**Appendix 1A.** List of boreholes used in this report

[Altitudes are in feet; latitude and longitude are in degrees, minutes, and seconds; VDEQ, Virginia Department of Environmental Quality; VPI, Virginia Polytech Institute; VEPCO, Virginia Electric Power Company; --, local number not assigned]

| Borehole location number on plate 1 | Local number | Identifying name, owner, or organization, and some references | Latitude | Longitude | Surface altitude | Bottom altitude |
|---|---|---|---|---|---|---|
| 1 | 58A76 | Dismal Swamp Corehole (Powars and others,1992; unpublished data, D.S. Powars, USGS and T.S. Bruce, VDEQ) | 36 36 55 | 76 33 20 | 33 | –1,857 |
| 2 | 61B11 | Fentress Corehole (Powars and others, 1992; unpublished data, D.S. Powars, USGS and T.S. Bruce, VDEQ) | 36 42 27 | 76 07 47 | 15 | –2,005 |
| 3 | 58C6 | Well #8 (Cederstrom, 1945a) Chuckatuck-Cedarbrook Farm | 36 51 16 | 76 33 26 | 15 | –535 |
| 4 | 58C5 | Well #37 (Cederstrom, 1945a) Drivers-Monogram Farm | 36 49 04 | 76 32 50 | 20 | –520 |
| 5 | 59C2 | Virginia Division of Forestry | 36 48 08 | 76 23 15 | 20 | –633 |
| 6 | 59C28 | City of Chesapeake-Bowers Hill-Production Well #1 | 36 47 02 | 76 24 55 | 21 | –979 |
| 7 | 58B11 | NAN-P-8 (Brown and others, 1972) | 36 44 28 | 76 33 32 | 20 | –634 |
| 8 | 59C2 | POR-P-10 (Brown and others, 1972) | 36 48 08 | 76 23 15 | 15 | –638 |
| 9 | 59C6 | CHE-P-11 (Brown and others, 1972) | 36 52 41 | 76 23 17 | 3 | –597 |
| 10 | 59C39 | MW4-1 Corehole (Powars and others, 1992) | 36 47 10 | 76 26 52 | 17 | –983 |
| 11 | 60C6 | Lone Star Cement Corp. | 36 48 53 | 76 17 09 | 5 | –790 |
| 12 | 60C7 | City of Portsmouth | 36 51 15 | 76 19 17 | 10 | –1,144 |
| 13 | 60B2 | CHE-P-5 (Brown and others, 1972) | 36 41 49 | 76 20 19 | 14 | –806 |
| 14 | 63C1 | VB-P-3 (Brown and others, 1972) | 36 52 00 | 75 58 51 | 5 | –1,583 |
| 15 | -- | Airfield Pond Corehole (unpublished data, J.S. Schindler, R. Weems, and D.S. Powars, USGS) | 36 54 48 | 77 01 28 | 91 | –130 |
| 16 | 57D1 | IW-P-13 (Brown and others, 1972) | 36 59 42 | 76 37 53 | 40 | –414 |
| 17 | 57D28 | VPI geothermal well #26,Town of Isle of Wight | 36 54 29 | 76 42 07 | 75 | ? –930 |
| 18 | 57D2 | Well #81 (Cederstrom, 1945a) Smithfield Ice Plant | 36 59 05 | 76 37 21 | 10 | –311 |
| 19 | 58D6 | Rescue Water Company | 36 59 39 | 76 33 30 | 22 | –528 |
| 20 | 58D7 | Town of Smithfield-Red Point Heights | 36 59 12 | 76 36 50 | 35 | –477 |
| 21 | 58C8 | Nimmo Well, Chuckatuck, Va. | 36 52 18 | 76 31 30 | 20 | –558 |
| 22 | 58D9 | Tidewater Virginia Properties-Graymor Estates | 36 57 27 | 76 31 39 | 15 | –541 |
| 23 | 58D2 | Well #54 (Cederstrom, 1945a) Battery Park Water Co. | 36 59 32 | 76 29 44 | 13 | –333 |
| 24 | 58D3 | Well #108 (Cederstrom, 1945a) Carrolton | 36 58 02 | 76 34 48 | 8 | –382 |
| 25 | 59D1 | Tidewater Water Co. | 36 52 55 | 76 23 11 | 15 | –573 |
| 26 | 59D20 | City of Newport News-City Hall Complex | 36 58 40 | 76 25 50 | 30 | –870 |
| 27 | -- | NAN-P-13 (Brown and others, 1972) | 36 52 30 | 76 28 25 | 22 | –633 |
| 28 | -- | Well #13 (Cederstrom, 1957) Buxton Hospital | 36 59 08 | 76 23 33 | 11 | –809 |
| 29 | 59D4 | Well #44 (Cederstrom, 1957) Newport News; Virginia Public Service Company (Gas Works) | 36 58 28 | 76 25 52 | 12 | –1,070 |
| 30 | 59D5 | Well #46 (Cederstrom, 1957) Newport News; Levinson Meat Packing | 36 59 08 | 76 25 07 | 8 | –892 |
| 31 | 60D7 | VPI geothermal well #c24 -Willoughby Bay | 36 57 27 | 76 29 19 | 5 | 1,030 |
| 32 | -- | Well #9 (Cederstrom, 1945a) Lamberts Point-Norfolk & Western Railway Co. | 36 52 26 | 76 18 56 | 10 | –606 |
| 33 | 61C1 | NOR-T-12 (Brown and others, 1972) | 36 52 23 | 76 12 21 | 15 | –2,567 |
| 34 | 61C1 | Well #20 (Cederstrom, 1945a) Moores Bridge | 36 52 21 | 76 12 13 | 10 | –1,730 |
| 35 | 62D2 | VB-T-4 (Brown and others, 1972) | 36 57 59 | 76 06 47 | –35 | –1,500 |
| 36 | 57E10 | VDEQ | 37 02 36 | 76 42 59 | 85 | –615 |

**Appendix 1A.** List of boreholes used in this report—Continued

[Altitudes are in feet; latitude and longitude are in degrees, minutes, and seconds; VDEQ, Virginia Department of Environmental Quality; VPI, Virginia Polytech Institute; VEPCO, Virginia Electric Power Company; --, local number not assigned]

| Borehole location number on plate 1 | Local number | Identifying name, owner, or organization, and some references | Latitude | Longitude | Surface altitude | Bottom altitude |
|---|---|---|---|---|---|---|
| 37 | -- | Well #3a (Cederstrom, 1945a) Rushmere | 37 04 34 | 76 40 05 | 5 | –381 |
| 38 | -- | Well #7 (Cederstrom, 1945a) Burwells Bay | 37 03 23 | 76 40 13 | 15 | –306 |
| 39 | -- | Well #25 (Cederstrom, 1945a) Lone Star Cement Co., near Mogarts Beach | 37 00 29 | 76 36 24 | 12 | –324 |
| 40 | -- | Well #42a (Cederstrom, 1945a) Bacons Castle Test Well | 37 06 10 | 76 44 13 | 70 | –985 |
| 41 | 59E5 | NASA Research Center-Langley Air Force Base | 37 05 38 | 76 22 43 | 9 | –2,084 |
| 42 | 59E6 | Big Bethel Water Plant | 37 05 11 | 76 24 54 | 15 | –990 |
| 43 | 60E42 | VPI geothermal well #c27-Langley Air Force Base | 37 05 32 | 76 22 12 | 5 | –1,000 |
| 44 | 60E43 | VPI geothermal well #c60-Bunny's bar | 37 02 12 | 76 19 03 | 10 | –1,000 |
| 45 | 60E1 | Well #8 (Cederstrom, 1957)-Fort Monroe | 37 00 05 | 76 18 25 | 3 | –2,251 |
| 46 | 60E2 | Well #9 (Cederstrom, 1957) Old Point Comfort: Hotel Chamberlain | 37 00 03 | 76 18 40 | 4 | –941 |
| 47 | 60E3 | Well #24 (Cederstrom, 1957) North End Point | 37 06 30 | 76 17 25 | 3 | –1,169 |
| 48 | 55F20 | Well #2, Town of Claremont | 37 13 21 | 76 57 06 | 90 | –313 |
| 49 | -- | Well #4 (Cederstrom, 1945a) 1 mile west of Claremont | 37 14 20 | 76 58 32 | 17 | –270 |
| 50 | 56F16 | First Colony | 37 14 34 | 76 48 15 | 30 | –464 |
| 51 | 56F42 | Surry Court House #2 | 37 08 32 | 76 50 27 | 103 | –375 |
| 52 | -- | Well #26 (Cederstrom, 1957) Jamestown; 4-H Club | 37 13 41 | 76 47 28 | 10 | –265 |
| 53 | -- | Well #27a (Cederstrom, 1957) Jamestown | 37 13 57 | 76 47 32 | 33 | –287 |
| 54 | -- | Well #51 (Cederstrom, 1957) James City County: Williamsburg, Carolyn Tourist Court | 37 17 13 | 76 43 22 | 90 | –258 |
| 55 | -- | Jamestown Corehole (unpublished data, D.S. Powars, USGS) | 37 13 05 | 76 46 37 | 1 | –272 |
| 56 | 57F2 | York Public Utilities | 37 14 21 | 76 38 28 | 80 | –586 |
| 57 | 57F5 | Hog Island Nuclear Power Plant | 37 09 50 | 76 41 52 | 34 | –386 |
| 58 | 57F7 | Busch Gardens | 37 13 43 | 76 40 08 | 53 | –457 |
| 59 | 57F8 | Busch Gardens | 37 14 06 | 76 38 43 | 85 | –435 |
| 60 | 57F25 | Hog Island (unpublished data, T.S. Bruce, VDEQ and D.S. Powars, USGS) | 37 11 33 | 76 40 53 | 5 | –1,235 |
| 61 | 57F26 | VEPCO | 37 09 51 | 76 41 57 | 35 | –385 |
| 62 | 58F3 | Dow Badische (JC-T-11) (Brown and others, 1972) | 37 11 20 | 76 36 54 | 20 | –1,540 |
| 63 | 58F18 | US Naval Mine Depot (Magazine #8) = #35 (Cederstrom, 1957) = YK-T-6 (Brown and others, 1972) | 37 14 15 | 76 35 39 | 50 | –490 |
| 64 | 58F38 | Grove | 37 12 50 | 76 36 52 | 40 | –455 |
| 65 | 58F50 | Newport News Park 1 corehole (Meng and Harsh, 1988; unpublished data, T.S. Bruce, VDEQ and D.S. Powars, USGS) | 37 12 08 | 76 34 11 | 55 | –1,423 |
| 66 | 58F67 | Newport News Park 2 Corehole (unpublished data, T.S. Bruce, VDEQ and D.S. Powars, USGS) | 37 12 08 | 76 34 11 | 52 | –570 |
| 67 | 58F57 | City of Newport News Golf Course | 37 11 14 | 76 31 21 | 20 | –487 |
| 68 | 58F81 | LH-3-8 (Lee Hall Treatment Plant) (Russnow, Kane and Associates, Inc., 1995) | 37 10 01 | 76 33 16 | 35 | –1,315 |
| 69 | 58F82 | LH-3-7 (Upper Potomac monitor well) (Russnow, Kane and Associates, Inc., 1995) | 37 11 29 | 76 30 38 | 56 | –1,244 |

**Appendix 1A.** List of boreholes used in this report—Continued

[Altitudes are in feet; latitude and longitude are in degrees, minutes, and seconds; VDEQ, Virginia Department of Environmental Quality; VPI, Virginia Polytech Institute; VEPCO, Virginia Electric Power Company; --, local number not assigned]

| Borehole location number on plate 1 | Local number | Identifying name, owner, or organization, and some references | Latitude | Longitude | Surface altitude | Bottom altitude |
|---|---|---|---|---|---|---|
| 70 | 58F89 | LH-1 (Upper Potomac production well) (Russnow, Kane and Associates, Inc., 1997) | 37 10 41 | 76 35 17 | 30 | –1,120 |
| 71 | 58F91 | LH-2 (Middle Potomac production well) (Russnow, Kane and Associates, Inc., 1997) | 37 11 12 | 76 34 13 | 35 | –1,113 |
| 72 | 58F92 | LH-1 (Upper Potomac monitor well) (Russnow, Kane and Associates, Inc., 1997) | 37 10 41 | 76 35 17 | 40 | –560 |
| 73 | 58F127 | Virginia Peninsula Economic Development Council | 37 11 49 | 76 35 34 | 50 | –530 |
| 74 | 58F2 | Well #3 (Cederstrom, 1957) Lee Hall (Skiffes Creek) | 37 11 54 | 76 35 00 | 10 | –517 |
| 75 | 58F5 | Well #8 (Cederstrom, 1957) Lee Hall Reservoir | 37 10 09 | 76 33 17 | 15 | –455 |
| 76 | 58F6 | Well #17 (Cederstrom, 1957) | 37 08 42 | 76 34 09 | 7 | –440 |
| 77 | 58F7 | Well #20 (Cederstrom, 1957) | 37 09 08 | 76 34 35 | 31 | –512 |
| 78 | 58F8 | Well #21 (Cederstrom, 1957) | 37 09 19 | 76 35 04 | 34 | –658 |
| 79 | 58F9 | Well #22 (Cederstrom, 1957) | 37 09 40 | 76 34 50 | 37 | –513 |
| 80 | 58F10 | Well #23 (Cederstrom, 1957) | 37 08 23 | 76 34 50 | 10 | –455 |
| 81 | 58F11 | Well #29 (Cederstrom, 1957) | 37 08 32 | 76 30 15 | 30 | –462 |
| 82 | 58F13 | Well #39 (Cederstrom, 1957) | 37 13 36 | 76 30 33 | 50 | –722 |
| 83 | 59F1 | US Naval Supply Center (correlation to Yorktown Battlefield borehole; unpublished data, T.S. Bruce, VDEQ and D.S. Powars, USGS) | 37 13 04 | 76 29 19 | 50 | –396 |
| 84 | 59F2 | US Navy Tank Farm-York River | 37 12 51 | 76 27 08 | 10 | –440 |
| 85 | 59F3 | Well #30 Warwick County (Cederstrom, 1957) | 37 08 09 | 76 29 30 | 30 | –524 |
| 86 | -- | Well #41 York County (Cederstrom, 1957) | 37 11 58 | 76 28 13 | 51 | –431 |
| 87 | -- | Well #49 York County (Cederstrom, 1957) J. Levinson Subdivision | 37 08 45 | 76 29 41 | 80 | –355 |
| 88 | 63F50 | Kiptopeke Corehole (Powars and others, 1992; unpublished data, D.S Powars, USGS and T.S. Bruce, VDEQ) | 37 08 07 | 75 57 08 | 7 | –1,993 |
| 89 | 63F | Well #82 (Cederstrom, 1945b) Cape Charles, Phil. & Norfolk RR | 37 15 56 | 76 00 44 | 20 | –1,790 |
| 90 | 55G4 | Charles City County | 37 18 45 | 76 56 13 | 35 | –303 |
| 91 | 56G5 | Water James City Service Authority | 37 16 10 | 76 45 43 | 90 | –307 |
| 92 | 56G52 | Water James City Service Authority-Powhatan Enterprise | 37 16 25 | 76 46 20 | 90 | –220 |
| 93 | 56G73 | Powhatan Village Corporation-east of Chickahominy River | 37 16 04 | 76 52 24 | 32 | –414 |
| 94 | 56G57 | Powhatan Village Corporation | 37 21 45 | 76 49 32 | 84 | –726 |
| 95 | 56G65 | Water James City Service Authority | 37 21 48 | 76 46 10 | 100 | –736 |
| 96 | 56G68 | Water James City Service Authority | 37 18 37 | 76 47 41 | 109 | –742 |
| 97 | 56G69 | Water James City Service Authority | 37 22 01 | 76 46 17 | 112.5 | –188 |
| 98 | 56G72 | Water James City Service Authority | 37 21 48 | 76 46 10 | 100 | –200 |
| 99 | 57G1 | Eastern State Hospital | 37 17 49 | 76 44 18 | 90 | –501 |
| 100 | 57G20 | Carven Gardens | 37 15 02 | 76 39 24 | 90 | –501 |
| 101 | 57G21 | James River Estates | 37 15 38 | 76 40 06 | 80 | –422 |
| 102 | 57G22 | Ewell | 37 19 34 | 76 44 14 | 100 | –330 |
| 103 | 57G25 | Williamsburg Lodge | 37 16 05 | 76 42 03 | 70 | –430 |

**Appendix 1A.** List of boreholes used in this report—Continued

[Altitudes are in feet; latitude and longitude are in degrees, minutes, and seconds; VDEQ, Virginia Department of Environmental Quality; VPI, Virginia Polytech Institute; VEPCO, Virginia Electric Power Company; --, local number not assigned]

| Borehole location number on plate 1 | Local number | Identifying name, owner, or organization, and some references | Latitude | Longitude | Surface altitude | Bottom altitude |
|---|---|---|---|---|---|---|
| 104 | 57G30 | Williamsburg Motor House | 37 16 56 | 76 41 51 | 55 | –445 |
| 105 | 57G3 | Well #7 (Cederstrom, 1957) Camp Perry | 37 18 36 | 76 38 52 | 74 | –390 |
| 106 | 57G4 | Well #13 (Cederstrom, 1957) Camp Perry | 37 19 07 | 76 40 59 | 84 | –359 |
| 107 | 57G5 | Well #20 (Cederstrom, 1957) Camp Perry | 37 19 25 | 76 39 13 | 41 | –393 |
| 108 | 57G6 | Well #22 (Cederstrom, 1957) Waller Pond Housing Development | 37 18 07 | 76 42 08 | 10 | –458 |
| 109 | 57G7 | Well #23 (Cederstrom, 1957) Williamsburg | 37 17 53 | 76 40 31 | 25 | –340 |
| 110 | 57G8 | Well #24 (Cederstrom, 1957) Pennimen Fuel Depot, US Navy | 37 16 33 | 76 38 04 | 83 | –450 |
| 111 | 58G1 | Well #26 (Cederstrom, 1957) Pennimen Fuel Depot US Navy | 37 16 58 | 76 36 33 | 20 | –515 |
| 112 | 58G5 | GLO-P-1 (Brown and others, 1972) | 37 21 10 | 76 36 48 | 7 | –417 |
| 113 | 59G2 | Well #45 (Cederstrom, 1945b) Severn | 37 17 39 | 76 25 00 | 8 | –602 |
| 114 | 55H1 | City of Newport News | 37 24 28 | 76 56 15 | 10 | –768 |
| 115 | 55H6 | Southern Properties | 37 23 59 | 76 54 04 | 95 | –183 |
| 116 | 56H25 | James City County Research Station | 37 24 51 | 76 51 33 | 90 | –905 |
| 117 | 56H38 | Water James City Service Authority | 37 23 12 | 76 48 06 | 106 | –701 |
| 118 | 57H6 | Yorkview Plantation | 37 23 10 | 76 41 14 | 50 | –503 |
| 119 | 57H20 | West End Station | 37 26 21 | 76 40 42 | 10 | –914 |
| 120 | 58H4 | Gloucester (unpublished data, D.S. Powars, USGS and T.S. Bruce, VDEQ) | 37 23 31 | 76 31 26 | 75 | –1,775 |
| 121 | 60H1 | Well #46 (Cederstrom, 1945b) Mathews-Elkins Oil and Gas Co. | 37 25 55 | 76 19 18 | 7 | –2,318 |
| 122 | 56J5 | West Point-Chesapeake Corporation | 37 32 46 | 76 48 30 | 27 | –1,252 |
| 123 | 56J11 | West Point-Chesapeake Corporation | 37 31 26 | 76 45 41 | 15 | –1,255 |
| 124 | 57J3 | Chesapeake Corporation | 37 30 08 | 76 42 56 | 51 | –100 |
| 125 | 58J5 | Barnhardt Farms | 37 36 30 | 76 31 26 | 40 | –702 |
| 126 | 58J11 | Rappahannock Community College | 37 33 52 | 76 37 28 | 110 | –590 |
| 127 | 60J7 | Windmill Point Corehole (unpublished data, D.S. Powars, USGS) | 37 36 50 | 76 16 55 | 4 | –744 |
| 128 | 64J14 | Exmore Corehole (Powars and others, 1992; unpublished data, D.S. Powars, USGS) | 37 35 08 | 75 49 09 | 30 | –1,366 |
| 129 | 59K17 | West Irvington Well #2 | 37 39 41 | 76 25 48 | 15 | –655 |
| 130 | 59K19 | Town of Kilmarnock Well #3 | 37 42 12 | 76 23 09 | 65 | –707 |
| 131 | -- | Essex Mill Pond Corehole (unpublished data, D.S. Powars and L.W. Newell, USGS) | 37 52 30 | 76 51 04 | 11 | –214 |
| 132 | 60L2 | Well #21 (Cederstrom, 1945b) Reedsville | 37 50 07 | 76 17 02 | 5 | –865 |
| 133 | -- | Haynesville Corehole (Mixon, Berquist, and others, 1989) | 37 57 14 | 76 40 10 | 87 | –469 |
| 134 | -- | Clarks Mill Pond Corehole (unpublished data, D.S. Powars and L.W. Newell, USGS) | 37 55 52 | 76 28 05 | 46 | –299 |
| 135 | 66M23 | Jenkins Bridge Corehole (unpublished data, D.S. Powars, USGS and T.S. Bruce, VDEQ) | 37 56 10 | 75 36 18 | 6 | –1,314 |
| 136 | 66M1 | Taylor #1, Oil test well | 37 53 03 | 75 31 01 | 42 | –6,237 |
| 137 | 57G66 | Waller Mill Park | 37 18 59 | 76 42 02 | 70 | –435 |
| 138 | 57E3 | Well #40 (Cederstrom, 1945a) Bacons Castle Estate | 37 06 33 | 76 43 22 | 19 | –348 |
| 139 | 59C40 | VPI geothermal well #25 | 36 51 01 | 76 28 49 | 22 | –1,978 |

**Appendix 1B.** Altitudes of the tops of stratigraphic units

[Altitudes are in feet; ?, unit present, contact uncertain; --, unit not present; nd, no data available; ??, insufficient data; *, contact extrapolated from compilation of cross section *B*–*B*' shown on plate 3; Fm., Formation]

| Borehole location number on plate 1 | Potomac Fm. | Upper Cretaceous beds | Aquia Fm. | Marlboro Clay | Nanjemoy Fm. | Piney Point Fm. | Chesapeake Bay megablock beds | Exmore tsunami-breccia deposit | Chickahominy Fm. | Delmarva beds | Old Church Fm. | Calvert Fm. Newport News unit | Calvert Fm. | St. Marys Fm. | Eastover Fm. | Yorktown Fm. | Chowan River Fm. | Bacons Castle Fm. | Pleistocene beds | Holocene beds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | –560 | –308 | –289 | –273 | –269 | -- | -- | -- | -- | -- | -- | -- | -- | –167 | –27 | 15 | -- | -- | 33 | -- |
| 2 | –1,035 | –687 | –645 | –635 | –620 | -- | -- | -- | -- | –612 | -- | -- | –600 | –346 | –172 | –65 | –52 | -- | 15 | -- |
| 3 | –535 | –415 | ?–365 | ? | ? | -- | -- | -- | -- | nd | nd | nd | nd | nd | nd | nd | nd | -- | 15 | -- |
| 4 | –489 | –334 | ?? | ?? | ?? | -- | ?? | ?–295 | ?–285 | ? | ? | –271 | -- | ? | ? | ?–25 | nd | -- | 8 | -- |
| 6 | –526 | –407 | –386 | –378 | –367 | -- | -- | -- | -- | ? | ? | –349 | –330 | –186 | –45 | 6 | -- | -- | 21 | -- |
| 10 | –540 | –397 | –384 | –372 | –350 | -- | -- | -- | -- | -- | ?? | –339 | –325 | –186 | –43 | –23 | ?? | -- | 17 | -- |
| 14 | –1,110 | –859 | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ? | ? | ? | ? | ?? | -- | ? | ?? |
| 15 | –69 | -- | –42 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | –20 | 33 | 68 | -- | -- | -- | -- |
| 16 | –356 | ?–300 | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ?–218 | ? | ?–124 | ?–36 | ?18 | -- | -- | ?40 | -- |
| 18 | –310 | –280 | ? | ? | –230 | -- | -- | -- | -- | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| 19 | –468 | –276 | –255 | –246 | –208 | -- | -- | -- | -- | nd | ? | ?–191 | ? | –149 | –34 | 22 | -- | -- | -- | -- |
| 20 | –425 | –294 | –247 | –227 | –219 | -- | -- | ?? | ?? | ?? | ?? | ?–215 | ? | –144 | –40 | –4 | -- | -- | 35 | -- |
| 22 | –409 | –294 | –280 | –262 | –245 | -- | -- | ?? | ?? | ?? | ?–241 | ?–235 | ? | –182 | –43 | 15 | -- | -- | -- | -- |
| 23 | –297 | –272 | –247 | ? | ? | nd | ?? | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| 24 | –378 | –252 | ? | ? | ? | nd | ?? | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| 26 | –700 | -- | -- | -- | -- | -- | ?? | –574 | –410 | –392 | –378 | –368 | –323 | –228 | –35 | 12 | -- | -- | 30 | -- |
| 27 | –456 | ?–400 | ?? | ?? | ?? | ?? | ?? | ?? | ?–370 | ?? | ?? | ?? | ?? | ?–195 | ?–36 | 1 | -- | -- | 22 | -- |
| 29 | –694 | -- | -- | -- | -- | -- | ?? | –592 | –413 | ? | ? | –391 | ? | –238 | –84 | –22 | -- | -- | 12 | -- |
| 30 | –722 | -- | -- | -- | -- | -- | ?? | –592 | –467 | ? | ? | –401 | ? | ? | ? | –12 | -- | -- | 8 | -- |
| 31 | nd | -- | -- | -- | -- | -- | ?? | –769 | –654 | –623 | –613 | –603 | –540 | –240 | –85 | –15 | -- | -- | 5 | -- |
| 32 | nd | –524 | ?? | ?? | ?? | -- | ?? | ?–397 | –387 | ? | ? | –367 | ? | ? | ? | –7 | -- | -- | 10 | -- |
| 33 | –777 | –667 | -- | -- | -- | -- | ?? | ?–618 | –610 | ? | ? | ?–595 | ?–490 | ?–230 | ?–140 | –72 | -- | -- | 15 | -- |
| 34 | –775 | –695 | ? | ? | ? | -- | ?? | –675 | –625 | ? | ? | –615 | ? | ? | ? | ? | -- | -- | 10 | -- |
| 35 | –991 | –870 | -- | -- | -- | -- | ?? | ? | –830 | ? | ? | –810 | ?–508 | ? –290 | ? –160 | ? | nd | -- | nd | nd |
| 37 | –294 | ? | ? | ? | –225 | -- | -- | -- | -- | ? | ? | ?–214 | nd | nd | nd | nd | nd | nd | nd | nd |
| 38 | –290 | ? | ? | ? | –245 | nd | ?? | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| 39 | –283 | ? | –253 | ? | ? | nd | ?? | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| 40 | –334 | –250 | –231 | ? | ? | ? | -- | -- | -- | ? | –169 | –167 | -- | –105 | ?–18 | 49 | -- | -- | 70 | -- |
| 41 | –1,279 | -- | -- | -- | -- | -- | –1,077 | –735 | –585 | –520 | –467 | –438 | –390 | –210 | –67 | ?–4 | -- | -- | 9 | -- |
| 42 | –868 | -- | -- | -- | -- | -- | -868 | –671 | –519 | –459 | –423 | –409 | –357 | –219 | –70 | 2 | -- | -- | 15 | -- |
| 43 | nd | -- | -- | -- | -- | -- | nd | –765 | –612 | –510 | –469 | –440 | –412 | –201 | –69 | ? | -- | -- | 5 | -- |
| 44 | nd | -- | -- | -- | -- | -- | nd | –777 | –646 | –591 | –545 | –532 | –407 | –262 | –81 | ?4 | -- | -- | 10 | -- |
| 45 | ?? | -- | -- | -- | -- | -- | –1,457 | –837 | –637 | ?–628 | ?–618 | –607 | ?–400 | –292 | –95 | –47 | -- | -- | ?3 | ? |
| 47 | -- | -- | -- | -- | -- | -- | –1,077 | –917 | –737 | ? | –623 | –597 | –390* | –272 | –87 | –72 | -- | -- | ?3 | ? |
| 49 | –130 | -- | –95 | -- | ?–63 | -- | -- | -- | -- | -- | ?–45 | -- | -- | ?–13 | 17 | -- | -- | -- | -- | -- |

**Appendix 1B.** Altitudes of the tops of stratigraphic units—Continued

[Altitudes are in feet; ?, unit present, contact uncertain; --, unit not present; nd, no data available; ??, insufficient data; *, contact extrapolated from compilation of cross section *B–B'* shown on plate 3; Fm., Formation]

| Borehole location number on plate 1 | Potomac Fm. | Upper Cretaceous beds | Aquia Fm. | Marlboro Clay | Nanjemoy Fm. | Piney Point Fm. | Chesapeake Bay megablock beds | Exmore tsunamibreccia deposit | Chickahominy Fm. | Delmarva beds | Old Church Fm. | Calvert Fm. Newport News unit | Calvert Fm. | St. Marys Fm. | Eastover Fm. | Yorktown Fm. | Chowan River Fm. | Bacons Castle Fm. | Pleistocene beds | Holocene beds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | –258 | -- | –217 | –202 | –158 | –140 | -- | -- | -- | -- | –114 | –100 | ?94 | ?–57 | ?–30 | ?? | -- | -- | 30 | -- |
| 52 | –263 | -- | ? | ? | –160 | –135 | -- | -- | -- | -- | ? | –100 | nd | ? | ?10 | -- | -- | -- | nd | -- |
| 53 | –256 | -- | –218 | –206 | –165 | –149 | -- | -- | -- | -- | ?–136 | ?–120 | ?–117 | ?–57 | –22 | nd | -- | -- | 33 | -- |
| 54 | nd | nd | nd | nd | nd | ?–207 | -- | -- | -- | nd | nd | nd | nd | ? | ? | ? | -- | -- | ? | -- |
| 55 | –258 | -- | –217 | –203 | –159 | –152 | -- | -- | -- | -- | –139 | –120 | ?–115 | –55 | –24 | -- | -- | -- | –14 | 1 |
| 56 | –380 | -- | –320 | –302 | –256 | –244 | -- | -- | -- | –233 | –223 | –216 | –176 | –104 | 0 | 40 | -- | ?? | 80 | -- |
| 57 | –333 | -- | –270 | –254 | –212 | –205 | -- | -- | -- | –196 | –187 | –168 | ? –162 | –92 | –66 | -- | -- | -- | 34 | -- |
| 58 | –345 | -- | –301 | –287 | –237 | –227 | -- | -- | -- | –217 | –207 | –200 | –177 | –95 | 1 | 34 | -- | -- | 53 | -- |
| 59 | –352 | -- | –325 | –315 | –255 | –245 | -- | -- | -- | –235 | –215 | –208 | –172 | –99 | –3 | 42 | -- | ?? | 85 | -- |
| 60 | –330 | -- | –300 | –286 | –232 | –215 | -- | -- | -- | ? | –200 | –185 | –166 | –125 | ?? | -- | -- | -- | –15 | 5 |
| 62 | –437 | -- | -- | -- | -- | -- | -- | –344 | –291 | ? | –264 | –233 | –194 | –123 | –102 | -- | -- | -- | 20 | ? |
| 63 | –356 | -- | -- | -- | -- | -- | -- | –277 | –244 | –221 | –209 | –202 | –144 | –102 | 8 | 50 | -- | -- | ? | -- |
| 64 | –354 | -- | -- | -- | -- | -- | -- | –320 | –279 | –263 | –250 | –238 | –191 | –119 | –14 | 14 | -- | -- | 40 | -- |
| 66 | –411 | -- | -- | -- | -- | -- | -- | –357 | –323 | –308 | –293 | –279 | –216 | –127 | –19 | 25 | -- | -- | 52 | -- |
| 67 | nd | -- | -- | -- | -- | -- | nd | –460 | –404 | –379 | –360 | –333 | –250 | –160 | –44 | 2 | -- | -- | 20 | -- |
| 68 | –430 | -- | -- | -- | -- | -- | -- | –395 | –303 | ? | –285 | –279 | –225 | –125 | –25 | 35 | -- | -- | ? | -- |
| 69 | –1,094 | -- | -- | -- | -- | -- | ?–984 | –588 | –408 | –378 | –355 | –336 | –261 | –194 | –37 | 36 | -- | -- | 56 | -- |
| 70 | –462 | -- | -- | -- | -- | -- | -- | –381 | –312 | –286 | –264 | –255 | –205 | –112 | –17 | 30 | -- | -- | ? | -- |
| 71 | –480 | -- | -- | -- | -- | -- | -- | –369 | –308 | –295 | –285 | –274 | –209 | –119 | –25 | 35 | -- | -- | ? | -- |
| 73 | –382 | -- | -- | -- | -- | -- | -- | –332 | –293 | –274 | –261 | –252 | –200 | –130 | –22 | 30 | -- | -- | 50 | -- |
| 74 | –397 | -- | -- | -- | -- | -- | -- | –366 | –317 | ? | –282 | –276 | –200 | –142 | –20 | –10 | -- | -- | 10 | -- |
| 75 | –429 | -- | -- | -- | -- | -- | -- | –395 | –307 | ? | –296 | –287 | –215 | ? | –20 | 0 | -- | -- | 15 | -- |
| 76 | –430 | -- | -- | -- | -- | -- | -- | ? | ? | ? | –274 | –252 | ? | ? | ? | -- | -- | -- | 7 | -- |
| 77 | –429 | -- | -- | -- | -- | -- | -- | –364 | –324 | ? | –284 | –259 | ? | –134 | ? | –6 | -- | -- | 31 | -- |
| 78 | –576 | -- | -- | -- | -- | -- | -- | –352 | –321 | ? | ? | –262 | ? | –146 | –29 | –4 | -- | -- | 34 | -- |
| 79 | –438 | -- | -- | -- | -- | -- | -- | –354 | –294 | ? | ? | –274 | ? | ? | ? | 7 | -- | -- | 37 | -- |
| 80 | –405 | -- | -- | -- | -- | -- | -- | –372 | –329 | ? | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| 81 | nd | -- | -- | -- | -- | -- | nd | –395 | ?–360 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| 82 | nd | -- | -- | -- | -- | -- | nd | –524 | –375 | –362 | –350 | –315 | ? | –145 | ? –50 | 35 | -- | -- | 50 | -- |
| 83 | nd | nd | nd | nd | nd | nd | nd | nd | nd | ? | –365 | –356 | –248 | –158 | –22 | 42 | -- | nd | 50 | -- |
| 84 | nd | nd | nd | nd | nd | nd | nd | nd | –427 | –410 | –372 | –352 | –254 | –182 | –38 | ?–9 | -- | -- | 10 | -- |
| 85 | nd | -- | -- | -- | -- | -- | nd | –400 | –350 | ? | ? | ? | ? | –170 | ? | 18 | -- | -- | 30 | -- |
| 86 | nd | nd | nd | nd | nd | nd | nd | nd | –410 | –393 | –380 | –370 | –257* | –187* | –38* | 32* | ?? | -- | 51 | -- |
| 87 | ? | -- | -- | -- | -- | -- | nd | –300 | ?–215 | ? | ? | –190 | ? | ? | –15 | ? | -- | 80 | -- | -- |
| 88 | -- | -- | -- | -- | -- | -- | –1,700 | –1,279 | –1,077 | –1,063 | -- | ?–1,028 | –613 | –455 | –189 | –74 | –49 | -- | 7 | -- |

**Appendix 1B.** Altitudes of the tops of stratigraphic units—Continued

[Altitudes are in feet; ?, unit present, contact uncertain; --, unit not present; nd, no data available; ??, insufficient data; *, contact extrapolated from compilation of cross section *B–B'* shown on plate 3; Fm., Formation]

| Borehole location number on plate 1 | Potomac Fm. | Upper Cretaceous beds | Aquia Fm. | Marlboro Clay | Nanjemoy Fm. | Piney Point Fm. | Chesapeake Bay megablock beds | Exmore tsunami-breccia deposit | Chickahominy Fm. | Delmarva beds | Old Church Fm. | Calvert Fm. Newport News unit | Calvert Fm. | St. Marys Fm. | Eastover Fm. | Yorktown Fm. | Chowan River Fm. | Bacons Castle Fm. | Pleistocene beds | Holocene beds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 89 | -- | -- | -- | -- | -- | -- | ?–1,700 | –1,210 | –1,080 | ? | ? | ? | ? | ?–290 | ?–212 | ? | ? –26 | -- | 20 | -- |
| 92 | ? | -- | –184 | –174 | –144 | –120 | -- | -- | -- | ? | –110 | –95 | –86 | –54 | 50 | 70 | -- | 90 | -- | -- |
| 93 | –222 | -- | –177 | –165 | –120 | –103 | -- | -- | -- | -- | –85 | –64 | ?? | –33 | –12* | ? | -- | -- | ?32 | ? |
| 99 | –294 | -- | –265 | –248 | –192 | –180 | -- | -- | -- | –169 | –164 | –149 | –130 | –80 | 29 | 65 | -- | 90 | -- | -- |
| 100 | –370 | -- | –312 | –294 | –246 | –237 | -- | -- | -- | –224 | –216 | –206 | –166 | –94 | 8 | 48 | -- | 90 | -- | -- |
| 101 | –350 | -- | –318 | –303 | –225 | –217 | -- | -- | -- | –212 | –202 | –195 | –158 | –92 | 10 | 30 | -- | 80 | -- | -- |
| 102 | –288 | -- | –252 | –234 | –190 | –164 | -- | -- | -- | ? | –154 | –142 | –124 | –80 | 44 | 65 | -- | 100 | -- | -- |
| 103 | –317 | -- | –288 | –273 | –222 | –200 | -- | -- | -- | –190 | –186 | –181 | –155 | –94 | 8 | 46 | -- | -- | 70 | -- |
| 104 | –331 | -- | –295 | –275 | –224 | –210 | -- | -- | -- | –203 | –191 | –181 | –156 | –97 | 15 | 35 | -- | -- | 55 | -- |
| 105 | –352 | -- | –308 | –298 | ? –286 | –271 | -- | -- | -- | ? –236 | ? | ? | –160 | ? –66 | ? 14 | 39 | -- | 74 | -- | -- |
| 106 | –330 | -- | –296 | –276 | ? –235 | ? –234 | -- | -- | -- | ? | –201 | –186 | –156 | –31 | ? | 54 | -- | 84 | -- | - |
| 107 | –351 | -- | –305 | –303 | –264 | ? –246 | -- | -- | -- | ? | ? | ?–229 | –154 | –23 | ? 31 | -- | -- | -- | 41 | -- |
| 108 | –345 | -- | –290 | ? | ?–220 | ? | -- | -- | -- | ? | ? –188 | ? –170 | ? –137 | ? | ? | ? –20 | -- | -- | 10 | -- |
| 109 | –321 | -- | –300 | –280 | ? | ? | -- | -- | -- | ? | ? | ?–177 | ? | ? | ? | ? –25 | -- | -- | 25 | -- |
| 110 | –395 | -- | –332 | –317 | ? –290 | ? | -- | -- | -- | ? | ? –242 | ? | ? | ? | ? | 42 | -- | 83 | -- | -- |
| 111 | –420 | -- | nd | nd | nd | nd | -- | nd | nd | nd | nd | nd | nd | nd | nd | –10 | -- | -- | 20 | -- |
| 112 | –395 | -- | -- | -- | -- | -- | -- | ?–305 | –269 | ?–261 | ?–254 | ?–243 | ?–190 | ? –111 | ? –14 | ? | -- | -- | 7 | -- |
| 113 | nd | -- | -- | -- | -- | -- | nd | –567 | –432 | ? | ?–417 | ? | ? | ? | ? –62 | 0 | -- | -- | 8 | -- |
| 118 | –342 | -- | –298 | –280 | –222 | –210 | -- | -- | -- | –206 | –192 | –172 | –144 | –76 | 32 | ? | -- | -- | 50 | -- |
| 119 | –358 | -- | –314 | –305 | –180 | –175 | -- | -- | -- | ? | ? | –160 | ? | ? | –10 | -- | -- | -- | –20 | -- |
| 120 | ?–795 | -- | -- | -- | -- | -- | ?? | –545 | –395 | –365 | –345 | –325 | –235 | –145 | –9 | 48 | -- | -- | 75 | -- |
| 121 | ?–1,483 | -- | -- | -- | -- | -- | ?? | ? –858 | ?–583 | ? | ? | ? –483 | ? | ? | ? | ?2 | -- | -- | 7 | -- |
| 127 | –593 | -- | -- | -- | -- | -- | ?–573 | –514 | –448 | ? | –438 | –429 | –222 | –163 | –92 | ? | -- | -- | ? | 4 |
| 128 | nd | -- | -- | -- | -- | -- | nd | –1,179 | –1,080 | –1,039 | –995 | ?–986 | –477 | –296 | –151 | -- | -- | -- | 30 | -- |
| 131 | nd | nd | nd | nd | –169 | –118 | -- | -- | -- | -- | -92 | -- | –5 | 12 | -- | -- | -- | -- | -- | -- |
| 133 | –450 | -- | –331 | –330 | –240 | –185 | -- | -- | -- | -- | –181 | -- | –49 | –12 | 43 | 87 | -- | -- | -- | -- |
| 134 | nd | nd | nd | nd | nd | ? | -- | -- | -- | -- | –250 | -- | –93 | ? | ? | -- | -- | -- | -- | -- |
| 135 | –1,292 | –1,173 | ? | ? | ?–1,144 | -- | -- | ?–1,144 | ?–1,106 | –1,058 | –1,030 | ? | –486 | –334 | –144 | –22 | -- | -- | 6 | -- |
| 137 | –318 | -- | –270 | –260 | –214 | –203 | -- | -- | -- | –198 | –181 | –170 | –143 | –88 | 16 | 36 | -- | 70 | -- | -- |
| 138 | –316 | –296 | –266 | ? | ? | -- | -- | -- | -- | ? | ? | ? | -- | ? | ? | 19 | -- | -- | -- | -- |
| 139 | ? | –398 | ?? | ?? | ? –338 | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ?? | ?? | -- | ?22 | -- |

**Appendix 2.** Selected lithic logs from Cederstrom (1945a, 1957) and this report's stratigraphic reinterpretations of portions of these logs

| Drillers' log Altitude, 7 feet | Thickness (feet) | Depth (feet) | This report's interpretation |
|---|---|---|---|
| **Well no. 46. (Cederstrom, 1945a) Mathews, Mathews County, Elkins Oil and Gas Co. Borehole location #121 on plate 1; GWSI #60H1.** | | | |
| Columbia Group: | | | Pleistocene |
| Sand and surface soil | 5 | 5 | |
| Chesapeake Group: | | | Pliocene and Miocene undivided |
| Sand | 78 | 83 | |
| Sand and shell | 16 | 99 | |
| Shell | 1 | 100 | |
| Sand and shell | 100 | 200 | |
| Shale | 10 | 210 | |
| Sand | 20 | 230 | |
| Gummy shale | 170 | 400 | |
| Sticky shale | 90 | 490 | –483 = top lower Miocene and Oligocene undivided |
| Driller reports sand; cored sample is gray shell marl containing minor glauconite, fish bones, and pyrite | 10 | 500 | |
| Sand and gravel | 60 | 560 | |
| Pamunkey Group: | | | |
| Sand, shell, and boulders | 30 | 590 | –583 = top Chickahominy Formation (upper Eocene) |
| Sandy shale | 5 | 595 | |
| Gumbo | 205 | 800 | |
| Shale | 10 | 810 | |
| Gummy shale | 55 | 865 | –858 = top of Exmore tsunami-breccia (upper Eocene) |
| Green glauconitic quartz sand | 7 | 872 | |
| Hard sand and pyrites | 1 | 873 | |
| Green sand | 5 | 878 | |
| Sand | 3 | 881 | |
| Gumbo | 14 | 895 | |
| Coarse glauconitic quartz sand | 7 | 902 | |
| Sand | 8 | 910 | |
| Gumbo | 7 | 917 | |
| Sand | 118 | 1,035 | |
| Shale | 15 | 1,050 | |
| Sand | 35 | 1,085 | |
| Shale | 5 | 1,090 | |
| Shale and sand | 20 | 1,110 | |
| Driller reports sand; core is light-green glauconite in limy matrix | 12 | 1,122 | |
| Gumbo | 38 | 1,160 | |
| Sand | 5 | 1,175 | |
| Gumbo | 40 | 1,215 | |
| Shell and black sand | 5 | 1,220 | |
| Sandy shale and shell | 60 | 1,280 | |

**Appendix 2.** Selected lithic logs from Cederstrom (1945a, 1957) and this report's stratigraphic reinterpretations of portions of these logs—Continued

| Drillers' log Altitude, 7 feet | Thickness (feet) | Depth (feet) | This report's interpretation |
|---|---|---|---|
| **Well no. 46. (Cederstrom, 1945a) Mathews, Mathews County, Elkins Oil and Gas Co. Borehole location #121 on plate 1; GWSI #60H1—Continued** | | | |
| Pamunkey Group—Continued: | | | |
| Gumbo | 54 | 1,334 | |
| Sand | 1 | 1,335 | |
| Sand, trace of glauconite | 75 | 1,410 | |
| Shale | 78 | 1,488 | |
| Sand | 2 | 1,490 | –1,483 = top of CBIC megablock beds (? upper Eocene) |
| Potomac Group: | | | |
| Red gumbo | 62 | 1,552 | |
| Sand | 118 | 1,670 | |
| Red shale, sticky | 10 | 1,680 | |
| Sand | 125 | 1,805 | |
| Shale | 65 | 1,870 | |
| Salt water and sand | 40 | 1,910 | |
| Sand | 20 | 1,930 | |
| Shale | 15 | 1,945 | |
| Salt water and sand | 5 | 1,950 | |
| Sand | 75 | 2,025 | |
| Shale | 40 | 2,065 | |
| Sand | 20 | 2,085 | |
| Sand and gravel | 90 | 2,175 | |
| Sand | 35 | 2,210 | |
| Sandy chalk | 16 | 2,236 | |
| Sand and shale | 4 | 2,240 | |
| Sand and gravel | 67 | 2,307 | –2,300 = top of crystalline basement |
| Precambrian (?): | | | |
| Rock | 6 | 2,313 | |
| Red and green rock | 5 | 2,318 | |
| Broken rock and shale | 2 | 2,320 | |
| Granite | 5 | 2,325 | |
| **Well no. 79. (Cederstrom, 1945a) Well no. 44. (Cederstrom, 1957) Newport News, Virginia Public Service Company, Gas Works Borehole location #29 on plate 1; GWSI #59D4. Log by Layne-Atlantic Co. and D.J. Cederstrom. Well drilled by the Layne-Atlantic Co. Foraminifera determined by J.A. Cushman. Log to 372 feet from cuttings collected by the Layne-Atlantic Co.; below 372 feet the well was logged by D.J. Cederstrom. Altitude, 12 feet** | | | |
| Columbia Group: | | | |
| Sand, fine, clayey | 34 | 34 | –27 = Pleistocene/Pliocene contact |
| Chesapeake Group: | | | |
| Sand, fine, clayey | 30 | 64 | Yorktown Formation (Pliocene) |
| Shelly marl, very sandy, gray | 32 | 96 | –89 = top of Eastover Formation (upper Miocene) |
| Sand, fine, gray | 30 | 126 | |
| Shelly marl, slightly sandy, gray | 30 | 156 | |
| Shelly marl, sandy, gray | 10 | 166 | |
| Sand and shells | 24 | 190 | |

**Appendix 2.** Selected lithic logs from Cederstrom (1945a, 1957) and this report's stratigraphic reinterpretations of portions of these logs—Continued

| Drillers' log Altitude, 7 feet | Thickness (feet) | Depth (feet) | This report's interpretation |
|---|---|---|---|
| **Well no. 79. (Cederstrom, 1945a) Well no. 44. (Cederstrom, 1957) Newport News, Virginia Public Service Company, Gas Works Borehole location #29 on plate 1; GWSI #59D4. Log by Layne-Atlantic Co. and D.J. Cederstrom. Well drilled by the Layne-Atlantic Co. Foraminifera determined by J.A. Cushman. Log to 372 feet from cuttings collected by the Layne-Atlantic Co.; below 372 feet the well was logged by D.J. Cederstrom. Altitude, 12 feet—Continued** | | | |
| Chesapeake Group—Continued: | | | |
| Clay, sandy, gray | 30 | 220 | |
| Shelly marl | 30 | 250 | –243 = top of St. Marys Formation (upper Miocene) |
| Clay, dark-gray | 92 | 342 | |
| Clay, tough, gray | 30 | 372 | (? Calvert Formation) |
| Clay, slightly glauconitic, gray | 31 | 403 | –396 = top of lower Miocene and Oligocene |
| Pamunkey Group (Cederstrom, 1945a) | | | |
| Chickahominy Formation (Eocene) (Cederstrom, 1957): | | | |
| Sand, medium- to fine-grained glauconite, quartz; water | 22 | 425 | –418 = top of Chickahominy Formation (upper Eocene) |
| Clay, glauconitic, gray | 78 | 503 | |
| Mattaponi Formation (Upper Cretaceous and Paleocene): | | | |
| Clay, glauconitic, gray; Nanjemoy foraminifera | 67 | 570 | |
| Clay, slightly glauconitic, gray; drills rather slowly | 34 | 604 | –597 = top of Exmore tsunami-breccia (upper Eocene) |
| Clay, sandy, gray; grades down to hard-packed glauconitic sand; Aquia (?) foraminifera | 40 | 644 | |
| Alternating streaks of glauconite and quartz sand and soft mottled (pink, brown, green) clay | 31 | 675 | |
| Sand, glauconitic quartz; contains about 35 percent mottled clay | 10 | 685 | |
| Clay, mottled; contains about 35 percent glauconitic quartz sand | 21 | 706 | –699 = top of Potomac Formation (Lower Cretaceous) |
| Clay, mottled; with streaks of more sandy clay | 31 | 737 | |
| Clay, mottled; drills very slowly | 23 | 760 | |
| Clay, sandy, mottled | 26 | 786 | |
| Sand, quartz, medium-grained, gray, slightly glauconitic; water | 18 | 804 | |
| Sand, slightly clayey | 4 | 808 | |
| Sand, quartz, medium-grained; contains very little clay, water | 27 | 835 | |
| Clay, sandy | 2 | 837 | |
| Sand; water | 2 | 839 | |
| Clay, slightly sandy, green | 14 | 853 | |
| Clay; drills very slowly | 5 | 858 | |

**Appendix 2.** Selected lithic logs from Cederstrom (1945a, 1957) and this report's stratigraphic reinterpretations of portions of these logs—Continued

| Drillers' log Altitude, 7 feet | Thickness (feet) | Depth (feet) | This report's interpretation |
|---|---|---|---|
| Sand, gray, slightly glauconitic, medium-grained; water | 14 | 872 | |
| **Well no. 79. (Cederstrom, 1945a) Well no. 44. (Cederstrom, 1957) Newport News, Virginia Public Service Company, Gas Works Borehole location #29 on plate 1; GWSI #59D4. Log by Layne-Atlantic Co. and D.J. Cederstrom. Well drilled by the Layne-Atlantic Co. Foraminifera determined by J.A. Cushman. Log to 372 feet from cuttings collected by the Layne-Atlantic Co.; below 372 feet the well was logged by D.J. Cederstrom. Altitude, 12 feet—Continued** | | | |
| Mattaponi Formation (Upper Cretaceous and Paleocene)—Continued: | | | |
| Clay, sandy | 39 | 911 | |
| Sand, loose; contains thin streaks of clay; good water-bearing formation | 18 | 929 | |
| Sand, quartz, clayey, slightly glauconitic | 10 | 939 | |
| Clay | 9 | 948 | |
| Sand, quartz, slightly glauconitic medium-grained; water | 3 | 951 | |
| Clay, mottled (pink, brown, green) | 4 | 955 | |
| Sand, medium-grained; water | 4 | 959 | |
| Sand, clayey, slightly glauconitic | 9 | 968 | |
| Sand, medium-grained; contains traces of glauconite and clay; water | 21 | 989 | |
| Sand, clayey | 9 | 998 | |
| Sand, loose; with thin clay streaks; water | 12 | 1,010 | |
| Clay, hard; drills very slowly | 3 | 1,013 | |
| Sand, quartz, gray, medium-grained; trace of glauconite; water | 22 | 1,035 | |
| Sand, slightly clayey | 10 | 1,045 | |
| Sand, trace of glauconite, coarse at 1,082 feet; water | 37 | 1,082 | |
| **Well no. 81. (Cederstrom, 1945a) Well no. 8c. (Cederstrom, 1957) Fort Monroe, Elizabeth City County, U.S. Army. Borehole location #45 on plate 1; GWSI #60E1. (Log originally from Folio 8, U.S. Geological Survey) Altitude, 3 feet** | | | |
| Columbia Group: | | | |
| Sand | 50 | 50 | –43 = Pleistocene/Pliocene contact |
| Chesapeake Group: | | | |
| Clay | 40 | 90 | Yorktown Formation (Pliocene) |
| Sand, gray | 40 | 130 | –123 = top of Eastover Formation (upper Miocene) |
| Clay | 30 | 160 | |
| Sand | 25 | 185 | |
| Clay, sandy | 25 | 210 | |
| Clay | 30 | 240 | |
| Sand | 15 | 255 | |
| Rock and boulders | 20 | 275 | |
| Sand; water | 20 | 295 | |
| Clay | 230 | 525 | –518 = top of St. Marys Formation (upper Miocene) |
| Clay and sand; forams | 85 | 610 | –603 = top of lower Miocene and Oligocene |

**Appendix 2.** Selected lithic logs from Cederstrom (1945a, 1957) and this report's stratigraphic reinterpretations of portions of these logs—Continued

| Drillers' log Altitude, 7 feet | Thickness (feet) | Depth (feet) | This report's interpretation |
|---|---|---|---|
| **Well no. 81. (Cederstrom, 1945a) Well no. 8c. (Cederstrom, 1957) Fort Monroe, Elizabeth City County, U.S. Army. Borehole location #45 on plate 1; GWSI #60E1. (Log originally from Folio 8, U.S. Geological Survey) Altitude, 3 feet—Continued** | | | |
| Pamunkey Group (Cederstrom, 1945a): | | | |
| Chickahominy Formation (Eocene) (Cederstrom, 1957) | | | |
| Sand and boulders; Eocene forams; water | 30 | 640 | –633 = top of Chickahominy Formation |
| Clay, glauconitic and pyritic; Eocene at forams; residue of sample at 698 ft contains glauconite and pyrite782 to 784 feet much glauconite, at 835 feet quartz with less glauconite and some pyrite | 200 | 840 | –833 = top of Exmore tsunami-breccia (upper Eocene) |
| Clay and gravel; washed residue of sample at 863 to 877 feet contains some glauconite and pyrite, at 877 feet some glauconite, at 885 feet residue largely glauconite, at 890 feet and 900 feet quartz and less glauconite | 80 | 921 | |
| Sand, gravel, and boulders | 25 | 945 | |
| Clay | 35 | 980 | |
| Sand; water | 5 | 985 | |
| Clay; residue of samples taken at 1,020 to 1,030 feet contains about 3 percent glauconite; at 1,050 to 1,058 feet about 20 percent glauconite | 105 | 1,090 | |
| Boulders | 5 | 1,095 | |
| Sand and clay | 30 | 1,125 | |
| Boulders | 5 | 1,130 | |
| Sand and clay; residue contains 3 percent glauconite | 20 | 1,150 | |
| Sandstone | 5 | 1,155 | |
| Sand and clay; trace of glauconite | 25 | 1,180 | |
| Clay and small gravel; residue contains about 20 percent glauconite | 20 | 1,200 | |
| Sand | 18 | 1,218 | |
| Sand and clay | 2 | 1,220 | |
| Hard sand | 30 | 1,250 | |
| Sand with some clay and boulders | 5 | 1,255 | |
| Sand, gravel, and boulders; sample at 1,280 feet contains trace of glauconite | 65 | 1,320 | |
| Potomac Group (Lower and Upper Cretaceous) (Cederstrom, 1957): | | | |
| Sand and clay | 45 | 1,365 | |
| Sand, mostly coarse, with some clay; at 1386 feet residue contains quartz, feldspar and minor glauconite, pyrite and rock; at 1,435 feet quartz, feldspar and 1 percent glauconite; Eocene forams | 70 | 1,435 | |

**Appendix 2.** Selected lithic logs from Cederstrom (1945a, 1957) and this report's stratigraphic reinterpretations of portions of these logs—Continued

| Drillers' log Altitude, 7 feet | Thickness (feet) | Depth (feet) | This report's interpretation |
|---|---|---|---|
| **Well no. 81. (Cederstrom, 1945a) Well no. 8c. (Cederstrom, 1957) Fort Monroe, Elizabeth City County, U.S. Army. Borehole location #45 on plate 1; GWSI #60E1. (Log originally from Folio 8, U.S. Geological Survey) Altitude, 3 feet—Continued** | | | |
| Potomac Group (Lower and Upper Cretaceous) (Cederstrom, 1957)—Continued: | | | |
| Clay, red; and sand; residue contains quartz, mica and trace of glauconite; Eocene forams and macrofossils | 5 | 1,440 | –1,437 = top of CBIC megablock beds (upper Eocene) |
| Potomac Group (Cederstrom, 1945a): | | | |
| Sand, coarse, trace of glauconite; water | 98 | 1,538 | |
| Clay | 20 | 1,558 | |
| Clay and sand | 17 | 1,575 | |
| Sand, coarse | 45 | 1,620 | |
| Sand and clay; water at 1,630 feet | 100 | 1,720 | |
| Sand and boulders | 10 | 1,730 | |
| Clay | 20 | 1,750 | |
| Sand | 50 | 1,800 | |
| Sand and clay | 20 | 1,820 | |
| Sand and pebbles | 10 | 1,830 | |
| Clay and white sand | 50 | 1,880 | |
| Sand with minor amount of clay; water at 1,915 feet and 1945 feet | 120 | 2,000 | |
| Sand, coarse | 60 | 2,060 | |
| Clay | 5 | 2,065 | |
| Sand, coarse | 115 | 2,180 | |
| Clay | 66 | 2,246 | –2,251 = top of crystalline basement |
| Precambrian (?) : | | | |
| Rock, crystalline | 8 | 2,254 | |
| **Well no. 82. (Cederstrom, 1945a) Cape Charles, Northampton County, New York, Philadelphia and Norfolk Railroad Company. Borehole location #89 on plate 1. Geologic boundaries are only Cederstrom's interpretations and were not based on a study of well cuttings or other data. Altitude, about 20 feet** | | | |
| Columbia Group: | | | |
| Clay, sandy, soft, yellow | 40 | 40 | |
| Sand, soft, yellow | 6 | 46 | –26 = Pleistocene/Pliocene contact |
| Chesapeake Group: | | | |
| Clay, soft, dark-gray | 54 | 100 | |
| Marl, soft, greenish | 45 | 145 | |
| Sand, soft, dark-gray | 17 | 162 | |
| Clay, soft, blue | 13 | 175 | |
| Marl, soft, green | 12 | 187 | |
| Sand, soft, gray | 2 | 189 | |
| Clay, soft, gray | 15 | 204 | |
| Sand, loose, glauconitic, quartz | 28 | 232 | –212 = ? top Eastover Formation (upper Miocene) |
| Clay, soft, green | 6 | 238 | |
| Shells, soft rock | 1 | 239 | |
| Sand, loose, gray | 39 | 278 | |
| Clay, soft, dark-gray | 3 | 281 | |

**Appendix 2.** Selected lithic logs from Cederstrom (1945a, 1957) and this report's stratigraphic reinterpretations of portions of these logs—Continued

| Drillers' log<br>Altitude, 7 feet | Thickness<br>(feet) | Depth<br>(feet) | This report's interpretation |
|---|---|---|---|
| **Well no. 82. (Cederstrom, 1945a) Cape Charles, Northampton County, New York, Philadelphia and Norfolk Railroad Company. Borehole location #89 on plate 1. Geologic boundaries are only Cederstrom's interpretations and were not based on a study of well cuttings or other data. Altitude, about 20 feet—Continued** | | | |
| Chesapeake Group—Continued: | | | |
| Sand, soft, dark-gray | 39 | 310 | –290 = ? top of St Marys Formation (upper Miocene) |
| Clay, soft, lead-colored | 70 | 380 | |
| Clay, sticky, light-green | 95 | 475 | |
| Clay, soft, dark-green | 20 | 495 | |
| Clay, rather tough, dark-green | 395 | 890 | –870 = ? near top of lower Miocene |
| Pamunkey Group: | | | |
| Clay, green with black specks | 60 | 950 | |
| Clay, soft and hard layers, light-green | 150 | 1,100 | –1,080 = top of Chickahominy Formation (upper Eocene) |
| Clay, gray | 32 | 1,132 | |
| Clay, soft, gray | 16 | 1,148 | |
| Clay, hard and soft layers, gray | 17 | 1,165 | |
| Sand, compact, greenish | 65 | 1,230 | –1,210 = top of Exmore tsunami-breccia (upper Eocene) |
| Rock, sandy, hard, gray | 7 | 1,237 | |
| Sand and gravel, compact, gray | 13 | 1,250 | |
| Mixed brown and gray sandy clay, hard and soft layers | 20 | 1,270 | |
| Sand, hard, green | 49 | 1,319 | |
| Sand, gravel and clay mixed, hard and soft layers | 12 | 1,331 | |
| Mottled clay, sand and gravel, hard and soft layers | 254 | 1,585 | -1,565 = ? top of CBIC megablock beds (upper Eocene) |
| Clay, sandy, hard, green | 22 | 1,607 | |
| Clay, sandy, pale-pink | 73 | 1,680 | |
| Clay, gray, with crusts of sandstone | 60 | 1,740 | |
| Potomac Group: | | | |
| Clay, sticky, reddish-brown, no sand | 70 | 1,810 | |

**Appendix 3.** Seismic field data and digital processing information

| | | | | |
|---|---|---|---|---|
| | FIELD DATA | | | |
| Recorded by | Teledyne Exploration party 724 | | | |
| Date | October 1986 | | | |
| Instruments | DFS IV | | | |
| Filter | 08-128 Hertz | | | |
| No. of channels | 96 | | | |
| Record length | 6.0 seconds | | | |
| Sample rate | 2 milliseconds | | | |
| Sample array | 410–4,305 feet | | | |
| Shotpoint interval | 82 feet | | | |
| Group interval | 41 feet | | | |
| Energy source | 6 air guns (984 cubic inches, 2,000 pounds per square inch) | | | |
| | DIGITAL PROCESSING INFORMATION | | | |
| Date processed | December 1986 | | | |
| Sample rate | 4 milliseconds | | | |
| Datum plane | Sea level | | | |
| Stack mutes | Time | 0.05 second | Distance | 431 feet |
| | Time | 0.05 second | Distance | 595 feet |
| | Time | 0.70 second | Distance | 4,285 feet |
| Data Reduction Sequence | | | | |
| 1. Gain recovery | | | | |
| 3. Divergence correction | | | | |
| 4. Deconvolution | | | | |
| Operator length (1) | 256 milliseconds | | | |
| Prediction length (1) | 4 milliseconds | | | |
| Correlation Gate (2) | 0.5–2.5 seconds | Distance | 431 feet | |
| Correlation Gate (2) | 1.0–2.8 seconds | Distance | 4,285 feet | |
| Band limit (1) | out-out | Time | Correlation Gates | |
| Operator length (2) | 256 milliseconds | | | |
| Prediction length (2) | 4 milliseconds | | | |
| Correlation Gate (2) | 0.5–2.5 seconds | Distance | 431 feet | |
| Correlation Gate (2) | 1.0–2.8 seconds | Distance | 4,285 feet | |
| Band limit (1) | out-out | Time | Correlation Gates | |
| 5. Velocity analysis | | | | |
| 6. Normal moveout | | | | |
| 7. Stack | 48 Fold CDP (common depth point) | | | |
| 10. Digital filter | | | | |
| Band limit | 15–60 Hertz | Time | 0.0–6.0 seconds | |
| Program gain | | | | |
| 9. Migration | 97-percent velocity adjustment | | | |
| Amplitude enhancement | | | | |
| Signature processing | | | | |
| 2. Other | 2 trace composite | | | |
| 8. Other | Post stack deconvolution | | | |

Remarks: 128 traces per mile; a positive reflection coefficient is a negative number on tape and is displayed as a peak.

**Appendix 4a.** Calcareous nannofossil occurrences in the Jamestown core, with age and formation correlation (L.M. Bybell)

[X, present; (.), not present; 1, 1 specimen observed; ?, possibly present; ??, very questionably present; depth of sample is in feet; Abundance: C, common or 1-10 specimens per field of view at X640; F = frequent or 1 specimen per 1-10 fields of view at X640; R, rare or 1 specimen per more than 20 fields of view at X640; B, barren of calcareous nannofossils; Preservation: F = fair; P = poor]

| Species[1,2] | Formation | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Potomac | Aquia | Aquia | Aquia | Nanjemoy | Nanjemoy | Nanjemoy | Nanjemoy | Piney Point | Old Church | Calvert | Calvert | Calvert | St. Marys |
| | Age | | | | | | | | | | | | | |
| | ?? | ?? | late Paleocene | late Paleocene | early Eocene | early Eocene | early Eocene | early Eocene | middle Eocene | late Oligocene-early Miocene | early Miocene | early Miocene | early Miocene | ?? |
| | Calcareous nannofossil zone | | | | | | | | | | | | | |
| | BARREN | BARREN | NP 8 | NP 9 | NP 10 | NP 12-14 | NP 12-14 | NP 12-14 | NP 16? | ?? | NN 2-3 | NN 2-3 | NN 2-4 | BARREN |
| | Depth | | | | | | | | | | | | | |
| | 273.7 | 255.9 | 241.5 | 220 | 201.8 | 196.2 | 186.6 | 168.8 | 157 | 149.3 | 137.1 | 128.3 | 121.3 | 105.1 |
| *Braarudosphaera bigelowii* | . | . | . | . | . | . | . | . | . | X | . | . | X | . |
| *Cepekiella lumina* | . | . | . | . | . | . | . | X | . | . | . | . | . | . |
| *Chiasmolithus bidens* | . | . | X | X | . | X | X | X | X | . | . | . | . | . |
| *Coccolithus eopelagicus* | . | . | . | . | . | . | X | . | . | . | X | . | . | . |
| *Coccolithus pelagicus* | . | . | X | X | . | . | X | X | X | X | . | X | X | . |
| *Cribrocentrum reticulatum* | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . |
| *Cruciplacolithus tenuis* | . | . | ? | . | . | . | . | . | . | . | . | . | . | . |
| *Cyclococcolithus formosus* | . | . | . | . | . | . | X | X | X | . | . | . | . | . |
| *Cyclococcolithus leptoporus* | . | . | . | . | . | . | . | . | . | . | . | . | X | . |
| *Discoaster barbadiensis* | . | . | . | . | . | . | . | X | . | . | . | . | . | . |
| *Discoaster lenticularis* | . | . | . | . | X | . | . | . | . | . | . | . | . | . |
| *Discoaster deflandrei* | . | . | . | . | . | . | . | X | . | . | X | . | . | . |
| *Discoaster druggii* | . | . | . | . | . | . | . | . | . | . | . | X | . | . |
| *Discoaster kuepperi* | . | . | . | . | . | . | X | ? | . | . | . | . | . | . |
| *Discoaster lodoensis* | . | . | . | . | . | . | X | 1 | . | . | . | . | . | . |
| *Discoaster multiradiatus* | . | . | . | X | . | . | . | . | . | . | . | . | . | . |
| *Discoaster woodringii* | . | . | . | . | . | . | . | . | . | X | . | X | ? | . |
| *Ellipsolithus distichus* | . | . | . | X | . | . | . | . | . | . | . | . | . | . |
| *Ericsonia subpertusa* | . | . | X | . | X | . | . | . | . | . | . | . | . | . |
| *Fasciculithus tympaniformis* | . | . | X | . | . | . | . | . | . | . | . | . | . | . |
| *Helicosphaera ampliaperta* | . | . | . | . | . | . | . | . | . | . | X | X | X | . |
| *Helicosphaera carteri* | . | . | . | . | . | . | . | . | . | . | . | . | X | . |

**Appendix 4a.** Calcareous nannofossil occurrences in the Jamestown core, with age and formation correlation (L.M. Bybell)—Continued

[X, present; (.), not present; 1, 1 specimen observed; ?, possibly present; ??, very questionably present; depth of sample is in feet; Abundance: C, common or 1-10 specimens per field of view at X640; F = frequent or 1 specimen per 1-10 fields of view at X640; R, rare or 1 specimen per more than 20 fields of view at X640; B, barren of calcareous nannofossils; Preservation: F = fair; P = poor]

| Species[1,2] | Formation | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Potomac | Aquia | Aquia | Aquia | Nanjemoy | Nanjemoy | Nanjemoy | Nanjemoy | Piney Point | Old Church | Calvert | Calvert | Calvert | St. Marys |
| | Age | | | | | | | | | | | | | |
| | ?? | ?? | late Paleocene | late Paleocene | early Eocene | early Eocene | early Eocene | early Eocene | middle Eocene | late Oligocene-early Miocene | early Miocene | early Miocene | early Miocene | ?? |
| | Calcareous nannofossil zone | | | | | | | | | | | | | |
| | BARREN | BARREN | NP 8 | NP 9 | NP 10 | NP 12-14 | NP 12-14 | NP 12-14 | NP 16? | ?? | NN 2-3 | NN 2-3 | NN 2-4 | BARREN |
| | Depth | | | | | | | | | | | | | |
| | 273.7 | 255.9 | 241.5 | 220 | 201.8 | 196.2 | 186.6 | 168.8 | 157 | 149.3 | 137.1 | 128.3 | 121.3 | 105.1 |
| *Helicosphaera intermedia* | . | . | . | . | . | . | . | . | . | X | . | . | . | . |
| *Helicosphaera lophota* | . | . | . | . | . | . | . | X | . | . | . | . | . | . |
| *Helicosphaera seminulum* | . | . | . | . | . | . | . | X | . | . | . | . | . | . |
| *Heliolithus riedelii* | . | . | X | . | . | . | . | . | . | . | . | . | . | . |
| *Hornibrookina arca* | . | . | . | X | . | . | . | . | . | . | . | . | . | . |
| *Lithostromation operosum* | . | . | . | . | . | . | . | . | X | . | . | . | X | . |
| *Lophodolithus nascens* | . | . | . | . | . | . | X | . | . | . | . | . | . | . |
| *Markalius inversus* | . | . | . | . | . | . | . | X | . | . | . | . | . | . |
| *Markalius* sp. | . | . | X | . | . | . | . | . | . | . | . | . | . | . |
| *Nannotetrina alata* | . | . | . | . | . | . | . | ?? | . | . | . | . | . | . |
| *Neochiastozygus concinnus* | . | . | X | X | . | . | . | . | . | . | . | . | . | . |
| *Neococcolithes dubius* | . | . | . | . | . | . | X | X | . | . | . | . | . | . |
| *Neococcolithes* spp. | . | . | . | . | . | . | . | . | X | . | . | . | X | . |
| *Pemma rotundum* | . | . | . | . | . | . | . | . | ? | . | . | . | . | . |
| *Placozygus sigmoides* | . | . | X | . | . | . | . | . | . | . | . | . | . | . |
| *Pontosphaera multipora* | . | . | . | . | . | . | . | X | . | ? | . | X | . | . |
| *Pontosphaera* spp. | . | . | . | . | . | . | X | . | . | . | . | . | . | . |
| *Reticulofenestra abisecta* | . | . | . | . | . | . | . | . | . | X | X | X | . | . |
| *Reticulofenestra floridana* | . | . | . | . | . | . | X? | . | X | X | . | . | . | . |
| *Reticulofenestra pseudo-umbilicus* | . | . | . | . | . | . | . | . | . | . | . | . | X | . |
| *Reticulofenestra umblicus* | . | . | . | . | . | . | . | ? | ? | . | . | 1? | . | . |
| *Reticulofenestra* sp. aff. *R. umbilicus* | . | . | . | . | . | . | X | . | . | . | . | . | . | . |
| *Reticulofenestra* spp. small | . | . | . | . | . | X | . | . | . | X | X | . | . | . |
| *Rhabdosphaera perlonga* | . | . | . | . | . | . | ? | . | . | . | . | . | . | . |

**Appendix 4a.** Calcareous nannofossil occurrences in the Jamestown core, with age and formation correlation (L.M. Bybell)—Continued

[X, present; (.), not present; 1, 1 specimen observed; ?, possibly present; ??, very questionably present; depth of sample is in feet; Abundance: C, common or 1-10 specimens per field of view at X640; F = frequent or 1 specimen per 1-10 fields of view at X640; R, rare or 1 specimen per more than 20 fields of view at X640; B, barren of calcareous nannofossils; Preservation: F = fair; P = poor]

| Species[1,2] | Formation | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Potomac | Aquia | Aquia | Aquia | Nanjemoy | Nanjemoy | Nanjemoy | Nanjemoy | Piney Point | Old Church | Calvert | Calvert | Calvert | St. Marys |
| | Age | | | | | | | | | | | | | |
| | ?? | ?? | late Paleocene | late Paleocene | early Eocene | early Eocene | early Eocene | early Eocene | middle Eocene | late Oligocene-early Miocene | early Miocene | early Miocene | early Miocene | ?? |
| | Calcareous nannofossil zone | | | | | | | | | | | | | |
| | BARREN | BARREN | NP 8 | NP 9 | NP 10 | NP 12-14 | NP 12-14 | NP 12-14 | NP 16? | ?? | NN 2-3 | NN 2-3 | NN 2-4 | BARREN |
| | Depth | | | | | | | | | | | | | |
| | 273.7 | 255.9 | 241.5 | 220 | 201.8 | 196.2 | 186.6 | 168.8 | 157 | 149.3 | 137.1 | 128.3 | 121.3 | 105.1 |
| *Rhomboaster bramlettei* | . | . | . | . | X | . | . | . | . | . | . | . | . | . |
| *Sphenolithus moriformis* | . | . | . | . | . | . | . | X | . | . | . | . | . | . |
| *Sphenolithus radians* | . | . | . | . | . | . | X | . | . | . | . | . | . | . |
| *Sphenolithus* spp. | . | . | . | . | . | . | X | . | . | . | . | . | . | . |
| *Thoracosphaera* spp. | . | . | . | . | . | . | . | X | X | . | . | . | . | . |
| *Toweius callosus* | . | . | . | . | X | . | . | . | . | . | . | . | . | . |
| *Toweius eminens eminens* | . | . | X | X | . | . | . | . | . | . | . | . | . | . |
| *Toweius eminens tovae* | . | . | X | X | . | . | . | . | . | . | . | . | . | . |
| *Toweius occultatus* | . | . | . | . | . | . | X | . | . | . | . | . | . | . |
| *Toweius pertusus* | . | . | . | X | . | . | . | . | . | . | . | . | . | . |
| *Transversopontis pulcher* | . | . | . | . | . | . | X | X | X | . | . | . | . | . |
| *Transversopontis pulcheroides* | . | . | . | . | . | . | X | X | . | . | . | . | . | . |
| *Zygodiscus herlyni* | . | . | . | X | X | . | . | . | . | . | . | . | . | . |
| *Zygrhablithus bijugatus* | . | . | . | . | . | . | X | X | X | . | . | . | . | . |
| Abundance | B | B | C | C | F | R | F | F | F | F | F | F | F | B |
| Preservation | | | F | F | P | P | F | F | F | F | F | F | F | |

**Appendix 4a.** Calcareous nannofossil occurrences in the Jamestown core, with age and formation correlation (L.M. Bybell)—Continued

**[1]Cenozoic calcareous nannofossil species considered in this report (in alphabetical order by genus).**

*Braarudosphaera bigelowii* (Gran & Braarud 1935) Deflandre 1947
*Cepekiella lumina (*Sullivan 1965) Bybell 1975
*Chiasmolithus bidens* (Bramlette & Sullivan 1961) Hay & Mohler 1967
*Coccolithus eopelagicus* (Bramlette & Riedel 1954) Bramlette & Sullivan 1961
*Coccolithus pelagicus* (Wallich 1877) Schiller 1930
*Cribrocentrum reticulatum* (Gartner & Smith 1967) Perch-Nielsen 1971
*Cruciplacolithus tenuis* (Stradner 1961) Hay & Mohler in Hay and others, 1967
*Cyclococcolithus formosus* Kamptner 1963
*Cyclococcolithus leptoporus* (Murray & Blackman 1898) Kamptner 1954
*Discoaster barbadiensis* Tan Sin Hok 1927
*Discoaster deflandrei* Bramlette & Riedel 1954
*Discoaster druggii* Bramlette & Wilcoxon 1967
*Discoaster kuepperi* Stradner 1959
*Discoaster lenticularis* Bramlette & Sullivan 1961
*Discoaster lodoensis* Bramlette & Riedel 1954
*Discoaster multiradiatus* Bramlette & Riedel 1954
*Discoaster woodringii* Bramlette & Riedel 1954
*Ellipsolithus distichus* (Bramlette & Sullivan 1961) Sullivan 1964
*Ericsonia subpertusa* Hay & Mohler 1967
*Fasciculithus tympaniformis* Hay & Mohler in Hay and others, 1967
*Helicosphaera ampliaperta* Bramlette & Wilcoxon 1967
*Helicosphaera carteri* (Wallich 1877) Kamptner 1954
*Helicosphaera intermedia* Martini 1965
*Helicosphaera lophota* (Bramlette & Sullivan 1961) Locker 1973
*Helicosphaera seminulum* Bramlette & Sullivan 1961
*Heliolithus riedelii* Bramlette & Sullivan 1961
*Hornibrookina arca* Bybell & Self-Trail 1995
*Lithostromation operosum* (Deflandre in Deflandre and Fert, 1954) Bybell 1975
*Lophodolithus nascens* Bramlette & Sullivan 1961
*Markalius inversus* Bramlette & Martini 1964
*Nannotetrina alata* (Martini 1960) Haq & Lohman 1975
*Neochiastozygus concinnus* (Martini 1961) Perch-Nielsen 1971c
*Neococcolithes dubius* (Deflandre in Deflandre and Fert, 1954) Black 1967
*Pemma rotundum* Klumpp 1953
*Placozygus sigmoides* (Bramlette & Sullivan 1961) Romein 1979b
*Pontosphaera multipora* (Kamptner ex Deflandre 1959) Roth 1970
*Reticulofenestra abisecta* (Müller 1970) Roth & Thierstein 1972
*Reticulofenestra floridana* (Roth & Hay in Hay and others, 1967) Theodoridis 1984
*Reticulofenestra pseudoumbilicus* (Gartner 1967) Gartner 1969
*Reticulofenestra umbilicus* (Levin 1965) Martini & Ritzkowski 1968
*Rhabdosphaera perlonga* (Deflandre in Grassé, 1952) Bramlette & Sullivan 1961
*Rhomboaster bramlettei* (Brönnimann & Stradner 1960) Bybell & Self-Trail 1995
*Sphenolithus moriformis* (Brönnimann & Stradner 1960) Bramlette & Wilcoxon 1967
*Sphenolithus radians* Deflandre in Grassé, 1952
*Toweius callosus* Perch-Nielsen 1971b
*Toweius eminens* var. *eminens* (Bramlette & Sullivan 1961) Gartner 1971
*Toweius eminens* var. *tovae* Bybell & Self-Trail 1995
*Toweius occultatus* (Locker 1967) Perch-Nielsen 1971
*Toweius pertusus* (Sullivan 1965) Romein 1979b
*Transversopontis pulcher* (Deflandre in Deflandre and Fert, 1954) Perch-Nielsen 1967
*Transversopontis pulcheroides* (Sullivan 1964) Báldi-Beke 1971
*Zygodiscus herlyni* Sullivan 1964
*Zygrhablithus bijugatus* (Deflandre in Deflandre and Fert, 1954) Deflandre 1959

**Appendix 4a.** Calcareous nannofossil occurrences in the Jamestown core, with age and formation correlation (L.M. Bybell)—Continued

**[2]Useful Cenozoic calcareous nannofossil datums.**

The following calcareous nannofossil species can be used to date sediments of Paleocene to early Miocene age. Many, but not all, of these species are present in the Jamestown core. FAD is a first appearance datum, and LAD is a last appearance datum. Zonal markers for the Martini (1971) NP zones are indicated with an *, and a # indicates a zonal marker for the Bukry (1973, 1978) and Okada and Bukry (1980) CP zones. L.M. Bybell has found the remaining species to be biostratigraphically useful in the Gulf of Mexico and Atlantic Coastal Plains.

FAD *Reticulofenestra pseudoumbilicus* - early Miocene
FAD *Cyclococcolithus leptoporus* - early Miocene
LAD *Helicosphaera ampliaperta* - within Zone NN 4, early Miocene
FAD *Helicosphaera ampliaperta* - within Zone NN 2, early Miocene
FAD **#Discoaster druggii* - base of Zone NN 2, early Miocene
LAD *Zygrhablithus bijugatus* - top of Zone NP 25, late Oligocene
LAD **#Reticulofenestra umbilicus* - top Zone NP 22, top of Zone CP 16c
LAD **Cyclococcolithus formosus* - top of Zone NP 21, early Oligocene
LAD **#Chiasmolithus bidens* - top of Zone NP 16, middle Eocene
FAD *Reticulofenestra* spp. - within upper Zone NP 12 or lower Zone NP 13
FAD *Helicosphaera lophota* - near top of Zone NP 12
LAD *Toweius callosus* - within Zone NP 12 - not exact
FAD *Helicosphaera seminulum* - mid Zone NP 12
FAD **#Discoaster lodoensis* - base of Zone NP 12, base CP 10
LAD *Zygodiscus herlynii* - within Zone NP 11 - not exact
LAD *Discoaster lenticularis* - upper Zone NP 10
LAD *Rhomboaster bramlettei* - upper Zone NP 10
LAD *Hornibrookina* spp. - lower Zone NP 10
FAD **Rhomboaster bramlettei* - base of Zone NP 10, early Eocene
LAD *Toweius eminens tovae* (consistent occurrence) - upper Zone NP 9
FAD *Toweius occultatus* - within upper Zone NP 9
FAD *Toweius callosus* - within Zone NP 9
FAD *Toweius callosus* - within Zone NP 9
FAD *Discoaster lenticularis* - near base of Zone NP 9
FAD **#Discoaster multiradiatus* - base of Zone NP 9, base CP 8a
FAD **Heliolithus riedelii* - base of Zone NP 8

**Appendix 4b.** Dinocyst occurrences in the Jamestown core, with age and formation correlation (L.E. Edwards)

[X, present; (.), not present; ?, questionably present; R, reworked; C, contaminated from above, probably burrowing; ?R, present, questionably reworked; ?C, present, questionably a contaminant; depth of sample is in feet; dinocyst zonation from Verteuil and Norris, 1996]

| Species | Formation | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Old Church | | | Calvert | | | St. Marys | |
| | Age | | | | | | | |
| | late Oligocene | | | early Miocene | | early or middle Miocene | late Miocene | |
| | Dinocyst zone | | | | | | | |
| | | | | DN 2 | DN 2 | DN 3-5 | DN 8-9 | DN 8-9 |
| | Depth | | | | | | | |
| | 158 | 149 | 142 | 135 | 124 | 117 | 104 | 61.4 |
| *Achomosphaera andalousiensis* | . | . | . | . | . | . | X | X |
| *Apteodinium spiridoides* | X | . | X | X | X | . | . | . |
| *Apteodinium tectatum* | . | . | . | . | X | X | . | . |
| *Barssidinium evangelineae* | . | . | . | . | . | . | X | X |
| *Batiacasphaera sphaerica* | . | ? | X | X | X | . | . | . |
| *Chiropteridium galea* | X | . | . | . | . | . | . | . |
| *Chiropteridium lobospinosum* | X | X | X | . | . | . | . | . |
| *Chiropteridium* sp. | . | . | . | . | ?R | . | . | |
| *Corrudinium* sp. | X | X | . | . | . | . | . | . |
| *Cousteaudinium aubryae* | . | . | . | . | X | . | . | . |
| *Cribroperidinium tenuitabulatum* | X | . | . | X | . | . | . | . |
| *Cyclopsiella* sp. | . | . | . | X | . | . | . | . |
| *Dapsilidinium pseudocolligerum* | . | X | . | X | . | . | . | . |
| *Deflandrea phosphoritica* var. *spinulosa* | . | . | X | . | . | . | . | . |
| *Dinopterygium cladoides sensu* Morgenroth (1966) | . | X | . | . | . | . | . | . |
| *Distatodinium biffii* | X | X | . | . | . | . | . | . |
| *Distatodinium* sp. | . | . | . | . | X | . | . | . |
| *Erymnodinium delectabile* | . | . | . | . | . | . | ? | X |
| *Exochosphaeridium insigne* | . | . | . | X | X | . | . | . |
| *Habibacysta tectata* | . | . | . | . | . | . | . | X |
| *Homotryblium plectilum* | X | X | X | . | . | . | . | . |
| *Hystrichokolpoma rigaudiae* | . | . | X | X | . | X | . | . |
| *Hystrichokolpoma* sp. | . | X | X | X | . | . | . | . |
| *Hystrichosphaeropsis obscura* | . | . | . | X | X | X | . | . |
| *Impagidinium* spp. | . | . | X | . | . | . | X | X |
| *Invertocysta lacrymosa* | . | . | . | . | . | . | . | X |
| *Labyrinthodinium truncatum* subsp. *truncatum* | . | . | . | . | . | . | X | X |
| *Lejeunecysta* spp. | X | . | . | X | X | . | . | X |
| *Lingulodinium machaerophorum* | X | X | X | . | X | X | . | . |
| *Lingulodinium multivirgatum* | . | . | . | . | ? | . | . | . |

**Appendix 4b.** Dinocyst occurrences in the Jamestown core, with age and formation correlation (L.E. Edwards)—Continued

[X, present; (.), not present; ?, questionably present; R, reworked; C, contaminated from above, probably burrowing; ?R, present, questionably reworked; ?C, present, questionably a contaminant; depth of sample is in feet; dinocyst zonation from Verteuil and Norris, 1996]

| Species | Formation | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Old Church | | | Calvert | | | St. Marys | |
| | Age | | | | | | | |
| | late Oligocene | | | early Miocene | | early or middle Miocene | late Miocene | |
| | Dinocyst zone | | | | | | | |
| | | | | DN 2 | DN 2 | DN 3-5 | DN 8-9 | DN 8-9 |
| | Depth | | | | | | | |
| | 158 | 149 | 142 | 135 | 124 | 117 | 104 | 61.4 |
| *Melitasphaeridium choanophorum* | . | . | . | . | X | . | X | X |
| *Operculodinium piaseckii* | . | . | . | . | . | . | X | . |
| *Operculodinium* spp. | . | X | X | X | X | X | X | X |
| *Palaeocystodinium golzowense* | . | X | X | X | X | . | . | . |
| *Pentadinium imaginatum* | X | X | . | . | . | . | . | . |
| *Pentadinium laticinctum* subsp. *laticinctum* | X | X | . | . | . | . | . | . |
| *Pentadinium* sp. cf. *P. laticinctum granulatum* | . | . | X | X | X | X | . | . |
| *Pentadinium* sp. I of Edwards (1986) | ?C | ?C | ?C | X | . | . | . | . |
| *Polysphaeridium zoharyi* | . | . | X | X | . | . | . | . |
| *Quadrina*? *condita* | . | . | . | . | . | . | . | X |
| *Reticulatosphaera actinocoronata* | X | X | . | . | X | . | X | X |
| *Riculacysta perforata* | X | X | . | . | . | . | . | . |
| *Selenopemphix brevispinosa* | . | . | . | . | X | . | X | X |
| *Selenopemphix nephroides* | X | X | . | X | . | . | . | . |
| *Selenopemphix quanta* | . | . | . | X | . | . | . | X |
| *Spiniferites mirabilis* | . | . | . | . | . | X | . | X |
| *Spiniferites pseudofurcatus* | X | . | X | X | X | X | . | . |
| *Spiniferites* spp. | X | X | X | X | X | X | X | X |
| *Sumatradinium druggii* | . | . | . | . | . | X | . | . |
| *Sumatradinium soucouyantiae* | . | . | C | X | X | X | . | . |
| *Sumatradinium* sp. | . | . | . | . | X | . | . | . |
| *Systematophora placacantha* | . | X | X | X | X | X | . | . |
| *Tectatodinium pellitum* | X | . | . | . | X | . | X | . |
| *Thalassiphora pelagica* | X | . | . | . | . | . | . | . |
| *Trinovantedinium* spp. | . | . | . | . | . | X | . | X |
| *Tuberculodinium rossignoliae* | . | . | X | . | . | . | . | . |
| *Tuberculodinium vancampoae* | X | . | . | X | X | X | X | X |
| *Charlesdowniea coleothrypta* | . | . | R | . | . | . | . | . |
| *Wetzeliella* sp. | . | R | . | . | . | . | . | . |
| freshwater alga *Pediastrum* | . | . | . | . | . | . | . | X |

# CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

For readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

| *Multiply* | *By* | *To obtain* |
|---|---|---|
| inch | 25.4 | millimeters |
| foot (ft) | 0.3048 | meter |
| mile (mi) | 1.609 | kilometer |
| cubic inch ($in^3$) | 16.387 | cubic centimeter ($cm^3$) |
| pound per square inch ($lb/in^2$) | 6.895 | kilopascal |

*Sea level*: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

*Altitude*, as used in this report, refers to distance above or below sea level (bsl).

*Concentrations of chemical constituents* in water are reported in milligrams per liter (mg/L).

*Age designations*: The time of a geological event and the age of an epoch boundary are expressed as Ma (mega-annum), and intervals of time are expressed as m.y. (million years). Both terms mean 1,000,000 years or years $\times 10^6$. For example, sediments were deposited at 85 Ma ($85 \times 10^6$ years before 1950 A.D.), and the deposition continued for the next 2 m.y.