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Geologic Map of the State of Hawai'i

By David R. Sherrod, John M. Sinton, Sarah E. Watkins, *and* Kelly M. Brunt

Open-File Report 2007–1089

U.S. Department of the Interior
U.S. Geological Survey

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qf **Fill (Holocene)**—Manmade fill forming piers and harbor breakwaters along coastline

Qa **Alluvium (Holocene and Pleistocene)**—Unconsolidated deposits of silt, sand, and gravel along streams and in valley bottoms. In some areas, grades upslope to talus and colluvium (unit Qtc). Where information is lacking, may include deposits more appropriately assigned to older alluvium (QTao) by virtue of greater consolidation or topographic settings not at grade with modern drainages

Qbd **Beach deposits (Holocene)**—Sand and gravel worked by surf into unconsolidated strand-line deposits along coastline. Chiefly cream-colored and calcareous in composition, derived from comminuted coral, shells, and foraminifera. Locally includes substantial stream-derived volcanic detritus ("black sand"), notably on East Moloka'i, East Maui, and Hawai'i. Also contains minor sandstone, known in Hawai'i as beach rock. Typically forms deposits parallel to coast, in contrast to alluvium, which extends up drainages perpendicular to coast. This criterion was used to demarcate beach deposits on those islands like Kaho'olawe where source maps showed all deposits as alluvium (unit Qa)

Qdy **Younger dune deposits (Holocene)**—Unconsolidated, mostly coralline sand forming eolian sheets and dunes. Found chiefly adjacent to beach deposits, but some reach inland as far as 2 km on Ni'ihau and Kaua'i and 7 km on western Moloka'i. As thick as 15 m. On Kīlauea volcano, comprises black glassy and lithic sand reworked downwind onto the volcano's southwest rift zone from 200–500-yr-old tephra deposits in the summit area

Qld **Lake deposits (Holocene)**—On Ni'ihau. Exceedingly fine-grained calcareous sand blown into intermittent Halāli'i Lake and washed into beach ridges by the lake. Natural lakes are rare in Hawai'i and exposures of lake deposits even rarer

Qlg **Lagoon deposits (Holocene)**—Unconsolidated or poorly consolidated mud, silt, and sand. Found chiefly as mudflats in back-beach setting and some estuaries, where sediment from beach deposits and younger dune deposits (units Qbd and Qdy) is washed by water of brackish lagoons. May include marine marl or limey beds. On south-central Moloka'i, includes reddish-brown mud "carried into the sea as a result of overgrazing in the past 150 [now 200] years" (Stearns and Macdonald, 1947). As a consequence, the Moloka'i shoreline west of Kaunakakai has prograded substantially since the mapping by Stearns and Macdonald (1947), so that several nearshore areas shown on their topographic base map as ocean or mangrove swamp have now become fully emergent

Qls **Landslide deposits (Holocene)**—Blocks of lava flows and admixed soil that have slid from steep valley walls and sea cliffs. Some deposits incorporated preexisting volcanic ash deposits, which locally contributes high proportion of matrix, as in the Wood Valley area on south flank of Mauna Loa (Stearns and Macdonald, 1946; Wolfe and Morris, 1996a)

Qtc **Talus and colluvium (Holocene)**—Unconsolidated or poorly consolidated, poorly sorted silt, sand, and blocks that mantle slopes. Typically forms sheet or wedge-shaped deposits downslope from cliffy bedrock outcrops

Qt **Tephra (Pleistocene)**—Ash deposits, commonly well sorted and well bedded. Includes primary and reworked tephra. Windblown glassy tephra on Ni'ihau was derived from Lehua cone (in unit QTekt) and forms both primary and reworked deposits (Stearns, 1947). This ash, which weathers into tan powdery soil, is younger than about 0.4 Ma on basis of its position above lava flows of Kiekie Basalt with ages 0.40±0.14 and 0.47±0.06 Ma (table 1). On Lāna'i, includes four small accumulations described as tuffaceous sandstone (Stearns, 1940c). These deposits, on southeast side of island, may have originated by downwind drift of ash from Haleakalā. Low on west flank of Mauna Kea (Island of Hawai'i), comprises unconsolidated, crossbedded, very fine grained to fine grained dune sand and loess blankets interpreted as deposits of wind-reworked ash derived from eruptions at vents of the Laupāhoehoe Volcanics (units Qlcy, Qlc, Qlbc) (Wolfe and Morris, 1996a; Porter, 1997). Deeply weathered elsewhere on Island of Hawai'i where encompassing the "Pāhala Ash," a stratigraphic name applied to both primary and reworked tephra-fall deposits that originated from Kīlauea, Mauna Loa, Mauna Kea, and perhaps Kohala volcanoes (Wolfe

and Morris, 1996a). Younger tephra of Kīlauea has been mapped as units within encompassing volcanic formations; for example, Keanakāko'i Ash Member is labeled as ash beds of age 200 to 500 yr within the Puna Basalt (unit Qpa4). So too for deposits on other islands; for example, widespread ash of the Hāna Volcanics that mantles the summit crater and southwest rift zone of Haleakalā Crater is contained within that formation (unit Qhnt)

QTao **Older alluvium (Pleistocene and Pliocene)**—Consolidated sand and gravel, some of it sufficiently lithified to warrant the designation "conglomerate." Chiefly well rounded and moderately sorted, but includes minor, poorly sorted colluvial deposits. Forms terrace deposits and thick valley fills now being incised by modern drainages. Less commonly found mantling ridges, as on western Moloka'i. Similar sedimentary strata on Kaua'i and O'ahu, not widespread, are found interbedded with Pliocene volcanic rocks and customarily mapped as sedimentary members within associated volcanic formations there

Qdo **Older dune deposits (Holocene and Pleistocene)**—Lithified calcareous sand or eolianite. Forms dune fields inland of modern coastline. Ranges in lithification downsection, corresponding to deposits of increasingly older age. Youngest are typically weakly cemented cream-colored sand without capping caliche or red paleosol (Hearty and others, 2000), whereas older part includes eolian limestone in which pore space is completely replaced by calcite cement and individual sand grains have lost much original texture (Blay and Longman, 2001). On O'ahu these deposits, encompassing 700 ha, have been assigned to the Bellows Field Formation of Lum and Stearns (1970) and Stearns (1970). On Kaua'i, deposits exceed 28 m thickness and are mapped as the Māhā'ulepū Formation of Blay and Longman (2001). Most extensive is the 2,000-ha dune field that mantles the isthmus between West and East Maui, where dune-sand thickness is as great as 10–12 m. Holocene age assignment for youngest part stems from shells and bird bones that yielded radiocarbon ages roughly from 4,700 to 6,750 ^{14}C yr BP (for example, Hearty and others, 2000). A minimum age for the oldest part on Kaua'i was obtained by dating an interbedded lava flow of the Kōloa Volcanics, which yielded a ^{40}Ar/^{39}Ar age of 375±4 ka (Hearty and others, 2005)

Qcrs **Calcareous reef rock and marine sediment (Pleistocene)**—Chiefly emerged coral reefs, but includes finely laminated lagoonal limestone. Reefs consist of coral heads and coralline algae cemented by a lime matrix (Stearns and Vaksvik, 1935, p. 169). Exposed subaerially on O'ahu only, although similar deposits are found as active and extinct submarine reefs that ring all the islands

Qcbc **Calcareous breccia and conglomerate (Pleistocene)**—Poorly to moderately sorted sedimentary deposits of marine provenance, as inferred from the presence of coralline detritus. Deposits on Lāna'i, which were subsequently assigned to the Hulopo'e Gravel (Moore and Moore, 1984) were described thusly: calcareous conglomerate consisting of subangular and angular lava rock, pebbles, and cobbles in a matrix of coral, coralline algae, and shells, or their weathered products (Stearns, 1940b, p. 52). Found on the south and southwest sides of the island at altitudes mostly below 170 m (550 ft) (Stearns, 1940b), these deposits emplaced during one or several events between about 105 and 137 ka, on basis of ages from coral fragments in deposits and estimated age of the 'Ālika 2 Slide (Moore and Moore, 1988; Rubin and others, 2000; McMurtry and others, 1999). Two sites at higher altitude were described, including crevice-filling fossiliferous marine limestone at 326 m (1069 ft) (Stearns, 1938). Moloka'i deposits, which extend 2 km inland and to altitudes as high as 72 m, have a matrix of sandy lime mud cemented with calcite (Moore and others, 1994). Their carbonate clast component is mostly branching coral and coralline algae, with lesser gastropod shells, echinoid spines, and carbonate mud rip-up clasts, whereas the basaltic rock clasts range from angular to subrounded (A.L. Moore, 2000). On Ni'ihau, two occurrences of fossiliferous limestone are shown by an an ×, mimicking the style on the source map (Stearns, 1947)

[In the following descriptions, many geologic notes for island stratigraphic features are drawn directly from bulletins of the Hawai'i hydrography publication series, and separate headnotes for each island's formations indicate the specific reference]

VOLCANIC AND INTRUSIVE ROCKS ON THE ISLAND OF NI'IHAU

[Bracketed page numbers refer to Stearns (1947) and Macdonald (1947), which are the chief source for description of Ni'ihau geologic map units]

Ki'eki'e Basalt (Pleistocene and Pliocene)—Moderately porphyritic and lesser nonporphyritic alkalic basalt

LIST OF MAP UNIT ON SHEET 7 (THIS MAP)

See explanatory pamphlet for complete descriptions

SURFICIAL DEPOSITS COMMON TO SEVERAL OF THE ISLANDS

Qf **Fill (Holocene)**

Qa **Alluvium (Holocene)**

Qbd **Beach deposits (Holocene)**

Qdy **Younger dune deposits (Holocene)**

Qls **Landslide deposits (Holocene)**

Qtc **Talus and colluvium (Holocene)**

Qdo **Older dune deposits (Holocene and Pleistocene)**

Qcbc **Calcareous breccia and conglomerate (Pleistocene)**

QTao **Older alluvium (Pleistocene and Pliocene)**

VOLCANIC AND INTRUSIVE ROCKS ON THE ISLAND OF MAUI

Hāna Volcanics (Holocene and Pleistocene)—Divided into:

Lava flows (Holocene and Pleistocene)—Divided into:

Qhn6
Qhn5
Qhn4
Qhn3
Qhn2
Qhn1
Qhn0

Lava flows	Age, years
Qhn6	0 - 1500
Qhn5	1500 - 3000
Qhn4	3000 - 5000
Qhn3	5000 - 13,000
Qhn2	13,000 - 30,000
Qhn1	30,000 - 50,000
Qhn0	50,000 - 140,000

Qhnv **Vent deposits (Holocene and Pleistocene)**

Qhnt **Tephra deposits (Holocene and Pleistocene)**

Qhni **Intrusive rocks (Holocene and Pleistocene)**

Qhne **Explosion crater deposits (Pleistocene)**

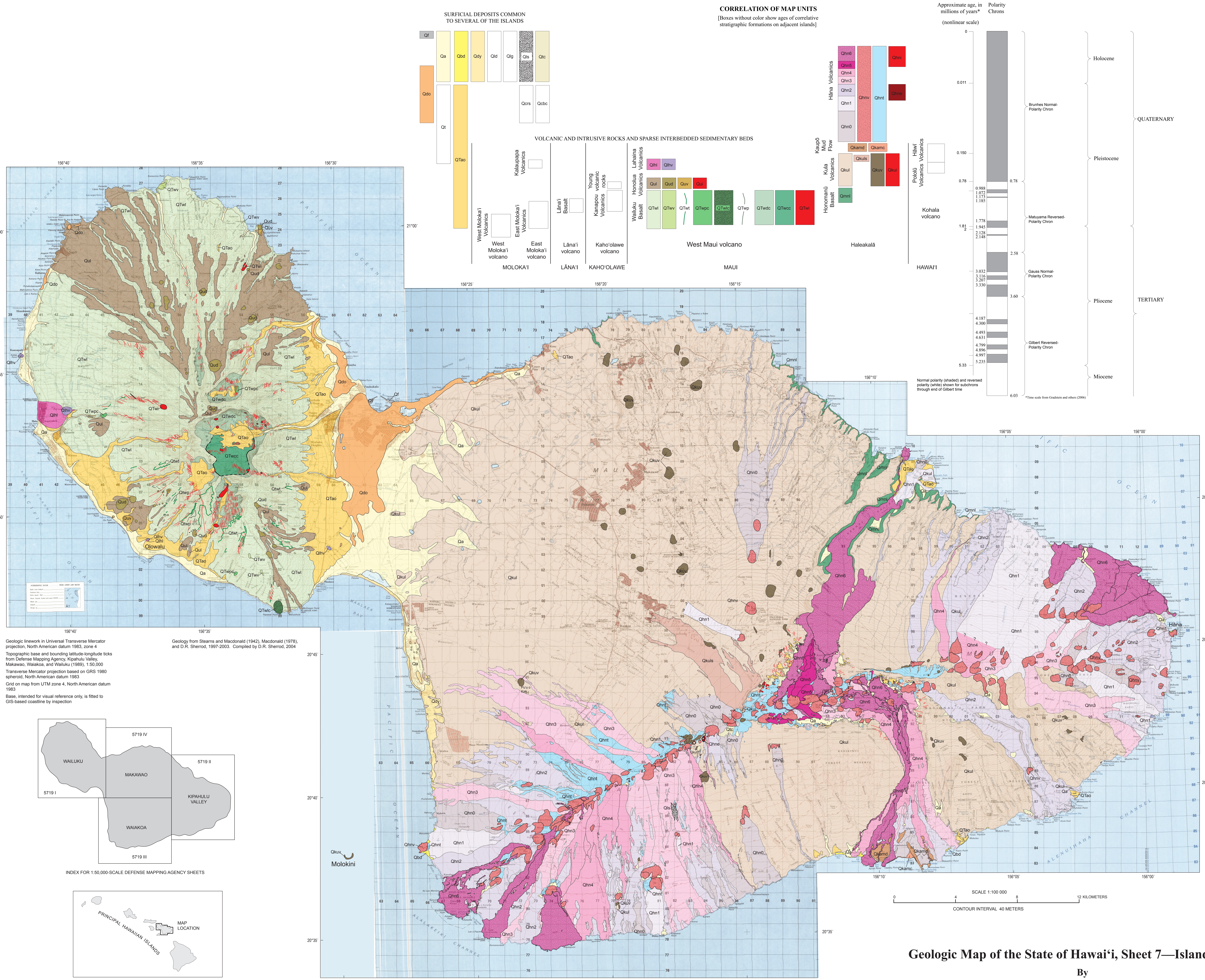
Qkamd **Kaupō Mud Flow (Pleistocene)**—Mapped separately is:

Qkamc **Conglomerate**

Kula Volcanics (Pleistocene)—Divided into:

CORRELATION OF MAP UNITS

[Boxes without color show ages of correlative stratigraphic formations on adjacent islands]



Geologic linework in Universal Transverse Mercator projection, North American datum 1983, zone 4

Topographic base and bounding latitude-longitude ticks from Defense Mapping Agency, Kipahulu Valley, Makawao, Waiakoa, and Wailuku (1989), 1:50,000

Transverse Mercator projection based on GRS 1980 spheroid, North American datum 1983

Grid on map from UTM zone 4, North American datum 1983

Base, intended for visual reference only, is fitted to GIS-based coastline by inspection

Geology from Stearns and Macdonald (1942), Macdonald (1978), and D.R. Sherrod, 1997-2003. Compiled by D.R. Sherrod, 2004

INDEX FOR 1:50,000-SCALE DEFENSE MAPPING AGENCY SHEETS

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Qhnt **Tephra deposits (Holocene and Pleistocene)**

Qhni **Intrusive rocks (Holocene and Pleistocene)**

Qhne **Explosion crater deposits (Pleistocene)**

Qkamd **Kaupō Mud Flow (Pleistocene)**—Mapped separately is:

Qkamc **Conglomerate**

Kula Volcanics (Pleistocene)—Divided into:

Qkul **Lava flows**—Mapped separately is:

Qkuls **Summit ankaramite**

Qkuv **Vent deposits**

Qkui **Intrusive rocks**

Qmnl **Honomanū Basalt (Pleistocene)**

Lahaina Volcanics (Pleistocene)—Divided into:

Qlhl **Lava flows**

Qlhv **Vent deposits**

Honolua Volcanics (Pleistocene)—Divided into:

Qul **Lava flows**

Qud **Domes**

Quv **Vent deposits**

Qui **Intrusive rocks**

Wailuku Basalt (Pleistocene and Pliocene(?))—Divided into:

QTwl **Lava flows**

QTwv **Vent deposits**

QTwt **Tuff**

QTwpc **Pit crater deposits**

QTwlc **Lava cone**

QTwp **Phreatic explosion debris**

QTwdc **Dike complex**

QTwcc **Caldera complex**

QTwi **Intrusive rocks**

Contact—Approximately located

Fault—Approximately located; dotted where concealed

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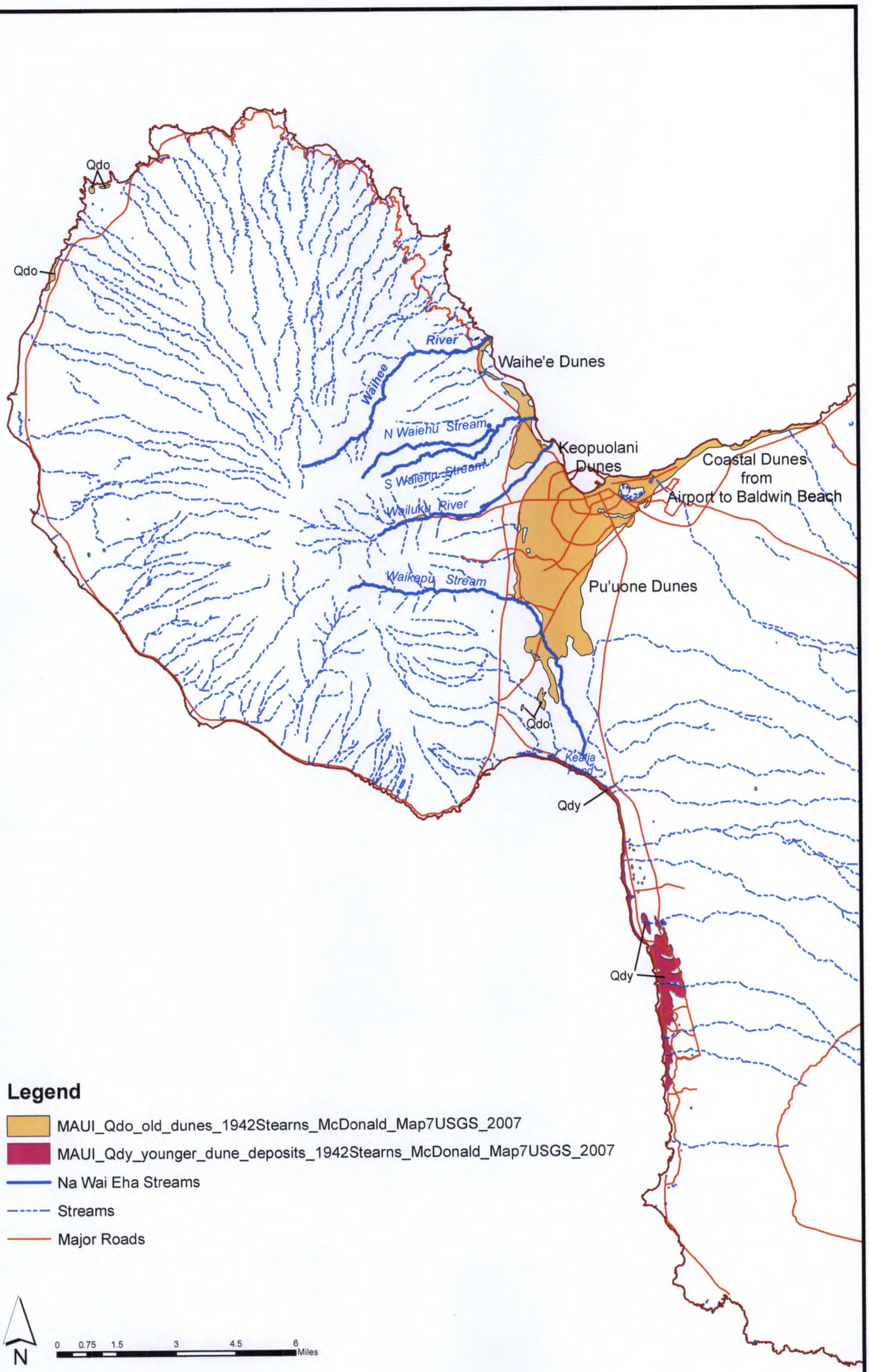
2007

Available on World Wide Web at http://pubs.usgs.gov/of/2007/1089/



Geologic Map of Hawaii_ Sheet 7 - Island of Hawaii
Open-File Report 2007-1089 USGS
Geology from Stearns and Macdonald (1942), Macdonald (1978),
and D.R. Sherrod, 1997-2003.

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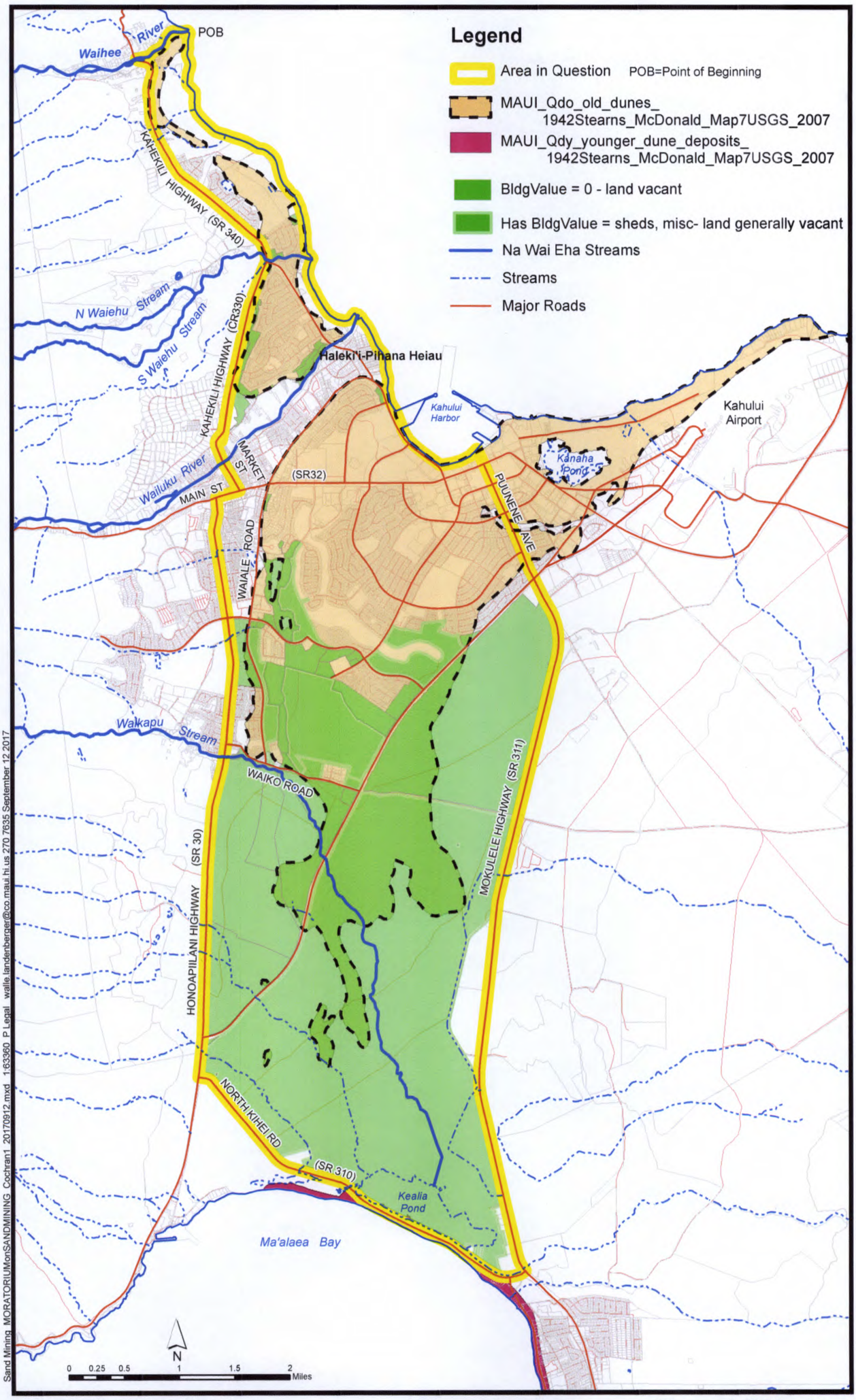
Maui Island - Older and Younger Dune Deposits

IEM-33

September 12, 2017



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Vacant Lands_ County of Maui Real Property files 2017

Moratorium on Sand Mining

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