an elevation higher than its floodplain.

Long Term

Decisions may need to be made regarding long-term occupation and use of flood-prone areas. Long-term occupation of the reach which includes the historic buildings will require continuous channel excavation of both the main channel and tributaries. There remain enormous volumes of sediment upstream that, over time, need to be routed downstream. The probable frequency at which excavation will be required is not known. However, considerably smaller events than the December 5, 1997, flood can serve to fill channels and make them more vulnerable to future flooding. It would not be surprising if some excavation will be required on the average of every 2 to 5 years. Channel excavation will have little effect on events of the magnitude of the December 5, 1997, flood, but should help reduce the frequency of impacts from smaller, more frequent floods.

Excavating a channel with dimensions of approximately 20-25 feet wide by 4-5 feet deep should be adequate to handle more common floods. This is the size channel that could carry a 100-year flood, assuming no sediment deposition, and is approximately the dimension of the natural channel in certain reaches less impacted by recent deposition. A channel of these dimensions would provide for some level of sediment deposition during modest flood events and continue to function.

Again, no channel will function under the conditions experienced December 5, 1997. Thus, the site will always remain vulnerable to extreme hydrologic events. One additional issue associated with a long-term excavation program is the question of where to place the excavated material.

In addition to periodic channel excavation, long-term occupation of the site may require that the coastal berm be breached at least annually prior to the runoff season, to minimize the effects of water impoundment during the first few events of the year. However, coastal berm breaching will not eliminate the problem of sediment deposition, channel realignment and flooding in the vicinity of the buildings.

Continued occupancy of the campground sites will require either periodic cleanup following flooding, or a continuous program of channel excavation. Probably the most realistic option for continued use of the campgrounds would be to commit to a program of cleanup following large main channel flows. Main channel excavation for the campgrounds would be a fairly costly long-term proposition. While it may be desirable to identify alternative (non-floodplain) campground locations (either in addition to or in place of the floodplain campgrounds), it is possible to utilize the floodplain sites safely. Because these sites are prone to flooding, some sort of flood warning rules and evacuation plans need to be developed, or seasonal closure of the campgrounds should be considered. Flood warning could be keyed to weather forecasts, and/or to measured rainfall on the island. Since evacuation from the island is not always possible, it may be necessary to be able to relocate campers to an upland site in the event of heavy rainfall.

Additional Monitoring and Assessment Needs

Considerably more refinement of this hydrologic/geomorphic assessment is possible. At a minimum, it is recommended that a more rigorous analysis of both island and regional event-based precipitation records be developed. It is possible that rainfall records on the mainland underestimate rainfall amounts on the islands. In any case, a good assessment of the return period associated with the December 5, 1997, event is needed. Rainfall frequency and flood frequency likely are closely correlated on Santa Cruz Island, and the relative magnitude of this flood event might best be estimated from the precipitation record.

It is also suggested that NPS begin to document sediment deposition and realignments, that occur during large runoff events. One way to do this would be to establish a series of 7 - 10 monumented cross-sections roughly between the adobe building upstream to the upper eucalyptus grove. A better ability to correlate sediment deposition to rainfall/runoff is needed. Cross-section information needs to be augmented by photographic or descriptive information related to patterns of sediment deposition, debris fan activity and channel adjustment. Unfortunately, there is no logical location to gage discharge with any degree of accuracy. Rainfall should be measured on Scorpion Creek.

The Potential of Improved Watershed Vegetation Cover

The NPS plans to remove sheep from Santa Cruz Island. This action clearly will result in long-term improvement in watershed cover, and could influence the severity of watershed runoff and erosion during storms. However, improved watershed cover will not change the fundamental fact that all developments along Scorpion Creek are effectively in the active channel. Enormous amounts of sediment are in the channel and will continue to be routed downstream, and these

developments will continue to be vulnerable to flooding and channel realignments. Also, many parts of the watershed (e.g., the upper watershed) are largely devoid of soil, and revegetation may be slow. It may be some time before improved vegetation cover influences landslide and debris flow processes on extremely steep slopes. So, while watershed revegetation should help, it will not eliminate the problems associated with long-term occupation of the Scorpion Creek valley.

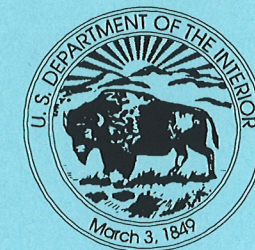
CONCLUSIONS

The December 5, 1997, flood on Scorpion Creek was caused when an estimated 11 inches of rain fell on the watershed over a 24-hour period. A very crude estimate is that the peak discharge on Scorpion Creek approached 1000 cfs and very roughly approximated a 100-year return period flood. Flood depths along lower Scorpion Creek were likely influenced by high tides or water impounding behind the beach berm at the mouth of the river. The flood was accompanied by massive amounts of sediment delivery to the channel, resulting in channel aggradation and realignment. In the vicinity of the historic ranch structures and park buildings the channel was completely obliterated by deposited sediment. This contributed to the amount and velocity of flow at the building locations.

Continued occupation and use of the site will require permanent commitment to periodic excavation to maintain an active channel away from park facilities. However, any excavated channel is subject to aggradation and filling, and no excavated channel can sustain and function in events as large as the December 5, 1997, flood. Therefore, facilities along Scorpion Creek will always exist with some level of vulnerability to impact from large floods such as this one.

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