November 29, 2017

Maya Buhler
Thurston County Resource Stewardship Department
2000 Lakeridge Dr. SW
Olympia, WA 98501-6045

RE: Supply and Demand of Jetty Quality Rock

Dear Ms. Buhler:

We are writing to provide supply and demand information for Weyerhaeuser jetty quality rock that is produced at the Columbia Quarry and that also exists in the area adjacent to the Columbia Quarry (the “Mineral Overlay Addition”). This letter will explain the unique characteristics of the Weyerhaeuser jetty rock, generally describe the current supply of the jetty rock, and outline the current and future demand for this resource.

A. Resource Characteristics

The Weyerhaeuser jetty rock site (the Columbia Quarry and Mineral Overlay Addition) has geologic characteristics that, in combination, make this site unique in the region. These characteristics include the rock type itself—gabbro—which is a high-density rock with large interlocking crystals that can withstand weathering and severe physical conditions, including erosion by ocean waves. In addition, millions of years of erosion have exposed the deposit at the site for development. The site is readily accessible and the transportation network to transport the resource to market is in place. And, most importantly, the rock at the site has an unusually wide joint pattern that allows it to be broken into large stones suitable for jetty applications.

This last characteristic is what makes this particular resource unique and important. Volcanic rock that forms from surface flows has close-spaced cooling fractures, but

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1 The Mineral Overlay Addition is depicted on the map designated as Attachment A.
the Weyerhaeuser jetty rock cooled slowly, deep within the earth, which allowed the crystals to grow large and nearly eliminated the existence of cooling fractures. This permits the rock to be quarried in the very large sizes needed to produce the individual stones of up to 35 tons or more that are essential for jetty construction and maintenance.

B. Supply

For over 100 years, the Weyerhaeuser jetty rock site has been a prime source of jetty rock for the region.2 By the early 1900s, the site was producing 1,600 tons of jetty rock daily. Rock from the site was used to construct essential infrastructure projects, including the Westport and Columbia River jetties.3 The Columbia River jetties themselves are nearly 10 miles long combined and required 9 million tons of rock for the initial construction. Repair work on the jetties has required more jetty rock since then.

The Weyerhaeuser jetty rock site has also been quarried on an as-needed basis to meet demand for local and regional infrastructure projects requiring large, hard rock. Over the last 20 years, the Columbia Quarry has supplied hundreds of thousands of tons of rock to Thurston County, Pierce County, the Washington Department of Transportation, the Port of Kingston and Mount Rainier National Park.4

The Columbia Quarry currently operates in a 40-acre parcel, but expansion will be required to meet future demand. Expansion into the Mineral Overlay Addition will allow Weyerhaeuser to continue to supply this important resource.5

C. Demand

Jetty quality rock is a strategic regional resource essential to the economy of the State of Washington and particularly to jetty-dependent communities such as Illwaco in Pacific County and Westport in Grays Harbor County. For example, an estimated

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2 Over the last one hundred-plus years, the area has been referred to as the Hercules Quarry No. 6, the Kaiser Quarry, the Vail Quarry, and the Columbia Quarry.

3 Jetty construction has been an important element in providing safe ship and barge passage and providing sustained, uninterrupted commerce since the late 1800s. Jetty structures allow dredged, deep-water channels to remain open, lessen wave damage to upstream shorelines, and provide calmer waters for shipping.

4 See Attachment B, which is a spreadsheet of Columbia Quarry’s major sales over the last 20 years.

$16 billion in annual regional commerce passes through the mouth of the Columbia River alone. The system of jetties at the mouth of the Columbia makes this possible by protecting the channels from waves and sedimentation. The jetties allow vessels to access the Ports of Portland, Longview and Kalama, among others.

These jetties are in a state of disrepair. In 2010, the Army Corp of Engineers ("COE") announced a long term plan to repair the jetties. COE is in the process of rebuilding the jetties during three twenty-year phases that overlap in time. During the first phase alone, an estimated 1.5 million tons of jetty rock will be required to repair and maintain the jetty system at the mouth of the Columbia River. The Weyerhaeuser jetty rock site contains one of the largest (if not the largest) source of suitable jetty rock in the region and has been the historic source of rock for those jetties.

In addition, a host of "smaller" projects that require similar rock are anticipated, such as the entrance stabilization project at Mount Rainier National Park. Finally, Columbia Quarry has consistently provided a steady supply of rock to local governments for planned and emergency projects.

Weyerhaeuser looks forward to continuing to work with Thurston County on this issue and is happy to provide any information that will assist the County. Please call with any questions.

Sincerely,

William T. Lynn

cc: Grant Newport

6 USACOE, Final Environmental Assessment: Rehabilitation of the Jetty System at the Mouth of the Columbia River, at 45 (May 2011). The Final Environmental Assessment is attached as Attachment E.

7 See Attachment B above.
Attachment A
Attachment B
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**TOTALS**

| 39,351 | 99,963 | 5,305 | 80,451 | 5,600 | 158,000 | 7,385 | 20,400 | 48,458 | 23,342 | 5,542 | 12,671 | 40,211 | 53,282 | 2,949 | 475 | 19,305 | 5,008 | 8,292 | 29,942 |

**TOTAL TONS ALL SIZES**

| 665,281 |
Attachment C
Report on the Geology and Potential Sources of Jetty Rock
in the Miller Hill, Bald Mt. and Columbia Quarry Areas
Thurston County, Washington

March, 2005

By Gary R. Heinemeyer

Consultant
Figure 1: Vail and relation to the Miller Hill – Columbia Quarry Area
Intrusive bodies of gabbro porphyry are chiefly found in the northeastern part of the mapped area. These rocks occur as sills or sill-like bodies and are more coarse-grained than the porphyritic basalt. The gabbro porphyry bodies have a maximum thickness of about 300 feet and they intrude rocks of the McIntosh, Northern, and Skookumchuck formations. Gabbro porphyry intrusives can best be studied and sampled at the Columbia quarry and along the gorge of the Skookumchuck River in the SW¼ sec. 11, T. 15 N., R. 1 E. (fig. 21). A gabbro porphyry mafically similar to that exposed in the Columbia quarry was found at a depth of about 4,200 feet in the Union Oil Co. Bannock test hole 1, in the NW¼ sec. 29, T. 15 N., R. 9 E.

In fresh exposures the gabbro porphyry is massively jointed, medium gray, medium grained, and has granular and porphyritic textures. Phenocrysts of feldspar and augite are visible without the aid of a lens. In several outcrops vesicles of aplitic cut the rock. The rock commonly weathers to spherulitic masses and the ferromagnesian minerals break down to reddish-brown masses set in a groundmass of light-gray altered feldspar.

Studies of thin sections indicate that the rock is holocrystalline with porphyritic and less commonly diabasic and gabbroic textures (fig. 23). Plagioclase An50 to An8 (labradorite) occurs as phenocrysts and in the groundmass and forms about 60 percent of the rock. Augite occurs as phenocrysts and granules in the groundmass and makes up from 10 to 25 percent of the rock; it is generally altered to chlorite minerals and biotite. Other constituents present in minor amounts are hypersthene, magnesite, ilmenite, and apatite. Late hydrothermal and perhaps deuteric alteration has produced abundant secondary minerals; those identified are biotite, chlorite, zeolite, saurite, kaolinite, and calcite.

The rock sections studied from the upper part of the sill at the Columbia quarry contain an unusually high concentration of feldspar, ranging from 60 to 80 percent. This high feldspar content may be due to magmatic differentiation in the sill, as the samples were taken from the upper 60 feet of the sill, which has a total thickness of about 600 feet.

A spectrographic analysis of the gabbro porphyry at the Columbia quarry was made by the State of Washington, Division of Mines and Geology. This analysis is given below and is compared with a chemical analysis of granophytic gabbro from the Coast Ranges of Oregon at Mount Hobe.

**Spectrographic analysis of gabbro porphyry from the Columbia quarry, Washington**

(Grant Valentine, analyst, Washington Division of Mines and Geology)

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**Chemical analysis of granophytic gabbro from Mount Hobe, Orge.**

(Unpublished records of U. S. Geological Survey)

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Rock Types

Introduction

Mapping efforts were focused on identifying the extent, geometry and contact locations of the gabbro. In addition, the amount of soil or volcanic overburden was estimated, an attempt was made to quantify the quality of the gabbro for use as jetty rock and locations for potential quarry sites were noted. Specific volcanic units of the Northcra1t Formation or their extent were not mapped. However, information regarding the volcanic rocks and their character around the contacts with the gabbro are noted on the surface geology map and in tabular information for the air-track holes (Plate 1).

Gabbro

The Miller Hill or Columbia Quarry gabbro forms an extensive sill intruding Northcra1t volcanics of Eocene Age; in Secs. 3, 10, 11, 14 and 15; T15N; R01E (Plate 1). Outcrops of the sill dip to the east-southeast, form an arcuate pattern concave to the east and extend for over 9000 feet along the southern and western flanks of Miller Hill. The sill is cut by the Skookumchuck River (Skookumchuck Reservoir) and prominent cliffs of gabbro over 460 feet high mark the north and south edges of the river canyon in the upper-east portion of the reservoir (Fig. 2). Much of the mapping delineating the presence of the gabbro is based on float mapping and associated soil development in areas of gabbro bedrock. Soils developed from gabbro have a regolithic appearance and consistency, and have a distinctive light brown to yellowish color. They also are often very clay rich. In contrast, soils developed on the andesitic volcanic rocks are grey to reddish in color.

Bald Mt. Area

Around the flanks of Bald Mt., the gabbro crops out at the highest elevations in the area. Snavely and later M. T. Hunting, 1979, mapped a large mass of gabbro at Bald Mt.; however, more detailed mapping revealed that the gabbro crops out only along the flanks of the hill which is covered by a veneer of volcanics with maximum thicknesses in excess of 100 feet on the summit of the hill. Subsequent air track drilling verified this interpretation. Weathered gabbro is present as float along the logging road (#2038)
crossing the west and south, upper flanks of Bald Mt. Along a logging road (#2038) to the northeast of the summit a few massive boulders of gabbro are present and to the east of Bald Mt. solid outcrops of gabbro are present along a logging road (#2037 and #2037R) approximately 240 feet below the Bald Mt. summit. All of these occurrences are likely near the upper contact of the gabbro sill.

Mapping by the USGS (P. D. Snavely, et. al., USGS Bulletin 1053) on the east side of Bald Mt., did not recognize gabbro sill rocks to the east of a major mapped fault (Plate 1). Based on both outcrop evidence and float mapping, a significant area of gabbro is present east of the fault and at a lower elevation. The lower elevation of the gabbro with respect to volcanic rocks drilled on the southeast, upper portion of Bald Mt. suggests there may be some down-drop to the east of the fault. However, the gabbro sill is also dipping to the east and there may be little displacement. The elevation differences between gabbro occurrences around the flanks of Bald Mt. seem to be the result of both the regional dip of the gabbro and potential down-drop of the sill to the southeast across one or more northeast trending normal faults. Evidence for this faulting is indirect, but suggested by clay zones in proximity to the potential fault traces, the abrupt change in rock types across the interpreted fault trace location and topographic depressions (gully development) which follow the suspected fault trends.

It had been hoped that the summit of Bald Mt. might provide a good location to initiate a quarry in the gabbro. However, the volcanic cover, indicated depth to the top of the sill and sill continuity seems to downgrade such a possibility. In addition, in outcrop the gabbro occurrences are weathered. Drill holes did encounter fresh, massive gabbro at shallow depths on the northeastern, upper flank of Bald Mt., indicating faulting may play a part in both the quality (fresh versus clay altered) of the gabbro encountered and the elevation at which the top of the sill was intersected.

**Miller Hill – West Slope**

The gabbro sill dips south and eastward from Bald Mt. beneath the main northwest trending ridge of Miller Hill. Up-dip outcrops and float from the sill are present along the entire western and lower southern flank of Miller Hill. Primary evidence for the presence of the sill along the flank of the hill is from rounded, low outcrops and float along the logging road (#2040) which traverses the slope. Additional indications are from mapping of the sparse float and soil profiles above and below the logging road. Follow-up air track drilling confirmed the general geometry of the gabbro sill on the south flank of Miller Hill. Based on topographic differences between interpreted tops and bottoms of the sill it is estimated that the sill may be as thick as 350 feet along the west flank of Miller Hill. Of particular note is a large outcrop of massive gabbro immediately southeast of the center of section.
10 (Figs. 3, 4). This is the largest outcrop of the gabbro other than the cliffs along the north and south shores of the Skookumchuck Reservoir and this occurrence offers a potential quarry site.

The competence of the gabbro for potential quarry rock is difficult to ascertain from the few shallow air track holes on the western slopes of Miller Hill. Holes interpreted to have been drilled both in the footwall (bottom) and hanging wall (top) of the sill have encountered zones of clay altered gabbro. This could have resulted from some degree of contact alteration developed during emplacement of the sill or more likely is due to subsurface water flow (and breakdown of ferromagnesian minerals in the sill) controlled by the top and bottom contacts of the sill with host volcanic rocks (Fig. 5). It is suspected that some areas which were drilled contain northeast-southwest trending faults which have sheared both the volcanic rocks and the gabbro sill. No strong evidence of such faults is present; however, the strong clay alteration seen in some areas adjacent to unaltered rocks a short distance laterally and the consistent orientation of minor drainages in a northeasterly direction seem to suggest such faults. Sparse joint sets in the gabbro (Figs. 3 and 4) parallel this trend as well.

**Miller Hill – South Slope**

Unlike the USGS interpretation (P. D. Snavely, et al., USGS Bulletin 1053), recent mapping did not confirm the presence of major right lateral strike-slip offset and "faulting-out" of the gabbro sill against a north-northwest trending fault on the southern flank of Miller Hill. Instead, the sill was mapped as a continuous mass from the top flanks of Bald Mt., along the entire west flank of Miller Hill (Fig. 6, 7 and 11) and extending southeastward into the cliffs above the north side of Skookumchuck Reservoir (Fig. 8) and into the area of the Columbia Quarry (Plate 1).

As the gabbro sill dips to the south and east, outcrops are exposed at lower elevations on the slopes of south Miller Hill. In a small, north-northeast trending gully, which has been recently logged, in the SE1/4, SE1/4 of section 10 (Fig. 11), gabbro sill rocks crop out along the road. Evidence of gabbro is also present as float in areas along the hillsides above logging road #2045. Rounded cobbles and rocks up to boulder size form the float.
Southeast of the north-northeast trending gully, larger boulders are present and drilling intersected fresh gabbro within a few feet of the surface. To the northwest of the north-northeast trending gully, gabbro does not form outcrops, but typical brown to yellowish soils are present indicating that gabbro does form the bed rock. A north-northwest trending fault mapped by the USGS trends through this area (Fig. 11; Plate 1), which may account for the strong clay alteration on the east side of the fault diminishing the resistance to weathering of the gabbro. It is also possible subsidiary splays to this fault may also be present. Air track drill holes verify the general interpretation of gabbro geometry and continuity in this area.

**North Shore Skookumchuck Reservoir**

From Miller Hill, outcrops of the gabbro sill rake southeastward and cross the Skookumchuck valley. Dips on the upper sill contact (measured in Columbia Quarry) range from 3° to 11° degrees toward the southeast. The sill has an average strike of N45°-60°E. Along the north side of the reservoir considerable “roll” in the top of the sill is present (Fig. 7) indicating either variation in the original intruded thickness, post
emplacement folding, or minor structural offsets sub-parallel to the strike of the sill. The gabbro forms massive cliffs on both the north and south sides of Skookumchuck Reservoir. Cliffs on the north side of the reservoir are over 460 feet high and extend for over one-half mile in an east-west direction along the edge of the reservoir (Fig. 8). The lower contacts are obscured by talus from the sill itself and the upper contact is covered by varying amounts of soil and/or Northcraft volcanic rocks. Proximity to the upper sill contact can be estimated by the abundance and size of the boulders weathering from the hangingwall of the sill.

The area along the north edge of Skookumchuck Reservoir in the western extent of the boundary between Sections 11 and 14 affords the best location for the development of a significant quarry in the gabbro sill. The gabbro sill is thick and massive, no clay altered zones were noted, there is little overburden, most of the rock is above base grade for mining (permitting and pit floor of the current Columbia Quarry), access is good and the area is along a continuation of the current Columbia Quarry (Fig. 7 and 8). If exploration verification of the quality of the gabbro is desired, an old logging road, which can be reopened, is present along the top of the cliffs providing excellent access for drilling.

**Columbia Quarry**

The Columbia Quarry currently mines large size rock for jetty and rip-rap applications. The quarry has been intermittently in operation since the mid 1930's and was begun well after original quarry activities on the south side of the Skookumchuck River (pre-reservoir) were underway to supply rock for construction of the original Columbia River jetty work. According to previous investigations (Hunting, M. T., 1979) approximately 8 to 10 million tons have been mined from the Columbia Quarry since inception. The quarry mines from faces near the top (hanging wall) of the gabbro sill where plagioclase phenocrysts have been noted as being especially abundant. Crystal segregation due to magmatic settling is suspected as being the cause of the high concentration of less dense plagioclase in the upper portions of the sill (Snavely, et al, 1979)
1958). This high feldspar content may account for the dense, unfractured nature of the sill rocks.

Gabbro in the quarry is massive and jointing or other structure is minimal. Sparse jointing trending N65°W, 85°SW and N57°E, 90° are present in the upper pit bench (Fig. 9). Structure is so sparse that blasted rocks often break too large and need to be further fractured by impact hammer to fall under maximum transportable weights.

From the north edge of the current Columbia pit, overburden in the form of soils or the Northcraft volcanics, thickens rapidly. The stripping ratio required to expose fresh gabbro for mining, will increase rapidly to the north. Small landslides are expected to be a problem if mining progresses too far northward. Several small slides have already occurred. The upper contact of the sill forms a subsurface watercourse (small, natural springs are present) and in conjunction with the dip-slope projection into the pit area the top of the sill forms an ideal landslide slippage plane.

**Baumgard Creek**

Late in the evaluation of the Miller Hill area, a rounded outcrop of rock was noted on the east side of Baumgard Creek north and slightly east of the Columbia Quarry. Because of time limitations this outcrop was not examined. The appearance of the rocks in this outcrop along with the weathering pattern (rounded low outcrop), suggest this outcrop may consist of the gabbro sill (Fig. 10). The gabbro sill on the west and southwestern flanks of Miller Hill dips in the direction of Baumgard Creek. There may be a fault along Baumgard Creek which causes the east side to be up or the dip of the sill may shallow, causing the sill to crop out on the east slope of the creek. This outcrop should be examined as a possible source for quarry rock.

**Sedimentary Rocks?**

A very minor occurrence of sedimentary rocks was noted in a road cut along forest road #2040 immediately east of drill hole 19B. In this outcrop, siltstones and several thin coal beds are offset by a minor north-south fault with beds down on the east side. Some thermal contact alteration as a result of proximity to the underlying gabbro sill may be present. These sediments may be part of the Northcraft volcanics or related to the Skookumchuck Formation.
Structure

As discussed under descriptions of the gabbro sill rocks in specific areas, structure as either faulting or jointing is sparse. Northeast drainages may represent fault zones cutting the sill; however, little or no offset can be ascertained across these drainages. Both northeast-southwest and northwest-southeast, high angle joint sets were observed in more massive gabbro sill outcrops (Figs. 3 and 4) and in the Columbia Quarry. The jointing is closed and does not seem to significantly weaken the massive nature of the gabbro. Northwest trending joints in Columbia Quarry contribute to the cleave direction during blasting and many of the blasted rock pieces slab along this direction (Fig. 9).

The most important structural feature which affects the gabbro sill is a north-northwest trending structural zone in the SE1/4; SE1/4 of Section 10. In this area, the sill is exposed in sparse outcrops along logging roads with occasional cobbles and boulders on the slopes. The gabbro is clay altered and strongly weathered forming a brown to tan regolithic soil. An incised, north to northeast trending valley is developed in this area and the western extent of the massive cliffs along the north side of Skookumchuck are truncated (Fig. 11). It is likely the fault postulated and mapped by the USGS is more complicated than originally envisioned. There may be numerous horsetail splays and sub parallel faults which cut the area. Within this zone, it is unlikely the gabbro will be competent enough to form good quarry rock. To the northwest of the USGS fault, the gabbro is similar to the Columbia Quarry rock and is massive and unaltered.
Alteration and Mineralization

Hydrothermal alteration is absent in the Miller Hill, Bald Mt., Columbia Quarry areas. Clay alteration is associated with discrete fault zones and accelerated weathering of mafic minerals and feldspar in these areas. Clay alteration is also more prevalent along the upper contact of the sill because the contact is often a well developed groundwater course. Natural springs are common along exposures of the upper contact (Fig. 5).

From field observations, it is suspected intrusion of the sill has caused some contact alteration along the hanging wall contact with the Northcraft volcanics. Volcanic outcrops near drill hole 19B are quite dense, very dark in color and were difficult to drill. Similar volcanics were encountered in drill hole 20. The hangingwall volcanics in these locations may be hornfelsed and recrystallized.

Air Track Drilling Results

To obtain a better understanding of the gabbro sill distribution in the Miller Hill area, Weyerhaeuser Minerals commissioned a shallow, air track drilling program. McCallum Rock Drilling Inc. was contracted for the work and drilling took place over a three day period from February 28th to March 2nd, 2005.

The drill rig used was fully contained with compressor, drill and controls on a track mounted unit (Figs. 11, 12 and 13). The drill had a sizable compressor and was capable of drilling in excess of 100 feet given ideal conditions. The drill came with approximately 120 feet of drill steel. Drilling proceeded rapidly in areas of good soil development with solid rock at depth. However, if significant moisture was present, especially in conjunction with any clay development, drilling was limited. Numerous holes had to be terminated because of these limitations. If additional information is needed in the future regarding rock quality, sill thickness or overburden thickness, a larger rotary or core drill should be used.
Areas of Potential Open Pit Resource

Two and possibly three areas offer good potential for future quarry rock mining in the Miller Hill area. In order of importance the areas are 1) gabbro sill rock forming massive cliffs adjacent to the west edge of the Columbia Quarry; 2) massive outcrops of gabbro on the southwest flank of Miller Hill and gabbro intersected in drill holes 14, 15, 16, 17, 18, 18B and 19; and 3) possible areas around the flanks of Bald Mt.

The area with most immediate potential is the large area of massive gabbro sill rocks forming the “Skookumchuck Cliffs” (>460 feet high) which extend for at least 1300 feet to the west from the edge of the Columbia Quarry (west property line between Columbia Quarry and Weyerhaeuser land)(Fig. 8). The width of this exposure, judging from the presence of abundant, large boulders on the forest floor, is approximately 700 feet. Using a thickness of 200 feet (to provide setback from Skookumchuck Reservoir with a permit level of approximately 650 feet in elevation) and a tonnage factor (density) of 12 cubic feet/ton, this area contains approximately 19 million tones of rock reserves. Estimating twenty percent of such material would break as large size jetty stones would result in nearly four million tones of resource. This area is a natural extension of the Columbia Quarry which has proven rock quality and blasting and mining techniques have been established. The gabbro sill extending to the west should produce good quality rock as well. The transportation route is established, an excellent sort yard is present and no radical change in haulage elevation would be required.

The second area for potential quarry development is the area along forest road #2040 on the southwest flank of Miller Hill (Figs. 14 and 15). Low lying, massive exposures of the gabbro sill are present over a distance of approximately 800 feet and fresh gabbro was intersected in shallow drill holes spanning a distance along strike (along the road) in excess of 2400 feet. The gabbro is likely to be at least several hundred feet thick and displays no faulting and few joints. Gross tonnages available may be on the order of 20 million tones with a jetty rock yield (20 percent) of 4 million tones. A staging area for initial work could be developed in the area near drill hole 18. Access and haulage
would likely follow existing logging roads with modifications to shorten the haul and remove curves. A drop of 700 feet in elevation would be required to reach valley bottom haulage currently being used by the Columbia Quarry. Additional drilling would be required to outline this resource and provide information for an initial mining plan and permitting.

The third possibility for a quarry in the gabbro sill may be along the northeast summit and flank of Bald Mt. Drilling immediately north of the summit (drill holes 3, 10 and 10B), intersected fresh gabbro at shallow depths. There may be a sizable mass of gabbro in the area and tonnages could be significant, but additional drilling, with capabilities to handle water and clay in the overburden, will be required to determine the extent of the gabbro sill. If it is possible to mine large, unfractured blocks of the gabbro near the summit of Bald Mt. it may be feasible to transport such material to the southwest toward Bucoda, Centralia and the I-5 corridor. Transportation costs to major jetty markets would be shorter via downhill haul and significant savings may be realized.

Summary

At least two good areas are present in the Miller Hill area to establish new or continued jetty stone quarry rock production: The area on the western flank of Miller Mt., and the extension of the operating Columbia Quarry along the north shore of Skookumchuck Reservoir. Independent of economics, dictated primarily by haulage costs (beyond the scope of this report), both locations contain high quality resources. With concise and comprehensive drilling and associated rock testing either location could be readied for mine planning and permitting.

Submitted by: Gary R. Heinemeyer
Attachment D
IN THIS ISSUE

- The metallic, nonmetallic, and industrial mineral industry of Washington in 1998, p. 3
- The H. P. Scheel family—A history in stone, p. 10
- INDEX TO WASHINGTON GEOLOGY, 1997–1998, p. 23
The H. P. Scheel Family—A History in Stone

David A. Knoblach
Outcrop Geological Services
58 Hylebos Avenue, Milton, WA 98354
e-mail: daknoblach@aol.com

Credited with saying “The bounty of the Earth is there to reap—take advantage of it!”, H. P. Scheel was a prominent Washington businessman and promoter in the early 1900s. Scheel preferred to be called by his initials ‘H.P.’ and gained the nickname ‘Horse Power’ for his legendary ambition. H.P. and his family (Fig. 1) became well known as quarriers, stonemasons, and prospectors. Together, they contributed much to the building stone, monumental stone, and jetty rock industries in the Pacific Northwest. H.P.’s youngest son, Lorenz ‘Larry’ Scheel, 91, passed away March 10, 1999, marking the end of an era. This is the story of the Scheel family and the industries they influenced.

Born into a stonemasonry family, Hans Peter Scheel (1866–1940) immigrated in 1882 with his father Hans Hinrich Scheel (1834–1894) from Germany to Iowa. After moving to Portland, Ore., in 1887, H.P. met his future wife Franziska ‘Frances’ Louisa Christina Stein (1870–1956). They were married in Tacoma in 1889.

In 1890, H.P. was a partner in a Tacoma stonemasonry business called Simpson & Scheel. Later, during the 1893 economic panic, he worked as a stonemason in the Tenino area. H.P. walked there from Olympia (about 15 miles), staying the week for work and walking back home for the weekends.

Moving to Spokane in 1896, H.P. became a partner with Frank Swanson (1862–1930) in the Washington Monumental Works, and in 1901, incorporated the business as the Washington Monumental and Cut Stone Company. This company became a significant building and monument stone quarrier and fabricator for the Inland Empire. (It was sold by Swanson’s grandson Byron ‘Bud’ Swanson (b. 1916) to Tresko Monument Company, also of Spokane, in 1971.)

Employing up to 30 men in 1902, the partnership worked local granite, marble (dolomite), and basalt, and imported stone for monuments and structures. At the time, Spokane was losing notable pioneers, and large tombstones were in demand. Additionally, Spokane was a growing regional economic and railroad hub. Spokane was a major supplier to the mines in the nearby Coeur d’Alene, Idaho, and Colville mining districts. Many men died in these mines, creating an ongoing need for tombstones. The partnership also furnished stone for the Spokane mansion (1899) of mining mogul Patrick ‘Patsy’ Clark (1850–1915), Spokane buildings like the Carnegie Library (1905), and memorials for the Grand Army of the Republic (Union Army, Civil War) in Spokane (1906) and Pomeroy (1905) (Fig. 2).

Figure 1. The Scheel family at their Tacoma mansion on Prospect Hill. Back row: Fran, Walt, Karl, Larry, Heine, Dorothy (Doe). Front row: Louise, H.P., Margaret, Frances. Picture taken at the time of Fran Scheel’s wedding on June 28, 1916. The stone circle (left side) has ‘H. P. Scheel’ cut into it. Photo courtesy of Scott McArthur.

Figure 2. H. P. Scheel (right) and an unidentified stone carver using a compressed air hammer in Spokane to finish the statue of a Union soldier that crowned the Grand Army of the Republic memorial in Pomeroy (ca. 1895). The statue was later damaged and removed from its pedestal. Photo courtesy of Byron Swanson.
With business quickly growing, H.P. went from stonecutting to promoting sales for the company. Typically, he kept track of obituaries in the newspaper and, after an appropriate time, queried survivors about possible monument orders. He could quickly figure in his head all the mathematics required for orders and other business deals. H.P. traveled Washington, Oregon, Idaho, and Montana by horse and buggy, and later by car and rail to promote his products. He spent much time away from home.

In 1902, H.P. founded the Hercules Sandstone Company in Tenino with Ritzville banker Claus Clodius (1871–1977?) and quarryman William McArthur (1866–1940). McArthur was responsible for hiring many stonecutters and quarrymen from Scotland for the Hercules quarries. The Hercules company quickly became successful despite competition from the well-established Tenino Sandstone Company. The businesses were located on opposite ends of town, working similar outcrops of sandstone from the Eocene McIntosh Formation (Shrevel and others, 1958).

In 1906, the great San Francisco earthquake created a tremendous demand for materials to rebuild that city. By chance, San Francisco's Calvary Presbyterian Church was one of the limited number of buildings to survive the earthquake and fire that followed. It was made of Tenino sandstone from the Tenino Sandstone Company. Since the Hercules company also quarried Tenino sandstone, orders grew rapidly to meet demand. H.P. sold his Spokane business interests to focus on his new company. When he sent employees to San Francisco to oversee the new stonework, his sons Karl (1891–1961) and Walt (1892–1984) went along to apprentice in San Francisco stone shops. Both sons returned to Tenino to add their expertise to the family business.

The Hercules Sandstone Company grew quickly and eventually became one of the largest stone companies on the West Coast. It supplied dimension stone for many buildings in Seattle, Tacoma, Portland, Spokane, and San Francisco. (For a list of these buildings, see Knobloch, 1994.) In 1914, the Hercules company carved the stone that represented Washington State at the Washington Monument in Washington, D.C. (Fig. 3). It is now displayed in the monument stairwell.

The Hercules Sandstone Company operated six quarries in its heyday. Opened in 1903 on Lemon Hill southwest of Tenino, Hercules Quarry No. 1 primarily supplied building stone (Figs. 4, 5). The stone's soft mineral composition made it less expensive and quicker to cut and carve, allowing competitive pricing at a profit. Its workability is illustrated by the rate at which it can be cut by a modern, 9-foot circular diamond saw: Wilkerson sandstone is cut in 1-inch increments and Tenino sandstone in 2½-inch increments. Although it was described as 'butter' by competing quarriers, Tenino sandstone has confirmed its relative durability in century-old buildings.

At Seattle's 1909 Alaska–Yukon–Pacific Exposition, the Hercules company featured a promotional display of a suspended, freshly quarried and cut stone slab (measuring 8 feet 4 inches by 4 feet 6 inches by only 1 inch thick). The slab was from the No. 1 quarry. By the end of the Exposition, the slab had elastically bowed four inches due to gravity and plastic deformation without visible signs of cracking. Freshly quarried sedimentary rock is temporarily softer and more flexible than aged quarried stone, because its stored elastic potential energy is being released from compression within the outcrop (Winkler, 1994). The company was awarded a Silver Cup for its 'flexible sandstone'. Thereafter, a picture of this slab (Fig. 6) highlighted the event on the back of the company's stationary. In 1904, Hercules' competitor, the Tenino Sandstone
Company, also had received a Silver Metal for Tenino sandstone at the Universal Exposition in St. Louis, Mo.

By about 1910, sales of building stone started to wane because of competing building materials. Local concrete, brick, and terra cotta had improved in quality and could be produced more quickly and cheaply than stone. Architectural styles also had changed, favoring taller buildings using structural steel and the new materials (Knoebelch, 1993). A major competitor, the Chuckanut sandstone quarry in Bellingham, which quarried sandstone in the Eocene Chuckanut Formation, permanently closed in 1913 after 57 years of production.

In search of more opportunities, H.P. sought and won a major government contract for jetty rock at Grays Harbor (U.S. Army Corps of Engineers Seattle District Office, 1912–1927). He retained the No. 1 quarry for building stone production and acquired the Eureka quarry in 1911. Also in an outcrop of Tenino sandstone, the Eureka was renamed Hercules Quarry No. 2 (Fig. 7). Located just east of Tenino, the Eureka quarry previously produced stone for the Northern Pacific Railway warehouses in Tacoma and for other structures.

A famous event occurred at the No. 2 quarry on Feb. 17, 1912. It was called the 'Big Blast'. Two three-foot diameter tunnels called 'coyote holes', with a combined length of 1,400 feet, were cut into the base of the outcrop (Fig. 8). The tunnels were carefully backfilled with two train car loads of explosives (43,100 pounds of black powder and 1,200 pounds of 60 percent dynamite).

H.P. saw the blast as a wonderful opportunity for publicity. Tenino residents turned out, officials arrived from Washington and Oregon, and camera crews came from Hollywood to film the explosion, probably for newsreels at cinemas (Roberts, 1912). Tenino residents were asked to secure fragile possessions in their homes against the expected ground motion.

The 'Big Blast' was one of the largest single detonations in Washington history (Fig. 9)—and it was larger than expected (an estimated 500,000 ton rockfall). It buried the quarry's rail spur with boulders (Fig. 10), damaged nearby quarry buildings with flying rock (Fig. 11), and pelted onlookers with rock fragments despite their 'safe' distant viewing positions. The cost of the event, including repairing the damage, totaled $20,000. However there was an additional cost—the huge concussion pulverized as much as 40 percent of the rockfall, making much of the rock either too small or too incompetent due to micro-fracturing for its intended purpose at the jetty.

By 1913, the Hercules company had over 100 employees. Scheel and McArthur acquired other quarries, including one of the trade-named Wilkeson sandstone quarries located near Wilkeson (enubarkosic sandstone of the Eocene Carbonado Formation); another quarry, possibly in the Tenino region (its location and stone type has been forgotten); and the trade-named Mother of Pearl granite quarry near Ymir, B.C. (a pulaskite in a syenite plug of the middle Eocene Coryell intrusion) (British Columbia Ministry of Energy and Mines).

Figure 5. A stone carver shows off a building pediment at the Hercules Quarry No. 1 (ca. 1907). William McArthur is second from left. Photo courtesy of South Thurston Historical Society, Tenino, Wash.

Figure 6. The cut slab of 'flexible' Tenino sandstone from the No. 1 quarry on its way to Seattle's 1909 Alaska–Yukon–Pacific Exhibition. A stone chisel was used here to notch the sides of the slab so it could be lifted without the rock slipping. This promotional photo was later printed on the back of Hercules Sandstone Company stationary. Left to right: H. P. Scheel, William McArthur, J. B. Jonas, Johnny Jonas, Andy McArthur, I. D. Jonas. Photo courtesy of Scott McArthur.

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1 Abundant biotite in this stone resulted in excessive wear, particularly along exposed edges and in fine detailing on monuments (such as the engraved plaques of the War Memorial, Nelson, B.C., ca. 1919). However, polished cut surfaces have weathered well in the base courses and entryways of the Hartford Building (1929), Seattle; the Bank of California (1929), Tacoma; and the Security Building (1927), Olympia.
1999). These quarries were respectively named Hercules Quarry No. 3, 4, and 5.

Additionally, H.P. acquired the Giles quarry, later known as the Silver Lake granite quarry, at Medical Lake (granodiorite possibly related to the Eocene(?) intrusives of the Silver Point quartz monzonite) (Joseph, 1990); the Dorset granite quarry, later renamed the Little Spokane granite quarry, north of Spokane (biotite granite similar to the Cretaceous Mount Spokane Granite) (Joseph, 1990); and a quarry in the trade-named Index granite near Index (granodiorite of the Oligocene Index batholith—some evidence has indicated that the No. 4 quarry was at Index). H.P. also dealt in many other types of stone from different quarries.

While fishing on the Skookumchuck River, H.P.’s son Walt discovered a granite outcrop about 9 miles southeast of Tenino (gabbro porphyritic dikes and sills, late Oligocene to possibly Miocene) (Schasse, 1978). Granite is important for its durability, and the relative scarcity of this competent rock in southwest Washington increased its potential value. It also surpassed the comparatively marginal quality and size of rock offered by most area competitors. To gain approval for use of this rock at Grays Harbor jetty, Walt guided officials from the bank and Army Corps of Engineers to the remote site, carrying them on his back over the meanders of the Skookumchuck River so they could keep dry.

After winning another jetty contract for this rock, H.P. began an ambitious push to quickly build a rail spur through the wilderness. The site was named Hercules Quarry No. 6 (Fig. 12 and cover). As the summer jetty work season approached, the Hercules Sandstone Company hired over 300 additional men to open the quarry. Four to five camps were built for the laborers. Working around the clock, they completed the 12-mile rail spur to the quarry in just 6 weeks. The quarry shipped its first rock on June 28, 1916, after more than $200,000 was spent on spur development. Soon, shipments to the jetty rose to 1,600 tons of rock daily (U.S. Army Corps of Engineers Seattle District Office, 1912–1927).

H.P. subsequently became a friend of railroad baron Samuel Hill (1857–1931), who profited from the heavy rail shipments by the Hercules company. Hill gave H.P. a pass for free travel anywhere on his railroad. H.P. used the pass to travel widely to promote his company.

Sheel became involved with other ventures. Needing water for his businesses and employees, Sheel helped to improve Tenino’s city water supply. He also was involved in the unsuccessful wildcat drilling for oil in the Tenino area around 1914–1915 (Fig. 13). Sheel was a founder of the Paraffin Oil Company (Tenino) and the Western Coke and Coal Company (Seattle), and was an investor in the Washington–Oregon Oil Company (Tenino), Spokane Marble Company (Spokane), American Onyx and Marble Company (Spokane), Royal Climar Group
Mining Company (Spokane) and the State Bank of Tenino (Tenino). H.P. also owned the Oasis Hotel in Tenino (renaming it the Frances Hotel, after his wife).

Additionally, H.P. was very interested in inventions, at least as a promoter and investor. However, his partner, William McArthur, was the one with the inventing skills. Some inventions were successful—such as a method for creating illuminating gas out of coal (Fig. 14). (McArthur had interests in local subbituminous coal mines near Tono.) McArthur had the first gas light in Tenino through this method. The invention sold for $50,000 (equivalent to $850,000 in 1999). However, other inventions were questionable. One was an "Inhalatorium" that operated in Tenino around 1915. It was a telephone-booth-sized spa where the patient sat and breathed piped-in coal gas as an aid to curing ills such as emphysema.

Under H.P.'s leadership and with McArthur's inventing skills, the Hercules company developed a process to protect Tenino sandstone against weathering discoloration. Deposited on an anoxic delta front, Tenino sandstone comes in two colors: Tenino 'blue' (a dark gray) and its oxidized counterpart, Tenino 'buff' (brown). Although color variations increased its aesthetic appeal, weathering sometimes ruined the architectural color schemes specifically designed for some buildings. To stop the oxidation, the exterior surfaces were painted with phosphoric acid. The result was a light-gray color that remained relatively stable over time. Since only the exterior surfaces were etched, the interior structural characteristics of the stone remained intact. Perhaps the first building to receive this treatment was the Federal Building (1915) at The Dalles, Ore. Conversely, a strong base will turn untreated Tenino 'blue' sandstone into 'buff'.

Work on the jetty proved to be very difficult for all parties. The Hercules company struggled to meet shipment quotas. Between 1911 and 1916, Pacific Ocean storms periodically

A total of 737 weathering depth measurements were taken every six inches along the blocks quarried and along associated quarried cuts near the high wall at the site. Measurements were rounded to the nearest eighth of an inch. The blocks were separated by about six inches by the channeled-cut of the Ditch Witch wheel into the stone. Measurements, however, were not taken from the most recently worked (ca. 1940) areas of the quarry. (continued on facing page)
washed away thousands of feet of jetty and the accompanying rail trestle used to place rock (Fig. 15). Floods in 1916 washed out a bridge on the rail line to the No. 6 quarry. Accidents, the lack of rail cars to ship rock, and inadequate mooring space to transfer rock onto barges in Aberdeen caused additional delays. Problems also hampered rock production at the quarries—including poor rock quality from over-blasting at Quarry No. 2 and blasting limitations within the narrow gorge at Quarry No. 6. During a period of tight funding for the jetty, H.P. continued rock deliveries to keep his employees working. However in 1912, he temporarily shut down operations until the government paid over $120,000 owed to Hercules (U.S. Army Corps of Engineers Seattle District Office, 1912–1927).

Unfortunately, U.S. involvement in World War I suddenly halted the contracted rock work on Grays Harbor jetty. In production for only four months, the idle No. 6 quarry could not repay the tremendous expense for its development, and the war economy tied up funds desperately needed for the ailing business. With about $112,000 in liabilities, the Hercules Sandstone Company failed in 1917 (U.S. Army Corps of Engineers Seattle District Office, 1912–1927).

The Scheel family lost everything except an undeveloped piece of land a mile north of Tenino. A financial statement made for H.P. a year before the failure listed assets after liabilities of over $700,000 ($11.4 million in 1999 dollars, based on the Consumer Price Index). All assets of the company were sold. The Scheel’s had to leave their $20,000 Prospect Hill mansion in Tacoma and lay off their house staff to pay their remaining debts. Their Cadillac car—the first on Prospect Hill—also was lost. Their youngest children were transferred from schools in Tacoma back to Tenino.

The Scheel’s temporarily returned to the Frances Hotel (under new ownership) until they had developed their remaining land for farming and built their new home. As Scheel and his older sons worked away from the farm, much of the credit for holding the family together during this time was due to H.P.’s wife and elder daughters Fran (1896–1998) and Doe (1902–1992). The youngest children, Larry (1908–1999), Louise (1912–1999), and Margaret (b. 1913) remained on the farm.

Until 1938, Scheel and McArthur attempted unsuccessfully to recover money from the U.S. Government. They felt that a broken government contract for jetty work ruined the Hercules Sandstone Company. Despite their issues about the contract, there is no doubt that Scheel and McArthur were victims of circumstance because of the war. Prominent businessmen from the Puget Sound area provided letters of support to the government on behalf of Scheel, vouching for his honesty and integrity as a businessman. However, the appeals were refused with-

Statistical analysis showed weathering depths compiled into a bimodal histogram that ranged from 3¾ inches to 24¾ inches. The resulting 85 percent confidence interval for the mean was (11.6606, 12.5475). The median was 12½ inches, and the standard deviation was 4.0582 inches. The bimodal histogram highlights the major influences on weathering at the site. The most protected portions of the site contained the least amount of weathering. These areas occurred along the base of the quarry highway in locations previously covered by a mushroom farm building. Constructed after quarrying had ceased, the structure was later torn down after operating for an unknown number of years.

Generally greater weathering depths were observed outside the footprint of the mushroom structure. Additionally, pronounced weathering depths corresponded to another factor: fractures or joints became conduits for water to oxidize the stone at depth. This observation indicated that localized variability in porosity also may influence percolation and weathering depth, but not to as great an extent as fractures and joints.

The horizontal quarried surface was askew to the bedding, which dips to the southwest at about 20 degrees. The surface also had areas of slightly higher and lower elevations that allowed localized water pooling or watershed areas that contained minor, but varying amounts of surface sediment and vegetation. These factors may have influenced water percolation and weathering rates. The results from the data should be considered estimates because modern quarrying was not oriented with the direction of previous quarrying. This created an approximate 60-year time period for weathering exposure at the site.
out compensation upon the government interpretation of the contract (U.S. Army Corps of Engineers Seattle District Office, 1912–1927).

The Scheel family slowly recovered after great hardship, but never regained the prosperity of the Hercules days. The Hercules office building was disassembled block by block from its location at the No. 1 quarry (Fig. 16) and rebuilt in downtown Tenino. It was moved by H.P. and his son Walt. It is currently used as the Tenino City Hall. Walt said it was the only structure that he built twice. H.P. searched in vain for another outcrop of stone on his remaining land and later opened a gravel pit near Tenino.

H.P.'s son Karl modified his stonedrafting skills and became a naval architect in Seattle, San Diego, and Los Angeles. He converted surplus war submarine chasers into luxury yachts. Karl's 110-foot yacht, *Tinino* (originally *USNSC 294*, ca. 1917), was used as a charter along the West Coast. It once hosted a Hollywood movie star (possibly John Barrymore) and his friends. Larry Scheel, a crew member on the yacht in the early 1920s, was shocked when the female guests blantly smoked cigarettes.

Walt Scheel had apprenticed at the McGilvray Stone Company in San Francisco and later was the foreman and a stonecutter for the Hercules Sandstone Company until its closure 1917. Turning to carpentry, he helped build the lumber town of Vail in Thurston County with his brother Larry, constructed housing for the building of Cushman Dam, and also built homes around Tenino.

Heinie or Hans Scheel (1900–1976) became a noted Sedro-Woolley prospector, dealing in many different types of stone. Before much of the North Cascades were designated park and wilderness areas, Heinie parachuted supplies into the back country and later sought the supplies on foot before he prospected and packed out samples. In Whatcom, Skagit, Island, Chelan, and Grant Counties and probably some others, Heinie opened soapstone, silica, travertine, andesite, basalt, gneiss, slate, jade, chert, and beach stone quarries. He was the first to quarry the Twin Sisters Dunite, the largest dunite deposit in the Western Hemisphere, near Twin Sisters Mountain. The deposit covers over 36 square miles (Valentine and Hunting, 1960; Moen, 1967; Corlis Smith, pers. correspondence, 1999). The dunite is an uncommon massive olivine-rich rock used for refractory purposes.

Heinie was an inventor too. He invented the 'Scheel Process' for converting sewage into fertilizer and sold it to a firm in Japan. He also invented a method for creating durable pulpstones (for grinding timber into pulp) using silica gravel spun to the perimeter of a quickly rotating mold before it was cemented with concrete. Using this method in 1928, he incorporated the H. P. Scheel Eversharp Pulp-Burz Company to market the pulpstones (Fig. 17). His father’s photograph was featured on the stock certificate. Later Heinie owned the Scheel Stone Company (Seattle) and Western Mineral Company (Seattle). Heinie’s quarries also provided silica for glass making in Seat-

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**Figure 14.** William McArthur (left) and his brother Robert (right) in a Tenino laboratory (ca. 1912) demonstrating William’s invention to convert coal in a furnace into illuminating gas. Note that the furnace is built of cut sandstone. The patent sold for $50,000. They used some of the money for a trip home to Scotland and invested the balance in Quarry No. 6. Photo courtesy of Doris Sterling.

**Figure 15.** Construction of the Grays Harbor north jetty March 5, 1937. The rock was carried out on the jetty trestle by rail car and dropped over the side. A similar method was used for jetty construction during the 1910s. The jetty was finished with rock from the Columbia quarry, located at the top of the Slocumchuck River valley in the same intrusion as the No. 6 quarry, and rock from the Fisher quarry in the Boring Lava (late Pliocene to early Pleistocene basalt-andesite) near Camas, Wash. (Phillips, 1987). Rock from the Fisher quarry was used on jetty construction in Eureka, Calif., to Alaska. Photo courtesy of the National Archives, Seattle.

16 Washington Geology, vol. 27, no. 1, July 1999
tle, tale for the paper mill in Longview, and various tale blocks and products for liners in furnaces and stove tops.

Larry Scheel worked as a stonemason for Andrew Wilson (1883–1970) at the old No. 1 quarry (renamed Western quarry) in the 1920s and 1930s. Around 1940, Larry worked for Robert ‘Bert’ Walker (1892–1971) on the trade-named Walker-Wilkeson sandstone at the Walker Cut Stone Company in Tacoma. After being wounded while fighting for the U.S. Navy in World War II, he moved to Union on Hood Canal where he worked for many years for the Mason County Public Utilities District.

Larry cut stone for the old Thurston County Courthouse (1930), Olympia; the Mason County Courthouse (1929), Shelton; and the 1411 Fourth Avenue Building (1929), Seattle. Later, he carved the stone representing Washington State in the Philadelphia Freedom Monument (1987), Philadelphia, Penn. He was accepted into the national Journeyman Stone Cutters Association as its youngest member when he started his trade in Tenino around 1925.

Historian Art Dwelle wrote that “The old Thurston County Courthouse across from the capitol campus in Olympia was one of the last [major] buildings to be built of Tenino stone. The stone eagles over its portico are a final tribute to the dying skill of stone carving.” Larry carved those eagles (Fig. 18).

For about 45 years, Hercules Quarry No. 1 remained quiet. In the mid-1980s, Louis Guinett (Guinett Masonry, Vancouver, Wash.) salvaged old stockpiles at the quarry for the Key Bank (formerly Puget Sound Bank) building in Tenino. In 1992, Doug Remmick of Northwest Stone (Tualatin, Ore.) started to quarry stone on a regular basis. In 1998, Marenakos Rock Center of Issaquah took over operations at the site. It is now called the Hercules quarry.

Today stonemason and carver Keith Phillips works independently at the quarry (Fig. 19). Larry Scheel taught Keith to carve stone and gave Keith his old stone tools to continue the trade. Keith uses them today. This tradition of passing on the tools was once common. Keith’s tools are engraved with the initials of the many stonemasons that have used them since the early 1900s (including Larry’s initials).

A love of stone, rocks and geology are still pervasive among the descendants of H. P. Scheel. Walt’s son David (now retired) was a successful geophysicist who worked worldwide in the petroleum industry. Heinie’s grandsons, Bill and Michael Sterling, independently operate retaining wall and landscaping stone businesses near Deming (at Van Zandt) and on Orcas Island, respectively. Other relatives live in residences either constructed with or landscaped by stones and minerals from the numerous quarries founded by the Scheels. Many significant structures throughout the Northwest are built of stone from the Scheel family and remain as a legacy of their love of stone through the generations.

ACKNOWLEDGMENTS

I thank the following for generously providing interview time, personal records, and proofreading essential to this article:
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REFERENCES


U.S. Army Corps of Engineers Seattle District Office, 1912–1927, [General subject files, alphabetical, Grays Harbor jetty]; U.S. National Archives and Records Administration Pacific Alaska Region [Seattle, Wash.], Box 30, 29 [sic], RG 77, serial nos. 120.04, 125.32, 125.355, and 146.


Editor's note: The author would appreciate hearing from anyone who has information about old quarries or historical photos of the stone industry. The author has applied for a copyright of this material.

Erratum

No one was given credit for the photo of Eocene footprints on p. 29 of Washington Geology, v. 25, no. 4, December 1997. That credit belongs to Dave Knoblauch, who says that the footprints have since been obliterated by a rockfall.

Figure 19. Keith Phillips and his trefoil foliated (as in foliage) archway for the Stading residence in Woodland. It was hand cut from the rough Tenino sandstone. Photo courtesy of Keith Phillips (ca. 1994).

PACIFIC MINERAL MUSEUM COMING SOON

After delays for structural upgrades to its heritage building, the Pacific Mineral Museum is set to open Nov. 6 at 848 W. Hastings St. in the heart of Vancouver, B.C. It features three galleries using 'superlative mineral specimens to produce awe-inspiring exhibits'. The introductory gallery, adjacent to the retail shop on the first floor, will include displays from the world of minerals. The main gallery, on the second floor, will feature regional mineralogy, anecdotal displays, and mineral objects d'art. The museum's finest gem and mineral treasures will occupy the vault, also on the second floor. The museum will also be exhibiting specimens from the University of British Columbia collection. For more information, contact Mark Mauthner, Pacific Mineral Museum Society, 1500 – 625 Howe St., Vancouver, B.C., Canada V6C 2T6; 604/606-3164; mauthner@pop.interchange.ubc.ca.
Attachment E
Columbia River at the Mouth, Oregon and Washington

Rehabilitation of the Jetty System at the Mouth of the Columbia River

May, 2011
# Table of Contents

1. INTRODUCTION........................................................................................................... 1
   1.1. Purpose and Need for Action.............................................................................. 2
       1.1.1. Purpose....................................................................................................... 2
       1.1.2. Need........................................................................................................... 2
   1.2. Project Area Description.................................................................................. 2

2. AFFECTED ENVIRONMENT...................................................................................... 3
   2.1. Physical Characteristics................................................................................... 3
       2.1.1. Waves, Currents, and Morphology......................................................... 4
       2.1.2. Foundation Conditions............................................................................. 6
       2.1.3. Landforms............................................................................................... 6
       2.1.4. Sediment, Water Quality, and Spill History at the MCR....................... 29
       2.1.5. Fish and Wildlife..................................................................................... 31
       2.1.6. ESA-listed Species under NMFS Jurisdiction......................................... 32
       2.1.7. ESA-listed Species under USFWS Jurisdiction...................................... 40
   2.2. Cultural and Historic Resources...................................................................... 42
   2.3. Socio-economic Resources.............................................................................. 43
       2.3.1. Communities near the MCR................................................................. 43
       2.3.2. Commercial Navigation.......................................................................... 46

3. BASE CONDITION OF MCR JETTIES...................................................................... 47
   3.1. North Jetty Base Condition............................................................................. 48
   3.2. South Jetty Base Condition............................................................................ 49
       3.2.1. Concrete Monolith................................................................................... 51
       3.2.2. South Jetty Existing Spur Groins............................................................. 51
   3.3. Jetty A Base Condition................................................................................... 53

4. ALTERNATIVES......................................................................................................... 54
   4.1. General Alternatives Analysis Categories and Features............................... 54
       4.1.1. Common Engineering Features for Rehabilitation Alternatives............ 55
       4.1.2. Evaluation of Engineering Features....................................................... 58
   4.2. Range of Alternatives Considered................................................................... 60
       4.2.1. No Action Alternative.............................................................................. 61
       4.2.2. Scheduled Repair without Engineering Features................................. 63
       4.2.3. Scheduled Repair with Engineering Features........................................ 64
       4.2.4. Immediate Rehabilitation using Minimum Cross Section....................... 65
       4.2.5. Immediate Rehabilitation using Small Cross Section............................. 65
       4.2.6. Immediate Rehabilitation using Moderate Cross Section....................... 65
       4.2.7. Immediate Rehabilitation using Large Cross Section............................. 66
       4.2.8. Immediate Rehabilitation using Composite Cross Section..................... 66
       4.2.9. Scheduled Rehabilitation using Minimum or Composite Cross Section..... 66
   4.3. Alternatives Comparison and Selection.......................................................... 71
       4.3.1. North Jetty Alternatives.......................................................................... 71
       4.3.2. South Jetty Alternatives......................................................................... 72
       4.3.3. Jetty A Alternatives................................................................................. 72

5. PROPOSED ACTION................................................................................................. 74
   5.1. Overview.......................................................................................................... 74
   5.2. Proposed Action for the North Jetty............................................................... 76
       5.2.1. North Jetty Trunk and Root.................................................................... 76
       5.2.2. North Jetty Spur Groins......................................................................... 79
LIST OF TABLES

Table 1. 2007 Wetland Scores, North Jetty ............................................. 7
Table 2. 2011 Wetland Classifications, North Jetty .................................... 10
Table 3. 2011 Wetland Rating Scores, North Jetty ..................................... 11
Table 4. 2011 Wetland Classifications, Jetty A ........................................... 12
Table 5. 2011 Wetland Rating Scores, Jetty A ........................................... 12
Table 6. 2011 Wetland Classifications, South Jetty and Mitigation Area ............... 18
Table 7. 2011 Wetland Functions and Values, South Jetty Depressional – Sheet A ...... 19
Table 8. 2011 Wetland Functions and Values, South Jetty Depressional – Sheet B .... 20
Table 9. 2011 Wetland Functions and Values, South Jetty Estuarine – Sheet A ..... 21
Table 10. 2011 Wetland Functions and Values, South Jetty Estuarine – Sheet B .... 22
Table 11. 2011 Wetland Functions and Values, Mitigation Area Depressional – Sheet A 25
Table 12. 2011 Wetland Functions and Values, Mitigation Area Depressional – Sheet B 26
Table 13. 2011 Wetland Functions and Values, Mitigation Area Estuarine – Sheet A 27
Table 14. 2011 Wetland Functions and Values, Mitigation Area Estuarine – Sheet B 28
Table 15. Threatened and Endangered Species under NMFS Jurisdiction ............... 33
Table 16. Threatened and Endangered Species under USFWS Jurisdiction ............... 40
Table 17. Additional Structures at the MCR South Jetty .................................. 51
Table 18. North Jetty Spur Groin Features .................................................. 79
Table 19. North Jetty Head Cap Features .................................................... 84
Table 20. North Jetty Lagoon and Wetland Fill Features ................................ 86
Table 21. South Jetty Spur Groin Features ..................................................... 89
Table 22. South Jetty Head Capping Features .................................................. 95
Table 23. Jetty A Spur Groin Feature ............................................................... 100
Table 24. Jetty A Head Cap Feature ................................................................. 104
Table 25. Quarry Information ......................................................................... 112
Table 26. Rock Volume and Area of Barge Offloading Facilities and Causeways ... 122
Table 27. Estimated Dredging Volumes for Barge Offloading Facilities .......... 122
Table 28. Acreages Needed for Construction Staging, Storage, and Rock Stock Piles 126
Table 29. Summary of Estimated Acreages for Habitat Improvement and Wetland Mitigation 139
Table 30. Possible Wetland Mitigation and Habitat Improvement Features .... 141

LIST OF FIGURES

Figure 1. Project Area Showing the MCR Jetties and Underwater Sand Shoals ...... 1
Figure 2. 2011 Wetland Delineations at the North Jetty ....................................... 9
Figure 3. 2011 Wetland Delineations at the Jetty A ............................................. 13
Figure 4. Clatsop Spit Vegetative Communities .................................................. 15
Figure 5. 2011 Wetland Delineations, Clatsop Spit West, South Jetty .................... 16
Figure 6. 2011 Wetland Delineations, Clatsop Spit West, South Jetty ................. 17
Figure 7. 2011 Wetland Delineations, Clatsop Spit West, South Jetty ................. 24
Figure 8. Sediment Trend Analysis in the MCR Area .......................................... 29
Figure 9. Shipwrecks at the MCR .................................................................... 42
Figure 10. Jetty System at the MCR ................................................................. 47
Figure 11. Clatsop Spit and South Jetty Root Erosion .......................................... 51
Figure 12. Existing Spur Groins at the MCR South Jetty ................................... 52
Figure 13. Typical Spur Cross Section - Change with Depth .............................. 58
Figure 14. 3-D Examples of Rehabilitation and Template Alternatives at All Jetties 68
Figure 15. North Jetty Cross Section for Existing Condition and Scheduled Repair Template ................................................................. 77
Figure 16. Proposed Action for the North Jetty ................................................. 78
Figure 17. North Jetty Spur Groin NJ1C ............................................................ 80
Figure 18. North Jetty Spur Groin NJ2C ............................................................ 81
Figure 19. North Jetty Spur Groin NJ3O ............................................................ 82
Figure 20. North Jetty Spur Groin NJ4C ............................................................ 83
Figure 21. North Jetty Head Cap ...................................................................... 85
Figure 22. South Jetty Cross Section for Existing Condition and Scheduled Repair 87
Figure 23. Proposed Action for the South Jetty ................................................. 88
Figure 24. South Jetty Spur Groin SJ1O ............................................................ 90
Figure 25. South Jetty Spur Groin SJ2C ............................................................ 91
Figure 26. South Jetty Spur Groin SJ3C ............................................................ 92
Figure 27. South Jetty Spur Groin SJ4C ............................................................ 93
Figure 28. South Jetty Spur Groin SJ5O ............................................................ 94
Figure 29. South Jetty Head Cap ...................................................................... 96
Figure 30. South Jetty Root Shoreline Area ...................................................... 97
Figure 31. Jetty A Cross Section for Proposed Action ....................................... 98
Figure 32. Proposed Action for Jetty A ............................................................ 99
Figure 33. Jetty A Spur Groin JA1C ................................................................. 101
Figure 34. Jetty A Spur Groin JA2O ................................................................. 102
Figure 35. Jetty A Head Cap ............................................................................ 103
Figure 36. Construction Schedule ................................................................. 106
Figure 37. Potential Quarry Locations (red dots) for Repairs to MCR Jetties .... 111
Figure 38. North Jetty Offloading, Staging, Storage and Causeway Facilities ... 115
ABBREVIATIONS AND ACRONYMS

AMT  Adaptive Management Team
BA  Biological Assessment
BMP  best management practices
cfs  cubic feet per second
Corps  U.S. Army Corps of Engineers
CRE  Columbia River estuary
cy  cubic yard(s)
DDT  dichloro-diphenyl-trichloroethane
DPS  Distinct Population Segment
DMEF  Dredged Material Evaluation Framework
EIS  Environmental Impact Statement
ESA  Endangered Species Act
EA  Environmental Assessment
EFH  Essential Fish Habitat
ERDC  Engineer Research and Development Center
ESU  Evolutionarily Significant Unit(s)
FONSI  Finding of No Significant Impact
FR  Federal Register
ft  foot or feet
HCP  Habitat Conservation Plan
IHA  incidental harassment authorization
MCR  Mouth of the Columbia River
mcy  million cubic yard(s)
MHHW  mean higher high water
MLLW  mean lower low water
NAVD  North American Vertical Datum
NMFS  National Marine Fisheries Service
ODEQ  Oregon Department of Environmental Quality
OPRD  Oregon Parks and Recreation Department
PAH  polynuclear aromatic hydrocarbon(s)
PCB  polychlorinated biphenyl(s)
PNWNL  Pacific Northwest National Laboratory
ppt  parts per thousand
PSMFC  Pacific States Marine Fisheries Commission
RM  river mile
SEF  Sediment Evaluation Framework
SWS  Shallow Water (ocean disposal) Site
TMDL  total maximum daily loads
USEPA  U.S. Environmental Protection Agency
USFWS  U.S. Fish and Wildlife Service
USGS  U.S. Geological Survey
WDOE  Washington Department of Ecology
1. INTRODUCTION

This final Environmental Assessment (EA) evaluates the environmental effects for major rehabilitation and repairs of the North and South jetties and Jetty A, which are part of the U.S. Army Corps of Engineers’ (Corps) mouth of the Columbia River (MCR) navigation project (see cover photo and Figure 1). It replaces the draft EA that was distributed for public review in June 2006, and updates both the alternative plans considered and the proposed action selected for the North Jetty and Jetty A, which were discussed in the second revised draft EA that was distributed for public review in January 2010. The current changes to the proposed action for the North Jetty and Jetty A and the preclusion of previously proposed fill in Trestle Bay would further avoid and minimize some of the formerly identified environmental impacts by reducing the final structure and construction footprints necessary to achieve a resilient jetty system at the MCR.

The features of the MCR navigation project were authorized by the River and Harbor Acts of 1884, 1905, and 1954. The navigation project consists of a 0.5-mile wide navigation channel extending for about 6 miles through a jettied entrance between the Columbia River and the Pacific Ocean. The MCR is the ocean gateway for maritime navigation to and from the Columbia-Snake River navigation system. Approximately $16 billion of commerce passes through the MCR jetty system annually. The ocean entrance at the MCR is characterized by large waves and strong currents and is considered one of the world’s most dangerous coastal inlets.

Figure 1. Project Area Showing the MCR Jetties and Underwater Sand Shoals

From 1885 to 1917, the North and South jetties were constructed. Jetty construction realigned the ocean entrance to the Columbia River, established a consistent navigation channel that was 40-feet deep across the bar, and significantly improved navigation through the MCR. Improvements made from 1930 to 1942 (including adding Jetty A and the Sand Island pile dikes) produced the present entrance configuration.

The MCR jetties are unique structures that help ocean-going vessels move between the Columbia River and Pacific Ocean. Simply put, a jetty is a rock finger that stretches out into the ocean from the shoreline,
essentially extending the mouth of the river well into the sea. Where a river empties into the ocean, currents slow and sand bars develop, which cause a dangerous situation for ships trying to navigate through an ever-changing channel. Jetties create more defined and concentrated flows at the mouth of the river to help scour out the shallow sand deposits and maintain a stable channel location and depth.

The forces of nature have taken their toll on the structural integrity of the MCR jetties, and the Corps is working at restoring them to acceptable levels of reliability. Repairs were made in 1965 for the North Jetty, in 1962 for Jetty A, and in 1982 for the South Jetty. Additional repairs to address immediate needs were completed at the North Jetty in 2005 and at the South Jetty in 2007.

1.1. Purpose and Need for Action

1.1.1. Purpose

The purpose of the proposed action is to perform modifications and repairs to the North and South jetties and Jetty A at the MCR that would strengthen the jetty structures, extend their functional life, and maintain deep-draft navigation.

1.1.2. Need

Structural degradation of the +100-year old MCR jetty system has accelerated in recent years because of increased storm activity and loss of sand shoal material upon which the jetties are constructed. In addition, beaches on the ocean sides of the North and South jetties, which formed as a result of jetty construction, have been receding gradually over the years, exposing previously protected sections of the jetties at the beach line to storm waves. Taking no action to protect and to extend the functional life of the jetties will result in further deterioration of the jetties and the sand shoals upon which they rest, increasing the likelihood of a jetty breach. Recent jetty repairs have addressed immediate critical needs. Additional modifications and repairs to the jetties are necessary to address significant near- and long-term needs and to reduce the potential for emergency repairs, emergency dredging, and impacts to navigation.

1.2. Project Area Description

The North Jetty and Jetty A are located in Pacific County, Washington, near Ilwaco and Long Beach on the Long Beach Peninsula (see cover photo). The 2.3-mile long North Jetty was completed in 1917. Three repairs to the North Jetty have been made with the last one completed in 2005. To date, jetty rock placement totals approximately 3.4 million tons. Since initial construction, about 0.4 miles of the North Jetty head has eroded and is no longer functional. Jetty A, positioned on the south side of the North Jetty, was constructed in 1939 to a length of 1.1 miles and is located upstream of the North Jetty. Jetty A was constructed to direct river and tidal currents away from the North Jetty foundation.

The South Jetty is located in Clatsop County, Oregon near Warrenton/Hammond and Astoria (see cover photo). The South Jetty is about 6.6 miles long. The initial 4.5-mile section of the South Jetty was completed in 1896, with a 2.4-mile extension completed in 1914. Currently, approximately 3 miles of jetty extends seaward of the shoreline. To stabilize the jetty foundation, six groins perpendicular to the South Jetty were constructed with lengths from about 100 to 1,000 feet (see Section 3.2.2). Over 6,100 feet of head loss has occurred at the South Jetty. Nine repairs to the South Jetty have been completed with the latest one in 2007. To date, jetty rock placement at the South Jetty totals approximately 8.8 million tons.
2.3.2. Commercial Navigation

The MCR is the gateway to the Columbia-Snake River system, accommodating commercial traffic with an approximate annual value of $16 billion dollars a year. The Columbia/Snake River navigation system from the Pacific Ocean to Lewiston, Idaho is a vital transportation link for the states of Oregon, Washington, Idaho, and Montana, as well as for the Nation as a whole. The Columbia/Snake navigation system flows through Idaho and Washington and forms the southern border of Washington and the northern border of Oregon, serving multiple ports along the way. The Corps maintains the navigation channels and operates navigation locks at eight federal hydropower projects on the Columbia/Snake River system. The navigation channels and locks provide access to markets for producers throughout the United States, and are part of a just-in-time delivery system for this major international trade gateway. The elements of the Columbia/Snake navigation system include the deep-draft navigation channel, the inland navigation channel, and the jetties, anchorages, turning basins, and upriver locks necessary to accommodate increasingly larger ships and growing inland barge movements.

The inland navigation channel runs about 365 miles upstream from Portland/Vancouver to Lewiston, Idaho. The Waterborne Trade Atlas indicates that about 10 million tons of cargo is barged annually, with an estimated value of $1.5 to $2 billion. The deep-draft navigation channel runs 110 miles downstream of Portland/Vancouver to the MCR. The Waterborne Trade Atlas indicates that the deep-draft channel carries about 40 million tons of cargo annually, with an estimated value of $16 billion. Also, about 40,000 local jobs are dependent on this trade.
3. BASE CONDITION OF MCR JETTIES

Each MCR jetty consists of three parts. The head is the seaward terminus and is exposed to the most severe wave action. The trunk forms the connection from jetty head to the shore, retains sub-tidal shoals, and confines circulation within the inlet. The root forms the connection from the jetty trunk to the shore and prevents accreted landforms from migrating into the inlet. The jetty system at the MCR and adjacent beaches and bays are illustrated below (Figure 5).

![Jetty System at the MCR](image)

The following discussions mention station numbers on each jetty. These stations indicate linear distance along the jetty relative to a fixed reference point near the jetty root. Numbering begins at the reference point (0+00) and increases seaward such that each station number represents that distance in feet, multiplied by 100, plus the additional number of feet indicated after the station number. For instance, station 100+17 would be 10,017 feet seaward from the reference point. The reference point (0+00) is located at the landward-most point on the jetty root.

The base condition described here was used as a comparative template in the alternatives modeling, and predictions about the occurrence of different events under the No Action scenario were generated. The number of necessary repair events, possible breaches, dredging needs, etc. were predicted both for the No Action alternative, as well as the additional alternatives that were selected for further evaluation and comparison. Further discussion of modeling used to generate and evaluation these predictions occurs in...
Section 4.1.2 Evaluation of Engineering Features, and under the discussion of Range of Alternatives Considered, 4.2.

For the base condition, it is assumed that no large-scale action (such as head-capping or spur groin construction) would be taken to slow down the large, physical processes (larger waves, increased storm activity, and others) that are negatively impacting the structural stability the MCR jetty system. The jetty heads would continue to recede, jetty trunks would continue to deteriorate, the ebb tidal shoal would continue to reduce in size, the shorelines would continue to recede, and the underwater sand shoals upon which the jetties are built would continue to erode, leaving deeper water depths along the jetties. Larger waves could attack the jetties resulting in greater jetty deterioration. Wave and current action within the MCR inlet would increase. However, on a smaller scale more immediate actions may be taken to address specific jetty sections and localized processes via an intermittent or fix-as-fails repair strategy. The base condition used to describe the No Action alternative and to compare alternatives could be somewhat characterized as a fix-as-fails approach at the South Jetty. In this scenario, jetty maintenance is deferred for a given segment until the upper cross-sectional area falls below about 30% of its standard template profile. At the North Jetty and Jetty A, the repair strategy is triggered at a lower threshold when at a given segment the upper cross-sectional area falls below about 40% of its standard template profile. Because of the greater potential navigational impacts from a failure at the North Jetty and because of the length and exposure making repairs difficult at the South Jetty, this results in relatively more frequent repair actions under the interim repair strategy for the North Jetty compared to fix-as-fails at the South Jetty. Depending on the condition and rate of damage to the jetty cross-section for either repair strategy, maintenance actions may be conducted as a normally planned operation, in an expedited fashion, or on an emergency basis. The following sections provide a detailed discussion of the base condition used here for each MCR jetty.

It is also noteworthy that augmentation of the foredune at the South Jetty is considered part of the base-condition, or No Action alternative. This is due to the fact that augmentation of the South Jetty foredune in order to avoid a breach will be implemented regardless of whether or not the additional major rehabilitation and repairs are completed. Therefore, foredune augmentation at the South Jetty is an assumed component when the base conditions are discussed. Though it will likely be a separate project, it is also further described here as part of the proposed action, since it has yet to be implemented and is closely associated with the other components of the proposed action. It would likely occur early in relationship to the overall rehabilitation and repair schedule that is also described.

3.1. North Jetty Base Condition

The North Jetty has receded approximately 2,100 feet in length since original construction in 1916. Under the base condition, the head of the jetty will continue to deteriorate at a rate of about 20-50 feet per year. In 50 years, it is expected to reach approximately station 91 (or about 1,000 feet of additional loss from its current position). Peacock Spit and Benson Beach are expected to continue to erode shoreward at a similar rate to the jetty length deterioration. Much of the sediment loss associated with shoreline retreat would migrate into the federal navigation channel and contribute to the overall O&M dredging.
requirement at the MCR. Maintenance dredging of the entrance could increase over time. The volume of maintenance dredging associated with the continued landward recession of Peacock Spit is estimated to be 25% of the O&M dredging at MCR (or 0.5 to 1 mcy per year). The resulting head loss would have moderate effect on wave climate and navigability. Erosion of the surrounding shoal would expose more vulnerable areas of the jetty to increased damage. Continued loss of jetty length (and Peacock Spit) could potentially expose the seaward half of the South Jetty to higher wave conditions.

The jetty trunk is expected to degrade by three distinct processes: direct wave impact, wave overtopping (affecting above water portion of the jetty), and scour at the jetty base (affecting the below water portion until it fails and destabilizes the above water portion). During the 50-year project life, modeling predicted that the North Jetty could breach, destabilizing more of the jetty and allowing significant amounts of sand to move through it. Breaching typically occurs during severe winter storm attack. Modeling suggests that during the 50-year project life, breaching will occur between 3 and 5 times at multiple locations along the North Jetty resulting in emergency repairs. If a segment breaches, it is predicted that adjacent segments have a high probability of also breaching.

For worst case breach event, it is predicted that approximately 2-3 mcy of material could move from Peacock Spit and Benson Beach into the navigation channel. A shoal within the navigation channel could begin to form. In the absence of emergency dredging, it is expected that the depth of the navigation channel could be reduced from -55 feet to -40 feet in about 2 to 4 months. In order to maintain navigability of the navigation channel, the Corps would likely perform emergency repairs on the breach and attempt to mobilize sufficient dredges to maintain the authorized channel depth. During the 50-year project life, modeling predicts approximately 1 to 4 repairs would be expected to occur along the North Jetty.

3.2. South Jetty Base Condition

The South Jetty has receded approximately 6,200 feet in length since original construction in 1885-1913. Under the base condition, the head of the jetty will continue to deteriorate at a rate of 5 to 20 feet per year until the concrete monolith collapses (see below), at which time the head is projected to deteriorate more rapidly. In 50 years, it is expected to reach about station 292 (or about 2,100 feet lost). Continued loss of the jetty length (and Clatsop Spit) would expose the seaward half of the South Jetty to higher wave conditions. Loss of jetty length would contribute to continued loss of the underwater shoal, exposing the jetty to increasing wave action and the shoreline at the root of the jetty to higher wave forces. The shoreline would continue to erode and recede, resulting in a shoreline breach into Trestle Bay in about 8 to 16 years.
Based on the present condition of the concrete monolith, it is expected to slump into the ocean and basically become non-existent within 12 to 20 years, adding additional deteriorating forces to the seaward half of the jetty. The remaining rubble mound portion of the jetty would then begin to deteriorate in an accelerated way.

The jetty trunk is expected to degrade by the three distinct processes discussed for the North Jetty. Modeling suggests that during the 50-year project life, breaching could occur between 3 and 6 times along the South Jetty. Unlike the North Jetty, emergency dredging would likely not occur because the material is not anticipated to affect the federal navigation channel in the short term. Increased dredging would likely occur during the summer maintenance months. The breach would not be repaired by emergency actions; rather, repairs would be performed during the following summer.

The shore area along the South Jetty root has experienced profound changes since the time of jetty construction. Before construction, the nearshore area immediately south of the jetty was dominated by a broad shallow ebb tidal shoal, exhibiting relatively shallow water depth. Construction of the South Jetty dissipated this shoal, resulting in a rapid trend of increasing water depth through time. As the water depth along the south side of the jetty increased, wave action along the jetty root and adjacent shore area increased. The increased wave environment motivated rapid deterioration of the entire South Jetty and culminated with the significant breaching event along the South Jetty root in the late 1920s. During the 1930s, extensive efforts were undertaken to rebuild the South Jetty and re-establish the shore land interface along the south-side root of the jetty. The effort was successful; however, the result has been subjected to an increasingly harsh environment of wave action and related circulation since the 1930s.

Currently, the coastal shore interface along the South Jetty is in a condition of advanced deterioration. The foredune separating the ocean from the backshore is almost breached (Figure 11). The backshore is a narrow strip of a low-elevation, accretion area that separates Trestle Bay from the ocean by hundreds of yards. The offshore area along the South Jetty (and to the south) continues to erode, promoting larger wave action to affect the shoreline along the South Jetty root. The back-dune of Trestle Bay has continued to advance westward due to increased circulation in the bay, seasonal wave chop, and hydraulic surcharging. Under the base condition, foredune augmentation adjacent to the South Jetty Root will be implemented in order to begin addressing erosion concerns (discussed in further detail in Erosional Areas 4.1.1.4 and the Proposed Action for the South Jetty, S.3). However, as mentioned, this is considered part of the No Action alternative, because it would be implemented regardless of whether or not the rest of the repair and rehabilitation components are completed. Without foredune augmentation, the shoreline at the root of the South Jetty will continue to erode and recede, resulting in a possible shoreline breach into Trestle Bay in about 8-16 years. If this sand spit breach occurs, the result would be catastrophic. The MCR inlet would establish a secondary flow way from the estuary to the ocean along this area (south of
the South Jetty). This condition would profoundly disrupt navigation at the MCR and bring lasting changes to the physical nature of the inlet.

Figure 11. Clatsop Spit and South Jetty Root Erosion

3.2.1. Concrete Monolith

During rehabilitation of the South Jetty in the 1930s, a concrete cap 500 feet long was constructed to secure the jetty head at station 330. The seaward most 200 feet of the concrete cap was composed of a solid core monolith. This cap has served well since 1940; however, the entire cap has been severely damaged due to the harsh wave climate that exists 3 miles offshore and is progressively failing. This cap serves as an anchor to secure and protect the un-reinforced area of the South Jetty immediately inshore of the cap. When the cap fails completely (i.e., falls off of the jetty crest), the land area adjacent to the cap will rapidly deteriorate due to relentless wave action. Based on the present condition of the concrete monolith, it is expected to slump into the ocean and basically become non-existent within 12 to 20 years, which will add additional deteriorating forces to the seaward half of the jetty. The remaining rubble mound portion of the South Jetty would then begin to deteriorate in an accelerated way.

3.2.2. South Jetty Existing Spur Groins

Historical records show that six spur groins (#1-4, #6-7) were constructed along the channel side of the South Jetty (Table 3). Four of the groins were buried by accreted shoreline or sand shoal. The two visible, most seaward spur groins (at stations 309 and 333) clearly show an influence on the surrounding underwater contours. The 100-foot spur groins push the more extreme tidal velocities channel-ward, so that the shoal material at the base of the jetty is stabilized. Figure 7 illustrates the important effect these spur groins have on stabilizing the underwater shoal and protecting the South Jetty. These small structural features help with the long-term structural stability of the South Jetty by: (1) promoting sediment deposition along the jetty foundation; and (2) inhibiting the shoreline erosion occurring at the root of the jetty.

Table 17. Additional Structures at the MCR South Jetty

Final EA, May, 2011
### Table: Additional Structures

<table>
<thead>
<tr>
<th>Additional Structures</th>
<th>Year Completed</th>
<th>Station Location</th>
<th>Length (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spur Groin #1</td>
<td>1893</td>
<td>228+00</td>
<td>500</td>
</tr>
<tr>
<td>Spur Groin #2</td>
<td>1893</td>
<td>156+00</td>
<td>600</td>
</tr>
<tr>
<td>Spur Groin #3</td>
<td>1895</td>
<td>88+00</td>
<td>1000</td>
</tr>
<tr>
<td>Spur Groin #4</td>
<td>1895</td>
<td>52+00</td>
<td>1000</td>
</tr>
<tr>
<td>Shore Revetment</td>
<td>1896</td>
<td>25+80</td>
<td>3955</td>
</tr>
<tr>
<td>Spur Groin #6</td>
<td>1913</td>
<td>309+33</td>
<td>~110</td>
</tr>
<tr>
<td>Spur Groin #7</td>
<td>1913</td>
<td>333+46</td>
<td>~90</td>
</tr>
</tbody>
</table>

**Figure 12. Existing Spur Groins at the MCR South Jetty**

- Existing spurs protect jetty toe from scour
3.3. Jetty A Base Condition

The main purpose of Jetty A is to direct river currents away from the North Jetty. Jetty A has receded approximately 900 feet in length since original construction in 1939. Under the base condition, the head of the jetty is expected to continue to deteriorate at a rate of about 5 to 20 feet per year. In 50 years, it is predicted to reach approximately stations 83 (or about 500 feet lost). Increases in dredging are expected as Jetty A recedes. Clatsop Spit could move northward toward the navigation channel. The bathymetry in front of Sand Island could be cut back, mobilizing additional material. The shallower area between Jetty A and the North Jetty is also predicted to be impacted allowing movement of that material toward the channel. The deepening expected to happen in the vicinity of the North Jetty could further destabilize the jetty’s foundation and impact its long-term reliability. It is expected that a one-time increase in dredging would occur on the order of 800,000 to 1.6 mcy followed by incremental increases in dredging that would depend on changes in channel shoaling patterns and spit movement.

The jetty trunk is expected to degrade by the three distinct processes discussed for the North Jetty. During the 50-year project life, it is predicted that Jetty A will breach, destabilizing more of the jetty and allowing significant amounts of sand to move through it. Modeling suggests that during the 50-year project life, breaching will occur between 2 and 4 times along Jetty A. If a segment breaches, adjacent segments have a high probability of also breaching. It is estimated that 2 to 3 repairs would occur along Jetty A. Unlike the North Jetty, emergency dredging would not be needed because the material is not expected to affect the navigation channel in the short term. Increased dredging would occur during the summer maintenance months. Also, repairs to the breach would occur the following summer.
4. ALTERNATIVES

4.1. General Alternatives Analysis Categories and Features

The proposed alternatives for the MCR jetties discussed in the revised Draft EA dated January 2010 and this final EA do not include rebuilding the three jetties to their originally authorized lengths, nor to the lengths proposed in the first Draft EA released in 2006. Evaluations of the proposed alternatives now consider the ends of the jetties at their current locations, which is short of both the authorized and 2006 recommended lengths. In addition, this current EA updates the alternative plans considered and the includes a revised plan selection for proposed actions at the North Jetty and Jetty A compared to those recently discussed in the revised Draft EA dated January 2010. The current changes to the proposed action for the North Jetty and Jetty A would further avoid and minimize some of the previously identified environmental impacts by reducing the final structure and construction footprints necessary to achieve a resilient jetty system at the MCR.

Alternatives were evaluated by comparing reliability of the system, average annual costs, potential environmental effects, and anticipated repair and breach frequencies for each alternative. Repair and rehabilitation options comprise the general categories of alternatives considered and evaluated for the MCR jetty system, as described below.

Repair Alternatives. The programmed repair strategy monitors each 100-ft jetty segment for current cross section and degradation rates. When a threshold occurs (usually about four-years before failure), this triggers a repair action. Repair alternatives involved adding limited amounts of stone to trunk and root features in order to restore the affected cross-section back to a standard repair template. Generally, they are triggered when the upper profile of the cross-sectional area falls below 30-40% of its standard template profile (or, 60-70% of the previously existing prism is gone). Under repair options, stone placement is generally limited to above-water sections and remains within the existing jetty and relic stone structures. Repair alternatives also considered differing degrees of repair. Repair alternatives were considered to occur either on the basis of a scheduled, predetermined time and place, or on an interim or fix-as-fails repair basis (used only in the base condition) for which a stochastic model predicted both jetty repair and/or breach scenarios. For the North and South jetties, the repair alternative included repair combined with and without engineering features.

Rehabilitation Alternatives. Rehabilitation alternatives generally incorporate engineering components which may extend beyond the current footprint of jetty and relic stone structures and could entail both above and below-water fill. Certain engineering features were incorporated as common components present in all rehabilitation alternatives considered. These engineering features included capping jetty heads, constructing additional spur groins, and filling the North Jetty lagoon area. Augmenting the South Jetty foredune is an engineering feature described under the proposed action, but is also considered a separate action that is implemented under the base condition, No Action alternative. Rehabilitation strategies were evaluated as both immediate and scheduled. Immediate rehabilitation begins at one end of the jetty and continues in succession along adjacent section of the jetties without prioritizing a reach based on its condition. The scheduled rehabilitation alternative constructs at specific locations along the jetty at specific time periods in order to prioritize areas where conditions warrant sooner attention.
Table 24. Jetty A Head Cap Feature

<table>
<thead>
<tr>
<th>Features</th>
<th>Jetty A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of cap</td>
<td>stations 91 to 93</td>
</tr>
<tr>
<td>Timing of construction</td>
<td>2015</td>
</tr>
<tr>
<td>Dimensions of cap:</td>
<td></td>
</tr>
<tr>
<td>length x width x height (feet)</td>
<td>200 x 160 x 40 (0.73 acres)</td>
</tr>
<tr>
<td>Stone size</td>
<td>30 to 40 tons</td>
</tr>
<tr>
<td>Area affected (outside relic stone)</td>
<td>None</td>
</tr>
<tr>
<td>% of cap constructed on relic stone</td>
<td>100%</td>
</tr>
<tr>
<td>Construction method</td>
<td>Land-based crane</td>
</tr>
</tbody>
</table>

For head capping, when placement is divided into elevation zones, about 7,920 cu yd of stone will be placed above MH HW. This represents 44% of the overall stone placement on this portion of Jetty A and there is very little or no existing jetty stone expected to be present within this elevation range. About 4,740 cu yd of stone will be placed between MH HW and MLLW. This represents a 26% of the overall stone placement on this portion of Jetty A and there is very little or no existing jetty stone expected to be present within this elevation range. About 5,420 cu yd of stone will be placed below MLLW. This represents 30% of the overall stone placement on this portion of Jetty A and a 1783% change from the existing jetty prism, as there is very little or no existing mounded jetty stone expected to be present within this elevation range.

In all zones, all proposed stone placement will occur on existing base relic stone that formed the original jetty cross-section and was displaced and flattened by wave action, and does not include any modification that changes the character or increases the scope or size of the original structure design. The terminus of the head is simply closer to shore on a shorter jetty structure. The footprint of the existing jetty mound on the flattened relic stone is approximately 0.64 acres, and the additional capping on the relic stone increases the width of the prism approximately 0.09 acres, for a total footprint of 0.73 acres on the existing relic stone.

5.5. Construction Measures and Implementation Activities

5.5.1. Construction Measures and Timing

The preferred in-water work window for the Columbia River estuary at the mouth is 1 November to 28 February. However, seasonal inclement weather and sea conditions preclude safe, in-water working conditions during this timeframe. Therefore, it is likely that most of in-water work for constructing spur groins, head capping, cross-section repairs, constructing off-loading facilities, etc. will occur outside this period during calmer seas, mostly between April and October. To avoid impacts to Southern resident killer whales, pile installation will be prohibited until on or after May 1 of each year.

Most landward work on the jetties will be occurring from 1 April to 15 October. Work is assumed to occur 1 June to 15 October on the more exposed sections of the jetties. Placement work may extend beyond these windows if weather and wave conditions are conducive to safe construction and delivery. Stone delivery by land or water could occur year-round, depending on delivery location, method, and weather breaks. Barge delivery would most likely occur during the months of April through October or at other times of the year depending on breaks in the weather and which jetty is
being used. Quarrying of the rock may be limited depending on the regulations pertinent to each quarry.

Work elements fall into four general categories for scheduling: (1) rock procurement, quarrying, and delivery transport, (2) construction site preparation, (3) lagoon fill and dune augmentations, and (4) jetty repair and rehabilitation work with construction of the design features including head capping and spur groins. Site preparation would consist of the preparation of the rock stockpile storage and staging areas, as well as the construction of any barge-offloading facilities that may be required. Approximate transport quantities by method are 30 tons per truck and 6,500 tons per barge. The majority of the jetty rehabilitation work is expected to be conducted from the top of the jetty downward using an excavator or a crane. Areas which may require marine plant work include construction at the South Jetty head and some of the deeper spur groins.

For design and cost-benefit estimates, the project was modeled and designed for a 50-year operational lifespan. The schedule shown in Figure 36 illustrates construction actions related to building engineered features anticipated to occur at any one or some combination of all three of the jetties for the duration of 20 years. It also includes a predicted schedule of repair actions that the Corps' model estimates will be necessary within that same time period. Additional repairs have also been predicted to occur after the initial 20-year construction schedule and within the 50-year lifespan of the project. Additional repairs beyond the 20-year schedule will be similar in scale and nature to those described above in the standard repair template. Repair actions are generally triggered when a cross-section of the jetty falls below about 30% to 40% of the standard repair template profile. The schedule described further in the narrative is a combined reflection of constructing specific engineered features and forecasting needed repairs. Real-time implementation of repair actions will likely vary based on evolving conditions at the jetties and could be shifted within and beyond this 20-year construction schedule.

In the construction schedule, rock production and stockpiling material begins in 2013. The first jetty installation is scheduled for late spring 2014 and continues through 2033. The estimate assumes the work will be accomplished with multi-year contracts.

Prior to construction activities, an incidental harassment authorization (IHA) for marine mammals at the South Jetty will be obtained from the NMFS. The Corps anticipates that the new IHA permit will entail requirements similar to those in the previous permit for repair of the South Jetty. These previous requirements included monitoring and reporting the number of sea lions and seals (by species if possible) present on the South Jetty for 1 week before (re)starting work on this jetty. During construction, the Corps provided weekly reports to the NMFS that included a summary of the previous week’s numbers of sea lions and seals that may have been disturbed as a result of the jetty repair construction activities. These reports included dates, time, tidal height, maximum number of sea lions and seals on the jetty and any observed disturbances. A description of construction activities at the time of observation was also included. Post-construction monitoring occurred with one count every 4 weeks for 8 weeks to determine recolonization of the South Jetty. The Corps anticipates future monitoring and reporting requirements will be similar and will designate a biologically trained on-site marine mammal observer(s) to carry out this monitoring and reporting. The required reports will be submitted to the NMFS and the AMT. The ODFW, who monitors sea lion use of the South Jetty, will also be apprised of the Corps work and results of the monitoring efforts.
Figure 36. Construction Schedule

Mouth of the Columbia River Jetty System Rehabilitation - Selected Plan
(Construction Schedule: Jetty stone placement, existing stone re-work, engr. features)

Includes stone tonnage associated with North Jetty root stabilization (lagoon fill) and jetty spur-groins for North Jetty, South Jetty, and Jetty A

- North Jetty - Scheduled REPAIRS
- South Jetty - scheduled REPAIRS
- Jetty A - Immediate REHAB plan

= Lagoon fill (North Jetty)
= Jetty spur-groins

Tons of Stone (1000 tons)


Construction Year

Mouth of the Columbia River Jetty System Rehabilitation - Selected Plan
(Construction Schedule: For stone placement on Jetties and existing stone re-work)

- North Jetty - Scheduled REPAIRS
- South Jetty - scheduled REPAIRS
- Jetty A - Immediate REHAB plan

Does NOT include stone tonnage associated with North Jetty root stabilization (lagoon fill) and jetty spur-groins for North Jetty, South Jetty, and Jetty A

Tons of Stone (1000 tons)


Construction Year
Conservation measures that will be implemented to minimize disturbance to Steller sea lions includes the following: during land-based rock placement, the contractor vehicles and personnel will avoid as much as possible direct approach towards pinnipeds that are hauled out. If it is absolutely necessary for the contractor to make movements towards pinnipeds, the contractor shall approach in a slow and steady manner to reduce the behavioral harassment to the animals as much as possible. Monitoring and reporting will occur as required.

Also, measures 1, 2, and 3 discussed below will be employed during the marbled murrelet nesting season (April 1 to September 15) to reduce impacts from noise to nesting marbled murrelets on the Washington side, and measure 4 will be considered to create western snowy plover nesting habitat:

1. Trucks will only be allowed to use roads through Cape Disappointment State Park during daylight hours.
2. Trucks will not unnecessarily stop along the roads through Cape Disappointment State Park.
3. Trucks will be prohibited from using compression brakes (jake brakes) on the roads through Cape Disappointment State Park.
4. The Corps is currently investigating opportunities to create western snowy plover nesting habitat on Clatsop Spit within Fort Stevens State Park. Since rock could be stored on Clatsop Spit for years, the Corps will consider creation of habitat after use of the spit for rock storage is complete to avoid potential limitations to rock storage and transport on the spit if plovers begin to nest. The Corps will also consider options to create plover habitat concurrently with rock storage if it is certain that plover use of the created habitats and beaches would not interfere with the Corps’ ability to use Clatsop Spit throughout the life of the project. Habitat maintenance each year after creation would be required to provide functional habitat, but maintenance would not be the responsibility of the Corps. Habitat creation work would be conducted under ESA Section 7(a) (1) authority. The Corps has had initial discussions with OPRD regarding plover habitat creation.

5.5.2. Construction Sequence and General Schedule

In 2013, rock procurement activities will be initiated for the North Jetty scheduled repair. In 2014, the on-site work will begin with filling the lagoon area behind the North Jetty root (stations 20 to 60) and installing a culvert to divert overland flow to another area that will not impact the North Jetty root stability. The lagoon area will be filled with rock, gravel, and sand. Once the lagoon is filled, it will serve as a staging and stockpile area for the rock delivered to the North Jetty site.

In 2014, construction will focus on reconstructing the North Jetty head (stations 88 to 99) to control further head recession of the jetty. This work will require haul road construction on top of the jetty from station 70 out to the head requiring approximately 31,000 tons of rock. The North Jetty will require installing a barge offloading facility on the channel side of the jetty at approximately station 45. Dredging of 30,000 cy is anticipated to provide a minimum 25 feet of working clearance.

Concurrently in 2014, work will begin on Jetty A beginning with constructing the off-loading facility, 60,000 cy of dredging to accommodate the rock delivery by barge, and constructing the jetty crest haul road from stations 40 to 80. Total new stone consists of approximately 50,000 tons of imported rock, equivalent to 1,700 trucks or 8 barges.

In 2015, construction will continue on the North Jetty head from station 99 to 101 and installation of one spur groin at station 50 on the channel side. The haul road will need to be reworked with
approximately 26,000 tons of new topping material. Work will occur concurrently with Jetty A beginning with 60,000 cy of dredging, completion of the jetty crest haul road from station 80 to 93, and installation of two spur groins. Total new stone for 2015 would consist of approximately 160,000 tons of rock, equivalent to 5,400 trucks or 25 barges. Work on Jetty A would be completed this year.

In 2016, work continues on the North Jetty with placement of 36,000 tons of large armor near the head at stations 80 to 88. This requires refurbishing the haul road and building vehicle turnouts. In addition, three spur groins will be installed at stations 70-C, 80-O, and 90-C with a total of 30,000 tons of new stone. Total new stone would consist of approximately 86,000 tons, equivalent to 2,900 trucks or 13 barges. Site preparation work and stockpiling stone at the South Jetty will occur to prepare staging and stockpile areas for 2017 construction.

In 2017, construction on the South Jetty is projected to begin, starting with construction work near the head from stations 173 to 176 and 180 to 195. South Jetty construction will require either a haul road be constructed on top of the jetty or constructed from a marine plant in order to get out to the head. Total work effort in 2017 is projected to consist of approximately 74,000 tons of rock, equivalent to 2,500 trucks or 12 barges.

Over the next 3 years, work continues on the South Jetty with work moving towards the head in 2018 with a total of 86,000 tons of rock at stations 290 to 311. Head construction begins in 2019 with 30,000 tons of armor stone and installation of four spur groins at stations 165-O, 210-C, 230-C, and 265-C for a total of 9,000 tons of spur groin rock. The South Jetty head completes in 2020 with 44,000 tons of armor stone.

In 2022, construction is projected to occur concurrently on the North and South jetties: (1) continuation of North Jetty rock placement at stations 40 to 45 and stations 65 to 73; and (2) continuation of South Jetty rock placement at stations 160 to 163, stations 170 to 173, stations 176 to 180, and stations 195 to 200. Total rock tonnage for 2022 is estimated at 115,000 tons, equivalent to 3,850 trucks or 18 barges.

In 2023, construction continues on the South Jetty with the placement of approximately 118,000 tons of rock between stations 205 to 250. The haul road will need to be reworked with approximately 62,000 tons of rock road base and topping material. Total jetty rock tonnage to be placed would require 4,000 trucks or 18 barge loads.

In 2024, construction continues on the South Jetty with the placement of approximately 76,000 tons of rock between stations 270 to 290. Total rock tonnage to be placed would require 2,600 trucks or 12 barge loads.

In 2026, construction resumes on the North Jetty with the placement of approximately 52,000 tons of rock between stations 20 to 30. The long time frame from the previous construction on the North Jetty will also require rebuilding the jetty haul road from stations 20 to 30. Total rock tonnage to be placed would require 1,800 trucks or 8 barge loads.

In 2030, construction is projected to occur on the North and South jetties: (1) continuation of North Jetty rock placement at stations 30 to 40; and (2) continuation of South Jetty rock placement at stations 223 to 237 and stations 250 to 253. Total rock tonnage to be placed is estimated at 129,000 tons, equivalent to 4,300 trucks or 20 barges.
In 2031, construction is projected to occur on the North and South jetties: (1) continuation of North Jetty rock placement at stations 88 to 99; and (2) continuation of South Jetty rock placement at stations 253 to 270. The North Jetty haul road will need to be re-built from stations 65 to 99 and will require 30,000 tons of quarry waste material. Total rock tonnage to be placed is estimated at 135,000 tons, equivalent to 4,500 trucks or 21 barges.

In 2032, construction continues on the South Jetty with the placement of approximately 85,000 tons of rock between stations 295 to 311. Total rock tonnage to be placed would require 2,850 trucks or 13 barge loads. The offloading facility will be removed and scheduled repair will be complete for the South Jetty.

The final anticipated year of North Jetty scheduled repair is projected for 2033 with construction from stations 80 to 88. Total rock tonnage estimated is 63,000 tons, equivalent to 2,100 trucks or 10 barge loads. The offloading facility will be removed and scheduled repair will be complete for the North Jetty.

Because construction at the North and South jetties is spaced out from 2014 through 2033 with intermittent work, dredging at the barge offloading sites will only be required prior to the year of actual rock delivery in preparation for upcoming construction work. The Jetty A barge offloading site will only require dredging to make that site accessible for 2 years. Dredging will only be needed if the clearance depth at the barge offloading site is not found to be adequate prior to rock delivery activities.

5.5.3. Rock Sources and Transportation

Currently, it is not exactly known where jetty rock will come from and how it will be transported to the jetty sites. However, one or more of the options discussed below would be employed (Figure 37 and Table 25). Rock sources located within 150 miles of a jetty would likely be transported by truck directly to the jetty. Stone sources located at further distances, especially if they are located near waterways, are likely to be transported by truck to a barge unloading facility, then transported by tug and barge to either a Government provided or commercial barge unloading site located nearby. Railway may also be an option for transporting stone, provided that an unloading site is convenient to the quarry. Most railroads follow main highway arterials, such as Interstate 5. The closest railroad terminal to the South Jetty is at Tongue Point, east of Astoria, OR, which is about 15 miles from the jetty. The nearest railroad terminal to the MCR on the north side of the Columbia River is at Longview, WA.

The Corps intends to use operating quarries rather than opening any new quarries. The Contractor and quarry owner/operator will be responsible for ensuring that quarries selected for use are appropriately permitted and in environmental compliance with all state and federal laws.

Canadian Quarries. Quarries in British Columbia are typically located adjacent to waterways and rock produced from these quarries will likely have a limited truck haul. Due to the long distance to the MCR, plus the immediate availability to deep water, rock would likely be loaded onto barges and shipped down the Washington Coast to barge offloading sites.

Washington Quarries. Quarries located in northern Washington are typically not on the water, but are generally located within 50 miles of a potential barge on-loading site. As a result, rock would need to be hauled, at least initially, by truck. Rock would be transported by trucks most likely to a barge on-loading facility or possibly all the way to the staging site at the jetty. In the event of a
combination of trucking and barging, trucks would be loaded at the quarry, and then traverse public roads to existing facilities. Once the rock is loaded on barges, it would be transported down the coast to barge offloading sites.

It also is possible that railway systems may be used to transport rock much of the way to the jetties. Burlington Northern Railroad operates a rail system that parallels Interstate 5 throughout Washington which would be the most likely route rock would be transported. Rock from the quarry would be taken by truck to a nearby railway station where they would be loaded onto railway cars and transported to an intermediate staging area. Trucks would then again take the rock the remainder of the way to the jetty staging areas.

Truck hauling of rock from northern Washington sources to the North Jetty or Jetty A most likely would be transported by public road to Interstate 5 or any of the main roads over to Highway 101. Trucks using Interstate 5 would either turn at Longview on Highway 4 to Highway 101, or cross over the Longview Bridge to Highway 30 near Rainier, Oregon. From this point they would proceed west to Astoria to Highway 101, crossing the Astoria-Megler Bridge through Ilwaco to the jetty staging areas. Delivery to the South Jetty most likely would use main roads to Interstate 5 or any of the main roads over to Highway 101.
Figure 37. Potential Quarry Locations (red dots) for Repairs to MCR Jetties

See corresponding quarry information located in Table 25.
Table 25. Quarry Information
See Figure 37 for site map.

<table>
<thead>
<tr>
<th>No.</th>
<th>Quarry</th>
<th>County and State</th>
<th>Nearest City</th>
<th>Road Miles from MCR</th>
<th>Unit Weight (pcf)</th>
<th>Reserves Available (tons)</th>
<th>Likely Transportation Method</th>
<th>Nearest Barge Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Columbia Granite Quarry</td>
<td>Thurston, WA</td>
<td>Vail, WA</td>
<td>129</td>
<td>168.5</td>
<td>28 M</td>
<td>Truck</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>Beaver Lake Quarry</td>
<td>Skagit, WA</td>
<td>Clear Lake, WA</td>
<td>251</td>
<td>181.1</td>
<td>1.86 M</td>
<td>Truck, then Barge</td>
<td>Anacortes, WA</td>
</tr>
<tr>
<td>3</td>
<td>Texada Quarry</td>
<td>BC, CANADA</td>
<td>Texada Island, BC</td>
<td>363</td>
<td>173.5+</td>
<td>275 M</td>
<td>Barge</td>
<td>Onsite</td>
</tr>
<tr>
<td>4</td>
<td>Steve Lake Quarry</td>
<td>BC, CANADA</td>
<td>Mission, BC</td>
<td>311</td>
<td>169.1</td>
<td>74 M</td>
<td>Truck, then Barge</td>
<td>Mission, BC, Canada</td>
</tr>
<tr>
<td>5</td>
<td>192nd Street Quarry</td>
<td>Clark, WA</td>
<td>Camas, WA</td>
<td>109</td>
<td>168.5</td>
<td>0.5 M</td>
<td>Truck/Barge</td>
<td>Camas, WA</td>
</tr>
<tr>
<td>6</td>
<td>Iron Mountain Quarry</td>
<td>Snohomish, WA</td>
<td>Granite Falls, WA</td>
<td>225</td>
<td>174</td>
<td>Unknown</td>
<td>Truck</td>
<td>N/A</td>
</tr>
<tr>
<td>7</td>
<td>Marble Mount Quarry</td>
<td>Skagit, WA</td>
<td>Concrete, WA</td>
<td>276</td>
<td>189.7</td>
<td>2 M</td>
<td>Truck, then Barge</td>
<td>Anacortes, WA</td>
</tr>
<tr>
<td>8</td>
<td>Youngs River Falls Quarry</td>
<td>Clatsop, OR</td>
<td>Astoria, OR</td>
<td>20</td>
<td>181.8</td>
<td>0.5 M+</td>
<td>Truck</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>Liscomb Hill Quarry</td>
<td>Humboldt, CA</td>
<td>Willow Creek, CA</td>
<td>515</td>
<td>179.1</td>
<td>0.5 M</td>
<td>Truck, then Barge</td>
<td>Eureka, CA</td>
</tr>
<tr>
<td>10</td>
<td>Baker Creek Quarry</td>
<td>Coos, OR</td>
<td>Powers, OR</td>
<td>275</td>
<td>200</td>
<td>Unknown</td>
<td>Truck, then Barge</td>
<td>Coos Bay, OR</td>
</tr>
<tr>
<td>11</td>
<td>Phipps Quarry</td>
<td>Cowlitz, WA</td>
<td>Castle Rock, WA</td>
<td>69</td>
<td>167.4</td>
<td>0.5 M</td>
<td>Truck</td>
<td>N/A</td>
</tr>
<tr>
<td>12</td>
<td>Cox Station Quarry</td>
<td>BC, CANADA</td>
<td>Abbotsford, BC</td>
<td>313</td>
<td>167.9</td>
<td>150 M</td>
<td>Barge</td>
<td>Onsite</td>
</tr>
<tr>
<td>13</td>
<td>Ekset Quarry</td>
<td>BC, CANADA</td>
<td>Mission, BC</td>
<td>309</td>
<td>172.2</td>
<td>10 M</td>
<td>Truck, then Barge</td>
<td>Mission, BC, Canada</td>
</tr>
<tr>
<td>14</td>
<td>Fisher Quarry</td>
<td>Clark, WA</td>
<td>Camas, WA</td>
<td>108</td>
<td>168.5</td>
<td>2 M</td>
<td>Barge</td>
<td>Camas, WA</td>
</tr>
<tr>
<td>15</td>
<td>Bankus Quarry</td>
<td>Curry, OR</td>
<td>Brookings, OR</td>
<td>347</td>
<td>183 &amp; 195</td>
<td>0.7M</td>
<td>Truck, then Barge</td>
<td>Crescent City, CA</td>
</tr>
</tbody>
</table>
Trucks using Highway 101 south through Washington would likely cross the Astoria-Megler Bridge, go through Warrenton using local roads into Fort Stevens State Park and the staging area. Trucks utilizing Interstate 5 would either turn at Longview on Highway 4 to Highway 101, or on Highway 30 near Rainier, proceeding through Astoria to Highway 101, going through Warrenton through local roads into Fort Stevens State Park and the jetty staging area.

Rock located within southern Washington would likely be trucked to the jetty staging areas. An exception to this would be a quarry that occurs within just a few miles of a port on the Washington Coast or a quarry that is near the Columbia River. In either of these two barge possibilities, rock would be delivered by truck to a barge on-loading facility, loaded on oceangoing or riverine barges, and delivered to one of the barge offloading facilities (see section on barge offloading facilities below). Truck hauling of rock from this area to the jetties would be as described above.

**Oregon Quarries.** Rock located in northern Oregon within 50 miles of the North Jetty and Jetty A would likely utilize any of the main roads over to Highway 101 or Highway 30. From this point they would cross the Astoria-Megler Bridge and proceed west through Ilwaco to the jetty staging areas. Quarries exceeding 50 miles from the jetties would likely utilize main roads at a farther distance from the jetty sites. This would involve longer haul distances on Highways 101, 30, 26, and others before crossing the Astoria-Megler Bridge and proceeding to the staging areas.

Truck hauling of rock from quarries within 50 miles of the South Jetty will most likely utilize any of the main roads over to Highway 101 or Highway 30. From this point they would proceed through Astoria and Warrenton, or Seaside and Gearhart to local roads leading to Fort Stevens State Park and the jetty staging areas. Quarries exceeding 50 miles from the jetty would likely utilize main roads at a farther distance from the jetty site. This would involve longer haul distances on Highways 101, 30, 26, and others before going through Astoria and Warrenton, or Seaside and Gearhart to local roads leading into Fort Stevens State Park and the staging areas.

The likely mode of transportation from southern Oregon quarries is trucking, or a combination of trucking and barging. Many of the quarries may be near the Oregon Coast; however, they may not be near a port facility that has barge on-loading capability. Providing that barge facilities are available, rock located south of Waldport would be loaded at the quarry onto trucks and traverse main public roads to the barge on-loading site, loaded on ocean-going barges, and shipped up the Oregon Coast to one of the barge offloading facilities (see section on barge offloading facilities below). Quarries north of Waldport would most likely be hauled by truck the entire distance.

Southern Oregon rock sources requiring trucking would be loaded onto lowboy trucks one to three at a time and would traverse main roads to more main arterials such as Highway 101 or, to a lesser degree, Interstate 5. An effort would be made to use the least distance possible to transport the rock without sacrificing transport time.

**California Quarries.** For northern California quarries, there would be a very long haul distance required to get rock to the jetty repair areas. Barging of rock would be the only economically feasible option. Rock would be transferred by truck from the quarries along main roads leading to Highway 101 to a barge offloading facility.

For water-based delivery of rock, a tow boat and barge would deliver the rock to the channel side of the jetties where water depth, waves, and current conditions permit. During rock offloading, the barge may be secured to approximately 4 to 8 temporary dolphins/H-piles to be constructed within 200 feet of the jetty. Rock would be off-loaded from the barge by a land- or water-based crane and
either placed directly within the jetty work area or stock piled on the jetty crest for subsequent placement at a later time.

For land-based delivery of rock, jetty access for rock hauling trucks would be via an existing paved road to the Benson Beach parking lot at Cape Disappointment State Park (North Jetty) and via an existing paved road to the Parking Lots C and D at the South Jetty. An existing overland route between Jetty A and North Jetty may also be used for land-based hauling. Work areas for delivery of rock, maneuvering of equipment, and stockpiling of rock near the jetties have been identified and are discussed in the next section.

5.5.4. Barge Offloading Facilities

Stone delivery by water could require up to four barge offloading facilities that allow ships to unload cargo onto the jetty so that it can then be placed or stockpiled for later sorting and placement. The range of locations for these facilities is shown in Figures 38-40. Depending on site-specific circumstances, offloading facilities may be converted to spur groins, may be partially removed and rebuilt, or may remain in place. Facility removal will depend on access needs and evolving hydraulic, wave, and jetty cross-section conditions at each offloading locations.

Additionally, in the draft EA released in January 2010, a third offloading facility was under consideration for the South Jetty in the bay adjacent to the area known as Social Security Beach. Due to the size of the footprint and the possible effects to shallow-water habitat in the vicinity, this option has been withdrawn from further consideration in order to avoid and minimize environmental impacts. The site near Parking Area D at the South Jetty was deemed to have a smaller footprint, was likely to require less dredging, and had fewer impacts to shallow-water habitat.

Facilities will range from approximately 200- to 500-feet long and 20- to 50-feet wide, which ranges from about 0.48 to 2.41 acres in total area. Examples are shown in Figure 41. For initial construction of all four facilities combined, approximately up to 96 Z- or H-piles that are 12-16-inches in diameter could be installed as dolphins, and up to 373 sections of Z- or H-piles installed to retain rock fill. Figure 41 shows a cross-section diagram for stone access ramp at potential barge offloading facilities and photos illustrating typical barge offloading facilities. Facilities will have a 15-foot NGVD crest elevation and will be installed at channel depths between -20 and -30 feet NGVD. A vibratory hammer will be used for pile installation and only untreated wood will be used, where applicable. Removal and replacement of the facilities could occur within the duration of the construction schedule. Volume and acreage of fill for these facilities are shown in Table 26.