

Changes in Built-Up Land
Grand Isle County, Vermont
1941-2003

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The USDA-Natural Resources Conservation Service (NRCS) mapped historical and current-day built-up land in Grand Isle County using several vintages of aerial photography from 1941-2003 (Table 1). There were several objectives of the mapping effort. This document is prepared in support of one of those objectives, namely:

To provide 100 percent mapped and measured built-up data for use by researchers, conservation groups, local planners, and policy makers.

The mapping was conducted using definitions and protocols established by the USDA-Natural Resources Conservation Service (NRCS) in its conduct of the National Resources Inventory (NRI). The NRI is a statistically based survey, designed and implemented to assess the conditions and trends of soil, water, and related resources on non-federal lands. It is conducted by NRCS, in cooperation with the Iowa State University Statistical Laboratory. Mandated by Congress, the NRI provides scientifically valid, timely, and relevant information that is used to formulate effective agricultural and environmental policies, and legislation to help implement national conservation programs. The data is also used to enhance the public's understanding of natural resources and environmental conditions. The NRI has been conducted on a 5-year cycle since 1982 with follow up inventories being done in 1987, 1992, and 1997. An annual/continuous inventory commenced in 2000, with the first annual data output being projected for 2006 or 2007.

Built-Up Land

The Grand Isle County mapping effort identified and mapped two NRI land cover/use categories: 'Urban and Small Built-Up' and 'Farmsteads'. For this effort, these categories were combined and referred to as 'Built-Up'.

Before discussing 'built-up', it is important to define both 'urban and small built-up' and 'farmsteads' in order to get a grasp of what 'built-up' includes, as used in this mapping effort. The following also defines the land cover/use categories, and describes the protocol for identifying and delineating them.

Urban and Small Built-Up

Urban and small built-up land is a land cover/use category consisting of several kinds of land areas and land uses as listed and described below.

- | | |
|---------------------|--|
| Airports | Playgrounds with permanent structures |
| Cemeteries | Public administration sites |
| Commercial sites | Railroad yards |
| Construction sites | Residences |
| Golf courses | Sanitary landfills |
| Industrial sites | Sewage treatment plants |
| Institutional sites | Water control structures and spillways |
| Parking lots | |

Highways, railroads, and other transportation facilities are considered to be part of urban or small built-up if they are surrounded by the urban and small built-up. If roads or railroads form

the boundary of an urban or small built-up area, one-half of the road or railroad area is considered as urban and small built-up and one-half as 'Rural Transportation' land.

Tracts of less than 10 acres that do not meet this definition (for example, small parks and water bodies) but are completely surrounded by urban land are included as part of the urban area.

Discernible features or distinct changes in land cover or use are used to delineate built-up boundaries. In the absence of discernible features or distinct changes in land cover or use, the following guidelines are used to delineate built-up boundaries:

The boundary is established 50 feet behind the substantial structure most distant from the road. The substantial structure is usually the residence, but could be a swimming pool, paved area, garage, or out-building.

Include areas between eligible structures that are less than 500 feet apart if there are no visible cover or use changes. If the distance between eligible structures is greater than 500 feet and there is no obvious boundary, define the side boundary as 50 feet from the structure.

The Grand Isle mapping effort was conservative regarding the 500 foot distance. In general, a shorter distance was used for inclusion as part of a built-up area, sometimes as narrow as 100-200 feet). This approach seems to work better on the Vermont landscape while helping to map a more accurate portrayal of built-up areas.

When a built-up area is bordered by public roads or railroads, the boundary would be the center of the road, railroad, or center of median for divided highways. When farmsteads border public roads, the boundary would be the edge of the road, not center.

Noncontiguous built-up areas must be delineated as separate areas (polygons). For example, a 0.5-mile road with five residences along the same side where four are adjoining form one built-up polygon and a single residence separated from the others form a second polygon.

Two size categories of Built-Up are recognized:

Large Built-Up - in a unit 10 acres and larger
Small Built-Up--in a unit 0.25 to 10 acres

The Grand Isle mapping did not break out these size categories but they could be determined from the resulting GIS data. Specific density requirements need to be met in order for an area to qualify as 'Built-Up'. The density requirements were NOT adhered to during the Grand Isle mapping. This requirement, while effectively used in NRI data collection, has proven too unwieldy and time consuming when mapping large land areas. Further, some earlier mapped data has shown that the density requirement actually makes little difference in the total amount of built-up land.

In order for construction sites to be classified as built-up, something beyond the presence of roads is required. This additional construction activity may be land leveling, installation of sewer

lines, etc. Land areas simply zoned as commercial/residential are not considered as urban and small built-up if no structures or evidence of conversion/construction are present.

Houses, barns, sheds, and the like that were abandoned as of 1995 were not identified and delineated as part of the built-up, nor were they considered for other years. This approach is consistent with NRI protocol.

Farmsteads

'Farmsteads' is the second NRI land cover/use category mapped and considered as 'Built-Up' in the Grand Isle effort. Farmsteads includes land used for dwellings, buildings, barns, pens, corrals, feedlots next to buildings, farmstead or barnyard/feedlot windbreaks, and family gardens associated with operating farms.

Farmsteads were included as part of 'Built-Up' in the Grand Isle effort because it is usually difficult to distinguish active from inactive farmsteads on older, small-scale aerial photography. Further, it is rare that the discontinuation of a farm operation results in the loss of farmstead buildings. In fact, the homes on the discontinued farms usually serve as homes for either the farmer who is often employed elsewhere, or a new owner. Considering these issues, the Grand Isle mapping was altered to include farmsteads as part of built-up.

Developed Land in 2003

'Developed land', as used in this report, refers to the total of built-up as described above, plus rural transportation facilities, commonly referred to as roads. Together, built-up and roads reflect those acres that are, for the most part, permanently converted and unavailable for other uses.

Roads include interstates, primary federal and state highways, other paved roads, gravel and dirt roads, railroads, and private driveways. Logging roads and access roads to gravel pits are also considered as roads, if they are deemed to be permanent. Logging skid trails and on-farm roads such as field lanes are **not** considered as roads.

There is no quick or easy way to map road changes over time. As such, this mapping effort focused on identifying and mapping the total developed land for 2003 only. While this approach does not reflect developed land change over time, it does accurately portray those areas that have, for the most part, been permanently converted from the land base as of 2003.

Results

Built-Up Land

Table 2 provides detail for the mapped built-up land in Grand Isle County for the period, 1941-2003. Built-up land increased from 1,250 to 6,092 acres, a growth of 4,842 acres (387%) during the 62-year time frame. This represents an average annual growth of about 78 acres and 6.2 percent. On a percentage basis, built-up land occupied about 2.3 of the County's land base in 1941 and 11.3 percent of the base in 2003.

Relative to other time frames, the growth between 1941 and 1962 was quite low at an annual rate of just 36 acres. The rate of growth increased significantly after 1962. Figure 1 is a graphic representation of how the built-up acreage changed from 1941-2003.

Tables 3-7 provide the same detail of changes for each of the Grand Isle County towns: Alburg, Isle La Motte, North Hero, Grand Isle, and South Hero.

The data shows that Alburg built-up land nearly doubled (437 ac., 98% increase) between 1962 and 1974. This rate of growth is considerably higher than the rate experienced in other towns for the same time period. Much of the difference may be attributed to the Alburg Country Club which had its start in 1964. Of the 437-acre growth between 1962 and 1974, 185 acres (42%) was from the establishment of the golf course.

Similarly, there was nearly a doubling (93%) of the built-up land in North Hero from 1941-1962. Nearly 20 percent of the 223 acre increase (43 acres) can be attributed to the establishment of Shore Acres. Some building construction occurred there in about 1951 and mowing of the large lawn area began in 1959.

Like North Hero, the growth in South Hero was also quite high from 1941-1962 (204 ac., 80%). It was however, unlike the 1941-1962 North Hero and the 1962-1974 Alburg growth in that the South Hero change seemed to be spread more uniformly across the Town.

Total Developed Land in 2003

There were about 1,330 acres in roads in Grand Isle County in 2003. Table 8 provides detail on those roads. About 467 acres (35%) occurred within areas mapped as built-up land. As such, they are considered as part of the built-up land. The remaining 860 acres occurred outside built-up areas. Of these 860 acres, 715 (83%) were public and 145 (17%) were privately owned.

The total developed land in 2003 then, was about 6,950 acres. This is the sum of the mapped built-up areas (6,092 ac., Table 2) and the remaining acres in roads (860) that occurred outside the mapped built-up areas. The 6,950 acres of developed land represents about 13 percent of the County's base.

Data Analyses

Other than the insights here, no detailed analysis has been conducted on the resulting data. Additional analyses might include such things as: detailed comparison of built-up changes between the towns, comparison of built-up changes with population changes, timing of economic or other related factors that may have led to growth changes, and factors relating to second homes, summer camps, and recreational opportunities. If these or other analyses are conducted, NRCS would be interested in learning about them.

Mapping Tools and Ancillary Materials

GIS technology and digital orthophotography were essential to this effort and it would not have been feasible or practical without them. The GIS software was ArcView 3.3. Vermont orthophotos (orthos), 1995 vintage, provided the orthophoto base upon which the work was done. The Vermont digital orthos are black and white, with a pixel resolution of 0.5 meter.

The study used several other vintages of aerial photography. With the exception of the orthorectified photography from the 2003 National Aerial Imagery Program (NAIP), the other photography was not orthorectified or in digital format. Table 1 provides detail about the photography used for the mapping.

An 11x18 inch Porta-Trace light box was used for remote sensing the 1994, 1:40,000 color infrared (CIR) and the 2003 natural color diapositives. Two Edmund hand magnifiers, a 6X and 12X, were used to remote sense the color diapositives and the hard copy print photography.

Mapping Methodology

As a first step, built-up land was mapped to 1995 conditions using the 1995 digital orthos and the 1:40,000 CIR diapositives. The CIR diapositives, acquired in 1994, provided a reference for remote sensing the 1995 orthos. Used over the light box with magnifiers, the 1:40,000 CIRs were an excellent tool for determining land cover/use, including the accurate delineation of lawn boundaries and the identification of other features and characteristics of built-up areas. The 1995 conditions were mapped first because of three factors.

First, the 1995 orthos were fairly recent and they were the only digital orthos available when the mapping commenced. Second, prior mapping experiences demonstrated that the only effective and accurate way to do this kind of mapping is to map the present conditions and then work backwards. Mapping early conditions, for example 1941, and then moving forward simply does not work. The approach is very prone to error, causing the mapper to continually move back and forth between map years to correct errors. Mapping 1941 and then moving forward might not be such a major problem if the older aerial photography were to be orthorectified. In this effort, and other similar efforts, it is usually difficult to justify the time and cost to orthorectify several vintages of older aerial photography.

The third reason for mapping present day or reasonably current conditions is to establish a base that can be field checked. Field verification in turn, helps establish an accurate base from which to develop data for other years.

Mapping was conducted on a town by town basis for the five towns in the County. After digitization of the 1995 conditions for a town, several plots were made of the built-up boundaries laid over the 1995 orthophoto base. The scale of the plots varied, but it was typically within the range of 1:10,000 and 1:12,000. The plots were then used to field check the built-up boundaries. Field checking was conducted to answer questions raised during the digitization and to confirm that all boundaries were correct.

All but a few of the 1995 built-up polygons were field checked. Access was difficult and even denied in some instances by signage. Despite some access denial, probably more than 95 percent of the built-up areas were viewed on the ground. The digital built-up files were edited after field verification. As a result of this process, the 1995 mapped conditions are considered to be very accurate.

After completion of the 1995 mapping, each town was mapped to 1986 conditions by determining whether or not a given built-up polygon was present on the 1986 aerial photo. This determination was made by visually inspecting the 1986 photography, and making any needed edits in GIS, either deleting polygons or editing their boundaries. Editing was done on-screen

with the 1995 VT orthophotos as a backdrop. This same process was used for all other years mapped.

This kind of mapping involves much going back and forth between the computer screen and hard copy photography. This factor, coupled with varying resolution, contrast, and scales of older aerial photography results in a tedious and error-prone process. Care, numerous check plots, and associated pen and ink changes helped alleviate errors. In addition, prior or more recent photography was checked when mapping a given year. For example, mapping 1974 conditions might necessitate a re-inspection of the 1977 photos, and in some cases, a check of the 1962 photos.

After the historical mapping, built-up areas were mapped to 2003 conditions using the 2003 NAIP digital imagery and the 1:40,000 natural color diapositives of the same imagery. Although the 2003 NAIP imagery was in natural color and more current, it is not as sharp as the VT orthos. The NAIP has a pixel resolution of 1.0 meter while the VT orthos have a 0.5 meter pixel resolution. In some instances, this lack of sharpness/clarity prevented easy interpretation of areas that were in a state of land cover/use change. The mapping erred on the side of being conservative when such instances arose. If there was question about the true identification or interpretation of change, the area in question was **not** mapped as built-up for 2003.

Although considerable care was used during the mapping, there are undoubtedly some errors in the data. However, the extent of those errors is considered to be low and overall, the data are considered to be very good. They represent an accurate portrayal of built-up land and its change over time.

GIS Files

The resulting GIS files are ArcView shape files. A built-up shape file exists for each mapped year: 1941, 1962, 1974, 1977, 1980, 1986, 1995, and 2003. In addition, a shape file represents the total developed land as of 2003. The data is available for download from the Vermont Center for Geographic Information (VCGI). VCGI has converted the original shape files to Arc/Info coverage region subclasses.

Technical questions concerning this mapping effort and document should be directed to:

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Table 1. Aerial photography used to map built-up land in Grand Isle County.

Date	Film Type	Acquisition Scale		Hard Copy Scale	
		Nominal	Feet/Inch	Nominal	Feet/Inch
1941	Black & white, mostly leaf off	1:26,000	2,167	1:26,000	2,167
1962	Black & white, leaf off	1:18,000;	1,500	1:18,000	1,500
1974	Black & white, leaf off	1:20,000	1,667	1:20,000	1,667
1977	Color Infrared, leaf off	1:80,000	6,667	1:20,000	1,667
1980	Black & white, leaf on	1:40,000	3,333	15,840	1,320
1986	Color infrared, leaf off	1:60,000	5,000	1:20,000	1,667
1994	Color infrared diapositives, leaf off	1:40,000	3,333	1:40,000	3,333
1995	Black & white, leaf off ^a	1:30,000	2,500	digital	NA
2003	Natural color, leaf on ^a	1:40,000	3,333	digital	NA

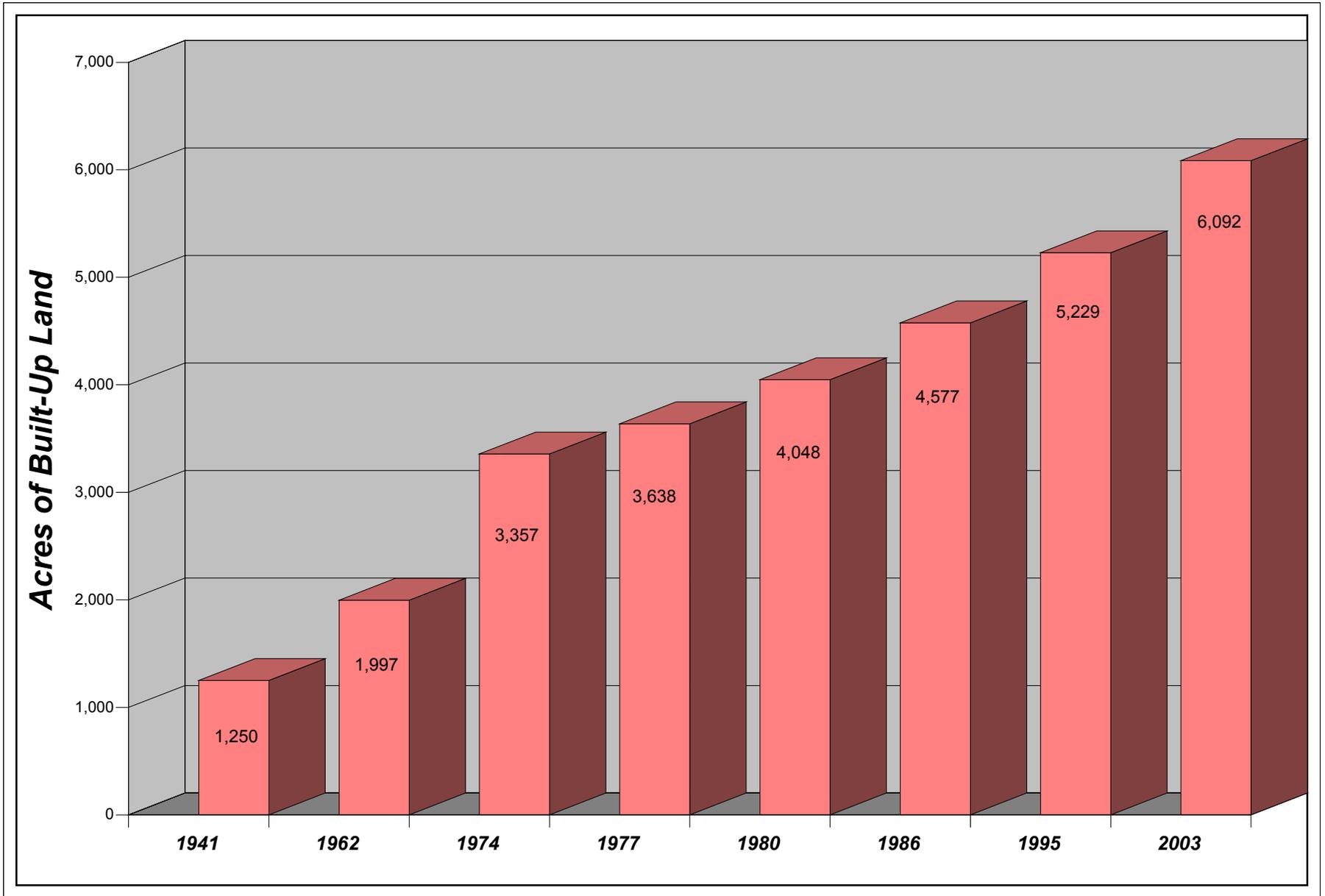
^a The 1995 VT orthophotos and the 2003 NAIP photos were orthorectified, digital, and were used in GIS.

Table 2. Built-up land in Grand Isle County by years, acres, and change ^a.

Year	Acres	Change Period	Years	----- Change -----			
				Time Frame		Annual	
				acres	percent	acres	percent
1941	1,250	1941-1962	21	747	60%	36	2.8%
1962	1,997	1962-1974	12	1,360	68%	113	5.7%
1974	3,357	1974-1977	3	281	8%	94	2.8%
1977	3,638	1977-1980	3	410	11%	137	3.8%
1980	4,048	1980-1986	6	529	13%	88	2.2%
1986	4,577	1986-1995	9	652	14%	72	1.6%
1995	5,229	1995-2003	8	863	17%	108	2.1%
2003	6,092						
1941	1,250	1941-2003	62	4,842	387%	78	6.2%
2003	6,092						

^a Built-up land includes 'urban and small built-up' and 'farmsteads' as defined for the NRI. See text for more detail and explanation.

Figure 1. Built-up land in Grand Isle County by years and acres from 1941-2003^a.



^a Built-up land includes 'urban and built-up' and 'farmsteads' as defined for the NRI. See text for more detail and explanation.

Table 3. Built-up land in Town of Alburg by years, acres, and change ^a.

Year	Acres	Change Period	Years	----- Change -----			
				Time Frame		Annual	
				acres	percent	acres	percent
1941	349	1941-1962	21	98	28%	5	1.3%
1962	447	1962-1974	12	437	98%	36	8.1%
1974	884	1974-1977	3	44	5%	15	1.7%
1977	928	1977-1980	3	96	10%	32	3.4%
1980	1,024	1980-1986	6	103	10%	17	1.7%
1986	1,127	1986-1995	9	212	19%	24	2.1%
1995	1,339	1995-2003	8	223	17%	28	2.1%
2003	1,562						
1941	349	1941-2003	62	1,213	348%	20	5.6%
2003	1,562						

^a Built-up land includes 'urban and small built-up' and 'farmsteads' as defined for the NRI. See text for more detail and explanation.

Table 4. Built-up land in Town of Isle La Motte by years, acres, and change ^a.

Year	Acres	Change Period	Years	----- Change -----			
				Time Frame		Annual	
				acres	percent	acres	percent
1941	123	1941-1962	21	65	53%	3	2.5%
1962	188	1962-1974	12	118	63%	10	5.2%
1974	306	1974-1977	3	45	15%	15	4.9%
1977	351	1977-1980	3	56	16%	19	5.3%
1980	407	1980-1986	6	46	11%	8	1.9%
1986	453	1986-1995	9	68	15%	8	1.7%
1995	521	1995-2003	8	76	15%	10	1.8%
2003	597						
1941	123	1941-2003	62	474	385%	8	6.2%
2003	597						

^a Built-up land includes 'urban and small built-up' and 'farmsteads' as defined for the NRI. See text for more detail and explanation.

Table 5. Built-up land in Town of North Hero by years, acres, and change ^a.

Year	Acres	Change Period	Years	----- Change -----			
				Time Frame		Annual	
				acres	percent	acres	percent
1941	239	1941-1962	21	223	93%	11	4.4%
1962	462	1962-1974	12	228	49%	19	4.1%
1974	690	1974-1977	3	48	7%	16	2.3%
1977	738	1977-1980	3	84	11%	28	3.8%
1980	822	1980-1986	6	72	9%	12	1.5%
1986	894	1986-1995	9	102	11%	11	1.3%
1995	996	1995-2003	8	168	17%	21	2.1%
2003	1,164						
1941	239	1941-2003	62	925	387%	15	6.2%
2003	1,164						

^a Built-up land includes 'urban and small built-up' and 'farmsteads' as defined for the NRI. See text for more detail and explanation.

Table 6. Built-up land in Town of Grand Isle by years, acres, and change ^a.

Year	Acres	Change Period	Years	----- Change -----			
				Time Frame		Annual	
				acres	percent	acres	percent
1941	296	1941-1962	21	165	56%	8	2.7%
1962	461	1962-1974	12	308	67%	26	5.6%
1974	769	1974-1977	3	99	13%	33	4.3%
1977	868	1977-1980	3	107	12%	36	4.1%
1980	975	1980-1986	6	189	19%	32	3.2%
1986	1,164	1986-1995	9	169	15%	19	1.6%
1995	1,333	1995-2003	8	205	15%	26	1.9%
2003	1,538						
1941	296	1941-2003	62	1,242	420%	20	6.8%
2003	1,538						

^a Built-up land includes 'urban and small built-up' and 'farmsteads' as defined for the NRI. See text for more detail and explanation.

Table 7. Built-up land in Town of South Hero by years, acres, and change ^a.

Year	Acres	Change Period	Years	----- Change -----			
				Time Frame		Annual	
				acres	percent	acres	percent
1941	243	1941-1962	21	195	80%	9	3.8%
1962	438	1962-1974	12	272	62%	23	5.2%
1974	710	1974-1977	3	43	6%	14	2.0%
1977	753	1977-1980	3	67	9%	22	3.0%
1980	820	1980-1986	6	119	15%	20	2.4%
1986	939	1986-1995	9	99	11%	11	1.2%
1995	1,038	1995-2003	8	194	19%	24	2.3%
2003	1,232						
1941	243	1941-2003	62	989	407%	16	6.6%
2003	1,232						

^a Built-up land includes 'urban and small built-up' and 'farmsteads' as defined for the NRI. See text for more detail and explanation.

Table 8. Grand Isle County roads in 2003 by ownership, class, width, and acres ^a.

Category	Width ^b	Acres
Private ^c		
Class 99	15	138
Driveways/roads not in e-911data	15-30	97
Total Private		<u>235</u>
Public		
State owned, class 5	25	3
State owned, classes 30-40	57	311
Town owned, classes 1-4	49.5	780
Total Public		<u>1,094</u>
Total Roads		<u>1,329</u>

^a Acres reflect total road acres. About 1/3 (35%) of these acres are included as part of the 2003 built-up areas. The remaining 860 acres (65%) occur outside built-up areas.

^b Except for class 5 roads, the width for public roads is the right-of-way width. Private road widths are based on approximate width of road surface and shoulders/ditches.

^c Private roads include driveways and other permanent roads, but not farm-field lanes.