ARCHAEOLOGICAL EVALUATION, LAND USE AND DEVELOPMENT:
An application of Decision Analysis to current practices within the local government development control processes in England.

Volume 1 of 2

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Abstract:

A variety of archaeological Field Evaluation techniques are used by Curatorial Archaeologists in England to assess archaeological remains prior to implementing strategies for their protection through Town and Country Planning or Scheduled Monument Consent procedures. Yet the effectiveness of these techniques and methodologies applied have not previously been quantitatively tested.

This innovative research uses Process Modelling to recognise the Decision-making processes within current archaeological Field Evaluation practice. This allows an application of Decision Analysis, a formal theoretical approach to Decision-making, to be used to identify thirteen Decision-making Points (DMPs) and DMP 12b is selected from these as the key point at which the success of Field Evaluation techniques can be tested. Data from a statistically sound Case Study sample of 100 development-led archaeological interventions is recorded using new characterisation and quantitative measurement methodologies.

This information is fed into the Process Model of Decision-making Point 12b to provide a measured degree of confidence in the effectiveness of a range of techniques and methodologies. Decision Matrices are produced which show that it is Logically Unsound to rely on Field-walking or Geophysical Survey to identify the type and date of archaeological features. Even Trial Trenching, the most effective technique, can only produce good Performance Scores for the identification of feature types on less than 32% of the Case Study sites. Statistical Analysis of Trenching methodologies shows that an increase to at least a 10% sample size is required for acceptable performance improvements.

This research changes the way we look at archaeological Decision-making with the identification of previously unrecognised Conditions of Incomplete Knowledge at DMP 12b. Two original new concepts (Local Locational Factors and Past Landscape Use Patterns) are introduced as tools to assist with these, and their utility for improvements in performance using Predictive Modelling is also explored to provide a body of archaeological research to stimulate the profession and its operators to advance our knowledge of Decision-making into the 21st Century.

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[Note: Appendices 6 & 7 supplied on a CD readable with Microsoft Access].

Abbreviations used in the text:

ACAO	Association of County Archaeological Officers.
ACCA	Association of Chartered Certified Accountants.
ADS	Archaeological Data Service.
AIP	Bournemouth University's Archaeological Investigations Project.
BPMN	Business Process Modelling Notation.
CIRIA	A member-based research and information organisation dedicated to improvement in the construction industry.
COE	Council of Europe.
DAS	Decision Analysis Society.
DCMS	Department of Culture, Media and Sport.
DMP	Decision-making Point.
DTA	Desk Top Assessment.
EA	Environment Agency.
GPR	Ground Probing Radar.
HER	Historic Environment Record.
HLC	Historic Landscape Characterisation.
HMSO	Her Majesty's Stationery Office.
IFA	Institute of Field Archaeologists.
LIDAR	Light Detecting and Ranging.
LUSAG	Land Use Statistics Advisory Group.
MIDAS	MIDAS Heritage is the UK data standard for information about the historic environment. developed for and on behalf of the Forum on Information Standards in Heritage.
MOLAS	Museum of London Archaeology Service.
MORI	Market & Opinion Research International Ltd
NMP	English Heritage's National Mapping Programme.
OAU	Oxford Archaeology Unit.
PLANARCH	Multi-state European Project published as Hey & Lacey 2001.
PPG16	Planning Policy Guidance Note 16: Archaeology and Planning.
SI	Statutory Instrument.

Glossary of technical terms

Note: The first usage of these technical terms in the text is denoted by **bold** text.

Alternative Courses of Action: The different types of future action which a Decision-maker must choose between to satisfy the objectives of a Decision. In this application of Decision Analysis to Decision-making Point 12b, the Alternative Courses of Action are defined as the alternative archaeological Field Evaluation techniques.

Alternative States of Nature: The different situations in which the Alternative Courses of Action must operate to satisfy the objectives of a Decision. In this application of Decision Analysis to Decision-making Point 12b, the Alternative States of Nature are defined as the alternative types of archaeological remains which may be present on a site.

Amenity Value: The description of the concept of value relating to the existence and use of an item.

Archaeological Appraisal: Stage 1 of the formalised Archaeological Assessment Process.

Archaeological Assessment Process: The assessment of potential impact of proposed development and land-use change on archaeological remains and the provision of advice on required mitigation which is formalised into processes required by Planning Policy Guidance Note 16.

Archaeological Brief: The written document which sets the parameters to guide archaeological fieldwork to be undertaken by Archaeological Contractors to the professional standards required by Archaeological Curators.

Archaeological Contractors: Professional archaeological organisations or individuals who undertake archaeological work under contract to Developers in response to the requirements of the local government planning process.

Archaeological Consultants: Professional archaeological organisations or individuals who are contracted to the developer to provide archaeological advice in a consultancy capacity before and during development proposals.

Archaeological Curators: Archaeologists whose role is to advise the Local Planning Authority on the sustainable management of the historic environment through the Development Control process.

Archaeological Mitigation Strategy: The written scheme setting out the archaeological requirements for Preservation in-situ or Preservation by record which result from development impact on the archaeological resource on a particular site.

Archaeological Sensitivity: The professional judgement of whether a potential development site may contain surviving archaeological remains which may be impacted upon by development proposals.

Capta: Term used to refer to the information recorded by archaeologists from the raw data of the archaeological resource (Chippendale 2000).

Characterisation: The classification of data by grouping elements of the descriptions of its nature.

Client Reports: Reports of Archaeological fieldwork or research which are produced on behalf of the developer by archaeological contractors.

Conditions of Incomplete Knowledge: The concept of a state of having limited Information available, but it is impossible to describe exact future Outcomes of a Decision. The limited Information available is then used to assign Probability to Outcomes.

Connecting Objects: Graphical elements used to represent sequential movement from one Action to another in Business Process Modelling Notation used in the Process Models in this research.

Controllable Variable: A type of Variable Element of the Decision Environment which can be fully predicted and controlled by the Decision-maker.

Data Objects: Graphical elements used to represent sequential movement from one Action to another in Business Process Modelling Notation used in the Process Models in this research.

Decision: The act or process of coming to a resolution as a result of consideration from a choice of alternative outcomes which will achieve a goal

Decision Analysis: An application of Decision Theory used to describe the philosophy, theory, methodology and professional practice of Decision-making in a formal manner.

Decision Environment: The elements of the behaviour, psychology, context, climate, Goals and Objectives of a Decision.

Decision Framework: a mathematical model designed to characterise the Decision-making process as a sequence of component processes.

Decision-maker: The individual or organisation operating the cognitive processes of Decision-making.

Decision-making: the cognitive processes leading to a course of action from a number of choices.

Decision-making Point: Each part of the Process Model at which a Decision must be made. These are the places in the Process at which the Archaeological Curator must operate professional judgement to make a selection from a number of Options.

Decision Objectives: The desired end points of the operation of a Decision.

Decision Options: All of the Alternative Courses of Action which can be applied to all of the Alternative States of Nature in a Decision-making process.

Decision Outcomes: The consequences of the occurrence of each Decision Option.

Decision Situation: The three elements of Information, Values and Logic from within the Decision Environment.

Decision Situation Elements: The most influential Elements of each Decision Situation.

Decision Strategy: The logical operation of the information and values of a Decision Situation to evaluate the Outcomes of Alternative Courses of Action

Decision Type: A classification used to define differences in Decisions by clarifying their nature and the Options available for each.

Desk-based Assessment: The collation and interpretation of documentary sources of information about the archaeological and historic environment resource which is usually the first Stage of an Archaeological Field Evaluation.

Development Control: The English Local Government Planning process which guides modern land-use development through a system of planning applications and planning permission.

Ecozone Factors: A type of Natural Affordances, the class of Local Locational Factors, which relate to those landscape zones which provided a mixture of resources types for food, water and materials.

Environment Impact Assessment: A formal process fulfilling the statutory requirement for an assessment of the likely positive and negative biophysical, social, and other relevant effects of development proposals prior to major decisions being taken.

Expert Models: Information on the predicted presence of archaeological remains produced from data in archaeological research frameworks and local knowledge of past human behaviour in the current landscape.

Explained Capta: The explained information given about the characteristics of the physical archaeological remains which is provided by the archaeological recording of that information in the archaeological records made during Excavation and Fieldwork.

Extreme Expected Values: The minimum and maximum expected values of a particular Value Scale which are used to provide further parameters for Decisions taken under Conditions of Incomplete Knowledge.

Field Evaluation: The archaeological sampling of a potential development site through the application of a number of Evaluation techniques designed to produce enough information on the date, nature, location, extent, fragility and state of preservation of any archaeological remains present. This action is carried out before the Local Authority Planning Committee determine whether planning permission is given, so that the opportunity for an informed Decision can be taken.

Field-walking: An archaeological technique which systematically records the location and type of archaeological material brought to the surface of arable fields by ploughing. Used to locate buried archaeological remains by surface recording.

Flow Objects: Graphical elements used to represent actions taken by the Decision-maker in Business Process Modelling Notation used in the Process Models in this research.

Geological Factors: A type of Natural Affordances, the class of Local Locational Factors, which relate to the geological conditions present on a site.

Geophysical Survey: A range of surface remote sensing scientific techniques used to record below ground archaeological resources.

Historic Environment Records: Databases of known information about the historic environment resource which are usually held by local authorities in England and Wales.

Human Factors: A class of Local Locational Factors, which relate to known contemporary or past human activities or structures on or in the immediate environs of a site.

Human Past Settlement: A class of Past Landscape Use Patterns, a new concept for the characterisation of archaeological remains developed by this research. This class includes all Past Landscape Use Patterns associated with human settlement.

International-environment scale: The scale of the Decision Environment which describes the influences of the international and world-wide arena of archaeological Field Evaluation.

Local Locational Factors: A new theoretical concept devised in this research which represents factors which might indicate that certain archaeological remains (States of Nature) from certain periods are present at the location of a specific site.

Macro-environment scale: The scale of the Decision Environment at the local operational level of Archaeological Decision-making. This is defined as the Environmental Elements of the Curatorial Decision-making process which affect the individual decisions being taken in the case of each development site.

Mega-environment scale: The scale of the Decision Environment which describes the management and execution of archaeological procedures within the environment of a framework of national historic environment legislation.

Message Channel: The medium that carries the message in Shannon's Communication Model (Shannon 1949).

Message Decoder: The object which converts the signals of a message into a form the Message Receiver can understand in Shannon's Communication Model (Shannon 1949).

Message Encoder: The object that connects the message to the physical signals that are sent in Shannon's Communication Model (Shannon 1949).

Message Noise: Anything which interferes with the transmission of the message in Shannon's Communication Model (Shannon 1949).

Message Receiver: The person, animal or object which receives the message in Shannon's Communication Model (Shannon 1949).

Message Source: The human, animal or inanimate object which originally creates the message in Shannon's Communication Model (Shannon 1949).

Micro-environment scale: The scale of the Decision Environment at the raw data level of operation and represents the actual archaeological remains which are encountered during the practical operation of the Field Evaluation process.

Mitigation: Archaeological action taken to protect or record archaeological remains from the physical effects of a development proposal. Mitigation can include the Preservation in-situ of important archaeological remains through redesign of development proposals or Preservation by record through full archaeological excavation.

Monetary Value: The description of the concept of value in financial terms relating to the exchangeability of an item.

Natural Affordances: A class of Local Locational Factors which represent the physical affordances provided by the surrounding natural environment of a site.

Natural or Managed Past Landscape Uses: A class of Past Landscape Use Patterns which relate to natural, non human processes or to less intense human processes to manage the landscape over large areas, e.g. forestry or agriculture.

Option Decision: The DAS classification of a class of Strategy Decision which gives the opportunity for the Decision-maker to choose Options for which there are future opportunities to make future Decisions following the input of information at a later date. These Options have the potential of adding value to a Decision Situation as they allow Actions to be made at a later date to make use of additional knowledge.

Other Explanations: Other explanations of the archaeological information made using Explained Capta as its source. This includes any archaeological research or interpretation using information provided by Historic Environment Records.

Parameter Element: An Element of the Decision Situation or Decision Environment with values that remain constant throughout the Decision process.

Past Landscape-use Patterns: A new theoretical concept devised in this research which characterises archaeological Deposit, Feature and Structures into Past Landscape Uses Patterns.

Portfolio Decision: The DAS classification of a class of Strategy Decision in which the different Decisions are of a similar nature, yet the Decision-maker does not have sufficient resources to fund all combinations of Actions required to satisfy the Decision Objectives.

Positivism: A philosophy that states that the only authentic knowledge is scientific knowledge, and that such knowledge can only come from positive affirmation of theories through strict scientific method.

Post-Processual: A form of archaeological theory related to the development of post-modernism in England in the 1980's and as a critique of the scientific method of Processual archaeological theory. Post-Processual archaeologies include Cognitive, Contextual and other perspectives which influence the objectivity of its practitioners.

Probability of Outcomes: The likelihood that certain Outcomes of a Decision will occur.

Predictive Model: Interpretations of the expected presence and absence of components of the archaeological resource.

Premise: A claim or reason that a particular Proposition is true or false.

Primary Raw Capta: The information contained in the single unit of information the individual artefact, ecofact or deposits recorded as "Context Matrix" in the archaeological record made up of the mass physical constituents of the Context.

Probability: The likelihood or chance that something is the case or will happen. Probability theory is used extensively in areas such as statistics, mathematics, science and philosophy to draw conclusions about the likelihood of occurrence of potential events.

Probability of Presence: The likelihood or chance that archaeological remains of a certain type will be present on a potential development site.

Professional Judgement: The balanced weighing of evidence in advance of providing a Decision.

Proposition: An element of logic which forms an assertion or statement which can be affirmed or denied by its Premises.

Process Model: Graphical representations which describe and explain the sequence of changes to the attributes,operations and actions which lead to a particular outcome of a specific system.

Prioritisation: A tool used to model Probability between Extreme Expected Values so that the distribution of Variables can be analysed.
Prior Knowledge: Information about the surviving archaeological and historic environment resource which is held in Historic Environment Record databases.

Raw Data: the information provided by the attributes of actual archaeological remains.

Reasoning: The thinking processes by which choices are made and problems solved.

Risk/Risk Proper: The concept of a state of Uncertainty where some possible Outcomes have an undesired effect or significant loss.

Scientific Value: The description of the concept of value measured in terms of the archaeological information content of an item.

Secondary Raw Capta: The information provided by groupings of Single Unit Information to provide more complex details of information than can be obtained from the Primary Raw Capta.

Simple Decision: The DAS classification of a Type of Decision for which only one Decision must be made between two Alternatives.

Soil Factors: A type of Natural Affordances, the class of Local Locational Factors, which relate to the soils present on or nearby a site.

Strategic Planning: English national, regional and local land-use planning through the production of strategies and policies.

Strategy Decision: The DAS classification of a Type of Decision for which there a number of Decisions to be made at the same time. Each of the Decisions may have any number of alternative options to choose between. The chosen options for each Decision must then combined into a coherent choice of Actions to satisfy the Decision Objectives.

Stratigraphic Units: The deposits and contexts which make up the constituent parts of the archaeological resource.

Subject: An issue about which Propositions are constructed.

System: A set of interacting or interdependent entities, real or abstract, forming an integrated whole and is a fundamental concept of Systems Thinking. heory, which views the world as a complex system of interconnected parts

Systems Thinking: A philosophical framework which views the world as a complex system of interconnected parts, or a System.

Topographic Features: A class of Local Locational Factors which represent the topographic elements of the physical environment of a site.

Trial Trenching: An archaeological sampling technique involving the hand or machine excavation and recording of a series of trenches on a potential development site.

Uncertainty: The concept of a lack of certainty, a state of having limited knowledge where it is impossible to exactly describe future Decision Outcomes.

Uncontrollable Variable: A type of Variable Element of the Decision Environment which cannot be predicted or controlled by the Decision-maker as it is generated by unrestrained and unpredictable factors.

Value Scale: A method of grading measurements of a particular type of Value on the same scale.

Variable Element: An Element of the Decision Situation or Decision Environment with values which takes on different values in different circumstances of the Decision-making process.

List of Legislation referred to in the text:

DoE, 1990. ***Planning Policy Guidance Note 16: archaeology and planning.*** London: HMSO

ETS 1992, 143. ***European Convention on the Protection of the Archaeological Heritage (revised).*** Council of Europe.

ODPM, 2004. ***Planning Policy Statement 12: Local Development Frameworks.*** Office of the Deputy Prime Minister, London: Her Majesty's Stationery Office.

PCPA, 2004. ***Planning and Compulsory Purchase Act 2004.*** London: Her Majesty's Stationery Office.

SI 1987, 764. ***Town and Country Planning Use (Classes) Order.*** London: Her Majesty's Stationery Office.

SI 1999, 293. ***The Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999. Statutory Instrument No 293.*** London: Her Majesty's Stationery Office.

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Chapter 1 – Introduction

1.1 Background to the research

The publication of the Secretary of State's guidance on archaeology and planning, "*Planning Policy Guidance Note 16: Archaeology and Planning*", referred to as PPG16, formally established the archaeological resource as one material consideration amongst the many other economic, social, financial, environmental, and planning concerns within the English Town and Country Planning system (Champion 1996).

The English local government planning system consists of two separate processes. The **Strategic Planning** operations are delivered through policies defining land-use change through the newly emerging Local Development Frameworks which are replacing the County Development Plans. The **Development Control** process operates the determination of planning permission for the development of individual sites. A body of archaeological processes and practice has developed in response to the material consideration of archaeological concerns within both of these areas of local government operation. The principles of the local government Development Control process involve a staged approach of informed decision-making in which evidence is gathered on the impact of a development proposal. PPG16 advocates a similar staged approach to the archaeological process involving sequential stages of appraisal, assessment, field-work and mitigation practices.

A fundamental concept within the operation of the Development Control processes of the planning system is the need for **Field Evaluation** of potentially nationally important archaeological remains before the determination of planning permission. Pre-determination Field Evaluation is required to allow archaeologists to gather enough data to formulate justifiable and sustainable judgements on the impact of development and the importance of the archaeological remains thought to be present on the site. These professional judgements result in local government archaeological advice on suitable **Mitigation** requirements to the planning officers and elected Development Control Committee Members who determine each planning application. The purpose of Field Evaluation within this planning framework is defined in PPG16 as:

> This sort of evaluation is quite distinct from full archaeological excavation. It is normally a rapid and inexpensive operation, involving ground survey and small-scale trial trenching, but it should be carried out by a professionally qualified archaeological organisation or archaeologist...Evaluations of this kind help to define the character and extent of the archaeological remains that exist in the area of a proposed development, and thus indicate the weight which ought to be attached to their preservation. They also provide information useful for identifying potential options for minimising or avoiding damage. On this basis, an informed and reasonable planning decision can be taken.
> (DoE 1990, 21)

These formalised processes require the identification of the presence of the surviving archaeological resource at specific sites and the assignation of suitable levels of archaeological importance with which any remains present can be weighed against other considerations within long established Development Control procedures. These requirements resulted in the rapid adoption of existing traditional field testing techniques and methodologies into archaeological Field Evaluation procedures. Quickly established as professional standards by the Association of County Archaeological Officers and English Heritage (ACAO 1993), the current approach to Field Evaluation has become accepted as routine by archaeologists and planning authorities during their operation in the 1990s (Tym & Pagoda 1995).

Curatorial Archaeologists operate the **Decision-making** processes within the PPG16 focussed arena of local government that culminate in the application of pre-determination Field Evaluations. This branch of the profession are required to facilitate the prediction of the nature, extent, date, location, fragility and importance through the application of archaeological techniques and methodologies prior to the determination of planning permission. The data informing the judgements of archaeological remains present, their importance and subsequent Mitigation requirements are provided by the Field Evaluation reports compiled by **Archaeological Contractors** after the fieldwork interventions are completed.

The operation of these PPG16 required archaeological practices has been carried out, over the last 17 years, by a growing body of professional archaeological organisations. The archaeological Decision-making processes within local government practice are the responsibility of **Archaeological Curators** who are usually employed by local authorities. The focus of this research will be the Decision-making processes of Field Evaluation. These processes will be examined through an analysis of decision theory and investigations into the results of PPG16-led Field Evaluations carried out in England over the last two decades.

There were early indications within the profession that the level of confidence in the results of the current operation of Field Evaluation is often neither high nor consistent. Darlington's paper from the professional seminar published by Chester City Council acts as a professional call for the effectiveness of the range of Field Evaluation techniques to be tested (Darlington 1993). The continuation of this distrust of the effectiveness of Field Evaluation approaches is shown by Cuming's paper at the Institute of Field Archaeologists Conference. This suggests that our current approaches must be used with caution as our practices may under-estimate the range of archaeological features present (Cuming 2000). Both papers clearly state the great importance of accurate known information about the archaeological resource to the beginning of the Field Evaluation process.

Yet many examples of the inability of current Field Evaluation approaches to identify the presence of important remains have occurred since this early professional request for caution in our methods. The unexpected discovery of continuous Late Neolithic to Roman settlement was made during an Archaeological Watching Brief at Milton in Cambridgeshire. Here a pre-determination Field Evaluation had produced no evidence of archaeological remains and known information suggested that the area was wooded and unoccupied during the prehistoric period. Yet the subsequent three year community excavation of the site negotiated with the developer demonstrated the failings of Field Evaluation as a predictive method. The Late Neolithic to Roman settlement revealed by the subsequent excavation included industrial and extensive religious and ritual structures within a contemporary farming landscape, none of which were predicted by the Field Evaluation process (Connor 1997).

The continuation of this pattern of Field Evaluation failure over the first ten years (1990-2000) of its application is demonstrated by the unexpected recovery of a unique Upper Palaeolithic site made at the end of a PPG16 required excavation of the remains of a Medieval village at Glaston, Rutland. Again, only negotiations with the developer after the Field Evaluation had failed to predict the presence of such remains resulted in a three month long rescue excavation funded by the British and Natural History Museums (Thomas & Jacobi 2001). This necessity for Curatorial Archaeologists to negotiate further excavation of unexpected remains has been experienced personally during my career as both Planning Archaeologist and County Archaeologist employed at three different English Local Authorities since 1992.

This early professional criticism of the current Field Evaluation process focussed on the untested nature of the techniques and its lack of archaeological research focus. Matthews assesses Evaluation Trenching as a poor tool for archaeological interpretation and decries the lack of investment in effective techniques. He suggests that the profession has taken a retrograde step with the adoption of keyhole trenching as a Field Evaluation technique (Matthews 1993).

The English Heritage analysis of the **Archaeological Assessment Process** includes a pronouncement that Field Evaluation is effective in general qualitative terms, but acknowledges that their qualitative comparison shows that it is not an accurate predictive tool (Champion *et al.* 1995, 49). Recommendations from this twelve year old study include the suggestions that more archaeological techniques need to be used and that theoretical and statistical methods should be applied to the improvement of our approaches. Even the statement that English Heritage will encourage the development of new techniques and research into the theoretical and statistical basis of Field Evaluations has actually resulted in little improvement in our approaches (English Heritage 1995).

The publication of the supposed quantitative measures of Field Evaluation effectiveness from the Hampshire and Berkshire case study as part of the 1995 assessment has somewhat muddied the waters of Decision-making amongst Archaeological Curators and Contractors (Champion *et al.* 1995). The results became accepted as part of the national published standard guide to our current approach. Yet the Hampshire and Berkshire study, whilst claiming to provide quantitative measures of effectiveness by counting the comparative numbers of finds and features, used a qualitative scale of the measure of success through an Archaeological Curator's interpretation of the results of Field Evaluations. Yet this pioneering study does clearly identify the potential benefits of quantitative measurements to the Decision-making process.

Field Evaluation, as a tool within the Development Control process, is an aggregation of different techniques, methodologies, sampling strategies and archaeological theory. Yet the adoption of current practice has developed with little critical assessment of the effectiveness of these Field Evaluation approaches at identifying the actual archaeological deposits and features on individual sites.

The lack of reliable quantitative measures of confidence in our application of techniques is particularly problematic because of two of the assumptions of the theoretical approach underlying the current operation of Field Evaluation.

The first assumption is that Curatorial Archaeologists have enough **Prior Knowledge** about the local archaeological resource from **Historic Environment Records (HERs)**, formerly known as Sites and Monuments Records, held at County, Unitary and some District Council and National Park levels, to be able to confidently predict the presence and importance of buried non-visible remains of the historic environment. Notwithstanding the lacunae of knowledge of some geographic areas due to the absence of systematic archaeological recording and the difficulties of predicting remains which are not visible above ground level, the importance of Prior Knowledge of the variability, density and characteristics of buried remains has been recognised (e.g. Haselgrove 1978). But there has been very little research into the use of guidance parameters for the predicted nature and date of the expected remains (Champion *et al.* 1995).

The second assumption is that we can reliably predict the nature of the archaeological resource present on a particular potential development site from the results of an investigation into a sample of it.

The complexity of the archaeological resource is widely accepted within the archaeological profession (Barker 1986; Renfrew & Bahn 2000). The extreme diversity of combinations of deposits, features and structures which represent past human activity is constantly being redefined by new discoveries. Several theoretical applications of characterisation have already been utilised for definition of the resource's complexity at various levels of focus for its management. Carver's approach to the characterisation of urban deposits and features has been adopted by some Archaeological Curators (Carver & Wills 1974, Carver 1980, Carver 1981, Ove Arup 1991; Carver 1999). The operation of English Heritage's national Monuments Protection Programme has categorized and sampled at a single monument, urban areas and landscape level (Darvill 1992; Cobham 1990). The methodologies for Historic Landscape Characterisation which are currently being applied on a county by county basis focus on the landscape element of the historic environment (Fairclough 1999; Herring 1998). Yet none of these current approaches are sensitive enough to provide characterisation tools which can adequately represent the elemental components of the physical remains of past human activity which make up the archaeological resource on a specific development site level.

The published literature recognises that external influential factors operate within the Decision-making situation of Field Evaluation which lie out of the control of the archaeological **Decision-maker.** Darlington highlights the site determinants and physical restraints of development (Darlington 1993). The practical constraints resulting from the nature of the developer-funded process are also highly influential. The commercial and temporal limitations have now been recognised in the published literature for over a decade (Carrington 1993). The external factors have a great influence on the methodologies including technique selection and sample size during the Decision-making process of selecting Field Evaluation approaches (Shennan 1985; Gaffney & Gater 1993).

Three immediate repercussions of the influences of these external constraints can be seen to have restricted the development of improvements in Field Evaluation approaches.

The first consequence of external constraints is demonstrated in Figure 1. This shows a pattern of gradual decrease of the combinations of archaeological techniques used in Field Evaluation approaches over the last decade of the 20th century. The figures are taken from studies compiled from national data collected from the archives of PPG16 **Client Reports** held by local authorities as assessed by English Heritage (1995), catalogued and indexed by Bournemouth University (Darvill & Russell 2002) and brought together as a library of "Grey Literature" by the OASIS project (ADS 2007).

Figure 1 clearly shows an increased reliance on machine trenching at the expense of other techniques. The recorded figures show that Trenching was carried out on 61% (900 of the 1493 interventions) of pre-PPG16 Field Evaluation interventions recorded in England between 1982 and 1991. Yet the same studies show an increase to 74% (4784 of 6492 interventions) of those undertaken nationally between 1994 and 1999. In addition it is recognised that this increased reliance on one technique is associated with a reduction in operation of suites of many techniques (Champion *et al.* 1995; Darvill *et al.* 1995; English Heritage 1995). This gradual decrease in options of Field Evaluation techniques and their use in combination is perceived by Archaeological Curators and Contractors as being influenced by financial and time constraints of the planning process and as not reflecting the actual effectiveness of archaeological practices (Hey & Lacey 2001, 2).

Another effect of the financial and other external considerations of the Development Control processes during this decade has been the limitation in application of alternative and new techniques to archaeological Field Evaluation interventions. The utility of Resistive Tomography (e.g. Noel & Walker 1991; Noel & Xu 1991); Seismic methods (Goulty *et al.* 1990); Radar (Stove & Addyman 1989), Soil Micromorphological analysis (Dalwood 1992; Macphail *et al.* 2000) and many other potential techniques have not yet been applied to English Field Evaluation procedures. Analysis of the 12,784 Field Evaluation interventions recorded in England between 1990 and 1999 shows that only one of the above methods was utilised. Use of Ground Probing Radar was restricted to only thirteen interventions and there are no examples of the use of Resitive Tomograpy, Seismic methods or Soil Micromorphology. As new techniques are not being used in Field Evaluations, their effectiveness for the identification of archaeological remains can not be assessed sufficiently and can not be compared to those already in use to assist the Decision-maker choose the most appropriate Field Evaluation approach

The final repercussion on the current Field Evaluation approach has been the failure to resolve the separation between development and application of archaeological theory as highlighted by Orton (2000a). Some archaeological research has focussed on the application of sampling theory to archaeological fieldwork. Binford's argument that archaeologists must aim to recover a representative range of the variable archaeological resource using systematic sampling has stimulated a number of publications which have proven influential for our current practices (Binford 1964).

Case studies of the British and American application of probabilistic sampling highlight the issues which have guided the limited research into Field Evaluation methodologies (Mueller 1975; Cherry *et al.* 1978). Champion's influential simulation of sampling strategies at Chalton has stimulated the adoption of the current "random sampling" practices used by Archaeological Curators, although Champion argues for a much larger sample size that is adopted in current practice (Champion 1978).

The extant professional research into sample size and the visibility of the sampled population have focussed subsequent studies towards these issues. O'Neill's demonstration of the unpredictability of a 5% excavation of a Californian midden concludes that larger samples are necessary for trenching interventions (O'Neill 1993). Yet the majority of current English archaeological Field Evaluations still operate with a much smaller sample size. All of the eleven trenching interventions recorded in Hey & Lacey's study, eight years after the publication of O'Neill's proposition, investigated less than 5% of the total site. Hey & Lacey, however, do include the proposition that a sample fraction of between 5% and 10% is the most appropriate for Field Evaluation (Hey & Lacey 2001, 49). English Heritage's earlier research also suggested that sample size, trench layout, trench length and number of trenches are important issues for development of trenching methodologies (Champion *et al.* 1995).

Research into the sample size issue has also dominated the development of Test Pitting methodologies (Ammerman *et al.* 1978; Nance & Ball 1986; Kintigh 1988;

Shott 1987). Yet as Orton points out, the early archaeological research into probabilistic sampling applications and our current professional practices still utilise developments of sampling theory from the first half of the 20th Century (Orton 2000a & 2000b).

More recent development of theoretical approaches allow the design of a sample to be modified in the light of prior and gained knowledge, whilst remaining statistically rigorous. These approaches have introduced the potential for increasing the number of tools available for Archaeological Curators, particularly some of the principles of adaptive sampling (Orton 2000b & 2000c).

Despite these theoretical advances in some areas of Field Evaluation practice, little research has been undertaken on the application of theory to actual Decision-making processes in the operation of Field Evaluation within the planning system. The archaeological profession has focussed on applications of professional judgement theory mirroring developments in medicine, law and the social sciences (Darvill 1995b; Startin 1993) operating under the assumption that the Decision-maker is operating under conditions of uncertainty or risk. No attention has been paid to the identification of underlying Decision-making processes or their improvement through the application of theoretical approaches. Because of my experience of the operation of Field Evaluation approaches in England over the last 16 years, I am interested in the benefits for Archaeological Curators of the investigation of the conditions under which our Decision-making operates and the utility of potential theoretical applications.

1.2 Aims and Objectives of the research

The necessity for further analysis and improvement of current pre-determination Field Evaluation approaches has emerged from a personal recognition of the limitations of their operation within my professional capacity as a Curatorial Archaeologist employed by three separate English local authorities over the last 16 years. My experience has provided examples of local and national discoveries of unexpected archaeological remains and demonstrated a lack of quantifiable effectiveness measures for individual Field Evaluation techniques. I have recognised the need for more robust predictive methodologies and the realisation that the current approach cannot evaluate potential development sites for which no Prior Knowledge is available. The desire to identify tools to assist my own operation in these areas of professional practice initiated the development of this research.

The pivotal role of pre-determination Field Evaluation in the preservation of nationally important remains and the recording of regionally or locally important deposits through developer-funding must be recognised. With developer-funded archaeological work in England each year estimated to be £30 - £40 million at the turn of the 20th Century, research into its improvement can have a real impact on the operation of professional archaeology in the 21st Century (Wainwright 2000; Darvill & Hunt 1999).

In seeking to provide the profession with tools to measure the degree of certainty with which Field Evaluation Decisions can be assessed and improved, this research aspires to ensure that more statistically measured judgements can be made between properly appraised consequences in order to manage the archaeological resource more effectively. The overall aim of this research is to investigate the effectiveness of Field Evaluation through an assessment of its Decision-making processes. This investigation aims to provide tools for Curatorial Archaeologists to better structure their approaches and to make better use of the information resources available. In order to achieve this aim, the following objectives can be identified:

- To use process modelling of current Archaeological Assessment practice to identify the Decision-making points at which improvements could be made;
- To use an application of Decision Analysis to identify the actual processes performed by the Curatorial Archaeologist when selecting Field Evaluation techniques for specific sites;
- To develop quantitative techniques to measure the effectiveness of current Field Evaluation techniques;

- To measure the effectiveness of archaeological techniques from a case study sample of PPG16-required Field Evaluations carried out in England between 1990 and 2004;
- To identify potential tools and approaches which might provide the profession with improvements at the selected Decision-making Points.

1.3 Measuring Field Evaluation 1990 to present

A small number of archaeological research projects have investigated the performance of some elements of Field Evaluations over the last two decades in England, with varying degrees of success. A suite of three volumes was published by English Heritage, the Government's advisers on the historic environment, in 1995 to document the effectiveness of the introduction of PPG16 to the Development Control process (English Heritage 1995; Darvill *et al.* 1995; Champion *et al.* 1995).

These documents provide a commentary on the insertion of the fundamental principles of archaeological input into the infrastructure of the planning process, with a review of the elements of the assessment procedures between 1982 and 1991. Information is provided on the size, land use and types of development subject to the 1333 Field Evaluations which were carried out in England during the period. However, the value of the study's conclusions on the effectiveness of Field Evaluation is greatly reduced by two factors.

The small number of six case study sites used to analyse sample trenching and test-pitting strategies in the third volume of this series preclude statistical analysis of the results or the correlation of patterns which could be applied to performance models to assist Decision-making. My personal motivation to carry out quantitative analysis of a larger, more representative sample was stimulated by the publication of the final volume of this study and the digestion of its implications for my own Decision-making as a Curatorial Archaeologist (Champion *et al.* 1995). The realisation that the body of Client Reports known in professional circles as "grey literature" held in County HERs could provide a dataset for such analysis was provided by the personal knowledge of the contents of such reports resulting from Field Evaluations for which I had provided the methodological requirements.

The incorrect assumption that the proportions of totals of features and finds recorded in both Field Evaluation and subsequent Excavation can be used to represent the diversity of archaeological remains also limits the use of the results of English Heritage's 1995 study. Whilst representing a simple model of concentrations of these archaeological elements as recorded by the interventions, the diversity, date, nature and function of the remains are not identified. From the perspective of a Curatorial Archaeologist requiring statistically valid propositions on which to select methodologies, this publication proved both a disappointment and a stimulus to personal research into more useful quantitative measurements (Champion *et al.* 1995).

Hey & Lacey (2001) provide the most recent study into the effectiveness of Field Evaluation techniques and methodologies in the PPG16 arena in England. This continues both the application of research tools to explore the performance of certain elements and the comparison of the predictions at the Field Evaluation stage with the actual remains recorded in the post-Evaluation interventions. A particularly valuable section of this study focuses on computer simulations of alternative trenching strategies, but again focuses on a statistically unsound small sample of twelve sites.

However, the comparative assessment of effectiveness is carried out using expert qualitative judgement on the likelihood of the identification of the significance of the remains present, rather than by using truly quantitative techniques. This does not provide the Curatorial Archaeological profession with a statistically valid measurement of effectiveness nor does it allow the assessment of whether Field Evaluation techniques are currently being used to their best capacity or where future improvements might be possible. The publication of the results of this study during the second year of my part time research into this issue highlighted the continued professional need for statistically valid analysis of quantitative measures and provided further evidence that my research would be of use to Curatorial Archaeologists.

Despite the failings noted above, some of the raw information from the 2001 study provides the archaeological profession with interesting patterns of the success of different Field Evaluation techniques. The qualitative performance scores assigned to the performance of **Desk Based Assessment, Field-walking, Geophysical Survey** and **Trial Trenching** provide some guidance for Curatorial Decisions. Each technique's success at identifying remains from each period is recorded (Hey & Lacey 2001, 60-61). This information is presented as percentage scores on bar charts although the raw data was not included in the publication. A performance comparison table can be compiled from a visual inspection of the data as presented, although metal detecting has been excluded as it provides performance data for the Roman period only. The table is shown in Figure 2 and uses the original authors' judgement of defining a good score as being over 66%, a moderate score being between 33% and 66% and a poor score being under 33%.

Figure 2 demonstrates Hey & Lacey's conclusions that expectations for most techniques are poor or moderate for most periods. The application of Trial Trenching to Roman remains is the only technique to provide a good score of 72% in their qualitative measurements. Trial Trenching also demonstrably outperforms all other techniques for the identification of the Neolithic and Bronze Age (29%), Iron Age (60%) and Medieval (61%) periods. Noticeably all of the techniques measured failed to score even 20% for the Anglo-Saxon period. Geophysical Survey was able to provide moderate results for the Iron Age (32%), Roman (42%) and Medieval (38%) periods and Field-walking produced one moderate score for the Roman period (43%) with poor scores for every other period recorded in the study.

These qualitative results are worked into two Propositions which conclude that none of the non-intrusive techniques were even moderately successful at identifying the range of archaeological remains which survived on a site and that only machine Trial Trenching was effective at predicting character. Such Propositions require testing by quantitative methods to allow confidence to be placed in them and my research will aim to investigate the validity of these conclusions by the development of a quantitative measurement technique.

Two other Propositions offered by the Hey & Lacey study will be reviewed in this research by the quantitative and statistical assessment of case study data through the proposed application of Decision Analysis. These are:

- That a 3-5% sample size is required for a moderately good assessment of linears, substantial and clustered remains whilst scattered and ephemeral sites need greater sample size;
- That the size of the gaps between trenches was the most important element in trench design;

1.4 The land-use context of Field Evaluation Decision-making approaches

The context of the Development Control decision-making process is highly relevant to the understanding of the potential tools for professional improvements to our own practices. The English Development Control process is essentially a spatial land-use based system which assesses both present and future land-use patterns against national legislation and Government guidance. The fundamental spatial land-use context for England and Wales is set out in the Town and Country Planning Act 1990 (as amended) which requires each Local Planning Authority to keep under review the principal purposes for which is land is used within their area of jurisdiction (TCP 1990, 2, 13). The classes of different land-uses recorded for the basis of this land and development system are set out in the Town and Country Planning (Use Classes) Order 1987 (SI 1987, 764).

The underlying context and principles of this national spatial land-use approach were reiterated in the most recent planning legislation, the first published for over a decade in England and Wales. The Planning and Compulsory Purchase Act 2004 also introduces a new two tier plan system for local government development processes (PCPA 2004). Planning Decisions are now managed by local authorities through the application of Regional Spatial Strategies and the development of a suite of documents which make up the Local Development Framework (ODPM 2004). The needs and opportunities for Curatorial Archaeologists to pro-actively input historic environment management requirements into both regional and local spatial strategies have become apparent as the process has been unfolded over the last three years. The Local Development Schemes and Development Plan Documents necessary for these Local Development Frameworks require assessment of impact of spatial land-use change on the historic environment. Yet the formats by which archaeological data is currently recorded and stored are based on deposit, feature, site or even landscape levels which accurately represent the archaeological resource. The Local Authority Planning processes require the integration of spatial past land-use approaches to inform sustainable historic environment management. Yet there has been little research into the linking of archaeological features and structures into land-use patterns which will integrate into these Local Government Development Plans.

The past decade of archaeological research has highlighted certain issues such as the relationships between modern land-use and survival of remains (Darvill & Fulton 1998). The recognition has been made that urban archaeologists are trying to reconstruct patterns of land-use within the economic and social framework of the past (Ayers 1991).

The most appropriate recent research for the purpose of linking past with present land-use patterns has been the application of characterisation approaches to describe the historic environment resource championed by English Heritage (Grenville & Fairclough 2005). This has included national programmes of Historic Landscape Characterisation, Extensive and Intensive surveys of historic towns and cities, characterisation of Farmstead settlements, 20th Century remains and Seascapes. English Heritage have shown that characterisation can be of great use in describing the elements of the resource so that it can be used for management purposes in spatial planning and strategic development design. They give examples of application in Government "Growth Areas" such as the M11 Corridor, Milton Keynes Urban Expansion Programme and the Thames Gateway (Went, 2005).

Bottom-up characterisation implicit in the Historic Landscape Characterisation programmes (e.g. Herring 1998) attempts to identify past land-use patterns from historical sources but concentrates on monuments or landscapes, remaining insensitive to smaller scale deposits, features and artefacts (Darvill & Gerrard 1994). The utility of characterisation of the smaller elements of the historic environment resource within a land-use context deserves further investigation. The nature of surviving archaeological remains is extremely complex and detailed research into this lies outside the scope of my research. However, Section 8.2 will investigate the potential of characterisation as a management tool by developing a methodology to classify the deposits, features and structures recorded from the case study sites within a land use context.

1.5 Utilisation of applications of Decision Theory to improve Field Evaluation approaches

Hearing Orton's call for the development of Decision Theory to identify potential outcomes of archaeological judgement models (2000a) at the Institute of Field Archaeologists annual conference in Brighton provided the long overdue impetus for personal investigations into potential mechanisms to address some of these professional limitations.

A variety of factors have combined to ensure that archaeologists have often misunderstood the nature of the decisions involved in the Field Evaluation process. These include lack of research resources and the pace of developer-led interventions precluding closer inspections of the Decisions. The lack of time and staff do not allow Curatorial Archaeologists to take advantage of the great advances in theoretical areas of our own and other disciplines. Previous research into archaeological Decision-making practice have recognised the need for archaeological Decisions to be made in a better way, but have focussed on the arena of professional judgement. Elementary Decision Theory shows that Decisions can be made by using two separate processes, either "mechanistically" in which the Decision-maker does not exercise their own judgement or "judgementally" in which they do (Cooke & Slack 1991). Archaeological Decisions are certainly made using professional judgement, but we must be wary of confusing the qualitative elements of Decisions with the Decision itself. A closer examination of the processes operated within the Decision-making of archaeological Field Evaluation shows that we are making qualitative Decisions using some quantifiable variables.

Comparisons have been made between some archaeological Decisions and professional judgements made by the medical profession, which conclude that the mode of cognition will necessarily be more intuitive than scientific analysis (Startin

1993; Darvill 1995). To ensure that a sound archaeological decision is made, it is important to distinguish between the Decision itself and the consequences. A good Decision is defined as being a statistically sound choice between properly evaluated consequences of a number of options. The consequences are determined by the extent to which each decision option meets the decision objectives (Cooke & Slack 1991). The utility of **Decision Analysis** to interrogate the form, environment and objectives of archaeological Decisions has not previously been recognised.

This research will follow a long established tradition amongst the archaeological profession by utilising applications of theory which were initially developed for other disciplines. Decision Analysis was developed during the later 20th century from its origins in early 20th century problem solving (Dewey 1910; Simon 1960) and through the application of Decision Theory to operational research and systems practice approaches made in economic, statistical, psychological, political, social sciences, philosophical and many other fields (Watson & Buede, 1987). The term Decision Analysis was first used by Howard in the 1960s to describe the philosophy, theory, methodology and professional practice used to address Decision-making in a formal manner (Howard & Matheson 1977).

Late 20th century Decision Analysis approaches have been applied to management (Cooke & Slack 1991), accountancy (ACCA 1991), and other general applications (Watson & Buede 1987). The Decision Analysis approach uses a mathematical model designed to characterise the Decision-making process as a sequence of component processes to create a **Decision Framework.** Relevant elements of Decision Theory can then be used within this framework to assist the tasks of ensuring that a sound Decision is made. A **Decision** is defined as the act or process of coming to a resolution as a result of consideration from a choice of alternative outcomes which will achieve a goal (Allen 1990, 300). The Decision-Maker will identify information about each outcome, and use logic to judge them by employing the values which are important to the goal.

Decision Analysis attempts to identify the relationships between the Actions of the Decision-maker and the Objectives of the Decision by the construction of models. These models act as logical and mathematical representations of the relationships within and between features of the specific Decision Situation and are used to estimate the possible Outcomes of each Course of Action.

Before undertaking the analysis, it is important to clarify the significance of the terminology which will be used in this study. Because of the highly technical nature of the theoretical concepts used in this research, a glossary has been provided at the beginning of Volume 1 of this research to explain all technical terms used. All Technical Terms are taken from other applications of Decision Analysis and appear in bold when first used in the text.

The general term **Decision Environment** is widely understood to include all of the elements of the behaviour, psychology, context, climate, Goals and Objectives of a Decision. Decision Analysis evaluates the quality of Outcomes using only the three elements of Information, Values and Logic from within the Decision Environment. These elements are defined as being the **Decision Situation** and the relationship of the Decision Situation to the wider Decision Environment is shown in the model in Figure 3. As this application of Decision Analysis concentrates upon only the three elements named above, full description of wider Decision Environment is not necessary.

This research aims to analyse a specific application of Decision Analysis by identifying and investigating the three elements which comprise the Decision Situation of the Field Evaluation. A Decision Framework will be created to identify the key dimensions of the Decision-making process which will be explained and discussed in detail in later chapters. Theoretical tools will also be used to address the implicit assumptions within five areas of the Decision-making process:

- The Decision Strategy;
- The Alternative Courses of Action;
- The Alternative States of Nature;
- The Decision Outcomes;
- The Prediction of Probability of Outcomes.

The **Decision Strategy** is the logical operation of the information and values of a Decision Situation to evaluate the **Outcomes** of **Alternative Courses of Action.** It is also necessary to identify methods of ensuring a quantifiable way to measure or estimate Outcomes and to assess or compare them within the **Alternative States of Nature** (Lindley 1994). The Outcomes are compared using the Decision Strategy to identify which Courses of Action best fulfil the **Decision Objectives.** The Decision Strategy requires the use of probability tools to predict which different States of Nature might occur.

A high degree of certainty is required for the identification of the dimensions of these archaeological Decisions, however previous studies have shown that Curatorial Archaeologists remain uncertain of the complexity of the archaeological resource (Champion 1995; Hey & Lacey 2001). The detailed modelling of Decision-making processes of Field Evaluation could identify the nature of the inherent uncertainties and the most appropriate theoretical tools for dealing with them, either from the existing multi disciplinary approaches (e.g. Watson & Buede 1987; Cook & Slack 1991, 54-60; Gilligan 1983; Lindley 1994; Chernoff & Moses 1988; Fischoff *et al.* 1981) or by the development of appropriate new theoretical concepts.

The fundamental role of information flows within the Archaeological Assessment Process has been demonstrated by previous studies (English Heritage 1995; Hey & Lacey 2001). It is helpful to identify the paths of information flow during this Decision Analysis in order to be able to assess the effectiveness of its use and potential. It is also necessary to identify methods of ensuring a quantifiable way to measure or estimate Decision Outcomes and to assess or compare them (Lindley 1994). The 2001 study relied on qualitative comparison and the data gathered from their case study sites cannot be used to establish the statistical validity of the results because the sample was too small. The attempt to produce a quantifiable measurement of the archaeological resource noted in Section 1.2.1 above will attempt to address this issue.

The measurements from a statistically valid sample of actual PPG 16-related pre-determination Field Evaluations from development sites, which have later gone on to be fully excavated, will be used within this study. Utilisation of theoretical tools might then allow the identification of the significant positions to insert that information within the process which could improve our Decision-making.

1.6 Structure of the research

Decision Analysis requires the Decision Framework to be defined. This sets out the processes, assumptions and theoretical tools available for the analysis of the Decisions in the Field Evaluation process. The Decision Framework created for this research is shown in Figure 4 and provides the structure of this research.

The first stage in the Decision Framework is the identification of the **Decision Type** of each Decision made in the pre-determination Field Evaluation processes. Chapter 2 provides models of the entire Archaeological Assessment process in order to allow the identification of the different Decision-making Points, which are those places where Decisions occur. The Decision-making Point at which the choice is made of the most effective Field Evaluation techniques for specific potential development sites can then be isolated. Chapter 3 then identifies the Decision Situation elements of Logic, Values and Information and provides models of the types of appropriate approaches to analyse them.

Stage 2 of the Decision Framework makes the selection of the Decision Strategy by identifying the Decision Objectives and the conditions under which the Decision Situation operates. This is done in Chapter 4 and includes the development of two new methodologies as potential theoretical tools for the identification of Alternative States of Nature and the Probability of Occurrence of Outcomes. The first methodology is the development of a quantitative performance measurement scale for Field Evaluation techniques and the second is a new theoretical concept of **Local Locational Factors,** intended to be useful in the prediction of Outcome probability.

The collection of a statistically valid sample of data, with which to identify the Outcomes of each Alternative Course of Action within each Alternative State of Nature, is the third Stage of the Decision Framework. The research methodology and commentary on methods used for this are outlined in Chapter 5. The identification of the **Decision Options,** that is the Alternative Courses of Action which can be applied to the Alternative States of Nature, as Stage 4 of the Decision Framework is carried out in Chapter 6.

Chapter 7 identifies the States of Nature from the case study sample sites which have undergone Field Evaluation to act as a model of the archaeological resource for Stage 5 of the Decision Framework. Performance measurement of Field Evaluation techniques is then carried out to allow the Outcomes of the Decision Options to be predicted, as required by Stage 6. However, Stage 7 of the Decision Framework requires the identification of probability of occurrence of each Decision Outcome. Chapter 8 carries this out using two new theoretical concepts of **Past Landscape-use Patterns** and Local Locational Factors as tools to provide more certainty to this operation. The assessment of each Course of Action is then carried out for the States of Nature recorded from the case study sample, as Stages 8 and 9, and the choice of the most appropriate Courses of Action is made as Stage 10 of the Decision Framework.

Chapter 9 uses statistical methods to suggest improvements in the performance patterns of the Field Evaluation techniques which make up our Alternative Courses of Action. A remodelling of the information flow processes within the Decision-making Point under analysis is also suggested as a means for performance improvement in Field Evaluation. Finally, Chapter 10 draws together the results of the research and addresses some of the implications for the archaeological profession.

Illustrations, Tables and Appendices have been combined together in Volume 2 to allow ease of reference for the reader.

Chapter 2 – Decision Frameworks for Archaeological Field Evaluation

Decision-making is central to the inputs made by Curatorial Archaeologists to the Development Control System in England and Wales. Decision-making can be heuristically broken down initially into three tasks. The initial selection of planning applications which require pre-determination Field Evaluation is carried out using Decisions made about the archaeological potential of each site. The second task requires the selection of the most effective Field Evaluation techniques and methodologies to provide data on the location, extent, nature, date, preservation and importance of archaeological remains from a sample of the site. The third task consists of a Decision on the requirement for further archaeological Mitigation work to be made using the professional interpretation of the data recorded by the Field Evaluation.

Analysis of each of the Decisions contained within all of these professional tasks is beyond the scope of this research. Yet detailed focus of Decision Analysis onto one Decision-making Point within one of these tasks might allow the utility of the application to be demonstrated. This forms the focus of the research reported here. The first stage of Decision Analysis, in order to allow the identification and selection of a meaningful Decision-making Point for detailed study, is to identify the Type of Decisions being made within the Archaeological Assessment process. The Decision-making Point which will be subject to Decision Analysis will then be selected.

2.1 Process Models for Archaeological Decision-making

The identification of Types, and consequently the nature, of the Decisions taken within current Field Evaluation practice can be achieved by the application of **Process Modelling**. The concept of Process Modelling has developed from **Systems Thinking** and has been used for mathematic modelling (Rutherford 1994), the Natural Sciences (Lin & Segel 1998), and the analysis of Business Systems (Fettke & Loos 2006).

Systems Thinking was applied to archaeological theory in England over 40 years ago, when Clarke used models as visual tools to create symbolic models of past cultural systems (Clarke 1971). The **Post-Processual** criticisms of this **Positivist** philosophy have been discussed elsewhere (Hodder 1999) and are acknowledged in this research. Yet the utility of my representation of the Decision-making processes in model form is free from any interpretative symbolism as the Model of Field Evaluation depicts stages in the actual Curatorial practice only. This approach has already been used by English Heritage to successfully demonstrate the stages of the Archaeological Assessment Process (English Heritage 1995, 2)

The assertions of generalization, subjectivity, simplification and omission through the use of models as conceptual representations for complex archaeological procedures are recognised. It is necessary to simulate the actions and processes operating within the Decision-making Framework of Field Evaluation procedures. This will allow the logical paths of actions and processes to be mapped into a set of statements which can assist the application of the Decision Analysis (Cook & Slack 1991).

Process Modelling, in particular, can help to define the sequence of operations and Decision-making Points at which professional judgements are made. In addition, because this type of modelling shows the resources required in each procedure, it can recognise the flow of information. This is particularly important within the operation of archaeological Field Evaluation within the local government Development Control practice.

It is essential to break the sequence of operations down into separate Stages so that the processes within each can be analysed. This application of Process-modelling will expand each of the Stages identified in the English Heritage appraisal of Archaeological Assessment practice. Operators and students of Curatorial Archaeology are familiar with the English Heritage model which describes the sequence of actions required by current English local government practice (1995, 2) and a copy of this is shown in Figure 5. Although highly simplified, this model can be used as a starting point for my application of Process-modelling. Expansion of the English Heritage model can be used to disentangle actions and information flows which are currently obscured by the complicated nature of the archaeological professional practice.

The utility of Process-modelling in this application of Decision Analysis is important as it provides Curatorial Archaeologists with the opportunity to describe what actually occurs during professional practice of Field Evaluation under the requirements of PPG 16. It also allows the explanation of the logical rationale behind the actions taken. The Decisions taken in this current practice impact on other areas of professional practice other than the requirement to manage the historic environment resource. This Decision-making process results in practical and financial expenses for the Developer who must fund further work undertaken by Archaeological Contractors and Consultants. A two-fold increase has occurred in the number of PPG 16-led Field Evaluations carried out in England each year between 1990 and 1999. This practical archaeological work was carried out in this ten year period by 275 Archaeological Contracting organisations, some of whose businesses depend upon the practices of the Archaeological Assessment system (Darvill & Russell 2002, 32).

The range of organisations and operators of the Field Evaluation process illustrates a need for the visual appearance and semantics of the Process Models designed for this research to be comprehensible to the wider archaeological community. Consequently a standardized notation has been used to develop the Models for this research. Business Process Modelling Notation (BPMN) represents best practice within the business modelling community. It is a standardized graphical notation for modelling business processes in a workflow context and was developed by the Business Process Management Initiative (White 2004). It was selected for use in this study to allow a standardised representation which is still relevant to the business environment of Field Evaluation.

BPMN uses simple linear process diagrams with a standard set of graphical elements to represent three different types of constituent parts of the model. **Flow Objects** represent the Actions to be taken by the Decision-maker. Three types of Flow Objects are used in these Models with the start and end of a Process defined by an irregular trapezoid(⏷). Activities which must be carried out within each Process are represented by a pentagon (⬠). The second constituent part of the Model is each point at which a Decision must be made. These are the places in the Process at which the Archaeological Curator must operate professional judgement to make a selection from a number of Options and have been identified in this study as **Decision-making**

Points (DMP). They are shown in the Process Models as red diamonds (◊) and are numbered sequentially through each Stage.

The third constituent of the Process Model are the **Connecting Objects** which represent the sequential movement from one action to another and are shown by thin arrows. In this application of Process Modelling wide arrows are used to illustrate the sequential flows of the information. In addition, because of the importance of information to the Field Evaluation Process, the graphical notation of **Data Objects** has been added to the Model. Data Objects represent the input of raw archaeological information to the Process and are represented by a curved parallelogram ( ). The input of the Data Object consisting of archaeological explanations of this raw data (see Section 3.5, 9) is shown by rounded oblongs ( ).

The expanded **Process Model** of English Heritage's Archaeological Assessment process is shown in Figure 6. The overall process is divided into six discrete Stages. Stage 1 is the **Archaeological Appraisal** operation at which three Decisions are made. Legislative guidelines are checked at DMP1 to assess whether each Planning Application requires Environmental Assessment. Next the impact of each application for development is judged for potential need for appraisal of archaeological potential. The action of Archaeological Appraisal is carried out with professional judgement and is informed by the use of known information recorded on HER databases. A judgement of the probability of presence of archaeological remains surviving on that specific site brings the end of Stage 1. The resulting choices of taking further action after this final Decision-making Point of Stage 1 are restricted to the two PPG 16 defined Options of yes or no to the necessity and reasonableness of further archaeological action.

Stage 2 formalises the Desk Based Assessment approach which requires the gathering of additional information from documentary sources, aerial photographs, historic maps and visual inspections of a site. The collation and interpretation of archaeological data from these sources allows for a more reliable analysis of potential of presence of archaeological remains. The function of Stage 2 is to allow a Desk

Based Assessment to be carried out to inform the knowledge of the requirement for further archaeological action.

Stage 3 encompasses the application of Field Evaluation techniques for the purpose of recording the actual archaeological remains present in a sample of the spatial area of the potential development site. This provides information which allows the Decision-maker 3 to provide an explanation of the location, extent, date, nature, fragility and importance of archaeological remains which might be present. The Decision-making in Stage 3 requires the selection of the most effective techniques to answer these six questions.

Stage 4 is the only currently statutorily established step of the Archaeological Assessment process, a European Community Directive requirement which is given legal effect in England by the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 (SI 1999, 293). Should the presence of important archaeological remains be identified by this statutory requirement or by any of the previous four local government process Stages, appropriate archaeological action is identified as a **Mitigation Strategy** in Stage 5 of the Process.

The final Stage of the Assessment process, shown in Stage 6 of the Model, requires Archaeological Curators to feed their professional judgement advice to planning officers and elected committee members on a range of Mitigation options required to preserve or record important archaeological remains. The archaeological Mitigation work required is secured through planning conditions or by legal agreements. Planning conditions can ensure that the PPG 16 presumption in favour of Preservation in-situ or recording by open area excavation is carried through into the Development Control process. Stage 6 details the final planning Decision made by Local Authority Development Control Committees, for whose elected Members archaeological concerns form just one material consideration to be weighed against other elements of each potential development application.

This study will focus on the critical assessment of the effectiveness of Decision-making Points in Stage 3 - Archaeological Field Evaluation. Because the flow and uses of information data from Stages 1 and 2 are integral to those Decision-making Points, these two preceding Stages will also be subjected to Process Modelling.

Process Models describe and explain the sequence of changes to the attributes of Operations and Actions which lead to a particular Outcome in a **System.** In this study the System is the practice of Archaeological Assessment and Field Evaluation. The aim of the present application is to expand and model the three Stages to identify the operation of archaeological Decisions made within the business environment of Field Evaluation practice.

The first Process Model of the Stage 1 Appraisal process is shown in Figure 7. It allows the immediate recognition of the actions and movements involved and can clearly identify the Decision-making Points. The function of this Stage is to use information on the potential for the presence of archaeological remains and the impact of proposed development for Decision-making on an individual site. The flow and sources of this information which assist the Decision-making are also shown clearly on the illustrated Process Model.

Figure 7 shows that there are five Decision-making Points within the Stage 1 Archaeological Appraisal process (DMP 1-5). DMP 1 requires the appraisal of whether the development proposal requires a formal assessment as set out in the legislation (SI 1999, 293). If an **Environmental Impact Assessment** is required, the Decision-maker then moves to Stage 4 of the process. If the development is not required to include this formal assessment, the Decision-maker moves to DMP 2. This requires an assessment of whether an Appraisal should be undertaken under the requirements of PPG 16. This is achieved in current professional practice through scrutiny of Weekly Lists of Planning Applications published by local authority Development Control Departments. In current practice all planning applications involving ground disturbance are deemed to require Appraisal.

The **Archaeological Sensitivity** of a site is determined at DMP 3 and requires two different sources of information. The first is the Prior Knowledge of predictive explanation of potential presence of archaeological remains. This information is provided from the HER database and other archaeological sources. The second datasource is the collection of raw data from the detailed Planning Application documents submitted by the applicant. This is used by the Decision-maker to provide an explanation of the impact of the proposed development. DMP 3 requires the comparision of both explanations to determine whether any identified or predicted archaeological remains might be affected by the development proposal.

A positive Outcome at this Decision-making Point results in the movement to DMP 4. This Decision requires Archaeological Curators to use professional judgement to compare the impact of the development on archaeological remains. The Decision to be made at this point is whether further archaeological action is required in the process.

The information gathered in the previous Decision-making Points is fed into the DMP 5 where they input into an explanation of the relationship between the impact of the propsal and the importance of predicted archaeological remains. This explanation is used to assist the Curatorial Archaeologist to use professional judgment at DMP 5 to ascertain whether futher archaeological action is needed. This final DMP ends the Actions of the Decision-maker in Stage 1 of the Archaeological Assessment Process Model. The three Outcomes of Stage 1 are that no further archaeological action is taken, or that the Decision-maker moves on to either Stage 2 (Desk-based Assessment) or Stage 4 (Environmental Impact Asessment).

Figure 8 describes the six Decision-making Points (DMP 6-11) required by Stage 2 of the Archaeological Assessment process. This comprises the compilation of a Desk Based Assessment report by Archaeological Contractors funded by the potential developer. This documentary search provides a detailed explanation from a wide variety of sources of data on the archaeological potential of a particular site. The practice on which this Process is modelled follows professional guidance on content and structure (IFA 1993a; ACAO 1993).

DMP 6 assesses whether enough information is available to move to Stage 3 (Field Evaluation). The information is provided by a professional judgement of accuracy and reliability of the Prior Knowledge gathered during Stage 1 of the Archaeological Assessment Process.

Decision-making Point 7 requires a choice between No Further Action and the collation of archaeological information through the Action of a Desk-based Asessment. This Action is carried out by Archaeological Contracting and Consultancy organisations.

The resulting archaeological information from the Desk-based Assessment report is fed into the Process at DMP 8. Here the Curatorial Archaeologist must decide if the site is Archaeologically Sensitive.

The information input to Decision-making Point 9 comprises the updated explanations of archaeological information from previous DMPs. The Decision comprises the choice of whether the development proposals impact upon any sensitive archaeological remains.

DMP 10 requires the provision of a professional judgement explanation of whether the archaeological remains are important enough to justify Field Evaluation or require No Further Action. This final DMP 11 of Stage 2 allows the Decision-maker to choose to move to Stage 3 (Field Evaluation) or Stage 5 (Mitigation).

The Process Model for Stage 3 Field Evaluation is shown in Figure 9. Decision-making Point 12 requires the Curatorial Archaeologist to design future Action which can identify the location, extent, date, type, fragility and state of preservation of potential archaeological remains. This process is guided by professional standards (IFA 1993b; ACAO 1993) and the requirements of PPG 16. These six questions are answered in a two-step approach. First the Prior Knowledge gathered from Historic Environment Records and Desk Based Assessments at DMP 10 is re-assessed to provide an explanation of probability of presence of remains. I have identified this step separately as DMP 12a. The second step is the professional design of an **Archaeological Brief** to guide the options of Field Evaluation Action. This Brief usually suggests the most effective techniques and methodologies to answer the six questions. I have designated this Step as DMP 12b.

Decision-making Point 12b is shown by the Process Model to be the most complicated of the thirteen Decision-making Points within the three modelled Stages of the Archaeological Assessment Process. It requires the Decision-maker to resolve six different questions. It is at this Stage in the Process that the Curatorial Archaeologist must choose the most appropriate combination of archaeological techniques and specific methodologies. Each combination must identify the many components of the predicted and unknown archaeological resource.

DMP 13 requires the final professional judgement of Stage 3. This is the choice of whether the information gathered in Field Evaluation shows that Archaeological Mitigation is necessary and reasonable. The input of new data from Field Evaluation interventions into DMP 13 is clearly shown in Figure 9. The archaeological explanation of the location, extent, date, type, fragility and state of preservation measured from a sample of development sites are provided by the Client Reports produced by Archaeological Contracting organisations. This information is utilised by the Decision-maker to provide a professional judgement of the importance of the measured and predicted archaeological remains in comparison with the explanations of development impact produced at DMP 10.

This Process Model for Stage 3 still simplifies the choice between combinations of non-intrusive and intrusive archaeological techniques and appropriate methodologies which are available at DMP 12b. The complexity of this Decision-making Point will benefit from identification of its nature using Decision Analysis.

2.2 Identification of Decision Type

The Process Models for the first two Stages of the pre-determination Archaeological Assessment procedures allow the identification of Decision Type by clarifying the nature of the Decision and the Options available at each.

Several methods of classifying Decision Types are used within the various professional applications of Decision Theory. The use of BPMN to describe the Processes as Models was adopted because of the business nature of the Decision Environment of Field Evaluation within PPG-led procedures as identified above. A search of Decision Type classification systems was made within professional

Business Management practice in order to retain consistency of approaches. Business Decisions have been classified by the level of programming in their operation. The degree to which the Actions of a Decision are repetitive or routine within already established procedures defines a "Structured decision". The Actions of a Structured Decision are clear, well defined, distinct and unambiguous. Other decisions are classed as "Unstructured Decisions" and their Actions are poorly understood and difficult to define (Gilligan *et al.* 1983). The degree of dependency on other future decisions has also been used to group the different natures of Business Decision Types (Simon 1960; Jennings & Wattam 1998; Cook & Slack 1991). These approaches are amongst many developed during many decades of the application of Decision Theory to professional Business practices. Yet, the complexity of specific classifications of Decision Types within the Business discipline has resulted in these classifications becoming relevant only to their own specific Business Decision Situations. This inability of Business applications of Decision Theory to be compatible with archaeological Decisions restricts their utility for this research. Therefore, an alternative approach to the classification of Decision Types must be considered.

The Decision Analysis Society (DAS), a subdivision of the Institute for Operations Research and the Management Sciences, have produced a more discipline-neutral classification of Decision Types. Their approach combines the differentiated structure, level of programming and dependency of different Decisions into more generic Types and is described in the DAS Lexicon of Decision-making (DAS 1997). The neutrality of each class in this definition of Decision Types is the justification for this classification being applied to the Process Models of each Stage of the Archaeological Assessment Process in this research.

Under the DAS classification, a **Simple Decision** is defined as a situation in which only one Decision must be made. There may be any number of alternatives options to choose between, but only one will be chosen to satisfy the Decision-maker's Objectives. These decisions have a tendency to be well established, distinct and clearly understood and are structured with little dependency on any Decision to be taken in the future. An example of a Simple Decision is the choice to purchase a loaf of bread from the many manufacturer's brands on the shelves of a supermarket. A loaf will be selected from the many possible alternatives using comparison of the cost, nutritional value, size, taste and other requirements of the Decision-maker.

More complicated Decisions are classed as **Strategy Decisions** in which there a number of Decisions to be made at the same time. Each of the Decisions may have any number of alternative options to choose between. The chosen options for each Decision must then be combined into a coherent choice of Actions to satisfy the Decision Objectives. These kinds of Decision are more unstructured, poorly understood, and ill-defined than Simple Decisions. A commonplace Strategy Decision faced by most of us is the choice of which meat and vegetables to buy from the large supermarket selection available on a weekly shopping trip. The Action required is the purchase of enough coherent combinations of food to provide all meals needed over the next seven day period. To allow further clarity in the definition of Strategy Decisions, The Decision-making Lexicon provides suitable tools for identifying some of the complexity of their definition. Strategic Decisions can be further classified into two groups by identifying factors affecting the operation of their Actions.

A **Portfolio Decision** is a class of Strategy Decision in which the different Decisions are of a similar nature, but the Decision-maker does not have sufficient resources to fund all combinations of Actions required to satisfy the Decision Objectives. An example of this Decision Type is an investment opportunity providing ten different potential investments at different costs. The Decision-maker on this occasion is the potential investor who does not have enough money to afford all of the alternative choices. The Decision-maker must use theoretical tools to analyse the complex variety of combinations using a Decision Strategy of Outcomes available within a cost limit.

An **Option Decision** is an even more complex class which requires the Decision-maker to choose Options for which there are future opportunities to make future Decisions following the input of information at a later date. These Options have the potential of adding value to a Decision Situation as they allow Actions to be made at a later date to make use of additional knowledge (DAS 1997). An example of this Type of Decision would be the same hypothetical investor described in the example above being allowed to choose to invest money in five of the best returning potential investments for two years. The additional money made on this initial investment could then be invested in the other five that were initially offered in the original Portfolio Decision.

The Process Models of Stages 1 and 2 of the Field Evaluation Process show that all of the Decision-making Points within both can be classified as Simple Decisions. Only one Action will satisfy the Decision-makers Objectives for each of the eleven DMPs of both Stages. A test of the accuracy of this definition can be carried out by the identification of the Actions required to satisfy the questions posed at each Decision-making Point. The Process Models in Figures 7 and 8 show that DMPs 1 to 11 all contain direct questions requiring either a "yes" or "no" answer. They are sequential process questions demanding the selection of one Action from a choice of two needed to satisfy the Decision-makers requirements, so are demonstrated to be Simple Decisions.

It is also clear that the structure of the Decisions in the Stage 3 Process Model is very different. The direct simple sequential nature of the first two Stages is not mirrored in the Stage 3 Process Model which is shown in Figure 9. Whilst this Stage contains only two Decision-making Points, they are both shown in the Process Model to be of a different complexity. DMP 12a asks the Archaeological Curator to use Prior Knowledge to provide a professional judgement of the location, extent, date, type, preservation and fragility of any potential archaeological remains on a specific site. Once the explanation of the Prior Knowledge is provided by the Archaeological Curator, the Process Model requires the move to DMP 12b. Decision-making Point 12b requires the concurrent selection from a variety of archaeological techniques and methodologies to answer six questions at once during Field Evaluation Action. However, the Decisions in each of these two Stages are of different natures. DMP 12a can, in fact, also be classed as a Simple Decision. Only the Action of providing an interpretative explanation will satisfy the Decision Objective, so this Decision only requires a binary response to the question asked.

There is also an external factor influencing the operation of DMP 12b which is not present at DMP 12a. The question at DMP 12b requires the selection of Actions which are proven to be the most effective Field Evaluation techniques and methodologies to provide its answer. However, the financial cost of the most effective

Actions to answer the six archaeological questions could be influenced by other operators within the market environment in which Field Evaluation currently operates. National Planning Guidance requires the Actions carried out during Field Evaluations to be a rapid and inexpensive operation. Because the undertaking of Field Evaluation Action is necessarily funded by the developer within the context of a competitive tendering situation, the Decision-maker must accept that there may not be sufficient resources to fund all combinations of Actions required by archaeological management purposes. Therefore, DMP 12b cannot be classed as a Simple Decision and must then be compared to the two Types of Strategy Decision. The Actions of this Decision are not informed by new information at a later date and so cannot be complex enough to be classed as an Option Decision. The different questions asked at DMP 12b are, however, answered by employing Actions of the same nature – the combinations of Field Evaluation techniques. In addition, the lack of sufficient resources limits the choice of combinations of Actions. Clearly DMP 12b is a Portfolio Type of Strategy Decision. Theoretical tools such as **Prioritisation** approaches are required to analyse the complex variety of combinations so that the most appropriate Action can be chosen.

The ensuing Action of the Field Evaluation intervention provides a new body of data requiring further Curatorial interpretation at DMP 13. The information is used to provide explanations of the predicted importance of any archaeological remains and the predicted impact of the development. This appears to be another Portfolio Decision, as there are more than one question to be answered and the Decision-maker will attempt to choose a coherent combination of Action for Mitigation under budgetary and temporal limitations.

This application of Process Modelling has achieved the first Objective of this research, as set out in Section 2.1 above. This was to identify Decision-making Points at which improvements in the performance of archaeological Field Evaluation could be made. The identification of Decision Type has shown DMP 12b is a critical point in the operation of this process. The Decision taken here results in Actions which produce the only source of reliable raw data to be recorded and used as evidence in this entire Stage of the Archaeological Assessment practice. DMP 12b is also the first Decision-making Point in the Process which is influenced by other elements of the

Decision Environment. The analysis of this more complex Portfolio Decision is, thus, of more interest for this demonstration of the possible utility of Decision Analysis for archaeological Decision-making. Consequently, the rest of the research in this study will focus on DMP 12b.

DMP 12b requires the selection of the most effective archaeological techniques and methodologies to identify actual archaeological remains present from a sample of the site. This is an area of archaeological practice, as Section 1.2.1 has shown, for which little quantitative research has been carried out. Indeed, it was my own inability to find published quantitative data to assist at this Decision-making Point when working as a Curatorial Archaeologist, that provided the stimulation to carry out the quantitative research carried out in Chapters 7 and 8. It is hoped that some of the quantitative results of this research can be considered to stimulate debate and improvement in future professional practice.

2.3 Decision Analysis of the Decision Framework of current Archaeological Assessment practice

The next stage in the Decision Analysis methodology is the compilation of the Decision Framework described in Section 1.2.3 above. This is built by identifying the Decision Type, the number of Actions, choice types and tools to assist that choice. The completed Decision Framework for each DMP in the three Stages of Archaeological Assessment is shown in Figure 10.

The complexity and uniqueness of the Type of Decision presented in Decision-making Point 12b is clear from the Process Model in Figure 9, which expresses the choice as a complex non-linear selection from many combinations of different alternatives. In practice the Decision is streamlined into the selection of the most effective combination of techniques and their methodologies to identify predicted and unknown archaeological remains. Figure 10 shows that the other twelve Decision-making Points are of a Simple Type which can be satisfied by the choice of one of two Actions. The tools of comparison of Outcomes of Actions or Prior Knowledge are used to assist the Decision-maker's choice at each. The more complex choices involved in the Portfolio Type DMP 12b, however, requires the use of Prioritisation as a tool.

The application of Process Modelling using BPMN in this research is now completed. It has produced detailed representations of the Decision-making Points in the first three Stages of current Archaeological Assessment practice in England. The thirteen individual Decisions identified by the Process Models have been classified into Types using Decision Analysis. The recognition of two more complicated Portfolio Decisions amongst the other Simple Types has been made. Prioritisation has also been identified as an appropriate tool for the Decision Analysis to be carried out in the following Chapters.

The Decision Analysis Society's methodology utilised for this research describes the combinations of archaeological Field Evaluation approaches, identified in Section 1.2.1 above, as the **Alternative Courses of Action.** This concept embraces the functional operational nature of the Field Evaluation techniques used in present professional practice. The complexity of the combinations of archaeological remains identified in Section 1.2.2 are defined as the **Alternative States of Nature.** The nature of this descriptive term is suitable to apply to the archaeological resource which it represents, and will be used through the research.

The application of Decision Analysis methods to the Decision Framework for DMP 12b now requires the identification of the Decision Strategy. This is the logical operation of the Elements of information and values found in the Decision Situation identified in Figure 3. This Decision Situation will be assessed in Chapter 3. The Decision Framework also carries forward to Chapter 4 which considers the Decision Strategy. Expanding on the plan outlined in Chapter 1, the identification of the Outcomes of all Alternative Courses of Action within each State of Nature are then predicted. The Prioritisation of each Outcome is calculated using the values and information of the Decision Situation as parameters. Chapter 5 describes the methodology for the collection of a case study of quantitative information on the effectiveness of combinations of archaeological techniques. Chapter 6 identifies the Alternative Courses of Action available for use at DMP 12b. Chapter 7 provides quantitative measurements of the Outcomes of the operation of Alternative Courses of

Action in the States of Nature recorded from the case study sample. The Probability of Occurrence of each State of Nature is then analysed in Chapter 8 using the case study data to simulate a model of the Probability of presence of States of Nature. The Outcome which fulfils the needs of the Decision Strategy most effectively can then be chosen. Chapter 9 will finally analyse the need for performance improvement in current national archaeological practice and identify and test possible conceptual tools which may assist the analysis.

Chapter 3 – Decision Situation for DMP 12b

The previous chapter has realised the first two Objectives of this research. The application of Process Modelling has identified the thirteen Decision-making Points of the Archaeological Assessment process and the initial application of Decision Analysis has recognized the Portfolio-type DMP 12b as the Decision-making Point at which Decision Analysis will be carried out. We now move to the identification of the nature of the Elements of the Decision Situation used in the logical operation of DMP 12b. As shown in Section 1.5 and Figure 3, the wider Decision Environment is made up of all of the influences of behavioural, political, cultural and social elements which affect the Decision. Process Modelling provides a useful tool to unpick the complexity of the Decision Environment of DMP 12b to identify the Decision Situation and its Elements. Decision Analysis identifies the Decision Situation as comprising the three most influential elements of Logic, Values and Information. This focus on the three elements only, rather than on all those of the larger and more complex Decision Environment allows this research to investigate the key elements of Decision-making in much greater detail. The natures of these **Decision Situation Elements** - Logic, Values and Information - will be analysed in the following Sections of this chapter.

3.1 The Decision Situation

The differences in scale of the Decision Environment are relevant to this analysis as they help to define the different levels of operation within the Field Evaluation process. Figures 11 and 12 show views of a Model of the scales of a general Decision Environment. Figure 11 shows the side view of a hollow cone with the scale increasing from the lowest on the left to the highest on the right. Figure 12 shows the same Model shown from above with the lowest scale represented at the centre core and the scale increasing with distance from that core.

The largest scale of operation of Field Evaluation practice is the **International-environment** scale. The most influential Element at this scale of operation is the legislative framework guided by the Council of Europe's Valetta Convention. This is the revised European Convention on the Protection of the Archaeological Heritage, signed by member countries in 1992 in Malta. Article 5 of the Valetta Convention sets out the requirements for archaeological management to be integrated into the country's planning process (ETS 1992, 143). The European Convention requires each of the Member Countries to ratify it in order to have the force of law. Following the UK Government's ratification of the Valetta Convention, it came into effect in England in 2001. The Government procedures to fulfil this legal requirement for protection and management of historic environment resource are set out at National Level in Planning Policy Guidance Notes. Other influential Elements of the International-environment scale of DMP 12b include the Information contribution of theoretical and practical research carried out world-wide by the archaeological profession.

The decrease in scale to the next level of the Decision Environment shows the National Strategic level of influence of legal, political and commercial factors on DMP 12b. This level of operation is defined in my Model as the **Mega-environment** scale. This describes the management and execution of archaeological procedures within the environment of a framework of national historic environment legislation. The legislative guidance of Actions at DMP 12b is provided by specialist historic environment laws which have devolved from 19th Century Ancient Monuments legislation. Thus, a large body of Case Law is available to assist the government's direct management of the historic environment through the Ancient Monuments and Archaeological Areas Act 1979 and through other legislation setting out the responsibilities of other organisations. Additional influence at this level of operation comes from the Element of archaeological professional Standards and Guidelines, as noted in Section 2.1 above. The current Government's Heritage Protection Review, as set out in the recent White Paper, promises new statutory requirements and reform of Heritage Consent processes (DCMS 2007). Until the recommendations in the White Paper are passed through the English Parliament, the existing legislative and professional guidelines provide the methodological influences at the Mega-environment scale of Decision-making Point 12b.

The wider commercial, financial and social influences of this National Scale of its Decision Environment also have an impact upon DMP 12b. The general cost and time limitations of Developer-funded archaeological fieldwork provide restrictions on the application of techniques and methodologies. The requirement for Field Evaluation work to be carried out at the pre-determination stage of a planning application also has influence. PPG 16 clearly places the responsibility for the costs of this work upon the Developer before any planning application is determined. The weighing of the practical and commercial impacts of Field Evaluation work against other development concerns may lead a Developer to try to restrict the financial cost of Decision Options.

The identification of the differences in the Environmental scales of the operation of DMP 12b provides some justification for the remodelling of English Heritage's original Model of Field Evaluation in Chapter 2. The original model, as shown in Figure 5, is at too low a scale to be of utility in this application of Decision Analysis. It is focussed on the Mega-environment Scale of the Decision-making Point 12b.

A further decrease in Environmental Scale of the operation of DMP 12b leads to the **Macro-environment** - the local operational level of Archaeological Decision-making. This is defined as the Environmental Elements of the Curatorial Decision-making process which affect the individual decisions being taken in the case of each development site.

A greater level of detail is provided by a decrease in scale to the smallest definition of **Micro-environment.** This is the raw data level of operation and represents the actual archaeological remains which are encountered during the practical operation of the Field Evaluation process. This greater level of detail is too highly focussed to assist this part of analysis of DMP 12b.

The Decision Situation Elements at the Macro-environment Scale are the most appropriate for this application of Decision Analysis and there are many of these. The physical conditions, such as geology, soils, existing structures and land-use, of each site and the availability of specialist contractors and equipment have influence over the choice and applications of archaeological techniques available at DMP 12b.

There are also temporal influences provided by the Development Control process itself. Within the framework of National Government legislation, most Local

Authorities have an eight-week period within which they must determine planning applications. Even with a longer timescale for larger scale commercial development proposals, these temporal influences require Field Evaluations to be carried within a small window of opportunity. The financial influences identified at the Mega-environment Scale of the Decision Environment are also in operation at the Macro-environment level. Yet all three of these Elements have been proven in my experience to have less influence than the three key Elements of Logic, Values and Information over the System of Decision-making at DMP 12b.

These three Elements operating at the Macro-Scale of the Decision Environment are fundamental to the logical operation of Decision itself. The Information Element is vital to the Decision-maker at DMP 12b. If accurate and full information about the predicted archaeological remains is available, the Archaeological Curator is able to tailor the requirements of the Field Evaluation techniques more closely to the six questions asked. The role of the Logic Element used in this Decision-making Point is also very influential. This is because the Outcomes of choices made during the operation of a Decision must be evaluated using well-established logical methodologies. The social Element of Values influencing DMP 12b is also fundamental to the Decision-maker's logical operation. The responsibility for the management of the historic environment on behalf of the local community requires certain Outcomes for its fulfilment. The Values ascribed to types of archaeological remains will affect the choice of Outcomes. That the Elements of Information, Logic. and Values act as major influences within the Decision Environment of DMP 12b can clearly be seen at this Macro-environment Scale. Because of this, I have chosen these three Elements to represent the Decision Situation of DMP 12b which will be analysed by this research.

Process Modelling can also be used to show how the three major Elements of the Decision Environment which comprise this specific Decision Situation interact. The processes of the System of DMP 12b take in resources, including Information, and use Logic and Values to generate the product of a recommendation for Field Evaluation action. Each Decision must be taken within the wider Environment of changing opportunities, threats and challenges (Cook & Slack 1991; Jennings & Wattam 1998). Figure 13 models the Macro-environmental reactions for the System of DMP 12b. It identifies the Information resource which feeds into the Decision Situation as being the explanation of archaeological remains predicted to be present on a site. This Information is fed into the Logical operation of selection using the Values Element scale of effectiveness of archaeological techniques and methodologies. Logic is the element used to operate the identification of the most effective combination of Alternatives within the influences of the other minor Elements. I have classed the minor Elements of the Decision Situation as "Changing Threats" and "Changing Opportunities".

3.2 Decision Situation Elements

Now that the Decision Situation has been identified and modelled, the natures of the Elements of Logic, Values and Information must be analysed. The nature of Decision Situation Elements can be defined by consistency of the behaviour of their values. A **Parameter** is an Element with values that remain constant throughout the Decision process and a **Variable** is an Element which takes on different values in different circumstances of the process (Cooke & Slack 1991, 130). It is clear that the nature of the Elements of Logic and Values should remain constant throughout the Decision process and can be defined as Parameters. The third Element, Information, is better defined as a Variable because of the many different types of information which can be fed into the Decision-making Point.

There are two types of Variable Elements which can be identification of the extent of influence that the Decision-maker has over their values. A **Controllable Variable** can be fully predicted and controlled, whilst an **Uncontrollable Variable** cannot as it is generated by unrestrained and unpredictable factors in the Decision Environment. The Information Variable in DMP 12b consists of the prediction of the archaeological remains thought to be present. But it also includes the Uncontrollable possibility that archaeological remains could be present which are not predicted using current approaches. This identification of Information about the archaeological resource as an Uncontrollable Variable Element is a useful tool to the Decision Analysis of Decision-making Point 12b.

The Actions of the operation of the separate Elements of Logic and Values and Information at DMP 12b define the Decision-making process itself. This is the operation of professional judgement by using Logic as a filter to compare the Decision Outcomes using Information and Values. This type of operation of professional judgement is the opposite of the systematic mechanistic operations made at the other Decision-making Points in the first three Stages of the Archaeological Assessment processes. The following identification of the components of each of the Decision Situation Elements is now required by this application of Decision Analysis.

3.2.1 Element 1: Logic

Our modern commonly-held perceptions of Logic range from mathematical puzzles to the fictionalised deductive methods of Sherlock Holmes. There is, however, a theoretical science of "Logic" as a branch of Philosophy which can provide a useful starting point for the analysis of this Decision Situation Element.

Logic is the science of **Reasoning** and developed as "Traditional logic" through the philosophical approach of the doctrines of Aristotle in the 4th Century BC. These early philosophies defined the formal structure of Reasoning through deduction. The subsequent development of philosophies of Deductive thinking branched out across Western Europe from this early period and were subject to changing cultural, social and technological influences.

Aristotle's approach was criticised by his pupil Theophrastus, who was the first writer known to examine the Logic of Propositions. Ancient Greek Logic was transferred to the Latin West of Europe through writers such as Boethius in the 5th Century AD. Their ideas were the main sources of the development of the science of Reasoning in Medieval Europe up to the 12th Century, despite the well developed tradition of Logical study in the Arab world. Through the 16th Century the theories of these Greek, Latin and Arabic sources were affected by the social changes of the European Renaissance. The experiments and Natural Philosophies developed from the 16th Century in Western Europe encouraged the use of alternatives to Deductive Reasoning for the philosophy of Logic. Concepts from Human Reasoning and

Psychology influenced the introduction of Inductive approaches to Reasoning allowing the inference of general laws from particular instances (Stebbing 1950).

The later technological advances of the 20th Century have influenced the development of "Mathematical logic" based on Pure Logic and abstract mathematics. Stebbing demonstrates how many of these modern applications of the science of Reasoning are closely developed from Aristotle's concepts of Logic (1950). Logic has traditionally been the focus of mathematicians and philosophers, however, there has also been many applications of logic to the study of Linguistics (Mc Cawley 1981), to Information Technology (Lemmon 1987) and Science (Galton 1990; Stebbing 1950) amongst many other disciplines. This has led to the more recent recognition that the application of Logical Philosophy to Reasoning has potential utility to other professional disciplines where reliable judgement is sought, such as Medicine (Copi & Cohen 2001).

Cultivated from this long tradition of theory, the modern science of Logic seeks to study the methods and principles used to distinguish good Reasoning from bad Reasoning. Reasoning is defined as "the thinking in which problems are solved" and the process of Reasoning requires conclusions to be drawn from the Premises of Propositions (Copi & Cohen 2001).

Logical Reasoning has been part of the body of British Archaeological Theory since the adoption of systematic investigation of archaeological remains by antiquarians since the 18th Century. The importance of the Reasoning processes of Inductive and Deductive arguments, including the development of Post-processual approaches, is well documented within archaeological professional practice (Renfrew & Bahn 2000). On the wider epistemological level, the Decision Situation of DMP 12b operates within from a predominantly Positivist perspective. This is not a conscious choice of the Decision-maker but exists because it is accepted due to the Positivist approach of the Local Government Spatial Planning process.

The science of Logic Reasoning can provide archaeologists with methods of distinguishing between logically correct and logically incorrect arguments which are defined as **Propositions.** Propositions are statements containing a **Subject** and a

Premise, an assertion about that Subject which must be confirmed or denied (Salmon 1973, 958). The professional judgement to be made at Decision-making Point 12b of the Archaeological Assessment process includes the selection of the most appropriate combination of Field Evaluation techniques and methodologies for a particular site and circumstances of development. The Propositions at DMP 12b are the statements claiming that each technique is the most effective at identifying certain types of archaeological remains. The Field Evaluation techniques are defined as the Subjects of these Propositions. Their Premises are the evidence for the effectiveness of each technique. Logical Reasoning requires the soundness of the Premises of each Proposition to be affirmed or denied.

Returning to the body of published archaeological research discussed in Chapter 1, it is clear that the current Inductive approach to performance measurement provides Propositions with Premises that are only tested using qualitative measures of effectiveness. The lack of compatibility between the various methods of testing the Premises for DMP 12b has resulted in the previous archaeological research providing only very broad Propositions. The performance scores assigned to the effectiveness of four Field Evaluation techniques by the Hey & Lacey study is an example of this approach (2001, 60-1). Their subsequent assertions that non-intrusive techniques were not even moderately successful at identifying the range of archaeological remains, and that only machine trenching was effective at predicting deposit character are two such broad Propositions. A third Proposition from that study is that a 3-5% sample size is required for a moderately good assessment of linear features and substantial and clustered remains, whilst scattered and ephemeral sites need much larger sample size.

Within the application of the processes of Logical Reasoning, the Premises of such Propositions could be tested for Soundness by using the Values Element of the Decision Situation for a comparison of quantitative measurements of the effectiveness of techniques. The Soundness of the Premises of DMP 12b could be improved by being able to compare the effectiveness of techniques on different types of archaeological remains on the same measurement scale. This study will attempt to improve the logical operation of DMP 12b by the development of a new concept. A measurement system to record and compare the performance of Field Evaluation techniques on one quantitative scale range will be devised in Chapter 5.

3.2.2 Element 2: Values

The variety of uses of the word "values" within modern society have served to shade its basic meaning. A Value is defined by the Encyclopaedia Britannica as a reference to a measure of worth (2002, 865-868). With Economists concentrating on measuring value by the amount an item would cost in exchange, it wasn't until the second half of the nineteenth century that the concept of "Value-in-use" became central to the European development of the theory of Value through the research of Jevons in England (1871), Menger in Vienna (1871) and Walras in Switzerland (1874).

The integration of archaeological concerns into the local authority planning process has seen the development of the current processes of preserving the most valued elements of the historic environment (Oxley 1996, 54). The nature of the many other concepts of Value that are in operation within current archaeological professional practice remain unclear.

Carman demonstrates that **Monetary Value,** which is described in financial terms relating to the exchangeability of an item, is considered to lie outside the realm of English heritage law (1996). Although English Heritage have funded some research into the translation of road option benefits into monetary terms at the World Heritage Site of Stonehenge, (Madison & Mourab, 1999), that concept of value is of little relevance to the legislative processes. The Value concepts which are assigned to archaeological remains by English law fall into the categories of **Scientific value,** as measured in terms of the information content, and **Amenity Value,** a value ascribed to an item is its existence and use.

The gradation of precise values along the scales of Scientific Value within the current legislative process include three grades of value: "National status, Importance and Interest" (Carman 1996) which seem to be reflected in the adoption of the terms National, Regional and Local Importance within the published corpus of archaeological reports produced through the local government planning process.

PPG16 and recent national programmes of monument evaluation, such as the Monuments Protection Program, consider the concepts of value in relation to the national importance of the remains and use scoring systems to assign values to the Department of the Environment's 1983 criteria for scheduling archaeological remains (Startin, 1993, 186).

The criteria of Period; Rarity; Documentation; Group value; Survival/condition; Fragility/vulnerability; Diversity and Potential can be grouped into the concept of Scientific value, as they demonstrate the amount of archaeological information contained within the remains.

"Amenity Value" is a little more difficult to define in relation to archaeological remains. Darvill has previously argued for the recognition of other Value concepts to archaeological Value systems, including those of Use, Option and Existence (1993). Indeed, the current body of legislation does assign value to components of the historic environment for reasons of aesthetic, archaeological, architectural, artistic, historic, public, scenic, scientific and traditional interest (Carman 1996). The influence of modern political issues upon the Values operating within the planning processes should also not be underestimated.

Whilst the archaeological profession is familiar with many concepts of the scale of Scientific Value and some recent research has been carried out into Amenity and Existence values (Priede 2007; Jennings 2007; MORI 2003), there has been little work undertaken on the definitions of the Value scale in operation at DMP 12b. Universal basic human values have been identified as biological, psychological and anthropological and operate within a hierarchy of changing personal and social systems (Drews & Lipson 1971). A professional Value Scale of Ethics of archaeological practice is one of these systems to guide Decision-making at DMP 12b. Archaeological Curators are governed by the ethical requirements set out by professional bodies to ensure that professional archaeologists operate to the highest standards of ethical behaviour. Two of the most important ethical concepts are fundamental to the operation of Decision-making at DMP 12b. Principle 2 of the Institute of Field Archaeologists Code of Conduct places the responsibility for the conservation of the archaeological heritage with professional archaeologists, who are required to strive to conserve archaeological sites for future generations (IFA 2006, 2). The IFA's Code of Approved Practice for the Regulation of Contractual arrangements in field archaeology also stresses that an archaeologist's primary responsibility is to safeguard the archaeological resource and to see Preservation in-situ as the first option (IFA 2002, 2). The ethical requirement for Preservation in-situ is an important element of Decision-making at DMP 12b, as it provides the assumption that Field Evaluation must not damage archaeological remains and that the Field Evaluation should provide information on the requirement of Preservation in-situ. The second professional ethical concept is also required by the Institute of Field Archaeologists' Code of approved practice for contractual arrangements which states that an archaeologist should only make a Decision if adequate information is available to reach an informed judgement (IFA 2002, 5). These ethical requirements drive home the importance of good Decision-making in our professional processes.

Yet the concept of the "Values" Element identified in operation of DMP 12b in Figure 12 is very different from the concepts discussed above. The Values Element of this Decision Making Point informs the comparison of effectiveness of evaluation techniques. Therefore the separate Values operating in DMP 12b are the different scores of effectiveness for each technique. The improvement to the logical process suggested in section 3.2 requires the development of a measurement system to record and compare performance of Field Evaluation techniques on the same quantitative Value scale.

Following the reasoning of the Inductive approach, the observance of specific performance of each Field Evaluation technique could be measured from a statistically valid sample of case studies of actual archaeological interventions. The Bournemouth University study records that 9554 Field Evaluations were carried out in relation to the requirements of local government Archaeological Curators between 1990 and 1999 (Darvill & Russell 2002). This body of data will provide a sample from which the performance of techniques can be measured and compared in an attempt to ensure that our Propositions are Logically consistent by identifying errors in Reasoning. This is the next sequential stage of the Decision Analysis process which requires the identification of the Alternative Courses of Action which will be carried out in Chapter 6 below. The Positivist nature of this approach is acceptable due to the lack of other quantitative sources of data to empirically verify the Premises of the Propositions. Reductionism can be avoided by ensuring the neutrality of verification.

3.2.3 Element 3: Information:

This Uncontrollable Variable represents the information available about the presence of the archaeological remains on a site. This is also the subject of two general Propositions from the Hey & Lacey study. The first states that the character and density of archaeological remains is different at each site and the second states that this has an impact on its visibility which is unrelated to its significance. The concept of visibility of archaeological remains used at DMP 12b refers to the Information available to predict the likelihood of their presence. Because the invisibility of archaeological remains within the modern landscape is accepted, the Information available to predict presence is highly variable. Several factors have influenced the current partial Information provision on presence of archaeological remains. The lack of systematic archaeological field surveys over large areas of the English landscape has resulted in no data being available for many potential development sites. The reduction in research funded archaeological field investigations since the introduction of PPG 16, and even the data from PPG-16 led interventions themselves, has not provided the Information needed by Archaeological Curators at every site for many areas of the country.

The current national approach in England to the gathering of this Information to predict presence uses intuitive expert prediction, described as Professional Judgement in Champion *et al.* (1995, 6). This Professional Judgement is a prediction based upon two sources of Information. Prior Knowledge is the information on known presence which is provided from the data held on HER databases. **Expert Models** of predicted presence are then produced from the data held in archaeological research frameworks and local knowledge of past human behaviour within the current landscape. This is an Inductive approach of constructing Models from known data, but improvements in the Logical operation of DMP 12b through other Reasoning approaches will be assessed in Chapter 9.

A detailed analysis of the Information Element of Decision-making Point 12b will assist this application of Decision Analysis. The term Information is used to describe the facts and opinions given and received by a Decision-maker:

> "These information phenomena permeate the mental and physical world, and their variety is such that it has defied so far all attempts at a unified definition of information." (Encyclopaedia Britannica 2002, 615).

That lack of definition has not stopped the development of an established body of theoretical research into the nature of Information. Advances in modern Information Theory were made in the 1940s by Shannon's recognition that communication signals must be treated in isolation from the meaning of the messages they transmit. This stimulated much research into the physiological, physical, linguistic and mathematical nature of the signals (Shannon 1949). It is in this area of the meaning of the message that Information Theory can assist this study.

Shannon's Communication Model is shown in Figure 14, where the **Message Source** is the human, animal or inanimate object which originally creates the message. The **Encoder** is the object that connects the message to the physical signals that are sent. The **Channel** is the medium that carries the message and **Noise** is anything which interferes with the transmission of the message. The **Decoder** is the object which converts the signals into a form the **Message Receiver** can understand. The Message Receiver is the person, animal or object which receives the message.

This theoretical approach shows how the meaning of a message contained within the Information it incorporates can be changed several times during the process of transmission. Archaeological Field Evaluation of a site necessarily includes the encoding of the Information contained within the Message Source (the archaeological remains) into an archaeologist's interpretation of past events on that site.

A Communication Model for the Field Evaluation process has been created using Shannon's model as a template. This identifies the relationship between the Message Source and the Message Retriever in DMP 12b and is shown in Figure 15. The Message Source is the surviving body of archaeological remains which actually exist on a site. The Message transmitted through this process is the Information recorded from the actual archaeological remains. That Information can range from that provided by a chance find of an archaeological object within plough-soil to the knowledge about visible above-ground remains from detailed archaeological excavation. The Message Information possessed by the Decision-maker is recorded in this instance through the Encoder of the Historic Environment Record, the database of known archaeological information. The Archaeological Curator operates their Professional Judgement as the Message Channel and Decodes the Message into the Interpretation of Presence of archaeological remains. There are many occasions for the meaning of Information provided by the Message Source to be changed by interpretation. These occasions are the subject of recent archaeological research into the role of the theoretical concept of Agency which accepts the implications of the influence of the Double-Hermaneutic, the subjective perceived influence of the Decision-maker's own social conditions on interpretation (Barrett 2002; Framework Archaeology 2006). Detailed discussion of this concept and its operation at DMP 12b lies outside the scope of this research, it is, however, important to recognise its existence. As these opportunities for change of the meaning of the Message exist, it is important to analyse the characteristics of the archaeological resource which acts as the Message Source so that the meaning of the Message can be understood.

The complexity of the archaeological resource itself has clouded past definition of the characteristics of the basic archaeological Information source, the deposits, features and structures which make up the surviving archaeological remains on a site. As Chippendale succinctly describes:

> "Archaeology is plagued in many an instance with poorly defined variables (usually thought of as "data") drawn from ill-understood populations, and with uncertain articulations between the entities whose logical relationships we seek to understand"
>
> (2000, 611).

Decision Analysis will provide a framework for us to deal with uncertainty at the necessary points in the process. Chippendale goes on to identify another important attribute of the nature of archaeological Information:

> "since any object, however small, contains an indefinitely large amount of information, any record of it – however full and fair it attempts to be - will be

> selective. From those aspects we can capture, because they are observable in the material evidence, we choose to capture some and set others aside"
>
> (Chippendale 2000, 608).

Chippendale's compelling argument that our archaeological Information should more correctly be termed **Capta** rather than "data" can assist in the description of the physical nature of the archaeological resource. The philosophical difference between the information and the explained information of Prior Knowledge which is recorded within Historic Environment Records allow the term to be adopted for primary archaeological records supplied by this source. The same term can be applied to the Expert Models of potential presence of remains compiled by archaeological research approaches. Therefore, the entire application of Decision Analysis in this research will use the term Capta when describing any explained information provided, even primary Archaeological Excavation records. The term Raw Data will be used to describe the attributes of actual archaeological remains. The difference between the two terms is that an archaeologist's knowledge, experience and skill in explaining the Raw Data changes the characteristics of the physical remains into explained information. The Logical operation of DMP 12b process requires the use of this explained Information, the **Explained Capta,** and not the Raw Data itself. Whilst the processes of explaining are the much-debated roles and responsibilities of all Curatorial Archaeologists, they are not directly relevant to this study.

The Sources of the Message from the Raw Data of any archaeological remains at DMP 12b can be identified by looking in detail at the input of Archaeological Capta to the Archaeological Assessment process.

Figure 9 shows the sources of Archaeological Capta as first introduced to Decision-making Point 12b to be from Historic Environment Records, Other Archaeological Information and Predictive Information. A detailed analysis of the constituents of these three Information sources may help to identify the nature of that Capta.

Historic Environment Record information includes details from previous archaeological interventions, details of remains recorded during archaeological or other landscape surveys, sites suggested by historical research, topographical studies or academic judgement as well as reports of chance finds. The common factor in all these sources of Information is that they describe characteristics of the upstanding remains, below ground deposits and structures which comprise the Explained Capta as representing the archaeological resource. Other Archaeological Information includes information about below ground remains on the site from sources other than the Historic Environment Record, all of which describe characteristics of these upstanding remains, below ground deposits and structures.

Predictive Archaeological Information includes predictive archaeological, landscape or topographic studies or research, local community information or the archaeologist's own professional judgement. Yet again, all of these extrapolative sources include details of the same types of upstanding remains, below ground deposits and structures.

The Raw Data which is explained in this archaeological Information are the upstanding remains, below ground deposits and structures which make up the physical archaeological resource. Archaeological explanations are derived from a selection of Capta taken from the measurable characteristics of that physical archaeological resource. In order to identify that Capta, we must look in detail at the components of the archaeological resource.

The complex combinations of the individual components of the archaeological resource at any site have precluded the development of an all-encompassing description or characterisation. National characterisation projects have attempted to divide the archaeological resource into single monuments, landscapes and accumulated deposits (EH 2000). But this is approach is not sensitive enough to individual feature components and must be expanded to include all types of components. The complexity of these components is further complicated by the importance of the physical interrelationships between them. The Monuments Protection Program Urban guidance identifies that

> "archaeological remains are one or more superimposed sets of associated, spatially related and physically connected archaeological remains and intervening deposits"
>
> (EH 1992)

Consequently an expanded version of the Monuments Protection Program's categorisation will be applied to Raw Data of the archaeological resource to identify the Capta required for the operation of Decision Making Point 12b. This characterisation must take account of the complexity and Scale of the Information provided by the archaeological resource. A Model of the scales of the Data and Capta can assist in the clarification of the relationships between information about components of the archaeological resource and two views of this are shown in Figures 16 and 17.

The simplest, smallest category of information is termed **Primary Raw Capta** and is that contained in the single unit of information the individual artefact, ecofact or deposits recorded as "Context Matrix" in the archaeological record made up of the mass physical constituents of the Context. Because of the importance of Information about stratigraphic relationships in the archaeological interpretation of event sequences (Harris 1989) it would also seem prudent to include this unit. The characteristics of these stratigraphic relationships can be grouped into a class of Information called the "Context Interface" which relates to the immediate stratigraphic relationships with other Contexts only. This identifies two types of Single Information Units of Primary Raw Capta which are represented in red on the three dimensional Model as the core of the expanding cone.

The next level of increased complexity and scale of archaeological Information is that of **Secondary Raw Capta.** This is information provided by groupings of Single Unit Information to provide more complex details of information than can be obtained from the Primary Raw Capta. These include the information about trade, industry, social influences and the natural environment made by comparing characteristics of artefacts and ecofacts. The stratigraphic relationships between Single Units is also measured at this level and all of these types of Secondary Raw Capta are shown in green in Figures 16 and 17.

The next increase in Information Scale is to the final archaeological level of the transformation of the Secondary Raw Capta into an explanation of the relationships between deposits and artefacts/ecofacts, their characteristics and the relative and absolute dates which they provide. This **Explained Capta** level represents the archaeological records made during Excavation and Fieldwork which record the archaeological resource and are shown in dark blue in the Model shown in Figures 16 and 17. The largest Scale of Information is shown at the top of the cone shaped Model in light blue. This represents other explanations of the archaeological information made using Explained Capta as its source. This includes any archaeological research or interpretation using information provided by Historic Environment Records and is classed as **Other Explanations** in the Model.

3.3 Analysis of the Decision Situation Elements

The use of Process-modelling to identify the Decision Situation Elements of DMP 12b has proven to be successful. It has shown how the Elements interact for the Decision to be made. Logical Reasoning has identified some of the Propositions which require testing for the soundness of their Premises.

The analysis of the nature of the Values used to test the Soundness of Premises has shown that it requires a measurement of the effectiveness of Field Evaluation techniques and that no such scale currently exists. The analysis of the Element of Logic has shown that one improvement to the Logical operation of DMP 12b could be the development of a classification system to record the range of deposits, features and structures which make up the known and excavated archaeological resource. Inductive Reasoning allows that the data collected from a sample of real archaeological sites might be used to compare the actual performance of evaluation techniques within the local government Field Evaluation process. Both of these approaches will be carried out on the case study data in Chapter 5.

Decision Analysis has also demonstrated that the nature of the Information Element operating as Explained Capta and the sources of transfer of Information from Primary and Secondary Raw Capta have been identified. The recognition of these aspects of the nature of Information will prove a useful tool for the later stages of the Decision Analysis in following chapters. National policy guidance defines the Explained Capta required to identify archaeological remains of potential national importance as being the date, nature, fragility, state of preservation, extent, and location (DoE 1990). An attempt to identify the Primary and Secondary Raw Capta required for translation into these six requirements will be made in Chapter 6. Returning to the methodological approach of Decision Analysis adopted in Section 2.3 above, the next sequential task of Decision Analysis requires this research to identify the Decision Strategy which will guide the Logical operation of DMP 12b.

Chapter 4 – Decision Strategy and Objectives for DMP 12b

The previous Chapter identified the procedures that must be followed to operate the Logical Reasoning of Decision-making Point 12b. The Premises of the Propositions of effectiveness of Field Evaluation techniques must be tested for Soundness against a measured Value scale. The testing of these Premises is carried out using the Logical tools provided by the Decision Strategy which is identified and discussed in this Chapter. The Decision Strategy is defined as the calculation process by which the Logically Sound Premises are compared to the **Decision Objectives.** The calculations comprising the Decision Strategy use the theoretical tools of Comparison and Probability. The tool of Comparison requires all Premises to be measured on a single Value Scale. Decision Analysis suggests that the most appropriate tool in a Decision Situation involving Probability is Prioritisation using a measured Value Scale of Probability of Presence (DAS 1997, 3). The Conditions of operation of the Probability of Presence of archaeological remains will be discussed in Section 4.1 to identify the most appropriate Decision Strategy for DMP 12b. The Decision Objectives are then identified in Section 4.2. The two quantified Value Scales required to operate the Comparison and Prioritisation of the Decision Outcomes are then discussed. The identification of a measured performance scale of effectiveness of Field Evaluation techniques is carried out in Section 4.2. A similar analysis is undertaken to identify a Value Scale of Probability of Presence. These analyses produce methodologies for the identification of potential theoretical tools to assist in the Logical Operation of DMP 12b.

4.1 Identifying the Decision Strategy

Figure 18 shows a Model of the Logical Operation of Decision-making Point 12b. It shows that the Decision comprises two different types of Proposition. The first group contains all of the assertions of the effectiveness of Field Evaluation techniques at identifying different types of archaeological remains. The Premises of these types of Proposition are tested for Logical Soundness using the tool of Comparison. The relative scores of all the Premises can be arranged along the same Value scale of

Effectiveness in descending order. Those which score the highest are then selected to identify the most effective techniques. The second type of Proposition is the group of assertions of different types of archaeological remains being present on the site. The Premises of all of these Propositions are that it is probable that certain combinations of archaeological remains are present. The Logical tool of Comparison is not appropriate to the many different alternative combinations which may be the Subject of Premises in DMP 12b. The test of each Premise being sound, that is that the combination of archaeological remains are present, is again judged on a Value Scale of Probability arranged in descending order. Yet the measurements on this Probability scale have been identified in Section 3.1 as Uncontrollable Variables. It is accepted that there may be many potential combinations of archaeological remains for the Probability of presence of each type to be calculated.

A major failing of previous research into Archaeological Decision-making has been the assumption that the Decision-maker is operating at DM12b within Conditions of Uncertainty, when no Probability information is available, or under Conditions of Risk, when Probabilities can be identified. The distinction between the concepts of Risk and Uncertainty was first made by Knight in a financial context during the first half of the 20th Century (e.g. Knight 1921).

Risk is the concept which denotes a possible future negative impact on the Decision Objective. It is measured in terms of the type of impact and the Probability of its occurrence. Risk Management, as adopted in the professions with tangible financial assets, involves the identification, assessment and control of potential negative impacts to provide the Decision-maker with a reasonable assurance of the achievement of the Decision Objectives. Knight termed this **Risk Proper** and identified that this concept allows for measurable grades of Certainty.

The opposite of Risk is the concept of **Uncertainty,** the condition of lack of Certainty. This is a situation of limited knowledge making it is impossible to exactly describe the Certainty of the achievement of the Decision Objectives (Knight 1921).

The concept of Risk is clearly embedded into current archaeological professional practice in England. Archaeological Contracting and Consultancy organisations advertise services to diminish or remove the archaeological risk (OAU 2007). These services represent the requirements of the Development Control process as "archaeological risk" (MOLAS 2007) or even as a business risk (Scott Wilson 2007) in order to attract business. This concept of Risk has permeated into the profession through the need to educate the Construction Industry. A research project currently being carried out by CIRIA, a Research Partnership of Industrial Organisations in England, is called "Managing archaeological risk in Construction". Part funded by English Heritage and Historic Scotland, this research is being carried out by a project team including the Museum of London Archaeology Service and the Institute of Field Archaeologists (CIRIA 2006).

The Process Modelling in Figures 8 and 9 and the discussion in Section 2.1 above have shown that Information gathered at DMP 8 is available at DM12b on the Probabilities of the presence of archaeological remains. Section 3.2.3 has also demonstrated that Information is a combination of Prior Knowledge, the records of known presence provided from the data held on Historic Environment Record, and the Expert Models of predicted presence. Neither the Conditions of Risk nor those of Uncertainty are applicable to this Decision Situation. Risk Proper requires the presence of measurable grades of Certainty which are not available at DMP 12b. Yet the Conditions of Uncertainty require no certainty at all. Whilst the Information available at DMP 12b is not comprehensive enough to specify exact Probabilities, it does provide a framework from which predictions can be made. This is a different Condition of Decision Operation to Risk and Uncertainty and has been described as working under **Conditions of Incomplete Knowledge** in Decision Analysis in the financial profession (Kmietowicz & Pearman 1981, 7). Conditions of Incomplete Knowledge arise when limited Information is available, but it is impossible to describe exact future Outcomes. The limited Information available is then used to assign Probability to Outcomes.

An early contribution to the study of Decision-making under Conditions of Incomplete Knowledge was made by Fishburn, who also proposed that Decision-makers use a measure of Probability between the extremes of Uncertainty and Risk. This can be done by ranking the Probabilities of the future states of nature and Fishburn suggests an alternative tool of Prioritisation to rank the probabilities of presence (1964). Prioritisation is a method of modelling Probability between **Extreme Expected Values** and its theory was originally developed as a mathematical tool for analysing the distribution of variables (Fisher & Hall 1969). Its use to model Probability in the Decision Strategy of various economic fields, such as the UK Housing Market (Salmon 2004), suggests that Prioritisation is a Decision-making aid which could have potential value for this analysis of DM12b.

Care must be taken to define the concept of Extreme Expected Value, as it will be used in this research, in a non-economic sense. The two Extreme Expected Values of DMP 12b are that a potential development site may contain no archaeological remains at all (Minimum Expected Value) or that complex archaeological remains from every period may be present (Maximum Expected Value). Every other Expected Value will lie between these two extremes. As these are non-numeric Values, mathematical calculations of the distribution variances are not possible. But the Decision-maker must make the choice of which Extreme Expected Value is relevant to the achievement of the Decision Objectives of that Decision.

In addition to the six questions asked at Decision-making Point 12b (see Figure 9), a primary purpose of archaeological Field Evaluation, as currently operated within the planning process, is to identify the presence or absence of archaeological remains. This necessarily involves the Decision-maker in a choice of two theoretical assumptions. The first assumption states that a potential development site is initially believed to contain no archaeological remains and the input of Information from the Field Evaluation following DM 12b adds data on the probability of presence to that empty site. Alternatively, the second assumption states that a site contains complex remains of every period and the input of Information from the Field Evaluation adds data to DMP 12b on the probability of absence.

The first assumption is embedded into the Development Control Process within which Field Evaluation is operated. The current local government spatial planning process assumes absence of all material considerations if there is no existing evidence of presence. The format and structure of Historic Environment Records held by English Local Authorities is essentially a blank map-based database onto which Information is added when it is received from a number of different sources. This is the Information source for Probability of Presence of archaeological remains at DMP 12b. The current use of this Information Source through the planning process assumes absence of archaeological remains if there is no evidence of presence from Prior Knowledge.

It is, however, common professional knowledge that the absence of Prior Knowledge about the presence of the archaeological resource is often a result of lack of recording rather than real absence. Factors such as the lack of systematic archaeological survey, recording and excavation in an area, or the masking of below ground features, particularly prehistoric below later human or natural land use patterns. The element of unpredictability (the presence of the unexpected and the absence of the expected) of the archaeological resource is a concept which Contracting and Curatorial Archaeologists regularly experience during the course of their careers.

Consequently, it seems incongruous to assume absence of remains due to lack of recorded information at DMP 12b and yet this is the approach which current practices of PPG16 Archaeological Evaluation require. As a Curatorial Archaeologist required to operate under this assumption since its national inception in 1990, I have regularly experienced the lack of corroborative archaeological evidence to persuade Development Control officers for the need for a pre-determination Field Evaluation. General guidelines using other criteria, such as large development size or general location, as the persuasive reasons for possible archaeological presence have to be operated on these occasions. The professional and ethical requirements for the Curatorial Archaeologist to conserve the archaeological resource demand that the assumption of **Extreme Expected Maximum Value** of presence is adopted. This allows the Curatorial Archaeologist to assume that many types of archaeological remains from all periods were present on a potential development site. Thus allowing for the presumption in favour of preservation in-situ, even for un-evidenced remains, to be upheld.

Therefore, the Decision-making Strategy of Prioritisation of choice based on Extreme Maximum Expected Value has been identified as the most appropriate aid to the Conditions of Incomplete Knowledge in the Logical Operation of DMP12b. Such a Decision Strategy would operate under the assumption of presence of archaeological remains at DMP 12b. This would require the Curatorial Archaeologist to choose techniques and methodologies which would identify the presence of all known archaeological remains from each period. That is, to select the maximum number of techniques, most ground coverage and most thorough recording required to gather maximum data on the archaeological resource.

The operation of this Strategy within the Decision Situation of DMP 12b would, of course, be subject to the diverse elements of the Decision Environment identified in Figure 13. The operation of the System of Field Evaluation within the current planning process requires prudent use of economic and temporal resources. These two influences alone can override the need for the maximum Field Evaluation work required by the assumption that complex multi period palimpsest sites might exist on every development site. The lack of information about the economic value and cost of the archaeological resource produces uncertainty of the trade off between maximum evaluative investigation and cost of discovery of important remains during ongoing development.

Despite the constraints of the influences of the Decision Environment, there is great utility to this application of Decision Analysis in identification of the Strategy of Choice based on Extreme Maximum Expected Value for the Logical Operation of DMP 12b. The use of this Decision Strategy to fulfil the Decision Objectives can now be incorporated into the Process Model of DMP 12b to inform the analysis of its Logical Operation.

4.2 Identifying the Decision Objectives

With the selection of the most appropriate Decision Strategy to deal with the Conditions of Incomplete Knowledge at DMP 12b made, the next step of this Decision Analysis is to identify the Decision Objectives. The Decision Objectives are the desired end points of the operation of the Decision and are shown in the model of the Decision Situation in Figure 18.The Objectives of DMP 12b are to identify the most effective techniques (the Alternative Courses of Action) to identify the date, nature, location, extent, fragility, state of preservation of archaeological remains which have the highest probability of presence on a particular site (the Alternative

States of Nature). The Propositions within these Objectives can be divided into two groups. The first group contains those with Premises that some Field Evaluation techniques are the most effective. The second group of Propositions have Premises which state that some of the Alternative States of Nature of the archaeological resource have the greatest Probability of Presence. Because these Propositions underpin the Logical Operation of DMP 12b, the Decision Objectives are shown supporting the operation of the Decision Situation in the Model in Figure 18. The Logical Tests of Soundness are Comparison and Prioritisation and are shown to weigh the Premise against the Value Scales in the Model. The identification of two quantifiable Value Scales required by the two Logical Tests of Soundness must now be carried out.

The Logical Testing of Soundness of the Premises of both Proposition groups from DMP12b requires the affirmation or negation of each using the two Value Scales also shown in Figure 18. The Decision Strategy and Objectives of DMP 12b require the creation of quantitative Scales of Effectiveness of techniques and Probability of Presence of archaeological remains. The first task requires the creation of one new Value Scale for performance measurement of the Effectiveness of archaeological techniques which will be carried out in Section 4.2.1. The second task requires two pieces of analysis .The creation of a characterisation of the archaeological resource to represent the Alternative States of Nature will be described in Section 4.2.2. The development of a new Value Scale of Probability of Presence will be analysed in Section 4.2.3.

4.2.1 Identifying a measured Value Scale of Effectiveness for Alternative Courses of Action: Performance measurement

The Alternative Courses of Action are defined in Section 2.3 as the range of archaeological techniques available for Field Evaluation. The development of a quantitative performance measurement for archaeological techniques at DMP 12b requires a method of scoring the success and failure rates of each technique for the identification of the different types of archaeological remains or Alternative States of Nature present on a site.

The concept of success is relatively simple to define in this instance. At DMP 12b, it can be measured as a binary choice of success or failure to identify each type of archaeological remains. However, for a measurement Scale which can be used to compare scores between different types of archaeological remains, a standardised measure of success must be chosen. The principle of preservation by record accepts that the Capta recorded by full Excavation represents the totality of the archaeological remains present on a site. This acceptance that Capta contained within Client Reports represent the Extreme Expected Maximum archaeological resource on a site, can provide the upper limit on our measurement Scale. If the total archaeological remains recorded from Field Evaluation and subsequent full Excavation of the same site can be measured in some way, this will allow a maximum to be set on the value Scale for each site. A measurement of success for each Field Evaluation technique could then be made by comparison of its success at identifying each type of archaeological remains as a percentage of that total number. It follows that Data can then be gathered from a case study of previously evaluated real archaeological sites to populate a Model with which to test the logical operation of Decision Making Point 12b. This will allow the measurement of success to be compared from actual Field Evaluation techniques applied to sites which have then gone on to be fully excavated in post DMP 12b mitigations in England through the local government planning processes. A numerical measurement can be made of the number of the different archaeological resource elements which were identified by Field Evaluation techniques compared to the total number of each element recorded by the combination of evaluation and excavation results. The identification of the detail of this quantitative Scale of effectiveness of Field Evaluation techniques will be carried out in Chapter 5.

4.2.2 A Characterisation of the Archaeological Resource: Alternative States of Nature

The Decision Framework developed in Chapter 2 shows the Portfolio Decision at DMP12b for which the Decision-maker analyses a complex variety of combinations of alternatives by using Prioritisation. This analysis requires Information on the Probabilities of each State of Nature occurring so that the Outcomes of each

Alternative Course of Action can be assessed. The Decision-maker requires to know the most likely combinations of remains present so that the most effective performance of each Field Evaluation techniques for each type of archaeological remains can be identified.

Other issues have influence over the Decision-maker's knowledge of presence of the archaeological resource. The invisibility and complexity of the deposits, features and structures of the archaeological resource has already been established in Section 3.4. Very little research has been carried out into the Probabilities of Presence due to the large numbers of possible combinations of archaeological remains. This has led to the assumption that the archaeological resource is too complex for the identification of all the combinations to be calculated, let alone the Probability of their Presence. Yet this absence of Information leads to an Unsound Logical Operation of Prioritisation of Outcomes at Decision Making Point 12b. Improvement of the Logical Operation of this Decision Situation could be achieved if the complexity of the resource could be characterised into components of a Model sensitive enough to its nature to be tested.

Decision Analysis allows the use of Models to represent the Informational Elements of a Decision Situation under the requirement to avoid the fallacies noted in Section 2.1. Therefore this study will attempt to develop a methodology for an appropriate Characterisation of the archaeological resource as Alternative States of Nature.

Characterisation is now a well-defined research tool for the management of historic landscapes through the definition of the concept of totality of place as championed by English Heritage (Grenville & Fairclough 2005). Historic Landscape Characterisation developed and utilised the "bottom-up" approach as being more objective, inclusive and comprehensive than the "top-down" characterisation approach of expert led designation (Herring 1998). Whilst this characterisation approach is indeed more empirical than previous research, it is restricted to a focus on landscapes and not archaeological sites or their components (Clark *et al.* 2004).

The need for the identification of the common components of urban archaeological sites has been long recognised (Schofield & Leech 1987) and Carver produces a classification of contexts, features and components commonly found on urban archaeological sites in the same volume (1987). Yet this useful study focuses on deposit legibility or quality, and little further research has been undertaken into the concept of characterisation of components, although Emery does identify a series of physical correlates of the data potential for urban deposits (1991).

Roskams gives one definition of the complexity of recording the archaeological resource:

> "The objective of excavation is to split the site into its constituent parts, the stratigraphic units, however defined – and then remove them in the reverse order to which they were deposited, recording their physical, spatial and stratigraphic properties and collecting artefacts and ecofacts from them"
>
> (2001, 110).

Just as the Excavation process splits the archaeological resource into stratigraphic units, the analysis in Section 3.2.3 has identified the constituent parts of the archaeological resource. The four Raw Capta groups are defined there as Context Matrix, Context Interface, Artefacts and Ecofacts. A detailed analysis of these physical, spatial and stratigraphic properties recorded from these four raw Capta groups will assist in the identification of this Characterisation methodology.

The archaeological field records, finds records and environmental records currently used within the archaeological profession can provide information on the four Raw Capta sets recorded during excavation. Indeed, after the destruction of the archaeological resource through excavation, the primary archaeological records represent the only remaining evidence of the combinations of deposits, features and structures which were present on a site.

Archaeological field recording systems in England have developed gradually from the practice of Rescue archaeology in the mid 20th Century and through the introduction of PPG 16 interventions. A range of recording systems provided by many archaeological contracting units are used in different geographical areas of the country and many are formalised into field manuals (Hammer 1992). The Museum of London

Archaeology Service's Archaeological Site Manual was selected to represent an appropriate general recording system. Developed from professional practice and specifically designed to record the complex characteristics of deeply stratified urban deposits, the manual has been regularly updated and used for both rural and urban excavations in a wide range of geographic areas. (MOLAS 1994).

The properties of Primary Raw Capta required to answer the six questions of Decision Making Point 12b which are recorded during excavation using the MOLAS Site Manual are summarised in the table in Figure 19. The complexity of these Capta are simplified through Explanation as they are recorded and thus, within the context of the scale of Information levels developed in Section 3.4 above, they become Secondary Raw Capta by the assignation of deposit, feature, structure and relational terms. As this is the level of Information scale required at DMP 12b, it will be adopted by this study.

To undertake this "bottom-up" Characterisation of the components of both the urban and rural archaeological resource requires the translation of the properties of the Primary Raw Capta into Secondary Raw Capta through the assignation of terms for the evidence for all structural and depositional events. In this analysis, these equate to the **Stratigraphic Units,** the deposits or contexts, previously defined by Roskams (2001).

The explanations of the Secondary Raw Capta provided in the Field Evaluation and Excavation reports can be used to define the groups of such terms which will be used to characterise the archaeological remains recorded in the case study sites for this study. These necessarily require the Stratigraphic Units to be defined by the period in which the events they represent occurred in order to allow multi period sites and palimpsests to be considered.

At the start of this research project, the archaeological intervention reports from a random sample of ten case study sites were collected from a grab sample of PPG16 generated Field Evaluations to provide the basis for a characterisation of the Stratigraphic Units of the Alternative States of Nature. The sites were chosen for this sample in 1999 from local authorities for which I had previously worked as an

Archaeological Curator. They were selected as examples of sites with large areas of complex archaeological remains from a variety of periods which had undergone both Field Evaluation and post-evaluation Excavation recording. They comprised three sites from Staffordshire County Council, four sites from Lincolnshire County Council, two from Shropshire County Council and one site from Birmingham City Council. The details of the reports used for this Characterisation are listed in the table in Appendix 1.

Three groups of descriptive terms were identified from the sample by using the scale of the Capta contained within them. The Stratigraphic Units were defined as Deposits, Features and Structures following standard Excavation terminology. The lowest scale of component consisted of each separate fill, surface, scatter, dump, deposit or natural layer which were termed Deposits. Individual Features which comprised combinations of deposits to produce a recognisable negative anomaly such as a pit, trench or posthole or a positive anomaly such as a wall or grave were defined as Features. The final group and largest scale of Capta includes the buildings, ritual and other upstanding structures which were defined as Structures.

In order for the bottom-up characterisation to be reflexive to the actual remains recorded in reality, this Characterisation was then applied to all of the archaeological remains recorded in the larger Case Study sample of 100 sites, for both Field Evaluation and post-evaluation Excavation interventions, with new terms added if required. This produced seven Deposit Groups which are shown in the table in Figure 20. Fourteen individual Feature Groups were produced, which are shown in Figure 21, and eight Structure Groups, as shown in Figure 22. These were then further divided into Types which were assigned from their functional use. Assigning a period of use to the States of Nature Groups and types can provide a common method of describing archaeological remains which will allow valid measurements and comparisons to be made between Excavation records written by many different archaeological contractors using alternative approaches to the recording of the Primary Raw Capta. The Characterisation of the Alternative States of Nature from the Case Study Model can now be used in Section 5.3.1.2 to describe the archaeological resource when identifying the Probability of Presence.

4.2.3 Probability of Presence of Alternative States of Nature

An acceptance of Conditions of Incomplete Knowledge provides the opportunity to allow the input of additional Information to DMP 12b to calculate and rank the **Probability of Presence** of States of Nature (Kmietowicz & Pearman 1981).

Calculating the Probability of Presence of archaeological remains over the spatial areas of the landscape is carried out at County level by most Curatorial Archaeologists. This research and interpretation is carried out in the production of Expert **Predictive Models,** each tailored at a specific site level. These Predictive Models for each site are interpretations of expected presence and absence of components of archaeological remains from all periods. They are formed using information gathered from patterns of local information on known presence, the HER, and regional or national information from archaeological research and theoretical frameworks. Yet these Predictive Models are focussed on the level of the structures, features and deposits which might be present on each site. This scale shows that these predictive modelling exercises are carried out at the Micro-environment scale of the Decision Environment. The process is carried out by the Curatorial Archaeologist for every potential development site subject to pre-determination Field Evaluation and require Micro-environment level Information about the archaeological resource.

English Heritage's programme of the development of Urban Archaeological Databases utilises mapping of archaeological remains at the Micro-environment scale. Information from excavations and other archaeological work resulting from the increased pace of urban redevelopment has assisted archaeologists to model presence of past features and structures within the modern landscape. The creation of these Urban Archaeological Databases, such as that under construction for Dorset, is intended to define and characterise surviving components of the archaeological resource on a map-based database (English Heritage 2007a). The Chichester Urban Archaeological Database is also designed to provide the basis for an interpretative model of archaeological remains (English Heritage 2006)

Because of these tools, Curatorial Archaeologists in urban areas can have greater confidence in their predictions of the Presence of archaeological remains. However, the rural archaeological resource is more inadequately served. No equivalent interpretative model exists to record Probability of Presence at the Micro-environment scale within the appearance of the modern landscape. Historic Landscape Characterisation was designed as a tool to link mapped historic landscape elements with past human activity. Yet this has been shown in Section 1.2.2 to be necessarily restricted to historical sources and to focus at a landscape scale. The relationship between Probability of Presence of individual components of the archaeological resource and the mapped elements of the modern landscape is not identified. So the need for Predictive Modelling of the presence of archaeological remains at the Micro-environment scale of features and structures for rural sites has been identified.

The development of such a Predictive Model of rural archaeological Presence could provide a tool which could be used in the Logical Operation of Prioritisation of the Probability of Presence in DMP 12b. The archaeological profession has previously lacked techniques to bring consistency to both the diverse range and combination of archaeological remains or to rank the Probability of Presence. A contributory factor to this lack has been the fact that few resources exist within the profession allow the research into Predictive studies of the Micro-environment of DMP 12b.

The calculation of Probabilities of Presence of the Characterised States of Nature that comprise this Model of the archaeological resource will require Propositions to be constructed. These Propositions will state that certain States of Nature are present because of a reason to assume Presence. In current practice, these reasons include Prior Knowledge of Presence and patterns of similarity of location with other known past human activities. Past human selection of sites for particular activities was dependant on many factors relating to the landscape, environment and resources of a particular local site. Because patterns may exist between these physical elements of the landscape and the chosen human activity, the identification of some of them may allow Propositions to be made about Probability of Presence for some Alternative States of Nature.

Applying the characterisation approach to the physical aspects of the landscape context of each site within the Case Study Sample may also provide data which can Model actual Presence of certain combinations of archaeological remains in that location. This Model will represent the locational factors which might indicate that certain States of Nature from certain periods were carried out at that specific site and I have termed these **Local Locational Factors.**

The identification of detailed Local Locational Factors from the Case Study Sample might allow the recognition that development of this methodology could produce local Predictive Models of Presence. Archaeological Curators of rural areas could then use these, as information from Urban Archaeological Databases is used, to more accurately state the Probability of the Presence of certain remains in particular locations. Data from the Case Study Sample of 100 rural sites was collected to provide a general Model of Local Locational Factors. Although this sample of sites represents many different physical environments within many different landscape types within many counties, the data collected can still be used create a Model. It is understood that the newly created Model does not be represent the Reality of the archaeological resource, yet its creation will illustrate the potential utility of the technique.

Some of the physical characteristics of the surrounding environments of each site are the visible landscape features and resources that it provides to any human undertaking activity at it in the past. Tilley discusses some of the theoretical concepts of the significance of places and spaces within landscapes and suggest a phenomenological approach to the understanding of the relationships between people and the features of those landscapes (1994). Although the appearance of modern landscapes is very different to the assumed appearances of prehistoric landscapes, Tilley asserts that:

> "The skin of the land has gone for good, and can only be partially recovered through the most diligent of scientific analyses; but not its shape. The bones of the land – the mountains, hills, rocks and valleys escarpments and ridges – have remained substantially the same since the Mesolithic, and can still be observed." (1994, 73-4)

He goes on to suggest relationships between landscape features and Mesolithic and Neolithic monuments in three areas of Southern England and Wales using dominant focal points as landmarks, orientation points, for patterns of inter-visibility and human movement within their landscapes. Such a Positivist approach is not appropriate to my present research, but it has demonstrated there may be relationships between past human action and characteristics of the Landscape

These characteristics, or Local Locational Factors, were recorded from the Case Study Sample by recording the physical characteristics of each site's location as recorded in the Client reports. The Physical characteristics of the landscape recorded were Topographic Features, Resources afforded and Perception of other nearby human activity. These were selected to represent the three most common patterns of factors associated with past human activity in my own experience as a Curatorial Archaeologist.

The first group of Local Locational Factors comprises the **Topographic Features** which were mentioned in both the Field Evaluation and Post-evaluation Client reports. Each term used to describe a Topographic Feature was recorded and grouped into types. The types of Topographic Features recorded divided distinctly into three classes. High-ground Features comprised hilltops, hillslopes and higher ground. Individual Feature types represent any localised topographic change to the immediate landscape and are recorded in the Client Reports using classifications used by physical geographer. The recorded Types included plateaus, coombes, spurs, ridges, terraces, bluffs, knolls and scarps/ escarpments. The final Topographic Feature Type relates to Water and include rivers, river gravel terraces, river valley slopes, river floodplains, river headwaters, streams, stream floodplains, Tributaries, tributary floodplains, coasts. The entire list of Topographic Local Location Factors recorded from the Case Study Sample are listed in Appendix 2.

The definition of the second group of Local Locational Factors relates to the resources which the landscape around a site could provide humans engaged in activity at a particular site. For this definition I have turned to the concept of "Environmental Affordances" originally developed by Gibson in the study of visual perception. This defined specific properties of a landscape as being perceived as providing resources which he termed "Affordances" (Gibson 1979). This Concept was later refined through great theoretical research into the study of Perceived Affordance (Norman 1988) and has been used in the Ecological research to investigate the perception of the affordances of the physical substance of the landscape for animals (Chemero 2003). Although wishing to avoid the in-depth theoretical discussion of spatial cognition in the past perception of the environment, the Concept of physical affordances provided by the surrounding natural environment has been adopted to identify the **Natural Affordances,** the second Group of Local Locational Factors

Affordances are the resources which an environment offers to a human agent with the capabilities to perceive and use them. They have a relational ontology in that they have existence in the interaction between the physical capabilities of the human agent and the physical properties of the environment. My definition of Natural Affordances for this study uses the concept that some of these resources provided by the immediate environment of a landscape can be proven from records of archaeological evidence. Excavated evidence of grain preparation and animal husbandry can show the nearby presence of arable and pastural land. The many resources offered by a floodplain environment can be evidenced from palaeo-environmental samples and excavated remains. Three types of these Natural Affordances were recorded by the Case Study data and were defined by the descriptive interpretation provided by the Archaeological Contractor and were grouped into three types.

The presence of certain types of **Geological Factors** were recorded, in particular the junctions of different geologies, or underlying chalk. Descriptions of the **Soil Factors** were present in most Client reports and the authors were disposed to describe the resources available at the junction of agriculturally productive and unproductive soils, as well as the presence of especially productive soils such as brickearth, colluvium and alluvium. The final type of Natural Affordance measured from the Case Study sample was the **Ecozone Factors.** This term defines those landscape zones which provided a mixture of resources types for food, water and materials. This includes Floodplains, Estuary edge, Springs, Watercourses and River terraces as well as landscapes with a mixture of land based and coastal resources. The Geological, Soil and Ecozone Local Locational Factors recorded from the Case Study sample are listed in Appendix 3.

Both of these groups of Local Locational Factors relate to the Natural features or the landscape. To avoid pure Environmental Determinism, this study will also recognise that the features of the past landscape would have held a perceived significance for the humans acting within it.

The third group of Local Locational Factors is defined using Barrett's concept of "Inhabitation", the practical ways in which humans established their presence in the material, social and political conditions of their environment Barrett suggests that Structuring Conditions and Principles operated on the lives of the people in the past. The Structuring Conditions include the human made architectural components and topographic features of a landscape. He argues that these places and the spaces between them were perceived in past human actions in reaction to the social, political and cultural requirements of the society in which they lived (Framework Archaeology 2006).

Adopting this phenomenological approach allows the identification of the third group of Local Locational Factors which relate to the human perception of the places, structures and spaces of the surrounding landscape. As the first two groups focus on the Physical components of the landscape, it seems logical to recognise that past human actions must also been guided by perceptions of structures and places, whatever those perceptions might have been. This research is not the appropriate place for a detailed discussion of the theoretical possibilities of the nature of those perceptions. It is enough to simply identify visible structures and places within a landscape which would have been visible in the past. These structures and places may have been in contemporary use or may have been subject to perceptions of previous or ancestral use. Previous archaeological research has recognised the positioning of past human activities, and consequently the surviving archaeological features which represent those activities, in relation to the existing human activities within a landscape (Tilley 1994).

Consequently, the third group of Local Locational Factors identified from the Case Study sample attempts to identify relationships between archaeological remains to known contemporary human activities or structures. This was done using the subjective interpretations of past or contemporary human activity and structures near to each site provided in the Client Reports. Termed the **Human Factors**, the data for other nearby human activity was recorded for each period of each site's archaeological record and are listed in Appendix 4.

Archaeological recording of the known remains of other human activity provides the Information source for the recording of this group of Local Locational Factors. The Case Study sample provided many examples of HER data showing that visible human architectural remains were present in the landscape from at least the Bronze Age onwards. Visible standing monuments still survive today from most periods. The Bronze Age burial mounds and field enclosures still survive in some form in parts of the modern English landscape. They are recorded in close proximity to the potential development sites in the Case Study sample, as are the Iron Age and Roman field systems, settlements and roads which are recorded on HERs around the country. Saxon settlements and cemeteries are known from archaeological evidence and are demonstrated to lie near by the Case Study sites. It is logical to assume that some of these past or contemporary structures would have been the subject of human perception in the past. The detail of that perception is not relevant to this study.

The three Groups of Local Locational Factors identified from the Case Study sites represent only a few of those which could be identified. This research has taken this Reductionist approach in order to stay within the word count requirements for submission of a thesis. Further research in the theoretical concept of Local Locational Factors belongs elsewhere, as its use in this research will be limited to the identification of their relationships between archaeological remains from the Case Study to illustrate the Decision Analysis of the Logical Operation of DMP 12b. The results of this characterisation exercise will be used in Chapter 8 to investigate whether Premises can be drawn up about Predicted Presence using Local Locational Factors.

4.3 Decision Strategy Conclusions

As DMP 12b was identified as operating under Conditions of Incomplete Knowledge in Section 4.1, the most appropriate Decision Strategy has been identified as the use of Extreme Expected Maximum Value. This is a radical new departure from existing thinking, which focuses on Uncertainty and Risk. This represents a significant breakthrough in approaching this problem. This research has introduced the two new concepts - Conditions of Incomplete Knowledge, and of the use of Extreme Expected Value - as a strategy to deal with these Conditions. The Process Model of the Decision Situation in Figure 18 is also an innovation, as the first archaeological representation of the Logical Operation of Decision-making in a Curatorial Archaeological context. The Decision Objectives, which guide the Logical Operation of DMP 12b, were identified and discussed in Section 4.2.

This application of Decision Analysis to DMP 12b still requires the creation of the two Value Scales which will be used to test the Soundness of its Premises. Sections 4.4.1 and 4.4.2 have shown that no appropriate Value Scales currently exists to measure the Effectiveness of Field Evaluation techniques and the Probability of Presence of the Alternative States of Nature. Therefore this study has identified and defined the additional concepts of the Characterisation of States of Nature and Local Locational Factors as appropriate Value Scales to assist the Decision Analysis. The next stage of this application of Decision Analysis to Decision-making Point 12b is the collection and analysis of the Case Study Data to feed into the Model of the Logical Reasoning of the Decision Situation. The methodology for the collection of this data is described in Chapter 5. The Model is then tested to investigate whether the Premises of the Propositions are Logically Sound in Chapters 6 and 7.

Chapter 5: Developing a methodology to investigate the effectiveness of Field Evaluation

Two of the Objectives of this research have now been successfully achieved. The concept of Process Modelling has now been applied to the Archaeological Assessment Process to identify Decision-making Point 12b as the most appropriate area for improvement. The Decision Analysis carried out in Chapters 3 to 4 has now identified the procedures and tools required for the Logical Operation of this Decision-making Point.

The third stated Objective is the development of quantitative methodologies to measure the effectiveness of Field Evaluation techniques. The need for the development of the two Value Scales of Effectiveness of techniques and Probability of Presence to assist the testing of Soundness of the Premises of Propositions has now been highlighted in Chapter 4. The remainder of this study will focus on the Logical testing of the Premises of DMP 12b. This will require the collection of Case Study Data, the definition of the two Value Scales, and the testing of their application.

The concept of Characterisation of the Archaeological resource has been introduced and used to define the States of Nature in Section 4.2.2. This has produced a standardised representation of archaeological remains which can be used to model the information from the Case Study sites. The introduction of the concept of Local Locational Factors and their identification from the Case Study sites will allow some measure of the Value Scale of Probability of Presence to be made from this Model. The Value Scale of Effectiveness of techniques will be identified in this Chapter. The Premises of DMP 12b can then be Logical tested for Soundness on the Model of Case Study Capta using these newly identified Value Scales. The methodology for the collection and recording of this Case Study information used to populate the Model is set out in this Chapter.

The methodological approach for this research is influenced by three assumptions. The philosophical study of the reality or the nature of being of academic research is called Ontology. The reality of this research is necessarily Interpretive, as it is carried out on a Model representing the archaeological resource. This Model will be built from Capta presented in Client Reports, thus allowing a level of subjective interpretation provided by the archaeological explanations made by the authors. The classification of that Explained Capta into the Characterised States of Nature, Scale of Effectiveness and Scale of Probability of Presence is also subjective to a degree.

Yet the second assumption, the Epistemology of this research, provides a greater level of Objectivity than previous studies. Epistemology is the philosophical study of the validity of knowledge. This defines Objectivity in research as the adherence to factual truth and the avoidance of prejudice and bias. Although this research is necessarily focused on Explained Information, two elements provide some degree of observance of Objectivity. The quantitative testing of the Effectiveness of Evaluation techniques in Chapter 7 conforms more to the Objective scientific approach than previous studies. The construction of the Model of the States of Nature using Information from a Case Study sample of actual evaluated and excavated sites also adheres to methods that have been shown in earlier chapters to improve the reliability of the results of the research.

The third assumption affecting this research has been demonstrated clearly in Sections 2.1 and 4.4.2. The assumption underlying my approach to the archaeological resource is that past human action requires interpretation within Socio-Cultural Systems. The methodology for the selection and collection of the Case Study sample, the selection and recording of Capta from the sample and the analysis of those Capta are influenced by all of these philosophical assumptions.

5.1 Case Study Sample Selection

The testing of the Logical Operation of Decision Making Point 12b requires the creation of the Model of the Alternative States of Nature, the Probability of their Presence and measurement of the Effectiveness of Alternative Courses of Action. To ensure the robustness of this Model, it will be populated with data recorded from real archaeological interventions carried out under the current approach required by PPG16 in England.

A useful starting point for the identification of an appropriate Case Study sample of sites was provided by the database of Grey Literature created by Bournemouth University's Archaeological Investigations Project (AIP). After undertaking the statistical analysis of Archaeological Assessments between 1990 and 1999 published by Darvill & Russell (2002), this project has continued to collect information from the reports published by archaeological contractors, curators and consultants in response to the requirements of PPG16.

The number of sites selected for the Case Study Sample was chosen to represent a statistically valid sample. The previous AIP research had shown that 9554 Archaeological Field Evaluations were carried out between 1990 and 1999 in England (Darvill & Russell 2002). It was decided a Case Study sample of two hundred of these interventions, representing 2.09% of the total, could act as a legitimate representation of the reality of the archaeological resource.

A batch of two hundred sites was initially selected from the AIP database using a random number generated selection procedure. Because of the complexity and differences between the Characterised components of urban and rural archaeological remains, it was initially decided that it might be difficult to make valid comparisons between them. So the first selection of Case Study sites was targeted to provide two separate groups of one hundred Field Evaluation interventions from both rural and urban sites.

Whilst the AIP project collects data from all geographical areas of the country, a smaller geographic area was required in order to provide compatibility of location and landscape types. The selection of the first random sample of AIP sites was made in November 2000 and the initial methodology was to restrict the number of Counties covered to the smallest possible and ensure that the Counties selected were in immediate proximity to each other. The geographic area was defined as the neighbouring local authority areas to the Isle of Wight as my current location, in order to reduce time and costs of data collection visits.

In practice, the research requirement for a site to have also been fully excavated as well as subject to a Field Evaluation greatly reduced the number of available sites. The number of Evaluated sites which subsequently went on to be fully excavated in each County or District was found to be small. This is mainly due to the Presumption in Favour of Preservation In-situ for any nationally important remains discovered during Field Evaluation as outlined in PPG 16. Full Excavation only occurs within PPG16-led Decision-making Situations as a Mitigation procedure to record remains which will be destroyed by development proposals that cannot be amended. The thoroughness of Archaeological Curators and Planning Officers in ensuring that Preservation In-situ is carried out at as many development sites as possible is evident from the figures produced in the AIP research.

The statistics collected by Bournemouth University show that only 1337 or 13.9% of the sites evaluated between 1990 and 1999 in England went on to be fully excavated (Darvill & Russell 2002). That this small national percentage was also reflected at a County level became apparent during the Collection phase. It is demonstrated by statistics collected during a data collection visit to Kent County Council's Historic Environment Record in December 2004. I carried out a manual search through the printed list of reports of archaeological interventions carried out in the County between 1990 and 2004. This revealed that only 918 of the total of 4024 archaeological interventions recorded on the HER database were Field Evaluations and of these, only 39 were on rural sites which has gone on to be fully excavated.

Consequently the initial random sample of Evaluated sites produced by the random generation from the AIP database did not provide the required number of Evaluated and Excavated sites for the Case Study sample. The geographic area required to gather the appropriate number of case study samples was subsequently redefined. It was widened to include those local authorities covered by the English Heritage Regions of the South of England as shown in Figure 23. This comprised the Counties of Bedfordshire, Berkshire, Buckinghamshire, Cornwall, Dorset, Essex, Hampshire, Hertfordshire, Kent, Oxfordshire, Somerset, Suffolk, Surrey, West Sussex and Wiltshire and the Unitary Authority areas of Milton Keynes, Peterborough, Plymouth, Southampton and Winchester. This geographic area equates to English Heritage's

South East and South West Regions, with the addition of the Counties of Essex and Suffolk from the Eastern Region.

The initial random sample of Case Study sites was then supplemented for the selected local authority areas by two additional searches of all Evaluated sites recorded on the AIP database. The second random search, carried out in January 2002, generated all of the Interventions for the wider geographic area between 1990 and 1999. The final random search, undertaken in August 2004, extended the chronological spread of the study to include all interventions recorded on the AIP Database between 1999 and 2004. These additional selections also failed to produce the chosen number of appropriate sites, but the shortfall was redressed by the identification of a number of additional extra sites produced since the AIP database search was carried out, during the data collection visits made to Historic Environment Records between 2004 and 2006.

5.2 Case Study Sample Collection

The collection of the Case Study sample reports was carried out between 2000 and 2006. Such a long period of data collection did not occur in isolation as other research was carried out during this period. But the time constraints produced by working as a full time County Archaeologist and undertaking the research on a part-time basis were considerable. The time required to make visits of several days duration to copy reports from twenty Historic Environment Records spread over the South of England was considerable. The time needed to read and record data from 390 archaeological reports collected was greater still.

The initial wider aim of the research to analyse and compare the collected data from 200 sites, half urban and half rural, had to be redefined in 2004 when it was realised that the collection of data for 200 sites would take too much time. It was decided to focus the research more tightly onto the analysis of the 100 rural sites only. The reasoning behind this selection was twofold. As Section 4.4.2 shows, the urban archaeological resource is better served during the PPG16 Decision-making process by Urban Archaeological Databases, which can act as Predictive Models for presence of archaeological remains. The more localised nature of archaeological remains within the spatial constraints of an urban settlement was the second reason for the restriction of this study to rural sites. The unused Case Study data for the 100 urban sites awaits further research. The 100 rural sites selected for the Case Study sample comprises a smaller sample of the total number of evaluations recorded within England between 1990 and 2004. The AIP database shows an additional 7335 Field Evaluation interventions carried out in England between 2000 and 2004, giving a total of 16,809 in this period. The Case Study sample of 100 sites represents 0.59% of that total. Although reduced from the initial sample percentage, this Case Study sample still represents a statistically valid number of sites and comprises by far the largest sample to be subjected to detailed quantitative analysis.

The Historic Environment Records holding copies of Grey Literature reports selected by the three interrogations of the Archaeological Investigations database were contacted in two phases by both email and letter. Reports from the first two AIP searches in November 2000 and January 2002 were collected during 2001 and 2002. Photocopied reports were provided by some HER Officers when paper or digital copies of reports could be sent through the post at a reasonable cost.

The first data collection phase resulted in copies of reports being sent by Gloucestershire County Council, Cornwall County Council, Dorset County Council, Essex County Council, Hampshire County Council, Hertfordshire County Council, Peterborough City Council, Suffolk County Council and Wiltshire County Council. Personal visits were then made to Gloucestershire County Council in 2001 and West Sussex Council and the Greater London Archaeological Advisory Service in 2002 to copy and record archaeological intervention reports from the larger numbers of sites.

Reports from the final AIP database search in August 2004 were requested by email and letter during the remainder of that year. This resulted in copies being received by post from Southampton City Council, Berkshire County Council, Dorset County Council, Milton Keynes Council, Plymouth City Council, Somerset County Council, Winchester City Council and Wiltshire County Council during 2004.
Personal visits were then made to Hampshire County Council and Kent County Council in 2004, to Surrey County Council, Southampton City Council, Bedfordshire

County Council, Buckingham County Council and the Greater London Archaeological Advisory Service in 2005 and to Kent County Council and West Sussex Council in early 2006.

The data collection phase resulted in the collection of copies of the 207 archaeological reports for one hundred rural sites and these are listed in Appendix 5. This detailed dataset is the largest sample collected from Field Evaluations in England. The data it contains will be analysed to improve Decision-making at DMP 12b. The breakdown of the Case Study Sample of rural sites by Local Authority and development type is shown in Figure 24. Reports were collected for ten sites from the County of Bedfordshire, nine of which were related to the A421 Great Barford Bypass development and the remaining site at Marsh Leys Farm associated with a commercial development scheme. Nine sites were discovered which fitted the parameters of the Case Study sample in the County of Buckinghamshire. These were split equally with three each related to road schemes, mineral quarrying and residential developments. Only two appropriate sites were collected from the County of Cornwall, one being associated with the St. Austell NE Distributor Road scheme and the other, West Waste, associated with a water main replacement programme. Reports for another ten sites were collected from the Greater London Authority area. Only Sipson Lane was related to mineral quarrying, with four of the remaining sites associated with commercial or industrial development. Five of the sites from the Greater London area resulted from residential development proposals.

Client reports for six sites were collected from the County of Hampshire and all were associated with residential development. The greatest number of sites from one Local Authority area were assembled from the County of Kent. This was mainly because of the major programme of archaeological works associated with the Channel Tunnel Rail Link and twenty of the thirty-nine sites from this County were associated with this major rail development scheme. Eight other sites from Kent were also related to road schemes, six to residential and two to commercial or industrial development. The final site from Kent was discovered due to proposals to construct a new crematorium. Only one site, Tanholt Farm, was identified from the Peterborough Local Authority area and was related to mineral extraction proposals. Another thirteen sites were identified from the County of Surrey. Five of these were also associated with mineral extraction, one with commercial development and the remaining seven with residential development proposals. Reports for five sites were collected from Suffolk. Again, three of these were related to road schemes and the remaining two related to commercial and residential schemes. The three sites from the West Sussex Local Authority area were associated with one road scheme and two residential development proposals. Finally, reports for one site, Rixon's Gate, were collected from the County of Wiltshire and one site, Buncefield Lane, from the County of Hertfordshire.

5.3 Selection of Data

5.3.1 Analysis of Performance Measurement Data

The initial aim of the research was to measure the performance of Field Evaluation techniques at identifying Secondary Raw Capta from the components of the archaeological resource characterised in Section 4.2.3 above for all of the six questions asked at Decision-making Point 12b. The Raw Capta groups required to answer the six questions of Date, Nature, Location, Extent, Preservation and Fragility of surviving archaeological remains were identified in Figure 19. The Secondary Raw Capta Sets of information required by each question were then identified and their appropriateness for use in Effectiveness measurement in this study was assessed.

5.3.1.1 Date of Archaeological remains

The importance of dating archaeological remains in the Field Evaluation process is enormous. Archaeological Curators require Information about the dates of periods of past human activity on a site in order to define the role of any surviving remains within the chronological development of the site, as well as the importance to be assigned for Mitigation purposes. Previous national professional archaeological studies and the required structure of HER data recording have used a classification based on broad cultural chronologies or "Periods". These are defined as being Palaeolithic, Mesolithic, Neolithic, Bronze Age, Iron Age, Roman, Saxon, Medieval, Post-medieval and Modern (Darvill & Fulton 1988, 8; Darvill 1988; MIDAS 1998). The exact dating of each period will vary from one region to another and archaeological remains will often only be able to be ascribed to the broad classifications shown in Figure 25. It was noted that the archaeological remains recorded from the one hundred Case Study sites were already ascribed to these broad Periods through the on-site recording procedures. Therefore this classification was adopted for this study.

The requirement for the Curatorial Archaeologist to know details of the individual phases of human activity on individual sites was recognised and the initial data collection included an attempt to record the range of phases on each site. However, limitations in consistency of phase recording between the Case Study sample reports caused a reassessment of data required for the measurement of performance to be made. It was not possible to find a standard classification for the measurement of phases between sites and this potential measurement was discarded.

Therefore one Effectiveness measurement for the identification of the Date of archaeological remains has now been defined. This will consist of the success or failure of each Field Evaluation technique to ascribe archaeological remains to the Periods shown to have been present on the site from the combined information recorded in Evaluation and post-evaluation archaeological interventions. This one measurement can allow two separate analyses to be carried out. A percentage Performance Score can be produced which demonstrates the success of each technique in identifying a percentage of the total number of Periods present on a site. An analysis of which techniques failed and succeeded to identify which periods can also be undertaken.

During the later analysis of the information on Periods present recorded from the Case Study sample, the inconsistency with which the presence of Post Medieval and Modern period remains are recorded became apparent. This realisation led to the decision to exclude these periods in order to retain a robust statistical reliability of the results.

5.3.1.2 Nature of Archaeological remains

The Characterisation of the States of Nature carried out in Section 4.2.3 has provided a standardised classification of the nature of the archaeological remains present on the

Case Study sites. A quantitative measure of the Effectiveness of each Evaluation technique can be made by recording the total number of different Deposit, Feature and Structure Types for each Period, as shown in Figures 20-22, recorded by the combination of all archaeological interventions including full excavation on each site. A measurement can then be taken of the total number of the different Deposit, Feature and Structure Types recorded by each Field Evaluation technique. Again a percentage Performance Score can be reached by comparing the numbers of those Types successfully recorded by different Evaluation techniques as a proportion of the total number recorded on that site. The actual numbers of each different Type of Deposit, Feature and Structure for each period were not recorded, as the aim of this research is to measure the success rates of Field Evaluation techniques at the identification of the full range of Types present.

The Characterisation of States of Nature into Deposit, Feature and Structure Types for each period, whilst sensitive enough to the smallest Micro-environment scale of archaeological remains, proved cumbersome to manipulate when the Probability of Presence Data was being collected. Section 1.2.2 highlighted the importance of the concept of Land-use within the Development Control context of the current PPG16-led operation of Field Evaluation and the aspiration of this research to develop the concept of Characterisation of the deposits, features and structures within a Land-use context. It is at this point in the research that such a Characterisation was developed and is termed **Past Landscape Use Patterns.** This further Characterisation exercise was carried out to refine the existing States of Nature into a more concentrated classification that could be more usefully compared for each Period of human activity on a site. The concept of Past Landscape Use Patterns as a characterisation tool can allow the linkage of actual patterns of features and structures present to a method of predictive inference of presence of those combinations of features.

The context of Land-use within which the Decision-making processes of archaeological Field Evaluation occur has been described in Section 1.2.2. A clear distinction must be made between the use of the term "Land-use" and that of "Past Landscape Use Patterns" as they are used within this study. Land-use is used to refer to the current landscape uses present within the modern landscape. My classification of Past Landscape Use has been developed as a new theoretical construct to represent the evidence of past patterns of human use of the landscape.

The selection of a Land-use based Characterisation methodology was guided by three principles of the current practice of archaeological Field Evaluation within the English Local Government Town and Country Planning Process.

The relevance of the concept of past Land-uses has already been recognised by the archaeological profession in the development of Historic Landscape Characterisation techniques in England (Clark *et al.* 2004). These techniques are applied to historic mapping of the landscape's physical appearance to provide an interpretation of the sequence of past Land-uses or "Time Depth". Such explanations can then be used to assist in local and national government spatial planning processes as they model changes and impacts of future land uses on those of the present and past.

Historic Landscape Characterisation cannot be used as a representative model of the Alternative Natures of the Archaeological Resource for several reasons. The methodology itself is necessarily based on historic sources of information and there is thus little correlation between the combinations of archaeological features from periods earlier than earliest land uses which those historical maps can demonstrate.

In addition, Historic Landscape Characterisation is carried out at a County level. This provides a useful characterisation of landscape areas, but does not focus at a small enough scale to provide detailed inclusion of smaller elements of these historic landscapes. The Field Evaluation of development sites requires a model of past cultural remains present on a more detailed scale than that of complete landscapes.

The concept of Past Landscape Use Patterns has been developed by this research as a suggested methodology to bridge the current gap between the landscape focus of Historic Landscape Characterisation and the focus on the deposits, features and structures taken by the archaeological records of sites investigated by the pre-determination Field Evaluation processes. It is of additional utility because the archaeological records held by English County Historic Environment Records to inform the Field Evaluation processes also record archaeological remains at this increased level of focus.

The second factor in the selection of a Land-use based Characterisation of archaeological remains is provided by the Land-use context of current spatial planning processes. In addition to the Land-use framework within which development control practices operate, the new raft of Local Development Frameworks provide a spatial Land-use approach to Local Government forward planning. By tailoring the results of this research to a Land-use based approach, the theoretical concepts and methodologies developed can be more tightly tied into patterns of modern and historical Land-use.

There is an additional benefit to this approach related to the familiarity in perception of other operators in the local government planning process with the concept of Land-use. In my own experience, it seems that Planning Officers and Elected Councillors are often unsure of the nature and importance of types of archaeological remains. Even when explanations of these factors are provided by a Curatorial Archaeologist, the specialist knowledge of the form, complexity and relative importance of the archaeological resource are little understood.

Whilst the English School system has ensured that many reasonably well informed members of modern communities are aware of Roman villas and Norman castles, for example, it is rare that many people understand what a Neolithic Mortuary Enclosure or Iron Age settlement is. A representation of the archaeological resource based upon Land-use may be perceived as being of more relevance to modern spatial planning processes than a site or feature based approach.

The final factor influencing the choice of a Land-use based Characterisation approach is the recognition amongst the archaeological profession that there are relationships between patterns of past Land-use at particular sites and archaeological monuments. The patterns of survival of archaeological monuments in relation to modern Land-use and their recent change patterns have been identified and used to produce projections of future change (Darvill & Fulton 1998). As a tool to manage the archaeological resource, this approach firmly set the management of monuments into a research structure responsive to land utilisation.

The selection of a suitable Land-use based classification system for the development of a system of Past Landscape Uses was suggested by the Monuments at Risk Survey (Darvill & Fulton 1998). Carried out in England between 1994 and 1996, this study suggests that, in the absence of a suitable classification within archaeological resource management, the Land-use classes published by the Land Use Statistics Advisory Group (LUSAG) could be used (LUSAG 1993). Developed on behalf of the British Government for the provision of statistics of land use change, this classification provides 12 broad and 53 narrower types that can be used as the basis for the development of this new concept.

Because of the reduction in sensitivity of the Broad LUSAG classification in correlation to rural areas, the 53 narrow land use types were reclassified for this research to produce three broad categories of Past Landscape Use types, numbered 1.0 to 3.0, below.

The three tiers of Land-use used in the classification of Past Landscape Use Patterns allow a differentiation to be made between the intensity of patterns of features. **Natural or Managed Past Landscape Uses** (1.0) are shown in the table in Figure 26. They are defined by their nature of either not being produced by human activity or being less intense activities over larger areas of a landscape, such as agriculture or forestry which can be classified as being isolated from human settlement.

Human Past Settlement Uses (2.0) are defined as composite patterns of intensive activity associated with either permanent or temporary settlement and are shown in Figure 27. They include the structures and activities of Single Dwellings as well as the social range of Aggregate Dwellings from the simplest Farmsteads to Cities and Palaces.

The final group of Past Landscape Uses have been termed **Other Human Landscape Uses** (3.0) and are shown in Figure 28. This last group includes all the remaining composite patterns of intensive human activity which are separate from the direct settlement Land-uses. Figure 28 shows that these have been classified into several distinct groups including Industrial and Commercial, Vacant, Boundaries, Ritual and Funerary, Defence, Military, Minerals and Landfill and Transport and Communication. All other Landscape Uses are grouped into the final class called Other. All of the Other Human Landscape Use Patterns may be associated with settlement or can occur in isolation.

The Maximum Extreme Expected Value on the Effectiveness Scale for each site was measured by recording of the total number of each different Past Landscape Use Pattern for each period identified from the combination of all archaeological interventions, including Full Excavation. A percentage Performance Score for each Field Evaluation technique can be measured by comparing the numbers of those Past Landscape Use Patterns successfully as a proportion of the total number recorded on that site.

This measurement of the Performance Patterns for the identification of both States of Nature and Past Landscape Use Patterns for each Period will allow detailed analysis of the Effectiveness of Evaluation techniques. The Effectiveness of each technique can be assessed by the success of which combinations of Deposits, Features and Structures it is able identify and which it is not. The analysis of Effectiveness of identification of Past Landscape Use Patterns can identify similar success patterns and also be used in the analysis of Probability of Presence.

5.3.1.3 Location of Archaeological Remains

The concept of location required by Curatorial Archaeologists at Decision-making Point 12b is defined as the place or position of archaeological remains within the development site. A measurement of the Effectiveness of Field Evaluation techniques to successfully identify the location of archaeological remains would have to compare the predictions of Field Evaluation Client Reports with the remains proven to be present on a site by subsequent Full Excavation.

Concerted and detailed attempts were made to identify a quantitative measurement of location from the Case Study sites. First a methodology of overlaying grids over horizontal archaeological plan diagrams from the Field Evaluation and Excavation reports was used. A measure of Presence or Absence was applied to each for archaeological remains from each period in each square metre of the site's area. However, it proved impossible to manually overlay the plans of recorded Primary Capta from the site reports due to the very large range of inconsistent, and sometimes absent, scales used.

A manual scanning into a digital format using the ArchView Geographic Information System programme was then attempted for twenty of the Case Study sites with the aim of rescaling and overlaying all plans with a 1m square grid. Unfortunately, the time limits of the Data Collection stage combined with the inconsistencies of drawn records and the huge number of plans of very different sizes and scales in the case study sample made this impossible to do within the time constraints of this current research. Consequently this Measurement was excluded from the Research.

5.3.1.4 Extent of Archaeological Remains

The Secondary Raw Capta Sets for the coverage of archaeological remains require the measurement of three-dimensional spatial characteristics. The Monuments at Risk Survey measures the physical characteristics of individual monuments using spatial measurements of area of current and estimated extent of remains. This approach was modified to include the Area of Extent in square metres and centimetres to measure horizontal characteristics. The vertical characteristics were measured using two measurements, both in metres and centimetres. A Maximum Depth was measured from the modern ground surface to the base of archaeological deposits and a Minimum Depth was recorded from the modern ground surface to the top of the archaeological deposits.

During the Data Collection visits and the actual recording of these measurements, it quickly became apparent that this data was not regularly included in either the Evaluation report or the Post-evaluation Excavation report. The absence of this data from a substantial number of the Case Study sites meant that not enough data was available for a valid comparison. Consequently, this Capta Set was discarded as a viable measurement of the Effectiveness of Field Evaluation Techniques.

5.3.1.5 Preservation of Archaeological Remains

The classification of the state of preservation of archaeological remains is difficult to measure objectively and previous national studies of preservation of visible monuments have identified that its definition is problematical (Darvill & Fulton, 1998, 99). The current professional interpretation of the state of preservation at Decision-making Point 12b is underpinned by information on several physical properties of the archaeological resource and its burial environment. This Capta Set is an aggregation of interpretations of the physical nature of archaeological remains, the physical burial conditions, post depositional disturbance affects. These are combined to produce an interpretation of the range of remains and the capability of the site for long-term preservation. Each of these three Capta Sets will be assessed to identify potential classifications of the State of Preservation which might be used to measure the Effectiveness of Evaluation techniques against.

Field Evaluation interventions at DMP 12b are required to provide information on the survival of the organic and inorganic components of the resource. The scientific value of organic archaeological materials is of particular interest as they can provide a wide range of evidence of the human activities and the surrounding environment of a site. In addition the nature of the Stratigraphic relationships between these components is important. Sites which contain archaeological remains with short, isolated stratigraphic sequences can provide less information about chronological relationships between human activity than those with long, well-dated sequences. Consequently, a simple classification of the range of components and their stratigraphic relationships can be made. The presence of a wide range of organic and inorganic components with long stratigraphic sequences can be classed as Good survival. A small range of components with short stratigraphic sequences can be classed as Poor Survival. This leaves survival of both categories of information between these extremes to be classed as Medium.

Schiffer has described the decay processes which result in the existing archaeological remains (1987), and it necessary for the Curatorial Archaeologist to consider likely taphonomic processes which may have caused chemical and physical attrition to buried remains. The physical burial conditions to which the archaeological have been subjected since deposition have been widely researched. The chemical affects of inorganic mineral and organic components of the burial environment, including water and acidity, have already been discussed in the context of development impact (Pollard 1996; Banwart 1996; Hopkins 1996). The effects of these processes can also be classed into the broad categorizations of Good, Medium and Poor Condition.

Post-depositional human and natural activities will all have exerted varying degrees of disturbance to archaeological remains over the centuries or millennia since burial. The nature of disturbances related to subsequent land-use, and the consequent effects on the potential survival of archaeological information for visible monuments has been demonstrated in previous studies (Darvill & Fulton 1998; Darvill 1987). The Monuments at Risk Study measured the degree of disturbance of archaeological monuments and their associated artefacts and ecofacts using a classification which is of use to this study. They include measurements of damage to a monument in relation to its size and form. "Widespread Disturbance" occurs over all or most of the site, "Localised Disturbance" is confined to a few areas; "No Impact" records undisturbed remains, "Peripheral Disturbance" for which only the edges of a site are affected, "Segmenting Disturbance" in which a site is split parts and "Neighbourhood Disturbance" which occurs all around, rather than over the site (Darvill & Fulton 1998).

A measurement of these three Capta Sets was then attempted for the archaeological Field Evaluation techniques from the one hundred Case Study sites. However, this proved unsuccessful for a number of reasons.

None of the Case Study Field Evaluation reports provided more that a general statement of Survival, Burial Conditions or Degree of Disturbance for the site as a whole. There were also very few statements of information for these three measurements in the post-evaluation Excavation reports. Although this is reasonable as the function of such reports within the Development Control process does not require such information, it did not allow the necessary accurate comparison to be made to measure Effectiveness of Field Evaluation techniques. The terms used to describe the Survival, Burial Conditions and Degree of Disturbance also varied too greatly for comparisons to be made between different sites. It was recognised that too little Information was available to allow quantitative measurement to be determined and this Capta Set was discarded as a viable Performance Measurement for this study.

5.3.1.6 Deposit Fragility

The concept of the fragility of archaeological remains is firmly embedded into the English Government's advice to planning authorities, property owners, developers, archaeologists, amenity societies and the general public (DOE 1990, 6). In this context, Fragility defines the inherent quality of archaeological remains to be damaged or destroyed by development and other land uses. This definition does not include the implications that the physical remains of past human activity lacks substance or are particularly delicate. Rather it sets out the Government view of the vulnerability of the remains to destruction within the context of the sustainable management of a finite resource.

However none of the Case Study reports yielded direct references to any interpretation of the Fragility of the archaeological remains recorded. It seems that the general principle of Fragility is implicit in both the recording of Raw Capta and its interpretation of this as Secondary Capta. The resulting Client Reports thus contain only descriptions of the additional special characteristics of the preservation of these fragile remains.

It seems that the accepted Fragile nature of archaeological remains is recorded and explained implicitly within archaeological Field Evaluation. Consequently, the need for the additional identification of this issue at DMP 12b, as set out in PPG16, has not been translated into the specific interrogation of the resource in current professional practice. This Capta Set was discarded as a viable performance measurement due to the complete lack of data within the Case Study sample.

5.3.1.7 Selection of final Performance Measurement Capta Sets

The analysis of the Secondary Raw Capta Sets required to answer the six questions asked at Decision Making Point 12b has now been undertaken. This shows that the questions asked of Fragility and State of Preservation cannot be used as quantifiable Effectiveness measures due to lack of information provide by the Case Study sample. The Capta Sets used to answer the questions and Extent and Location of archaeological remains were demonstrated to be too time consuming and technologically difficult to measure. Therefore the two Secondary Raw Capta Sets selected for the research into the Effectiveness of Field Evaluation techniques will be the Date and Nature of the surviving archaeological resource.

The measurement of the Effectiveness of the Field Evaluation techniques as Alternative Courses of Action at Decision-making Point 12b will thus be based upon the performance of each to identify the Capta Sets of Date and Nature.

5.4 Data Recording

Two different types of Data Collection Sheet were designed to collect the information from the Case Study reports in a consistent manner. A Site Data Recording Sheet was completed for each of the 100 rural Case Study sites and a completed example is shown in Figure 29. This allowed information to be recorded about the site and its Local Locational Factors including the Geology, Topography, Soils and Natural resources. All intervention reports collected for each site were used to gather the information for the Site Data Recording Sheet. This form also recorded any available evidence for the immediate environment of a site, often relying on Environmental Archaeological analysis carried out after the full excavation, to identify any other natural resources evidenced to have been made use of during each period of past human activity. Information about the human activities and structures from each archaeological period in the near vicinity of each site was recorded in the Situation box. This was usually provided by the Desk Based Assessment part of the intervention reports and its collection will allow the Human Factors of each period to be analysed. The final recording box on the Site Data Recording Sheet was completed after the rest of the analysis had been completed. This was used to define the Past Landscape Use Patterns evidenced by all of the Features and Structures recorded to have been present by all of the interventions.

The Case Study Intervention Data Recording Sheet was designed to record the Performance Measurement Data for every separate Field Evaluation intervention on each site. The completed example shown in Figure 30 is for the Evaluation Trenching intervention carried out at Sipson Lane. Information was recorded about the methodologies of each technique, including the spatial area of the Field Evaluation compared to the total spatial area of the site, patterns of Field-walking and Trenching arrays, size of trenches and any information contained within all the reports about the Effectiveness of the Evaluation technique. The success of the technique at identifying each Period shown to be present in the Full Excavation was also recorded and the percentage of periods successfully identified was recorded on this Sheet. Finally the names of each characterised Feature and Structure for each period successfully identified by that Intervention were recorded.

The same form was used to measure the Information from the post-evaluation Excavation interventions and the completed Case Study Intervention Data Recording Sheet for the Post-evaluation Excavation at Sipson Lane is shown, as an example, in Figure 31. This recorded any Information from the Excavation about the overall sequence of past human action which might be of use during the analysis of Effectiveness of techniques and Probability of Presence of the States of Nature. Every period which was identified as being present on the site was recorded on this Sheet, as were the names of each characterised Feature and Structure for each Period identified. It was important to record the data from the post-evaluation Excavations on a separate Sheet so that the comparison of this information with the Performance of Field Evaluation techniques could be made.

The data collected on all of the Data Collection sheets was then added to an Access database created specifically for this project, to allow comparisons to be made. The completed Database is included as Appendix 6 on the attached disc.

This Database was designed to be in a Switchboard of Forms format to allow easy access to the data. Once the Database has been opened the Main Switchboard provides three options that can be accessed by clicking on the relevant box. The Main Switchboard Form is shown in Figure 32.

The Query Option allowed the comparison of Features and Structures recorded in all Interventions to be made. Clicking on the Deposits, Features and Structures box brings up a Query Form, shown in Figure 33 for which the name of each of the 100 Case Study sites can be selected by clicking onto it on the pull down list accessed by clicking on the arrow to the right on the blank box. Once the site name is selected, a click on the Query box below it performs the search of the database to produce a list of all Deposits, Features and Structures recorded for each period by every Archaeological Intervention carried out in the site.

The add/Edit Switchboard Option allows the user to reach the Data Collection Switchboard as shown in Figure 34. The add/edit Land Use Groups box allows access to the list of Past Landscape Use Patterns classifications as identified in Section 5.3.1.2 and the tables in Figures 26-28. The add/edit Settlement Group box allowed access to a list of the Human Settlement classifications. The next three boxes allow access to the lists of the characterised States of Nature identified in Section 4.4.1. The add/edit Deposit Groups box allows access to the characterised list of Deposit Types shown in Figure 20. The add/edit Feature Groups box brings up the list of the characterised Feature Types identified in Figure 21 and the add/edit Structure Groups box provides the same function for the list of characterised Feature Types identified in Figure 22.

The data recorded on the Data Collection Sheets can be accessed by clicking on the add/edit Site Details box. This reaches the Forms recording all data about each individual site. The Forms for each site can be accessed by either typing the site name into the search box at the top of the page or selecting a site from the drop down list provided when one clicks onto the arrow at the right of the box and clicking on the Return key. There are six Forms for each site, each accessed by clicking onto the Tab below the Site Name, and they record the data collected from the Case Study reports under the headings of Topography, Natural Resources, two Situation pages, Land Use Patterns and Interventions.

The first four Forms record the information about the Local Locational Factors identified in Section 4.4.1. The Topography Form records the position and orientation of the archaeological remains in relation to the Topographic Factors shown in Appendix 2. A completed Form is shown as an example in Figure 35. The Natural Resources Form allowed the free text recording of information on the geology, soils, water supplies, flora, fauna and other Natural Affordance Factors listed in Appendix 3 and a completed example is shown in Figure 36. The two Situation Forms recorded any free text information from all of the intervention reports about the Human Factors listed in Appendix 4. This included relationships between nearby existing or past human settlement, structures, communication activity and other evidence of human activity. These were recorded for the Palaeolithic, Mesolithic, Neolithic, Bronze Age, Iron Age, Roman and Saxon periods on Situation Form 1 and a completed example is shown in Figure 37. The second Situation Form recorded the same data for the Saxo-Norman and Medieval periods as well as the 16^{th} Century, 17^{th} Century, 18^{th} Century, 19^{th} Century and the current 20^{th} Century. A completed example is shown in Figure 38.

The Land Use Form recorded the sequence of characterised Past Landscape Uses identified in Section 5.3.1.2 above for each period and listed in Figures 26-28. A completed example is shown in Figure 39. Drop down lists of periods and Landscape Uses were available for the Data entry to ensure consistency of recording and any found to be not present were added to the list as the Data was entered into the Database.

The Interventions Tab allows access to a Form for every Intervention carried out at each site. Separate Forms were used for the data on each Intervention Data Recording Sheet. An example of the completed Forms for Evaluation Trenching and Post-evaluation Excavation Interventions at Sipson Lane are shown as examples in Figures 40 and 41.

5.5 Assessment of Data Quality

The quality of the Data provided in the Case Study Reports varied in content and quantity. Generally the information required to populate Site Data Recording Sheets proved to be easier to gather and required less interpretation than that required for the Intervention Data Recording Sheets.

Descriptions of the Geology at each site were included in Client Reports for 80 of the Case Study sites and, because of the consistency of descriptions of Solid and Drift geology, was judged to be reliable enough to be simply copied onto the Data Recording Sheets. However fewer descriptions of nearby Topographic Features (78 sites) and Soils (64 sites) were present in the reports. There was also less consistency in the descriptions of both. With no professional requirements for standard description of Topographic features in Client reports, the Information provided seemed to rely on the author's recognition of such features, rather than a full description of all present. The collection of the data for the completion of this part of the Data Collection forms required the close scrutiny of the entire report to identify mentions of any Topographic Features or soils present. It is accepted that the data collected from the Case Study sites may not represent the full range of those present on the actual sites. However, the Model populated by the data collected will be appropriate to use as a Model for the archaeological resource for this analysis.

The descriptions of the Resources available in each Period, Environmental Evidence and Situation in each Period proved to be even less consistent and required an element of archaeological interpretation to gather. The Resources and Environmental data were particularly difficult to identify and involved the detailed interpretation of limited HER data and any Environmental Analyses carried out during Post-evaluation Excavation Interventions. In particular, Client Reports for large sites which were subject to many sequential Archaeological Interventions (e.g. the Channel Tunnel Rail Link Project sites in Kent) often omitted this information as it was available in the Desk Top Assessment (DTA) phase of the project. Some of these DTA reports were not available at the Historic Environment Records when the Data Collection visits were carried out. It must also be accepted that the Information for the Situation in each Period data does not represent the full record of past human activities and structures, but only the known information recorded on the HER databasess.

Detailed archaeological interpretation was required to classify the patterns of Features and Structures into the Past Landscape Use Patterns which were also recorded on the Site Data Recording Form. However the simplicity of the classification system meant that, although extremely time consuming, this interpretation was straightforward.

The data collected for the Intervention Data Recording Sheets was more complicated and required repeated detailed analysis of the Information actually held in the Client Reports. The descriptions of the methodologies of the different Field Evaluation techniques were particularly difficult to gather. The majority of the Field Evaluation reports referred the reader to the Archaeological Curator's Brief for Archaeological Works which guided the specifications of the Evaluation. Very few of these were available in the HERs visited and those which were accessible provided inconsistent information with many implicit assumptions of methodologies. Consequently the information recorded for the Intervention Data Collection Sheets had to be supplemented by manual measurements. These included total site area, sample size, arrays, trench sizes which had to be measured from plans at many scales in the Client Reports.

The range of Field Evaluation techniques for which the performance scores could be measured was affected by two biases of the data collection method. The initial identification of relevant reports for the selected sites from the AIP database proved difficult as site names varied between reports and it was impossible to identify all techniques used on some sites. The initial aim to record performance scores for all of the techniques used on all of the Case Study sites also proved unachievable because some Client Reports for some Interventions were not found during the personal visits to Historic Environment Records. This was the case in particular when the sites were part of large spatial area of development proposals or an Environmental Impact Assessment which comprised documentation produced by different Consultants and Contractors over a number of years.

The detection of the success of each Evaluation technique to identify the presence of the Characterised Features and Structures proved relatively straightforward, if extremely lengthy and time-consuming. Every description of all of the contexts recorded by every technique was read through and the first mention of each was listed. This involved the analysis of technical descriptive text and tables of contexts recorded. The list of names of Features and Structures were then consistently classified using the Characterisation system devised in Section 4.4.1.

Despite the limitations of some of the information provided by Client Reports discussed above, the data collected can still act as an appropriate model of the reality of the archaeological resource for the Decision Analysis of DMP 12b.

5.6 Data Analysis

The third Objective of this research, as set out in Section 2.1, has been fulfilled by the development of quantitative methodologies to measure the Effectiveness of Field Evaluation techniques. Now that the Case Study Data has been recorded on the Database, the analysis required to fulfil the two remaining Objectives of the research can be carried out. The Data can be interrogated to measure the Effectiveness of the Alternative Courses of Action within the States of Nature of the Case Study Sample. It can also be scrutinised to test the utility of the new concepts of Local Locational Factors and Past Landscape Use Patterns as tools to assist in the measurement of Probability of Presence. This will allow the final Objective of the identification of potential tools and approaches to provide improvements at Decision-making Point 12b to be fulfilled.

The study aims to measure the Effectiveness of the Courses of Action to test the Premises of the Propositions at DMP 12b. The three Propositions identified in Section 1.1.2 are that only Trenching is effective for the identification of the nature of the archaeological resource, that a 3-5% Trenching sample size is required and that the size between the gaps of Trenches is important. These propositions are based on the two main types of Premise, identified in Section 3.2, the proven Effectiveness of each

Field Evaluation technique in certain States of Nature and the high Probability that those certain States of Nature are present on a particular site.

The Access Database was interrogated to provide the data on the Decision Outcomes which will prove the Logical Soundness of both of these Premises, partly by using the integral query function built into the Database and partly by creation of tables which were analysed manually. That data was fed into 28 Tables within a new Access database called "Analysis Results", a copy of which is attached on disc as Appendix 7. The names of each of the Analysis Tables are underlined when first described in the text to allow ease of reference to the Analysis Results Database.

The measurement of the Effectiveness of the Alternative Courses of Action within the States of Nature of the Case Study Sample was carried out for both the Date and Nature Capta Sets identified in Section 5.3.1.7 above. This was achieved by the creation of a Table called List of Field Evaluation Techniques which recorded the 153 measurable separate Evaluation techniques carried out on the Case Study sites. The measurements of each technique's success at identifying the Date Capta Set were added to the Rural Technique Date Table. This shows the percentage Date score as well as recording which Periods were identified, which were missed and for which Periods false identifications were made. The Performance measurements of these techniques for the Type Capta Set were embedded into the same table using a small tab marked with a plus sign and placed in a column to the left of the ID number. However, it was found to be easier to analyse these if they were placed in a separate Table and the Rural Technique Type Score Table was created. This was linked to the original Rural Technique Type Score Table by the use of the same Primary Identification Key, a number in the ID column which allows the Site Name for each technique to be identified from the ID column in the embedded section of the original Table. The Rural Technique Type Score Table records the percentage score of each Type of Feature and Structure successfully identified by each Technique by period. It also provides lists of which Features and Structures were successfully and unsuccessfully recorded by each technique for these periods. This Table resulted in the scores for 550 separate periods being recorded from the 153 Evaluation Interventions from the Case Study sample.

During the analysis of the methodologies of the Field Evaluation Techniques (see Section 9.3 below), it became apparent that the only Alternative Course of Action for which the performance of different methodological approaches could be compared was machine trenching. Consequently, only that Data was collated into the Rural Trenching Methodologies Table. This Table displays the area of the total development site in square metres, the size, number and area of the Evaluation Trenches, percentage of the development site evaluated, the number of Trenches which did identify archaeological remains from the total, and any details of targeting and array methodologies which could be recorded. Data could be collected for 99 of the 100 Trenching interventions and was not able to be recorded for some classes of this Table. Enough Data was collated to allow the population of five more Trenching Methodology Tables. Four of these provide measurements for the Effectiveness of Targeted and Non Targeted Trenching for both Date and Type Capta sets. These are the Targeted Trenching Date Scores Table with data for 34 interventions, Non Targeted Trenching Date Score Table (65 interventions), Targeted Trenching Type Score Table (32 interventions) and Non Targeted Trenching Type Score Table (49 intervention) which both provide data on the nature of the targeting or lack of it. However the final Trenching Methodology Table was only able to record Performance Scores for the Type Capta Set. This is the Trenching Array Type Scores Table which contains the data from the 76 interventions at which the array and percentage Type Scores for each period could be measured.

The recording of Local Locational Factors was only carried out for the Type Capta Set and was achieved by the creation of three Tables on the Analysis Results Database. The Rural Topographic Factors Table records the general locations of the archaeological remains and their relationships to the Topographic Features listed in Appendix 2. Data was collected from 99 of the Case Study sites for this Table. The Rural Natural Affordance Factors Table records the Water, Geology and Soils data listed in Appendix 3 for 93 of the sites and the Rural Human Factors Table records the relationships to known human structures and activities as listed in Appendix 4 for 224 periods at 66 of the Case Study sites.

The analysis of Effectiveness of the Alternative Courses of Action for the Past Landscape Use Patterns was also carried out for Trenching Interventions only using just the Type Capta Set. The Rural Landuse Patterns Table records the Past Landscape Use Types for 406 different periods from 98 of the Case Study sites together with the Features which comprise those Use Types. These were distilled into Land-use Tables for each period with percentage Type scores and lists of which Features were identified and missed. 124 individual Bronze Age Land-use Types are recorded in this way in the BA Land-uses with Type Scores Table. These were concentrated into two more detailed Tables, the BA Intensive Land-uses with Type Scores Table and the BA Isolated Land-uses with Type Scores Table. A total of 144 Iron Age Land-use Types are included in the IA Land-uses with Type Scores Table. Again these were broken down into two more detailed Tables, the IA Intensive Land-uses with Type Scores Table and the IA Isolated Land-uses with Type Scores Table. A total of 175 Roman Land-use Types are recorded in the Rom Land-uses with Type Scores Table and concentrated into the Rom Intensive Land-uses with Type Scores Table and the Rom Isolated Land-uses with Type Scores Table. Only 61 Saxon Land-uses are recorded in the Sax Land-uses with Type Scores Table and were split into the Sax Intensive Land-uses with Type Scores Table and the Sax Isolated Land-uses with Type Scores Table. Finally 85 Medieval Landscape Use Types were recorded on the Med Land-uses with Type Scores Table and were further divided into the Med Intensive Land-uses with Type Scores Table and the Med Isolated Land-uses with Type Scores Table.

The Logical testing of the Premises of the Propositions at Decision-making Point 12b will be carried out within the Decision Analysis Framework which forms the structure of this research. This was identified in Section 1.3 and is shown in Figure 4. The next stage of this application of Decision Analysis is the identification of the Decision Options from the Alternative Courses of Action undertaken at the Case Study sites.

The creation of the 28 Tables in the Analysis Results Database will allow the precise nature of the Decision Options to be refined so that the Outcomes can be quantitatively measured. This will be carried out in Chapter 6, which will identify the Alternative Courses of Action from the Case Study data. The data contained in the twenty eight Tables of the Analysis Database will then permit the necessary comparisons of the quantitative measurements of the Effectiveness of the Alternative Courses of Actions in the Alternative States of Nature (the Decision Outcomes) to be made in Chapter 7. The analysis of the results of the quantitative measurements of Effectiveness of Trenching interventions in relation to Past Landscape Use Patterns and the recognition of relationships between those Patterns and Local Locational Factors will be discussed in Chapter 8.

Chapter 6: Identification of Decision Options

6.1 Decision Options

This application of Decision Analysis to Decision-making Point 12b now requires the identification of the consequences of Decision Options. The Decision Options referred to throughout this research are defined as the choices of available Alternative Courses of Action available for each mutually exclusive Alternative State of Nature. The range of archaeological techniques available for the Field Evaluation of proposed development sites initially appears to be extensive. Many different archaeological survey and investigation techniques have been applied for Field Evaluation over the seventeen years of PPG 16 led investigation in England.

The Bournemouth University overview of archaeological fieldwork carried out in England between 1990 and 1999 lists 17 archaeological techniques which were recorded as 12,203 separate interventions from the 9554 PPG16-led Field Evaluations during this period (Darvill & Russell 2002, 34). A table showing these techniques and the numbers and proportions of each recorded by the Bournemouth University study is shown in Figure 42. The Decision Options at DMP 12b are not just restricted to the choice from the available techniques, as Figure 42 shows that 12 of the techniques also have different methodologies that can be used to achieve different results. The methodological choices can be condensed into four factors which are the size of the sample units recorded, the distance between these units, the percentage of the site sampled and the array of sample units. The 17 available Field Evaluation techniques and the methodologies of the 12 for which they are available will be discussed in Sections 6.2 and 6.3 below.

The consequences of the occurrence of each Decision Option are termed the **Decision Outcomes,** as described in Section 1.2.3. It is these Outcomes which will be compared in the Prioritisation process which will select the most appropriate techniques and methodologies at Decision-making Point 12b. The development of the quantitative measurement techniques in Section 5.3.1.7 allow us to calculate the consequences of the use of each technique and any methodologies used on the Case Study sites within the same Value Scale of Effectiveness. This will allow the consistent comparison and Prioritisation of the Outcomes of the Decision Options.

An additional tool to display the Outcomes of the Decision Options is available in some applications of Decision Analysis (Cooke & Slack 1991, 14) and can be of great utility in this current application. That tool is called a **Decision Matrix** and an example of a Decision Matrix is shown in Figure 43. It is a graphic device used to assist the Decision Maker in the selection of the most appropriate Courses of Action in the Alternative States of Nature. The two-dimensional matrix models the Alternative Courses of Action on the horizontal axis and the Alternative States of Nature on the vertical axis. The Alternative States of Nature are represented by the letter N and the Alternative Courses of Action by the letter A. Each is then assigned a sequential number (N_n; A_n) The separate Outcomes of the operation of each technique in each State of Nature can then be added to the boxes created where rows and columns meet. These Outcomes are represented by the letter O and the combination of sequential numbers from both the States of Nature and the Courses of Action (e.g. O_{11}; O_{34}). For this research the value of the Outcome of each Course of Action will be calculated using the Performance Measurements scores identified in Sections 5.3.1.1 and 5.3.1.2 above. Decision Matrices will be produced for the Date Performance Scores, the Type Performance Scores and the Past Landscape Use Pattern Scores.

The Prioritisation of Decision Outcomes can then be carried out by selecting the Decision Options whose consequences best fulfil the requirements of the Decision Objectives identified in Section 4.2.

Some attributes of the nature of each of the Field Evaluation techniques available at DMP 12b are also of importance to this discussion of the Alternative Courses of Action. This is because the physical characteristics of the archaeological resource recorded by each are very different. The archaeological resource is recognised as being three-dimensional and investigative techniques are required to measure the details of its characteristics on both the horizontal and vertical scales. The ability of some of the existing techniques to record archaeological remains provides limitations in their physical scale of operation. The most limited technique in the table in Figure

42 is that of Documentary Search. This is carried out in isolation from the site itself and chronicles only information that is previously known.

Other techniques are only able to record some of the evidence available at the horizontal surface of a site and investigate the physical characteristics of any archaeological remains present at a low resolution. Ten of the 16 remaining techniques in Figure 42 are limited in this way and I have termed these as **Extensive Techniques** because they are limited to the collection of information on the horizontal extent of the site only. These Extensive Techniques include Aerial Photography, Field-walking, all three of the Geophysical Survey methods, Ground Probing Radar, Metal Detecting, Structural Survey, Topographic Survey and Visual Inspection. These Extensive Techniques are commonly used in the initial stages of a phased Field Evaluation to ascertain where Intensive Techniques should be targeted in a later phase.

The remaining six Field Evaluation techniques listed in Figure 42 have been termed **Intensive Techniques** as they record information from the vertical scale of the below ground remains as well as some of the horizontal spatial elements. These techniques are not restricted to the ground surface but record information from the below ground resource at a much higher resolution. These Intensive Techniques are Augering, Environmental Sampling, Phosphate Survey, Sample Trenching, Targeted Trenching and Test Pits.

Effectiveness scores for Date, Type and Past Landscape Use Patterns were measured as the Outcomes for 153 separate Field Evaluation techniques from the Case Study sample. The Field Evaluation techniques available and those actually recorded from the sample of 100 sites are discussed below under the groupings of Extensive and Intensive Decision Options.

6.2 Extensive Evaluation Techniques

6.2.1 Aerial Photography

Aerial photography is the oldest remote sensing technique available for the identification of archaeological remains (Wilson 2000). Photography from the air is able to recognise above ground earthworks, in conditions of shadow, frost and snow cover, in addition to the soil, moisture and crop marks that indicate below ground remains.

There are three elements to Aerial Photography Analysis for Field Evaluation purposes. An Archive search of existing photographic resources at both local and national levels can identify coverage of a particular site. The Mapping of archaeological features from known aerial photographs will rectify the measurements to allow them to be plotted on Ordnance Survey maps at scales showing their location on a site. Finally and more rarely, Reconnaissance fieldwork comprising the taking of new air photographs for Field Evaluation purposes can be carried out.

The types of Aerial Photographic survey undertaken in England can be grouped into two classes. Vertical photography is based on the high level survey of large areas carried out for military purposes during the Second World War. Cameras attached to the underside of aeroplanes fly in straight lines to take continuous photographs of the landscape. Oblique photographs are taken much closer to the ground and at an angle to the ground surface. Taken with hand held cameras they are used for specific sites which are visible to the trained aerial photographer (Wilson 2000).

The National Monuments Record of England holds 680,000 oblique and two million vertical photographs which cover the whole country and systematic Aerial Photography recording programmes are still being carried out by private specialists and archaeological bodies. English Heritage's National Mapping Programme (NMP) continues to carry out large-scale aerial surveys which identify large number of unknown sites of archaeological importance. Eighteen hundred new sites were identified during the mapping of Salisbury Plain Training Area (McOmish *et al.* 2002). The NMP mapping of the Thames Valley covered an area of 1450 km^2 and covered the Thames River Valley over parts of six English counties. This mapping programme identified over 5000 new archaeological sites, including important evidence of the layout of Neolithic sites in relation to waterways within the landscape (Fenner & Dyer 1994).

There are, however, serious limitations to the use of this archaeological technique for Field Evaluation purposes. The practical considerations of organising and funding the flights, suitable aircraft and photographic equipment often preclude the commissioning of new Reconnaissance for specific Field Evaluation situations if no aerial photographic coverage for a site exists.

The visibility of below ground remains is also inconsistent, depending on geological conditions, agricultural practices and water content on the soil at the time of the photograph being taken. In addition, there is often a very short period for which cropmarks are visible and the quality of evidence provided has been shown to be improved greatly if regular photographs are taken of the same site over many seasons (Wilson 2000).

Aerial photography techniques are also far less sensitive to smaller archaeological features such as postholes and pits. The presence of deposits of alluvium and colluvium in many areas of the English landscape also mask the underlying archaeological remains for this technique. Because of these limitations, Aerial Photography used in isolation cannot be relied on as a Field Evaluation technique. It is, however, extremely valuable as part of a programme of archaeological techniques and the value of the evidence collected by large scale systematic survey programmes is immense in England and other European countries (Evans & Williams 2000).

Use of Aerial Photography for Field Evaluations in England is shown to decline from 2.1% of interventions carried out before 1990 to only 0.54% between 1990 and 1999 (Darvill & Russell 2002). The analysis of the Case Study sites showed that Aerial Photographic Assessment was routinely carried out at almost all sites as part of the Desk Based Assessment Stage of the Field Evaluation process.

The majority of information about the results of this technique was not available in the reports collected for Data Analysis. Performance Scores for Aerial Photography were only available for the site at Marsh Leys Farm in Bedfordshire where this technique did succeed in identifying features and structures of Iron Age and Roman settlement. Because of the lack of data recorded from the Case Study reports, no analysis of the effectiveness of this technique can be carried out as part of this research, but the value of its role in identifying unknown remains over large areas of the landscape as part of systematic surveys must be recognised.

6.2.2 Documentary Search

The desk-based collation and analysis of data from maps, historical documents, geological sources, place-name evidence, HERs, the National Monuments Record and any previous archaeological literature has been formalised into the Desk Based Assessment Stage of Archaeological Assessment across Europe (Evans & Williams 2000). In England, the publication of PPG 16 with its requirement for "archaeological assessment" (DOE 1990, Para. 20) resulted in professional definition of sources and methodologies to guide its operation (IFA 1993a & b).

This formal stage has adopted the function of screening the state of existing knowledge and precedes Decision-making Point 12b. The technique itself is widely used in many other disciplines to provide exhaustive information at a minimum cost where an ample body of evidence is available. However its greatest drawback for application to the archaeological resource is the lack of systematic survey of many areas of the English landscape which may result in a lack of evidence for many potential development sites. Although it is suggested that the operation of Desk Based Assessment allows Curatorial Archaeologists more success in the persuasion of developers to fund pre-determination Field Evaluation, the profession must seriously consider the role of this technique in the Archaeological Assessment process (Tym *et al.* 1995, 12).

The increase in use of this technique since the 1990 publication of PPG 16 has been demonstrated (Darvill & Russell, 2002, 20). We must consider whether it is being used as tool of persuasion, rather than an effective Field Evaluation technique because of the poverty of the known data already collected. Hey & Lacey conclude that Desk Based Assessment performs poorly in their case study and is not cost effective as a stand alone Field Evaluation technique, yet it is invaluable as the first stage of definition of broad potential of archaeological survival (2001, 21). The absence of the results of systematic archaeological surveys of large rural areas, such as the Aerial Photographic surveys which revealed the large numbers of unknown sites described above or systematic Field Walking programmes, must be addressed. Only then will the data available for Desk Based Assessment be exhaustive enough for Archaeological Curators to have confidence in its operation. This technique will not be measured for Performance Scores in this research as it occurs prior to the operation of Decision-making Point 12b.

6.2.3 Field-walking

Field-walking comprises the systematic recording of the location and nature of archaeological artefacts from the surface of arable land where they have been deposited by plough action. Centuries of arable cultivation in many rural areas of England has produced a layer of regularly turned soil called the "Plough Zone" which often contains artefacts brought up from archaeological layers. The technique is carried out by walking in straight lines across the surface of ploughed fields at measured intervals. Each Field-walker bags and numbers all human made objects seen and the precise location of each is then recorded. The plotting of the positions of all artefacts can allow the locations of concentrations, which may indicate subsurface deposits and structures from different periods, to be identified (Haselgrove *et al.* 1985).

The importance of archaeological information held within the Plough Zone was demonstrated in England in the 1970s (Fowler 1972; Hinchliffe & Schadla-Hall 1980). The utility of Field-walking was subsequently established as a tool for both the extensive survey of large areas (Aston & Rowley 1974) and for area intensive survey (Shennan 1980, 1985; Holgate 1985). The technique has continued to be used in archaeological surveys at landscape level (e.g. Fulford *et al.* 2006) as well as becoming a regular tool at Decision-making Point 12b. The national survey of the 1333 Field Evaluations carried out between 1982 and 1991 shows that 123 Field-walking interventions were employed (English Heritage 1995, 9). This comprises 11.8% of total Field Evaluation techniques recorded in the study. The subsequent survey of similar interventions between 1990 and 1999 shows that this proportion has fallen to 6.99% (Darvill & Russell 2002).

Whilst recognised as being a relatively cost and time effective technique (Hey & Lacey 2001, 52), there are some important limitations to the use of Field-walking. Because detection of past cultural remains depends upon the presence of artefacts within the plough soil, it cannot be used on unploughed sites, limiting its use to arable fields only. In addition, the identification of some Prehistoric Periods and Saxon activity, which are often characterised by the presence of fewer artefacts, is much less reliable. The problems of correlation between surface artefacts and the identification of potential buried deposits, features and structures are also recognised (Mills 1985). A temporal limitation is provided by the fact that the arable site must be walked without the presence of crops. This produces small time windows in which Field-walking survey is possible and the technique may not be available within the Development Control process timescale of pre-determination Field Evaluation. It is recognised that an increase in the quality of archaeological data collected by this technique can be greatly improved by repeat application to the same site over many seasons. Again this approach is not possible for Field Evaluation unless long-term Field-walking programmes have already been undertaken for research purposes.

Field-walking was measured on 19 sites within the Case Study sample of 100 sites producing a total of 21 separate interventions, as two applications of the technique were used at Kennel Farm. The Field-walking interventions are listed in the table in Figure 44.

Different Field-walking methodologies comprise appropriate distances between collecting transects across an area. The methodologies used at the Case Study sites were not obvious from the reports collected and were only identified at three sites. All three methodologies used a grid system to measure the transect lines walked. At Prospect Park, an area of 0.75 hectares was Field-walked on a North-South grid at 25 metre intervals. This application succeeded in identifying concentrations of Bronze Age, Iron Age and Roman artefacts as shown in Figure 45. However, subsequent excavation revealed the presence of substantial settlement features and structures from the Mesolithic, Neolithic and Saxon Periods which had not been identified by this intervention. A similar methodology was used at Rixons Gate, with a 25 metre transect interval set out on the Ordnance Survey national grid, but Performance Scores were not able to be measured and this site was not included in the Case Study analysis. A closer transect interval of 14 metres was used at RAF Wattisham which successfully identified Medieval activity but failed to find evidence for the Bronze Age and Roman settlement on the site.

The lack of data available about the methodologies of the twenty-one Field-walking interventions from the Case Study reports has resulted in the exclusion of detailed analysis of different methodologies in this research. Instead the Performance Scores of these interventions will be analysed as one single technique in Chapters 7 and 8.

6.2.4 Geophysical Survey

Geophysical Survey involves the remote sensing of the below-ground remains using scientific instruments carried over the surface of a site (Clarke 2000). Geophysical Survey approaches have proved successful in research-orientated fieldwork projects in England, such as the large-scale study of the landscapes surrounding the Roman town of Wroxeter in Shropshire (Gaffney *et al.* 2000). Although these techniques are not currently used in Field Evaluation in some areas of Europe (Evans & Williams 2000), the development of more sophisticated software and portable equipment has increased their use in this capacity in England over the last twenty years. English Heritage guidance even advises that Geophysical Survey should be one of the main techniques used at Decision-making Point 12b (David 1995).

The history of the development of the suite of scientific techniques has been described in detail elsewhere (Gaffney & Gater 2003) and professional guidelines are well established, having been published for over a decade (Gaffney *et al.* 1991). It is also recognised as being the most expensive of non-invasive archaeological techniques with considerable limitations to its application (Hey & Lacey 2001). Local surface and geological conditions, including the masking of responses by other sediments, affect the recording ability of different Geophysical techniques at each site. Together with interference from a number of sources these factors require specialist advice for technique selection and for final interpretation of the results. This has resulted in the recent growth in numbers of commercial organisations offering a range of Geophysical Survey techniques for Field Evaluation purposes in England (Hey & Lacey 2001, 76).

Some Geophysical Survey techniques can be used for initial scanning of large areas and others for more detailed investigation of archaeological remains at sites identified by the scanning surveys. Accepted practice of application of the range of Geophysical Survey techniques for Field Evaluation approaches in England follows the English Heritage advice of a staged approach of large area scanning techniques, usually Magnetometry, followed by more detailed site investigation (David 1995, 27).

There are three main types of scientific techniques used for the identification of below ground archaeological remains. These involve recording of magnetic, electrical and electro-magnetic characteristics of any subsurface components present.

Magnetic Techniques are the most used in Field Evaluation processes in England and the most popular are Magnetometry and Magnetic Susceptibility. Magnetometry was used in 10.8% of Evaluations between 1982 and 1990 (EH 1995, 9) with a decline to 7.23% over the next ten years (Darvill & Russell 2002, 34). Magnetic Susceptibility was employed on only 0.6% of Evaluations between 1982 and 1990 (EH 1995) but shows an increase in use to 1.16% between 1990 and 1999 (Darvill & Russell 2002, 34).

Magnetometry measures the changes in the subsurface magnetic field associated with archaeological features. This is usually done with the Fluxgate gradiometer, a hand held instrument developed for rapid survey of large areas, which is carried over the site surface on transects of one metre apart. This equipment can detect human activities which have affected the earth's magnetic field, not only the introduction of magnetic materials such as iron, brick and burnt material, but the changes caused by the past digging of ditches, pits and other negative features. The technique has proven highly effective for identification of archaeological remains on the gravel terraces of the Upper Thames Valley, for example the Yarnton-Cassington Project which revealed a complex palimpsest landscape of Iron Age settlement (Linford 1995).

The utility of Magnetometry is not consistent in all circumstances. The nearby presence of ferrous structures such as fences, overhead cable, pylons, pipelines, buildings and even vehicles can provide interference to the recording equipment. The ground surface conditions of crops or dense vegetation can prevent operation, as can the masking by deep deposits of alluvium or colluvium.

Because Magnetometry has the ability to reduce financial costs by covering large areas in a short time, it is the most widely used Geophysical technique used for the initial scanning of large areas prior to detailed survey of specific sites followed by other techniques.

Magnetic Susceptibility measures the ability of soil components to become magnetised and identifies archaeological remains by recording differences in magnetism using topsoil and sub-soils (Scollar *et al.* 1990). The use of sensor or probe equipment can locate areas of past human occupation and industrial activity. This technique has been mainly applied to Field Evaluation approaches to corroborate and expand on Magnetometry results. Recent applications at a scanning level have been made but the utility of this approach for Field Evaluation is as yet unknown (David 1995, 21).

The limitations on the use of Magnetic Susceptibility techniques include interference from the widespread presence of modern ferrous objects and the masking of responses from vegetation cover or recent ploughing activity. The need for other techniques to explain concentrations of anomalies recorded by Magnetic Suceptibility currently preclude the use of these approaches on their own for Field Evaluation purposes.

The most popular of the **Electrical Techniques** used for archaeological purposes is **Resistivity** Survey. Initially the second most widely used Geophysical technique for Field Evaluation purposes in England, used at 5.7% of interventions between 1982 and 1990 (EH 1995), its use has fallen to only 2.82% between 1990 and 1999 (Darvill & Russell 2002, 34).

This technique feeds electrical currents into the ground and measures the resistance and resistivity of their flow. The majority of these surveys are currently carried out using Twin Probe arrays. A theoretical introduction to electric currents and soil resistivity, along with the practical limitations is available elsewhere (Scollar *et al.* 1990). Generally high resistance is indicative of non-soil materials such as the stone or brick of walls, rubble or even coffins or human made surfaces such as roads. Low resistivity is provided by negative soil-filled features such as ditches, pits, slots and gullies.

The limitations of Resistivity Survey techniques include water content of the site, modern electrical interference, ground conditions and local geological and soil types. The financial cost of surveying large areas using this technique is also recognised These factors contribute to the less frequent use of this technique at present and it is recommended that Resitivity Survey should be used for detailed investigation of sites identified at the scanning stage.

The only **Electro-magnetic Technique** recorded to have been used in English Field Evaluation is **Ground Probing Radar (GPR).** This method directs radio wave pulses into the earth and measures the time delay of reflections of them off subsurface anomalies with a receiving antenna (Conyers & Goodman 1997).

One ability of this technique which is beneficial for Field Evaluation purposes is the provision of subsurface linear profiles through deep stratigraphy. Ground Probing Radar techniques have been used successfully by English Heritage's Ancient Monuments Laboratory, as part of a suite of Geophysical techniques to investigate the Richborough Roman Ampitheatre site in Kent (Martin 2001). On this site GPR provided deeper penetration of subsurface deposits than Resitivity Survey, yet it is acknowledged that the expense of this technique requires more technological development to make it more efficient (David 1995).

The limitations of the use of GPR on clay or for wooden structures, in addition to instrumentational restrictions, have caused it to be used with caution in archaeological research at present. Its use in Field Evaluation in England shows a decline from 1% of Interventions before 1990 (EH 1995) to only 0.14% between 1990 and 1999 (Darvill & Russell 2002, 34). Ground Probing Radar was recorded in use at only one of the Case Study sites collected for this research. The technique was applied at Queen Mary Hospital in advance of archaeological fieldwork, but for the geo-technical purpose of identifying unstable voids in the underlying chalk to inform on stability of the site for development foundations. No details of the methodology or results of this application were contained within the Field Evaluation reports. Therefore Performance Measurement scores were not collected for this technique.

Seismic techniques send artificially generated seismic waves through the subsurface of a site (Gater & Gaffney 2003, 52) and has been used to successfully identify archaeological remains along Hadrian's Wall (Goulty *et al.* 1990). This technique, along with Ground Based Thermal Sensing, Probing and others requires further development to be adaptable as efficient forms of Geophysical Survey for Field Evaluation.

The testing and research into the development of new Geophysical Survey techniques is extremely important for the improvement of Field Evaluation approaches, particularly the combinations of different techniques for scanning and detailed investigation. But current practice appears to have become restricted to one approach with Magnetometry used to scan large areas, followed by detailed Magnetometry, Magnetic Susceptibility or Resistivity. The PLANARCH study shows that Geophysical Survey was used at five of the 12 case study sites and was Magnetometry was used as the sole technique at four of these. The remaining site combined this technique with Resistivity Survey.

A similar picture is shown from the Case Study sites collected for this research where Magnetometry was either used alone for both scanning and investigation or for the detailed investigation phase after a scanning survey carried out with Magnetic Susceptibility techniques. The results of detailed investigation at Monkston Park Area

1 can be seen in Figure 46, where Magnetometry successfully identified the presence of Roman, but not Iron Age remains.

It proved impossible to differentiate between each technique when Performance Measurements were attempted from the Field Evaluation reports. Geophysical Survey techniques could not be used at some sites due to geological conditions and the presence of alluvial deposits on river valley sites, such as at Townmead School. A large proportion of the Case Study sites which did use these techniques were part of large developments subject to the requirement for Environmental Impact Assessment, such as the Channel Tunnel Rail Link sites from Kent. The results of Geophysical Survey on these sites were reported in separate Environmental reports which were not referred to in the later Field Evaluation reports and were not available at the HERs when visited. Analysis of the Client Reports recorded evidence for the use of Geophysical Survey on 31 interventions and these are shown in Figure 47. The lack of information in the reports collected resulted in methodological details being recorded for only 14 of the sites. 50% of the sites for which details could be collected used a methodology of scanning Magnetic Susceptibility with detailed Magnetometry. The other 50% relied on Magnetometer survey alone. Performance Scores were measured from only 22 of these interventions, not all of them with attendant methodological information. Therefore, this research will discuss each Geophysical Survey intervention separately, whether single or combinations of different techniques, rather than attempt to measure the performance of each technique.

The urgent need to develop and test newer techniques for Field Evaluation purposes is evident, as it appears that current practice is limited to one of two methodological approaches. The need for investment into the development of appropriate techniques and the testing of further combinations of techniques is essential if improvements are to be made in the application of Geophysical Survey at Decision-making Point 12b.

6.2.5 Metal Detecting Survey

Metal Detecting is the surface identification of usually non-ferrous metal objects to a depth of up to eighteen inches with the use of hand held magnetic equipment. The lack of correlation between isolated metal objects and the entire buried archaeological resource has resulted in this technique being used only as a supplement to Trial Trenching in Field Evaluation. Indeed, it was used to screen the soil and base of the trench at Wortham in Suffolk because Saxon pottery was recovered during earlier Field-walking. This screening proved successful as a 6^{th} Century Saxon brooch was recovered, indicating the possible presence of buried remains from this period. However, the discovery of the Saxon pits and ditches found in the post-Evaluation Excavation on this site was also suggested by the pottery collected in the first stage of the Field Evaluation and this technique was not used on any other site within the Case Study sample.

There are two serious limitations of Metal Detecting as a potential Field Evaluation technique. The focus on metal objects means that it fails completely to identify cultural remains from periods where metals were not present and the removal of objects from their surviving stratigraphic relationships with buried deposits without record is too destructive to be used at Decision-making Point 12b. However, this technique does have two uses potential supplementary uses at different stages in the process of Field Evaluation. The information collected by the Portable Antiquities Scheme, a national programme that records the finds made by amateur metal detecting activity, can be very valuable in suggesting areas of past human activity. In particular, the locations of Saxon sites in ploughed land can be clearly shown by detailed regional and local analysis. This information must be added to the Prior Knowledge made available at earlier stages of Archaeological Assessment through the HER. The screening role of the technique during machine Evaluation Trenching can also be useful, as shown by the example at Wortham above.

The increase in use of this technique from 0.2% of interventions before 1990 to 1.45% between 1990 and 1999 is perhaps a result of the increasing formalisation of the amateur metal detecting activity through the recent growth of the national Portable Antiquities Scheme, rather than its recognition as being particularly effective.

6.2.6 Structural Survey

The detailed recording and analysis of built structures present on a site is more frequently carried out as a Mitigation option rather than at the Field Evaluation Stage. This is because the visible structural elements present on a potential development site may not relate to the previous landscape uses on rural sites. Only one of the Case Study sites made use of this technique at Decision-making Point 12b. An Historic Buildings Appraisal was carried out in advance of Trial Trenching at Loxwood Place Farm in West Sussex. However this technique did not assist in the identification of any archaeological features at this site and has not been included in the analysis of Performance Scores.

6.2.7 Topographic Survey

Topographic Survey comprises the recording of the form and extent of any earthworks, positive and negative features, which are visible on the ground surface of a site. This technique can greatly improve the understanding of landscape use and can help to indicate potential buried features, but its greatest utility lies within the input it can make to Prior Knowledge. This speed with which this technique can be carried out has been greatly increased by the development of Electronic Distance Measuring equipment.

However the main limitations of this technique relate to its inability to predict the full range of buried deposits, features and structures. Visible earthworks may mask and not relate to past landscape uses which are not evident from the surface. The decline in use as a Field Evaluation technique from 7% in 1990 to 2.71% in the next decade (Darvill & Russell 2002), perhaps indicates that its utility lies at an earlier stage in the Decision-making process.

Technological development of certain **Remote Sensing Techniques** may allow the topographic survey of large areas of landscape to be carried out which may bring additional value to the study of the landscape through recording surviving topographic changes. **Light Detecting and Ranging (LIDAR)** techniques use lasar beams to measure the height of the ground surface from the air. LIDAR can create high-resolution detailed models of the landscape which can identify Palaeochannels, archaeological earthworks and provide three-dimensional terrain models for impact assessment. First used in England by the Environment Agency to produce flood risk terrain maps, the technique has been successfully commissioned by English Heritage to identify unknown archaeological remains in the Witham Valley in Lincolnshire and the Mendip Hills (EA 2007). As a newly emerging technique, the potential use of LIDAR in Field Evaluation requires further research, but systematic surveys of large rural areas would provide HERs with area scanning information which could be used in the assessment of known information to model prediction of Probability of Presence of archaeological remains at Decision-making Point 12b. It would seem that future improvements in this technique may benefit the Field Evaluation process at an earlier stage than Decision-making Point 12b.

6.2.8 Visual Inspection

Visual inspection of a potential development site by an experienced landscape archaeologist can reveal landscape, topographic and spatial factors which might lend themselves to the prediction of unknown archaeological remains. This technique is, however, firmly embedded into the operation of archaeological assessment procedures at the detailed assessment or Decision-making Point 7 of the Desk Based Assessment Stage. No information on the use of this technique was noted or recorded from the Case Study sample of Client reports.

6.3 Intensive Evaluation Techniques

The national approach, as enshrined in PPG16 and the consequent professional standards, recognises that the complete range of archaeological remains actually present on a site cannot yet be fully predicted from the generally non-invasive Extensive Techniques. Intensive archaeological Techniques are defined as those which record the vertical and horizontal information in great detail and are required to investigate the nature of a sample of the below ground evidence. It is recognised that full archaeological excavation of a site is the only archaeological technique which can guarantee an accurate representation of the full range and nature of the archaeological resource in that location. But this process is too costly and time consuming, hence the application of more Intensive Techniques used to sample the below ground remains.

Intensive Field Evaluation techniques have been developed as forms of excavation with reduced spatial areas so that the stratigraphic sequences and some idea of the form of deposits and features can be identified. These have the inherent advantage of recovery of stratified artefactual evidence from the localised below-ground remains which can be used to interpret date and phasing of past human cultural activity.

6.3.1 Augering

The term **Auger Survey** will be used to define all methods of the collection of a vertical core or column of the subsoil by boring or drilling downwards with a hollow device. Also called "borehole survey" or "coring" this technique can be carried out with mechanical or manual equipment which produces a column sample through deposits. Geo-archaeological and/or Palaeo-environmental assessment of one of these samples can provide detailed information on the stratigraphy, deposits and site formation processes at one specific location on a site (English Heritage 2007b, 16). The survey of an entire area can produce patterns of deposit survival over an entire site depending in the sampling interval.

This technique is frequently used in an archaeological context in Belgium where it has developed from the original use for soil mapping. Auger Surveys here have revealed the extent of Mesolithic occupation at Verrebroek with a close correlation to the final excavated record (Evans & Williams 2000).

Augering or the use of boreholes is used much more restrictedly in English approaches to Field Evaluation, yet its use has doubled from 1.1% of Field Evaluations recorded before 1990 to 2.02% between 1990 and 1999 (Darvill & Russell 2002). They tend to be used where the stratigraphy is known to be deeply buried or to map the location and extent of specific underground conditions or deposits such as alluvium, peat or waterlogging. Geo-archaeological analysis is, however, more likely to be carried out on deposits revealed during Evaluation Trenching.

The limitations to the use of this technique at Decision-making Point 12b include the very small size of the column sample and the fact that it is difficult to interpret the form and nature of any archaeological features. The time taken to drive the equipment into the ground for the collection of each core is also considerable if sampling a large area. Attempts to improve the practicalities of sampling were made in America and England by the use of mechanical devices in the 1990's (Odell 1992; Canti & Meddens 1998) but seem to have little impact of the use of this technique for Field Evaluation purposes in England.

One Auger Survey was carried out within the Case Study sample of sites, although archaeological observation of boreholes made for geological purposes were recorded at two others, but neither of the latter included geo-archaeological assessment. The Auger Survey undertaken at Prospect Park failed to identify any archaeological remains and the technique has not been included in the analysis of Performance Patterns in this study.

6.3.2 Phosphate Survey

Past human activity can redistribute the background levels of phosphorous within the soil. Because the relatively stable phosphoric compounds are increased by organic human detritus, the recording of the location of high levels over a grid system can locate concentrations of past human settlement activity (Crowther 1997). The chemical effects of modern agricultural fertiliser regimes upon phosphate levels still requires more research. The technique is time consuming and expensive and for these reasons the use of phosphate survey for Field Evaluation has stayed consistently low at below 0.5% (Darvill & Russell 2002).

6.3.3 Trial Trenching

Trial Trenching is the generic name given to the current application of archaeological excavation techniques to Field Evaluation. The technique involves a reduction in scale from the open area excavation used in research projects to a sample of the site by machine-excavated trenches. Although excavation machinery is used to strip the topsoil and overburden, any archaeological features and deposits identified before the natural geology is revealed are usually excavated by hand. Trenching is perceived as being effective for the identification of the nature of archaeological features, particularly those of larger spatial area and those of linear form.

Because of the use of excavation machinery, Trenching is recognised to be a swift and non-destructive method of archaeologically recording the three-dimensional components of a sample of the subsurface deposits of a site. The 2001 assessment of cost-effectiveness acknowledges that, although this technique is the most expensive archaeological method and comprised roughly half of the total costs of the Field Evaluations in the study (Hey and Lacey 2001, 54), this total cost was still a very small proportion of the total development costs. The qualitative assessment of effectiveness of Trial Trenching from this study suggests that it was the only technique which would allow reasonable confidence for the Decision-maker at DMP 12b.

Trial Trenching was carried out on 61% of the Field Evaluations recorded nationally between 1982 and 1991 (EH 1995) and on 74% of those undertaken in England between 1994 and 1999 (Darvill & Russell 2002). It is proven to be the most widely used Field Evaluation technique in England, yet Figure 1, from Section 1.1, clearly shows this increased reliance on machine trenching has occurred at the expense of the use of other techniques. Trial Trenching was used on 100% of the Case Study sample sites. Performance measurements for a total of 106 separate Trenching interventions were recorded as six sites included multiple applications of the technique.

Because of the utilisation of the sampling approach for this technique, a variety of methodologies exist for its application. The percentage of a site which is sampled by

Trial Trenching currently follows an industry standard of around 2.5% which seems to have been adopted following the publication of the Berkshire and Hampshire study (Champion *et al.* 1995). Hey and Lacey's much more detailed study of twelve sites also records a similar average use of 2.4% with sample percentages of between 0.8% and 5.4% (2001).

Computer simulation techniques were applied to the excavated archaeological remains recorded during the Hey and Lacey study to investigate increases in sample fractions. This demonstrated that a 2% sample was a high-risk methodology for the prediction of the full range of archaeological remains on a site. A significant gain in qualitatively measured information was suggested with a sample fraction of between 5% and 10% (Hey and Lacey 2001). This conclusion will be tested by the quantitative assessment of sample sizes from the Case Study sites in Section 9.3.1.

Sample size was recorded from 80 Trenching interventions from the Case Study sites and these are shown in the table in Figure 48. The sample sizes recorded can be sorted into five groups of similar sizes with similar numbers of Interventions within each group. Eighteen of these interventions used a sample size with less than 1%, with the smallest sample of 0.006% taken at Lower Icknield Way. Twenty interventions used a sample of size between 1% and 2% and another 20 used a sample size between 2% and 3%. Nineteen interventions used a sample size between 3% and 8% and the final three sites recording the highest sample sizes. 12% of the sites at Ibis Hotel and Progress Way were investigated with Trial Trenching and the largest sample size of 19.8% was recorded at Loxwood Place Farm.

A methodological choice about the targeting of Trenches can be made at Decision-making Point 12b. Targeted Trenching involves the positioning of trenches to investigate remains identified during prior phases of Evaluation or Prior Knowledge and the subsequent blank areas. Non-targeted approaches aim to investigate the site using random sampling approaches with an array chosen to provide even coverage or to reduce the gaps between Trenches. These randomly placed Trenches can be systematically aligned on the National Grid or another uniform distribution alignment or randomly placed. English Heritage's two studies of Field Evaluation approaches show a significant reduction in the use of Targeted Trenching from 54% before 1990 to 18% between 1990 and 1999 with a corresponding increase in Non-targeted or random trenching from 32% to 58% also recorded (Darvill & Russell 2002).

Analysis of the Case Study sites shows the adoption of a pragmatic approach to Targeting in current practice. Explicit information stating that the Trenching was Targeted at specific elements was only available for thirty three of the Trenching interventions and this is condensed into the table in Figure 49. This shows a combination of Targeted Trenches at Prior Knowledge of archaeological remains provided by Aerial Photographic evidence, Geophysical and Field-walking surveys, the presence of earthworks and results of previous Trenching interventions. Client reports for six sites stated that the Trenches were Targeted at development foundations and at the gaps between existing buildings at another five sites. Site plans of Trenches targeted at gaps between existing buildings from two of these interventions at Queen Mary Hospital and Townmead School are shown in Figures 50 and 51. These two Figures reveal just how restricted the spatial areas available for Field Evaluation are when standing structures still remains on development sites. Only thirteen sites had reports which stated that the blank areas were Targeted and all of these interventions also Targeted known remains evidenced by prior knowledge, such as that at Little Marlow, shown in Figure 52, which was focussed on remains evidenced from Aerial Photographs, earthworks and blank areas. I have termed the fifty-seven interventions for which no Prior Knowledge was available or for which the Trenches appear to have been randomly located as Non-targeted. Examples of these are shown from the sites at Saltwood Tunnel and Blind Lane in Figures 53 and 54. Detailed study of the Trenching plans show that all interventions used a pragmatic combination of Targeting known remains whilst providing coverage of blank areas. An analysis of Targeted and Non-targeted interventions will be carried out in Section 9.2.4.

The array or layout of Trial Trenches is another methodology available to Decision-makers at DMP 12b. Seven different random Trenching array patterns were identified in the PLANARCH study and are shown in Figure 55. That study applied the arrays to plans of archaeological remains recorded during full excavation at 11 sites by computer simulation and measured a qualitative assessment of their effectiveness. The Standard Grid pattern of Trenches of 30 metres by 2 metres aligned at right angles was compared to similar arrays with shorter or wider trenches, to Offset parallel arrays, to Continuous and Centre Line Trenching and a "Ramsgate Harbour Array" of a line of Trenches of 20x2 metres and an adjacent arrangement of angled Trenches. But none of these simulations proved any more successful than the Standard Grid array (Hey & Lacey 2001).

A detailed analysis of Trenching arrays was originally planned for quantitative analysis in this research, however the range of actual arrays used proved to be too small to compare. Arrays could be identified from plans within the Client reports for sixty-nine of the Trenching interventions and the details are shown in the table in Figure 56. Only two of the arrays described in the Hey & Lacey study were used for the recorded Case Study sites. Two variations on the Standard Grid array were used on forty-one occasions. The first consisted of north to south and east to west Trenches Examples of these are shown at Saltwood Tunnel (Figure 53), Blind Lane (Figure 54) and Brisley Farm Areas 1-4 in Figure 57. The second variation combines the first with South-east to North-west and North-east to South-west alignments, as used at the interventions at Little Marlow (Figure 52) and Kingsnorth Power Station shown in Figure 58. These grids were aligned either with the National Grid as at Kingsnorth or with the boundaries of the development site, as at Little Marlow. Parallel arrays were used for seven interventions, as shown example of the sites plan at Shrubsoles and RAF Wattisham in Figures 59 and 60. In addition, Discontinuous Linear arrays were used for six interventions, with five of these used on linear road developments such as at Palgrave in Figure 61. Long Linear Trenches were used at Copdock Mill as shown in Figure 62. The remaining sixteen interventions used arrays which I have termed Non-standard. These include Trenches at all alignments such as the example from the first Trenching intervention used at Cobham Park Golf Course shown in Figure 63. Both Standard and Non-standard arrays were used at Little Stock Farm. An analysis of the Performance Measurement for Standard and Non-standard Grid arrays is carried out in Section 9.2.5.

The PLANARCH study suggests that two other methodological choices may also be of importance. It concludes that Trenching patterns with large gaps between Trenching units performed poorly (Hey & Lacey 2001, 59). Measuring the gaps between Trenches from the Case Study sample proved difficult. The measurements were taken from the site plans contained within the Client reports and some of these reports had been copied or reduced without an accurate scale on the plan. The measurement was taken of the spatial area of gaps in square metres taking the most common occurrences of all the different gap sizes. Consequently measurements were recorded for only thiry-six of the Trenching interventions as shown in the table in Figure 64. Because the PLANARCH study differentiated between the length of Trenches in the different arrays, the Trench lengths were also measured from the Case Study sample. Figure 64 also shows the details of the seventy-two interventions for which Performance scores could be measured. An analysis of these performance scores is made in Section 9.2.3.

6.3.4 Test Pitting

Sample Test Pitting is another Intensive Field Evaluation technique which involves the hand or machine excavation of a much smaller area, a Test Pit, often with the accompanying sieving of deposits to recover artefacts and ecofacts. The benefits of the use of this technique are that it provides a good recovery rate for artefacts and can be particularly useful for identifying Prehistoric occupation sites from lithic scatters. It can also identify the presence of subsurface archaeological features if positioned over them. Disadvantages include the lack of provision of information about the horizontal spatial relationships between features, and that the tehnique can be time-consuming and labour, and thus cost, intensive.

This technique was used on 16% of Evaluations carried out between 1982 and 1990 (English Heritage 1995) with a reduction to 8.43% during the next ten years of operation (Darvill & Russell 2002). It is accepted that the use of Test Pits does have utility for investigating deeply stratified urban deposits although the decrease of use on rural sites did not allow their cost effectiveness to be assessed by the Hey & Lacey study (2001, 54). This technique is often used at Decision-making Point 12b to investigate sites of small spatial areas and is often used in combination with Extensive scanning techniques or as an Intensive sampling approach on non-ploughed sites where Field-walking is not possible.

Two methodological choices are available for this technique. The size of each unit can range from 1x1m to 10x10m, although there is a tendency to use the size of unit which can be excavated quickly by machine bucket. The layout of Test Pits has been subjected to much research as it has been used for archaeological research surveys in America and in Scandinavian countries for many years where the technique is called "Shovel-testing". Proven to be more effective for regional survey (Krakker *et al* 1983; McManaman 1984), research has been undertaken to improve the efficiency of this approach by mechanisation (Odell 1992; Steinberg 1996). Recent use in England includes the research surveys to successfully identify the extent of the Medieval village at Bamburgh (Bamburgh Research Project 2006). The technique has also been tested as a method to inform the production of Shoreline Management Plans in wetland areas of Essex (Wessex Archaeology 2005).

English Heritage's simulation study analyses the probability of a range of Test Pit sizes for the Newbury Sewage Works site and suggests that the most appropriate layout to maximise the probability of detection of archaeological remains is a hexagonal array with a scale calculated using a mathematical formula (Champion *et al.* 1995, 39). The formula was developed in an American study of the technique (Kintigh 1988) and the Newbury simulations provide a useful tool to Archaeological Curators and Contractors.

Test Pitting was only used on two sites within the Case Study sample and archaeological observations of boreholes was only used on one further site. The results of the use of Test Pitting at Prospect Park are shown in Figure 45. One hundred and fourteen Test Pits, all 0.5x0.5m square were excavated at 2 metre intervals on a Standard Grid array. This approach did identify the presence of Bronze Age activity but failed to recognise its nature as a settlement or the Neolithic and Saxon settlements also present at this site. Test Pitting at the Park Lane site involved the excavation of 1% of the site area using six Pits measuring 2mx2m in size. This identified a Roman ploughsoil but failed to identify Bronze Age activity and a Saxon Ritual and Funerary landscape shown to be present by subsequent excavation. This technique was not used frequently enough in this Case Study sample for the measurable Performance Scores to be meaningfully representative and appropriate guideline for its use are provided in other research (Champion *et al.* 1995, 53).

6.4 Combinations of Techniques

Because DMP 12b is a Portfolio Type of Decision, as well as simple choices between each Field Evaluation technique, there is a need to consider suites and complex combinations in order to identify the Effectiveness of all available Alternative Courses of Action.

A surprisingly small number of Field Evaluations carried out in England between 1982 and 1990 comprise combinations of different techniques. The limitations of time and cost factors seem to have resulted in the utilisation of a very narrow range of the alternative courses of action at this Stage in the Decision-making process. Imprecise figures available from the national survey of Evaluations for this period show that approximately 24% of projects used two different archaeological techniques, 9.5% used three methods, 4% used four methods and less than 2% used five techniques (Champion *et al.* 1995, 36). No figures of technique combinations are published from the national survey of Field Evaluations carried out between 1990 and 1999.

64% of the Case Study sites only used one single measurable Trenching intervention and the Data Gathering Stage of this current research only managed to measure combinations of techniques on the 36 sites. These are listed in the table in Figure 65.

The use of Extensive Techniques as a first phase to inform a subsequent application of the Intensive Trenching is recognisable from these 36 Combination approaches used. Intensive Techniques were only used on their own at four of the sites, each consisting of the use of two distinct phases of Trial Trenching, with the first of these informing the subsequent intervention. Field Evaluation approaches at eleven other sites preceded the Trial Trenching with a phase of Field-walking and twelve with a preceding use of Geophysical Survey, making a total of 23 sites on which combinations of two techniques were used.

The remaining nine sites made use of all of the three measurable techniques with eight of them using a single phase of Field-walking and Geophysical Survey followed by Trial Trenching. The greatest number of Combined intervention techniques were used at Kennel Farm in Hampshire, where two Field-walking and one Geophysical Survey stages were used to inform the subsequent two Trial Trenching interventions. An analysis of the Effectiveness of these Combinations is carried out in the following chapter.

6.5 Alternative approaches to pre-determination Field Evaluation

There has been no professional research into the development of new archaeological techniques to fulfil the specific requirements of archaeological Field Evaluation. Some different approaches to Field Evaluation have been considered. The recent suggested adoption of the use of the **Strip, Map, Sample** techniques (Hey & Lacey 2001, 32) affects one of the fundamental issues at the heart of the Field Evaluation process in England. In Kent, and some other counties, there has been a move towards the machine stripping of topsoil from large areas of a site with little or no previous Field Evaluation work. All features are then identified and recorded and then a sample of features is then excavated to answer specific research questions (Evans & Williams 2000, 36).

The Strip, Map Sample approach seems to suggest a dissatisfaction in the current Field Evaluation methodologies and accepts a reduction of pre-determination investigation in return for the horizontal planning of archaeological features over large areas of the landscape and research-focussed targeted sampling. Published claims have been made that Strip, Map, Sample can identify more ephemeral remains which are highly likely to be missed by current Field Evaluation techniques, such as the Saxon houses at Cheviot Quarry (Johnson & Waddington 2007) and the Neolithic Longhouses at Yarnton and White Horse Stone (Glass 2000; Hey & Lacey 2001). The value of this technique for the archaeological investigation of large landscapes able to be stripped prior to development is immense.

This philosophical change in the approach to pre-determination and post-determination recording requires greater discussion. The abandonment of Field Evaluation as a pre-determination sampling approach to inform the post-determination choices between Preservation In-situ and Preservation by Record raises a number of issues.

The current approach of PPG 16 suggests that we investigate a sample of a potential development site in acknowledgement of the incomplete state of Prior Knowledge. The Strip, Map, Sample approach abandons the use of three fundamental principles espoused by PPG 16. These are the value of Prior Knowledge in the prediction of presence, the sampling of a small area of the site to define the range of archaeological remains present and the principle of presumption in favour of preservation in-situ for Nationally Important remains.

A fundamental reason for undertaking quantitative testing of the Effectiveness of the Field Evaluation techniques identified in this Chapter is to investigate whether our current professional approach is the most appropriate. The use of Strip, Map, Sample at Decision-making Point 12b is symptomatic of a loss of professional confidence in pre-determination Field Evaluation. The need for other approaches to the process required at this Decision-making Point will be assessed in Chapter 9.

Chapter 7: Measurements of the Outcomes of Decision Options

With the Alternative States of Nature and the Decision Options now identified in Chapters 4 to 6, the quantitative measurements of the performance of each Decision Option can now be described. In the Logical Testing of Decision-making Point 12b, these Performance Scores will represent the Decision Outcomes. Each Decision Outcome forms the Premise of the Propositions identified in Section 3.2.

Figure 18 demonstrated that these Propositions are of two different types. The first group contains the statements that each Alternative Course of Action is the most effective at identifying the Alternative States of Nature. The six measurable Alternative Courses of Action identified in the previous chapter are the Field Evaluation techniques of Geophysical Survey, Field-walking and Trial Trenching as well as the three different combinations of Trenching with Field-walking, Trenching with Geophysical Survey and Trenching with both Geophysical Survey and Field-walking. Two Decision Matrices will be created for these Courses of Action within the States of Nature of Periods Present and Types of Features for each period. A third Decision Matrix will be compiled for the Performance of Trenching on Past Landscape Use Patterns. It must be remembered that, although these Performance Scores represent a standardisation of the population of archaeological remains, this modelling is necessary to provide surrogates on which the parameters of performance of techniques can be compared on the same value scales. The Logical Soundness of each Premise of the Effectiveness Propositions can then be assessed.

The second group of Propositions involve the Statements that Alternative States of Nature are present on a site. The Logical Testing of the Premises of these Propositions will be carried out in Chapter 8.

7.1 Dates of Alternative States of Nature

Two methods of studying the results of these Performance Measurements can be made. A more general analysis of the success of each technique in the identification of the total number of sites will be carried out Section 7.1.1. This will be followed by more detailed analysis of the Performance of each Course of Action for each period in Section 7.1.2.

7.1.1 Date measurements for Total periods identified

The first Performance Measure recorded from the Case Study sample represents the success of each Course of Action to identify all of the periods which were proven to be present during the subsequent Excavation of the Evaluated site. A percentage score is assigned to each technique and represents the number of sites at which all of the periods present were successfully identified. This provides a general view of performance which allows the Decision-maker at DMP 12b to compare the most effective techniques across the entire Case Study sample.

The results of this analysis are shown in Figure 66 and are surprisingly disappointing. The best performing technique was Trial Trenching, which was able to identify all of the Periods present on only twenty-seven of the one hundred and six interventions for which it was used. This represents only a 25% success rate leaving the archaeological curator confident that only 1 in 4 Trenching interventions can identify the full range of periods present.

Interestingly the 36 interventions using Combinations of Field Evaluation techniques succeeded in identifying all of the periods present on only six of the sites at which they were used. The 17% success rate is surprising as all 36 Combinations included Trial Trenching and with the 25% success rate of Trenching used in isolation, one might expect a better performance from the Combinations. A close analysis of the results reveals that there was a tendency to use Combinations of techniques when the number of periods present was predicted to be large from Prior Knowledge. Twenty-eight of the sites at which Combinations were used evidenced three or more periods present, with seven of these containing between five and seven Periods. It is also noticeable that three of the sites at which Combinations did identify 100% of Periods present only contained one period of archaeological activity. In addition, it was also apparent that a greater proportion of Trenching interventions combined with other techniques used a smaller sample size. Only 23% of the Trenching interventions measured from the Case Study sample investigated less than 1% of the total development site area. This did increase to 44% of the measurable Combined Trenching interventions and fourteen of the eighteen sample sizes below 1% were used in Combination with other techniques. This suggests that the use of a Combination of techniques is currently used with unrealistic expectations of the results which can be achieved. The results also demonstrate that Trenching sample sizes should not be reduced despite the use of other techniques.

Field-walking only succeeded in the identification of all Periods present on two of 21 sites on which it was used, giving a Success Rate of only 10%. Geophysical Survey proved the poorest performer, not being able to identify all Periods present on any of the twenty-two sites for which it was used.

These results show that the Decision Maker can only have the confidence that Trial Trenching will identify all of the Periods present on 25% of sites. That Field-walking can achieve this Outcome on only 1 in 10 sites and that Geophysical Survey can not be relied on at all for this purpose. This Performance Measurement provides a timely warning to the profession that we are currently reliant on Field Evaluation techniques which perform poorly for the identification of the full range of Periods present. However, the analysis of Total Periods present must be put into context as only one of the parameters in the measured Capta sets of Decision-making Point 12b.

7.1.2 Date measurements for each Period

The Performance Measurement of this State of Nature for the six Alternative Courses of Action is binary in nature. This is because the Field Evaluation techniques record only the presence or absence of archaeological remains from a particular period. Consequently, a general technique of assessing the levels of confidence of the results from the one hundred Case Study sites within the spectrum of negative and positives can be used (Darvill & Russell 2002, 35).

Positive outcomes are defined when a particular Course of Action taken during Field Evaluation does identify cultural remains from a period as being present on a site. A True Positive Outcome occurs when the identification of the presence of a period is proven to be correct by the recording of remains from that period during subsequent full Excavation of the site. A False Positive occurs when the post-evaluation Excavation shows that no remains of that period are actually present on the site.

Negative Outcomes are defined by the Courses of Action failing to identify remains from a particular period as being present on an Evaluated site. A True Negative Outcome occurs when the subsequent Excavation confirms that the remains from that period are not present. A False Positive occurs when the Excavation shows that remains from that period are present and these were not identified by the Alternative Courses of Action of the Field Evaluation.

All of the Positive and Negative Outcomes for each period of the Date identifications are shown in the Rural Techniques Scores by Period Table in the Analysis Results Database in Appendix 7. A matrix of proportions of False Positives for each technique by period is shown below:

	Field Evaluation Evidence	Post-evaluation Excavation Evidence
True Positive	Remains from a period identified as present	Remains from a period identified as present
False Positive	Remains from a period identified as present	No remains from a period identified
True Negative	No remains from a period identified	No remains from a period identified
False Negative	No remains from a period identified	Remains from a period identified as present

It is reassuring to find that a very small number of techniques incorrectly identified periods as being present when they were absent (False Positives) within the Case Study sample of 100 sites. Field-walking provided one false identification for the Mesolithic period (5%) and two each for the Neolithic, Bronze Age, Roman and Medieval periods (10%). Trenching provided two false identifications for the Mesolithic (2%), Neolithic (2%) and Bronze Age (2%) and one each for the Iron Age (1%), Roman (1%) and Medieval periods (1%). Geophysical Survey produced no False Positive identification for any period.

Whilst the percentage of False Positive identifications is acceptably small for Trenching, it is clear that there is a higher percentage risk at 10% from the use of Field-walking to identify Neolithic, Bronze Age, Roman and Medieval remains.

The analysis of the Periods present will focus on the True Positives and True and False Negatives only. The Performance Measurement for Periods present is also a binary measurement as it records the ability of each technique to succeed or fail in the identification of the presence of cultural remains from each period subsequently shown to have been present by full excavation of the site.

7.1.2.1 Geophysical Survey

Geophysical Survey, the poorest performer for total period identification, also proves to be the poorest performer for separate period identification, as shown in the Performance Table in Figure 68. Iron Age remains were successfully recorded on six of the eighteen sites at which they were present giving a success rating of 35%. But this was by far the best performance of all periods present for this Field Evaluation technique. The success rating of Geophysical Survey fell to 17% for Neolithic remains with successful identification of presence at one of six sites. Even poorer performances were achieved for the remaining periods measured. A 12% score was measured for Roman remains with success occurring at only two of 17 sites. A 7% Performance Score was achieved for the Medieval period with successful identification at only one of 15 sites at which they were shown to be present. Total failures (0%) were recorded for the identification of Mesolithic remains at from four sites and Saxon remains from nine sites.

It is perhaps initially surprising that the Geophysical Survey is shown to be most successful at identifying the date of Iron Age remains. However the primary function of this technique is to identify the form and plan of below ground archaeological remains. It is noticeable that the physical form of some Iron Age structures, such as round houses, are often unique to this period. Consequently it proves easier for the assignation of an Iron Age date to these features than for features for which the form is a less clear indication of Period.

The role of Geophysical Survey as an Extensive Evaluation Technique should also be remembered. The results above clearly show that this technique cannot be relied upon to identify the dates of any periods present on its own. With its most effective success rating being just over 1 in 3 for the Iron Age period, but greatly reduced ratings of 1 in 5 for the Neolithic, 1 in 8 for Roman remains and 1 in 4 for the Medieval period, as well as total failure for Mesolithic and Saxon remains, Geophysical Survey is not reliable for the identification of periods present and should not be used for this purpose.

7.1.2.2 Field-walking

Field-walking shows improved performance scores for periods whose presence can be inferred from the surface identification of ceramic and stone artefacts. The results of the Performance Measurements for this technique are shown in Figure 69.

Field-walking proved the most effective for the Roman period by identifying the presence of archaeological remains from this period at eight of sixteen sites (50%). A similar Performance Score was produced for Iron Age remains with nine of nineteen sites identified (47%). This technique produced a much better performance than Geophysical Survey techniques for Neolithic remains, with success at three of seven sites (43%). It is interesting to note that the periods for which Field-walking proved most successful are the same for the use of Geophysical Survey. Both techniques perform better for the identification of the Roman, Iron Age and Neolithic periods, albeit in differing proportions. It is not, however, surprising that the surface collection of artefacts through Field-walking proves more successful for these periods as all are represented in the archaeological record by high proportions of artefactual remains.

Field-walking produced slightly poorer performances for the Bronze Age and Medieval Periods in interestingly similar patterns to the Geophysical survey results. Field-walking identified Bronze Age remains at five of thirteen sites to give a Performance Measure of 39%. A 36% Performance Measure was achieved for remains from the Medieval period by the successful identification of four of eleven sites.

Mirroring the performance of Geophysical Survey, Field-walking proved a total failure for the Mesolithic remains present at one site and for the nine sites which contained

Saxon remains. This failure of both techniques to identify both periods can perhaps be explained by the smaller proportions of artefactual materials and the invisibility of below ground features of the cultural remains of both periods.

These results provide the Archaeological Curator with quantitative Effectiveness Measures for these two archaeological techniques which can be compared at Decision-making Point 12b. It is clear that from these results that greater degrees of confidence can be assigned to the use of Field-walking for the identification of more periods than to the use of Geophysical Survey. The results of this study show that Field-walking can identify Roman, Iron Age and Neolithic remains on almost 1 in 2 sites at which they are present. Slightly poorer proportions of successful identifications exist for Bronze Age and Medieval remains with positive identifications at 1 in 2.5 and 1 in 2.7 respectively. This technique still proves a total failure for the Mesolithic and Saxon periods.

7.1.2.3 Trial Trenching

The performance of Trial Trenching for separate period identification proved to be the strongest of any of the single techniques measured and the Performance Scores are shown in Figure 70. Trial Trenching was the only single technique to score consistently over 50% for the Bronze Age, Iron Age, Roman and Medieval periods.

The best performance of this technique was for the identification of Bronze Age remains, with the successful identification at forty-three of sixty-six sites giving a success rating of 65%. Trenching was the only technique to perform best for Bronze Age remains and with a Performance Score considerably greater than those produced by Field-walking or Geophysical Survey. A very similar pattern of increased Performance is demonstrated for archaeological remains from the Iron Age period. Trenching successfully identified remains from this period at forty-four of sixty-nine sites to give a Performance Score of 64%. Improvement was also demonstrated for the identification of remains from the Medieval period with success recorded at twenty-three of forty-three sites (53%).

Yet the Roman period, the most successful period for Field-walking performance and the third most successful period to be identified by Geophysical Survey is reduced to the fourth most successful by Trial Trenching with thirty-four of sixty-seven sites (51%). Yet this different pattern of period identification should not mask the huge increase in success ratings of Trial Trenching at the identification of separate periods. With success ratings of 65% for Bronze Age and 64% of Iron Age remains, it is clear that Trenching can identify remains from these periods on 2 out of every 3 sites on which they occur. Similar success patterns are demonstrated for the 53% of Medieval and 51% of Roman periods, suggesting that the Archaeological Curator have the confidence that this technique can identify remains from these periods on 1 out of 2 occasions.

The periods for which Trial Trenching was less successful were the Mesolithic, Neolithic and Saxon. Showing a similar pattern of total failure for the Mesolithic periods as the other measured Techniques, Trenching failed to identify the presence of remains from this period at any of the ten sites on which they were present. This demonstration of the failure of all single techniques to identify the presence of Mesolithic remains is very important and both the Curatorial and Contractual operators of our current Field Evaluation approaches must be made aware of this defect in current practice.

Although Trenching produced slightly poorer Success Patterns for the Saxon (14 of 34 sites) and Neolithic (8 of 21 sites) periods, at 41% and 38% respectively they are both considerable improvements on the abilities of the other two single techniques. These performance Scores give Success Ratings of 1 in 2.5 for Saxon remains and 1 in 2.6 for Neolithic remains. The dramatic increase of the success of this technique indicates that Trial Trenching must be included in all Field Evaluations. It is also the only single technique able to identify Saxon remains and the only one to provide a consistent identification Success Rating of over 50% for four of the periods present.

7.1.2.4 Combinations of techniques

It is interesting to observe the patterns of Performance Scores measured by the Combinations of Field Evaluation techniques from the Case Study sample as identified in Section 6.4 above. Despite the very small number of sites for which the effectiveness of these Combinations could be measured, the results can still provide a guide for Decision-making at DMP 12b.

With similarly disappointing results to all of the single Field Evaluation techniques, none of the Combinations were able to identify any of the Mesolithic period remains on any of the sites at which they were present. Although Mesolithic remains were only present at five of the sites at which Combinations of techniques were used, the resounding failure of all Field Evaluation approaches within the Case Study sample to identify remains from this period must be noted.

The Performance Scores of the eleven Field Evaluations which used a Combination of Trial Trenching and Field-walking are shown in Figure 71. These demonstrate an improvement in performance for the identification of Iron Age, Roman and Medieval remains from the use of Trenching alone. The greatest improvement was shown on the five sites at which Medieval remains were present, with an increase from the 53% Score of Trenching alone to a Performance Score of 100%. This Combination of techniques produced increases in Performance Scores to 83% and 88% for the six sites with Roman remains and eight sites with Iron Age remains. Yet poorer performances were recorded for other periods present. A 25% decrease to a Performance Score of 40% was recorded for the five Bronze Age sites and a 5% drop in effectiveness to 33% occurred at the three Neolithic sites. The Performance Score of 41% recorded by Trenching alone for Saxon sites was much more effective than the total failure scored by its combination with Field-walking at the four sites at which they were measured.

The number of sites in this sample is too small to be used as a statistically meaningful result but the general patterns of Performance improvement or decrease are very interesting. The results suggest that a Combination of Trenching and Field-walking can identify every site with Medieval remains present. It is noticeable that the three periods for which Performance improvements were recorded are those with high visibility of artefactual evidence. It is also noticeable that the improvements for the Roman and Iron Age periods are between 24% and 32%, whilst the decrease in Performance for the Bronze Age is of a similar proportion at 25%. Whilst all three of these periods do have high proportions of artefactual material, that material for the two periods which record increases is primarily ceramic, rather than ceramic and lithic as in the Bronze Age. It is not surprising that this Combination failed to identify Saxon remains, due to the low visibility of archaeological remains from this period. Further measurement of the success of Performance Improvement by the use of this Combination of techniques must be carried out on larger samples in future studies.

The use of a combination of Trenching and Geophysical Survey on twelve sites scored consistently lower than the use of Trenching alone for every period except for Medieval remains and the results are shown in Figure 72.

Neolithic remains were only identified at one of the three sites at which they were present and the 33% performance score showed a slight decrease in Performance from the 38% recorded by the use of Trial Trenching alone. Yet this Performance Score matches that of the Combination of Trenching with Field-walking, suggesting comparable patterns despite the small number of sites within the sample. Slight decreases from the Performance of Trenching used alone were demonstrated by the successful identification of three of the five sites for both Bronze Age and Iron Age to produce performance scores of 60% at each. This proved to be an improvement on the Success Rating of the Combination of Trenching and Field-walking for the Bronze Age, but a significant decrease from the 88% scored by that Combination for the Iron Age.

A similar Performance to the use of Trenching alone was, however, recorded for the use of Trenching and Geophysics for the Roman period with the successful identification of 50% of the eight sites at which they were present. Yet the use of this Combination of techniques, whilst demonstrating a decrease from the 100% performance of Trenching with Field-walking for the Medieval period, did show an improvement from the 53% scored by the use of Trenching alone. With the successful identification of four of the six sites at which Medieval remains were present, the use of Trenching and Geophysical Survey produced a success rating of 66%. The total failure of this technique Combination for remains from the Saxon period at four sites is also noticeable, continuing the poor Performance of all single and Combined techniques within the study for this period.

The expectation that the application of more Field Evaluation techniques to a site can improve the effectiveness of identification the date of remains present can be examined by the results of the Combination of all three single techniques on the nine sites on which they were used in the Case Study sample. These are shown in Figure 73 and produced a marked improvement for the identification of Neolithic remains over the use of Trenching alone, with successful identification of both sites at which they present. Again, the number of sites is far too small to prove statistically valid, but the 100% success rating raises an interesting pattern which requires more detailed analysis. Neolithic activity was identified by the Field-walking component of the Field Evaluation at both Marsh Leys Farm and Kennel Farm. However, the subsequent Excavations at both sites showed that no features from this period were actually recorded on either site and it appears that the Field-walking elements identified the background spread of artefacts from this period, rather than being effective at the identification of the presence of features and structures.

The Performance of this Combination of three techniques for the Bronze Age was poorer than the use of Trenching used alone and Trenching combined with Geophysical survey. By identifying three of the seven sites at which Bronze Age remains were present, this multiple Combination produced a success rating of 43% which is only a slight improvement on the Performance of the Combination of Trenching and Field-walking.

The triple technique Combination also produced a similar score to those of Trenching with and without Geophysical Survey for the Iron Age by successfully identifying the presence of remains of this period at six of nine sites. But this Performance Score of 66% is noticeably poorer than the 88% achieved by the Combination of Trenching with Field-walking.

A similar pattern of improvement for this triple combination for Roman remains is also shown. By identifying six of the nine sites at which Roman remains were present, this combination demonstrates an improvement on trenching with and without geophysical survey, but the 66% is lower than the 83% success rating of the use of trenching with Field-walking. The same pattern emerges for Medieval remains with five out of seven sites successfully identified by the triple Combination. The Success Rating of 72% is greater than that of Trenching alone and with Geophysical Survey, but smaller than the 100% scored by combining Trenching with Field-walking.

The triple Combination does produce the best score of all single and combined techniques for the identification of remains from the Saxon period. By identifying two of four sites, the 50% Success Rating suggests that the use of Trenching with both Geophysical Survey and Field-walking is the only Field Evaluation approach to be able to identify remains from this period. It is interesting that structural remains were present at both Lower Icknield Way and Roxton Road West and were successfully identified. The two sites at which this triple Combination failed to identify the presence of Saxon remains both contained single features, a grave at Tring Hill and a waterhole at Water End East. Again the disappointingly small number of sites able to be measured in this way from the Case Study sample precludes the use of these figures as a statistically valid sample. Yet it does point out the direction for future measurement and research into the improvement of Evaluation Performance through the use of Combined techniques.

The comparison between these three different Combinations of Field Evaluation techniques and the three single techniques are shown in Figure 74. They provide a useful comparison of the measurements of the Consequences of the Decision Options for the successful identification of Date in Archaeological Evaluation.

7.1.2.5 The Logical Testing of the Premises of Propositions for Periods Present

As outlined in the beginning of this chapter, these results can be tabulated into a Decision Matrix to assist the Decision Makers choice of Alternative Courses of Action at DMP 12b. The Decision Matrix for Periods Present is shown in Figure 75 and can be used to test the Logical Operation of Decision-making-point 12b. The Premises of the Propositions which can be tested with these results are that the three single and three Combinations of Field Evaluation techniques are the most effective for the identification of periods present on site.

The analysis of the three single techniques measured in Section 7.1.1 above proves that the reliance on Field-walking and Geophysical Survey for the identification of all of the periods present in the Case Study are both Unsound Logical Premises. Field-walking has been shown to be able to achieve identification of all periods at only 10% of sites and Geophysical Survey has been shown to be totally unreliable for this purpose. The Premise that the Decision Maker can have confidence that Trial Trenching will identify all of the periods present is also proven to be Logically Unsound as it can only be relied upon to succeed in the identification of all periods present at 25% of sites. This Logical Testing now provides the archaeological profession with an unsatisfactory general picture of the ability of our current approaches to the identification of all of the periods of archaeological remains which might be present on a potential development site.

The Logical Testing of the Premises of Propositions that each single technique and the three Combinations are the most effective for the identification of the date of periods present can assist with more detailed analysis of this disappointing general picture. The Logical analysis will only be carried out for the statistically sound results for Trenching, Field-walking and Geophysical Survey Techniques, as the less reliable results from the Combined techniques can only give a general picture that suggests where further research should be carried out by other studies. The Premise that any of the Field Evaluation techniques measured in the Case Study sample can identify the date of Mesolithic remains present is shown to be Logically Unsound by the Outcomes O_{11}, O_{21}, O_{31} on the Decision Matrix. This situation must now be explicitly recognised by Archaeological Curators, Contractors and Consultants in the operation of Decision-making Point 12b. It provides implications for future archaeological research into this period which include the implicit detail that PPG16-related Excavations record Mesolithic remains by chance and not design.

The Field Evaluation technique with the most Sound Premise for the identification of date for the Neolithic period is shown to be Field-walking by Decision Outcome O_{22}. However, the value of that Outcome at 43% does not produce a high level of confidence. Logical Testing of the Premises relating to the identification of Bronze Age, Iron Age and Medieval periods does succeed in demonstrating three Sound Premises. Outcomes O_{13}, O_{14} and O_{17} show that Trenching is the most effective Field Evaluation technique for these periods. Similar Outcome Values at O_{15} and O_{25} show that the Premises that Trenching and Field-walking are the most effective techniques for the identification of the date of Roman remains present are the most Sound. The only Sound Premise for Saxon remains is that Trenching is the only Field Evaluation technique to be able to identify the presence of remains of this date.

This testing of the Premises of Propositions at Decision-making Point 12b relates only to the identification of periods present. The other primary purpose of Field Evaluation is to provide the Decision-maker with enough information about the nature of the archaeological remains from each period to assess their function and subsequent importance. This allows the appropriate Decisions relating to the appropriate Mitigation actions to be made in Stage 5 of the Archaeological Assessment process. The Performance Measurements and subsequent Logical Analysis of the Evaluation techniques in relation to the Type Classifications identified in Section 4.4.1 give a much more detailed picture of the Effectiveness patterns of our current approaches.

7.2 Types of Alternative States of Nature

The measurements for the Types of Alternative States of Nature were taken from the Case Study data and were recorded for each of the Alternative Courses of Action actually used for the Field Evaluation on the 100 sites in the sample.

7.2.1 Alternative Courses of Action used

Due to the limitations of data collection outlined in Section 5 above, measurements of Type scores for each period could only be recorded on 18 Case Study sites for the use of Field walking and on 20 sites for Geophysical Survey techniques. Type Scores could be measured for 103 Trenching interventions from 100 sites on which this technique was used. This produced a total of 543 different Type Scores for every period present and these results are held in the Rural Features and Structure Scores Table of the Analysis Results Access Database shown in Appendix 7. Each Intervention and site can be identified by the site and intervention numbers which relate to those in the Rural Technique Scores Table. These results have also been embedded into the Rural Technique Scores Table in Appendix 7. They can be accessed by clicking on the plus sign to the left of the ID number column.

Type Scores were recorded for Combinations of different Techniques on 31 sites. With ten of these interventions using a Combination of Trenching and Field-walking. A further twelve combined Trenching with Geophysical survey and the Combination of Trenching, Field-walking and Geophysical Survey was used on the remaining nine sites. After measurement of the Performance Scores of the three different Combinations were recorded, it was observed that all of the Combinations Scores were exactly the same as the Scores for the sole use of Trenching on those sites. Consequently no comparison was able to be made between Combinations and single techniques for the analysis of Type Performance measurement.

7.2.2 Levels of Confidence

Unlike the binary nature of the Date measurements in Section 7.1, which measure the success of a technique in identifying only the presence or absence of one variable, the measurements of Types of Features present are a ratio level measurement. These represent the percentage of the different Types of the archaeological features from each period from the total proven to be present by subsequent excavation. Therefore, a professional judgement must be made of the level of success for these percentage scores.

In order to eliminate the subjectivity inherent in the intuitive approaches, a mathematical probability ranking technique was used to assess distribution breaks between the groupings of scores within a range of the period Type scores.

In order to achieve consistency, the period Type scores from the use of Trial Trenching were selected as the group to which the probability ranking was applied. The reasoning behind this selection was that this group of Type Scores was the largest in number and provided measurements which ranged across the full range of Scores from 0 to 100%.

To identify a grouping of Scores which can be classified as "Good" there is a requirement for the number of Scores within the group to be large enough to measure in comparison with poorer scores. The 261 period Type Scores for Trial Trenching were placed in sequential order in the bar chart shown in Figure 76. The technique involves the identification of the largest breaks between different Scores based on their distribution and is designed to identify balanced numbers within each group. The six largest distribution breaks are shown on the distribution chart by arrows.

Whilst the largest and first break moving down the range from the highest Score occurs between 83% and 100%, there are only thirty two Scores within this group. Moving to the next break at 66% gives a group of fifty five Scores which gives a probability of a random intervention falling into this group of 1in 4.7 which equates to the upper quartile of the entire range. Selection of Scores above this distribution break as Good allows a Decision-maker to know that a Good Performance Score will identify between 66% and 100% of the Types of features present. Therefore I have classified everything below this as a "Poor" performance.

It is also worth noting other characteristics of the general distribution pattern of Trenching Type Scores. With one hundred and twenty one interventions scoring 0%, the probability of a Trenching intervention from the Case Study sample producing a Poor Score is 1 in 2.15. The same poor general performance is shown by the calculation of the Mean Score which is 30% and the Median Score (number 130) which is only 17%.

7.2.3 Type performance for Alternative States of Nature

The 550 Type Scores recorded for all of the three Field Evaluation techniques were divided into each period for analysis of performance. Mesolithic and Neolithic remains were only present on a small number of the Case Study sites, so these results will be discussed separately. Mesolithic remains were recorded in the post-evaluation Excavations at 7 sites, with one Field-walking, one Geophysical Survey and eight Trenching interventions used at the Field Evaluation investigations. Only one Trenching intervention at Little Marlow was able to identify any of the Feature Types present to produce a Performance Score of 13%. In addition, the ephemeral nature of the Mesolithic activity must be noted. The Mesolithic activity at Little Marlow and four of the other sites consisted only of an artefact scatter. Mesolithic features and structural remains, consisting of pits, gullies, post-holes, ditches and post-pits, were only present at the sites at West Waste, Monkston Park Area 3 and Netherne-on-the-Hill, none of which were identified by any of the Field Evaluation techniques used. The single Field-walking and Geophysical Survey interventions were unable to identify any of the Mesolithic remains.

Neolithic remains were present on 21 sites within the Case Study sample. Eight of the twenty-one Trenching interventions used succeeded in identifying some of the remains from this period, but Good Scores were only recorded at Chineham Lane, Prospect Park and Duncroft Site D, giving a Performance Score of 14% for the identification of Feature Types by Trial Trenching. The four Geophysical Survey interventions failed to identify any of the Neolithic Feature Types and Field-walking recorded only one Good Score at Marsh Leys Farm to give a Performance Score of 25% for this technique.

The Performance Scores for both the Mesolithic and Neolithic periods will be added to the Type Decision Matrix, but the small number of Case Study sites at which activity from these periods were present must be borne in mind when using the results.

The remaining Performance Scores for the Bronze Age, Iron Age, Roman, Saxon and the Medieval periods have been displayed on the graph in Figure 77 to illustrate the comparisons between performances more clearly and they produce a more disappointing picture than the Date Scores.

Bronze Age remains were present on 68 of the Case Study sites with sixty-eight Trenching, thirteen Field-walking and twelve Geophysical Survey interventions used. Trenching proved the most effective method for the identification of Feature Types as it was able to identify over 66% on twenty-two of the sites to give a Performance Rating of 32%. Field-walking was the only other technique to be able to produce any Good scores for Type with a Score of 100% at Marsh Leys Farm, but eight of the other uses of this technique produced Scores of 0% to give the overall Performance Score for Bronze Age remains as 8%. Geophysical Survey failed to identify any remains of this period on eleven of the sites, but did score 50% at Kennel Farm by managing to identify a ring ditch, giving a Performance Scores of 0%.

The Iron Age proved to be the most ubiquitous period of all those measured with Features representing activity being present on seventy one Case Study sites. Measurable Performance Scores were recorded from seventy-one Trenching interventions, fifteen Field-walking and fifteen Geophysical interventions. Figure 77 shows that Trenching produced a poorer Performance for Iron Age Feature Types than the Bronze Age with Good scores recorded on thirteen sites. The resulting 18% Performance Score was, however, the highest of all the Evaluation techniques for this period. Both Field walking and Geophysical Survey recorded only one Good Score for the Iron Age period, producing performance ratings of 7% for each technique.

Roman remains were present on just over half of the Case Study sites and Trial Trenching was used on all of those 56 sites. Performance Scores were also measured for a further fourteen Field-walking and sixteen Geophysical Survey interventions. Again Geophysical Survey only produced one Good Score with Boundary and Enclosure ditches identified at the St Austell NE Distributor Road site, to give an overall Performance Score of only 6%. Field-walking was not able to record any Good Type Scores for this period, resulting in a Performance pattern similar to the Bronze Age and Iron Age periods with Trenching proving the most effective Field Evaluation technique. Trenching was able to identify over 66% of Roman Feature Types on seven of the 56 sites at which remains of this period were present to produce an overall Performance Score of 13%.

Forty sites contained Saxon remains with Trenching used once on all of these and Performance Measurements recorded for 12 Field-walking and 9 Geophysical Survey Interventions. Neither Geophysical survey nor Field-Walking were able to identify over 66% of Feature Types on any of the sites, giving both an overall Performance Score of 0%. Geophysical Survey was, in fact unable to identify any Saxon Features at all and Field-walking identifying an artefact scatter at Roxton Road West only. Trenching, although proving the most effective technique, was only able to identify Good Scores on six sites to give an overall Performance Score of 15%.

Medieval remains were present at forty-four of the Case Study sites with Scores measured from forty-four Trenching, eleven Field-walking and eleven Geophysical Survey interventions used at the Field Evaluation stages. Figure 77 shows that Trenching was the only technique able to identify over 66% of Feature Types for this period. The Medieval period provided the second highest Performance Score for this Trenching with Good Scores being identified on ten sites to give the overall Score of 23%.

The Performance Ratings for each Technique within each archaeological period can now be added to a Decision Matrix of the Consequences each Decision Option as shown in Figure 78.

7.2.4 The Logical Testing of the Premises of Propositions for Feature Types

The Decision Matrix in Figure 78 can be used to test the Logical Operation of Decision Making-point 12b. The Premises of the Propositions which can be tested with these results are that the three single Field Evaluation techniques are the most effective for the identification of the nature of Features for each periods present on the Case Study sites.

The Premise that Trial Trenching is the most effective Field Evaluation technique for the identification of the nature of remains from the Mesolithic, Bronze Age, Iron Age, Roman, Saxon and Medieval periods is proven to be Logically Sound by the Outcomes O_{11}, O_{13}, O_{14}, O_{15}, O_{16} and O_{17}. In addition, the Outcome O_{22} shows that the Premise that Field-walking is the most effective technique for the Neolithic period appears to be the most Logically Sound. This Outcome requires further analysis, however, as it was noted in Section 7.2.3 that there were only four Field-walking interventions for which Performance Measurements could be recorded. The site at which the Field-walking interventions scored 100% was Marsh Leys Farm at which Neolithic activity only consisted of an artefact scatter. The Feature Types present at the three other sites were not identified by this technique. Neolithic activity represented by single Features of a pit at Little Stock Farm and a ditch at Prospect Park was not recognised by Field-walking interventions. Structural activity at Snarkhurst Wood consisting of pits and gullies was identified through an artefact scatter to give a performance Score of 33%. It is clear that the number of Field-walking interventions from which Performance Scores could be measured is too small to rely on for the Logical Testing of this Premise for the Neolithic period.

The Outcomes O_{23}, O_{24}, O_{25}, O_{26} and O_{27} in the Decision Matrix show that it is Logically Unsound to rely on Field-walking for any indication of the nature of archaeological remains for all other periods. Geophysical Survey interventions were also only able to produce Good Scores at 8% of Bronze Age, 7% of Iron Age and 6% of Roman sites. It is, therefore, Logically Unsound to rely on this technique for this purpose. In my personal experience as an Archaeological Curator, there have been several occasions when Archaeological Contractors and Consultants have argued to Local Authority Development Control Committees that a Field Evaluation relying on Field-walking as the sole technique was an acceptable and reliable sample of the nature of the archaeological remains. These results show that this approach is Logically Unsound and should never be propagated in any circumstances in future.

These results for identification of Feature Types should hardly be surprising for the archaeological profession as it is in accordance with the recognition in Section 6.2.1 above that both Field-walking and Geophysical Survey are extensive and non intrusive techniques. Whilst they have been proven to have no utility for the identification of Feature Types, they both have great utility for the identification of location of archaeological remains under appropriate site conditions. What the Performance Scores do show is that the use of extensive Field Evaluation Techniques should be restricted to the initial location of archaeological remains. This suggests that the current multi-staged approach to Field Evaluation should perhaps be analysed from the perspective of the different types of information they produce. The current approach of undertaking certain Extensive Techniques followed by a small sample size of Trenching is underpinned by the expectation that information to answer all of the six questions asked at Decision-making Point 12b can be produced by every Decision Option. Yet this assumption has now been proven to be Logically Unsound by the Decision Matrix for Feature types. Further analysis of the current approach to information provision will be carried out in Chapter 9.

It is also clear that the nature of the archaeological remains is important. The ability of the nature of activity from some periods as artefact scatters to skew the Decision Outcomes for Field-walking Performance Scores has been noted above. Section 7.3 will make use of the Characterisation concept of Past Landscape Use Patterns to refine the existing States of Nature to allow the linkage of actual patterns of features and structures present.

7.3 Types Scores for Local Past Landscape Use Patterns

The Characterisation technique of Past Landscape Use Patterns was introduced in Section 5.3.1.2 to provide a standardised model of the range of archaeological remains recorded at the Case Study sample sites. The combinations of Feature types present on the one hundred sites were assigned to the Past Landscape Uses Types for each period present using the interpretations provided in the Evaluation reports. These represent the

Explained Capta level of Information scale as defined in Section 3.4. All of the combinations of Feature and Structures Types assigned to the Past Landscape Uses recorded from the Case Study Sample sites are listed in Appendix 8.

To aid the analysis of Past Landscape Uses, a distinction has been made between the **Composite** remains on sites with complex combinations of features associated with settlement and with other associated human land uses and **Isolated** Past Landscape Uses which occur spatially separately from the more complex combinations. The category of Composite Settlement Landscape Uses has been further divided into three groups of features associated with Settlement Enclosures, Structural Remains and Occupational Use features in order to give a definition to the Types of features present. Other Settlement-associated and Isolated Past Landscape Uses have been split into two classes: Extensive Land Management Activities, and Human Resource Gathering Activities.

7.3.1 Mesolithic Past Landscape Use Patterns

Mesolithic remains were present at nine sites and the Past Landscape Use Patterns for this period are shown in Table 2 in Appendix 8.

Unknown Activity was recorded at five sites, and was represented by artefact scatters alone. Settlement Activity was recorded at the four other sites. West Waste and Monkston Park Area 3 Waste disposal was identified by the presence of pits at Netherne-on-the-Hill and by the presence of pits and scoops at Sandway Road. Structural remains of Settlement Activity was present in the form of post pits, unidentified ditch and post holes of a Post Built Building at Monkston Park Area 3. The most extensive combination of Mesolithic Settlement Activity Features were the stakeholes and slots of an Unknown Structure, a bank, post hole, gully and pits at West Waste.

This represents a presence of Mesolithic remains on 9% of the Case Study sites. Although showing a dispersed pattern of landscape use with isolated structures occurring rarely within the surrounding natural environment, the presence of Settlement Activity is demonstrated. The degree of dispersion from the Case Study sample does not allow patterns of settlement and other human activities to be developed for entire Mesolithic landscapes in this study, rather the results should suggest areas where the identification and Field Evaluation of Mesolithic remains require further research.

Accordingly, because of the small number of sites on which Mesolithic remains were recorded, this period has been excluded from the analysis of Past Landscape Use Patterns.

7.3.2 Neolithic Past Landscape Use Patterns

Neolithic remains were present at 21 of the Case Study sample sites and the Past Landscape Use Patterns are shown on Table 3 of Appendix 8. Non-intensive remains were present on twelve sites with activity represented by artefact scatters on five of these. Individual features were present on two sites, a waterhole at Duncroft B and a depression at Sandway Road. Neolithic activity was represented by pits at the remaining five sites. The detailed descriptions of context properties and contents were assessed to identify functions of all the Neolithic pits recorded on the Case Study sites. Where form or ecofacts present suggested a function other than Waste Disposal, such as the burial pit at Mill Farm Quarry or post pit at Chineham Lane, they were assigned to other Types. All the remaining pits were interpreted by the Client Reports as representing Waste Disposal activity, and have been classified as such. The Waste Disposal activity evidenced at the five remaining non-intensive Mesolithic sites appeared in isolation at Little Stock Farm and Battlebridge Lane, but were associated with other Past Land-use Patterns at three sites. A boundary ditch/gully showed Land Division Boundary activity at Home Farm Area 5 and Snarkhurst Wood, and a tree-throw hole represented Woodland Clearance at Hurst Park.

Eight of the sites with Neolithic remains showed more intensive Composite Settlement Landscape Use patterns. These were represented by post holes, gullies, beamslots and post pits of Post Built Buildings and unidentified scoops or gullies of Unknown Structures on four sites. Enclosure ditches and entrances were present on three sites. Chineham Lane and Prospect Park were the only sites to show an isolated Post Built Building with no associated land-uses.

The Structures present on the seven Neolithic settlement sites were associated with different combinations of Land Uses. Pits were present at five and boundary ditches at three of these sites. Home Farm 4. Three sites with Composite Neolithic Settlement remains were associated with Funerary and Ritual Activity. Home Farm 4 also recorded a cremation pit, whilst a burial at Home Farm 6 and a ritual pit at Sipson Lane were documented. One site revealed funerary and Ritual activity in isolation from a settlement site. The ditches of a Mortuary Enclosure, a ring ditch and burial were excavated at Mill Farm Quarry.

The patterns of Past Landscape Use for the Neolithic period show a slightly more intensive use of the landscape than those of the Mesolithic period. This is to be expected with the gradual adoption of permanent settlements which accompanied the arrival of agriculture related to this period. The introduction of archaeological remains which can be assigned a Funerary and Ritual function is also noted for the Neolithic period.

To achieve some level of statistical soundness, any period present on less than 25% of the Case Study sites will be excluded from the analysis of Past Landscape Use Patterns in Section. Therefore the twenty-one sites with Neolithic activity will not be included in the further analysis.

7.3.3 Bronze Age Past Landscape Use Patterns

Archaeological features dating to the Bronze Age were shown to be present on sixty-three sites from the Case Study sample and the details are shown in Table 4 of Appendix 8. Thirty four of these sites contained Composite patterns of complex combinations of features associated with Settlement. The Settlement Past Landscape Patterns comprise eight Unknown Structures, thirteen Single Farmsteads, eleven Isolated Domestic Structures and five Domestic Waste Disposal Activities. The features which were classified into these patterns include ditches, terminals and entrances associated with settlement enclosures. Structural features comprised post holes, post pits, stake holes, beam slots, and foundation and drainage gullies. Occupational Use features include middens, rubbish pits, cess pits, cooking pits and hearths. Domestic Waste Disposal activity was represented by pits at five sites.

Seventeen of the Bronze Age Settlement sites had associated combinations of other human and natural land-uses. Boundary ditches represented Land Division Boundaries at seven sites. Agricultural Landscape Use was represented by field enclosure ditches and tree throw holes at seven sites. The quarry pits of Mineral Quarrying was associated with one of these Bronze Age settlement sites. Transport was represented by one trackway and one droveway on two separate sites. Water Collection was represented by wells at two Settlement sites, with Woodland Clearance shown by tree throw holes at two others.

Funerary and Ritual Past Landscape Uses were associated with Settlement sites at twenty-two sites and were represented by a range of Feature Types. Ritual Structures comprised a ceremonial enclosure, ceremonial pits and a burnt mound. Funerary Structures included a barrow burial and a post-hole structure, whilst Human Burial included both cremation pits and inhumation burials.

Thirty of the sites with Bronze Age remains showed less complex combinations of Isolated Human Landscape Uses. These can be classified into the Extensive Land Management Activities of Land division boundaries (8), Agricultural (7), Transport (1) and Woodland clearance (1) and Human Resource Gathering Activities of Water collection (2), Mineral quarrying (1), and Activity (1). Isolated Funerary and Ritual Landscape Use was present on eleven sites and consisted of Human Burial in the form of cremations and Funerary Structures of ring ditches and were associated with rubbish pits.

The more complex combinations of Settlement and associated Past Landscape Use Patterns are evident for the Bronze Age remains within the Case Study sample of sites. An increase in the proportions of Settlement Past Landscape Uses compared to Isolated Landscape Uses is clear, as is the broader range of the Feature types within all groups of Uses. It is clear that the increases in Settlement sites has been accompanied with much wider areas of the surrounding landscape becoming subject to human management. The beginning of the formalisation of the rural landscape can be noted from the different types of Past Landscape Use Patterns during this period. Further analysis of Past Landscape Use patterns will be carried out in Chapter 8.

7.3.4 Iron Age Past Landscape Use Patterns

Sixty-two of the Case Study sites were found to contain remains dating to the Iron Age period, and these are shown in Table 5 of Appendix 8. Forty-seven (75%) of these sites revealed Composite Settlement remains consisting of eleven Unknown Structures, thirty-three Single Farmsteads and four Isolated Domestic Structures with associated Waste Disposal (7) and Funerary and Ritual (20) Past Land Use Patterns.

The Features recorded as these settlement remains included the Settlement Enclosure related features of enclosure ditches, entrances and terminals, and a post hole enclosure structure at two sites. Structural Features included postholes of post built buildings, posts pits, stake holes, beam slots, foundation gullies, drainage ditches and the post holes of a fence line. Other structural features included drip-ring-gullies of round houses and a four-post granary structure on one site.

Occupational Use Features included rubbish pits, cooking pits, hearths, working surfaces, storage pits, industrial gullies and pits, kilns, water holes and wells and an iron-working feature on one site.

Waste Disposal Features comprised pits which were present on seven of the Iron Age Composite Settlement Sites. Twenty contained Ritual and Funerary Land Use Patterns. These comprised the Ritual Structures of ceremonial pits at six sites and even a shrine at Marsh Leys Farm and Funerary Structures as evidenced by a post-hole Structure at Brisley Farm 1. Human Burial features included cremation pits at ten sites and inhumation burials at five others.

Nineteen of these Iron Age Settlements had associated Past Landscape Uses with the Extensive Land Management Activities of land division boundaries represented by boundary ditches at one site, Agricultural Activity shown by field enclosure ditches at six sites, Transport Landscape Activity was present at two sites and Colluvium build-up shown at two others. Human Resource Gathering was limited to Domestic Industry which was present on four sites. This Past Landscape Use was represented by industrial pits, working surfaces, a kiln and even a furnace at White Horse Stone. An iron-working structure was also present at the Harvest Home site.

The remaining nineteen Case Study sites contained Iron Age remains with less complex combinations of Isolated Past Landscape Uses. The Extensive Land Management Activities include Land Division Boundaries represented by boundary ditches on sixteen sites. Agricultural Activity was evidenced by the presence of field enclosure ditches at twenty four sites. Transport Landscape Use features included trackways, roads, hollow-ways, cart rut feature, roadside ditches and droveways at eight sites.

Human Resource Gathering activity was more frequent on Isolated sites with Domestic Industrial features present at eight and Mineral Quarrying at five sites. Water Collection (4) and Woodlands Clearance (4) were also shown to have been carried out in isolation from Settlement in this period. Isolated Funerary and Ritual Patterns were present on twenty two sites and evidenced by the same features as those Patterns associated with Settlement.

Altogether, these remains represent an increase in complexity and concentration of Settlement and Landscape Uses. A picture of a network of interlinked rural settlements can be produced from the Case Study sample of sites. These Settlements are associated with Extensive human management and utilisation of the resources of the surrounding environment during the Iron Age. Further analysis of these Past Landscape Use Patterns will be carried out in Chapter 8.

7.3.5 Roman Past Landscape Use Patterns

Roman remains were present on sixty-two of the Case Study sites and the Past Landscape Uses into which they were classified are shown in Table 6 of Appendix 8.Thirty-six of these sites contained Composite Settlement remains consisting of seven Unknown Structures, twenty-three Single Farmsteads, and four Isolated Domestic Structures with Waste Disposal on seventeen sites. Settlement Features included the Enclosure related features of enclosure ditches at fifteen sites, a timber palisade, posthole enclosure structures and annexe enclosure ditches on five sites. Structural Features comprised post holes, post pits, beam slots, foundation ditches, a floor, an external surface and the drip ring gullies of round houses on eight of these settlement sites. Occupational Use Features were represented by rubbish pits on seventeen sites, a fireplace and two hearths and Water Collection Features of waterholes and wells with a pond on one site.

Funerary and Ritual Past Landscape Uses were associated with these Roman Composite Settlement remains at twenty-nine sites. This Past Landscape Use was represented by the Ritual Structure Features of kiln pits, ceremonial pits, a ceremonial enclosure and pyres or hearth pits.

Other associated Landscape Uses include Extensive Land Management Activities with land division boundaries on sixteen sites. The Settlement-associated Agricultural Activity present on eighteen sites was represented by field enclosure ditches, two corndryers and ploughsoil and plough furrows. Transport Landscape Uses were represented on eight sites by trackways, holloways, a droveway and roadside ditches. The Human Resource Gathering Activities of these Roman Composite Settlement sites comprised three types. Domestic Industry was represented at ten sites by kilns, dump deposits and pits and two working surfaces. Mineral Quarrying and Water collection activities were present on five and four Roman Composite Settlement sites respectively.

Twenty-six of the Roman sites contained less complex combinations of Isolated Past Landscape Uses. Extensive Land Management Activities included land division boundaries (1), Agricultural (6), Transport (2) and Colluvial build-up (2). Isolated Funerary and Ritual Patterns were present on twenty two sites.

The archaeological remains from the Case Study sites dated to the Roman period seem to show a continuation of the formalised rural landscape demonstrated from the Iron Age period. The lower proportions of Composite Settlements seem to indicate increased dispersion, but the wide range of Extensive Landscape Management, combined with the decrease in Isolated Human Activity also show a well-established agricultural landscape.

7.3.6 Saxon Past Landscape Use Patterns

Saxon remains were present on fewer sites within the Case Study sample with only 31 sites being recorded to contain remains of this period. These are shown in Table 7 of Appendix 8. Sixteen of the rural sites with Saxon remains contained the complex

Activities associated with Composite Settlement Activity and these comprised six Unknown Structures, and ten Single Farmsteads. These were represented by enclosure ditches at eight sites. Structural Remains included postholes, stakeholes, beam slots, gullies, post pits, a floor and external surfaces with a hall was discovered at Prospect Park and Sunken Featured Buildings at four sites.

All of the Saxon Settlement sites had associated Past Landscape Uses and this was the earliest archaeological period at which the Funerary and Ritual Landscape Uses were shown to be not associated with Settlement remains. Extensive Land Management Activities were represented by the boundary ditches of Land Division Boundaries at ten sites, and by Agricultural and Transport Uses at one site each. Settlement-associated Human Resource Gathering was restricted to the hearths of Domestic Industry on three sites and Water Collection on four sites.

Ten of the sites with Saxon remains contained less complex combinations of Isolated Past Landscape Use Patterns. Extensive Land Management activities comprised only Land Division Boundaries on two sites. Human Resource Gathering Activities were also limited to Water Collection on one site. All five of the Funerary and Ritual Landscape Uses were restricted to Human Burial with cremation pits on one site and burials on four others. No Saxon Ritual or Funerary Structures were present in any of the 100 Case Study sites. The presence of archaeological remains from the Saxon period indicate the reduction of human activity within the rural landscape. The drastic reduction in proportions of Isolated Extensive Land Management activities perhaps indicates an increase in settlement dispersion.

7.3.7 Medieval Past Landscape Use Patterns

Fifty-six of the Case Study sites contained remains dating to the Medieval period and the breakdown of Past Landscape Uses are shown in Table 8 of Appendix 8. Twelve of the sites containing Medieval remains contained Composite Settlement Activity consisting of six Unknown Structures, four Single Farmsteads, and one High Status Residence. These were represented by features including enclosure and annexe ditches, boundaries, and a moat. Structural Features included post holes, post pits, beam slots, a floor, foundation gullies, walls, a house, a causeway and a stream revetment. Occupational features included rubbish pits, industrial pits, three hearths, a yard and working surfaces.

Medieval Settlement-associated Past Landscape Uses included the Extensive Land Management Activities of Land Division Boundaries and Agriculture at six sites each and Transport at one site. Human Resource Gathering Activities were restricted to Domestic Industry on four sites and the moat at Parsonage Farm

There were no Medieval Funerary and Ritual Landscape Uses associated with any of the Composite Settlement or Isolated Landscape Uses. This is to be expected because of the requirements of the Medieval Church for burial within churchyards.

Thirty-four of the Case Study sites contained Medieval remains of the less complex combinations of Isolated Landscape Uses. Extensive Land Management Activities included Land Division Boundaries at nine sites, Agricultural Activity at sixteen, Transport at seven sites and woodland clearance at one site. Isolated Human Resource Gathering was restricted to Domestic Industry on one site and Mineral Quarrying at two others.

The archaeological remains dated to the Medieval period display the expected patterns of increase of small dispersed rural settlement from the Saxon period. However, the increase in Isolated Human Landscape Uses show the beginning of the distinction between the settlement features of urban areas and village and the widespread limiting of rural areas of the landscape to agricultural uses. The survival of some of these elements of this Medieval Landscape developed by Historic Landscape Characterisation may allow links to be made between the chronology of Past Landscape Use and those visible in the modern landscape.

7.3.8 Patterns for Evaluation Trenching of Past Landscape Use Patterns

The identification of Performance Patterns of the Type Scores for the archaeological remains from in each period identified in Section 7.2 could provide useful representations of the Effectiveness of Evaluation Techniques from a different perspective. With the poor success ratings demonstrated in Section 7.1 and 7.2 for the use of Field-walking and Geophysical Survey, the effectiveness of these Techniques will not be measured again. Instead the success of Trial Trenching at identifying the Past Landscape Use Patterns identified above will be carried out in order to assess the utility of the methodology. The resulting success ratings will then be set into the third and final Decision Matrix to show the Outcomes of the Decision Options for this approach.

The application of this methodology requires a fundamental change in the Scale of Information used. The Type scores were measured from the actual presence of Features and Structures recorded at the Secondary Raw Capta Level of Information from the Client reports. As demonstrated in Section 3.4, the characterisation of the types of archaeological Features and Structures into Past Landscape Use Patterns requires the use of Information taken at the Explained Capta Level of the Information Scale. Measuring the Performance Scores of Past Landscape Use Patterns requires the recording of additional information from the Explained Capta sets provided by the interpretation of those features set out by Contracting Field Archaeologists. As with the Date scores in Section 7.1, these measurements are of a binary nature. They measure the success or failure of Trial Trenching to identify the presence of the Past Landscape Use Patterns and there is no requirement for percentage scores on each site. Percentages of each Past Landscape Use type successfully identified from the total of the 100 case study sample sites will be analysed to provide an overall picture of Performance Patterns.

7.3.8.1 Composite Settlement and Isolated Patterns

The Success Scores for the identification of the Composite and Isolated Past Landscape Use Patterns by the Case Study Trial Trenching Interventions are shown in Figure 79.

The results show a mixed pattern of success for identification of Composite and Isolated remains from each period. Trenching proved most successful at the identification of Composite Settlement remains for the Medieval period with a Performance Rating of 62% from twelve sites. This was the only period for which this Technique was able to identify more than half of the Composite Settlement Patterns present. The second highest performance rating for Composite remains was for the Iron Age period as Trenching successfully identified 46% of the Composite Settlement Patterns on forty-seven sites. Poorer scores of 32%, 29% and 23% were scored for Composite remains from the Roman, Bronze Age and Saxon periods respectively. Yet the performance of Trial Trenching for the identification of Isolated Past Landscape Use Patterns shows higher success rates for the Bronze Age, with 48% of thirty sites, and the Roman, with 41% of twenty-six sites, periods. Lower Performance Scores were recorded for the Iron Age (23%), Saxon (10%) and Medieval (30%) periods.

It should be expected that the Composite Settlement Patterns are identified with more success than the Isolated ones, as the spatial area covered by the Composite remains is much larger than the individual Features and Structures of the Isolated Landscape Use Patterns. Indeed, this is the case for the Iron Age, Saxon and Medieval periods. Trenching produced a 46% Success Rate for Composite Iron Age Patterns and only a 23% Score for Isolated remains of this period. A disappointing Score of 23% for Saxon Composite Patterns compares favourably with the even poorer Success Rate of only 10% for Isolated Patterns. Trenching's highest score for all periods was the 63% Success Rate for Medieval Composite Patterns, which is more than twice as successful than the 30% of Isolated Patterns identified for this period. Yet two Performance Patterns show that Trenching has considerably more success at the identification of Isolated Bronze Age (48%) remains than the Composite Patterns for this period (29%). The same difference in performance is shown for the Roman period with 41% of Isolated and only 32% of Composite Patterns being successfully identified.

This suggests that our current approach to Trial Trenching is better able to the identify Isolated Bronze Age and Roman Isolated Landscape Use Patterns than Composite Settlement remains. The difference in sizes between these Past Landscape Use Patterns suggest that some of the physical characteristics of these remains may be important to their detection.

7.3.8.2 Composite Settlement Patterns

A more detailed view of the Performance of Trenching for the identification of the Features and Structures comprising the Settlement Landscape Uses for each period is shown in Figure 80. The Structural remains have been divided into their constituent Types of Unknown Structures, Single Farmsteads and Isolated Domestic Structures. Performance for the identification of Domestic Waste Disposal was also measured.

Figure 80 shows that Evaluation Trenching was able to identify 50% of Bronze Age, 73% of Iron Age, 28% Roman, 27% of Saxon and 66% of Medieval Unknown Structures from Composite Settlement sites from the Case Study sample. Poorer performance was shown by the identification of Isolated Domestic Structures with only 36% of Bronze Age, 25% of Iron Age and 50% of Roman occurrences of this Past Landscape Use Patterns being identified. These structures were not present on Saxon or Medieval Composite Settlement sites. Evaluation Trenching did identify 54% of Bronze Age, 49% of Iron Age, 43% of Roman, 27% of Saxon and 100% of Medieval Single Farmsteads from Composite Settlement sites. Trenching also succeeded in identifying 40% of Bronze Age, 100% of Iron Age, 41% of Roman, 28% of Saxon and 33% of Medieval Domestic Waste Disposal from Composite Settlement sites from the Case Study sample.

These results here suggest that the methods of interpretation used to assign Structure Types to the Secondary Capta of Features and Structures identified are important. The difference between an Unknown Structure and Isolated Domestic Building is interpreted at the Explained Information level. Therefore the actual difference between Structure Types is subject to more expert interpretation than the classification into Feature Types used in Section 7.2. However, the Performance Scores of Settlement Structures can be combined to provide a representation to test the effectiveness of Trenching at the identification of individual Structures from each period. The combined Scores show that Trenching can identify 46% of Bronze Age, 49% of Iron Age and 40% of Roman Structure Types when they are present on a potential development site. A much poorer performance of 27% is recorded for the Saxon period. The best Performance Score was the 83% of Medieval Structures which were identified by Trial Trenching from the Case Study. The differences between the Success Scores for the identification of Structures from these two periods may relate to difference in the size and form of Structures in each period. This Proposition will be tested in Chapter 8.

7.3.8.3 Extensive Landscape Management Uses

Due to the small number of Human Resource Gathering Past Landscape Uses recorded from the Case Study sample, these activities have been excluded from the statistical analysis, which focus on the Extensive Landscape Management Uses alone. The Extensive Uses of Woodland Clearance, Transport and Colluvial build up have also not been included in this analysis due to very small numbers present in the Case Study. The Performance Scores of Trial Trenching for the identification of Extensive Land Management Uses associated with Settlement were combined into the charts in Figures 81 and 82.

Evaluation Trenching is far more successful at identifying Land Division Boundaries associated with Composite Settlement sites for most periods, apart from the Iron Age where it identified 50% Isolated Boundaries and no Composite patterns of these features. Trenching was also far more successful at identifying the Composite-associated Agricultural Landscape Uses for all periods, apart from the Bronze Age where this 57% of Isolated examples were identified compared to the 29% of Composite Uses. These Patterns of effectiveness could relate to the physical properties of the Features themselves.

7.3.8.4 Funerary and Ritual Patterns

The Performance Scores for the identification by Evaluation Trenching of Funerary and Ritual Landscape Uses are shown in Figure 83. Every occasion of this Past Landscape Activity for both the Isolated and Composite-associated Uses were measured. These show much poorer Performance Patterns with Trenching unable to identify any of the eleven Isolated Bronze Age, twenty two Roman and four Saxon occurrences of this Pattern. The only period for which Trenching was able to provide a Performance Score for this Isolated Landscape Use was the 5% of the twenty-two occurrences of Iron Age remains.

Trenching also failed to identify any of the occasions on which this Landscape Use was associated with Composite Settlement remains from twenty Iron Age sites on which it was present. A poor score of 5% was achieved from the twenty-two sites associated with

Composite Patterns for the Bronze Age period. Trenching only shows a better performance for Composite Funerary and Ritual remains for the Roman period. Here Trenching was able to identify 28% of the twenty-nine sites on which this Landscape Use occurred. There were no instances of Funerary and Ritual Landscape Use Patterns being present on Composite Saxon or on Composite and Isolated Medieval sites.

It is clear that Trial Trenching can identify 28% of Roman and 5% of Bronze Age Funerary and Ritual remains associated with Settlement sites, but fails to identify this Past Landscape Pattern at Iron Age Settlement sites. Trenching also failed to identify any of the Isolated Funerary and Ritual activity for any periods apart from the Iron Age for which it is able to identify on 5% of sites.

7.3.8.5 Logical Testing of Trenching Performance for Past Landscape Use Patterns

The Performance Patterns of Trial Trenching for the identification of the Past Landscape Patterns discussed above can be compiled into a Decision Matrix as shown in Figure 84. This complexity of this Matrix illustrates a characterised model of the Alternative States of Nature which is far more detailed and informative than used in Section 7.2. Outcomes from this Decision Matrix can be used to test the Soundness of Premises of Propositions at Decision Making-point 12b.

All of the Performance Scores on the Past Landscape Use Patterns Matrix are on the same Value Scale and can thus be compared by Prioritisation or "Ranking". The "Good" Scores will again be those between 66% and 100%, with "Poor" Scores designated as any Score below 32%.

Outcomes O_{35}, O_{42}, and O_{55} show that the Premises that Trial Trenching is the most Effective for the identification of Medieval Farmsteads and their Land Division Boundaries and Iron Age Settlement Waste Disposal pits are Logically Sound. Other Outcomes prove the Soundness of Premises that state that Trenching is totally Ineffective for the identification of either Composite or Isolated Funerary and Ritual Uses (O_{91}, O_{92}, O_{101}, O_{102}, O_{103} and O_{104}). The converse assumption to these Logically Sound Premises are that Trenching is not Effective for any other Past Landscape Uses Patterns from any other period.

The analysis of Feature Types in Sections 7.3.1 to 7.3.7 shows the combinations of Features which comprise each Past Landscape Use Pattern against which the Performance of Trenching was measured. The final Decision Matrix illustrates that Effectiveness of one Field Evaluation Technique seems to vary greatly depending on the nature of the Feature Types which make up each Past Landscape Use Pattern.

7.4 Implications of Logical Analysis of Decision Options for current practice

One implication of these results is that these quantitative methods of measuring performance of the effectiveness of Field Evaluation Techniques from Case Study sites do have utility for the Decision-maker at the Portfolio type Decision-making Point 12b.

The overall picture of both Date and Type results demonstrates a clear but worrying representation of the effectiveness of our current approaches to the Field Evaluation of archaeological sites. The Logical Analysis also suggests that, as Trenching is the most effective technique for both identification of Date and Type, it must be used on every Field Evaluation intervention. The additional use of Field-walking to identify the Date of Neolithic remains must also be considered where site conditions allow. The general picture provided by the analysis of Combinations of Techniques for Date identification also suggests that further quantitative research into this area could benefit our current approaches.

Given the poor performances of all Techniques for the identification of Date and Type of Mesolithic and Neolithic remains, it appears that great improvements of existing Techniques or research into new approaches must be developed.

Focussing on the Type results, however, provides an even more worrying picture of the effectiveness of Trial Trenching. The number of such interventions able to identify between 66% and 100% of the Feature Types actually present on the Case Study sites was much lower than expected. Despite being the most effective on Bronze Age remains, Outcome O_{13} shows that an Archaeological Curator can only rely on 32% of these interventions being able to identify over 66% of Types present. Much poorer performance is shown for Iron Age (18%), Roman (13%), Saxon (15%) and Medieval (23%) remains.

Analysis of the Effectiveness of the Trenching, as the most effective technique available to this research, on the Past Landscape Use Patterns has produced even more stark results. These show that only certain Types of Past Landscape Use Patterns from certain periods can be identified effectively by current Trenching approaches. This highlights two philosophical issues which must be addressed by the archaeological profession if improvements to the operation of Decision-making Point 12b are to be made.
The first philosophical choice which faces the archaeological practitioner stems from the results of this first quantitative measurement of the Effectiveness of our current Evaluation techniques. The results show that it appears that Archaeological Curators are currently relying on the most effective technique for the identification of Alternative States of Nature available to them at Decision-making Point 12b. The results also show that all those operating the current approach to Field Evaluation through Trial Trenching are poorly served by the ability of its current application. The philosophical choice to seek to improve existing techniques and approaches must actively be made within the academic and operational fields of the profession. Achieving such improvement will require the commitment of resources to a wide variety of research. A brief analysis of the requirements of potential improvements to the methodology of Trial Trenching and alternative application of this and other Field Evaluation approaches will be carried out in Chapter 9.

The second Philosophical matter concerns the actual purpose of Field Evaluation approaches. The operation of Decision-making Point 12b has been shown in Section 4.1 to occur under Conditions of Incomplete Knowledge. The performances of Trenching on Past Landscape Use Patterns show that this technique is only effective for certain combinations of Features from different periods. If we thus identify that our Objectives are limited by the ability of our Field Evaluation techniques, we must also recognise that our current approach provides an unnecessarily weighted set of objectives. The strategies we currently use have a tendency to identify the Composite Settlement patterns from certain periods. Yet this does not sit comfortably with the Decision Strategy of Choice of Extreme Expected Value, which was shown to be the most appropriate to this Type of

Decision. If Curatorial and Contracting Archaeologists continue to be satisfied with the current approach of Field Evaluation, they will be applying the philosophical approach that complex archaeological remains from every period may be present on every site but that the full range will not be identified by Field Evaluation. The need for improvement to this situation will be discussed in Chapter 9.

As discussed in Chapter 3, the full Logical Operation of DMP 12b requires the satisfaction of the Decision Objectives by the selection of the most effective archaeological techniques for the identification of Alternative States of Nature which might be predicted to be present on a site. Now that the quantitative assessment of effectiveness has been carried out, the Logical Testing of the Premises of Propositions relating to the Probability of Presence of certain Types of archaeological remains from certain periods at certain sites must be carried out in the next Chapter.

Chapter 8: Probability of Presence of Alternative States of Nature

8.1 Probability of Presence

The Logical Testing of the Propositions of Probability of Presence requires the Soundness of the Premises of such Propositions to be identified. These Premises consist of the statements that certain types of archaeological remains from certain periods are likely to be present on a site. This concept of Probability of Presence at Decision-making Point 12b is currently defined using very broad categories of Probability using the inductive Professional Judgement identified in Section 3.4. This approach uses Prior Knowledge on known presence from Historic Environment Records and data held in archaeological research frameworks and local knowledge of past human behaviour within the current landscape to produce Expert Models of Predicted Presence. These models consist of the Propositions that archaeological remains from certain periods are highly likely to be present because of specific indicators of known presence or association with nearby known remains or general indicators of the suitability of the site for known patterns of past human activity.

These indicators were recorded from sixty-seven of the Case Study sites and the details are shown in The Human Factors Table in the Analysis Results Database in Appendix 7. This shows that only 13 (19%) of the Case Study sites used the actual known presence of archaeological remains prior to the Field Evaluation as a Premise for the Probability of Presence. The sixteen Premises from these sites are shown in Figure 85 and a simple test of Soundness can be carried out using the comparison with the Excavation results. Thirteen (81%) of these Premises are proven to be Sound with the three Unsound Premises at the Copdock, Marconi and Monkston Park 1 sites mis-identifying the dates of archaeological remains later proven to be present. The gaps in Prior Knowledge of Presence have already been described in Section 3.4, but indications of the much higher proportion of land without this information can been seen in the small percentage of Case Study sites with Prior Knowledge. Some idea of the information gaps can also been taken from the additional seventeen periods of archaeological activity which were recorded but not predicted by the ten sites with

Sound Prior Knowledge Premises. This figure represents an additional 130% of the Sound Premises which are just not predicted from the records of known remains. Fifty (74%) of the sixty-seven sites used the specific indicators of association with adjacent or nearby known remains. The 159 Premises of Propositions produced are shown in the Human Factors Table in Appendix 7. Comparison with the excavated remains shows that 102 (64%) of these Premises can be proved to be Logically Sound. The remaining fifty-seven (36%) are proven to be Unsound. Yet there are still sixty-five additional periods of archaeological activity which are not indicated by these Premises which represent an additional 40% of unpredicted Premises.

General explicit indicators of the Probability of Presence are only recorded on twelve (18%) of the Case Study Sites and vary greatly. A mathematical model based on spatial distribution of known archaeological sites in the landscape as recorded on the Historic Environment Record is used at the Copdock Mill site. The Field Evaluation report states that the average distribution is the presence of one site within every five hectares of the landscape. As the area of the proposed development was 5 hectares in area, it was suggested that at least one archaeological site lay within its boundaries. This prediction was proven to be Logically Sound by the subsequent excavation of a Saxon Farmstead Settlement and associated Land Division Boundaries. But this broad method of prediction provides too general a model to provide information on the nature and thus importance of expected remains.

The remaining eleven sites use combinations of Expert models of past human activity within the landscape to suggest that Presence is Probable. The nineteen Premises presented by these general indicators are shown in Figure 86. Twelve (63%) of these are shown to be Sound and seven (37%) are Unsound, with an additional twenty-two (115%) periods of activity not predicted.

The proportions of Sound, Unsound and Unidentified Premises for the three types of indicator of Probability of Presence are shown in Figure 87. This shows that the highest proportion of Sound Premises comes from the Known Presence indicators at 81% but with an attendant 130% of additional Unknown periods of activity. This large number relates to the gaps in knowledge of all surviving archaeological remains.

Whilst the nearby Presence indicators provide a lower proportion of 64% of Sound Premises, there is a much lower proportion of Unknown Premises at 40%. Yet the Expert Models, whilst performing with very similar proportions of Sound and Unsound Premises as Nearby Presence indicators, show a proportion of Unknown Premises of 115%, almost as large as that for Known remains. This proportional analysis suggests that the current approach to Expert Models of past human activity within the landscape has as many gaps in knowledge as exist in our Historic Environment Records and they could be of greater assistance with the calculation of Probability of Presence.

No Expert Models are currently in use which record Probability of Presence within the modern landscape at the Micro-environment Information scale as described in Section 4.4.2. Although Historic Landscape Characterisation was designed as a tool to link mapped historic landscape elements with past human activity, it is focussed at a landscape scale and any relationships between probability of presence of individual components of the archaeological resource and the mapped elements of the modern landscape are not identified. An example of this is the general Expert Model provided for the Case Study site at St. Austell NE Distributor Road in Cornwall. This site lies within the HLC Character Area of "Anciently Enclosed land" which is characterised by having been enclosed and farmed since the Late Bronze Age (Johns 1995 – see Appendix 5). The reorganisation of this rural landscape into extensive strip fields in the Late Medieval period has masked the presence of earlier activity. The results of the excavation of this site suggest that it is the site of a ritual shrine first used in the Bronze Age with continued use through the Iron Age and into the Roman period with at least nine different spatial reorganisations of landscape. This level of detail is not possible with the current application of Historic Landscape Characterisation. The concept of Past Landscape Use Patterns could be adapted to provide the missing layer of detail at the Micro-environment scale of features and structures to HLC characterised areas for the production of more detailed Predictive Models of Rural Archaeological Presence.

Predictive Models of Presence require two parameters to be defined, the Nature of expected archaeological remains and the Locations in which those remains are to be expected. The first parameter will be defined by an analysis of the Past Landscape

Use Patterns from the Case Study. The parameter of Probable Location will be analysed using the concept of Local Locational Factors as identified in Section 4.4.2.

8.2 Analysis of Past Landscape Use Patterns

The results of the Past Landscape Use Pattern characterisation methodology carried out on the Case Study sample do not adequately represent the full range and types of all archaeological sites in England. Yet they can be used to populate a Model which can be analysed in a number of different ways to demonstrate a methodology which, in due course, could assist the development of detailed Models of Rural Presence. Such Models could then be attached to Historic Landscape Characterisations. The Methodology will be applied to the Past Landscape Use Patterns recorded from the Case Study Sample in order to demonstrate its application and potential utility. This analysis will be limited to the Patterns from the Bronze Age, Iron Age, Roman, Saxon and Medieval periods only as remains from other periods are present on too few of the Case Study Sites.

The reality of this model of archaeological remains can be tested by application to data from similar applications of this characterisation technique from groups of sites, from individual County Historic Environment Records or from the future measurement of all archaeological sites on a national basis.

8.2.1 Proportions of Past Landscape Use Patterns

The proportions of these remains on rural sites could be used to demonstrate existing patterns on known sites. Probability will be expressed as the frequency of occurrence, usually expressed mathematically as a 1 in x chance.

The proportions of Composite and Isolated Landscape Use Patterns for each period are shown in Figure 88. Composite Settlement remains were present for over half of all periods except for the Medieval period (38%). The presence of this type of Past Landscape Use at 54% of Bronze Age and 58% of Roman sites suggest that they are more common occurrences. Greater proportions of Composite Settlement Patterns are present on 76% of sites with Iron Age and 68% of sites with Saxon remains. A similar analysis of Funerary and Ritual Landscape Uses is shown in Figure 89. All Funerary and Ritual activities were associated with Settlement in the Bronze Age, and 95% of Iron Age and 97% of Roman remains recorded. This picture changes for the Saxon period with all instances of this Past Landscape Use being isolated and, of course, not occurring on any sites of Medieval date. The resulting Probability Premises from this analysis are:

If Bronze Age remains are present, there is a 1 in 1.85 chance of them being Composite Settlement remains and a 1 in 2.17 chance they will be Isolated Past Landscape Use Patterns; If Bronze Age Funerary and Ritual remains are present, they will be associated with Composite Settlement remains;

If Iron Age remains are present, there is a 1 in 1.31 chance of them being Composite Settlement remains and a 1 in 4.16 chance they will be Isolated. If Funerary and Ritual remains are present from this period, there is a 1 in 1.05 chance that they will be associated with Composite Settlement remains;

If Roman remains are present, there is a 1 in 1.72 chance of them being Composite Settlement remains and a 1 in 2.38 chance they will be Isolated. If Funerary and Ritual remains are present from this period, there is a 1 in 1.03 chance that they will be associated with Composite Settlement remains;

If Saxon remains are present, there is a 1 in 1.47 chance of them being Composite Settlement remains as opposed to a 1 in 2.38 chance they will be Isolated. However, all Funerary and Ritual remains will be Isolated from Composite Settlement remains;

There is more likelihood of remains from the Medieval period being Isolated, with a 1 in 1.61 chance, than being Composite settlements (1 in 2.63).

Although these Premises are only Logically Sound for the Case Study data recorded, they do illustrate one analytical method to utilise the large quantities of data which are held in the Grey Literature reports and Historic Environment Records.

8.2.2 Change and consistency of Past Landscape Use Patterns

When trying to assess probable patterns of different archaeological Features and Structures for potential development sites, the Decision-maker at DMP 12b is not just interested in the remains from one particular period. The modelling utility of Past Landscape Use Patterns allows detailed analysis of Change patterns to be carried out between periods. Accordingly, a Past Landscape Use Pattern Model has been constructed for the 100 Case Study sites and is shown in Appendix 9.

This Model has been created by mapping each Past Landscape Use onto a table with each archaeological period arranged as the horizontal axis along the top. With the 100 Case Study sites arranged along the vertical axis of the table, the Past Landscape Use Patterns are then represented by different coloured arrows inserted into the corresponding period columns for each sites. The continuation of one Landscape Use into another period is shown by the continuation of the appropriate coloured arrow and a cessation of that Landscape Use is shown by the terminal of the arrow. It is recognised that this present study necessarily records continuity through the recorded presence of archaeological remains from the Case Study reports resulting from archaeological fieldwork. Whilst the assumption of absence of remains that are not recorded is admitted, it must be remembered that the intention of this research is to demonstrate only the potential utility of the methodology. More sophisticated modelling of the Past Landscape Use Patterns can be carried out by other research projects.

Continuity or change of Composite and Isolated Past Landscape Uses can be mapped out from the Landscape Use Pattern Model. Eleven of the Case Study sites revealed single period Landscape Uses, twenty-four had two continued Patterns over two periods and thirty four contained three period Landscape Use Patterns. Recordable Human Activity stretched over four contiguous periods on twenty-one sites, with six more exhibiting five-period Landscape Use Patterns and one site revealed a period of archaeological activity which spread over seven periods. Of the multi period patterns, some sites had breaks in activity between periods and these were identified as "No activity periods" for the purposes of this analysis. The many philosophical concepts of lack of human remains on a site can be discussed in future studies.

The proportions of Past Landscape Use change between two immediately contiguous periods are summarised in Figure 90. The changes are recorded between the Bronze Age and Iron Age, Iron Age to Roman, Roman to Saxon, and Saxon to Medieval. Consistency of Landscape Uses can be assessed by looking at the proportions of Composite and Isolated combinations which continue between two periods. The type of analysis should allow Probability patterns to be produced for the continuity of different Past Landscape Use Patterns. This has important implications for assessing the likelihood that archaeological remains present on a site might be associated with human activity from preceding and following periods.

Looking in more detail at the changes, the percentages of Continuity of Composite Landscape Uses between periods are shown in Figure 91 and those of Isolated Uses between the four sets of contiguous periods are shown in Figure 92. The greatest consistency between periods is that between Iron Age and Roman with 34% of Composite and 16% of Isolated Landscape Uses continuing. The change from the Bronze Age to Iron Age also shows a greater measure of consistency with 30% of Composite and 11% of Isolated Landscape Uses continuing. Lower measures of consistency are evident between the Roman and Saxon periods with only 7% of both Composite and Isolated Landscape Uses continuing. 7% of Composite and 30% of Isolated Landscape Uses continue from the Saxon to the Medieval periods. Transposing these results into Probability Rates suggests that at least one third of sites with Bronze Age and Iron Age Composite Settlements will evidence the continuation of that settlement activity into the next period. However, it is extremely unlikely that Roman and Saxon Composite Settlements will continue. This can provide useful parameters for the Decision-maker to assess the Probability of Presence of archaeological remains from different periods.

Change between Composite and Isolated Use Patterns can also be analysed and the percentages of change from Composite Landscape Uses to Isolated between the period groupings are shown in Figure 93. Similar change from Isolated to Composite Uses is shown in Figure 94. The highest percentage of change in any one period is the

21% of Bronze Age sites at which Isolated Landscape Uses change to Composite by the Iron Age. 8% of Bronze Age Composite sites change to Isolated Iron Age Landscape Use patterns. A slightly higher percentage change also occurs in the Iron Age with 19% of Composite sites changing to Isolated Roman Uses and 7% of Isolated Iron Age Uses changing to Composite within the Roman period. Change between the Roman Composite and Saxon Isolated (15%) and Roman Isolated and Saxon Composite Landscape Uses (7%) is less frequent. There are no Composite Saxon sites changing to Isolated Uses in the Medieval period and only 11% of change from Saxon Composite to Isolated Medieval Landscape Uses. These result suggest that only small numbers of Composite Settlements are reduced to Isolated Uses between periods and that very few sites with Isolated Uses in one period will see them develop into Settlement sites. The Model produced shows considerable continuity between Past Landscape Uses for most periods, but also provides the quantitative data required to assist calculation of Probability of Presence.

The change patterns are even clearer when looking at change from Composite or Isolated Use Patterns to No Activity and the percentages for each of the four period groupings are shown in Figure 95. The greatest period of such change is between the Roman and Saxon periods when 45% of Roman Composite and 16% of Roman Isolated Landscape Uses change to No Activity in the Saxon period. 26% of both Saxon Landscape Use types also change to No Activity in the Medieval period. 19% of Composite and 6% of Isolated Bronze Age remains change to No Activity in the Iron Age and 20% of Iron Age Composite and 9% of Isolated sites change to No Activity in the Roman period. The resulting Probability Rates suggest that almost half of the Composite Roman Settlement sites will cease to exist in the Saxon period. Conversely over 70% of this type of Bronze Age, Iron Age and Saxon activity will continue into the next period of human use.

These periods of No Activity, or Gap periods can indicate radical Landscape Use change which merits further research as it indicates the operation of change processes in each period. Thirty-six of the Case Study sites produced Gap periods and the proportions of these by period are shown in the Figure 96. It is interesting to note that the greatest number of Gap periods occurred in the Saxon period (51%), with 25% of period gaps occurring in the Iron Age, 16% in Roman, 5% in Neolithic and 3% in

Bronze Age. This suggests that over half of all Saxon sites within the Case study were followed by no human activity. Although it may be suggested that Gaps between human activity for some periods may be the result of the inherent perceptions of the archaeological recorders, analysis of patterns of such change could benefit all areas of archaeological research. The Model produced from the Case Study cannot produce real patterns to be assessed, but demonstrates the potential of the utility of the concept of Past Landscape Patterns.

8.2.3 Details of the Nature of Past Landscape Use Patterns

The use of Past Landscape Use Patterns to record the archaeological remains from the Case Study sample also allows the collection of the nature and some of the physical properties of the Features and Structures from different periods to be gathered. Data about the shapes, sizes, spatial arrangement and nature of all of the individual and associated archaeological remains could be gathered to produce Past Landscape Use Models. If these Models are populated with information from all archaeological Interventions from a particular region, they can be interrogated to assess the usual size of Settlement Features, their associations with other features and to develop predictions of the form, nature and spatial arrangements of features which might be present in certain locations within the landscape.

The frequency and details of Features of all Composite Settlement Landscape Use Patterns for the five periods are shown in Figure 97. Although this represents the Model of the Case Study sample, the tables show the range and types of structural and occupation Features recorded. Time constraints to this current research do not allow further detailed analysis. However, for example, the excavation records of Bronze Age Composite settlement remains could be used to measure the shapes and sizes of enclosure ditches and the enclosed settlements which they surround. The plans, shapes and sizes of the post-built buildings and their associations with other features can help to produce a database which can be used to accurately model the reality of the archaeological resource.

8.2.4 Identification of spatial characteristics of Past Landscape Use Patterns

Previous studies have recognised the importance of the spatial characteristics of archaeological remains to the success of Field Evaluation techniques:

> "The separation between the centre parts of uniform distributed trenches should depend on the curator's estimations of likely dimensions of any remains in the area"
>
> (Champion *et al.* 1995, 52)

For the identification of archaeological remains by Trial Trenching, an obvious correlation exists between the size of the gaps between trenches and the size and gaps between any archaeological remains present. A Predictive Model populated with data from local excavations could assist in the Prediction of sizes of expected Past Landscape Patterns to produce minimum gap requirements for this Technique. Accordingly, the spatial areas of the Past Landscape Use Pattern Types from each archaeological period and the spatial relationships between different Past Landscape Uses in the Case Study sample will be assessed to show the utility of the methodology.

8.2.4.1 Spatial area of Past Landscape Use Patterns

Limitations to the recording of Case Study data, as demonstrated in Section 5.5, caused great difficulty for the spatial analysis of Past Landscape Use Patterns from all of the 100 sites. The main problem was that PPG16-related intervention reports only record the spatial area of land related to the development proposals rather than the full extent of archaeological remains. It proved rare for a large enough area of the landscape to have been excavated to provide measurements of the spatial relationships between all Past Landscape Uses. Consequently, I have analysed some of the spatial patterns of Bronze Age Composite Settlement Uses to demonstrate another facet of the utility of the concept, but have not analysed the full Case Study data.

Only eleven of the thirty-four Bronze Age Composite Settlement Patterns identified from the case study sites had been subject to excavation of a large enough area of the landscape to measure the full extent and relationships between different Landscape Uses. It is noticeable that six of the Trenching Interventions used on these sites produced high Performance Scores for the identification of this Past Landscape Use with small enough spatial areas between Trenches to locate the Bronze Age Settlement remains present.

Figure 98 shows the excavation plan of the Mid to Late Bronze Age Settlement remains present at the Blind Lane site. The Enclosure ditch and associated pits, post-holes and slots which comprise the settlement remains measure 1200m^2 in area. The minimum spaces between the Trenches for the Field Evaluation of this site was 1600$m^2$and the effectiveness of this approach is shown by the Type Score of 80% for this Intervention. The Trenching intervention at Home Farm 6 left gaps of only 600m^2in size and it is no surprise, with the two areas of Bronze Age Settlement Features measuring 200m^2 and 900m^2, that they were successfully identified. Trenching gaps of 400m^2 used at Innova Business Park were able to correctly identify the Bronze Age Unknown Structures shown in Figure 99. The second Trenching intervention at Cobham Park Golf Course had one gap of 2500m^2, but the remainder of the gaps between Trenches was only 600m^2. The Bronze Age roundhouse later excavated on that site measured 900m^2 with the small gaps between Trenches allowing more probability of detection by this technique which produced an Effectiveness Type Score of 50%.

The probability of detection does seem to increase if gaps between trenches are not significantly larger than the spatial area of the Past Landscape Uses present. Two of the Trenching interventions which used larger spatial gaps performed very differently because one ensured that smaller gaps were also used. Although 100m gaps from east to west between Trenches were present at Little Stock Farm, the north to south gaps of only 2500m^2 were sufficient to identify the concentration of Bronze Age Settlement remains to a 700m^2 area within the large ditched field system. At Tanholt Farm large gaps of 10000m^2 were only able to identify the field enclosure of 10400m^2 and could not identify the nearby settlement remains which covered an area of 2170$m^{2.}$

The seven poorer performing Trenching interventions do show a general tendency to larger gaps between units. Gaps of 2100m^2 at Broughton Barn were not sufficient to identify the small Bronze Age Settlement remains of 1000m^2 in size, nor the even smaller associated cremation remains 180m to the west. Both Trenching interventions at the A24 Ashington Bypass site had gaps of only 30m east to west between units. But as a linear array aligned along the road route, the trenches investigated none of the land to the north or south. As the Figure 100 shows, the Bronze Age Settlement focus on this site measured 3300m^2 and was not on the road alignment, so that the probability of the remains falling into one of the large gaps of un-investigated land was high. In fact both of these Trenching Interventions produced Effectiveness Type Scores of 0% for the Bronze Age.

The size of measurable enclosed Bronze Age Settlements ranged from a spatial area of 4000m^{2}at Little Marlow to 1600m^{2}at Woodlands Roundabout. The spatial area of unenclosed Settlements also varied with two areas of 875 m^2 and 1200m^2 of features located 130m apart at Home Farm Site 4. Figure 101shows the excavation plan of two unenclosed small Settlements of 3500 m^2 and 4900m^2 extending 150 metres along the edge of the floodplain at Hurst Park. It is clear that large gaps of 2800 m^2 at Brisley Park 3, 4200 m^2 at Brisley Park 4 and 6400 m^2 at Hurst Park could cause the Trenching interventions to miss the entire spatial area of Bronze Age remains.

The implications of this type of research are important. It might allow the size of the gaps between sample units required to identify different Past Landscape Use Patterns to be modelled.

8.2.4.2 Spatial relationships between Past Landscape Use Patterns

There is not enough data available for most Case Study sites to measure the spatial relationships between human activities over a wide landscape area. A detailed look at one site can illustrate the range of data available. Sipson Lane, investigated by a poor performing Trenching intervention which failed to identify any Bronze Age remains, is a good example of a large spatial area of a Bronze Age settlement landscape which is worth consideration as an illustration of possible potential.

Figure 102 shows the Excavation plan of the three Bronze Age enclosed Farmstead Settlements with Funerary Landscape Uses in measurable spatial associations. Enclosure 1 is 14000m^2 in area and lies 40m to south of a Neolithic Funerary Enclosure with a zone of woodland clearance between the two.

A nearby Cremation Cemetery (750m^2) lies 210m to the north of the Settlement Enclosure and 50m to the west of the Neolithic Funerary Enclosure. The second Enclosure of 5400m^2 lies 230m to the east of Enclosure 1 and 170m to the south east of Enclosure 3. Enclosure 2 is 60m to the east of Field Enclosures and 190m to the north east of a group of Pennanular Funerary Enclosures, 179m to the west of another group of Pennanular Enclosures and 120m north east of a Cremation Cemetery. The third Enclosure was 80m wide but not revealed to its full extent in the excavation and lies 90m to the north of a group of Pennanular Funerary Enclosures.

It is noticeable that the Excavation report from Sipson Lane carries an assessment of the Effectiveness of the Field Evaluation which concluded that it failed to identify the Bronze Age foci of activity including funerary, agricultural and settlement edges and had not identified the density and distribution of Bronze Age occupation. The report concludes that "such omissions may lead to a significant underestimation of the quantity of archaeology present" (Wessex Archaeology 2000). The Field Evaluation consisted only of Trial Trenching and the intervention produced an Effectiveness Type Score of only 28%.

With gaps of 2500m^2 between trenches on this site, it is clear that these foci were missed partly because of a combination of the spatial elements of the Trenching did not coincide with the location of the remains. The spatial limitations of development related excavation are shown by the high number of sites within the case study which do not provide a large enough spatial area to reveal large areas of rural landscape uses, another reason to combine the data from fully excavated local and national sites for this Predictive Modelling process.

The range of information produced by the above analysis of Past Landscape Use Patterns shows that there is potential utility for its use in Decision-making Point 12b.

From my own experience, especially when first working in a new Local Authority area, Archaeological Curators require as much information as possible about the Types and Nature of expected archaeological remains and further research should be undertaken to provide curators with accurate spatial data to include this tool in their armoury. It is hoped that the application of this same methodology could be made to gather this data from local excavation data held in HERs and from any national research projects which identify the spatial requirements of Past Landscape Uses and the spatial patterns between combinations of the archaeological features.

8.3 Local Locational Factors – a tool to assist prediction of Probability of Presence of Alternative States of Nature

To use Past Landscape Use Patterns as a predictive tool for the Probability of Presence, a third characteristic of archaeological Features and Structures must be defined. This characteristic comprises the reasons why certain combinations of archaeological remains are present in one location and not in others.

At DMP 12b, the Decision-maker must decide which techniques will be most effective in recognising the visibility of archaeological remains of different character and density. In addition, calculations must be made as to the Probability of Presence in certain locations. As Section 8.1 has demonstrated, the Conditions of Incomplete Knowledge operating at this Decision-making Point do not currently allow enough to be available to rank the Probabilities of Presence of States of Nature. Use of the Concept of Local Locational Factors, as developed in Section 4.4.2, may provide a methodology to assist this point in the Decision-making.

Because the past human selection of sites for particular Landscape Uses was dependant on many factors relating to the landscape, environment and resources of a particular local site, it might be useful to analyse any correlations between Past Landscape Use Patterns and Local Locational Factors recognised from the Case Study sample sites. The data from the Case Study can, of course, only provide a general Model as it represents many different physical environments within many landscape types within many Counties. Yet correlations might illustrate the patterns of human use of certain parts of the landscape for certain actions and show any potential of this methodology to allow Archaeological Curators to more accurately state the Probability of the Presence of certain Past Landscape Use Patterns in particular locations.

Any criticisms of Environmental Determinism of this approach can be defended by the explanation of the bottom-up nature of this identification process. An Environmentally Deterministic model would apply general rules to patterns of past human activity in relation to the recorded environment features in a generally Top-down approach. The approach taken by this study is to record the relationships between visible Local Locational Factors and the recorded Past Landscape Uses from the Case Study sites. This is intended to demonstrate the new methodology, rather than set a set of rules to govern explanation of archaeological data in future research.

The use of Local Locational Factors is necessary in order to make the correlation between the Past Landscape Use Patterns and the appearance of the modern landscape in rural areas. At the start of this research, it was hoped that the results of Historic Landscape Characterisation could be used to link these patterns of archaeological features and structures to visible elements of the modern landscape. This would then be used to provide the information required for prediction of Probability of Presence. However, the incompleteness of the Historic Landscape Characterisation approach and its current lack of linkage with patterns of archaeological remains recorded in the Historic Environment Records meant that this was not possible.

Consequently, Local Locational Factors of Topographic Features, Physical Affordances and Relationships to other perceived Human Landscape Uses were identified from the data supplied in the archaeological reports from the Case Study sample. The links between these Local Locational Factors and certain Past Landscape Use Patterns were then identified and recorded. The Local Locational Factors associated with the Composite Settlement Landscape Uses for the periods present in the Case Study sample will be used for this analysis from those listed in Appendices 2, 3 and 4. The information for the Local Locational Factors was taken from the Client Evaluation and Post-evaluation Reports and, as described in Section 5.5, was not available for some sites. The recorded results represent only those relationships which were clear from the Explanations recorded in the archaeological reports and as such, cannot provide exact figures for Probability of Presence. Instead they should be treated as indicators of Probability.

8.3.1 Topographic features

The proportions of Topographical features with associations to Composite Settlement remains are shown in Figure 103. The analysis of associations with Topographic features shows that twenty-two of the thirty-four Bronze Age, twenty-four of the forty-seven Iron Age, eighteen of the thirty-six Roman, four of the sixteen Saxon and none of the 12 Medieval Composite Settlements were associated with High Ground. High ground is the class of Local Locational Factors which include hilltops, hill-slopes or higher ground, including dry valleys. These figures produce the Probability Factors of any Settlement remains from the Case Study being associated with High Ground shown in Figure 103. This means that there is a 1 in 1.53 chance of any Bronze Age Composite Settlement in the Case Study sample being located on High Ground. It seems there is a 1 in 2 chance of Iron Age and Roman Settlements being so located, and a 1 in 4 chance of Saxon remains being associated with this Local Location Factor. No Medieval Settlement sites are on Higher ground.

Ten of thirty-four Bronze Age, nineteen of forty-seven Iron Age, twelve of thirty-six Roman, six of sixteen Saxon and two of the twelve Medieval Composite Settlement sites were associated with Topographic Features. These are the visible plateaux , coombes, spurs, ridges, terraces, bluffs, knolls, and scarp/ escarpments which are identified by the Field Archaeologists in the immediate landscape of a site. Figure 103 shows the proportions of correlations between these Features which provide the Probability Factors. These show there is around a 1 in 3 chance of any if the Settlement sites being associated with Topographic Features.

Sixteen of the thirty-four Bronze Age, nineteen of the forty-seven Iron Age, eighteen of the thirty-six Roman, eight of the sixteen Saxon and four of the twelve Medieval Composite Settlement sites which could be measured were associated with Waterways. This class of Topographic Features includes rivers, river gravel terraces, river valley slopes, river floodplains, river headwaters, streams tributaries and their floodplains and Palaeo-channels. Again Figure 103 shows strong correlations between Settlement and Waterways with a 1 in 2-2.5 chance for the Bronze Age to Saxon periods and a 1 in 3 chance for the Medieval period.

Further detailed analysis can record the Probability Rates for the individual Topographic Features within each class. Three sites within the Case Study sample demonstrate the usefulness of collective local information for such individual Features as they show patterns relating to the Taplow river terrace gravels on which they lie. Townmead School shows a pattern of Bronze Age Ritual activity and Farmstead Settlement which ceases with subsequent Iron Age accumulation of flood deposits (alluvium). Past Landscape Uses are adjusted to make use of the alluvial deposits with Roman Settlement waste disposal and subsequent Saxon to modern agricultural use. The lithostratigraphical analysis in the Excavation report suggests a pattern of a basal gravel deposited by Devensian melt waters, followed by a typical river deposit, then a gravel land surface indicating a redundant water channel which remained as an exposed land surface within an oxbow lake with floodplain alluvial deposits upon which prehistoric people were active until the surface they occupied was widely flooded in the Iron Age period. The suitableness of this location for Settlement was removed by this flooding and subsequent human use of the site was for agricultural and waste disposal purposes.

If the Past Landscape Uses of the river gravel terraces were not disturbed by flooding, as the site at Prospect Park shows, Settlement Patterns can be continuous. Mesolithic activity followed by Neolithic to Saxon Settlement and Use of the floodplain and adjacent river terraces for Resource Gathering were recorded at Prospect Park, another post-glacial river valley terrace with brick-earth soils. Here continuous settlement activity is demonstrated until the Saxon-Norman period when the reversion to continuous agriculture occurs.

A similar pattern of continuous settlement with Ritual activity from Neolithic to Iron Age, followed by Roman Farmstead Settlement and Funerary deposition with a distinct landscape use change to Agriculture from the Saxon period onwards is recorded at Sipson Lane which is also situated on the Taplow gravels. The archaeological excavation report suggests that the Field Evaluation was successful in predicting the date range and main areas of archaeological activity at this site, but it failed to locate archaeological cut features masked by horizontal spreads, such as Roman midden deposits, which were larger than the Trench dimensions. A Trenching array and sample size suitable for the detection of continuous Settlement remains might have been possible if the Probability Rates for such activity in this type of location had been available.

8.3.2 Physical affordances

The proportions of Physical Affordances demonstrating an association with Composite Settlement remains are shown in Figure 104. The analysis of associations with Physical Affordances shows that seven of the seventeen Bronze Age Settlement, twelve of the thirty-two Iron Age, six of the twenty Roman, one of the eight Saxon, and two of the six Medieval Settlement sites which could be measured were associated with chalk geologies. Other geologies including the junction between different geologies were not measured for this study, but clear associations were noted. This shows a weak correlation between Settlements of all periods and chalk geologies.

Much stronger correlations are demonstrated between Settlement and Soil Types. A range of these Soil Types are recorded from the Case Study. One such Type is defined as the junction of agriculturally productive and unproductive soils, which can provide land for both crop and animal farming. Another Types includes the presence of particularly fertile, agriculturally productive soils such as brickearth, colluvium or alluvium. Nineteen of twenty-two Bronze Age, twenty-one of thirty-seven Iron Age, twelve of twenty-four Roman, two of eight Saxon and seven of the ten Medieval measurable Composite Settlement sites were associated with this fertile colluvial, alluvial and brickearth soils. Figure 104 shows that the Probability Rate of Bronze Age Settlement occurring on this Type of Local Locational Factor is very high with a 1 in 1.16 chance of occurrence. This Probability rate falls in subsequent periods until it rises to a 1 in 42 chance in the Medieval period.

The presence of brickearth deposits at the sites at Little Marlow and HRI Littlehampton are associated with change of Landscape Uses between the Prehistoric and Post Roman periods which might reflect environmental change factors. At Little Marlow, Taplow gravels and floodplain terrace show a pattern of Mesolithic to Iron Age use which excavated environmental evidence shows contrasts sharply with uses of the later floodplain relating to the colluvial and alluvial deposits present for post Iron Age landscape uses. At HRI Littlehampton, Bronze Age, Iron Age and Roman exploitation of the brickearth for pottery production seems to relate to farmstead settlement until a break in occupation in the Saxon period, after which the land was continuously used for agricultural purposes

The excavation reports from sites on the Taplow gravel terraces in Kent show the relationship between brickearths, Aeolian sediments conducive to arable farming, and the choice of Landscape Use. Indeed this analysis shows Patterns of Past Landscape Use changes related to broader environmental changes, such as at North of Brewers Hill Farm which showed Bronze Age Settlement extending on to the poorly drained soils in favourable environmental conditions of the time, only for it to move back to better soils in the Iron Age and this poor agricultural is not exploited again until greater productivity is required in the Roman period.

Similar patterns of settlement of land which is shown by environmental evidence to have been of lesser agricultural quality is shown at the RAF Wattisham site where heavy, poor quality soils were used for non-agricultural purposes in the Neolithic and Bronze Age periods, until the Roman exploitation of a silty subsoil introduced agricultural exploitation which peaked with a medieval farmstead settlement until population pressures subsided and the site returned to agricultural use.

The final Type of Physical Affordance Local Locational Factors are the Ecozones. One particular Type of Ecozone, which provided a mixture of land based and water based resources for food, water and materials was demonstrated to provide correlations with Past Settlement Patterns from the Case Study sites. Sixteen of the eighteen Bronze Age, nineteen of the twenty Iron Age, fifteen of the seventeen Roman, five of the six Saxon and both of the Medieval Composite Settlement remains which could be measured were associated with River Terrace Ecozones. All

Settlement sites within the Case Study sample showed a marked tendency to provide a mixed agricultural economy of arable and animal husbandry with a coastal or riverine resources of estuarine or floodplain wetland muds in addition to the use of sub littoral resources. Indeed the pattern for Settlement Landscape Uses to be located on river terraces and near to the floodplain, due to the ease of access to the different environments of agricultural land and floodplain resources available at that location, is very clear for all periods.

The geoarchaeological assessment carried out as part of the post-evaluation Excavation at Townmead School provides information that can be used to map processes of Ecozone change which could be linked to human Past Landscape Use choice. At this site, the natural processes of alluviation in the floodplain around the gravel terraces used for prehistoric settlement had created flood deposits which made a once active watercourse became redundant. These well-drained, fertile and light soils were used for Neolithic and Bronze Age agriculture and settlement and provided damp grasslands for cattle grazing as well as access to the rest of the floodplain.

8.3.3 Relationships to other perceived human Land-uses.

The measurement of all of the relationships between other perceived human Land-uses and tables showing Probability Rates was not produced as part of this research, as it lies outside the scope of the present study. However, some obvious correlations visible from a very light analysis of these patterns in relation to Bronze Age Settlement sites were noted.

Correlations between this Past Landscape Use Pattern and existing Land-uses from the same period were clear from the Case Study sites. The proximity of Bronze Age Settlement to other known Bronze Age Landscape Uses was recorded on several sites and the spatial analysis and mapping of the excavated remains for each period from HER data could allow predictive estimations of direction and proximity to be made available at Decision Making Point 12b.

The proximity of Bronze Age Landscape Uses to activity representing antiquity to the Bronze Age community themselves can also be identified from the Case Study sample. Bronze Age Settlement and Funerary Uses were closely associated with nearby Neolithic activity at some sites including a cluster of Neolithic monuments including an adjacent chambered tomb at Pilgrims Way and White Horse Stone. A Neolithic landscape of enclosures, burials and a cursus had formalised into a landscape of Bronze Age fields and Settlement enclosures at Sipson Lane. Thus the predictive estimations of direction and distance between Landscape Uses and other human elements of the landscape must include data from earlier periods.

Measuring this element from the Iron Age rural Settlement sites within the case study sample does show a pattern of proximity to Bronze Age Landscape Uses, particularly the continuation of Settlement activity and field systems within the landscape.

There is also a locational link between both Bronze and Iron Age Settlement and known later Roman activity such as the Bronze to Iron Age Settlement at all of the Brisley Farm sites which were sited 750m to the east of a later Roman crossroads Settlement. This particular location was preferred for settlement in all three periods because of its proximity to route-ways which were later formalised into Roman roads, as were the Iron Age settlements along a major prehistoric routeway which later developed into a major Roman road along the dipslope of the North Downs. Bronze Age Settlement at Westwood Cross was 550m from a Roman settlement, at Pilgrims Way it was 300m to the north of a Roman building and burials and associated with the line of a Roman road, whilst a Roman field system and droveway were 400 m to the east of a Bronze Age Settlement at Beechbrook Wood.

These relationships between Landscape Uses of different periods also show broader patterns of association. A link can be made from the restricted data of this case study between Saxon and Bronze Age Funerary Landscape Uses with Saxon burials and Settlement having been placed in association with Bronze Age burials at Little Marlow, Andover Area 6, Cuxton and Townmead School.

8.4 Conclusions about Probability of States of Nature

The Logical Testing of the Soundness of Premises of Propositions concerning Probability of Presence has been undertaken in this chapter. The recognition has been made that not enough information is available to accurately calculate the Probability of Presence of archaeological remains at particular locations within the landscape.

Too little information is currently available from Historic Environment Records to provide indicators from Known Presence or from nearby archaeological remains. There remains a great need to improve the General Models of Past Landscape Use as the existing models are lacking in important areas. Regional and Local Research Frameworks are shaped by the research interests of their creators and produce Models which are too generalistic to be used at the individual site level of the operation of Decision-making Point 12b. The PPG16-driven archaeological work carried out in the Bedfordshire Clay Uplands for the A421 Great Barford Bypass shows a greater concentration of settlement and landscape use from the Bronze Age onwards. The nine Case Study sites from this development demonstrate much denser archaeological activity in the Iron Age and Roman periods than was previously thought and provide important modifications to the General Model of clay uplands being marginal land. Historic Landscape Characterisation has been shown to lack the linkages between patterns of archaeological features and structures and elements of the visible modern landscape. The example of the Case Study site at St. Austell NE Distributor Road has shown how the re-organisation of the landscape in the Medieval period had masked the continuous Ritual activity from the Bronze Age to Roman periods. The cursory analysis of Past Landscape Use patterns carried out by this research has shown that patterns of change and continuity exist which could help to elucidate the relationships between visible and non visible past human activity within the landscape.

The currently unused body of information held within the Grey Literature resource could provide data to assist the calculation of Probability. The archaeological profession has previously lacked the methodologies and resources to measure and quantitatively analyse this data, leaving a valuable information source un-interrogated.

The above analysis of Past Landscape Use Patterns has demonstrated that patterns exist for the Types of archaeological remains present on sites which have been excavated. These Patterns of Types of Features and their spatial characteristics could be used to build a Model of the archaeological resource. The utility of the concept of Past Landscape Use Patterns has been demonstrated to assist with future research into such Model building.

The ability to interrogate such a Model to provide quantitative calculations of Probability of Presence using Local Locational Factors has also been demonstrated. This inductive approach to the production of Predictive Models for unknown areas from known data could be expanded by future research to provide much needed assistance with calculation of Probability of Presence. Here, we must accept that this research clearly shows the current state of archaeological knowledge is inadequate for the practice at this Decision-making Point of archaeological Field Evaluation. If we recognise that we do not have enough information to accurately predict Probability of Presence, we must also accept that the Logical Operation of Decision-making Point 12b cannot be carried out properly.

From a personal perspective, as one who acts as the Decision-maker at DMP 12b, this situation is not acceptable. Improvements in our practices must be made to resolve this unsatisfactory situation. The analysis of Past Landscape Use Patterns also revealed correlations between the effectiveness of Trial Trenching approaches and the spatial characteristics of both the archaeological activity and Trench sizes and arrays. The data provided from the Case Study sample of sites can be analysed to assist in the identification of potential improvements to our current approaches. Chapter 9 will now assess areas where such improvement could be made.

Chapter 9: Discussion of improvements to current archaeological Field Evaluation approaches

The results of this application of Decision Analysis to the examination of pre-determination Field Evaluation approaches have demonstrated that improvement is necessary. This research has elucidated two of the basic assumptions which, philosophically, underlie current approaches to the entire process as highlighted in Section 1.1. The assumption that Field Evaluation techniques and methodologies can effectively identify the range of archaeological remains present on a site has been tested using the results of the quantitative measurement techniques devised in Section 4.2. Chapter 7 has shown that the Field Evaluation techniques currently in use are not as effective as they have been assumed to be.

The second of the basic assumptions inherent to the current approaches to Field Evaluation in England is that Curatorial Archaeologists, as the Decision-makers at DMP 12b, can reliably predict the nature of archaeological remains present on a site. Yet Chapter 8 has demonstrated that the logical operation of DMP 12b cannot be carried out because of the lack of accurate data for the calculation of Probabilities of Presence. With the recognition that this Decision Making Point is operating under Conditions of Incomplete Knowledge comes the attendant recognition of the need for improvements to assist the logical choice from the Outcomes of Decision Options.

This Chapter will analyse the Case Study dataset drawn out in Chapters 6 to 8 to suggest possible improvements to Evaluation techniques. It will also assess whether other improvements can be made in the wider approaches to the processes of our current practice.

9.1 The Effectiveness of Field Evaluation techniques

The analysis of Effectiveness Scores in Chapter 7 uses the new quantitative methods of measuring Performance of patterns of individual techniques from Case Study sites. This quantitative assessment of information from Raw Capta does appear to have utility for the Archaeological Curator at the Portfolio Decision Type that is DMP 12b.

The performance of each technique in the particular conditions of each site can now be used as a tool when the Decision-maker uses Prioritisation to analyse the complex variety of Alternatives Courses of Action available. The generation of these Performance scores for the Date of archaeological remains has allowed the Premises of Propositions which have been tested to help define the patterns of effectiveness of for three single techniques and three Combinations.

My results show that no single Field Evaluation technique or Combination from the Case Study sample can confidently identify the date of Mesolithic remains on rural sites. The implications of this Proposition suggest that the archaeological profession must invest research and experiment into the discovery of alternative techniques or the improvement of current techniques to identify this part of the archaeological resource.

None of the individual techniques scored highly for the identification of any period present. Field-walking is, surprisingly, the most effective technique for the identification of the date of Neolithic remains, with all other techniques and combinations producing poor scores. This means that our currently used techniques can only identify the presence of Neolithic remains at 43% of sites at optimum performance. The fact that Field-walking has been demonstrated to be the most effective technique for this period suggests that it should be used on all rural sites for which the conditions allow. This supports the suggestion that a staged Field Evaluation approach is necessary, with a requirement for Field-walking to be carried out prior to a phase of Trial Trenching.

Taking a broader philosophical approach, the results of this research also suggest that perhaps Field-walking as a technique should be used more widely than the opportunities afforded by developer-led archaeological interventions. As the most effective technique for the identification of Neolithic remains, it is appropriate to suggest that improvement could be made by lessening the conditions which limit its use. As described in section 6.2.3 above, the use of Field-walking in pre-determination Field Evaluation is constrained by the requirements for crop-free, ploughed land. These conditions may not be available during the time frame of the Field Evaluation process. A more pro-active approach to the use of this technique might be to fund local programmes of Field-walking carried out, separately from the requirements of developer-led interventions, when the land was available. An even greater improvement might be the creation of appropriate conditions on unploughed land by the requirement for it to be ploughed specifically to allow the use of Field-walking.

Trenching proved the most effective technique for the identification of Date on Bronze Age, Iron Age, Saxon and Medieval periods, again with only medium scores ranging from 42% to 65%. However, as the only single technique to identify Saxon remains its performance for Date identification suggests that all Field Evaluations must include a phase of Trenching or run the risk of missing any Saxon remains present.

Whilst the Combinations of techniques measured performed rather better in the Case Study than any single technique, the bias of the small number of sites within the sample must be taken into account. However the general pattern of Combinations improving the performance of Date identification of several periods is important. The greatest increase was shown for Neolithic remains, from the 43% Score of Field-walking to 100%. Other increases, from 64% to 88% for Iron Age, from 51% to 83% for Roman and from 53% to 100% for Medieval, suggests the appropriateness of further testing of their use for improvement of Field Evaluation approaches on rural sites. This research clearly shows that not enough Combinations of techniques are currently being used in Field Evaluation practice. The results of the Date Capta Effectiveness measurements, therefore, show that improvements are required in our current use of single techniques, in the use of Combinations and through further research into alternative Field Evaluation techniques.

The Performance Patterns assessed by the PLANARCH study, shown in Figure 2, seem to demonstrate that Trenching markedly out-scores any other technique for identification of remains from each period. However, the results of my quantitative study and the difference in success measures for the Date and Type results show that this proposition is part of a professional assumption that Trial Trenching can perform far better that it actually does in reality. Whilst the Performance Scores of Trenching for Date identification agree with the general trend of performance from the PLANARCH study, the results of the Type Scores present a very different picture. The Propositions presented by the PLANARCH study have acted as the most recent updating to the archaeological profession's basic philosophical approach to the effectiveness of archaeological Field Evaluation. The results of the quantitative measurement of the effectiveness of techniques has tested the Soundness of some of these basic propositions.

The ability to assign numerical values to the measurements of effectiveness of each Alternative Course of Action provides the first opportunity to describe the accurate Performance Patterns on the same value scales for the identification of Types of archaeological remains. The Proposition that none of the non-intrusive techniques were even moderately successful at identifying the range of archaeological remains which survived on a site was proven to be Logically Sound in Section 7.1.2.

The results of the success ratings of the only two measurable non-intrusive techniques from the Case Study sample show an even lower performance than the PLANARCH study suggests. Geophysical Survey was unable to identify the full range on any of the Case Study sites and Field-walking able to achieve a 10 % success rating. The analysis of the Case Study sample sites has proven the Soundness of the Proposition that machine Trenching was the only technique to be effective at predicting character. But this first quantitative measure of a statistically valid sample of current techniques shows that our most effective technique can only identify the full range of periods present on a potential development site once in every four attempts.

The role of Trenching as the most effective Field Evaluation technique is confirmed by the Performance Patterns resulting from my analysis of Type identification. It is the only technique able to identify Mesolithic, Saxon and Medieval Type remains and the best performing technique for all periods except the Neolithic, as discussed above. But it is the much poorer performance scores for the Type results which show that the archaeological profession must make improvements to our Evaluation approaches. Under 15% of all Trenching interventions were able to achieve a good score for the identification of Mesolithic, Neolithic and Roman Types. A slight improvement to 15% and 18% was achieved respectively for the Saxon and Iron Age periods.

However, even the two periods for which Trenching proved most effective produced Good Scores on only 23% of Medieval and 32% of Bronze Age sites.
This picture of poorer Success Ratings than previously thought must galvanise the archaeological profession into further research into improvements of effectiveness. The acceptance of these low performance ratings would represent the denial of the spirit of enquiry and reflexive improvement of techniques which have characterised the philosophical approach to archaeological practice since the 18th Century. The analysis of potential improvements to our approaches should provide the impetus for further research. The need for improvements in single techniques is very clear from the results of this research. Potential improvements can be made by providing greater resolution and stronger sampling strategies and an analysis of the potential for these for Trenching will be carried out in Section 9.2. However the wider need for improvement includes the requirement for the archaeological profession to develop new techniques, test their effectiveness and to build confidence in their uses.

9.2 Improvements to Trenching Methodologies

Because it proved to be the most effective Field Evaluation technique use in the Case Study, Trial Trenching has been selected for the analysis of methodological improvements. Previous analyses of Trenching methodologies have focussed on spatial improvements such as sample size, trench length and width and patterns of layout arrays. However, they have concentrated on too small a number of sites and not included a quantitative measurement, and have therefore not provided enough data for a mathematical model to be developed (Champion *et al.* 1995; Hey & Lacey 2001). Although this Case Study sample of 100 rural sites is still too small to accurately represent the full range of Alternative States of Nature which occur in reality, the body of data which it provides is large and complicated enough to provide a representative Model which is amenable to basic statistical analysis.

Statistical analysis provides methods of establishing relationships between Variables, in this case the Trench methodologies and Performance Scores, and then establishing the direction and strength of that relation using Correlation. Positive Correlation occurs when changes in one Variable are accompanied by changes in the other in the same direction. Negative Correlation occurs when two Variables change in opposite directions and Zero Correlation occurs when two variables have no relationship at all (Drennan 1996).

This study has used the Statistical Analysis tool of "Line of best-fit" Regression to explain the general trends of Correlation direction and strength in order to assess if changes of Trenching methodologies are related to performance improvement for both Date and Type Performance Scores. The type of "Line of best-fit" Regression to be used is determined in part by the type of data it is to be applied to and partly by the strength or reliability of the Trend line (Thomas 1986). Power, Exponential or Moving average Trendlines cannot be used in this case as the data is a simple linear dataset and contains zero values. Therefore Linear, Logarithmic and Polynomial Trendlines were applied to all scattergraphs created from the dataset for every relationship illustrated and the strength of each was measured until the strongest Best-fitting Trendline could be identified.

Analysis of the dispersion of a data set can be used to test the strength of each Best-fit Trendline by measuring the degree to which individual observations are dispersed around the Best-fit line. The use of the Pearson's Product-movement Correlation Coefficient calculation gives a numerical value to the distance each point lies away from the regression line and is denoted by the mathematical symbol "R" (Fletcher & Lock 2005).

The mathematical formula for Pearson's Product-movement Correlation Coefficient is set out overleaf:

$$R = \frac{S_{xy}}{S_x S_y}$$

where x is the variable on the horizontal axis; and y is the variable on the vertical axis

S_{xy} is the covariance, given the formula $\frac{\sum xy}{n} - \bar{x}\bar{y}$

S_x is the standard deviation of $X = \sqrt{\frac{\sum x^2}{n} - \bar{x}^2}$

Sy is the standard deviation of $Y = \sqrt{\frac{\sum y^2}{n} - \bar{y}^2}$

(Graham 1999, 191).

This calculation of Correlation arranges the measurements around zero with minus 1 showing perfect Negative Correlation and 1 showing perfect Positive Correlation. A score of zero shows Zero Correlation. On this scale a score of minus 0.84 is a strong Negative Correlation and a score of 0.15 is a weak Positive Correlation.

Regression techniques can help to provide a predictive measure of the rate of improvements in methodology required to give higher Performance Scores. By identifying the equation necessary to show the Trend of the relationship when both the Variables of each methodology and Performance Scores are known, an extension of that Trend can be made on the graph to discover the change the methodology requires to achieve 100% Performance Scores. Keeping in mind the limitations of measuring only the Types of archaeological features present, rather than the quantities, this analysis will only demonstrate the utility of applying these analytical tools to the much wider dataset contained within the body of grey literature generated by PPG16 interventions and held in every County Historic Environment Record database. This is an important innovation in archaeological research as it is the first time predictions of this nature have been attempted on the data from PPG-led archaeological data.

9.2.1 Sample Percentage Size

The origins of sample percentages used in Field Evaluation seem to lie in estimation rather than any statistically proven methodologies. Champion *et al.* show that the average sample percentage sizes used in two counties in the immediate years after the publication of PPG 16 was small. Berkshire used an average sample size of 2.26% and Hampshire used an average of 3.16% (1995, 52). A later Proposition was put forward that a 3-5% sample size is required for a moderately good assessment of linears, substantial and clustered remains whilst scattered sites would need a greater sample (Hey & Lacey 2001, 50). Despite this Proposition, the majority of archaeological Trenching interventions from the Case Study sample used a smaller percentage of the site which is based around the accepted industry standard of 2%.

Eighty of the Trenching interventions provided measurable Sample percentage sizes and Total Date performance scores, that is the performance of the intervention to identify all of the periods present . These are listed in the Rural Trenching Methodologies Table in the Analysis Results Database in Appendix 7. The Sample Percentage sizes ranged from the smallest at 0.006% at Lower Icknield Way to the largest of 19.8% at Loxwood Place Farm. These were placed onto the graph in Figure 105 and the Correlation Patterns were analysed. The Polynomial ($R^2 = 0.0683$) Trendline showed the strongest of very weak Positive Correlations between the two variables. Because this shows that Total Date Performance Scores increase when sample size increases, the Correlation Co-efficient equations of the Trendline can be used to produce an extension to show the Percentage Sample sizes required to achieve increased Date identification performance.

This extension to the Trendline shown in Figure 105 has been carried out in Figure 106. This shows that if the Decision-maker at DMP 12b wishes to be sure that Trenching can identify all of the periods present on a site, an increase of Sample size to between 21% and 30% of the total area of the site will be required. The extension of the Trendline shows that for an Intervention to identify 66% of the periods present will require an increase to at least a 6% sample of the development site.

Two hundred and twenty five Trenching interventions were recorded with Type Performance Scores from all of the periods on each site and Percentage Sample size measurements. These were combined onto a scatter graph, shown in Figure 107, and the Polynomial ($R^2 = 0.0105$) Trendline again shows a very weak Positive Correlation between the two variables. Using the Polynomial Trendline so that a valid comparison can be made between Type and Date Scores suggests that the maximum Type Performance score that Trenching can reach is around 40% and that requires a 10% Sample size. Previous studies into Percentage Sample size seem to have focussed on Date identification only. The Macro-environment at Decision-making Point 12b requires all of the six questions to be asked as shown in Figure 9, not just Date. The inclusion of the Type scores in the Regression analysis is very important as it shows that the maximum performance is limited and that a bigger sample is needed to achieve this.

With the Type Performance Scores available for each of the Periods or remains present in the Case Study, a sharper focus on the Regression of Trenching performance can be made. This should provide an accurate pattern of the specific types of Features actually present from each period on the archaeological sites.

The Case Study sample contained fifty six Trenching interventions for which Percentage Sample size and Type Performance Scores could be measured for Bronze Age remains. These were added to the scatter graph in Figure 108, where the Polynomial Trendline, on this occasion, shows that the increase in Sample size to 7% can only identify a maximum of 60% of Bronze Age Feature Types and produces lesser returns as Sample size increases beyond that.

There were sixty Trenching interventions for which Percentage Sample size and Type Performance Scores could be measured for Iron Age remains and these are shown in Figure 109. The Polynomial Trendline shows a similarly very weak correlation between variables but with the highest type scores of 38% identified at around a 2.5% Sample size. This statistic is very similar to current Field Evaluation Trenching methodologies.

There were fifty six Trenching interventions at which Percentage Sample size and Type Performance scores could be measured for Roman remains. Shown in Figure 110, the Polynomial Trendline here shows a weak Positive Correlation between increases in Percentage Sample size and Performance Scores for Roman Feature Type identification. Using the Correlation equation of the Polynomial Trendline (y = 0.7152x2 - 3.0792x + 23.196) for extension, Figure 110 suggests that a 13% Sample size is optimum for the identification of all Roman Feature Types. A Good Type Score of 66% can be achieved by a Sample size of 10%.

There were only twenty four Trenching interventions at which Percentage Sample size and Type Performance Scores could be measured for the Saxon period. They are shown in Figure 111 and the Polynomial Trendline with R^2=0.0703 Correlation shows that 100% identification of all Saxon feature types can will require a 22% Sample and the Good Score of 66% will require a 17.5% Sample size.

There were thirty Trenching interventions for which Percentage Sample size and Type Performance Scores could be measured for Medieval remains. The polynomial trendline on the scatter graph in Figure 112 shows very weak Positive Correlation. Extending the Polynomial Trendline using its Correlation equation (y = 0.152x2 - 3.3512x + 38) suggests that a Sample Size of around 35% will provide the identification of all of the Medieval Feature Types present. Identification of 66% of Medieval Feature Types will require a 28% sample size.

The results of this basic statistical analysis are important and can be used with confidence as they are based on a large enough sample population to be statistically sound. They suggest that there are optimum results and more reasonable results which might be acceptable. For instance, although a 21% to 30% Percentage size will be required to identify the Dates of all of the periods present, a 6% Sample could identify 66%. The Type Scores produce a more disappointing picture with the optimum Type Scores limited to 60% of Bronze Age Feature Types (at 7%) and to 38% for Iron Age (at 2.5%) remains. 100% Type Scores can be achieved for the other three periods with a 13% Sample of Roman, 22% Sample of Saxon and a 35% Sample of Medieval periods required. This optimum performance can be tailored to more reasonable Scores of 66% Type Scores using a 10% Sample for Roman, 17.5% Sample for Saxon and a 28% Sample for the Medieval periods. There is a great deal of variety between the Sample size required for each period. The 2.5% required to produce the optimum 38% of Iron Age Type remains suggests that much more research must be carried out into alternative approaches.

9.2.2 Trench length

The strength of the separate relationships between Trench length and Date and Type Performance success have been tested with the creation of similar scatter graphs. These scatter graphs have been created with the removal of Scores from the Woodlands Roundabout site which performed as an outlier from the rest of the Trench Lengths with Trenches of 250 metres in length. Thus 72 measurable Date Scores and Trench lengths from the Case Study sample produced the graph in Figure 113. The Polynomial Trendline here has very weak Negative Correlation showing a reduction in Type Scores as Trench length increases. This suggests that the use of more shorter Trenches might be preferable to the use of fewer, longer trenches.

Figure 114 shows the relationship between Type Scores for all periods and Trench Length. Very weak Negative Correlation (R=0.01) is shown by the Trendline for the 152 Type Scores and this suggests that Trench Length has little effect on improvement of Type Score identification.

9.2.3 Gaps between Trenches

PLANARCH's proposition that the size of the gaps between Trial Trenches is most important element in Trenching design can be tested using the same techniques. It was noted in Section 8.2.4.1 that there may be a possible relationship between the gaps between trenches and the performance of Trenching at identifying Past Landscape Use Patterns with certain spatial areas. Thirty one Trenching interventions were identified with measurable Date Scores and Gaps between Trenches and have been plotted on the scatter graph in Figure 115. The Polynomial Trendline shows a definite Negative Correlation between decrease in size of the gaps between Trenches and increased Performance Scores. The 98 Type Scores for different periods for which the gaps between Trenches could be measured show a more confusing picture in Figure 116.

It is clear from Figure 115 that there is a definite relationship between a decrease in the size of gaps between Trenches and improvements in Date Score. The spatial characteristics of Past Landscape Use Patterns noted in Section 8.2.4.1 now become more important. Future improvements in Trenching methodologies should include the tailoring of size of gaps between Trenches to the expected spatial areas of Past Landscape Patterns of different periods.

9.2.4 Targeted and Non-targeted Trenches

Other methodological approaches to Trial Trenching noted from the Case Study sample of sites included whether the Trenches were targeted at any particular area of the site or whether they were randomly placed. This aspect of methodology is distinct from the use of arrays for layout of Trenches. It defines whether Trenches have been deliberately placed certain areas of the site and the reasons for that placement and has not been previously tested using quantitative methods. Thirty five Trenching interventions from the Case Study produced evidence for forty nine occasions of the targeting of the Trenches. The details of these sites are shown in the Targeted Trenching Date Scores Table in the Analysis Results Database in Appendix 7. Twenty five of the Targeted Trenches were deliberately sited over Known presence from Aerial photograph, Geophysical Survey, Field-walking and Earthwork evidence. Seven interventions were targeted on the area of the development impact, with another five targeted at the only available spaces between standing buildings. Client Reports noted that twelve sites deliberately targeted Trenches at blank areas. The differing proportions of targeting types are shown in Figure 117.

In contrast, fifty seven Trenching interventions from the Case Study sample recorded no evidence of targeting. Some Client reports stated that the aim was to produced even coverage of the entire site and others stated explicitly that random coverage was intended to reduce the gaps between Trenches. For the purposes of this research, it was assumed that Trenching was not targeted if the Client Reports contain no mention of targeting. All of the Non-targeted Trenching interventions were aligned on some form of grid array, which will be discussed below. The differing proportions of Targeted to Non-targeted Trenching interventions is shown in Figure 118, with a considerably larger number of Non-targeted types.

A fairly balanced picture is given when the different proportions of Good, Fair and Poor Date Scores are compared between the Targeted and Non-targeted interventions, as shown in Figure 119. Both types of targeting score with 1% of each other for Good Scores (over 66%), Targeted out performs Non-targeted by 9% for the Fair Scores (33% – 64%) and the situation is reversed with a 10% gap for Poor Scores (under 33%).

Yet, once again, the Type Scores show a different picture. Figure 120 shows a comparison of the Good Type Scores only (over 66%) for Targeted and Non-targeted Trenching interventions for the different periods recorded in the Case Study. Non-targeted Trenching completely outperforms Targeted for the Bronze Age period by 11%. It is in the Iron Age that the difference in performance becomes obvious, as none of the nineteen Targeted interventions can produce a Good Score, yet 30% of the Non-targeted interventions do. The pattern of Non-targeting performing better continues into the Roman period with a slight increase of 4%, but there is a marked change by the Saxon period when Targeted Trenching outperforms Non-targeted by 4%. This rises to a 6% gap in the Medieval period.

Overall the results of this analysis show that, on balance, Non-targeted Trenching should be used for the Field Evaluation of Bronze Age to Roman remains and Targeted Trenching for Saxon and Medieval remains. The complete failure of Targeted trenching for the identification of Good Iron Age Type Scores is very interesting. It may suggest that Non-targeted Trenching is the only approach to take for remains of this period.

9.2.5 Trench arrays

Although Hey & Lacey test several types of Trenching arrays, they conclude that none are more effective than the standard grid array (2001, 59). Only two of the four different types of Trenching arrays recorded from the Case Study sample in Section 6.3.4 will be tested by quantitative analysis due to insufficient number of sites for Parallel and Discontinuous Linear arrays.

The Date Scores achieved by these different arrays are shown in Figure 121. It is clear that the use of a Standard Grid is 18% better at producing the Good Scores at 43% than the 25% of Non-standard Grid arrays. It is also 6% better at producing Fair Scores, but produces only half as many Poor Scores with 26% as opposed to the 50% scored by Non-standard Grid arrays. It seems safe to assume confidently that Standard Grid arrays produce the best results for identification of the Date of archaeological remains.

The Type Score performances for each period are shown in Figure 122. They have been restricted to the Good Scores (0ver 66%) only, in order to avoid overcomplicating the graph. This shows that once again, the Standard Grid array performs 16% better for the Bronze Age period, 5% better for the Iron Age, 19% better for the Roman period and 42% better for the Saxon period. It is only for the Medieval period that the Standard Grid array does not produce any Good Type Scores, whilst the Non-standard array produces 23%.

It is clear that the Standard Grid array is the most effective for all but the identification of Medieval remains.

9.2.5 Conclusions on methodological improvements for Trenching

The statistical analysis allows the production of Propositions for which the Premises have been proven to be Logically Sound from the Case Study sample. The analysis of Trench Length shows that length of the sample unit is not important in the design of sample strategy but suggests that more shorter rather than fewer longer Trenches should be used. Non-targeted Trenches are more Effective than Targeted and a Standard Grid arrangement is preferable to other arrays. This implies that, of the methodological aspects tested in this study, the Gaps between Trenches and Sample Percentage size are the most important.

The correlation between the reduction of size of Gaps between Trenches and the improvement of Performance Scores for both Date and Type has been proven. The analysis recommends that the size of the Gaps between Trenches should relate to the spatial area and arrangement of the expected Past Landscape Use Patterns.

The most innovative and fundamental outcome of the statistical analysis, however, relates to Sample Percentage size and it requires the archaeological profession to radically change the approach to Field Evaluation Sampling. Regression of Sample percentage size for Date Scores has shown that Trenching methodologies require a Percentage size of at least 21% to identify 100% of periods present and at least a 6% Sample size to identify a Good Score of 66% of periods present.

The Sample Percentage size required for the successful identification of Types of Features from each period produces a much different picture suggesting that much greater Sample Percentage sizes are needed to improve performance of our Evaluation Trenching. The Regression exercise suggests that 60% of Bronze Age Feature Types could be identified from a 7% Sample and 40% could be identified from a 2% sample. It shows that 38% of Iron Age Features can be identified from a 2% sample. 100% of Roman Feature Types present on a site can be identified with a Trenching Sample size of 13% whilst 66% will require a 10% sample and 40% will require an 8% sample. 100% of Saxon features could be identified by a 22% sample and 66% requiring a 17.5% sample; 100% of Medieval Feature Types could be identified with a Trenching Sample size of 35% whilst 66% will require a 28% sample and 40% will require a 22% Sample.

All of this information can be put into a Decision Matrix to make comparison easier and this is shown in Figure 123. The different Sample sizes required for each period are very mixed, with the Medieval period remains requiring a much bigger sample than any other period. This may be because the rural Medieval activity was the least frequent and consisted of more dispersed activity with only 38% consisting of Composite Settlement Past Landscape Use Patterns.

These results show that the current professional use of an untested industry standard set around a 2% Sample Percentage size is flawed and unsustainable. The first mention of a 2% Sample as the minimum requirement was made in a model specification for Project Designs presented to a conference on Competitive Tendering in 1990 (Chadwick 1990). Based on an Archaeological Curator's estimate of minimum percentage with the factored in issues of "Reasonableness", this Sample size has now been demonstrated to be Logically Unsound by the Case Study analysis of this research.

Trial Trenching has now been shown by this research to require at least a 6% sample to identify 66% of periods present on a site and a Sample Percentage size of 10% is even more preferable, even though it can only identify only 40% of Types present. The requirement for an increase to 10% of Percentage Sample size will allow Archaeological Curators to be confident that the results of Field Evaluation will provide enough Information to accurately predict the Date and Type of any archaeological remains present on a potential development site.

A 10% Sample size would also be able to identify around 50% of Bronze Age, 40% of Iron Age, 66% of Roman Feature Types, but will still produce poor scores of around 30% for Saxon and 20% for Medieval. It is recommended that an increased Sample size to 15% is necessary for improving Trenching Performance for Types of Saxon and Medieval features to around 40%.

This Logical Analysis has provided one way to improve Decision-making at Decision-making Point 12b. The operation of Decision Situation described in Chapter 3, however, shows the relationship between the external Elements. The temporal and economic factors influencing the Decision Environment of DMP 12b have been shown to often outweigh the need for increase in Sample size because of the requirements of PPG 16 for the Field Evaluation process to be "reasonable and cost effective" (EH 1995). This study was published seventeen years ago and included an important analysis of costs of actual and simulated evaluation methodologies in a case study of 6 sites which concluded:

> "Although current Berkshire and Hampshire evaluations appear to address the concerns of the curators successfully, the margin of error produced by the cost constraints is inevitably greater than it would be were the constraint not present, or if the undefined term "rapid and inexpensive" were interpreted at a higher level. "
>
> (EH 1995, 41).

Yet the required increase in Sample Percentage size has not been put into practice during more than a the decade of operation of PPG16-led Interventions. An example of the operation of this relationship is shown by Figure 124. This model of the Value Weighing Process of the Decision Situation identifies the two most influential external Elements of Cost and Time. It also shows that the Decision-maker is the Archaeological Curator with whom the final judgement of reasonable Sample size lies. The lack of economic values ascribed to archaeological remains has allowed 17 years of the operation of a misconception that Field Evaluation is economically expensive and has contributed to the continued use of the untested 2% Sample size for Trial Trenching. However the analysis of one hundred and eighteen Evaluations undertaken in England between 1982 and 1991 shows that the majority of projects cost less than £5000 (Darvill *et al.* 1995, 38).

The Hey & Lacey study included estimations of cost and calculations of the increases in increases in cost and information curve. This showed a general pattern of an increase to 150% costs with an increase to 5% Sample size and an increase to 300% costs with an increase to a Sample Percentage of 10% (Hey & Lacey 2001, 43). Although the cost figures provided by the 1995 study are now out of date, they can be used to illustrate the level of increased costs of an increase in Sample Percentage size. With the majority of Field Evaluations costing under £5000 in 1995, an increase to a Sample size of 10%, as recommended by this study, would produce an increased cost of £15,000. Even with the increase in costs of Field Evaluations over the last decade and a half, this was a tiny proportion of the total costs of development.

The research into the effectiveness of our Field Evaluation techniques in Chapter 7 plainly shows that Archaeological Curators need to gain more information from Field Evaluations that at present. The need for the archaeological profession to adopt the increased Trenching Sample size of 10% is obvious, yet it seems likely that economic factors operating within the wider Decision Situation of DMP 12b could constrain this improvement if the Decision-makers and those operating within the Competitive Tendering market do not support the increases as necessary.

The question of "Reasonableness" will of course be raised in professional discussions of the recommendations of this research. If it is thought to be unreasonable to require a 10% Trenching Sample of every potential development site, perhaps different approaches to our Field Evaluation process should be considered. Hey & Lacey's Best Value assessment was used to demonstrate that Strip, Map, Sample was a cost effective Field Evaluation tool (2001). In the few English Counties in which it is currently used, it is often a replacement for the pre-determination sampling approach, sidestepping the fundamental role of Field Evaluation to identify archaeological remains which require Preservation in-situ. Yet the information provided by development-led archaeological fieldwork over the last 17 years has radically rewritten the archaeological research agendas which are the basis for the selection of sites worthy of Preservation In-situ. It seems appropriate for the archaeological profession to re-assess the objectives of Field Evaluation.

Personal discussions with Archaeological Curators visited for the collection of Case Study data for this research highlighted similar concerns. The role of the processes we currently operate in the provision of information to provide accurate mitigation strategies is paramount. Nevertheless, Chapter 8 of this research has illustrated the lack of information available for the Prediction of Probability of Presence and concluded that the Logical Operation of DMP 12b cannot be fully carried out. In a real step forward for our Decision-making, this research has recognised that Field Evaluation is operating under Conditions of Incomplete Knowledge. This advancement can allow improvement by the gathering of additional information to feed into the Process Model.

9.3 Improvements to the Decision Making Process of DMP 12b

The improvements to the effectiveness of archaeological Field Evaluation approaches suggested so far in this research do not require any changes to be made to the sequence of the Decision-making processes set out in the original Process Model in Figure 9. Yet the utility of Process Modelling allows another option for improvement through change. Our understanding of the detailed processes which make up our current approach can allow changes to actions and sequences which could also improve the effectiveness of Archaeological Field Evaluation. Two such different approaches will be described below.

9.3.1 Staged Field Evaluation Approach.

The need for increased use of Combinations of Field Evaluation techniques has been demonstrated in Chapter 7 and the utility of combining them more effectively in a Staged approach will be investigated in the first instance. Any different Combinations of techniques used must be appropriate to the questions being asked at Decision-making Point 12b. The six questions of Date, Nature, Fragility, State of Preservation, Extent and Location are identified in Figure 9. Section 5.3.1 suggests that the questions of Fragility and State of Preservation are answered generically rather than specifically from the results of Field Evaluation work. If a dimensional distinction is made between the remaining four questions being asked of the physical nature of the archaeological resource, we can see that the questions of location and extent require the effective testing of spatial area of the site using Extensive Techniques, whilst the questions of Date and Nature are answered by the use of Intensive Techniques.

English Heritage's original study distinguishes between the site detection and site investigation requirements of Field Evaluation strategies and notes that the strategies within their case study sites "usually expended most of their efforts on site detection, leaving little available trenching for site investigation" (1995, 53). Their recommendation was for a Staged approach that focuses on establishing the presence/absence of archaeological activity first and then investigating the characteristics of the resource located. This position was adopted and combined with a further application of Decision Modelling to re-model the Decision-making approach to the questions asked at DMP 12b so that appropriate combinations of techniques could be suggested.

The remodelling is based on the division of the questions asked at DMP 12b into four stages rather than the one stage shown in Figure 9. The new Model is shown in Figure 125 and was constructed with the purpose of making the Processes of Field Evaluation more effective. The first stage of the Process is the analysis of Prior Knowledge which can be gathered from documentary sources and site inspection. This Stage is primarily the same as the existing Process Model and still includes Decision-making Point 12a which asks what the Prior Knowledge of the site is. Change is seen at Stage 2 with the application of Extensive survey Techniques designed to identify the location of any remains only. The new Decision-making Point 12b only requires the location of archaeological remains to be assessed. Stage 3 includes a new Decision-making Point 12c which specifically asks questions of the Date and Nature of any remains which might be present. This is carried out by using Intensive sampling Techniques to gather information which can be supplemented by the contingency Stage 4 if more intensive targeted information is required. Fundamental issues of this changed Process Model are the lack of specific questions on Fragility and State of Preservation and that, under no circumstances, should Stages 2 and 3 be omitted.

This suggested remodelling would require changes to archaeological Field Evaluation practice. Stage 1, the gathering of Known information would remain unchanged. But Stage 2 would require Archaeological Contractors to provide a full range of Extensive Techniques to gather data on location of potential archaeological remains. At present some of these Techniques are provided by specialist Contractors and changes would include the widespread availability of these procedures to all Contractors. The effectiveness results in Chapter 7 have demonstrated that the use of Trenching is essential, therefore it must be utilised with at least a 10% Sample size in Stage 3. If more information is needed after Stage 3, then Stage 4 can act as a contingency to gather enough data to allow a Sound Mitigation Decision to be made.

This Four Stage Field Evaluation Process will necessarily require changes to the timetabling of interventions to allow completion within the timeframe of the Development Control process. Yet it could easily be incorporated into the practice of large-scale developments to provide a more effective Field Evaluation approach.

9.3.2 Predictive Modelling approach

The effectiveness of a Staged Evaluation approach could be further increased if the gathering of locational information had already been provided. Systematic Extensive surveys of the rural landscape could be carried out independently from the Development Control process. The Case Study analysis and Process Modelling of DMP 12b have demonstrated that the profession's current approach is based on intuitive expert prediction using information in the form of HER data as Prior Knowledge, and expert models in the form of research frameworks and local knowledge. Yet this approach has now been proven to be deficient in the provision of enough information to allow the full Logical operation of Decision-making Point 12b.

Recent Dutch analysis has shown that this Inductive approach can lack both external testing mechanisms and the opportunity to used theoretical considerations of human behaviour (Van Leusen & Kammermans 2005). A more effective approach might be the use of a Deductive model constructed from Prior and Gathered Knowledge which can then be tested using known site data to determine a level of best fit. The Models of Elements of the Decision Environment in Section 3.1 and that of the operations of DMP 12b in Figure 15 have shown that current English practice prefers to use direct prospection as an alternative to Model-based Prediction. Yet the recognition that Decision-making Point 12b is operating under the Conditions of Incomplete Knowledge could suggest ways to utilise the benefits of Predictive Models. The great potential for the gathering of locational information from the systematic use of Extensive archaeological techniques still remains untapped by the current focus of funding on development-led sites alone. The archaeological profession must realise that without the addition of more information to the Conditions of Incomplete Knowledge, we cannot make the Field Evaluation process anywhere near as effective or efficient as it was probably first designed to be.

The Dutch study provides a commentary on improvement in the theory and methodology of Predictive Mapping Models, evolved from late 20th Century North American government land management projects, which are used in current Dutch and International practice. This produces Heritage Presence Models which attempt to predict the presence or absence of well preserved archaeological remains on a site given the variables of current states of knowledge, models of past human behaviour, reconstructions of past landscapes, the operation of research biases and taphonomic influences (Van Leusen *et al.* 2005).

Although the Dutch approach is focussed at the regional scale, this concept has great utility for the improvement of Field Evaluation of rural sites in England. The development of Predictive Models of archaeological Features and Structures using the newly identified concepts of Past Landscape Use Patterns and Local Locational Factors could be used to construct past spatial patternings of human behaviour with a Post-processual theoretical context. Whilst previous applications of Predictive Modelling can be seen as deterministic expressions of past human behaviour, the approach advocated by Van Leusen *et al.* investigates methods of incorporating social and cultural variables in to the modelling process (2005, 30).

Predictive Modelling used in the context of Prediction of Presence of archaeological remains is based on either observed patterns of a sample or on assumptions about human behaviour. It has been used in North America to produce Regional models of Settlement to allocate "suitable" locations to specific behaviours using locational analysis, the generalisations of behavioural rules from a set of observations about how people behaved in the past (e.g. Kvamme 1993). The Dutch study shows that North American approach, though firmly set within the Explanation-based approaches advocated by New Archaeology (Hodder and Orton 1976; Clarke 1977), is management orientated and inductive.

The quantitative analysis of effectiveness of our current Field Evaluation approach suggests that our use of Known Information is far too idealistic and our Expert Models do not contain enough data to allow the Logical Operation of Decision-making Point 12b. The adoption of a new Predictive Modelling approach based on the Dutch Model could allow the patterning of archaeological Features and Structures relating to past human behaviour to be identified for rural landscapes. If the concepts of Past Landscape Use Patterns and Local Locational Factors were harnessed through such a theoretical methodologies, we could ensure that, for the first time, the Macro-environment level of the archaeological resource could be modelled. The large body of recently developed theoretical techniques, such as Bayesian statistics which has produced such radical steps forward in other archaeological applications (e.g. Bayliss & Whittle 2007) could then be utilised to assist with the development and testing of Predictive Models. The bare technological framework for such Models is increasingly available as GIS-based HER databases at the County level in England (Lang 2000, 216).

The identification that our knowledge base is operating under Conditions of Incomplete Knowledge provides the opportunity for the gathering of accurate data from local systematic surveys of the rural landscape using Extensive Evaluation Techniques. If national programmes of such fieldwork were carried out separately from the development-led archaeological intervention process, it could help to fill the gaps in our Prior Knowledge and accurate local Predictive Models to be built. A final remodelling of the Process of Field Evaluation demonstrates how such information gathering could further improve the effectiveness of our techniques. The Model shown in Figure 126 represents the most efficient approach to the Field Evaluation Process discussed by this research. Figure 126 shows how the improvement to Prior Knowledge and use of Predictive Models of past human activity within the landscape can improve the efficiency of Field Evaluation. The remodelled Process contains only two Stages and requires only one Stage of fieldwork, reducing the time and cost implications whilst greatly improving the overall effectiveness of Field Evaluation.

The streamlining of the Process could even by taken to greater extremes if Archaeological Curators decide on the purpose of Field Evaluation. Stage 2 fieldwork involving a 10% Sample by Trial Trenching could be chosen for sites thought to contain archaeological remains worthy of Preservation In-situ. Other sites thought to be worthy of Preservation by record could be subjected to Strip, Map, Sample without the need for a Field Evaluation. The resulting data could then be used to test and inform the Predictive Models in an iterative Process.

This Predictive Modelling approach could be developed as the next stage in the progression of current Characterisation applications to the rural landscape. The use of Past Landscape Use Patterns could allow linkages to be made between the map-based visible landscape patterns recorded by Historic Landscape Characterisation and the actual Features and Structures of the surviving archaeological resource. The use of Local Locational Factors could help to produce more useful Past Landscape Use Models to help the mapping of the Probability of Presence and allow Archaeological Curators greater confidence in the Logical Operation of Decision-making Point 12b.

Chapter 10: Conclusions: Implications of Performance Improvements to Decision Making at DMP 12b

The foregoing Chapters have unfolded an analysis of the Decision-making process of one of the Decision-making Points used in current English archaeological practice. Research reported here shows that Decision-making in archaeology is far more complex than archaeologists allow. In drawing together the conclusions of this research, this Chapter will discuss them under the headings of Theoretical Conclusions, Critique of current practice, Alternative approaches and the Implications for future work.

10.1 Theoretical Conclusions

The detailed application of Process Modelling to the Decision-making practices focussed around Field Evaluation has allowed the individual Stages of the current usage to be dissected in Chapter 2 of this research. The utility of the Process Model of Field Evaluation in Figure 13 has been demonstrated for the identification of not only the Decision-making Points, but also the flow, sources and input of information to the Processes. The application of Decision Analysis to the Process Model in Section 2.2 has established the Types of Decisions being made and the identified theoretical tools that assist the Decision-maker with his or her work. The realisation that Decision-making Point 12b is a Portfolio Type Decision has greatly informed its operation by the suggestion of the theoretical concept of Prioritisation as an aid. This Model has allowed the context of the operation of DMP 12b within the Local Government Planning Process to be further understood. The subsequent analysis has suggested that Archaeological Curators must debate and agree the Objectives of this Decision-making Point.

The increased sophistication of the application of Process Modelling has allowed the Elements of the Decision Environment and Decision Situation of Decision-making Point 12b to be recognised in Chapter 3. The importance of the different Scales of the Decision Situation has been indicated, as has the fact that the Element of Information is recorded at the Micro-environment scale but explained at the Macro-environment level. The Decision Situation has been taken apart to reveal how the primary Elements of Information, Logic and Value interact with each other. However, one of the most primary consequences of the application of the Process Modelling has been the recognition that detailed analysis of Decision-making Point 12b can assist with the improvement to our current approach to Archaeological Field Evaluation.

The recognition that Decision-making Point 12b is operating under Conditions of Incomplete Knowledge in Chapter 3 is a radical new discovery. It is no longer appropriate for Archaeologists to labour under Conditions of Risk if we can improve our practice with this new understanding that more information can be gathered and used to improve the Decision-making Process. Yet the demonstration that the Logical Operation of DMP 12b cannot be carried out to its full conclusion because of the lack of information on the Probability of Presence in Chapter 7 is important and disheartening to current operators. Whilst we can use the theoretical tool of Strategy of Choice based on Extreme Expected Value, it is perhaps not the most efficient approach to the question of Prediction of Probability of Presence.

The assistance of the three new archaeological concepts introduced and tested by this research is an important step forward in the improvement of the effectiveness of Field Evaluation. The three new concepts are:

- The quantitative measurements of Performance of Evaluation Techniques through the Classification of Features and Structures into Past Landscape Use Patterns developed in Chapter 5 and tested in Chapter 7.
- The use of the concept of Past Landscape Use Patterns in Chapter 8 to produce useful and accurate Models for the representation of the Alternative States of Nature at both the Micro-environment and Macro-environment Scales of information.
- The use of the concept of Local Locational Factors to assist the development of assignation of Probability of Presence in Chapter 9.

This quantitative measurement methodology in Chapter 5 has great utility for the standardisation and understanding of the local archaeological resource. This first use of quantitative measurements of Performance of Type in Chapter 7 has produced an unsatisfactory realisation that Field Evaluation techniques are less effective than has previously been recognised. With Trial Trenching identified as the only technique able to identify the nature of archaeological remains, the roles of other current techniques must be reassessed and the development of new techniques requires considerable future research.

The potential benefits of the use of the concept of Past Landscape Use Patterns stretches much further than the measurement of the Performance of Field Evaluation. This characterisation technique can provide great utility for the linking of the Micro-environment Scale of Features and Structures with the current Characterisation approaches being applied to rural landscapes.

The final new concept of Local Locational Factors can help us move towards the development of assignation of Probability of Presence to allow the proper and full Logical Operation of Decision-making Point 12b.

10.2 Critique of existing practices

The Decision Matrices produced as a result of the quantitative measurement of performance for the identification of Date and Type of Features are extremely important and should be made available to all Archaeological Curators, Contractors and Consultants on a nationwide basis. Figures 75 and 78 provide the profession with quantitative measures of effectiveness of Field Evaluation techniques for the first time. They also show that our current Field Evaluation approaches are not effective enough and that further research into potential improvements are essential.

Analysis of the spatial attributes of Bronze Age Settlement Past Landscape Use Patterns in Chapter 8 has demonstrated that the relationship between the spatial area of such patterns and the size of the gaps between Trial Trenches is a crucial element in the effectiveness of Field Evaluation. The subsequent analysis of the Trenching methodologies in Chapter 9 has confirmed this Premise. Chapter 9 has also produced the first basic statistical analysis of Performance Patterns which has revealed important guidelines for the performance improvement of Trial Trenching. A radical shift in the application of percentage sample size must be put into place with an increase to at least 10% for Trial Trenching. This is not required to produce the optimum performance of Feature identification, but to finally introduce an acceptable and reasonable sampling strategy with our current Field Evaluation techniques.

The decline of Staged Evaluation approaches and use of Combinations has been documented within the Case Study sample of sites. The continued influence of External Decision Situation Elements has been shown in Figure 124 and the profession must reconsider the strengthening of policy and strategic guidance for necessary improvements to Evaluation Performance to be made.

An important revelation of the Decision Analysis of Decision-making Point 12b is that the operation of our current approach does not provide enough information for the Logical Operation to be properly carried out. The lack of information to provide calculations of the Probability of Presence of certain Types of archaeological remains at certain locations should be considered a grave concern. It shows that our inductive Expert Models and Prior Knowledge are currently not serving the purposes for which they are used. The National, Regional and Local Research Frameworks currently developed cannot be used effectively for the provision of Probability of Presence information. Without the development of an alternative approach, Archaeological Curators will be left to operate a failing system of Prediction. The data held in County Historic Environment Records has often been gathered by extremely selective methods and there are too many gaps in knowledge for reliance on them as representative models of the actual archaeological resource.

Our current Research Frameworks are compiled from Expert Knowledge and Research priorities and some, at least, may be too focussed on information available to their compilers. These Problem-orientated Models can prove too circular and closed to be used for Prediction purposes in the Field Evaluation process. Yet the large body of data from the grey literature held in Historic Environment Record databases could be utilised by other approaches to provide more accurate predictions of Probability of Presence.

The conclusions of this research relating to current practice of Field Evaluation are that:

- Our current Field Evaluation approaches are less effective than assumed (cf: Figures 75 and 78);
- An increase to at least 10% percentage sample of each potential development site by Trial Trenching is required to produce an acceptable and reasonable sampling strategy with our current Field Evaluation techniques.
- The relationship between the spatial area of Past Landscape Use Patterns and the size of the gaps between Trial Trenches is a crucial element in the effectiveness of Field Evaluation.
- All archaeological practitioners should be made aware of this research and further research into potential improvements should be encouraged.
- The archaeological profession must reconsider the strengthening of policy and strategic guidance for necessary improvements to Field Evaluation performance to be made.
- Alternative approaches to the current methods of predicting Probability of Presence are required.

10.3 Development of alternative approaches

Initial improvements to Field Evaluation are suggested by the quantitative assessment of performance of current techniques and the basic statistical analysis of the results. Yet Chapter 9 has shown that improvements can also be made through the acceptance of radical changes in our approach to the Field Evaluation process itself. The profession must decide on the Objectives of Field Evaluation and could adopt the attitude that Field Evaluation may never be an adequate approach. The least radical improvement to Field Evaluation could be made by the changes to the processes as set out in Section 9.3.1. The first remodelling of the Process Model of DMP 12b, as shown in Figure 125, provides improvement through the Staged use of Extensive and Intensive Techniques. The use of these three separate Stages to answer the six questions originally posed by DMP 12b will still allow the Pre-determination identification of archaeological remains for mitigation of development impact by Preservation In-situ. But will not improve the actual performance of the Field

Evaluation techniques, nor provide enough information for the prediction of Probability of Presence.
The most extreme approach would be to remove Field Evaluation as an option in the development-led management of the archaeological resource. Accepting the importance of the preservation of information by record, rather than by Preservation In-situ would require that all development sites should be excavated, or recorded by Strip, Map, Sample techniques. The fundamental philosophical principles of the utility of Preservation In-situ as a management tool must be discussed, as should the importance of the information provided by PPG 16-led archaeological interventions.

A less radical, but fundamentally more far-reaching approach would be the acceptance that the Conditions of Incomplete Knowledge allow the gathering and input of additional information. Improvement to the operation of Decision-making Point 12b could be made by undertaking future research to provide data on the relationships between Local Locational Factors and Past Landscape Use Patterns. This could provide information on the Probability of Presence, along with contiguous research into the spatial characteristics of the Past Landscape Use Patterns, which could be fed into the production of Deductive Predictive Models through an application of the Dutch approach outlined in Section 9.3.2. This will also change the current mechanistic approach of Field Evaluation into a more reflexive one. These Predictive Models will need to be continuously refined and to also include the negative information of Presence.

10.4 Implications

Figure 127 illustrates the changes in practice required to implement the Staged Field Evaluation approach for the Curatorial and Contracting archaeological practitioners, for developers and the implications for the archaeological resource. The process involves four and possibly five Stages, if the contingency Intensive Evaluation Stage is used. Archaeological Curators would be required to produce Briefs to guide the Desk Top Assessment and two or three Field Evaluation interventions, as well as providing on-site monitoring of the Evaluation fieldwork. Following the production of the Desk Top Assessment, Archaeological Contractors will undertake a similar number of Fieldwork actions and produce the resulting Client Reports. The archaeological resource itself will benefit from three or four informed Stages of archaeological fieldwork. The developer, as client, will be required to fund three and one possible contingency Stages of the Process. The result would be the production of an informed Mitigation Strategy with the options of Preservation In-situ and Preservation by Record.

This Staged approach would require greater time and Curatorial resources to produce the Briefs and on-site monitoring. This approach would also require greater time commitment from the Archaeological Contractors, but would result in a Mitigation Programme of great benefit to the archaeological resource allowing the option of Preservation In-Situ. The Developer would be presented with a series of defined costs, which might however increase from those currently in operation. Yet, as the Developer's main concern about the archaeological resource is to reduce the risks to their programme, this cost-effective method of a Staged Field Evaluation approach may be welcomed. Other implications would include the complication of the production of a series of Client Reports and problems caused by the possibility of having to take each separate Stage in the process out to the competitive tendering market.

The changes in practice required by the removal of the Field Evaluation Stage are shown in Figure 128. This approach would produce great economies of time and resources for the Developers with only one uniformed archaeological fieldwork Stage. The fieldwork would consist of the recording of archaeological remains present using either Strip, Map, Sample or Excavation techniques. It would also be likely to increases the amount of research required by the Archaeological Curators to produce the Brief to guide the fieldwork. However, the apparent reduction in cost for the Developer may not be as great as first imagined if the fieldwork Stage consists of the archaeological recording of the entire development site. The costs would also be undefined and dependant on the unknown quantity and nature of the archaeological resource present. The greatest detrimental implication of this change would be to the archaeological resource, for which Preservation In-situ would not be available. This approach would be most unsuitable for the sustainable archaeological management of the archaeological resource for future generations.

The model of changes needed in current practice for the introduction of use of Deductive Process Models is shown in Figure 129. This three Stage approach would remove the Desk Top Assessment phase which might benefit both the archaeological profession and the Developer. The DTA process itself can be perceived as a less effective method of collating Known Information and as a confusing element to the Developer who is required to fund the desk-based operation. This economy of practice would reduce the Evaluation Process to one of a single document submission. Because the Prior Knowledge would be already gathered and recorded in Historic Environment Records, the Field Evaluation itself would be very highly informed and targeted at Predictive Models rather than at the Decision-making Strategy of Prioritisation of choice based on Extreme Maximum Expected Value as at present. The Field Evaluation would still serve the purpose of informing the Mitigation Strategy, but at the same time the results could be used to test and refine the Predictive Models. The implications for the Developer would be the two Stages of defined costs, rather than the five Stages of the first approach described above. This option is also the most effective for the environmentally sustainable management of the archaeological resource as it presents the option of Preservation In-Situ. However, the costs and expenditure of time and resources to gather the Prior Knowledge from systematic survey and the production of the theoretical Models would have to be borne by, as yet, unknown sources.

This issue is one which English Heritage, as the Government's advisors on the Historic Environment and a major funding source for research into archaeological matters, must consider. This research shows that national programmes of local systematic survey may be a much more effective method of improving the performance of Field Evaluation and the sustainable management of the archaeological resource than currently thought. If Curatorial practice and processes are carried out from a basic position of improved Prior Information, this much surely result in better Decision-making. The benefits, detriments, economies and increases of resources of the three suggested changed approaches to Field Evaluation discussed above and others as yet unidentified must be re-assessed in the light of the results of this research and the outcomes of the last seventeen years of operation of PPG 16-led archaeological practice.

10.5 Future work

This study has identified numerous areas in which future research should be undertaken. The most important of these are discussed below.

10.5.1: Professional debate

This research has demonstrated the value of the quantitative analysis of the effectiveness of current Field Evaluation techniques and the enormous potential of body of data held in the Grey Literature at Historic Environment Records. The results of this research need to be disseminated through the Curatorial and Contracting practitioners on a nationwide level, so that strategic and operational Decisions can be made in respect of current practices. Debate amongst Curatorial practitioners must also be stimulated so that the profession can be informed of the philosophical implications of the practices we are operating can be analysed and produce real changes to the effectiveness of our sustainable management of the archaeological resource.

10.5.2: Innovation and testing of Field Evaluation techniques:

Time and resources must also be used to experiment and provide confidence in other, possibly new and innovative, Field Evaluation techniques. In particular, the use of Strip, Map, Sample techniques should be tested as it could not be evaluated as part of this research. The Curatorial and Contracting branches of the archaeological professional must be assisted by those with the time and financial resources to carry out such a task. The financial constraints upon Local Government funded Curatorial Archaeologists are too great to allow time or staffing resources to be invested in this extremely important areas of archaeological research. With ever-dwindling local government resources, we are in no position of carry out the necessary research and testing required to improve the effectiveness of our operations, particularly in the light of possible additional statutory duties which may result from the Government's current Heritage Protection Review.

10.5.3: Pilot study of deductive dynamic deposit Modelling:

The Predictive Modelling approaches using the new concepts of Past Landscape Use Patterns and Local Locational Factors must also be thoroughly research and tested. As simplified representations of past human landscape use, these Characterisation methodologies have enormous potential to provide the missing link between the actual archaeological resource and Historic Landscape Characterisation. This must be considered within the current Government's ambitious reform agenda for the Town and Country Planning system in England.

This reform agenda has two main implications for the management of the Historic Environment. The emphasis on increasing the speed and responsiveness of the system, especially for major infrastructure projects, is set out in the Planning for a Sustainable Future White Paper (DCMS 2007). The Planning and Compulsory Purchase Act 2004 (PCPA 2004) introduces a two level strategic framework for development through Regional Spatial Strategies and Local Development Frameworks. As a spatial planning process, the production of the suites of Local Spatial Planning development documents which comprise the Local Development Frameworks require a move away from the application of the previous Policy-based system which could be applied by Archaeological Curators to the needs of each individual potential development site. Instead we are required to produce spatial plans which must take into account the sustainable needs of future communities and the use of environmental resources. The Isle of Wight's Local Development Framework, known as the Island Plan, is currently in production and the sustainable management of the historic environment resource is included in this process by the production of an Historic Environment Action Plan which has been drawn up from the recently completed Isle of Wight Historic Landscape Characterisation. Yet there is still no link between the actual features and structures of the archaeological resource and we are, as yet, unable to provide the most effective spatial planning documents possible to input into this process. Research into the use of the two new concepts and Predictive Modelling should be carried out by the archaeological profession should allow us to produce suitable and appropriate spatial plans for future use in this process.

The Planning and Compulsory Purchase Act also requires Local Authorities to maintain effective knowledge bases to support these spatial planning documents (PCPA 2004). Yet the Historic Environment Record held by the Isle of Wight Council has far too many gaps in our knowledge of the archaeological resource to act as the effective knowledge base for our predictions of the Probability of Presence or nature of expected archaeological remains for the majority of its rural landscape. With a lower rate of development than many other mainland English counties, the Isle of Wight has a higher rate of survival of large elements of the archaeological resource. Yet, with the lack of any modern systematic surveys, large areas of the rural landscape are recorded as blank on the Historic Environment Record. Yet systematic surveys of small areas, such as the Wootton-Quarr Survey have shown the wealth of archaeological features and structures surviving in the landscape. The introduction of a national programme of systematic Extensive surveys is required to supplement the information held within Historic Environment Records. Research into the production of informed, accurate theoretical models of past human activity within the landscape can then be built up and used to effectively manage the Historic Environment Resource.

A pilot study should be carried out on one distinct geographic area using the concepts analysed within this research and the systematic gathering of information from Extensive surveys, the Prior Knowledge held in Historic Environment Record and in the grey literature dataset of all PPG16-led Interventions. With the range of Landscape Types and completed Historic Landscape Characterisation, the Isle of Wight represents a microcosm of the rural landscapes of the South of England and would make an extremely good subject for such a pilot project. The results of such a study could provide important statistical data for the utility of such an approach for the rest of England.

10.5.4: Review of procedures and processes

Finally, philosophical debate must be carried out within the archaeological profession in respect of the function of pre-determination Field Evaluation. The objectives of our Decision-making must be clarified so that the most effective Field Evaluation approaches can be adopted in our future use of this archaeological tool. The unequal weighing process of the benefits and economies of our current practice over the last 17 years of compromise has taken its toll on our expectations and operations of Field Evaluation. Too many economies have been made in our operation of the Decision-making process which have acted to the detriment of the archaeological resource and its knowledge base. The archaeological profession in England does not have the information required to operate the system of Field Evaluation effectively at present and a review of the processes and procedures required by the legislation and guidance should be undertaken. This should be carried out in conjunction with Government plans to make Historic Environment Records a statutory requirement for local authorities.

This research cannot provide definitive solutions to solve this dilemma. It does, however, show how research methods, new tools and philosophical debate can assist us in the improvement of our practice. Having fulfilled its aim to investigate the effectiveness of Field Evaluation through an assessment of its Decision-making processes, this study will serve to stimulate fresh discussion, further research and new actions to help the profession sustainably manage the historic environment in the future. It is now the responsibility of those involved in archaeological research and practice to move the issue of the effectiveness of archaeological Field Evaluation forward into the 21st Century.

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Note: All legislation referred to in the text is listed on Page xix and is not included in this Bibliography.

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