SYNOPSIS

The N25 Waterford Bypass comprises a 16.3 km of dual carriageway bypass of Waterford City, 9.5 km of major link roads and an additional 13 km of side roads. It includes a 465 metre long dual carriageway cable-stayed bridge over the River Suir (with a 230m main span), plus a number of major viaduct and grade separated interchange structures totalling over 50 bridges. This paper describes the development of the current route for the N25 Waterford Bypass including the various phases of route selection. It deals with the project’s inclusion as a pilot PPP project and the development of the PPP contract. It follows the project through the statutory processes (including the discovery of Viking remains and the need to find a new route around the designated national monument site in Woodstown). The paper also describes the selection of the chosen bridge type for the Suir River Crossing and looks at some of the other major structures. Finally, the paper will briefly describe the construction contract and various aspects of construction.
INTRODUCTION

The need for a second river crossing of the River Suir in Waterford has been recognised over many years. For example, the need was put forward in the 1967 Development Plan by the then City Engineer and since that time, a second crossing together with approach roads has been included in the City & County Development Plans, (though the original location selected was closer to the city).

This paper describes the development of the current route for the N25 Waterford Bypass including the various phases of route selection. It deals with the project’s inclusion as a pilot PPP project and the development of the PPP contract. It follows the project through the statutory processes (including the discovery of Viking remains and the need to find a new route around the designated national monument site in Woodstown). The bypass includes an iconic cable stayed structure crossing the River Suir and the paper describes the selection of the chosen bridge type and the issues associated with it. It also deals with some of the other major structures among over 60 structures on the bypass. Finally, the paper will briefly describe the construction contract and various aspects of construction.

The N25 Waterford Bypass is included in the National Development Plan and is part of Transport 21. The N25 (part of the E30 Euro Route) connects Cork at one end to the port of Rosslare at the other end, via Waterford City. The original route at Waterford went right through the city, travelling along the congested city quays and crossing the River Suir over Rice Bridge - an opening span bridge which is required to open for shipping. The existing traffic volumes and the anticipated growth in traffic clearly indicated that a new bypass and crossing of the river was needed.

FEASIBILITY STUDY

Background

In March 1996, Mott MacDonald Ireland (then known as Ewbank Preece O hEocha) were appointed as Consulting Engineers to undertake a feasibility study in relation to the need for, and potential type and location of, a second river crossing and associated roads at Waterford.

The Feasibility Study set out to identify feasible routes and crossing locations, evaluate and quantify the costs and benefits associated with these schemes, recommend a new crossing and approach roads, and examine the justification of the scheme. A new crossing of the Suir in the Waterford area would impose costs on, and produce benefits for, the community at large. Such a crossing would be justified if the benefits that it produced exceeded their associated costs, and did so by more than would be the case for any alternative investment of the same funds.

The benefits that could arise from a new river crossing include:

i) travel cost savings enjoyed by motor vehicles and their occupants,
ii) increased travel opportunities arising from improvement of the local highway network,
iii) stimulation of the local economy by increasing its potential to attract commerce, trade and industry to the area,
iv) positive environmental impacts of the crossing.

The costs that might be associated with these benefits include:

v) the capital, land, and property acquisition costs of the crossing and its associated roadworks,
vi) the annual operating and maintenance costs of the crossing,
vi) costs associated with the protection of river navigation,
viig) negative environmental impacts of the crossing.

Evaluation Methodology

The costs and benefits were quantified and evaluated during the course of the study. Items i) and ii) were derived from traffic modelling which utilised a computerised behavioural transportation model. The actual modelling suite used was the DELTRAN suite of programs (including a set of survey analysis programmes). Item iii) arises from land use growth forecasts which were used as inputs to the model. Items iv) and viii) were evaluated without quantification while items v), vi), and vii) were derived in the process of the preliminary designs for the different options.

The traffic modelling began with the extraction and analysis of the raw data from a 12-hour Origin & Destination surveys carried out at 18 sites in Waterford in September 1994 by the Local Authority Working Group. Peak hour and typical Offpeak hour matrices were derived using “sparse matrix filling techniques” and a gravity distribution model was then calibrated so that only the input of the zonal trip end totals (rather than all the details of the trip matrix) was required to allow a “variable” matrix to be “synthesised”. After assignment of the “synthesised” trip matrices, the resulting flows were compared with actual flows on key links and revealed a worst case fit of 10%. Projections of the trip ends for two horizon years (2006 & 2016) were prepared taking into account existing trip ends as well as projections of land use, population, employment, development, car ownership, etc. This, in turn, allowed variable trip matrices to be created. This was an important facet of the study in that the numbers of trips to and from different zones varied depending on the links between the zones which allowed a more realistic evaluation of alternatives for two horizon years - 2006 and 2016.

Alternative Crossings and Road Networks

Suggestions for possible river crossing sites were sought during the early stages of the study. Fourteen potential sites - variously suggested by the City Council, the two County Councils, the NRA, the Consultant and the general public - were identified.

A comprehensive network of approach
roads and other link roads was developed (See Figure 1). The principal objective of the Study was to identify the best overall solution to the different needs of local traffic and people in Waterford, and those of long-distance high-speed National Primary Road traffic. It was thus necessary to test potential new crossings, with different combinations of approach roads, and in combination with other new crossings (and associated approach roads). In total one hundred and five alternative road networks were tested and evaluated.

Environmental Assessment of Different Route Options

The route segments were selected to minimise known adverse potential environmental impacts where possible. An outline environmental assessment was carried out on each route. This assessment covered the following categories:

- Impact on buildings.
- Impact on environmentally sensitive areas - areas of scenic beauty, specific heritage areas, areas of special scientific interest, and special landscape control zones.
- Land Quality - quality of agricultural or development land.
- Potential noise impact.
- Visual impact - both positive and negative - views of the road and views obscured by the road.
- Road alignment - proportional impact on rural and urban areas.
- Severance - broad examination in the absence of detailed information on property boundaries.

Performance of Alternative Road Networks

The computerised mathematical model of traffic behaviour was used to produce forecasts of the study area traffic conditions that might be associated with each of the road networks tested. For each network, separate forecasts were made for an evening peak hour and a typical off-peak hour, for each of the years 2006 & 2016. These forecasts enabled assessments to be made of the economic benefit, and the traffic and residual congestion implications of each alternative network. Comparison was made with a ‘do nothing’ base network. This network included road improvements that were already in physical or administrative progress, i.e. known schemes that will be implemented but were not yet in place. The economic benefits, together with capital costs, enabled the economic rate of return to be calculated and a ranking order of possible schemes to be prepared.

Feasibility Study Conclusions

The need for a Second River Crossing & Bypass was clearly established having regard to traffic performance, benefits and economic return. Having assessed and evaluated a large number of networks a recommended road network was selected, taking account of economic rate of return, Waterford City traffic performance, National Primary Route traffic performance, outline environmental examination, and the projected development of Waterford City and environs. The recommended scheme had an internal rate of return of around 20% which confirmed the need for the scheme. The selected network comprised:

i. a new road bridge across the Suir between Gracedieu and Grannagh.
ii. a new approach road to the south end of the bridge from the N25 at Dooneen (subsequently extended to Mathews Cross to bypass Kilmeadan), with an intermediate access near Knockhouse Upper,
iii. an at-grade link road from the Knockhouse Upper interchange to the Cork Road/Southern Ring Road intersection, with intermediate access as required in the context of planning for the area.
iv. a Northern Ring Road, connecting the N9/N24 intersection at Grannagh with the N25 beyond Slieverue,
v. dualling of Newrath Road (existing N9) between Grannagh and the end of the Sallipark improvement.
vi. construction of a grade-separated interchange near Grannagh to interconnect the N9, N24, bridge approach road, Northern Ring Road, and improved Newrath Road.

The separate completion of the Southern Ring Road was also envisaged. The recommended road network indicated a corridor which was to be further refined in the course of the preparation of the Route Selection Report. Subsequent to the publishing of the Waterford Second River Crossing Feasibility Study Report, a decision was taken to extend the Waterford Bypass by adding a bypass of Kilmeadan. This decision was taken in view of the poor standard of the existing approach through Kilmeadan to the proposed bypass. The scheme was also extended at the northern end. Refer to Figure 2.

Road Type

In 1999 a further set of model runs were undertaken for the “Design Year” (then selected as 2025) using new trip ends which would take account of the additional trip potential arising from the fact that the new network of roads would lead to changes in development policies and trends. At the same time, the model network was extended to the west to include Kilmeadan.

The 2025 daily traffic volumes resulting from this analysis in AADT vehicles were as follows:

- Kilmeadan Bypass 14,629
- Western Bypass/Suir River Crossing 35,237
- Northern Bypass 18,495
- Western Link 31,918

Following detailed evaluation the following road type selection (using DMRF classification) was determined:

- Kilmeadan Bypass D2AP
- Western Bypass/Suir River Crossing D2AP
- Northern Bypass D2AP
- Western Link D2AP (Urban)
- Newrath Link D2AP (Urban)
- N24 connection S2
- N9 connection D2AP
- Northern Tie in S2

where:

- D2AP = Dual Carriageway All Purpose
- S2 = Standard two lane

Fig 2: Recommended Route Corridor
RIVER SUIR CROSSING

Suir Crossing Alternative Routes

The feasibility study had identified the best location for the main bridge crossing of the Suir to lie in an area approximately 3.5 km upstream of Rice Bridge. The crossing corridor is bounded between the bend in the river at Grannagh Castle and the Railway Bridge, which is approximately 1 km downstream. It also recommended that a junction be constructed on the north side of the river, which would interconnect the N9, N24, the proposed realigned N25 (i.e. Grannagh Junction) and link back to the city via the northern side of the river (i.e. Newrath link). As a result three possible crossing alignments were selected. These routes were labelled Routes 1, 2 and 3 (see Figure 3).

Site Investigation & Hydraulics

Ground Conditions

As part of the route selection process a preliminary site investigation was carried out to assess the geology in the environs of the crossing corridor. Fugro Ltd. were appointed to conduct the site investigation which commenced in April 1998 and was completed in July 1998. An extensive programme of geotechnical fieldwork was carried out.

One of the key findings of the geotechnical investigation was that there were extensive areas of very soft ground at the northern side of Route 1 which would almost certainly require viaducting and would lead to significant cost penalties.

Hydraulic Study

As part of the route selection process Irish Hydrodata Ltd. were commissioned in April 1998 to conduct bathymetric and current flow studies within the corridor of the proposed river crossing. The objectives of the study were to determine the river bathymetry and the flow patterns within the corridor under typical tidal conditions and to estimate the tidal levels at the site for mean spring tides.

The bathymetric survey has shown the river to be a smooth erosional river channel varying in depth from -18 m O.D. at the upstream end to -9 m O.D. at the downstream end. The deepest waters occur on the Kilkenny side of the river. The contours were clearly defined with no major obstructions or unusual features. Currents were found to be strong and well defined and reach peak surface mean spring speeds of 1.5 and 1.1 m/s on the flood and ebb tides respectively near the Kilkenny shoreline.

Extreme tidal currents during highest astronomical tide conditions are likely to exceed 2.0 m/s and these may be elevated further by river flows. Such currents would be expected several times each year. The hydraulic study did not favour any particular route, however, the results did indicate that it would be preferable to minimise the number of structures in the river.

Environmental Impact Assessment

An Environmental Impact Assessment was carried out by RPS Consultants in conjunction with Ewbank Preece O hEocha (now Mott MacDonald Ireland) and Tramore House Regional Design Office as part of the Route Selection Report. The scope of the environmental assessment was based upon the statutory environmental topics defined in the EIA Regulations. In addition, an Environmental Impact Study of the Suir River Crossing is included in the overall EIS for the scheme.

Navigation Clearance

An analysis of the number of openings for the Rice Bridge over a three year period, from 1993 to 1995, found that the average number of openings per year was 174 with the maximum number of openings occurring between 12 noon and 1.00 p.m. The quays directly to the west of Rice Bridge account for a small number of these movements and the remainder traverse the crossing corridor.

The principal commercial operator using the river and passing the site of the proposed crossing location was Morris Oil Company Ltd., who owned and operated an oil storage depot at Fiddown, Piltown, Co. Kilkenny, approximately 13 miles upstream. The river was also used for recreational and amenity purposes. Occasionally yachts came up beyond the proposed crossing location, as did snap fishermen who fish the river in this area.

There were two options available in relation to navigation clearance:

1. Provide a high level (or opening span) crossing which permits all existing shipping to continue passing the crossing location.
2. Provide a crossing which is optimised in relation to cost, topography, aesthetics etc. and provides limited navigation clearance. This option has impacts on river users, however, there are significant cost savings and aesthetic advantages if navigation clearance can be limited.

Initial Options

Crossing Types

A number of river crossing options were considered on each route including High Level Fixed Bridges (clearance 25.5m which had no impact on existing users), Medium Level Fixed Bridges (clearance 12-14 m. approx. which would impact on existing commercial river users but not recreational users), Low Level Fixed Bridges (clearance 3 m which would impact on all river users both commercial and recreational) and Low Level Opening Bridges (which could significantly impact road traffic).

Crossings providing full navigation clearance

There were structural crossing options available on each of the three routes which would provide the full navigation clearance. The lowest cost option (for crossing and approaches) at each location was as follows (1998 prices converted from IRE):
Crossings providing limited navigation clearance

The lowest cost option providing clearance to recreational users but not to commercial users on each route was as follows (1998 prices converted from IRE):

<table>
<thead>
<tr>
<th>Route</th>
<th>Option</th>
<th>Clearance (m)</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route 1</td>
<td>Medium Level Girder Bridge</td>
<td>13</td>
<td>€34.8 m</td>
</tr>
<tr>
<td>Route 2</td>
<td>Medium Level Girder Bridge</td>
<td>13</td>
<td>€20.1 m</td>
</tr>
<tr>
<td>Route 3</td>
<td>Medium Level Girder Bridge</td>
<td>13</td>
<td>€29.2 m</td>
</tr>
</tbody>
</table>

The relatively high costs of the options on Route 1 and Route 3 were due to topographical and ground conditions factors.

The only route for which a low level crossing was appropriate (for reasons of topography, alignment and ground conditions) was Route 1. However, because of poor ground conditions and the long lengths of viaduct required, the costs of a low level fixed girder bridge at Route 1 was €34.4 million. It is interesting to note that (because of the additional costs of adding an Opening Span to a Low Level Fixed Bridge) an opening span bridge on Route 1 at €45.2 million was the most expensive option.

Thus, if navigation clearance was to be maintained, any route would be acceptable though the cost on Route 3 is more favourable. If navigation clearance is to be limited, then there was a clear preference for Route 2 in terms of cost.

Suir Crossing Section – Route Selection

The three horizontal alignment options were assessed i.e. Route 1, Route 2 (single junction and two junction variants) and Route 3. Five vertical alignment options were also assessed: Route 1 High Level, Route 1 Low Level, Route 2 High Level, Route 2 Medium Level and Route 3 High Level.

The major considerations included:
- creating the optimum journey lengths for traffic on the three National Primary routes (Journey Length).
- road safety at the major interchange required to connect three National Primary routes (Road Safety).
- adverse ground conditions along the alignment of Route 1, north of the crossing (Ground Conditions and Construction Risk/Buildability).
- the requirement, or otherwise, to maintain navigation for commercial shipping upstream of the proposed crossing (Navigation Clearance).
- impacts of the various options on residential property and community severance (Local Community, Noise and Landscape).
- the impacts of Routes 2 and 3 on the Grannyperry proposed Natural Heritage Area, and populations of the protected plant species, Meadow Barley (Ecology).
- the impacts of the crossing options on the landscape quality of the Suir valley and the protected view at Granny Castle (Recreation/Amenity and Landscape).

A major factor in the route selection at the Suir Crossing Section was the type of Junction which could be provided to connect the N9, N24, Newrath Link, and the new N25 routes on the northern side of the river at Granny. In this regard, safety considerations had a major influence on the final selection which is an option which involves the N9 and N24 meeting at an at grade junction in advance of the grade-separated junction on the N25 (i.e. a two-junction option).

A single grade separated roundabout was considered to connect the N9, N24, Newrath Link, and both legs of the N25. However, this would involve 5 entries onto the roundabout. The Design Manual for Road and Bridges (TD 19/93) recommended either three or four entries to roundabouts. It states: ‘If the number of entries is above four, driver comprehension is affected and the roundabout becomes larger with the probability that higher circulatory speeds will be generated’.

Because of this, an alternative layout was examined for the single junction option. This layout comprised 3 smaller roundabouts, all of which were interlinked in a triangular formation. Following a safety audit, this too was considered to be undesirable. It was thought that signing would be difficult and too many alternatives would lead to driver confusion.

A two-junction option was selected as the preferred option in this situation because of the number of roads to be interconnected. It was not feasible to provide a two-junction option on the Route 3 Suir Crossing Option.

Careful evaluation of all of the factors outlined above indicated a clear preference for Route 2, over the other two routes considered, due to: ground conditions, road safety, junction layout, journey lengths and construction costs.

This route was selected as the preferred route. Due to the engineering considerations and the large number of environmental constraints in this area, it was not possible to select a route which avoided significant potential environmental impacts. The preferred route, Route 2, had potential impacts on a proposed Natural Heritage Area and a protected plant species – Meadow Barley (Hordeum Secalinum). Consequently, a detailed mitigation/compensation strategy for Route 2 was developed in consultation with the National Parks and Wildlife.

Fig 4: Meadow Barley (Hordeum Secalinum)

High vs. Medium

The High Level Bridge options all had extensive lengths of viaduct involving substantial cost. They also tended to present a significant visual impact. The alternative was a bridge where the level was dictated by factors other than navigation clearance. In practice, this is represented by the Medium Level Bridges above. After due consideration, it was considered that a Medium Level Bridge Crossing should be preferred having regard to:

- Significant cost savings (in excess of €12.7 million at 1998 prices for Route 2)
- Preferable visual impact
- Better road and junction design characteristics.

The Selected Route

The preferred solution, therefore, was Route 2 with a medium level bridge crossing and a two junction option to connect the N9, N24, and N25 roads.

STRUCTURAL FORMS

For a river crossing of this size, several practical structural forms existed which
could be used to support a fixed road crossing. An initial examination was undertaken of a wide range of options including:

- Arch Bridges
- Truss Bridges
- Girder Bridges
- Cable Stayed Bridges
- Suspension Bridges
- Opening Span Bridges

Initial Choice

From the initial review of possible structural forms outlined above, two forms were chosen for detailed consideration and costing. These were:

1. the girder bridge
2. the cable stayed bridge.

Experience from other projects worldwide suggested these two structural forms were likely to be the best practical and economical types for the span ranges contemplated at the Suir site. A number of options were taken forward for preliminary design and costing. The bridge types were considered under various headings as follows:

GIRDER BRIDGES
- Span Arrangements
- Materials
- Design Loadings
- Superstructures
- Steel Superstructures
- Concrete Superstructures
- Piers and Abutments
- Foundations
- Finishings
- Environmental Considerations
- Services
- Construction Methods
- Working Space and Access
- Construction Programme
- Maintenance

CABLE STAYED BRIDGES
- Span Arrangements
- Materials
- Design Loadings
- Seismic Response
- Aerodynamic Behaviour
- Superstructures
- Stay Cable Arrangement
- Pylon
- Deck
- Piers and Abutments
- Finishings
- Environmental Considerations
- Services
- Construction Methods
- Working Space and Access
- Construction Programme
- Maintenance

AESTHETICS

A review of the aesthetic considerations was undertaken in relation to the site and the various options. A number of Artist’s sketches were prepared and a physical model was made to assist with evaluation of the alternative structures – principally from a visual and aesthetic viewpoint. The sketches and photographs of the model are illustrated below. For example, road layouts may have changed slightly since the model was made. Also, the model was designed to permit the interchange of the two types of structures and so, for example, cables are not represented on the model for practical reasons.

Girder Bridge Option

![Fig 5: Artist’s Sketch of Girder Bridge Option](image)

Cable Stay Bridge Option

![Fig 7: Artist’s Sketch of Cable Stay Bridge Option](image)

COSTINGS

Cost estimates were prepared for the various Route 2 medium level bridge options under consideration. Measured approximate quantities were prepared for each option and priced on a common basis using experience of projects of a similar nature.

RECOMMENDED BRIDGE

The advantages and disadvantages of a Girder Bridge relative to a Cable Stay Bridge were summarised as follows:

Disadvantages of a Girder Bridge relative to a Cable Stay Bridge:
- Risks (time & cost) due to the construction of piers in fast-flowing and deep river
- Flat soffit deck construction requires temporary support (cables on cable stay bridge are used for support)
- Construction of caissons or cofferdams involves
  - risk of release of sediment to river during excavation
  - disturbance of river bed (silt & alluvium into suspension, possible contaminated material)
- Interference with river flows (not critical)
- Interference with fish & fishing (e.g. sedimentation of eel pots)
- Time of Year limits may be imposed/desirable on pier construction activities

Account was taken of the likely unique temporary works requirements, programme, construction techniques, special plant and significant material imports, and implications of undertaking the works at the particular location. Particular impacts included:

- Flat/curved soffit girder bridges attracting higher caisson foundation costs by size, number required and installation difficulty.
- Steel bridge delivery/erection attracting cost of special floating plant, stagings and a greater premium for imported steelwork.
- Concrete bridge erection attracting cost of working platforms/temporary supports - significantly greater for flat/curved soffit than the "self supporting" construction techniques afforded by the cable stayed option.
- Cable stayed option requiring the longest construction programme and the flat/curved concrete girder options taking longer than steel.

The estimated costs in € (converted from IRE) at 4th Quarter 2000 prices were summarised as follows:

<table>
<thead>
<tr>
<th>Bridge Option</th>
<th>€million (4th Q 2000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Soffit girder bridge - Medium Level</td>
<td>30.0</td>
</tr>
<tr>
<td>Curved Soffit girder bridge - steel</td>
<td>30.9</td>
</tr>
<tr>
<td>Flat soffit girder bridge - concrete</td>
<td>29.5</td>
</tr>
<tr>
<td>Curved soffit girder bridge - concrete</td>
<td>27.9</td>
</tr>
<tr>
<td>Cable stayed bridge</td>
<td>29.8</td>
</tr>
</tbody>
</table>
The chosen structure would be delivered within the Bridge Order to ensure that the essentials of the bridge design, however, it was also desirable to give latitude to the Private Partnership. As a result some bidding consortia in relation to detail would need to be procured by means of Public Private Partnership. Having regard to all of the factors considered, a Cable Stay Bridge was recommended (See Figure 9).

**Advantages of a Girder Bridge relative to a Cable Stay Bridge:**

- **Cost:** up to €1.9 million approx. less (assuming curved soffit Girder Bridge is selected)

Having regard to all of the factors considered, a Cable Stay Bridge was recommended (See Figure 9).

**BRIDGE ORDER**

At that time it was necessary to receive a statutory Bridge Order for a bridge of that size. By then it had been decided that the N25 Waterford Bypass scheme would be procured by means of Public Private Partnership. As a result some latitude would need to be given to the bidding consortia in relation to detail design, however, it was also desirable to enshrine the essentials of the bridge within the Bridge Order to ensure that the chosen structure would be delivered. For the purposes of the Bridge Order, the essential features of the recommended scheme were described as follows at the Bridge Order Public Inquiry and these were enshrined in the published order:

- Route 2 Medium Level Cable Stayed Bridge.
- Cable stayed structure with one ‘A’ frame pylon or tower on the southern shore of the river (placed to the south of the line of MLWS).
- Tower height of between 80m and 100m above deck.
- A twin fan of cables supporting the deck edge.
- Feature lighting on the inner face of the tower legs.
- Modified fan arrangement of cable stays as illustrated below.
- Medium Level with a guide Navagation clearance of approximately 14m over a width suitable for the safe navigation of vessels that will be able to pass under the bridge.
- Spans (from south) of approximately 45m, 70m, 90m (back span), 225m (main span) and 45m.
- Pier on northern shore to be no more than 10 metres to the south of the line of MLWS.
- Foundation details, materials and deck construction to be determined at detailed design stage.

The Bridge Order Public Inquiry took place in June 2001.

**CPO AND EIS ORAL HEARING**

An Oral Hearing into the CPO and the EIS was held by An Bord Pleanála in August 2001. The hearing was reconvened in November 2001. A request for further information was received and a further hearing took place in July 2002. In October 2002, An Bord Pleanála issued an order granting approval to the Scheme and confirming the CPO Order.

**PILOT PPP PROJECT**

In 1999, there had been a Government announcement about Public Private Partnership (PPP) quoting the aim of attracting private investment. The Waterford Bypass project was specifically earmarked as a PPP scheme (at that stage it was one of two pilot PPP Projects along with the Limerick Tunnel project). The scheme would include hard tolling.

Mott MacDonald were appointed in 2001 to act as Client’s Representative for the preparation of PPP tender/contract documents and the procurement of Waterford Bypass as a PPP Project. The various work packages associated with the commission included:

1. Overall Commission Management
2. Statutory Procedures
3. Risk Management
4. Site Investigation and Archaeological Investigations
5. Topographic Survey
6. Advance Works
7. Traffic Data
8. Information Room
9. Specimen Design
10. Employer Requirements
11. Accommodation Works
12. Specification
13. Tolls
14. Third Party Requirements
15. Pre-Qualification
16. Tender Period
17. Tender Assessment
18. Contract Administration

**PPP TENDER PROCESS**

Following a prequalification process, four consortia including major national and international contractors along with technical, financial and legal advisors were shortlisted to tender for the project. They were:

- **Celtic Roads Group** – HBG Ascon Limited, Edmund Nuttal Limited, National Toll Roads plc and Grupo Dragados S.A.

Tender documents were issued in September 2001 and following a number of tender consultation meetings tenders were returned in April 2002.

**ADVANCE ARCHAEOLOGICAL WORKS**

In order to minimise risk and quantify remaining risk, a significant amount of advance archaeological testing was undertaken. This included centreline trenching along the entire length with offset trenches at 45 degrees every 25m. A number of archaeological sites were identified along the route during the testing phase for which archaeological resolution was subsequently undertaken.

Early in 2003 the test trenching at Woodstown on the banks of the river Suir revealed that “a large substantial...”
and important archaeological site had been exposed. Further trenched excavations were subsequently carried out later in 2003. The site appeared to be multi-period. The limited archaeological excavation indicates Early Christian and Later Viking Age occupation of the site. There was abundant evidence for craft-workings in fine metals (e.g. silver), as well as iron working, stone, glass, bone, antler and amber. Some finds, including copper-alloy stud mounts with gold foil and a copper-alloy book clasp may have been treasure trove from monastic raiding.

The site was abandoned c. AD 1050, for reasons as yet unknown. The site may have been an upriver trading station, 6 km from the Viking town of Waterford.

The archaeological evidence indicated that during the middle of the ninth century the site was occupied, and presumably taken over, by Viking raiders. Evidence of Viking metalworking in silver and lead was found, and the site has produced the largest assemblage of lead pan weights outside of Viking Dublin. Exotic finds of possible Norwegian schist whetstones and a fragment of a silver Kufic coin from Byzantium reflect the wider world in which Vikings operated. Ships nails and rivets reflect their maritime basis. A single warrior grave with full battle armour was also discovered, but due to the acid soil no skeleton survived.

The site was abandoned c. AD 1050, for reasons as yet unknown. The site may have been an upriver trading station, 6 km from the Viking town of Waterford.

Initially, consideration was given to preserving the site in-situ by using lightweight fills and other geotechnical techniques to permit the road to be built over the topsoil. The possibility of full excavation and resolution of the site was also considered, however, the timeframe for such resolution would have been prohibitive.

**NATIONAL MONUMENT SITE**

Following consideration of the archaeological information on the Woodstown 6 site, the Minister for the Environment issued directions to Waterford City Council in respect of the site in May 2005. The monument is considered to be a *multi-period site with Viking occupation* and *of national importance because of its archaeological and historical significance and is a National Monument within the meaning of the Act*, the Act being Section 14A(4)(d) of the National Monuments Act 1930 (as amended).

As a result, it was considered necessary to establish an alternative route so that the National Monument site could be preserved.

**WOODSTOWN ROUTE SELECTION Scheme Description**

Given that the optimum routes for the remainder of the project had been carefully selected and approved, it was considered desirable to develop alternative routes which utilised as much as possible, the original routes while at the same time avoiding the National Monument at Woodstown. In essence, a route was sought which connected the original route from the Kilmeadan Section in or around Dooneen and rejoined the original route on the eastbound approach to the Western Link junction.

The study area was examined in relation to topography, road design constraints, land boundaries, residences and dwellings, and available archaeological and environmental information, etc. Two main feasible alternative routes were established - the Green Route and the Red Route. Refer to Figure 13 which shows the original route as the Blue Route. From an engineering viewpoint both the Red and the Green routes were acceptable and neither route was favoured. In terms of cost, neither route was particularly favoured having regard to base cost before environmental mitigation.

The alternative routes were considered between approximate Chainages 3800 and 7400 of the original route. The proposed Green alternative route was approximately 3.4 km in length. The proposed Red alternative route was approximately 4.0 km in length. Both routes converge with the existing route at the beginning and end.
Route was not deemed viable from an archaeological or cultural heritage perspective, as it would involve a higher amount of impacts on known and significant cultural heritage sites. In particular, the assessment stated "it is likely that the Green Route will have a severe impact on the National Monument site of Woodstown 6. All available indicators point to a corresponding set of problems associated with the Green Route as had pertained to the original preferred alignment. The Green Route does not completely eliminate the possibility of impacts on Woodstown 6. Under the Minister’s direction, such an impact would be unacceptable. Therefore the Green Route is not considered viable from an archaeological or cultural heritage perspective".

In addition, the Green Route "will impact on a recorded monument (earthwork (WA009-006)) and a buffer zone established around a newly discovered archaeological site, both of which are located to the west of the Waterford Manor Hotel".

Given the anticipated archaeological impacts of the Green Route, the Red Route was recommended as the preferred route.

Environmental Impact Assessment

An Environmental Impact Statement (EIS) for the proposed alternative route at Woodstown (also referred to as the Red Route) was then carried out. The Environmental Impact Statement included a detailed assessment of the route under the following headings:

- Human Environment
- Air Quality
- Noise
- Landscape & Visual
- Flora & Fauna
- Water Quality & Fisheries
- Soils, Geology & Hydrogeology
- Surface Water/Hydrology
- Material Assets
- Agriculture
- Cultural Heritage

In particular, the impact on Cultural Heritage and Archaeology was given particular emphasis and was informed by a significant level of investigations and physical testing. This was considerably in excess of the level of information normally available for such evaluation.

A CPO and EIS for the Alternative Route at Woodstown were published in June 2006. Following the receipt of objections/submissions, An Bord Pleanála convened an Oral Hearing in October 2006.

In February 2007, approval was granted by An Bord Pleanála to the CPO and EIS for the alternate or re-aligned route of the Bypass.

Best and Final Offer (BAFO)

Tenders for the Project had been received in April 2002 and these were evaluated in detail and two of the four consortia were short-listed for BAFO stage. They were:

- Celtic Roads Group – HBG Ascon Limited, Edmund Nuttal Limited, National Toll Roads plc and Grupo Dragados S.A.

The invitation to submit Best and Final Offers (BAFO) was initially issued in July 2003 and the process commenced. However, having regard to the uncertainties relating to the archaeological discovery, the process was delayed so that the contract could be amended if necessary to reflect the outcome of the discovery. Once it became clear that a new route should be found which avoided the National Monument site, the process recommenced with amended requirements which divided the project in two at the Western Link Junction and allowed for a delayed site handover of the Western Section (which included the Woodstown Alternative). This gave time to carry the alternative section through the statutory process. The amended contract also allowed for the omission of the western section in the event that the statutory approval was not obtained in a timely fashion.
The BAFO tenders were finally submitted on 7th November 2005. Following evaluation of the tenders, both technical and financial, a contract was awarded to Celtic Roads Group and the contract was signed on 21st April 2006.

CONSTRUCTION - DESIGN REVIEW PROCESS

The PPP Agreement between the Authority (National Roads Authority) and the PPPCo (Celtic Roads Group) comprises the NRA PPP Contract and NRA PPP Contract Schedules. The contract schedules include Tender Proposals/Conceptual Design (Sch 28), Quality and Environmental Management (Sch 10), Certification Procedure (Sch 5), Land Issues Roads and Orders (Sch 2), Third Party, Construction and O&M Requirements (Sch 3, 4 & 7).

Obligations of the PPPCo include the design, construction, operation, maintenance and financing the Works. Responsibility for the design, construction, supervision and commissioning works lies with the Waterford Joint Venture (WJV) comprising a joint venture between BAM Civil (formerly Ascon Ltd) and Dragados SA. Design and construction of the works is required to be undertaken in accordance with the Construction Requirements (Sch 4), the Conceptual Design (Sch 28) and the Certification Procedure (Sch 5). The Certification Procedure provides for the submission of Quality Documentation, Design (Highway, Structures, Buildings, Tolling etc), Departures from Standard, Archaeology, Alternative Conceptual Designs, Third Party Consultation, Road Safety Audits and Temporary Works Design under an appropriate certificate by the PPPCo to the Authority. The review of the documentation is a function delegated by the Authority’s Representative (AR) to Mott MacDonald (MM) and the Authority’s Site Representative (ASR).

Documentation received from the PPPCo under certificate, in accordance with the provisions of the Certification Process (Sch 5) is examined for compliance with the Agreement including examination for:

- Consistency with the Conceptual Design included in Schedule 28
- Compliance with the Certification Procedure
- Consistency with the EIS and compliance with the Orders
- Compliance with the Construction Requirements
- Compliance with other provision of the Agreement.

The PPP Contract provides for review periods of 20, 10 and 2 days, depending on the type and status of certificate received. Within the relevant time the ASR will return a signed certificate advising a status of Acknowledged, Acknowledged with Comments or Rejected, together with reasons for rejection or acknowledgement with comments. The ASR may also request further information considered necessary for the purpose of review for compliance of such submissions with the Agreement.

In advance of the initiation of the submission of documentation under the certification procedure, MM and WJV agreed a procedure for the submission and tracking of documentation. The procedure included the transmission of documents electronically by the use of a secure Extranet. Further to the uploading of documentation, electronic notification is automatically circulated to relevant parties with original hard copies of certificates being provided directly to the ASR.

A scheme of the magnitude of the Waterford Bypass necessitated the submission of a large volume of design statements, drawings and specifications. The Certification process has produced approximately 2500 Design submissions and 500 Method Statements. In the region of 9000 design drawings have accompanied designs received.

For the purposes of ensuring a coordinated and timely response to documentation received under the certification process, a comprehensive database driven document control system was created and is maintained by dedicated MM Document Controllers. This provides real-time listings of necessary actions, document status and register listings of all certificates, design drawings and other documentation received. Such listings can be tailored to suit the needs of each of the design review teams needs and is available on demand. Response sheet forms which contain commentaries returned with certificates reviewed by MM/ASR are automatically generated using document information contained in databases.

The design/documentation reviewed by MM includes the following:

- Quality Documentation (Design, Construction, O&M) including Method Statements
- Alternative Conceptual Designs
- Review of Departure and Variation applications
- Design Review including Site Clearance, Fencing, Ecology, Road Layout, Structures, Earthworks, Drainage, Utilities, Lighting, Kerbs, Pavement, Signs & Roadmarkings, Safety Fencing Landscaping and Environmental Works, Accommodation Works
- Temporary Works and Third Party certification
- Traffic Management and Road Safety Audits
- Toll Collection Infrastructure Design
- Toll Collection Equipment
CONSTRUCTION - SCHEME REQUIREMENTS IN BRIEF

The Construction Requirements set down particular design and construction requirements for the scheme. In brief the requirements included for the following (Refer also to Fig 14):

- 16.3 km Dual Carriageway (Mainline) between Kilmeaden Co Waterford (to the West) and Luffany Co Kilkenny (to the East).
- 2.8 km Dual Carriageway including Quarry Link, N9 Link and Slieverue Link providing connection between Mainline and the N24 (Limerick), N9 (Dublin) and the N29 (Waterford Port).
- 3.5 km of Urban Dual Carriageway including the Western Link 1 and the Newrath Links 1 & 2, Quarry Link and the N9 Link providing connection from Mainline to Waterford City.
- 3.2 km of Std Single Carriageway forming tie-ins between the existing N25 N24 and N29.
- Five At Grade Junctions, at Carrick Road, Luffany and Slieverue forming connections between the Mainline and the existing N25 and N29, at Quarry forming a connection with the M9, and a connection to the WIT campus on the Western Link.
- Two Grade Separated Junctions, at Knockhouse Upper (Western Link Jnt) and at Grannagh (Grannagh Jnt), connect the mainline to the Western Link south of the river and to the N24, the N9 (M9) and the Newrath Link north of the River Suir.
- 13 km of local road connections.
- The construction of in excess of 60 principal Structures including 5 viaduct structures, 10 overbridges, 5 road underbridges, 3 railway underbridges, 3 river underbridges and 8 accommodation underpasses.
- The construction of a 465m long Cable Stayed bridge with a main span of 230 carrying the Mainline across the River Suir.
- Toll Plaza comprising Administration Building, Toll Plaza Canopy & Tunnel and associated Toll Collection System, located in Gracedieu.
- Diversion of various Services, Landscaping, Accommodation Works and the relocation of a section of the Waterford & Suir Valley Tourist Rail line.

As described in previous sections of this paper, the construction of the Works is divided into two principal elements, namely, the Main Section and the Western Section. The Main Section, which comprises all works east of and including the Western Link Junction, commenced in April 2006. Access was provided to the Western Section, (comprising Works west of the Western Link Junction), in accordance with the Agreement in July 2007. However, to facilitate earthworks construction in the Main Section, provision was made for access to Borrow Areas in the Western Section in advance of the Western Section Effective Date, for the purpose of making available cut material for use in embankment construction.

CONSTRUCTION – ELEMENTS OF SCHEME DESIGN

Earthworks

By careful management, areas of cut generated sufficient material for the necessary formation of embankments, generation of road construction product, environmental berms and landscaping areas. Cut slopes in competent rock were optimised by detailed design. Design in softground areas, located principally at Western Tie-in, Dooneen, Western Link Junction, Newrath and Smartscastle, comprised either replacement, vertical drainage with controlled embankment lifts, driven piles with reinforced basal layer.

Structures

In addition to the numerous underbridges, overbridges, underpass culverts and the 465m Cable Stay crossing of the River Suir, Waterford Bypass boasts five other significant viaduct structures.

Structure S01: a 196m long six span viaduct carrying the N25 Mainline across the steeply sloped valley at Whelansbridge. With spans up to 34m the “diaphragmless” bridge deck comprising a precast beams and insitu slab resting on elastomeric bearings, is at it highest point some 30m above the valley floor.

Structures S20, 21, 22 & 23: three 194m long five span Grannagh Viaducts carry the N25 Mainline and On and Off Ramps from the Grannagh Junction over the existing N9, the Blackwater River and the Waterford to Dublin & Waterford to Limerick Railway lines on two deck types.

The decks crossing the road and river consist of a composite structural steel ladder and an insitu concrete deck slab. Bridge deck crossing the railway consists of precast U-Beams and insitu concrete slab. Pilecap to piers are supported using micropile technology.

Structure S40: a 112m long 4 span structure carries the N9 Link over the Blackwater River with a bridge deck design similar to S01.
The Waterford Bypass opened to traffic on 19th October 2009 by Mr Martin Cullen TD. The new River Suir Bridge has the longest span in the Irish Republic.

**Project Statistics**
- 22.6km Dual Carriageway
- 3.2km Single Carriageway
- 13km Side Roads/Realignment
- 2 Grade Separated Junction
- 60 Structures including: -10 overbridges -5 underbridges for roads -3 underbridges for railways -3 underbridges for rivers -8 underpasses -5 viaducts
- 465m Cable Stayed River Suir Bridge
- 1 Toll Plaza

**River Suir Bridge Statistics**
Cable Stay Bridge carrying dual carriageway over the River Suir crossing between Waterford and Kilkenny.

- Overall width: 30.60m – 36.6m
- Over length: 465m
- Main span length: 230m (Longest span in 26 counties. Foyle Bridge in Derry NI has a main span of 234m)
- Side span lengths: 42, 66.5, 91.5, (230), 35m
- Clearance over MHWS: 14m above MHWS
- Overall Tower height: 117m (above foundation)
- Height of Tower above road level: approx. 90m
- Tower width at base: 53m
- 4 x 19 cables (Modified Fan)
- Total length of cable ~ 11900m
- Diameter of cables (Outer sheath): Between 355-455mm comprising between 31 and 55 strands (Approx 550km of strand)

**ACKNOWLEDGEMENTS**
The authors wish to thank Waterford City Council and the National Roads Authority for their permission to publish this paper. They wish to record their thanks to the staff of both organisations as well as the staff of Tramore House Regional Design office for their invaluable contributions throughout the project.

**PROJECT SUMMARY**

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
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<tbody>
<tr>
<td>Mar 1996</td>
<td>Appointment of MM.</td>
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<tr>
<td>May 1997</td>
<td>Stage 1 Final Report</td>
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<td>July 1997</td>
<td>Public Consultation</td>
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<td>July 1998</td>
<td>Public Exhibition</td>
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<td>Nov 1999</td>
<td>Route Selection Report</td>
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<td>Mar 2001</td>
<td>EIS &amp; CPO</td>
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<td>Jun 2001</td>
<td>Bridge Public Inquiry</td>
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<td>Nov 2001</td>
<td>Oral Hearing CPO, EIS</td>
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<td>Sep 2001</td>
<td>PPP Tender Issue</td>
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<td>Apr 2002</td>
<td>ABP Scheme Approval</td>
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<td>Jan 2003</td>
<td>Bridge Order Signed</td>
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<td>Early 2003</td>
<td>Woodstown discovery</td>
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<td>Jul 2003</td>
<td>PPP BAFO Invitation</td>
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<td>Oct 2005</td>
<td>Alt Route R/Sel Report</td>
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<td>Nov 2005</td>
<td>PPP BAFO Return</td>
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<td>Apr 2006</td>
<td>PPP Contract signing</td>
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<tr>
<td>Jun 2006</td>
<td>Alt Route EIS &amp; CPO</td>
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<tr>
<td>Feb 2007</td>
<td>ABP Alt Route Approval</td>
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<tr>
<td>Oct 2009</td>
<td>Bypass Opened to traffic Contract Completion</td>
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**PROJECT TEAM**

**Waterford City Council:**
- F. Galvin Director of Services
- F. Roche Senior Engineer
- T. Hartery Project Liaison Officer
- T. F. Mackey Former City Engineer
- L. Power Former Director of Services
- P. Power Former Director of Services

**Waterford County Council:**
- M. Quinn Director of Services
- P. Daly Senior Engineer
- J. O’Flynn Former County Engineer
- V. O’Connor Former Senior Engineer

**Kilkenny County Council:**
- J. Mulholland Director of Services
- B. Mernagh Senior Engineer
- D. O’Sullivan Former County Engineer
- T. Gunning Former Director of Services
- O. Mannion (RIP) Former Sen. Engineer

**National Roads Authority:**
- E. O’Connor Head of Eng. Operations
- H. Cregan Head of PPP Unit & Authority’s Representative
- D. Minnock PPP Sen Proj Mng
- B. McHugh PPP Proj Mng
- M. Kennedy PPP Sen Manager
- J. Fitzsimons Sen. Proj. Manager
- W. Douglas Proj. Manager
- P. Maher Head of Network Ops
- J. Iliff Senior Proj. Manager
- R. Bowen Proj. Manager
- H. Hughes Sen. Proj. Manager (Stds)
- D. O’Driscoll (RIP) Chief Engineer
- D. McInraithe Former Regional Manager
- G. Murphy Former PPP Manager
- T. McCormack (RIP) Bridge Manager

**Tramore House RDO:**
- R. Butler Senior Engineer
- R. Basquill Senior Exec Engineer
- C. Fitzgerald Proj Manager
- J. Eogan Sen Archaeologist
- C. Feely Former Senior Exec Engineer

**Mott MacDonald**
- J. T. Murphy Project Director
- J. Shinkwin Project Manager
- B. Williams Tolling Infrastructure
- J. Hawe Highways
- J. O’Riordan Highways
- J. Aldridge Road Safety Audits
- S. Rotherham Drainage
- N. Samachetty Drainage
- J. Young Director – Bridges
- P. Churton Suir Bridge & Viaducts
- E. Morrissey Bridges
- I. Farooq Geotechnics
- T. O’Neill Toll Collection Systems
- L. Cahill Document Controller
- J. D. Shinkwin Former Project Director

**Mott MacDonald – Site Staff**
- S. Meyrick Authority’s Site Rep
- P. Flynn Sen Resident Engineer
- P. McAndrew Sen Resident Engineer
- E. Kirwin Sen Resident Engineer
- C. Kehoe Sen Resident Engineer
- M. Kahramam Resident Engineer
- F. McGowan Clerk of Works
- M. Gill Clerk of Works
- R. Doherty Administration
- M. Fitzsimons Administration

**Celtic Roads Group**
- L. Wood PPPCo Representative
- I. Cunningham PPPCo
- M. O’Flaherty PPPCo

**WJV - BAM/Dragados**
- T. Cullinane Project Director
- T. Lucey Construction Manager
- J. Luis Conesa Contractor’s Rep
- R. Casanova Contractor’s Rep

**WJV Designers**
- Ove Arup & Partners
- P.H. McCarthy & Partners (WYG)
- Eptisa Grupo
- Carlos Fernandez Casado
- Suir Bridge
- Indra Toll Collection System