



## Mount St. Helens 2004-2008 Eruption Timeline

**September 23, 2004** **Volcanic Events:** A swarm of tiny, shallow earthquakes begins at 0200 Pacific Daylight Time (PDT) on Sept 23 beneath 1980–86 lava dome (depths less than 1 km, magnitudes  $<2$ ); 200 events recorded by 1800 PDT. Swarm increases in intensity through Sept 24, then declines to a minimum early on Sept 25.

**Human Response:** Information Statement released by U.S. Geological Survey–Cascades Volcano Observatory (USGS–CVO) and the Pacific Northwest Seismic Network (PNSN) at 1800 PDT describing earthquake swarm and increased probability of small steam explosions in the crater. Eruption deemed unlikely without significant further precursors.

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**September 25, 2004** **Volcanic Events:** Earthquakes increase in magnitude starting mid-day on Sept 25. Low-frequency earthquakes (commonly seen in association with eruptions) start to occur. By the morning of Sept 26, a total of ten earthquakes with magnitudes  $>2.0$  recorded—the most in a 24-hr period since lava-dome building ended in 1986.

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**September 26, 2004** **Volcanic Events:** Localized cracks appear in glacier ice on Sept 26.

**Human Response:** At 1500 PDT on Sept 26, USGS–CVO and PNSN release a Notice of Volcanic Unrest and aviation color code Yellow, indicating that seismicity has surpassed background levels and that the volcano is in a state that could evolve toward eruption. The greatest immediate concern is for explosions that could shower the crater and upper flanks with ballistic fragments and create ash clouds affecting aircraft and downwind communities. Media flock to USGS–CVO, and the Mount St. Helens National Volcanic Monument’s Johnston Ridge Observatory (JRO) visitor center. Media calls arrive from across the nation; public interest is high. Field crews begin installation of additional seismometers and GPS receivers around the volcano.

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**September 29,  
2004**

**Volcanic Events:** Shallow seismicity accelerates overnight with 3 events occurring per minute. Maximum magnitudes are 2.4–2.8, and increase in the evening to 2.8–3.3. Rate of earthquakes of magnitudes >2 is about 1 per minute. GPS equipment detects northward movement of 1980–86 lava dome, consistent with a shove from a rising mass south of the dome. No magmatic gases detected.

**Human Response:** USGS-CVO and PNSN issue Alert Level 2: Volcano Advisory, and caution that explosions, crater ballistics and ash clouds could occur at any time. Aviation color code raised to Orange because of increasing concern that explosions could send ash to altitudes where air traffic would be affected.

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**October 1,  
2004**

**Volcanic Events:** Seismicity continues at 1–2 events per minute, with largest up to magnitude 3. First flight of a helicopter-mounted forward-looking infrared radiometer (FLIR) captures steam and ash explosion in the crater. Twenty-minute explosion clearly visible from the Portland metropolitan area (80 km southwest), as an ash and vapor cloud rises about 2 km above the crater rim and drifts southwestward. Earthquakes stop about 1 minute after the explosion begins and are quiet for about 3 hours after the explosion ends. Elevated CO<sub>2</sub> detected on 1980–86 dome, and weak sulfurous odor but no SO<sub>2</sub> or H<sub>2</sub>S. Observations reveal uplift of Crater Glacier by several meters.

**Human Response:** USGS-CVO and PNSN issue Information Statement regarding events. Local, state, and federal officials meet to discuss implementation of Unified Command and establishment of a Joint Operations Center. USGS-CVO and USDA Forest Service (FS) officials discuss potential hazards and trigger points for closure of the Johnston Ridge Observatory and viewpoints closest to the volcano. Visitor center staff request additional help to handle expected crowds of volcano watchers for the coming weekend.

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**October 2,  
2004**

**Volcanic Events:** Seismicity remains high. Vigorous ~1-hour-long, low frequency tremor occurs at 1215 PDT, suggesting magma movement or pressurization. Following the tremor, shallow seismicity continues at 1–2 per minute, with largest event a magnitude 3. Continued high rate of localized glacier deformation. Only hints of volcanic gases.

**Human Response:** USGS-CVO issues an Alert Level 3: Volcano Alert and aviation color code Red at 1400 PDT. Key concerns are that an explosive magmatic eruption could produce ash clouds reaching high altitudes affecting aviation, and pyroclastic flows could swiftly melt large amounts of snow and ice surrounding the vent and generate lahars that could sweep into the upper North Fork Toutle River valley. JRO evacuated. In less than an hour, 2,500 visitors and 14 satellite trucks are safely relocated. State highway, lands, and airspace within 8 km of volcano are closed. Secretary of Interior Gayle Norton flies over Mount St. Helens and visits CVO to better understand the unrest and response. Norton and local congressional delegates offer support during afternoon news conference.

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**October 3,  
2004**

**Volcanic Events:** Seismicity remains high, a 25-minute low-frequency tremor occurs at 0250 PDT. Magnitude 3 earthquakes occur at a rate of one every 5 minutes. Additional explosions late in the day. Large-scale uplift and fracturing of Crater Glacier.

**Human Response:** A Joint Information Center (JIC) is established at FS' Gifford Pinchot National Forest Headquarters.

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**October 4,  
2004**

**Volcanic Events:** A 22-minute-long steam and ash emission (to an altitude of 3,700 m) occurs mid-morning. Vent area is a bubbling lake. Visual observations assess tens of meters of uplift of Crater Glacier. Magma is at shallow level and could soon reach surface. Increased likelihood of larger steam and ash emissions. Gas flight detects CO<sub>2</sub> and low levels of H<sub>2</sub>S.

**Human Response:** FS brings in a regional Incident Management Team; Unified Command coordinates the multiagency response effort.

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**October 5,  
2004**

**Volcanic Events:** At 0905 PDT, a 70-minute-long steam and ash emission (to an altitude of 4,500 m) deposits dusting of ash 60 miles to northeast. The ash plume is visible on Doppler weather radar. Seismicity drops and remains at low levels following emission.

**Human Response:** Status remains at Alert Level 3: Volcano Alert. Emergency response is directed by Incident Commander (IC) and two other co-ICs representing Washington State Emergency Management Division and four county sheriffs. Joint Operations Center is established. Resources include gate guards, traffic-control personnel at visitor centers, and fixed-wing observation aircraft.

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**October 6,  
2004**

**Volcanic Events:** Seismicity remains at reduced level. Rainfall overnight generates small debris flows in the crater. Low clouds and rain limit visibility and air operations.

**Human Response:** Imminent threat of explosive eruption reduced, USGS-CVO decreases Alert Level to 2: Volcano Advisory, aviation color code lowered to Orange. IMT-2 and FS representatives meet with local and state law enforcement and emergency managers to define closure zones; considerable discussion about the value of linking closure zones to specific alert levels. USGS-CVO and FS stress the importance of maintaining flexibility so closures can be adjusted according to current eruptive behavior and potential threats.

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**October 7–10,  
2004**

**Volcanic Events:** Shallow seismicity continues. Brief views through the clouds show that a portion of the glacier continues to deform upward and outward, reaching more than 100 m above the former glacier surface. By October 11, the deformed area had a volume of about  $10 \times 10^6 \text{ m}^3$ . FLIR measurements confirm that by October 10, an area on the northwest part of the deforming glacier reaches temperatures  $>270^\circ\text{C}$ , suggesting that the crater floor was being heated and pushed upward by rising magma. An airborne survey measures modest gas emission rates.

**Human Response:** Status remains at Alert Level 2: Volcano Advisory, aviation color code Orange. IMT-2 departs and operations are transitioned back to local IMT-3. As hazards diminish, some road closures are lifted but temporary flight restrictions remain in effect. Public and media interest declines as explosive activity subsides and weather obscures volcano.

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**October 11,  
2004**

**Volcanic Events:** Thermal imaging indicates a fin-shaped rock spine approximately 30 m high and 60 m long with a maximum temperature of 580°C. The spine is considered to have been the initial appearance of new lava and the start of growth of what is called the new lava dome. The spine occupies the approximate location of the vent.

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**October 12–  
30, 2004**

**Volcanic Events:** The spine continues to grow. Its base and cracks show temperatures as high as 700°C. Growth progresses steadily (from mid-October), apparently without pause. The new dome grows initially as a series of recumbent, smoothly surfaced spines or “whalebacks” that extrude to lengths of almost 500 m. As is typical for such spines, their surfaces are striated and grooved and formed of powdery, crushed rock (gouge) that results from the solid extrusion grinding against the conduit walls during its last few hundred meters of ascent.

Ingenuity, combined with the skill of pilots, allows for the first samples of new lava to be dredged from spine 1 on October 20, using a weighted bucket on the end of a 30 m line slung from a helicopter. The samples look like typical Mount St. Helens dacite, similar in chemical composition and mineralogy to the dacite erupted on May 18, 1980.

During mid-October, seismicity settles into a pattern of repetitive small (magnitudes <1) earthquakes, dubbed “drumbeats,” occurring at rates of one to two per minute, with larger events at longer intervals.

Single frequency GPS receivers and accelerometers (seismometers) mounted alone or together on tripods (dubbed “spiders”) are deployed in the crater.

**Human Response:** To reduce the potential risk to field crews to unpredictable explosions, most new and replacement instruments in the crater are deployed by helicopter sling.

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**Late Autumn  
2004**

**Volcanic Events:** Spine 3 is growing in late October 2004. A GPS spider riding on spine 3 moves at an average rate of about 10 m/d for 8 days. Spine 3 is about 475 m long when it reaches the base of the southeast crater wall.

By mid-December, the total volume increase represented by the three spines of the new dome and deformed glacier is about  $30 \times 10^6 \text{ m}^3$ . As spine 3 was pushed eastward, it becomes increasingly fractured and little of its original smooth, gouge-covered surface remains intact. The remaining stump of spine 3 grows to form a new spine (spine 4) that pushes most of the old spine 3 aside (to the east).

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**January to  
July 2005**

**Volcanic Events:** Growth and disintegration of spines continues through the first 8 months of 2005. Growth periods of spines 4 and 5 each last about 13 to 14 weeks. Extrusion rates during the growth of spines 4 and 5 are lower than during the growth of spine 3.

A vigorous 10-minute explosion occurs under good viewing conditions late on the afternoon of March 8, 2005. Seismicity increases slightly for several hours before the explosion. A white vapor cloud billows high above the crater rim and drifts east-northeastward. Pilots report the top of the cloud reaches an altitude of 11 km; NEXRAD detects it up to 6 km. Ballistic fragments destroy two seismometers. A narrow deposit of coarse ash and fine lapilli extended east-northeastward, discernible on snow for about 7 km from the vent. Dustings of ash are reported in Ellensburg, Yakima, and Toppenish, Washington.

By midsummer 2005, the top of spine 5 reaches the highest altitude attained by the new dome, 2,368 m. At that time, the top stands only a few meters below the lowest point on the crater rim (Shoestring notch). Spine 5 is a prominent feature in the view of the crater from JRO in midsummer 2005.

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**August 2005  
to late 2007**

**Volcanic Events:** Continued extrusion of spines 5, 6 and 7, collectively forming a more dome-like mass. Photogrammetric techniques estimate a rate of movement of several meters per day, westward and upward. Even though spines form and crumble repeatedly throughout the eruption, the vent area (the area at which the extrusion breached the ground surface) remains in the same approximate position since the early October 2004 explosion and emergence of initial spine. Modest rates of gas emissions during this period.

The movement of lava spines pushes glacier aside, accelerating surface movement of Crater Glacier to more than 1 m/d; Crater Glacier advances markedly during the winter of 2005. A remarkable aspect of the interaction of the growing lava dome and glacier is the apparent lack of significant glacier melting. Rapid dewatering of glacier beds through the highly permeable crater-floor material discourages basal sliding, and most glacier movement consists of internal flow.

Studies of crater-floor and flank thermal and cold springs show little to no effect from the current eruption; it is as though the eruption is not happening.

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**Late January  
2008**

**Volcanic Events:** Repeat photographs show some extrusion in early January, diminishing by late January.

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**February 2008**

**Volcanic Events:** Analysis of repeat photographs from fixed cameras shows no evidence of extrusion, only the gravitational settling of the last spine (spine 7). Settling confirmed by a GPS spider atop the spine. Seismicity gradually diminishes through 2006-2007 and remains shallow. There is cessation of ground-tilt events and barely detectable SO<sub>2</sub>. Crater Glacier continues to flow. The snouts of the east and west arms touch, enveloping the 1980–1986 lava dome.

**Human Response:** USGS–CVO and PNSN reduce the alert level to Volcano Advisory and aviation color code lowered to Yellow on February 21, 2008, to signify that volcanic activity has decreased significantly; volcano is closely monitored for possible renewed activity. USGS–CVO states eruption over in July 2008 and lowers Volcano Advisory to Normal and aviation color code to Green.

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