To:

Date: 21 June 96

Re: Town of Philipstown
Road Study

We are sending to you via US Postal Service the following items:

Copies	Dated	Description
1	21 June 96	Draft Report entitled "Road Inventory and Evaluation"

Comments

Copy to:

Sender: Gary L. Wood, P.E.

TRANSMITTAL LETTER

GARY L. WOOD, P.E.
Soils, Foundations, & Construction Materials Engineering

JANE L. WOOD, INC.
Construction Materials Inspection & Testing

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520 Peru Road • Groton, NY 13073

ROAD INVENTORY
&
EVALUATION

Prepared for
Town of Philipstown
21 June 96

DRAFT

William Mazzuca, Supervisor
Anthony Merante, Councilman
Betty Budney, Councilwoman
Stephen M. Rosario, Councilman
Al Hosmer, Councilman

Attachments

Town of Philipstown
Road Study

I. EXECUTIVE SUMMARY

We have performed the following services:

1) A survey of existing conditions, viz.:

- the condition of all roads by means of a walking/driving tour
- the current maintenance/repair and capital improvement costs in the form of information supplied by your Highway Superintendent
- a view, albeit not perfect, of the sentiment of your constituents in the form of **Vision Statements**

2) Made analyses of:

- present cost of highway maintenance and repair
- budget costs of alternate methods of repair, as well as capital improvements

3) Applied the **Cornell University's Road Surface Management System** (RSMS) to your road system by:

- entering your data in the system database
- adjusting its decision tree to reflect your conditions
- checking and adjusting the results by means of a second on-site tour

4) Developed 20-year cost projections and a sample five-year plan which implicitly contains our recommendations. At the same time, we have provided the data and methodology for you to make alternate plans if you wish.

We **did not** design any roads -- this project is strategic not individual, or what we call "project level". Once you have adopted **your** five-year plan, and only then, should individual designs be prepared. Parenthetically, it is apparent to us that it is more important for you than for most towns to prepare individual designs for each road -- standard cross sections do not appear to be compatible to your situation. Even relatively simple improvements should be preceded by **design** so the drainage, cross sections, grades, signs, etc. can be tailored to the existing conditions. A corollary to this is that our cost projections will require adjustment as designs are refined. Their purpose is to support the strategic decisions and long-term budgeting, not funding individual projects.

We believe the unpaved roads are in generally good condition even though the RSMS system produced a rating of only 33%. This low number was the result of universal drainage problems, but the materials and conditions of the traveled portion of the roads are generally good. Improved drainage will dramatically increase this assessment.

In our opinion, the effectiveness of money being spent on paved road maintenance and/or upgrading can be enhanced by different practices such as the use of the life cycle concept, programmed maintenance, and adaption of some relatively new procedures.

This leads to another comment regarding the adjustments we made to the RSMS decision tree. The priority listing of individual projects depends on the relative weight assigned to the three "priority factors" at the bottom of the first sheet of the vision statements. For your study, we used the average values from the vision statement returned to us, which were 54% road condition, 23% for roughness, and 23% for traffic. Incidentally, this prioritization, or strategic planning, of the projects is the only place where traffic volume (that is, the number of vehicles per day) is a factor. In fact, even when it comes to individual project design the traffic count will not be significant because most of your traffic is light vehicle. Consequently, the design of your road structures will be essentially the minimum thickness that is practical.

Finally, it seems important to re-state the idea, which was presented at our initial meeting at the Town Hall, that soils which make good unpaved roads are not good bases for paved roads. This is because unpaved roads need a substantial amount of fine particles to "bind" the surface matrix together. Conversely, a paved surface needs a base beneath it which has voids to allow the removal of any moisture that gets through this surface, or comes up from below. This means that the paving of a presently unpaved road should be preceeded by base improvement using one of the techniques that will be described subsequently.

II INTRODUCTION

A. Background

In the Fall of 1995 The Philipstown Roads Advisory Committee contacted our office with a request for proposal to study the Town of Philipstown road system. Our subsequent proposal was approved and the study began in May 1996. This report presents the results.

B. Purpose

The purpose of this report is to provide an objective measure of the current conditions of the roads and to make recommendations for technically appropriate and feasible repair and maintenance treatments, along with companion cost estimates for various options. These recommendations may be applied to any level of service, or master plan that the Town may envision.

C. Overview

Key elements of the report include the following:

1) An Inventory Listing and Condition Rating of Each Road.
2) A List of Repair/Maintenance. Alternatives and Costs
3) The Public Vision Statements.
4) Life cycle Costs for Two Sample Roads
5) Sample 5 Year Plan
6) Capital Improvement Cost Projections for Paved and Unpaved Roads
7) Design Standards for Road Construction

III. CURRENT PRACTICES

A. Geometry

The town roads vary dramatically in width and cross section. In general unpaved roads tend to be one lane with a traveled way of 8 to 12 feet. The paved roads are mostly two lanes, with lane widths of 8 to 12 feet, for a total road width of 16 to 24 feet. Of course exceptions exist, but these are dominant trends. The narrow width, especially of the unpaved roads, presents a challenge in respect to safety since there is often inadequate passing width or distance, stopping distance, and other safety concerns. This can present a liability in the event of accidents.

The Highway Department crowns its unpaved roads well. However, in some cases crowns are a little excessive, but this is better than too little crown, or none at all. On the other hand more design detail is required for proper shaping of paved roads. Some are too flat as a result of paving over poorly shaped subgrade.

B. Alignment

It is doubtful that the town roads consistently meet contemporary standards for grades, adequate curve radii, super elevation, allowable speeds, etc. Paving roads also poses a potential rise in the average travel speed. This in turn will increase liabilities. In any case, an effort to bring town roads into compliance with generally accepted standards would be cost prohibitive and disruptive to adjoining owners. In lieu of this, appropriate signage should be installed.

C. Drainage

The narrow widths of the dirt roads, while perserving historical and rural character, pose some engineering challenges. Most of these are problems with drainage. The limited space resulting from a narrow right-of-way makes it very difficult for the highway department to establish adequate ditching, culverts/headwalls, etc. The result is costly damage to the roads, and erosion of materials onto neighboring properties. With this in mind, it is important to realize that drainage problems are not merely an oversight of the highway department. It is also an issue of public policy regarding right-of-way, budget allocation, and design support.

In general, there is a lack of adequate ditching, culverts, headwalls etc. In some cases there are good ditches, but these are an exception. The existing "gutters" or "ditches" are clearly inadequate in view of the hilly terrain and high runoff potential. This was made evident by meandering "streams" and erosion into the traveled way of many road sections. What is more disturbing is the intentional shaping of some roads into a trough form, actually channeling water down the traveled way. A case in point is the recent paving of Canopus Hill Road, where asphalt concrete was used to fashion berms on both sides of the road. Such an approach should only be taken with a full curb-gutter design and underground storm drainage, as has been properly done on Mountain Brook Road. Poor ditching is also taking a heavy toll on pavements due to erosion and serious edge cracking in many locations.

Many culverts are not aligned correctly. Instead of following natural flow paths they are set at awkward angles resulting in turbulence and erosion. This is exacerbated by the almost complete lack of headwalls, and questionable culvert sizing. Without headwalls the natural soil around culvert entry/exits is gradually eroding. In some cases there are significant cuts made for the placement of culverts leaving exposed faces which are eroding onto neighboring properties. Correction of these problems requires proper design, adequate funding, and public support for the necessary right-of-way for placement of drainage structures.

D. Current Maintenance Practices

Unpaved Roads

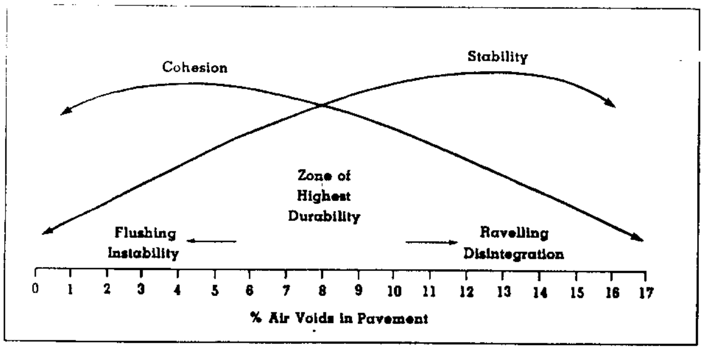
Maintenance includes grading several times a year, spot repairs of washout damage, gutter cleaning, filling potholes, etc. These functions are maintained adequately and result in predominantly satisfactory ratings in respect to the roadway surface.

Paved Roads

Maintenance includes typical items such as ditch cleaning, pothole filling, signage etc. It also includes a lot of patching which could be decreased with proper design and construction. The Town could benefit by applying more preemptive routine maintenance such as crack sealing, or asphalt emulsion sealers in cases of high oxidation or low severity/high extent cracking. A good example would be Steuben Drive, or sections of Hustis Road. There was no evidence the Town was using these simple and cost effective treatments which extend pavement life.

E. Capital Improvement

Capital Improvement is a matter that needs refinement. A step in the right direction is the recent **Chip Seal** applications; for example Diner Road. These not only provide a higher level of service (almost as good as Asphalt Paving at very low cost), they also preserve the rural character of the roads, especially with the excellent choice of brown stone that was used. Aside from these chip seal projects, current paving practice generally involves the placement of 1/2" to 1" layers of Asphalt Concrete (AC) shim coats over the top of natural unimproved (but graded) subgrade. Extensive review of in-place asphalt during our survey reveals a lack of appropriate design procedure. The built-up, thin layers of asphalt, are not yielding the quality and life span that could be achieved through proper design. Among other things, it is impossible to properly compact thin layers because they cool too quickly and the pavement performance is directly related to the density achieved, both of these conceptsbeing shown by the following figures from the Asphalt Institute's Handbook. In other words, the return on investment for asphalt dollars is currently too low. Good design with state of the art processes could yield more pavement, and higher serviceability.



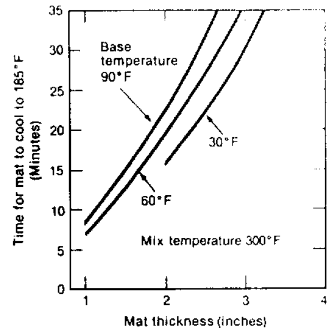


Figure 7.1 Pavement Durability vs. Air Voids.

Another current practice is the placement of shim coats over failing pavement. Underlying problems such as improper subgrade drainage are not corrected. Instead, thin overlays are placed on top which adds up to more cost, not less. For example, we observed major failures within a year or two of such repairs, and in general total failure within seven or eight years. The properties of asphalt concrete are such that underlying cracks and defects rapidly reflect through new overlays, and render the investment useless. It is very important to progress from a reactionary mode to a proactive life cycle design approach. For example, a road that has deteriorated too far may better be left to total failure (deferred maintenance) and then be completely rebuilt. This is preferable to nursing it along with expensive, but ineffective overlay treatments.

IV. ROAD INVENTORY AND CONDITION RATING

A. The RSMS Program

The RSMS program provices several different types of information, separately for unpaved and paved* roads, which are attached in Section 6. They are:

1) An alphabetical list of the roads with recommended treatments, based on our on-site review. This list ends with a summary of the percentage of the roads that require one of the following treatments:

- Reconstruction: The road surface has failed. The majority of the surface is covered with major defects such as potholes, alligator cracking, rutting, etc. The defects indicate serious subgrade and/or base problems which can only be corrected by reconstructing from the bottom up.
- Rehabilitation: The road surface has failed. But the defects, such as transverse/longitudinal cracking, minor alligatoring, potholes, etc. show no indication of underlying base or subgrade instability. The surface course can therefore be recycled or overlayed without disturbing the base.

* The term "flexible" refers to asphalt pavement as differentiated from concrete pavement.

- Preventive Maintenance: The surface course has minor defects, light cracking, edge cracking, raveling, etc., noe on which is extensive. The surface has not failed, and special treatments will retard further degradation and extend pavement life. Such treatments may include chip seals, micro-surfacing, asphalt emulsion sealer, crack sealing.
- Routine Maintenance: There are minor defects or none at all. Treatments are routine in nature such as ditch cleaning, or very minor crack sealing.

2) A second listing with a "menu" of repair alternatives, along with their associated costs. These costs are based on the unit costs we developed in Section 9 of the attachments.

3) A prioritized list which is generated from the weighted factors of **Road Condition, Roughness, and Traffic** taken from the vision statements.

B. <u>Condition Survey</u>

The recommendations provided by the RSMS system are based on the existing conditions as established by our field survey. This survey was made using the condition survey forms, samples of which are attached in Section 2. The results are summarized in the two tables starting on the following page.

C. <u>Commentary</u>

Paved Roads

The overall RSMS rating of the paved roads was 65 (out of 100 possible points). In general, the wearing course of the paved roads showed minor overall distress across the total network. There are few roads (10%) that indicate the need for total reconstruction. Signs of radical base failure, such as major alligator cracking, potholes, and rutting were relatively limited. Several roads such as Healy, Allan, Aqueduct, and Steuben Drive are notable exceptions, where defects are severe and extensive. The overall good conditions is the result of a generally high quality natural subgrade, resulting in a lack of extensive, or serious base problems. Therefore, in some cases new or rehabilitation paving over graded natural subgrade may be justifiable. In other cases it may need to be augmented with imported gravel, or stabilized with asphalt emulsion. With this in mind, it is still necessary, at project level to take subgrade samples and have them tested for various physical qualities in order to determine appropriate action for a specific road.

Despite these positive factors, it is evident that current practices are not as cost effective as they could be. There is clear evidence that the level of service is too low, and too expensive. In other words, more rigorous design of the pavements, and underlying bases could offer longer pavement life, higher quality, and reduced costs.

Town of Philipstown Road Condition Rating
Paved Roads

Road Name	Section	Length	x1	x2	x3	x4	x5	x6	x7
Allan Road	P01	0.300	5	8	1	1	3	2	1
Aqueduct	P02	0.700	5	9	2	1	3	2	1
Arden	P03	0.500	0	1	0	1	3	2	1
Avery (paved)	P04	0.600	1	1	0	1	3	1	1
Barrett (Part I)	P06	0.250	1	2	1	0	3	2	1
Barrett (Part II)	P06	0.250	0	0	0	0	3	1	1
Barrett	P05	0.500	1	2	1	0	3	2	1
Beale	P07	0.300	1	5	2	5	3	1	1
Birch Terrace	P08	0.200	0	0	0	0	3	2	1
Canopus	P09	0.400	0	0	0	0	3	1	1
Clove Brook	P10	0.300	1	1	1	0	3	1	1
Coleman	P11	0.000	0	1	1	1	3	2	1
Cross Road	P12	0.100	1	0	0	5	3	2	1
Diamond Road	P13	0.250	0	1	1	1	2	1	1
Diner	P14	0.350	0	0	1	1	3	2	1
East Mountain South (Paved)	P15	2.000	1	5	0	4	3	1	1
East Mountain South (Paved II)	P16	2.600	1	5	1	5	3	2	1
Evans Knoll	P17	0.100	0	0	0	0	3	1	1
Evans Terrace	P18	0.100	0	1	0	1	3	1	1
Fenichel	P19	0.100	0	0	0	0	2	1	1
Ferris	P20	1.400	1	1	1	1	3	2	1
Old West Point/ Forsonville	P21	0.350	2	6	1	1	3	2	2
Foundary Dam	P30	0.600	1	1	0	1	3	1	1
Frazer	P24	0.500	1	1	0	1	3	2	1
Healy Road	P25	0.550	5	9	3	1	3	3	2
Hiram	P26	0.400	0	0	0	1	3	1	1
Horton Road Part A	P27	0.300	0	0	0	0	3	1	1
Hustis Road	P29	1.000	1	5	1	9	3	1	2
Hy View Terrace	P30	0.400	1	1	0	0	1	1	1
Jay Cox Part A	P31	0.150	0	1	0	0	3	2	1
Lake Surprise Paved	P32	1.100	1	6	1	5	3	1	1
Moffet Road	P34	0.900	1	5	0	4	3	1	1
Morris	P35	0.300	1	1	0	1	3	1	1
Mosher	P36	0.550	0	4	1	4	3	2	2
Mountain Brook Drive	P37	0.400	0	0	0	0	1	1	1
Oak Ridge	P38	0.150	0	1	0	0	3	1	1

(continued next page)

Ox Yoke Drive	P40	0.000	0	0	0	0	2	1	2
Perks	P41	0.600	4	5	0	4	3	1	1
Putnam	P42	0.220	1	0	0	1	3	2	1
Rochembeau	P43	0.250	1	0	0	0	3	1	1
Schofield	P44	0.200	1	4	1	1	3	2	1
Short Street	P45	0.100	0	0	0	0	2	1	1
Sprout Brook	P46	0.350	1	1	1	1	3	1	1
Steuben	P47	0.600	1	5	1	5	3	1	1
Travis	P48	0.900	0	0	0	1	3	1	1
Trout Brook Road	P49	0.400	0	1	0	1	1	1	1
Old West Point Part B	P50	0.350	0	0	0	0	3	1	1
Winston Lane	P51	1.500	1	1	1	1	3	1	1
Woods	P52	0.250	1	1	0	1	1	1	1

Rating Key:

x1 Longitudinal/Transverse Cracking
x2 Alligator Cracking
x3 Patching/Potholes
x4 Edge Cracking
x5 Drainage
x6 Roughness
x7 Rutting

Severity Index: Numbers are taken from the matrix on the "Flexible Pavement Condition Survey" sheets, see sample in Section 2 of attachments. For example, a "2" in the x1 box means that the cross section is "fair". A "5" in the x5 box means that there are moderately deep potholes to a medium extent along the road section.

Town of Philipstown Road Condition Rating
Ratings for Unpaved Road Sections

Road Name	Section	Length	x1	x2	x3	x4	x5	x6	x7
Avery Road	D01	1.300	2	3	1	1	4	0	2
Chapman (Donnelly) Road	D04	0.500	2	3	0	1	1	0	1
Derham Cross Road (Beverly Warren)	D03	0.100	3	3	0	1	6	1	0
East Mountain Road South to cty ln	D08	1.200	2	3	0	1	4	5	0
East Mountain Road North	D05	2.800	1	3	0	1	4	4	1
East Mountain Road (Walker)	D06	1.000	1	1	1	1	0	0	0
East Mountain Road South	D07	0.600	1	2	0	1	0	0	0
Esselborne	D09	0.900	3	3	1	1	1	6	1
Forsonville (West) Old West Point	D10	0.800	3	3	1	1	1	6	1
Horton Mill Road	D11	0.400	1	3	0	1	1	4	0
Horton Road (Part B)	D12	0.250	2	3	0	1	1	1	0
Indian Brook Road East	D13	1.500	3	3	1	1	5	5	1
Indian Brook Road West	D14	1.850	2	3	1	1	5	1	1
Jay Cox Road (Part B)	D18	1.200	2	3	0	1	4	6	1
Lake Surprise Road	D15	0.400	2	3	1	1	1	1	1
Lane Gate Road	D17	0.700	3	3	1	1	1	0	0
Nelson Lane	D19	0.250	3	3	6	1	5	0	0
Old Albany Post (Main)	D20	5.600	3	3	1	1	5	0	1
Old Manitou (Belcher Road)	D02	0.350	3	3	1	1	1	0	0
Old West Point Road (East)	D26	0.950	2	3	1	1	5	0	1
Osborne Road	D21	0.300	3	3	5	1	1	5	0
Philips Brook (East)	D22	1.000	2	3	1	1	5	0	1
Philips Brook (West)	D22	0.700	3	3	1	1	9	6	0
South Mountain Pass Road	D24	1.900	2	3	5	1	1	1	1
Valahalla Road	D25	0.800	2	3	1	1	1	1	0

Rating Key

x1 Cross Section
x2 Drainage
x3 Corrugations
x4 Dust
x5 Potholes
x6 Rutting
x7 Loose Aggregate

Severity Index: Numbers are taken from the matrix on the "Unpaved Road Condition Survey" sheets, see sample in Section 2 of attachments.

Unpaved Roads

The single greatest enemy of the unpaved roads is water. This factor translated into high computer defect ratings for the unpaved network as a whole. Although the "traveled ways" of the unpaved roads are in good condition, the overall low rating of the computer program, 33%, is due to the universal drainage problem. As can be expected, we observed typical maintenance glitches such as excessive crowns, unnecessary washboarding due to grader blade chatter, and the occasional need for local reconstructions, sometimes with the addition of imported gravel. Never-the-less, it is obvious that the roads are being routinely graded and reshaped, resulting in smooth, crowned, roads free of major rutting, and potholes *most of the time*. This was made clear to us, because we observed many roads at the end of a maintenance cycle, just before regrading, and defects were not that bad, from a statewide perspective. Furthermore, as with the paved roads, there is no evidence of serious subgrade instability. This is indicated by the fact that nowhere was serious rutting encountered. Where rutting was observed, it was more a result of water channeling (poor drainage) than unstable base material. There were some exceptions, such as Esopus Rd., the outer limits of Philips Brook Road, and Canopus Hill Road. In conclusion, the unpaved network is in generally good condition, but as indicated by a low overall RSMS rating it is adversely affected by serious drainage problems.

V. REPAIR ALTERNATIVES AND COST ESTIMATES

A. <u>Maintenance Costs</u>

The following costs were excerpted directly from the information in Section 8 of the attachments. It is very significant that these figures do not include any costs for owning and maintaining the highway equipment. That is, none of budget line D5130 is apportioned to these costs. Even if this is based on the philosophy that the town has to own the equipment for snow removal and that, therefore, there is "no cost" for road work, at least some allowance for wear and fuel should be made to make comparisons more relevant. Since we can't make this assessment, we are simply suggesting that a subjective allowance be kept in mind when reviewing these figures, and that the unpaved roads are likely to be more labor and equipment intensive than the paved roads.

Annual Maintenance Costs per Mile

Unpaved Roads

Road Name	1994 Cost	Length (Miles)
Belcher	$656	0.36
Donnelly	$1,323	0.45
East Mountain North	$21,891	2.80
East Mountain Walker - ESSERBOURNE	$4,139	1.10
Forsonville	$3,354	1.20
Gillet	$370	0.19
Highland Drive	$4,093	0.36
Indian Brook	$6,371	3.62
Jay Cox Road	$7,649	1.37
Manitou	$4,000	0.61
Nelson Lane	$541	0.26
Old Albany Post	$36,344	6.6
Philipsbrook	$12,292	2.5
South Mountain Pass	$13,985	2.3
Total	$117,008	23.72
Cost $$/mile	$4,933	

ESSERBOURNE ?
EAST MTN. SO. - (WIPPERPEE)

Paved Roads

Road Name	1994 Cost	Length	1994 Cost less Pavement
Allan	$2,361	0.25	$1,740
Arden	$758	0.49	$0
Beale	$481	0.31	$481
Birch	$601	0.15	$601
Canopus	$1,420	0.36	$1,266
Coleman	$1,622	0.24	$978
Clovebrook	$213	0.42	$0
Finchel	$217	0.11	$135
Frazer	$421	0.55	$421
Horton	$6,176	0.60	$4,781
Hustis	$2,542	0.90	$2,542
Moffet	$3,442	0.89	$3,442
Mountain Brook	$150	0.39	$150
Ox Yoke	$2,584	0.37	$2,022
Perks	$827	0.69	$556
Rochambeau	$45	0.27	$45
Short Street	$256	0.05	$256
Sprout Brook	$1,240	0.32	$1,240
Steuben	$989	0.42	$798
Travis	$14,780	0.86	$8,768
Winston	$7,497	1.48	$$6,315
Total	$48,622	10.12	$36,537
Cost $$/mile	$4,805		$3,610

We have no definitive explanation for the stark difference between these figures and those developed by the roads committee based on the first six months of 1993 (See the last sheet of Section 8). Perhaps it is related to the fact that their analysis did not include the summer months. It <u>does</u> appear to have the same bias in that equipment costs are missing.

B. <u>Strategic Cost Estimates</u>

The table on the following page indicates repair alternatives and associated cost estimates. The alternatives include current practice as well as our recommendations for new procedures. Current practices include graded subgrade bases for paving, unpaved road grading/shaping, road widening, Asphalt Concrete (AC) overlays, and chip seals. New recommendations include new base construction options with imported gravel rejuvenated bases using asphalt emulsion stabilization with existing material and/or imported gravel and properly designed hot or cold mix AC overlays.

Repair Alternatives
Paved Roads

Category	Option	Description	Outside Purchase♥	Town Expense♥	Total	Unit
Reconstruction	1♦	Grade Subgrade	$100	$1,185	$1,285	$0.22/SY
Reconstuction	2♦	Light Duty 6" Gravel	$17,047	$7,713	$24,760	$4.22/SY
Reconstruction	3♦	Heavy Duty 12" Gravel	$32,488	$12,417	$44,905	$7.65/SY
Reconstruction	4♦	6" B.S. In-Place	$19,370	$255	$19,625	$3.34/SY
Reconstruction	5♦	6" B.S. Import	$26,895	$3,156	$31,856	$5.43/SY
Reconstruction	6♦	9" B.S. In-Place	$$28,700	$255	$28,955	$4.93/SY
Reconstruction	7♦	9" B.S. Import	$40,340	$7,315	$47,655	$8.12/SY
Reconst/ Rehab	8	Widen Road	$100	$2,400	$2,500	$0.50/LF
Reconst/ Rehab	9	Ditch Road	$100	$1,185	$1,285	$0.25/LF
Reconst/ Rehab/PM	10♦	Single Chip Seal	$3,560	$552	$4,112	$0.70/SY
Reconst/ Rehab/PM	11♦	Double Chip Seal	$10,910	$560	$11,470	$1.96/SY
Reconst/ Rehab	12♠	2" AC Hot Mix	$45,270	$192	$45,462	$4.30/SY
Reconst/ Rehab	13♠	3" AC Hot Mix	$67,900	$192	$68,092	$6.45/SY
Reconst/ Rehab	14♠	4" AC Hot Mix	$90,540	$192	$90,632	$8.58/SY
Reconst/ Rehab	15♠	2" Cold Mix	$36,784	$256	$37,040	$3.50/SY
Reconst/ Rehab	16♠	3" Cold Mix	$54,700	$256	$54,956	$5.20/SY
Reconst/ Rehab	17♠	4" Cold Mix	$72,616	$256	$72,872	$6.90/SY
PM	18	Crack Seal	$4,000	$256	$4,256	$0.75/LF
Rehab	19	Revert to Gravel	$240	$700	$940	$0.18/LF
Reconst/ Rehab	20♦	Full Depth Reclamation	$6.750	$250	$7,000	$1.20

♥ Costs per mile of road
♦ **Calculated for a 10' existing unpaved road**
♠ **Calculated for an 18' existing paved road**

It is very important to understand the use of these estimates. The costs per mile are for strategic analysis only, not necessarily project level work. In other words, they have been developed with average figures which, may or may not, apply to a given road. For example average road widths were assumed in order to develop costs per mile. Hence if applied against a road which varies significantly in width, the estimates will vary. Another example involves haul costs. We developed an average price per ton-mile to haul gravel an average distance within the town, which is appropriate for estimates involving all roads throughout the town. However for a given project the haul distance may vary significantly from the average.

To facilitate more specific estimates the costs have been presented in dollars per square yard of road surface or per linear foot. These figures may be extended against a proposed section of road with exact dimensions to generate more accurate cost projections, such as those presented in the RSMS reports of Section 6.

The material costs were obtained from local vendors. They are accurate for the current year. We did this in order to provide consistent comparisions, but their use in out years must be accompanied by adjustments for fluctuations in vendor costs, inflation, and the cost of money.

Lastly, the costs represent assumed construction methodologies based on our experience and typical town highway procedures. An example of this is the haul cost for base reconstructions. Since this has never been done for an entire road by the current administration of your highway department, we have assumed the crew would haul gravel from a nearby pit (Thalle Inc. in Newburgh) and stockpile it at the town barns prior to construction. From there it would be hauled to the project site as needed. Of course, it is possible to haul it directly from the pit to the construction site. We opted for the former because it is often practical to do this during times of slack work load

With the above in mind it is essential to emphasize that these are not project level engineering estimates, and should not be used as such. Rather these estimates are *strategic projections* for the purpose of relative comparisons between various proposed courses of action.

C. Service Level Categories

We solicited the Vision Statements, which are attached in Section 5, as a means of attaining the residents' view in respect to future planning. The only conspicuous and consistent common opinion was that there shouldn't be much increase in the highway budget. With this in mind we have utilized the vision statements for three purposes.

First they have been used as a basis for comparing the long range cost of "unpaved" vs. asphalt pavement, and "unpaved" vs. chip seals. These numbers are presented in tables which follow.

Second, the vision statements included rating factors for the prioritization of road repair projects. These factors were, 1) road condition, 2) road roughness, and 3) traffic volume. The total of the three factors had to equal 100 and the average of the values submitted on the vision statements was; Road Condition 54%, Roughness 23%, and Traffic Volume 23%. The generated project priority listing thus ranked future projects according to this weighted rating; that is road condition had twice the influence of the other factors. The resulting priority list is submitted in Section 6.

The third use of the vision statements was for generation of the sample Capital Improvement Five Year Plan of Section 3. In view of the "pavement" vs. "unpaved" controversy, essentially mirrored by the vision statements, we are recommending a compromise solution of improving 5 to 10 miles of roads with chip seals over properly engineered bases. The chip seals, with brown aggregate, have the rural look and character of "unpaved" but the serviceability of pavement. They are affordable and offer a realistic compromise.

D. <u>Life Cycle Cost Ananlysis</u>

At the heart of pavement management is the understanding of roads from a life cycle perspective. Generally speaking a paved road should be thought of as a 20 year project. It begins with design and initial construction, and is followed up with planned rehabilitation treatments at key milestones in the pavement life. Finally at about 20 years the pavement is rebuilt, starting a new life cycle. Based on this approach the cost of the pavement is the total cost of construction, rehabilitation, and routine maintenance over 20 years. The objective is to maximize quality and serviceability, while minimizing this total cost. It is more cost effective to lay down substantial amounts of pavement initially with long lasting strength, as opposed to repetitive, thin overlays at shorter intervals with less strength and durability. Secondly, it is crucial to consider contemporary techniques that avoid costs for new materials by recycling, or enhancing the properties of in place materials. Such technologies include Cold-in-Place Recycling, Base Stabilization, Full Depth Base Reclamation etc. Last but not least, it is important to look beyond traditional asphalt concrete. Contemporary chip seals over well engineered bases can provide a pavement every bit the equal of traditional asphalt concrete at much less cost. This is our recommendation.

Based on this premise, we have completed life cycle analyses of two roads. For each road we calculated the 20 year cost of 4 design approaches; A) Current Practice (Status Quo), B) 3" AC Concrete Over 6" Imported Gravel Base, C) Double Chip Seal Over 6" Emulsion Stabilized Existing Base, and D) Revert to Gravel.

Our cost estimates for each of these four approaches are based on current year labor, material, and equipment costs. The out years were not adjusted for inflation in order to show direct relative comparisons. This also provides a clear "baseline" of costs that may be manipulated as desired for any funding strategy.

In order to generate these life cycle costs we used the construction estimates developed in paragraph B. In addition we calculated the average annual cost of maintenance per mile for unpaved/paved roads based on the 1994 Maintenance Cost Report provided by the Highway Department, and enclosed in Section 8. The average annual cost per mile to maintain unpaved roads is $4,933, as compared to $4,805 per year per mile for paved roads. The figure for paved roads could drop to as low as $3,610 for properly designed roads. It is important to note that these numbers do not mean that the cost to ***own*** paved roads is equal to or less than unpaved roads. While the ***maintenance*** of paved roads is currently about the same as for unpaved roads, ***over 20 years these tables show that it costs substantially more (capital improvement plus maintenance), to own a mile of paved road vs. a mile of unpaved road.***

Hustis Road (10,560 square yards)

Hustis Actual Costs (per Highway Department)

Year	Item	Capital Improvement
1982	1" AC	$23,599
1989	1' + AC	$39,462
1997	2" AC	$43,639
1982-2002	Maintenance	$86,482
Total		$193,182

Hustis as 3" AC over 6" Import Gravel Base

Year	Item	Cost
1982	6" Emulsion Stab	$44,563
	3" AC	$65,474
1989	S. Chip Seal	$7,392
1997	2" AC Overlay	$43,624
1983-2002	Maintenance	$72,208
Total		$233,261

Hustis as Double Chip Seal over 6" Stabilized Existing Base

Year	Item	Cost
1983	6" Base Stab	$29,568
	Double Chip	$20,592
1990	Single Chip	$7,392
1995	Single Chip	$7,392
1998	Single Chip	$7,392
1983-2003	Maintenance	$72,208
Total		$144,544

Hustis as Unpaved Road

Year	Item	Cost
1983-2003	Maintenance	$98,658
Total		$98,658

Winston Lane (15,628 square yards)

Actual Costs (per Highway Department)

Year	Item	Capital Improvement
1983	AC	$8,400
1985	AC	$20,963
1986	AC	$12,203
1987	AC	$35,105
1988	AC	$10,293
1994	AC	$46,911
1983-2003	Maintenance	$142,215
Total		$276,090

Winston as a 2" AC over 6" Imported Gravel Base

Year	Item	Cost
1983	6" Gravel	$65,950
	3" AC	$96,900
1990	S. Chip Seal	$10,953
1998	2" AC Overlay	$64,923
1983-2003	Maintenance	$106,867
Total		$345,593

Winston as Double Chip Seal Over 6" Stabilized Existing Base

Year	Item	Cost
1983	6" Imported Gravel	$45,009
	Double Chip	$30,475
1990	Single Chip	$10,940
1995	Single Chip	$10,940
1998	Single Chip	$10,940
1983-2003	Maintenance	$106,867
Total		$215,169

Winston as Unpaved Road

Year	Item	Cost
1983-2003	Maintenance	$146,013
Total		$146,013

In both cases it is clearly cheaper to maintain the roads unpaved over 20 years. In the case of Winston lane, under current paving practice, it costs 50% more to maintain a paved road as compared to an equivalent sized unpaved road. For Hustis the paved costs are 100% more than those of an equivalent unpaved road. The Actual Cost figures come from the highway department historical data in Section 7, and the Revert to Gravel costs come from actual maintenance costs recorded for sample year 1994, Section 8. Note, that the roads used to calculate the average annual maintenance costs are roads selected on the basis of 100% unpaved or 100% paved configurations. Those roads that are part unpaved and part paved, were not used in order to keep the analysis based on pure sample types. Different sampling methodology would yield slightly different average annual maintenance costs, but not of significant variation to alter these results.

In summary, the life cycle costs for these two sample roads are:

Road	Option	Average Annual Cost	20 Year Total Cost
Winston	Current Practice	$13,805	$276,090
	3" AC, 6" Base	$17,280	$345,590
	Double Chip Seal	$10,760	$215,170
	Revert Gravel	$7,300	$146,000
Hustis	Current Practice	$9,659	$193,180
	3" AC, 6" Base	$11,660	$233,260
	Double Chip Seal	$7,230	$144,545
	Revert Gravel	$4,930	$98,660

The next five pages present the life cycle analyses for five different strategic concepts for the entire road system.

Status Quo

Year	Unpaved Miles	Maint-enance $	Paved Miles	Maint-enance $	Cap. Imp. $ - Initial Outlay	Capital Plan	Total $$
1	35	$172,651	24	$115,309	$0	$0	$287,960
2	35	$172,651	24	$115,309	$0	$0	$287,960
3	35	$172,651	24	$115,309	$0	$0	$287,960
4	35	$172,651	24	$115,309	$0	$0	$287,960
5	35	$172,651	24	$115,309	$0	$0	$287,960
6	35	$172,651	24	$115,309	$0	$0	$287,960
7	35	$172,651	24	$115,309	$0	$0	$287,960
8	35	$172,651	24	$115,309	$0	$0	$287,960
9	35	$172,651	24	$115,309	$0	$0	$287,960
10	35	$172,651	24	$115,309	$0	$0	$287,960
11	35	$172,651	24	$115,309	$0	$0	$287,960
12	35	$172,651	24	$115,309	$0	$0	$287,960
13	35	$172,651	24	$115,309	$0	$0	$287,960
14	35	$172,651	24	$115,309	$0	$0	$287,960
15	35	$172,651	24	$115,309	$0	$0	$287,960
16	35	$172,651	24	$115,309	$0	$0	$287,960
17	35	$172,651	24	$115,309	$0	$0	$287,960
18	35	$172,651	24	$115,309	$0	$0	$287,960
19	35	$172,651	24	$115,309	$0	$0	$287,960
20	35	$172,651	24	$115,309	$0	$0	$287,960
Totals		$3,453,019		$2,306,182	$0	$0	$5,759,200

Add 5 Miles of Pavement, One Per Year, Starting in Year Two

Year	Unpaved Miles	Maint-enance $	Paved Miles	Maint-enance $	Cap. Imp. $ - Initial Outlay	Capital Plan	Total $$
1	35	$172,651	24	$115,309	$0	$0	$287,960
2	34	$167,718	25	$118,919	$110,000	$3,420	$400,058
3	33	$162,785	26	$122,530	$110,000	$6,840	$402,155
4	32	$157,852	27	$126,140	$110,000	$10,260	$404,252
5	31	$152,919	28	$129,751	$110,000	$13,680	$406,350
6	30	$147,987	29	$133,361	$110,000	$17,100	$408,447
7	30	$147,987	29	$133,361	$0	$17,100	$298,447
8	30	$147,987	29	$133,361	$0	$17,100	$298,447
9	30	$147,987	29	$133,361	$0	$17,100	$298,447
10	30	$147,987	29	$133,361	$0	$17,100	$298,447
11	30	$147,987	29	$133,361	$0	$17,100	$298,447
12	30	$147,987	29	$133,361	$0	$17,100	$298,447
13	30	$147,987	29	$133,361	$0	$17,100	$298,447
14	30	$147,987	29	$133,361	$0	$17,100	$298,447
15	30	$147,987	29	$133,361	$0	$17,100	$298,447
16	30	$147,987	29	$133,361	$0	$17,100	$298,447
17	30	$147,987	29	$133,361	$0	$13,680	$295,027
18	30	$147,987	29	$133,361	$0	$10,260	$291,607
19	30	$147,987	29	$133,361	$0	$6,840	$288,187
20	30	$147,987	29	$133,361	$0	$3,420	$284,767
Totals		$3,033,723		$2,613,064	$550,000	$256,500	$6,453,287

Averate Annual Budget: $322,664
Increase: 12%

Add 10 Miles of Pavement, One Per Year, Starting in Year Two

Year	Unpaved Miles	Maint-enance $	Paved Miles	Maint-enance $	Cap. Imp. $ - Initial Outlay	Capital Plan	Total $$
1	35	$172,651	24	$115,309	$0	$0	$287,960
2	34	$167,718	25	$118,919	$110,000	$3,420	$400,058
3	33	$162,785	26	$122,530	$110,000	$6,840	$402,155
4	32	$157,852	27	$126,140	$110,000	$10,260	$404,252
5	31	$152,919	28	$129,751	$110,000	$13,680	$406,350
6	30	$147,987	29	$133,361	$110,000	$17,100	$408,447
7	29	$143,054	30	$136,971	$110,000	$20,520	$410,545
8	28	$138,121	31	$140,582	$110,000	$23,940	$412,642
9	27	$133,188	32	$144,192	$110,000	$27,360	$414,740
10	26	$128,255	33	$147,802	$110,000	$30,780	$416,837
11	25	$123,322	34	$151,413	$110,000	$34,200	$418,935
12	25	$123,332	34	$151,413	$0	$34,200	$308,935
13	25	$123,332	34	$151,413	$0	$34,200	$308,935
14	25	$123,332	34	$151,413	$0	$34,200	$308,935
15	25	$123,332	34	$151,413	$0	$34,200	$308,935
16	25	$123,332	34	$151,413	$0	$34,200	$308,935
17	25	$123,332	34	$151,413	$0	$30,780	$305,515
18	25	$123,332	34	$151,413	$0	$27,360	$302,095
19	25	$123,332	34	$151,413	$0	$23,940	$298,675
20	25	$123,332	34	$151,413	$0	$20,520	$295,255
Totals		$2,737,750		$2,829,686	$1,100,000	$461,700	$7,129,137

Average Annual Budget: $356,457
Increase: 24%

Add 5 Miles of Chip Seal, One Per Year, Starting In Year Two

Year	Unpaved Miles	Maint-enance $	Paved Miles	Maint-enance $	Cap. Imp. $ - Initial Outlay	Capital Plan	Total $$
1	35	$172,651	24	$115,309	$0	$0	$287,960
2	34	$167,718	25	$118,919	$51,000	$1,850	$339,488
3	33	$162,785	26	$122,530	$51,000	$3,700	$340,015
4	32	$157,852	27	$126,140	$51,000	$5,550	$340,542
5	31	$152,919	28	$129,751	$51,000	$7,400	$341,070
6	30	$147,987	29	$133,361	$51,000	$9,250	$341,597
7	30	$147,987	29	$133,361	$0	$9,250	$290,597
8	30	$147,987	29	$133,361	$0	$9,250	$290,597
9	30	$147,987	29	$133,361	$0	$9,250	$290,597
10	30	$147,987	29	$133,361	$0	$9,250	$290,597
11	30	$147,987	29	$133,361	$0	$9,250	$290,597
12	30	$147,987	29	$133,361	$0	$9,250	$290,597
13	30	$147,987	29	$133,361	$0	$9,250	$290,597
14	30	$147,987	29	$133,361	$0	$7,400	$288,747
15	30	$147,987	29	$133,361	$0	$5,550	$286,897
16	30	$147,987	29	$133,361	$0	$3,700	$285,047
17	30	$147,987	29	$133,361	$0	$1,850	$283,197
18	30	$147,987	29	$133,361	$0	$0	$281,347
19	30	$147,987	29	$133,361	$0	$0	$281,347
20	30	$147,987	29	$133,361	$0	$0	$281,347
Totals		$3,033,723		$2,613,064	$255,000	$111,000	$6,012,787

Average Annual Budget: $300,639
Increase: 4%

Add10 Miles of Chip Seal, One Per Year, Starting in Year Two

Year	Unpaved Miles	Maint-enance $	Paved Miles	Maint-enance $	Cap. Imp. $ - Initial Outlay	Capital Plan	Total $$
1	35	$172,651	24	$115,309	$0	$0	$287,960
2	34	$167,718	25	$118,919	$51,000	$1,850	$339,488
3	33	$162,785	26	$122,530	$51,000	$3,700	$340,015
4	32	$157,852	27	$126,140	$51,000	$5,550	$340,542
5	31	$152,919	28	$129,751	$51,000	$7,400	$341,070
6	30	$147,987	29	$133,361	$51,000	$9,250	$341,597
7	29	$143,054	30	$136,971	$51,000	$11,100	$342,125
8	28	$138,121	31	$140,582	$51,000	$12,950	$342,652
9	27	$133,188	32	$144,192	$51,000	$14,800	$343,180
10	26	$128,255	33	$147,802	$51,000	$16,650	$343,707
11	25	$123,332	34	$151,413	$51,000	$18,500	$344,235
12	25	$123,332	34	$151,413	$0	$18,500	$293,235
13	25	$123,332	34	$151,413	$0	$18,500	$293,235
14	25	$123,332	34	$151,413	$0	$16,650	$291,385
15	25	$123,332	34	$151,413	$0	$14,800	$289,535
16	25	$123,332	34	$151,413	$0	$12,950	$287,685
17	25	$123,332	34	$151,413	$0	$11,100	$285,835
18	25	$123,332	34	$151,413	$0	$9,250	$283,985
19	25	$123,332	34	$151,413	$0	$7,400	$282,135
20	25	$123,332	34	$151,413	$0	$5,550	$280,285
Totals		$2,737,750		$2,829,686	$510,000	$216,450	$6,293,887

Average Annual Budget: $314,694
Increase: 9%

E. 5 Year Plans

The Five Year Plan is the ***heart*** of the life cycle road management process. Here is where the following information comes together for action: 1) Public Opinion for desired level of service, 2) Actual Road Conditions based on the Survey, 2) Project Prioritization based on Public Opinion, 3) Cost Estimates, 4) Life cycle Pavement Management Strategies, and 5) Engineering Design and Recommendations. This information can be utilized to come up with any number of possible plans. The one we present in Section 3 represents one such synthesis, but the same process may be used to come up with any Five Year Plan that meets the needs.

The following rationale was used to generate this sample:

1) Projects have been selected in the order of priority presented by the RSMS computer report in Section 6. The computer ranking is based on the priority assigned to traffic, condition, and roughness on the vision statements.

2) The repairs shown are based on a combination of the computer selected treatments, and our engineering judgment. For each road a number of possible treatments are listed on the report. Our final selection is based on field inspection. The field inspection notes are enclosed in Section 4.

3) Based on the public discussion of "unpaved' vs. "pavement", and our recommended compromise (chip seal 5 to 10 miles), we have added a chip seal project (one mile) to each year of the plan, for a total of 5 new miles of chip seal.

4) Based on the overall problems with drainage, as often repeated in this report, we have added a $50,000 dollar capital improvement line item for drainage work in each year of the plan, for a total of $250,000 over the next five years.

5) The Five Year Plan only shows *road maintenance* and *capital improvement*. It does not show other budget areas such as snow removal etc.

6) The costs for each project are taken from the RSMS report in Section 6. These, in turn, are based on the calculations for each repair alternative in Section 9, which were entered into the database. The program then applied the unit cost of each repair to actual road dimensions

7) Finally, it is important to note that the project costs for each road are strategic estimates. Though from the perspective of the total budget these numbers are accurate, they may not work out exactly as depicted for each road.

VI. CONCEPTUAL RECOMMENDATIONS

A. Budgets

The following is a summary of the average annual costs from the previous Section.

Option	Average Annual Maintenance	Average Annual Capital Improvement	Total Annual Cost	% Increase Above or Over Status Quo
Status Quo	$287,960	$0	$287,960	NA
Add 5 miles of Asphalt Pavement	$282,339	$40,325	$322,660	12%
Add 10 miles of Asphalt Pavement	$278,370	$78,080	$356,460	24%
Add 5 miles of Chip Seal	$282,340	$18,300	$300,640	4%
Add 10 miles of Chip Seal	$278,370	$36,320	$314,700	9%

Note: Average annual maintenance costs are based on three numbers, as calculated earlier. The first is the average annual cost for a mile of unpaved road. The second is the same for paved roads under current practice. And the third is the projected maintenance cost for paved roads based on more rigorous design. This figure is somewhat lower than current practice and was used for projected miles of new pavement.

From the summary table the following general conclusions/trends can be observed:

1. Adding pavement of any kind (3" Asphalt Concrete, Chip Seal etc.) will permanently raise total budget costs above the current baseline. The investments will have to be repeated every 20 year cycle when the pavements are rehabilitated. On the positive side, in out year cycles, investments made during initial base constructions will carry over, and subsequent front end rehabilitation costs will be less due to good bases being already in place. Never-the-less total costs within the network will rise as a function of ongoing increased levels of rehabilitation and reconstruction for more miles of pavement.

2. The example budget increase ranges from 4% for 5 miles of chip seal, to 24% for 10 miles of Asphalt Concrete.

3. All projections are based on properly designed roads. Chip seals would be cheaper than current practice, but 3" Asphalt Concrete over a good base would be more expensive.

In view of the above, we recommend the addition of 5 to 10 miles of road with chip seals over improved bases (imported gravel, or stabilized natural sub-grade). These chip seals could be done without altering current widths or alignment, but with proper drainage added (ditches, culverts etc.). Brown aggregate could be used, as was done with other recent projects. This would yield a road that has the rural character of "unpaved" with the serviceability of pavement. It would be very cost effective. Though somewhat more expensive than unpaved, a 4% budget increase seems modest.

B. Drainage

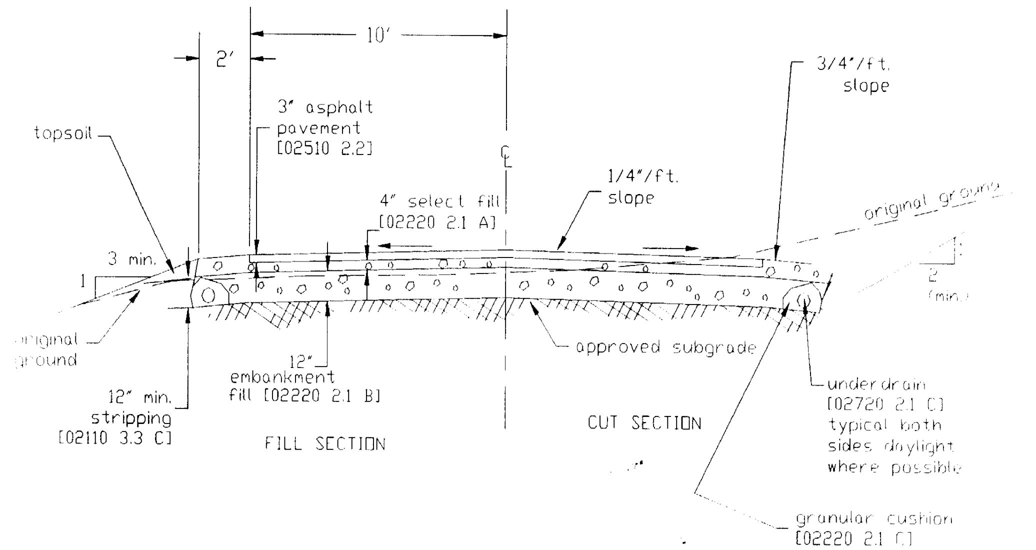
Throughout the report comments have been made regarding drainage. It cannot be emphasized enough that the number one enemy of roads is water. Therefore we are going to summarize here, the recommendations that appear throughout this report with regard to drainage.

1. Culverts need to be checked, and redesigned/reconstructed if necessary for sizing and alignment.
2. Culverts must have adequate headwalls designed and installed in order to prevent unnecessary erosion around entrances and exits.
3. Cut slopes/faces along roads need to be stabilized with retaining walls or vegetation in order to prevent erosion.
4. Wherever possible minor widening should be allowed to accommodate the improvement of gutters into real ditches large enough to channel flow, and prevent it from eroding the traveled way.
5. In many locations culverts should be added for driveways. In addition flows from adjoining properties should be channeled into ditches/culverts rather than down driveways onto the road way.
6. Wherever cross sections resemble troughs reshaping is essential to channel flow off the roads, not onto them. If trough shaped roads are paved they should be curb-gutter design with storm sewers.
7. Berms left along roads due to grading should be removed to allow the escape of water from the road surface.
8. Overlays must never be placed over roads that have failed due to underlying drainage or base problems.

In view of your historic drainage problems, which are exacerbated by the hilly terrain, we recommend that no road rehabilitation, new construction, or rebuild project should be undertaken without a hydrologic analysis.

C. Reconstruction

The following figure shows a typical roadway section. The left-hand side is the typical cut condition (or where the roadway is below existing grade) and the right-hand side is fill.



TYPICAL ROAD SECTION

Not to Scale

The salient features of this section are:

- Two lanes, each of which are typically 8 to 12 feet in width.
- A crown in the center with the pavement sloping towards both shoulders at 1/4 inch per foot. On curves, the outside edge is raised so that the slope is across both lanes to the inside edge. This is called superelevation and is provided to help the vehicle stay on the road as it goes around the curve.
- A free-draining base course for strength with a water-shedding wearing surface on top. In the case of unpaved roads, the base and wearing course are one, which must be dense rather than free-drainage.
- Shoulders which provide the margin of safety and have a steeper slope, typically 3/4 inch per foot, to carry the water away from the paving.
- Roadside ditches that extend below the base course to provide an escape path for seepage. The slopes are made relatively flat, 2 or 3 feet horizontally for each foot vertical as shown, for safety reasons as well as to prevent sloughing.

These are typical conditions and each of your roads (and sections thereof) should be tailored to the prevailing terrain, as first stated in the Executive Summary. In other words, this typical section may have only conceptual applicability to your roads.

Respectfully Submitted,

Steve Messmer, Intern Engineer

Pete Messmer, Collaborating Engineer

Gary Wood, Principal