Peacocke Growth Cell Wastewater Connection to Cambridge WWTP

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EXECUTIVE SUMMARY

Opus International Consultants were commissioned by McConnell Property to investigate pumping wastewater to the Cambridge Wastewater Treatment Plant (CWWTP) for the proposed Peacocke Growth Cell. By 2020, the Growth Cell is predicted to support up to 20,000 residents in approximately 600 hectares of urban development.

This report recommends that the Peacocke Growth Cell's wastewater be disposed of to the Cambridge Wastewater Treatment Plant via rising mains between the Peacocke area, Hamilton Airport, and the CWWTP. While many route configurations are possible, the seemingly shortest feasible route has been assumed for the purpose of conducting a capital cost estimate of the project. Thus, the cost of a Peacocke pumping station, Airport transfer station, 20km of pressure main pipe and the required upgrades to CWWTP are expected to cost approximately $31 million.

Several issues need to be addressed in the design of such a scheme. Opus recommends that priority be given to investigating the E/One reticulation system for use within the Peacocke development. The E/One system has the potential to reduce capital costs significantly throughout the project. Life-cycle costs for various rising main sizes/configurations should be evaluated, and matters including septicity, inspection and maintenance, mitigating the risk of failure and power usage should be considered in the detailed design. Moreover, a detailed investigation is required at the Cambridge Wastewater Treatment Plant to determine the necessary upgrades to meet the increased flow and loads.

Opus advises that dialogue between the Hamilton City and Waipa District Councils be initiated promptly. Consultation with Environment Waikato, Transit NZ, affected landowners and other parties will also be required.

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1 GENERAL

Opus International Consultants were commissioned by McConnell Property Ltd to investigate pumping wastewater to the Cambridge Wastewater Treatment Plant for the proposed Peacocke Growth Cell. By 2020, the Growth Cell is predicted to support up to 20,000 residents in approximately 600 hectares of urban development.

Previous reports have evaluated connecting the Peacocke sewer system to the Hamilton City Council (HCC) network, leading to the Pukete Wastewater Treatment Plant. The Eastern Interceptor and an independent treatment plant have both been rejected; connection to the Western Interceptor will require sizeable storage at Peacocke or upgrading the Interceptor, at a cost of NZ$52 million or NZ$34 million respectively.

This report's preliminary concept is for Peacocke's wastewater to be transferred in two stages: the initial 8km would be a dedicated rising main from the Peacocke Growth Cell to Hamilton Airport; the Airport is already investigating a rising main from its site to the Cambridge treatment plant.

1.1 Scope of Works

The scope of this investigation includes the following:

- A planning assessment of the potential issues associated with transferring wastewater to another District that needs to be considered in this proposal.
- Preparation of a basic sewer pumping design concept from the main pump station at the Peacocke Growth Cell to Hamilton Airport.
- Preparation of a basic sewer pumping design concept from Hamilton Airport (including the Airport development flows) to the Cambridge Wastewater Treatment Plant.
- A list of the major engineering design issues associated with pumping wastewater from the Peacocke area to Cambridge.
- Capital cost estimates for the above wastewater pumping concepts, including a first-order cost for the required upgrade of the Cambridge Wastewater Plant (based on volume comparison only).

1.2 Location

The Peacocke Growth Cell is south-east of Hamilton city. The area is bordered by Glenview on the west, Waikato River on the north-east and rural property in the Waipa District to the south (see Fig. 1.1). Wastewater will be pumped from a central collection point in the north-western corner of the Cell, at its lowest point.

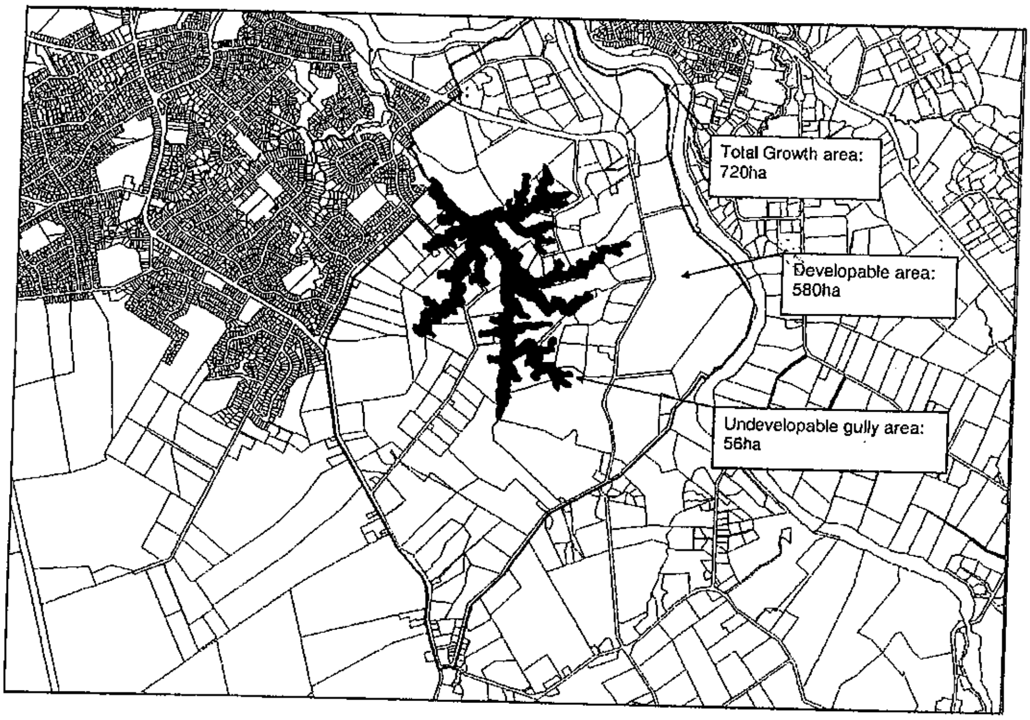


Fig. 1.1 The Peacocke Growth Cell outline showing the Mangakotukutuku gully system

At the time of writing, Opus is examining the transfer of Waikato Regional Airport's wastewater to the Cambridge Wastewater Treatment Plant. This study assumes that Peacocke's wastewater will be pumped with the Airport development's flows from a common transfer station just east of the Airport. The Airport lies approximately 8km south of the Peacocke main pump station location. Cambridge Wastewater Treatment Plant is a further 11km east of the Airport.

2 PLANNING ASSESSMENT

Two main methods of allowing for this type of proposal (Installation of a pipeline within District Council Road and private land) under the Resource Management Act (RMA) are available, either through resource consents or a designation. Both methods offer different benefits that need to be worked through at the start of the project. Both methods involve public consultation, an assessment of environmental effects and a formal process through the relevant council.

It is likely that a resource consent/designation will be necessary from both Hamilton City Council (HCC) and Waipa District Council (WDC) for land use. In addition, and depending on the nature of the proposal, is it likely that resource consents will be required from Environment Waikato for matters such as earthworks. Transit consents for easements will also be required where any State Highways are involved.

It may be necessary to obtain private land to physically enable the laying of the pipe along the shortest alignment. This may complicate the process because one could have a series of private landowners who become directly affected and will actively participate in the process. Furthermore there may be land requirements needed unless alternative means of establishing the pipe over private land is utilised.

Given that the proposal is to take wastewater from one District to another, it is worth noting that some type of agreement, outside of the RMA, may be required between HCC and WDC to enable such a proposal to proceed. It is likely that such an agreement would be required before proceeding with any major work to ensure viability of the proposal. Both parties would need to agree with the concept in principal and an agreement signed on this basis in order to obtain commitment from both parties.

3 SEWER PUMPING DESIGN

3.1 Peacocke to Hamilton Airport

It is proposed to build a rising main from a proposed Wastewater Pump Station in the northern corner of the Peacocke Growth Cell to the Hamilton Airport Wastewater Transfer Station. Opus recognises that many configurations of the route are possible. For the purpose of this conceptual design, what appears to be the shortest feasible pipeline alignment has been considered. Confirmation of the sewer alignment will require consultation with private landowners, Hamilton City Council, Waipa District Council, Transit New Zealand, and any other affected parties.

In modelling a potential sewer route, care was taken to avoid Peacocke's distinctive gully system and to follow carriageways while minimising length and impact on private landowners. It is assumed that a 3m-wide easement will be contained within road reserve where the route follows carriageways.

The route shown in Fig. 3.1.1 follows Peacockes Road south from the collection point in the vicinity of the Waiora Terrace-Peacockes Road intersection, before crossing the Hamilton City-Waipa District boundary. Between the southern end of Peacockes Road and Lowe Road, the sewer is aligned with private property boundaries and crosses Nukuhau Stream. From Lowe Road, the route continues to Airport Road along Raynes Road, stopping at the Airport WW Transfer Station just south of the Airport Road-Lochiel Road intersection. If kept at this alignment, a total of 8.1km of sewer pipe would be needed.

Transit NZ manages Airport Rd (SH 21) and is also proposing a Southern Link route that will cross the southern tip of the Peacocke development. The alignment of the Southern Links system is subject to further investigation and may have some bearing on the wastewater pipeline alignment between Peacockes and Lowe Roads. Furthermore, Hamilton Airport is investigating a business case for extending its runway to 2500m or 2700m. The runway may impact the sewer's required depth of fill and pipe strength along a section of Raynes Road.

Peacocke Growth Cell is expected to support 20,000 residents by 2020. Assuming wastewater production at 200L/head/day, as per HCC standards, the development will generate an average dry weather flow of 46.3 L/s. Peak dry weather flow is estimated to reach 120.4 L/s, based on population density peaking factors in the HCC Development Manual. The Manual makes allowances for infiltration and surface water ingress besides, at 2,250 L/hectare/day and 16,500 L/hectare/day respectively. Thus, the peak wet weather wastewater flow for Peacocke is estimated to be 250.6 L/s.

Note that all Peacocke-related figures quoted in this report assume traditional gravity reticulation unless expressly stated otherwise.

The static head between Peacocke and the Airport is 9.7m. To achieve the minimum self-cleaning velocity (0.6 m/s) at peak dry weather flow, accounting for a Colebrook-White roughness coefficient of 1.0mm, the main will be 500mm in internal diameter. The pumping requirements would equal 157kW at peak wet weather flow, against a head of 41.5m. The capital cost estimates in §5.1 and Appendix 3 are based on a DN500 pipe. However, DN450 would be more certain of achieving self-cleaning velocities at least once daily.

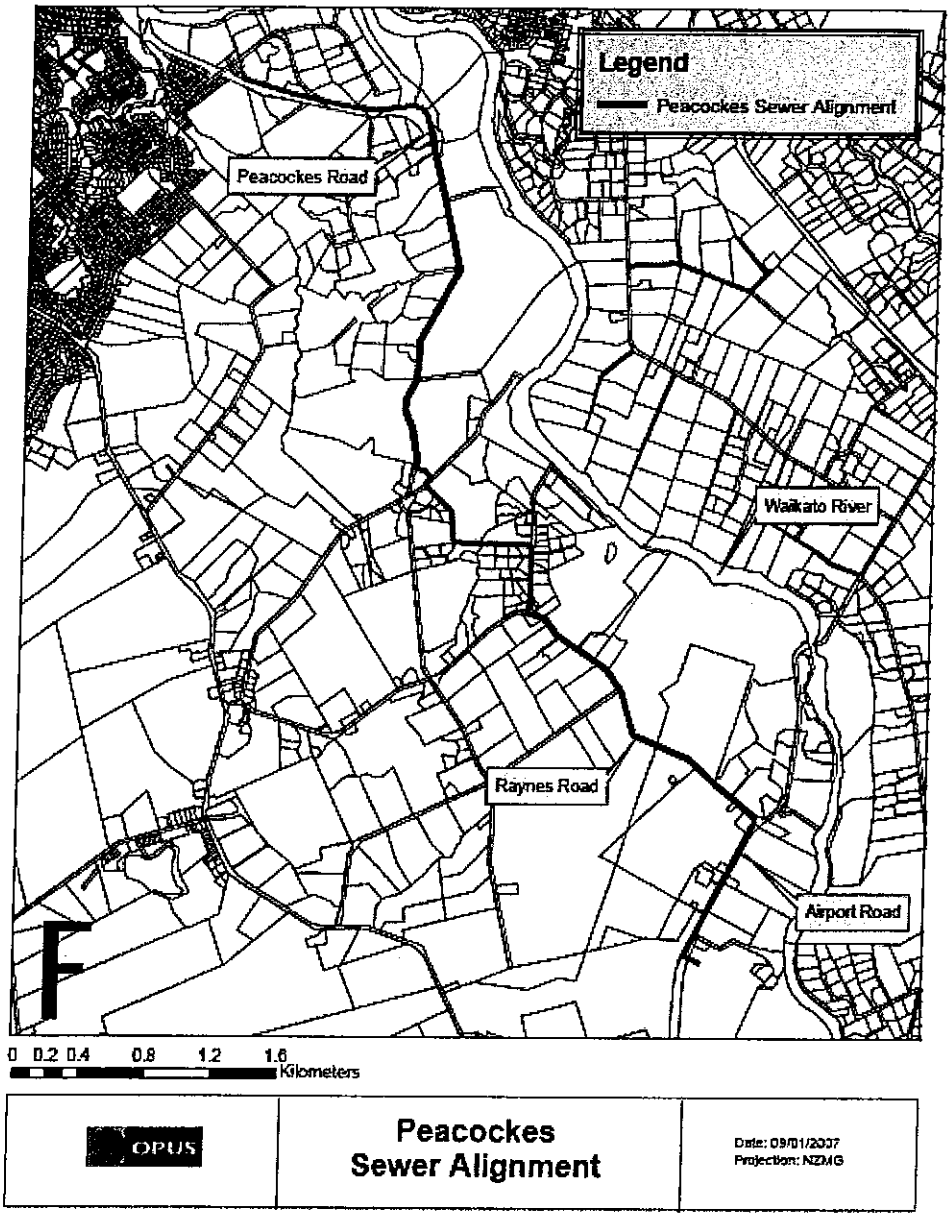


Fig. 3.1.1 Conceptual Alignment for Peacocke Growth Cell Sewer

3.2 Hamilton Airport to Cambridge Wastewater Treatment Plant

Waipa District Council (Waipa DC) has commissioned Opus to revise a previous desktop scoping study investigating Hamilton International Airport's wastewater infrastructure options. The report recommended transferring the Airport Development's flows to the Cambridge Wastewater Treatment Plant (CWWTP) along a new, 12km-long rising main. It is proposed that Peacocke's wastewater system be connected to a transfer station on Lochiel Road, from where the Peacocke and Airport flows will be pumped together to Cambridge. The sewer route is currently modelled to follow Mystery Creek Road, McEldownie or Mellow Road, Kaipaki Road and Pukemiro Lane to the CWWTP (see Appendix 3).

Hamilton Airport's wastewater flows are calculated based on wastewater production of 200L/capita/day and an equivalent population density of 30 people per hectare. Two internal reticulation options are being considered: a traditional pump and gravity-based scheme, and the E/One low-pressure system.

Under a traditional system accounting for surface water ingress and infiltration in small catchments, the Airport's peak dry weather flow is estimated to be 550L/capita/day, with the peak wet weather flow (PWWF) being twice that amount. This equates to a PWWF of 47.83 L/s. Waipa DC's Code of Practice delivered the bases for these calculations.

The E/One Sewer system is completely pressurised, thereby preventing surface water ingress. Peak wet weather flows are reduced to 454.9 L/capita/day, or 19.78 L/s. Thus, installing an E/One central sewer system will reduce flows by 58.6%.

The choice of Airport reticulation system is significant for the viability of the Peacocke/Airport wastewater scheme, as each development's capital contribution to the rising main and transfer station will be proportional to its wastewater flow. If the Peacocke Growth Cell uses a gravity sewer system and the Airport opts for an E/One scheme, 92.7% of the wastewater in the Airport-to-Cambridge rising main will originate in Peacocke.

A static head of approximately 22.2m exists between the airport and CWWTP. Calculations are based on PN16, PE100 pipe that has a Colebrook-White roughness coefficient of 1.0mm. To achieve a velocity of 1.29 m/s against a total head of 69.75m, a single rising main would be 512mm in internal diameter. Several pumping options are presented in the report to Waipa DC. The most promising scenario appears to be a single variable speed drive Pioneer pump (with another pump on standby) operating at 315kW. Detailed design of the Airport-to-CWWTP rising main and transfer station will be influenced by decisions made concerning Peacocke's reticulation and initial wastewater disposal.

4 ENGINEERING DESIGN ISSUES

4.1 Buffer Storage

Buffer storage is generally required by both Waipa and Hamilton City's Engineering Codes of Practice. Storage capacity is useful in the event of a prolonged power or pump failure or other such emergency, for conducting inspections or maintenance, and for equalising flow rates. Buffering will be needed at the Peacocke Pumping Station and at the Airport Transfer Station.

The governing Codes of Practice call for 6 hours' peak wet weather storage. Assuming Peacocke uses a gravity reticulation system, 5412m³ of storage would be needed. Alternative solutions should be explored due to the wastewater volume involved. Table 4.1.1 lists different combinations of options for the two pump stations.

Table 4.1.1 Buffer Combinations Showing the Division of Peacocke's PWWF

Buffer Options	Pump Station	6hr Storage Volume		Generator	HCC Capacity	
		Percentage	m^3		% Used	Volume
1	Peacocke	100%	5413			
	Airport	100%	5413			
2	Peacocke	100%	5413			
	Airport			X		
3	Peacocke	83.9%	4543		50%	16.1%
	Airport			X		
4	Peacocke	74.3%	4021		80%	25.7%
	Airport			X		
5	Peacocke	74.3%	4021	X	80%	25.7%
	Airport			X		

Councils' main motivation for requiring storage is avoiding system failure during electricity outages. Rather than construct large tanks at both Peacocke's pump station and the Airport (Option 1, Table 4.1.1), the Airport Transfer Station could be fitted with an emergency generator to overcome this problem (Options 2 - 5, Table 4.1.1). Acquiring a generator would be cheaper than building a full-size storage vessel at the Airport.

Both transfer stations would still benefit from some extra capacity to spread out peak flows over several hours and thus decrease the rising main diameters needed. A more constant flow rate would also help to stabilise processes at the CWWTP.

Of note is the spare capacity identified in Hamilton City Council's Western Interceptor by a previous Opus report. Up to 32% of Peacocke's PWWF of 250.6 L/s (80.5 L/s, or 1738.8m³/6 hours) could be redirected into the Western Interceptor without surging the most vulnerable sewer section. A conservative approach would entail using a smaller fraction of the Interceptor's spare capacity, perhaps 50 - 80%. Options 3 - 5 in Table 4.1.1 show how much of the 6 hr storage volume could be fed into the HCC network using various fractions of the Western Interceptor's excess capacity.

To make use of the Western Interceptor, storage would still need to be built in Peacocke, and the Pump Station would be best kept at its conceptual location in the north-west corner of the Growth Cell. Hamilton City Council has already budgeted $6.479 million to be spent on the design and installation of a Peacocke Wastewater Storage Chamber, aeration treatment and odour management system before 2010.[1]

The spare capacity in the HCC network may initially be used for all of the Peacocke flows until sufficient flow is produced to economise using the large-diameter rising main to the Airport. The Airport-to-Cambridge rising main may legitimately be designed as dual pipes: Airport wastewater could then be pumped to Cambridge efficiently before Peacocke flows are directed to the Airport Transfer Station.

4.2 Inspection and Maintenance

Wastewater mains' continued, efficient operation is essential to the health of the community. The pressure mains connecting Peacocke, Hamilton Airport and the Cambridge Wastewater Treatment Plant will require regular inspection and maintenance to this effect. Unchecked cracks, corrosion, loss of strength or tensioning, sludge or slime layer build-up and gas pockets all affect a main's performance, and may lead to leaks, increased head loss and structural failure. It is important to inspect the entire line for localised problems.

Likewise, timely attention to the Peacocke Pump Station and the Airport Transfer Station will ensure the best possible outcomes for all. Power failure is the most likely incident at a pump station: effects are rarely serious if pumps and generators' mechanical and electrical components are kept in good repair.

A cyclic inspection programme, and real-time monitoring of pump stations' flows, well levels and pressures, allows accurate analysis of the system's condition. Annual inspections for rising mains and more frequent pump station assessments are prudent. Contemporary methods employ remote control and Geographic Information System (GIS) technology to map, monitor, maintain and model sewer schemes. The information gathered is useful for devising contingency plans and initial response strategies for emergencies, while helping to prioritise remedial action based on the likelihood and expected consequence of a given event.

Preventive/predictive maintenance for the Peacocke WW project is likely to be cheaper than the cost of remediation after an avoidable failure. An example of preventive maintenance is scouring or pigging the main to remove slime and scale from the pipe surface. Smoother, correct-diameter pipes decrease head loss and lower pumping requirements, while helping to control hydrogen sulphide production. However, such measures may involve increased capital outlay along with the cost of operation.

[1] Hamilton City Council. *Highlights of other key projects and programmes*. Retrieved 11 January, 2007, from http://hamilton.co.nz/page/pageid/2145833423.

Good design and careful material/equipment selection reduces the need for maintenance. §4.3.2, 4.5 and 4.6 of this report detail the importance of choosing the most reliable pipe material and designing the main to reduce septicity effects. §4.7 explores the possibilities of a low-pressure reticulation system.

Moreover, the final plans are to take ease of access for maintenance and inspection into account. Pump stations need space for technicians to reach and operate components. Access chambers are to be sulphide-resistant, sufficiently ventilated and in accordance with confined-space safety standards. Lastly, the system must remain usable while undergoing maintenance. Redundancy, such as two-stage duty-assist pumps, buffer storage and dual pipes, should be considered in the detailed design stage.

4.3 Pipe Selection

4.3.1 Size

Common practice is to determine a pipe's size by its maximum expected flow, normally the peak wet weather flow. By this method, the Peacocke-to-Airport rising main will have a nominal diameter (DN) of 500. The Airport-to-CWWTP main will have an internal diameter of 512mm. Pipes are sized in this way to assure ability to cope with any reasonable volume of liquid entering the system, and to keep pumping costs to a minimum.

The Peacocke Growth Cell's situation is unique: initial wastewater flows will be much less than the eventual quantity; at full capacity, the Development's flows will be very large. If a single pipe is used for each main, small wastewater volumes will not be under enough pressure to reach the end of the line. Fluid velocities would be too low to regularly rinse the pipe clean of settled solids.

Thinking beyond sizing conventions may bring improved economy. As the rising mains' quoted diameters will already be excessive for all but Peacocke's final population, increasing the pipe diameter further is not an option. Smaller pipes or dual pipes may provide the best solution.

A smaller-diameter pipe has some clear advantages. Smaller pipes require less material and are easier to handle. Installation costs would be proportionately lower. If flow rates are kept constant, the velocity in a smaller pipe would be increased. This would lower the wastewater's detention time and limit the slime layer's thickness. Both of these effects would decrease the total amount of sulphide generated. Slime increases head loss in the pipe, so less slime betters the pumping efficiency. Physically removing slime and dealing with sulphide corrosion heightens maintenance costs.

Unfortunately, increasing fluid velocity through a pipe increases pumping costs. The capital cost estimates in §5.1 and Appendix 3 are based on a DN500 pipe for the Peacocke-to-Airport rising main. A DN450 line would require 20.7kW more power to pump Peacocke's peak dry weather flow (PDWF) than a DN500 sewer. The difference increases to 88.7kW at its peak wet weather flow (PWWF). However, DN450 would be more certain of achieving self-cleaning velocities at least once daily.

A smaller pipe diameter may be achieved for Peacocke or the Airport's pressure main by specifying some value and adjusting the pumping requirements accordingly. Alternatively, storage capacity at the pumping station prior to the main would allow peak flows to be fed into the pipe over several hours, thereby reducing the design flow. Another solution is to reduce the absolute wastewater volume, as would occur if a low-pressure reticulation system were installed in the Peacocke Development. Excluding infiltration and ingress from the system in this way would not only allow for smaller-diameter mains, but would also lower the pumping costs accordingly.

Laying two pipes along either section of the rising main route may be one way of applying benefits of smaller pipes to the Peacocke wastewater scheme. One line would be commissioned to serve Peacocke's initial growth, with the second brought into action as the population swells. Although material costs would be higher than for a single pipe, pumping efficiency would be greater for the initial development. The number of pumps and pipes in service could potentially be adjusted in response to the load. Furthermore, the redundancy in the line would mean that the system would remain operational while one pipe undergoes maintenance. The dual pipe concept extends to include using spare capacity in Hamilton City's Western Interceptor as one of the 'pipes'. See §4.1 for a discussion of this option.

It is recommended that the system's life-cycle costs for various rising main sizes/configurations be evaluated.

4.3.2 Material

Pipe material selection is one of the most influential of all engineering design issues related to rising main design. As is evident in the capital cost analyses, rising main unit rates are the largest single contributor to the project cost, both directly and by flow-on effects to percentage-based items (establishment, design, and so forth).

The ideal pipe material is able to withstand grit, pressure and corrosion, has a low failure rate and, by corollary, a long design life. The majority of materials require external protection of some kind, whether by an epoxy coating, composite structure, or cathodic protection.

Flexibility becomes increasingly important for larger pipe sizes. Surge will be a major consideration for the Peacocke-to-Airport and Airport-to-Cambridge rising mains; PE, for instance, is a very good material in this regard because the wave celerity is much lower than for stiff materials like steel. Medium-density PE has been tested to 2 million cycles at 10°C with no sign of failure.

Flexible joints allow a dynamic response to seismic movement or vibrations from nearby operations. Correct fittings allow vibrations from pump stations to be isolated from the main. A pipe material's compatibility and ease of coupling with the types of fittings necessary is also a consideration. In general, a pipe's joints will have a noteworthy bearing on the cost and constructability of the pipeline.

Some materials are not suitable for wastewater, and are not available in sufficiently large pipe sizes, perhaps due to inherent strength or limitations in the manufacturing process. If available in according to basic specifications, the structural requirements to support a given pipe type varies further.

Along with the design life and projected maintenance costs, material for a rising main may be evaluated in terms of the cost per effective metre. Freight depends on the factory location relative to the construction site, and increases for heavier and longer pipes. Heavier pipes raise the installation and establishment costs as well.

Of all of these concerns, strength and corrosion resistance were deemed to be of utmost importance to the Peacocke rising main. PE-lined mild steel would be the ultimate choice in terms of these characteristics; however, ready-made products investigated in the creation of this report were restrictively expensive. Spiral-welded steel with coatings and linings of epoxy or plastic may be valid alternatives at a later design phase. Quality-assured linings would be essential for steel pipes, as hydrogen sulphide brittles especially low-nickel steels and causes stress corrosion cracking.

New concrete pipes can be made with a sulphate-resistant mix, and are required to have a sacrificial cement lining. While new concrete satisfies the strength requirement for this project, the Engineers feel that concrete's intrinsic susceptibility to corrosion is more significant. For the same reason, mild steel cement-lined pipes and ductile iron pipes have been rejected.

For the purpose of this conceptual report, polyethylene (PE) has been chosen as a suitable rising main material. Like epoxy-coated steel, PE is up to 40% smoother than concrete, thereby reducing pumping costs.[2] PE100 is virtually immune to surge, is naturally resistant to hydrogen sulphide corrosion and a range of common chemicals, and is relatively easy to handle. Jointing methods would need careful evaluation, as welding is much more expensive to perform than, say, rubber ring-jointed pipes. Glass-reinforced plastic (GRP) was also considered for this project. Ironically, the reinforcement has been known to be a source of failure, as cracks may develop along the glass fibres. PE's main advantage over GRP is cost.

4.4 Power Usage

See Appendix 3 for OPEX cost comparison for the various pump options. Currently pump options and scenarios investigated in this report have mainly focused on a single rising main and pumps operating on a duty/standby only basis. In terms of OPEX cost between the various pump scenarios the running costs are relatively insignificant and the focus has been on Capital expenditure.

However, if the design brief was to focus more on savings in Opex rather than Capex and with further detailed design, potential Opex cost savings could be made.

One way to improve Opex costs would be to construct two rising mains. One rising main would transfer the dry/average flows and would be in operation the majority of the time. The second rising main would transfer the infrequent peak flows and would be only in operation during wet weather or peak periods. Dedicated pumps wpould transfer the average and peak flows and they would be dedicated to either the average flow rising main or peak flow rising main. With this arrangement the pumps would be operating within a more efficient position on the pump curve. If this arrangement was considered over a 25 year NPV the Opex saving could be significant. A single duty

[1] U.S. Department of Energy – Industrial Technologies Program. (October, 2005). *Energy Tips – Pumping Systems.* Retrieved 15 January, 2007, from http://www1.eere.energy.gov/industry/bestpractices/pdfs/pumping_9.pdf

pump and rising main does not run very efficiently during low/average flows as it has to have the capability to transfer the peak flows, at the top end of the pump curve which is were it is at its most efficient.

The saving in Opex however, does obviously increase Capex with twice as many pumps, rising mains and associated drives etc.

4.5 Risk of Failure

4.5.1 Backflow

As with any pressurised system it is common practice to install backflow prevention within the system to prevent flooding during pump stop, mechanical failure or power failure. Installed on the discharge side of the delivery pump will be non-return valves that will automatically close when a pump has stopped to prevent backflow and thus flooding of the pump wet well. The non-return valves operate under gravity and will therefore automatically close even in the event of power failure.

4.5.2 Blockage

Rising mains, especially, must be kept free-flowing at all times. Debris' size and quantity have to be limited to minimise the risk of blockage anywhere in the sewer system, and to prevent damage to pumps and pipe linings. Debris and grease control would ideally be exercised by households and businesses; this may be facilitated by community education through local media, letterbox drops, or information given at the time a property in Peacocke is sold. Such an initiative may help to foster a perception of its sponsors as responsible and interested in community wellbeing.

Arrangements should be made for the inevitable wastewater solids content. The Airport development's liability for blockages in the Airport-to-Cambridge rising main will be low, provided E/One reticulation is chosen for the Airport and screening options are examined. Responsibility lies with Peacocke's developers, therefore, to make decisions that will protect the integrity of the sewer scheme.

Debris may be chopped or ground, and/or removed by screening. Screening is best done at the central Pumping Station to the Airport, but would involve a high operating cost, and additional steps to dispose of the solids and manage associated odour issues.

Grinding units could be installed at either the main pumping station, or at each property's sewer connection. If gravity reticulation is used, a central grinding or chopping unit would be the most cost-effective for the Peacocke Growth Cell. Installing E/One reticulation would virtually remove the need for more blockage mitigation since every household's wet well unit includes a grinder pump. E/One reports that its pumps routinely shred wood, plastic and cloth.

The Cambridge WWTP upgrades would need to assess the effect of prior solid grinding on its operations. The existing step-screen is likely to remain in use and is expected to remove ground debris capably.

Peacocke's staged development implies another blockage risk: initial velocities in a full-size rising main may be too low for the pipe to rinse clean regularly. Settled solids would foster increased microbe growth and would increase the head loss in the pipe. Suggestions for initial wastewater disposal are mentioned in §4.1.

4.5.3 Fatigue

The pressure rating attributed to a pipeline is derived on the basis of burst regression lines for pipes with a constant internal pressure and serves as a first indication of the duty for which it is suitable. However, the operating pressure of a typical pressure system varies throughout its lifetime, often subjected to a regular pressure cycle resulting from operational processes like pump start-up and shut-down. Pressure surges in excess of the pressure rating can lead to premature failure of the pipe as can a large number of repetitive events, the maximum of which are below the pressure rating of the pipe. This cyclic type of failure is known as fatigue and results because many materials will fail at lower stress when subjected to repetitive loads under static loads.

The severity of fatigue is determined by three factors:

- The magnitude of the stress fluctuation.
- The loading frequency
- And the intended service life

The number of pressure cycles over the pipeline's design life need to be estimated and is based on the normal number of cycles expected, most often being the pump start and pump shut-down. A rising main will experience a number of decaying surges on each pump start and pump shut-down. It is normal practice to double the number of pump starts to allow for the decaying surges.

Surge mitigation can be incorporated in to a wastewater rising main which will maintain the design service life of the rising main, as follows:

- Using Variable Frequency Drives (VFDs) to reduce the number of pump starts/stops. These will also slowly "ramp" up and "ramp' down during pump start/stop limiting the "water hammer" effect.
- Use of pipe material that dampen surge waves such as PE pipe.
- Use of air release valves along critical points along the rising main prevents high surge pressures

It is therefore proposed to incorporate all of the above surge mitigation devices in to this scheme to maintain the design service life of such a critical rising main.

4.6 Septicity

Wastewater quickly becomes anaerobic in pressure mains due to its high biological oxygen demand (BOD). As septicity develops, the microbes in the slime layer on the submerged pipe wall begin to produce hydrogen sulphide (H_2S), methane, ammonia and carbon dioxide. These species (collectively termed 'sewer gas') are dangerous and irritating to humans through direct contact, as well as indirectly, by corrosion. The risk of biological contamination to workers or if a leak occurs is also high.

Of all the products of septicity, hydrogen sulphide causes the most concern. As such, §4.6.1 below discusses H_2S and its effects in some detail. Methane is noted for its extreme flammability, wide explosive range and low flash point. (Flammable liquids entering the sewer – as industrial waste or cleaning products, for example – will be another fire hazard.) Ammonia and related compounds have strong, distinct odours. Ammonia is toxic, corrosive, and irritates the eyes and mucous membranes. All of the above may induce drowsiness, fatigue or asphyxiation from displaced or consumed oxygen; or poisoning by inhalation. Those exposed to sewer gas may not perceive the lack of oxygen or the presence of air-borne hazards, as all species are essentially colourless, and one's sense of smell is curbed by the toxins themselves.

4.6.1 Hydrogen Sulphide

Sulphate-reducing bacteria generate sulphide (S^{2-}) as a by-product of digesting organic matter. The sulphide ions react with water to form hydrogen sulphide gas (H_2S), which collects in the headspace above the liquid in a sewer. The gas gives septic sewerage its characteristic "rotten egg" odour, although the detection level is a mere 0.5ppt to 0.1ppm. Above this concentration, H_2S deadens the olfactory nerves. The gas irritates eyes and mucous membranes, affects the nervous system, and blocks breathing and cellular respiration. Exposure to 300ppm is known to cause coma and death. Furthermore, H_2S tends to accumulate in poorly ventilated spaces as it is 20% heavier than air. The H_2S/air mixture is explosive above -82°C between 4.3% and 46% H_2S v/v.

Thiobacilli on the moist sewer surface oxidise the H_2S to sulphuric acid. By convection, this process occurs most readily at the peak waterline and the pipe crown. Concrete, asbestos cement, mortar and metal are readily corroded: without remedial maintenance, pipes begin to leak, infiltration increases, and sections of the pipeline may collapse.

Wastewater sulphide concentrations vary with the diurnal changes in velocity, temperature, depth of flow and sewerage strength. Peak levels may be ten times the average. H_2S formation fluctuates further according to the turbulence at a given point. At a drop or junction, 0.01mg/L dissolved sulphide can cause severe corrosion; little H_2S may be released in a large, calmly-flowing sewer section at dissolved sulphide concentrations of 0.1mg/L.

4.6.2 Downstream Processing

Anaerobic digestion in septic wastewater promotes floating sludge in primary sedimentation tanks. Higher-than-normal populations of *Thiothrix* and *Beggiatoa* cause filamentous bulking in the activated sludge, and decreases waste removal efficiency overall.

Primary treatment preceding the rising main would help to lower the biodegradable material concentration in the rising main. Oxygen or chlorine added at the CWWTP inlet may also reduce the effects of septicity on the treatment plant by re-oxidising H_2S and suppressing anaerobic bacteria. It may be possible to design the discharge end of the pressure main to re-aerate the wastewater, although the surface turbulence will release dissolved sulphide that has accumulated. Installing an entry trap on the incoming pipeline can isolate the hydrogen sulphide released to the pumpwell.

4.6.3 Solutions

Septicity solutions either seek to prevent the condition from forming, most commonly by chemical addition, or to mitigate its effects. Chemical approaches can be categorised according to the type of intervention; mitigation is largely a matter of design.

Since anaerobic conditions are necessary for septicity, adding oxygen in some form will avert septic effects, at least for some time. In order of increasing cost, air, pure oxygen, nitrate salts or hydrogen peroxide will encourage aerobic bacterial growth. Another approach to inhibiting anaerobic bacteria is to raise the wastewater pH to very high levels. Strongly alkaline conditions (pH 8.5-9) will slow the sulphide-producing microbe's growth, while maintaining a pH of 10-11 for 20 minutes will kill most of the culprit organisms. Sodium hydroxide is most commonly used for this purpose. Calcium hydroxide may be substituted, but may form scales in the pipe and pumps. An important consideration is the effect on downstream processing: biological treatment plants require wastewater to have a pH of 9 or less. Chlorine compounds also kill microbes, and oxides H_2S. Lastly, some methods seek to interrupt dissolved sulphide's release as hydrogen sulphide gas. Iron salts form an insoluble complex with sulphide ions, thereby preventing hydrogen sulphide from forming.

Chemical addition's success depends on carefully balancing dosage with pH, temperature and secondary effects. Transportation and storage is costly and requires health, safety and environmental risk management. Moreover, most methods are ineffectual for long retention times, yet repeated dosing along the length of the main is not practicable. Chemical sulphide control represents an ongoing expense and relies on trained personnel's adherence to a regular and somewhat tedious regime. Dr. Richard Pomeroy, author of definitive texts on hydrogen sulphide, asserts, "It is dubious practice to plan a new sewerage system in a way that will make the durability of the pipe dependent upon continued chemical treatment (bactericides, lime, etc.) for sulphide control."[3]

The design approach to septicity mitigation may well specify chemical use, but its basis is by far more fundamental. The goal is to minimise the system's propensity to generate sulphide, and to reduce its vulnerability to the inevitable presence of septic products. It is prudent to assume that the Peacocke Pump Station and all downstream components will handle domestic strength, septic wastewater, and to design accordingly.

Sulphide generation is a function of retention time and flow profile. The retention time between the Peacocke Pump Station and Cambridge Wastewater Treatment Plant (CWWTP) is expected to be around two days at peak dry weather flow. Reducing the retention time by using the shortest possible main and a small diameter will allow aerobic conditions to prevail for a larger fraction of the total length. Greater velocities resulting from a smaller-diameter main has the added advantage of raising the shear stress on the pipe wall: the slime layer harbouring sulphide-producing bacteria may be

[3] Dr. Richard D. Pomeroy. (1976). *The Problem of Hydrogen Sulphide in Sewers*. 19. Retrieved 5 December, 2006, from http://www.cpda.co.uk/techn/clay/w2253.pdf.

kept as thin as to be inconsequential. Note that significant slime growth may increase the pipe's Colebrook-White roughness coefficient 30-fold from that of a new pipe.

The system's fortitude against septicity's adverse effects hinges on corrosion protection. §4.3.2 deals with pipe material selection; some, such as plastic and properly jointed vitrified clay, suffer no damage from hydrogen sulphide exposure. The Peacocke and Airport pump stations, Cambridge WWTP's inlet and ancillary systems will require adequate coating with epoxy, plastic or rubber if corrosion-resistant materials cannot be substituted. Any increases in capital outlay must be evaluated in light of a longer, lower-maintenance service life.

4.6.4 Odour Control

Odour removal is essential along the length of the pipeline. Where possible, the main should be rising, to facilitate gas collection. Air valves should be located with regard to residential or oft-frequented areas. Treating the released gas through bio-filters is preferable to building vent stacks, although filter media, such as activated carbon or bark, requires renewal, perhaps as often as twice a year. Another option is to install a small suction pump at the rising main outlets to provide negative head in each air valve chamber. The pumps and connective hose would effectively remove odour issues along the length of the rising main. A surveyed long section of the pipe will be needed to finalise the number of air valves required. The cost of odour control has not been estimated in this report.

4.7 The E/One System

Traditional central sewer systems are prone to groundwater infiltration, which dilutes the wastewater, increases pipe diameters and pumping costs, and requires larger storage and treatment plant volumes. Infiltration and ingress accounts for 52% of Peacocke's peak wet weather flow.

Design standards commonly specify peaking factors of 5 or more to account for expected ingress into pipelines. For low-pressure sewer systems, peaking factors of 2 - 3 are conservative. The factor allows for the risk of illegal future connections and infiltration between the wastewater origin and local pump.

The E/One Sewer system leads the low-pressure sewer market. In short, E/One units, consisting of a PE or fibreglass wet well and submersed grinder pump, are installed for each property. Waste is ground to a slurry and pumped to a main along a small-diameter pipe. The pressurised system prevents infiltration and allows shallow-trench installation in almost any terrain, irrespective of the water table or site gradient.

Analyses for Hamilton Airport's development has yielded promising forecasts for the E/One system: capital costs for reticulation, pumping and a rising main to Cambridge would be 39% cheaper under the E/One scheme than under gravity, for the Airport flows alone. Opus' report to Waipa DC will recommend installing an E/One Sewer system at the Airport.

Peacocke Growth Cell's peak wet weather flow would decrease from 250.6 L/s to 120.4 L/s if the E/One system were installed throughout the area. More than halving the wastewater volume through E/One would likely bring these benefits:

- Smaller rising mains required between Peacocke, the Airport and CWWTP.
- The potential for a shorter rising main to the Airport. Since reticulation would not require gravity, the rising main could be constructed from Peacocke's southern side, saving 3.7km of pipe. Note that moving the Pump Station to the south would most likely preclude using spare capacity in the HCC sewer network for buffering or initial flows.
- Shorter residence time in the pipe, which helps to mitigate septicity.
- Debris is ground to reduce downstream blockages and pump damage.
- Ease of installation. Less excavation and laying costs.
- Added value to properties.
- Operating costs shared with the homeowners, as each household pays for its pump's electricity (equal to a 40 W light bulb annually).
- More concentrated wastewater, so less flow reaches the CWWTP.
- Smaller emergency storage volumes required.
- Capital costs for transfer from the Airport to CWWTP would be less overall and would be shared more equally.
- Pumping costs will be reduced.
- Opus recommends that priority be given to investigating the E/One system for use in the Peacocke development. Alternative low-pressure systems may also be considered.

5 CAPITAL COST ESTIMATIONS

5.1 Peacocke-to-Hamilton Airport Rising Main

The capital cost estimate for the Peacocke-to-Hamilton Airport sewer includes the cost of the rising main and the pumping station. An effort was made to approximate additional costs that would be involved in establishing a wastewater connection between the Developments.

By far the largest component of the estimate is the rising main itself: based on an industry quote, DN500 polyethylene pipe at the required pressure rating costs will cost $800/m to supply and install. Including reinstatement of the pipeline, thrust blocks, and air valves, (the latter two items being subject to confirmation), the pressure main will conservatively cost $6.6million for 8.1km.

The internal wet well pumping station, including wells, minimal storage, two Pioneer variable speed pumps (one on stand-by) and building are estimated to cost $997,200. A further $180,800 would be needed for a stand-by generator and telemetry. These figures exclude odour control, primary treatment, emergency storage or a possible connection to the HCC wastewater network.

$175,300 for establishment and other preliminary costs were estimated as percentages of the total capital cost. The same method was used for design and tendering, contract supervision and commissioning of the system. Together, these items may cost as much as $368,800. Fifteen percent ($1.2 million) for contingencies is included in the overall capital cost of $9,203,010. Appendix 3 shows the cost estimate in full.

This report has noted what appears to be the shortest possible alignment for the Peacocke-to-Airport sewer line. As modelled, the alignment runs between 14 private properties for 998m.

Opus emphasizes that many potential configurations could be contemplated. One such option is to follow Peacockes Road to its intersection with Gainsford Road, then veer west to Faiping Road. As of January, 2007, Faiping Road is only partially built. Its road reserve meets with Raynes Road 750m to the west of the Lowe Road-Raynes Road junction.

The Faiping Road route crosses the Nukuhau Stream twice and is 620m longer than the alignment modelled elsewhere in this report. Tracking road reserve along the length of the sewer would minimise the impact on private properties but carries a higher capital cost: by example, DN500 PE100 PN16 pipe costs approximately $800 per effective metre to supply and install. An extra 620m of pipeline would cost $495,200 in pipe alone. Including installation, establishment and other relevant costs, the additional pipe length could cost as much as $0.6 million. An extra 10-16kW would be required to pump this distance.

5.2 Hamilton Airport-to-Cambridge Wastewater Treatment Plant

The capital costs for the rising main from the Hamilton Airport to the Cambridge Wastewater Treatment Plant (CWWTP) were estimated in the same way as for the Peacocke-to-Airport main. Since the Airport's wastewater account for only 7.3% of the total flow, the pipe specification for both rising mains is the same. The cost estimate would need revision if the Airport installs gravity reticulation, or if the Peacocke flows are greatly altered.

Based on a typical rising main specification and excluding the Peacocke development's flows, pumping the Airport's wastewater to Cambridge by the preferred transfer pump configuration would cost $3.9million using E/One reticulation. With no allowance made for odour control or storage, pumping Peacocke and the Airport's wastewater together to Cambridge will cost in the order of $13million. Opus has not presumed how this amount will be applied to each development. Please refer to Appendix 3 for the complete cost estimate.

A November, 2004, report from Opus estimated a rising main between the Hamilton Airport and Cambridge WWTP to cost $2.5 million, with $360,000 for a primary treatment system and pumping station. The report has since been reviewed and the estimate increased to the current amount. Note also that the 2004 report dealt solely with projected Airport flows. As demonstrated, Peacocke's wastewater flows will be more than 12 times that of the Airport. Pump and pipe prices increase exponentially, so that a revised cost estimate of barely five times the original is excellent.

Table 5.2.1 summarises the increases between the November, 2004 and January, 2007 estimates, for the Airport flows only:

Table 5.2.1 Cost Estimation Methods and Items; Nov. 2004 and January, 2007.

	November, 2004	January, 2007	Difference in Estimates
Preliminary and General Costs	Fixed amounts	Percentages of total cost	$38,500
		Programming included	$2,000
Supply and Installation	$160/m	$200/m	$540,000
	$1000 air valves	$10,500 air valves	$106,000
		Thrust blocks included	$8,750
Emergency Storage	Specific volume	Estimated volume	$134,148
Design, Tendering and Contract Supervision	Fixed amounts	Percentages of total cost	$19,600
Commissioning		Included; percentage of contract cost	$19,600
Contingency	15% of total cost		$188,333
		Total	**$1,056,931**

The effect of inflation has not been isolated in Table 5.2.1. Unit rates for rising main supply and installation are the most significant contributor to the capital cost increase between the two Opus reports. Polyethylene material prices have soared in recent years; combined with more precise estimates (which is the intent of the January, 2007 report), rising labour and fuel costs, and inflation, the effect is clear.

5.3 Cambridge Wastewater Treatment Plant Upgrade

The Cambridge Wastewater Treatment Plant (CWWTP) was designed to treat an average dry weather flow of 53.3 L/s for a 2016 population of 20,000. By comparison, the Peacocke development's average dry weather flow is predicted to be 46.3 L/s. The plant comprises screening and anaerobic pre-treatment, and an aerobic lagoon and settling basin, before effluent flows through a wetland and into rapid infiltration beds.

Waipa District Council intends to upgrade the CWWTP before the end of 2008 to meet discharge conditions set in its current resource consent, which expires in 2016. The upgrades are likely to supply increased aeration and a new anoxic zone for denitrification. Servicing Peacocke and the Airport may only begin once upgrades are complete.

A previous Opus report estimated that upgrading the CWWTP at current operation levels to meet existing resource consent conditions would cost $350,000. Additional work will be required to deal with the Peacocke and Airport flows. Charges for the upgrades are expected to be on a flow and load basis, as governed by a Trade Waste Agreement between the parties. Both flow and load are taken into account, as the CWWTP will be affected by changes in the volume, as well as the strength, of the wastewater.

In November, 2005, Opus produced a capital cost estimate for the Thames-Coromandel District Council (TCDC) regarding the provision of wastewater treatment to Tairua-Pauanui, Whangamata and Whitianga. The data approximate likely costs for CWWTP works, should Peacocke flows be directed to the plant.

Whangamata and Tairua-Pauanui figures are for sequencing batch reactor-based (SBR) wastewater treatment plants. The estimates in Table 5.3.1 include project management and TCDC costs, but exclude biosolids disposal or reduction costs outside of the treatment plants. Note that the estimates exceeded the final tender amount.

Table 5.3.1 Capital Cost Estimates for Eastern Seaboard WWT Works[4]

Date & Purpose	Tairua / Pauanui	Whangamata	Whitianga
2003 for 2004 LTCCP	$9,500,000	$7,200,000	$9,900,000
Business Plan 05/06	$13,500,000	$5,580,000	$9,900,000
11/2005 Update most likely	$18,942,000	$19,977,000	$17,887,000

The original cost estimate was based on a range of source data including direct quotes from suppliers, recent treatment plant construction, recent regional civil engineering contracts and recent electrical and automation contracts of a similar magnitude. The data was scaled to match site-specific process sizing based on the flow and loading surveys, as referenced in Table 5.3.2.

[4] Opus International Consultants. (2005). *Eastern Seaboard Wastewater: Business Case.* 107.

While populations between the Eastern Seaboard towns and Peacocke vary widely, the above-average wastewater production per capita in the towns means that the costing bases are comparable. Whitianga's peak wet weather flow in 2036 is of the same order as the Peacocke Growth Cell prediction at full capacity in 2020. The estimated capital cost of substantial works in Whitianga is $17.9 million. Based on these figures, the CWWTP upgrades may cost up to the order of $20 million.

Table 5.3.2 Influent Flows for Each Treatment Plant during Off-peak and Peak Conditions.[5] Peacocke Flows Added for Comparison.

Parameter	Whangamata		Whitianga		Tairua/Pauanui		Peacocke
	Off-peak	Peak	Off-peak	Peak	Off-peak	Peak	
2005							
Population (PE)	4,153	48,400	3,563	20,250	2,291	22,478	
ADWF (m^3/d)	1,620	4,341	1,782	2,730	870	3,551	
PWWF (m^3/d)	6,479	-	7,126	-	3,480	-	
2021							**2020**
Population (PE)	5,274	48,400	7,018	29,957	4,222	34,460	20,000
ADWF (m^3/d)	2,057	5,343	3,509	4,915	1,604	5,435	4,000
PWWF (m^3/d)	8,227	-	14,036	-	6,417	-	21,650
2036							
Population (PE)	6,300	48,400	10,300	39,000	6,000	45,500	
ADWF (m^3/d)	2,457	6,300	5,150	7,000	2,280	7,200	
PWWF (m^3/d)	9,828	-	20,600	-	9,120	-	

Table 5.3.3 shows the projected flows into the CWWTP, based on its current design volume. The proportion of wastewater contributed by each source is shown, and the estimated upgrade cost is divided among the Treatment Plant, Peacocke Growth Cell and the Hamilton Airport. Assuming 2.8 people per dwelling in Peacocke – and thus 7,143 dwellings in the area – Peacocke's contribution on a flow basis alone is approximated to be $1,194 per lot.

Table 5.3.3 Average Dry Weather Flows and Percentage Contributions to the Upgraded CWWTP

Contributor	Wastewater Volume		Contribution	Upgrade Cost	Cost per Lot
CWWTP	53.3	L/s	49.1%	$9,815,838	
Peacocke	46.3	L/s	42.6%	$8,526,703	$1,194
Airport	9	L/s	8.3%	$1,657,459	
Total	**108.6**	**L/s**	**100.0%**	**$20,000,000**	

[5] Opus International Consultants. (2005). Appendix 5: Process Options Evaluation. *Eastern Seaboard Wastewater: Business Case.7.*

Upgrades to the CWWTP are very likely to use existing infrastructure, so final costs may be well below $20million. Peacocke Development's actual charges depend on factors outside the scope of this report and cannot be set with certainty without further investigations. It is recommended that a detailed study be completed to determine the process and control upgrade requirements at the CWWTP to cater for the additional load from the Peacocke Growth Cell and Airport Development.

5.4 Capital Costs Summary

Many options have been offered within this report's brief to investigate transferring Peacocke Growth Cell's wastewater to the Cambridge Wastewater Treatment Plant (CWWTP) via a transfer station at the Hamilton Airport. For convenience, Table 5.4.1 reviews the figures in §5. Note that figures are for costs applied to the Peacocke Development only, except for the Airport-to-CWWTP rising main since the proportion paid by each development is open to negotiation.

Table 5.4.1 Capital Cost Estimation Summary for Peacocke WW Disposal

Peacocke to Airport		
Route 1: 8061m	$9,203,010	
Route 2: 8680m		$9,794,685
Airport to CWWTP	$12,920968	
CWWTP Upgrade	$8,526,703	
TOTAL	$30,650,681	$31,242,356

Figures assume that Hamilton Airport will install an E/One reticulation system and that the Peacocke Growth Cell reticulation will be gravity-driven. The conceptual route between Peacocke and the Airport, as considered throughout this report, is labelled as 'Route 1'. Another option following road reserve is designated 'Route 2'. Possible effects of installing E/One reticulation in Peacocke are not shown in this table. By these calculations, the total capital cost to transfer wastewater to Cambridge WWTP would be approximately $4,300 per lot in Peacocke.

RECOMMENDATIONS

Opus recommends that the Peacocke Growth Cell's wastewater be disposed of to the Cambridge Wastewater Treatment Plant via a rising main after the plant upgrades are completed.

A detailed investigation is required at the Cambridge Wastewater Treatment Plant to determine the required upgrades to meet the increased flow and loads.

Opus recommends that priority be given to investigating the E/One system, which has the potential to reduce capital costs significantly, for use within the Peacocke development.

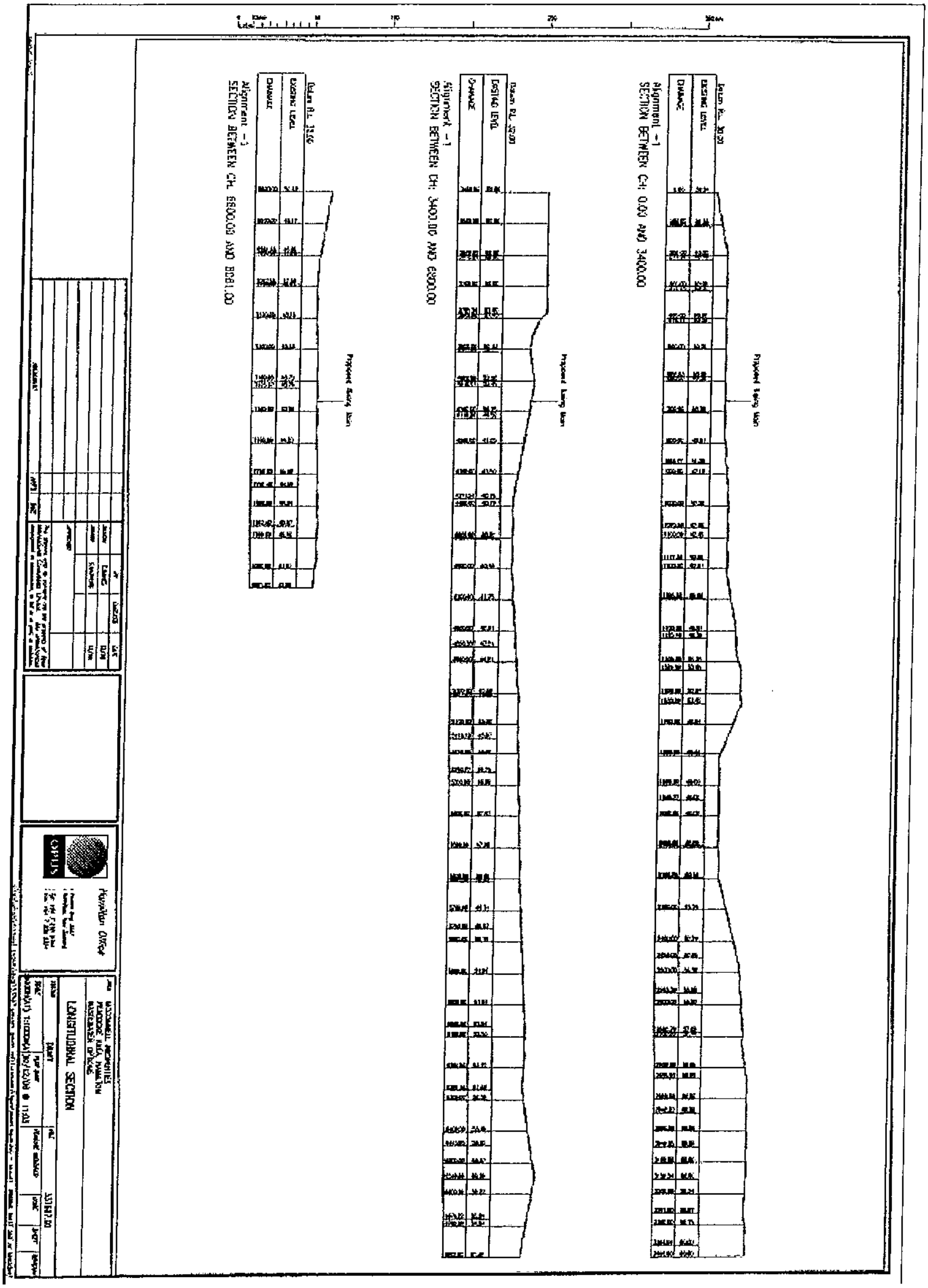
It is recommended that the system's life-cycle costs for various rising main sizes/configurations be evaluated.

Dialogue between Hamilton City Council and Waipa District Council should be initiated as soon as possible.

Appendices

APPENDIX 1

PEACOCKE-TO-AIRPORT LONG SECTION



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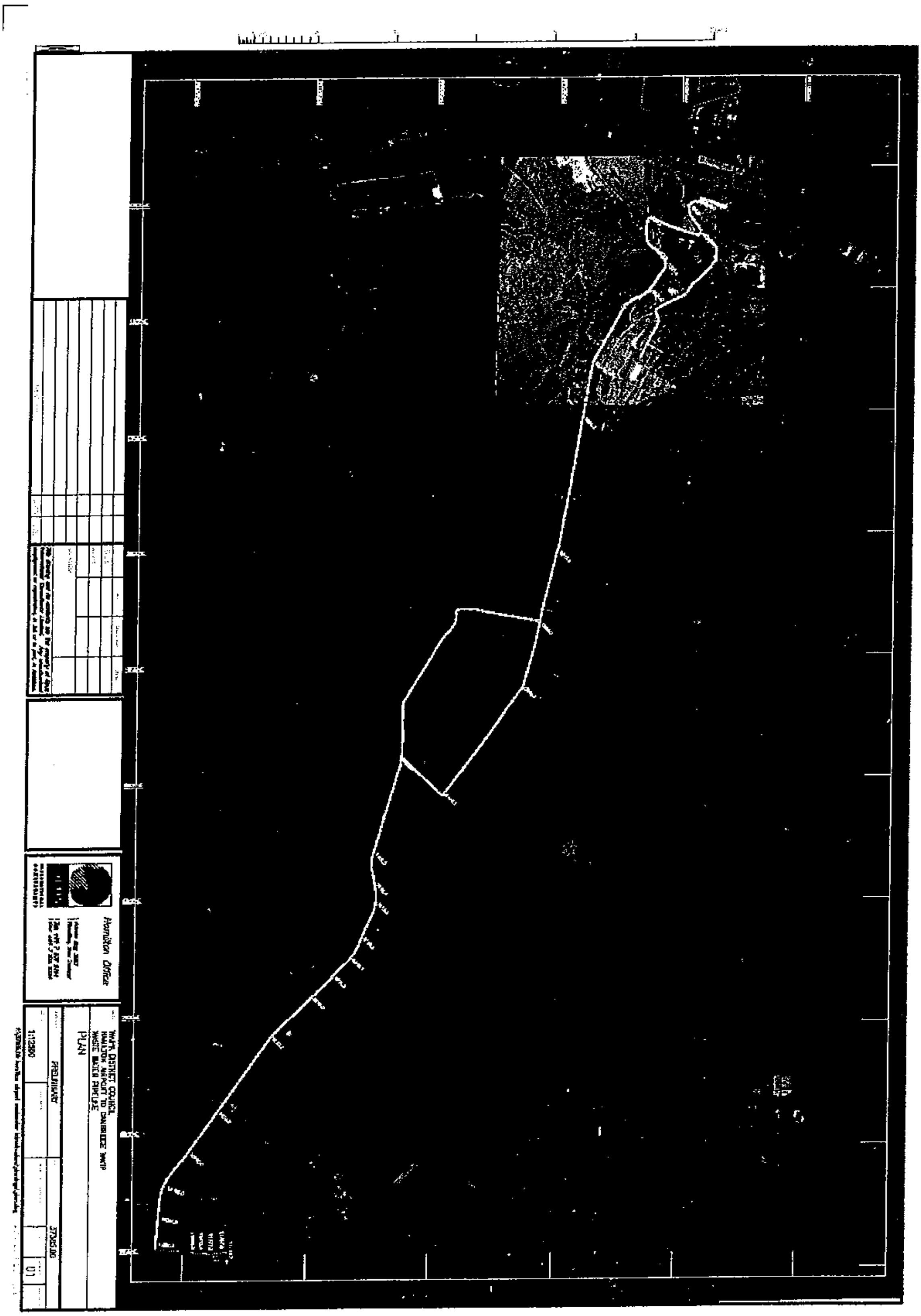
SECTION BETWEEN CH: 0.00 AND 3400.00
Alignment - 1
SECTION BETWEEN CH: 3400.00 AND 6800.00
Alignment - 1
SECTION BETWEEN CH: 6800.00 AND 8881.00
LONGITUDINAL SECTION
OPUS

APPENDIX 2

AIRPORT-TO-CAMBRIDGE ALIGNMENT


Hamilton Office
WAIPA DISTRICT COUNCIL
HAMILTON AIRPORT TO CAMBRIDGE WWTP
WASTE WATER PIPELINE
PLAN
PRELIMINARY
1:12500
U1

APPENDIX 3

COST ESTIMATES