Executive summary

On March 22, 2014, a massive landslide occurred between the towns of Arlington and Darrington near the community of Oso in Snohomish County, Washington. Mud and debris slid down into the North Fork of the Stillaguamish River valley blocking the river’s flow and causing upstream flooding. The slide material, estimated at approximately 8 million cubic meters, covered an area of approximately one square mile in less than one minute. A section of State Route 530 (SR 530) was blocked, isolating the community of Darrington.

The two agencies, Washington State Department of Transportation (WSDOT) and Snohomish County worked side by side with the local communities, volunteers, and the staff from local, state, and federal jurisdictions, as well as Native American tribes, in response to the SR 530 landslide and in the reconstruction of the damaged section of SR 530.

WSDOT and Snohomish County are jointly applying for the APWA Public Works Project of the Year Award in the category of Disaster or Emergency Construction/Repair, as our two agencies share in the achievement of supporting each other during the response to this catastrophic event and in the reconstruction of SR 530.

The reconstruction efforts consisted of six projects:

1. Emergency Temporary Berm Construction and Dewatering
2. North Fork Stillaguamish River Pilot Channel Project
3. SR 530 Access Road Maintenance and Traffic Control Project
4. SR 530 Roadway Clearing Project
5. SR 530 Emergency Roadway Reconstruction Project
6. SR 530 Incident Debris Removal Project

The six projects were unique, in that they:

- Took place under adverse conditions and during a compressed timeframe of 6 months.
- Involved many of the same agencies, contractors, and local community members working together toward the common goal of recovering landslide victims, restoring access between Arlington and Darrington, and restoring 80 acres of land to a safer and more stable condition.
- Were supported by emergency funding.
The incident

SR 530 was covered with mud and debris from the landslide.
(photo by WA State Patrol)

A devastating landslide

At 10:37 a.m., on March 22, a massive landslide occurred near the community of Oso in Snohomish County, Washington. There was no time to escape. Surrounding neighbors described the ground shaking and hearing a deafening noise like a freight train. Forty-three people lost their lives and 10 were seriously injured. More than 36 structures were destroyed and nine others were damaged by the flooding that followed. Emergency calls to 911 were made and the community responded. A quick-thinking Sheriff’s Deputy summoned the Snohomish County Helicopter Rescue Team, training in the area at the time. The Helicopter Rescue Team responded and rescued 14 people. Snohomish County’s Department of Emergency Management (DEM) activated its Emergency Operations Center and called rescue teams and support staff. Local, state and federal personnel, contractors, and volunteers joined in the search and rescue operations.

Local volunteers brought excavating equipment and shovels to help with the search and rescue effort. At times they were digging with their hands. They were there to help, to find survivors, and to recover friends and loved ones. This small community is close knit and determined. The mantra, “Oso Strong,” characterizes their spirit, as they did not stop searching until July 22, when the last of the 43 victims was recovered. Gregg Sieloff, an assistant chief from the Lynnwood Fire Department who responded to the incident, recalled local volunteers saying “logger up” and “make it happen” as they searched in the mud day after day.


President Barack Obama responded by issuing a Presidential Disaster Declaration for the SR 530 Flooding and Mudslide incident, which made federal disaster aid available to supplement state, tribal, and local response, search, and restoration efforts in the area. President Obama followed up with a visit to the slide area on April 22, meeting with survivors and community members.

A united response

More than 900 local, state, tribal, and federal personnel, trained and untrained volunteers, contractors, families, and neighbors were involved in the search, rescue, and recovery operations. Lorena Eng, WSDOT’s Northwest Regional Administrator, and Steve Thomsen, Snohomish County’s Public Works Director, led a strong, coordinated, team effort founded on many years of working together.

WSDOT sent employees to support the county staff in the Emergency Operation Center and the Incident Command Locations (ICL). Snohomish County and WSDOT worked together to respond to needs and support the communities.

Washington State Urban Search and Rescue Team, search and rescue dog teams, and local loggers and sawyers participated in the recovery efforts. (photo by Snohomish County)
The town of Darrington could not be reached from SR 530, which was blocked. The only viable detour was SR 20, a trip that added more than two hours and 100 miles one way for commuters and freight haulers. On March 26, just four days after the slide, WSDOT and Snohomish County Public Works crews began working together to restore access around the slide.

The first task was clearing and opening the Mountain Loop Highway, normally closed because of snow, to provide an alternate route in and out of Darrington. On the same day, local contractors built a road connecting SR 530 to an existing Seattle City Light utility access road. That access road was quickly made available to emergency responders. WSDOT and Snohomish County roadway crews supported the recovery efforts by building staging areas and a helicopter landing pad, and providing water trucks for decontamination.

The search for the victims had to be completed before SR 530 could reopen. More than 900 people worked together in the search while fighting cold weather, rain, quicksand-like mud, and large areas inundated with water. The Snohomish County Emergency Operations Center remained activated for 40 days while the operation took place; the longest activation on record for the County. On April 28, the Sheriff’s Office ended the formal search efforts, with 41 out of 43 victims recovered and identified. Everyone involved was still mindful that there were still two victims yet to be recovered. Out of respect, WSDOT delayed the process of clearing the highway until the Sheriff’s Office formally ended the search. WSDOT and Snohomish County then began developing plans to clear SR 530, reconstruct the portion destroyed by the landslide, and restore 80 acres of surrounding land to a safer and more stable condition.

WSDOT and Snohomish County response and repair projects

Six major projects addressing the SR 530 Landslide Emergency Response and Repair were bid at a combined total of $43 million and were scheduled to be completed before October 1, 2014. Cumulatively, the six projects came in $7.5 million under budget and finished 22 days early. WSDOT, Snohomish County, and their contractors worked within the same footprint to get the work done before the fall rains.

**Project 1: $300,000**

**Emergency Temporary Berm Construction and Dewatering**

Lead agency: Snohomish County | Major Contractor: Army Corps of Engineers | Work began April 7 and was completed on April 30, 2014.

Snohomish County’s Public Works Surface Water Management team worked with the Army Corps of Engineers to design and construct a temporary berm to isolate a search area and provide more safety and stability for the search and recovery teams. The Corps imported 5,800 cubic yards of quarry spalls and built a 2,900 foot-long berm. The Corps also installed and operated dewatering pumps to assist search and recovery efforts.

Crews used pumps to drain water from search areas. (photo by Snohomish County)

The Army Corps of Engineers constructed a berm. (photo by Snohomish County)
Project 2: $480,000
North Fork Stillaguamish River Pilot Channel Project

Lead agency: Snohomish County | Major Contractor: BCI Contracting, Inc. | Work began April 7 and was completed on April 30, 2014

Snohomish County Public Works contracted with BCI Contracting, Inc. to provide amphibious excavators to reconstruct a portion of the river channel, in order to drain the impounded water upstream of the slide debris. The standing water upstream of the slide was an impediment to recovery efforts and to the highway reconstruction project.

BCI’s unique excavators are designed to float and provide low ground pressure for use in soft soils. BCI excavated about 44,000 cubic yards of material, creating a 900 linear foot pilot river channel through the debris that would drain the backwater and a large portion of the eastern debris field. The excavations were challenging. Trained spotters accompanied the contractor while the work was completed in this unstable area.

Within days, the completed excavations dropped the backwater by several feet, greatly aiding the recovery work and the effort to rebuild the affected section of SR 530. BCI also provided mobile pumps and drainage expertise to assist in searching for victims.
IMCO hauled away 127,000 tons of mud and debris to clear SR 530. (photo by Will Austin; provided by IMCO)

SR 530 was reconstructed by WSDOT and Snohomish County activities made the surrounding area safer and more stable. (photo by WSDOT)

Project 4: $5.0 million
SR 530 Roadway Clearing Project
Lead agency: WSDOT | Major contractor: IMCO General Construction and ESA Consulting | Executed May 9 and issued substantial completion on May 30, 2014 | Completed 1 week early and $2.3 million under budget

IMCO Construction responded to the landslide and performed volunteer emergency work for more than a month before starting the SR 530 Roadway Clearing Project. The contract called for clearing 90,000 cubic yards of landslide material from SR 530. The contract required the roadway to be cleared by June 5, and crews worked around the clock—seven days a week for two weeks—to achieve this. By the end of two weeks, IMCO crews moved 127,000 tons of mud and debris, including more than 11,000 tons in one 24-hour period. This required great dedication and careful coordination with all those involved.

IMCO followed the material removal plan developed by WSDOT and Snohomish County in concert with the Medical Examiner’s Office. Archeologists and spotters searched for possible human remains and personal belongings while material was being removed. ESA consulting provided more than 40 spotters, many of them local residents, to perform this work.

SR 530 was reconstructed by WSDOT and Snohomish County activities made the surrounding area safer and more stable. (photo by WSDOT)

Project 5: $21.0 million
SR 530 Emergency Roadway Reconstruction Project
Lead agency: WSDOT | Major contractors: Guy F. Atkinson Construction (construction), Jacobs Engineering (design), KLB Construction (earthwork), Geo Engineers (geotechnical), O’Neill Service Group (environmental and quality assurance), PRR Inc. (public outreach and communications) | Executed May 30 and issued Substantial Completion on September 22, 2014 | Completed 9 days early and on budget

WSDOT contracted with Atkinson Construction to rebuild the portion of SR 530 damaged by the slide using the design-build project delivery method. The project goals were to minimize impacts to the traveling public and the local community, and to restore access as soon as possible. Because of the revised floodplain risk resulting from the landslide and the geographic changes to the North Fork of Stillaguamish River, the contract required raising the profile of the new roadway 4-20 feet above its original elevation.

Work included importing 60,000 cubic yards of roadway embankment, repairing the existing roadway to reopen it temporarily to two-way traffic within the first 18 days of the project, installing six fish passable culverts, scour protection along the north roadway embankment, and completing landscaping, wetland mitigation, and other environmental improvements.
Project 6: $13.0 million

SR 530 Incident Debris Removal Project
(3 simultaneous contracts)

Lead agency: Snohomish County | Major contractors: IMCO General Construction (construction), AECOM (archaeology and spotting), URS (monitoring and inspection) | Execution June 19 to Substantial completion on September 16, 2014 | Completed 6 days early and $5.2 million under budget

Following the landslide and recovery operations, piles of debris including homes, vehicles, personal belongings, and possible human remains remained upon 80 acres of private and public property in Snohomish County. To make the area safer and more stable, Snohomish County contracted with IMCO General Construction to sort through approximately 200,000 cubic yards of material and remove man-made items while leaving native materials on site in a safe, stable and free draining condition.

As part of this project, the County also contracted with AECOM to provide archaeologists and spotters to work alongside equipment operators to ensure respectful recovery of human remains and personal property. From the beginning, Snohomish County established a Property Reunification Center so families could be reunited with their personal belongings. More than 1,000 personal belongings were collected during the material screening process and sent to the center. The County also contracted with URS to assist in the monitoring and tracking of the contract work for FEMA reimbursement.

Construction schedule, management & control techniques used

Use of alternative materials and practices of funding that demonstrates a commitment to sustainability

Within six months from the day of the landslide, six projects were designed and constructed, at a total advertised cost of $43 million. WSDOT, Snohomish County, and their contractors worked within the same footprint to get the work done before the fall rains began. Cumulatively, the six projects came in $7.5 million under budget and were completed 22 days early. Completing the work quickly was important due to the limited weather window, the need to re-establish a direct roadway connection between Darrington and Arlington, and to provide a sense of ongoing healing for the community.

Construction schedule, management, and control techniques used

With multiple fast-paced projects needing to occur within the same area in succession and simultaneously, interagency coordination was critical to develop and implement the projects. Examples include:

- **Managing the work carefully, in a respectful and sensitive way:** The community was very sensitive to any construction efforts in the slide debris area. Time was needed to recover victims before debris removal could begin on the SR 530 Roadway Clearing Project. Many community meetings were held and a task force was formed to develop a protocol to respectfully and carefully screen the material for human remains and personal belongings. The task force included staff from Snohomish County’s Public Works and the Medical Examiner’s office, the US Army National Guard and WSDOT. This process was first implemented on the SR 530 Roadway Clearing Project, and then refined by Snohomish County prior to the SR 530 Incident Debris Removal Project.

- **Managing newly formed teams on a continuous 24 hour ongoing schedule:** The SR 530 Roadway Clearing project required a significant amount of staffing and a complex staff scheduling plan to ensure that work hours were covered and that staff did not
suffer from overwork. WSDOT pulled together staff from offices that spread 100 miles from Seattle to Bellingham, as well as reassigning the office secretary and office assistant to work on the project. Workers were scheduled for eight-hour shifts, six days a week; including driving to the site, they were working 10-hour days. As the work continued 24 hours a day, it took three people to cover each task from excavator operator to inspection. This schedule continued for a little over three weeks. During the SR 530 Roadway Clearing Project, a moment of silence was observed every Sunday at 10:30 a.m. with all work, equipment and activities stopped.

Often challenging were the around-the-clock phone calls and endless visits—from the media, government agencies, and various groups (i.e.: scientists from around the world studying landslides, the Governor, FEMA, design teams)—and the twice daily phone calls updating management on progress or issues encountered.

Along with the debris removal, WSDOT staff managed the maintenance and operation of the detour. They also managed the full-time network of pumps that helped route water around the debris field. Daily quantity reconciliation played a big part on the debris removal project. Each contract bid item was measured by the hour, except the imported material which was measured by the ton. There were no material quantity disputes; remarkable on a 24/7 project with so many parties involved.

- **Agency partnering**: WSDOT and Snohomish County Public Works design and construction teams frequently exchanged draft plans and learned from each other’s experiences in the community and work zone. Snohomish County used WSDOT’s SR 530 Roadway Clearing Project plans as an example to begin building their SR 530 Incident Debris Removal plan. WSDOT and Snohomish County attended each other’s contractor pre-construction meetings and weekly construction meetings to ensure seamless coordination.

- **Sharing resources and best practices**: Contractor management teams collaborated with each other to share information and work efficiently. During the SR 530 Emergency Roadway Reconstruction Project, Snohomish County’s contractor AECOM provided the Atkinson team with spotting training materials and contact information for local and/or experienced spotters to hire to support the excavation portion of the project. They also shared GPS units and paperwork with Atkinson team spotters to provide continuity with the Snohomish County Sheriff’s Department and the personal belonging reunification process.

- **Planning ahead to minimize impacts to the traveling public**: On WSDOT’s SR 530 Emergency Roadway Reconstruction Project, the contractor stockpiled material to be readily available to minimize the duration and number of full roadway closures needed to complete the construction work.

On the SR 530 Roadway Clearing Project, WSDOT coordinated with a potential landfill site owner in the close proximity of the landslide to obtain necessary permits to be available as an option for the contractors for a disposal site for the debris. This landfill site was used by IMCO and resulted in significant reduction in haul time, compared to other available disposal sites, and eliminated significant noise and traffic impact to the communities in Arlington, which was a big concern to WSDOT and Snohomish County.

- **Being prepared**: Because of its existing FEMA-approved Disaster Debris Management Plan, Snohomish County was well-prepared to meet the challenges of the disaster. Although this plan was not tailored specifically to a large landslide incident, Snohomish County was able to develop an operational concept that was flexible enough to adapt to field conditions and approaches that changed daily. The County held daily debris team meetings to inform the planners, contract writers and operations crews about changing conditions so they could adjust their operations accordingly.

- **Co-locating staff on site**: Partnering and collaboration is critical on fast-paced projects. For the SR 530 Emergency Roadway Reconstruction Project, WSDOT chose to locate its staff and the design-builder team in adjacent trailers at the project site. This arrangement allowed the teams to more easily participate in over-the-shoulder reviews, spontaneous meetings and other communications to advance the project. The Snohomish County team and their contractors had trailers just down the road and often stopped by to coordinate. The Atkinson team convened a series of task forces on various design and construction disciplines so that WSDOT, third parties and stakeholders could collectively determine the best solutions and resolve issues as a team.

- **Ensuring quality control**: Atkinson construction crews completed quality control checklists in the field prior to placing permanent materials, to ensure materials were installed properly and the survey was correct. In addition, the O’Neill Service Group was hired as a quality assurance team and they used checklists to monitor and ensure that material and installations met required standards.
MARCH 22, 2014 - massive landslide occurs on SR 530. 14 people were rescued by emergency responding helicopters. The first fatalities were recovered.

Snohomish County Executive John Lovick issued a Local Proclamation of Emergency and Washington State Governor Jay Inslee proclaimed a State of Emergency for Washington state. The Snohomish County and Washington State Emergency Operations Centers were activated.

MARCH 25, 2014 - Snohomish County Public Works initiated meetings with WSDOT with the goal of opening SR 530 as quickly as possible.

MARCH 26, 2014 - WSDOT and Snohomish County crew worked jointly to clear and open the Mountain Loop Highway. In addition, local contractors worked to connect SR 530 to an existing Seattle City Light utility road to provide access for first responders.

April 2, 2014 - President Barack Obama issued a Presidential Disaster Declaration, making federal disaster aid available to supplement state, tribal and local response and recovery efforts in the area.

APRIL 7-30, 2014 - At the request of Snohomish County, the Army Corps of Engineers used 5,800 cubic yards of quarry spalls to build a 2,900 foot-long berm to control water that was hampering search efforts. More than 43,000 cubic yards of landslide material were removed to open 900 linear feet of channel to drain the backwater and a portion of the eastern debris field. This supported safer and more efficient search and recovery efforts.

APRIL 28, 2014 - Formal search efforts end with 41 out of 43 victims recovered.

APRIL 29, 2014 - The site was turned over to WSDOT by Snohomish County Medical Examiner.

MAY 2, 2014 - WSDOT executed a $5 million, federally funded contract for IMCO General Construction to begin clearing landslide material from SR 530. They were assisted by archeologists and spotters from ESA Consulting.

MAY 22, 2014 - The second-to-last victim was recovered.

MAY 30, 2014 - IMCO completed the SR 530 Roadway Clearing Project, removing 127,000 tons of landslide material and uncovering 600 feet of missing roadway.

MAY 31, 2014 - WSDOT reopened SR 530 to one-way, piloted traffic after an event that brought the community together for a moment of silence and the opportunity to walk the road.

APRIL 25, 2014 - WSDOT executed a $3.4 million, FHWA-funded contract for Granite Construction to pilot citizen traffic on the Seattle City Light Access Road.

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June, 2014 - See next page.
JUNE 16, 2014 - Granite Construction achieved substantial completion of the SR 530 Access Road Project which piloted traffic on the Seattle City Light Access Road.

JUNE 20, 2014 - SR 530 was reconstructed and reopened to two-way traffic while permanent road construction continued.

JULY 22, 2014 - Construction crews working for the Sheriff’s Office located the last remaining landslide victim. All 43 victims were now recovered.

SEPT 22, 2014 - The Atkinson design-build team reached substantial completion on the new, permanent SR 530. The roadway reopened to two-way traffic at full speed (50 mph) after 111 days of design and construction, and exactly 6 months to the day following the landslide.

“*We were truly inspired by the strength, determination and resilience of the many people who were involved in the rescue and recovery effort . . . The efforts of the many people who assisted in the SR 530 slide response exemplify the compassion and dedication that Washingtonians are known for.*”

– Governor Jay Inslee, quoted from a letter to contractors working on this project

SEPT 16, 2014 - Snohomish County’s SR 530 Incident Debris Removal project was substantially completed six days early and $5.2 million under budget.

SEPT 27, 2014 - WSDOT and Atkinson closed SR 530 temporarily to host a reopening event. Family members and friends of the deceased planted 43 cedar trees in a grove alongside the road in memory of the landslide victims. Community members, local leaders, and people who worked on the projects attended the gathering.
Use of alternate materials, practices of funding that demonstrates a commitment to sustainability

WSDOT and Snohomish County sought out federal and local funding opportunities to supplement the cost of the repair and reconstruction projects. The receipt of outside source funding was critical to complete the necessary disaster repair work while maintaining funding for normal WSDOT and County programs.

- WSDOT worked closely with the Federal Highway Administration (FHWA) to secure full emergency federal funding for the activities associated with WSDOT’s initial response to the disaster, the SR 530 Access Road Maintenance and Traffic Control Project, and the SR 530 Emergency Roadway Reconstruction Project. The Sauk-Suiattle Indian Tribe was a key participant to inform WSDOT that SR 530 is designated as a Tribal Transportation Facility which increased the Federal share from 86.5% to 100% for the final contract.

- WSDOT’s SR 530 Emergency Roadway Reconstruction Project received FHWA Emergency Relief funding participation for costs associated with scour protection material placed outside of right of way, and for restoration of a wetland area that was used for staging emergency response and recovery operations. These changes were incorporated by change order.

- Snohomish County worked closely with the Washington Military Department Emergency Management Division to secure Federal Emergency Management Agency (FEMA) for funding associated with the Search and Rescue, Emergency Protective Measures, and the SR 530 Incident Debris Removal Project. The County is also coordinating reimbursement for future expenses for repair of the Whitehorse Trail.

- Snohomish County developed a Northeast County Road Program that allocates approximately $5M to capital improvement projects in the Town of Darrington, City of Arlington and Oso. Additionally, the Town of Darrington was awarded approximately $635K in Transportation Improvement Board (TIB) funds. Several projects were completed as part of the County’s 2014 Chip Seal Program. Future capital projects include improvements to sidewalks, drainage, corridors and intersections. Projects are anticipated to be built over the next five years.

- Snohomish County’s SR 530 Incident Debris Removal contractor IMCO Construction worked six days a week to develop the most optimum screening methods and to ensure work was completed on schedule. IMCO completed 75% of the work within the first 30 days enabling the County to capitalize on a FEMA pilot reimbursement program that pays 87% of this work. This is 12% greater than the standard 75% reimbursement rate.

- On the SR 530 Emergency Roadway Reconstruction Project, WSDOT’s contractor Atkinson Construction needed to remove a large quantity of material from an existing knoll to make room for the reconstructed roadway. Atkinson developed a plan to reuse the knoll material by placing it just across the road to assist Snohomish County in rebuilding a pedestrian and bicycle path, known as the Whitehorse Trail.

- WSDOT’s contractor Atkinson assisted the County by removing a temporary roadway that had been built on private property during the recovery effort. Atkinson was able to reuse this material as roadway fill for SR 530. The sustainability practice of reusing on-site native material minimized trucking emissions and fuel use. In addition, it saved time and money.

- WSDOT’s contractor Atkinson Construction used a quarry five miles from the project site to crush rock material for the new SR 530 roadway base, reducing haul distance and fuel usage that would have been associated with importing material.

The SR 530 emergency restoration project used materials from Boulder Creek Pit, a quarry just five miles away, reducing haul distance and fuel usage. (photo by WSDOT)
Safety performance

Including number of lost-time injuries per 1,000 manhours worked and overall safety programs employed during the construction phase

The combined projects logged in 54,861 worked man-hours with no injuries and only one lost time incident related to heat stress. At the peak of construction, with both the SR 530 Emergency Roadway Reconstruction Project and the SR 530 Debris Removal Project underway there were 140 workers on the 80 acre site each day. The safety focus included clear protocols and training, job hazard analysis and communication. All these efforts were effective in keeping lost work hours near zero—despite the challenges of working in an area of unstable mud with the potential for future landslides, a high density of personnel and heavy construction equipment, and as summer came, the extremely hot weather conditions. On top of all this, employees were confronted with the stress of working long work hours in an emotionally-charged recovery environment.

Core safety commitments were focused around three key principles: training, hazard assessment, and communication. The priority was for each person to return home safely every day. Each project had a comprehensive safety plan implementing key safety elements:

Training and education

- Comprehensive safety training was required for all employees who worked in the field, including the project owner, contractors, designers, and subcontractors.
- For the SR 530 Incident Debris Removal Project, Snohomish County held a mandatory all-hands safety training session for 150 people including Snohomish County staff, contractors, archeologists, spotters, equipment operators, surveyors, and engineers. The meeting goal was to unite the spotters and equipment operators to safely sort through the debris. Equipment operators had to watch for spotters on the ground. Spotters had to stay close to the excavators to keep watch for personal belongings and human remains. Fire Chief Willy Harper from the Oso Fire Department kicked off this session, thanking everyone for the work we were about to start.
- IMCO Construction conducted an exercise giving each spotter an opportunity to sit in the excavator seat to see the limits of vision. This helped the spotters understand how valuable eye contact is when working around equipment.

Job hazard assessment/work plans

- Managing to support workers: Snohomish County had a warm spring and hot summer with temperatures often in the 80’s and 90’s. Conditions in the debris field were hot as there was no shade with all the trees demolished. To reduce the heat stress on the staff, IMCO Construction decided to change the start time from 7 a.m. to 6 a.m. Rest areas with picnic tables, shade covers and coolers of ice water were set up at multiple locations and rotating staff schedules allowed workers to take breaks and get out of the sun. To support those who were doing the difficult work of searching for personal belongings and human remains, Snohomish County had Critical Incident Stress Management teams on site each day to check in with staff members and be available to talk at the picnic tables. Overall:
  - Employees at every level were expected to be involved in creating and maintaining a safe work zone.
  - Safety was thoroughly evaluated during the pre-planning efforts, as well as during each work day.
  - Team members were encouraged to take breaks from their work and stay alert to their surroundings.
  - Employees wore monitoring equipment to evaluate noise levels and the information was used to ensure on-site personnel had proper hearing protection.
  - The County required all workers to carry water, and all spotters were provided Camelback water reservoirs to ensure they had immediate access to water at all times. The County enforced shade breaks, meal breaks and employees watched each other for signs of heat illnesses.
  - IMCO Construction developed a wellness check-in plan to proactively manage the effects of fatigue. The HR director checked in with employees regularly, and offered counseling sessions to address the difficulties of recovering personal belongings and remains.
  - Employees had designated work zones due to the large quantity of heavy equipment in operation onsite. Spotters and operators were set up in teams that stayed together to be able to anticipate movement and understand the blind spots on equipment.
Eye contact was required between the spotters and operators to ensure safety. Radios and horns were used if someone could not be seen.

- Working in the remote location was challenging not only for safety concerns but site access. A strategic plan was developed for locating first aid stations, communication on the site, recall, and how to safely transport an injured worker, as most of the site was only accessible by 4x4 or tracked equipment. Staging each work zone with shade areas, water, facilities, and first aid huts was a priority.
- The speed limit was lowered on SR 530 from 50 mph to 25 mph to improve the safety of the traveling public and workers.
- Flaggers were employed to help residents within the project limits travel safely in and out of their driveways, as well as to allow construction equipment to move safely in and out of work zones.
- Department of Labor and Industries officials visited the SR 530 Incident Debris Removal Project site and commented on how meticulously clean and organized the site was.

**Communication**

- Daily tailgate safety meetings served to alert people to hazards and reinforce safety practices.
- Safety officers completed safety reviews to assess work conditions and immediately communicated actions needed to enhance safety.

**Environmental considerations**

Including special steps taken to preserve and protect the environment and endangered species, etc., during the construction phase

WSDOT, Snohomish County and their contractors made every effort to minimize environmental impacts during recovery efforts, debris removal and roadway reconstruction.

- **Streamlining and expediting the initial permit process:** Prior to conducting debris removal and other emergency work, both WSDOT and Snohomish County Public Works collaborated with federal, state, tribal, and local regulatory agencies to obtain the applicable emergency permits and authorizations.

WSDOT and Snohomish County worked closely with environmental regulatory agencies to acquire emergency authorization to start work with the condition that the projects would avoid or minimize impacts to the environment. Staff continued the open dialogue with the regulatory agencies during project design and construction. The team worked most closely with the U.S. Army Corps of Engineers, the Washington State Department of Ecology, and the Washington State Department of Fish and Wildlife. As construction advanced to completion, the staff completed emergency permit applications and secured the necessary approvals to complete the project permitting documentation.

- **Incentivizing environmental mitigation through the contract:** In the contract language for the SR 530 Emergency Roadway Reconstruction Project, WSDOT gave the design-builder the option of buying established wetland mitigation bank credits at $1 to $1.5 million per acre or acquiring and designing its own site. As an environmental innovation, the contractor’s design reduced the original wetland impact area from 1.5 acres to roughly one-half acre. Furthermore, the contractor purchased private property within the slide area for use as a wetland mitigation site that created open space, species habitat and room for additional wetland mitigation development on the project site.

Six new fish-friendly culverts were installed under SR 530. (photo by WSDOT)
• **Protecting wildlife and habitat:** During the initial recovery phase, Snohomish County staff found Coho salmon fingerlings in a waterway that had found its way back through the debris field. The County environmental team coordinated with the Native American tribes, environmental services, DNR and other interested parties to develop a plan to manage the fish while completing the construction work.

Prior to beginning the SR 530 Emergency Roadway Reconstruction Project, the contractor identified marbled murrelet and spotted owl habitat on the knoll adjacent to SR 530. The team surveyed for nests before clearing vegetation and beginning new roadway excavation. They also installed six new fish passable culverts. At the rock-crushing pit site and along the roadway, water trucks patrolled to manage fugitive dust which protected the adjacent salmon spawning areas.

• **Reducing our environmental footprint:** For the SR 530 Emergency Roadway Reconstruction Project, the team employed a number of practices designed to reduce the carbon footprint of its work, including:
  - Using a pit site adjacent to the project to crush rock into crushed surface base course for the new roadway, which reduced hauling distances and associated traffic and fuel use.
  - Using a two percent biodiesel blend in all diesel-powered heavy equipment.
  - Adhering to a no-idling policy for trucks and equipment.

• **Recycling construction materials:** WSDOT, Snohomish County and the Atkinson team collaborated to place granular material excavated from a large knoll as part of the SR 530 reconstruction onto the Whitehorse Trail, a bicycle and pedestrian facility adjacent to SR 530 that was damaged during the slide. This practice reduced the need for outhaul of material and associated environmental impacts. In doing so, contractor crews began to raise the profile of the Whitehorse Trail and move closer to completion of what will ultimately be a Snohomish County-led project. The Whitehorse Trail is expected to be a future recreational resource in the area and assist with economic recovery.

• **Applying construction Best Management Practices:** All projects implemented a series of best management practices (BMPs) to meet permit requirements. Practices included relocating waterways to dry out the area so new channels could be graded, working proactively to protect areas before earthwork activities began, and promptly stabilizing areas after work was completed.

Teams used BMP’s such as silt fence, straw wattles, plastic sheeting, fiber matting, compost, and seeding to prevent the transport of sediment. Many on-site coordination meetings were held with regulatory agencies to ensure everyone was aware and confident that the environment was being protected as the work moved forward. The drainage courses and streams that were blocked by the landslide were reconstructed through the debris field and once they were stabilized, water was directed through them. WSDOT and Snohomish County worked together to ensure the drainage courses and streams were stabilized and connected to the river.

• **Convening a stakeholder task force to weigh in on “next steps” for river management:** In June, after the recovery phase was well underway, the County convened a group of local, state, federal, tribal representatives, and river experts to work together as a task force to determine whether actions should be taken to support the newly established course of the river before flood season began in October. The task force considered a set of alternative actions in light of existing river and geologic conditions, impacts on flooding and habitat, feasibility of construction, and feasibility of funding. A final consensus supporting a “no action” alternative was reached; given such a limited time frame and lack of funding.

Members of the task force generally believed that the river channel would continue to naturally widen itself during the fall/winter flood season, which it has done. The group agreed that the County and other stakeholders should continue focusing on monitoring the river flows, the stability of the river channel, the transportation of sediment downstream, and making the river data available online.

The County also continued its outreach to residents in the affected area through the SR 530 website, social media, and flood safety information tailored to local concerns and mailed to residents.
Community relations

A summary of the efforts by the agency, consultant and contractor to protect public lives and property, minimize public inconvenience and improve relations

Communicating with the community

This was a sudden catastrophic incident. Families were grieving the loss of loved ones. There was widespread loss of personal property, the inability to commute to work, and businesses lost access to their employees, customers, and supplies. The community had urgent concerns that needed to be addressed. Communication had to be two-way. The community voiced their concerns. The team kept them up-to-date on how those concerns were being addressed by sharing priorities, plans, and actions.

It was important to have direct communication between the families and property owners before information was released by the mass media. Public information professionals came from across Washington State to assist with communication efforts. WSDOT, Snohomish County, and local representatives from Oso, Darrington, and Arlington were besieged by the press. Representatives who provided support to supplement our communication experts were greatly appreciated.

“We’ve changed how we see community involvement in disasters. You can’t worry about whether somebody’s got a uniform on or not; you take the help and you go forward.”

– Snohomish County Sheriff Sheriff Ty Trenary

Protection of public lives and property

• The recovery and operation centers: The need for a rescue response was immediately and effectively communicated to get helicopters into the area at once. Air and land crews worked together to locate and stabilize survivors. Of the 14 people who survived, all were rescued by helicopter within six hours of the landslide.

The Department of Emergency Management (DEM) activated the Washington State and the Everett Emergency Operations Center, Incident Command Post in Arlington, and a coordination site in Darrington. WSDOT and Snohomish County Public Works staff assisted the DEM with manpower and equipment. WSDOT’s and Snohomish County’s maintenance crews supported the search and rescue efforts.

• Recovering human remains and personal belongings with sensitivity: The Snohomish County’s Medical Examiner’s office performed identification of human remains. Public Works crews assembled locations for this work to take place. The search for human remains continued for 40 days. On April 28, the Sheriff’s office ended the formal search efforts, with 41 out of 43 victims recovered. The last two victims were recovered on May 22 and July 22, giving some needed comfort to the victims’ families and the community.
A highly effective “Personal Belongings Program” was created by Snohomish County departments. Personal property was transferred to a county-established facility known as the “Property Reunification Center” to facilitate collection by the survivors or victims’ family members. Personal property included both items typically carried on one’s person, as well as items potentially holding personal or sentimental value. County staff worked closely with the families to reunite them with sentimental items. More than 2,300 personal belongings, 20,000 photos and documents, and over 100 controlled items (weapons or items of value) were recovered, 1,001 of which were found during the SR 530 Incident Debris Removal Project.

Minimizing public travel inconveniences and detours

The town of Darrington could not be reached from SR 530, which was blocked. The only viable detour was via SR 20 and Interstate 5, which added more than two hours and 100 miles one-way for commuters and freight haulers. On March 26, just four days after the slide, WSDOT and Snohomish County crews worked jointly to clear and open the Mountain Loop Highway, normally closed because of snow, to provide an alternate route in and out of Darrington. On the same day, local contractors and volunteers built a road connecting SR 530 to an existing Seattle City Light utility access road. With this new connection, a road was quickly open and available for emergency responders.

- In late April, while SR 530 remained blocked by landslide material, WSDOT contracted with Granite Construction Inc. to pilot traffic to and from Darrington around-the-clock on the primitive Seattle City Light access road. This 30-minute detour provided much needed relief to local residents.

- WSDOT’s SR 530 Roadway Clearing contractor worked 24/7 from May 9 to May 30 to clear debris material from SR 530. The SR 530 Emergency Roadway Reconstruction Project immediately followed. WSDOT’s contractor committed to reconstructing and repaving the existing SR 530 roadway for use as a temporary two-way roadway within three weeks of their contract execution on June 3. They exceeded this commitment, reopening the roadway on June 20.

- The contractor was also able to maintain two-way traffic on a paved surface which was an upgrade from the gravel borrow surface expected in the contract. The contractor made it a priority to minimize necessary roadway closures and only used 3 of the allowable 17 31-hour road closures. On one occasion, in response to community concerns, the contractor canceled and rescheduled a planned road closure that fell on the first day of school. This significant reduction in road closure impacts provided relief to a community that was already weary of transportation challenges.

Improving relationships

- Engaging the community with sensitivity and compassion: WSDOT and Snohomish County immediately initiated meetings with the families of the missing and the communities by reaching out to community leaders and requesting their assistance to connect with those affected. WSDOT and the County held regular meetings in Oso, Darrington, and Arlington. Over time both the County and WSDOT found it helpful to meet with affected family members before meeting with the public.

WSDOT and Snohomish County knew that meeting with families, tribes and the communities of Oso, Darrington, and Arlington was crucial. The community meetings focused on topics such as opening and rebuilding SR 530, future slide danger, plans for a memorial, material removal, river studies and the potential for future flooding. Most importantly, WSDOT and the County needed to hear and understand the community’s concerns in order to plan the next steps accordingly.

Lorena Eng, Washington State Dept. of Transportation NW Regional Administrator, and Steve Thomsen, Snohomish County Public Works Director, talked with citizens at community meetings. (photos by WSDOT and Snohomish County)
Through this outreach, affected families, communities, and tribes saw WSDOT and Snohomish County as agencies that listened, and made real changes to construction activities and temporary detour operations based on their feedback. Dozens of local and national media stories cast WSDOT and Snohomish County in a positive light before, during, and after construction. Most importantly, impacted families and communities trusted that WSDOT and the County actively communicated with them at critical points during the projects.

Snohomish County and WSDOT staff also took steps to preserve sensitive community assets. For example, at the beginning of the SR 530 Emergency Roadway Reconstruction Project, construction crews washed the root system of a Sitka spruce tree that survived the landslide, which came to be known in the community as the “Memorial Tree,” in an attempt to save it from suffocation.

The Sitka spruce that survived became an important symbol to the community and it has been decorated as a “memorial tree.” (photo by Snohomish County)

• **Keeping the community informed:** WSDOT and Snohomish County teams notified the community, media and area stakeholders (transit, tribes, Hampton Mill) early and often via email, social media, traffic advisories and the project hotline about road closures, detours and other impacts. Communications specialists from WSDOT, Snohomish County and the contractor’s teams engaged in frequent emails, phone calls and text messages with nearby residents and stakeholders who had questions or concerns about the road and debris removal work. Thousands of personal connections were developed between individuals in the community and the first responders, the county, WSDOT, and contractor staff. There was a common theme of camaraderie surrounding this event—willingness by many to help, and a feeling that it was an honor to be of service.

• **Fostering strong community relations:** The team recognized the need to maintain strong relationships with neighbors to the project. Steps included:
  - Cell phone numbers of on-site construction staff, agency representatives, public information specialists and a 24/7 hotline were provided for use during the projects.
  - There were numerous meetings with area property owners to listen to their concerns, answer questions, provide information updates, and coordinate relocation of their fences from WSDOT right-of-way to their own property lines to accommodate the new roadway alignment.
  - WSDOT’s SR 530 Roadway Reconstruction contractor supplied white noise machines to landowners adjacent to the pit during rock-crushing operations. There were special accommodations made for neighboring property owners, such as preserving wood from trees removed during the project, ensuring driveway grading satisfaction, water line protection, and supplying dirt, boulders and other landscaping materials similar to what existed pre-slide.

• **Supporting the local economy:**
  - Agencies and contractors made extra efforts to support local communities during the project. Local community members were recruited to work on the construction project teams, and efforts were made to purchase supplies at local stores, eat at local restaurants, and stay at local accommodations.
  - On the SR 530 Roadway Clearing Project, WSDOT worked with the County Medical Examiner’s Office on a plan that allowed ESA to hire and train local community members as second spotters on each piece of excavating equipment.
  - The SR 530 Emergency Roadway Reconstruction Project worked with union representatives to employ more than 20 local community members.
  - For the SR 530 Incident Debris Removal Project, half of the AECOM spotting team was composed of local community members (24 total). The AECOM team made a commitment to stimulate the local economy during the course of the project, including contracting with local cabin owners and the bed and breakfast establishments in Oso for temporary lodging over the course of the project, renting equipment (water tanks, gator, storage facilities) from local community members and businesses, and shopping local for food and incidentals. AECOM team members donated more than $700 to the local Darrington and Arlington Community Food banks.
over the course of the project. In addition, the AECOM Project Manager hosted several career workshops for the local spotting team during the final weeks of the project to assist with resume writing, job searches and application processes to assist with employment transition following completion of the project. In December of 2014, AECOM held a project reunion party at the Darrington Community Center.

- **Providing opportunities for the community to gather and reflect:** WSDOT organized two events to provide opportunities for reflection to assist with the healing process. The first event occurred after IMCO Construction finished clearing the debris from the roadway. On May 31, WSDOT allowed community members to walk the road and observe a moment of silence before it reopened to one-way, piloted traffic for the first time in two months.

The second event, on Sept. 27, marked the reopening of the new, elevated roadway to two-way, 50 mph traffic. It began with a solemn ceremony in which family members and friends of the landslide victims were invited to help plant 43 cedar trees in a grove adjacent to SR 530. The gathering also included remarks by state and local officials, a ceremonial tribal tree planting, and an opportunity for members of the broader community and project teams to take a walk on the road.

- **Unusual accomplishments**

  Under adverse conditions, including but not limited to, adverse weather, soil or site conditions, or other occurrences over which there was no control

- **The site was visually impacting:** Crews were surrounded by the devastation of the landslide. The view of the side scarp and mounds of dirt and debris were surreal. Work proceeded carefully and respectfully with the community watching. Local equipment operators and spotters worked alongside archeologists to look for human remains and personal belongings. Even small items had personal significance.

  People were deeply affected by this disaster and signs of this showed as work was conducted. Workers were asked to be kind to each other and take time to smile, talk, and check-in with each other for support. Friendships formed. On the SR 530 Incident Debris Removal Project, Snohomish County Critical Incident Stress Management teams supported on-site workers. They were on-site and available to those who wanted to talk.

  All projects were requested to sort native and man-made material in a respectful and careful manner. Spotters and archeologists observed all mechanical excavation, screening and grading activities. Previous archaeological investigations and tribal consultation determined that the slide area could contain cultural resources. Archaeologists were on site during construction to conduct archaeological monitoring during all ground-disturbing activities with the potential to penetrate the buried historic surface or the native pre-slide surface.

- **The river was blocked and flooded upstream properties and rescue areas:** Slide debris immediately blocked the North Fork of the Stillaguamish River and caused upstream flooding. Snohomish County Public Works collaborated with Native American tribes to discuss how best to reopen the North Fork Stillaguamish River and allow search and rescue teams to continue looking for victims. Because only a small channel had formed to convey the river through the debris dam, more than 15 feet of backwater rapidly impounded on the upstream side. The impoundment area upstream of the slide was approximately 343 acres.
- Snohomish County contracted with BCI Contracting of Portland Oregon to bring in amphibious excavators to reestablish a river channel to relieve flooding upstream and increase the viability of another area for search and recovery. BCI’s machines are 100 percent amphibious and had the capability to traverse across the River. They used Caterpillar Class 200 and 330DL amphibious excavators to move 44,000 cubic yards of material which created a 900 linear foot pilot river channel through the debris to drain the backwater and a large portion of the eastern debris field. Excavation progressed quickly and within days dropped the backwater by several feet, greatly aiding the search, rescue and recovery efforts. BCI also assisted with dewatering for search and recovery activities. Work began on April 8 and was completed on April 30, 2014 with a total contract amount of $480,000.

- At the same time, Snohomish County’s Surface Water Management team worked with the Army Corps of Engineers to design a berm to isolate a search area and provide more safety and stability for the search and recovery teams. The Corps’ imported 5,800 cubic yards of quarry spalls and built a 2,900 foot-long berm.

- Weather extremes: The landslide occurred during March when the weather was extremely wet and temperatures averaged in the 30’s at night and mid 50’s during the days with rain on most days. There were extreme challenges working in an area that had a high density of personnel and heavy construction equipment, unstable mud, and the potential for future landslides. The terrain was difficult to move through and it was exhausting in many ways. During the summer months, the weather was in the upper 70’s to low 90’s with limited shade; working conditions were extremely hot and workers had to stay hydrated

- Monitoring and addressing dynamic hydrologic conditions: WSDOT’s Hydraulic Office and Snohomish County collaborated with the U.S. Geological Survey (USGS), NOAA Northwest River Forecast Center, Washington State Department of Natural Resources (DNR), U.S. Army Corps of Engineers, and FEMA for ongoing river monitoring during and after the recovery operations. WSDOT and FEMA developed real-time hydraulic models which forecasted flow data to determine potential water surface elevations throughout the slide area.

The interagency teams relied upon hydraulic models to understand potential risks to recovery efforts and infrastructure, as well as to assess forecasted hydrologic events throughout the basin. Post-slide aerial photography and LiDAR were compared with historical LiDAR data to estimate the depth of the debris. However, the impounded water obscured estimates of water depth/volume and debris depths upstream of the debris dam. To supplement the LiDAR data in the inundated areas, Snohomish County contracted with a David Evans and Associates to collect bathymetric data that enabled development of a complete digital terrain model (DTM) of the affected area and a baseline hydraulic model of the site. This complete model provided accurate information to all teams involved, improving planning, safety and efficiency.

When WSDOT developed the Request for Proposal (RFP) for the SR 530 Emergency Roadway Reconstruction project, they knew that modeled water surface elevations using current (May 2014) topography and bathymetry were much higher than what they would be when the river adjusted to its equilibrium state. A sensitivity analysis was conducted using geomorphic factors from a historic slide (Rowan slide) which occurred just downstream. The sensitivity analysis showed that as the slide reached its equilibrium state, water surface elevations would continue to drop.

At the time the RFP was developed, the elevation for the eastern portion of the roadway was set at approximately two feet above the two-year water surface elevation and thus would be inundated during a 100-year event. This elevation was chosen to balance impacts to wetlands, private driveways, and minimize potential unnecessary costs.

If the highway would have been designed to the 100-year water surface elevation at the time of RFP, it would have been approximately four feet higher in the eastern section. As of January 2015, the river had continued to widen as anticipated. The modeled 100-year water surface elevation east of the knoll was approximately 293.8 feet; more than four feet lower than what was modeled during the development of the RFP. This planning, knowledge of the river system and collaboration with several agencies saved the taxpayers significant costs while also allowing a faster construction period to restore SR 530 for the traveling public.

In addition to the new river gages installed shortly after the event, Snohomish County partnered with the USGS to install three additional new gages to monitor sediment transport and river water levels in between the slide and Whitman Bridge.
Additional considerations

Such as innovations in technology and/or management applications during the project

Assessing and monitoring the slide area

- Snohomish County’s geotechnical team performed a helicopter flyover to assess conditions on March 23, the day after the slide. On March 24, Snohomish County geologists observed the slide from the top of the headscarp and the west flank to evaluate risks to personnel in the search, rescue and recovery zone. Snohomish County surveyors also surveyed locations behind the head scarp and placed 16 targets on the head scarp and flanks of the landslide to monitor for new movement. These monitoring activities continued until active recovery and debris removal activities were completed.

- WSDOT mobilized instrumentation specialists to install three extensometer arrays behind the head scarp to monitor for potential failure extending further into the Whitman bench. The devices include fixed stakes attached to sensors by long cables strung from the edge of the head scarp up slope away from the slide. Any ground movement of the remaining hillside would pull the cable and the instruments would measure that pull. The extensometers were attached to data loggers, which connected to a solar-powered telemetry station so data could be monitored remotely. WSDOT also performed terrestrial laser scans from the flanks of the landslide to measure slide movement.

- The USGS provided consultation to establish a landslide monitoring and notification protocol. USGS deployed three “spiders,” equipped with GPS units and geophones to measure surficial movement and detect seismic signals related to deep-seated movement. This data was transmitted in real time giving teams working on the ground early warning if anything started to move. The spider is a custom designed unit made by USGS. They deployed one by truck on the head scarp and two others by helicopter, one on the west margin of the slide and one within the landslide.

Texas A&M Center for Robot-Assisted Search and Rescue

Snohomish County Public Works collaborated with Dr. Robin R. Murphy, PhD who leads the Center for Robot-Assisted Search and Rescue (CRASAR) at Texas A&M University. Murphy and her team flew both a Precision Hawk and an Air Robot drone over the slide area and river shortly after the event and then a few months later. With just a 10 minute flight, these cutting edge drones obtained precision survey data. Each of the flights took over 300 images which were then reconstructed into high resolution 3D images. This data can be used to document slide area and river channel migration.

Three USGS-built “spiders” monitored both deep-seated and surface land movement. (photo by U.S. Department of Interior, U.S. Geological Survey)

The Texas A&M University CRASAR Team used drones to collect survey data for Snohomish County. (photo by Snohomish County)
Conclusions

This was an emotionally charged project in a grieving, tight-knit community. There were many needs requiring the dedication and cooperation of more than 900 individuals. WSDOT and Snohomish County brought their considerable resources to assist. The success of all the resources was even greater because of their collaboration.

Project achievements

- Cumulatively, the six projects came in $7.5 million under budget and finished 22 days early.
- The SR 530 Incident Debris Removal Project recovered 1,001 personal items and construction crews worked under the direction of the Snohomish County Sheriff’s office during the recovery of the last victim.
- The project replaced six culverts with fish passable culverts which improved fish habitat.
- The worksites maintained strict safety practices that resulted in no OSHA recordable events and only one lost-time incident due to heat stress.
- The new mile-long section of SR 530 has been restored to two lanes and was elevated to minimize the chance of flooding.
- The community was supportive of our work to stabilize the area.
- WSDOT and Snohomish County applied for and met eligibility requirements for FEMA and FHWA funding. This funding enabled completion of these projects.

President Obama flew over the landslide area. The President and Snohomish County Executive John Lovick met with community members at the Oso Fire Department. (photo by Joshua Trujillo, SeattlePI.com)

The mantra, “Oso Strong,” characterizes the spirit of this small community. They did not stop searching until July 22, when the last of the 43 victims was recovered. (photo by Snohomish County)