HOUSE..... .....No. 9.

REPORT

ON

TROY & GREENFIELD RAILROAD SURVEYS.

JANUARY, 1874.

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Commonwealth of Massachusetts.

Executive Department, Boston, 20th January, 1874.

To the House of Representatives.

I have the honor herewith to lay before the General Court a Report of Surveys and Investigations relative to the Troy & Greenfield Railroad, made by Edward S. Philbrick, Civil Engineer, under instructions from the Governor and Council, given in pursuance of chapter 346, Acts of 1873.

W. B. WASHBURN.

REPORT.

To His Excellency WILLIAM B. WASHBURN, *Governor, and the Honorable Council.*

A sum was appropriated by the last general court, chapter 346, section 1, to be expended by the governor and council upon the Troy & Greenfield Railroad and Hoosac Tunnel, partly "in making such surveys and investigations as they may deem necessary to enable them to report to the next general court such plan as they think best for the interests of the Commonwealth to adopt in reference to said Tunnel and the Troy and Greenfield Railroad, and the probable cost of improving the same, and completing them for railroad service."

On the 5th of August last I was instructed to make such surveys and estimates as might be found necessary to a proper understanding of the case, and would now present my report.

The history and general characteristics of the Troy & Greenfield Railroad are now tolerably familiar to a large number of our citizens. It is located in a narrow valley or gorge, alongside of a turbulent mountain-torrent, necessarily requiring very expensive works, and great thoroughness in their construction, to insure their permanence.

The original promoters of the enterprise were led, through lack of means, to bend all their energies upon keeping the first cost within certain limits, ignoring, or being unable to appreciate, the necessity of constructing durable work. So that, aside from the doubtful merits of the general location, its details were carried out by the original company on a plan which was more commensurate with their means of payment, than likely to produce work suitable for future use.

The largest proprietor of the company being at the same

time contractor and engineer, an unusual degree of concentration of talent and power was brought to bear upon the details of construction, which tended to produce a railroad line of the cheapest possible first cost, regardless of curvature and liability to wash, in a place requiring extraordinary expenditure to secure durability.

At the time when the State took possession of the property, so much work had been done in the construction, that it was thought best to complete it on the same general plan as begun, hoping it might stand till something better was needed; and since its completion, the road has been kept passable, for the moderate amount of traffic developed, by dint of constant watchfulness and expenditure on the part of the lessees.

Some of the weak points in its construction were developed by the freshet of October, 1869, when the track was washed away, or rendered impassable, in fifty-nine separate places, some of which left gaps of five hundred feet length and sixty feet depth. More than half the culverts were torn out, and two spans of the bridge at Bardwell's Ferry carried off, with the pier between them.

The sum of $142,160.21 was spent during the ensuing year by the lessees, and afterward refunded by the State, in repairing the line and rendering it passable. These repairs occupied a period of eleven months, during nine of which traffic was suspended.

Having been employed by His Excellency, Governor Claflin, in June, 1870, to superintend these repairs, I made a report upon their completion, from which I quote the following, viz. :—

"The road is in some respects better able to resist the floods than ever before, inasmuch as new culverts have been built, in over twenty places, of largely increased opening, and on more secure foundations than before.

"But several miles of the embankment are exposed to the Deerfield River, a mountain torrent, which may at any time destroy all such structures within its reach which are not thoroughly faced with stone.

"Several hundred carloads of loose rock have been picked up and applied to this purpose, so that, in this respect, the work is as

well protected as before the great freshet of 1869, if not better, and therefore able to resist all ordinary stages of water.

"But another flood like that of October, 1869, or an unusual flood of even less dimensions, would be likely to destroy many of the embankments. There is scarcely any more broken stone left on the line of the road available for this sort of protection. I would therefore recommend an expenditure of some $25,000 in bringing down the surplus stone from the Hoosac Tunnel as soon as a connection can be made with the present track.

"As the embankment this side of the tunnel will be finished during the coming year, at present rates of progress, a very large surplus of excellent material will become available for this purpose. Until such protection is effected, the road is at the mercy of the floods, and in no reliable condition for traffic."

In pursuance of this recommendation, an appropriation of $25,000 was made in 1872 (chapter 287) for applying the protection spoken of, but on examination it was found that the location of the road was so faulty in most of the points where protection was needed, that it was thought best to risk further interruption by freshets, until the proper time should arrive for improving the location, and properly protecting it.* So that this sum was never drawn, nor any part of it.

During the past autumn I have inspected, on foot, every rod of the line from Greenfield to the Tunnel, not only for the purpose of forming an opinion of the present condition of the road, its safety and repair, but to study in detail such changes of location as might be necessary to bring the line up to some definite standard in regard to curvature, which might be suitable to a road likely to have a considerable traffic, and at the same time within reasonable limits of expense.

* Since writing the above, I read for the first time a description of this location by Mr. J. W. Brooks, in the Report of the Commissioners upon the Troy & Greenfield Railroad and Hoosac Tunnel, of February 28, 1863, which I now quote in corroboration of what I had written above:—

"The line, as now located, is essentially a contractors' line,—such a one as might fairly be anticipated where the contractor and engineer were the same person, intensified, if possible, by his controlling a majority of the stock. Everything has apparently been sacrificed to save present outlay. That we do not advise the immediate abandonment of a considerable portion of it is because of the large amount of work already done upon the most objectionable parts of the line, and the small amount of business to be done upon it until the Tunnel is completed, to which period, under existing circumstances, its improvement may be wisely deferred."—*Page 27 Commissioners' Report.*

Its condition as to repair is quite as low as, if not lower than, is consistent with the safety of the limited business now done upon it. The sleepers are very much decayed, especially on the eastern half, below Shelburne Falls, and the rails are all worn out, except for such short distances as it has been found absolutely necessary to replace them with new iron, for the sake of safety, proving their wretched quality when new, while the embankments, never finished at a liberal width, or with suitable materials, have been continually slipping away since first built, and have been merely kept in a passable condition. Very few have any shoulders beyond the ends of the sleepers, while the sleepers themselves project, in some cases, the earth having slipped away from under their ends, which are supported by blocking. This narrowness of embankments is not due to recent river-wash, for there has been no freshet worth mentioning since 1869, but is attributable to the clayey soil of which, and the careless way in which, they were first built, and the lack of proper drainage of their slopes. The cuttings are in many instances of slippery clay, the slopes of which had never been properly protected or drained, which breaks off every winter and spring, covering the track in many places, filling the ditches for long distances, and rendering proper drainage of the road-bed impossible.

Under such circumstances, it is not surprising to find that the lessees, whose interest expires with the coming year, should have hesitated to spend more upon repairs than the obligations of their lease and a proper regard for safety required. This state of things follows as a natural consequence of the original imperfect construction, with subsequent occupation by lessees who have no interest or apparent obligation to maintain the condition of the road above the requirements of the immediate safety of their small traffic.

As to improvements to be made in the character of the curves, I have made a separate study of each curve, and have made cross-sections of the hill-sides, at intervals of 100 feet or less, on all difficult ground, from which tolerably accurate estimates could be made of the quantities of earth or rock to be removed, or of wall to be built, to effect any desired change within reasonable limits.

In making up these estimates, I have taken first as a standard a minimum radius of 1,146 feet, or 5° per 100 feet, in five of the most difficult places, with a minimum of 1,432 feet radius, or 4° per 100 feet at other points. This is about the same standard as was adopted upon the Mountain Section of the Boston & Albany Railroad. This line is drawn in blue on the maps.

It is to be observed that the sharpest curves occur, either on gradients descending, or but very slightly ascending, in the direction of the ruling traffic, moving eastward, so that their effect will not be found to limit the length or weight of freight trains. This will be governed by the maximum grade ascending eastward.

For this reason, and on account of the very great cost of attaining such a high standard, I have made another estimate on a line drawn in red ink upon the map, using as a standard a minimum radius of 955 feet (6° per 100 feet) in four of the most difficult places. This estimate gives a total cost of $1,510,300, while the blue line, using a larger radius in four places, costs $161,362 more, making in all $1,671,662, exclusive of land damages.

In nearly all the changes on which I have estimated the cost, and which are represented on the accompanying map by the blue and red lines, it has been thought best to adopt the same general location that the old line is on, using the old land and grading for a large part of the way, the changes extending over 75 per cent. of the whole track, leaving 25 per cent. untouched, while of the 75 per cent. where changes occur a large part of the old work is used. By this means local interests have been protected, which might have been injuriously affected by a more radical change, for which change, with the exception named below, there seems to be no good reason. This is particularly the case with the whole of the portion above Bardwell's Ferry station. Below this point there are other lines to be considered, and a wider choice. Before deciding upon any definite course for future construction farther examination should be made as to the merits of such other lines. There is an apparently very practicable line, formerly called the Deerfield Route, described by Mr. J. W. Brooks in his report, as follows :—

"Another line was surveyed from the Vermont & Massachusetts Railroad to Bardwell's Ferry. This line commences about $1\frac{1}{3}$ miles east of the present terminus of the Troy & Greenfield Railroad, and keeping on the south side of the Deerfield River crosses the Connecticut River Railroad, south of the Cheapside Bridge over the Deerfield River; thence, nearly parallel with that road, to Deerfield Centre, and, crossing the Deerfield River at Martin's Falls, it joins the present location at Bardwell's Ferry.

"The whole length of this line is $8\frac{11}{100}$ miles, it has 489° less curvature, and 150 feet less rise and fall than the present route, and reduces the maximum grade ascending westward from $58\frac{6}{10}$ to $50\frac{16}{100}$ per mile; but this latter is not so important as might appear, for the grade ascending east, in the direction of the heaviest trade, is quite as strong relatively as the $58\frac{6}{10}$ rising west in the present line.

"Its adoption would involve the abandonment of $7\frac{7}{10}$ miles of the present track; as a through line it would save a mile in distance."

This Deerfield line was estimated by Mr. James Laurie, C. E., in his report to the commissioners, January 10, 1863, to cost $220,000 for the $8\frac{11}{100}$ miles. Assuming his estimate of quantities to be correct, and carrying them out at present prices for similar work, and adding for superstructure, we obtain a total of $551,855, which is to be compared to the sum of $593,615, and the land damages estimated as needed for an improvement of the present location east of the point of divergence as represented by the *blue* line, and compared to the sum of $578,455, as represented by the *red* line, between the junction of the Vermont and Massachusetts Railroad and a point common to both below Bardwell's Ferry.

Thus the Deerfield line appears not only to possess advantages over the present line with its improvements, both in distance and rise and fall, but actually costs $26,600 less, if we may trust Mr. Laurie's quantities, than the proposed improvements on the lowest standard as to curvature, and $41,760 less than those on the highest standard on that portion of the old line which it is intended to replace.

Mr. Laurie in his report to the commissioners (page 172) speaks of this line through Deerfield, as follows:—

"Viewed as a through line the saving of nearly a mile in distance, 489° of curvature, the reduction of the maximum grade and the

avoidance of the Green River Bridge with its sharp curve would be of considerable importance."

These advantages are to be weighed against the local business of Greenfield and Turner's Falls, which may be better accommodated otherwise.

For this end still another line has been surveyed recently, which leaves the present line of the Troy & Greenfield Railroad about $1\frac{1}{2}$ miles west of the present junction with the Vermont & Massachusetts Railroad, and passing through Greenfield and Turner's Falls intersects the present Vermont & Massachusetts track at Grout's Corner. This line is found to be a trifle longer (565 feet) than thepresent through line, but accommodates Greenfield and Turner's Falls to good advantage. It requires about $9\frac{3}{10}$ miles of independent construction, of which about two miles lie west of the Connecticut River Railroad, replacing nearly the same length of the present line of the Troy & Greenfield Railroad. This two miles, if built for a single track, would cost about $166,000 less than the improvement noted on my map on that part of the line which would be replaced by it between Blakely Hollow and the present junction.

Although the northern line is slightly longer as a through line than the present one, the large local interests at Greenfield and Turner's Falls may do much towards its construction; while the greater chances of developing business from these towns by building a thoroughfare *through* them than by having them on one side merits due consideration. The portion of this line lying east of the Connecticut River Railroad is estimated by Mr. Wm. P. Granger, C. E., who made the surveys, to cost $361,000 for a single-track line and wooden bridges.

For the sake of exhibiting in a concise form the nature of the changes contemplated, and the comparative merits, as to curvature, of other lines in mountainous districts, I have prepared tables, which will be found in the Appendix.

As to the propriety of bringing the location of this line up to either of the standards upon which these estimates are based, there may be some difference of opinion even among experts. Some arbitrary standards must be taken for the

purposes of a preliminary estimate, though it may be found perfectly proper to depart from these, in construction, in extreme cases, where the large expense to be incurred may prove incommensurate with the advantage to be gained.

Such questions can better be settled in detail whenever the work of construction shall be done.

In deciding such questions, it should be borne in mind that a sharp curve, say of 1,000 feet radius, is not a serious obstacle to a freight traffic when it occurs upon gradients descending, or but slightly ascending in the direction of the heavy traffic, and nearly the whole of the thirty miles we are now considering, between Greenfield and the Tunnel, presents this mitigating feature.

Were a passenger traffic to be provided for, however, such curves would present an obstacle by limiting the speed at which trains could be moved with safety, especially when running along the edge of high declivities, beside adding considerably to the wear and tear of permanent way and rolling-stock.

As to the standard held in view in regard to permanence of work in the grading, masonry and bridging, I do not anticipate much difference of opinion, though a large expense may be incurred. All the leading railroad lines in the country have, after twenty years' experience, abandoned wood as an improper material for bridge building, whenever the traffic has developed to any considerable importance. The building of wrought-iron bridges has in the same time had a large developement, in which many reliable firms are now engaged. Some of the first efforts in this direction were failures, having been constructed without sufficient allowance for the depreciation of metal under vibration, and such cases have done much to throw iron bridges into disrepute; but the more recent works have generally been governed in this respect by the rules adopted by the English and French governments for similar cases, promising entire safety for a long period, while the workmanship of American artisans is not excelled by any in other countries.

As to permanence in grading and masonry, it is hardly necessary to point out the folly of constructing such work upon improper principles or on insecure foundations. The

experience of the past five years has shown to all who have observed the character of the Deerfield River, that it is a stream not to be trifled with or ignored with impunity.

In judging of the propriety or necessity of making such improvements in the Troy & Greenfield Railroad, the only question seems to me to be as to the *time* when it shall be done. There is no doubt that the present line is good enough for present traffic, and with a few months' work with a gravel train and a renewal of the track, and some additional sidings, it would doubtless answer very well for as large a freight traffic as can be conducted on a single line of rails.

But if it be taxed with any considerable passenger traffic, with such an increase of freight as may very likely be developed after opening the Tunnel, a double line of rails from Troy to Fitchburg will become indispensable. The changes of location and the work of grading for a double track, can be carried on to much better advantage *together* than *separately*, and as they will in all probability be demanded by the increase of traffic at one and the same time, it has, therefore, seemed best to me to make an estimate of the cost of both, which is herewith presented in detail.

Respectfully submitted by your obedient servant,

EDWARD S. PHILBRICK,
Civil Engineer.

Boston, January 6th, 1874.

APPENDIX.

Summary of Estimate of Cost of the proposed improvements of the location of the Troy & Greenfield Railroad, as indicated by the blue line on the accompanying Map.

MATERIAL.	For Single Track.			For Double Track.		
	Quantity—Yds.	Price.	Cost.	Quantity—Yds.	Price.	Cost.
Earth excavation,	1,148,134	$0 45	$516,660 00	1,496,545	$0 45	$673,445 00
Loose rock,	7,948	1 00	7,948 00	10,438	1 00	10,438 00
Solid rock,	144,391	2 00	288,782 00	216,244	2 00	432,488 00
Tunnel at North Adams,	–	–	50,000 00	–	–	50,000 00
Pier masonry,	2,548	20 00	50,960 00	3,596	20 00	71,920 00
Abutment masonry,	12,288	15 00	184,320 00	15,591	15 00	233,865 00
Arches,	5,997	15 00	89,955 00	8,545	15 00	128,175 00
Culverts,	13,908	5 00	69,540 00	17,923	5 00	89,615 00
Retaining walls,	12,703	4 00	50,812 00	25,000	4 00	100,000 00
Rip-rap,	153,077	1 75	267,885 00	153,077	1 75	267,885 00
Bridges,	–	–	94,800 00	–	–	216,700 00
				Grading, &c., on 6.65 miles west of North Adams,		99,750 00
				2d track, 43⅔ miles at $11,000,		480,270 00
Total,			$1,671,662 00	Total,		$2,854,551 00

Comparative Curvature of the Present Line of the Troy & Greenfield Railroad and the Proposed Line, drawn in Blue on Map.

Degrees.	Radius—feet.	Present Line.		Proposed Line.	
		Total Curvature.	Length of Curve—feet.	Total Curvature.	Length of Curve—feet.
1, . .	5,730	8° 21′	1,060	–	–
2, . .	2,865	198° 28′	10,888	121° 21′	6,785
3, . .	1,910	430° 56′	14,267	626° 11′	21,383
4, . .	1,432	735° 45′	18,807	1,533° 21′	39,834
5, . .	1,146	1,000° 49′	19,762	427° 23′	8,540
6, . .	955	1,125° 54′	19,044	–	–
7 to 11, .	819 to 522	486° 49′	6,071	–	–
–	–	3,987° 02′	89,899	2,708° 16′	76,542

Present Line.

Curvature per mile, ... 133°
Percentage of line curved, ... 56

Proposed Line.

Curvature per mile, ... 90°
Percentage of line curved, ... 49

Table showing saving by adopting 6° per 100 feet as sharpest curve, in place of 5°.

This contemplates the blue line to be modified as shown in *red* upon the map at four places, viz., Bardwell's Ferry bridge, West Deerfield, above Zoar and near the tunnel station. Whole length of line changed, 9,490 feet. Total amount of curvature not changed.

Red Line, for Single Track.

Saving of Material.	Quantity.	Price.	Saving of Cost.
Rock, ...	41,531 yards, .	$2 00	$83,062 00
Pier masonry, . . .	980 " .	20 00	19,600 00
Abutment masonry, . .	1,780 " .	15 00	26,700 00
Bridging, ...	400 lineal feet,	80 00	32,000 00
Total saving, as compared with blue line, . . .			$161,362 00

Double Track. Saving by adopting Red Line in place of Blue.

Saving of Material.	Quantity.	Price.	Saving of Cost.
Rock, ...	57,923 yards, .	$2 00	$115,846 00
Pier masonry, . . .	980 " .	20 00	19,600 00
Abutment masonry, . .	1,780 " .	15 00	26,700 00
Bridging, ...	500 lineal feet,	80 00	40,000 00
Total saving, as compared with blue line, . . .			$202,146 00

Comparison of Lines via Greenfield and via Deerfield.

MATERIALS.	JAS. LAURIE'S LINE VIA DEERFIELD.			BARDWELL'S FERRY TO JUNCTION* VIA GREENFIELD. PRESENT JUNCTION.		
	Quantity.	Price.	Value.	Quantity.	Price.	Value.
Earth and ballast,	275,600 cub. yds.,	$0 45	$124,020 00	554,902 cub. yds.,	$0 45	$249,706 00
Solid rock,	82,000 "	2 00	164,000 00	50,515 "	2 00	101,030 00
Loose rock,	5,000 "	1 00	5,000 00	– –	1 00	–
Box culverts,	947 "	5 00	4,735 00	2,689 cub. yds.,	5 00	13,445 00
Arch culverts,	2,484 "	15 00	37,260 00	5,267 "	15 00	79,005 00
Bank wall,	500 "	4 00	2,000 00	4,055 "	4 00	16,220 00
Rip-rap,	1,200 "	1 75	2,100 00	5,333 "	1 75	9,334 00
Road-bridge masonry,	1,120 "	10 00	11,200 00	†1,445 "	20 00	28,900 00
River-bridge masonry,	1,470 "	15 00	22,050 00	3,665 "	15 00	54,975 00
Foundations,	– –	–	1,500 00	– –	–	–
Bridge superstructure,	370 lin. feet,	80 00	29,600 00	500 lin. feet,	80 00	40,000 00
Road-bridge superstructure,	100 "	15 00	1,500 00	– –	–	1,000 00
Altering town roads,	– –	–	1,500 00	– –	–	–
Farm crossings and cattle-guards,	– –	–	2,000 00	– –	–	–
Land damages,	– –	–	39,000 00	– –	–	–
Fencing,	3,700 lin. rods,	2 20	8,140 00	– –	–	–
Track-laying, iron, &c.,	8.75 miles,	11,000 00	96,250 00	– –	–	–
Totals,	. . .	–	$551,855 00	– –	–	$593,615 00

* Blue line on Map.

† Pier masonry.

Comparative cost of line indicated in blue ink on map, from present junction of Vermont & Massachusetts Railroad to Blakely Hollow, with line of W. P. Granger, from Connecticut River Railroad to Blakely Hollow.

Blue line on the Map for single track from junction of the Vermont & Massachusetts Railroad to Blakely Hollow.

Material.	Quantity.	Price.	Cost.
Earth,	284,175 yards,	$00 45	$127,879 00
Pier masonry,	1,445 "	20 00	28,900 00
Abutment masonry,	2,747 "	15 00	41,205 00
Arch masonry,	2,620 "	15 00	39,300 00
Bridging,	500 lineal feet,	80 00	40,000 00
Total,			$277,284 00

Line of Survey of W. P. Granger, Blakely Hollow to Connecticut River Railroad, single track.

Material.	Quantity.	Price.	Cost.
Earth,	84,300 yards,	$00 40	$33,720 00
Rock,	3,735 "	2 00	7,470 00
Bridge masonry,	2,980 "	15 00	44,700 00
Culvert masonry,	190 "	5 00	950 00
Bridging,	300 lineal feet,	80 00	24,000 00
Total,			$110,840 00

Comparison with other Lines.

		Maximum grade per mile, rising easterly.	Maximum grade per mile, rising westerly.	Rise and fall.	Whole length.	Sharpest Curve.	Percentage straight.	Percentage curved.	Degrees of Curve per mile.	T. & G. R. R. Estimated cost of changes.
Between Hoosac Tunnel and Connecticut Valley.	Troy & Greenfield R. R., present line,	30.6	58	810	31.6*	10°	44	56	133	–
	" " " improved blue,	23.8	50	767	30.8	5°	51	49	90	$1,671,662
	" " " improved red,	23.8	50	767	30.8	6°	51	49	90	1,510,300
	Troy & Greenfield via Deerfield to V. & M. R. R.,	–	50	660	30 3	6°	–	–	94	1,483,700†
	Troy & Greenfield via Turner's Falls to C. R. R. R. line,	–	50	749	–	5°	–	–	–	1,344,310†
Boston & Albany R. R.,		75	83	5,606	200	5°	–	–	41.1	–
Providence & Worcester R. R.,		–	–	582	43.4	8°	–	–	58.7	–

* The distances in the column of "lengths" count from the eastern portal of the Hoosac Tunnel to a common point on the Vermont & Massachusetts Railroad 1¼ miles south of the present junction.

† The cost set against the lines via Deerfield & Turner's Falls includes their construction from the east end of the Hoosac Tunnel, following the red line on the map, or the blue line where no red one is drawn, to the points of divergence; thence over the independent line via Deerfield to its junction with the Vermont & Massachusetts Railroad 1¼ miles south of the present junction, and upon the line towards Turner's Falls as far its intersection with the Connecticut River Railroad at Greenfield.

Comparison with other Lines—Concluded.

	Maximum grade per mile, rising easterly.	Maximum grade per mile, rising westerly.	Rise and fall.	Whole length.	Sharpest Curve.	Percentage straight.	Percentage curved.	Degrees of Curve per mile.
Cheshire R. R.,	–	60	–	53.6	5°	–	–	59°
Fitchburg R. R.,	34.3	40.7	1,052	51.0	5°	–	–	33.2°
Vermont & Massachusetts R. R.,	48	58	1,798	69.0	5°	–	–	47.8°
Erie Railroad, Delaware Division,	–	–	–	103.3	6°	–	54	88°
Baltimore & Ohio R. R., 4 divisions as below,*	39.6	116.0	9,643	379	9° 33′	42	58	119°
" " Baltimore to Martinsburg,	39.6	–	2,033	99	9° 33′	45	55	121°
" " Martinsburg to Piedmont,	39.6	–	1,029	107	5° 42′	41	59	80°
" " Piedmont to Grafton,	–	116.0	4,681	74	9° 33′	46	54	152°
" " Grafton to Wheeling,	–	79.2	1,900	99	9° 33′	37	63	154°
Pennsylvania Central,	52.8	95	–	–	8° 45′	–	–	–

* I am indebted to Mr. B. D. Frost, C. E., for the information given above concerning the Baltimore & Ohio & Pennsylvania Central lines. The characteristics of the Massachusetts roads and the Erie Railway are taken from their official reports.