EXHIBIT N. STUDY AREA CHARACTERISTICS

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A. Sudden Valley

Sudden Valley is a planned community of 1,576 acres, nearly 3,000 single family lots, condominium areas, and recreational/open areas located on the west shore of Lake Whatcom. Development of the planned, residential resort began in 1968. The developers included access to all utilities, including water and sewer. Typically, the original lot sizes were approximately 6,000 square feet.

The development of lots and utilities in Sudden Valley was unusual. The developers conceived the project as a single, large development with all platting and construction of utilities occurring at one time (as opposed to a phased development). The local economy experienced a down-turn in the late 1970s and early 1980s. All costs for the operation and maintenance of an extensive infrastructure had to be borne by a small base of customers. By the end of the 1970s, developers and home owners had built improvements on less than one-quarter of the lots.

1. Boundaries

For the purposes of this comprehensive plan, the Sudden Valley future service area is an area slightly larger than the original Sudden Valley development. The boundaries of the future service area follow the limits of the original development from the northwest corner of the development south and west to Lake Louise Road.

Upon reaching the District Boundaries at the boundary of Sections 7 and 18 the boundary continues east toward the lake. Beyond this point, the Sudden Valley future service area boundary deviates from the original Sudden Valley Development Boundary. The future service area boundary includes additional areas that have the *potential* for utility service (Camp Firwood, Morrison property, Lane Older, Byron Tract, Airstrip, etc.).

The Sudden Valley *Development* Boundary skirts north of an area zoned for R5A to Lake Whatcom northwest of Reveille Island. This area was down-zoned from UR3 and includes both Camp Firwood and an area of undeveloped land. This area was outside the original Sudden Valley Development. Therefore, the original developers did not design the Sudden Valley utilities, storage and treatment facilities to serve the entire area. An exception to this is the Camp Firwood area. When the Sudden Valley Development was designed, the developers negotiated with *the Firs Bible and Missionary Conference* to allow easements and a reservoir site on Camp property. As part of this negotiation, the *Sanwick Corporation* (Sudden Valley's developer) agreed to reserve service capacity for Camp Firwood. The District accepted these obligations when they accepted the Sudden Valley System in 1977, and Camp Firwood now has water and sewer service.

We have included the area within the future service area because of the proximity to the Sudden Valley Area rather than with South Lake future service area. Therefore, the Sudden Valley *future service area* Boundary includes Camp Firwood and the area potentially served by the Camp Firwood pump station.

2. Topography

The topography of the Sudden Valley Area is characterized by five topographic sub-areas. Each sub-area has its own slope orientation, height, and development and service challenges. The first area is characterized by a series of steep rides, Beaver Creek, Lake Louise Road and Lookout Mountain. The development on these ridges represents much of the Sudden Valley residential development. Further to the south, the Sudden Valley Development abuts Austin Creek and extends up the slopes of Lookout Mountain. At the extreme southeastern portion of the Area (immediately east of Lake Louise) a steep hill rises from Lake Whatcom. Sudden Valley Division 7 occupies the north side of this hill while Camp Firwood occupies the south. The remaining portion of the area is the valley floor and Lake Louise. This area is typically recreational. A topographic map of the District is included in Exhibit A.

3. Geology

The entire Lake Whatcom area forms part of the western foothills of the Cascade Range. Bedrock conditions are important considerations of the suitability of the land for different uses; the cost of development, and the production of ground water.

The predominant rock type in the Sudden Valley area consists of Tertiary sandstone, conglomerate, and shale of the Chuckanut Formation (TKc). This rock type also can be found to the north and east of Lake Whatcom.

Cross-bedding in both the sandstone and conglomerate formations are common. The relationship between the inclined bedding and fractures in the Chuckanut Formation is important to determine slope stability. Potential landslide hazards exist where either bedding or fracture planes intersect the land surface. Chuckanut Sandstone is generally a poor producer of ground water. However, wells that intercept a fracture zone can produce small yields.

4. Soils

Stream and runoff sediments (Qal) have accumulated in the delta of Beaver Creek/Austin Creek in Sudden Valley. These alluvial deposits can produce limited quantities of ground water. However, there has been no significant development of ground water within Sudden Valley.

5. Hydrology

The entire Lake Whatcom Watershed is 35,800 acres, of which approximately 5,003 acres are lake surface. The Lake itself is divided into three major basins. The deepest sections (to 100+ meters or 330 feet) are in the most southern basin north of South Bay. The large central basin has depths of over 85 meters or 280+ feet and is separated from the southern basin by the *Sunnyside Sill*. The northern basin is separated from the central basin by the *Strawberry Sill*. This is the smallest and shallowest of the basins with depths to 25 meters or 85 feet. The northern basin is separated into two minor basins by the *Geneva Sill*.

Austin Creek (and a large tributary Beaver Creek) is the major drainage course in the Sudden Valley area.

Lake Whatcom Water and Sewer District started recording daily rainfall in June 1983. The District maintains three rain gauges: one at the District shop at 1010 Lakeview Street; one at the District's Airport Pump Station on Lake Whatcom Boulevard, and one at the Division 30 water

reservoir at the south end of Sudden Valley. The City of Bellingham records their rainfall at the Post Point Sewage Treatment Plant (200 McKenzie Avenue). During some periods, there is significantly more rainfall at the Lake Whatcom Water and Sewer District rain gauge stations than at the City of Bellingham Station. The LWWSD shop recorded rainfall for the twelve months ending 1984-1985 with 60.45 inches. For the same year, the City of Bellingham recorded 36.81 inches.

On January 9-10 1983, heavy continuous rains caused major slumping of unstable soils and the failure of large debris dams on major streams. Several days of rain (January 2-8) preceded the major storm event. When rainfall occurs, part of the water runs off directly into streams or over land into the Lake within a short period. Due to the combination of shallow soils in the area, bedrock and the heavy rains, the ground was not able to absorb the water. This resulted in the accretion and subsequent failure of large debris dams.

This flooding caused major changes in Lake chemistry, turbidity, phytoplankton, and loading rates of phosphorus, sediment, and other nutrients in streams. Because of the volume and shape of Lake Whatcom, the Lake took several years to return to an equilibrium state.[1]

Future similar flooding events have the potential for similar results. During these events, the Sudden Valley Water Treatment Plant will require careful monitoring. If the changes in water character are significant enough the Water Treatment Plant may require temporary changes in operations to handle the changes in raw water quality.

Records do not show the recurrences interval or the relative magnitude of the 1983 storm event. However, in the 1983 storm five inches of rain fell within the six day period. This combined with the presence of the debris dams made it difficult to evaluate on a relative scale. The Washington State Department of Emergency Services offered long-term mitigation recommendations for their *Flood Mitigation Implementation Measure Report for Whatcom County* in November 1983 (available from Whatcom County Department of Public Works).

These recommendations included suggestions on land use planning, zoning, the installation of rain gauges in higher altitudes, and debris collectors and surge dams.

B. Geneva

1. Boundaries

The Geneva future service area represents the area between the City of Bellingham and the Sudden Valley area described above. The boundary extends west along the City of Bellingham City Limits (at Lake Whatcom) to the boundary between Township 38-North and Range 4-East Sections 33 and 34. This north-south section line represents the City of Bellingham/ Lake Whatcom Water and Sewer District boundary lines and the approximate watershed boundaries.

The limits of the Geneva future service area continue along the southern edge of potential development in this area. The area south of the future service area has been purchased by the City of Bellingham and will not be developed. The future service area boundary continues roughly east along the south edge of areas down-zoned to R5A (from RR2 and R2A) to Lake

[1] The relatively rapid return of the lake to equilibrium was to some degree a result of increased diversion by the City of Bellingham from the Middle Fork of the Nooksack into the Lake through the City's Mirror Lake Inter-basin Water diversion.

Whatcom (approximately 1/2-mile northwest of Dutch Harbor) and continuing along Lake Whatcom to the Sudden Valley boundary.

2. Topography

The topography of the Geneva area is considerably less complex than the Sudden Valley Area. Most of the area forms moderately steep, north facing slopes leading down to Lake Whatcom. A series of broad north-south ravines and ridges traverse the western portions of this area. Further to the south and east, the topography forms the broad, steep, northeast facing slopes of Lookout Mountain. A topographic map of the District is included in Exhibit A.

3. Geology

The Geneva area also forms part of the western foothills of the Cascade Range. The bedrock conditions are similar to Sudden Valley. The existence of bed rock conditions is an important determinant of the suitability of the land for different uses, costs of development, and the production of ground water.

The predominant rock type in the area consists of Tertiary sandstone, conglomerate, and shale of the Chuckanut Formation (Tkc). Cross-bedding in both sandstone and conglomerate formations are also common in the Geneva Area. Likewise, the relationship between the inclined bedding and fractures in the Chuckanut Formation is important to determine slope stability. Potential landslide hazards exist where ever either bedding or fracture planes intersect the land surface. As above, Chuckanut Sandstone is a poor producer of ground water, although wells that intercept fracture zones can produce small yields.

4. Soils

Soils in the Geneva Area are typically shallow over bedrock. There are no significant ground water sources known in the Geneva Area.

5. Hydrology

No major creeks enter Lake Whatcom in the Geneva Area. However, Whatcom Creek flows from Lake Whatcom immediately north of the future service area. Although this out-fall is outside District Boundaries, the creek is important to all water uses in the area as the natural outlet from Lake Whatcom.

C. North Shore

1. Boundaries

The eastern boundary of the North Shore future service area starts at Lake Whatcom and heads north following the City of Bellingham / Lake Whatcom Water and Sewer District boundary. It then follows the District boundary to the east. It encompasses the areas adjacent to the North Shore interceptor, pump station service areas, and gravity service areas, and extends through the developed areas at the east end of North Shore Road. Much of the potential development in this service area has been eliminated through density reduction programs where the property was purchased and restricted from development.

2. Topography

The topography of the North Shore future service area can be divided into five separate sub areas. The areas furthest to the west form moderate slopes. These lead down to North Shore Road and form a portion of the southern flank of Squalicum Mountain. Several shallow ravines with associated small creeks cross this section of the area to Lake Whatcom. The area then levels to form a gently sloped area that is over 1-mile wide.

Immediately west of Agate Bay, a steep north-south escarpment marks the western boundary of the second topographic area of North Shore. As with the area described above, this second area ends with a moderately sloped area approximately 1/8 of a mile wide.

The North Shore future service area enters a third topographic area of mild slopes that form Squalicum Valley between Squalicum Mountain and Stewart Mountain. Carpenter Creek flows from Stewart Mountain through Squalicum Valley into Lake Whatcom. Further to the east, the larger Olsen Creek flows from a deep ravine on the flanks of Stewart Mountain. Close to the lake, mild slopes continue approximately 1/2 mile east along the shore before running into the steep southwest-facing slopes of Stewart Mountain.

Steep slopes beginning at Olsen Creek form the boundary of the fourth area. Steep slopes lead up to the 2,800 MSL (feet above mean sea level) peak of Stewart Mountain. More moderate slopes exist close to the lake and southwest of the BPA power line. The steeper areas northeast of the power line are zoned for Forestry.

The fifth topographic area is the small area known as Sunnyside. The areas of steep ravines and slopes are zoned ROS (Rural Open Space) and Forestry.

Beyond this last portion of the North Shore future service area, Stewart Mountain continues as a steep ridge rising from the more southern portions of Lake Whatcom. The steep west facing slopes of this area preclude development. Zoning in this area is forestry. A topographic map of the District is included in Exhibit A.

3. Geology

The predominant rock type in the North Shore Area consists of Tertiary sandstone, conglomerate, and shale of the Chuckanut Formation (Tkc). Cross-bedding in both sandstone and conglomerate formations are common. The same factors we discussed above for this rock type apply in this area.

4. Soils

Along Agate Bay, construction would find out-wash sand and gravel (Qso), and undifferentiated glacial drift (Qf) deposits. Bellingham drift (Qb), and inter-glacial sandy silt occurs north of Agate Bay. Stream and runoff sediments (Qal) have accumulated in deltas at Sunnyside. The ground water developments are typically on the glacial outwash sands and gravels mapped at Agate Bay. The alluvial deposits at Sunnyside produce limited quantities of ground water.

5. Hydrology

Several major creeks enter Lake Whatcom in the North Shore area. Olsen, Carpenter, and Smith Creeks all enter the lake from the mountains to the east and provide significant recharge to the lake.

Other, smaller creeks also add significantly to the Lake recharge. The high and steep wet-facing slopes intercept much of the summer rains and winter snows that recharge the Lake. The sparsely developed residential areas and forested slopes combine to form the conditions for high quality surface recharge. In addition to the surface creeks, recharge on these high peaks provides artesian conditions in the Squalicum Aquifer. This aquifer eventually flows into the lake and also provides a significant source of lake water.

D. South Lake

1. Boundaries

The South Lake future service area begins at the northwest corner where it connects with the southeast corner of the Sudden Valley Area. From this point, the South Lake future service area boundary continues south and east along the Lake. This includes all residentially zoned areas south of the Sudden Valley area and the North Shore area.

2. Topography

There are three major topographic regions of the South Lake future service area. From the Sudden Valley Area south to South Lake, the area is steep with east facing slopes cut by small mountain streams. Areas closer to Lake Whatcom have progressively milder slopes. Lake Whatcom Boulevard crosses close to the lake to take advantage of the milder slopes within this first topographic sub-area. The flanks of Lookout Mountain continue to rise to the west beyond the District Boundaries.

South Bay is a narrow bay extending from Lake Whatcom to the southwest. The area including South Bay and the areas from South Bay to Blue Canyon form the second topographic sub-region of the South Lake future service area. Slopes to the northwest of South Bay are steep. However, slopes to the southeast are considerably milder.

The valley southwest of the Bay broadens as it extends to the Lake watershed / District boundaries. The topography in these areas is potentially well suited for development. The zoning in these areas is R5A for rural development. The lack of utilities and roads, the rural zoning, and the physical distance to either Bellingham or the Skagit Valley has limited growth in this area. [2]

Between South Bay and Blue Canyon, the flanks of a knoll form another area potentially suited to development. The eastern slopes of the knoll are gentle and lead to the broad valley of Brannian Creek. However, the zoning is R5A so any new development will be rural in nature. The higher slopes are zoned for Forestry.

[2] The broadest and most developed sections of this entire area are actually beyond both the watershed and the District Boundaries. This developed area includes *Glenhaven Lakes* and *Whatcom Meadows* and surrounds Reed (394 MSL) and Cain Lakes (391 MSL). However, both of these lakes drain away from Lake Whatcom south past the town of Alger into Friday Creek and eventually into the Samish River.

The State Fish Hatchery occupies a portion of the area zoned ROS (Recreation Open Space) south of the Creek. East of Brannian Creek (and immediately west of Blue Canyon) mild slopes lead up to Anderson Mountain.

Blue Canyon also forms a steep walled canyon. The flanks of Anderson Mountain bound one side of the canyon while the northeast side of the Canyon forms slopes leading up to Stewart Mountain. The floor of Blue Canyon is narrow and contains the small Mirror Lake. The outlet to this lake flows into Lake Whatcom. The City of Bellingham uses Mirror Lake and Anderson Creek as part of the inter-basin diversion from the Middle Fork of the Nooksack River. [3]

Areas immediately to the east of Mirror Lake flow the opposite direction. The water enters the South Fork of the Nooksack River close to the town of Acme. The County has zoned almost the entire floor of Blue Canyon as R5A. The surrounding slopes are zoned for Forestry. A topographic map of the District is included in Exhibit A.

3. Geology

Near Blue Canyon, pre-Jurassic phyllite (metamorphic slate, pJm) occurs in limited quantity. The ground water characteristics are similar to those of the Chuckanut Formation near South Bay, Sudden Valley and Geneva. Water in some locations in the phyllite yield sufficient quantities for single family residential use.

4. Soils

Along South Bay, there are areas of out-wash sand and gravel (Qso), and undifferentiated glacial drift (Qf) deposits. Stream and runoff sediments (Qal) have accumulated in deltas at the Lake Whatcom outlet of Anderson Creek. In some areas on the glacial out-wash sands wells have developed limited ground water. Limited quantities of ground water may also be available from the alluvial deposits at Anderson Creek.

5. Hydrology

Both Anderson Creek and Brannian Creek flow into Lake Whatcom in the South Lake area. While Anderson Creek is larger, Brannian Creek is important as a source of water for the State Fish Hatchery. Anderson Mountain, Anderson Creek, Brannian Creek and the sparse density and forestry zoning make this sub-area another valuable watershed area.

[3] The City of Bellingham historically diverted water from the Middle Fork of the Nooksack because that fork provides a better source than the closer South Fork. Waters from the Middle Fork are piped under the South Fork before entering Mirror Lake.