For the Journal of the Franklin Institute.

On the Improvement of Rivers and Harbors. By D. S. HOWARD, Civil and Marine Engineer.

There is no question within the reach of science, that remains more indefinitely settled than how these improvements may be made with the most economy, and to the best interest of the country.

It is evident that any one system will not answer for the improvement of all rivers or harbors, or all parts of the same river at all times.

The true way then to arrive at the best system, is to consider what are the causes of the obstacles to be overcome, and how those causes may best be removed, as no improvement can be considered permanent until the operating causes of the difficulty are eradicated.

The Improvement of Rivers—Consists in the removing of obstructions, the securing of the proper depth and width of channel, the proper uniform quantity and motion of water, and preventing the formation of bars, the accumulation of snags, &c.

The manner of accomplishing these objects, constitutes the great question which science, as yet, has been unable to settle, to the satisfaction of all whose profession interest them in the subject.

The physical formation of the great slope, which is drained into the Gulf of Mexico, by the rivers lying between the Mississippi and the Rio Grande inclusive, together with the climate and consequent habits of those rivers, points unmistakably to Mr. Ellet's plan for their improvement. All require similar treatment, being subject alike to great floods and great scarcity of water at times, in consequence of the extensive prairies which abound more or less throughout this great slope, and the periodical rain common to the climate, which, from the general scarcity of trees and shrubs, and the nature of the soil, the water is not prevented from finding its way immediately into the streams, forming capacious ravines on its way, which seem to invite us to consider the proper remedy, by pointing us to the old aphorism, that "whatever produces an evil, furnishes the means of counteracting it." We here find the means of counteracting the floods and lack of water at times, by making reservoirs of these ravines.

These rivers are susceptible of this kind of improvement for a long distance from the coast. When we arrive at a point where the inclination is too great for slackwater navigation, there nature has provided high banks and good materials for dams and locks, which may be so constructed as to serve the double purpose of continuing the navigation and assisting the upper reservoirs in equalizing the flow of water below.

Nothing can be more clear than Mr. Ellet's calculations on the improvement of the Ohio River, and his estimates are uncommonly liberal. Where a new and favorite theory is proposed, it is not unusual for the estimates required to favor it more than practice will warrant, but if Mr. Ellet has erred in his estimates on the Ohio River improvement, they are too high.

So far as my observation extends, the Ohio River is not as well calculated for this kind of improvement as the other rivers here mentioned

and it may be observed by any person who has the opportunity, that the natural facilities for this kind of improvement, are found in the greatest abundance, where the height of the floods above low water is the greatest in any river.

The rivers subject to great floods will be found to flow through a prairie country, where the soil is more or less impervious to water, and liable to wash into extensive ravines, causing the physical formation of the country about them to be favorable to a rapid gathering of the copious rains common to the climate in such cases, into pools, which find their way to the river sooner than when shed upon forest land, which not only absorbs a large part of the rain, but forbids the formation of ravines, and other facilities for conducting the water more speedily to the river bed.

It is a common observation that the rivers of a thickly timbered country, are more subject to extreme floods, and consequently extreme low water at times, as the country becomes cleared up for agricultural purposes.

From this cause alone, in many of the old settled countries, the planters have been forced to prevent the escape of the waters too soon for their purposes, by forming reservoirs to irrigate their lands, thus unconsciously commencing a system of river improvement, which if carried out, would not only add incalculable advantages to the country in commercial facilities, but restore the fruitfulness of the soil, the original uniformity and congeniality of the climate, banishing the sickly seasons, beautifying and enriching the whole country and coast, without the slightest drawback of any kind, or draft upon any other country or people.

The fact that deserts are formed only at great distances from the face of any waters, adds force to the argument in favor of the reservoir system in improving our south-western rivers, and at the same time the extensive prairies between.

Nature has, in many instances, some few in our own country, imperfectly carried out this plan of improvement, by locating lakes at the head waters of streams, narrowing their outlets, as if to point us to the facilities of building dams and completing the plan; illustrating, by limited benefits, the beauties and advantages of the system, even without the dams and gates. The great river St. Lawrence is a sublime example. We have only to trace it to its numerous sources, to see the full benefit of the system upon the climate and soil, and the great superiority in the navigation over any other river without these natural reservoirs. The country about the head waters of the Oswego River, one of its tributaries, emptying into Lake Ontario, is a bright example of the benefits to the climate and soil, arising from the fall of waters distributed among the otherwise well formed features of the country. Numerous other tributaries to the St. Lawrence, might be mentioned if necessary.

In the absence of natural lakes, supplied by living water (in some of the south-western States), nature has furnished a peculiarity of climate which prevents the stagnation of water, wherever the surface is exposed to the air and sunshine; and also an impervious soil with numer-

ous formations, as if by special design for the purpose, strongly inviting the energies of art to perfect the system, that man might reap the triple benefits of the whole design.

Numerous small beginnings have already been made in Western Texas, in the construction of small reservoirs for the purpose of irrigation, and the herding of cattle—enough to verify the above facts.

In full view of the immense prospective advantages of this system of improvements, when applied to the Texas Rivers, it is not to be supposed that it can be completed on any one of these streams for some years to come, but there is one feature which will insure its adoption at some future time, which is, that all progress made affords an immediate return. The first dam, if only for the purpose of herding cattle, checks the freshet in the river that would have received the water retained, in proportion to the capacity of the tank, at the same time repays the investment by accomplishing the original purpose. When it shall be convenient and profitable to cultivate the soil in the vicinity, it may be still more useful for irrigation, which will call for a gradual extension of the system. Thus we see the adoption of this system inevitably follows the development of this rich country; in fact, it has already been unconsciously commenced.

The Mississippi and the Texas Rivers drain the largest extent of the richest country in the known world, the particular features of which are prominently suggestive of this kind of improvement.

A very fair estimate of the distance which these rivers may be available for navigation by this system, to the first dam and lock, may be set down at a point where the highest freshets allow it to be extended, not above where the inclination of the channel exceeds two feet to the mile.

Taking this for our datum, we have for the Mississippi River and its tributaries in round numbers, say about 8000 miles of uninterrupted navigation, and about the same amount by dams and locks, a rule that will hold good in all of the Texas Rivers.

The thirteen principal rivers of Texas, counting the distance from where their waters enter the Gulf, would afford, including five principal Bayous, about 5000 miles of uninterrupted navigation, and about the same amount by dams and locks.

In addition to these rivers, there are numerous smaller streams and Bayous, extending back through the low rich lands along the bays, which skirt the coast, receiving all the rivers mentioned except the Mississippi, Brazos, and Rio Grande, and discharge their waters into the Gulf through four principal passes, Sabine pass, Galveston pass, pass Cavallo, and Aransas pass. These passes afford from eight to twelve feet water in their natural condition, for the passage of vessels from the Gulf into the bays and rivers.

The Improvement of Harbors—Like that of rivers, cannot be confined to any uniform system under all circumstances.

Where a movable material prevails on the coast, or is brought down the stream whose waters pass out of the entrance to the harbor, it will be necessary to guard against the deposit of this material in the channel,

by piers and breakwaters, situated so as to suit the direction of the currents, the prevailing winds, the quantity of water passing out, &c.

The removing of deposit or bars to open a harbor is done in various ways, by dredging or scouring. Dredging was formerly seldom resorted to, on account of the imperfection of the machinery required. Where the current of the streams entering the harbor, or that afforded by the natural tide, was not sufficient for the purposes of scouring, dams and sluices were resorted to; but at the present day, when from the perfection of machinery for the purpose, underwater excavations can be done cheaper than on dry land, scouring is almost entirely done away with, except where circumstances are most favorable. It is, however, now being adopted at the mouth of the Mississippi, with what success is not yet determined.

The Texas harbors are peculiarly situated within the bays bordering the coast, secured from the Gulf by long narrow sand islands founded on clay, the sand being so fine as to be so near the weight of the water as not to sink in salt water below twenty-four feet, or thereabout; at least there is none found below that depth, either in the Gulf or in the bays, although the sand is blown very freely across the narrow islands between the Gulf and bays, in some places into the water of the bays, where it is found filling up the shoal places, but at the bottom of the deeper holes none is discovered.

I would not wish to be understood as favoring a once popular fallacy, that no substance could sink except to a certain depth in water, but in advertent to these facts, I would say in explanation, that there are ingredients in sea-water heavier than pure water not held so perfectly in solution as to prevent their occupying a lower position in proportion to their specific gravity, thereby rendering the deeper water somewhat heavier than that at the surface, enough, with the natural circulation of deep water, to prevent this sand from lodging any where on the Texas coast below twenty-four feet.

In view of these facts, it is proposed, that if the Texas harbors were opened to the depth of thirty feet, there would be no tendency to fill up, from the fact that no other movable material heavier than this sand is to be found in the vicinity. The fact that the Pensacola harbor, which is thirty feet deep, and surrounded by this and no other material, has no such tendency, gives force to such a conclusion.

From the foregoing it would seem to be the duty of the Federal Government, inasmuch as there are but four harbors on the whole coast of Texas, that these should be made to admit any vessel that sails the Gulf, for the safety as well as the convenience of commerce in time of peace, and each entrance should be defended by a competent fort, that in time of war, our fleet may have the benefit of the spacious bays bordering the whole coast, which are only approachable by these four passes.

These bays are so situated, that at a trifling expense compared with the importance of the improvement, could be so connected, as to create over five hundred miles of inland navigation, along the coast of Texas, perfectly secure from invasion by sea or land, from storms, or any other conflicting force, so long as the four entrances are defended.